



CSI Technical Guidance

Operating Instruction – Measurement of Roller Wave, Edge Kink and Glass Flatness

A Practical Guide for Manufacturers, Testing Laboratories and Regulators



This publication is provided as technical guidance only. It does not replace AS/NZS 2208, applicable Standards, legislation, accreditation requirements, certification scheme rules or professional engineering advice. Users remain responsible for ensuring compliance with all applicable regulatory, accreditation and certification requirements.

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Distribution and Use

This guidance may be issued to CSi personnel, prospective clients, certified clients, manufacturers, laboratories and other interested parties. It may be used to support product-development planning, test-facility preparation, client education and the preparation of evidence for product certification. It must not be represented as a substitute for the controlled text of AS/NZS 2208 or as approval of a specific glazing construction.

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Publication Notice

Scope of this Publication

This publication provides practical guidance for manufacturers, testing laboratories, certification bodies, regulators and other interested parties undertaking testing and conformity assessment of products.

It has been developed from Certification Solutions International's experience in accredited product certification, factory inspections, witness testing and conformity assessment.

This publication explains recognised industry practice but does not replace applicable legislation, Standards, accreditation requirements or certification scheme rules.

Intended Audience

This publication has been prepared for:

- Manufacturers
- Glass processors
- Product certification clients
- Testing laboratories
- Regulatory authorities
- Engineers
- Building surveyors
- Technical managers
- Factory quality personnel
- Importers and distributors

Relationship to Product Certification

Successful testing does not, by itself, constitute product certification.

Product certification requires the evaluation of manufacturing controls, quality management, traceability, surveillance, product testing and ongoing conformity assessment in accordance with the applicable certification scheme and ISO/IEC 17065.

Testing forms only one component of the certification process.

Relationship to Building Regulations

Compliance with AS/NZS 2208 alone does not necessarily demonstrate compliance with the National Construction Code (Australia), the New Zealand Building Code or other applicable statutory requirements.

Product suitability should always be assessed against the applicable Building Code, referenced Standards and project-specific design requirements.

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Always verify the current Issue and Revision recorded in CDA_010 – Master Document Control List before use.

Abbreviations

Abbreviation	Meaning
CSi	Certification Solutions International Pty Ltd
ISO	International Organisation for Standardisation
IEC	International Electrotechnical Commission
AS	Australian Standard
NZS	New Zealand Standard
AS/NZS	Joint Australian/New Zealand Standard

Foreword

Certification Solutions International Pty Ltd has developed this Technical Guidance publication to assist manufacturers, testing laboratories and certification clients in understanding the practical implementation of AS/NZS 2208.

Although AS/NZS 2208 specifies the technical requirements applicable to safety glazing materials, it does not explain how manufacturers should establish testing facilities, prepare representative specimens, document testing or integrate testing into an accredited product certification programme.

This publication has been prepared from practical experience gained during factory inspections, witness testing, product certification and conformity assessment activities undertaken throughout Australia, New Zealand and international manufacturing facilities.

The objective of this publication is to improve the quality, repeatability and consistency of safety glazing testing while reducing invalid testing, product failures and certification delays.

It is intended to assist manufacturers in developing robust testing systems capable of consistently demonstrating product conformity while supporting accredited third-party product certification.

Throughout this publication, recommendations identified as **CSi Recommendations** represent recognised industry best practice developed through Certification Solutions International's experience in product certification, factory inspections and witness testing. Although these recommendations may exceed the minimum requirements of AS/NZS 2208, their implementation is encouraged to improve product conformity, test repeatability and certification outcomes.

The guidance provided throughout this publication represents recognised industry practice developed by Certification Solutions International and should be read together with the current edition of AS/NZS 2208 and all applicable regulatory and certification requirements.

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1. Purpose

This Operating Instruction establishes the method used by CSI auditors for the measurement and recording of roller wave, edge kink and associated flatness characteristics in flat heat-treated glass during factory business reviews, surveillance inspections, product assessments and witnessed testing.

Measurement and conformity assessment are separate activities. The measured value shall be recorded first. Pass/fail criteria shall then be taken from the applicable product Standard, certification specification, client specification or other nominated conformity requirement.

2. Scope

This instruction applies principally to horizontally heat-treated flat glass, including toughened and heat-strengthened glass. Roller wave, edge kink, localised warp and overall bow/warpage are different characteristics and shall be measured and recorded separately.

Roller wave is periodic distortion produced by contact with furnace rollers during horizontal heat treatment. Edge kink is distortion occurring at the leading or trailing edge associated with loss of roller support during processing.

3. Reference Documents

- AS/NZS 2208:2023 – Safety glazing materials in buildings, incorporating Amendments 1 and 2:2025.
- AS 1288:2021 – Glass in buildings — Selection and installation.
- AS/NZS 4667:2000 – Quality requirements for cut-to-size and processed glass.
- NZS 4223.1:2008+A1 – Glazing in buildings — Part 1: Glass selection and glazing.
- NZS 4223.2:2016 – Glazing in buildings — Part 2: Insulating glass units.
- NZS 4223.3:2016+A1 – Glazing in buildings — Part 3: Human impact safety requirements.
- NZS 4223.4:2008+A1 – Glazing in buildings — Part 4: Wind, dead, snow, and live actions.
- ASTM C1651-25 – Standard Test Method for Measurement of Roll Wave Optical Distortion in Heat-Treated Flat Glass, where applicable.

4. Equipment

- Digital dial-indicator roller-wave/flatness gauge.
- Reference beam/base supplied with the gauge.
- Steel straightedge where required.
- Calibrated feeler gauges where required.
- Suitable means of identifying the 150 mm edge exclusion zone.
- Clean lint-free cloth suitable for glass and gauge contact surfaces.
- CSI inspection/test record.

The digital indicator shall have sufficient resolution for the tolerance being assessed. The CSI instrument photographed with this instruction displays in millimetres with 0.01 mm resolution.



Figure 1 — Digital dial indicator forming part of the CSI roller-wave/flatness measurement system.

5. Equipment Identification and Pre-use Checks

- Record the CSI equipment identification or serial number, where applicable.
- Confirm the digital indicator operates correctly, and the display is clear and stable.
- Confirm the measuring spindle moves freely and returns consistently.
- Check the measuring contact, reference beam and contact surfaces are clean, secure and undamaged.
- Check fasteners and adjustment mechanisms are secure.
- Confirm the battery has sufficient capacity.
- Confirm the equipment is within its applicable calibration or verification period.
- Do not use equipment where damage, contamination, instability or excessive movement could affect the result.

6. Preparation and Positioning of the Glass

Identify the glass, manufacturer, plant, batch/job number, glass type, nominal thickness, panel dimensions, furnace/line and applicable Standard or specification where this information is available.

The glass surface shall be clean and dry. Remove dust, grit, labels or other material that could interfere with the gauge contact points.

Establish the furnace direction of travel wherever possible. This is necessary to correctly distinguish roller wave from leading/trailing edge kink.

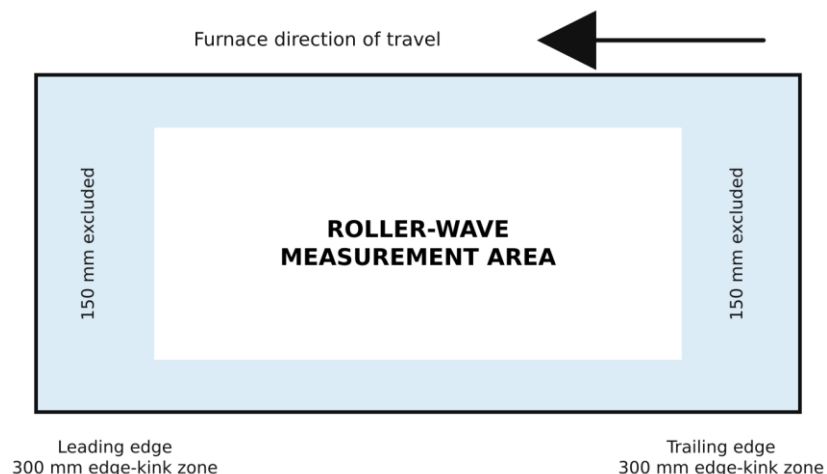


Figure 2 — Measurement zones. For AS/NZS 2208 roller-wave assessment, exclude 150 mm from all edges. Edge kink is assessed separately at the leading and trailing 300 mm, parallel to furnace travel.

7. Roller-Wave Measurement Procedure

Roller-wave measurements shall be taken along measurement lines parallel to the furnace direction of travel, so that the gauge traverses' successive roller-wave peaks and troughs.

1. Place the gauge/reference assembly carefully on the glass without impact or excessive pressure.
2. Ensure all required reference/contact points are properly seated on the glass.
3. Switch the digital indicator on and select millimetres (mm).
4. Zero the complete gauge assembly on a clean, stable and verified flat reference surface in accordance with the equipment manufacturer's instructions. Do not establish the instrument zero from an unverified area of the test specimen.
5. Move the gauge progressively across the glass so the measuring contact traverses successive roller-wave peaks and troughs. Do not press down on the gauge in a manner that could alter the reading.
6. For AS/NZS 2208 assessment, do not use readings taken within 150 mm of any glass edge for the roller-wave conformity result.
7. Observe and record the relevant readings and identify the maximum measured roller-wave distortion.
8. Take measurements at sufficient locations across the usable area to identify the maximum condition.
9. Repeat the measurement at the location of the maximum or abnormal reading before recording the confirmed result.

This procedure provides the peak-to-valley measurement required for assessment against AS/NZS 2208. It shall not be reported as a complete ASTM C1651 test unless the apparatus, measurement of peak-to-valley depth and wavelength, optical-distortion calculation, units and reporting requirements of ASTM C1651 have all been satisfied.

8. Edge-Kink Measurement Procedure

Edge kink, also described as edge lift or edge curl, shall be measured and reported separately from roller wave, even where both measurements are obtained using the same combined instrument.

Identify and record the direction of travel through the furnace and the corresponding leading and trailing edges of the glass. For AS/NZS 2208 assessment, evaluate both the leading and trailing 300 mm edge zones along measurement lines parallel to the furnace direction of travel.

8.1 Measuring Equipment

Use a CSI-approved combined roller-wave and edge-kink gauge operating in its dedicated edge-kink or edge-lift configuration.



Figure 3—CSI combined roller-wave and edge-kink measurement gauge.

Before measurement:

- Confirm that the gauge is within its current calibration or verification period.
- Inspect and clean the gauge contact points, reference surfaces and the glass surface.
- Check that the indicators move freely and display in millimetres.
- Place the gauge on a clean, stable reference surface and switch on both digital indicators. Confirm that each indicator self-zeros or is adjusted to zero and remains stable within ± 0.01 mm. This check verifies the zero setting and does not replace calibration or verification.
- Confirm that the gauge configuration and measurement geometry are suitable for the applicable AS/NZS 2208 requirement.

The combined gauge may measure both roller wave and edge kink, but the two results shall be recorded separately.

8.2 Measurement Method

1. Support the glass in a stable, substantially horizontal position with the surface to be measured clean, dry and accessible.
2. Mark or otherwise identify the furnace direction of travel and the leading and trailing edges.

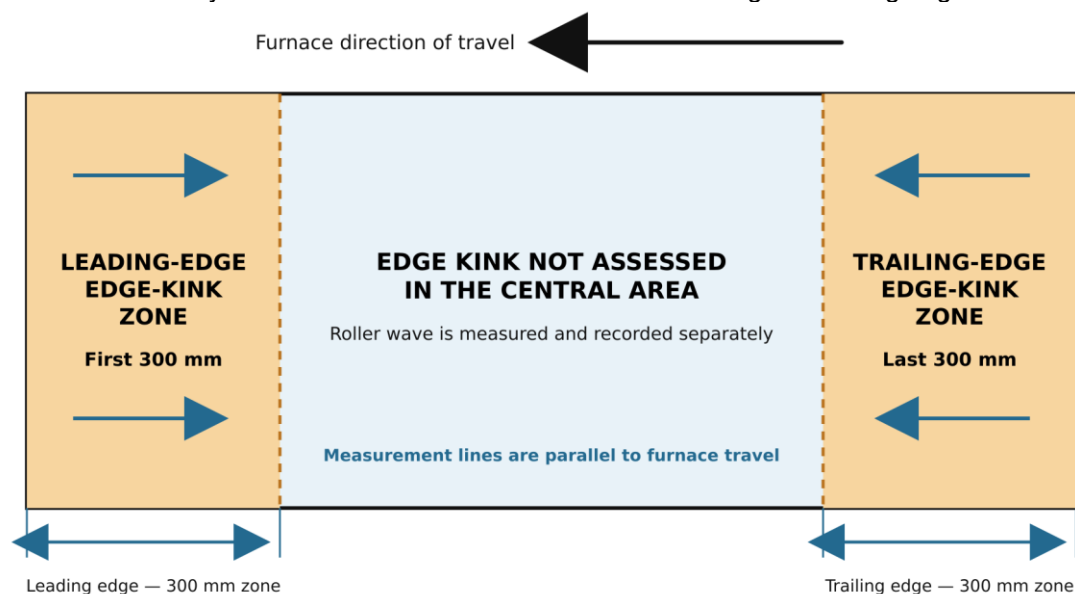


Figure 4 — Edge-kink measurement zones.

3. Select the gauge's edge-kink or edge-lift measurement configuration.
4. Position the gauge parallel to the furnace direction of travel. Place the edge-measuring contact at the edge being assessed, with the gauge's remaining contact or reference points properly supported on the adjacent glass surface, as specified by the equipment manufacturer.
5. Allow the gauge to rest naturally on the glass. Do not apply downward pressure or other force that could flatten the glass or influence the reading.
6. Traverse or reposition the gauge as appropriate within the leading or trailing 300 mm assessment zone. Take sufficient measurements across the width of the glass to identify the location of maximum edge kink.
7. Read the dedicated edge-kink or edge-lift indicator and record the maximum deviation in millimetres. Where the instrument identifies the direction of deviation, record whether the edge is raised or depressed.
8. Repeat the measurement at the location of the maximum recorded deviation. If the repeat reading does not agree within the resolution of the instrument, inspect the contact surfaces, recheck the zero setting and repeat the measurement.
9. Repeat the procedure for both the leading and trailing edges.

10. Recheck the gauge zero after completing the measurements. Where the zero verification is unsatisfactory, disregard the affected results and repeat the measurements after the instrument has been correctly verified.

8.3 Measurement Record

Record all edge-kink measurements using the inspection record provided in Section 13.

As a minimum, record:

- specimen or product identification;
- glass type, nominal thickness and dimensions;
- furnace direction of travel;
- identification of both the leading and trailing edges;
- measurement position across the glass width;
- measured value for both the leading and trailing edges;
- three confirmed readings, including the initial reading, at the location of maximum edge kink;
- maximum confirmed edge-kink value in millimetres;
- direction of deviation, where applicable;
- gauge identification and calibration or verification status;
- applicable acceptance criterion;
- conformity decision; and
- inspector's name and measurement date.

Where the combined gauge is also used to measure roller wave, the roller-wave and edge-kink results shall be entered separately in the Section 13 inspection record. The results shall not be substituted for, combined with or averaged against each other.

9. Other Flatness Measurements

Where required by the inspection scope, record roller wave, edge kink, localised warp and overall bow/warpage separately. Do not report localised warp, overall bow or edge kink as a roller-wave result.

For AS/NZS 2208, localised warp is limited to 1.0 mm over any 200 mm span. Overall bow/warpage is assessed separately in accordance with the applicable thickness and panel-dimension requirements.

10. Understanding Optical Distortion

Optical distortion is the apparent deformation of an image viewed through, or reflected from, glass. In heat-treated flat glass, optical distortion can result from small variations in surface flatness produced during heating, transport through the furnace and cooling.

