



Standard Specification for Fiber-Reinforced Polymer (FRP) Gratings Used in Marine Construction and Shipbuilding¹

This standard is issued under the fixed designation F3059; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This specification provides the testing and performance requirements for fiber-reinforced polymer (FRP) gratings used in marine construction and shipbuilding as an equivalency to the specification of steel gratings rated for a maximum load of 94 lbf/ft² (4.5 kN/m²).

1.2 The purpose of this specification is to ensure that all FRP gratings are designed and tested appropriately to ensure personnel safety. It does not address the ability of the gratings to support either moving or stationary equipment during or after a fire exposure.

1.3 This specification addresses fire conditions based on Test Methods E119 fire exposure and does not address hydrocarbon pool or jet fire exposures.

1.4 This specification is intended for use by all persons designing, manufacturing, testing, inspecting, and maintaining FRP gratings.

1.5 *Units*—The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 This specification does not constitute regulations or ship classification rules, which shall be consulted where applicable.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.03 on Outfitting and Deck Machinery.

Current edition approved Sept. 15, 2024. Published October 2024. Originally approved in 2014. Last previous edition approved in 2018 as F3059 – 18. DOI: 10.1520/F3059-24.

2. Referenced Documents

2.1 ASTM Standards:²

- B117 Practice for Operating Salt Spray (Fog) Apparatus
 - D2047 Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine
 - D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
 - D4329 Practice for Fluorescent Ultraviolet (UV) Lamp Apparatus Exposure of Plastics
 - E84 Test Method for Surface Burning Characteristics of Building Materials
 - E119 Test Methods for Fire Tests of Building Construction and Materials
 - E695 Test Method of Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading
- ### 2.2 Other Standards:
- 46 CFR 159.010 Shipping—Approval of Equipment and Materials³
 - NVIC 02-06 Follow-Up Programs for Fire-Safety Type-Approved Products⁴
 - NVIC 9-97 Change 1—Guide to Structural Fire Protection⁵

3. Terminology

3.1 Definitions:

3.1.1 *compression molding, v*—manufacturing process involving match die molds that compress the fiber reinforced matrix, generally under pressure and heat, to produce the finished product.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

⁴ Available from United States Coast Guard (USCG), U.S. Coast Guard Headquarters, 2703 Martin Luther King Jr. Ave. SE Stop 7509, Washington, DC, 20593-7509, <https://www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/5ps/NVIC/2006/NVIC%2002-06.pdf>.

⁵ Available from United States Coast Guard (USCG), U.S. Coast Guard Headquarters, 2703 Martin Luther King Jr. Ave. SE Stop 7509, Washington, DC, 20593-7509, <https://www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/5ps/NVIC/1997/n9-97ch1.pdf>.

3.1.2 *fiber-reinforced polymer, FRP, n*—composite material made of a resin matrix reinforced with fibers.

3.1.2.1 *Discussion*—The fibers are usually made of glass or carbon fiber, while the polymer is usually an epoxy, vinyl ester, or polyester thermosetting plastic. The term “polymer” is sometimes replaced by “plastic.”

3.1.3 *fire integrity, n*—ability of a structure to retain functionality after a fire.

3.1.3.1 *Discussion*—Fire integrity levels for FRP gratings are described as (from lowest to highest) Level 3, Level 2, and Level 1. Level 0 gratings are not qualified for fire integrity.

3.1.4 *glass-reinforced polymer, GRP, n*—fiber-reinforced polymer made of a resin matrix reinforced by glass fibers.

3.1.5 *molded grating, n*—FRP grating produced by the open mold process in which dry glass fiber and thermoset resin is placed in the mold in both directions.

3.1.5.1 *Discussion*—After filling the mold with the designated amount of material, the resin is allowed to cure in the open mold. Square mesh molded grating has nearly equal strength and stiffness in longitudinal and transverse directions. Molded grating is usually manufactured in square mesh or rectangular mesh configurations. See Fig. 1 and Fig. 2.

3.1.6 *open molding, v*—manual process involving the combination of liquid resin and fiber reinforcements in an open mold to produce a finished part resembling the inverse of the mold.

3.1.6.1 *Discussion*—Liquid resin and continuous fibers are systematically laid in a mold—layer upon layer manually to a desired thickness and panel dimension.

