ABCB SANITARY PLUMBING & DRAINAGE PIPE SIZING

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EXECUTIVE SUMMARY

The Australian Building Codes Board (ABCB) engaged Lucid Consulting Australia to undertake a review of sanitary plumbing and drainage standards BS EN 12056-2:200, BS EN 752:2017. The contract was to assess the suitability of using these plumbing and drainage pipe sizing methods in conjunction with that currently prescribed within AS/NZS 3500.2:2018, by reviewing and reporting on three main criteria, these being:

1. Identify areas where the sanitary plumbing and drainage design requirements fundamentally differ between the standards.
2. Determine whether pipe sizing methodology in the British Standards would be suitable for use in conjunction with the sanitary plumbing and drainage practice prescribed in the Australian Standard.
3. Identify areas where further testing (physical or other) may be required to ensure that there will be no unintended consequences from the use of the British Standards approach to sizing with the Australian sanitary plumbing and drainage practice.

Following a review of both BS EN 12056-2:200, BS EN 752:2017 standards, it was apparent that BS EN 752:2017 did not relate closely for comparison with AS/NZS 3500.2:2018 as the standard relates to a broader level of sanitary plumbing and drainage design, at infrastructure level.

BS EN 12056-2:2000 was noted as relevant, due to the areas of similar overall sanitary plumbing and drainage design, yet there are fundamental differences in the way systems are calculated and options that are available to the designer of the system(s). The areas of most interest for further review, consideration and possible testing were found to be:

- Waste water flow calculation methodology, utilising the below formula:

$$\mathbf{Q_{ww}} = \sqrt{\sum \quad}$$

Where:
Q_{ww} = Waste water flow rate
K = Frequency factor
$\sum$DU = Sum of discharge units

- Frequency factor (K) applied to specific sanitary plumbing and drainage systems and configurations varying from:
  - Intermittent use (e.g. dwelling, guest house, office) = 0.5
  - Frequent use (e.g. hospital, school, restaurant, hotel) = 0.7
  - Congested use (e.g. Toilets and or showers open to public use) = 1.0
  - Special use (e.g. laboratory) = 1.2

- Discharge units (DU) utilising l/s rather than fixture units (FU) number (e.g. 1 – 6) as used within AS/NZS 3500.2:2018. The difference between the two is that the DUs within BS EN 12056-2:200 are allocated a flow rate in litres per second (/s) and this flow rate differs dependent on which drainage system is selected (System 1, 2, 3 or 4).

Recommendations included further review of the following;

Calculation of capacity -

- Detailed review of current fixture unit ratings and possible re-calibration of fixture units to accommodate flow rates of modern fixtures.
- Consideration of either:
  - Converting FU number to litres per second L/S; or
  - Including this information to sizing and calculation tables or methods within the PCA framework for sanitary plumbing and drainage.
- Consideration of revising sanitary plumbing and drainage sizing tables to accommodate greater fixture numbers down part or whole of sanitary plumbing and drainage systems to increase flows

that have decreased through systems with the introduction of high efficiency fixtures (appliances) within the industry.

Calculation of flow rate and frequency factor -

- Consideration of introducing (K) 'frequency factor', to allow systems to be sized in accordance with likely usage patterns; or
- Consideration of creating different fixture unit ratings (flow rates) to be applied to differing sanitary plumbing and drainage systems, based upon building type or use.

Recommendations included and further testing of the following;

- Verification of sanitary plumbing and drainage systems using configurations prescribed within BS EN 12056-2:2000
- Creation of alternative fixture unit tables using current fixtures (appliance flows).
- Creation of frequency factor (K) for sanitary plumbing and drainage within the Australian plumbing industry.

CONTENTS

TABLES

ABBREVIATIONS

Acronym	Description
ABCB	Australian Building Codes Board
PCA	Plumbing Code of Australia
BS	British Standards
EN	European Norm
AS/NZS	Australian Standard / New Zealand Standard
DtS	Deemed to Satisfy
FU	Fixture Unit
DU	Discharge Unit
DN	Nominal Diameter
Q_{ww}	Waste Water Flow
K	Frequency Factor
∑DU	Sum of Discharge Units
Q_{tot}	Total Flow rate
Q_{c}	Continuous Flow rate
Q_{p}	Pumped Water Flow rate
Q_{max}	Pipe Capacity
L	Maximum Length (of Pipe)
H	Maximum Drop (of Pipe)
WC	Water Closet
HB	Hand Basin
SHW	Shower
%	Pipe Gradient
MM	Millimetres
M	Meters
No.	Number of (Bends)
L/S	Litres Per Second

LPM	Litres Per Minute
GPM	Gallons Per minute
M^3	Cubic Meter
Ft^3	Cubic Foot
H	Height
WELS	Water Efficiency Labelling and Standards Scheme

An explanation of terms used in this report can be found in Appendix A.

1 INTRODUCTION

1.1 OVERVIEW

The Australian Building Codes Board (ABCB) engaged Lucid Consulting Australia to undertake a review of sanitary plumbing and drainage standards BS EN 12056-2:200 and BS EN 752:2017 to assess the suitability of using these standards in conjunction with that currently prescribed within AS/NZS 3500.2:2018.

It is recognised within the Australian construction and hydraulic services industry generally that AS/NZS 3500.2:2018 is limited in flexibility and is based upon outdated, historical research data as the foundation for many of its design principles. While some of these principles remain relevant there have been many advancements in material and equipment available within the industry while standards have not seen major changes to fundamental drainage design.

1.2 SCOPE AND LIMITATIONS

Lucid Consulting Australia was engaged by the ABCB to deliver the scope of this investigation which was to review and report on three main criteria relating to BS EN 752:2017, BS EN 12065-2:2000 and AS/NZS 3500.2:2018 sanitary plumbing and drainage standards, this scope as defined within the report being:

- Identify areas where the sanitary plumbing and drainage design requirements fundamentally differ between the standards.
- Determine whether pipe sizing methodology in the British Standards would be suitable for use in conjunction with the sanitary plumbing and drainage practice prescribed in the Australian Standard.
- Identify areas where further testing (physical or other) may be required to ensure that there will be no unintended consequences from the use from the British Standards approach to sizing with the Australian sanitary plumbing and drainage practice.

The investigation undertaken by Lucid Consulting Australia was conducted in June 2019 at the request of the ABCB. The scope of works is essentially a review of three different standards BS EN 752:2017, BS EN 12065-2:2000 and AS/NZS 3500.2:2018 relating to the design of sanitary plumbing and drainage systems.

It is noted that many other standards are referenced within both BS EN 752:2017, BS EN 12065-2:2000 and AS/NZS 3500.2:2018 standards. While it is acknowledged that information contained within additional resources and standards relating to sanitary plumbing and drainage systems may be relevant and of interest, such standards, other than specifically stated above, have not been requested, nor included within scope of this Report.

1.3 STAKEHOLDERS

Plumbing Designers - Engineers, Consultants, Plumbers & Installers

Standards Australia

Suppliers – Materials / Equipment

Public – End Users & Pay for Services

Authorities & Regulatory Bodies (State & Territories)

Commonwealth of Australia - Australian Building Codes Board (ABCB)

2 CONTEXT FOR COMPARISON & HISTORY OF AS/NZS 3500.2

2.1 CURRENT DTS SANITARY PLUMBING AND DRAINAGE DESIGN

Sanitary plumbing and drainage design in accordance with Deemed to Satisfy (DtS) provisions within the PCA and AS/NZS 3500.2:2018 framework is based upon fixture unit (FU) ratings which are used for the sizing of all drains, stacks and graded discharge pipes. A fixture unit' as described within AS/NZS 3500.0:2003 (Glossary) is:

"A unit of measure, based on the rate of discharge, time of operation and frequency of use of a fixture, that expresses the hydraulic load imposed by that fixture on the sanitary plumbing installation".

Each fixture is assigned a value between 1 and 6, for example a:

Hand Basin (HB) has a FU rating of 1;

Shower (SHW) has a FU rating of 2;

Water Closet (WC) has a FU rating of 4 (with Cistern) or 6(with Flush Valve);

The cumulative FUs are used in conjunction with various tables within AS/NZS 3500.2:2018 to size and grade sanitary plumbing and drainage systems.

