BS ISO 14886:2014

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# Ships and marine technology — Large yachts — Structural fire protection for FRP yachts

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# Ships and marine technology — Large yachts — Structural fire protection for FRP yachts

*Navires et technologie marine — Grands yachts — Protection structurelle contre l'incendie pour les yachts en plastique renforcé*

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# Foreword

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The committee responsible for this document is ISO/TC 8, *Ships and marine technology*, Subcommittee SC 12, *Large yachts*.

# Introduction

Many existing standards are based on protection of steel and equivalent metallic materials. This International Standard recognizes that FRP is an entirely different material than steel and aluminium, and addresses all of the relevant mechanical, thermal, and physical properties of the insulation and the FRP laminate.

**INTERNATIONAL STANDARD** **ISO 14886:2014(E)**

# Ships and marine technology — Large yachts — Structural fire protection for FRP yachts

## 1 Scope

This International Standard applies to the structural fire protection of large FRP yachts of 24 m in length and over, and carrying up to 12 passengers. The International Standard is not applicable to vessels subject to SOLAS.

By using the heat transfer Fourier Number, the International Standard determines the equivalency of any proposed insulated FRP sandwich laminate to the model insulated sandwich laminate based on a fire tested insulated laminate approved in accordance with IMO FTP Code as a fire-resisting division.

The method considers the relevant mechanical, thermal, and physical properties of the insulation and the FRP laminate.

The technology of the elements of the insulation and FRP resistance to heat, smoke, and fire used in the International Standard and the effectiveness of the insulation are applicable in general to insulated FRP as a fire-resistant material.

This International Standard does not cover the heat, fire, smoke resistance of the attachments of insulation to the laminate, of penetrations, doors, windows, hatches, or of any other detail in insulated laminate divisions that might impair the heat, fire, and smoke resistance performance of the divisions.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 834-1:1999 + Amd 1:2012, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

ISO 9705:1993, *Fire tests — Full-scale room test for surface products*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**fire-resisting division 30**
fire-resisting division classified for moderate fire hazards

Note 1 to entry: Fire-resisting property is the ability of the construction to insulate/protect an area from the influence of a fire in an adjoining area by having a separating performance during a fire. Such constructions are fire-resisting bulkheads, decks, ceilings, linings, and doors.

[SOURCE: IMO FTP Code.Resolution MSC.45(65) “Test Procedures for Fire-Resisting Divisions of High Speed Craft”, Annex]

**3.2**
**fire-resisting division 60**
fire-resisting division classified for major fire hazards

Note 1 to entry: Fire-resisting property is the ability of the construction to insulate/protect an area from the influence of a fire in an adjoining area by having a separating performance during a fire. Such constructions are fire-resisting bulkheads, decks, ceilings, linings, and doors.

[SOURCE: IMO FTP Code.Resolution MSC.45(65) "Test Procedures for Fire-Resisting Divisions of High Speed Craft", Annex]

**3.3**
**fire-restricting material**
material which has properties complying with the IMO Fire Test Procedures Code

[SOURCE: IMO HSC Code, Chapter 7, Fire Safety]

**3.4**
**length**
load line length according the ICLL 1966 as amended

## 4 Symbols (and abbreviated terms)

| | |
|---|---|
| Fo | Fourier Number, a number that measures heat flow |
| FRP | Fibre reinforced plastic |
| FTP | IMO Code for application of fire test procedures |
| HTD | Heat deflection temperature |
| ICLL | International Convention on Load Lines |
| PVC | Polyvinyl chloride |
| SAN | Styreneacryonitrile |
| Tg | Glass transition temperature |
| $Tib_{mw}$ | Bulkhead insulation thickness of mineral wool |
| $Tid_{mw}$ | Deck insulation thickness of mineral wool |

## 5 Design criteria

### 5.1 Tests on models and equivalency

The model insulated sandwich laminate referred to in Annex A shall have a core thickness and core density, and an insulation thickness and density that are taken from the test results of a Rockwool insulated sandwich laminate, tested, and approved in accordance with the IMO FTP Code as a fire-resisting division, as referred to in Annex B.

Required details of insulation of the model insulated FRP sandwich laminate and of the insulated FRP sandwich laminate being assessed for equivalency shall be as given in Annex C.

The report certificate on the equivalency assessment is to provide the information given in Annex D.

Details of the insulation of the model insulated FRP sandwich laminate are to be used to determine the Fourier Number heat flow through the insulation to assess the Fourier Number equivalence of the insulation of any proposed insulated sandwich laminate for consideration as a fire-resisting division.

For equivalency the Fourier Number heat flow through the insulation of the proposed insulated FRP sandwich laminate is not to be greater than the Fourier Number for heat flow through the insulation of the model insulated sandwich laminate.

