# Appendix 5-14
# Cable Rating Report

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

A TETRA TECH COMPANY

PARK WIND
JERA GROUP

Energy for generations

# ORIEL WIND FARM PROJECT

## Environmental Impact Assessment Report
## Appendix 5-14: Cable Rating Report

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# Oriel Windfarm

## Cable Rating Report

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# Change History of Report

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| 25/03/2022 | 000 | J. Martin | First Issue |
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# Executive Summary

The Oriel wind farm is planned to be Ireland's first large-scale offshore wind farm. The project will be located in the Irish Sea, off the coast of Dundalk and will produce green energy for over 300,000 houses.

The wind farm will have a capacity of 375 MW and its lease area is approximately 20 km off the coast of Dundalk, Co Louth, in the territorial waters of the Republic of Ireland. The Oriel location was chosen, following an extensive review of sites in the Irish Sea, as being the ideal site on which to develop an offshore wind energy project. The electricity generated will be exported to the existing national transmission grid at a new substation to be constructed at a site close to Ardee. The offshore export cable is planned to make a landfall at a location close to Dunany Head, County Louth.

This report details the cable rating study for the onshore 220 kV export power cable.

The aim of this study is to determine the most appropriate cable and installation type capable of meeting the wind farm export capacity of 375 MW @ 0.9 PF which translates to a 1093 A at 220 kV.

The study focused solely on cables with aluminium conductors, due to the considerable price differential between aluminium and copper. The cross-sectional area of these cables ranged from 1000 mm² to 1600 mm².

The study assessed the current carrying capacity of each cable type for the following scenarios:

- Installation type 1 - Flat Formation.
- Installation type 2 - Trefoil Formation – 800 mm wide trench.
- Installation type 3 – Horizontal Directional Drill (HDD).

Where the static current rating of cable circuits failed to meet the wind farm export capacity, then the cyclic current rating of the cable circuit was assessed in line with IEC 60853 to determine what load factor would be required to meet the wind farm export capacity.

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# 1 Calculation Methodology

## 1.1 Software

The rating of the cable circuit is calculated by considering the thermal limits of the equipment. In this case the cross-linked polyethylene (XLPE) constrains the operational temperature limit and allows for a maximum continuous operation of 90°C.

CYMCAP software (Version 8.0 rev 1) by CYME International was used to compute the maximum operating currents as limited by the thermal conditions.

## 1.2 Input Parameters & Assumptions

### 1.2.1 Cable Models

The cables modelled in this report are based on generic cable designs and the electrical characteristics are in line with the values in IEC 60287.

The cyclic rating was carried out in line with IEC 60853.

### 1.2.2 Environmental and Thermal Parameters

**The environmental and thermal parameters used in simulations may be seen in**

Table 1. Unless otherwise stated, these ambient temperature and thermal resistivity values were used for summer, autumn and winter conditions in all calculations.

| Ambient Ground Temperatures | |
|---|---|
| Summer | 20°C |
| Spring/Autumn | 15°C |
| Winter | 10°C |
| **Thermal Resistivity of Native Soil** | |
| Summer | 1.2 K.m./W |
| Spring/Autumn | 1.2 K.m./W |
| Winter | 1.0 K.m/W |
| **Thermal Resistivity of CBGM** | |
| Summer | 1.0 K.m/W |
| Spring/Autumn | 1.0 K.m/W |
| Winter | 0.85 K.m/W |

**Table 1: Environmental and Thermal Parameters**

## 1.3 Installation Parameters– Trench Type 1.

| Installation Parameters | |
|---|---|
| Duct inner diameter | 180.95 mm |
| Duct outer diameter | 200 mm |
| Duct material | High Density Polyethylene (HDPE) |
| Duct formation | Flat |
| Medium in duct (standard trench) | Air |
| Depth – Surface to top of duct | 950 mm |

