Ksandr Live XL 2025

Ksandr

Het collectieve brein voor de instandhouding
van het Nederlandse elektriciteitsnet.

Vind de echte kabelcapaciteit!

Marcel den Haan
Robbert de Ruiter

Grid Design Solutions
www.griddesignsolutions.nl

Vind de echte kabelcapaciteit!

IEC 60287 (voor kabelcapaciteit),

Het biedt een **gestandaardiseerde methode** om de **continue stroombelasting (ampaciteit) van kabels te berekenen, onder normale bedrijfstoestanden.**

Het houdt rekening met:

- ✅ **Bepalen van de capaciteit**: hoeveel stroom een kabel continu kan voeren zonder dat de maximale toegestane geleider- of isolatietemperatuur wordt overschreden.
- ✅ **Warmteberekening**: de norm beschrijft hoe de warmte die in de kabel ontstaat door ohmse verliezen (en eventueel scherm- of mantelverliezen) zich verspreidt naar de omgeving.
- ✅ **Omgevingsinvloeden**: houdt rekening met bodem / grondweerstand, installatiemethoden (grond, lucht, buis, etc.), groepering van kabels en ventilatie.
- ✅ **Ontwerp en dimensionering**: wordt gebruikt door ingenieurs en kabelproducenten om kabeldoorsnedes correct te selecteren en veilige, efficiënte kabelinstallaties te garanderen.
- ✅ **Internationale standaardisatie**: zorgt ervoor dat berekeningen wereldwijd op dezelfde manier gebeuren, wat uitwisselbaarheid en betrouwbaarheid bevordert.

GDS
GRID DESIGN SOLUTIONS

Vind de echte kabelcapaciteit!

IEC 60502

IEC 60502 beschrijft hoe middenspannings- en laagspanningsvermogenskabels tot 30 kV moeten worden ontworpen, geproduceerd en getest, zodat veiligheid en betrouwbaarheid in de praktijk gegarandeerd zijn.

✅ Technische eisen voor kabels met geëxtrudeerde isolatie (PVC, XLPE, EPR, enz.).
✅ Constructievoorschriften zoals opbouw van geleider, isolatie, scherm, bewapening en mantels.
✅ Typebeproevingen en routinetesten (o.a. elektrische testen, mechanische sterkte, brandgedrag, veroudering).
✅ Prestatiecriteria voor mechanische, elektrische en thermische eigenschappen.
✅ Toebehoren zoals kabelmoffen en eindsluitingen.

NEN – HD 620 (S3 2023) – was NEN 3620 NL

- Uniformering van kabelkwaliteit, veiligheid en duurzaamheid
- Europees geharmoniseerd document (CENELEC)
- Spanningsbereik 3,6/6 kV tot 20,8/36 kV (tot 42 kV Um)

Vind de echte kabelcapaciteit!

Comsol en Finite Element Modellen

Waar de **IEC 60287**-norm gebruikmaakt van **vereenvoudigde analytische formules** (met aannames over homogene materialen, uniforme temperatuurverdeling, standaardopstellingen), laat **COMSOL** toe om:

- **Echte geometrieën** van kabels te modelleren (bv. complexe doorsneden, bochten, niet-symmetrische opbouw)
- **Inhomogene omgevingscondities** mee te nemen (zoals wisselende grondsoorten, betonblokken, ventilatie, vochtigheid)
- **Thermisch gedrag dynamisch en lokaal te analyseren**
- **Transiënten** (tijdafhankelijke variaties) te simuleren, bv. bij belastingpieken

COMSOL / FEM = digitale laboratoriumomgeving waar je fysisch gedrag van kabels realistisch en gekoppeld kunt simuleren, veel preciezer dan klassieke normen zoals IEC 60287.

Vind de echte kabelcapaciteit!

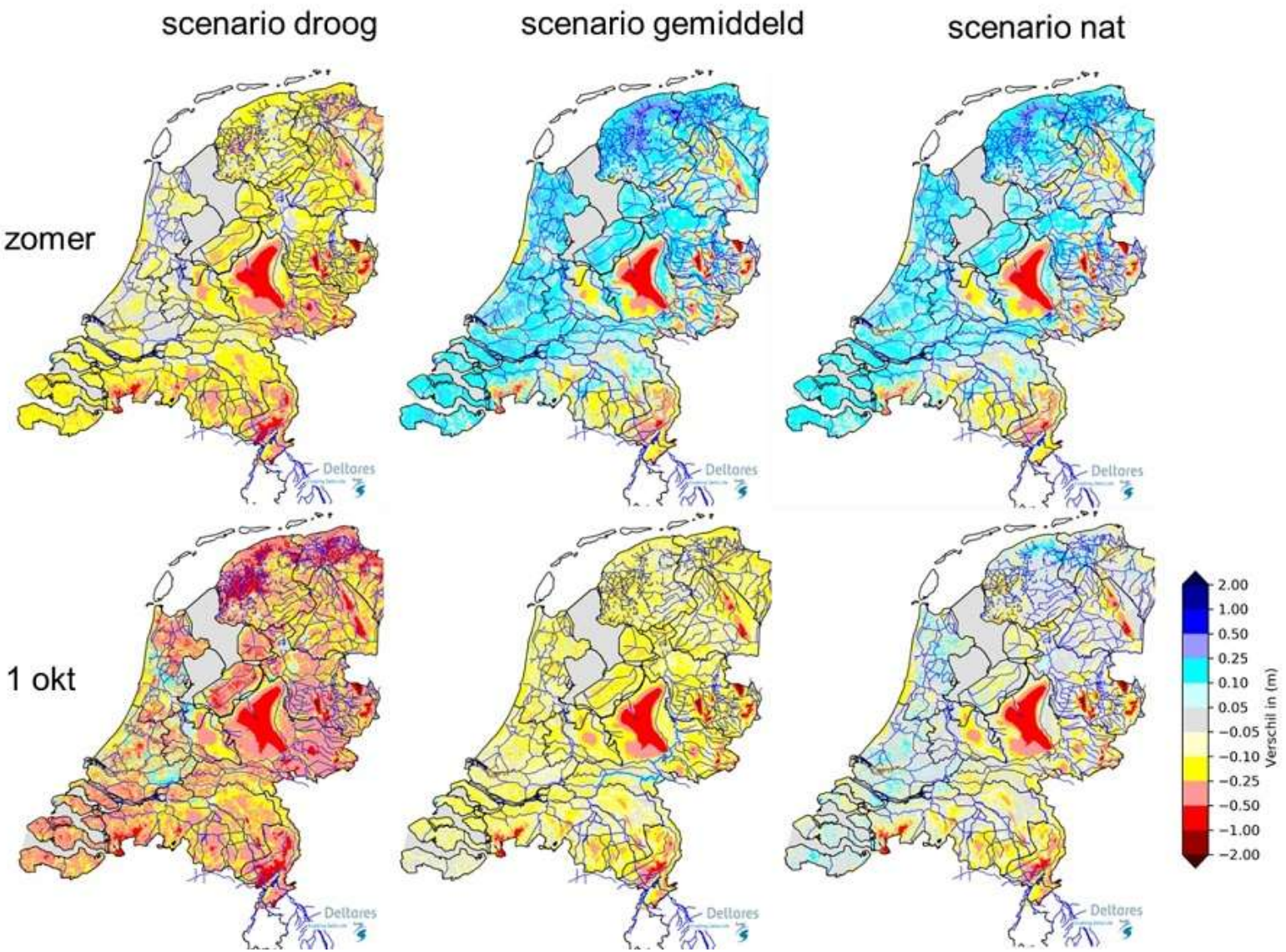
Voldoen de huidige standaarden dan nog?

