PETROBRAS	TECHNICAL SPECIFICATION	N°: I-ET-3010.00-1352-130-P4X-001	
	CLIENT: SRGE		SHEET: 1 of 24
	JOB: -		-
	AREA: -		
SRGE	TITLE: FLOOR GRATINGS, TRAY SYSTEMS AND GUARDRAILS MADE OF COMPOSITE MATERIALS		INTERNAL
			ESUP

INDEX OF REVISION

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DATE	JUL/20/20	APR/01/21	AUG/17/21	OUT/10/22	NOV/06/2023	JUN/11/24
EXECUTION	DANISCHMIDT	CJH4	CJH4	CJH4	CJX4	CJX4
CHECK	FABIANA	CJX4	CJX4	CJX4	CJH4	CJH4
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1. OBJETIVE

1.1 The objective of this Technical Specification is to establish the minimum requirements that shall be met in providing and installing of composite materials for topsides structures.

1.2 This Technical Specification covers requirements for:

- Floor gratings
- Handrails / Guardrails
- Personnel walkways
- Platforms
- ladders' treads
- Stairs
- Catwalks
- Cable tray systems

1.3 For the purpose of this document, composite materials shall be understood as fiber reinforced plastic (FRP), also known as glass reinforced plastic (GRP), manufactured by pultrusion process for use in offshore facilities.

1.4 The requirements herein listed are applicable to all players performing such related activities within the scope of this unit, including SELLERs, main contractor, subcontractors, manufacturer, packager, suppliers, sub suppliers, integrators, constructors, and all technical personnel involved. Within the scope of this document, they are all referred to as being a SELLER.

1.5 In addition to the requirements of this technical specification, SELLER shall follow all the requirements of the Exhibit I (SCOPE OF SUPPLY), as well as Exhibit III (DIRECTIVES FOR PRODUCT DEVELOPMENT), Exhibit IV (DIRECTIVES FOR PRODUCT FABRICATION), Exhibit V (DIRECTIVES FOR ACQUISITIONS), Exhibit VI (DIRECTIVES FOR PLANNING AND CONTROL), Exhibit VII (DIRECTIVES FOR QUALITY ASSURANCE SYSTEM) and Exhibit VIII (DIRECTIVES FOR COMMISSIONING PROCESS).

2. NORMATIVE REFERENCES AND DESIGN SPECIFICATIONS

The application of composite materials shall be in accordance with this Technical Specification, with the following references and with Rules and Regulations of Classification Society. SELLER shall perform the work in accordance with the requirements of Classification Society.

2.1 CLASSIFICATION RULES, CODES & STANDARDS

Refer to Project General Conditions and Data Specification for nominated Classification Society. Relevant Class rules shall apply.

2.2 CODES AND STANDARDS

2.2.1 The following standards shall be considered for the application of FRP pultruded components within the scope of this specification. The latest version of the referenced document (including amendments) applies.

ABNT NBR 15708	Indústria de petróleo e gás natural – Perfis pultrudados – Partes 1 a 6
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C953	Standard Test Method for Time of Setting of Grouts for Preplaced-Aggregate Concrete in the Laboratory

ASTM D2565	Standard Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
ASTM D4385	Standard Practice for Classifying Visual Defects in Thermosetting Reinforced Plastic Pultruded Products
ASTM D4329	Standard Practice for Fluorescent Ultraviolet (UV) Lamp Apparatus Exposure of Plastics
ASTM E119	Standard Test Methods for Fire Tests of Building Construction and Materials
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F3059	Standard Specification for Fiber-Reinforced Polymer (FRP) Gratings Used in Marine Construction and Shipbuilding
EN 13706-2	Reinforced Plastics Composites – Specifications for Pultruded Profiles – Part 2: Methods of Test and General Requirements
EN 13706-3	Reinforced Plastics Composites – Specifications for Pultruded Profiles – Part 3: Specific Requirements
IACS Rec. No 73	Type approval procedure for cable trays / protective casings made of plastics materials
IMO RESOLUTION A.653	Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials
ISO 527-4	Plastics - Determination of Tensile Properties - Part 4: Test condition for isotropic and orthotropic fibre-reinforced plastics composites
ISO 4892-3	Plastics - Methods of exposure to laboratory light sources - Part 3: Fluorescent UV lamps
ISO 5658-2	Reaction to fire tests — Spread of flame — Part 2: Lateral spread on building and transport products in vertical configuration
ISO 5659-2	Plastics - Smoke generation - Part 2: Determination of optical density by a single-chamber test
ISO 14125	Fibre-reinforced plastic composites - Determination of flexural properties
ISO 14130	Fibre-reinforced plastic composites - Determination of apparent interlaminar shear by short-beam method

2.2.2 Testing´s criteria established in similar standards may be accepted, under previous PETROBRAS assessment (e.g., use of ASTM standard instead of ISO). The list of alternative standards below has already been approved by PETROBRAS:

a) ASTM E 84 or ISO 5658-2

b) ASTM E 84 or ISO 5659-2

c) ASTM D2565 or ASTM D4329 or ISO 4892-3

2.3 GOVERNAMENTAL REGULATION

NR-12 Brazilian Regulatory Standard - Safety in Machinery and Equipment work

NR-26 Brazilian Regulatory Standard - Safety Signing

NR-37 Brazilian Regulatory Standard - Safety and Health in Petroleum Platforms

*Note: Brazilian Government regulations are mandatory and shall prevail, if more stringent, over the requirements of this specification and other references herein.

2.4 REFERENCE DOCUMENTS

DR-ENGP-M-I-1.3	SAFETY ENGINEERING GUIDELINE
DR-ENGP-I-1.15	COLOR CODING
I-ET-3010.00-1200-956-P4X-002	GENERAL PAINTING
I-ET-3010.00-5140-700-P4X-002	SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS
I-ET-3010.00-5140-700-P4X-001	SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS
I-DE-3010.00-1400-140-P4X-011	STANDARD-PULTRUDED GUARDRAIL – TYPICAL DETAILS
I-DE-3010.00-1400-140-P4X-007	MODULES SECONDARY STRUCTURE – TYPICAL DETAILS
I-DE-3010.00-5140-700-P4X-002	POWER INSTALLATION TYPICAL DETAILS
I-DE-3010.00-5140-700-P4X-003	GROUNDING INSTALLATION TYPICAL DETAILS
I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
I-ET-3010.00-1200-251-P4X-001	REQUIREMENTS FOR BOLTING MATERIALS
I-ET-3010.00-1200-970-P4X-004	NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS

2.5 CONFLICTING REQUIREMENTS

In case of conflicting requirements between this technical specification and the referred applicable standards, the most stringent requirement shall prevail. In case of conflicting information between this specification and other specific document issued by PETROBRAS, a formal technical query shall be submitted, seeking clarification.

3. DEFINITIONS

All Terms and definitions are established in the latest revision of I-ET-3010.00-1200-940-P4X-002 – GENERAL TECHNICAL TERMS.

4. GENERAL REQUIREMENTS

4.1 SCOPE

4.1.1 This specification covers the requirements for Fiber Reinforced Plastic structures to be installed on open decks or semi-enclosed areas of floating production offshore facilities. The use of structural composite material in closed areas, such as accommodation, services, or control rooms, where smoke and toxicity are a concern, is not permitted.

4.1.2 This technical specification is not applicable to fabrication processes other than pultrusion. Items obtained by other processes shall be previously evaluated by PETROBRAS before being accepted and used.

4.2 MANDATORY USE OF FRP FOR SPECIFIC TOPSIDES STRUCTURAL APPLICATION

4.2.1 Material selection for outfitting's structure shall complies with Table 1. The application of FRP components for topsides structures established in the following table is mandatory and shall be assumed as minimum implementation of the material.

