Cable Fire Protection
Flammability tests on ship and offshore cables
Cables for ship and marine technology are exposed to varying, in some cases extreme, conditions. While in theory the cables will last a lifetime, in day-to-day operation they may be destroyed by malfunction or outside influences.

Destruction by exposure to fire is an especially critical situation. In addition to losing the cable’s functions, burning of all the nonmetallic materials, such as insulation, jacket and foils, can create toxic and/or corrosive substances. Toxic substances directly affect people close to the fire, whereas corrosive by-products of fire and their effects cannot be detected immediately.

It frequently takes weeks or even months before such by-products of fire, dissolved into extinguishing water or atmospheric moisture, corrode metal materials. Fire damage can occur even at locations a long way from the actual source of the fire.

Flammability tests and determination of combustion products are therefore vital to cable technology. They provide information on how fire spreads along the cable as well as on the potential threats to people and materials in the event of a cable fire.

The corresponding tests study:
- the flammability of non-metallic cable components
- the toxicity of fire by-products, especially the gases
- spread of the fire along the cable
- flue gas density in the event of fire
- the corrosiveness of the combustion gases.

The essential flammability tests on ship and offshore cables are described in this brochure. It should be noted that these tests are conducted under standardized conditions and do not reflect the individual behaviour of installed cables and cable bundles in an actual fire.
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Abbreviations of Standards

IEC | International Electrotechnical Commission
EN | Europäische Norm
UIC | Union Internationale des Chemins de Fer (International Union of Railways)
VG | Verteidigungsgerätenorm (Germany)
MIL | Military Standard (USA)
BS | British Standard (GB)
Def.-St. | Defence Standard (GB)
NES | Naval Engineering Standard (GB)
UL | Underwriters Laboratories Inc. (USA)
NF | Norme Française (National Standard France) (France)
DIN VDE | Deutsche Industrienorm Verband der Elektrotechnik (Germany)

All dimensions given in mm.
Flammability and spread of fire

1.1 IEC 60332-1-2 / EN 50265-2-1 / VG 95218-2 Method 1 / BS 4066 Part 1

Test set-up: The single cable to be tested is fixed vertically and exposed to a Bunsen burner flame at a 45° angle to the vertical.

Flame temperature: Determined by the specified setting of the Bunsen burner flame.

Test duration:
- Cable with a diameter of \( \leq 25 \text{ mm} \): 60 sec
- Cable with a diameter of \( 25 < D < 50 \text{ mm} \): 120 sec

Compliance criterion: The fire damage must end at least 50 m below the upper fixing clamp. The cable must be self-extinguishing.

1.2 IEC 60332-2 / EN 50265-2-2 / VG 95218-2 Method 2 / BS 4066 Part 2

Test set-up: The single cable to be tested is fixed vertically and exposed to a Bunsen burner flame at a 45° angle to the vertical.

Flame temperature: Determined by the specified setting of the Bunsen burner flame.

Test duration: 20 seconds

Compliance criterion: The fire damage must end at least 50 m below the upper fixing clamp. The cable must be self-extinguishing.
1.3 MIL-W-22758 / MIL-W-8104 / VG 95218-2 Method 4

Test set-up: The single cable to be tested is fixed at an angle of 30° to the vertical, weighed down over a reel. The Bunsen burner flame is directed at the cable from below an angle of 60° to the vertical. Tissue paper (S) is stretched out underneath the sample.

Flame temperature: At least 950 °C

Test duration: 30 seconds

Compliance criterion: The sample may continue to burn for a maximum of 30 seconds after the flame is removed and the total permissible length of fire damage to the cable is 76 mm. Material dripping off must not ignite the tissue paper (S) stretched out underneath.

1.4 VG 95218-2 Method 3

Test set-up: The single cable to be tested is fixed at an angle of 5° to the vertical, weighed down over a reel. The Bunsen burner flame is directed at the cable from below an angle of 5° to the vertical. Tissue paper (S) is stretched out below the sample.

Flame temperature: Determined by the specified setting of the Bunsen burner flame.

