

DEP SPECIFICATION

GLASS REINFORCED PLASTIC (GRP) GRATINGS FOR OFFSHORE INSTALLATIONS

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the design, purchase, manufacturing, qualification testing and use of glass-fibre reinforced plastic (GRP) grating systems. It is primarily intended for offshore applications on both fixed and floating topsides facilities; but, it may also be used as guidance for the specification, purchase and use of GRP grating systems in other similar applications found onshore. This DEP does not apply to the subsea use of GRP grating systems.

Its objective is to enable the purchase of GRP grating products with known and consistent properties from any source that meet specified performance requirements.

GRP is a combination of glass-reinforcing fibres and a thermosetting resin (typically polyester, vinyl-ester or phenolic).

It should be noted that for some applications GRP grating will not be able to satisfy all the identified performance requirements for the specific location on the facility and a suitable steel grating will be required. Further guidance is provided in this DEP.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to offshore oil and gas production. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Anisotropic	Exhibiting different properties when tested along axes in different directions
Cure	Change irreversibly the properties of a thermosetting resin by chemical reaction
Curing agent	Catalytic or reactive agent that, when added to a resin, causes polymerization
Cut-out	Area where grating has been removed to permit services, plant or structural members to pass through or clear obstructions
Delamination	Separation of two adjacent plies or layers of material in a laminate resulting from lack of adhesion
Depth	Overall depth of the load bearing bar
Differential scanning calorimetry	Method for determining the glass transition temperature of a polymer
Dynamic thermal mechanical analysis	Method for determining the glass transition temperature of a polymer or FRP component
Effective span	Clear span between supports
E-glass	Glass fibre normally used to reinforce GRP gratings, consisting mainly of SiO ₂ , Al ₂ O ₃ and MgO
Electrically conductive	Having a volume resistivity equal to or lower than 10 ⁴ Ω·m
Electrostatic dissipative	Having a volume resistivity higher than 10 ⁴ Ω·m but lower than 10 ⁹ Ω·m or a surface resistivity less than 10 ¹⁰ Ω measured at ambient temperature and 50 % relative humidity
Fibre	Filamentary material with a finite length that is at least 100 times its diameter and prepared by drawing from a molten bath, spinning or deposition on a substrate
Fibre-reinforced plastic	Plastic-based composite that is reinforced with any type of fibre, not necessarily glass
Fire classification code	Code designation of the fire performance of grating component in terms of fire endurance and fire reaction properties
Fire endurance Fire resistance	Ability to maintain functional performance in a fire
Fire-reaction property	Material property which contributes to spread of fire, heat release and smoke/toxic emissions
Furnace test	Test in a compartment furnace where the time-temperature curve to be followed is to a defined standard
Glass-fibre-reinforced plastic	Polymeric resin-based composite that is reinforced with glass fibre
Glass transition temperature	Temperature at which amorphous polymer undergoes a marked change in properties on passing from the rubbery to glassy state.