When glass is heated to the temperature required for toughening or heat strengthening, it becomes sufficiently pliable for its surface profile to be influenced by the furnace rollers. Slight sagging between adjacent rollers can produce a repeating peak-and-trough profile known as roller wave. The resulting surface curvature changes the angle at which light is transmitted through or reflected from the glass and can therefore cause straight lines or reflected objects to appear wavy or distorted.



Figure 5 — Visual indication of roller-wave optical distortion in horizontally toughened glass. The glass is shown exiting the toughening furnace onto the roller bed. Distortion of the reflected zebra-board pattern provides a visual indication of changes in the glass surface profile.

The visual significance of roller wave is influenced by both:

- **Peak-to-valley depth** — the physical difference between the highest and lowest portions of the wave; and
- **Wave wavelength or peak-to-peak distance** — the distance between successive peaks or troughs.

Consequently, two pieces of glass having the same measured peak-to-valley depth may not necessarily produce the same apparent optical distortion if their wave spacing differs. ASTM C1651-25 uses both peak-to-valley depth and wavelength when determining roller-wave optical distortion.

Optical distortion should therefore not be considered synonymous with a single flatness measurement. Physical measurements such as roller wave, edge kink, localised warp and overall bow describe particular geometric characteristics of the glass, whereas optical distortion describes the effect those characteristics may have upon transmitted or reflected images.

Roller wave is generally most apparent in reflection where regular straight lines, building edges or other rectilinear objects are reflected from the glass. The apparent severity can vary with viewing distance, viewing angle, glass orientation, reflected background, installation conditions and other optical characteristics of the glazing.

Other forms of distortion, including edge kink, overall bow, localised warp and pocket-type distortion, may also affect appearance but shall not be reported as roller wave. ASTM C1651-25 is specifically concerned with roller-wave deformation and does not address edge kink, bow, pocket distortion or other flatness characteristics.

CSi Recommendation

Where optical appearance forms part of the product specification or client acceptance requirement, the physical flatness measurement should be supplemented by the applicable recognised optical-distortion assessment method. The method, viewing conditions and acceptance criteria shall be identified before making a conformity decision.

A visual observation alone should not be substituted for a specified quantitative measurement where the applicable Standard, specification or certification requirement requires an instrumental result.

11. Repeat Measurements

Where a result is close to the applicable acceptance limit, appears inconsistent with adjacent readings, or could materially affect the conformity decision, repeat the measurement.

CSi inspectors shall take three readings at the location producing the maximum observed distortion. If the readings differ materially, check gauge position, contact surfaces, zero setting and the glass surface before continuing. Unless the applicable test method specifies otherwise, record the highest confirmed value.

12. Acceptance Criteria

The inspector shall identify the applicable Standard or specification before making a conformity decision. Where no specified tolerance applies, CSi shall not create or assume an acceptance limit.

Characteristic	AS/NZS 2208 criterion	Measurement area / condition	Reference
Roller wave	≤ 0.15 mm	Exclude 150 mm from all edges	Clause 2.5.3
Edge kink	≤ 0.20 mm	Leading/trailing 300 mm, parallel to travel	Clause 2.5.2
Localised warp	≤ 1.0 mm over 200 mm	Any applicable 200 mm span	Clause 2.5.1
Overall bow/warpage	As applicable	By glass thickness and panel dimension	Clause 2.5.1 / Table 2.3

AS/NZS 4667 provides that where a separate surface-distortion criterion is not otherwise specified, the manufacturer and customer agree the tolerance, measurement method and magnitude of distortion. It also excludes a 150 mm edge band from surface-distortion measurement.

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13. Recording and Reporting

All measurements shall be recorded in millimetres (mm). The inspection record shall identify the glass, measuring equipment, inspector, date, applicable Standard or specification, individual readings, maximum confirmed result, applicable acceptance criterion and conformity decision.

Roller wave, edge kink, localised warp and overall bow/warpage shall be recorded separately. Results shall not be combined or averaged between different flatness characteristics.

