

SAMPLE PARTICULAR SPECIFICATION
FOR
NOISE BARRIERS WITH TRANSPARENT PANELS

SECTION 27 – NOISE BARRIER SYSTEM

GENERAL

General requirements

27.01

(1) The Noise Barrier Works shall comprise main structural steel frame (main frame), steel sub-frame(sub-frame), noise barrier panels, acoustical gasket profiles, clamping bars, acoustic sealing, fasteners, enclosure plates and sealant, base plates, holding down bolts, and any other accessories necessary for the completion of the entire noise barrier as shown on the Drawings and herein specified.

(2) The design of the noise barrier foundation, the main structural steel frames and the schematic arrangement of the sub-framing has been provided by the Employer. Locations and details of which are shown on the Drawings.

(3) Typical fixing details of the noise barrier shown on the Drawings are indicative only. The Contractor shall appoint a Noise Barrier Works Sub-contractor (NBWSC) who shall design the sub-frames, the noise barrier panels and all the fixing details including the associated fittings, joints and flashing details. The NBWSC's design shall be submitted by the Contractor for the approval by the Engineer.

(4) The transparent panels for noise barriers on highways shall be supplied by a supplier on the List of Approved Suppliers of Materials and Specialist Contractors for Public Works in the "Transparent Panels for Noise Barriers on Highways" category. Structural steelwork shall be fabricated and installed by a contractor on the List of Approved Suppliers of Materials and Specialist Contractors for Public Works in the "Structural Steelwork" category.

(5) The transparent panels shall possess minimum five years of application history in weather conditions similar to Hong Kong climate, and the supplier shall produce documentary evidence for satisfactory completion of at least 1 project for noise barriers on highways or similar works involving the use of the proposed panels in Hong Kong in the past 3 years, each with a value of \$0.8M or more worth of noise barriers with transparent panels. The manufacturer of the transparent panels shall be awarded certification of relevant requirements in ISO 9001.

(6) To ensure the integrity and continuous warranty of the soundness of the noise barrier, the Engineer may approve the NBWSC to appoint a designer to design the sub-frame and/or his specialist workforce to fabricate and install the structural steel frames and noise barrier panels. The NBWSC shall review the main structural frame design to ensure its adequacy if necessary.

(7) Alternatively, the Contractor may himself appoint a designer to carry out the review of the design of the main frame, design the sub-frame and employ his specialist workforce to fabricate and install the noise barrier. If this is the case, the NBWSC shall appoint his own supervising team to supervise the Contractor's work.

(8) All detailed designs, drawings and calculations carried out/prepared by the Contractor or the NBWSC or the appointed designer in connection with the Noise Barrier Works shall be subject to checking by an Independent Checking Engineer. The Independent Checking Engineer means the person, firm or company employed by the Contractor, having a corporate membership of Hong Kong Institution of Engineers or equivalent, and responsible for the independent checking of the Contractor's work, whose qualifications, skill and experience are deemed satisfactory by the Employer and who shall be independent of the Designer and the Contractor.

MATERIALS

Alternative materials	27.02	The materials used for noise barrier panels shall be as shown on the Drawings. Alternatives which are in full compliance with the requirements of the specified material may also be considered. Complete details of the proposed alternative material shall be furnished to the Engineer for approval.
Transparent noise barrier panels	27.03	<p>(1) Transparent noise barrier panels and their associated fixing details shall be designed by the Contractor's Designer or the NBWSC to the requirements as stated in Clause 27.13.</p> <p>(2) The panels shall bear the manufacturer's brush mark.</p> <p>(3) The panels shall be supplied with dimensions to suit the framing arrangement as specified on the Drawings. Unless specially agreed by the Engineer, alternative panel sizes requiring changes in the framing or sub-framing arrangement shall not be allowed.</p> <p>(4) The panels shall have a weighted sound reduction index of at least 25dB which shall be tested in accordance with EN 1793 or JIS 1416.</p> <p>(5) The panels shall be ultra-violet light resistant.</p>
Warranty	27.04	As part of the guarantee of the Contractor on the performance of the Noise Barrier Works described in SCC Clause Y, transparent noise barrier panels shall also carry a warranty on the properties specified in Cl. 27.05(2) for PMMA panels / Cl.27.06(2) for polycarbonate panels/ Cl. 27.07(2) for glass panels of the Specification. The warranty shall be provided to the Employer in the manner as stipulated in SCC Y(6).
PMMA panels	27.05	<p>(1) (a) Polymethyl Methacrylate (PMMA) transparent noise barrier panels shall be either extruded or cast fully satisfying the EN 1793 noise barrier standard and the requirements of this Specification.</p> <p>(b) The PMMA transparent noise barrier panels shall possess</p>

the following properties :

- i. light transmittance of at least 90% for clear panel.
 ___% for coloured panel.
 ___% for translucent panel.
- ii. tensile strength of at least 65 N/mm².
- iii. modulus of elasticity of at least 2900 N/mm².
- iv. fire retardant property complying with the requirements in EN 1794-3 Class 2.
- v. stone impact resistance complying with the requirements in EN 1794-1 Annex C.
- vi. impact strength as Class A complying with BS 6206.
- vii. no emission of noxious fumes or leachates as a result of fire.