Table 1 – Required material selection for tertiary structures of topside modules.

Pultruded Systems	Oil processing and modules with liquid hydrocarbon / inflammable inventories[1]	Gas treatment and compression modules[2]	Utilities and power generation modules[3]
Floor grating / Stair treads[4]	Steel[5]	FRP	FRP
Ladders for equipment´s access	FRP	FRP	FRP
Ladders for elevation change	Steel	Steel	Steel
Guardrails[6,7]	FRP	FRP	FRP

NOTES

1) Oil processing and modules with liquid hydrocarbon / inflammable inventories: e.g. Oil Processing, Well Service, PIG receivers / launchers, production, and injection manifolds, produced water treatment and chemical injection systems and product storage.
2) Gas treatment and compression Modules: e.g. CO_2 removal, H_2S removal, Gas dehydration, hydrocarbons dew point control, VRU, main gas, CO_2, injection, and export compression.
3) Utilities and power generation modules: e.g. Water injection, sulfate removal unit, water deaeration, utilities, power generation, Automation and electrical.
4) Flare tower structure shall consider metallic material, due to the possibility of high temperature scenarios.
5) Liquid hydrocarbon processing locations are usually constructed with plate deck floor, instead of gratings.
6) Guardrails for fitted on exposed freeboard are to be provided in steel.
7) For laydown areas, the use of metallic guardrails shall be considered, to avoid damage of structures, due to the possibility of impact, during handling activities.

4.2.2 The use of pultruded components for structural profiles shall not be limited to the definition of Table 1. Others application may be approved based on the applicable rules of Classification Societies and the statements of International / local statutory laws and regulations.

4.2.3 In addition to the mentioned requirements, for floor grating application, the risk assessment of escape, evacuation and rescue shall be performed considering the selected material, to ensure that the use of FRP would not have a negative impact on safe escape and evacuation, as well as firefighting access.

4.2.4 For guardrails, the approved areas of application on offshore facilities shall be the same as established for grating panels, considering the Fire Integrity Matrix of ASTM F3059.

4.3 DESIGN

4.3.1 The composite components shall be designed for a minimum design life of 30 years.

4.3.2 The use of floor gratings, stair treads, ladders, catwalks, access platforms, structures and guardrails made of composite material shall observe the structural fire integrity matrix presented at ASTM F3059.

4.3.3 Composite materials for offshore installation shall have a type-approval certificate that attest that it complies with all relevant requirements mentioned in this document.

4.3.4 The design engineering, fabrication, and pre-assembly of structures shall be carried out at MANUFACTURER facilities. At the installation site is allowed final assembly and adjustments and finishing.

4.4 MATERIALS

4.4.1 RESIN SYSTEM

4.4.1.1 The application of acrylic or phenolic resin system is acceptable for cable trays.

4.4.1.2 Structural components as floor gratings, handrail systems, vertical ladders, shall be produced using phenolic resin.

4.4.1.3 The resin system shall be informed at project documentation, in addition to the statements of type approval certificates.

4.4.2 FIRE REACTION

4.4.2.1 FRP components shall consider the following fire reactions properties:

a) Flame propagation shall be tested in accordance with the method and acceptance criteria of ISO 5658-2.

b) Smoke density shall be verified to comply with ISO 5658-2, expect for 50 kW/m² test with flame.

c) Smoke toxicity according to ISO 5659-2.

4.4.2.2 The smoke toxicity test shall be performed during smoke density testing. The measuring shall be performed on the second or third test coupon at each established condition, with 3 minutes

maximum after the smoke density is achieved. The concentration of each toxic gas shall be determined in ppm at the chamber volume, being collected at the geometric center.

4.4.3 SALT MIST RESISTANCE

Salt mist resistance shall be evaluated with a saltwater spray test to be conducted in accordance with Practice ASTM B117.

4.4.4 WEATHERING RESISTANCE

4.4.4.1 For phenolic pultruded components, resistance to weathering shall be guarantee with an ultraviolet (UV) resistant coating, applied to the entire surface of the FRP component. The coating activity shall be performed in manufacturer facilities by its responsibilities and shall have at least 50 µm of dry film thickness. The coating thickness shall be assured by wet film thickness measurement.

4.4.4.2 For others resin systems, alternatively to the paint procedure, a gel coat with the incorporation of a surface veil may be considered, under previous approval by PETROBRAS.

4.4.4.3 Painting procedure shall be in compliance with technical specification I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING.

4.4.4.4 The color adopted shall be as defined in document DR-ENGP-I-1.15 – COLOR CODING.

4.4.4.5 UV resistance test methods and acceptance criteria shall conform with ASTM D2565 or ISO 4892-2 (cycle 1 for 720h). The tests results shall not evidence any damage on composite material, as cracks, blistering, delamination, exposure of fibers.

4.4.5 ANTI-SPLIT SURFACE REQUIREMENTS

If the component is specified with an anti-slip surface, the MANUFACTURER shall present the tests´ reports to ensure the attendance of this requirement. The anti-slip surface shall consider a uniform non-metallic grit and a heat cured adhesive. Static coefficient of friction and the durability of the anti-slip surface shall be included in reports.

4.4.6 STRUCTURAL PROPERTIES

4.4.6.1 All structural profiles shall full comply with Table 2 below.

Table 2 - Minimum Properties required for each grade.

Property	Unit	Test Methody	Minimum Properties	
			E23	E17
Full section test	GPa	EN 13706-2 (Annex D) or ABNT NBR 15708 Part 5 (Annex B)	23	17
Tension modulus-axial	GPa	ISO 527-4	23	17
Tension modulus-transverse	GPa	ISO 527-4	7	5
Tension strength-axial	MPa	ISO 527-4	240	170
Tension strength-transverse	MPa	ISO 527-4	50	30
Pin-bearing strength-axial	MPa	EN 13706-2 (Annex D) or ASTM C 953	150	90

Pin-bearing strength-transverse	MPa	EN 13706-2 (Annex D) or ASTM C 953	70	50
Flexural strength – axial	MPa	ISO 14125	240	170
Flexural strength – transverse	MPa	ISO 14125	100	70
Interlaminar shear strength-axial	MPa	ISO 14130	25	15

4.4.6.2 The coefficient of variation of mechanical properties (Table 2) shall not exceed 10% to ensure confirm the homogeneity of the pultruded profile.

4.4.6.3 The reports of all tests required by ABNT NBR 15708, as well as the tests to obtain the type-approval certificates shall be submitted to PETROBRAS to review.

5. SPECIFIC DESIGN REQUIREMENTS FOR FLOOR GRATINGS AND STAIR TREADS

5.1 All floor gratings, including stair treads, personnel walkways, catwalk, platforms, and others FRP´s gratings shall be designed according to ASTM F3059. The appendixes of the ASTM standard, stated as nonmandatory information, shall also be incorporated as technical requirements under the scope of supply, unless otherwise stated in this Technical Specification.

5.2 Gratings shall meet at least Level 2 (L2) performance criteria of structural fire integrity, regardless the topside area where the FRP grating will be installed, to guarantee the highest degree of safety and the proper logistics of installation and to avoid mistakes if the component needs to be replaced.

5.3 All components of grating panels and stair treads (as bearing bars, crossroads, nosing, tread covers, etc.) shall be produced using phenolic resin and manufactured from the pultrusion process.

5.4 The definition of areas where grating panels may be applied in offshore facilities shall consider the criteria of Table 1 - Structural Fire Integrity Requirements of ASTM F3059.