2.2 UNDERSTANDING A FIXTURE UNIT

Fixture units are a derivative of previous research undertaken by Roy B Hunter and colleagues. The work was commissioned by the American Standards Association (ASA) between the late 1920's to mid-1940's. Part of their research culminated in Report BMS 65 'Methods of Estimating Loads in Plumbing Systems'. Among other research within this report (simultaneous water pipe supply etc.) it was intended to standardise and simplify the approach to plumbing drainage design, that would provide safe, hygienic cost-effective design that was based upon scientific principles (probability theory).

The BMS 65 report defines a fixture unit as follows:

"Fixture unit, or load factor, is a numerical factor which measures on some arbitrary scale the load-producing effect of a single plumbing fixture of a given kind. The use of the fixture unit makes it possible to reduce the load producing characteristics to a common basis".

The ABCB has previously undertaken work in this area, the 'Fixture Unit Rating Systems Discussion Paper' (fixture unit rating systems, 23/15402 June 2015). This report provides detail about the historical research, methods of calculation, regulations and design and development of plumbing standards, within Australia. Part of the report focuses on the origin, basis and value of the current fixture unit values used in hydraulic design in Australia and compares the following:

- An overview of the system design methodology, using current fixture unit ratings, including current methods and design principles.
- An indication of the basis and values of overseas ratings compared to that currently used within Australia.
- Similarities and differences of Australian and overseas ratings.

Within the ABCB 'Fixture Unit Rating System Discussion Paper', it is noted that initial unit value within BMS 65 was based on a water closet. This shifted within Australia, and other countries to the unit value being based on a hand basin, sometime during the 1960's.

2.3 BASIS FOR REVIEW & OPPORTUNITIES

The BS EN 12056-2:2000 standard uses discharge units (DU) which use flow rates (l/s) for fixtures. This differs to the AS/NZS 3500.2:2018 standard where fixture unit tables with predetermined value are given.

Based upon limited understanding and review of resources referenced within this report, below summarises:

AS/NZS 3500.2:2018 Fixture, unit rating and converted flow rate:

Water Closet (with cistern) 4 FU = 4 GPM (15.14LPM) or 0.25 l/s

Sink (single or double) 3 FU = 3 GPM (11.36LPM) or 0.19 l/s

Shower (per head) 2 FU = 1 GPM (3.79LPM) or 0.06 l/s

Basin 1 FU = - GPM (- LPM)

Similar fixtures within BS EN 12056-2:2000 and given flow rates:

Water Closet (with 6.0 L cistern) = 1.2 l/s - 2.0 l/s (72 LPM – 120 LPM, dependent on system type selected)

Sink (single or double) = 0.5 l/s – 1.3 l/s (30 LPM - 78 LPM, dependent on system type selected)

Shower (without plug) = 0.4 l/s – 0.6 l/s (24 LPM – 36 LPM, dependent on system type selected)

Basin = 0.3 l/s – 0.5 l/s (18 LPM – 30 LPM, dependent on system type selected)

The fixture flow rates above provides one example of difference between the two standards. It also indicates that both discharge units and fixture units utilise flow rate values higher than that comparative of modern fixtures. Below provides similar fixture selections to above fixtures, with modern comparative flow rates:

Toilet (3 Star Rating) 6 L Full flush / 3 L Half flush

Tap (3 Star Rating) 7.5 LPM – 9 LPM or 0.13 l/s - 0.15 l/s

Shower (3 Star Rating) 7.5 LPM – 9 LPM or 0.13 l/s - 0.15 l/s

The intended outcome of any proposed amendment to current DtS design should provide greater versatility of sanitary plumbing and drainage systems design, to accommodate economic and industry change, such as reduced flow of fixtures and appliances.

3 REVIEW & OBSERVATIONS

3.1 OVERVIEW OF STANDARD BS EN 752:2017

The BS EN 752:2017 standard specifies the objectives for drainage and sewer systems outside buildings. It specifies functional requirements for achieving these objectives and the principles for strategic and policy activities relating to:

- Planning
- Design
- Installation
- Operation
- Maintenance
- Rehabilitation

A summary of BS EN 752:2017 is provided below:

Section 1 through to Section 5 – Information provided within these sections is: Scope, Normative References, Terms & Definitions, public health & safety, OH&S, environmental protection, sustainable development.

Section 5 through to Section 7 – Information within these sections relating to: high-level assessment for environmental impact, protection against flooding, determination of requirements for system, operational requirements, maintainability, structural design criteria, identification and assessment of impacts, assess solutions, prepare action plans, health and safety.

Section 8 through to Section 10 – Information within these sections relating to high-level design and hydraulic design considerations for: physical layout, location, overflows, structural design, material selection, control of inputs (sediment, grease separators, light liquid etc.). 8.7.3 self-cleansing conditions, testing, operation, maintenance, monitoring, dealing with major incidents.

Section 11 through Section 12 – Information relating to: qualifications, training (of personnel carrying out work within these areas) & sources of additional information.

Annex A to D and Bibliography – Annex A (informative) additional sources of information, Annex B (informative) rehabilitation approaches, Annex C (informative) operation and maintenance techniques, Annex D (normative) physical layout of the system & bibliography.

3.2 OBSERVATIONS RELATING TO STANDARD BS EN 752:2017

Review of BS EN 752:2017 highlighted fundamental differences in the way that drainage systems are designed and managed within many of these regions where it is applicable; the main difference being that rainwater or surface water and sanitary plumbing and drainage systems are often combined within the same system. Given that these regions only recently unified their standards in historical terms; the assumption can be made that this may be a legacy of historical development processes, rather than by initial design intent.

The information within this standard is based around mitigation of risk and impact to buildings (e.g. flooding of basements), infrastructure (surcharge or flood events that affect the whole of the local network and treatment plant etc). The standard relates more to broader 'system management' than specific design relating to sanitary plumbing and drainage loading, pipe size, pipe gradients, types of systems and distances of drains, both vented and unvented within buildings.

The standard (BS EN 752:2017) is applicable to drain and sewer systems from the point where waste water leaves a building, roof drainage system or paved area, to the point where it is discharged into a waste water treatment plant or receiving water body (e.g. is infrastructure standard for authority or regulator network design).

BS EN 752:2017 includes drains and sewers located below buildings; however this is only where the drain is applicable to the paragraph above and provided the system does not form part of the sanitary plumbing and drainage system for the building itself (e.g. sewer main running below a building but the appliances or fixtures within that building are not directly connected into the drain).

Although this standard (BS EN 752:2017) has areas that may be of interest for the future scope of investigations it is unrelated to current AS/NZS 3500.2:2018 in that the systems described within the standard are of larger scale than individual dwellings or developments. This standard is mainly related to the planning and management of infrastructure for a region or township. Based upon this, the standard would need to be reviewed against local authority guidelines to assess any opportunities within the specific regional State or Territory that the standard was to be applied. This would be considered a lower value area of interest for State and Territory authorities, who have developed a strategy for management of expansion, risk management, construction and design within their regions based upon local factors.

3.3 OVERVIEW OF STANDARD BS EN 12056-2:2000

ES BN 12056-2:2000 is applicable to waste water drainage systems which operate under gravity. It is applicable for drainage systems inside dwellings, commercial, institutional and industrial buildings.

A summary of the BS EN 12056-2:2000 content within the standard is listed below:

Section 1 through to Section 3 – Information provided within these sections on:

- Scope
- Normative References
- Terms & Definitions

Section 4 through to Section 6 – Information provided within these sections on:

- System types
- Configurations (relating to primary ventilated, secondary ventilated, unventilated discharge branch & ventilated discharge branch configurations)
- Layout rules (relating to compliance with European standards, protection against flooding, odour, trap seal, reduction of nominal diameter & ventilation, air admittance valves)
- Basic data (pipe diameter, discharge units & discharge from non-domestic sanitary fixtures or appliances)
- Calculation of flow rate (waste water flow rate, frequency factor, total flowrate & calculation rules)
- Layout of branches (unventilated discharge branches, ventilated discharge branches & air admittance valves for branches)
- Layout of discharge stacks (primary ventilated discharge stacks, secondary ventilated discharge stacks, air admittance valves for stacks and ventilating pipework)
- Layout of drains.

3.4 OBSERVATIONS RELATING TO STANDARD BS EN 12056-2:2000

Review of design methods within ES BN 12056-2:2000 indicates fundamental differences from that currently used within the PCA framework for sanitary plumbing and drainage design.

Differences in plumbing within European regions have led to numerous system varieties being developed. ES BN 12056-2:2000 describes a number of these 'systems types' (4 x System Types).