WG B1 – 72 | Cable rating verification – application in complex situations

Doelen / Scope:

Ontwikkelen van richtlijnen voor het verifiëren van kabelstroom-draagvermogens in complexe situatieconfiguraties (zoals variabele inrichting, ingewikkelde grondgesteldheden, nabij warmtebronnen, gemengde en ongebruikelijke installaties Case-studies faciliteren om rekentools en methoden te testen en vergelijken. Zien waar standaardbenaderingen (zoals in IEC 60287) tekortschieten of adaptatie behoeven.

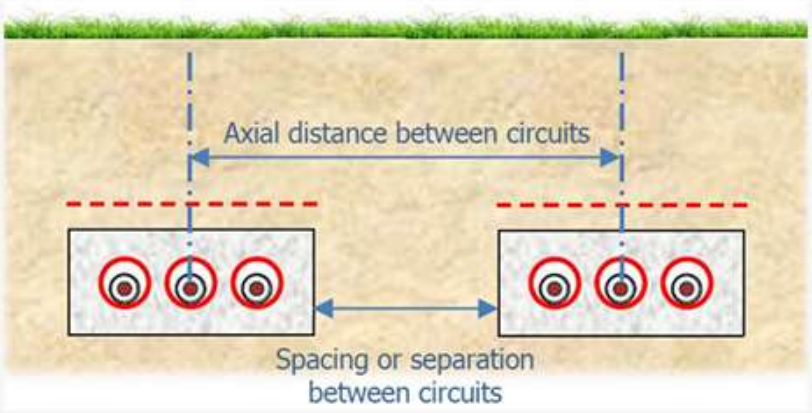
Verificatie volgens TB 880


scenario droog
scenario gemiddeld
scenario nat
zomer
1 okt
Deltares
2.00
1.00
0.50
0.25
0.10
0.05
−0.05
−0.10
−0.25
−0.50
−1.00
−2.00
Verschil in (m)

CIGRE workflow

- National Representatives suggest proposal for Work
- 1 year Task Force to prepare Terms of Reference
- 3 year Working Group to produce Technical Brochure

Often copied to an IEC Standard.



Example of evolving from 2010:

B1.35 – Guide For ratings calculation (TB 640 - 2015)

B1.56 – Cable Rating verification (TB 880 – 2022)

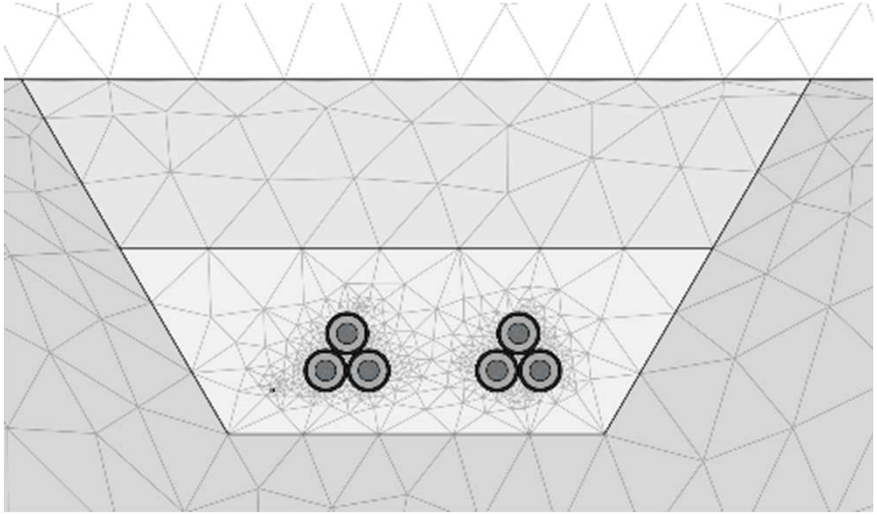
B1.64 – Evaluation of Losses in armoured three core power cables

B1.67 – Loading Pattern on cables connected to windfarms

B1.72 – Cable Rating verification – part 2

B1.87 – Finite Element Analysis for cable rating calculations

B1.91 – Calculation of Cycling current rating (IEC 60853)



