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GUIDELINES FOR USE OF FIBRE-REINFORCED PLASTICS (FRP) WITHIN SHIP STRUCTURES

Proposal for a test procedure for FRP Elements to be included in the interim guidelines

Submitted by CESA

SUMMARY

Executive summary:	This document contains a proposal on how to assess the fire-resisting properties of fibre-reinforced plastic elements. The goal is to introduce a test procedure for structural integrity that is suitable and valid for non-metallic materials in order to use them in maritime applications in a safe and economically efficient way and include this procedure in the revision of the Interim FRP Guidelines. It is suggested that the test procedures for load-bearing and non-load-bearing elements could be substantially simplified and in favour of a more goal-based approach, by omitting the temperature-based criterion on both the exposed and unexposed side of the specimen and by applying the failure criterion from section 4.7 of the appendix to annex 1, part 11, of the 2010 FTP Code.
Strategic direction, if applicable:	2
Output:	2.6
Action to be taken:	Paragraph 13
Related documents:	SDC 11/11, SDC 11/17; MSC 110/21 and SDC 12/7

Introduction

1 This document contains a proposal on how to assess the fire-resisting properties of fibre-reinforced plastic elements to be used in maritime applications. The goal is to introduce a test procedure for structural integrity that is suitable and valid for non-metallic materials in order to use them in maritime applications in a safe and economically efficient way and include this procedure in the revision of the *Interim guidelines for use of Fibre Reinforced Plastic (FRP) elements within ship structures: Fire Safety Issues* (MSC.1/Circ.1574) (Interim FRP Guidelines).

Background

2 SDC 10 established the Correspondence Group (CG) on the Revision of the Interim Guidelines for Use of Fibre-Reinforced Plastic (FRP) (MSC.1/Circ.1574), under the coordination of Sweden (SDC 10/17, paragraph 12.9). The report of this CG was submitted to SDC 11 as document SDC 11/11 (Sweden).

3 SDC 11 further discussed the scope of the output, following request for clarification in the CG report, and continuing from earlier discussion on the subject matter at SDC 10, in which delegations expressed different opinions. Subsequently, the Sub-Committee agreed to re-establish the CG and instructed it to address also load-bearing divisions and elements, in addition to other aspects, as part of its revision work, within the scope of SOLAS chapter II-2 from fire safety perspective (SDC 11/17, paragraph 11.10.2).

4 In addition, SDC 11 invited MSC 110 to confirm whether or not load-bearing divisions and elements contributing to global strength were considered as part of the scope of the existing output, i.e. clarification on whether the scope of the output was limited to SOLAS chapter II-2 only, or wider, with a view to advising the CG, and to instructing SDC 12 accordingly (SDC 11/17, paragraph 11.10.3)

5 Following the request of SDC 11, and considering further documents submitted to the consideration of the Committee, MSC 110 (MSC 110/21, paragraph 11.20):

.1 confirmed that the scope of the revision of the Interim FRP Guidelines should remain limited to fire safety aspects under SOLAS regulation II-2/17, and did not extend to elements contributing to global strength;

.2 agreed that load-bearing elements not contributing to global strength might be considered within the scope of the revision; and that a new output would be required for considering such elements contributing to global strength; and

.3 instructed the FRP CG established at SDC 11 to continue to address load-bearing divisions and elements, within the scope of SOLAS chapter II-2 from a fire safety perspective accordingly.

Discussion

6 While expressing appreciation for the work done on this topic by the CG, in particular to Germany for taking over the coordination, CESA supports:

.1 in general, the outcomes of the CG as presented in document SDC 12/7 (Germany); and

.2 the establishment of a working group on the topic at this session, with the terms of reference as proposed by the CG (SDC 12/7, paragraph 48), as the very technical nature of the discussions would benefit from having a working group discussion.

7 The CG noted that the test methods currently available under the 2010 FTP Code for testing the structural fire integrity of fibre-reinforced plastics are inadequate and not meaningful, and should therefore be amended (SDC 12/7, paragraph 31 and 45).

8 There is scientific consensus that the structural fire integrity of fibre-reinforced composites can be evaluated if the specimen is tested under the design load.[1] This differs from the provisions in section 4.5 of the appendix to annex 1, part 11, of the 2010 FTP Code, which requires a static load for testing load-bearing fire-resistant divisions.

Proposals

9 It is, therefore, proposed to replace paragraphs 6 and 6.1 to 6.5 in appendix D.7 of the current draft Revised Interim Guidelines (SDC 12/7, annex) with the following paragraphs (proposed text follows that of the appendix to annex 1, part 11, of the 2010 FTP Code, where the static loads required in its paragraph 4.5 are replaced).

