Understanding International Window Performance Standards

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window & glass association nz

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UNDERSTANDING INTERNATIONAL WINDOW PERFORMANCE STANDARDS

Contents

Introduction

The Window & Glass Association of New Zealand have undertaken this project to help better understand how international window performance standards compare with our own. The intent of this guide is to assist our regulators in understanding the comparative performance of imported window and door products, whilst ensuring it is of a quality that meets or exceeds equivalent criteria here in Aotearoa New Zealand.

TS 4211:2022, and its predecessor NZS 4211:2008, are our industry's go to standards for the classification of window performance, and the focus of this guide is to compare these with common test and/or performance standards from Australia, Europe, and the U.S.

It is not always easy to compare one standard with another and the aspiration here is that we will establish a basis for decisions about the likely performance of windows relative to their exposure, for demonstrating compliance with the minimum requirements of the New Zealand Building Code.

In the development of this guide, the tests/standards for each region were divided into two groups;

a) **Integrity** – the tests/values that directly impact the life of the building – strength, watertightness, air infiltration.
b) **Operation** – the tests/values that define the function and usability of the window – operating forces, torsional strength, security, etc.

Just the tests that impact group a) Integrity have been compared in this guide, which is intended for residential use, within the five generic wind zones only.

Note: *Thermal performance has not been considered as a part of this guide.*

Definitions

For the purposes of this guide the following definitions apply.

ASD	Abbreviation for Allowable Stress Design. Refer **Appendix A**
AWS	Abbreviation for Air, Water, Structure. AWS clauses outline the primary performance requirements for safety, weather-ability, and structural integrity applicable to assembled and glazed products.
Deflection	The amount of relative displacement of the structural components in a window. Deflection is usually measured in each of the unique full height mullions, stiles, and/or interlockers.
DP	Abbreviation for Design Pressure.
LSD	Abbreviation for Limit State Design. Refer to **Appendix A**.
Non-specific design	Design that does not require project specific engineering calculation and design.
Production window	A window intended for use in building work and classified in accordance with TS 4211 based on testing a representative specimen.
SLS	Abbreviation for Serviceability Limit State. A state that corresponds to conditions beyond which specified service criteria for a structural element are no longer met. In terms of wind pressure for windows and doors, this refers to the pressure the unit might experience on a day to day basis.
SED	Abbreviation for Specific Engineering Design. Project specific engineering calculations of structural parameters, such as wind pressures, deflections, and/or strength under structural loads.
STP	Abbreviation for Structural Test Pressure. Project specific engineering calculations of structural parameters, such as wind pressures, deflections, and/or strength under structural loads.
ULS	Abbreviation for Ultimate Limit State. A state associated with collapse or other similar forms of structural failure. In terms of wind pressure

	for windows and doors, this refers to the pressure at which the unit will fail.
Wind zone	Classification of the level of wind actions on a non-specific design building into one of five zones (L, M, H, VH, EH), using the methodology provided in NZS 3604.
Window assembly	A complete unit comprising a frame, couplings, sashes, glazing infill panels and hardware.
WTP	Abbreviation for Water Test Pressure. The static water penetration test is undertaken at this minimum positive pressures.
WPR	Abbreviation for Water Penetration Resistance.

Standards and Related Documents

The following Standards and Related Documents are referenced in this guide.

NZBC Clause B1	Structure
NZBC Clause E2	External Moisture
NZS 3604:2011	Timber Framed Buildings
AS/NZS 1170.2:2021	Structural design action – Wind actions
TS 4211:2022	Specification for the classification of windows
NZS 4211:2008	Specification for performance of windows
AS/NZS 4420.1:2016	Windows, external glazed, timber and composite doors
AS 2047:2014	Windows and external glazed doors in buildings
EN 12210:2016	Windows and doors – Resistance to wind load – Classification
EN 12211:2016	Windows and doors – Resistance to wind load – Test Method
EN 12208:2003	Windows and doors – Watertightness – Classification
EN 1027:2016	Windows and doors – Watertightness – Test Method
EN 12207:2016	Windows and doors – Air Permeability – Classification
EN 1026:2016	Windows and doors – Air Permeability – Test Method
AAMA/WDMA/CSA 101/I.S.2/A440:22	North American Fenestration Standard/Specification for windows, doors, and skylights
ASTM E330-14 (2021)	Standard Test Method for Structural Performance
ASTM E331-00 (2023)	Standard Test Method for Water Penetration
ASTM E283-19	Standard Test Method for Determining Rate of Air Leakage

What the New Zealand Building Code Says…

Whilst all aspects of window performance must ensure compliance with the New Zealand Building Code, NZS 4211, and therefore TS 4211 by evolution, is only specifically raised in two of Code Clauses, B1 and E2 as follows.

Clause B1 – Structure

Section 12 of B1/VM1 refers to the structural performance of windows but modifies NZS 4211 to remove elements of the test that do not apply to the structural considerations.

Thus, in terms of Clause B1, only the Ultimate strength and Deflection of structural members tests are applicable.

> **12.0 Windows**
>
> **12.1 NZS 4211** subject to the following modification:
>
> References to air leakage, water leakage and operational effectiveness of opening sashes in NZS 4211, are non-structural considerations and do not apply to this document.

Clause E2 – External Moisture

Paragraph 9.1.10 of E2/AS1 notes that windows and doors shall comply with NZS 4211, suggesting that compliance consists of all parts of the standard.

> **9.1.10 Windows and doors**
>
> Windows and doors shall comply with the requirements of NZS 4211, and reveals shall comply with NZS 3602. *Flashings* shall comply

However, paragraph 1.2.1 refers to compliance with the relevant requirements of NZS 4211, which in terms of Clause E2, is only the Water penetration resistance, by static pressure test.

> **1.2 Scope**
>
> **1.2.1** The scope of this Verification Method shall be restricted to *buildings* that:
>
> c) include window and door units that are manufactured to comply with the relevant requirements of NZS 4211, and

Therefore, in terms of strict compliance with our Building Code, and for in the interests of comparing the performance of windows and doors tested to international standards, there are four priority tests,

1) Ultimate strength test,
2) Deflection of structural members,
3) Water penetration resistance, by static pressure,
4) Air permeability.

All other tests speak to the quality and/or operation of the window. Air permeability is sometimes referred to as an indicator of expected water penetration resistance.

Part One - New Zealand Test Standards

1.0 SNZ TS 4211:2022- Specification for the classification of windows

SNZ TS 4211:2022 (TS 4211) supersedes NZS 4211:2008 Specification for performance of windows and, although not cited by the Building Code at the time of writing, provides a methodology for classifying windows and exterior doors through testing. And from that testing establishes a basis for demonstrating compliance with the minimum requirements of the New Zealand Building Code. The classification system ensures that windows and doors can be appropriately manufactured and/or selected to satisfy the demands of the exposure categories, or wind zones, in which they will be used.

TS 4211 is designed for use with standalone window and door units which are to be installed within the walls of buildings but excludes the actual installation details at the window perimeter. It also does not cover durability, thermal, acoustic, or the fire-rating performance requirements for windows.

Classification of a window using TS 4211 requires the performance testing of a representative specimen in a controlled test facility. The methods, parameters, and performance criteria for each test are prescribed within this singular technical specification, rather than being separated into separate documents, as is done in other parts of the world. In terms of residential joinery to be used with in the generic wind zones, described in *NZS 3604*, the list and sequence of tests is as follows,

1) Deflection of structural members,
2) Operating force- if required,
3) Air permeability,
4) Water penetration resistance, by static pressure,
5) Ultimate strength test,
6) Torsional rigidity test- if required.

Note: *TS 4211 includes a series of additional tests for windows designed to be used in mid-rise buildings, which has not been taken into account in this guide.*

Whilst the full sequence of tests provides a comprehensive picture of the expected performance of a window or door, it could be argued that in terms of compliance with our Building Code, and the comparison of products tested to other standards, some tests are more important than others.

As noted previously, window performance must satisfy the provisions of Clauses B1 and E2 of the Code, regardless of the test standard being used. For this reason, this guide focuses on the comparison of standards for the following tests,

1) Ultimate strength test,
2) Deflection of structural members,
3) Water penetration resistance, by static pressure.
4) Air permeability.

The air permeability test provides an indication of the impact of the window or door on the thermal envelope of the building and therefore its influence on annual energy demand and is sometimes referred to as an indicator of expected water penetration resistance.

There is a further part of TS 4211 that is worthy of consideration when comparing the performance of windows for use in housing in Aotearoa New Zealand,

5) Section 2.3 of TS 4211- Application to production windows. This section of the standard works to ensure that test reports adequately represent the production windows being used in our buildings and is important in ensuring the indicated performance of the unit is likely to be achieved in-situ.

