

1

Document Title : Technical Specification VEOC KM3NeT

KM3NeT_DET_2017_003-Technical_Specification_VEOC_ORCA/ARCA

Prepared by : Hans Band / Frank Kayzel

Nikhef

Rev. : 1.1

Abstract

The object of this Technical Specification is to describe the requirements of the VEOC of the KM3NeT.

Recipients

The KM3NeT Collaboration

2

Document Status

Revision	Date	Comment	Reviewed by	Approved by
1.1	22/03/2018		Sylvian Henry Jan-Willem Schmelling	

4

Revision History

Revision	Date	Description
1	20/10/2017	Document initiated Comment Sylvian Henry and Jan-Willem Schmelling: §3.1.1 Req.5 Added (NA for manufacturer). Req.6 changed wording (text JWS) Req.7 added fiber requirement for ORCA (Text JWS). Table 1 and Table 2 changed DOM in BoB and reference red/white to fiber bundle. §3.1.2 Req.13 added Req.16 Added (NA for manufacturer).
1.1	8/3/2018	§3.1.3 Req.18 Added OCRA Req.19 Added ARCA §3.2 Added (NA for manufacturer) for several requirements. §3.7.2 Req.42 added 9 upper and 9 lower Req.43 added this req. §3.7.6 Req.54 added length wire §3.7.8 Added Req.64 cables not pinched §3.8.2 Req.72 added repaired §3.9.2.1 Req.80 added

5



Technical_Specification

[KM3NeT_DET_2017_003-Technical_Specification_VEOC_ORCA/ARCA]

Frank Kayzel, Nikhef

Rev. :1.1

Date: 20/01/2020

Page 2 of 18

§3.9.2.2 Req.81 new wording

§3.10.5 Req.90 one repair per fiber and max six repair in total

§3.11.2 Req.95 changed wording



Table of Contents

1	Documentation and Acronyms.....	5
1.1	Abbreviations/Acronyms	5
1.2	Applicable Documents	5
1.3	Reference Documents.....	5
2	Introduction	5
2.1	Scope.....	5
2.2	Purpose of Specification	5
2.3	Description.....	5
3	Requirements.....	7
3.1	Functional Requirements	7
3.1.1	<i>Fiber Cable</i>	<i>7</i>
3.1.2	<i>Electrical connection.....</i>	<i>9</i>
3.1.3	<i>Mechanical</i>	<i>9</i>
3.2	Performance Requirements.....	10
3.2.1	<i>Lifecycle.....</i>	<i>10</i>
3.3	Environmental Requirements.....	10
3.3.1	<i>Humidity/salt.....</i>	<i>10</i>
3.3.2	<i>Pressure Requirements.....</i>	<i>10</i>
3.3.3	<i>Temperature requirements.....</i>	<i>10</i>
3.3.4	<i>Shock/vibration.....</i>	<i>10</i>
3.4	Operational Requirements	10
3.4.1	<i>Reliability.....</i>	<i>10</i>
3.4.2	<i>Availability.....</i>	<i>10</i>
3.4.3	<i>Maintenance.....</i>	<i>10</i>
3.4.4	<i>Safety Requirements.....</i>	<i>11</i>
3.4.4.1	<i>Flammability.....</i>	<i>11</i>
3.4.4.2	<i>Toxicity.....</i>	<i>11</i>
3.5	Ergonomics, Human Factors.....	11
3.6	Interfaces	11
3.6.1	<i>Mechanical</i>	<i>11</i>
3.6.2	<i>Thermal</i>	<i>11</i>
3.6.3	<i>Electrical</i>	<i>11</i>
3.6.4	<i>Software</i>	<i>11</i>
3.7	Design Requirements	11
3.7.1	<i>Components list.....</i>	<i>11</i>
3.7.2	<i>VEOC ARCA.....</i>	<i>13</i>
3.7.3	<i>VEOC ORCA.....</i>	<i>14</i>
3.7.4	<i>Compression/Depression.....</i>	<i>15</i>
3.7.5	<i>Materials.....</i>	<i>15</i>
3.7.6	<i>Configuration.....</i>	<i>15</i>
3.7.7	<i>Fiber</i>	<i>15</i>
3.7.8	<i>DC/DC converter</i>	<i>16</i>



1	3.7.9	Tests.....	16
2	3.7.10	Final fiber test.....	16
3	3.8	Manufacturing Requirements	16
4	3.8.1	Tooling.....	16
5	3.8.2	Fiber	16
6	3.8.3	Oil filling.....	16
7	3.9	Validation Requirements	16
8	3.9.1	Electrical.....	16
9	3.9.1.1	Grounding / bonding	16
10	3.9.1.2	Insulation	16
11	3.9.2	Optical.....	17
12	3.9.2.1	Mechanical.....	17
13	3.9.2.2	Optical.....	17
14	3.10	Documentation and Data	17
15	3.10.1	Documentation.....	17
16	3.10.2	Part number requirement	17
17	3.10.3	Test and Inspection.....	17
18	3.10.4	Test Reporting.....	17
19	3.10.5	Non Conformance Reporting.....	18
20	3.10.6	Acceptance / Rejection Criteria.....	18
21	3.10.7	Manufacturing and Material Process Specification.....	18
22	3.11	Logistics.....	18
23	3.11.1	Marking.....	18
24	3.11.2	Packaging.....	18