**Table 2: Installation Parameters – Trench Type 1**

## 1.4 Installation Parameters– Trench Type 2.

| Installation Parameters | |
|---|---|
| Duct inner diameter | 180.95 mm |
| Duct outer diameter | 200 mm |
| Duct material | High Density Polyethylene (HDPE) |
| Duct formation | Trefoil |
| Medium in duct (standard trench) | Air |
| Depth – Surface to top of duct | 950 mm |

**Table 3: Installation Parameters – Trench Type 2**

## 1.5 HDD Installation Parameters – Trench Type 3.

| Installation Parameters | |
|---|---|
| Ambient Ground Temperature | 14°C |
| Thermal Resistivity of Soil | 0.7 K.m/W |
| Depth – Surface to top of duct | 11,400 mm |

**Table 4: HDD Installation Parameters – Trench Type 3**

## 1.6 Windfarm Power Factor.

In the absence of revised grid code compliance for offshore windfarm connections a conservative Power Factor (pf) of 0.9 was used for the purpose of these calculations. Taking this into account the wind farm would have an export capacity of 375 MW @ 0.9 PF which translates to a 1093 A at 220 kV, as per the formula below. When the actual pf is determined the below ampacity will be revised and it is expected that the rating of 1093A will reduce as we expect the pf to be higher than 0.9.

$$\mathbf{A} = \frac{MW}{kV\ x\ \sqrt{3}\ x\ pf}$$

$$\mathbf{1093A} = \frac{375MW}{220\ kV\ x\ \sqrt{3}\ x\ 0.9\ pf}$$

## 1.7 EMF Data Calculation.

The emf data for the 220 kV 1600 mm² Al/APL cable was also reviewed. The circuits associated µT value at 1m height is below the 100µT reference value as per International Commission on Non-Ionizing Radiation Protection (ICNIRP) 1998 guidelines for Limiting Exposure To Electromagnetic Fields (100 kHz to 300 GHz). The magnetic field data is shown in the graph in Figure 1 below.