5.5 Bearing bars of FRP gratings shall have minimum nominal beam depths of 38 mm.

5.6 The stair treads design shall consider a structural reinforcement of a square pultruded shaped Integrated nosing, made of the same resin as the grating, installed in the front ends of the panel. All components shall be assembled fixed together by means of secondary beams or bolts. It shall ensure that the stair treads widths are terminated with closed ends on both sides of the panel.

5.7 All gratings and stair treads, as well as all catwalk levels and steps, shall have an anti-slip surface. Stair treads nosing shall have an anti-slip surface on both the horizontal and vertical faces.

5.8 The fasteners for attaching the grating panel to the supporting structure shall be made of UNS S31600 stainless steel. Screws, nuts, and washers shall be austenitic stainless steel 316 (UNS S31600), and insulation systems in non-metallic materials shall be provided for to avoid contact with a carbon steel structure (e.g., rings, bushings, washers, spacers, polypropylene, polychloroprene, etc.).

6. SPECIFIC DESIGN REQUIREMENTS FOR GUARDRAIL / HANDRAIL SYSTEMS

6.1 Guardrails shall be design according to ABNT NBR 15708 part 2. All structural components of guardrails systems shall be pultruded.

6.2 Guardrails´ typical details and dimensions shall be as defined at I-DE-3010.00-1400-140-P4X-011 – STANDARD-PULTRUDED GUARDRAIL.

6.3 Handrail shall include at least two midrails (crossbars) at an equivalent distance from the handrail and kickplate. There shall not be more than 3 (three) crossbars, which shall keep the same distance between each other and between the handrail and the kickplate.

6.4 Handrail profiles shall be constructed as per ABNT NBR 15708 part 2 and NR-12 requirements.

6.5 The kickplate of the guardrails shall be provided as W-shaped or M-shaped pultruded plate.

6.6 The anchoring system of the guardrail shall be made of painted/coated carbon steel suitable for the installation site according to PETROBRAS´ specifications. Provision for water drainage shall be provided. The anchoring supports shall be bottomless or, in case of support with closed bottom, drilled holes for water drainage shall be provided to avoid corrosion.

7. SPECIFIC DESIGN REQUIREMENTS FOR VERTICAL LADDERS AND ACCESS PLATFORMS

7.1 Catwalks or vertical ladder profiles shall follow ABNT NBR 15708 part 6.

7.2 Vertical ladder and cage system in composite material shall be designed by MANUFACTURER. The specification and installation details shall be indicated in a general arrangement drawing to be issued by the MANUFACTURER to PETROBRAS´s approval.

7.3 The application of vertical ladders and platforms shall comply with the requirements of Technical Specification I-ET-ERGONOMICS REQUIREMENTS FOR TOPSIDES [document supplied by PETROBRAS].

7.4 In case of ladders to be installed at escape routes, the requirement of fire resistance established in item 7.1.6. of ABNT NBR 15708 part 6 is mandatory.

7.5 Adequate anti-slip material shall be applied in the region of the steps (rung).

8. SPECIFIC REQUIREMENTS FOR CABLE TRAY SYSTEM

8.1 Cable Tray systems shall be according to the requirements of I-ET-3010.00-5140-700-P4X-002 – SPECIFICATION FOR ELECTRICAL MATERIAL FOR OFFSHORE UNITS.

8.2 Cable trays installation shall comply with I-ET-3010.00-5140-700-P4X-001 – SPECIFICATION FOR ELECTRICAL DESIGN FOR OFFSHORE UNITS, I-DE-3010.00-5140-700-P4X-002 – POWER INSTALLATION TYPICAL DETAILS and I-DE-3010.00-5140-700-P4X-003 – GROUNDING INSTALLATION TYPICAL DETAILS.

9. SCOPE OF SUPPLY

9.1 The MANUFACTURER´ scope of supply shall include, but is not limited to:

a) Datasheets of all components.

b) Bill of materials.

c) Drawings for each typical component with dimensions.

d) Structural calculation report for all non-typical structural manufactured with pultruded profiles.

e) Installation drawings (assembly diagram)

f) Installation procedures

g) Cut-off procedure and instruction for sealing cut ends of FRP grating panel and other components.

h) Inspection procedure.

i) Required documentation for the certifying authority, in compliance with the latest edition of their rules for offshore facilities.

j) Provision of all required component, material, accessory, and special tools, to carry out the field assembly, installation, and inspection of the composite components.

k) Raw material certificates

l) Type approval certificates.

m) Data-book of each FRP component, including its specific documents, all tests' reports required by this specification, type-approval certificates issued by a Classification Society.

10.PACKING, PRESERVATION, HANDLING, STORAGE AND SHIPPING

10.1 SELLER shall present a procedure for delivery inspection, storage, preservation, and handling of pultruded components, approved by PETROBRAS and by MANUFACTURER.

10.2 The transport and handling of the composite materials shall be carried out carefully, avoiding impacts. Components shall be packed using protections to avoid damage between the parts.

10.3 Smaller components, such as screws and metal supports, shall be transported in cardboard boxes, wooden boxes, or other suitable packaging.

10.4 Shop-assembled sections shall be kept protected in the original packing of the transport until the beginning of the field assembly. Pre-assembled sections shall not be stacked or placed on top of hard or sharp surfaces that may cause damage (such as stones, for example).

10.5 Components in FRP (Fiber Reinforced Plastic) shall never be thrown or dragged on to the ground, as they are susceptible to mechanical damage by impact and by hard or sharp surfaces. Because of their low weight, some components in FRP may be erected manually, however, components of large lengths, or volumes, shall be erected with appropriate equipment or adequate amount of people, avoiding bending.

10.6 When unloading individual components and pre-assembled sections, visual inspection shall be carried out to verify possible damages caused during transport or not detected after manufacturing, according to ASTM D4385.

10.7 Materials and accessories shall be handled in such a way as to prevent damage. The execution of the loading and unloading service shall be carried out in such a way as to avoid impacts and the equipment used shall be in accordance with the operation performed.

10.8 To ensure integrity of components during transportation and handling, original packaging shall be removed only at the time of installation. If the packaging is required to be opened, it shall be replaced. If there is no packaging or damaged packaging, use plastic wrap or other suitable material. The use of metal straps is not allowed.

10.9 FRP components shall not be stored directly on the ground, on sharp metal surfaces or on concrete floors. Wooden or polymeric decks may be used.

10.10 The MANUFACTURER´s recommendations for packing and maximum stacking of components shall be followed.

11.INSTALLATION

11.1 GENERAL REQUIREMENTS

11.1.1 MANUFACTURER shall present a procedure for installation and assembly of all components and structures in composite for evaluation and approval by PETROBRAS.

11.1.2 Components in composite materials (guardrail, floor grating, stair treads and their subcomponents, traying systems, structural profiles, and ladders) shall be installed in accordance with the rules of the Classification Societies of each Unit, where applicable.

11.1.3 Drilling and/or cut-off of structural profiles shall be carried out according to the design and MANUFACTURER’s procedures. If any change is required, MANUFACTURER shall approve it previously.

11.1.4 Cut ends of shapes shall be properly sealed with compatible resin and then painted using specification of composite MANUFACTURER.

11.1.5 Pressure washer with a flat washer or self-locking nut with a flat washer shall be used to secure structures.

11.1.6 Any amendment to the structural profile required to be made in the field shall have approval from the MANUFACTURER.

11.1.7 The acceptable torque range on the structural profile fixing screws is shown in Table 1 of this Technical Specification.

11.1.8 After installation of a composite structural material an inspection shall be carried out to ensure compliance with all requirements presented at design documentation prior the release of the area.