IEC 60287-1-2

Edition 2.0 2023-05

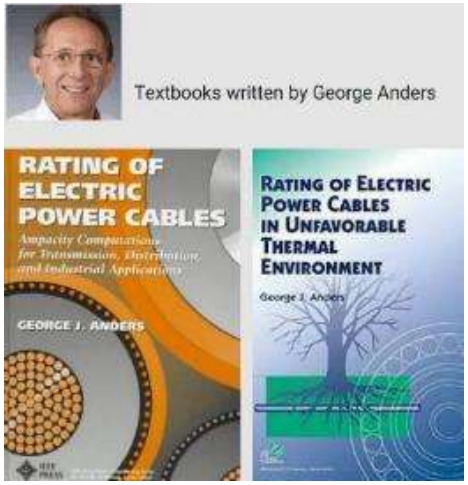
INTERNATIONAL STANDARD

GROFTDESIGN

Developed with Norwegian grid operators

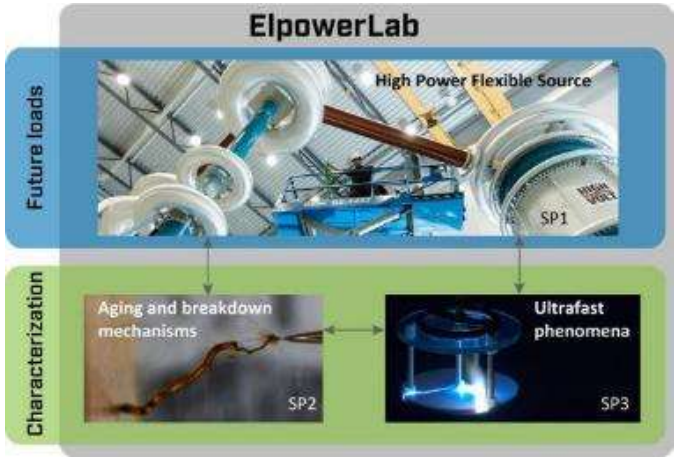
https://www.groftdesign.net/

SINTEF



Experts

Norwegian Grid operators



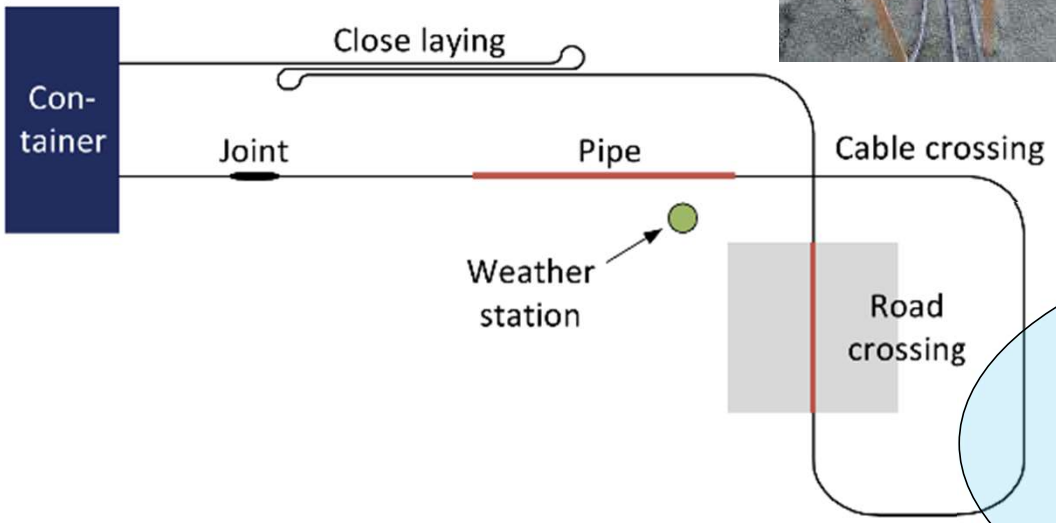
SINTEF Energy Research Lab

REN

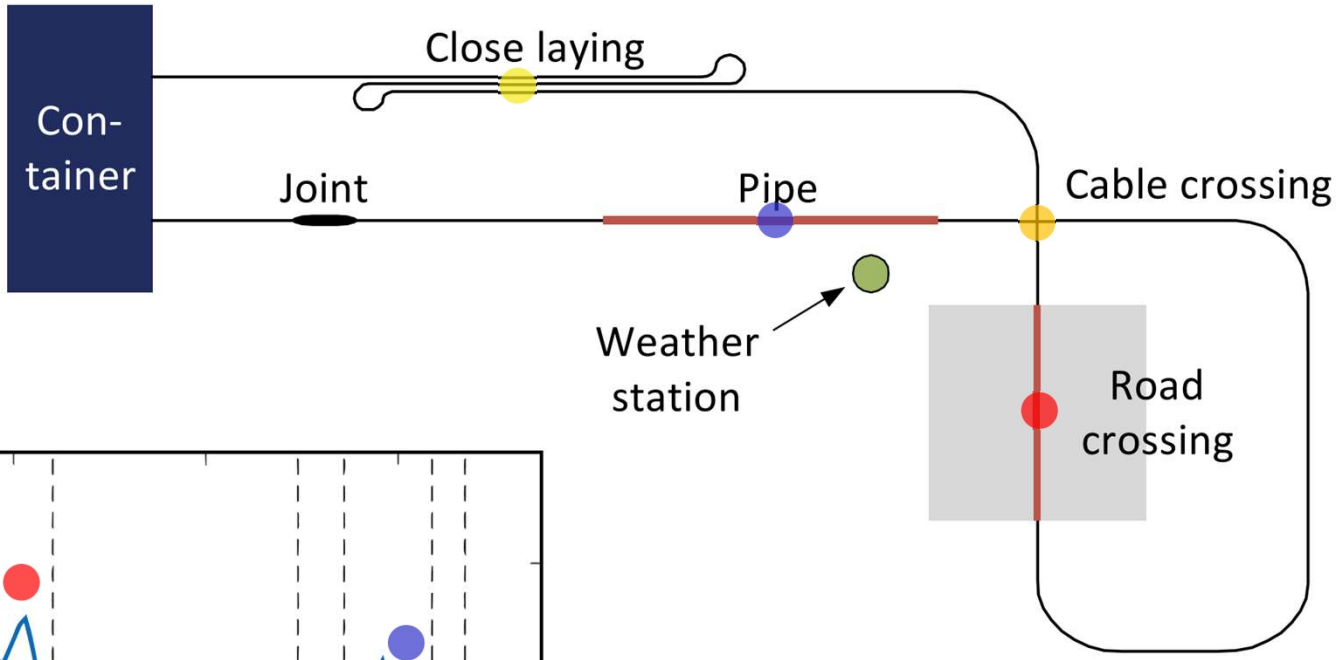
REN AS

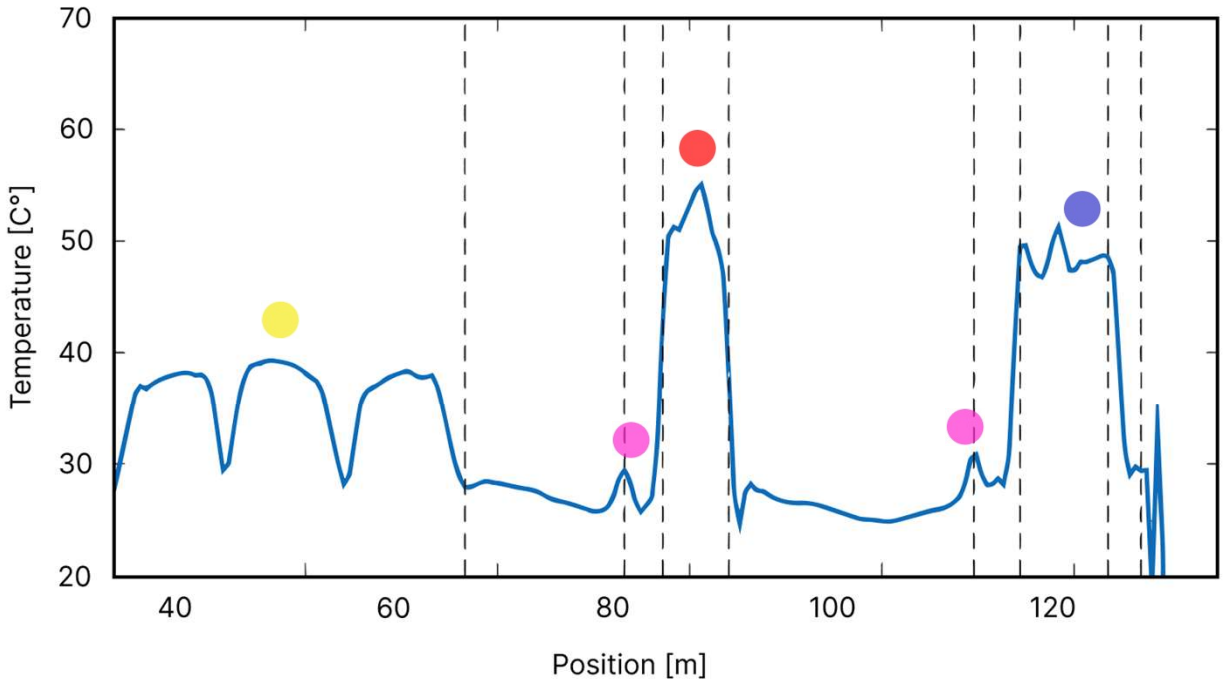
GDS

Hot Spots


Con-
tainer
Close laying
Joint
Pipe
Cable crossing
Weather
station
Road
crossing

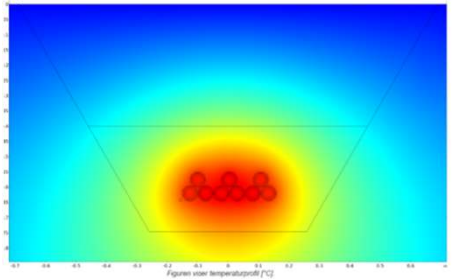
Hot Spots


Con-
tainer
Close laying
Joint
Pipe
Cable crossing
Weather
station
Road
crossing

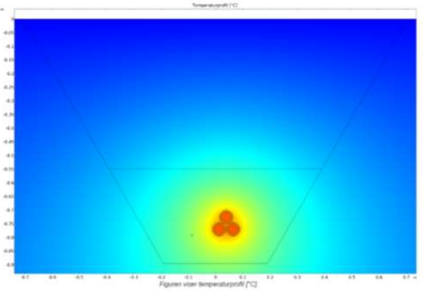