The second part of the standard sets out sanitary plumbing and drainage design principles for both layout and calculation, including limited provision for both trade waste drainage systems and pumped wastewater systems.

It is within sections four to six of ES BN 12056-2:2000 that the greatest differences are evident with that of AS/NZS 3500.2:2018 in regard to sanitary plumbing and drainage design. This report shall be focused on review and investigation into what opportunities or risks these may present if incorporated in part or whole into the future PCA or AS/NZS 3500.2:2018 framework.

4 FUNDAMENTAL DIFFERENCES & COMPARISON

4.1 FUNDAMENTAL DIFFERENCES – BS EN 752:2017

Upon review of the standard it is apparent that the information within the standard is unrelated to sanitary plumbing and drainage design within AS/NZS 3500.2:2018. As such it is not suitable to be included in a comparison for fundamental differences or for possible future inclusion in AS/NZS 3500.2 or for further testing as defined within section 1.2 'Scope and Limitations' of this Report.

4.2 FUNDAMENTAL DIFFERENCES – BS EN 12056-2:2000

The fundamental differences within this standard for sanitary plumbing and drainage design, from that of AS/NZS 3500.2:2018, evident upon review, are as follows:

4.2.1 BS EN 12056-2:2000 SECTION 4.2 SYSTEM TYPES

Sanitary plumbing and drainage systems described in BS EN 12056-2:2000, may be divided into four system types. Each system type is designed to allow for differing range (percentage) of filling degree within the branch discharge pipe.

The four system types for sanitary plumbing and drainage are:

SYSTEM 1 - Single discharge stack system with partly filled branch discharge pipes.

Sanitary fixtures (appliances) are connected to partly filled branch discharge pipes. The partly filled branch discharge types are designed with filling degree of 0.5 (50%) and are connected to a single discharge stack.

SYSTEM 2 - Single discharge stack system with small bore discharge branch pipes.

Sanitary fixtures (appliances) are connected to small bore branch discharge pipes. The small-bore branch discharge pipes are designed with a filling degree of 0.7 (70%) and are connected to a single discharge stack.

SYSTEM 3 - Single discharge stack system with full bore branch discharge pipes.

Sanitary fixtures (appliances) are connected to full bore branch discharge pipes. The full-bore branch discharge pipes are designed with a filling degree of 1.0 (100%) and each branch discharge pipe is separately connected to a single discharge stack.

SYSTEM 4 - Separate discharge stack system.

Drainage systems Type 1, 2 and 3 may also be divided into black water stack serving WCs and urinals and a grey water stack serving all other fixtures (appliances).

COMPARISON TO SYSTEM TYPES WITHIN AS/NZS3500.2:2018

The four System Types provided within BS EN 12056-2:2000 differ from that in the current Australian DtS framework. The selection of System 1 – 4 allowing differing filling degrees from 0.50% through to 1.0% provides flexibility with both pipe sizing, grade and flow, or fixtures (appliances) connected through any drainage pipe or system. It is also noted that many of the national or regional regulations for countries that fall under the BS EN standard, such as Belgium, Ireland and Switzerland require 'System 1' to be used, as provided in BS EN 12056-2:2000-Annex. A.

In comparison, size, grade and limitations of drains within AS/NZS 3500.2:2018 are bound by the same accumulative total of fixtures proposed to be connected to the system, whether a branch drain or stack. AS/NZS 3500.2:2018 has no scope to vary filling degree percentages of discharge pipes within systems and provided only limited scope for altering sizes and grades. The associated sections which determined size, grade of pipework generally within AS/NZS 3500.2:2018 are as follows:

AS/NZS 3500.2:2018 Section 3 ‘Drainage Design’ - This section includes:

- Maximum fixture unit loading for vented drains (Table 3.3.1)
- Minimum size of main drains and branch drains (Section 3.3)
- Minimum grade of drains (Table 3.4.1)
- Reduced grades and ‘minimum fixture unit loadings for reduced grade drains (Table 3.4.2)
- Unvented branch drains (3.10)

The above sections are used in conjunction with AS/NZS 3500.2:2018 Section 6 ‘General Design Requirements for Sanitary Plumbing Systems’ This section includes:

- Fixture unit ratings (Table 6.3(A))
- Graded discharge pipes and minimum grade of discharge pipes (Section 6.6.1 & Table 6.6.1)

The above sections are used in conjunction with the selected sanitary plumbing and drainage system ‘configuration’ within Sections 8, 9, 10.11 and 12 which has additional design, sizing and limitations relating to each specific system. These configurations shall be discussed below in comparison to BS EN 12056-2:2000 Section 4.3 ‘configurations.’

4.2.2 BS EN 12056-2:2000 SECTION 4.3 CONFIGURATIONS

These four system types can be configured in a number of different ways, governed by the need to control pressure in the pipework in order to prevent foul air from wastewater system entering the building.

There are four principal configurations being:

4.3.1 primary ventilated system – similar to AS/NZS 3500.2:2018 – Section 9 ‘Single stack system & single stack modified systems’ (unmodified).

4.3.2 secondary ventilated system – similar to AS/NZS 3500.2:2018 – Section 8 ‘fully vented system & fully vented systems’ or modified-single stack system.

4.3.3 unventilated discharge branch – similar to AS/NZS 3500.2:2018 – Section 9 ‘Single stack system & single stack modified systems’ – Section 9.5 ‘Connection of fixtures without trap vents’ - unvented fixture branch connections.

4.3.4 ventilated branch configurations – similar to AS/NZS 3500.2 – Appendix B – ‘Maximum length of fixture discharge pipe without venting’ applicable for section 8 and section 9 ‘Single stack system & single stack modified systems’.

COMPARISON TO CONFIGURATIONS WITHIN AS/NZS 3500.2:2018

These four configurations do not fundamentally differ from those in AS/NZS 3500.2:2018; however, they assist in understanding the similarities between the BS EN 12056-2:2000 system configurations and those within AS/NZS 3500.2:2018. This, in principle, indicating how calculation of these systems, which does differ fundamentally, may be adapted within Australian systems (refer to notes above regarding each system and comparable system within AS/NZS 3500.2:2018).

In addition, the current BS EN 12056-2:2000 standard does not refer to system configurations such as ‘Reduced Velocity Aerator Stack (RVAS) system’ or ‘elevated drainage principles’ that are available within AS/NZS 3500.2:2018 Sections 10.11 & 12. These additional configurations appear to allow greater selection than that available within the BS EN Standard.

Processes for approval of alternative sanitary plumbing and drainage systems, such as reduced velocity aerator stack systems, not described within BS EN 12056-2:2000, are not known. Review in this area has not been undertaken for the purpose of this reporting or comparison; however, it is acknowledged that such systems may be widely accepted and utilised for countries where BS EN 12056-2:2000 is statutory.

4.2.3 BS EN 12056-2:2000 SECTION 6.2.1 PIPE DIAMETER

Table 1 — Nominal diameters (DN) and related minimum internal diameters ($d_{i\ min}$)

Nominal diameter	Minimum internal diameter
DN	$d_{i\ min}$ mm
30	26
40	34
50	44
56	49
60	56
70	68
80	75
90	79
100	96
125	113
150	146
200	184
225	207
250	230
300	290

Table 1: Nominal Diameters – Table 1

It is suspected that this variance in pipe diameters is a derivative of having many countries or regions that the BS EN 12056-2:2000 Standard is applicable and the origins of these countries and regions having historically used differing sizing through the evolution of each of their plumbing standards before the creation of a unified standard being adopted.

COMPARISON TO PIPE DIAMETER WITHIN AS/NZS 3500.2:2018

Pipe diameters nominated within the BS EN 12056-2:200 standard offer greater range of pipe sizes, when compared to AS/NZS 3500.2:2018. This is also reflected in design of sanitary plumbing and drainage systems within the BS EN 12056-2:200 standard where sizes DN 30, 60, 70, 80 & 90 are referred to within pipework sizing tables (DN 70 being the equivalent of DN 65 in AS/NZS 3500.2:2018).

These additional pipe sizes in the BS EN 12056-2:2000 standard do not differ greatly from those in AS/NZS 3500.2:2018. If introduced to the Australian market, the benefit of any reduction in pipe sizing from DN 40 to DN 30 or similar would likely serve to only cause confusion within the industry. Further to this, alternative range of pipe sizes would require adaptation (connectors) from current standardised pipe sizing used within the Australian plumbing industry. No apparent, significant, design benefit has been identified for the use of intermediate pipe sizing that would warrant further investigation or consideration for inclusion within future Australian sanitary plumbing and drainage standards or the PCA.