Table of Figures

28	Figure 1 Sketch of VEOC ARCA	6
29	Figure 2 For information only on the use of the VEOC showing the routing of the VEOC at the	
30	DOM. A PE tube (BEOC) connects the cables coming out of the DOM trough the penetrator to the	
31	DOM Breakout Box. In red Dyneema ropes that support the vertical structure of the DU.....	7
32	Figure 3 DU ORCA configuration	10
33	Figure 4 VEOC ARCA configuration	14
34	Figure 5 VEOC ORCA configuration.....	15

Table of Tables

36	Table 1 ORCA Fiber, color according to EIA/TIA-598	8
37	Table 2 ARCA Fiber, color according to EIA / TIA-598	9
38	Table 3 Components used in VEOC ORCA.....	12
39	Table 4 Components used in VEOC ARCA.....	13

40



1 Documentation and Acronyms

1.1 Abbreviations/Acronyms

Abbreviation	Description
BEOC	Break out Electrical Optical Cable
BoB	Breakout Box
DOM	Digital Optical Module
DU	Detection Unit
HDPE	High Density Poly Ethylene
KM3NeT	Cubic Kilometre Neutrino Telescope
OTDR	Optical Time-Domain Reflectometer
TBD	To Be Defined
VEOC	Vertical Electrical Optical Cble

1.2 Applicable Documents

Ref.	Title	Reference	Version
RD 1.	VEOC ORCA/ARCA Assembly Procedure and Report	KM3NeT_MECH_2017_001	6.2

1.3 Reference Documents

Ref.	Title	Reference	Version
RD 2.	DOM Integration Sequence	KM3NeT_INT_2015_002	1.8

2 Introduction

2.1 Scope

This document contains the requirements for the VEOC ORCA and VEOC ARCA as it has to be deployed in the KM3NeT infrastructure.

2.2 Purpose of Specification

The specification is written to formulate the requirements of the sub-system. We can use the following definition of requirement:

Requirement: a statement that identifies a product or process operational, functional, or design characteristic or constraint, which is unambiguous, testable or measurable, and necessary for product or process acceptability (by users or internal quality assurance guidelines).

2.3 Description

The Vertical Optical and Electrical Cable (VEOC) is a pressure compensated oil filled Poly Ethylene system. The function is to establish electrical power and glass fiber connections to each DOM. At the level of each DOM a Breakout Box (BoB) is made that must have following functions:



Technical Specification

[KM3NeT_DET_2017_003-Technical_Specification_VEOC_ORCA/ARCA]

Frank Kayzel, Nikhef

Rev. :1.1

Date: 20/01/2020

Page 6 of 18

1. Provide connection points for one fiber and two electrical cables that will come from the penetrator (which is part of the DOM)
2. Transform 400 V DC to 12 V DC and lead through the 400 V cable to the remainder of cable
3. Feed through remaining fibers without attenuation. No splice connection.
4. Ensures closed volume that can be leak tested and filled with oil.

For an ORCA line the HDPE breakout boxes are connected with 10 m LDPE tubes. The VEOC starts at the exit of the base container where 24 fibers and 2 copper wires exit through penetrators and end at the top DOM.