Test duration: Cable with a diameter of ≤ 25 mm: 60 sec
              Cable with a diameter of 25 < D < 50 mm: 120 sec

Compliance criterion: The sample may continue to burn for a maximum of 30 seconds after the flame is removed and the total permissible length of fire damage to the cable is 76 mm. Material dripping off must not ignite the tissue paper (S).
1.5 UL 1581 Section 1060 (FT1) / Section 1061 (Cable Flame) / Section 1080 (VW-1)

- **Test set-up**: The cable is fixed vertically and fitted with a paper indicator flag (P, 10 x 20 mm). A Bunsen burner, fixed at an angle of 20° to the vertical, is used to apply the flame.

- **Flame temperature**: Determined by the specified setting of the Bunsen burner flame.

- **Test duration**:  
  - Section 1060: 5 cycles of flame applied for 15 seconds with a break of 15 seconds  
  - Section 1061: 3 cycles of flame applied for 60 seconds, with a break of 30 seconds  
  - Section 1080: 5 cycles of flame applied for 15 seconds, with a break of 30 seconds and a maximum break of 60 seconds

- **Compliance criterion**: The sample may continue to burn for a maximum of 60 seconds after the flame is removed and the paper indicator flag (P) can be max. 25 % carbonized. Material dripping off must not ignite the cotton wool (B).

1.6 UL 1581 Section 1090 (H) / Section 1100 (FT2)

- **Test set-up**: The cable is fixed horizontally with the Bunsen burner flame applied vertically. The burner is angled 20° from the vertical. The cotton wool (B) is laid out next to the burner.

- **Flame temperature**: Determined by the specified setting of the Bunsen burner flame.

- **Test duration**: 30 seconds

- **Compliance criterion**: The flame propagation speed must not exceed 25 mm/min. Material dripping off must not ignite the cotton wool (B).  
  - Section 1090: The rate of dispersion of the cable may not exceed 25 mm/min  
  - Section 1100: The length of the carbonized part may not exceed 100 m
1.7 IEC 60332-3 / EN 50266-2

Test set-up
The cables are fixed to a ladder, close together or at a distance depending on the type of fire. The cables may be fixed in several layers.

Flame temperature
Determined by the specified volume of propane and air.

Test duration
IEC part 21/EN part 1: Category A F/R only for special applications
IEC part 22/EN part 2: Category A (7 l flammable material/m): 0 min
IEC Part 23/EN part 3: Category B (3.5 l flammable material/m): 0 min
IEC part 24/EN part 4: Category C (1.5 l flammable material/m): 20 min
IEC part 25/EN part 5: Category D (0.5 l flammable material/m): 20 min

Compliance criterion
Fire damage to the cable may be visible for a maximum of 2.5 m from the bottom of the burner to the top.

1.8 UL 1685 Vertical Tray

Test set-up
One layer of cables is fixed to a ladder (quantity depends on the cable diameter). The length of each sample is 2.44 m.

Flame temperature
Determined by the specified volumes of propane and air.

Test duration
20 minutes (2 test runs)

Compliance criterion
Fire damage to the cable must be less than 2.44 m from the bottom of the ladder.
1.9 UL 1685 FT4 / IEEE 1202

Test set-up
The cables are fixed in several layers on a ladder (the quantity depends on the cable diameter). The length of each sample is 2.44 m. Cables with a diameter < 13 mm may be fixed to the ladder in bunches. The burner is angled 20° from the horizontal.

Flame temperature
Determined by the specific volumes of propane and air.

The power amounts to 20.5 kW (70000 Btu/hr).

Test duration
20 minutes (2 test runs)

Compliance criterion
Fire damage must be less than 1.5 m from the lower edge of the burner nozzle.

1.10 UL 1666 Riser

Test set-up
One layer of cables is fixed in position to a ladder (quantity depends on the cable diameter). The length of each sample is 5.33 m. A burner diffusion plate is used to apply the flame.

Flame temperature
Determined by the specified volumes of propane and air.

The power amounts to 154.5 kW (527500 Btu/hr).