Table 3 - Recommended torque (N.m)

COMPONENT	CONDITION	MINIMUM	MAXIMUM
Guardrails	2" or 50mm square tube with reinforcement, 1/4 or 6mm thick. Fixation types: Lateral plate; square tube sleeve, Double lateral plate	15	22
	Handrail / intermediate crosspiece connection, 1/4 or 6mm thick - without reinforcement	10	15
Structural profiles Cable trays Ladders / catwalks	Union of non-tubular pultruded profiles with thickness > 3mm	15	22

11.2 SPECIFIC REQUIREMENTS FOR GRATINGS

11.2.1 In cases where there is interference in the grating, it shall be checked in the field whether each part is adequately identified as to its location and positioning, to follow the sequence defined in the assembly diagram. If a divergency is confirmed (e.g., no position identification, inadequate identification, different dimensions), SELLER shall correct or replace it.

11.2.2 When installing the stair treads, attention shall be paid to the correct position of the tread set + side support (in the case of profile “F”), considering that the bevel of the side bracket shall be aligned with the slope of the ladder, i.e., in the rear position of the ladder.

11.2.3 The bearing bars of the grating panels shall consider at least 36 mm on each side of the grating support beam. Details are presented at I-DE-3010.00-1400-140-P4X-007 – MODULES SECONDARY STRUCTURE - TYPICAL DETAILS. The support beam shall have a width of 75 mm, as shown in Figure 1.

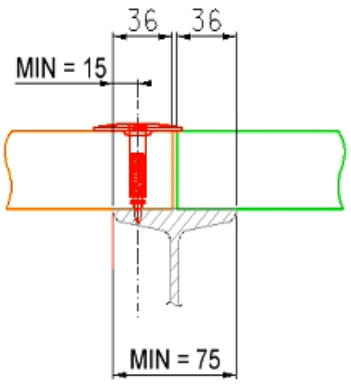

Figure 1: Fixation of grating at support beam.

11.2.4 The gap between floor grating panels that share the same support beam and between any restraints shall not exceed 8 mm.

11.2.5 Where there is no lateral containment to ensure this maximum distance (i.e., no other nearby floor grating, guard kick boards, or others that may serve as a stopper) the containment of the floor grating shall be provided to avoid any horizontal displacement.

11.2.6 Figure 2 illustrates the correct direction to install the grid panel, the bearing bars shall be transversal to the support beams.

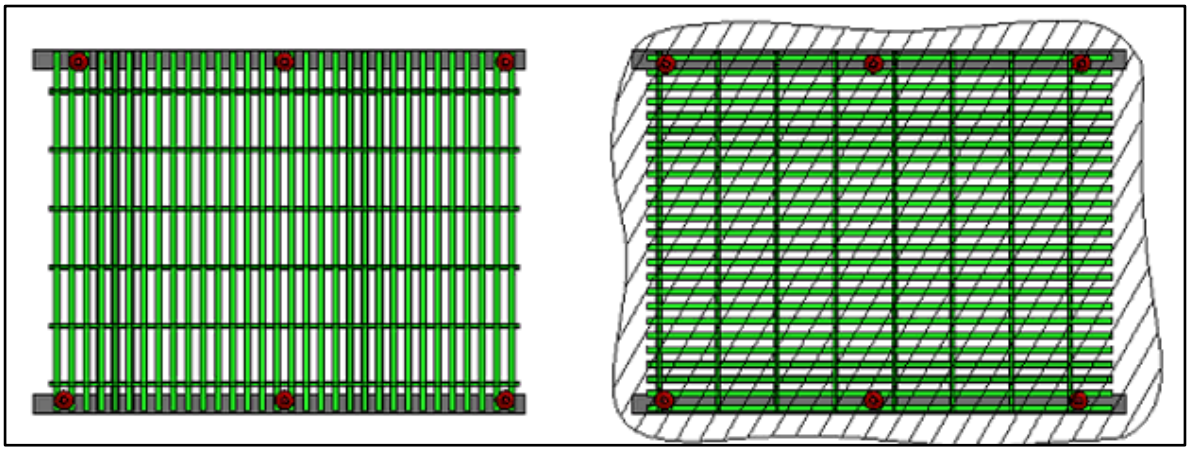

Figure 2 – Orientation regarding gratings supporting beams.

11.2.7 In case the width of support beam is insufficient, considering the indication of item 11.2.3, SELLER shall present to PETROBRAS a construction drawing with a detail of the solution for approval.

11.2.8 The following assembly alternatives were validated by PETROBRAS for grating support with insufficient width:

a) Assembly may be carried out as long as the panels are confined at both ends of the port elements. To do this, the assembly shall provide the installation of additional elements to the fasteners that prevent any displacement in the horizontal plane of the grating. In these situations of confined grating, it shall be accepted that the bearing bar are supported with a minimum of 22 mm on the support beam. Under no circumstances may there be clearance that, with the displacement of the grating to one side, the port bars are less than 22 mm on the beam. Figure 3 and Figure 4 Illustrate details for this alternative.

b) The following alternative allows the grating to be mounted on profiles with a flange width bf ≥ 49 mm. In these cases, it shall be necessary to interlace the bearing bars (for gratings of pultruded composite material), and the fixation shall be by pin stuck in the support beam, respecting the criteria presented in Figure 5.

c) The grating panel shall always be sized so that it fills the gap between the supports without any leftovers that exceed the limits of the supports (ends that are in balance). However, in some situations such as in proximity to equipment or out of accommodation, there may be openings that do not have sufficient supports for supporting of gratings (only one support, for example), with an opening with consequent risk of fall. In that case, the grating may have a length that exceeds the width of the support, with swing ends. However, the unsupported part (in balance) shall not be longer than 400 mm (see Figure 6). In addition, the number of fixed brackets of the grating should be increased by placing 4 (four) additional fasteners to the 4 (four) already mandatory, totaling 8 (eight) fasteners (4 (four) equidistant in each grating support).

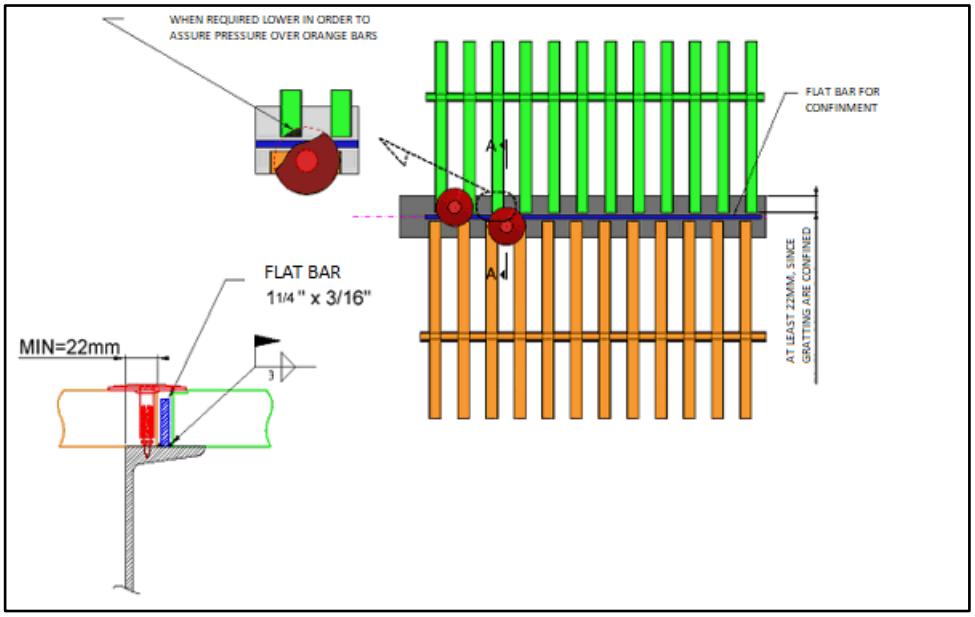

Figure 3 – Alternative with confined gratings with a port bar at the extremity.