Temperature [C°]
70
60
50
40
30
20
40
60
80
100
120
Position [m]

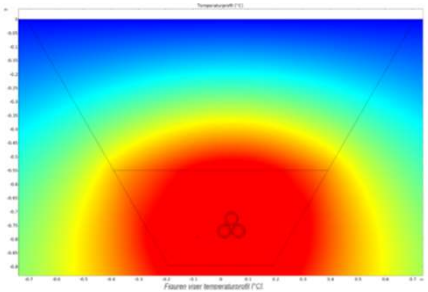
Thermische weerstand – belang van installaties

Kabels installeren zonder tussenruimte-
- Vermindert de overdrachtscapaciteit met 10-15%

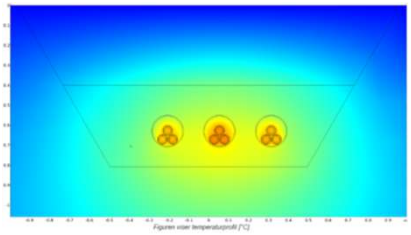


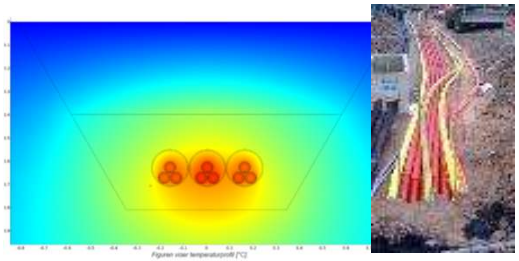
Hoge temperaturen na verloop van tijd (zand droogt uit)
- Kan het overdrachtsvermogen met 30-60% verminderen



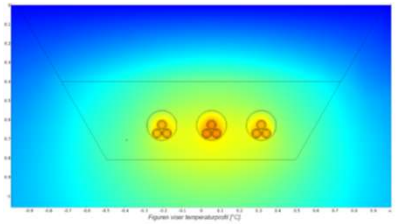


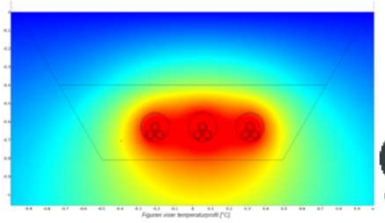
Leidingen zonder tussenruimte geïnstalleerd
- Vermindert het overdrachtsvermogen met 10-15%





Grind en verkeerd zand vergeleken met goed zand
- Vermindert de overdrachtscapaciteit met 40-50%