Term	Definition
Heat-distortion temperature	Temperature at which a standard test bar deflects a specified amount under a stated load
Incendive discharge	Electrostatic spark discharge of sufficient energy to ignite a flammable atmosphere
Length (Span)	Overall size of grating in a direction parallel to the load bearing bars
Load bearing bar	Longitudinal load bearing member spanning between supports
Moulded grating	Fibre-reinforced plastic grating products that are manufactured in a one piece construction process by interlacing pre-wetted glass reinforcing strands in a liquid resin matrix within a square or rectangular mesh pattern. The ratio of resin to fibre volume fraction is usually about 65:35.
Phenolic	Class of polymer resins made from phenol and formaldehyde, and cured by air drying or heat baking
Pitch	Distance centre to centre of load bearing bars or between centres of points of lateral restraint to load bearing bars
Porosity	Ratio of open area to total area
Product family	Component type all of whose variants have the same function
Product family representative	Component that is taken to be representative of that particular product family
Product sector	Subdivision of a product family that groups variants into specific loading bar and transverse spacing
Product sector representative	Component variant taken to be representative of that product sector and upon which the basic qualification testing is performed
Pultruded grating	Fibre-reinforced grating products that are assembled from bearing bars and transverse bars that are manufactured by the pultrusion process. The ratio of resin to fibre volume fraction is usually about 35:65.
Pultrusion process	Manufacturing process for producing continuous lengths of reinforced polymer structural shapes with constant cross-sections. Process involves pulling reinforcement through a liquid resin bath and then into a heated shaping die where the resin is thermoset. For GRP grating, the reinforcement is usually glass fibre consisting of continuous longitudinal strands (roving) and wrapped with multidirectional strand matt.
Qualification	Process of demonstrating that a component is in accordance with the requirements of this DEP specification
Qualified span	Span of grating used in accordance with qualification requirements given in (4.3). This is equal to 1200 mm (47 in) with an effective or clear span of 1120 mm (44 in).
Roving	Collection of parallel strands assembled without intentional twist
Support	Member supporting grating
Thermoset	Plastic which, when cured by application of heat and/or chemical reaction, changes into a substantially infusible and insoluble material
Thermosetting polyester	Thermosetting class of resin produced by dissolving unsaturated, generally linear, alkyd resins in a vinyl-type active monomer such as styrene, methylstyrene or diallyl phthalate
Transverse bar	Member fixed at right angles to load bearing bars to provide lateral restraint

Term	Definition
Tribocharging	Generation of electrostatic charge caused by moving contact of one insulating material over another
Variant	Component with a unique combination of loading bar configuration and surface coating
Vinyl ester	Class of thermosetting resin containing esters of acrylic and/or methacrylic acids, many of which have been made from epoxy resin
Width	Overall size of grating measured in a direction at right angles to the load bearing bars over the transverse bars

1.3.3 Abbreviations and symbols

Term	Definitions
ABS	American Bureau of Shipping
ALARP	As Low As Reasonably Practicable
ASTM	American Society of Testing and Materials
BSI	British Standard International
CEAC	Composite Engineering & Applications Centre, University of Houston, USA.
DSC	Differential scanning calorimetry
DTMA	Dynamic mechanical thermal analysis
EI	Product of Young's Modulus and the 2 nd moment of area
FRP	Fibre-reinforced plastic
GRP	Glass-fibre-reinforced plastic
HDT	Heat-distortion temperature
IMO	International Maritime Organization
L	Length of span
MDSC	Modulated differential scanning calorimetry
T_g	Glass transition temperature
UDL	Uniformly distributed load
USCG	United States Coast Guard
UV	Ultraviolet

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (11).

1.5 SUMMARY OF MAIN CHANGES

This is a new DEP.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. MATERIALS AND GRATING TYPES

2.1 GENERAL

1. Only GRP grating products that meet the requirements of this DEP and that have been approved by the Principal shall be used.
2. GRP grating may be considered as an alternative to traditional materials such as carbon steel, provided it can be demonstrated that it satisfies all the relevant design and performance criteria for the specific location on the facility. For some applications GRP grating will not be able to satisfy all the identified performance requirements for the specific location on the facility and a suitable steel grating shall be specified.

Risk analysis may be required to identify and assess any risk inherent in the selection of GRP grating and to compare this risk with a steel system operating under the same conditions.

2.2 MATERIALS

1. The manufacture of fibre-reinforced plastic grating components shall be limited to thermosetting resins. Typical resins are polyester, vinyl ester, epoxy and phenolic. Thermoplastic resins shall be excluded.
2. Phenolic resins should be used for offshore topsides facilities out with the wave zone where it can be demonstrated that GRP grating satisfies all the relevant design and performance criteria for the specific location on the facility. Vinyl ester or polyester resin may be considered for use in the wave zone.