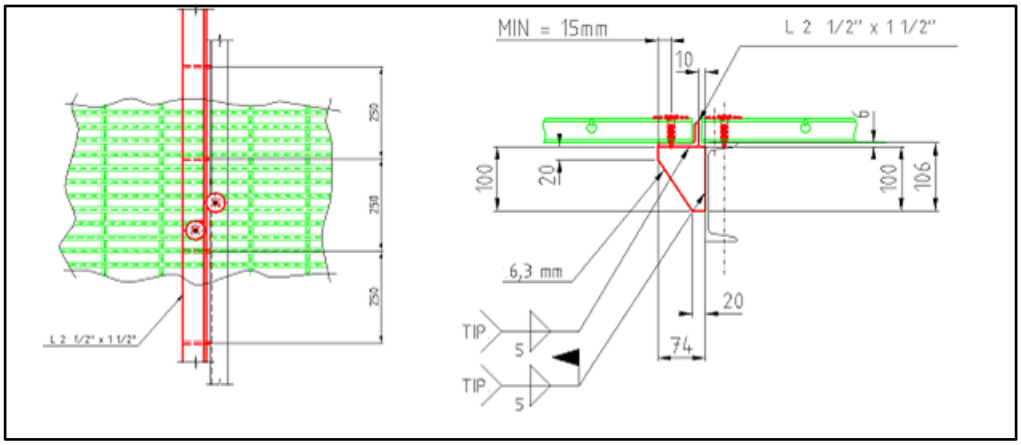

Figure 4 – Alternative for confinement with increase of support width.

Note: In this case the assembly shall be preceded by a specific design drawing. The interlacing of composite material grating is only allowed if fixing pins are installed at the end of the bearing bars, thus ensuring that the panels do not move in the horizontal plane.

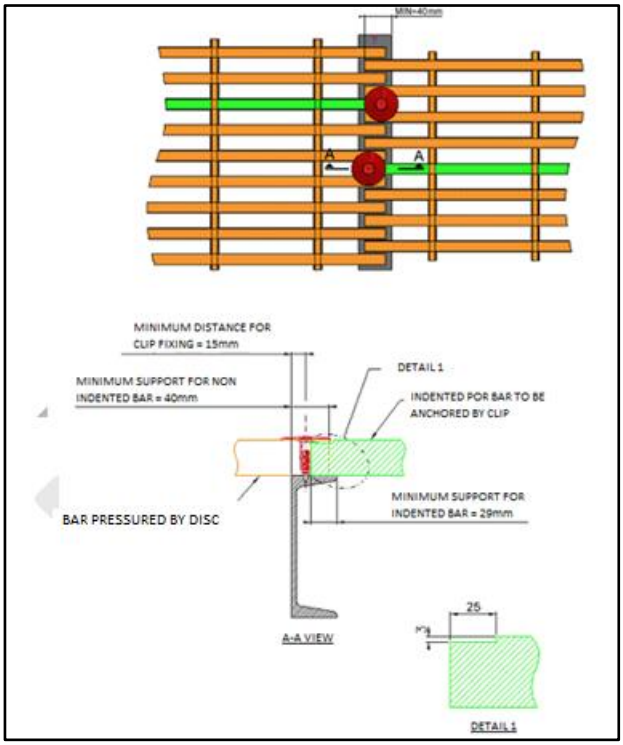

Figure 5 - Alternative for optimization of support with interlacing of composite material gratings and the support beam.

11.2.9 For this solution it is considered that the existing supports have sufficient widths for grating support. Otherwise, one of the previous alternatives shall be adopted to increase the width of the supports.

11.2.10 This balance-end solution is restricted to the conditions described herein, i.e., when sufficient supports are missing in an opening not larger than 400 mm.

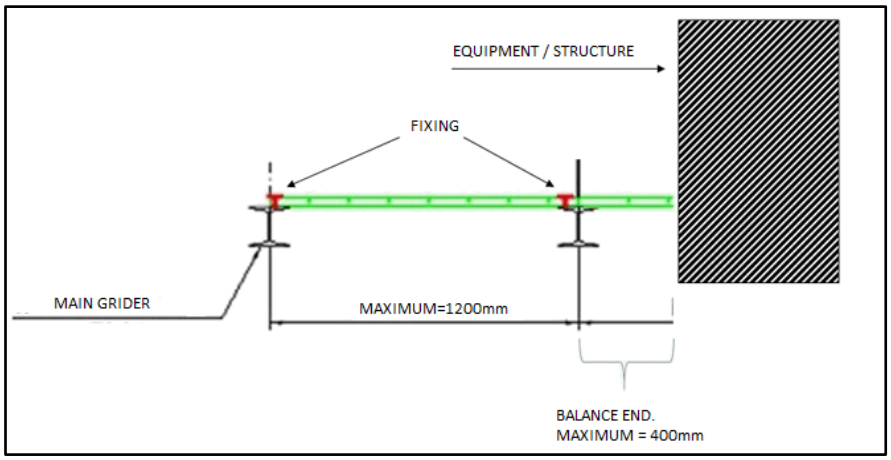

Figure 6: Detail of grating installation in balance.

11.2.11 Floor grating panels shall be mounted as Figure 7, so that there are:

a) At least 04 (four) fasteners per each grating panel, except for triangular geometries where 03 (three) fasteners may be accepted.

b) In the longitudinal direction of the bearing bars the maximum spacing between fasteners shall be 1200 mm.

c) In the transverse direction to the bearing bars, the maximum spacing between fasteners shall be 1500 mm. When the number of fasteners exceeds 04 (four) per grating panel, they shall be equally distributed.

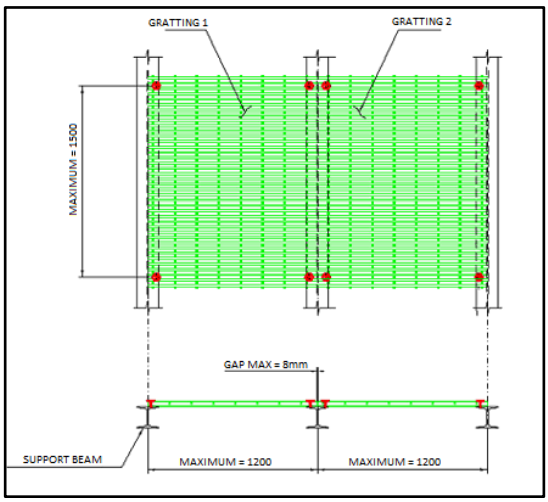

Figure 7: Maximum distance between fixings.

11.2.12 Whenever possible the fasteners should be installed in positions that contribute to avoid the sliding of the grating, that is, that they may act as stops for the horizontal displacement of the floor grating.

11.2.13 Care shall be taken in the assembly of the fastener with pin discs. It shall be guaranteed sufficient contact with the grating, as shown in Figure 8. The minimum thickness for applying the pin disc by pistol is 4 mm.