Test duration
30 minutes (2 test runs)

Compliance criterion
Fire damage must be less than 3.66 m from the base of the ladder and at a height of 3.66 m the temperature of none of the thermal elements may exceed 454.4 °C. If the difference between both runs exceeds 1.52 m, a third test run is in order.
1.11 NFPA 262 / FT6 Steiner-Tunnel (UL 910 reclusive)

Test set-up
One layer of cables is fixed to a ladder horizontal (quantity depends on cable diameter). The length of each sample is 7.32 m. A measuring device is set up behind the combustion chamber to record smoke density.

Flame temperature
Determined by the specified volume of propane and air. The power amounts to 86 kW (294000 Btu/hr).

Test duration
20 minutes (2 test runs)

Compliance criterion
Fire damage may not exceed 1.52 m. The average optical density may reach 0.15 at max. The peak value may not exceed 0.5 (32 % light transmission).

1.12 NF C32-070 Test 2/UIC 895 VE appendix 7

Test set-up
The cable is fixed vertically into a kiln with a subsequent pipe (125 mm diameter).

Flame temperature
830 °C ± 50 °C

Test duration
30 minutes

Compliance criterion
The end of the cable protruding from the pipe above must not be damaged.
1.13 Def-St 02-641 (formerly NES 641)

Test set-up: Three cables are fixed vertically in a pipe ("Swedish chimney"). Flame is applied by burning of liquid contained in a dish below the pipe.

Flame temperature: Is determined by the flammable liquid.

Test duration: Until all the liquid has been burnt.

Compliance criterion: Fire damage to the cable may be visible up to a maximum of 250 mm below the top end of the cable.

1.14 BS 6387 Category W

Test set-up: The cable is laid horizontally, with the core and shield connected to a power supply at a voltage of U0/U. Flame is applied across a width of 1500 mm. A sprinkler is turned on after 15 minutes.

Flame temperature: 650 °C ± 0 °C

Test duration: 30 minutes (2 test runs)

Compliance criterion: It must be possible to transmit power or signals through all conductors while the flame is applied. There must be no short circuit between the conductors or to the shield.
1.15 DIN VDE 0472-814/BS 6387 Category C

Test set-up: The cable is laid horizontally, with the cores and shield connected to a power supply at the following voltages:
- Data cables: 110 V
- High voltage cable 0.6/1 kV: 230/400 V
- BS: All cables U0/U

Flame is applied from below across a width of 1200 mm. The flame is directed at the cable.

Flame temperature:
- Min. 750 °C
- BS: 950 °C ± 40 °C

Test duration: 180 minutes

Compliance criterion: It must be possible to transmit power or signals through all conductors while the flame is applied and also during a cool-down period of 12 hours. There must be no short circuit between the conductors or to the shield, and no open phase.
1.16 IEC 60331-21/IEC 60331-23

Test set-up
The cable is laid horizontally, with the core and shield connected to a power supply at the following voltages:
- High voltage cable 0.6/1 kV: U0/U min 100 V
- Data cables: 110 V

The flame is applied from a horizontal offset position below the cable across a width of 1200 mm.

Flame temperature
Min. 750 °C (Apparatus IEC 60331-11)

Test duration
90 minutes recommended

Compliance criterion
It must be possible to transmit power or signals through all conductors while the flame is applied and also during a cool-down period of 15 minutes. There must be no short circuit between the conductors or to the shield, and no open phase.
### 1.17 IEC 60331-25

<table>
<thead>
<tr>
<th><strong>Test set-up</strong></th>
<th>The fiber optic cable is laid horizontally, and the fiber optic conductors must be connected. The flame is applied from a horizontal offset position below the cable across a width of 1200 mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flame temperature</strong></td>
<td>Min. 750 °C (Apparatus IEC 60331-11)</td>
</tr>
<tr>
<td><strong>Test duration</strong></td>
<td>90 minutes</td>
</tr>
<tr>
<td><strong>Compliance criterion</strong></td>
<td>It must be possible to transmit signals through the optical fibers while the flame is applied and also during a cool-down period of 15 minutes.</td>
</tr>
</tbody>
</table>

![Diagram](image-url)
1.18 IEC 60331-31

**Test set-up**
The cable is fixed on a positioning board and flame is applied from the front. The positioning board is subjected to knocks every 15 minutes during the burn period.