1.1 Classification

The classification of windows in accordance with TS 4211 primarily establishes (in terms of this document),

a) the exposure rating, and
b) the air permeability performance.

For a window to be classified, the mandatory tests applicable to the classification must have been completed, as noted above.

1.2 Exposure Categories

NZS 3604 nominates the five non-specific, or generic, exposure categories, or wind zones, used across the country. There is a sixth category, SED or specific engineering design, which is outside the scope of this guide. For areas requiring specific design, the performance of windows tested to international standards must be considered separately to establish compliance.

TS 4211 Exposure Categories			
Exposure Category (Wind Zone)	ULS (Pa)	SLS (Pa)	WTP (Pa)
Low (L)	+/- 720	+/- 510	+ 155
Medium (M)	+/- 960	+/- 680	+205
High (H)	+/- 1360	+/- 970	+290
Very High (VH)	+/- 1760	+/- 1250	+375
Extra High (EH)	+/- 2130	+/- 1515	+455

Table 1.2- Exposure categories

Table 1.2 describes the pressures at which a representative specimen is tested, in order to demonstrate its compliance and to set its classification.

- the ULS pressure is used in the ultimate strength test. Tests are carried in both the positive and negative directions,
- the SLS pressure is used in the deflection of structural member's test. Again, tests are carried in both the positive and negative directions and provide the data used to calculate the suitability of members when used at differing lengths, and
- the WTP (water test pressure) is used in the water penetration resistance test. Tests are only carried out at positive pressure and often become the driver for a specimen's wind zone classification.

1.3 Window Ratings

The window or exposure rating of each production window and door assembly is based on the lowest performing element of those listed in **Table 1.2**- ULS, SLS, or WTP.

E.g. A test specimen that satisfies the requirements of TS 4211 as follows,

ULS = +/- 3000Pa, SLS = +/- 1250Pa, & WTP +290Pa,

will have a rating of High (H), based on the water penetration test.

Air permeability is considered separately, and the Air Class is derived from **Table 1.4** below.

TS 4211 Air Permeability Classes				
	l/s.m^2		l/s.m	
	@+/-75Pa	@+/-150Pa	@+/-75Pa	@+/-150Pa
Class 1	11.40	18.30	2.86	4.57
Class 2	6.17	9.88	1.54	2.47
Class 3	2.06	3.29	0.514	0.823
Class 4	0.685	1.10	0.171	0.274

Table 1.4- Air permeability classes

1.4 Labelling

Each production window shall be affixed to a framework member for each window and/or door by the window manufacturer or supplier, stating,

a) the window manufacturers, or supplier's name, or brand name, of the window,
b) the number of the standard tested to,
c) the exposure rating, and

d) the air permeability class.

The labelling shall be durable, have lettering not less than 2mm high, and be located so that it is readable after the installation of the window.

Example - Type of classification TS 4211:2022, exposure rating VH, air permeability class 2

1.5 Application to Production Windows

Test specimens should represent the largest production unit, of the same construction, that is likely to be manufactured. Section 2.3 of TS 4211:2022 works to ensure that test reports adequately represent the production windows being used in our buildings and is important in ensuring the indicated performance of the unit is likely to be achieved in-situ.

Smaller Sizes

Production windows of the same construction but are smaller than the tested specimen shall have,

- the same air permeability class as the tested specimen,
- the same wind zone rating as the tested specimen, and
- the deflection of structural members can be shown by calculation as being suited to the size and configuration of the unit for the site SLS, provided the calculations use actual test data for the structural members selected and are documented by a suitably qualified person.

Larger Sizes

Production windows of the same construction that are larger than the tested specimen, within the limits set out in Figure 2 of the standard, shall have,

- the same air permeability class as the tested specimen,
- the same, or lower, wind zone rating as the tested specimen, and
- the deflection of structural members can be shown by calculation as being suited to the size and configuration of the unit for the site SLS, provided the calculations use actual test data for the structural members selected and are documented by a suitably qualified person.

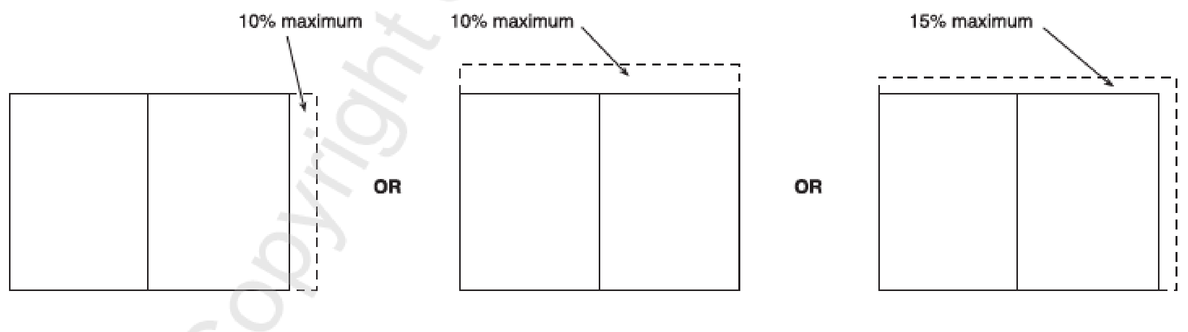


Figure 2 – Allowable dimensional increase

Wider Sizes and Coupled Units

There are provisions within the standard to use wider and/or coupled units provided these meet the requirements of the standard that relate to these situations. Refer to sections 2.3.1.3 and 2.3.2 of the TS 4211.

1.6 TS 4211 Test Methods and Performance Requirements

The test methods and performance requirements for windows and doors to be classified in accordance with TS 4211, are set out in sections 5 and 6 of the standard. The following summarises these tests.

1.6.1- Ultimate Strength

Test Method	Per section 5.7 of TS 4211. The specimen shall be tested in accordance with *section 7 of AS/NZS 4420.1.* Tests are undertaken in both positive and negative directions to the ULS pressures nominated in **Table 1.2**. Pressure representing the desired wind zone, is held against the specimen for not less than 10 seconds.
Performance	Per section 6.8 of the standard. The specimen shall not collapse, as defined in section 1.4 of the standard.

1.6.2- Deflection of Structural Members

Test Method	Per section 5.1 of TS 4211. Structural members of the specimen shall be tested in accordance with *section 3 of AS/NZS 4420.1.* Tests and measurements are undertaken in both positive and negative directions to the SLS pressures nominated in **Table 1.2**.

Measurements are taken after at least 1 minute at each of no less than four incremental pressure steps toward the desired wind zone, with a final zero displacement measurement taken two minutes after the pressure is removed.

Performance Per section 6.1 of the standard.
The maximum deflection of any structural member, relative to its ends, shall not exceed the span/200, unless a smaller value is specified.
The maximum deflection of any member shall not exceed 20mm, again unless a smaller value is specified.

1.6.3- Water Penetration Resistance by Static Pressure

Test Method Per section 5.5 of TS 4211.
Structural members of the specimen shall be tested in accordance with *section 6 of AS/NZS 4420.1.*
The test is undertaken to the minimum positive WTP pressures nominated in **Table 1.2**.
The test specimen is subjected to water sprayed uniformly and continuously over its exterior face at a rate not less than 0.05 L/m^2.s.
The test pressure is maintained for 15 minutes, and visual observations of the internal surfaces are performed throughout the test and for 5 minutes after pressure has returned to zero. The total length of the test, for any one test pressure, including wetting and final inspection is 25 minutes.

Performance Per section 6.1 of the standard.
The specimen shall not show uncontrolled water, as defined in section 1.4 of the standard.

1.6.4- Air Permeability

Test Method Per section 5.3 of TS 4211.
Structural members of the specimen shall be tested in accordance with *section 5 of AS/NZS 4420.1.*
The test is undertaken at both positive and negative pressures of 75 and 150Pa, regardless of wind zone classification.

Performance Per section 6.1 of the standard.
For each test pressure the measurements are averaged providing four data points which are then plotted on the graph in Figure 1 of the standard. The air permeability is the lowest numbered class indicated by the four plotted points from **Table 1.4**.
The method has been adapted from *EN 12207.*

Part Two - Australian Test Standards

2.0 AS 2047:2014 – Windows and external glazed doors in buildings

AS 2047 is the test method used for establishing the performance ratings for windows and doors used in housing in Australia. Whilst very similar in test content to TS 4211, AS 2047 has an extended scope, including a number of normative and informative appendices.

Similar to TS 4211, the test procedures used in AS 2017:2014 are based on *AS 4420* for its test methods. However, the timing of the standard means AS 2047 refers to an earlier version of *AS 4420*, where the tests are separated into six individual parts, rather than being captured in one document- *AS/NZS 4420.1:2016*.