4.2.4 BS EN 12056-2:2000 SECTION 6.2.2 DISCHARGE UNITS

Refer to below extract of BS EN 12056-2:2000 Table 2, for fixtures (appliances) and Discharge Unit (DU) flow rates for various Systems.

Table 2 — Discharge units (DU)

Appliance	System I	System II	System III	System IV
	DU l/s	DU l/s	DU l/s	DU l/s
Wash basin, bidet	0,5	0,3	0,3	0,3
Shower without plug	0,6	0,4	0,4	0,4
Shower with plug	0,8	0,5	1,3	0,5
Single urinal with cistern	0,8	0,5	0,4	0,5
Urinal with flushing valve	0,5	0,3	-	0,3
Slab urinal	0,2*	0,2*	0,2*	0,2*
Bath	0,8	0,6	1,3	0,5
Kitchen sink	0,8	0,6	1,3	0,5
Dishwasher (household)	0,8	0,6	0,2	0,5
Washing machine up to 6 kg	0,8	0,6	0,6	0,5
Washing machine up to 12 kg	1,5	1,2	1,2	1,0
WC with 4,0 l cistern	**	1,8	**	**
WC with 6,0 l cistern	2,0	1,8	1,2 to 1,7***	2,0
WC with 7,5 l cistern	2,0	1,8	1,4 to 1,8***	2,0
WC with 9,0 l cistern	2,5	2,0	1,6 to 2,0***	2,5
Floor gully DN 50	0,8	0,9	-	0,6
Floor gully DN 70	1,5	0,9	-	1,0
Floor gully DN 100	2,0	1,2	-	1,3

* Per person.
** Not permitted.
*** Depending upon type (valid for WC's with siphon flush cistern only).
\- Not used or no data.

Table 2: Discharge Units - Table 2

COMPARISON TO FIXTURE UNITS WITHIN AS/NZS 3500.2:2018

Discharge units (DU) used within BS EN 12056-2:2000 are similar to fixture units used within the AS/NZS 3500.2:2018 standard, in that both are used for the purpose of calculation but are not related to discharge rates of sanitary fixtures (appliances) within product standards (e.g. they do not relate to specific water efficient tapware. The difference between the two is that the DUs within BS EN 12056-2:200 are allocated a flow rate in litres per second (L/S) and this flow rate differs depending on which drainage system is selected (System 1, 2, 3 or 4). This is a fundamental difference to the current FU rating that is used to design sanitary plumbing and drainage systems within the current DtS framework using AS/ NZS 3500.2:2018. A fixture unit FU does relate to discharge rate; however, this is derived from historical research and fixture flows that were conducted in the early to mid-1900's. Refer to Section 2.2 of this report for context regarding development of fixture units (FU).

As summarised in section two above, FUs are based on the flow rates and observations of inefficient water fixtures. Fixture units are rigid and cannot be tuned or adjusted to the specific system or configuration of sanitary plumbing and drainage, types or use that they are intended for. The use of flow rate allocated to Discharge Units (DU) for fixtures (appliances) to size sanitary plumbing and drainage pipe work within the BS EN 12056-2:2000 standards allows for varied flow rate (l/s), allocated to fixtures dependent on drainage system selection.

The discharge unit (DU) table above, Table 2 BS EN 12056-2:2000, lists the flow rate of a Wash Basin between 0.5l/s (System 1) and 0.3l/s (Systems 2, 3 & 4), where as a Kitchen Sink varies between 0.8l/s (System 1), 0.6l/s (System 2), 1.3l/s (System 3) and 0.5l/s (System 4).

Comparatively the single fixture unit (1 x FU) used for a basin Table 6.3(A) AS/NZS 3500.2:2018, equates to approx. 1.89LPM or 0.03l/s. While a kitchen sink (3 x FU) is approx. 11.36 LPM or 0.18 l/s.

The difference in 'values' for 'theoretical flow rates' for a number of fixtures (appliances) is tabled below:

Fixture/Appliance	AS/NZS 3500.2:2018 Fixture Unit Rating - FU (& Approx. calculated flow rate)	BS EN 12056-2:2000 Discharge Unit – DU l/s	Difference in flow (l/s) BS EN compared to AS/NZS
Basin	1 FU (or 0.03 l/s) **Refer note's 1 & 2 below**	0.3 l/s (Systems 2, 3 & 4) 0.5 l/s (System 1)	+ 0.27 l/s(System 2, 3 & 4) + 0.47 l/s (System 1)
Sink (Single or Double)	3 FU (or 0.18 l/s)	0.5 l/s (System 4) 0.6 l/s (System 2) 0.8 l/s (System 1) 1.3 l/s (System 3)	+ 0.32 l/s (System 4) + 0.42 l/s (System 2) + 0.62 l/s (System 1) + 1.12 l/s (System 3)
Shower (Without Plug)	2FU (or 0.06 l/s) **Refer note 1 below**	0.4 l/s (System 2, 3 & 4) 0.6 l/s (System 1)	+ 0.36 l/s (System 2, 3 & 4) + 0.54 l/s (System 1)
Bath	4FU (or 0.25 l/s) **Refer note 1 below**	0.5 l/s (System 4) 0.6 l/s (System 2) 0.8 l/s (System 1) 1.3 l/s (System 3)	+ 0.25 l/s (System 4) + 0.35 l/s (System 2) + 0.55 l/s (System 1) + 1.05 l/s (System 3)
Water Closet (6.0L Cistern)	4FU (or 0.25 l/s) **Refer note 1 below**	1.2 - 1.7 l/s (System 3) 1.8 l/s (System 2) 2.0 l/s (System 1 & 4)	+ 0.95 - 1.45 l/s (System 3) +1.55 l/s (System 2) +1.75 l/s (System 1 & 4)

Table 3: Comparison FU & DU Flow rates

NOTE 1 – Table does not include 'bathroom group' FU reduction within AS/NZS 3500.2:2018, Table 6.3(A)

NOTE 2 – For simplicity, one fixture unit (1 x FU) flow rate is indicated as half that of two fixture units (2 x FU) however

Fixture (appliance) flow rates differ significantly between FU and DU methods, with DU method providing a much lower flow rate attributed to that fixture than the DU method. For small groups of fixtures this would not be expected to affect drain design (grade or size) significantly. Where medium to high numbers of fixtures are proposed to be connected however, this cumulative difference would likely be far greater in significance to impact drainage design (grade or size).

For example:

30 basins would equate to -

- 15 l/s within BS EN 12056-2:2000 Standard, using System 1 (0.5 l/s x 30 Basins = 15 l/s)
- 0.9 l/s using the AS/NZS 3500.2:2018 Standard (1FU x 30 Basins or 0.03 l/s x 30 Basins = 0.9 l/s)

The difference between the two standards in 'theoretical flow rate' through the two systems is 14.1 l/s in favour of AS/NZS 3500.2:2018.

30 sinks would equate to -

- 24 l/s within BS EN 12056-2:2000 Standard, using System 1 (0.8 l/s x 30 Basins = 24 l/s)
- 5.4 l/s using the AS/NZS 3500.2:2018 Standard (3FU x 30 Sinks or 0.18 l/s x 30 Sinks = 5.4 l/s)

The difference between the two standards in 'theoretical flow rate' through the two systems is 18.6 l/s in favour of AS/NZS 3500.2:2018.

Total theoretical design flow of fixtures (appliances) -

- BS EN 12056-2:2000 = 39 l/s
- AS/NZS 3500.2:2018 = 6.3 l/s

The total difference between the two standards in 'theoretical flow rate' for 30 basins and 30 sinks is 32.7 l/s, an 83.8% reduction in favour of AS/NZS 3500.2:2018.

NOTE – The above theoretical flow rates do not include 'K' frequency factor calculation and is only used to represent sum of discharge units (DU) to that of fixture units (FU).

NOTE – The above theoretical flow rate comparisons are based on the limited observations and understandings of AS/NZS 3500.2:2018, BS EN 12056-2:2000 and Reports BMS 65 'Methods of Estimating Loads in Plumbing Systems' and ABCB 'Fixture Unit Rating Systems Discussion Paper', referenced within this report.