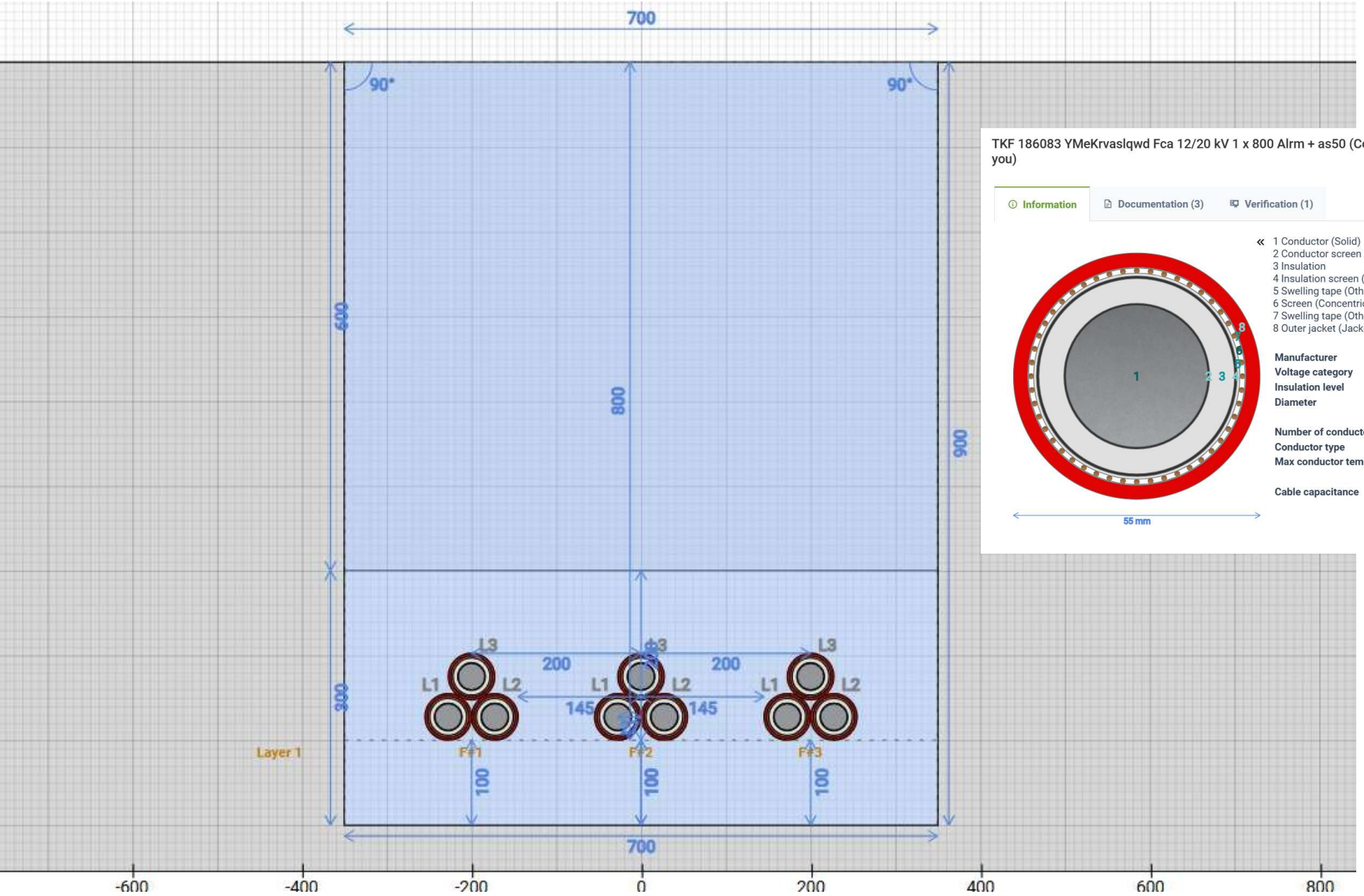




Mass	Wet [mK/W]	Dry [mK/W]	Source
Gravel (coarse-fine)	0.5	2.5	Cigre TB 714 (2017)[12]
Sand (coarse-fine)	0.5	2.0	Cigre TB 714 (2017)[12]
Sand (sorted)	0.6	3.5	Cigre TB 714 (2017)[12]
Silt	0.7	2.5	Cigre TB 714 (2017)[12]
Topsoil	0.7	2.0	NMBU measurement[10]
Turf	2	17	SINTEF measurement[10]
Clay	0.25	17	SINTEF measurement[10]

Mass	Thermal Resistivity [mK/W]	Source
Bentonite	0.4- 0.6	SINTEF measurement[10]
Tarmac	0.5-1.0	SINTEF measurement[10]
Concrete for duct banks	1.0	IEC 60287-2-1:2023[9]
Concrete for duct banks	0.6[13]	SINTEF measurement[13]

[10] SINTEF measurment is based on the report: H. Strand, “Stedlige Masser” 01.04.2021



TKF 186083 YMeKrvaslqwd Fca 12/20 kV 1 x 800 Alrm + as50 (Components shared with you)

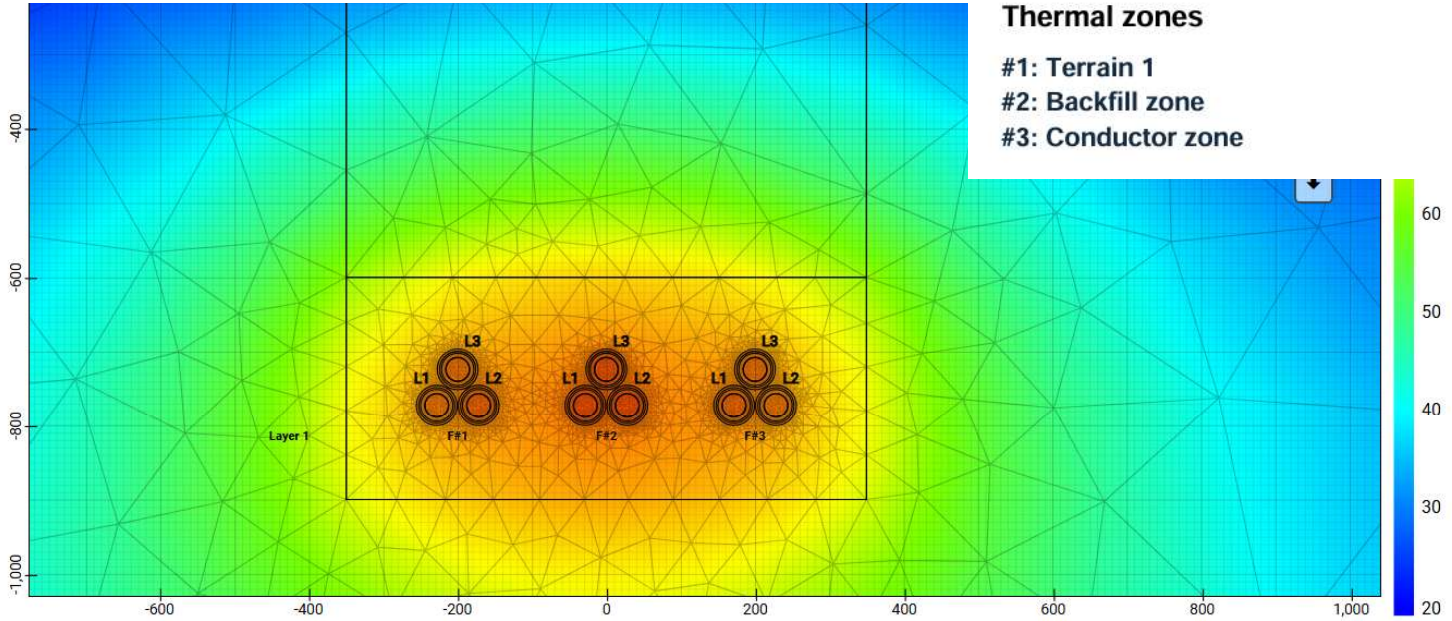
Information | Documentation (3) | Verification (1)