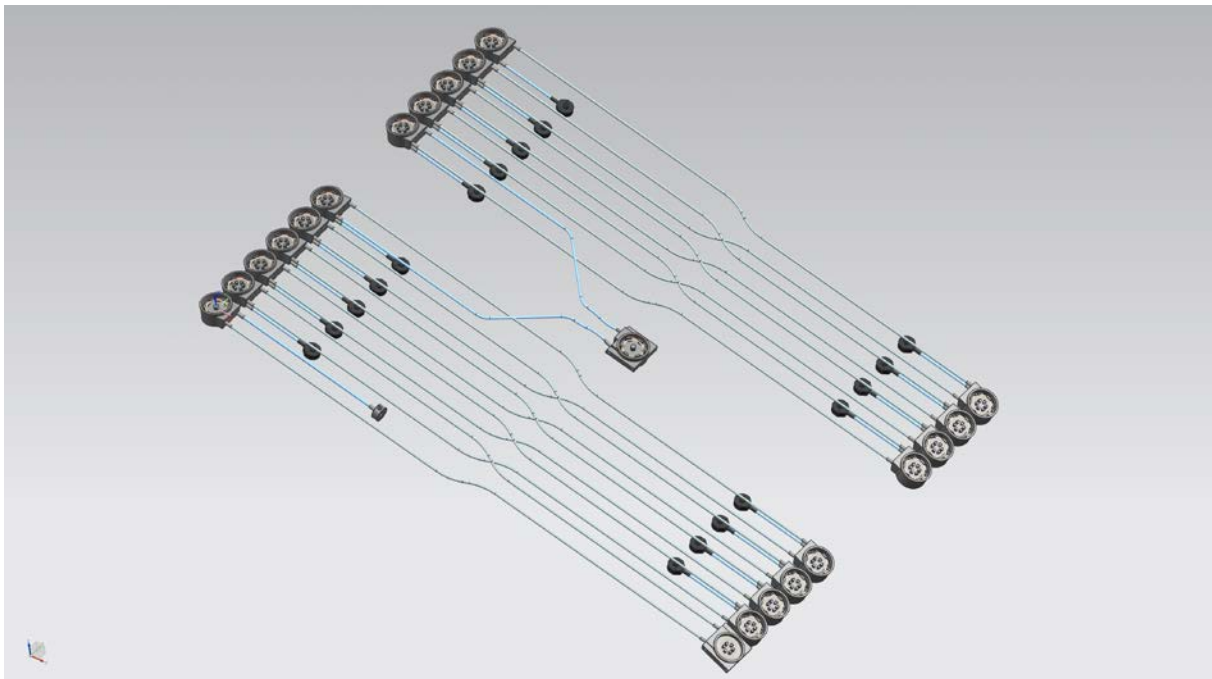


Figure 1 Sketch of VEOC ARCA



Figure 2 For information only on the use of the VEOC showing the routing of the VEOC at the DOM. A PE tube (BEOC) connects the cables coming out of the DOM through the penetrator to the DOM Breakout Box. In red Dyneema ropes that support the vertical structure of the DU.

Each BoB is connected through the Break out Electrical Optical Cable (BEOC) to a DOM, see Figure 2.

The VEOC ORCA/ARCA line is integrated with 18 DOMs to form either a DU ORCA (see Figure 3) or a DU ARCA.

3 Requirements

Several of the following requirements are covered in the design and have been qualified. In this chapter summarized requirements are not applicable for the producer if the remark “NA for manufacturer” is added.

3.1 Functional Requirements

3.1.1 Fiber Cable

Req.1. The VEOC shall connect through the base BoB all 18 DOMs: the cable exists of 24 optical fibers.

Req.2. The fibers are bundled in two cables, one with a red identifier and one with a white identifier. Each cable contains 12 fibers.

Req.3. Each BoB is connected to one fiber.

Req.4. The color coding of the wire shall be according to EIA/TIA-598.

Req.5. The fiber shall be resistant to Midel 7131 Transformer Insulating Fluid (NA for manufacturer).



Technical Specification

[KM3Net_DET_2017_003-Technical_Specification_VEOC_ORCA/ARCA]

Frank Kayzel, Nikhef

Rev.:1.1

Date: 20/01/2020

Page 8 of 18

Req.6. For ARCA: All fibers shall have an attenuation below 0.5 dB when the measurement setup is connected using temporarily splices or 0.8 dB when connectors are used. A maximum splice loss of 0.07 dB applies. The attenuation shall be measured using a stable light source and power meter or an OTDR. Both at wavelength 1550 nm and wavelength 1350 nm with an accuracy of <0.01 dB.

Req.7. For ORCA: All fibers shall have an attenuation below 0.35 dB when the measurement setup is connected using temporarily splices or 0.5 dB when connectors are used. A maximum splice loss of 0.07 dB applies. The attenuation shall be measured using a stable light source and power meter or an OTDR. Both at wavelength 1550 nm and wavelength 1350 nm with an accuracy of <0.01 dB.

		BoB																			
Position	Color	BoB	Base	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Red bundle																				
1	blue			1																	
2	orange				2																
3	green					3															
4	brown						4														
5	slate							5													
6	white								6												
7	red									7											
8	black										8										
9	yellow											9									
10	violet																				
11	rose																				
12	aqua																				
	white bundle																				
1	blue												10								
2	orange													11							
3	green														12						
4	brown															13					
5	slate																14				
6	white																	15			
7	red																		16		
8	black																			17	
9	yellow																				18
10	violet																				
11	rose																				
12	aqua																				

Table 1 ORCA Fiber, color according to EIA/TIA-598

Req.8. The VEOC ORCA fibers shall be connected to the BoB according to Table 1

Req.9. The VEOC ARCA fibers shall be connected to the BoB according to Table 2



1

		BoB																				
Position	Color	Base	Anchor	1	2	3	4	5	6	7	8	9	middle	10	11	12	13	14	15	16	17	18
	Red bundle																					
1	blue			1																		
2	orange				2																	
3	green					3																
4	brown						4															
5	slate							5														
6	white								6													
7	red									7												
8	black										8											
9	yellow											9										
10	violet																					
11	rose																					
12	aqua																					
	white bundle																					
1	blue													10								
2	orange														11							
3	green															12						
4	brown																13					
5	slate																	14				
6	white																		15			
7	red																			16		
8	black																				17	
9	yellow																					18
10	violet																					
11	rose																					
12	aqua																					

2

3

Table 2 ARCA Fiber, color according to EIA / TIA-598

4

3.1.2 Electrical connection

5

Req.10. Two high voltage electrical cables shall connected to and from the DC/DC converter in the BoB.