4.2.5 BS EN 12056-2:2000 SECTION 6.3.1 WASTEWATER FLOW RATE (Q_{ww})

Q_{ww} is the expected flow rate of wastewater in a part or in the whole drainage system where only domestic sanitary fixtures (appliances) (see Table 2 within BS EN 12056-2:2000) are connected to the system.

$$Q_{ww} = \sqrt{\sum}$$

Where:

Q_{ww} = Waste water flow rate (l/s)

K = Frequency factor

∑DU = Sum of discharge units

4.2.6 BS EN 12056-2:2000 SECTION 6.3.2 FREQUENCY FACTOR (K)

Typical frequency factors associated with different usage of fixtures (appliances), are given in Table 3 of BS EN 12056-2:2000. There are four (K) factors used to define frequency (usage of appliances / fixtures) within Table 3, these are:

TABLE 3 – TYPICAL FREQUENCY FACTORS (K)

Usage of Appliance (Fixture)	K - Factor
Intermittent use (e.g. dwelling, guest house, office)	0.5
Frequent use (e.g. hospital, school, restaurant, hotel)	0.7
Congested use (toilets and or showers open to public use)	1.0
Special use (e.g. laboratory)	1.2

Table 4: Frequency Factors

4.2.7 BS EN 12056-2:2000 SECTION 6.3.3 TOTAL FLOWRATE (Q_{tot})

Q_{tot} is the design flow rate in a part or in the whole drainage system where sanitary fixtures (appliances), fixtures (appliances) with continuous flow and/or wastewater pumps are connected to the system.

Continuous flows and pump discharge rates shall be added to the waste water flow rate without any reduction.

$$Q_{tot} = Q_{ww} + Q_c + Q_p$$

Where:

Q_{tot} = total flow rate (l/s)

Q_{ww} = Waste water flow rate (l/s)

Q_c = Continuous flow rate (l/s)

Q_p = Pumped water flow rate (l/s)

4.2.8 BS EN 12056-2:2000 SECTION 6.3.4 CALCULATION RULES

The pipe capacity (Q_{max}) shall be at least the larger of:

1. The calculated waste water flow rate (Q_{ww}) or total flow rate (Q_{tot}); or
2. The flow rate of the fixture (appliance) with the largest discharge unit (refer section 4.2.4 of this report for extract of BS EN 12056-2:2000 Table 2).

Note - Some values of Q_{ww} or Q_{tot} calculated for different frequency factors (K) and sums of discharge units (DU) are tabulated in annex B (refer annex B within BS EN 12056-2:2000).

COMPARISON OF CALCULATING CAPACITIES WITHIN AS/NZS 3500.2:2018

BS EN 12056-2:2000 and AS/NZS 3500.2:2018 are similar, as both standards use the cumulative total sum of fixtures (appliances) to determine a pipe's size, length and grade. Both Discharge Units (DU) for BS EN 12056-2:2000 and Fixture units (FU) AS/NZS 3500.2:2018, are used with relevant tables, listed previously above, to determine size, length and grade of sanitary plumbing and drainage systems.

Provisions within BS EN 12056-2:2000 to calculate 'theoretical wastewater flows' (Q_{ww}) through part of whole of a system and the ability to apply a 'frequency factor' (K) for a system is a fundamental difference form the current AS/NZS 3500.2:2018 framework.

The frequency factors (K) provided within the BS EN 12056-2:2000 Standard appear similar to building classifications within current NCC (PCA) Framework. These are observed to be:

Usage of Appliance (Fixture)	K - Factor	NCC (PCA) Building Classification
Intermittent use (e.g. dwelling, guest house, office)	0.5	Class 1a, 1b, 2, 5
Frequent use (e.g. hospital, school, restaurant, hotel)	0.7	Class 3, 6, 9a, 9b
Congested use (toilets and or showers open to public use)	1.0	Class 9
Special use (e.g. laboratory)	1.2	Class 8

Table 5: Comparison of Frequency Factor to NCC Building Classifications

It is anticipated that the BS EN 12056-2:2000 method of calculation, would have the greatest impact, compared to AS/NZS 3500.2:2018, where a substantial number of fixtures (appliances) is proposed to be connected.

This assumption assumes the frequency factor (K) would impact total flow rate $Q_{tot,}$ when compared to current FU sizing methods within AS/NZS 3500.2:2018, which does not differentiate frequency of use.

4.2.9 BS EN 12056-2:2000 SECTION 6.4.1 UNVENTILATED DISCHARGE BRANCHES

Section 6.4.1 provides design for size and limitations of unventilated discharge branches. These are provided in Tables 4 and 5 of BS EN 12056-2:2000. Where limitations within the tables cannot be met, vents shall be provided for discharge branches. Section 6.4.1 generally aligns with AS/NZS 3500.2 design methodology for unventilated discharge pipes.

Table 4 – hydraulic capacity (Q_{max}) and nominal diameter (DN)

Refer to below extract of BS EN 12056-2:2000 Table 4

Table 4 — Hydraulic capacity (Q_{max}) and nominal diameter (DN)

Q_{max}	System I	System II	System III	System IV
l/s	DN	DN	DN	DN
0,40	*	30	see Table 6	30
0,50	40	40		40
0,80	50	*		*
1,00	60	50		50
1,50	70	60		60
2,00	80**	70**		70**
2,25	90***	80****		80****
2,50	100	90		100

* Not permitted.
** No WC's.
*** Not more than two WC's and a total change in directions of not more than 90°.
**** Not more than one WC.

Table 6: Unventilated Discharge Branches – Table 4

Table 4 provides Q_{max} (pipe capacity) in l/s and varies from 0.40l/s to 2.5l/s for allowable flows through discharge branches. The size of pipe is nominated for each of the four discharge system types (Systems 1, 2 or 4, excluding System 3, as this is referred to in Table 6).

For example -

- A discharge branch with capacity/flow rate (Q_{max}) of 0.8L/S can utilise a pipe size DN 50 for System 1 but is 'not permitted' for System 2 or 4.
- A discharge branch with capacity/flow rate (Q_{max}) of 2.25L/S can utilise a pipe size DN 90 for System 1 (no WC's can be connected), and DN 80 for Systems 2 or 4 (no more than 1 WC can be connected).

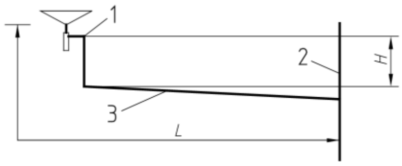
Table 5 – Limitations

Refer to below extract of BS EN 12056-2:2000 Table 5 & Figure 6

Table 5 — Limitations

Limitations	System I	System II	System III	System IV
Maximum length (*L*) of pipe	4,0 m	10,0 m	see Table 6	10,0 m
Maximum number of 90° bends	3*	1*		3*
Maximum drop (*H*) (45° or more inclination)	1,0 m	**6,0 m DN > 70 **3,0 m DN = 70		1,0 m
Minimum gradient	1 %	1,5 %		1 %

* Connection bend not included.
** If DN < 100 mm and a WC is connected to the branch no other appliances can be connected more than 1 m above the connection to a ventilated system.



1 Connecting bend   2 Stack   3 Branch ventilating pipe

Figure 6 — Limitations for unventilated discharge branches in system I, II, IV

Table 7: Limitations for Unventilated Discharge Branches – Table 5 & Figure 6

Table 5 refers to discharge pipe maximum length, number of bends, maximum drop and minimum gradients for each different system type (Systems 1 through 4), excluding System 3 as this is referred to in Table 6.