Notes:

- a. *The fire performance of the grating system is determined by the resin type and state of cure. Phenolic resin systems can withstand much higher temperatures than the other resins listed above and will emit significantly less smoke and toxic fumes.*
 - b. *It is noted that even a phenolic resin system may not satisfy the hydrocarbon fire performance requirements for a specific location on a facility and a steel based grating system may need to be specified.*
3. The principal reinforcement material shall be glass-fibre. The sizing agent used to coat the glass-fibre shall be compatible with the resin used. Other types of reinforcement such as carbon or aramid fibre shall not be used.
 4. The minimum recommended temperature for GRP regardless of the resin system is -40 °C (-40.0 °F). Lower temperatures may be considered but this shall be discussed and agreed with the Principal.
 5. Caution shall be applied to the use of fillers within the resin, since these can result in differing properties compared to the base resin, which will affect the long-term performance of the grating. Fillers are used to provide fire retardant, anti-static and anti-slip properties, etc.
 6. External coatings may be used to provide ultraviolet (UV) protection, anti-slip properties, fire protection or electrical conductivity.

2.3 GRATING TYPES

2.3.1 General

1. GRP gratings are available in two main forms: Pultruded and Moulded.
2. Pultruded grating products are assembled from load bearing bars and transverse bars that are manufactured by the pultrusion process. Pultruded grating has more strength and stiffness in the direction of the load bearing bars than moulded grating.

3. Moulded grating products are manufactured in a one piece construction process by interlacing pre-wetted glass reinforcing strands in a liquid resin matrix within a square or rectangular mesh pattern. The square pattern has similar strength and stiffness in both directions.
4. Figure 2.3 identifies the main grating components and parameters associated with a pultruded grating. The moulded grating is similar although the transverse bars should be the same height and width as the load bearing bars.

2.3.2 Pultruded GRP grating

1. Pultruded (phenolic) grating should be used in preference to moulded grating for offshore topsides facilities out with the wave zone.

Note: Pultruded grating is designed for parallel support beams running perpendicular to the load bearing bars.

2. The ratio of resin to fibre volume fraction should be approximately 35:65. The fibre content shall be greater than 60% by weight.
3. Load bearing bars shall consist of a core of continuous glass strand rovings and continuous strand matt glass-fibre reinforcement; only glass-fibre reinforcement shall be used.
4. Load bearing bars shall be restricted to I-shaped profiles with a flange width of 15 mm (0.6 in). Bearing bars shall have a minimum depth of 38 mm (1.5 in) and shall have a maximum centre to centre spacing of 38 mm (1.5 in).

Note - Manufacturers often catalogue grating types in terms of porosity, e.g., I-60 refers to an I-shaped load bearing bar and the spacing between load bearing bars is adjusted to provide a 60% ratio of open area to total plan area.

5. Load bearing bars shall be provided with lateral restraint by means of transverse bars mechanically locked and chemically bonded to the web of each bearing bar. Transverse bars with round profiles and using tube sleeve spacers shall not be used.
6. Each transverse bar should have a minimum cross-sectional area of 230 mm² (0.35 in²) and a minimum moment of inertia I_{xx} of 6600 mm⁴ (0.016 in⁴).
7. The spacing between the transverse bars shall not exceed 150 mm (6 in).
8. All transverse bars shall be placed below the walking surface of the grating and shall be centrally located about the neutral axis of the bearing bars.
9. Grating produced using phenolic resin shall be brown in colour.
 - a. Non-phenolic resins should be yellow in colour.
10. The grating panels shall have an anti-slip surface made from uniformly applied grit and a heat cured epoxy coating. Cold cured systems shall not be used.
11. Phenolic pultruded grating shall have a UV resistant epoxy coating applied to all grating surfaces. The colour shall be brown for fire integrity.
 - a. If pultruded polyester or vinyl ester grating is used, UV protection shall be provided by a synthetic surfacing veil on both the load bearing bars and transverse bars, and the resin throughout the structure shall contain UV inhibitor.

2.3.3 Moulded GRP grating

1. Moulded grating may be considered for some applications provided it can meet all specified performance requirements. For example, moulded grating may have an advantage in splash zone areas because of its porosity.

