Certificate No:
TAE00004W9

TYPE APPROVAL CERTIFICATE

This is to certify:

That the Fire Protective Systems for Cables

with type designation(s)
Øglænd's passive fire protection system FireSys, Powered by Favuseal®

Issued to
Øglænd System AS
KLEPPE, **Norway**

is found to comply with
DNV offshore standards

Application :

Approved for use as 250 kW/m2 Jet fire protection of power cables and data cables.

Issued at **Høvik** on **2024-07-01**
This Certificate is valid until **2029-06-30** .
DNV local unit: **Stavanger**

Approval Engineer: **Ivar Bull**

for **DNV**

Frederik Tore Elter
Head of Section

This Certificate is subject to terms and conditions overleaf. Any significant change in design or construction may render this Certificate invalid.
The validity date relates to the Type Approval Certificate and not to the approval of equipment/systems installed.

Product description

Øglænd's passive fire protection system FireSys, Powered by Favuseal®
Approved for use as 250 kW/m^2 Jet fire protection of power cables and data cables.

FireSys is a sandwich construction inside of which an object to be protected from fire is laid in. The sandwich construction is made of a 0.7mm thick outer steel cladding and an inner steel box with a layer of Polymer-Based Fire Protection (PBFP) technology-based material fitted between the inner box and outer cladding. The inner steel box of the sandwich construction also serves as a load-carrying structure of the system (e.g., inner steel box can be a covered cable tray, a support channel, etc.). Inside of the inner steel box cables can be installed. The steel components of the sandwich construction are manufactured by Øglænd System. A volume surrounded by such sandwich structure is further referred to as a protected chamber.

The PBFP technology-based material is manufactured by Favuseal. Nominal density of “Favuseal NKX-6174” material is 1776 kg/m^3. Thickness of PBFP layer is 8mm. The construction may incorporate a Ø21 mm Favuseal Fireproof Drain Plug. In normal operation (virgin state) Favuseal has high thermal conductivity (λ=0.927 [W/(m·K)] @50°C) enabling transfer of heat away from power cables in the protected chamber. Drain plugs can be installed to create air circulation for better cooling of cables. When a PBFP (Favuseal) material is exposed to heat, it will utilize two strongly endothermic reaction processes and change state from a flexible polymer into a micro-porous ceramic state, generating a delayed heat rise/response curve inside the sandwich construction.

Type:	FireSys cable tray 450
Outer dimensions (LxWxH):	3000 x 535.4 x 138.4
Inner dimensions (LxWxH):	3000 x 450 x 102
Available fittings/accessories:	Elbow 45° Inside riser 45° Outside riser 45° T-piece Crosspiece Cable exit box Cable transit cover Reducer 450/150mm

Type:	FireSys cable tray 150
Outer dimensions (LxWxH):	3000 x 235.4 x 138.4
Inner dimensions (LxWxH):	3000 x 150 x 102
Available fittings/accessories:	Elbow 45° Inside riser 45° Outside riser 45° Cable exit box

For the purpose of IEC 61537 testing of the inner steel boxes, i.e., load-carrying structures:

Support system

Type:	Mekano CH100-3
Material:	Stainless steel SS316L
Thickness:	2.5 mm
Support set up:	U and L support, refer to IEC 61537 Figure 47, 36c

Cable tray system

Type:	FSYS CT-IN
Material:	Stainless steel SS316L
Thickness:	2 mm
Width:	454 mm
Height of side piece:	104 mm

For further details see Quality Assurance Plan under Type Approval documentation.

Test method

In order to approve a complete fire protection system consisting of FireSys and cables installed inside, two separate test steps 1 and 2 shall be carried out.

Test STEP 1. Establish temperature response curve of the fire protection system itself:
When the passive fire protection system is exposed to a **Jet fire curve according to ISO 22899-1**, temperatures are measured at several locations inside the protected chamber. Based on this, an average temperature response curve is established. Fire test STEP 1 is performed with an empty inner steel box. There is no extra mass of test objects (cables) which would cause a heat sink effect by delaying the temperature rise. The temperature response curve generated in an empty inner steel box is therefore considered a conservative approach.

Provided that surface-to-mass ratio of the inner steel box and PBFP layer thickness do not change, the temperature response curve remains the same. Reducing surface-to-mass ratio and / or increasing thickness of the PBFP material layer would improve the fire resistance properties of the system, thus requiring an updated response curve.

Test STEP 2. Testing fire performance of a cable heated inside the passive fire protection system:
To document fire performance of a cable installed inside the protected chamber, a small-scale slow heat radiation test shall be performed on the cable. The temperature response curve, as determined in test STEP 1, is applied inside a slow heat radiation furnace. The cable will therefore be exposed to the same heat curve as if the cable was installed in a FireSys during a full-scale Jet fire.

