

CERTIFICATION & COMPLIANCE GUIDELINES FOR MARINE POOL GLAZING

A Technical Framework for Classification, Structural Engineering, and Factory Pre-Assembly

Classification Authority & Cross-Licensing Strategy: DNV possesses extensive, proven experience with Hydrosight's underwater acrylic glazing designs and pre-assembled stainless steel frame technology. This established track record makes DNV an ideal baseline classification society for **cross-licensing and mutual recognition** with other leading societies, such as **Lloyd's Register (LR)**, Bureau Veritas (BV), or the American Bureau of Shipping (ABS).

1. Regulatory Framework & International Class Rules

Underwater acrylic pool glazing installed on passenger vessels and superyachts is classified as a safety-critical structural component of the vessel. Certification requires compliance with stringent international classification rules and maritime pressure vessel standards:

- **DNV Class Rules:** *DNV-RU-SHIP Pt. 2 Ch. 3 Sec. 5* (Non-metallic materials – Acrylic Plastic) and *DNV-RU-UWT Pt. 2 Ch. 5 & Ch. 6* (Underwater Technology).
- **Pressure Vessel & Material Standards:** *ASME PVHO-1* (Safety Standard for Pressure Vessels for Human Occupancy) and *DIN EN ISO 7823-1* for cast PMMA blocks.
- **Cross-Classification Acceptance:** Because DNV's technical rules for underwater acrylics align with international PVHO standards, design approvals and material test reports issued under DNV oversight are readily accepted by Lloyd's Register (LR) and other IACS members under standard cross-recognition procedures.

2. Raw Material Qualification & Supply Chain Compliance

To ensure optical perfection and prevent catastrophic brittle failure under hydrostatic load, the acrylic raw material must fulfill rigorous metallurgical and chemical criteria:

- **Monolithic Cast PMMA (100% Virgin MMA):** Only cell-cast Polymethyl Methacrylate produced strictly from 100% virgin methyl methacrylate monomer is permitted. Laminated sheets or recycled acrylics are strictly prohibited due to delamination and yellowing risks.
- **Approval of Manufacturer (AOM):** Raw acrylic blocks are sourced exclusively from cell-cast manufacturers holding a valid DNV Approval of Manufacturer certificate.
- **Material Declaration (EN 10204 3.1):** Each production batch is delivered with an inspection certificate verifying tensile strength (≥ 62 MPa required, typically $> 70\text{--}82$ MPa), elastic modulus ($\geq 3,000$ MPa), residual monomer content ($\leq 1.6\%$), and light transmission ($\geq 92\%$).

3. Structural Engineering & Finite Element Analysis (FEA)

Because acrylic glass exhibits viscoelastic material behavior (susceptible to time-dependent creep under sustained stress), structural verification requires advanced numerical modeling:

- **Multi-Load Case FEA Simulations:** Finite Element Analysis evaluates static hydrostatic pressure, dynamic water sloshing, wind pressure on exposed balustrades, deck railing loads, and global ship hull deflections (*Hull Deflection*).
- **Long-Term Stress Thresholds:** To prevent micro-crazing and long-term creep deformation, long-term bending stress under continuous water pressure is restricted to ≤ 3.0 MPa.

- **Safety Factors:** Structural dimensioning incorporates a conservative safety factor of **SF = 4** against short-term material yield and fracture.

4. Workshop Processing, Annealing & Hydrostatic Testing

The transformation of raw acrylic blocks into finished marine window modules follows controlled manufacturing protocols:

- **Thermal Stress-Relief Annealing:** Following precision machining, edge chamfering, or chemical bonding (polymerization seams), all acrylic panels undergo oven annealing to completely eliminate internal residual stresses.
- **100% Factory Pressure & Tightness Test:** Prior to dispatch, each window module undergoes a documented hydrostatic pressure test at Hydrosight's testing facility in the presence of a class surveyor.
- **Stamping & Traceability:** Certified panels are permanently engraved with the manufacturer's mark, serial number, design pressure, test temperature, and official classification stamp.

5. Marine-Grade Stainless Steel Load-Bearing Frame

The load-bearing frame forms the structural bridge between the vessel's steel hull and the acrylic panel, providing essential stiffness while isolating the glass from ship motion:

- **High-Grade Material (1.4571 / AISI 316Ti):** Fabricated from titanium-stabilized austenitic stainless steel, engineered for superior resistance against pitting and crevice corrosion in marine spray and chlorinated pool environments.
- **Welding & Non-Destructive Testing (NDT):** All structural welds are executed under inert gas shielding by certified welders in accordance with qualified Welding Procedure Specifications (WPS/ WPQR). Structural load-bearing welds undergo 100% Non-Destructive Testing (NDT / PT / MT per ISO 23277 / ISO 23278).
- **Passivation & Hull Integration:** The entire frame assembly is acid-pickled and passivated. Side mullions provide seamless structural integration into the vessel's deck or windscreen assembly.

6. Engineered Sealing, Primer & Elastomer Bearing System

To accommodate differential thermal expansion between PMMA ($CTE \approx 70 \times 10^{-6}/K$) and stainless steel ($CTE \approx 16 \times 10^{-6}/K$), a highly resilient sealing architecture is implemented:

- **Elastomer Bearing Bed:** The acrylic panel is embedded in a high-density polyurethane elastomer bed (Shore 90A) to ensure point-load-free hydrostatic force transmission and prevent direct steel-to-glass contact.
- **Structural 2K Marine Silicone:** Primary weather and water sealing is executed using high-modulus two-component structural silicone approved under ETAG 002 guidelines, providing $\pm 12.5\%$ movement accommodation.
- **Hydrothermal Primer Validation:** To guarantee long-term underwater adhesion under elevated temperatures (up to $45^{\circ}C$) and chlorine exposure, the silane-based primer system undergoes a 12-week ETAG 002 accelerated immersion test at $55^{\circ}C$ with daily dynamic fatigue cycles. Certification requires **100% cohesive failure** within the silicone matrix during destructive tensile testing.

7. Factory Pre-Assembly vs. In-Situ Shipyard Installation

Hydrosight delivers complete, factory-preassembled glazing modules rather than performing loose-panel installation at the shipyard:

Parameter	In-Situ Shipyard Assembly	Hydrosight Factory Pre-Assembly
Environmental Control	Uncontrolled dust, grinding sparks, humidity	Cleanroom-like temperature & humidity control
Primary Seal Quality	Risk of contamination & adhesion loss	100% void-free silicone bond with certified primer
Testing & Verification	Difficult on-site pressure testing	100% factory pressure & tightness certified
Shipyard Integration	High risk, weather-dependent, long labor	Turnkey 'Plug-and-Play' weld-in installation
Total Cost of Ownership	Higher risk of rework, delays & claims	Minimized shipyard lie-time & zero rework risk

8. Company Contact Details & Corporate Information

For technical inquiries, structural calculations, or classification support regarding marine pool glazing projects, please contact our engineering headquarters:

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