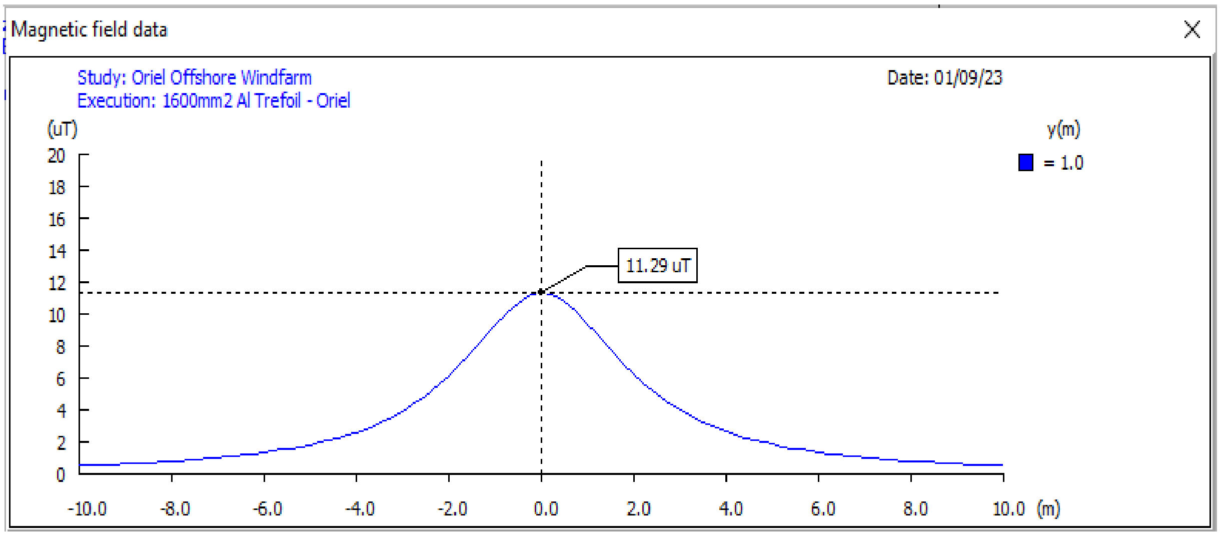


**Figure 1: EMF Rating at Trench Cross Section**

# 2 Rating Calculations

## 2.1 Generic Cable Inputs

The XLPE insulated cables that are outlined below consist of Aluminium (Al) conductors. The conductor designs are generally stranded up to 1000 mm² cross section. The conductor construction above 1000 mm² is also stranded but with the overall cross section divided into segments to minimise circulating current losses and boost ratings.

An inner semi conductive layer separates the conductor from the insulation layer. The insulation layer for all cables installed since the 1990s is XLPE insulation (triple extruded and dry cured). An outer semi conductive layer separates the insulation layer from the outer metallic screen/sheath layer.

This study focused on two metallic screen sheaths designs, smooth aluminium (Al) and aluminium foil with aluminium wires (APL). The metallic screen/metallic sheath layers are in turn overlain by an outer plastic protective layer consisting of high-density polyethylene with a thin layer of conductive material added on the outside to facilitate sheath testing.

The cable construction and dimensions for each cable type modelled in this study can be seen in figure 2 to figure 5 below.