The small-scale slow heat radiation test in STEP 2 shall be done in accordance with Appendix 1.

Time-temperature graphs of applied Jet fire curve 250kW/m2 and corresponding response curve are shown in Figure 1. Test STEP 1 establishes the blue response curve and test STEP 2 determine the time when the different cables fail when heated according to the response curve. The black dashed line in Figure 1 illustrates an example of a typical industry requirement in minutes. The red dashed line illustrates an example of a result in minutes from STEP 2. In this example, the tested cable meets an industry requirement of 30 minutes.

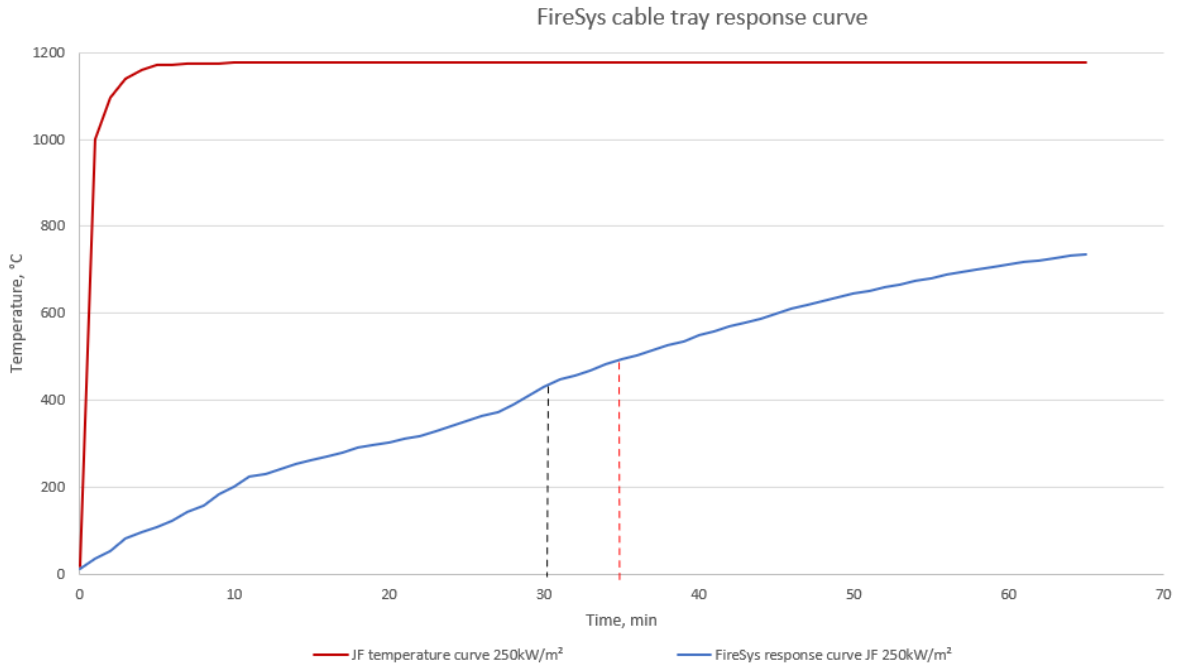

Figure 1. Jet fire curve ISO 22899-1 250kW/m^2 and FireSys response curve.

Application/Limitation

Approved as a system for ISO 22899-1 250kW/m^2 Jet fire protection of cables.

This approval refers to the fire-resistant properties of the passive fire protection system FireSys (STEP 1). This TAC also covers the load-carrying structures tested according to IEC 61537.

For approval of a complete system consisting of FireSys with a protected object, such as cable, inside, this type approval certificate has to be supplemented with a test report according to STEP 2.

Each product shall be supplied with its manual for installation and maintenance. The installation of each product shall be performed in accordance with the manufacturer's installation manual and loading tables.

The sum of the cables' total cross section, based on the cables' external diameter, shall not exceed the recommended space factor of 40% of the FireSys internal cross section.

Power cables with cross sectional area less than 50mm^2 can be installed in bunches with maximum 6 cables with minimum 2x cable outer diameter between trefoils. Power cables with cross sectional area 50mm^2 and upwards shall be installed in spaced configuration as shown in figure 2 and figure 3 to allow air circulation around cables inside the FireSys

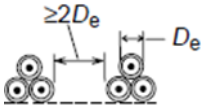

Figure 2. Single core power cables shall be installed in trefoil with minimum 2x cable outer diameter between trefoils as illustrated in IEC 60092 Part 352.

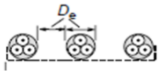

Figure 3. Multicore power cables shall be installed in flat formation with minimum 1x cable outer diameter between cables as illustrated in IEC 60092 Part 352.

