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Large yachts — Strength, weathertightness and watertightness of glazed openings —

Part 3: Quality assurance, installation and in-service inspection

Grands yachts — Résistance, imperméabilité au mauvais temps et étanchéité des ouvertures vitrées —

Partie 3: Assurance qualité, installation et inspection en service

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 12, *Large yachts*.

A list of all parts in the ISO 11336 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Large yachts — Strength, weathertightness and watertightness of glazed openings —

Part 3: Quality assurance, installation and in-service inspection

1 Scope

This document specifies

— the content of the product data sheet of glazing materials for use on yachts,

— the evaluation of conformity to the product data sheet of laminated glass and laminated safety glass for use on yachts,

— the product labelling and identification methods for glass supplied for installation on board a yacht, and

— methods for survey of installed glazing.

It does not cover distortion of view or aesthetic aspects.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 1288-3, *Glass in building — Determination of the bending strength of glass — Part 3: Test with specimen supported at two points (four point bending)*

ISO 11336-1:2012, *Large yachts — Strength, weathertightness and watertightness of glazed openings — Part 1: Design criteria, materials, framing and testing of independent glazed openings*

ISO 11963, *Plastics — Polycarbonate sheets — Types, dimensions and characteristics*

ISO 12543-1, *Glass in building — Laminated glass and laminated safety glass — Part 1: Definitions and description of component parts*

ISO 12543-2, *Glass in building — Laminated glass and laminated safety glass — Part 2: Laminated safety glass*

ISO 12543-3, *Glass in building — Laminated glass and laminated safety glass — Part 3: Laminated glass*

ISO 12543-4, *Glass in building — Laminated glass and laminated safety glass — Part 4: Test methods for durability*

ISO 12543-5, *Glass in building — Laminated glass and laminated safety glass — Part 5: Dimensions and edge finishing*

ISO 12543-6, *Glass in building — Laminated glass and laminated safety glass — Part 6: Appearance*

ISO 21005, *Ships and marine technology — Thermally toughened safety glass panes for windows and side scuttles*

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

EN 572-1, *Glass in building — Basic soda-lime silicate glass products — Part 1: Definitions and general physical and mechanical properties*

EN 1863-1, *Glass in building — Heat strengthened soda lime silicate glass — Part 1: Definition and description*

EN 12150-1, *Glass in building — Thermally toughened soda lime silicate safety glass — Part 1: Definition and description*

EN 12337-1, *Glass in building — Chemically strengthened soda lime silicate glass — Part 1: Definition and description*

EN 12603, *Glass in building — Procedures for goodness of fit and confidence intervals for Weibull distributed glass strength data*

EN 14449, *Glass in building — Laminated glass and laminated safety glass — Evaluation of conformity*

DIN 2304, *Adhesive bonding technology — Quality requirements for adhesive bonding processes*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12543 (all parts), ISO 11336-1, and the following apply.

3.1
initial examination
initial verification that the properties of the product are as given in the product description

Note 1 to entry: The initial examination can and generally does consist of a combination of actual (physical) testing of representative samples of production or of prototypes and assessment of documentation.

3.2
test report
document that gives the results of an initial examination

3.3
product description
document that details the relevant properties of the glazing product, including the permitted tolerances for the properties, as well as specific reference(s) to characteristics that are modified by the production process and the information required to carry out survey on the manufacturing process

3.4
significant change
variation in performance beyond the permitted tolerance for the relevant parameters

3.5
glazing manufacturer
entity issuing and signing the declaration of conformity

3.6
product data sheet
document giving the properties of the final product, intended to be published to be used for engineering purposes

3.7
recognized organization
institution authorized by the Flag State of the vessel to do load line inspections for the Flag State , typically the Classification Societies

3.8
monolithic glazing
glazing material of which the panes consist of one single ply of one material only

EXAMPLE Single pane thermally toughened safety glass (TTG) and sheets of polycarbonate or polyacrylic material.

3.9
compound glazing material
glazing material of which the panes consist of stacks of plies of similar or different materials that are laminated or otherwise permanently connected to each other

EXAMPLE Laminated glass and laminates of glass plies with polycarbonate or polyacrylic material.

3.10
declaration of conformity
statement by the manufacturer declaring that the properties of the product are as given in the relevant product data sheet

3.11
marine grade TTG
thermally toughened safety glass as assumed in existing maritime standards, typically compliant with ISO 21005, which can be vertically processed, need not to be heat soaked, and accepted by batch testing

3.12
L1
virtual line drawn at a height of 2,5 % of the breadth of the yacht (B), or a height of 500 mm, whichever is greater, above the design waterline

3.13
L2
virtual line drawn at a height of h_{std} + 0,02×L above the design waterline, with 0,02×L not exceeding 3 m

Note 1 to entry: h_{std} (standard superstructure height) and L (load line length) are defined in ISO 11336-1.

3.14
L3
virtual line at a height of 2×h_{std} + 0,02×L above the design waterline, with 0,02×L not exceeding 3 m

Note 1 to entry: h_{std} (standard superstructure height) and L (load line length) are defined in ISO 11336-1.

4 Requirements for glazing material products

4.1 Product data sheet

4.1.1 General

For each glazing material a product data sheet shall be provided.

All glass elements shall meet the characteristics and properties declared in the product data sheet for that element.

The product data sheet is the central document on the basis of which conformity with this standard shall be examined.

The product data sheet gives a specification of the product properties that are relevant for the application on board.

The glazing manufacturer is responsible for the preparation and maintenance of the product data sheet.

The product data sheet can describe a single product or a family of products.

The product data sheet shall be public or available upon request.

The product data sheet shall contain at least the normative information given in 4.1.1 and, as applicable, in 4.1.2 to 4.1.4. The product data sheet may also contain other information.