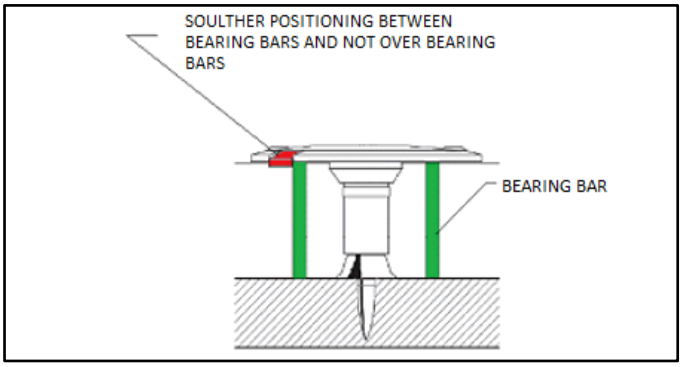

Figure 8: Detail related to pin disc positioning.

11.2.14 Typical models of accepted grating hold down fasteners are presented in Figure 9, Figure 10 and Figure 11, which are the saddle clips, insert clips and the pin disc attached by pistol (shot

stud). Each type of fixation has specific characteristics and criteria that shall be observed for correct fixation.

11.2.15 Each type of fixator has its characteristic, and some criteria shall be observed for a correct fixation:

11.2.15.1 Metallic Clip:

a) These typical clips are those for fixing on the side of the "U" profile support beam, clips with lower plate/bar type "L" fixing on the support beam flange, and clip with attachment through hole in the surface of the support beam.

b) The metallic clip models shall also be chosen according to the following criteria:

- Profile of the bearing bars: as the profile of the bars of the metal and composite bars differ from each other (profile "I" without flange and with flange), the clips shall be such that they match each type of profile. For this, the upper clip part that is in contact with the grating shall have an appropriate shape that adapts to the shape of the bearing bar of each grating.
- Grating mesh opening dimension: the dimension of the upper clip shall correspond to the width dimension between the grating bars.
- Size and profile of the support beam: some clips have a shape that are best suited to certain types of support beams, such as "L" lower plate clips for "I" beams.

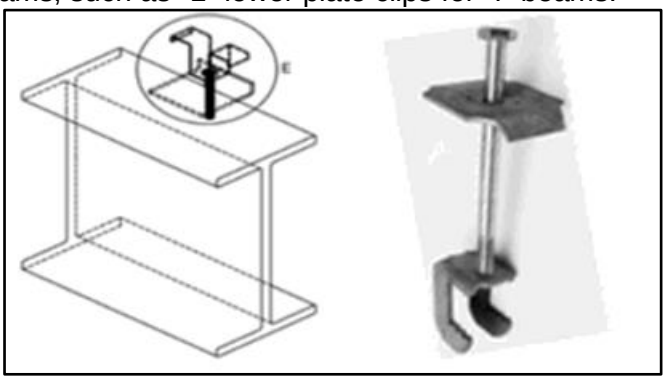

Figure 9: At left, saddle clip with inferior “L” plate for fixing at beam flange; and at right, saddle clip with inferior “L” plate for fixing at beam flange with stud from set top.

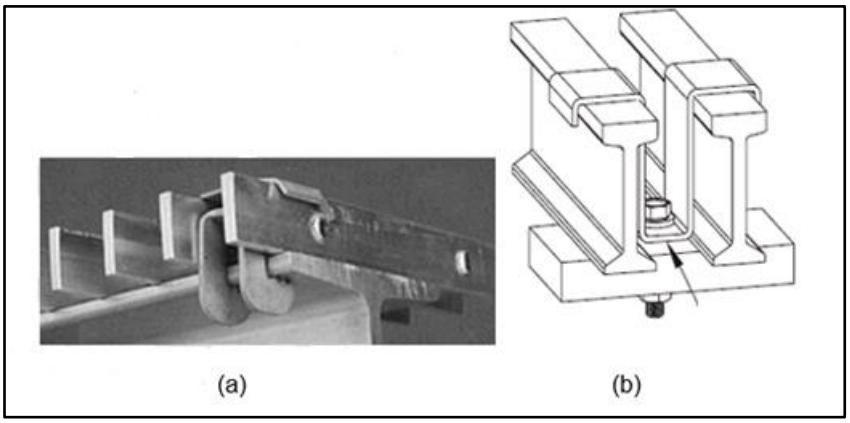

Figure 10: (a) “G” saddle clip for flange beam fixing. (b) “U” saddle clip with fixing through support beam.

c) In case of use grating attachments with metal clamps in regions subjected to vibration, physical means to mitigate the loss of preload of the fasteners shall be provided. It shall be adopted a solution as stainless steel nylon lock nuts ("nyloc") or anti-vibration nut serrated base or chemical locking (thread lockers) that allows the nut to be removed without the need for heat application.

11.2.15.2 Pin disc by fastening tools (e.g., shot gun)

a) The use of this fastener requires a professional trained by the tool´s SUPPLIER.

b) For the correct installation, two preliminary checks are required, i.e.:

- Thickness of the profile flange where the pin will be fixed - the type of pin to be chosen depends on the thickness, which shall not be less than 4 mm. The thickness value is important to determine the choice of the type of pin to be spiked, which implies the correct type of fastening tools and cartridge to be used.

- Floor grating height: The discs to be threaded into the pin shall be chosen depending on the height of the grating. The application of a disc with height incompatible with the grating generates an inadequate fixation, and the disc may come loose from the pin.

- When using pin-type fasteners, it is essential to follow the correct installation instructions of the MANUFACTURER.

Figure 11 : Pin disc by fastening tools.

11.2.16 Although the cut-out in grating panels is accepted, the assembly field installation shall consider the use of grating panels manufactured already in the required dimension, to minimize the need of the cut-outs required for achieve the target position.

11.2.17 MANUFACTURER shall provide all required instructions for cutting procedure.

11.2.18 After cutting procedure, cut ends shall be sealed with the resin recommended by MANUFACTURER.

11.2.19 If the grating panel needs to be cut-outs for pipe and / or equipment passage, the ends of the retaining bearing bars shall be supported, in addition of the resin sealer. If the cut-out clearance is greater than 10% of the penetration diameter or 50 mm, whichever is shorter, the ends shall be reinforced with composite material of the same specification as the grating. The design of this reinforcement shall have approval from the MANUFACTURER and PETROBRAS.

11.2.20 The floor grating panel shall have at least 9 (nine) bearing bars. Modifying the floor grating mesh is not permitted, either by removing bearing bars or connecting elements. Even for clipped panels, the original mesh configuration shall be maintained. Some clippings may imply that bearing bars are connected by only one connecting element. In these cases, devices shall be included to

ensure that the bars are connected. Figure 12 and Figure 13 present typical details for cut-outs on floor gratings.

11.2.21 In addition of the reinforcements presented in Figures 12 and 13, a proper finishing shall be used on open mesh flooring. Fire resistant non-slip FRP kickplate systems, as sleeve, collars, or penetration plates, shall be installed to guarantee grating integrity and personnel safety. An example of typical pipe collar for finishing of grating penetration is shown in Figure 14.

11.2.22 To avoid unnecessary cut-off of the floor grating panel, SELLER shall preferably consider the installation of guardrails externally to the grating support beam.