### 2.1.1 1000 mm² Al/Al

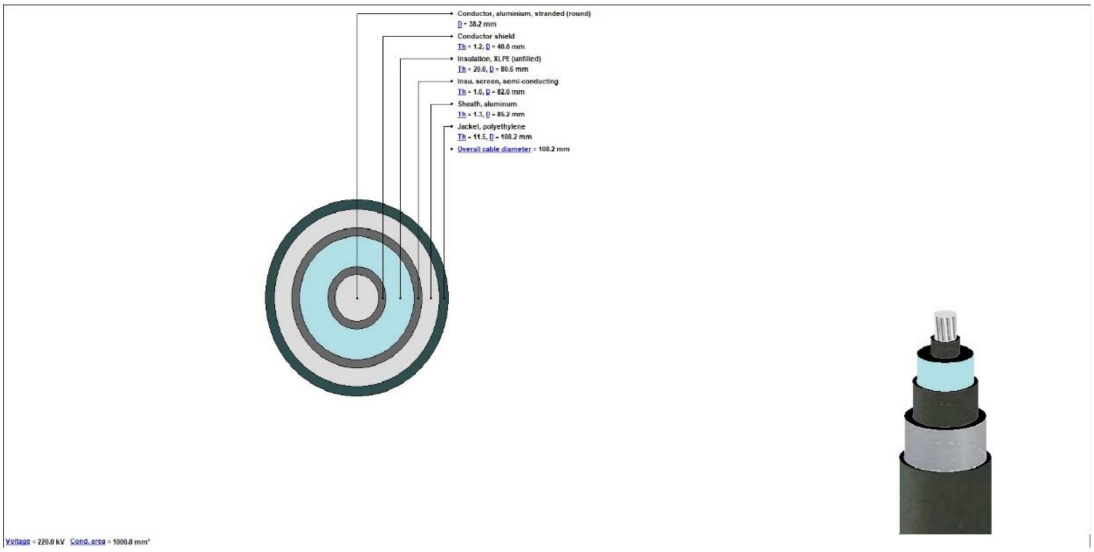


**Figure 2: Generic Cable 1000 mm² Al/Al**

## 2.1.2 1200 mm² Al/Al

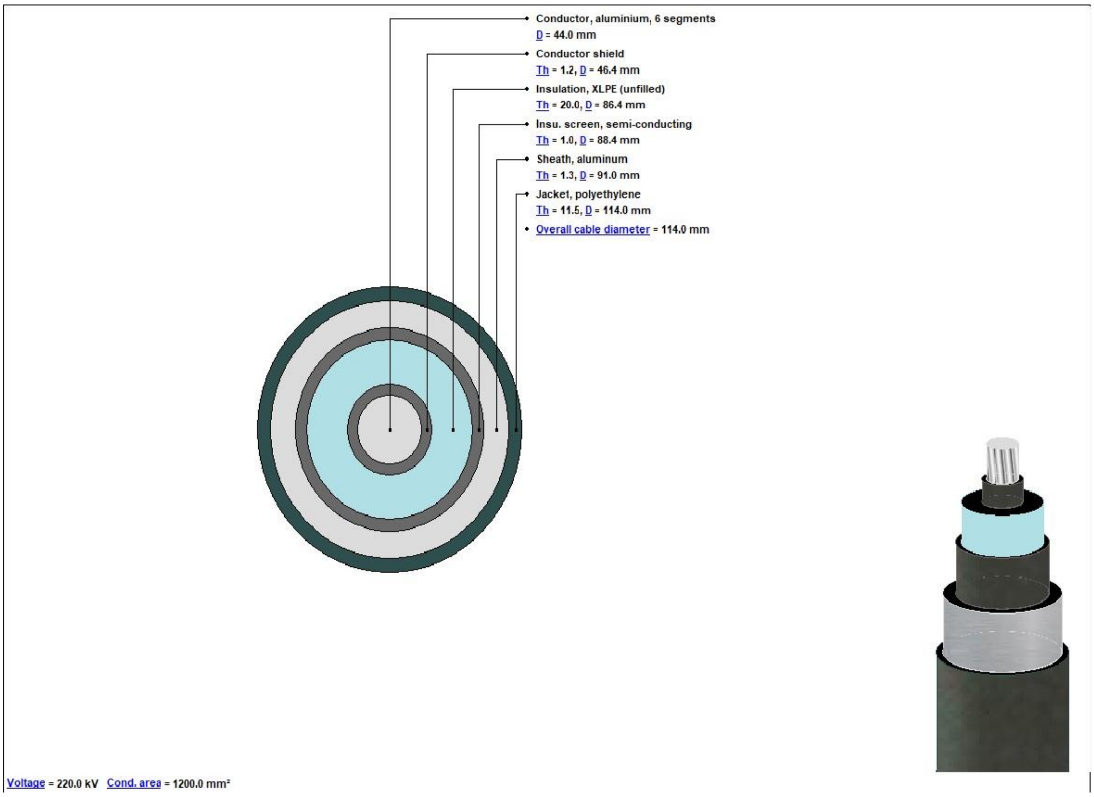


**Figure 3: Generic Cable 1200 mm² Al/Al**

## 