**Flame temperature**
Min. 830 °C (Apparatus IEC 60331-12)

**Test duration**
120 minutes recommended

**Compliance criterion**
It must be possible to transmit power or signals through all conductors while the flame is applied. There must be no short circuit between the conductors or to the shield.
1.17 EN 50200

Test set-up: The cable (maximum 20 mm diameter) is fixed on a positioning board and flame is applied from the front. The positioning board is subjected to knocks every 15 minutes during the burn period.

Flame temperature: 842 °C

Test duration: 90 minutes

Compliance criterion:
- For cable and conductors with voltage rated up to 600 /1000 V: There must be no short circuit between the conductors and no open phase.
- For data and communications cable without voltage rating: There must be no short circuit between the conductors and no open phase.
- For fiber optic cables: The increase in attenuation must not exceed the figure specified in the respective design standards.
1.20 BS 6387 Category Z

Test set-up: The cable is fixed on a positioning board and flame is applied from below. The positioning board is subjected to 2 knocks every minute during the burn period.

Flame temperature: 950 °C ± 40 °C

Test duration: 15 minutes

Compliance criterion: It must be possible to transmit power or signals through all conductors while the flame is applied. There must be no short circuit between the conductors or to the shield.
Smoke density

2.1 IEC 61034-2/EN 50268-2

Test set-up: Using a flammable liquid, a cable specimen is burnt in a closed chamber. The light transmittance of the resulting smoke is measured optically.

Flame temperature: Determined by the quantity and composition of the flammable liquid.

Test duration: 40 minutes

Compliance criterion: The smoke must transmit at least 60 % of the light at the end of the test’s duration, unless stated otherwise in individual specifications.

2.2 Def-St. 02-711 (formerly NES 711)

Test set-up: The specimens are burnt in a test chamber using a gas burner. The light transmittance is measured optically.

Flame temperature: Not specified (specimens must be fully burnt).

Test duration: 20 minutes

Compliance criterion: At the end of the test’s duration the smoke must transmit at least 70 % / 40 % / 10 % of the light depending on the product category, unless stated otherwise in individual specifications.
Toxicity of the combustion gases

3.1 IEC 60695-7-1

This standard covers general aspects of the toxicity of smoke and combustion gases as well as the potential danger (general guidelines).

3.2 Def-St. 02-713 (formerly NES 713)/VG 95218-2 Method 1

Test set-up
The individual non-metallic components of the cables are burnt in a test chamber.
The toxicity of the fire gas is determined analytically covering 1 substances.

Flame temperature
1150 °C ± 50 °C

Test duration
5 minutes

Compliance criterion
The toxicity readings of the individual non-metallic components of the cable are added according to their proportion of the total volume. The toxicity index for the overall cable must not exceed 5.
Corrosiveness of the combustion gases (halogen-free readings)

4.1 IEC 60754 / EN 50267

This standard covers general aspects of the corrosiveness of smoke and combustion gases, released in water or atmosphere moisture, as well as the potential danger (general guidelines).

4.2 IEC 60754-1 / EN 50267-2-1

**Test set-up**

A sample of between 0.5 and 1 g is heated in a pipe. The resulting gases are separated and tested for halogen content.

**Flame temperature**

800 °C ± 10 °C

**Test duration**

40 ± 5 minutes in total, with at least 20 minutes at maximum temperature

**Compliance criterion**

The halogen content of all non-metallic components must not exceed 0.5 % or 5 mg/g.
**4.3 IEC 60754-2/EN 50267-2-2**

**Test set-up**
A sample of 1 g of all non-metallic components of a cable is burnt in a furnace. The pH value and conductivity of the combustion gases released in water is measured.

**Flame temperature**
Min. 935 °C

**Test duration**
30 minutes

**Compliance criterion**
The pH value of the wash water must be at least .3, and the conductivity of the wash water a max. of 10 µS/m.
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