Table 6 – Limitations for unventilated branch-discharge-pipes in System 3

Refer to below extract of BS EN 12056-2:2000 Table 6

Table 6 — Limitations for unventilated branch-discharge-pipes, system III

Appliance	Diameter DN	Min. trap seal depth mm	Max. length (*L*) of pipe from trap outlet to stack m	Pipe gradient %	Max. number of bends No.	Max. drop (*H*) m
Washbasin, bidet (30 mm diameter trap)	30	75	1,7	2,2[1)]	0	0
Washbasin, bidet (30 mm diameter trap)	30	75	1,1	4,4[1)]	0	0
Washbasin, bidet (30 mm diameter trap)	30	75	0,7	8,7[1)]	0	0
Washbasin, bidet (30 mm diameter trap)	40	75	3,0	1,8 to 4,4	2	0
Shower, bath	40	50	No Limit[2)]	1,8 to 9,0	No Limit	1,5
Bowl urinal	40	75	3,0[3)]	1,8 to 9,0	No Limit[4)]	1,5
Trough urinal	50	75	3,0[3)]	1,8 to 9,0	No Limit[4)]	1,5
Slab urinal[5)]	60	50	3,0[3)]	1,8 to 9,0	No Limit[4)]	1,5
Kitchen sink (40 mm diameter trap)	40	75	No Limit[2)]	1,8 to 9,0	No Limit	1,5
Household dishwasher or washing machine	40	75	3,0	1,8 to 4,4	No Limit	1,5
WC with outlet up to 80 mm[6)]	75	50	No Limit	1,8 Min.	No Limit[4)]	1,5
WC with outlet greater than 80 mm[6)]	100	50	No Limit	1,8 Min.	No Limit[4)]	1,5
Food waste disposal[7)]	40 Min.	75[8)]	3,0[3)]	13,5 Min.	No Limit[4)]	1,5
Sanitary towel disposal unit	40 Min.	75[8)]	3,0[3)]	5,4 Min.	No Limit[4)]	1,5
Floor drain	50	50	No Limit[3)]	1,8 Min.	No Limit	1,5
Floor drain	70	50	No Limit [3)]	1,8 Min.	No Limit	1,5
Floor drain	100	50	No Limit [3)]	1,8 Min.	No Limit	1,5
4 basins	50	75	4,0	1,8 to 4,4	0	0
Bowl urinals[8)]	50	75	No Limit[3)]	1,8 to 9,0	No Limit[4)]	1,5
Maximum of 8 WC's[6)]	100	50	15,0	0,9 to 9,0	2	1,5
Up to 5 spray tap basins[9)]	30 Max.	50	4,5[3)]	1,8 to 4,4	No Limit[4)]	0

1) Steeper gradient permitted if pipe is less than maximum permitted length.
2) If length is greater than 3 m noisy discharge may result with an increased risk of blockage.
3) Should be as short as possible to limit problems with deposition.
4) Sharp throated bend should be avoided.
5) For slab urinal for up to 7 persons. Longer slabs to have more than one outlet.
6) Swept-entry branches serving WC's.
7) Includes small potato-peeling machines.
8) Tubular not bottle or resealing traps.
9) Spray tap basin shall have flush-grated wastes without plugs.

Table 8: Limitations for Unventilated Discharge Branches, System 3 – Table 6

Table 6 is for exclusive use with System 3 and lists appliances (fixtures) with allowances and limitations for each individual fixture (appliance), in relation to:

- Diameter (DN) discharge drain minimum size.
- Minimum trap seal depth (MM).
- Maximum length of pipe from trap outlet to stack (M).
- Pipe gradient (%).
- Maximum number of bends (No.).
- Maximum drop discharge drain (H), greater than 45 degrees.

4.2.10 BS EN 12056-2:2000 SECTION 6.4.2 VENTILATED DISCHARGE BRANCHES

Sizes and limitations upon the use of ventilated discharge branches are given in Table 7 and 8 of BS EN 12056-2:2000.

Table 7 – Hydraulic capacity (Q_{max}) and nominal diameter (DN) & Table 8 – Limitations

Refer to below extract of BS EN 12056-2:2000 Table's 7 & 8 and Figure 7

Table 7 — Hydraulic capacity (Q_{max}) and nominal diameter (DN)

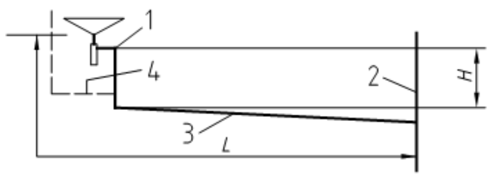
Q_{max} l/s	System I	System II	System III	System IV
	DN	DN	DN	DN
	Branch/Vent	Branch/Vent	Branch/Vent	Branch/Vent
0,60	*	30/30	see Table 6	30/30
0,75	50/40	40/30		40/30
1,50	60/40	50/30		50/30
2,25	70/50	60/30		60/30
3,00	80/50**	70/40**		70/40**
3,40	90/60***	80/40****		80/40****
3,75	100/60	90/50		90/50

* Not permitted.
** No WC's.
*** Not more than two WC's and a total change in directions of not more than 90°.
**** Not more than one WC.

Table 8 — Limitations

Limitations	System I	System II	System III	System IV
Maximum length (*L*) of pipe	10,0 m	No Limit	see Table 9	10,0 m
Maximum number of 90° bends*	No Limit	No Limit		No Limit
Maximum drop (*H*) (45° or more inclination)	3,0 m	3,0 m		3,0 m
Minimum gradient	0,5 %	1,5 %		0,5 %

* Connection bend not included.



1 Connection bend
2 Stack
3 Branch discharge pipe
4 Branch ventilating pipe

Figure 7 — Limitations for ventilated discharge branches in system I, II and IV

Table 9: size and Limitations for Ventilated Discharge Branches – Table 7 & 8, Figure 7

Table 7 and 8 replicate Table 4 and 5, however they are used for ventilated discharge branches, rather than unventilated discharge branches. Equally these tables are used in determining size (DN), discharge pipes maximum length, number of bends, maximum drop and minimum gradients for each different system type (Systems 1 through 4), excluding System 3 as this is referred to Table 6.

Table 9 – Limitations for ventilated branch-discharge-pipes, System 3

Refer to below extract of BS EN 12056-2:2000 Table 9

Table 9 — Limitations for ventilated branch discharge pipes in system III

Appliance	Diameter DN	Min. trap seal depth mm	Max. length (*L*) of pipe from trap outlet to stack m	Pipe gradient %	Max. number of bends No.	Max. drop (*H*) m
Washbasin, bidet (30 mm diameter trap)	30	75	3,0	1,8 Min.	2	3,0
Washbasin, bidet (30 mm diameter trap)	40	75	3,0	1,8 Min.	No Limit	3,0
Shower, bath	40	50	No Limit[2)]	1,8 Min.	No Limit	No Limit
Bowl urinal	40	75	3,0[3)]	1,8 Min.	No Limit[4)]	3,0
Trough urinal	50	75	3,0[3)]	1,8 Min.	No Limit[4)]	3,0
Slab urinal[5)]	60	50	3,0[3)]	1,8 Min.	No Limit[4)]	3,0
Kitchen sink (40 mm diameter trap)	40	75	No Limit[2)]	1,8 Min.	No Limit	No Limit
Household dishwasher or washing machine	40	75	No Limit[3)]	1,8 Min.	No Limit	No Limit
WC with outlet up to 80 mm[6) and 14)]	75	50	No Limit	1,8 Min.	No Limit[4)]	1,5
WC with outlet greater than 80 mm[6) and 14)]	100	50	No Limit	1,8 Min.	No Limit[4)]	1,5
Food waste disposal[7)]	40 Min.	75[8)]	3,0[3)]	13,5 Min.	No Limit[4)]	3,0
Sanitary towel disposal unit	40 Min.	75[8)]	3,0[3)]	5,4 Min.	No Limit[4)]	3,0
Bath drain, floor drain	50	50	No Limit[3)]	1,8 Min.	No Limit	No Limit
Floor drain	70	50	No Limit[3)]	1,8 Min.	No Limit	No Limit
Floor drain	100	50	No Limit[3)]	1,8 Min.	No Limit	No Limit
5 basins[9)]	50	75	7,0	1,8 to 4,4	[2)]	0
10 basins[9)and 10)]	50	75	10,0	1,8 to 4,4	No Limit	0
Bowl urinals[9) and 11)]	50	75	No Limit[3)]	1,8 Min.	No Limit[4)]	No Limit
More than 8 WC's[6)]	100	50	No Limit	0,9 Min.	No Limit	No Limit
Up to 5 spray-tap basins[12)]	30 Max.	50	No Limit[3)]	1,8 to 4,4	No Limit[4)]	0

1) For maximum distance from trap to vent; see Figure 8.
2) If length is greater than 3 m, noisy discharge may result with an increased risk of blockage.
3) Should be as short as possible to limit problems with deposition.
4) Sharp throated bends should be avoided.
5) For slab urinal for up to 7 persons. Longer slabs to have more than one outlet.
6) Swept-entry branches serving WC's.
7) Includes small potato-peeling machines.
8) Tubular not bottle or resealing traps.
9) See Figure 9.
10) Every basin shall be individually ventilated.
11) Any number.
12) Spray tap basins shall have flush-grated wastes without plugs.
13) The size of ventilating pipes to branches from appliances can be DN 25 but, if they are longer than 15 m or contain more than five bends, a DN 30 pipe shall be used.
14) If the connection of the ventilating pipe is liable to blockage due to repeated splashing or submergence, it should be DN 50, up to 50 mm above the spill-over level of the appliance.