2.1.3 1600 mm² Al/Al

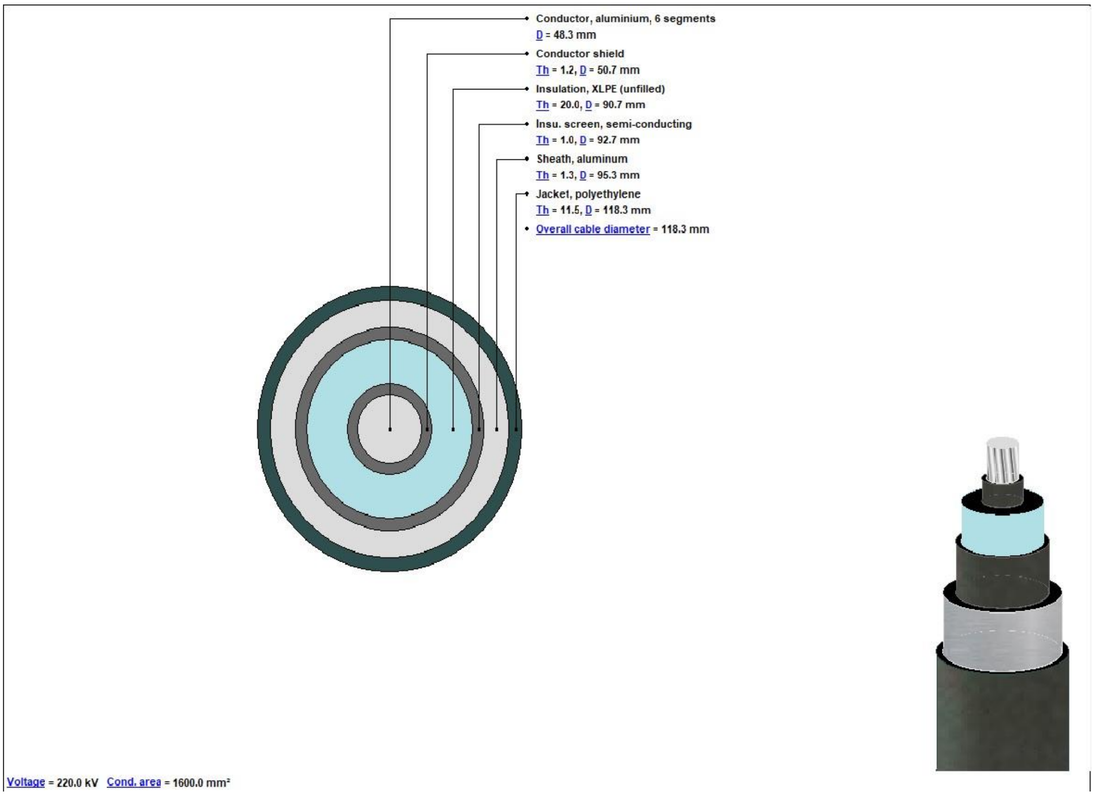


**Figure 4: Generic Cable 1600 mm² Al/Al**

## 2.1.4 1600 mm² Al/APL

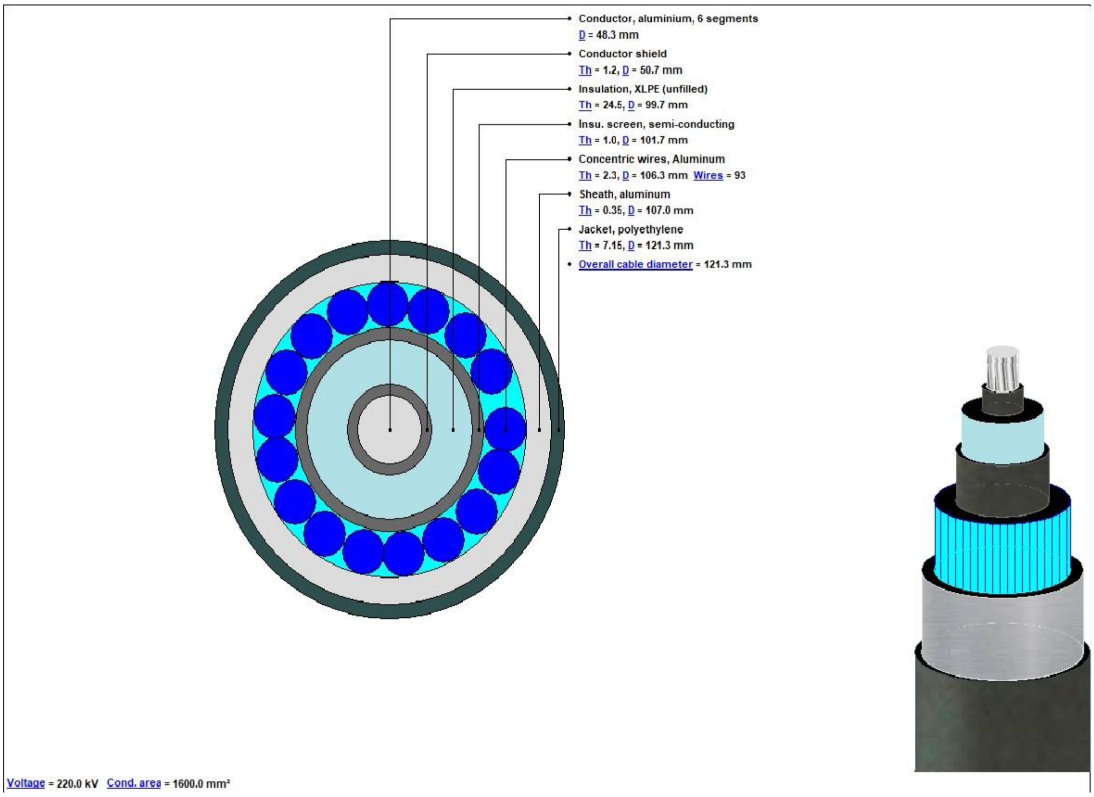


**Figure 5: Generic Cable 1600 mm² Al/APL**

## 2.2 Trench Type 1 - Flat Formation

The cables were modelled in 200mm ducts in flat formation. The width of the trench is 1100 mm with a phase separtation of 300 mm as per drawing PE424-D7001-001-005-008. This is shown in Figure 6 below.