4.1.2 Data to be provided for all glazing materials

For all products, the product data sheet shall contain the following.

1) How the product can be recognized and global characteristic properties: overall thickness, weight per square meter, characteristic visual features.
2) The specific information on material and build-up as described in 4.1.3 or 4.1.4 for monolithic and compound glazing respectively.
3) Characteristic mechanical properties of the product. See 4.2.1.
4) An indication of the failure mode and load bearing capabilities after failure. See 4.2.2.
5) Confirmation that the product does not contain materials not permitted for the application on board. See 4.3.
6) A description of the edge finishing method.
7) Category of durability. See 4.4.
8) Confirmation whether the product is suitable for application in way of control positions. See 4.5.
9) Information about any fire rating in accordance with the FTP Code the material complies with and any particular conditions pertaining to this approval.
10) Instructions or a reference to instructions for mounting the product.
11) Instructions or a reference to instructions for maintaining the product.
12) Instructions or a reference to instructions for inspection of the product.
13) Instructions or a reference to instructions for replacing/disposing the product.

4.1.3 Data to be provided for monolithic glazing materials and monolithic glazing components

For thermally toughened safety glass (TTG) compliant with EN 12150-1 or ISO 21005, the normative part of the product description shall contain a reference to EN 12150-1 or ISO 21005, whichever the manufacturer claims compliance with. In addition the toughening process (horizontal or vertical) shall be specified.

For polycarbonate compliant with ISO 11963, the normative part of the product description shall as a minimum contain a reference to ISO 11963.

For polymethyl methacrylate (PMMA) and other transparent materials of which the properties are not laid down in an ISO standard, the normative part of the product description shall be as for compound glazing materials.

4.1.4 Data to be provided for laminated safety glass and for compound glazing materials

The normative part of the product description shall as a minimum contain the following information.

— For laminates made only of glass and interlayer: a reference to ISO 12543 (all parts) and all other standards with which the manufacturer claims compliance.

— For laminates in which other materials than glass and interlayer material are applied: a reference to any standard with which the manufacturer claims compliance.

— Component parts:

  — glass types and thicknesses applied in the laminates:

    (i) for glazing components of chemically strengthened soda lime silicate glass (CSG) compliant with EN 12337-1, the normative part of the product description shall contain a reference to EN 12337-1,

    (ii) for glazing components of heat strengthened glass (HSG) compliant with EN 1863-1, the normative part of the product description shall contain a reference to EN 1863-1,

    (iii) for glazing components of annealed float (AG) compliant with EN 572-1, the normative part of the product description shall contain a reference to EN 572-1;

  — edge finishing type including e.g. sealing, protection;

  — plastics glazing sheet materials types and thicknesses;

  — interlayer types and thicknesses.

— The order of stacking of the components.

— Lamination process applied, e.g. foil, cast-in-place.

— Coatings if present and their position relative to an interlayer.

The interlayers may be listed either

a) in full, i.e. chemical composition and mechanical properties, or

b) by a manufacturer's code that refers to a material information sheet.

The definition of product families shall be consistent with the normative part of the product data sheet.

The substitution of materials and/or components shall maintain the conformity with the product data sheet.

When there are defined alternative materials for a certain component, these substitutes can be added to the product family and also the product data sheet when compliance has been demonstrated.

When a component is described by a manufacturer's code, the data of the component shall be available.

4.1.5 Insulated glazing units

The normative part of the description shall as a minimum contain the following information.

— Information as in 4.1.3 or 4.1.4 as applicable for the panes.

— Type/material of spacer.

— Permissible temperature range.

— Load bearing capacity of spacer and of connection between spacer and glass.

— Suitability and limitations for application in situations where the glazing is mounted with free edges.

4.2 Detailed description of the properties

Most properties in 4.1 are straight forward, but some require explanation or specification. This section describes how properties can be determined.

4.2.1 Mechanical properties

The property values shall reflect values as obtained from 4-point bending test according to ISO 1288-3, and to represent the load level at which there is 5 % probability of breakage.

The reference method to assess the results is using the Weibull distribution according to EN 12603. The values given should represent the stress level corresponding to the lower 95 % probability curve at 5 % fractile.

Alternatively this probability can be taken as the lower threshold of the 90 % confidence interval to the t-Student distribution. This is the simplified method.

The product data sheet shall specify whether the statistic analysis of the results is carried out via the standard Weibull method or the simplified t-Student method.

See Annex E for a further explanation of the reference method and the simplified method.

Where properties are derived from results of pressure tests, the results shall be corrected for diaphragm effects and statistically processed to derive the 5 % probability of breakage load level.

4.2.1.1 Mechanical properties to be specified

Mechanical properties of laminates with interlayers causing partial collaboration between plies cannot be expressed well in terms of stress and strain. For reasons of simple application, flexural strength and flexural stiffness are therefore given in terms of thickness of a pane of monolithic TTG giving the same properties:

— $t_{eq,\sigma}$, in mm, the thickness of a pane of marine grade TTG giving the same breaking strength as the product;

— $t_{eq,w}$, in mm, the thickness of a pane of marine grade TTG giving the same bending stiffness as the product.

For ease of reference and to support engineering, the actual bending properties shall be given also:

— M_f, in Nmm, the breaking moment per mm width;

— D, in Nmm^2, the bending stiffness per mm width.

4.2.1.2 Methods to derive mechanical properties of the product

1) For monolithic thermally toughened safety glass (TTG) in compliance with ISO 21005, in the absence of other data, the following nominal mechanical properties can be assumed for a panel with thickness t_{act} in mm:

$t_{eq,\sigma} = t_{act}$

$t_{eq,w} = t_{act}$

$M_f = 20 \times t_{eq,\sigma}^2$

$D = 5\,833 \times t_{eq,w}^3$

2) For monolithic material in general, material properties can be assumed as minimal values permitted by the referenced standard for the material (for example EN 12150 or ISO 11963).