The standard specifies requirements, materials, construction, installation and glazing for external,

a) windows,
b) sliding and swinging glazed doors, including French and bi-fold doors,
c) adjustable louvres,
d) shopfronts and
e) window walls with one-piece framing elements.

NOTE: *Window walls do not include curtain walls using stacked or vertically spliced framing systems, manufactured from any material and installed in external walls of all classes of buildings*.

AS 2047 refers to 'housing' which is defined as Class 1 buildings as described in the National Construction Code (NCC) and is governed by the limitations specified in *AS 4055*.

As with TS 4211, AS 2047 rates or classifies window and door units as standalone entities which are to be installed within the walls of buildings. Whilst the standard includes some generic installation details the window rating refers to the window or door only.

Window performance in New Zealand must satisfy the provisions of our Building Code, specifically in terms of this guide, Clauses B1 and E2. The comparisons made in this section of the guide focus on the following tests,

1) Ultimate strength,
2) Deflection/span ratio,
3) Water penetration (by static pressure),
4) Air infiltration.

The Building Product Specification (BPS) introduced in July 2025 acknowledges the performance of product tested to AS 2047, as follows.

The testing cannot be used in isolation to demonstrate compliance with any requirements of the Building Code, it must also comply with the applicable acceptable solution or verification method. Building products must be used within the scope, limitations, and other applicable requirements set out in the test reports and acceptable solution or verification method.

Windows and external doors shall have a window rating suitable for the building's wind zone, as described in sections 1, 2.1.1, 2.3, 2.4, 2.5, 2.6, and 8 of AS 2047:2014 provided that,

a) the required testing is performed by an *ISO/IEC 17025* accredited test facility registered for such tests, and
b) windows and external doors are rated for serviceability limit state wind pressure, ultimate limit state wind pressure, and water penetration resistance as specified in Table 4.4.1.2 for the building's wind zone. 4.4.1.2

NOTE: *The comparisons in this guide vary from Tables 4.4.1.2. 4.4.1.3, and 4.4.1.4 in the BPS.*

2.1 Window Ratings

AS 2047 provides a window rating for windows and doors used in housing in Australia. The following apply,

a) Window assemblies shall be rated in accordance with **Table 2.1.1** and by achieving the test results to the appropriate test in AS 4420 Parts 2, 3, 4, 5, 6. In terms of this guide we have chosen not to consider Part 3- Operating force.
b) Windows and doors with 25% or more of the width of a single panel or pane within 1200 mm of the building edge shall be classified as corner windows and doors.
c) For the water test pressure and exposed site meets one or more of the three conditions noted in *AS 4055*. Any other site is considered non-exposed.
d) The maximum air infiltration is nominated in **Table 2.1.2**.

AS 2047 - Window Ratings for Housing						
Window Rating	SLS (+/- Pa)		ULS (+/- Pa)		WTP (+Pa)	
	General	Corner	General	Corner	Non-exposed	Exposed
N1	400	600	600	900	150	200
N2	400	600	900	1300	150	200
N3	600	800	1400	2000	150	300
N4	800	1200	2000	3000	200	300
N5	1200	1800	3000	4500	300	450
N6	1600	2500	4000	6000	450	600
C1	600	800	18000	2700	150	300
C2	800	1200	2700	4000	200	300
C3	1200	1800	4000	5900	300	450
C4	1600	2500	5300	8000	450	600

Table 2.1.1- Window ratings

NOTE: *The pressures are as per AS 4055, rounded to the nearest 100Pa.*

AS 2047 Maximum Air Infiltration		
Air infiltration level	Pressure direction	Maximum air infiltration l/s.m^2 @75Pa
Low	+/-	1.0
High	+ only	5.0

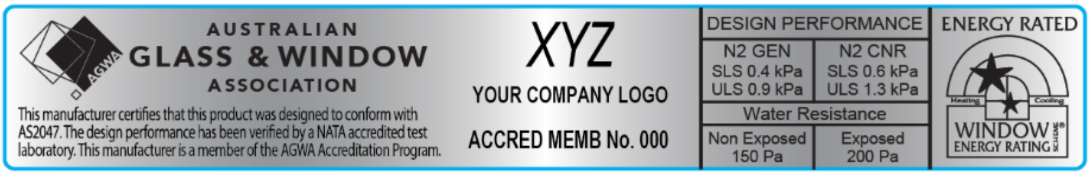
Table 2.1.2- Air infiltration levels

2.2 Labelling

AS 2047 requires that window assemblies for housing be labelled in accordance with Clause 8.2 of the standard, with the following information marked anywhere on the window assembly, except on the glazing (the application of rating labels

a) The manufacturer's identification mark.
b) The serviceability limit state wind pressure.
c) The ultimate limit state wind pressure.
d) The water penetration resistance.

The label shall be so positioned that the window can be identified when viewed in situ.



NOTE: Where windows for housing are supplied as incomplete assemblies, a certificate and a label giving manufacturer's identification marks, window rating and water penetration resistance should be provided with the window.

2.3 Comparison

Generally, TS 4211:2022 and AS 2047:2014 are very similar in terms of test content, and at a regulatory level considering window performance, the two could be relatively easily interchanged. New Zealand's recently introduced Building Product Specification recognises this.

2.3.1- Window Ratings and Design Wind Pressure

The nomination of window ratings or design wind pressures for each window and door assembly should be as follows:

a) For housing, the purchaser should nominate,

- the window rating,
- the window exposure classification, and
- whether the window is a corner window when ordering the window assemblies.

b) For other residential buildings, the purchaser should nominate the design wind pressures when ordering the window assemblies.

c) For commercial buildings, the purchaser should nominate the design wind pressures for the window assemblies when ordering the windows.

d) The manufacturer of the window assemblies should verify the window assemblies meet the window rating or design wind pressures as provided by the purchaser.

AS 2047 rates the performance of tested window assemblies, within ten primary categories, dependent on their test performance. **Table 2.3.1a** includes these ratings and they're comparison with New Zealand's Wind Zones. **Table 2.3.1b** compares the ratings by the lowest performing element similar to the NZ requirement.

AS 2047 - Comparison by Rating						
Window Rating	SLS (+/- Pa)		ULS (+/- Pa)		WTP (+Pa)	
	General	Corner	General	Corner	Non-exposed	Exposed
N1	400	600	600	900	150	200
N2	400	600	900	1300	150	200
N3	600	800	1400	2000	150	300
N4	800	1200	2000	3000	200	300
N5	1200	1800	3000	4500	300	450
N6	1600	2500	4000	6000	450	600
C1	600	800	1800	2700	150	300
C2	800	1200	2700	4000	200	300
C3	1200	1800	4000	5900	300	450
C4	1600	2500	5300	8000	450	600

Colour Key - NZ Wind Zone						
Wind Zone	None	Low	Medium	High	Very High	Extra High +

Table 2.3.1a - Ratings Comparison

AS 2047 - Comparison by Lowest Performing Element					
Window Rating		SLS (+/- Pa)	ULS (+/- Pa)	WTP Non-exposed	WTP Exposed
N1	General	400	600	150	200
	Corner	600	900	150	200
N2	General	400	900	150	200
	Corner	600	1300	150	200
N3	General	600	1400	150	300
	Corner	800	2000	150	300
N4	General	800	2000	200	300
	Corner	1200	3000	200	300
N5	General	1200	3000	300	450
	Corner	1800	4500	300	450
N6	General	1600	4000	450	600
	Corner	2500	6000	450	600
C1	General	600	1800	150	300
	Corner	800	2700	150	300
C2	General	800	2700	200	300
	Corner	1200	4000	200	300
C3	General	1200	4000	300	450
	Corner	1800	5900	300	450
C4	General	1600	5300	450	600
	Corner	2500	8000	450	600

Colour Key - NZ Wind Zone						
Zone	None	Low	Medium	High	Very High	Extra High +

Table 2.3.1b - Ratings Comparison

NOTE: The non-exposed water ratings in Table 2.3.1b have been compared separately due to their low performance values. Be sure to check labels for the water test rating appropriate to your site.

These tables provide a comparison of the performance of a window or door product as a standalone item, and based on its performance, evaluates its suitability for a site. This does not necessarily mean it is suited to the building's construction type. In residential construction, window installation is guided by E2/AS1 and stands separately to the individual unit's performance. Differences in the perimeter frame design may exclude it from E2/AS1, meaning alternative installation details may be required to demonstrate compliance with the building Code.