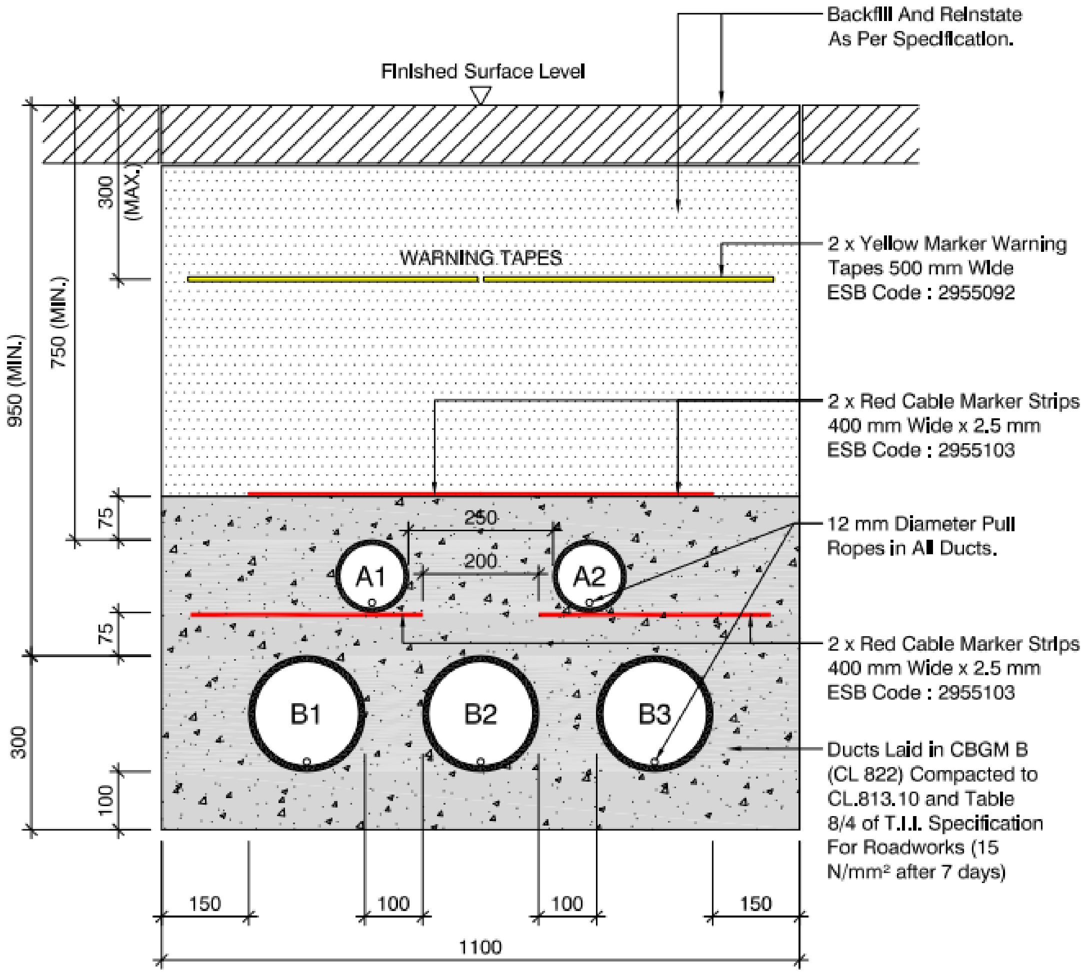


**Figure 6: 1.1m Trench in Flat Formation**

The cable rating results for trench type 1 are summarised in Table 5 below. The static current rating for both 1600 mm² Al cables exceed the target rating of 1093 A at a load factor of 100%. To meet the required target ratings with the smaller 1000 mm² and 1200 mm² cables, their respective load factors were required to be lowered, while the rest of the installation parameters were unchanged. The 1000 mm² Al cable would require a load factor of 69%, while the 1200 mm² Al cable would require a slightly higher load factor of 87% to achieve the target rating of 1093 A.

| Summary of Results – Trench Type 1 | | | | |
|---|---|---|---|---|
| Cable Size | Load Factor | Ampacity Rating (A) | MVA Rating (MVA) | Pass / Fail |
| 1000 mm² Al/Al | 0.69 | 1097 | 418 | Pass |
| 1200 mm² Al/Al | 0.87 | 1094 | 416 | Pass |
| 1600 mm² Al/Al | 1.0 | 1158 | 441 | Pass |
| 1600 mm² Al/APL | 1.0 | 1181 | 450 | Pass |

**Table 5: Summary of Results - Trench Type 1**

## 2.3 Trench Type 2 - Trefoil Formation

The cables were modelled in 200 mm ducts in trefoil formation. The width of the trench is 800 mm as per drawing PE605-D027-083-001-001. This is shown in Figure 7 below.

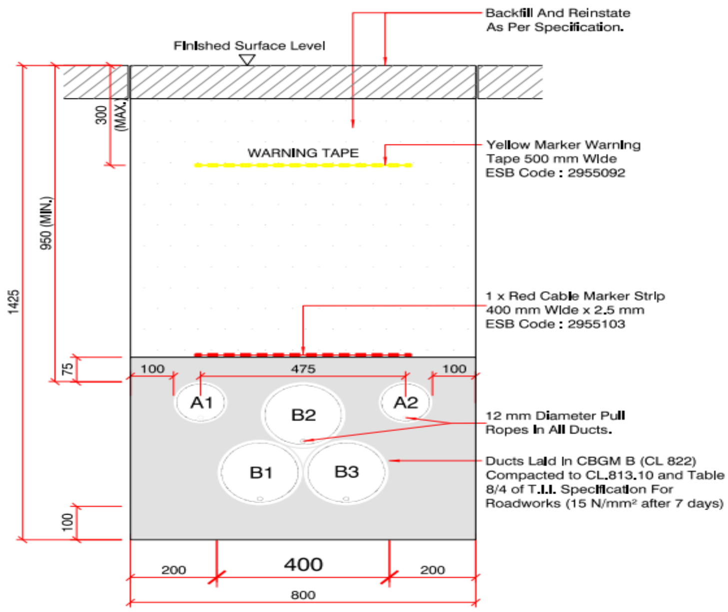


**Figure 7: 800mm Trench in Trefoil Formation**

The cable rating results for trench type 2 are summarised in Table 6 below. The static current rating of the 1600 mm² Al/APL cables exceed the target rating of 1093A by 12 A when a load factor of 100% is applied, while the 1600 mm² Al/Al cable is 4 A shy of the required rating when the same load factor is applied. To meet the required target ratings with the smaller 1000 mm² and 1200 mm² cables, their respective load factors were required to be lowered, while the rest of the installation parameters remained unchanged. The 1000 mm² Al cable would require a load factor of 62%, while the 1200 mm² Al cable would require a slightly higher load factor of 70% to achieve the target rating of 1093 A.