Table 10: Limitations for Ventilated Branch Discharge Pipes, System 3 – Table 9

Table 9 is for exclusive use with System 3 and replicates Table 6 however it is used for ventilated branch discharge pipes and lists appliances (fixtures) with allowances and limitations for each individual fixture (appliance).

COMPARISON OF DISCHARGE BRANCHES WITHIN AS/NZS 3500.2:2018

Table 6 and Table 9 (for use with System 3) appear closer to AS/NZS 3500.2 Appendix B. While BS EN 12056-2:2000 Systems 1, 2 and 4 utilise Tables 4, 5, 7 & 8 for size, grade, maximum drop (H), length (L) and number of bends. Although the calculation method is fundamentally different, these tables are comparable, in principle, to AS/NZS 3500.2:2018; main clauses and tables as listed:

Section 3 (drainage design)

Table 3.3.1 (maximum loading units for vented drains)

Table 3.4.1 (minimum grade of drains)

Table 3.4.2 (minimum fixture unit loadings for reduced drains)

Clauses 3.10.2 & Table 3.10.2 (size of unvented branch drains)

Clause 3.10.3 (maximum length)

Clause 3.10.4 (vertical sections)

Section 8

Table 8.2.2(A) (maximum fixture unit loadings for graded discharge pipes)

BS EN 12056-2:2000 Tables 4, 5, 7 & 8 appear similar; however, they use a 'simplified' approach to that of AS/NZS 3500.2:2018 and minimum gradients are given without any range of gradients (%).

4.2.11 BS EN 12056-2:2000 SECTION 6.5.1 PRIMARY VENTILATED DISCHARGE STACKS

Sizes and limitations of primary ventilated discharge stacks are given in Table 11:

Table 11 — Hydraulic capacity (Q_{max}) and nominal diameter (DN)

Stack and stack vent	System I, II, III, IV Q_{max} (l/s)	
DN	Square entries	Swept entries
60	0,5	0,7
70	1,5	2,0
80*	2,0	2,6
90	2,7	3,5
100**	4,0	5,2
125	5,8	7,6
150	9,5	12,4
200	16,0	21,0

* Minimum size where WC's are connected in system II.
** Minimum size where WC's are connected in system I, III, IV.

Table 11: Primary ventilated Discharge Stacks – Table 11

4.2.12 BS EN 12056-2:2000 SECTION 6.5.2 SECONDARY VENTILATED DISCHARGE STACKS

Sizes and limitations of primary ventilated discharge stacks are given in Table 12:

Table 12 — Hydraulic capacity (Q_{max}) and nominal diameter (DN)

Stack and stack vent	Secondary vent	System I, II, III, IV Q_{max} (l/s)	
DN	DN	Square entries	Swept entries
60	50	0,7	0,9
70	50	2,0	2,6
80*	50	2,6	3,4
90	50	3,5	4,6
100**	50	5,6	7,3
125	70	7,6	10,0
150	80	12.4	18,3
200	100	21,0	27,3

* Minimum size where WC's are connected in system II.
** Minimum size where WC's are connected in system I, III, IV.

Table 12: Secondary ventilated Discharge Stacks – Table 12

COMPARISON OF DISCHARGE STACKS WITHIN AS/NZS 3500.2:2018

A comparison is provided below by using:

BS EN 12056-2:2000
Tables 11 and 12, System Type 1 for both primary and secondary ventilated stack configurations, for comparison with:

AS/NZS 3500.2:2018

Section 9 - Table 9.7.1(A) single stack 'domestic or residential style building' and Section 8 - Table 8.2.2(B) 'fully vented stack 'configurations.
Each system has the following fixtures (appliances) connected:
30 x basins
30 x water closets (cistern)
30 x sink and bath
All fixtures (appliances) are connected to a single stack.

NOTE - For simplicity, offsets have not been considered within any of the nominated drainage configurations. Inclusion of offsets would introduce additional graded drainage rules for all systems to be incorporated.

BS EN 12056-2:2000 (TABLE 2)				
SYSTEM TYPE - 1				
FIXTURE	NO OF	DU (L/s)	TOTAL	
WASH BASIN	30	0.5	15	
WC (7.5 L CISTERN)	30	2	60	
KITCHEN SINK	30	0.8	24	
BATH	30	0.8	24	
SHOWER (NO PLUG)	30	0.6	18	
SUM OF DISCHARGE UNITS			141	∑DU
FREQUENCY FACTOR (K)			0.5	(K)
WASTE WATER FLOW RATE (Qww)			5.94	K√∑DU
TABLE 11 - PRIMARY VANTILATED STACK				
STACK (DN)	ENTRY TO STACK			
	SQUARE	SWEPT		
100MM	4	5.2	MAX L/S	
150MM	9.5	12.4	MAX L/S	
TABLE 12 SECONDARY VENTILATED STACK				
100MM	5.6	7.3	MAX L/S	
150MM	12.4	18.3	MAX L/S	
** NOTE - DOES NOT CONSIDER STACK OFFSET OR GRADED DISCHARGE PIPE LIMITATIONS**				

AS/NZS3500.2:2018					
FIXTURE	NO OF	FU	TOTAL		
WASH BASIN	30	1	30		
WC (CISTERN)	30	4	120		
KITCHEN SINK	30	3	90		
BATH	30	4	120		
SHOWER	30	2	60		
SUM OF FIXTURE UNITS			420		
** NOTE - REDUCTION OF GROUPED BATHROOM FU FOR WC/HB/SHW/BTH TO TOTAL OF 6FU NOT USED ABOVE**					
SUM OF FU WITH BATH ROOM FU GROUPED			270		
SECTION 9 - SINGLE STACK & SINGLE STACK MODIFIED SYSTEMS					
TABLE 9.7.1(A) SINGLE STACK - DOMESTIC OR RESIDENTIAL STYLE BUILDINGS					
STACK (DN)	NO GROUP FU		GROUP FU		MAX CONSECUTIVE FLOORS
100MM	260	MAX FU	260	MAX FU	10
150MM	780	MAX FU	780	MAX FU	30
SECTION 8 - FULLY VENTED SYSTEMS AND FULLY VENTED MODIFIED SYSTEMS					
TABLE 8.2.2(B) FULLY VENTED STACK					
MAX FU	NO GROUP FU		GROUP FU		
100MM	500	MAX FU	500	MAX FU	
150MM	2400	MAX FU	2400	MAX FU	
** NOTE - DOES NOT CONSIDER STACK OFFSET OR GRADED DISCHARGE PIPE LIMITATIONS**					

Table 13: Example Comparison of Stacks – AS/NZS 3500.2:2018 & BS EN 12056-2:2000

Similarities between both systems are apparent in the above calculations. By no means is this intended to provide a representative comparison of what may be the outcome of thorough comparison including testing various configurations, systems, offsets sizing and other design elements within either standard. The above calculation was undertaken to provide a simple, single instance between both standards BS EN 12056-2:2000 and AS/NZS 3500.2:2018 where fundamental differences in calculation occur, yet similar systems and configurations are also used. The result in this instance is such that the same outcome for both standards would apply, in that:

Neither the primary ventilated stack (BS EN 12056-2:2000) or single stack (AS/NZS 3500.2:2018) system, to be used with 100mm.

Both the above configurations could be used with 150mm.

Both 100m and 150mm could be used for the secondary ventilated stack (BS EN 12056-2:2000) or fully ventilated stack (AS/NZS 3500.2:2018) systems.

5 RECOMMENDATIONS

The following recommendations have been made based upon the review and observations of BS EN 12056-2:2000, BS EN 752:2017 and AS/NZS 3500.2:2018 standards. While there are areas within the standards that may differ and represent further opportunities for additional review, further research or testing is required. It would appear that aspects or whole sections of the BS EN Standards would be suitable for use in conjunction with or to be used as the basis for future revisions of AS/NZS 3500.2:2018. The below items have been considered highest in value for further testing and review for the following reasons:

- There are differences between the two standards that require further testing to verify opportunities identified within this report that may be beneficial to the Australian plumbing industry.
- These differences present potential, high value, benefit to industry should they be adopted in part or whole within future AS/NZS 3500.2:2018 standards, or should they sit alongside future AS/NZS 3500.2, but be included within the PCA.
- The areas listed below while different, have fundamental similarities in overall design between the two standards.
- The recommendations listed present opportunities that would appear relatively non-complex (in principle) to be included, adapted or adopted either holistically or partly into the AS/NZS3500.2 framework; or alternatively, to be used in conjunction with AS/NZS 3500.2:2018 (however this would need considerable testing and verification).