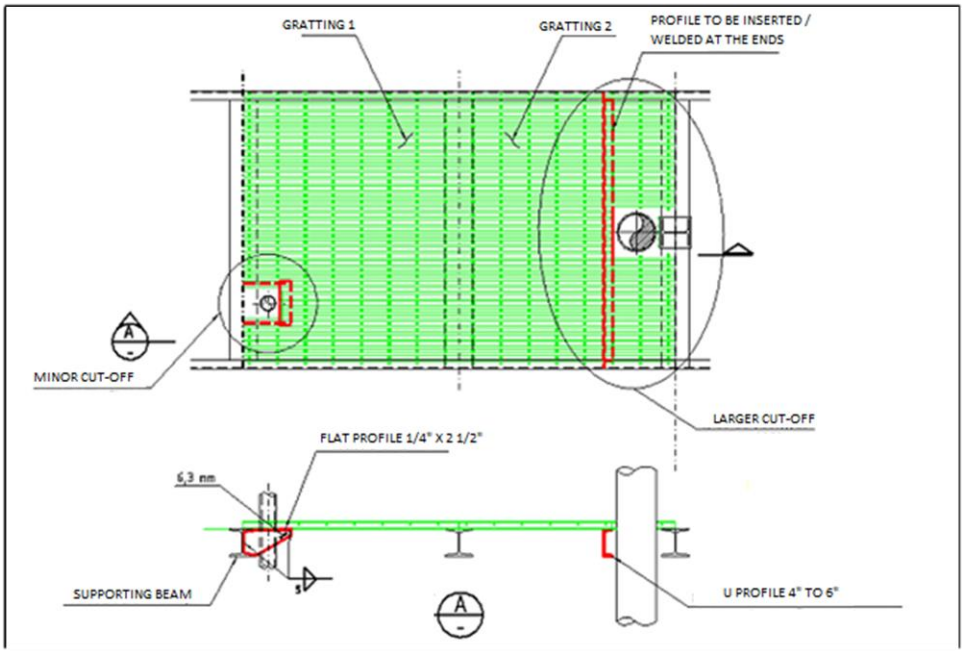

Figure 12: Examples of additional support for cut-off bearing bars.

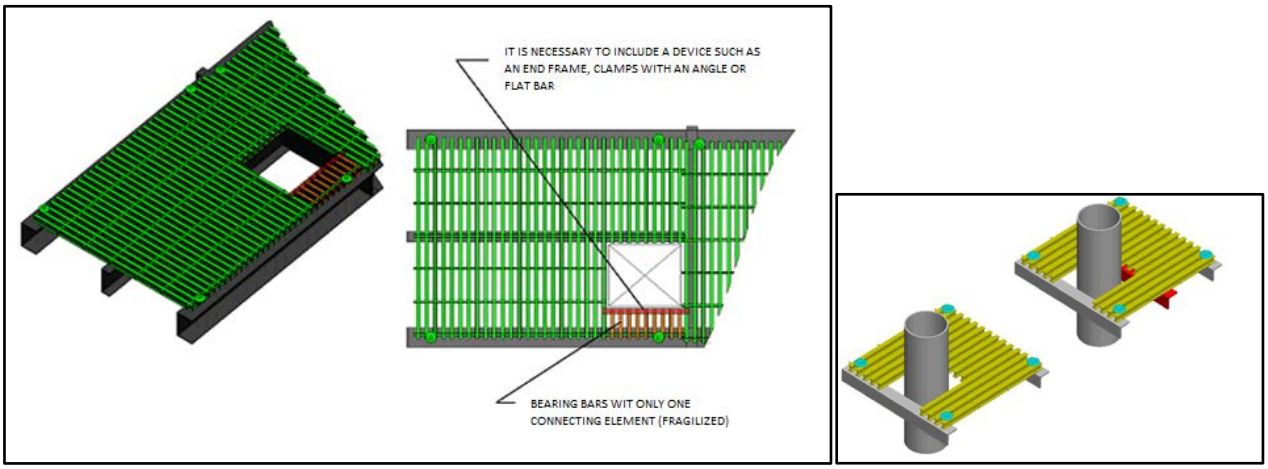

Figure 13: Details of cut-off in pultruded grating.

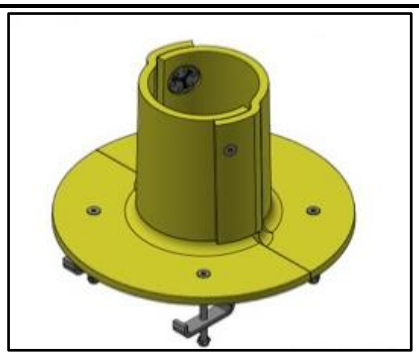

Figure 14 - Pipe collar for floor grating penetration.

11.3 SPECIFIC REQUIREMENTS FOR GUARDRAILS

11.3.1 The guardrail anchoring system shall have previous approval by MANUFACTURER and PETROBRAS and shall be designed to avoid damage to the composite material and decrease of mechanical strength (e.g., unnecessary drilling). The guardrail attachment shall be according to one of the schemes of Figure 15, Figure 16, and Figure 17 (installation with two side plates, fixation with square tube sleeve or installation with one side plate).

11.3.2 The guardrail shall be fixed to the floor by means of 1/2” bolts and nuts and 25 mm washers in accordance with I-ET-3010.00-1200-251-P4X-001 - REQUIREMENTS FOR BOLTING MATERIALS. Bolts shall have a partial thread and be sized so that the thread is not in contact with the composite material of any of the profiles or inserts, thereby avoiding wear on the holes of these profiles and inserts.

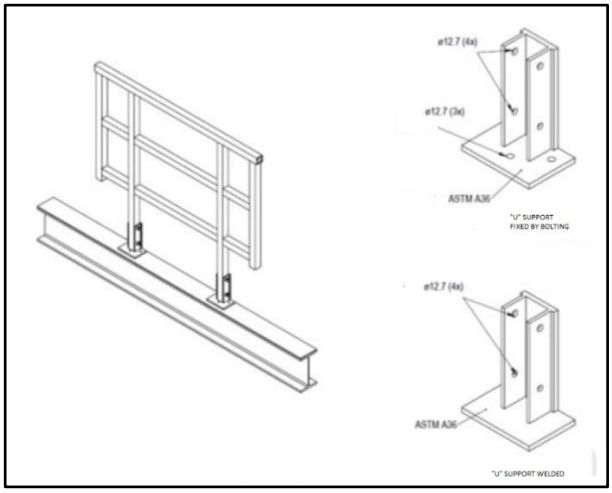

Figure 15: Fixation type two side plates.

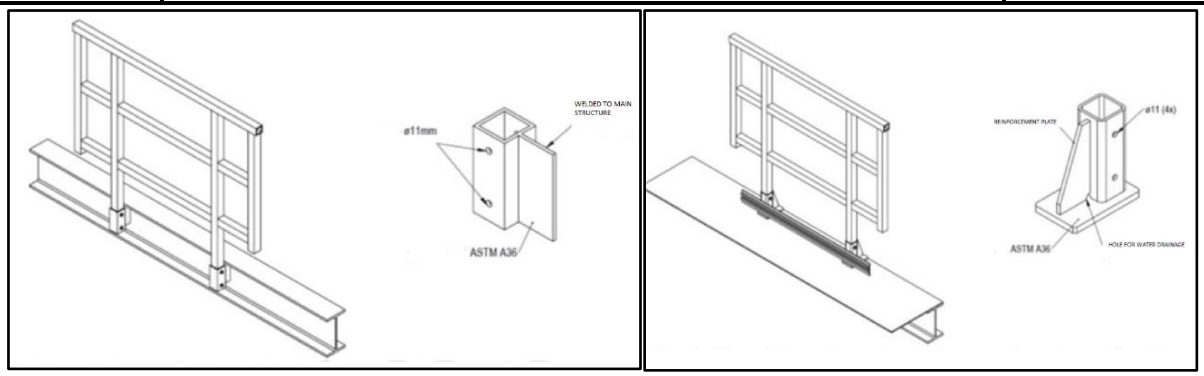

Figure 16 : Fixation with square tube sleeve.