2.3.2- Deflection Ratio

AS 2047 defines that under SLS loads structural members will deflect no more than,

a) span/250, for windows and sliding doors,
b) span/100, for doors other than sliding,

which differs to the span/200 requirement from TS 4211 (also at SLS). This means that windows and sliding doors tested to AS 2047 are slightly stiffer than those tested to TS 4211 (4mm vs 5mm deflection per metre of span) and doors other than sliding are less rigid (10mm vs 5mm per metre). To establish suitability and compliance will require a review of the test report. The data contained in the test reports will allow any structural member to be reverse engineered, based on the recorded deflection values. From the test data, the span ratio can be re-calculated based on the configuration of the unit.

2.3.3- Water penetration Resistance

Tables 2.3.1a & 2.3.1b above provide a comparison of water test pressures (WTP) between TS 4211 and AS 2047 based purely on the test pressure. In both standards the tested window assembly is subjected to same water flow rate, sprayed uniformly and continuously over the exterior face, with the pressure maintained for the same 15 minutes. Visual observations of the internal surfaces are also assessed in the same way.
Where the two vary is in the relationship between the WTP and the SLS wind load,

a) TS 4211 has a clear relationship where the WTP is ~33% (rounded to nearest 5Pa) of the SLS wind load.
b) However, with AS 2047 there is no direct correlation between WTP and SLS pressures. It varies 17-38% for Non-exposed tests and 24-50% for Exposed, largely depending on whether the sample is in a General or Corner zone.

Because a water penetration/resistance test performed to either standard at a specific pressure, say 300Pa, will deliver the same result, the comparisons in **Table 2.3.1a** are definitive. However, **Table 2.3.1b** makes the comparison based on the lowest performing test element (excluding the Non-exposed WTP), meaning, depending on which is the lowest performing element, the comparison may require further investigation to confirm suitability and compliance.

2.3.4- Air Infiltration

AS 2047 rates the performance of tested window assemblies, within ten separate categories, dependent on their test performance. **Table 2.3.3** includes these ratings and how they compare with New Zealand's Exposure Ratings.

AS 2047 Maximum Air Infiltration Comparison			
Air Infiltration Level	Max. Air Infiltration L/s.m^2	Test Pressure	NZ Classification
Low	1.0	+/- 75Pa	Class 3
High	5.0	+75Pa only	Class 2

Table 2.3.4 - Air Infiltration

Note: *The NZ test for air permeability takes two separate measurements at each of two pressure steps 75Pa and 150Pa. The results are then plotted on a graph to establish the class rating. The NZ classifications shown in* ***Table 2.3.4*** *assume air infiltration at the maximum rate for the 75 Pa step only.*

2.4 Application to Production Windows

AS 2047 refers to the previous iteration of AS 4420.1 in requiring that window assemblies be representative of the largest standard assembly in the product range as specified by the manufacturer. The requirements are for smaller and larger assemblies are comparable with those stated in TS 4211:2022, having been developed from the same document, including a similar diagram (Figure 2.2 below) describing the extrapolation of sizes.

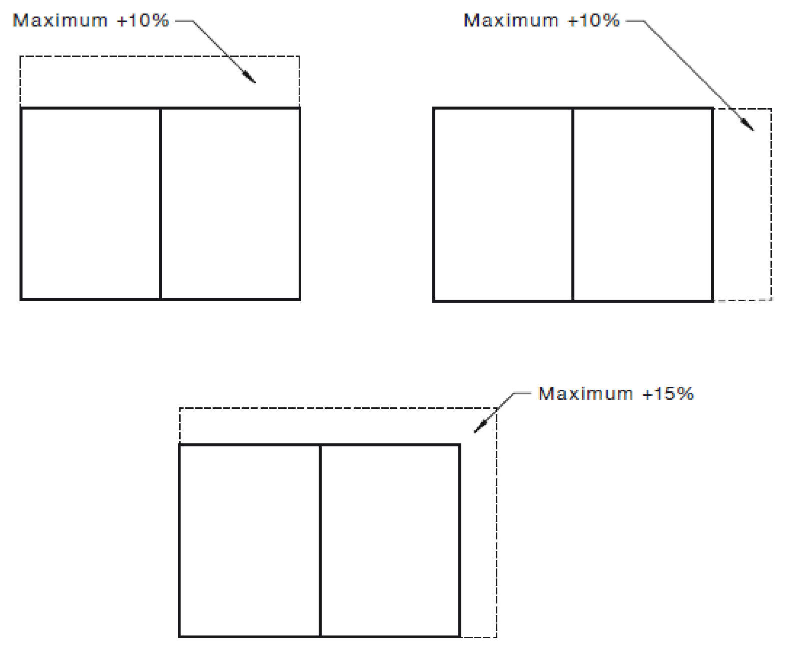


FIGURE 2.2 LARGER SIZE ASSEMBLIES

2.5 AS 2047 Test Methods and Performance Requirements

As noted earlier, similar to the NZ Standard TS 4211:2022, AS 2017:2014 refers to AS 4420. Parts 1-6 for its test methods. However, the timing of the standard means AS 2047 refers to an earlier version of AS/NZS 4420, where the tests were separated into individual parts, rather than being captured in one document. These methods and the performance requirements for the rating of windows and doors in accordance with AS 2047, are as follows.

2.5.1- Ultimate Strength

Test Method	Per section 2.3.1.7 of AS 2047. The window assembly shall be tested in accordance with *AS 4420.6:1996 (similar to section 7 of AS/NZS 4420.1).* Tests are undertaken in both positive and negative directions to the pressures not less than the value given in Table 2.5 of AS/NZS 2047:2014. Pressure representing the desired wind zone, is held against the window assembly for not less than 10 seconds.
Performance	The window assembly shall not collapse, as defined in section 2.3.1.7.

2.5.2- Deflection / Span Ratio

Test Method	Per section 2.3.1.3 of AS 2047. Window assemblies shall be tested in accordance with *AS 4420.2:1996 (similar to section 3 of AS/NZS 4420.1).* Measurements are taken in both positive and negative directions at no less than the **SLS** pressures nominated in Table 2.1 of AS/NZS 2047:2014.
Performance	As defined in section 2.3.1.3, no structural member, shall deflect more than, a) span/250, for windows and sliding doors, b) span/100, for doors other than sliding.

2.5.3- Water Penetration Resistance

Test Method	Per section 2.3.1.6 of AS 2047. Window assemblies shall be tested in accordance with *AS 4420.5:1996 (similar to section 6 of AS/NZS 4420.1).* The test is undertaken to the minimum positive WPR pressures nominated in Table 2.4 of AS/NZS 2047:2014. The window assembly is subjected to water sprayed uniformly and continuously over its exterior face at a rate not less than 0.05 L/m^2.s, initially at zero pressure for 5 minutes. The test pressure is maintained for 15 minutes, and visual observations of the internal surfaces are performed throughout the test.
Performance	During and at completion of the test, the window assembly shall have no penetration of uncontrolled water, as defined in section 2.3.1.6.

2.5.4- Air Infiltration

Test Method

Per section 2.3.1.5 of AS 2047.

Window assemblies shall be tested in accordance with *AS 4420.4:1996 (similar to section 5 of AS/NZS 4420.1).*

The test is undertaken at both positive and negative pressures of 75Pa for the "Low" level test but only positive 75Pa for the "High" level rating.

Performance

The Low rating is applied if the window assembly has ≤ 1.0 L/s m^2 of air infiltration and a High rating if the window assembly has ≤ 5.0 L/s m^2.

Part 3 - European Test Standards

3.0 European window and door test standards

Rather than being contained in one document, the European approach to window and door test standards is to divide the tests into individual documents. In terms of this guide, where we're considering wind load resistance, water penetration, and air permeability, the following standards are applicable,

a) EN 12210:2016 - Windows and doors - Resistance to wind load - Classification,
b) EN 12211:2016 - Windows and doors - Resistance to wind load - Test method,
c) EN 12208:2003 - Windows and doors - Watertightness - Classification,
d) EN 1027:2016 - Windows and doors - Watertightness - Test method,
e) EN 12207:2016 - Windows and doors - Air permeability - Classification,
f) EN 1026:2016 - Windows and doors - Air permeability - Test method.

Each of the classification documents, EN 12210, EN 12208, and EN 12207 rate their performance elements separately, so there is no generic zone that covers them all. The classifications are worked through in section **3.1** below.

> ***NOTE:*** *The European Standards are based on Allowable Stress Design (or Working Stress Design) for calculating wind loads, versus the Limit State Design used by New Zealand and Australia. A brief summary of the differences can be found in* ***Appendix A*** *of this guide.*
> *The differences are in the relationship between the design wind pressures, the proof loads, and water test pressures. But in terms of testing, 400Pa of load is still 400Pa and the test samples reactions to that pressure are therefore comparative.*

Window performance in New Zealand must satisfy the provisions of our Building Code, specifically in terms of this guide, Clauses B1 and E2. The testing cannot be used in isolation to demonstrate compliance with any requirements of the Building Code, it must also comply with the applicable acceptable solution or verification method. Window and door products must be used within the scope, limitations, and other applicable requirements set out in the test reports and acceptable solution or verification method.

3.1 Window Classification

The classification for windows and doors tested to the European standards are specific to each of the tests. The following outlines theses classifications in the areas covered within this guide.

3.1.1- Resistance to Windload

The Wind load class is defined by the standard EN 12210, when tested in accordance with EN 12211. Windows tested to this standard are classified for wind load resistance based on a two-part system, as described in **Table 3.1.1.**

i) a Wind load class from 1 to 5, indicating the pressure (in Pa) the window can withstand (P1 is similar to the SLS pressure used in TS 4211), and

ii) a deflection class (A, B, or C) indicating how much the window frame deforms under pressure.

iii) As a part of the test method, there are two other pressure values tested in EN 12211. P2, which we do not have an equivalent for in TS 4211, applies 50 cycles of pressure at half of the P1 pressure for the class, after which the moving parts of the test specimen are checked for functional defects.

iv) And P3 the Safety test which is similar to the Ultimate test in TS 4211, performed at 150% of P1.

The classification indicates the relative frontal deflection of the frame, with Class C having the smallest deflection and best wind resistance:

E.g. A window labelled C5 is the highest-rated category, meaning it can withstand up to 2000 Pa of load, with a maximum deflection of 1/300.

A window labelled A3 can withstand 1200 Pa of pressure but has a larger maximum deflection of 1/150.

EN 12210 - Resistance to wind load - Classification					
Wind load class P1 - (Pa)	Relative deflection - (Maximum Ratio)			Repeat pressure test P2 - Pa	Safety test P3 - Pa
	A - (≤ 1/150)	**B** - (≤ 1/200)	**C** - (≤ 1/300)		
1 - (400)	A1	B1	C1	*200*	***600***
2 - (800)	A2	B2	C2	*400*	***1200***
3 - (1200)	A3	B3	C3	*600*	***1800***
4 - (1600)	A4	B4	C4	*800*	***2400***
5 - (2000)	A5	B5	C5	*1000*	***3000***
E*xxxx* [a] - (>2000)	AE*xxxx*	BE*xxxx*	CE*xxxx*	*P1 x 0.5*	*P1 x 1.5*

Table 3.1.1 - Wind Load Classification

NOTE:[a] *The test specimen with a tested loading above class 5, where xxxx is the actual test pressure P1 expressed in Pa (e.g. 2350).*

3.1.2- Watertightness

The Wind load class is defined by the standard EN 12208, when tested in accordance with EN 1027. Windows tested to this standard are classified for watertightness based on test pressure and exposure, as described in **Table 3.1.2.**

i) There are nine pressure classes, and

ii) Two test methods, Test method A for fully exposed and Test method B for partially exposed. Test method B uses half the amount of water ($1L/(min.m^2)$) as that used in method A, ($2L/(min.m^2)$)

EN 12208 - Watertightness - Classification			
Test Pressure	Classification		Specification (Timing)
Max Pa	Test method A (fully exposed)	Test Method B (partially exposed)	
0	1A	1B	15min
50	2A	2B	Class 1 + 5min (20min)
100	3A	3B	Class 2 + 5min (25min)
150	4A	4B	Class 3 + 5min (30min)
200	5A	5B	Class 4 + 5min (35min)
250	6A	6B	Class 5 + 5min (40min)
300	7A	7B	Class 6 + 5min (45min)
450	8A	-	Class 7 + 5min (50min)
600	9A	-	Class 8 + 5min (55min)
> 600	*Exxx*	-	Above 600Pa in steps of 150Pa, the duration at each step shall be 5min [b]

Table 3.1.2 - Watertightness Classification

NOTE: [b] Test specimens that are watertight to pressures greater than 600Pa for a minimum of 5min shall be classified as Exxx, where xxx is that maximum test pressure (e.g. 750, 900 Pa).

3.1.3- Air Permeability

The Air permeability class is defined by the standard EN 12207, when tested in accordance with EN 1026. Windows and external pedestrian doorsets tested to this standard are classified for air permeability based on both overall area and opening joint length as described in **Table 3.1.3.** If a specimen is classified according to the overall area and the opening joint length, which give,

i) the same class, the specimen shall be specified in the same class,
ii) two adjacent classes, the specimen is classified in the class with the lower rate,
iii) a difference of two classes, the specimen is classified in the mean class, and

iv) a difference of more than two classes, the specimen is not classified.

EN 12207 - Air Permeability - Classification			
Class	Reference air permeability @100Pa Overall area ($m^3/(h.m^2)$)	Reference air permeability @100Pa Opening joint length ($m^3/(h.m)$)	Maximum test pressure
1	50	12.50	150
2	27	6.75	300
3	9	2.25	600
4	3	0.75	600

Table 3.1.3- Air permeability classes

3.2 Labelling

Whilst the Association believes the labelling of all windows and doors for site should be a fundamental of window supply in Aotearoa New Zealand, the reality is that windows and doors sourced from other countries may not include this. It seems it is more common for European windows to be labelled with their thermal performance characteristics, than their structural, watertightness, air permeability performance.
In order to establish compliance and suitability for site, we encourage the provision of test reports for overseas product, for comparison against the tables assembled within this guide.

3.3 Comparison

Comparison between TS 4211:2022 and the European standards discussed in this guide is not a simple task. The layers of classifications in these standards mean that in some instances there may be no easy comparison and these situations may require further investigation and or calculation to understand whether product tested to the European standards is suitable for the site in question.

The following sections and Tables note the simpler comparisons.

3.3.1- Window Classifications and Design Wind Pressure

To reiterate the European wind load classifications are based on allowable stress design, rather than the limit state design used in the NZ test standard (and Building Code), which complicates our comparisons if considering the relationship between the design wind pressures, the proof loads, and water test pressures. But in terms of testing, 400Pa of load is still 400Pa and the test samples reactions to that pressure are therefore comparative. Refer to **Appendix A** of this guide.

The European standards have five classifications for wind load, extended based on their maximum deflection ratios, for their windows and ten classifications for watertightness, which we've merged into one table for ease of comparison. **Table 3.3.1** includes these classifications and their comparison with New Zealand's Wind zones.

European Performance Classifications - Comparison with NZ Wind Zones								
Wind load class P1 - (Pa)	Relative deflection (Maximum Ratio)			P2 Pa	P3 Pa	Watertightness class		
	A (≤ 1/150)	B (≤ 1/200)	C (≤ 1/300)		General	Method A	Method B	Pa
1 - (400)	A1	B1	C1	*200*	*600*	A1	B1	0
2 - (800)	A2	B2	C2	*400*	*1200*	A2	B2	50
3 - (1200)	A3	B3	C3	*600*	*1800*	A3	B3	100
4 - (1600)	A4	B4	C4	*800*	*2400*	A4	B4	150
5 - (2000)	A5	B5	C5	*1000*	*3000*	A5	B5	200
E*xxxx* - (>2000)	AE*xxxx*	BE*xxxx*	CE*xxxx*	*P1 x 0.5*	*P1 x 1.5*	A6	B6	250
						A7	B7	300
						A8	-	450
						A9	-	600
						Exxx	-	> 600

Colour Key - NZ Wind Zone						
Wind Zone	None	Low	Medium	High	Very High	Extra High +

Table 3.3.1 - Classification Comparison

Table 3.3.1 provides a comparison of the performance of a window or door product as a standalone item, and based on its performance, evaluates its suitability for a site. This does not necessarily mean it is suited to the building's construction type. In residential construction, window installation is guided by E2/AS1 and stands separately to the individual unit's performance. Differences in the perimeter frame design may exclude it from E2/AS1, meaning alternative installation details may be required to demonstrate compliance with the building Code.

3.3.2- Deflection Ratio

The European standards modify the classification based on the maximum deflection of the structural members within the test specimen, e.g.,

a) Class A2 = 800Pa test load where the member deflected ≤ span/150,
b) Class B2 = 800Pa test load where the member deflected ≤ span/200,
c) Class C2 = 800Pa test load where the member deflected ≤ span/300.

Classification B provides a direct comparison with the span/200 requirement from TS 4211, but classes A and C will require further evaluation of the test data to establish suitability and compliance. The data contained in the test reports will allow any structural member to be reverse engineered, based on the recorded deflection values. From the test data, the span ratio can be re-calculated, based on the configuration of the unit.

3.3.3- Watertightness

EN 1027 tests the watertightness of a window or door, with a range of spray patterns depending on the size and configuration of the test specimen. The spray pattern for test specimens up to 2.5m high includes a single row of nozzles, spaced at 400mm ctrs, with a flow rate of 2l/min each.

EN 12208 classifies the achieved performance over 17 classes based on test pressure, time, and test method. There are two spraying methods,

a) Method A, for the fully exposed classification,
b) Method B, for the partially exposed classification,

where Method B uses less water than Method A.

The 17 classes have been included into **Table 3.3.1** for comparison against the NZ Wind Zone.

NOTE: *TS 4211 has no comparison for Method B.*

3.3.4- Air Permeability

EN 1026 measures air permeability at a series of pressure steps (both positive and negative). For classification EN 12207 takes the total air permeability and defines the class at a reference pressure of 100Pa, whilst TS 4211 graphs the test measurements at each of the test pressures. Some complexity is added through differing units of measurement - cubic metres per hour vs litres per second, but ultimately the values are comparative and the classifications align. Bracketed numbers in the Table have been converted to (m^3 per hour) and are included for reference. **Table 3.3.3** provides a comparison of these values for each of the classes.

EN 12207 - Air Permeability - Comparison						
Class	Overall Area			Overall Joint Length		
	Euro @100Pa	NZ @75Pa	NZ @150Pa	Euro @100Pa	NZ @75Pa	NZ @150Pa
1	50	11.4 (41.04)	18.3 (65.88)	12.5	2.86 (10.30)	4.57 (16.45)
2	27	6.17 (22.21)	9.88 (35.57)	6.75	1.54 (5.54)	2.47 (8.89)
3	9	2.06 (7.42)	3.29 (11.84)	2.25	0.514 (1.85)	0.823 (2.96)
4	3	0.685 (2.47)	1.1 (5.04)	0.75	0.171 (0.62)	0.274 (0.99)

Table 3.3.3 - Air Permeability

Note: *The basics are that a Class 2 classification under EN 12207 is equal to a Class 2 classification under TS 4211.*

3.4 European Test Methods and Performance Requirements

As noted earlier, rather than being contained in one document, the European approach to window and door test standards is to divide the tests into individual documents. In terms of this guide, where we're considering wind load resistance, water penetration, and air permeability, as follows.

3.4.1- Resistance to Wind Load (P1)

Test Method The specimen is tested in accordance with EN 12211:2016. Deflection measurements are taken in both positive and negative directions for members of the test specimen, at no less than the P1 pressures nominated in Table 1 in EN 12210:2016.

Performance Deflection measurements are recorded, and the test specimen is classified A, B, or C, based on the deflections measured, for the applicable wind load class, 1- 5.

E.g. A C5 classification, means a maximum deflection of up to 1/300 under 2000 Pa of load.

3.4.2- Resistance to Wind Load (P2)

Test Method The specimen is tested in accordance with EN 12211:2016. The specimen is subjected to 50 cycles of both negative and positive pressures, at 7(+/-3) seconds, to the P2 values nominated in Table 1 in EN 12210:2016. The P2 pressures are 50% of P1.

Performance At the completion of the 50 cycles, the moving parts of the test specimen are opened and closed, noting any damage or function defects, if any.

3.4.3- Resistance to Wind Load (P3)

Test Method The specimen is tested in accordance with EN 12211:2016. Referred to as the Safety Test, the specimen is subjected to one cycle of both negative and positive pressures, at 7(+/-3) seconds, equal to the **P3** values nominated in Table 1 in EN 12210:2016. The **P3** pressures are 1.5 times those for **P1**.

Performance At the completion of the safety test the test specimen is checked to ensure it remains closed and whether any parts have become detached.

3.4.4- Watertightness

Test Method The test specimen is tested in accordance with EN 1027:2016. The test specimen is subjected to water sprayed in accordance with the standard at pressure steps nominated in Table 1 of EN 12208:2003. There are two spraying methods,

a) Method A, for the fully exposed classification,
b) Method B, for the partially exposed classification,

where Method B uses less water than Method A.

Performance The limit of water tightness is the maximum test pressure up to which the test specimen remains watertight under the test conditions for the specified time. Water penetration is deemed to occur when continuous or repeated wetting of,

a) parts of the inside face of the test specimen, or
b) any parts of the test specimen intended to remain dry, not being part of the water drainage system to the outside, or
c) any parts of the test specimen where water does not drain to the outside in a controlled way.

NOTE: Continuous wetting could be described as an uninterrupted sequence of water, e.g. thin line of water.
Repeated wetting could be described as frequent intervals of water, e.g. more than one drop of water.

3.4.5- Air Permeability

Test Method The test specimen is tested in accordance with EN 1026:2016. The test measures the air permeability of the specimen at pressure steps (both positive and negative) nominated in Tables 1 and 3 of EN 12207:2016.
Air permeability is described as the amount of air passing through the joints of the specimen caused by the test pressure. It is expressed in cubic metres per hour (m^3/h).

Performance	The classification is based on a comparison of the air permeability of the test specimen related to the overall area, and on the air permeability related to the length of the opening joint(s). EN 12207 takes the total air permeability and defines the class at a reference pressure of 100Pa, through calculation. This value is then used to graph the result, per Figure A.1, and establish an air permeability class.

Part 4 - American Test Standards

4.0 American window and door test standards

Similar to the Europeans, the American window standards are divided into a series of individual test documents, with one which overall establishes the levels of performance for windows and doors. A440 defines the requirements for the four Performance Classes and the 18 Performance Grades. The specifier or purchaser selects the appropriate level of performance, depending on climatic conditions, type of building, type of window, door, and a number of other conditions that do not form a part of this guide.

In terms of this guide, we're considering what A440 refers to as AWS – air, water, and structural. *"AWS clauses outline the primary performance requirements for safety, weather-ability, and structural integrity applicable to assembled and glazed products. In general, these are also the requirements mandated by building codes, adopted by authorities having jurisdiction, and enforced for specific projects."*

The test methods for these are included in following standards,

a) AAMA/WDMA/CSA 101/I.S.2/A440:22 - North American Fenestration Standard/Specification for windows, doors, and skylights
b) ASTM E330-14 (2021) - Standard Test Method for Structural Performance,
c) ASTM E331-00 (2023) - Standard Test Method for Water Penetration,
d) ASTM E283-19 - Standard Test Method for Determining Rate of Air Leakage.

Each of the classifications/grades are worked through in section **4.1** below.

> ***NOTE:*** *The American Standards are based on Allowable Stress Design (or Working Stress Design) for calculating wind loads, versus the Limit State Design used by New Zealand and Australia. A brief summary of the differences can be found in* ***Appendix A*** *of this guide.*
> *The differences are in the relationship between the design wind pressures, the proof loads, and water test pressures. But in terms of testing, 400Pa of load is still 400Pa and the test samples reactions to that pressure are therefore comparative.*

Window performance in New Zealand must satisfy the provisions of our Building Code, specifically in terms of this guide, Clauses B1 and E2. The testing cannot be used in isolation to demonstrate compliance with any requirements of the Building Code, it must also comply with the applicable acceptable solution or verification method. Window and door products must be used within the scope, limitations, and other applicable requirements set out in the test reports and acceptable solution or verification method.

4.1 Window Classification

Windows and doors rated in accordance with A440 are to conform with all of the applicable requirements of the standard and cannot claim partial compliance. Minimum Performance Grades (PG), ASD design pressures (DP), Structural Test Pressures (STP), air leakage limits, and water penetration resistance test pressures are summarized in the standard. Once achieved, the product will be rated with the applicable Performance Class (R, LC, CW, or AW).

a) **R**: commonly used in one- and two-family dwellings.
b) **LC**: commonly used in low-rise and mid-rise multi-family dwellings and other buildings where larger sizes and higher loading requirements are expected.
c) **CW**: commonly used in low-rise and mid-rise buildings where larger sizes, higher loading requirements, limits on deflection, and heavy use are expected.
d) **AW**: commonly used in high-rise and mid-rise buildings to meet increased loading requirements and limits on deflection, and in buildings where frequent and extreme use of the fenestration products is expected.

Table 4.1 provides an overview of the structural and water penetration resistance requirements for the common Performance Classes and Grades. Given the focus of this document is residential construction Performance Classes R and LC are most applicable and the only ones listed. The table has removed the higher Performance Grades which are unlikely to apply to residential construction in New Zealand.

A440 - Performance Requirements for Windows and Doors				
Performance Class & Performance Grades		ASD Design Pressure (DP)	Structural Test Pressure (STP)	Water Penetration Resistance Test Pressure
R	LC	+/- Pa (~psf)	+/- Pa (~psf)	+ Pa (~psf)
PG15	-	720 (15.04)	1080 (22.56)	140 (2.92)
PG20	-	960 (20.05)	1440 (30.08)	150 (3.13)
PG25		1200 (25.06)	1800 (37.59)	180 (3.76)
PG30		1440 (30.08)	2160 (45.11)	220 (4.59)
PG35		1680 (35.09)	2520 (52.63)	260 (5.43)
PG40		1920 (40.10)	2880 (60.15)	290 (6.06)
PG45		2160 (45.11)	3240 (67.67)	330 (6.89)
PG50		2400 (50.13)	3600 (75.19)	360 (7.52)
PG55		2640 (55.14)	3960 (82.71)	400 (8.35)
PG60		2880 (60.15)	4320 (90.23)	440 (9.19)
PG65		3120 (65.16)	4680 (97.74)	470 (9.82)
PG70		3360 (70.18)	5040 (105.26)	510 (10.65)
PG75		3600 (75.19)	5400 (112.78)	540 (11.28)
PG80		3840 (80.20)	5760 (120.30)	580 (12.11)

Table 4.1 - Performance Requirements

4.1.1- Structural Performance

The test method ASTM E330-14 (2021) is used to determine the structural performance of exterior windows and doors (and skylights and curtain walls) under uniform static air pressure differences translated from building design wind velocities, both inward and outward, using a test chamber. There are two test procedures depending on whether a load deflection curve is required or not.

Deflection measurements are recorded at a range of increments, each held for 10 seconds, up to the specified maximum test load, the design pressure (DP). The DP is used in establishing the Performance Grade (PG) classification for the specimen. For Performance Classes R and LC there is no maximum allowable deflection, the deflection ratio is simply recorded as a part of the test report.

The test specimen is finally subjected to a proof load at the structural test pressure (STP), equal to 1.5 x DP, after which there shall be no permanent damage or deformation.

Pressure values for each of the Performance Grades are described in **Table 4.1** above.

4.1.2- Water Penetration Resistance

The test method ASTM E331-00 (2023) is used to determine the resistance of exterior windows and doors (and skylights and curtain walls) to water penetration when water is applied to the outside face with a uniform static air pressure, equal to 15% of the DP (for Performance Classes R and LC). The test addresses and defines acceptable water penetration through a manufactured assembly.

The water spray system delivers water uniformly across the face of the test specimen at a minimum rate of 3.4L/m^2.min, (5.0US gal/ft^2.hr)

Water test pressure values for each of the Performance Grades are described in **Table 4.1** above.

The Performance Grade (PG) rating for a product is sometimes limited by structural performance rather than by water penetration resistance performance. In these cases, the tested specimen might have successfully passed a water penetration resistance test at a pressure greater than the minimum specified for the Performance Class and Performance Grade.

4.1.3- Air Leakage

The test method ASTM E283-19 is used to determine the air leakage rates of exterior windows and doors under specified pressure conditions (typically +/-75Pa). The test method recognises air leakage rates at both per unit length of operable perimeter and per unit area. However, A440 notes that for the purposes of the standard, air leakage shall be expressed in units of litres per second per square meter of frame area (cubic feet per minute per square foot of frame area) [L/s.m^2 (cfm/ft^2)]. The maximum allowable leakage in accordance with A440, shown in **Table 4.1.3** below (for Performance Classes R and LC).

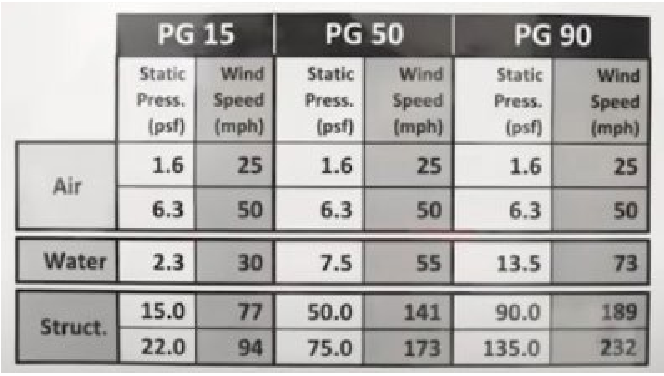
ASTM E283 - Air Leakage		
Performance Class	Air Leakage Test Pressure Pa (~psf)	Maximum Allowable Air Leakage L/s.m^2 (~cfm/ft^2)
R	+/- 75 (+/- 1.57)	1.5 (0.3)
LC		

Table 4.1.3 - Air Leakage

4.2 Labelling

Whilst the Association believes the labelling of all windows and doors for site should be a fundamental of window supply in Aotearoa New Zealand, the reality is that windows and doors sourced from other countries may not include this. However, labels such as the one shown below are seen on some US product.

In order to establish compliance and suitability for site, we encourage the provision of test reports for overseas product, for comparison against the tables assembled within this guide.



	PG 15		PG 50		PG 90	
	Static Press. (psf)	Wind Speed (mph)	Static Press. (psf)	Wind Speed (mph)	Static Press. (psf)	Wind Speed (mph)
Air	1.6	25	1.6	25	1.6	25
	6.3	50	6.3	50	6.3	50
Water	2.3	30	7.5	55	13.5	73
Struct.	15.0	77	50.0	141	90.0	189
	22.0	94	75.0	173	135.0	232

4.3 Comparison

Comparison between TS 4211:2022 and the American standards discussed in this guide is not a simple task. The layers of performance classes and grades in these standards mean that in some instances there may be no easy comparison and these situations may require further investigation and or calculation to understand whether product tested to American standards is suitable for the site in question.

4.3.1- Performance Grades and Design Pressure

Despite the large number of Performance Grades set by A440 the comparison with New Zealand's Wind Zones is relatively simple. **Table 4.3.1a** shows these comparisons element by element and **Table 4.3.1b** compares them by the lowest performing element. In all cases the comparison is driven by the pressure of the water test.

A440 - Comparison by Rating				
Performance Class & Performance Grades		ASD Design Pressure (DP)	Structural Test Pressure (STP)	Water Penetration Resistance Test Pressure
R	LC	+/- Pa (~psf)	+/- Pa (~psf)	+ Pa (~psf)
PG15	-	720 (15.04)	1080 (22.56)	140 (2.92)
PG20	-	960 (20.05)	1440 (30.08)	150 (3.13)
PG25		1200 (25.06)	1800 (37.59)	180 (3.76)
PG30		1440 (30.08)	2160 (45.11)	220 (4.59)
PG35		1680 (35.09)	2520 (52.63)	260 (5.43)
PG40		1920 (40.10)	2880 (60.15)	290 (6.06)
PG45		2160 (45.11)	3240 (67.67)	330 (6.89)
PG50		2400 (50.13)	3600 (75.19)	360 (7.52)
PG55		2640 (55.14)	3960 (82.71)	400 (8.35)
PG60		2880 (60.15)	4320 (90.23)	440 (9.19)
PG65		3120 (65.16)	4680 (97.74)	470 (9.82)
PG70		3360 (70.18)	5040 (105.26)	510 (10.65)
PG75		3600 (75.19)	5400 (112.78)	540 (11.28)
PG80		3840 (80.20)	5760 (120.30)	580 (12.11)

Colour Key - NZ Wind Zone						
Wind Zone	None	Low	Medium	High	Very High	Extra High +

Table 4.3.1a - Ratings Comparison

A440 - Comparison by Lowest Performing Element				
Performance Class & Performance Grades		ASD Design Pressure (DP)	Structural Test Pressure (STP)	Water Penetration Resistance Test Pressure
R	LC	+/- Pa (~psf)	+/- Pa (~psf)	+ Pa (~psf)
PG15	-	720 (15.04)	1080 (22.56)	140 (2.92)
PG20	-	960 (20.05)	1440 (30.08)	150 (3.13)
PG25		1200 (25.06)	1800 (37.59)	180 (3.76)
PG30		1440 (30.08)	2160 (45.11)	220 (4.59)
PG35		1680 (35.09)	2520 (52.63)	260 (5.43)
PG40		1920 (40.10)	2880 (60.15)	290 (6.06)
PG45		2160 (45.11)	3240 (67.67)	330 (6.89)
PG50		2400 (50.13)	3600 (75.19)	360 (7.52)
PG55		2640 (55.14)	3960 (82.71)	400 (8.35)
PG60		2880 (60.15)	4320 (90.23)	440 (9.19)
PG65		3120 (65.16)	4680 (97.74)	470 (9.82)
PG70		3360 (70.18)	5040 (105.26)	510 (10.65)
PG75		3600 (75.19)	5400 (112.78)	540 (11.28)
PG80		3840 (80.20)	5760 (120.30)	580 (12.11)

Colour Key - NZ Wind Zone						
Wind Zone	None	Low	Medium	High	Very High	Extra High +

Table 4.3.1b - Ratings Comparison

These tables provide a comparison of the performance of a window or door product as a standalone item, and based on its performance, evaluates its suitability for a site. This does not necessarily mean it is suited to the building's construction type. In residential construction, window installation is guided by E2/AS1 and stands separately to the individual unit's performance. Differences in the perimeter frame design may exclude it from E2/AS1, meaning alternative installation details may be required to demonstrate compliance with the building Code.

4.3.2- Deflection Ratio

TS 4211 has a maximum allowable deflection of span/200 at SLS, whilst A440, for Performance Classes R and LC does not have a maximum, it simply requires that the measured deflection ratio is nominated in the test report. For Performance Classes CW and AW the maximum deflection is set at span/175 at DP.

If required, compliance will require a review of the test report. The data contained in the test reports will allow any structural member to be reverse engineered, based on the recorded deflection values. From the test data the span ratio can be re-calculated based on the configuration of the unit.

4.3.3- Water Penetration Resistance

Tables 4.3.1a & 4.3.1b above provide a comparison of water test pressures (WTP) between TS 4211 and A440/E331-00 based purely on the test pressure. In both standards the tested window assembly is subjected to similar water flow rates (0.05L/m^2.sec (3.0L/m^2.min) vs 3.4L/m^2.min), sprayed uniformly and continuously over the exterior face, with the pressure maintained for 15 minutes for TS 4211 and 20 minutes for A440. Visual observations of the internal surfaces are used to assess pass or fail.

Where the two vary is in the relationship between the WTP and the wind load,

a) TS 4211 has a clear relationship where the WTP is ~33% (rounded to nearest 5Pa) of the SLS wind load.
b) However, with A440 Performance Classes R and LC, is 15% (with a minimum of 140Pa) of the DP associated with the Performance Grade.

Because a water penetration/resistance test performed to either standard at a specific pressure, say 300Pa, will deliver the same result, the comparisons in **Table 4.3.1a** are definitive. However, **Table 4.3.1b** makes the comparison based on the lowest performing test element meaning the comparison may require further investigation to confirm suitability and compliance.

4.3.4- Air Leakage

A440 notes that air leakage, measured at +/-75Pa, shall be expressed in units of L/s.m^2 (cfm/ft^2) for Performance Classes R and LC with a maximum allowable leakage of 1.5 L/s.m^2 as shown in **Table 4.1.3**. By comparison TS 4211 expresses air permeability in the same units but measures it at both +/-75Pa and +/-150Pa.

An air leakage of 1.5 L/s.m^2 at 75Pa is equivalent to a Class 3 Air Permeability in TS 4211 which allows up to 2.06 L/s.m^2.

4.4 Application to Production Windows

TS 4211:2022 requires that window assemblies be representative of the largest standard assembly in the product range as specified by the manufacturer, with an allowance of up to 10% extrapolation of sizes.

Under A440, in order to claim compliance with a given Performance Class, the product needs to meet or exceed all of the minimum requirements for the product type and/or Performance Class. This set of minimum requirements is called the gateway performance requirements. After meeting the minimum requirements, the manufacturer is permitted to test a second time at a reduced size. The first test at the gateway test size provides apples for apples comparison of products rated in the same Performance Class. Thus, it becomes necessary to report to the user the actual specimen size during test. Indicating the "maximum size tested" fulfils this reporting function. For this reason, the MST is a mandatory part of the product rating but should never be included in a project specification.

After passing all of the performance requirements for the product type, Performance Class (where applicable), and Performance Grade (PG), the product shall be designated with the appropriate Primary Designator. This designation shall only be applied to products of functionally identical construction. Neither width nor height shall be larger than the size tested.

4.5 American Test Methods and Performance Requirements

As noted earlier, rather than being contained in one document, the American approach to window and door test standards is to divide the tests into individual documents. In terms of this guide, where we're considering structural performance, water penetration resistance, and air leakage, as follows.

4.5.1- Structural Performance- Deflection

Test Method	The specimen is tested in accordance with ASTM E330-14 (2021). Deflection measurements are taken in both positive and negative directions for members of the test specimen, at the Allowable Stress Design Pressure (DP) applicable to the Performance Grade. There are two test procedures (A and B) depending on whether or not the specifier requires a load-deflection curve.
Performance	For Performance Classes R and LC, the deflection measurements are recorded in the test report. For Performance Classes CW and AW, the maximum allowable deflection is L/175. Pressure values for each of the Performance Grades are described in **Table 4.1** above.

4.5.2- Structural Performance- Proof Load

Test Method The specimen is tested in accordance with ASTM E330-14 (2021). The test specimen is subjected to a proof load at the structural test pressure (STP), equal to 1.5 x the Allowable Stress Design Pressure (DP) applicable to the Performance Grade.

Performance The test specimen shall be evaluated for permanent damage. There shall be no visually observable permanent damage to fasteners, hardware parts, support arms, or actuating mechanisms and there shall be no disengagement or non-superficial cracking (cracking that weakens the components) of the sash, frame, or glazing. In addition, if other damage or deformation is evident, the test specimen shall be operable within the limits specified in A440.

Pressure values for each of the Performance Grades are described in **Table 4.1** above.

4.5.3- Water Penetration Resistance

Test Method The test specimen is tested in accordance with ASTM E331-00 (2023). The test specimen is sprayed uniformly and continuously over the exterior face, at a flow rate of 3.4l/m^2.min, over four cycles of 5 minutes each. For Performance Classes R and LC at a pressure of 15% (with a minimum of 140Pa) of the DP associated with the Performance Grade.

Performance For conformance with the Standard there shall be no water penetration as defined in the Standard. Unless otherwise specified, failure criteria of this test method shall be,

- whenever water penetrates through the perimeter frame of the test specimen,
- penetration of water beyond a plane parallel to the glazing (the vertical plane) intersecting the innermost projection of the test specimen, not including interior trim and hardware, under the specified conditions of air pressure difference across the specimen.

NOTE: *Water contained within drained flashing, gutters, and sills is not considered failure.*

Pressure values for each of the Performance Grades are described in **Table 4.1** above.

3.4.5- Air Leakage

Test Method The test specimen is tested in accordance with ASTM E283-19. The test measures the air flow through the specimen in both positive and negative directions. For Performance Classes R and LC, the test is performed at +/-75Pa.

	The measured air leakage is expressed in litres per metre squared per minute (L/m^2.min) or cubic feet per minute per foot squared (cfm/ft^2).
Performance	For Performance Classes R and LC with a maximum allowable leakage of 1.5 $L/s.m^2$.min.

Appendix A

Allowable Stress vs Limit State Design

Comparison of Allowable Stress Design and Limit State Design for Windows and Doors

Purpose

This note outlines the key principles and differences between Allowable Stress Design (ASD) and Limit State Design (LSD), as applied to window and door systems. It aims to assist the users of this guide in aligning fenestration design methods with current New Zealand Building Code (NZBC) performance requirements.

A1. Design Basis

Allowable Stress Design (ASD)

ASD, or *Working Stress Design*, checks that calculated stresses under *service loads* (such as wind and self-weight) do not exceed specified allowable values. These allowable stresses are derived by dividing the material's yield or ultimate strength by a global *factor of safety*.

a) Commonly used in earlier glass and frame design standards.
b) Serviceability (deflection, appearance) and strength are treated together.
c) Load effects are typically unfactored, based on expected in-service conditions.

Limit State Design (LSD)

LSD (also called *Ultimate Limit State Design*) separates performance into two categories:

1) **Ultimate Limit State (ULS)** — safety and strength under factored load combinations.

2) **Serviceability Limit State (SLS)** — performance under normal service loads (deflection, vibration, watertightness, etc.).

LSD applies *load factors* and *material reduction factors* to account for variability and uncertainty, in line with probabilistic design methods under NZS 1170.

A2. Application to Windows and Doors

Aspect	Allowable Stress Design (ASD)	Limit State Design (LSD)
Design loads	Service (unfactored)	Factored per NZS 1170
Safety treatment	Global factor of safety	Partial factors on load and material
Checks performed	Stress ≤ allowable value	ULS: strength / SLS: deflection, water
Design outcome	Conservative; simplified	Rational; optimized for efficiency
Complexity	Simpler, deterministic	More analytical; requires load cases

A3. Summary

ASD ensures safety by restricting stresses to conservative limits, while LSD ensures reliability by factoring both loads and material strength to achieve consistent safety levels.

New Zealand's transition toward Limit State Design aligns fenestration engineering with the NZBC's performance-based framework, offering improved consistency, efficiency, and transparency in demonstrating compliance.