6

7

Req.11. Two low voltage cables shall be connected to the DC/DC converter on the BEOC side to connect to the DOM.

8

9

Req.12. Electrical wire for the low and high voltage supply shall be AWG 18 with PPE insulation.

10

11

Req.13. Volume resistivity of the wire insulation shall be better than $10^{14} \Omega\text{cm}$.

12

Req.14. The electrical wire shall be red and black.

13

Req.15. Wire shall be 100% recyclable

14

Req.16. Wire shall be resistant to Midel 7131 Transformer Insulating Fluid (NA for manufacturer).

15

16

3.1.3 Mechanical

17

Req.17. The connection between the BoBs shall be of 7 mm LLDPE tubing.

18

Req.18. The End Cover of the ORCA shall be connected with 7 mm LLDPE tubing to the Anchor BoB.

19

20

Req.19. The End Cover of the ARCA shall be connected with 8 mm LLDPE tubing to the Anchor BoB.

21



Req.20. The inside of the tubing shall be continues without sharp edges.

Req.21. The BoB/ Tube welding shall be free of air inclusions.

Req.22. The VEOC shall be filled with Midel 7131.

3.2 Performance Requirements

3.2.1 Lifecycle

Req.23. The Unit shall be functional for 15 years. (NA for manufacturer)

3.3 Environmental Requirements

3.3.1 Humidity/salt

Req.24. The unit shall withstand during 15 years Mediterranean salt see water. (NA for manufacturer)

Figure 3 DU ORCA configuration

3.3.2 Pressure Requirements

Req.25. The unit shall be deployed for 15 years at maximum 3500 meter under see level. (NA for manufacturer)

Req.26. The VEOC shall with stand a pressure of 2 Bar without leaking.

3.3.3 Temperature requirements

Req.27. The unit shall be functional in an environmental temperature between 5°C to 50°C. (NA for manufacturer)

Req.28. The unit shall withstand storage/transport environmental temperature between -10°C and 70°C. (NA for manufacturer)

3.3.4 Shock/vibration

Req.29. The unit shall withstand transport on a road vehicle. (NA for manufacturer)

Req.30. During deployment the unit shall withstand, see below ,g shock ± 3 shocks $\frac{1}{2}$ sine
15G/11ms $\rightarrow$ representative of real shock (hard but rare) ± 500 shocks $\frac{1}{2}$ sine
10G/16ms $\rightarrow$ representative of shake (soft but repeated) (NA for manufacturer)

3.4 Operational Requirements

3.4.1 Reliability

Req.31. The MTBF (mean time between failure) assessment will be only qualitative but compatible with the operational lifetime. (NA for manufacturer)

3.4.2 Availability

Not applicable

3.4.3 Maintenance

Req.32. There shall be no maintenance after deployment. (NA for manufacturer)

Req.33. Further maintenance shall be made on shore, at KM3NeT premises. (NA for manufacturer)



3.4.4 Safety Requirements

3.4.4.1 Flammability

3.4.4.2 Toxicity

Req.34. No sea water environmental hazardous materials shall be used. (NA for manufacturer)

3.5 Ergonomics, Human Factors

Not Applicable

3.6 Interfaces

3.6.1 Mechanical

Req.35. VEOC ORCA /ARCA shall be ready to connect to DOM penetrator (18x) and to the Base penetrator.

3.6.2 Thermal

Not Applicable.

3.6.3 Electrical

Req.36. The supply voltage shall be 380 V $\pm$ 30 V.

Req.37. The voltage after the DCDC converter shall be 12 V $\pm$ 1 V. This is delivered by the DC/DC converters inside the BoB

3.6.4 Software

Not Applicable

3.7 Design Requirements

3.7.1 Components list

Req.38. The VEOC ORCA consists of the components listed in Table 3

Req.39.The components listed as “Nikhef” will be supplied to the manufacturer.

Req.40.The components listed as “Nikhef or sub-contractor” can be supplied by Nikhef to the sub-contractor or procured by the sub-contractor himself.