1 Conductor (Solid)
2 Conductor screen (Semiconducting layer)
3 Insulation
4 Insulation screen (Semiconducting layer)
5 Swelling tape (Other)
6 Screen (Concentric wires)
7 Swelling tape (Other)
8 Outer jacket (Jacket)

Manufacturer	TKF
Voltage category	HV
Insulation level	23 kV
Diameter	54.9 mm
Number of conductors	1
Conductor type	Solid
Max conductor temperature	90 °C
Cable capacitance	0.48 µF/km

Cable circuits

Description	Conductor connection	Phase system	Cables	Operating voltage	Current (RMS)	Transfer capacity
A, Cable circuit	Connected	Three-phase	HV cable group @ free #3	22 kV	515 A	19.6 MVA
B, Cable circuit	Connected	Three-phase	HV cable group @ free #1	22 kV	515 A	19.6 MVA
C, Cable circuit	Connected	Three-phase	HV cable group @ free #2	22 kV	515 A	19.6 MVA



Grøft Design ⊟

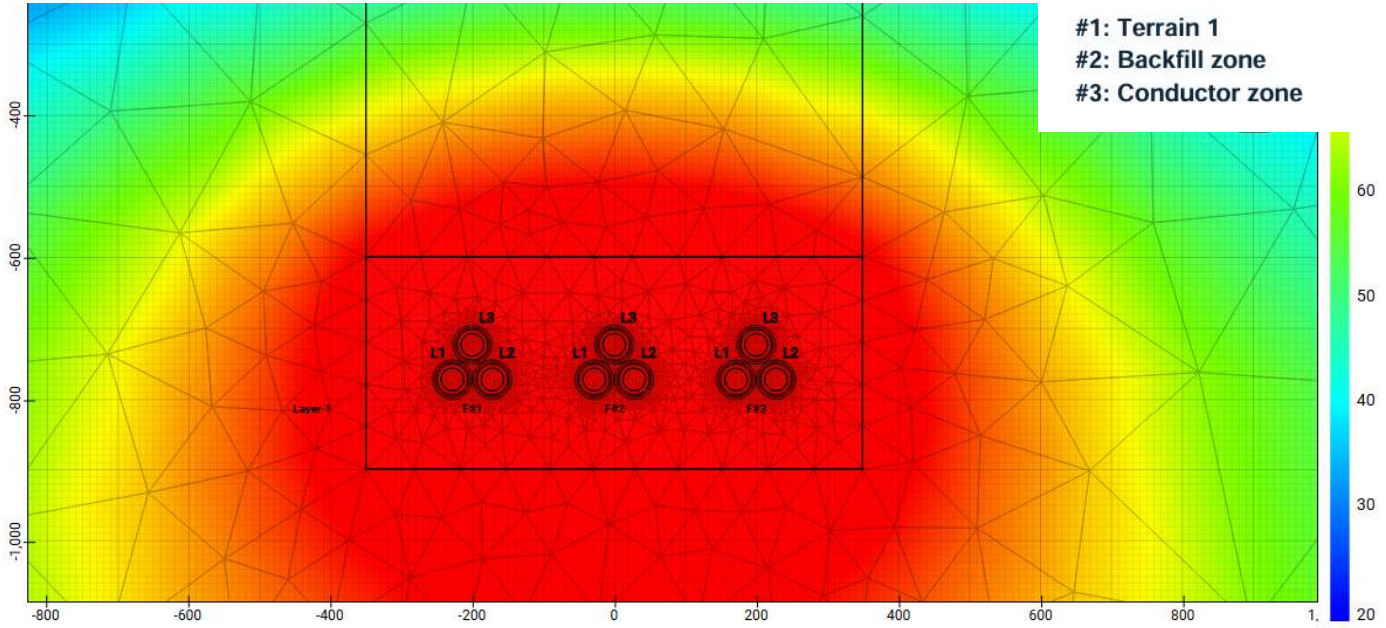
	The whole trench
Highest temperature [°C]	89.9
Highest cable temperature [°C]	89.9
Maximum temperature in conductor zone [°C]	86.8
Highest temperature in the backfill masses [°C]	74.6
Highest temperature at ground level [°C]	15.0

Cable circuits

Description	Conductor connection	Phase system	Cables	Operating voltage	Current (RMS)	Transfer capacity
A, Cable circuit	Connected	Three-phase	HV cable group @ free #3	22 kV	513 A	19.5 MVA
B, Cable circuit	Connected	Three-phase	HV cable group @ free #1	22 kV	513 A	19.5 MVA
C, Cable circuit	Connected	Three-phase	HV cable group @ free #2	22 kV	513 A	19.5 MVA