The HDT of the skins of the model insulated FRP sandwich laminate shall be equal to or less than the HDT of skins of the insulated FRP sandwich laminate being assessed for equivalency and shall be given and identified as to whether not post cured or post cured.

The skins of the sandwich laminates are not to be less than 3 mm.

NOTE The heat, fire, and smoke resistance of the attachments of insulation to the laminate, of penetrations, doors windows, hatches, or of any other detail in insulated laminate divisions that might impair the heat, fire, and smoke resistance performance of the divisions, are not covered by this International Standard.

The equivalency of the insulation of any proposed insulated FRP sandwich laminate, shall be assessed by comparing the Fourier Number, Fo, of that insulation with the Fourier Number of the insulation of the model insulated FRP sandwich laminate.

Equivalency exists when the Fourier Number of the insulation of the proposed insulated sandwich laminate is equal to or less than the Fourier Number of the sandwich laminate model insulation and the FRP sandwich laminate has skins and core not less than the FRP insulated sandwich laminate model.

$$Fo = (k/\rho \cdot Cp) \times (t/x^2) \quad (1)$$

where

k is the thermal conductivity of insulation [J/(s m °K)];

J is in Joules;

s is the time in seconds;

m is measurement in metres;

K is the Kelvin temperature;

ρ is the density of insulation [kg/m$^3$];

Cp is the thermal heat capacity of insulation [J/(kg °K)];

t is the time of exposure to fire, fire test time [s];

x is the thickness of insulation [m].

The thickness of model insulation mineral wool is given in Table 1. Thermal conductivity and thermal heat capacity of model insulation mineral wool are given in Table 2.

**Table 1 — Thickness of model insulation mineral wool (ρ mw, if unknown use 112 kg/m3)**

| Location | Fire-resisting division 60 | Fire-resisting division 30 |
|---|---|---|
| Bulkhead | tib $_{mw}$ mm | 0,70 tib $_{mw}$ mm |
| Deck | tid $_{mw}$ mm | 0,70 tid $_{mw}$ mm |

NOTE For determination of tib $_{mw}$ and tid $_{mw}$ see Annex A.

**Table 2 — Thermal conductivity (k) and thermal heat capacity (Cp) of model insulation mineral wool (112 Kg/m 3)**

| Temperature [°C] | k [J/(s m °K)] | Cp [J/(kg °K)] |
|---|---|---|
| 1 000° | 0,40 | 800 |
| 700° | 0,15 | 750 |

The test temperatures shall be:

— Fire-resisting division 60: 25 °C to 945 °C;

— Fire-resisting division 30: 25 °C to 841 °C.

### 5.2 Protection against resin ignition

The exposed surface of laminates shall be protected by insulation or coatings.

### 5.3 Laminate

Where an insulated sandwich laminate has been tested and approved as a fire restricting material as part of fire-resistant division in accordance with the IMO FTP Code, it shall be used to establish the model given in Annex A to verify the equivalence in accordance with this International Standard, of any proposed insulated FRP sandwich laminate having a different type, density, and thickness insulation.

### 5.4 Insulation

The insulation shall be fitted on the fire exposed side of the laminate. The exposed surface of the insulation shall be protected from splash or spray from fuel oil or other flammable liquids and the method of attachment shall not impair the fire-resistance of the insulation.

Main load: bearing structures within major fire hazard areas and structures supporting control stations shall be insulated such that there will be no collapse of the construction when exposed to fire for the appropriate fire protection time. The class of fire-resisting division shall be as required by the flag administration.

### 5.5 Other

Other aspects to be considered during the construction connections are the following:

a) quality control;

b) paint systems, surface finish;

c) penetrations, doors, hatches, windows.

## 6 Material testing

### 6.1 Qualification of insulated laminate as a fire-restricting material

The model insulated sandwich laminate referred to in Annex A shall have been tested and approved in accordance with the following tests referred to in the IMO FTP Code:

— Corner Room Test IMO MSC 40 (64);

— Room Corner Test of insulated laminate ISO 9705:1993.

The performance required is indicated in Table 3.

**Table 3 — Room corner test performance**

| Criterion measured | Performance required |
|---|---|
| Average heat release | <100 kW |
| Maximum heat release | <500 kW |
| Average smoke production | <1,40 $m^2/s$ |
| Maximum smoke production | <8,30 $m^2/s$ |
| Flame spread on walls | No nearer than 0,50 m from floor in area 1,20 m distance from burner |
| Flaming droplets | None in the area 1,20 m distant from burner |

### 6.2 Qualification of insulated laminate as a fire-resistant division

Compliance with IMO Resolution MSC 45 (65) using IMO Resolution A 754 (18) shall apply to load bearing and non-load bearing insulated laminates.

### 6.3 Resin ignition tests

The tests shall be developed from IMO FTP Code.