(2) The NBWSC shall guarantee the panel properties at the end of the 10 -year period, which shall include but not limited to the following :

- (a) light transmittance loss not exceeding 5% from the original value.
- (b) tensile strength of at least 50 N/mm².
- (c) modulus of elasticity of at least 2600 N/mm².
- (d) colour difference shall be less than 20 units of ΔE_{ab} to BS EN ISO 11664-4.
- (e) no mottling.
- (f) no loss in acoustic property, fire retardant property and stone impact resistance.

Polycarbonate panels

27.06

- (1) (a) Polycarbonate transparent noise barrier panels shall be coextruded (i.e. fusion), with weather protection on both sides against UV radiation from sunlight and for avoidance of coating failure. Unless specified otherwise in the Specification, requirements in EN 1793 shall be fulfilled.
- (b) The polycarbonate transparent noise barrier panels shall possess the following properties :
- i. light transmittance of at least 80% for clear panel.
 ___% for coloured panel.
 ___% for translucent panel.
 - ii. tensile strength of at least 55N/mm².
 - iii. modulus of elasticity of at least 2100 N/mm².
 - iv. fire retardant property complying with the requirements in EN 1794-3 Class 2.
 - v. stone impact resistance complying with the requirements in EN 1794-1 Annex C or JIS K 6735.
 - vi. fire spread property complying the requirements of Class 1 or 2 Surface Spread of Flame under BS 476 Part 7.
 - vii. impact strength as Class A complying with BS 6206.

(2) The NBWSC shall guarantee the panel properties at the end of the 10-year period, which shall include but not limited to the following :

- (a) light transmittance loss not exceeding 7% from the original value.
- (b) tensile strength of at least 45 N/mm².
- (c) modulus of elasticity of at least 1800 N/mm².
- (d) yellowing index shall be less than 10 to ASTM D 1925 or JIS K 7373.
- (e) no mottling.
- (f) no loss in acoustic property, fire retardant property and stone impact resistance.

Glass panels

27.07

- (1) (a) Glass transparent noise barrier panels shall be tempered (thermally toughened) and laminated glass complying with BS 952 as specified on the Drawings. Unless specified otherwise in the Specification, requirements in EN 1793 shall also be fulfilled. The panels shall have thickness and colour as specified on the Drawings unless otherwise agreed with the Engineer.
- (b) Heat soaking shall be carried out to tempered glass to reduce the risk of damaging due to nickel sulphide. The process shall comply with BS EN 14179.
- (c) Different sheets of the laminated glass noise barrier panels shall be bonded together by Polyvinyl butrate (PVB) interlayers or similar material with minimum thickness not less than 1.52mm.
- (d) The tempered glass transparent noise barrier panels shall possess the following properties :
- i. light transmittance of at least 85% for clear panel.
____% for coloured panel.
____% for translucent panel.
 - ii. breaking strength of at least 110 N/mm².
 - iii. fire retardant property complying with the requirements in EN 1794-3 Class 2.
 - iv. stone impact resistance complying with the requirements in EN 1794-1 Annex C.
 - v. fire spread property complying the requirements of Class 1 or 2 Surface Spread of Flame under BS 476 Part 7.
 - vi. impact strength as Class 1 complying with BS EN 12600.
 - vii. static or cyclic load resistance complying with requirements as stated in Clauses 27.14(7) and 27.14(8).

(2) The NBWSC shall guarantee the panel properties at the end of the 10-year period, which shall include but not limited to the following :

- (a) light transmittance loss not exceeding 5% from the original value.
- (b) breaking strength of at least 95 N/mm² for tempered glass, 65 N/mm² for laminated heat strengthened glass or 40 N/mm² for laminated float glass.
- (c) colour difference shall be less than 20 units of ΔEab to BS EN ISO 11664-4.
- (d) no mottling
- (e) no loss in acoustic property, fire retardant property and stone impact resistance.

(The Engineer may specify other materials if necessary)

**Supporting
Frames and
Mountings**

27.08

(1) Supporting frames and foundation details shall be in accordance with the Drawings. The NBWSC shall review the compatibility of the frame design with the noise barrier panels. Any modifications to the frame design to suit the noise barrier panels should be proposed to the Engineer for approval.

(2) Typical fixing details of the noise barrier shown on the Drawings are indicative only. The NBWSC shall design all the fixing details including the associated fittings, joints and flashing details to the Engineer's approval.

(3) All steelworks of noise barrier shall comply with Section 18 of the GS.

(4) Bolts connecting components of the structural frame and holding down bolts shall be stainless steel with strength grade A4-80 to the requirements of BS EN ISO 3506-1&2.

(5) Structural steel shall be hot dip galvanized to BS EN ISO 1461 or equivalent.

(6) Unless otherwise stated in the Contract, the painting system to be used for steelwork shall be one of the following:

(a) For galvanized surfaces

Life to first maintenance in very high corrosivity (C5) environment as defined in BS EN ISO 12944 Part 2 : - 15 to 25 years, high (H) durability as defined in BS EN ISO 12944 Part 1

Pretreatment - two-pack etch primer

Primer - two-pack epoxy zinc phosphate primer, 80 μm minimum total dry-film thickness

Undercoat	- two-pack micaceous iron oxide epoxy undercoat, 140 µm minimum total dry-film thickness
Finish	- two-pack polyurethane finish coat, 100 µm minimum total dry-film thickness

(b) For metal sprayed surfaces

Life to first maintenance, in very high corrosivity (C5) environment as defined in BS EN ISO 12944 Part 2 : - 15 to 25 years, high (H) durability as defined in BS EN ISO 12944 Part 1

Pretreatment	- two-pack zinc tetroxychromate, polyvinyl butyral pretreatment
Sealer	- two-pack epoxy sealer applied by brush until absorption is complete

(Pretreatment and sealer shall be applied immediately after metal spraying)

Primer	- two-pack epoxy zinc phosphate primer, 80 µm minimum total dry-film thickness
Undercoat	- two-pack micaceous iron oxide epoxy undercoat, 140 µm minimum total dry-film thickness
Finish	- two-pack polyurethane finish coat, 100 µm minimum total dry-film thickness

(7) The external and internal acoustical sealing material located inside and outside of the noise barrier panels shall be extruded siliconized Ethylene Propylene Diena Monomer (EPDM) type gasket profile with hardness of 60 degree shore and with quality compatible with the noise barrier panel. Such gaskets shall be supplied by the noise barrier panel manufacturer and supported by an original test report.

(8) Fixing of glass transparent noise barrier panels shall comply with the following requirements:

- (a) Contact between glass and any other hard substance with a hardness equivalent to or greater than the hardness of glass shall be prevented.
- (b) For framed systems, the frame section shall give a minimum of 15 mm edge cover to the glass.
- (c) For point bolted supports, tempered glass shall be used and the position of the connectors shall not allow the glass to undergo

reverse curvature effects. Glass shall not come into direct contact with the bolts or clamping plates. There shall be clamping plates and gaskets on both sides of the glass that provide a minimum of 50 mm diameter cover to the glass. The cantilevered portion of the panels shall not be less than one-quarter of the span between the bolted connector.

- (d) For clipped infill panels, the clips shall be positioned around the periphery of infill panels, at a maximum spacing of 600 mm. Each clip shall be at least 50 mm in length and shall give a minimum depth of cover to the glass of 25 mm.

(9) All fixings, fittings and any accessories shall be of fire retardant materials.

SUBMISSION

**Particulars of
Noise Barrier
Works**

27.09

- (1) The Contractor shall submit to the Engineer for approval at least 60 days before the date of commencement of Noise Barrier Works :-
 - (a) Three copies of literature on the noise barrier panels from the panel manufacturer.
 - (b) Details of all components of the Noise Barriers Works, including any related test methods and results of the proposed materials.
 - (c) Three copies of full detailed design, drawings and calculations with Independent Checking Engineer's check certificate demonstrating the adequacy of all components of the Noise Barrier Works.
 - (d) Three copies of drawings showing the plan, sections and elevations of the Noise Barrier Works at a scale of not less than 1:100. Exact location and spacing of the structural frames shall be clearly shown.
 - (e) Three copies of drawings showing all details necessary for the complete installation of the Noise Barrier Works.
 - (f) A certificate for each type of noise barrier panel showing the manufacturer's name, the date and place of manufacture and showing that the panels comply with the requirements stated in the Contract
 - (g) Results of following tests or equivalent to the satisfaction of the Engineer:

I) For PMMA transparent noise barrier panels

- i. light transmittance to EN 1794-2 Annex E or ASTM-D1003;
- ii. tensile strength to ISO 527;
- iii. modulus of elasticity to ISO 527 or BS EN ISO 604;

- iv. flexural strength to ISO 178;
- v. impact strength (Class A to BS 6206);
- vi. stone impact resistance to EN 1794-1 Annex C;
- vii. weighted sound reduction index to EN 1793;
- viii. stability under wind load to EN 1794-1 Annex A;
- ix. fire retardant property to EN 1794-3;
- x. holding device to EN 1794-2;
- xi. catching contrivances, if applicable; and
- xii. colour difference to BS EN ISO 11664-4.

II) For polycarbonate transparent noise barrier panels

- i. light transmittance to EN 1794-2 Annex E or ASTM-D1003;
- ii. tensile strength to ISO 527;
- iii. modulus of elasticity to ISO 527 or BS EN ISO 604;
- iv. flexural strength to ISO 178;
- v. impact strength (Class A to BS 6206);
- vi. stone impact resistance to EN 1794-1 Annex C or JIS K 6735;
- vii. weighted sound reduction index to EN 1793 or JIS 1416;
- viii. stability under wind load to EN 1794-1 Annex A;
- ix. holding device to EN 1794-2;
- x. catching contrivances, if applicable;
- xi. fire retardant property to EN 1794-3;
- xii. fire spread property to BS 476 Part 7 ; and
- xiii. yellowing index to ASTM D 1925 or JIS K 7373.

III) For glass transparent noise barrier panels

- i. light transmittance to EN 1794-2 Annex E;
- ii. impact strength (Class 1 to BS EN 12600);
- iii. bending strength to EN 1288-3;
- iv. humidity and radiation tests to BS EN ISO 12543;
- v. stone impact resistance to EN 1794-1 Annex C;
- vi. Weighted sound reduction index to EN 1793;
- vii. static and cyclic load test to Clauses 27.14(7) and 27.14(8);
- viii. holding device to EN 1794-2;
- ix. catching contrivances, if applicable;
- x. fire spread property to BS 476 Part 7; and
- xi. colour difference to BS EN ISO 11664-4;

(IV) For other materials (to be specified by the Engineer))

- (h) Accelerated exposure test results (in accordance with the guidelines stipulated in Appendix 27.1), if applicable.
- (i) Method of installation.
- (j) Programme of manufacture, testing and delivery, including name and address of testing institute.

(2) The Contractor shall be responsible for ensuring that sufficient time is allowed for submission and approval of his proposal as well as for ordering, production, testing and delivery of the noise barrier panels. Insufficient time for submission cannot substantiate itself in any case as a justification for applying alternative material.

(3) Approval of any calculations, drawings or method of installation by the Engineer shall not relieve the Contractor of any of his obligations under the Contract.

Samples

27.10

(1) The Contractor shall supply the Engineer with 3 sample panels of at least 0.5 sq.m. for each type of noise barrier panel for approval of their finish, colour and quality 30 days before the date of commencement of Noise Barrier Works. Once approved by the Engineer, these samples shall be retained as the quality standard throughout the Contract.

(2) The colour reference of each type of the noise barrier panels and of the structural steel members shown on the Drawings is subject to confirmation by the Engineer. The colour reference shall be confirmed by the Engineer as part of the approval of the sample panels and the Contractor shall obtain the confirmation prior to placing his order.

(3) The Contractor shall provide a full size mock up sample of all of the panels and supporting posts. The mock up sample shall be at least 3 bays wide and in full height or as directed by the Engineer, and identical to the permanent Noise Barrier Works to be installed. The mock up sample shall be used to demonstrate workmanship. Location of the mock up sample shall be agreed with the Engineer. The mock up sample shall not be incorporated into the permanent works unless otherwise agreed by the Engineer.

As-constructed drawings and as-built Building Information Modelling (BIM) model of Noise Barrier Works

27.11

The Contractor shall submit to the Engineer within 30 days of completion of the Noise Barrier Works, the as-constructed drawings in which all information and details for the complete Noise Barrier Works installation shall be given. The as-constructed drawings shall include one set of digital data files in .DGN format and .pdf format, in the form of CD-ROM.

If the capital works projects meet the requirements on the adoption of BIM technology as stipulated on Development Bureau Technical Circular (Works) No. 2/2021 or its latest version, the Contractor shall follow the arrangement as stipulated in relevant Particular Specification and associated Appendix regarding BIM to develop and submit to the Engineer the As-built BIM Model (ABIM) as well as the Asset Information Model (AIM) of the Noise Barriers together with other BIM Models.

OPERATING CONDITONS

- Operating conditions** 27.12 The Noise Barrier Works shall be designed to have a high level of aging and corrosion resistance to withstand the local climatic conditions specified hereunder:-
- (a) The atmosphere under which the Noise Barrier Works will be operating is highly humid, salt laden and corrosive.
 - (b) The maximum and minimum operating temperature shall be taken as 42°C and 0°C respectively.
- Design requirements** 27.13 (1) The noise barrier main frame have been designed to the requirements given in the Highways Department – Structures Design Manual for Highways and Railways which is applicable at the date of the invitation for tenders. The sub-frames, the noise barrier panels and all the fixing details proposed by the NBWSC shall be designed to withstand a nominal wind pressure equivalent to ___ kN/m² under working conditions, subject to a load factor of ___ for ultimate load. In case of glass panel, the design shall follow AS 1288 or other standards accepted by the Engineer.
- (2) Apart from wind loads, the vertical posts supporting the noise barrier panels, if located adjacent to carriageway, have been designed to resist vehicular impact loads.
- [Designers shall revise this Clause to specify the magnitude, direction and point of application of the vehicular impact loads adopted in the design.]*
- (3) Where specified in the Contract, the noise barrier shall incorporate holding devices to prevent panels from falling off the noise barrier in the event of accidental impact by vehicles. The holding devices shall comply with the following requirements:
- (a) The device shall hold the four corners of each panel member by wire ropes. Design holding force of the device shall be 10 kN.
 - (b) The device shall allow a relative movement of 0.3 m between the panels and the structural frames.
- If external guard nets as mentioned in Sub-clause (5) is used, this Sub-clause is deemed not compatible and shall not be used.
- (4) Where specified in the Contract, if the noise barrier is vulnerable to direct vehicular impact and the spread of panel fragments will pose serious hazard to pedestrians/cyclists, the noise barrier shall be fitted with catching contrivances. Catching contrivances shall either be:
- (a) laminates between different sheets forming the panels; or
 - (b) embedded mesh within the panels.

(5) Where specified in the Contract, if the noise barrier is vulnerable to direct vehicular impact and without catching contrivances, external guard nets made from wire mesh shall be provided. Details of the guard nets shall be designed by the Contractor and approved by the Engineer.

(6) Catching contrivances and external guard nets are deemed not necessary if the noise barrier is mounted on concrete profile barrier, or if alternative measure is provided to the satisfaction of the Engineer.

(7) To alleviate the potential problem with birds colliding onto the transparent noise barrier panels, the transparent noise barrier panels shall be provided with either:

- (a) embedded/superimposed opaque stripes,
- (b) embedded/superimposed opaque dots/visual markers, or
- (c) angled panel.

For item (a), stripes shall be at least 6 mm wide with a maximum spacing of 100 mm for vertical stripes or a maximum spacing of 50 mm for horizontal stripes. For item (b), large dots/visual markers with vertical and horizontal spacings not more than 50 mm and 100 mm respectively are recommended. The color of the stripes, dots and visual markers shall contrast well with the background or reflection on the panels. For item (c), the panel shall be angled at 20 to 40 degree from the vertical.

Incorporation of any of the above shall not adversely affect the overall appearance of the noise barrier and shall be subject to the satisfaction of the Engineer. Should the Contractor wish to adopt item (a) or (b) above, he shall further substantiate to the satisfaction of the Engineer that the stripes or dots are durable. For the adoption of item (a), (b) or (c) above, no adverse effect on the performance and maintenance of the noise barrier panels shall be ensured.

[Designers shall seek advice from the Agriculture, Fisheries and Conservation Department and revise this clause to adopt alternative measures where necessary.]

(8) The noise barrier panels shall not reflect light in such a way as to prejudice road safety. Top surface of roof panels shall be non-glaring.

(9) The noise barrier shall be of the dimensions, geometry and the type as indicated on the Drawings or otherwise accepted by the Engineer.

(10) Material used at overhead locations shall not form sharp and harmful pieces when shattered. Where glass is used, the risks and consequences of fracture and broken glass falling shall be duly considered and appropriate mitigation measures shall be taken. Fixings shall be carefully detailed to avoid direct contact between the glass and other hard materials and undue differential thermal stresses or acutely punching impacts to the glass. The use of glass for overhead installations shall be avoided as far as possible, particularly at blackspots and locations prone to fallen objects.

(11) In the case of a noise barrier system whose elements whilst having the fire retardant property as specified in the Specification, are nevertheless combustible, the following provisions shall be incorporated into the system:

- (a) either the post shall be non-combustible and function as a fire break, or a minimum 4 m wide section made of non-combustible material shall be required for every 100 m in length.
- (b) panels on side wall shall be supported on raised plinth made of non-combustible material and shall be at least 800 mm above adjacent carriageway.

(12) The stability of the noise barrier and its anchoring shall meet the requirements of EN 1794-1 Annex A under the wind loads as specified in sub-clause (1) above.

TESTING

Testing

27.14 (1) All tests shall be carried out in accordance with internationally recognized standards and at an accredited testing institute approved or specified by the Engineer. Such tests shall have been carried out not more than 72 months for accelerated exposure test and 36 months for other tests, before the time of submitting the noise barrier proposal. All samples delivered to the testing institute shall be indelibly printed with the manufacturer's brushed mark for clear identification.

(2) If evidence cannot be produced that the proposed barrier panels have satisfactorily performed either locally or in similar weather conditions for at least 5 years, the panel manufacturer shall carry out accelerated exposure test to substantiate the compliance of the panel properties with the specification requirements. The accelerated exposure test shall be carried out at an accredited testing institute approved or specified by the Engineer in accordance with the guidelines stipulated in Appendix 27.1. Previous accelerated exposure test results could also be accepted provided the tests are properly performed and witnessed in a manner acceptable to the Engineer.

(3) Upon delivery of the noise barrier panels on the Site, the Engineer may at his discretion select ___sample(s) randomly from each type of noise barrier panel and order any of the tests as specified in Clause 27.09 (1)(g) to be carried out on the selected samples as a quality control and continued monitoring of the barrier panels. In case of glass, at least one selected sample from each type of glass panel shall be subjected to each of (i) impact strength test in accordance with the requirements for Class 1 Safety Glass to BS EN 12600 and (ii) static load test or cyclic test in accordance with sub-clause (7) and (8) below respectively.

(4) If the result of any test stated in Clause 27.09(1)(g) does not comply with the specified requirements for the test, the test shall be carried out on additional samples to be selected by the Engineer. The number of additional samples shall be twice the number for the original test. The noise barrier panel shall be considered as not complying with the specified requirements for the test if the result of any additional test does not comply with the specified requirements for the test.

(5) Where accelerated exposure tests are carried out pursuant to sub-clause (2) above, the test panels shall be considered as complying

with the specified requirements for the accelerated exposure test stated in Clause 27.09(1)(h) if the two test specimens after the accelerated exposure test meet the following criteria :

- (a) one specimen fully meets the specified requirements stipulated in Clause 27.05(2) for PMMA panels, 27.06(2) for polycarbonate panels or 27.07(2) for glass panels; and
- (b) the other specimen at least meets 90% of the specified requirements stipulated in Clause 27.05(2) for PMMA panels, 27.06(2) for polycarbonate panels or 27.07(2) for glass panels.

(Note : Each and every specimen referred to in this sub-clause are additional to those selected by the Engineer under sub-clause (3) above and must have undergone the full exposure test including the exposure treatment stipulated in Appendix 27.1 and the physical tests.)

Otherwise, the sample panels shall be considered as not complying with the specified requirements for the test.

(6) Static load test for PMMA and Polycarbonate transparent noise barrier panels shall follow EN 1794-1 Annex A.

(7) Static load test for glass transparent noise barrier panels shall comply with the following procedures and requirements:

- (a) A representative prefabricated production sample unit, consisting of the glass panel, supporting frame and associated fixing components, shall be mounted in a test pressure chamber. The gap between chamber and glazing frame shall be clamped and sealed to withstand the pressure during the test without leakage.
- (b) The test load shall be 1.25 times the nominal wind pressure of the noise barrier system as stated in Cl. 27.13(1) and shall be maintained for at least 15 minutes.
- (c) During the load test, the panel shall not break and the deflection of any structural element of the specimen shall not exceed 1/180 of the span or 20 mm, whichever is the less; and
- (d) The extent of recovery of deformation 15 minutes after the removal of the test load shall be at least 95 % and the panel shall not show any signs of separation, plastic deformation or deleterious effect.

(8) Cyclic test for glass transparent noise barrier panels shall comply with the following procedures and requirements:

- (a) A representative prefabricated production sample glazing unit, consisting of glass held to the frame all round with a fully cured structural grade silicone bead, shall be mounted vertically in one side of a test pressure chamber. The gap between chamber and glazing frame shall be clamped and sealed to withstand the pressure during the test without leakage.

- (b) The sequence and duration of tests for both positive and negative Pressure in the chamber shall be varied in with following table -

Test	Test Preparation	Repeated Test	Test Safety
Pressure*	0-p1-0-p1-0-p1-0	0-p2-0-p2-0-p2-0-p2-0-p2	0-p3-0
Duration	The period of transition from one pressure value to another should be not less than 1 second. The pressures are to be held at maximum or minimum values for at least 3 seconds.		

*p1 = 0.5p2, p2 = the nominal wind pressure as stated in Cl. 27.13(1), p3 = 1.25p2

- (c) Each of the three tests shall be carried out first under positive pressure then under negative pressure. For the repeated test, the number of pressure pulses should not be less than 5.
- (d) During the test, the glass panel shall not break and the deflection of any structure element of the specimen should not exceed 1/180 of the span or 20mm, which ever is the less, during the repeated positive and negative pressure tests.
- (e) The extent of recovery of deformation at 15 minutes after the removal of the test loads shall be at least 95% and the specimen, shall not show any signs of separation, plastic deformation or deleterious effect.

(9) The Contractor or NBWSC shall make adequate allowance for the quantity of sample panels required in the tests, including those used as control samples, in his order of noise barrier panels and for the additional time required for the tests to be carried out on the sample panels in his programme.

INSTALLATION

Installation

27.15

- (1) The Noise Barrier Works shall be installed to the details approved by the Engineer. Provisions shall be made for both the horizontal and vertical adjustments of the structural frame and the noise barrier panels during installation.
- (2) Site storage of materials shall comply with the recommendations and instructions of the supplier.
- (3) After installation, framing members and accessories shall be cleaned by an approved method. Transparent noise barrier panels shall be left in a clear and scratch free condition, both inside and outside, with all labels removed. Abrasive materials of any kind and sharp instruments shall not be used in cleaning surfaces. Benzene, leaded gasoline, acetone, carbon tetrachloride and cleaning liquids containing abrasives or powder cleaners shall not be used in cleaning surfaces. All rubbish, cartons crates and any excess materials from the manufacture, delivery and installation shall be removed.

Appendix 27.1 - Accelerated Exposure Test

The test method and the associated equipment for carrying out the accelerated exposure test on transparent noise barrier panels as described in this Appendix is derived from the guidelines given in BS EN ISO 4892-1, ISO 4892-4 and BS EN ISO 4892-2. Reference shall be made to the above ISO standards for any areas not covered by this Appendix.

27.1.1. Apparatus

27.1.1.1 Radiation System

- i. The radiation system shall consist of xenon arc lamp or carbon arc lamp fitted with suitable filters and be capable of producing radiation with a spectral energy distribution similar to that of terrestrial sunlight in the ultraviolet and visible regions of the spectrum i.e. wavelength range of 290nm to 800nm.
- ii. An air- or water-cooled absorber shall be used as the heat-absorbing system. For water-cooled absorber, distilled or deionized water shall be circulated through the lamp assembly. To prevent contamination and minimize the formation of deposits, the water shall be purified by the use of a mixed-bed deionizer just ahead of the lamp. The recirculated lamp water shall be cooled without contaminating it by the use of the heat exchange unit employing either tap water or a refrigerant as the heat-transfer medium.
- iii. The radiation system shall emit irradiance of 550 W/m² to 800 W/m² in the wavelength range of 290nm to 800nm on the specimen surface.
- iv. UV-radiation distribution of filtered xenon arc source together with tolerance limits shall comply with the values as given in Table 1 of BS EN ISO 4892-2. Filters used for carbon arc light source shall comply with Type 1 spectral transmittance as specified in Table 1 of ISO 4892-4.

27.1.1.2. Test Chamber

The exposure chamber shall contain a frame, carrying specimen holders if necessary, with provision for passing air over the specimens for temperature control.

27.1.1.3 Radiometer

- i. A radiometer which complies with the requirements outlined in ISO 9370 may be used to measure the irradiance or spectral irradiance and the radiant exposure or spectral radiant exposure on the specimen surface.
- ii. The radiometer shall be mounted so that it receives the same radiation as the specimen surface. If it is not positioned in the specimen plane, it shall have a sufficient field of view and be calibrated for irradiance at the specimen distance.
- iii. The radiometer shall be calibrated in the emission region of the light source used. Calibration shall be checked in accordance with the manufacturer's instruction of the radiation measuring instrument.

27.1.1.4 Black-panel Temperature Sensors

- i. A black-panel temperature sensor shall be used to measure and control the temperature within the test chamber. Two types of black-panel temperature sensor may be used :
 - (a) Black-standard thermometers complying with BS EN ISO 4892-1 Clause 5.2.2.1.
 - (b) Black-panel thermometers complying with BS EN ISO 4892-1 Clause 5.2.2.2.
- ii. The black-panel temperature sensor shall be mounted on a support within the specimen exposure area so that it receives the same radiation and experiences the same cooling conditions as a flat test panel surface using the same support.

27.1.1.5 Humidity Control Device

- i. Depending on the type of apparatus, the test chamber shall be air-conditioned by adding moisture to the air using an ultrasonic humidifier unit or by means of water atomized by an aerosol device and fed into the air stream. The relative humidity in the test chamber shall be measured and controlled using either a capacitance sensor or a contact hygrometer.
- ii. The sensors used to measure the humidity shall be placed within the test chamber air flow and shielded from direct radiation and water spray.
- iii. Any device intended to simulate the effects of moisture shall have means to programme intervals with and without wetting of the specimens.

27.1.1.6 Spray System

- i. The specimens shall be sprayed with distilled or demineralized water (having a conductivity below 5 $\mu\text{S}/\text{cm}$ and containing a maximum of 1 $\mu\text{g}/\text{g}$ of solids and a maximum of 0.2 $\mu\text{g}/\text{g}$ of silica) intermittently with spray cycles as specified in Clause 27.3.4 of this Appendix. The spray system shall be made from inert materials that do not contaminate the water employed. The water shall leave no observable stains or deposits on test specimens. In addition to distillation, a combination of deionization and reverse osmosis can be used to produce water of the required quality. The pH of the water used shall be reported.
- ii. Recirculation of water used for specimen spray is not recommended and shall not be done unless the recirculated water meets the purity requirements listed above.
- iii. If bacterial contamination is detected, the entire system used for specimen water spray shall be flushed with a chlorinating solution such as sodium hypochlorite and thoroughly rinsed prior to resuming exposures.

27.1.1.7 Specimen holders

- i. Specimen holders may be in the form of an open frame, leaving the back of the specimen exposed. They shall be made from inert materials that will not affect the test results, for example non-oxidizing alloys of aluminum or stainless steel. Brass, steel or copper shall not be used in the vicinity of the test specimens. Provision of solid backing shall be avoided and can only be used with prior agreement of the Engineer.
- ii. Depending on the apparatus, the specimen holders can be designed to be mounted on a vertical or inclined cylindrical frame or rack which is rotated at 1rpm around the lamp which is centred both horizontally and vertically with respect to the exposure area in the

sample holders.

27.1.1.8 Temperature control device

- i. The temperature control device shall consist of a ventilation system which provides a constant stream of air through the test chamber and over the test specimens. The temperature of the air is automatically controlled by recirculating warm air from the test chamber mixed with cooler room air.
- ii. The device shall incorporate temperature sensors shielded from direct radiation and water spray and shall be able to control the temperature of the black temperature sensor to within $\pm 3^{\circ}\text{C}$ of the desired temperature. They shall be designed such that the temperature of a black panel temperature sensor placed anywhere within the specimen exposure area is within $\pm 5\%$ of the desired Celsius temperature.

27.1.2. Specimen

27.1.2.1. A minimum of three replicate specimens shall be selected from each batch of transparent panels, two of which shall undergo accelerated exposure test. The third specimen shall be properly protected and maintained at its original condition and shall be taken as control specimen for comparison with the other two specimens after the exposure test.

27.1.2.2 The form and shape of test specimens shall be those specified in the appropriate test method for the properties to be measured after exposure. Method used for the preparation of test specimens shall be submitted by the Contractor for the approval of the Engineer.

27.1.3. Test Condition

27.1.3.1 Irradiance

- i. The irradiance on the specimen surface shall comply with Clauses 27.1.1.1 (iii) and (iv).
- ii. Exposure devices shall be designed such that the irradiance at any location in the area used for specimen exposures is at least 70 % of the maximum irradiance measured in this area. Procedures for measuring irradiance uniformity shall be in accordance with Annex A of BS EN ISO 4892-1.
- iii. If the irradiance at any position in the area used for specimen exposure is at least 90 % of the maximum irradiance, periodic repositioning of the specimens during exposure is not necessary.
- iv. If irradiance at any position in the area used for specimen exposure is between 70 % and 90% of the maximum irradiance, specimens shall be periodically repositioned during the exposure period to ensure that each receives an equal amount of radiant exposure. The repositioning schedule shall be agreed by the Engineer .

27.1.3.2 Temperature

- i. The black-panel temperature shall be $65^{\circ}\text{C} \pm 3^{\circ}\text{C}$
- ii. If water spray is used, the temperature requirements shall apply to the end of the dry period. If the thermometer does not attain equilibrium during a short cycle, the specified temperature shall be established without water spray and the maximum temperature

attained during the dry cycle shall be reported. Even if the exposure apparatus is operated in an alternating mode, measurement by black-standard/panel thermometer shall be carried out in the continuous mode.

27.1.3.3 Relative Humidity

The relative humidity shall be $75\% \pm 5\%$.

27.1.3.4 Spray cycle

Duration of spray : 18 min \pm 0.5 min
Dry interval between spray : 102 min \pm 0.5 min

27.1.4. Submission

Prior to commencement of the test, the Contractor shall submit the following information to the Engineer for approval :

- i. Details of all apparatus used in the test including but not limited to shop drawings, catalogue, user manuals etc.
- ii. Calibration reports of all measuring devices.
- iii. Proposed method statement and test procedures with calculations to substantiate the specified period of exposure based on meteorological data obtained from the Hong Kong Observatory.
- iv. Form and shape of the specimens.
- v. Method used for the preparation of test specimens.

27.1.5. Procedure

27.1.5.1 Mounting the test specimens

- i. Attach the specimens to the specimen holders in the equipment in such a manner that the specimens are not subject to any applied stress. Identify each test specimen by suitable indelible marking, avoiding areas to be used for subsequent testing.
- ii. When instructed by the Engineer, a portion of the test specimen shall be shielded by an opaque cover throughout the test with a view to obtaining an unexposed area adjacent to the exposed area for comparison.

27.1.5.2 Exposure

- i. Before placing the specimens in the test chamber, ensure that the apparatus is operating under the specified test conditions and maintain these conditions throughout the specified exposure period.
- ii. Expose the test specimen for the specified period of exposure. It is desirable to vary the position of the test specimens in the apparatus from time to time to reduce any local inequalities of exposure. When the specimens are so adjusted, they shall remain in the same orientation as when initially mounted.

- iii. If it is necessary to remove a test specimen for a periodic inspection, care shall be taken not to handle or disturb the test surface. After inspection, the test specimen shall be returned to its holder or to the test chamber with its test surface in the same orientation as before.
- iv. The period of exposure shall follow table 2, and shall be worked out based on the power of the proposed xenon arc lamp/carbon arc lamp.

Table 2 : Exposure Time

Lamp Irradiance W/m ²	Exposure Time
	Hours
550	8300
600	7600
650	7000
700	6500
750	6100
800	5700

27.1.5.3 Measurement of radiant exposure

- i. Mount the light-dosage measurement instrument so that the radiometer indicates the irradiance at the exposed surface of the test specimen.
- ii. The exposure interval shall be expressed in terms of incident spectral radiant energy per unit area of the exposure plane, in joules per square metre, for the range of wavelength selected.

27.1.6. Test Report

The test report shall contain the following information:

(I) Specimen description

- i. A full description of the specimens and their origin.
- ii. Compound details, cure time and temperature where appropriate.
- iii. A complete description of the method used for preparation of the test specimens.

(II) Description of exposure test conducted including:

- i. A description of the exposure device and light source, including:
 - (a) type of device and light source;
 - (b) description of the filters used;
 - (c) irradiance at the specimen surface (including the range of wavelength in which the radiation was measured);

- (d) number of hours that the filters and the light source had been used prior to commencement of the exposure.
- ii. The type of black panel temperature sensor used and the exact position of the sensor.
- iii. The type of instrument used to measure the humidity.
- iv. The type of thermometer and the way in which it is mounted on the specimen holder and the selected temperature of operation.
- v. A complete description of the exposure cycle including:
 - (a) the mean and the tolerance limits for the temperature recorded.
 - (b) the mean and the tolerance limits for the relative humidity of the air passing over the specimens;
 - (c) the duration of the water spray and whether the water was sprayed on the exposed face, the back or both surfaces of the specimens; if the total solids of the water used for the spray is greater than 1 µg/g, report the total solids and the silica content;
- vi. A description of the method used to mount the specimens in the exposure frame, including a description of any material used as backing for the test specimens.
- vii. The procedure for test specimen repositioning, if used.
- viii. A description of the radiometer used for measuring the light dosage.

(III) Test results

- i. A complete description of the test procedure used for measurement of any properties reported.
- ii. The results, presented in accordance with ISO 4582, and including:
 - (a) the results from property measurements on the test specimens;
 - (b) the results from property measurements on control specimens;
 - (c) the exposure period (the time in hours, and the radiant energy in J/m^2 and the range of wavelength in which it was measured).

(IV) The date of the test