3.1.7 *pultruded grating, n*—grating produced from an assembly of pultruded structural shapes assembled into a grid pattern.

3.1.7.1 *Discussion*—Pultruded FRP grating products are assembled from bearing bars and cross rods manufactured from the pultrusion process as shown in Fig. 3.

3.1.8 *pultrusion, n*—manufacturing process to form continuous lengths of reinforced polymer structural shapes.

3.1.9 *qualified span, n*—FRP grating span used during preload and post load fire tests [minimum 44 in. (112 cm)].

3.1.10 *surface flame spread, n*—propagation of a flame away from the source of ignition across the surface of the specimen.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *shall, v*—in this specification, indicates a mandatory requirement.

3.2.2 *should, n*—in this specification, indicates a recommended requirement.

3.3 Abbreviations:

3.3.1 *AFFF*—Aqueous film-forming foam

3.3.2 *AHJ*—Authority having jurisdiction

3.3.3 *ASTM*—American Society for Testing and Materials

3.3.4 *L1*—Level 1 fire integrity grating

3.3.5 *L2*—Level 2 fire integrity grating

3.3.6 *L3*—Level 3 fire integrity grating

3.3.7 *L0*—Flame spread only

3.3.8 *MODU*—Mobile offshore drilling unit

3.3.9 *NVIC*—Navigation and Vessel Inspection Circular

3.3.10 *USCG*—U.S. Coast Guard

3.3.11 *UV*—Ultraviolet

4. Significance and Use

4.1 This specification is for FRP gratings used in machinery spaces, cargo areas, and on-deck areas but not within accommodation, service, control spaces, and areas where smoke and toxicity is a concern. The test requirements and criteria for FRP gratings have been developed based on the expected environmental conditions, intended use, and fire hazard the gratings could be exposed to in conjunction with requirements for means of escape and fire brigade access to the area where the FRP gratings will be located. The structural fire integrity test requirements have been developed based on