Note: Generally, moulded grating will have a higher porosity (i.e., open area to total plan area) compared to pultruded grating so that wave action effects should be slightly less severe.

2. The ratio of resin to fibre volume fraction should be approximately 65:35.
3. Grating panels shall be produced by interweaving high strength pre-wetted continuous roving and resin within a square mesh mould to produce an integral laminate with load bearing bars in both the longitudinal and transverse directions.
4. The longitudinal and transverse load bearing bars shall be equal depth and should be arranged on a 38 mm x 38 mm (1.5 in x 1.5 in) square mesh pattern.
5. The bearing bars shall have a minimum depth of 38 mm (1.5 in).
6. Grating produced using a phenolic resin shall be brown in colour.
 - a. Non-phenolic resins should be yellow in colour.
7. The grating panels shall have an anti-slip surface made from uniform grit and a heat cured epoxy coating. Cold cured systems shall not be used.
8. A UV resistant epoxy coating shall be applied to all grating surfaces, even if UV inhibitors are used in the construction phase.

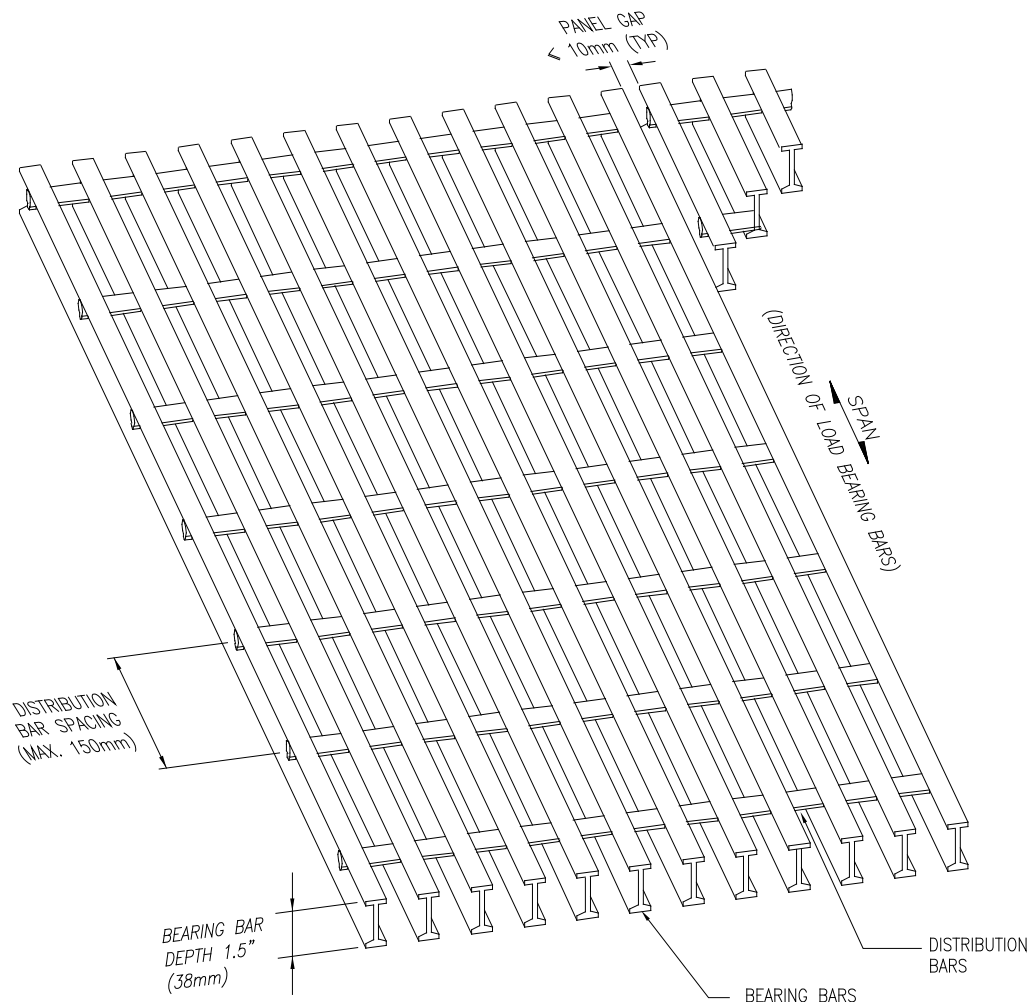


Figure 2.3 Identification of main grating parameters

Note: The above drawing is for a pultruded grating. However, the same principles apply to a moulded grating where the transverse bars should be the same section height and width as the load bearing bars.