Technical Specification

[KM3NeT_DET_2017_003-Technical_Specification_VEOC_ORCA/ARCA]

Frank Kayzel, Nikhef

Rev. :1.1

Date: 20/01/2020

Page 12 of 18

1

Drawing	version	Drawing NX	version	Name	21 pcs	Material	Procured / supplier
AA8735	A	020593	B	BoB Housing - Top 7mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8734	A	020592	B	BoB Housing 7 mm	17	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8736	A	020594	A	BoB Housing - Anchor 7 mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8783	C	022254	A	Cover VEOC	18	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8785	B	022255	A	Cover BEOC	20	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8996	A			Extension BoB Anchor	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8967	B	022261	A	End Cover DOM Ø7mm	18	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8968	A	022295	A	End Cover Straight Anchor Ø8mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8760	A	022250	A	Power Transit	38	CuZn39Pb3 (Ms58)	Nikhef
AA8762	A	022257	A	Fiber Transit for 1 fiber	18	CuZn39Pb3 (Ms58)	Nikhef
AA8763	A	022258	A	Fiber Transit for 4 fiber	6	CuZn39Pb3 (Ms58)	Nikhef
AA8792	A	022259	A	Sealing screw BoB	18	Ti-6Al-4V	Nikhef
AA8213	A	022260	A	Sealing screw End Cover	0	Ti-6Al-4V	Nikhef
AA8947	A	022268	A	Star 32mm	36	PA6	Nikhef
AA8948	A	022270	A	Star 13mm	1	PA6	Nikhef
10024025				O-ring Viton 51414 Ø6x1.5	38	Viton	Nikhef
				Crossed Pan Head Screws M2,5x6 DIN7985	54	PA 6.6	Nikhef or sub-contractor
				Spacer 25xM2.5	54	Black PA 6.6	Nikhef or sub-contractor
				Stop pod	19	Skiffy 004 0790 005 03	Nikhef or sub-contractor
		022281	A	Length [m] tube Ø8mm	0.5	LLD-PE 44P	Nikhef or sub-contractor
		022280	A	Length [m] tube Ø7mm	3.96	LLD-PE 44P	Nikhef or sub-contractor
				Length [m] tube Ø7mm	216.8	LLD-PE 44P	Nikhef or sub-contractor
				Oil [l]	5	Midel 7131 Transformer Insulating Fluid	Nikhef
UPI 3.3.1.2.2	5		5.4	DC-DC converter	18		Nikhef
				12 Fibre strain [m]	250	Red	Nikhef or sub-contractor
				12 Fibre strain [m]	250	White	Nikhef or sub-contractor
				Alpha ECO wire AWG 18 [m]	250	AWG 18 Red	Nikhef or sub-contractor
				Alpha ECO wire AWG 18 [m]	250	AWG 18 Black	Nikhef or sub-contractor

2

3

Table 3 Components used in VEOC ORCA

4

Req.41. The VEOC ARCA consists of the components listed in Table 4



Technical Specification

[KM3NeT_DET_2017_003-Technical Specification_VEOC_ARCA/ARCA]

Frank Kayzel, Nikhef

Rev. :1.1

Date: 20/01/2020

Page 13 of 18

Drawing	version	Drawing NX	version	Name	21 pcs	Material	Procured / supplier
AA8735	A	020593	B	BoB Housing - Top 7mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8734	A	020592	B	BoB Housing 7mm	17	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8741	A	021020	A	BoB Housing - Middle 7mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8750	A	021017	A	BoB Housing - Between 7mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8736	A	020594	A	BoB Housing - Anchor 7mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8783	C	022254	A	Cover VEOC	18	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8785	B	022255	A	Cover BEOC	4	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8996	A			Extension BoB Anchor	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8967	B	022261	A	End Cover DOM Ø7mm	18	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8968	A	022295	A	End Cover Straight Anchor Ø8mm	1	SIMONA PE-HWU Black 9500 Pressed	Nikhef
AA8760	A	022250	A	Power Transit	40	CuZn39Pb3 (Ms58)	Nikhef
AA8762	A	022257	A	Fiber Transit for 1 fiber	18	CuZn39Pb3 (Ms58)	Nikhef
AA8763	A	022259	A	Fiber Transit for 4 fiber	12	CuZn39Pb3 (Ms58)	Nikhef
AA8792	A	022259	A	Sealing screw (BoB)	18	Ti-6Al-4V	Nikhef
AA8213	A	022260	A	Sealing screw (End Cover)	0	Ti-6Al-4V	Nikhef
10024025				O-ring Viton 51414 Ø6x1.5	41	Viton	Nikhef
AA8947	A	022268	A	Star 32mm	37	PA6	Nikhef
AA8948	A	022270	A	Star 13mm	4	PA6	Nikhef
				crossed pan head M2,5x6 DIN7985	54	PA 6.6	Nikhef or sub-contractor
				Spacer 25xM2.5	54	Black PA 6.6	Nikhef or sub-contractor
				Stop pod	21	Skiffy 004 0790 005 03	Nikhef or sub-contractor
		022281	A	Lengte (m) tube Ø8mm	0.50	LLD-PE 44P	Nikhef or sub-contractor
		022280	A	Lengte (m) tube Ø7mm	3.96	LLD-PE 44P	Nikhef or sub-contractor
		022326	A	Lengte (m) tube Ø7mm	720	LLD-PE 44P	Nikhef or sub-contractor
		022327	A	Lengte (m) tube Ø7mm	40		
				Oil [l]	15	Midel 7131 Transformer Insulating Fluid	Nikhef
UPI 3.3.1.2.2			5.4	DC-DC converter	18	Nikhef design	Nikhef
				Fibre [m]	758	Red	Nikhef or sub-contractor
				Fibre [m]	758	White	Nikhef or sub-contractor
				Alpha ECO wire AWG 18 [m]	758	AWG 18 Red	Nikhef or sub-contractor
				Alpha ECO wire AWG 18 [m]	758	AWG 18 Black	Nikhef or sub-contractor