> "6 This section is designed to be used to supplement part 11 of the 2010 FTP Code and gives a methodology for elements constructed from FRP composite materials. This method considers a standard FRP construction which consists of a core material which is bonded to a fibre-reinforced polymer FRP skin layer consisting of a polymer matrix which is reinforced with fibres. The FRP skin may or may not be coated with an external gelcoat. Where fire resistance performance is required, these elements are typically insulated with a high density, non-combustible, insulation material on both sides.
>
> 6.1 FRP Composite structures classification should be limited to the exact composition of the specimen tested including and assigned the classification as follows;
>
> .1 Fire-resisting divisions for moderate fire hazard are classified as "fire-resisting divisions 30".
>
> .2 Fire-resisting divisions for major fire hazard are classified as "fire-resisting divisions 60"; and
>
> .3 30 minute or 60-minute divisions are classified as either load bearing or non-loadbearing depending on whether they are tested with or without load.
>
> 6.2 Testing of specimens for load bearing and non-load bearing elements
>
> Testing of fire-resisting divisions and reporting should generally be in accordance with the requirements given in annex 1, part 3 of the 2010 FTP Code (hereinafter part 3). Where additional interpretation, adoption and/or supplementary requirements may be necessary, these are detailed in this part.
>
> The following performance criteria for insulation and integrity should be fulfilled within the classification period (either 30 or 60 minutes):
>
> .1 Insulation: Thermocouples should be placed on the fire exposed side underneath the insulation of the FRP division to measure the temperature of the FRP skin directly underneath the insulation layer(s).

[1] Evegren, F. (2025). Assessing fire safety of fibre reinforced polymer composite ship structures. Ref. to Chapter 5.2.3.2.

Thermocouple positions should be similar to those given in part 3 except that they are on the fire exposed side. (i.e. to be placed under the insulation and under insulation joints. The average exposed face temperature rise should not be more than [value to be discussed], and the temperature rise recorded by any of the individual exposed face thermocouple should not be more than [value to be discussed].

.2 Integrity:

.2.2 there should be no flaming on the unexposed face;

.2.3 there should be no ignition, i.e. flaming or glowing, of the cotton-wool pad; and

.2.4 it should not be possible to enter the gap gauges as described in paragraph 8.4.4 of appendix 1 to part 3 into any opening in the specimen.

6.3 In this appendix, testing of fire-resisting divisions is described in two separate parts, as follows:

.1 non-load bearing fire-resisting divisions; and

.2 load bearing fire-resisting divisions.

6.4 Non-load bearing fire-resisting divisions

The approach adopted for testing of fire-resisting divisions which are non-load bearing should follow the requirements for testing "B" class divisions in part 3 where relevant and appropriate.

6.5 Load bearing fire-resisting divisions

6.5.1 The approach adopted for testing of other load bearing fire-resisting divisions should follow the requirements for testing "B" class divisions in part 3 where relevant and appropriate.

6.5.2 In addition, such load bearing divisions should be tested with their design load and they should maintain their load bearing ability within the classification period (see paragraph 6.2 above).

6.5.3 Nature of test specimen

6.5.3.1 The construction, erection and stiffening of the test specimen should be typical of the use in practice.

6.5.3.2 For vertical divisions (bulkheads), the minimum overall dimensions for the exposed part of the test specimen are 2,440 mm width and 2,500 mm height, or full height if the height is smaller than 2,500 mm.

6.5.3.3 For horizontal divisions (decks), the minimum overall dimensions for the exposed part of the test specimen are 2,440 mm width and 3,040 mm length (span), or full length if the length is smaller than 3,040 mm.

6.5.4 Mounting of test specimen

6.5.4.1 A horizontal test specimen should be simply supported at the two ends and should not be supported along its edges parallel to the span.

6.5.4.2 A vertical test specimen should be simply supported at the top and the bottom and should not be supported along its vertical edges.

6.5.5 Design load

6.5.5.1 The design load should be applied uniformly, as far as practicable, along the top edge of the vertical specimen or surface of the horizontal specimen. The load may be applied hydraulically, mechanically or by the use of weights.

6.5.5.2 The loading equipment should be able to simulate the conditions of loading, as appropriate, for the test construction. The loading equipment should also be capable of maintaining the test load at a constant value (to within ± 5% of the required value) without changing its distribution for the duration of the load-bearing capacity period; it should not significantly influence the heat transfer through the specimen nor impede the use of the thermocouple insulating pads; it should not interfere with the measurement of surface temperature and/or deformation and should permit general observation of the unexposed face.