| Summary of Results - Trench Type 2 | | | | |
|---|---|---|---|---|
| Cable Size | Load Factor | Ampacity Rating (A) | MVA Rating (MVA) | Pass / Fail |
| 1000 mm² Al/Al | 0.62 | 1097 | 418 | Pass |
| 1200 mm² Al/Al | 0.79 | 1097 | 418 | Pass |
| 1600 mm² Al/Al | 1.0 | 1089 | 414 | Fail |
| 1600 mm² Al/APL | 1.0 | 1105 | 421 | Pass |

**Table 6: Summary of Results - Trench Type 2**

## 2.4 Trench Type 3 - HDD

There is a number of pinch points along the route and it is envisaged that the HDD method will be implemented at these locations. The M1 HDD crossing is expected to be the deepest the cable will be installed.At this early stage the depth is expected to be approx. 11.4 meters from the top of ducts to the surface. All cable types were modelled as a single bore, which means all three power cable ducts will be bundled into the one bore to see if the target rating could be achieved.

For the purpose of HDD calculations, a non-standard ambient soil temperature of 15 ºC and native soil TR of 0.8 K.m/W values were assumed. It is recommended that site specific tests are obtained at a later date to back up the above design assumptions.

The cable rating results for trench type 3 are summarised in Table 7 below. The static current rating of the 1600 mm² Al/APL cables exceed the target rating of 1093 A by 15 A when a load factor of 100% is applied, while the 1600 mm² Al/Al cable only achieves the required rating when the same load factor is applied. To meet the required target ratings with the smaller 1000 mm² and 1200 mm² cables, their respective load factors were required to be lowered, while the rest of the installation parameters remain unchanged. The 1000 mm² Al cable would require a load factor of 60%, while the 1200 mm² Al cable would require a slightly higher load factor of 74% to achieve the target rating of 1093 A.

| Summary of Results - Trench Type 3 | | | | |
|---|---|---|---|---|
| Cable Size | Load Factor | Ampacity Rating (A) | MVA Rating (MVA) | Pass / Fail |
| 1000 mm² Al/Al | 0.60 | 1100 | 419 | Pass |
| 1200 mm² Al/Al | 0.74 | 1126 | 429 | Pass |
| 1600 mm² Al/Al | 1.0 | 1093 | 416 | Pass |
| 1600 mm² Al/APL | 1.0 | 1108 | 422 | Pass |

**Table 7: Summary of Results - Trench Type 3**

# 3 Conclusion

The required target continuous current rating of 416 MVA (1093 A) at a 0.9 pf is achieved by means of either static current ratings or cyclic current ratings with the various cable types. The assumed power factor of 0.9 used in the calculations will be revised when the grid code compliance for offshore windfarm connections issues from EirGrid.

The 1000 mm² Al/Al cable can only achieve the target ratings when the cyclic current rating of cable is set to a load factor of 69% for trench type 1, 62% for trench types 2 and 60% for trench types 3.

The 1200 mm² Al/Al cable can only achieve the target ratings when the cyclic current rating of cable is set to a load factor of 87% for trench type 1, 79% for trench types 2 and 74% for trench types 3.

The 1600 mm² Al/Al cable can achieve the target ratings when the static current rating of cable is applied to Trench types 1 and 3, in trefoil formation trench type 2 the cable current rating is only 1089 A which is 4 A shy of the required target rating.

The 1600 mm² Al/APL cable can achieve the target ratings when the static current rating of cable is applied for each of the three trench types. As this cable type achieves the required target rating in all trench types it is recommend using a cable of similar design to the generic cable used in the rating study.

The trefoil trench formation would be the trench of choice as the footprint is smaller and it also removes the need to transpose the conductors at each joint bay which in turn will simplify the installation.

This study only took account of three trench types, any other physical or electrical constraints along the route will be captured during the detailed design stage.