2.4 LOCATIONS FOR USE OF GRP GRATING

1. GRP grating may be considered as an alternative to carbon steel grating where it can be demonstrated that it satisfies all the relevant design and performance criteria for the specific location on the facility. Risk analysis may be required to identify and assess any risk inherent in the selection of GRP grating and to compare this risk with a steel system operating under the same conditions.
2. In the absence of a detailed risk assessment, the default locations where GRP grating may be considered are outlined in the Table below.

Table 2.4.1 Default locations for use of steel and GRP grating

Location / Area	Material
Main escape/evacuation routes and any access routes needed to control an emergency	Steel
Walkways and access routes NOT designated as main escape routes	GRP (Phenolic) Steel
Access and maintenance platforms	GRP (Phenolic) Steel
Laydown areas and any areas subject to heavy localised loading and impact	Steel
Lifeboat muster stations and tertiary escape stations	Steel
Wave zone walkways	GRP (Vinyl ester, polyester), Steel

3. DESIGN AND PERFORMANCE REQUIREMENTS

3.1 GENERAL

1. The GRP grating system shall be designed and manufactured to withstand all the conditions that can reasonably be foreseen to occur during its use, including temporary conditions occurring during transportation and installation.
2. The design and performance requirements may vary from one part of an installation to another. Careful consideration shall be given to selecting the most appropriate criteria for the specific location on the installation.
3. GRP grating shall be designed in accordance with (3.2) to (3.13), where appropriate. Design and performance criteria shall be agreed with the Principal.
4. For some locations, GRP grating may not be able to satisfy all the identified performance requirements and a suitable steel grating shall be specified. Such locations could include primary escape routes that may be exposed to hydrocarbon fires or areas subject to heavy localised loading and impact where robustness to duty is essential.
5. As a minimum, the following design requirements shall be considered in assessing and selecting a suitable GRP grating product:
 - a. Layout requirements;
 - b. Spacing between load bearing bars;
 - c. Uniformly distributed loads and concentrated loads, including trolley wheel loads;
 - d. Span of grating and deflection limits;
 - e. Impact resistance;
 - f. Fire performance, including fire endurance, flame spread, smoke and toxic gas emissions and residual strength following fire exposure;
 - g. Skid resistance and durability of anti-slip surface;
 - h. Ultraviolet protection;
 - i. Chemical resistance;
 - j. Maximum and minimum ambient temperatures
 - k. Static electricity discharge;
 - l. Grating fixing system;
 - m. Cut-outs and penetrations
 - n. Regulatory requirements
6. The GRP Grating Procurement Form in (Appendix B) may be used to assist in defining the design and performance requirements.

3.2 LAYOUT REQUIREMENTS

1. Grating layout shall comply with the requirements of DEP 80.00.10.12-Gen. as well as ISO 14122-2 and DEP 37.19.00.12-Gen.
2. Careful consideration shall be given to the selection of GRP grating products for escape and evacuation routes where there is a risk of impairment due to hydrocarbon fires.
3. Hydrocarbon fires pose a significant threat to all types of grating systems including the support structure. Whilst the fire performance of phenolic GRP grating is superior to other GRP resin systems, a steel grating may need to be specified to ensure risks are reduced to as low as reasonably practicable (ALARP). Risk analysis should be used to

identify any risk inherent in the selection of GRP grating and to compare this risk with a steel grating system operating under the same conditions.