Table 4 Components used in VEOC ARCA

3.7.2 VEOC ARCA

Req.42. VEOC ARCA shall be made in two sections (9 upper and 9 lower) connecting in total 18 BOB's each.

Req.43. VEOC ARCA Red fiber bundle shall stop in the middle BoB.

Req.44. The VEOC ARCA configuration shall be according to Figure 4.

Req.45. The VEOC ARCA cable distance between the BOB's shall be 40m (+/- 10 cm). See table 3 in RD 1 for all distances.

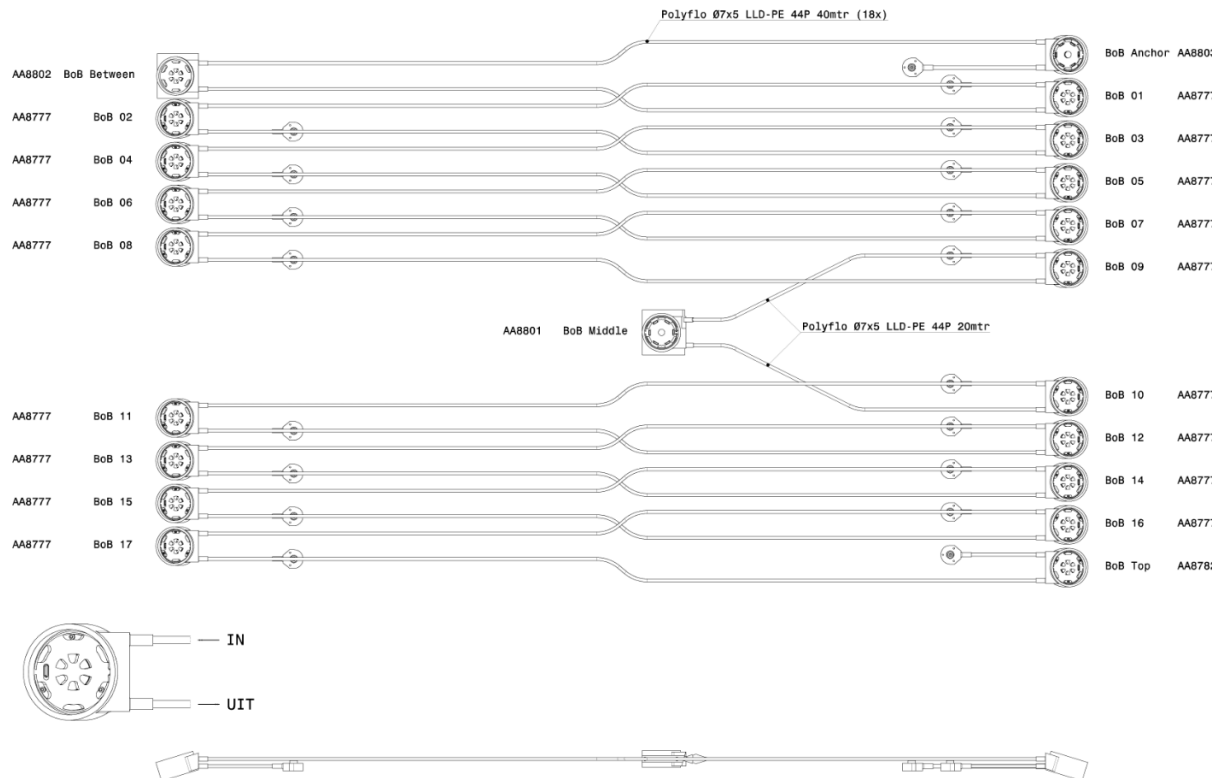


Figure 4 VEOC ARCA configuration

3.7.3 VEOC ORCA

Req.46. VEOC ORCA shall be one single line connecting 18 BOB's.

Req.47. The VEOC ORCA configuration shall be according to Figure 5.

Req.48. For the VEOC ORCA cables the distance between the BOB's shall be 10.1m (+/- 10 cm). See table 3 in RD 1 for all distances .