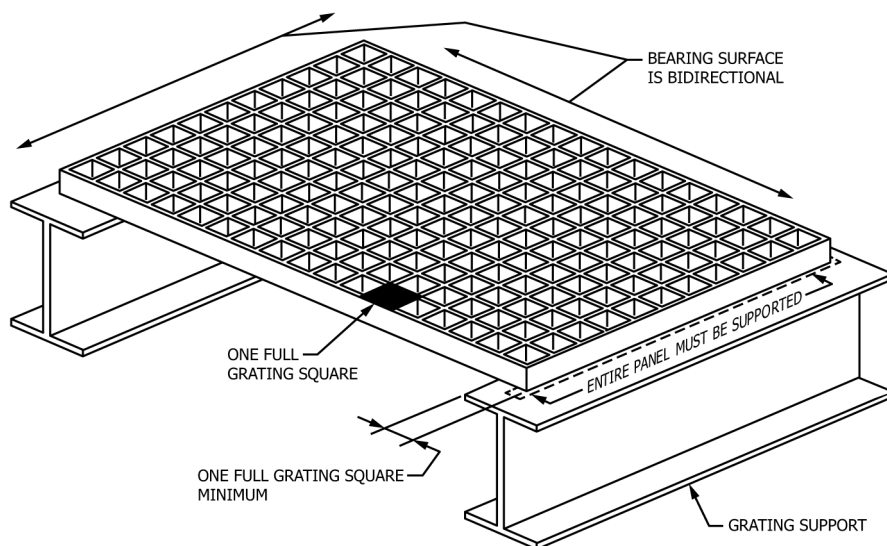


FIG. 1 Square Mesh Molded Grating

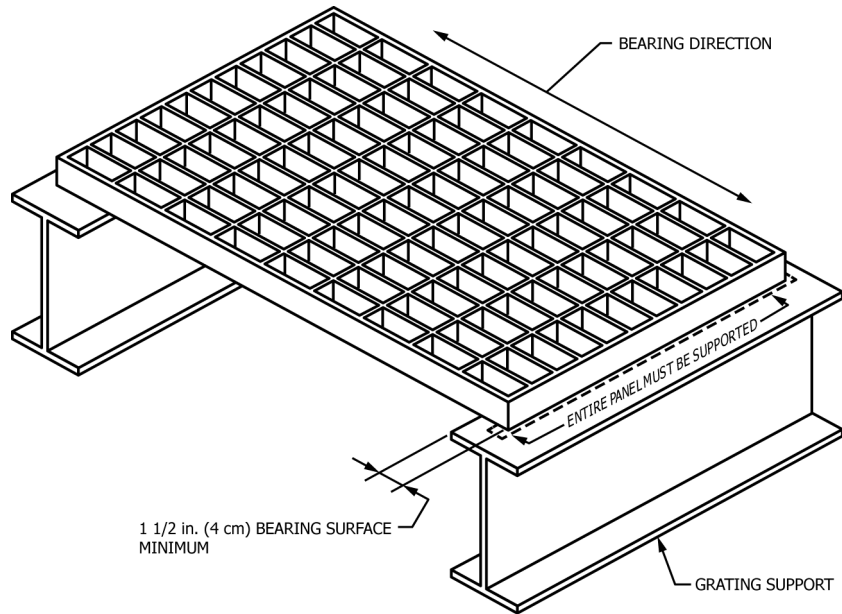


FIG. 2 Rectangular Mesh Molded Grating

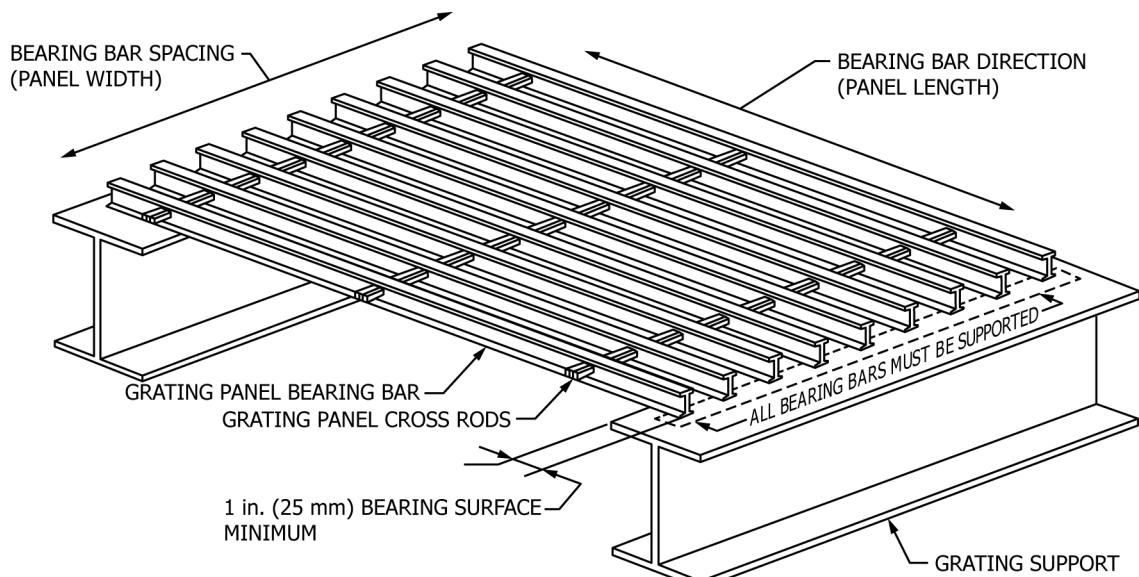


FIG. 3 Pultruded Grating

comparative testing with steel gratings rated for maximum load of 94 lbf/ft² (4.5 kN/m²). The fire test requirements include surface flammability testing and structural fire integrity testing with three levels of structural fire integrity that may be achieved as follows:

4.1.1 *Level 1 (L1)*—FRP gratings meeting the L1 performance criteria provide the highest degree of safety and are intended for use in escape routes or areas in which access for firefighting, emergency operation, or rescue is needed after a significant fire exposure that may weaken the gratings. Level 1 gratings may also be used in any areas requiring Levels 2 or 3 gratings.

4.1.2 *Level 2 (L2)*—FRP gratings meeting the L2 performance criteria are intended for use in areas in which personnel may need to assemble after the grating has been exposed to a

fire and are tested to ensure that they will be able to sustain a post-fire structural loading. Areas in which L2 gratings are specified include temporary safe refuge or lifeboat embarkation stations. Level 2 gratings may also be used in any areas requiring Level 3 gratings.

4.1.3 *Level 3 (L3)*—FRP gratings meeting the L3 performance criteria are intended for use in areas used as egress routes or that may require access for firefighting, emergency operations, or rescue during or shortly after exposure to a very limited fire not likely involving flammable liquids.

4.1.4 *Level 0 (L0)*—FRP gratings tested to Test Method E84 with a flame spread index ≤20 and a smoke developed index of ≤450. L0 FRP gratings have no level of fire integrity. L0 gratings are used for personnel walkways, catwalks, ladders, platforms, or access areas in cargo holds or tanks.

4.2 These test methods in this specification do not provide the following:

4.2.1 Full information as to the performance of the FRP grating with materials, construction, dimensions, coatings, and so forth, other than tested.

4.3 In these test methods, the test specimens are subjected to one or more specific tests under laboratory conditions. When different test conditions are substituted or the end-use conditions are changed, it is not always possible by, or from, these test methods to predict changes to the characteristics measured. Therefore, the results of these laboratory tests are valid only for the test conditions described in these test methods.

4.4 The fire-resistance test methods specified herein require test specimens to be exposed to a standard fire that is controlled to achieve specified temperatures throughout a specified time period or heat exposure. These are followed by the application of specified loads. These test methods provide a relative measure of performance under the specified test conditions. The fire exposure is not representative of all fire conditions. Variation from the test conditions or test specimen construction, such as size, materials, method of assembly, and so forth, may affect the fire-test response. For these reasons, evaluation of such variations may be required for application to construction in the field. However, variations in the required test exposure conditions are considered outside the scope of this specification.

4.5 Use of FRP gratings on vessels, including offshore facilities and floating production platforms, shall be in accordance with the applicable laws and regulations. Authorized locations where FRP gratings can be installed may vary among jurisdictions. Manufacturers, designers, ship builders, installers, and users of FRP gratings must refer to the appropriate AHJs for the authorized locations for FRP gratings. (see [Appendix X4](#) for additional information).

5. Sampling

5.1 Sampling methods shall be as required to provide reasonable assurance that the test samples are truly representative of the standard manufactured product. When required, test specimens of products shall be sampled at the manufacturing facility by personnel representing an accredited testing laboratory, accredited inspection agency, or accredited certification agency. Sampling at a warehouse or distribution center in lieu of sampling at the manufacturing facility is permitted provided the testing laboratory, inspection agency, or certification agency samples the materials and correlates the sampled materials with the finished product specification. The test specimens shall be representative of the FRP gratings to be qualified including materials, construction, profile, dimensions, coatings, and so forth.

6. Number of Tests and Retests

6.1 *General*—The number of tests are as described in the test requirements portion of this specification. If significant changes occur to the manufacturing process or material specifications that may affect the physical properties or system qualification requirements, qualification tests related to the significant change shall be required.

TEST REQUIREMENTS

7. Summary

7.1 The following test requirements shall be met: serviceability, assembled grating flexural strength, wheel resistance, impact resistance, skid resistance, durability, ultra-violet (UV) resistance, salt spray, surface flammability, and structural fire integrity. Testing shall be conducted by a laboratory acceptable to the AHJ.

8. Serviceability

8.1 The grating panel shall meet the following load deflection limits:

8.1.1 The specified performance requirements for each platform area shall include the qualified span (L), the uniform load (U), or the concentrated load (C), or combination thereof.

8.1.2 The minimum uniform design load of the grating shall be 150-lb/ft² (7.2 kN/m²).

8.1.3 The minimum concentrated design load of the grating shall be 345-lb/ft (4.8 kN/m).

8.1.4 The maximum mid-span deflection of the grating panel shall not exceed 0.25 in. (0.6 cm) when tested at the qualified span.

9. Assembled Grating Flexural Strength

9.1 Five test specimens shall each be 11⁷/₈ in. to 13⁷/₈ in. (302 mm to 352 mm) in width to allow for the differences in the spacing of longitudinal load-bearing members. The individual bearing bars shall be full width and shall not be modified or trimmed to meet the width tolerance. For molded gratings, the edge bearing bars shall be excluded from the test specimens if the crosssection of the edge bearing bars is different than bearing bars in the center of the panel. The width shall be measured at the top surface from outside load-bearing member to outside load-bearing member. The unsupported span of each specimen shall be equal or greater than the qualified span. Test specimens shall be cut when required using representative methods and equipment as recommended by the manufacturer.

9.2 The grating panel shall have a flexural strength of 50 000 psi (344 738 kPa) or greater using the three-point bending test procedure in [Appendix X5](#) and calculated as described in [Appendix X6](#). The flexural strength shall be determined from an average of the five test specimens. The area used for determining the flexural strength shall be calculated as the qualified span multiplied by the effective width of the panel. The effective width shall be calculated as the load bearing bar spacing multiplied by the number of load bearing bars.

10. Wheel Resistance

10.1 The manufacturer shall supply test data showing that the proposed grating product, as intended use condition, has passed the following wheel load test:

10.1.1 A minimum 36-in. (91-cm) wide panel shall be supported on two steel beams at the qualified span.

10.1.2 A hard rubber wheel shall be cycled over the stationary panel. One cycle is equal to two passes.

10.1.3 The wheel shall travel 24 in. (610 mm) across

10.1.4 The wheel shall have a cast iron or steel core, wrapped with polyurethane or hard rubber.

10.1.5 The wheel surface shall have a flat profile and have a minimum durometer hardness of 75 - 100 (Shore A).

10.1.6 The wheel shall be 6 in. (15 cm) in diameter by 2 in. (5 cm) wide. (See Fig. 4).

10.1.7 The wheel travel shall be perpendicular to the bearing bars.

10.1.8 The wheel shall be positioned at the midspan of the qualified span.

10.1.9 The wheel shall make a minimum of five cycles (ten passes) per minute.

10.1.10 The wheel shall be loaded to a minimum of 1000 lbs (454 kg).

10.1.11 The loaded wheel shall be cycled 500 times (1000 passes).

10.1.12 The grating panel shall be considered to have successfully passed the wheel loading test if:

10.1.12.1 After the grating is conditioned by the wheel load, an 11 $\frac{7}{8}$ in. to 13 $\frac{7}{8}$ in. (302 mm to 352 mm) wide panel shall be cut from the 36 in. panel (see Fig. 5) and shall be tested at the qualified span in a simply supported condition to determine the stiffness. The stiffness shall retain sufficient stiffness to meet the performance requirements of Section 8.

11. Impact Resistance

11.1 The manufacturer shall supply test data showing that the proposed grating product has passed the following impact test:

11.2 One 11 $\frac{7}{8}$ -in. to 13 $\frac{7}{8}$ -in. (302-mm to 352-mm) wide panel of sufficient length shall be subjected to an impact on the qualified span (see Fig. 5).

11.3 There is no bearing bar alignment for molded grating.

11.4 The impact test panel shall be tested as follows:

11.4.1 The grating shall be tested at the qualified span (see Fig. 6).

11.4.2 An impact load of 333 lb (151 kg) [± 35 lb (15.9 kg)] shall be dropped from a free fall height of at least 35 in. (89 cm) measured above the grating such that the product of the impact load and free fall height is no less than 12 000 in.-lb (see Fig. 7). The impact head shall be guided in so that it contacts all bars simultaneously, squarely, and repeatedly.

11.4.2.1 The impact load should include impact head and the associated guide system that moves with impact head.

11.4.3 The surface that impacts the grating shall be steel, it shall directly impact the grating (that is, the grating shall not be buffered with sand bags), and it shall be allowed to bounce uninterrupted until it comes to rest by itself. The bottom face of impact head shall have minimum 6 in. (150 mm) radius (see Fig. 7).

11.5 After the grating is subjected to the impact load, the test panel shall be tested at the qualified span in a simply supported condition to determine the stiffness. The test panel shall retain sufficient stiffness to meet the performance requirements of Section 8.

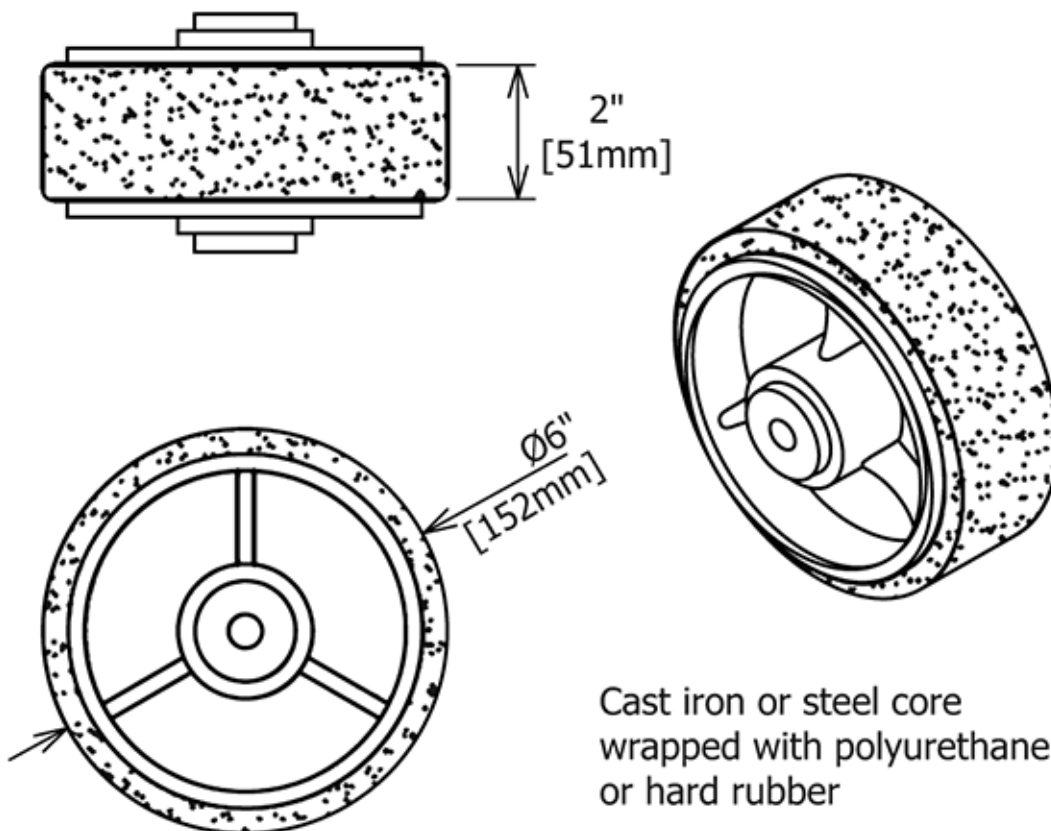


FIG. 4 Wheel Assembly Detail

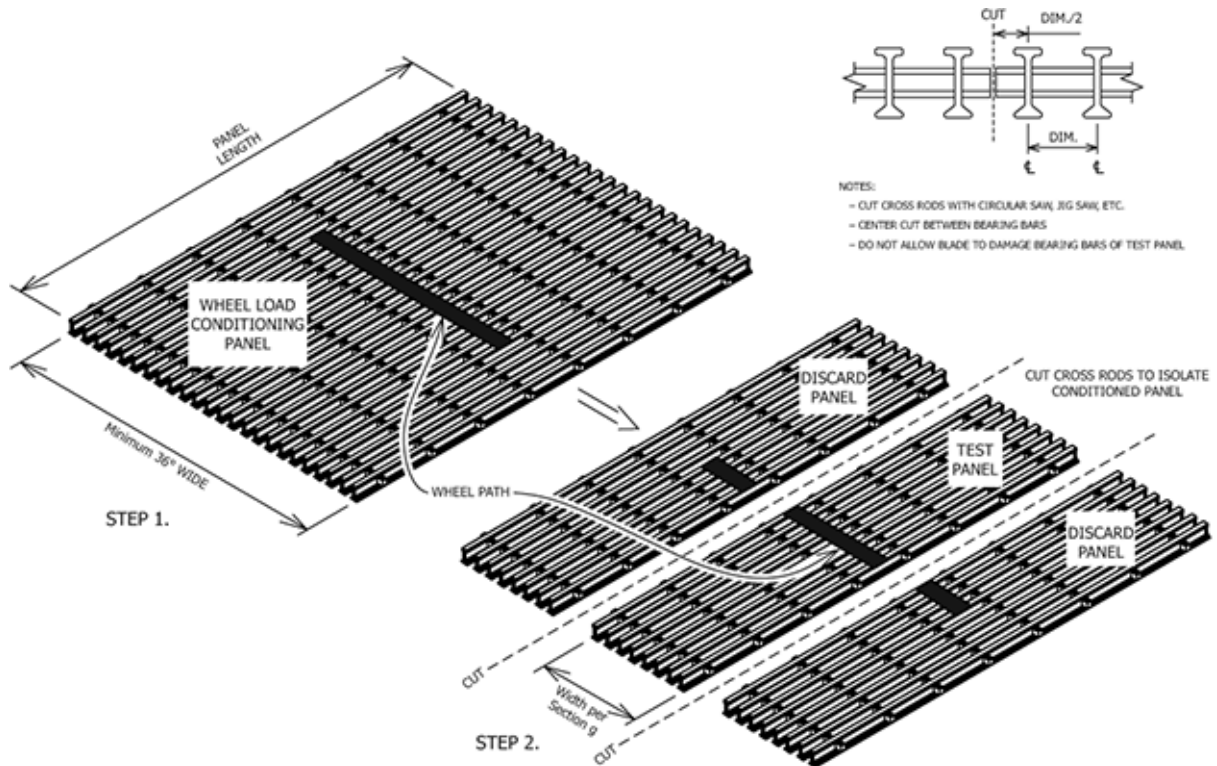


FIG. 5 How to Obtain Impact Test Panel and Control Panel

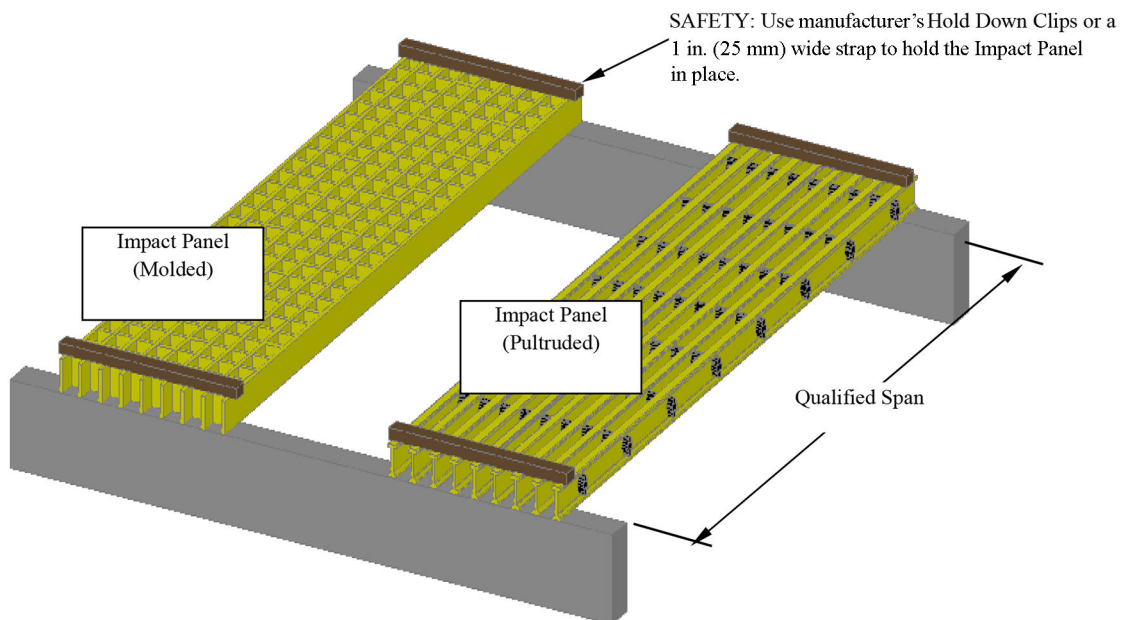


FIG. 6 Impact Panel Simply Supported at the Qualified Span

12. Skid Resistance (Test Method D2047)

12.1 FRP grating shall be evaluated for skid resistance in accordance with Test Method D2047 and shall have an average coefficient of friction greater than 0.75 for dry leather conditions in accordance with the referenced standard.

13. Durability (Test Method D4060)

13.1 FRP gratings shall be tested for durability in accordance with Test Method D4060.

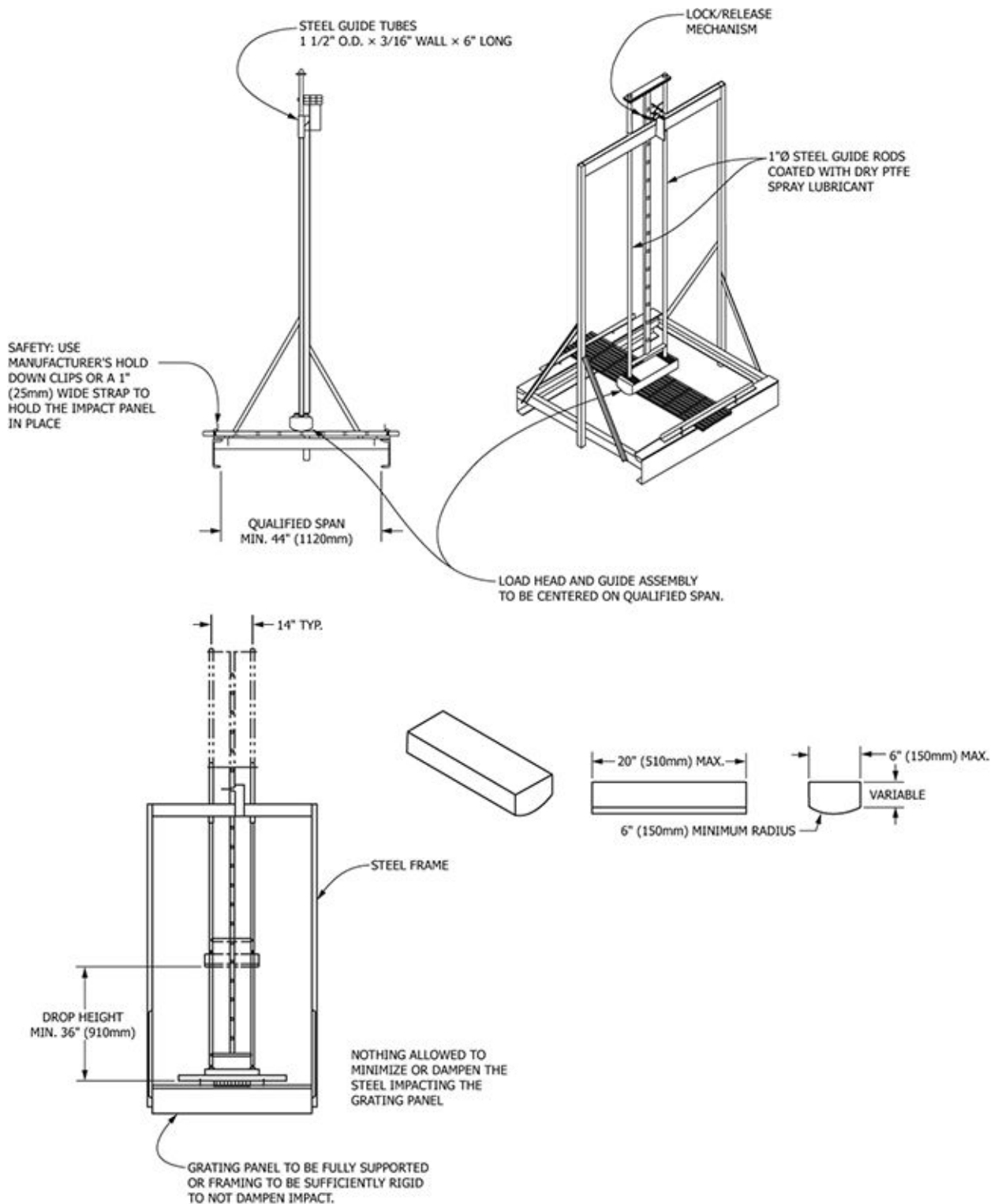


FIG. 7 Impact Load Schematic

13.2 The test requires a 4-in. (10-cm) square or 4-in. (10-cm) diameter round, flat plate.

13.3 For the flat plate, the manufacturer shall use the same composite laminate as would be used in the FRP grating.

13.4 The manufacturer shall prepare two sets of samples using the same nonskid surface (grit and adhesive combination) that is intended to be applied to the FRP grating.