Thermal zones

#1: Terrain 1	2.5 mK/W
#2: Backfill zone	2.5 mK/W
#3: Conductor zone	1.0 mK/W

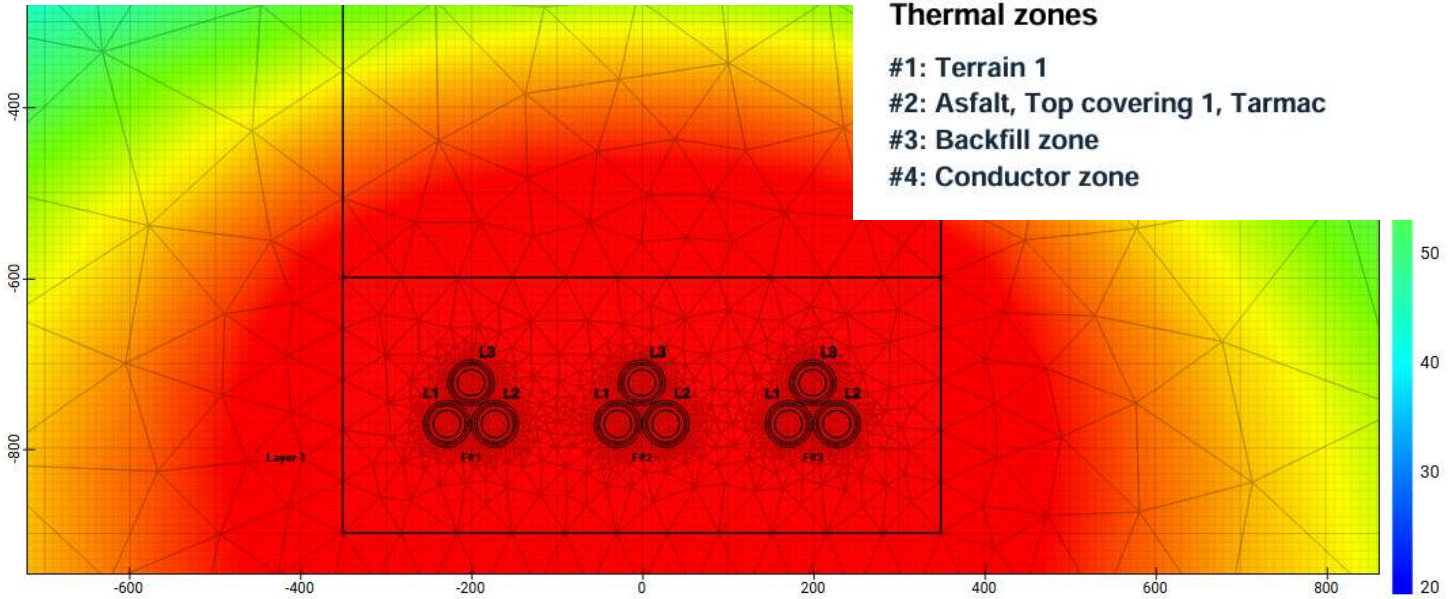


Grøft Design ⊟

	The whole trench
Highest temperature [°C]	144.0
Highest cable temperature [°C]	144.0
Maximum temperature in conductor zone [°C]	140.5
Highest temperature in the backfill masses [°C]	123.5
Highest temperature at ground level [°C]	15.0

Cable circuits

Description	Conductor connection	Phase system	Cables	Operating voltage	Current (RMS)	Transfer capacity
A, Cable circuit	Connected	Three-phase	HV cable group @ free #3	22 kV	513 A	19.5 MVA
B, Cable circuit	Connected	Three-phase	HV cable group @ free #1	22 kV	513 A	19.5 MVA
C, Cable circuit	Connected	Three-phase	HV cable group @ free #2	22 kV	513 A	19.5 MVA



Thermal zones

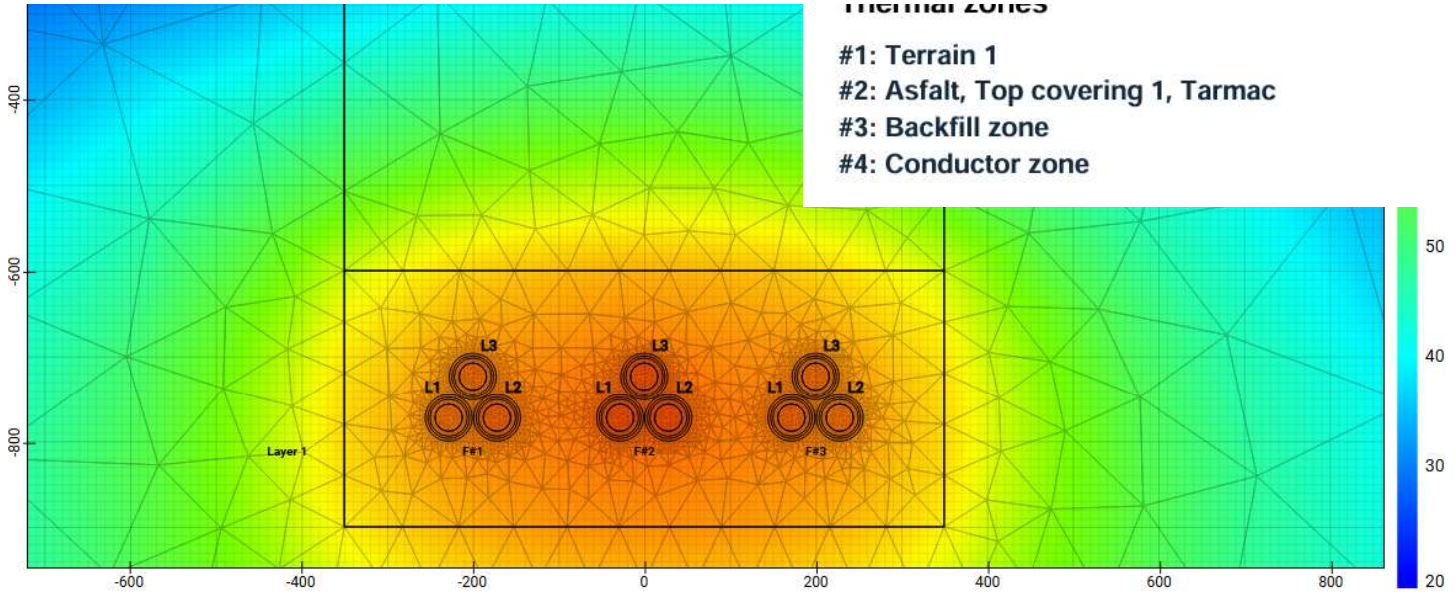
#1: Terrain 1	2.5 mK/W
#2: Asfalt, Top covering 1, Tarmac	2.0 mK/W
#3: Backfill zone	2.5 mK/W
#4: Conductor zone	1.0 mK/W

Grøft Design ⊟

	The whole trench
Highest temperature [°C]	151.3
Highest cable temperature [°C]	151.3
Maximum temperature in conductor zone [°C]	147.8
Highest temperature in the backfill masses [°C]	130.3
Highest temperature at ground level [°C]	20.0

Cable circuits

Description	Conductor connection	Phase system	Cables	Operating voltage	Current (RMS)	Transfer capacity
A, Cable circuit	Connected	Three-phase	HV cable group @ free #3	22 kV	413 A	15.7 MVA
B, Cable circuit	Connected	Three-phase	HV cable group @ free #1	22 kV	413 A	15.7 MVA
C, Cable circuit	Connected	Three-phase	HV cable group @ free #2	22 kV	413 A	15.7 MVA