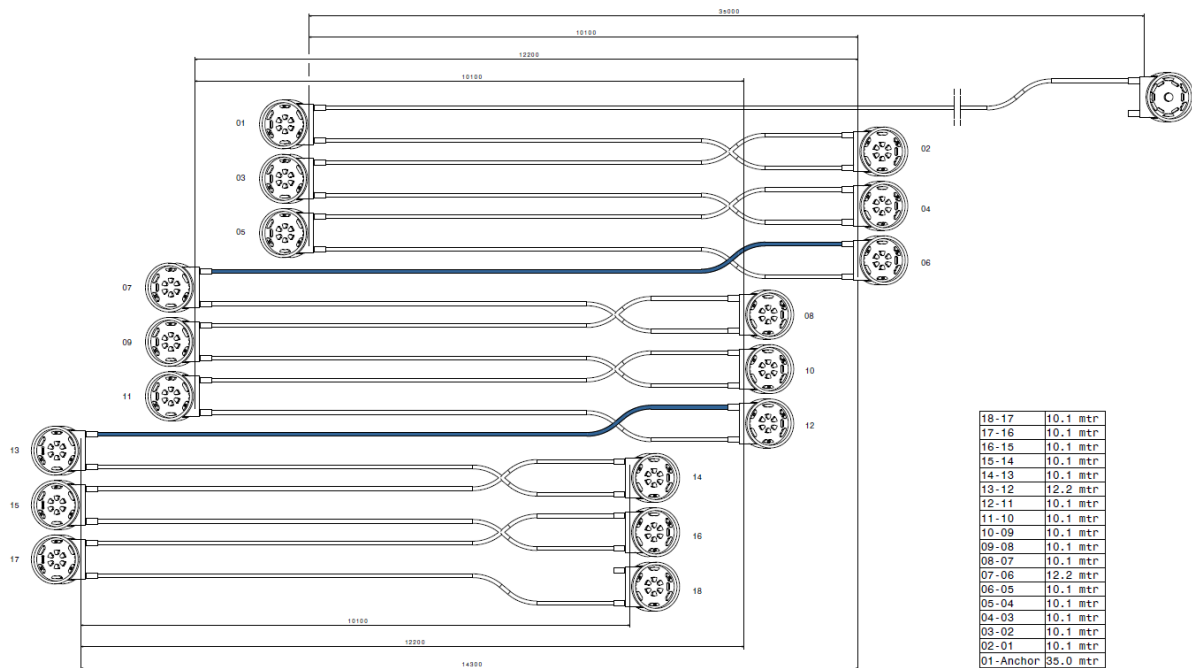


Figure 5 VEOC ORCA configuration

3.7.4 Compression/Depression

Req.49. The unit shall withstand the atmospheric pressure (during transport) between 76 kPa and 120 kPa (atmospheric pressure at 2400 m and sea level).

3.7.5 Materials

Req.50. The VEOC shall be constructed with a LLDPE tube with an outer diameter of 7 and an inner diameter of 5 mm.

Req.51. The VEOC shall hold two Alpha ECO wires (red and black) or equivalent wire.

Req.52. The VEOC shall hold two bundles of 12 fibers each of Draka single mode Bend Bright XS fibers or equivalent fibers. The fibers must fully comply or exceed ITU-T Recommendations G.657.A2, G.657.B2 and G.652.D. The bundles shall have differently colored cotton wire.

3.7.6 Configuration

Req.53. A VEOC shall have 18 DOM breakouts with one fiber and two Alfa wires each.

Req.54. In each DOM breakout the Alfa wires are cut 200 mm length [ORCA or ARCA].

Req.55. The fibers shall be continued to the next VEOC section without splicing. The bundles must be coiled around the heart of the BOB without mechanical tension or torsion.

3.7.7 Fiber

Req.56. There shall be with at least 2 turns of fiber bundle in each BoB.

Req.57. The fiber bundle is kept in place with a nylon star shaped clip.

Req.58. This clip shall not put any stress on the fiber bundle.

Req.59. The length of the fiber at the BEOC side shall be at least 50 cm.

Req.60. The length of the fibers at the anchor BoB shall be at least 200 cm.

**3.7.8 DC/DC converter**

Req.61. In every DOM breakout box one DC/DC convertor is connected and mounted.
This involves six solder joints.

HV_in	HV_GND
HV_out	HV_GND
12 V	12V_GND

Req.62. The solder joints shall be a lead soldering.

Req.63. The wires from and to the DC/DC converter shall be as short as possible.

Req.64. Cables shall not pinched.

3.7.9 Tests

Req.65. The complete VEOC is leak tested with air in a water submerge bubble leak test.
($<10^{-3}$ ml/s).

3.7.10 Final fiber test

Req.66. The final acceptance of the cable shall be based on reported optical performance, see §3.1.1, in the final acceptance test.

3.8 Manufacturing Requirements

Req.67. Assembly procedure described in RD 1 shall be followed.

Req.68. Cleanliness shall conform with a visibly clean level

3.8.1 Tooling

Req.69. Nikhef shall supply a tool for the PE welding of the BoB's to the tubing.

Req.70. Nikhef shall supply a tool to fill the VEOC with oil.