Inspection details			
Client / Manufacturer		Plant	
Date		Inspector	
Product / Batch		Glass type	
Nominal thickness	____ mm	Panel size	____ mm × ____ mm
Furnace direction of travel	☐ ← ☐ → ☐ Not identified	Leading / trailing edges identified	☐ Yes ☐ No
Equipment and verification			
Equipment ID		Calibration / verification due	
Applicable standard / specification			
Gauge zero check before measurement	☐ Satisfactory ☐ Unsatisfactory		
Gauge zero check after measurement	☐ Satisfactory ☐ Unsatisfactory		
Roller wave			
Readings	1: ____ mm 2: ____ mm 3: ____ mm		
Maximum	____ mm	Criterion	____ mm
Result	☐ Conforms ☐ Does not conform ☐ N/A		
Edge kink			
Leading edge	____ mm	Trailing edge	____ mm
Confirmed readings at maximum location	1: ____ mm 2: ____ mm 3: ____ mm		
Maximum	____ mm	Criterion	____ mm
Result	☐ Conforms ☐ Does not conform ☐ N/A		

Glass flatness and warpage			
Localised warp	_____ mm over 200 mm	Criterion	_____ mm over 200 mm
Localised-warp result	☐ Conforms ☐ Does not conform ☐ N/A		
Overall bow / warpage	_____ mm	Criterion	_____ mm
Overall bow / warpage result	☐ Conforms ☐ Does not conform ☐ N/A		
Completion			
Comments / observations			
Inspector signature		Date	

14. Equipment Care and Storage

- Clean the measuring contact and reference surfaces after use.
- Do not use abrasive materials on precision contact surfaces.
- Do not leave the measuring spindle under unnecessary load.
- Switch the digital indicator off after use.
- Inspect the equipment for damage before returning it to storage.
- Return all components to their designated positions in the protective case.
- Store the case in a clean, dry location protected from impact, excessive heat, moisture and contamination.
- Do not use the reference beam as a general straightedge, lever or support.



Figure 6 — CSI roller-wave/flatness gauge kit. Store all components in the protective case after use.

15. Calibration and Verification

The digital indicator and associated measurement system shall be controlled under the CSI equipment calibration and verification system. Calibration or verification shall provide traceability appropriate to the measurements being made.



Before use, perform a zero and repeatability check on a clean, stable reference surface. Where the instrument cannot be zeroed, does not return consistently to zero, produces unstable readings, has been dropped or damaged, or is outside its calibration/verification status, remove it from service until its suitability has been confirmed.

Where measurements form part of certification evidence, record the equipment identification and calibration/verification status on the inspection record.

16. Inspector Decision

The inspector shall record the measured result before entering the applicable acceptance criterion. A conformity decision shall only be made against the identified Standard, certification requirement or agreed specification. Any uncertainty regarding the applicable criterion shall be referred to the CSI Technical Manager before the result is reported as conforming or nonconforming.

Where measurement uncertainty could affect the conformity decision, the applicable CSI decision rule shall be applied and identified on the inspection record or associated report. A result shall not be reported as conforming solely because the displayed value is equal to or marginally below the acceptance limit where the measurement uncertainty has not been appropriately considered.

17. International Status and Application

This Operating Instruction has been developed principally for conformity assessment against AS/NZS 2208 and associated Australian and New Zealand requirements. Its equipment-control, measurement, repeatability, traceability, recording and reporting principles are also consistent with internationally recognised conformity-assessment practice.

Where this instruction is used outside Australia or New Zealand, the applicable national, regional or international product Standard, regulatory requirement, test method and acceptance criteria shall be identified before measurement. The acceptance limits specified in Section 12 shall not be represented as universally applicable where another jurisdiction or product specification establishes different requirements.

Where ASTM C1651-25 is nominated, compliance shall only be claimed when all applicable apparatus, measurement, calculation, unit and reporting requirements of that Standard have been satisfied. ISO 12540, ISO 22509, relevant European Standards and other jurisdiction-specific requirements may also apply according to the glass type and intended market.

This instruction provides a controlled and internationally applicable measurement framework but does not replace the authorised text of any applicable Standard or establish universal acceptance criteria.



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EXPERIENCE THE DIFFERENCE