5.1 CALCULATION OF CAPACITY

Calculation of Fixture Loading (Discharge Units (DU) or Fixture Units (FU))

As previously summarised within this report, design and calculation of capacities within sanitary plumbing and drainage systems, specifically relating to fixture units, do not consider modern flowrates of fixtures. It is also generally understood within the industry by designers, plumbers, authorities and regulators that reduced flows within systems has caused increased maintenance issues. This is considered to be, in part, due to high efficiency fixtures (low flow fixtures) as other areas within the industry have remained, in large, unchanged. For this reason and for additional opportunities that may become evident through further investigation, it is recommended that the following areas, relating to fixture units, be undertaken:

- Detailed review of current fixture unit rating and possible re-calibration of fixture unit to accommodate flow rates of modern fixtures.
- Consideration of either:
    - Converting FU number to litres per second l/s to enable the designer to understand actual flow limitations within a system; or
    - Including this information to sizing and calculation tables or methods within the PCA framework for sanitary plumbing and drainage.
- Consideration of revising sanitary plumbing and drainage sizing tables to accommodate greater fixture numbers, based on current FU table and calculations down part or whole of sanitary plumbing and drainage systems to increase flows, that have decreased, with the introduction of high efficiency fixtures (appliances) within the industry.

Refer to section 5.2 for 'further research and testing' recommendations.

Calculation of Waste Water Flow Rate (Qww) & Frequency Factor (K)

Current sanitary plumbing and drainage design has little flexibility in relation to variable design flows through part or the whole of the system. The ability to inform design relating to reduced or increased hydraulic capacities within drainage systems through frequency of use, type of system etc. is the basis for the following recommendations:

- Consideration of introducing (K) 'frequency factor', to allow systems to be sized in accordance with likely usage patterns; or
- Consideration of creating different fixture unit ratings (flow rates) to be applied to differing sanitary plumbing and drainage systems, based upon building type or use.

Refer to section 5.2 for 'further research and testing' recommendations.

5.2 FURTHER RESEARCH & TESTING

It is recommended that further research and testing could assist in validating and assessing whether the BS EN Standards or part of these standards are relevant to the Australian context. Recommended research to be undertaken is listed below:

- Comparison of sanitary plumbing and drainage systems using configurations prescribed within BS EN 12056-2:2000 (sections as listed within this report) against a number of differing, real world, examples designed under current AS/NZS 3500.2:2018 standards. Report on differences, similarities and impacts on such design examples.

Example – Selection of 3-5 differing building configurations with differing usage patterns and building classification. Examples differing in sanitary plumbing and drainage system configurations available within AS/NZS 3500.2 standards. Re-design the sanitary plumbing and drainage system for each of the selected examples by:

- Redesign strictly to BS EN 12056-2:2000 standards (redesign to either one or all system types and configurations that are suitable to the buildings use and sanitary plumbing and drainage requirements)
- Redesign selected examples using a hybrid of both standards, base design upon AS/NZS 3500.2:2018 standard but introduce the following to check how the system would be impacted if:
    - A frequency factor (K) was introduced; or
    - Fixture units were allocated L/S based upon reduced flow, efficient, fixtures (appliances); or
    - Both of the above.
- Estimate expected construction cost variance through verification exercise (examples) of both systems.
- Report on outcomes of the above for consideration.
- Potential to create calculator that would allow various fixture flows (e.g. WELS 4 star to WELS 6-star etc) that would allow design flows through part or all of the system to be optimised.

Example – Higher efficiency fixtures (e.g. tapware) would enable greater number of these fixtures to be connected to the discharge pipe or stack before exceeding the maximum design capacity. This also ensuring the self-cleansing properties within the system are maintained, while velocities are not exceeded.

- Creation of frequency factor (K) for sanitary plumbing and drainage for implementation into future AS/NZS 3500.2 or PCA for use within the Australian plumbing industry. Testing of various 'frequency factors' (e.g. starting with those prescribed within BS EN 12056-2:2000) and applying these to current DtS design within AS/NZS 3500.2:2018 standard. Reporting on what reductions this may create and if this would possibly reduce or remove the need to re-calibrate current fixture units FUs.

Example – Applying (e.g. 0.5) 'frequency factor' (K) to total FU number to residential DtS sanitary plumbing and drainage design systems, it would be expected that parts or the whole system could likely be reduced in size or enable greater fixture numbers to be connected to parts or the whole of the discharge branch or stack systems, before triggering an increase in pipe diameter or grade.

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BS EN 12056-2:2000 Gravity Drainage Systems Inside Buildings - Part 2:Sanitary Pipework, Layout and Calculation.

AS/NZS 3500.2:2018 Plumbing and Drainage - Part 2: Sanitary Plumbing and Drainage.

AS/NZS 3500.0:2003 Plumbing and Drainage - Part 0: Glossary of Terms.

APPENDIX A: DEFINITION OF TERMS

Terms used in this report generally followed the definitions in AS/NZS 3500.0:2003 or BS EN12056-2:2000

Term	Explanation
Designer	The person or organisation designing the sanitary plumbing and drainage system and are responsible for deciding system type, pipework routing, grade, length and sizing.
Deemed to Satisfy	In this report, refers to the prescriptive requirements of the Plumbing Code of Australia, primarily AS/NZS 3500.2:2018.
Fixture Unit (FU)	A unit of measure, based on the rate of discharge, time of operation and frequency of use of a fixture, that expresses the hydraulic load imposed by that fixture on the sanitary plumbing installation.
Discharge Unit (DU)	The average discharge rate of a sanitary fixtures (appliances) expressed in litres per second (L/S)
Branch Discharge Pipe	Pipe connecting sanitary fixtures (appliances) to a discharge stack or drain
Discharge Stack	Main (generally vertical) pipe, conveying discharges from sanitary fixtures (appliances)
Ventilating Pipe	Pipe to limit the pressure fluctuations within the discharge pipe system
Frequency Factor (K)	Variable to take into account the frequency of use of sanitary fixtures (appliances) (dimensionless)
Waste Water Flow Rate (Q_{ww})	Total design flowrate from sanitary fixtures (appliances) in a drainage system or in part of a drainage system in litres per second (L/S)
Continuous Flow Rate (Q_c)	Flow rate of all continuous flows, e.g. cooling water, etc., in litres per second (L/S)
Pumped Water Flow Rate (Q_p)	Discharge rate of waste water pumps in litres per second (L/S)
Total Flow Rate (Q_{tot})	The total flow rate is the sum of the waste water flow rate (Q_{ww}) and continuous flow rate (Q_c) and pumped water flow rate (Q_p), in litres per second (L/S)
Hydraulic Capacity (Q_a)	Maximum flow rate of water permitted in a branch, stack or drain in litres per second (L/S)
Air Flow Rate (Q_a)	Minimum flow rate of air through a ventilating pipe or air admittance valve, measured at 250 Pascal (Pa) pressure drop, in litres per second (L/S)
Regulatory Authority	The authority that is empowered by statute to exercise jurisdiction over the installation of water, plumbing, sewerage or stormwater works.
Sanitary Appliance	An appliance intended to be used for sanitation, and which is not a sanitary fixture. Included are machines for washing dishes and clothes.

Sanitary Fixture	Any fixture which is intended to be used for sanitation.
Sanitary Drainage System	An assembly of pipes, fittings and apparatus, which is used to collect and convey the discharge from the sanitary plumbing system, together with discharges from fixtures directly connected to the drain, to the sewer. Usually located below ground level.
Wastewater	The spent or used water of a community or industry, which contains dissolved and suspended matter.
Nominal Size (DN)	A numerical designation of size, which is common to all components in a piping system other than components designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions. NOTES: 1 Nominal size is designated by DN followed by a number. 2 Not all piping components are designated by nominal size, for example, steel tubes are designated and ordered by outside diameter and thickness. 3 The nominal size (DN) cannot be subject to measurement and is not to be used for purposes of calculation.
Bend	A short length of pipe or a manufactured fitting used to make a change in direction in pipework.
Water Efficiency Labelling and Standards Scheme	The Water Efficiency Labelling and Standards (WELS) scheme is an Australian government initiative in partnership with state and territory governments. The purpose of the scheme is to conserve water by helping consumers make informed decisions and encouraging uptake of water-saving technologies.