6.5.5.3 For decks, the total area of the contact points between the loading equipment and the test specimen surface should not exceed 10% of the total area of the surface of a horizontal test specimen. The equipment should be capable of following the maximum deformation and the rate of deformation of the test specimen. For bulkheads, the loading equipment should produce a load uniformly applied to the total width of the bulkhead.

6.5.5.4 If the tested assembly includes load bearing elements such as beams, they should be exposed to the furnace on all faces except for the face in contact with the specimen and should not be placed at less than 200 mm from the furnace walls.

6.5.5.5 In practice, it may be difficult to produce a uniform load, especially on decks. When determining a load distribution that is representative of the standard conditions described in paragraphs 6.5.4.2 and 6.5.5.1, the laboratory should consider the degrees of freedom, maximum shear force and bending moment.

6.5.5.6 Mounting methods and loading conditions different to those in paragraphs 6.5.4.1 and 6.5.5.1 may be used. In that case, the test conditions and load distribution should be acceptable to the Administration.

6.5.5.7 The test report should include justifications of approximations to uniform load and mounting. The report should include a description of load repartition in terms of force, surface of contact and position of these contacts.

6.5.5.8 The test load should be applied at least 15 min before the commencement of the heating period."

10 Regarding the discussion about temperature measurements in fire tests, the following aspects are highlighted:

.1 The motivation for measuring the temperature on the unexposed side of the laminate is containment of fire. However, fire tests on FRP samples show that the temperature on the side facing away from the fire only rises by a few degrees (< 15K) during standard fire tests. For this reason, it is proposed that this criterion is not relevant for FRP elements due to their good insulating properties.[2]

.2 Measuring the temperature on the exposed side would serve the purpose of verifying whether or not a certain temperature is reached during the standard fire test. In contrast, section 4.7 of the appendix to annex 1, part 11, of the 2010 FTP Code, specifies clear performance criteria for load-bearing elements. These refer only to the structural behaviour of the sample (amount and rate of deflection), not to a certain temperature.

11 The two aspects mentioned in paragraph 10 are illustrated in the figure below. It shows the temperature profile at the moment of failure for a typical FRP laminate. The temperature at the exposed surface upon failure is typically significantly lower (~100 K) than the polymer pyrolysis temperature (>350°C) and significantly higher (~100-150 K) than the Heat Deflection Temperature of the material (ca. 85°C).[2]

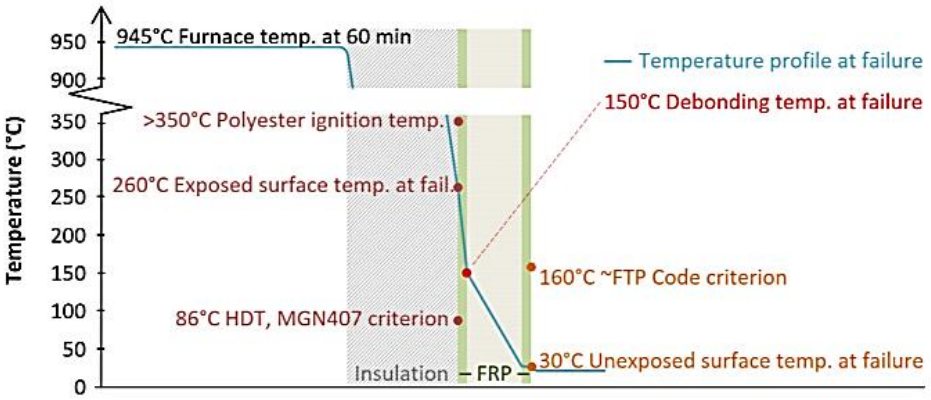

Figure: Typical temperature profile at failure (turquoise) and critical temperatures of typical FRP composite sandwich structure (not to scale). From: Evegren, F. (2025). Assessing fire safety of fibre reinforced polymer composite ship structures

12 Considering these two aspects, it is proposed that the test procedures for load-bearing and non-load-bearing elements could be substantially simplified and adopt a more goal-based approach by:

.1 omitting the temperature-based criterion on both the exposed and unexposed side of the specimen; and,

.2 applying the failure criterion from section 4.7 of the appendix to annex 1, part 11 of the 2010 FTP Code.

Action requested of the Sub-Committee

13 The Sub-Committee is invited to consider the information contained in this document, as well as the proposals contained in paragraphs 9 to 12, and to take action, as appropriate.

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[2] Evegren, F. (2025). Assessing fire safety of fibre reinforced polymer composite ship structures. Ref. to Chapter 5.2.3.2.