   In the absence of other data, the following nominal mechanical properties can be assumed:

   $t_{eq,\sigma} = t_{act} \times (120/0{,}05 \text{ probability breaking strength of material})^{1/2}$

   $t_{eq,w} = t_{act} \times (70\,000/\text{Young's modulus of material})^{1/3}$

   $M_f = 20 \times t_{eq,\sigma}{}^2$

   $D = 5\,833 \times t_{eq,w}{}^3$

3) For laminated glazing using glass plies and interlayers of material complying with a relevant standard, computational methods as described in ISO 11336-1:2012, 5.6.3 or similar methods described in the other parts of ISO 11336 can be used.

   For application of ISO 11336-1:2012, 5.6.3, a shortest clear opening dimension a of 1 000 mm can be assumed for the calculation of the mechanical properties.

   $t_{eq,\sigma} = t_{eq,Pt1} \times (120/\text{ CFS})^{1/2}$

   $t_{eq,w} = t_{eq,w,Pt1}$

   with $t_{eq,Pt1}$ and $t_{eq,w,Pt1}$ representing t_{eq} and $t_{eq,w}$ calculated per ISO 11336-1:2012, 5.6.3.

   $M_f = 20 \times t_{eq,\sigma}{}^2$

   $D = 5\,833 \times t_{eq,w}{}^3$

   Depending on the lamination process applied, the characteristic failure strength (CFS) of chemically strengthened glass (CSG) can be changed significantly. Therefore, the strength of a laminate with CSG plies shall be verified by testing as specified in ISO 11336-1.

4) For any material or laminates that

   — feature structural plies of material other than glass, or

   — feature different types of interlayers, or

   — do not have otherwise documented mechanical properties,

   mechanical properties shall be derived from 4-point bending strength tests carried out in accordance with the method described in ISO 1288-3. Where the strength of the material is such that breakage cannot be achieved with standard bending test machines, the distance between the supporting rollers can be increased. The distance between the load rollers shall be kept constant.

   Values of M_f, D follow directly from the test results.

   $t_{eq,\sigma}$, $t_{eq,w}$ can be calculated as per Annex B.2.

   The result of the 4-point bending test is expected to show a linear relationship between the load on the rollers and the deflection, represented by a straight line in a load/displacement plot. When the behaviour becomes non-linear, that is the plotted line is no longer straight, failure in any part of the system shall be assumed. The failure point of the material shall be taken where the behaviour becomes non-linear, i.e. where the plotted line is no longer straight.

4.2.2 Post failure behaviour

It is considered that application of glass elements onboard is subject to requirements for safe failure being complied with. To enable designers to develop failure scenarios for the glass elements, information shall be provided about the nature of the failure mode and the residual strength of the material.

The actual performance of a glass element after failure strongly depends on the fracture pattern, the orientation, and the way of mounting of the glass pane. It is therefore not possible to give exact predictions for the behaviour of a specific glass element, but characteristic behaviour in common conditions can at least give basic input for development of failure scenarios.

Failure modes can be characterized related to behaviour after failure in typical application conditions:

— pressure test: vertical mounting; 4-sided simple support;

— 4-point bend test;

— impact test;

and can be categorized according to the following.

— Loss of shape (to indicate behaviour):

  — none: permanent deformation is less than 1,0 % of the size of the pane. ('Failure' caused by sample falling through supporting rollers in ISO 1288-3 test);

  — bent: pane takes on permanent set greater than 1,0 % of the size but large and by remains in one piece. Loss of weight is less than 5,0 % of unbroken pane;

  — broken: pane separates into pieces with edge length typically not smaller than 0,30 times the smaller dimension of the pane;

  — fractured: between broken and fragmented;

  — fragmented: pane disintegrates into particles with edges typically perpendicular to surface and edge length as in TTG fragmentation test in EN 12150-1;

  — shattered: pane disintegrates into particles smaller than in TTG fragmentation test in EN 12150-1.

— Loss of strength:

  — negligible: load bearing capacity is not less than 90 % of undamaged pane;

  — impaired: load bearing capacity is not less than 40 % of same for undamaged pane (typically 3 ply laminate with one broken layer);

  — severely impaired: load bearing capacity is not less than 22 % of same for undamaged pane (typically 2 ply laminate with one broken layer);

  — self-sustaining: pane can sustain its own weight with a margin of 50 % (meaning it would not easily collapse by itself and could be approached safely for adding support or controlled removal);

  — lost: pane is not self-sustaining and may collapse under its own weight and when not come down already must be considered an immediate threat for its surroundings.

— Loss of collaboration/delamination (for laminated construction):

  — none: the area where adhesion between glass and interlayer was lost is less than 1 % of the area of the panel;

  — impaired: adhesion lost over not more than 10 % of area of panel distributed along edge of panel or along edges of shards;

  — severely impaired: adhesion lost over between 10 % and 50 % of area of panel;

- complete: more than 50 % of area of panel delaminated.

— Loss of tightness:

  - intact watertightness: when broken pane does not lead to leakage;
  - minor: opening is less than 0,01 % of pane area (1 cm^2/m^2, practical implication: for deckhouse windows needs attention but can do without regular monitoring);
  - moderate: opening is less than 1 % of pane area (1 dm^2/m^2, as may be achieved with 'emergency blanking plates' needs no fix but needs attention);
  - substantial: opening is more than 1 % and less than 50 % of pane area (0,5 m^2/m^2, needs a fix and monitoring);
  - complete: opening is more than 50 % of pane area.