Req.71. Nikhef shall supply a tool to PE weld the BoB Cover to the BoB housing.

3.8.2 Fiber

Req.72. In the final acceptance test repaired fiber(s) shall be acceptable, see Req.90 for number of acceptable repaired fibers.

3.8.3 Oil filling

Req.73. After oil filling there shall be no air bubbles in the tubing.

3.9 Validation Requirements

Req.74. All tests described in RD 1 shall be performed and reported.

3.9.1 Electrical

Req.75. Low voltage electrical connection on the BEOC side shall have a length of length 30 cm

Req.76. Low Voltage shall be $+12.2 \text{ V} \pm 0.4 \text{ V}$ and GND, with the Nikhef DC/DC converter

3.9.1.1 Grounding / bonding

Req.77. Resistance between HV wire in Anchor BoB and HV wire in any BoB shall be $<10 \text{ Ohm}$

3.9.1.2 Insulation

Req.78. Between the High voltage and low voltage shall be a high resistance $> 10 \text{ MOhm}$



3.9.2 Optical

3.9.2.1 Mechanical

Req.79. The fiber length in the BoB at delivery shall be at least 50 cm measured from the BoB feedthrough.

Req.80. The fiber length in the Anchor BoB at delivery shall be at least 200 cm measured from the BoB feedthrough.

3.9.2.2 Optical

Req.81. The attenuation of all fibers shall be measured individually not exceeding:
For ARCA: All fibers shall have an attenuation below 0.5dB when the measurement setup is connected using temporarily splices or 0.8dB when connectors are used. A maximum splice loss of 0.07dB applies. The attenuation shall be measured using a stable light source and power meter or an OTDR. Both at 1550nm and 1310nm and with an accuracy <0.1dB.

For ORCA: All fibers shall have an attenuation below 0.35dB when the measurement setup is connected using temporarily splices or 0.5dB when connectors are used. A maximum splice loss of 0.07dB applies. The attenuation shall be measured using a stable light source and power meter or an OTDR. Both at 1550nm and 1310nm and with an accuracy <0.1dB.

3.10 Documentation and Data

3.10.1 Documentation

Req.82. Acceptance of the VEOC is on the basis of reports. The report shall be delivered in digital format (MS-Word or pdf).

Req.83. All data shall be in English, or shall provide a English translation

Req.84. Document RD 1 shall be completed as report and delivered with each VEOC.

3.10.2 Part number requirement

Req.85. The following information shall be marked on the Anchor BoB using materials and processes that will ensure legibility during the integration of the product :

- a) Supplier's Hardware Part-Number
- b) Supplier's Hardware Serial Number (if equipment is serialized) or Year and month of manufacture (if equipment is not serialized)
- c) Supplier's Name
- d) The Top Assembly Drawing number and revision that the part is manufactured to

3.10.3 Test and Inspection

Req.86. New test plans or changes in test plans shall be approved prior to testing.

Req.87. The tests mentioned in RD 1 should be performed.

3.10.4 Test Reporting

Req.88. The Test Report shall include the following:



- a) Identification of test plan/procedures when the plan & report are separate documents and identification/explanation of deviations to the test plan/procedure.
- b) A record of all tests, test results and test data. All recorded test results will be quantitative in that actual test results will be recorded. Graphic, tabular and photographic entries will be made as required for clarity and completeness. Supporting test data will include a narrative history or log of the test.
- c) A description of and the disposition of any equipment failures or defects occurring during the tests.

3.10.5 Non Conformance Reporting

Req.89. The manufacturer shall report every incident or anomaly during production.

Req.90. Any deviation shall be reported to Nikhef by e-mail. Each VEOC shall have no more than *one* repair per fibers with a maximum of *six* repaired fibers for the complete VEOC. In the final report all measurements shall be reported [electrical tests, fiber attenuation and date/time of visible inspection and leak tests].

3.10.6 Acceptance / Rejection Criteria

Req.91. Nikhef will review supplier documents to verify compliance with this document and any other applicable Nikhef documentation. Nikhef approval does not relieve the supplier of the responsibility of compliance with this document and other applicable documentation. The responsibility for the compliance remains that of the supplier.

3.10.7 Manufacturing and Material Process Specification

Req.92. A list process specifications that are used to manufacture the VEOC shall be submitted.

Manufacturing process.

- Welding PE
- Pressure testing
- Leak testing
- Oil filling

3.11 Logistics

3.11.1 Marking

Req.93. The package shall be marked to show its content.

Req.94. All equipment containers, including individual packages and outer cartons, shall be marked with the following information:

- 1) Supplier's Name
- 2) Supplier's trademark (Optional)
- 3) Part Name
- 4) Supplier's Part Number
- 5) Manufacturing Date
- 6) Quantity in container
- 7) Purchase order number
- 8) Supplier's serial number

3.11.2 Packaging

Req.95. The transport container shall protect the unit from damage or induced malfunction during normal shipping and handling.