Determination of current carrying capacity of power cables inside FireSys:
IEC 60092 Part 352: Choice and installation of electrical cables, General Installation, Table B.4 provides current carrying capacities for cables in continuous service at maximum rated conductor temperature of 90 °C and ambient temperature of 45 °C.

When power cables carry nominal current, cable resistance will create heat losses, which in turn increase temperature inside FireSys. When temperature around cables is higher than 45°C, a correction factor shall be applied to reduce the nominal ampacity of the cable. Inside temperature should not be confused with ambient temperature 45°C surrounding the FireSys cable tray. When cable conductor temperature is higher than 20°C, resistance increases and a correction factor for conductor resistance shall be applied. Using corrected values for conductor resistance and ampacity for various ambient temperatures, heat loss can be calculated as [W/m]. Figure 4 shows an example where cable losses and FireSys ability to remove heat are plotted for various ambient temperatures. Steady state situations (equilibrium) are found where the lines intersect. At these points, heat loss generated by cables equals the heat flux FireSys can remove from the protected chamber.

Table 1. Correction factors to be used when temperature around cables is above 45℃. Correction factor shall be multiplied with nominal cable ampacity from IEC 60092-352 Table B.4.

Temperature inside FireSys	45℃	50℃	55℃	60℃	65℃	70℃	75℃	80℃
Correction factor	1	0,94	0,88	0,82	0,74	0,67	0,58	0,47

Depending on number of cables installed in FireSys, an equilibrium temperature can be determined as shown in example Figure 4:

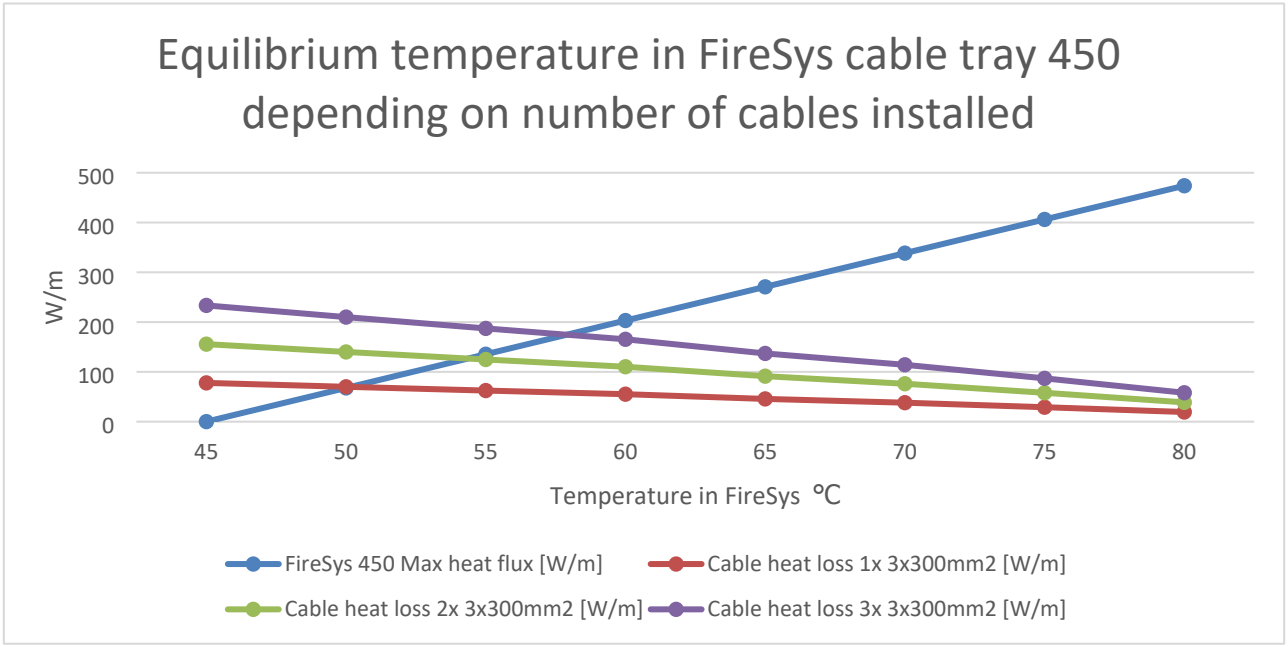

Figure 4: Cable losses adjusted for ambient temperature correction factors vs FireSys ability to remove heat plotted as function of temperature inside FireSys.

Following de-rating factors from IEC 60092-353 Table 3 shall be used for cables installed in FireSys 450:
1x 3x300mm^2: Equilibrium temperature 50°C Cable ampacity de-rating 0,94
2x 3x300mm^2: Equilibrium temperature 55°C Cable ampacity de-rating 0,88
3x 3x300mm^2: Equilibrium temperature 60°C Cable ampacity de-rating 0,82

Following de-rating factors from IEC 60092-353 Table 3 shall be used for cables installed in FireSys 150:
1x 3x300mm^2: Equilibrium temperature 50°C Cable ampacity de-rating 0,94

The same de-rating factors also applies for single core cables 185mm^2 and 240 mm^2.