Where no information of failure modes is provided, the value 'NPD' (no performance defined) can be given.

NOTE A value 'NPD' generally leads to the least favourable option being assumed in failure scenarios. For example, loss of shape is assumed as 'shattered' for scenarios concerning breach of watertight integrity and as 'none' for scenarios related to pane falling from upper tier on muster station below.

4.3 Dangerous substances

Materials used in products shall not release any dangerous substances in excess of either:

— the maximum permitted levels specified in the referenced standard for the material;

— the values mentioned in the IMO MEPC.197(62), 2011, Annex 3, as amended.

4.4 Durability

The following durability categories are defined in terms of exposure in a type A climate zone according to ISO 877-1. These categories indicate the design lifetime of the product.

a) >25 years

b) 10–25 years

c) 5–10 years

d) specified period

Monolithic TTC and HSG can be considered category a).

Durability of compound glazing and monolithic non-glass products shall be determined in accordance with ISO 527-2. The category stated shall reflect the period over which it is expected that:

— strength and stiffness will be not less than 90 % of the strength and stiffness stated in the product data sheet,

— the failure modes (according to 4.2) of the compound, including the interlayer, will not change, and

— for glazing claimed suitable for fitting in a wheelhouse: deterioration of optical properties will not be such that the glass can no longer be considered as 'non-tinted and non-polarized'. (See 4.5).

4.5 Suitability for application on control positions

Only non-tinted and non-polarized clear glass with a transmission of at least 65 % (see ISO 3538) shall be used.

5 Evaluation of conformity

5.1 General

Conformity to this standard shall be as a result of initial examination and factory production control in accordance with 5.2 and 5.3.

5.2 Initial examination

The initial examination shall consist of the verification of the data in the product description.

Any testing done as part of the initial examination shall be done under supervision of a recognized organization or at a test laboratory meeting the requirements of ISO/IEC 17025.

In the initial examination, results of previous tests can be taken into account.

When actual testing is required, then the initial examination shall be undertaken on samples representative of the product taken from direct production or on prototypes produced with the same method of production.

Whenever a change occurs in the raw material or the production process which would or could change significantly one or more of the characteristics, the type tests shall be repeated for the appropriate characteristics (see Annex C for criteria).

5.3 Factory production control

The production shall be controlled and monitored in accordance with EN 14449 or equivalent.

6 Marking and/or labelling

6.1 General

Any voluntary marking and/or labelling shall not cause confusion with respect to the mandatory requirements.

6.2 Product marking

All glazing items are to be uniquely identified in a way to allow verification they are installed in the intended location. The marking can be such that it can be removed after installation in the final location and inspection of correct mounting.

This system shall be documented.

6.3 Product records

The manufacturer shall maintain a system in which each glazing item, by its identification or by location of mounting if identification is removable, can be traced back to the records of its production.

This system shall be documented. Data shall be kept available for the lifetime of the product (see 4.4).

7 Information to be provided to the vessel

The manufacturer shall provide with every project the information to be supplied to the vessel, or to the builder for delivery with the vessel, as given in Annex F.

The conditions of use of NPD will depend on the conditions of certification of the vessel and the application of the glass elements on board.

The information on board should be self-containing, unambiguous, and not contain info not relevant to the glazing installed on board.

8 Inspection during installation

All bonding to glazing shall be assigned one of the safety classes from Table 1.

The assigned safety class shall at least be as indicated in Table 4. A higher safety class may be assigned depending on the situation and the arrangement.

If a case would fall in more than one class, the highest safety class (that is the one with the lowest number) shall be assigned.

The assigned safety class of the bonding shall be listed in the documentation on board.

Design, execution and monitoring of the bonding shall be in accordance with DIN 2304 for the safety class assigned.

The bonding process shall be documented, monitored and recorded. Annex G gives an example of forms that can be used for the records.

Table 1 — Safety classes

Safety class	Level of safety requirement
S1	**High level** Failure of the bond — directly or indirectly leads to an inevitable hazard to life or limb; — results in a failure of the function, the effect of which most likely leads to an inevitable hazard to life or limbs.
S2	**Medium level** Failure of the bond — can lead to a hazard to life or limb; — results in a failure of the function, the effect of which probably involves personal injury or results in major environmental damage; — results in a failure of the function, the effect of which most likely involves major damage to property.
S3	**Low level** Failure of the bond — results in a failure of the function, the effect of which probably does not involve personal injury neither results in major environmental damage; — results in a failure of the function, the effect of which affects comfort or performance at the most; — results in a failure of the function, the effect of which probably does not involve major damage to property.

Table 1 *(continued)*

Safety class	Level of safety requirement
S4	**No safety requirement** Failure of the bond — results in a failure of the function, the effect of which does not, under foreseeable circumstances, involve personal injury neither results in environmental damage; — results in a failure of the function, the effect of which only affects comfort or performance; — results in a failure of the function, the effect of which does not involve major damage to property.

Table 2 — Positions in vessel regarding water/weathertightness

Position	The glazing is relevant for the water/weathertightness of the yacht and the lowest point of the glazing is:
P1	Located in a position below L1.
P2s	For side or aft facing positions aft of the forward 0,25×L: Located in a position at or above L1 but below 150 mm above the deck closing the buoyant volume.
P2f	For length positions other than P2s: Located in a position at or above L1 but below the higher of: L2 or 600 mm above the deck closing the buoyant volume. (Forecastle deck)
P3s	For side or aft facing positions aft of the forward 0,25×L: Located in a position at or above 150 mm above the deck closing the buoyant volume but below L2.
P3f	For length positions other than P3s: Located in a position less than h_{std} above the upper position where P2f would be required.
P4	Any position above P3s or P3f but below L3.
P5	Any position above L3.
P6	Glazing not closing openings to outside but relevant for safety of people or environment. (Railings, glass balconies).
P7	Any other glass part or component.

See also D.7 for more information.

Table 3 — Design levels

Design class	Design level
D1	Without a risk analysis.
D2	Without additional protection in case of partially or complete failure of the bond.
D3	With additional protection against loss/loss of components but without additional protection against water ingress in case of partially or complete failure of the bond.
D4	Without additional protection against loss/loss of components but with additional protection against water ingress in case of partially or complete failure of the bond.
D5	With additional protection against loss/loss of components and with additional protection against water ingress in case of partially or complete failure of the bond.

Table 4 — Required design level

	P1	P2a P2f	P3a P3f	P4	P5	P6	P7
D1	S1	S1	S1	S1	S1	S1	S1
D2	S1	S1	S1	S1	S1	S1	S1
D3	S2[a]	S2[a]	S2[a]	S2[a]	S2[a]	S2[a]	S2[a,b]
D4	S2[a]	S2[a]	S2[a]	S2[a]	S2[a]	S2[c]	S3[a,c]
D5	S3[a]	S3[a]	S3[a]	S3[a]	S3[a]	S3[a]	S3[a,c]

[a] Proof of sustainability of additional protection necessary.

[b] Attachment parts which not close openings: additional protection needs to prevent that persons get hurt through loosened components.

[c] All glazing and components which not close outwards openings — but are not additionally protected — can lead in case of failure of the bond to an inevitable hazard through fall down or loosed parts.

9 Lifetime inspections

9.1 General

To ensure the safety of the yacht and its passengers all windows in classes S1 and S2 shall be subjected to inspections as indicated below.

9.2 Inspections

a) The glass, black border and sealant should be routinely checked when washing the yacht. Any special observations are to be documented.

b) A bi-monthly visual inspection should be carried out and documented by experienced crew in a logbook (e.g. the engineers log). See 9.6.

Inspection by external qualified people should be carried out:

c) within one year after delivery (or sooner as agreed with the manufacturer),

d) every five years to the same schedule as the classification societies survey schedule.

Handling of defects shall take account of the safety classes as defined in Tables 1 to 4.

9.3 Inspection of glazing

9.3.1 General

The inspection shall make a difference between the structural plies and the protective plies of glazing, as identified in the information on board the vessel (See Annex F).

Inspection shall focus on the structural plies.

Protective plies shall be inspected only for being present and being in a state fit to provide the protection they are meant to provide.

9.3.2 Inspection of glazing containing TTG

For TTG glazing material, both laminated and monolithic, inspection shall identify:

— presence of significant surface scratches (e.g. palpable), delamination;

— damage to exposed edges in the structural plies (see Annex D.4).

Glazing elements with such scratches and damages in the structural plies shall be replaced.

9.3.3 Inspection of glazing containing CSG

For CSG glazing material inspection shall identify in the structural plies (see Annex D.5):

— presence of surface wear or scratches;

— presence of signs of surface wear or scratches being removed by polishing;

— edge damage;

— cracks in the glazing.

Glazing shall in general be replaced if any of such defects is found.

9.3.4 Inspection of laminated glazing and glazing with materials other than glass

For laminated glazing and for glazing made from materials other than glass or laminated glass the inspection shall identify:

— for TTG and CSG elements the defects mentioned under 9.3.2 and 9.3.3;

— visual signs of delamination of the interlayer from the glass;

— visual signs of deterioration of the interlayer;

— for glazing around the control position any coloration of the interlayer beyond the use limit (see also 4.5 above);

— age of the glazing relative to the durability.

Visual deterioration of the interlayer or plies not being glass does not necessarily lead to loss of structural strength of the glazing. Further investigation may be required before making a decision about replacement.

9.4 Inspection of bonding

The actual bonding area is protected and is not normally open for visual inspection. The condition of the actual bonding therefore shall be determined from durability data of the materials used in the bonding and absence of signs of malfunctioning or deterioration of the protective sealant.

Further investigation is required when the materials have reached their lifetime limit or when signs of deterioration or malfunctioning are found.

Replacement of sealing and/or bonding shall be carried out as necessary based on the findings in the further investigation.

A documented scheme of continuous inspection by the crew, with records of inspections and results, shall be maintained.

Such system shall be agreed beforehand by all parties involved in survey and inspection of the glazing system on board.

9.5 Durability of materials

Unless other information exists, the durability of the adhesive and glazing can be assumed as specified by the manufacturer.

When the time since fitting reaches the durability period, a further investigation as per 9.7 shall be carried out, and a new durability period for the aged system shall be established based on the findings. The durability for the aged system shall not exceed $1/5^{th}$ of the durability for the new system.

9.6 Routine inspections

Regular routine inspections by the crew, as part of the customary washing/cleaning on board a yacht are at the heart of the condition monitoring. The typical cycle is once every month, but this can be varied depending on the situation and use of the vessel.

The results of the inspections shall be recorded in a logbook of some form. The logbook shall be available to the class or statutory surveyors during survey.

Entries in the logbook shall be made after every routine inspection, also if no deterioration or malfunctioning was observed, and immediately if deterioration or malfunctioning is observed outside the regular routine inspections.

Entries in the logbook concerning observations made shall include information about which glazing panels are concerned and the nature and position of the observed deterioration/malfunction on the window. Entries shall provide information about date and identity of the person who made the observation, and the actions taken as a consequence of the observation.

Annex H gives an example of an inspection report.

9.6.1 Signs of deterioration

Deterioration means the protection of the adhesive bonding may be impaired while the adhesive bonding itself may be intact.

Signs of deterioration can be any or a combination of the following.

— Scratching, chipping or abrasion of the glass surface.

— Delamination of laminated glass.

— Colour changes in the interlayer of laminated glass.

— Separation of sealant from glass or supporting structure.

— Cracks or flaking in the sealant surface; hardening or embrittlement of the sealant.

— Colour change of sealant (depending on type).

— Signs of corrosion or delamination of the supporting structure or any coating.

Observation of deterioration normally shall be followed up by further investigation.

9.6.2 Signs of malfunctioning

Malfunctioning means the bonding does no longer fully perform its functions: holding the glazing in place and close the necessary opening between glazing and structure.

Signs of malfunctioning can be any or a combination of the following:

— leakage or signs of leakage of the window;

— atypical movement or looseness of the window;

— broken glass;

— gross delamination of laminated glass, to an extent that the load bearing capacity would be significantly affected.

Observation of malfunctioning typically means the bonding shall be taken out and replaced.

9.7 Further investigation

In case deterioration is observed, a further investigation shall be made to ensure that the protection of the bonding is not impaired and the bonding is still intact.

Such investigation could be made using the following methods, depending on the nature of the observation.

— Non-destructive examination of the glass surface using photoelastic methods.

— Stub-test of coating/fairing of supporting structure.

— Ultrasonic testing of the bonding.

— Hose-testing.

— Acoustic leak measurement of the bonding.

— Taking out the sealant to examine the adhesive directly by ultrasound or acoustic leak.

If the further investigation leaves any doubt about the integrity of the bonding, the deterioration shall be considered as a malfunctioning.

Further investigation on bonding shall be carried out by a specialist with European Adhesive Specialist (EAS), or equivalent, as a minimum.

Further investigation on glazing shall be carried out by a person qualified for the job.

All glass panes in similar operation positions, built-in with the same bonding material and at the same time, shall also be examined, visually, and a further investigation shall be made on them based on observations.

9.8 Replacement or renewal of bonding and sealing.

Replacement shall be made with materials equal to or equivalent to the original materials and be subject to inspection as described in Clause 8.

If the bonded glass is chemically strengthened it may not be possible to take out the glass and remove the existing sealant and adhesive without damage to the surface or the edges and glazing may need to be replaced with new.

Annex A
(normative)

Tests for ensuring conformity

A.1 Testing other than in EN 14449

The tests covered by EN 14449 are a means of ensuring on-going compliance of the factory production control. However, none of the tests check the mechanical performance of the laminated safety glass.

Therefore a minimum of 3 test specimens should be subjected to a 4-point bend test for determining overall strength and bending stiffness, see B.2.

The frequency of testing shall depend on the production volume.

— For continuous production tests shall be carried out every week.

— For batch production test shall be carried out before restarting production and then weekly as long as the batch production lasts.

— If the batch consists of pieces applied in a low level or no safety class (S3 or S4 in Table 1), performance can be considered achieved by adherence to procedures described in the product description.

Tests are aimed to ensure the load bearing capacity meets the specification. There is no need to test until breakage.

In individual tests, deviations of up to 10 % in deflection from the values in the product description are permissible, but the average shall be consistent with the description.

Date, scope and results of all tests shall be recorded and be held available for inspection.

NOTE Annex B lists a number of test methods that a manufacturer could employ to demonstrate on-going mechanical performance.

Annex B
(informative)

Laminated safety glass: Mechanical resistance tests

B.1 General

The tests for ensuring conformity given in EN 14449 do not always act as a good indicator of the future mechanical behaviour, i.e. safety in use performance resistance.

The tests in EN 14449 give an insight into the effectiveness of the laminating process. However, the mechanical behaviour of the assembly is as a result of the inherent properties of the interlayer, sometimes referred to as tenacity, and the adhesion of the interlayer to the other components of the assembly.

A number of mechanical tests have been used to check that the laminated safety glass offers the expected performance.

B.2 4-point bending strength test to determine the characteristic failure strength of glazing materials

ISO 11336-1:2012, 5.6.3.3, permits to determine the flexural properties and equivalent thickness of the cross section by 4-point bending tests.

ISO 11336-1:2012, 7.2.1, gives the method to determine the characteristic failure strength.

The following procedure can be used to determine the equivalent thickness of monolithic TSG (thermally strengthened glass) according to EN 12150.

1) The method of the 4-point bending test is described in ISO 1288-3. Even though that standard applies only to monolithic glass, the 4-point bending method is a general one and can be considered applicable for all glazing products where the main structural section is made of glass plies combined with every interlayer irrespective of the type. Glazing of polycarbonate or acrylic type is not covered by this procedure.

2) The aim is to establish the bending strength and stiffness, expressed in an equivalent thickness of monolithic thermally toughened safety glass (TTG) with Characteristic Failure Strength (CFS) of 120 MPa. The process is based on proving that a beam of the investigated laminate has strength properties equivalent to a beam made of TTG with the Rule thickness and exhibits stiffness comparable with, at least, a 4-plies laminate without collaboration.

3) Qualification of glass:

   The batch shall contain not less than 10 samples.

   Each of the samples is tested in accordance with ISO 1288-3 up to breakage.

   When non symmetrical laminates are used, the glass shall be loaded in the same direction as the window placed on board (so side that will face the outside on the ship shall be placed on top in the test).

   During the test, force and deflection shall be measured. If the measured deflection is not the central deflection but, for example, the deflection at loading rolls position, this deflection value shall be corrected in order to provide the central deflection value.

To help with breakage evaluation, a flexible adhesive foil of thickness less than 0,1 mm is allowed on both sides of the tested sample provided that the two foils on the two sides are not connected together.