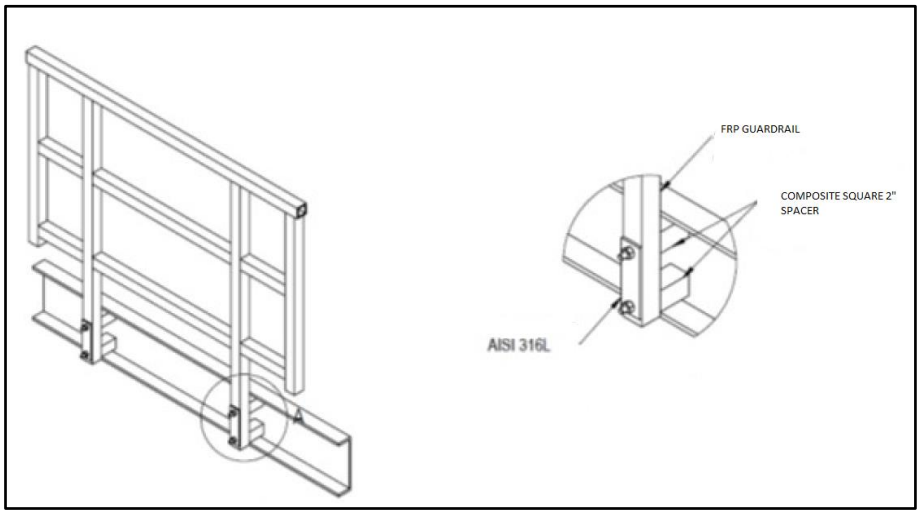

Figure 17: Fixation type one side plate.

11.3.3 Screws, nuts, and washers made with austenitic stainless steel 316 (UNS S31600) shall have insulation systems in non-metallic materials (e.g., rings, bushings, washers, spacers, using materials like polypropylene, polychloroprene, etc.) to avoid contact with carbon steel structure.

11.3.4 The guardrails shall be checked with regards to dimensions and identification of position prior the assembly.

11.3.5 During anchoring/fastening of guardrails it shall be verified the presence of the solid internal element (plug) in the connections, to prevent tube crushing. In case of absence of the plug, MANUFACTURER shall repair the component to install the solid internal element.

11.3.6 At the side edges of the guardrail, the length of the handrail, crossbars and kick board beyond the fixation point shall not exceed 500 mm. When this length exceeds 200 mm, a connection and locking system shall be provided in the parts (handrail bar, crossing bars and kick board) to

ensure the stiffness of the system, as shown in Figure 18. Attention to the proper position of the screws. Screw size shall be kept avoiding risks to users due to possible sharp edges.

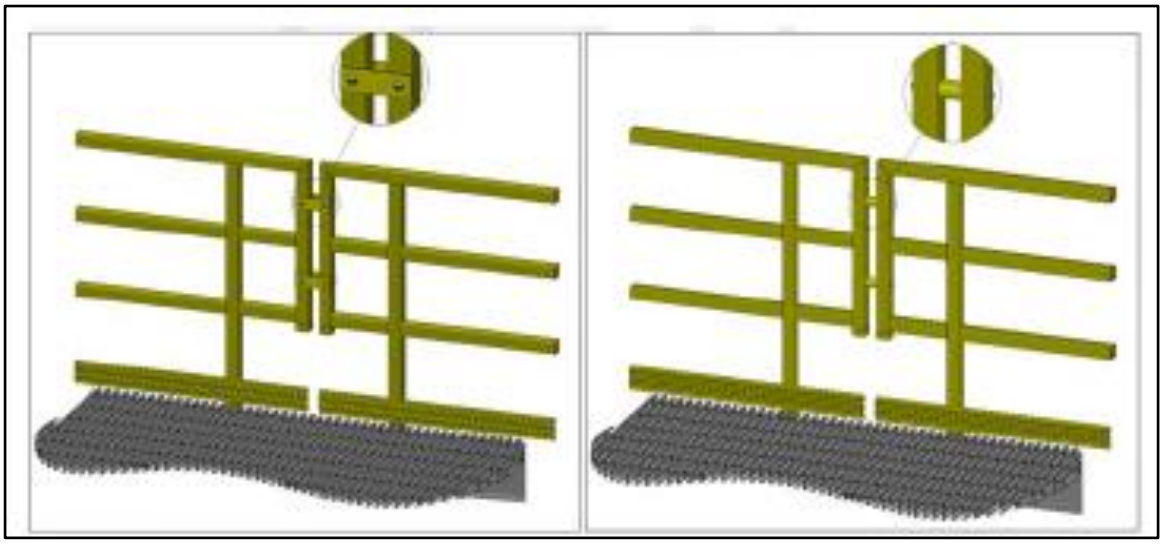

Figure 18: Connection and locking system.

11.3.7 Critical regions such as gaps between the guardrail and metallic supports, as well as dissimilar material joints, shall be protected by a suitable anticorrosive coating, as determined at I-ET-3010.00-1200-956-P4X-002 – GENERAL PAINTING.

11.3.8 It is not permitted to attach seat belt carabiners to the composite handrails/guardrails and to use these guardrails for attachment to other secondary structures, accessories, or anchor points for scaffolding. For activities requiring the use of a seat belt, a life cable shall be provided.

11.3.9 The acceptable torque range on the fixing screws is shown in Table 3.

11.4 **SPECIFIC REQUIREMENTS FOR VERTICAL LADDERS**

11.4.1 If the design specifies a splice on the main shaft of the ladder, the joint shall be made with locking by means of a solid element with at least two screws at each end of the reinforcement.

11.4.2 The anchor points of the ends (top and bottom) of the ladder shall be provided with an internal solid internal element (plug) to prevent tube crushing during assembly.

11.4.3 The acceptable torque range on the vertical ladder fixing screws is shown in Table 3 of this technical specification.

12.INSPECTION

12.1 The standard ASTM D4385 shall be used as criteria for visual inspection.

12.2 MANUFACTURER shall provide documented schedules with the estimated completion dates. These schedules shall be issued by the same time the drawings are submitted for approval, as indicated in the agreed document schedule.

12.3 PETROBRAS reserves the right to inspect all items at any time during fabrication to ensure that the materials and workmanship are in accordance with this specification and all applicable documentation.

12.4 SELLER is responsible for the overall compliance of the Unit when it comes to the CLASS requirements, including certificates, work examinations and tests, as well as final inspection activities and shipment.

12.5 The materials delivery inspection shall, at least, include the following inspections and check activities, that may be witnessed by PETROBRAS inspector. After proper notification of the scheduled point, PETROBRAS will advise SELLER about the availability to hold the activity.

a) Verification of construction materials for conformity with the specification requirements.

b) A visual check noting:

- That the thickness of the parts meets or exceeds the quoted design thickness.
- Any repairs.
- Dry-film thickness of applied coatings.
- The general appearances, materials, workmanship and standard of finish.
- Dimensional tolerances by ASTM D3917.
- Visual inspection by ASTM D4385.
- Correct alignment.

c) Barcol hardness test, in accordance with ASTM D2583. The acceptance criteria shall be minimum 40.

12.6 In case of use of transport trolleys, care shall be made to avoid damage to the grid rail.

12.7 Adhesives or resins that may be required for assembly shall not be exposed to heat, sunlight, and or moisture, as determined in the MANUFACTURER's guidelines. In that case, the batch and validity of the products should be used in order not to use expired products.

12.8 For sampling system, it shall be considered as batch each group of component / material listed in the specific invoice.

12.9 The testing shall also observe the requirements of I-ET-3010.00-1200-970-P4X-004 - NON-DESTRUCTIVE TESTING REQUIREMENTS FOR METALLIC AND NON-METALLIC MATERIALS.

12.10 Certificates of raw material and reports of the type and of the finished product tests performed at the MANUFACTURE’s site shall be analyzed according to ABNT NBR 15708 Parts 1 and specific Part for each component.