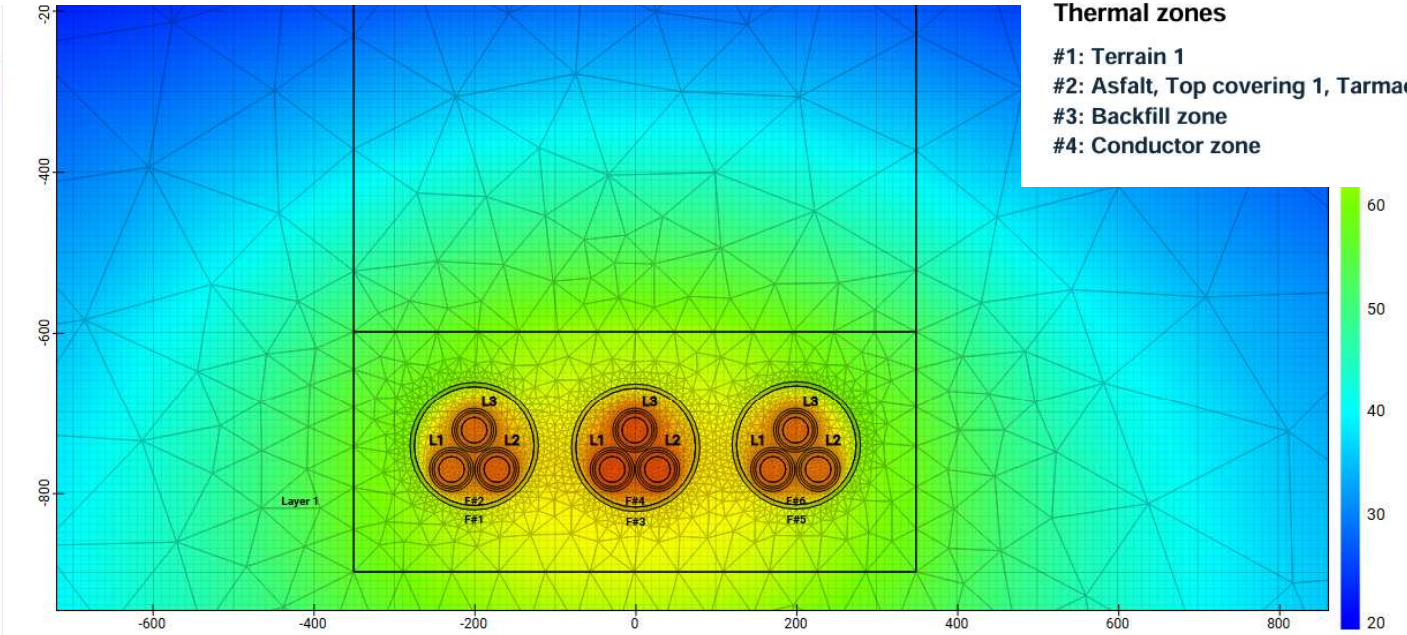


Grøft Design ⊟

	The whole trench
Highest temperature [°C]	90.2
Highest cable temperature [°C]	90.2
Maximum temperature in conductor zone [°C]	88.2
Highest temperature in the backfill masses [°C]	78.2
Highest temperature at ground level [°C]	15.0

Cable circuits

Description	Conductor connection	Phase system	Cables	Operating voltage	Current (RMS)	Transfer capacity
A, Cable circuit	Connected	Three-phase	HV cable group @ free #6	22 kV	459 A	17.5 MVA
B, Cable circuit	Connected	Three-phase	HV cable group @ free #2	22 kV	459 A	17.5 MVA
C, Cable circuit	Connected	Three-phase	HV cable group @ free #4	22 kV	459 A	17.5 MVA

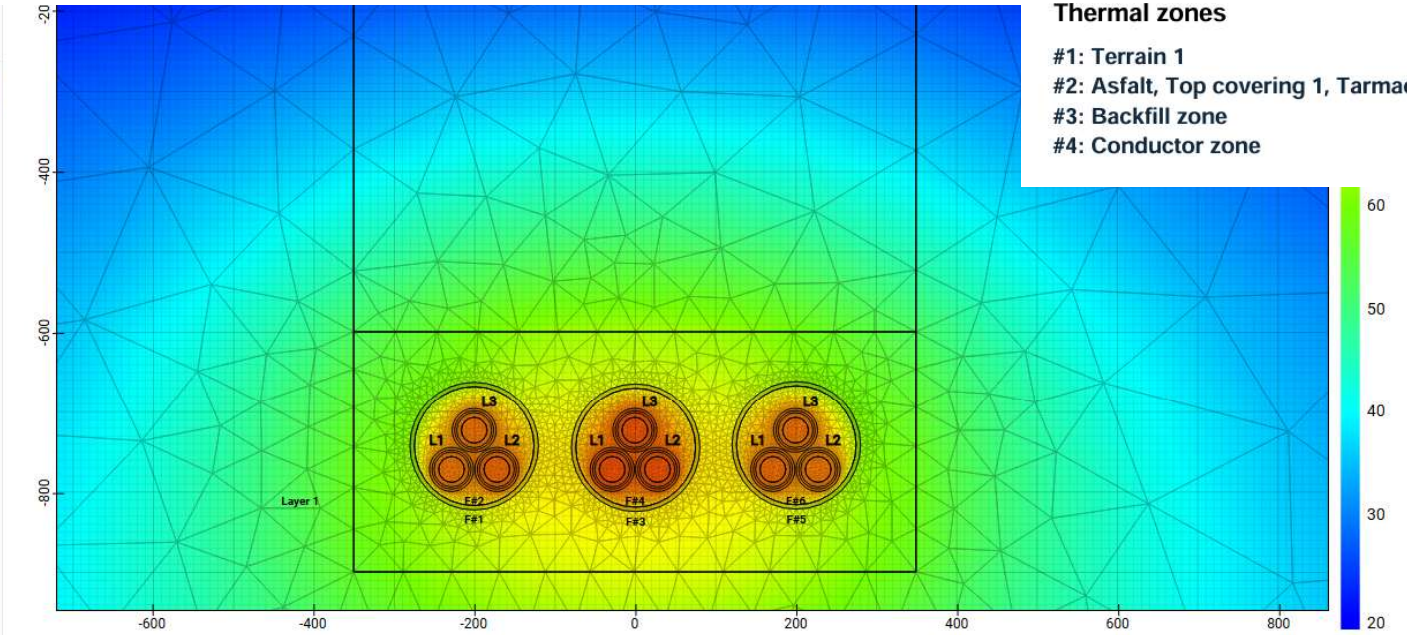


Grøft Design ⊟

	The whole trench
Highest temperature [°C]	89.9
Highest cable temperature [°C]	89.9
Maximum temperature in conductor zone [°C]	72.9
Highest temperature in the backfill masses [°C]	63.2
Highest temperature at ground level [°C]	15.0

Cable circuits

Description	Conductor connection	Phase system	Cables	Operating voltage	Current (RMS)	Transfer capacity
A, Cable circuit	Connected	Three-phase	HV cable group @ free #6	22 kV	459 A	17.5 MVA
B, Cable circuit	Connected	Three-phase	HV cable group @ free #2	22 kV	459 A	17.5 MVA
C, Cable circuit	Connected	Three-phase	HV cable group @ free #4	22 kV	459 A	17.5 MVA



Grøft Design ⊟

	The whole trench
Highest temperature [°C]	89.9
Highest cable temperature [°C]	89.9
Maximum temperature in conductor zone [°C]	72.9
Highest temperature in the backfill masses [°C]	63.2
Highest temperature at ground level [°C]	15.0

Measure to Stay on the Safe Side