For each sample the following shall be recorded:

F_i: force at which the first of the plies fails, in Newton.

d_i: deflection at the moment of breakage, in mm.

The deflection response r_i (in mm/N) of each sample is then calculated as: $r_i = d_i[\text{mm}]/F_i[\text{N}]$.

The statistical breaking strength F_{STAT} is calculated as the lower threshold of the 90 % reliability interval as determined in the t-Student test.

The statistical flexural response r_{STAT} is calculated as the upper threshold of the 90 % reliability interval as determined in the t-Student test.

The equivalent thickness of monolithic TSG with regard to strength can then be calculated as: $t_{\lim F} = \sqrt{(F_{STAT}/40)}$.

The equivalent thickness of monolithic TSG with regard to stiffness can then be calculated as: $t_{\lim d} = 3\sqrt{(18{,}7/r_{STAT})}$.

Condition is to ≤ min $[t_{\lim F}; t_{\lim d}]$.

B.3 Factory acceptance test without breakage

B.3.1 General

The factory acceptance test without bringing the glass to breakage consists of tests on representative laminates 4 mm + 4 mm, 6 mm + 6 mm and 8 mm +8 mm. The aim is to show that both strengthening and lamination are above the minimum acceptable level consistent with the product description.

B.3.2 Test for complete laminate

The test consists of 4-point bending (1 000 mm support and 200 mm load distances) with samples 360 mm × 1 100 mm. The factory acceptance test can be extended also to annealed glass in case only lamination quality is concerned.

When quality requirements are for both strengthening and lamination this can be proved by applying a defined load for at least one minute of duration (60 s).

Test load shall be such that the load is 90 % of the flexural strength of the laminate according to the product description. Deflection shall not be more than 110 % of what would be under that load consistent with the flexural stiffness according the product description.

The representative laminate shall be produced in the same production as used for the product.

B.3.3 Alternative method to test interlayer only

When quality requirement is limited only to lamination this can alternatively be demonstrated by a similar 4-point test arrangement and laminates of float glass. To avoid failure of the test piece through breakage of the glass the bending moment can be reduced by locating the supports closer to the loading rollers. The length shall be chosen such that the bending stress in the glass plies does not exceed 20 MPa.

The length of the test pieces shall be such that they extend 50 mm over the loading rollers on both sides.

Load duration shall be 60 s. Under these conditions no glass breakages are allowed and deflection shall not exceed 110 % of the value consistent with the properties in the product description.

The representative laminate shall be produced in the same production batch. The samples shall be stored for at least 24 h at 25 °C ± 5 °C and tested in the same range of temperature.

B.3.4 Test rig setup

Because this is supposed to be a factory test it can be performed quite easily even without a dynamometer. One just needs to have a steel supporting structure with two rolls at a distance of 1 m (adjustable to less for the shear-only test) and a loading platform made of a steel plate with two rolls separated by 200 mm. One of the rolls may be fixed to prevent the load rolling on the test piece.

B.3.5 Typical execution of test

— Position the supporting rollers at the distance needed for the test.

— Place the glass specimen over the supporting rollers with some rubber strip as interface.

— Take a reference for measuring central deflection.

— Verify correct position of specimen on the supporting rollers, centred, aligned symmetrically.

— Position the loading platform over the glass specimen at the loading rolls again with rubber strip interface.

— Adjust the weight over the loading platform (taking into account the self weight of the loading platform) to match the requested force values (remember 1 kg = 9,81 N).

— Check deflection to make sure it stays within the requested limit.

— Leave the full load for 1 min.

— Record sample identification, loading, support and results: central deflection, breakage, signs of delamination.

B.4 Other test methods

B.4.1 General

There is not yet a fully defined test method for determining the tenacity of the interlayer or the adhesion of the interlayer.

The following are references to articles on this subject:

B.4.2 Compressive shear test

See References [6] and [7].

Compressive shear adhesion is a measure of the bond strength between the interlayer and the glass. The laminate bond strength shall be controlled to avoid problems of delamination at low adhesion and impact failure at high adhesion.

B.4.3 Pummel test

Pummel adhesion is a measure of the bond strength between the interlayer and the glass. The laminate bond strength shall be controlled to avoid problems of delamination at low adhesion and impact failure at high adhesion.

The test can be performed on samples of laminated glass sized 80 mm × 300 mm.

Prior to the test the samples shall be aged for 24 h at –18 °C to –12 °C and removed from there not earlier than immediately prior to testing.

The test pummel shall be a hammer with a round head, mass 500 grams, providing blows at precise location with an energy of approximately 1,0 J each. (corresponding drop height 0,2 m).

This may not be sufficient for thick glazing. For thick glazing the energy may need to be increased as necessary to ensure the glass is broken without damaging the interlayer.

The supporting surface shall be a firmly mounted metal surface inclined 45 degrees from the horizontal. A rest bar shall be provided to ensure the test piece is inclined at about 5 degrees to the surface, so 50 degrees from the horizontal.

The test piece is held with the short side horizontal and pummeling shall start from a corner, then repeated blows progressing along the short edge so that there is about 75 % overlap between the impacted areas, or closer pitch when required to attain a constant result. When the whole length of the short edge is impacted, the next sweep is made at greater distance from the short edge, progressing in opposite direction, and so forth until the glass over a distance of 60 mm from the short edge is shattered and possibly segregated from the interlayer.

Next, the specimen is lightly tapped to remove all loose fragments and in the fraction of area of exposed film surface is examined visually and the result is graded on a scale of –1 to 10, see Table C.1.

Table B.1 — Pummel scale definition

Amount of exposed film surface in %	Pummel value
Separation of large-area sections of glass	–1
100	0
99	1
97	2
92	3
83	4
67	5
43	6
20	7
8	8
1	9
0	10

Test outcome:

For material qualification in the Initial type tests, the pummel value shall not be less than 8.

For fabrication control tests the pummel value shall be within the margins specified in the product description.

See References [8] and [9].

B.4.4 Tenacity and adhesion test for determination of link between product and impact performance, i.e. EN 356, EN 12600

See Reference [10].

The performance of a laminated glass under impact, i.e. EN 356, EN 12600, is influenced by the adhesion and tenacity of the interlayer. The adhesion is how well the interlayer sticks to the glazing material. This is related to the inherent properties of the folio interlayer and the processing parameters. Tenacity is the capability of the material to keep performing its function under adverse conditions. It is a basic characteristic of the folio interlayer. This method allows a manufacturer to determine the appropriate parameters that will ensure the product performance is maintained.

Annex C
(informative)

Criteria for deciding if a change within an assembly requires a new initial type test

C.1 General

Subclause 5.2 discusses the requirement for initial type testing the characteristics of laminated safety glass. The general rules for initial type testing and renewal are given in EN 14449.

However, there are circumstances when due to changes in the material design, e.g. change of components, changes in thickness, alteration of the stacking order, etc., that the 'new' design is outside the product description/product families and requires being a new initial type test.

Annex D
(informative)

Background notes on certain clauses in this document

D.1 Subclause 4.1.3: Horizontal or vertical process for TTG

There is good evidence the TTG produced by the horizontal toughening process used on modern ovens has a more reliable quality than the TTG produced in the traditional vertical process that was the basis of existing standards for marine glazing.

Where at present ISO 11336-1 does not make a distinction, it is expected that, following the building codes, in the future the permissible design stress for TTG can be taken dependent on the toughening process.

D.2 Subclause 4.1.4: Use of annealed glass (AG)

Where the material is not used as glazing by itself, AG is listed because certain coatings used in yacht glazing can be applied on annealed glass only, in which case the material is used in a non-structural ply or core ply in a laminate. With the material being part of the laminate, it must be mentioned in this document.

D.3 Terms 3.3 and 3.6: Product description versus product data sheet

For some properties of the final product it may be impossible or impractical to determine them on the final product. Compliance is then ensured by ensuring properties of components of the product or of the part completed product.

The product description explains how these part ensures build up to the final product and how this process can be monitored. This document is for use between the manufacturer and any supervising body.

The product data sheet describes the properties of the final product as relevant for the end user.

There is not necessary a one-to-one relationship between product description and product data sheet. There can be multiple product descriptions (alternative manufacturing processes) for a product, and there can be multiple product data sheets (brands) for products derived according to a single product description.

D.4 Subclause 9.3.2: Risks associated with edge damage in TTG glazing

Edges of TTG are not strengthened and edge damage outside the strengthened areas may therefore not lead to immediate fragmentation but micro-fractures from the damaged area may easily lead to fragmentation setting off.

D.5 Subclause 9.3.3: Risks associated with surface or edge damage in CSG glazing

The strengthening of CSG material extends only very thin layer of material below the surface. Removal of cracks by polishing will remove the strengthening and leave the glass surface in annealed glass state.

D.6 Terms 3.12 to 3.14: Lines L1 to L3 describing levels above the design waterline

The formulations for L1, L2 and L3 were adopted from the REG Yacht Code[20].

D.7 Clause 8: Table 2, positions on board

Positions P1 to P5 reflect the various positions in ICLL[21] and REG Yacht Code[20]. The descriptions below would have made the tables in Clause 8 cumbersome to use.

	Description	Rationale
P1	Located in a position below L1.	Located in the shell in a position below L1. The location of the bond can be immersed permanently or for a long time. ICLL would not permit 'portlights' in that location. Related regulations (stability, damage stability) are based on ship's hull construction (welded, laminated), in those locations.
P2s	For side or aft facing positions aft of the forward 0,25×L: Located in a position at or above L1 but below 150 mm above the deck closing the buoyant volume.	This reflects the area where direct and repeated water loading can be expected and where failure of the bond/loss of the component could lead to very serious ingress of water into the hull. It reflects the areas where ISO 11336-1:2012, 3.22 and 6.4, sets limits to the area of glazed openings and on materials for the framing. The 150 mm height addition reflects the sill height and ensures glass parts of the deck are included. It is also considered that glazing extending to less than 150 above the deck is more vulnerable to damage by objects on the deck and therefore a higher reliability of the post-failure mechanisms of the glazing is required.
P2f	For length positions other than P2s: Located in a position at or above L1 but below the higher of: L2 or 600 mm above the deck closing the buoyant volume, whichever is higher. (Forecastle deck)	
P3s	For side or aft facing positions aft of the forward 0,25×L: Located in a position at or above 150 mm above the deck closing the buoyant volume but below L2.	This reflects the area where spray but also incidental direct water loading can be expected and where failure of the bond/loss of the component *could* lead to serious ingress of water. It reflects the areas where ISO 11336-1 calls for (enhanced scantlings in lieu of) storm shutters.
P3f	For positions other than P3s: Located in a position less than h_{std} above the upper position where P2F would be required.	
P4	Any position above P3s or P3f but below L3.	'Catch' category to avoid panes in some configurations falling between categories. Criteria typically the same as for P5.
P5	Any position above L3.	Area where glazing is considered to be effective only to keep rain/spray out of the superstructure.
P6	Glazing not closing openings to outside but relevant for safety of people or environment. (Railings, glass balconies, glazing forming fall protection).	Failure of the bond may lead to risk of falling overboard or on a deck/construction more than 1,0 m below the surface people stand on.
P7	Any other glass part or component.	Inherent hazard of injury by the component if not fixed in place.