### 6.4 Resin adhesion to insulation securing pins tests

These tests, or high temperature adhesive tests as alternative, shall be considered.

### 6.5 Other

Other tests could be requested, depending on the specific situation.

## 7 Production FRP laminate testing

### 7.1 Fire tests

Research has shown that the temperature of an FRP laminate at the interface with the insulation varies with the thermal characteristics of the different elements of the laminate. FRP skins and PVC cores are insulants and prevent the transmission of heat through the single skin or sandwich laminate.

This means that where several different FRP laminates, with the same type, density, and thickness insulation, are to be approved by fire tests, it is advantageous to identify the critical laminate elements so that tests can be focused on the critical features of the FRP laminates.

Table 4 identifies the critical elements of the laminates of any group of different laminates, and indicates the laminates that shall be tested to cover the most critical laminate features.

The research addressed the fire protection of GRP laminates, the procedures developed will be equally applicable to other fibre types used to reinforce plastics.

**Table 4 — Critical elements to be tested**

| Laminate | Variant | Laminate to be tested |
|---|---|---|
| Single skin GRP | Thickness | Thickest laminate tested |
| Sandwich GRP | Skin thickness | Thinnest skin laminate tested |
| Sandwich GRP | Core thickness | Thickest core laminate tested |
| Sandwich GRP | Core density | Least dense core laminate tested |

## 7.2 Test procedure

The fire tests shall be performed in a test furnace of 1m × 1m or more, capable of generating the standard time/temperature curve specified in ISO 834-1. The test panels shall be of same size as the furnace in which they are being tested.

The fire test durations shall be 60 min for “fire-resisting divisions 60” (“A“ Class equivalent) boundaries and 30 minutes for “fire-resisting divisions 30“ (“B” Class equivalent boundaries).

No less than five thermocouples shall be used on the exposed face of the structure and these shall be placed on the exposed face of the composite structure. This is the interface between the fire insulation and the GRP structure that it protects. At least one thermocouple shall be placed on the unexposed face of the structure.

## 7.3 Compliance criteria

The temperature measures both on the fire side and non-fire side of the construction material shall remain below the HDT of the laminate for the full duration of the fire test.

The HDT of resins vary with their curing agents and cure cycle. The following are typical values: Isopolyester 70 to 90 °C; Vinylester 90 to120 °C; epoxy 50 to 120 °C (highly dependent on cure cycle).

## 7.4 Fixings

The fixings used to attach the insulation onto the laminate in the fire test shall be the same as method intended for use in the vessel itself. Due consideration shall be given, when choosing the method and type of fixing, to take into account the maximum permissible operating temperature of the fixing system. It shall be noted that metallic fasteners transmit heat readily and this will have an impact on both the structure and the medium used to fix the metallic fastener onto the structure.

## 7.5 Alternatives

Consideration can be given to identifying the most critical laminate for testing by determining the Fo value for each of the laminates.

The critical laminate for the temperature increase in the FRP laminate that reduces the laminate strength is that with the greatest value of Fo.

The critical laminate for the temperature increase in the skin of the sandwich laminate next to the insulation on the fire exposed side, that would result in a greater increase in the skin HDT is the laminate with the lowest value Fo.

# Annex A
(normative)

# Structural model

A model insulated FRP sandwich laminate shall be used to determine the equivalence of any proposed insulated FRP sandwich laminate. The model shall be an insulated FRP sandwich laminate already IMO FTP test certified as a fire restricting material and as a fire-resisting division to heat, fire, and harmful emissions.

The insulation of the model and the proposed insulation shall be non-combustible and fitted on the fire exposed side of the laminate.

The model laminate is a sandwich laminate with at least 3 mm thick skins of fire retardant isophthalic polyester, vinylester, or epoxy resin, reinforced with e-glass fibre, woven roving, or other woven glass fibre reinforcement, of at least 45 % fibre content by mass.

The model is to be used to determine the equivalence of any proposed sandwich laminates of skin thickness ≥3 mm.

For fire-resisting division 60, the mineral wool insulation thickness of the model insulation for the deck is $tid_{mw}$ mm thick of density $\rho_{mw}$ kg/m3. See Table 1.

For Fire-resisting division 60, the mineral wool insulation thickness for the model insulation for bulkhead is $tib_{mw}$ mm thick mineral wool, density $\rho_{mw}$ kg/m3. See Table 1.

The values of $tid_{mw}$, $tib_{mw}$ and $\rho_{mw}$ for the model insulation shall be obtained from a mineral wool insulated laminate, fire tested and approved in accordance with the IMO FTP as a fire-resisting division 60.

The value of thickness 2 × density of the core of the model insulated sandwich laminate shall be equal to or less than that of the proposed insulated sandwich laminate. The HDT of the resin of the skins of the model laminate shall be equal to or less than that of the proposed insulated sandwich laminate.