4. The use of GRP grating systems shall also be considered with respect to operation and maintenance activities, e.g., where trolley access is required.
 - a. Care should be taken to ensure that GRP grating cannot be damaged from trolley wheel impact loading at the leading edge of any panel. This is particularly important where there is a height difference between adjacent panels, e.g., where GRP is used next to a steel flooring system. Transition plates should be provided, where practical, to avoid damage.
 - b. Consideration shall be given to the risk of temporary high mechanical and abrasive loading to GRP grating during installation and service and the need for temporary protection, e.g., by use of a protective plate.

GRP gratings are less robust than steel and are vulnerable to damage from point loads and severe abrasion, e.g., dragging of equipment across the surface.

5. GRP grating systems shall be supported using the same principles as those for metallic grating systems. The top surface of the relevant steelwork shall be prepared to prevent high contact stresses. Weld beads, spatter, etc., should be ground flush to within 1.0 mm (0.04 in).
6. The clear width of walkways for main escape and evacuation routes should be 1200 mm (47.25 in).
 - a. The qualification testing described in this DEP is based upon a grating span of 1200 mm (clear span of 1120 mm (44 in)). For applications where the grating span exceeds 1200 mm (47.25 in) additional qualification testing should be carried out to ensure the GRP product meets the requirements of this DEP.
 - b. The need for additional qualification testing should be discussed and agreed with the Principal.
7. To avoid trip hazards, the maximum height difference between adjacent flooring surfaces shall not exceed 4 mm (0.16 in).
 - a. It is not acceptable to trim or chamfer the surface of GRP panels; adjustment should be made to the supporting members to achieve a level walking surface.
 - b. Panel connectors may be required at mid-span, or other locations as necessary, to minimise differential deflection of adjacent panels and minimise potential trip hazards.
8. Structural arrangements and details shall be compatible with the existing walkways, if applicable, and should avoid the use of ramps at the interfaces wherever possible.
9. Pultruded GRP grating panels shall be orientated to ensure that load bearing bars span between supporting steelwork.
10. Grating panels should not be cantilevered more than 38 mm (1.5 in) beyond the edge of any supporting member.
11. The load bearing bars should be supported over a minimum length of 38 mm (1.5 in).
 - a. The minimum bearing length for pultruded grating shall be 25 mm (1.0 in).
12. Where a grating cut-out is required, consideration shall be given to providing additional support as described in (3.13).
13. Grating widths should be chosen so that, as far as possible, no grating panel is less than 300mm in width.
14. The exposed edge of a GRP grating panel at the top of stairs shall be protected from impact damage by fitting a suitable steel or FRP nosing. The nosing shall have a gritted surface for slip resistance and shall have a high visibility coloured leading edge.

3.3 SPACING BETWEEN LOAD BEARING BARS

1. The spacing between the load bearing bars shall be specified to ensure the grating system can resist the appropriate actions for the specific location in accordance with (3.4) as well as considering the risk of objects dropping through the grating.
2. In accordance with ISO 14122-2, the clear distance between load bearing bars shall not exceed 35 mm.
 - a. Where people are likely to be working below the grating system, consideration shall be given to reducing the spacing between the bearing bars to a maximum of 20 mm (0.8 in) or providing temporary protection such as the use of a protective plate to reduce the risk of dropped objects.
3. For routes subject to trolley wheel loading, the gap between the bearing bars should be reduced as much as possible to avoid grating damage.
 - a. Depending upon the actual wheel load and size of the wheels, the gap between the bearing bars may need to be reduced to less than 10 mm (0.4 in), i.e., a grating porosity of 40 percent.
 - b. For occasional trolley wheel traffic, the grating may need to be temporarily protected using boards or plate.
4. Load bearing bars for GRP grating will generally provide less porosity than steel grating. In some circumstances, the design of the grating may encourage the accumulation of snow and ice. This action effect shall be considered in design.
5. In areas where the grating system is considered to act as a vent for mitigating the effects of an explosion, the blockage caused by the grating shall be taken into account.
6. The effect of reducing the spacing between the load bearing bars should also be considered when developing the in-service inspection requirements for the grating fixings and immediate supporting structure.