The FireSys max heat flux values are theoretically calculated based on an ambient temperature of 45°C and a the FireSys inner steel box. Conductivities of materials are determined by tests according to ISO 22007-2: SS316L stainless steel 16.33 W/(m*K); Favuseal NKX-6174 0.927 W/(m*K). For air gaps within the FireSys sandwich construction, the following air conductivity values are assumed: air with convection 0.215 W/(m*K); air without convection 0.0285 W/(m*K). The inner steel box has a perforated bottom surface, therefore, the calculation is assuming that the bottom surface of FireSys sandwich construction has a gap of air with convection, while the bottom and side surfaces of FireSys have a gap of air without convection.

Type Approval documentation

Tests carried out

Fire test according to Jet fire curve ISO 22899-1.
Cable tray system: Test for SWL and Electrical Continuity test according to IEC 61537.
Support system: Test for SWL according to IEC 61537.

Marking of product

Marked with Øglænd System logo and product identification. Refer to DNV Type Approval Certificate TAE00004EN for required de-rating of cables installed in FireSys. (cover marking).

Periodical assessment

This certificate is only valid if required periodical assessments are carried out with satisfactory results. To check the validity of this certificate, please look it up in https://approvalfinder.dnv.com

The scope of the periodical assessment is to verify that the conditions stipulated for the Type approval are complied with and that no alterations are made to the product design or choice of materials.

The main elements of the assessment are:

- Inspection on factory samples, selected at random from the production line (where practicable)
- Results from Routine tests (RT) and selected type tests (ref. to applicable class programs) checked (if not available these tests shall be carried out)
- Review of type approval documentation
- Review of possible change in design, materials and performance
- Ensuring traceability between manufacturer's product type marking and Type Approval Certificate.

Periodical assessment is to be performed after 2 years and after 3.5 years. A renewal assessment will be performed at renewal of the certificate.

END OF CERTIFICATE

Appendix 1. Small Scale Slow Heat Radiation test (STEP 2)

STEP 2 Small Scale Slow Heat Radiation tests are offered by Safezone, a Norwegian advisory company specialized on fire safety. Favuseal and Safezone have developed a DNV approved Slow Heat Radiation oven with tailor made control, monitoring and reporting tools. STEP 2 tests shall be witnessed by a DNV surveyor.

All equipment for measurements shall be calibrated. A temperature-time curve shall be logged together with critical cable and test parameters. A standard test report shall be issued after each test. The test report shall state the observed functioning time during fire (excluding any pre-heating time) for a specific cable type. Failure criteria shall be stated.

Power cables shall be preheated to a temperature of 90°C to achieve a worst case start temperature as indicated in the time-temperature graph below.

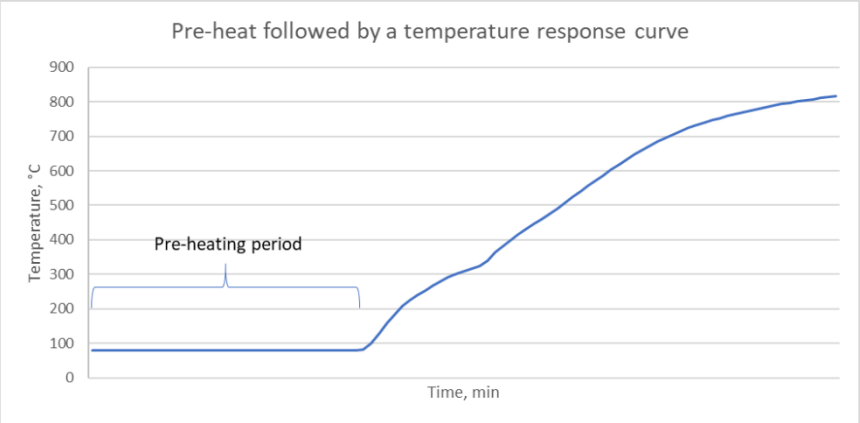

Figure 2: Example of pre-programmed heating curve for Slow Heat Radiation test. Power cables shall be pre-heated sufficient time to reach 90°C.

Failure criteria:
Monitoring of cable performance during fire and acceptance criteria for cable failure will depend on cable type.
Each cable being tested should be monitored separately.

Cable type:	Failure criteria based on:	Failure criteria:
Power, control & instrument cables	Insulation resistance between phases and braid / earth conductor	Leakage current exceeds 30 mA → Insulation level falls below 33,3 Ohm/Volt
Data communication cables	Transmission properties	Transmission speed falls below specified value
Fibre Optic cables	Transmission properties	Attenuation exceeds 1,5 dB per fibre