For the Fourier Number equation, the required insulation thickness for fire-resisting division 30 shall be 0,70 × thickness for fire-resisting division 60.

It is considered that the insulation shall prevent the surface of the laminate skin at the interface with the insulation from reaching the laminate resin heat deflection temperature (HDT). However, load-carrying fire tests carried out on insulated sandwich laminate decks have shown the laminate to retain its design load-carrying capacity with the temperature on the surface of the laminate skin at the interface with the insulation to have exceeded the HDT.

# Annex B
(normative)

# Tests

## B.1 General

The International Standard specifies the various tests required by the IMO FTP Code to qualify an insulated FRP laminate as a fire restricting material and as part of a fire-resisting division meeting tests for “fire-resisting divisions 60”, “fire-resisting divisions 30”, and IMO FTP tests for resistance of resins to ignite and produce harmful emissions.

The model insulated FRP sandwich laminate shall have been approved in accordance with these tests.

The HDT of the skin of the sandwich laminate of the fire-resisting division in contact with the insulation shall not be exceeded during the specified time of the test.

However, where in a fire test the laminate retains its design load-carrying capability as given in the IMO FTP Code during and at the end of the specified fire test time and the temperature on the surface of the skin in contact with the insulation exceeds heat deflection temperature (HDT), the test shall be considered in compliance with the IMO FTP Code requirements.

## B.2 Fire-resisting divisions — Performance criteria

### B.2.1 Insulation

#### B.2.1.1 Fire-resisting division 60 – Including fire-resisting division 60 doors

The average unexposed-face temperature rise as determined in accordance with IMO FTP fire test shall not be more than 140 °C and the temperature rise recorded by any of the individual unexposed-face thermocouples should not be more than 180 °C during the periods given below for each classification.

#### B.2.1.2 Fire-resisting divisions 30 – Including fire division doors

The average unexposed-face temperature rise as determined in accordance with IMO FTP fire test should not be more than 140 °C and the temperature rise recorded by any of the individual unexposed-face thermocouples should not be more than 225 °C during the periods given below for each classification.

### B.2.2 Fire-resisting division integrity

For all fire-resisting divisions 60 and fire-resisting divisions 30, including their class doors, the following requirements should be satisfied for the minimum test duration relevant to the classification.

#### B.2.2.1 Flaming

There should be no flaming on the unexposed-face.

#### B.2.2.2 Cotton–wool pad

There should be no ignition, i.e. flaming or glowing of the cotton-wool pad when applied in accordance with IMO FTP Code 8.4.3 or when used to assist evaluation of flaming, see IMO FTP Code 8.4.2.

### B.2.2.3 Gap gauges

It should not be possible to enter the gap gauges into any opening in the specimen in the manner described in IMO FTP Code 8.4.4.

### B.2.2.4 Structural core temperature

Where the structural core is of a material other than steel or aluminium alloy the administration should decide the rise in temperature which should not be exceeded during the test duration.

For application of this standard the structural core temperature should not exceed the HDT of the resin in the laminate.

NOTE The structural core is the load-carrying structure that is insulated. In this International Standard, it is the entire FRP sandwich laminate and it is not to be confused with the core of a sandwich laminate.

# Annex C
(informative)

# Specifications to be included

For reference and for use, the following specification of insulation properties should be included:

— insulation type: the insulation of the model insulated FRP sandwich laminate and the insulation of the proposed insulated FRP sandwich laminate assessed for equivalency;

— insulation density: the insulation of model insulated FRP sandwich laminate and the insulation of the proposed insulated FRP sandwich laminate assessed for equivalency;

— insulation thickness: the insulation of model insulated FRP sandwich laminate and the insulation of the proposed insulated FRP sandwich laminate assessed for equivalency;

— temperature dependent thermal conductivity: for fire division 60 at 25 °C and at 945 °C; for fire division 30, at 25 C and 841 C;

— temperature dependent thermal heat capacity: for fire division 60 at 25 °C and at 945 °C; for fire division 30, at 25 °C and 841 °C.

# Annex D
(normative)

# Reporting of equivalency assessment data

The certificate of verification of equivalency or its annex shall include information, on the model insulated FRP sandwich laminate and on the proposed insulated FRP sandwich laminated being assessed for equivalency, on the insulation type, density, and thickness, temperature dependent thermal conductivity and temperature dependent thermal heat capacity.

For fire-resisting division 60, at 25 °C and at 945 °C; for fire division 30, at 25 °C and 841 °C.

The information shall include, for the model insulated FRP sandwich laminate and for the proposed insulated FRP sandwich laminated being assessed for equivalency, the sandwich laminate skins thickness, fibre reinforcement type, fibre weight, and fibre content by weight and resin type and resin heat deflection temperature (HDT) and glass transition temperature (Tg), with and without the fibre reinforcement.

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