3.4 DESIGN LOADING AND DEFLECTION

1. Gratings shall be designed to resist the most appropriate imposed loading for the specific area on the installation in accordance with DEP 37.19.00.12-Gen.
 - a. Values may need to be revised for an area to reflect actual usage.
 - b. Imposed loading for a specific location shall be agreed with the Principal.
2. Grating used for walkways which are not subject to wheel loads should normally be designed for a uniformly distributed load (UDL) of 5 kN/m² (104 lb/ft²).
 - a. A concentrated load of 5 kN (1124 lbf) applied in the most unfavourable position over an area of 300 mm x 300 mm (11.8 in x 11.8 in) should also be considered as a separate load case.
3. The maximum vertical deflection of the grating should not exceed 6.0 mm (0.25 in) or 0.5% of the span length, whichever is smaller, for the specified design loading.
4. For access routes used by maintenance trolleys, the wheel loads and loading arrangement should be established for the specific case.
 - a. Where the wheel contact area is undefined, the concentrated load should be assumed to be applied over a square area of 100 mm x 100 mm (3.9 in x 3.9 in).
 - b. Gratings subject to wheel loads shall also satisfy the wheel cyclic loading qualification tests described in (4.3.3).
5. Where grating is located in the wave zone, the panel and fixing system shall be designed to resist the appropriate environmental actions.
6. If the grating is located in a hazardous area, the effects of an explosion (drag loading) on both the grating and its fixing system should be taken into account.

7. If the grating can be exposed to loads in excess of that described in (3.4), the Manufacturer shall demonstrate that the grating product has satisfactory load and deflection performance.
 - a. Additional qualification tests should be considered and agreed with the Principal.
8. Load testing undertaken as part of the qualification programme, shall need to demonstrate that the ultimate strength of the grating product is at least five (5.0) times greater than the specified UDL and concentrated design loads.

3.5 IMPACT RESISTANCE

1. An impact assessment should be carried out to determine the likely dropped objects for a specific area and the associated impact energy.
2. As a minimum, gratings shall be designed to resist two levels of impact:
 - a. Level I: resistance against the impact of a flat circular object with a diameter of 254 mm (10.0 in) dropped from a height sufficient to develop an energy of 1355 J (1000 ft-lbf).
 - b. Level II: resistance against the impact of a 48 mm (1.9 in) diameter tube with a 4 mm (0.16 in) wall thickness dropped from a height sufficient to develop an energy of 522 J (385 ft-lbf).
3. After the impact, the panel shall have sufficient residual strength to resist a concentrated load applied over an area of 300 mm x 300 mm (11.8 in x 11.8 in) in accordance with (4.3.4).
4. If the grating can be exposed to impact in excess of the values specified above and cannot otherwise be protected, the Manufacturer shall demonstrate that the grating has satisfactory impact performance.
 - a. Additional performance tests should be considered and agreed with the Principal.

3.6 FIRE PERFORMANCE

3.6.1 General

1. For each location on the facility, the fire performance requirements shall be established.
2. Fire performance shall be characterised in terms of the following properties:
 - a. Fire endurance;
 - b. Fire reaction.

Fire endurance relates to the ability of the grating system to maintain load bearing capacity both during and after being exposed to the effects of a fire for a specified period of time. This may be important for escape and evacuation from the installation, access for fire fighting, emergency operations or rescue.

Fire reaction properties are material-related and are concerned with time to ignition; the surface flame spread characteristics including smouldering and post-fire-exposure flaming; and the rate of heat, smoke and toxic gas release.
3. A fire hazard analysis should be carried out to identify and assess fire events for the installation. This should be used to determine the fire performance requirements for the grating system based upon its specific location.
 - a. The performance requirements should be selected to ensure that the consequence of the fire event is consistent with the perceived risk level.
 - b. As a minimum, the following consequences should be considered: