VEOC ARCA/ORCA Assembly Procedure and Report

KM3NeT_MECH_2017_001
Els Koffeman/Frank Kayzel
Nikhef

Abstract

This is document describes the assembly procedure and tests to be done for the manufacturing of a VEOC ORCA line.

Recipients

The KM3NeT Collaboration

Document Status

Revision	Date	Comment	Reviewed by	Approved by
6.2	22/3/2018			
6	4/12/2017			
5	22/09/2017	Changed but not issued		
4	08/05/2017	Changed but not issued		
3	18/04/2017	Changed but not issued		
2	30/03/2017	Changed but not issued		
1	24/03/2017	e-mail dd 17/3/2017 e-mail dd 16/3/2017	Sylvian Henry Paschal Coyle	

Revision History

Revision	Date	Description
6.2	9-Mar-2018	Added visual inspection by endoscope to §9.1.2 Removed Catia numbering Added pictures for assembly Moved components list from chapter 9 to chapter 6
6.1	15-Dec-2017	After review by manufacturer: §5 1)c. removed reference to Nikhef §5 5)b. changed to 24 hrs and rephrased test criteria. §5 8)c.1 added to DCDC board §5 10)b. changed 380±20V and 12.2±0.4V §5 13) removed reference to Nikhef §5 17) added package description §7 Req.4 Fiber 50 cm and alpha wire 10 cm and 20 cm

		§7 Req.8 added "r equivalent" §9.1.1. 7. Rephrased passage test §9.2 Added "and 7 mm tube for all others" in heading §9.3 18 -> 19 Power transit red and 19 black, added tolerance on alpha wire §9.4 split table in two one for BoB weld IN and one for BoB weld OUT §9.5 changed wording test criteria. §9.6 changed wording test criteria. §9.8 removed double mentioning glue and silicon filling §9.9.1 removed reference to crocodile clip
6	4-Dec-2017	§5 point 5) added "No additional air bubbles collected in tray during 12 hr §7 removed Req.9 No connectors in anchor required §9.1.1 added point 7 check on passage tube weld. §9.9.2 added two columns to table for second voltage measurement §9.10 added three columns in table for second fiber loss measurement §9.12 added explicit Voltage and fiber test §9.11 1x BEOC cover
5	22-Sep-2017	Update of BoB tube welding procedure §9.1
4	8/05/2017	Added Anchor BoB with Fiber feed through: Figure 13.
3	1/05/2017	Added column in §9.8, page 29 for S/N DCDC converter
2	30/03/2017	Added in §9.9.2 the expected voltage of the DCDC converter: 12.4V
1	24/03/2017	§5 added retest optical fiber (16) and retest 400V – 12V output (15) §7 Req4 added : "There shall be with at least 2 turns."
0	12/03/2017	First Issue

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1 Documentation

1.1 Abbreviations

Abbreviation	Description
ARCA	Astroparticle Research with Cosmics in the Abyss
BEOC	Break out Electrical Optical Cable
BoB	Break out Box
DU	Detection Unit
DOM	Digital Optical Module
HDPE	High Density Poly Ethylene
KM3NeT	Cubic Kilometre Neutrino Telescope
ORCA	Oscillation Research with Cosmics in the Abyss
OTDR	Optical Time-Domain Reflectometer
VEOC	Vertical Electrical Optical Cable
TBD	To Be Defined

1.2 Reference Documents

Abbreviation	Title	Reference
RD1	KM3NeT TDR	KM3NeT_DS_TDR
RD2	KM3NeT CRD	KM3NeT_DS_CDR
RD3	VEOC BoB - DCDC assembly procedure	KM3NeT_MECH_2017_003

2 Introduction

This is document describes the assembly procedure and applicable tests for the manufacturing of a VEOC ORCA line. All test and inspection points are reported in this document. After finishing the manufacturing the document is issued under a new number as an assembly report. The report will be uploaded to the KM3NeT Google Drive database.
In a separate document [RD3] the assembly of the DCDC converter into the BoB is described.

3 General 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:

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 380 V DC to 12 V DC and lead through the 380 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 exit and 2 copper wires through a penetrators and ends at the top DOM.

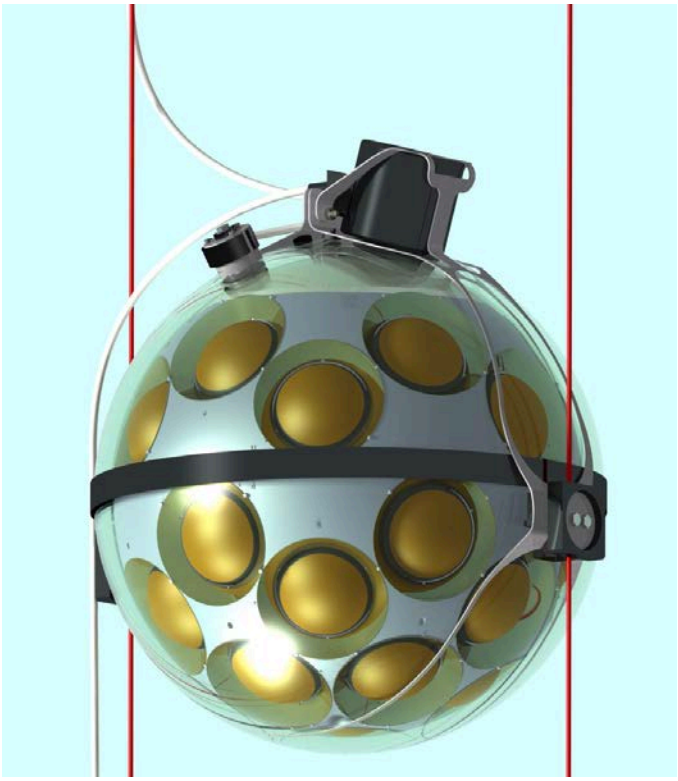


Figure 1 Routing of the VEOC at the DOM. A small PE tube (BEOC) connects the cables coming out of the DOM trough the penetrator to the DOM breakout Box. In red the Ultra High Molecular Weight Polyethylene (Dyneema) ropes that support the vertical structure of the DU.

4 General Production Method

The VEOC is manufactured in four basic steps listed below with required test procedures

1) Prepare by welding all sub-assembly PE parts
    a. leak test see §9.5
2) Pulling the electrical wires and the fiber bundles through the PE tube and make feedthroughs and connections
    a. test connections (fiber and copper), see §9.7
    b. Inspection point before continuation
3) Closing the VEOC side with PE welding
    a. Perform Leak test, see §9.6
4) Oil filling
    a. Leak test with increased oil pressure. See §9.12

All part drawings are given in §9.19

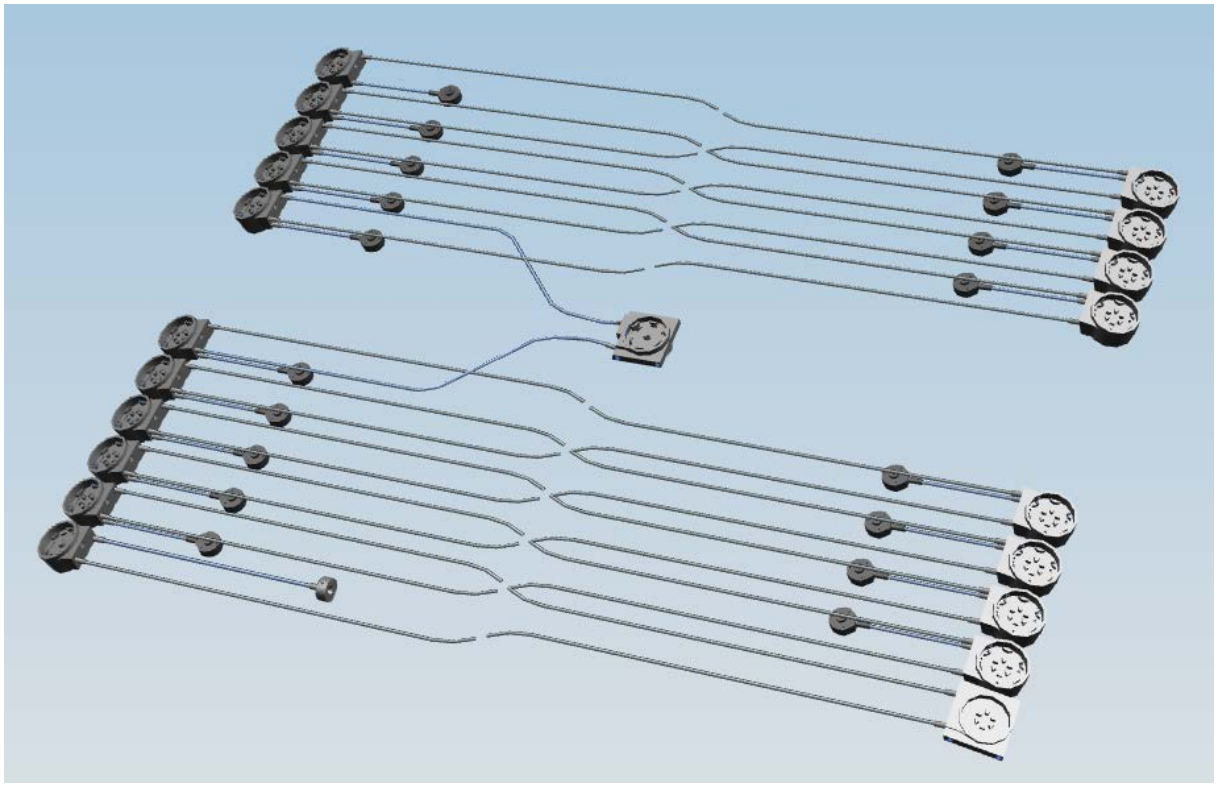


Figure 2 ARCA VEOC configuration

5 Step by step procedure

From prototyping, test and the first deployments we distilled a production procedure.

1) Prepare BEOC
    a. Cut and clean LDPE 7 mm tube [according to drawing]
    b. Weld sample according to procedure
    c. Check welding with X-Rays (TBD)
    d. Weld to penetrator cap
2) Prepare 18 DOM breakouts
    a. Optical feed through
    b. Electrical feed through with two power leads
    c. Weld BEOC [according to drawing]
3) Cut and clean [ORCA length] m segments LDPE 7 mm tube, see **Error! Reference source not found.**
4) Welding LDPE tubes to Breakout Box
    a. Visual inspection tube and the matching insert at the BOB
    b. Welding with automatic welding machine
    c. Inspect quality of the weld. Report anomalies
5) Perform leak test with air pressure and bubble test
    a. To be done in sections while temporarily closing the BOB's
    b. Go/NoGo values for the leak test: No air bubbles coming from the welds. Air bubble size in tray should not be changed after being immersed in water for 24 hrs. If bubble size has increased check if the sealing of the test device is not leaking. (TBD)
6) Arrange welded cables and breakout boxes in stretched layout fixating the BOB's

7) Pull fiber and copper though the PE tube and through the Breakout boxes
8) In each breakout box the following steps shall be performed. For detail see RD3.
    a. Branch off one fiber and guide it through feed through
        i. Specify length / silicone filling / routing at BEOC side
    b. Coil the remaining bundle around the center studs
    c. Cut copper wires and connect to the DCDC board (see RD3).
        i. Specify length and routing of 6 leads to the DCDC board.
        ii. Check length and orientation/photograph connections and serial numbers of DCDC converters
        iii. Note the BOB number and DCDC S/N
9) Check resistance of all wire combinations [report measurements] (Go/NoGo: R>20 MΩ)
10) After processing all breakout boxes
    a. Perform optical attenuation of the fiber connection (from bottom to exit at VEOC side)
    b. Connect 380(±20) V and confirm 12V output at each BEOC side (12.2V ±0.4V)
11) Close breakout box VEOC side with HDPE welding
12) Perform leak tightness tests (bubble tests with air over pressure)
13) Oil filling according to procedure
14) Retest electric connections
15) Connect 380(±20) V and retest Low voltage side: 12.2V ±0.4V output
16) Retest optical fiber
17) Materials and methods used in packaging shall ensure protection of the equipment from handling damage or deterioration during storage.
18) The VEOC is stored and shipped in a wooden pallet

6 Component list

6.1 Drawing and parts list VEOC ORCA

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

Table 1 VEOC OCRA Drawing and parts list

6.2 Drawing and parts list VEOC ARCA

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	022258	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 or sub-contractor
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	LLD-PE 44P	Nikhef or sub-contractor
				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 2 VEOC ARCA drawing and parts list

7 Quality specifications VEOC

Req.1. VEOC ARCA shall be made in two compartments (upper and lower) connecting in total 18 BOB's each. The ARCA configuration shall be according to Figure 18. For the ARCA cables the distance between the BOB's shall be 40m (+/- 10 cm).

Req.2. VEOC ORCA shall be one line connecting 18 BOB's. The ORCA configuration shall be according to drawing. For the ORCA cables the distance between the BOB's shall be10.1m (+/- 10 cm). The ORCA configuration shall be according to Figure 19.

Req.3. The VEOC shall be constructed with a PE tube with an outer diameter of 7 and an inner diameter of 5 mm. The VEOC shall holds two Alfa ECO wires (red and black) and two bundles of 12 fibers each of Draka single mode Bend Bright XS fibers or equivalent fibers. The bundles shall have differently colored cotton wire.

Req.4. A VEOC shall have 18 DOM breakouts with1 fiber and two Alfa wires. In each DOM breakout the Alfa wires are cut [length ORCA]. 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. There shall be with at least 2 turns. The fiber bundle is

kept in place with a with nylon star shaped clip. This clip shall not put any stress on the fiber. The length of the fiber at the BEOC side shall be 50 cm(TBD). The length of the Alfa wires shall be 10 cm (BEOC side) and 20 cm.

Req.5. In every DOM breakout box one DCDC converter is connected and mounted. This involves six solder joints.

HV_in	HV_GND
HV_out	HV_GND
12 V	12V_GND

Req.6. During pressure tests the BOB is temporarily closed with aluminum lid and clamps. See leak test setup.

Req.7. Acceptance of the cable is on the basis of reports. The report shall be delivered in digital format (MS-Word of pdf). The manufacturer shall report every incident or anomaly during production. Any deviation shall be reported to Nikhef by e-mail. Each VEOC shall have no more than six repairs in the fibers. In the final report all measurements shall be reported [electrical tests, fiber attenuation and date/time of visible inspection and leak tests].

Req.8. Additional the final acceptance of the cable shall be based on reported optical performance: OTDR (1550 nm) or equivalent measurements showing attenuation below 0.1 dB per 100 and lower and 01. dB per splice. Every fiber shall be tested additionally with 1350 nm.

8 Additional information: the DOM Breakout Box (BoB).

For each DOM a breakout of the cables is made. This is done inside the DOM breakout box. From this box a short cable leads to the penetrator: this is the BEOC cable which ends in the (HDPE) penetrator cap. When the DU is integrated the fiber and copper is fed though from the penetrator and welded/spliced in the BEOC side of the breakout box. Subsequently the BEOC side is closed (PE welding), filled with oil and mounted with titanium clamp to the titanium DOM collar.

So far all Breakout Boxes were designed and ordered by Nikhef and produced outside Nikhef. There are no known problems with delivery times and quality assurance to date. In Figure 3 a cross section of the breakout box is shown. At the top the VEOC_in and VEOC_out connection are made. At the bottom side the BEOC tube is connected that leads from the breakout to the DOM.

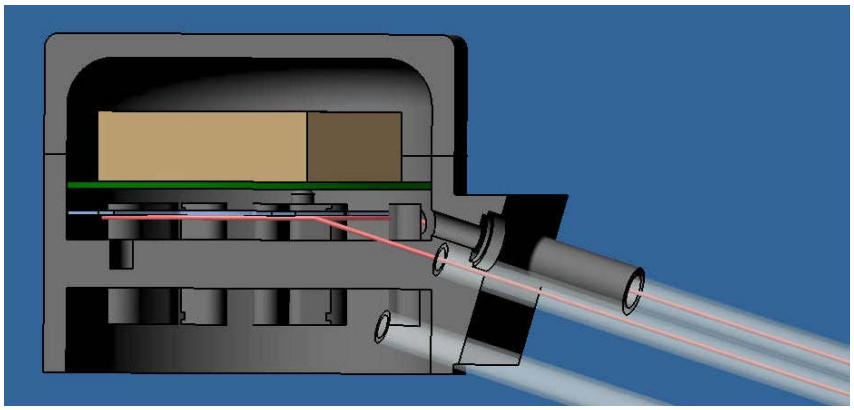


Figure 3 Cut open view of the DOM breakout box.

The DOM breakout box has two sides: VEOC and BEOC side. The VEOC compartment is separated from the VEOC side with a diaphragm that contains a fiber and two power feed troughs. The VEOC compartment holds the DCDC board. During test it must be leak tight [so far test with approx. 2 bar over pressure]. Upon delivery the BEOC side is only temporarily closed. Each DOM contains one oil-filling hole that is closed with a screw and an O-ring.

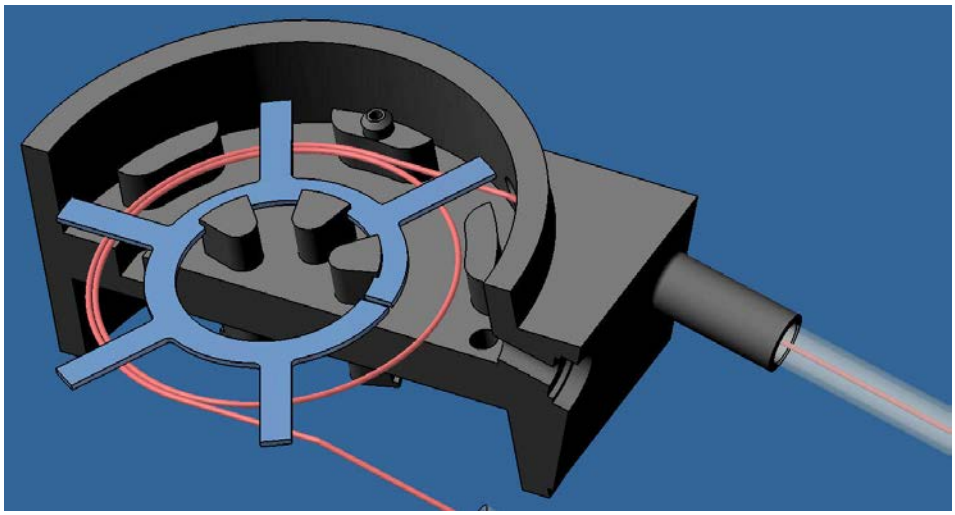


Figure 4 The routing and fixation of the fiber bundle inside the DOM breakout box.

9 Appendices: VEOC assembly report and test sheets

Nikhef shall receive a digital version of the report (filled word version or a pdf)
VEOC Assembly and Test Report
VEOC ORCA Identifier : [. . . . .]
VEOC ARCA Identifier : [. . . . .]
In Table 3 a list of tube length. Length of tubes are also shown in Figure 11 and Figure 19.

BoB Type	DOM nbr	Length [m] tube Ø7mm	BEOC
BoB Top	DOM 18	10.1	BEOC DOM
BoB 17	DOM 17	10.1	BEOC DOM
BoB 16	DOM 16	10.1	BEOC DOM
BoB 15	DOM 15	10.1	BEOC DOM
BoB 14	DOM 14	10.1	BEOC DOM
BoB 13	DOM 13	10.1	BEOC DOM
BoB 12	DOM 12	10.1	BEOC DOM
BoB 11	DOM 11	10.1	BEOC DOM
BoB 10	DOM 10	10.1	BEOC DOM
BoB 09	DOM 09	10.1	BEOC DOM
BoB 08	DOM 08	10.1	BEOC DOM
BoB 07	DOM 07	10.1	BEOC DOM
BoB 06	DOM 06	10.1	BEOC DOM
BoB 05	DOM 05	10.1	BEOC DOM
BoB 04	DOM 04	10.1	BEOC DOM
BoB 03	DOM 03	10.1	BEOC DOM
BoB 02	DOM 02	10.1	BEOC DOM
BoB 01	DOM 01	35	BEOC DOM
BoB Anchor		0	BEOC Anchor
ORCA			

BoB Type	DOM nbr	Length [m] tube Ø7mm	BEOC
BoB Top	DOM 18	40	BEOC DOM
BoB 17	DOM 17	40	BEOC DOM
BoB 16	DOM 16	40	BEOC DOM
BoB 15	DOM 15	40	BEOC DOM
BoB 14	DOM 14	40	BEOC DOM
BoB 13	DOM 13	40	BEOC DOM
BoB 12	DOM 12	40	BEOC DOM
BoB 11	DOM 11	40	BEOC DOM
BoB 10	DOM 10	21	BEOC DOM
Middle			
BoB 09	DOM 09	19	BEOC DOM
BoB 08	DOM 08	40	BEOC DOM
BoB 07	DOM 07	40	BEOC DOM
BoB 06	DOM 06	40	BEOC DOM
BoB 05	DOM 05	40	BEOC DOM
BoB 04	DOM 04	40	BEOC DOM
BoB 03	DOM 03	40	BEOC DOM
BoB 02	DOM 02	40	BEOC DOM
BoB 01	DOM 01	40	BEOC DOM
Between		40	
BoB Anchor			BEOC Anchor
ARCA			

Table 3 VEOC ORCA and ARCA tube length

9.1 Welding tube on the BEOC, BEOC preparation

Date	
Approval KM3NeT welding prosess	

9.1.1 Parts

ARCA/ORCA			
Drawing	Version	Name	Qty
022295	**A**	End Cover Straight Anchor Ø8mm	1
022281	**A**	Polyflo 8x5x500 mm3	1
022261	**A**	End Cover DOM Ø7mm	18
022280	**A**	Polyflo 7x5x220 mm3	18

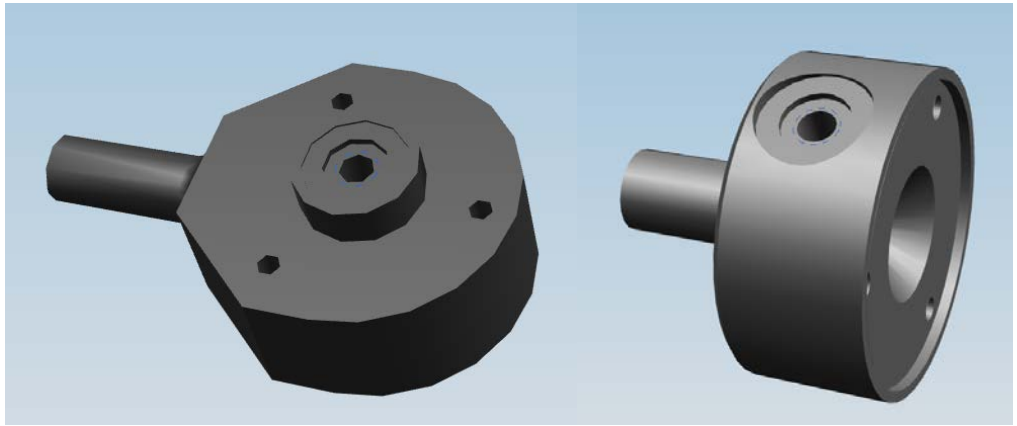


Figure 5 End Cover DOM (left) and End Cover Anchor Straight (right)

9.1.2 Welding Machine

Welding of the tube into the BoB shall be done with a welding machine: WIDOS 2500 SPS Nikhef

9.1.3 Welding Procedure:

Ensure that the Tube and BoB connection stay in line during the welding process

1. Clean inner part of BoB tube fitting (where it will be welded) with alcohol and special tool and textile.
2. Clean the outside of the Tube with alcohol.
3. Straighten the last 20 cm of the Tube before welding
4. Use the silicone insert
5. Heating cycle :
    a. Heating for 2 min with Clamp temperature : 140°C (TBC)
    b. Cooling until BoB is 80°C (~ 5 min)
6. Remove from machine
7. Verify the welding inside the tube for free passage. This can be done by inserting a tool e.g. an endoscope. See for the endoscope https://www.endoscoopcamera.nl/product/pce-ve-200-s-video-endoscoop-37mm/ or equivalent should be used.

Welding tube on the BEOC, BEOC preparation			
End Cover	**Date**	**Name**	**Visual check + photo of outside weld, check inside passage**
Anchor			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18 Top			

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.2 Weld BEOC on the BoB with 8 mm tube on Anchor BoB and 7 mm for all others BoBs.

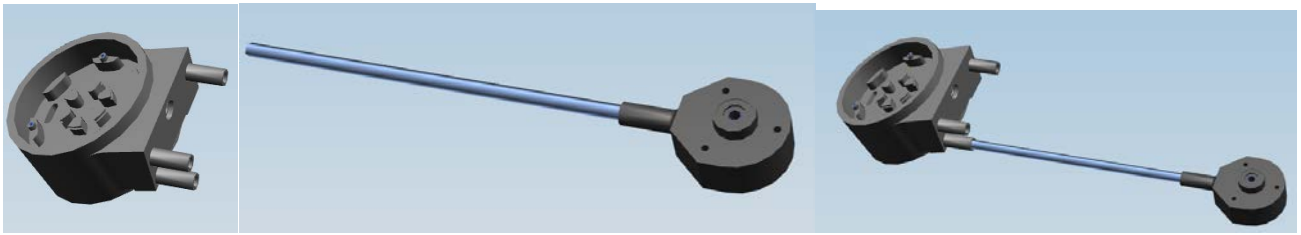


Figure 6 BoB and End Cover-assy before and after welding

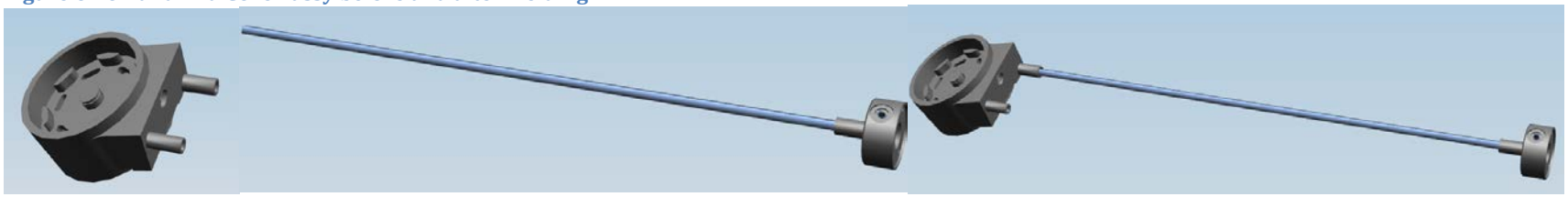


Figure 7 Anchor BoB an End Cover Assy () before and after welding

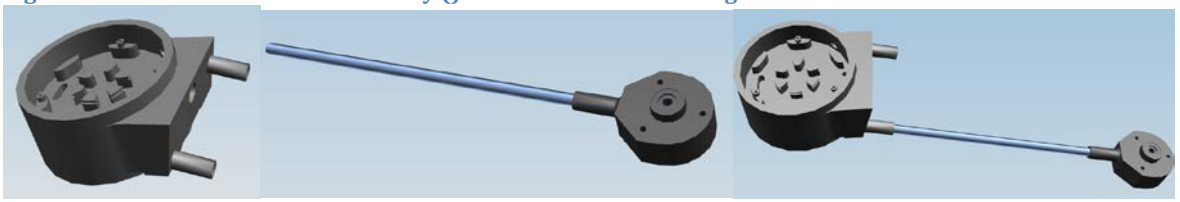


Figure 8 BoB housing Top And End cover Assy

Note orientation of the BEOC w.r.t. BoB

Date	

Name KM3NeT witness (if present	

Welding BEOC to BoB					
BOB	**Date**	**Name**	**Orientation Check BEOC**	**Visual check + photo of weld**	**Visual check + photo of weld**
Anchor					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18 Top					

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.3 Insert brass glass fiber and electrical feedthrough

The wiring from the BoB Anchor through BoB 01 to the BoB Top (number 18)

- 19 Power transit Red
- 19 power transit Black
- 18 Fiber transit for 1 wire
- 6 Fiber transit for 4 wires
- power wires red and black

9.3.1 Procedure

1. Cut red and white wire in length of 200 mm ±10 mm (VEOC side) and 100 mm ±10 mm (BEOC side)
2. Crimp wire on power transit.
3. Press Power transit in BoB
4. Press fiber transit in BoB (18x)
5. Press fiber transit in BoB Anchor (6x)

After assembly take photo of BoB

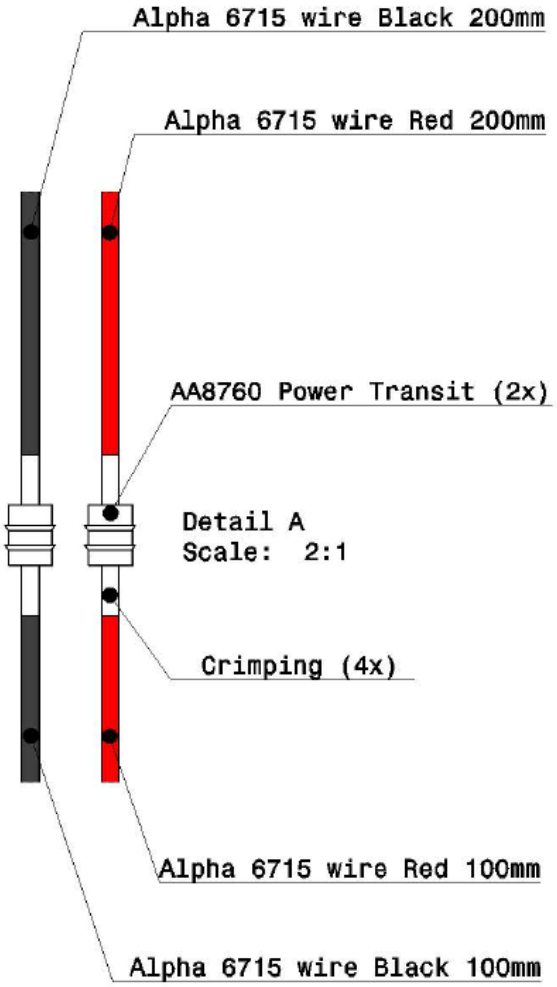


Figure 9 Power transit assembly

9.3.2 Parts

Remark : Anchor BoB has larger fiber transits (drawing 020594 and 022259)

ARCA/ORCA			
020594	**A**	BoB Housing - Anchor	1
022259	**A**	Fiber Transit for 4 fiber	6
020592	**A**	BoB Housing	18
022250	**A**	Power Transit	38
022257	**A**	Fiber Transit for 1 fiber	18
ARCA			
021020	**A**	BoB Housing - Middle	1
022259	**A**	Fiber Transit for 4 fiber	6
022250	**A**	Power Transit	2

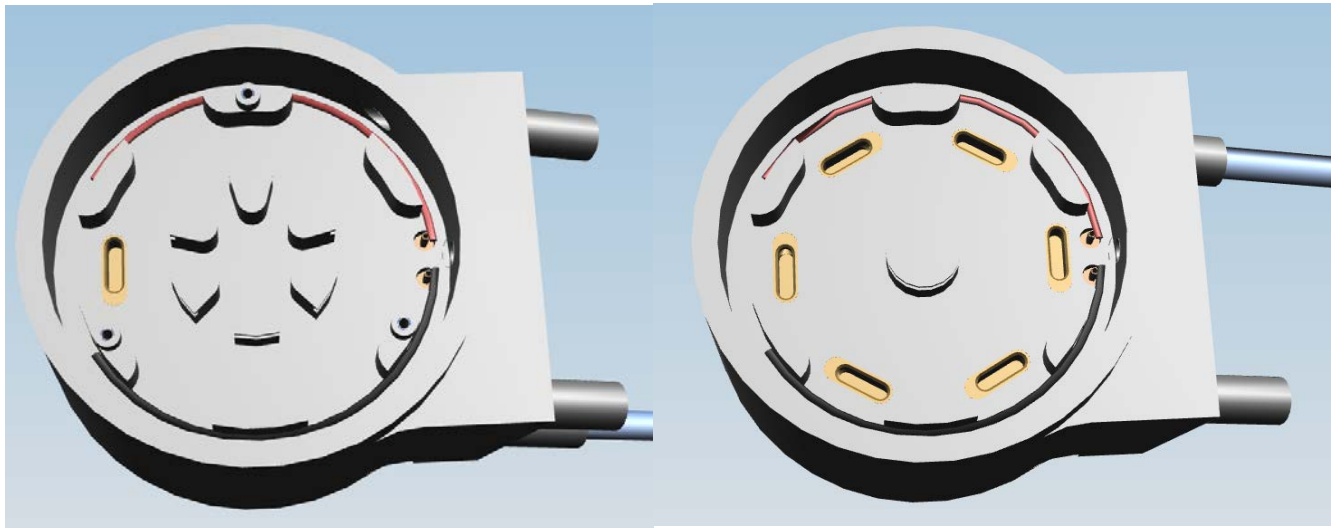


Figure 10 Power and fiber transits BoB (left) and Anchor BoB (right)

Pre-assembly BOB				
BOB	**date**	**name**	**Photo**	**Remark**
ANCHOR				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				

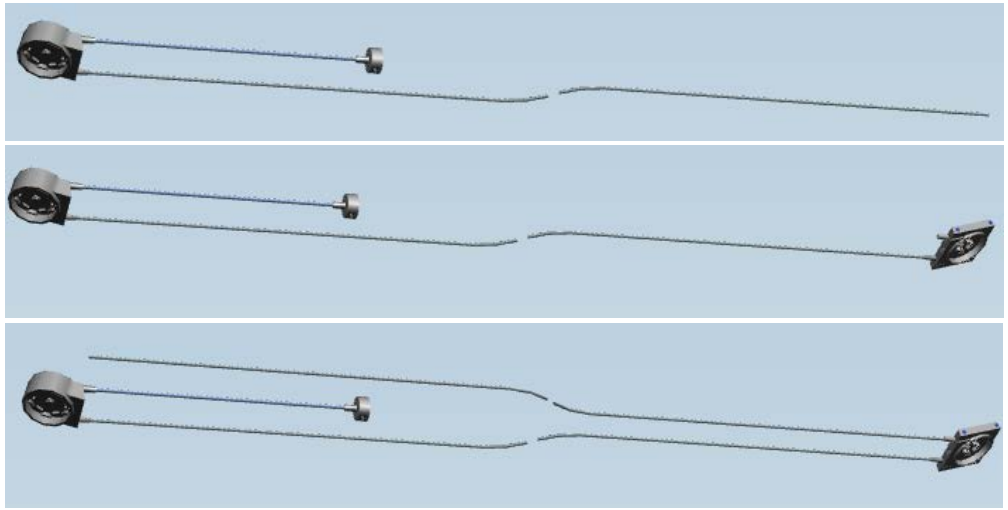
Note any and all anomalies	
Signature KM3NeT representative for proceeding to next step	

9.4 LPDE tube welding to BEOC's and penetrator caps

9.4.1 ARCA Production steps

For the ARCA see Figure 11 VEOC ARCA tubing:

1. Anchor Bob is connected to Between BoB with 40 m tubing.
2. Middle BoB is connected to first BoB with 40 m tubing
3. First BoB is connected to second BoB with 40 m tubing
4. Connect 2nd to 3rd
5. Etc. to 9th
6. 9th is connected to Middle BoB with 19 m tubing
7. Connect 10th BoB to Middle BoB with 21 m tubing
8. Connect 10th BoB to 11h BoB with 40 m tubing
9. Etc. to 18th BoB



9.4.2 ORCA production steps

For the ARCA see Figure 19 VEOC ORCA configuration:

1. Anchor Bob OUT is connected BoB 01 IN with 35 m tubing
2. BoB 01 OUT is connected to BoB 02 IN with 10.1 m tubing
3. Connect BoB 02 OUT to BoB 03 IN
4. Etc. to the 6th BoB IN
5. 6th BoB OUT is connected to 7th BoB IN with 12.2 m tubing
6. 7th BoB OUT is connected to 8th BoB in
7. Etc. to the 12th BoB IN
8. 12th BoB OUT is connected to 13th BoB IN with 12.2 m tubing
9. 13th OUT is connected to 14th IN
10. Etc. to 18th BoB (Top BoB)

11. Parts

		ARCA	
022326	**A**	Lengte (40 m) tube Ø7mm	18
022327	**A**	Lengte (21 m and 19 m) tube Ø7mm	1+1
022294	**A**	Assy BoB Anchor	1
022289	**A**	Assy BoB	18
020593	**A**	BoB Housing - Top 7mm	1
021017	**A**	BoB Housing - Between	1
021020	**A**	BoB Housing - Middle	1
		ORCA	
022280	**A**	Lengte (10.1 m) tube Ø7mm	17
020593	**A**	BoB Housing - Top 7mm	1
020592	**A**	BoB Housing 7 mm	17
020594	**A**	BoB Housing - Anchor 7 mm	1

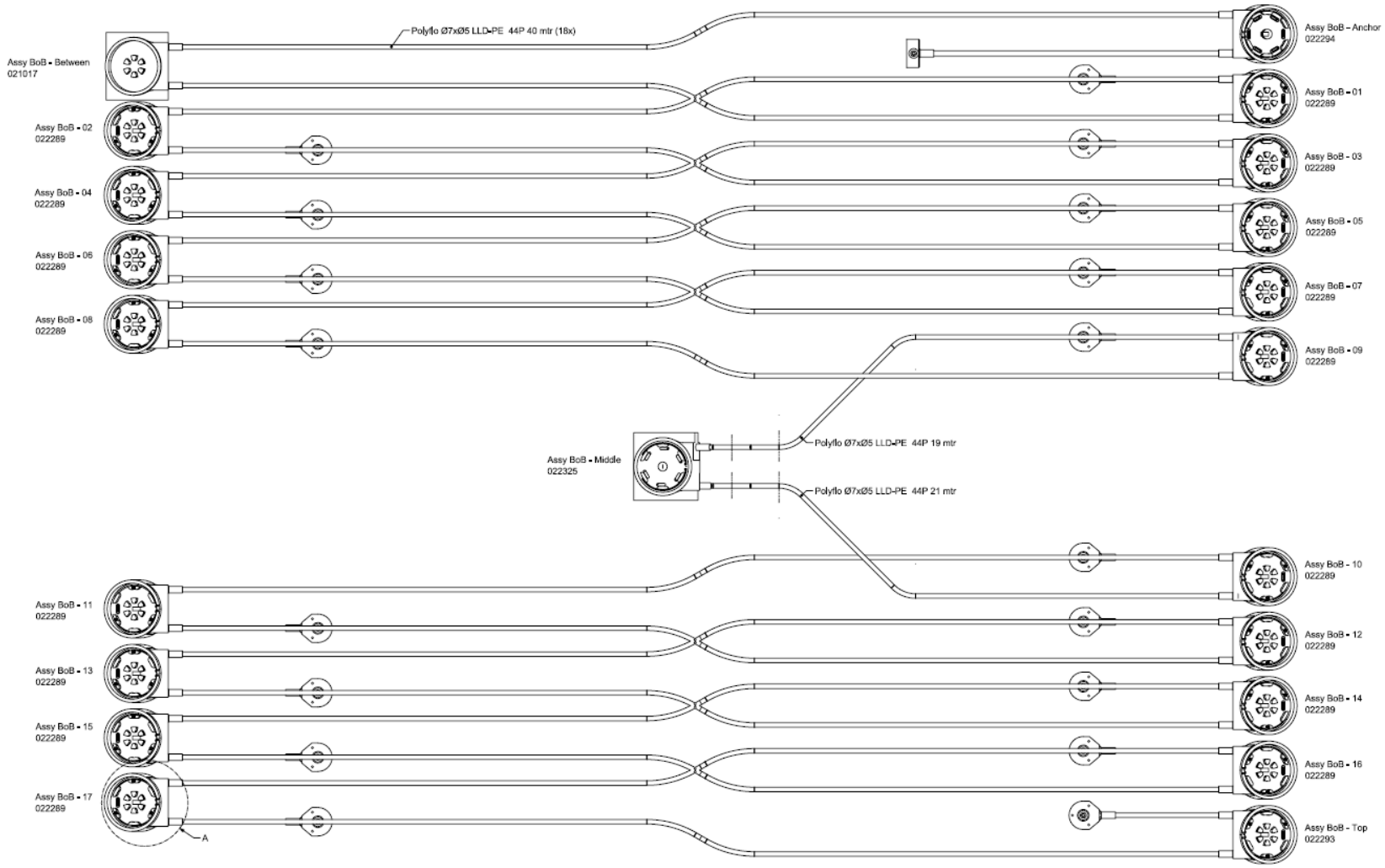


Figure 11 VEOC ARCA tubing

Date	
KM3NeT witness (if present)	

Welding PE tubes		**Weld Tubing to BoB IN**		
BOB	**date**	**name**	**Photo**	**Remark**
ANCHOR	NA	NA	NA	
Between				
1				
2				
3				
4				
5				
6				
7				
8				
9				
Middle				
10				
11				
12				
13				
14				
15				
16				
17				
18				

Welding PE tubes			**Weld tubing BoB OUT**	
BOB	**date**	**name**	**Photo**	**Remark**
ANCHOR				
Between				
1				
2				
3				
4				
5				
6				
7				
8				
9				
Middle				
10				
11				
12				
13				
14				
15				
16				
17				
18				

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.5 Submersion leak test of each BOB

The VEOC is tested at an air pressure of 2.5 bar. The BEOC leak tightness is tested by keeping the BEOC 24 hours immersed in water.
Qualification criteria: Air bubble size in tray should not be changed after being immersed in water for 24 hrs. If bubble size has increased check if the sealing of the test device is not leaking.
Test tool to close BoB see §9.17

Date	
KM3NeT witness (if present)	

Leak Test			
BOB	**duration**	**Test result**	**Photos of submerged BOB at begin and after 24 hr**
Anchor			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Leak Test			
BOB	**duration**	**Test result**	**Photos of submerged BOB at begin and after 24 hr**
17			
18			

9.6 BEOC leak tests

The End Cover welding on the LLD-PE 44P tube is tested at a pressure of 2.5 bar. The BEOC leak tightness is tested by keeping the weld 24 hours immersed in water.

Qualification criteria: Air bubble size in tray should not be changed after being immersed in water for 24 hrs. If bubble size has increased check if the sealing of the test device is not leaking.

Leak Test			
BEOC	**duration**	**Test result**	**Photo of submerged BEOC at begin and after 24 hr**
BEOC 1			
BEOC 2			
BEOC 3			
BEOC 4			
BEOC 5			
BEOC 6			
BEOC 7			
BEOC 8			
BEOC 9			
BEOC 10			
BEOC 11			
BEOC 12			
BEOC 13			
BEOC 14			
BEOC 15			

Leak Test			
BEOC	**duration**	**Test result**	**Photo of submerged BEOC at begin and after 24 hr**
BEOC 16			
BEOC 17			
BEOC 18			

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.7 Wire and Fiber pulling LPDE tube

Wire passing through tube. Take photos of deviations.
Test fibers with laser to exclude fractures.

Date	
KM3NeT witness (if present)	

9.7.1 Parts

ARCA

		12 Fibre strain [m]	758
		12 Fibre strain [m]	758
		Alpha ECO wire AWG 18 [m]	758
		Alpha ECO wire AWG 18 [m]	758
022268	**A**	Star 32mm	37
022270	**A**	Star 13mm	11

ORCA

		12 Fibre strain [m]	250
		12 Fibre strain [m]	250
		Alpha ECO wire AWG 18 [m]	250
		Alpha ECO wire AWG 18 [m]	250
022268	**A**	Star 32mm	36
022270	**A**	Star 13mm	8

Laser Test			
BoB/DOM			**Incidents / observations**
1	Blue	Red	
2	Orange	Red	
3	Green	Red	
4	Brown	Red	
5	Slate	Red	
6	White	Red	
7	Red	Red	
8	Black	Red	
9	Yellow	Red	
10	Blue	White	
11	Orange	White	
12	Green	White	
13	Brown	White	
14	Slate	White	
15	White	White	
16	Red	White	
17	Black	White	
18	Yellow	White	

Fiber wire 9 to 12 (violet, rose and aqua) in both fiber bundles (Red and White) are spare wires to repair any broken of fractured fibers.

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.8 Fiber to BEOC and mounting of DCDC convertor

Date	
KM3NeT witness PRESENT	

Mounting Fiber inside BoB have the following steps:

- Wire passing through
- Wind remaining fiber wire
- Check continuity of fiber
- Glue fiber with Araldite 2011 (brown part in drawing, see Figure 12).
- Fill remaining space of fiber feedthrough with silicone Dow Corning 3140 RTV coating.
- The silicone glue provides a smooth transition out the box.
- The BEOC side space shall also be filled with silicone.
- The excess-length of fiber shall be stored in the reserved space in the BoB.
- The fibers are enclosed within a star.

For each bob Provide 2 photos of:

- Fiber feed through and silicone filling
- Fiber coil inside the BOB

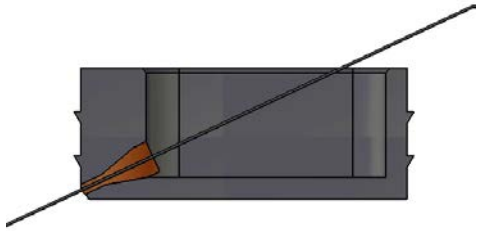
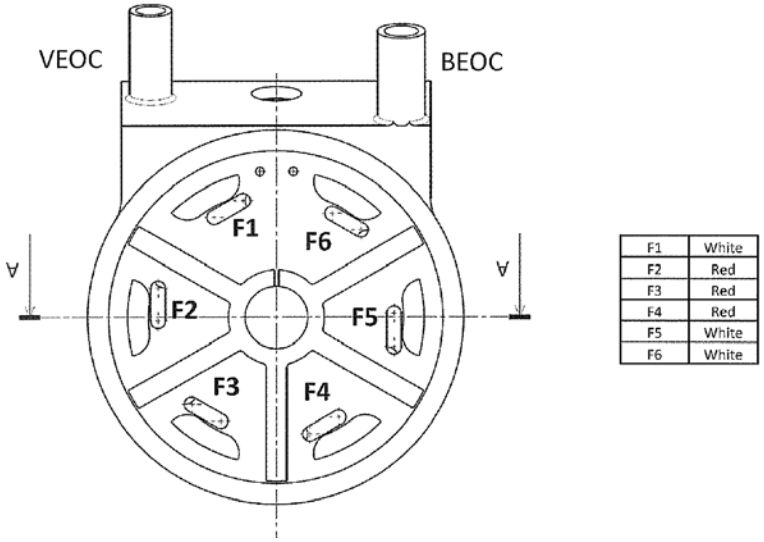


Figure 12 Fiber feedthrough



F1	White
F2	Red
F3	Red
F4	Red
F5	White
F6	White

Figure 13 Anchor BoB with 6 fiber feed through F1 to F6

In the Anchor BoB the fibers from the red bundle are passing through F2, F3 and F4. The fibers from the white bundle are passing through F5, F6 and F1.

Mounting Fiber			
BOB	**Date**	**Photo**	**Remark**
Anchor			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

DC/DC converters are mounted with three screws M2.5x8 and the power wires connected in : BoB 01 to BoB Top.

Mounting electrical wire inside BoB steps
For each bob Provide 2 photos of:

- Electrical wire routing inside the BOB
- Solder joints, soldering should not exceed 2.5 mm from the PCB

		Mounting Electrical wire to DCDC PCB			
BOB	**Date**	**Photo Soldering**	**Photo Inside BoB**	**S/N DCDC**	**Remark**
Anchor	NA	NA	na	NA	NA
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					

Note any and all anomalies	

Approval KM3NeT representative for proceeding to next step	

9.9 Voltage and resistance measurements

9.9.1 Resistance

Date	
KM3NeT witness (if present)	

Measurement device : Capable of measuring resistance at least up to 20 MΩ (Calibrated). Measure resistance on wire and with a probe on the PCB.

Brand & type measurement device:

Resistance measurement (unpowered board)

When all DCDC converters are connected:

R1 : resistance between HV_IN- any BoB (black wire) ⟺ and black wire at anchor BoB (expected R ~1-10 Ω; wire resistance +connector resistance)

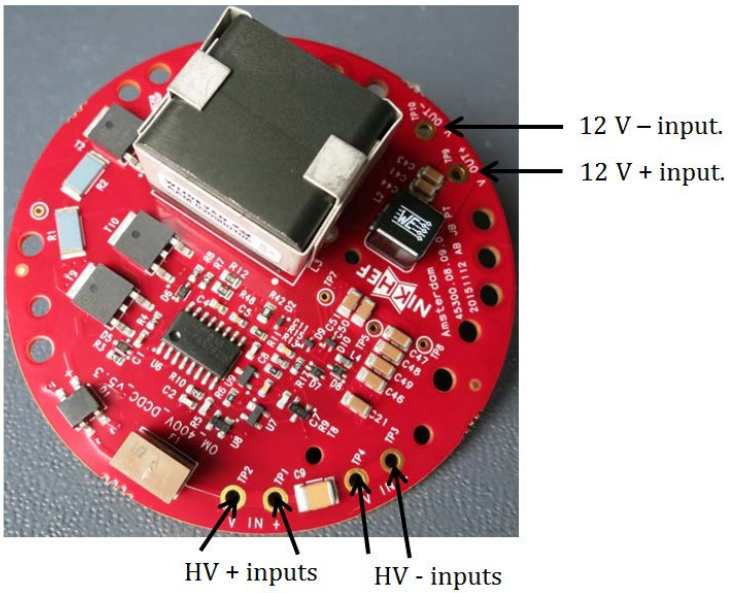
R2 : resistance between HV _IN+ any BoB (red wire) ⟺ and red wire at anchor BoB (expected R ~1-10 Ω; wire resistance +connector resistance)

R3 : Resistance between red and black wire at anchor BoB (expected R > 1 MΩ)

R4 : resistance between 12V_OUT- (black wire BEOC side) and HV_IN- (black wire at any bob) (R >20 MΩ)

R5 : resistance between 12V_OUT+ (red wire BEOC side) and HV_IN+(red wire at any bob) (R >20 MΩ)

Top side of the converter.



Resistance measurement								
BOB		**R1**	**R2**	**R3**	**R4**	**R5**	**OK/NOK**	**Expected**
Anchor HV-								1-10 Ω
1-18 HV-								
Anchor HV1+								1-10 Ω
1-18 HV+								
Anchor HV-								20 MΩ
Anchor HV1+								
					12V-/HV-	**12V+/HV+**		1-10 Ω (R1, R2) >20 MΩ (R4, R5)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Resistance measurement								
BOB		**R1**	**R2**	**R3**	**R4**	**R5**	**OK/NOK**	**Expected**
11								
12								
13								
14								
15								
16								
17								
18								

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.9.2 Voltage

Connect power supply with capable to deliver 375-400 V DC to the anchor BoB. Measure voltage between red and black wire on BEOC side.

	Brand and Type
Power supply	
Voltage measurement device	

		Measured first time date:		**Measured second time (§9.12)**	
BOB	**Expected/Measured**	**Tolerance/Remark**		**Tolerance/Remark**	
	12.2 V	**Min 11.8 V / max12.6 V**	**OK/NOK**	**Min 11.8 V / max12.6 V**	**OK/NOK**
Anchor	NA				
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

		Measured first time date:		**Measured second time (§9.12)**	
BOB	**Expected/Measured**	**Tolerance/Remark**		**Tolerance/Remark**	
	12.2 V	**Min 11.8 V / max12.6 V**	**OK/NOK**	**Min 11.8 V / max12.6 V**	**OK/NOK**
17					
18					

Voltage and current during measurement:

Voltage applied [V]	
Current [A]	

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.10 Optical loss measurements in the fibers

Date	
KM3NeT witness (if present)	

Optical Loss test first date:					**Optical loss test second date (§9.12):**		
BOB	**Fiber color at anchor**	**dB - 1310**	**dB - 1550**	**anomalies**	**dB - 1310**	**dB - 1550**	**anomalies**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

Equipment used

Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.11 Weld Cover BoB

Weld Covers to BoBs.

18x Cover VEOC	(AA8783) (protect PCB with foil during heating process)
1x Cover BEOC	(AA8785)
19x Skiffy stoppod	004 0790 005 03

After connecting to the DOM another 19x Cover BEOC (AA8785) are needed.
Use Protective foil on DCDC converter to prevent warming up the wires and PCB
Do not clean the welding surfaces with sand paper. You can clean the surface with a sharp knive.
Welding tool:

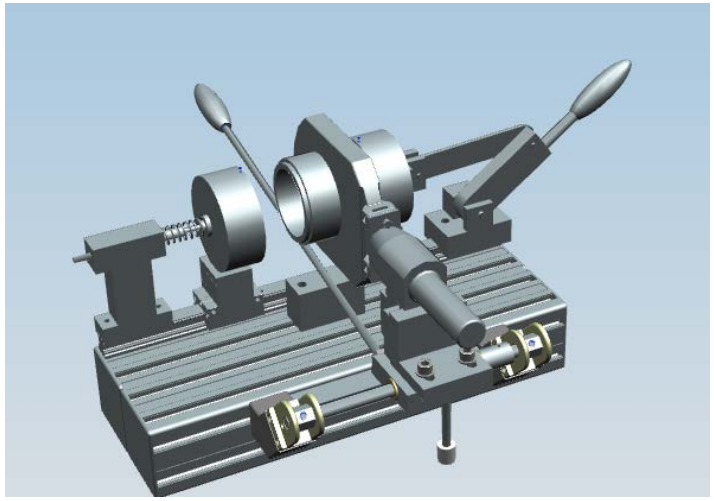


Figure 14 BoB cover welding tool

Welding procedure during welding:
- pressure BoB and Cap on heater during 60 s,
- remove heating device and protecting foil
- Press two parts during 120 s.

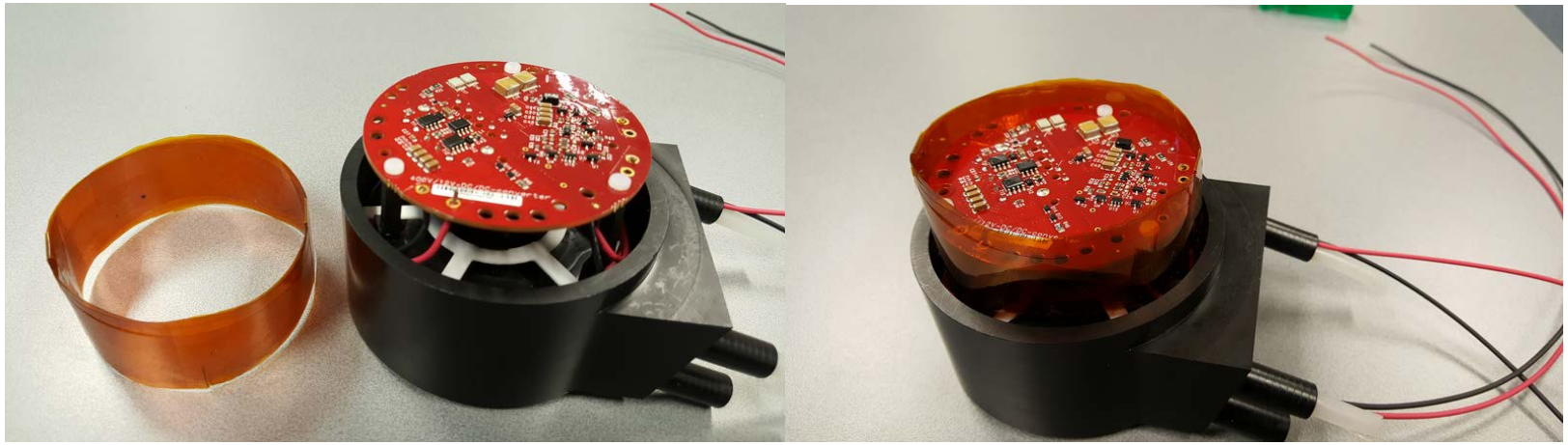


Figure 15 DCDC converter and heat protection

9.12 Final VEOC test

The complete VEOC is tested.

- Repeat optical fiber test of §9.10 and report in §9.10
- Repeat voltage test §9.9.2 and report in §9.9.2

Final test with a pressure of 2,5 bar during 60 minutes.
Test covers with soap water, do not immerse in water.

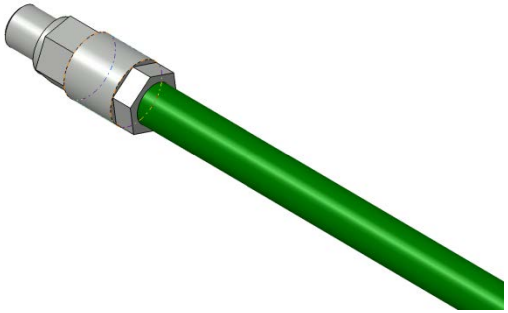
9.13 Fill VEOC with oil

Fill the VEOC with 17L Midel 7131 transformer Insulating Fluid (M&I Materials)
Connect fill hose to the olie fill point of the BoB.
Connect according to table (below)

BoB Type	IN/OUT
BoB 18 (Top)	IN
BoB 17	OUT

BoB 16	IN
BoB 15	OUT
BoB 14	IN
BoB 13	OUT
BoB 12	IN
BoB 11	OUT
BoB 10	IN
BoB 09	OUT
BoB 08	IN
BoB 07	OUT
BoB 06	IN
BoB 05	OUT
BoB 04	IN
BoB 03	OUT
BoB 02	IN
BoB 01	OUT
BoB Anchor	IN

After filling with oil is competed the VEOC oil fill point is sealed with a Sealing screw with O-ring (AA9008).



Note any and all anomalies	
Approval KM3NeT representative for proceeding to next step	

9.14 Delivery

After successful filling the cable is wound (not on a reel) and put in transport container.
The transport container shall protect the unit from damage or malfunction during normal shipping and handling.

9.15 Equipment (I) PE tube welding machine

The PE welding machine is a WIDOS 2500 SPS Nikhef
The welding machine has the following specification:

1.4.1. Technische Daten

Aufgeführt werden alle wichtigen technischen Daten der Einzelkomponenten.
Sie erlauben eine schnelle Information über Leistungsfähigkeit und Aufbau.

1.4.1.1. WIDOS 2500P SPS NIKHEF Allgemeine Daten

Material:	Thermoplaste
Einspeisung:	max. 16 A
Leistung:	max. 3,6 kW
Versorgungsspannung:	230 V (± 10 %)
Frequenz:	50 Hz (± 10 %)
Leitungsquerschnitt:	3 x 1,5 mm²
Umgebungsbedingungen im Schweißbereich:	- Auf Sauberkeit achten (kein Staub an der Schweißstelle) - Wenn durch geeignete Maßnahmen sichergestellt wird, dass zum Schweißen zulässige Bedingungen angegeben sind, darf – soweit der Schweißer nicht in der Handfertigkeit behindert ist – bei beliebiger Außentemperatur gearbeitet werden. - vor Feuchtigkeitseinwirkung schützen - starke Sonneneinstrahlung vermeiden
max. Arbeitsdruck:	8 bar
Abmaße (BxHxT):	ca. 1090 x 2050 x 750 mm
Heizelemente:	
Leistung je Heizelement:	0,44 kW
Spannung:	230 V
Stromstärke je Heizelement:	1,9 A

9.16 Equipment (I) Oil filling station

KM3NET Oil fill and degassing system VEOC

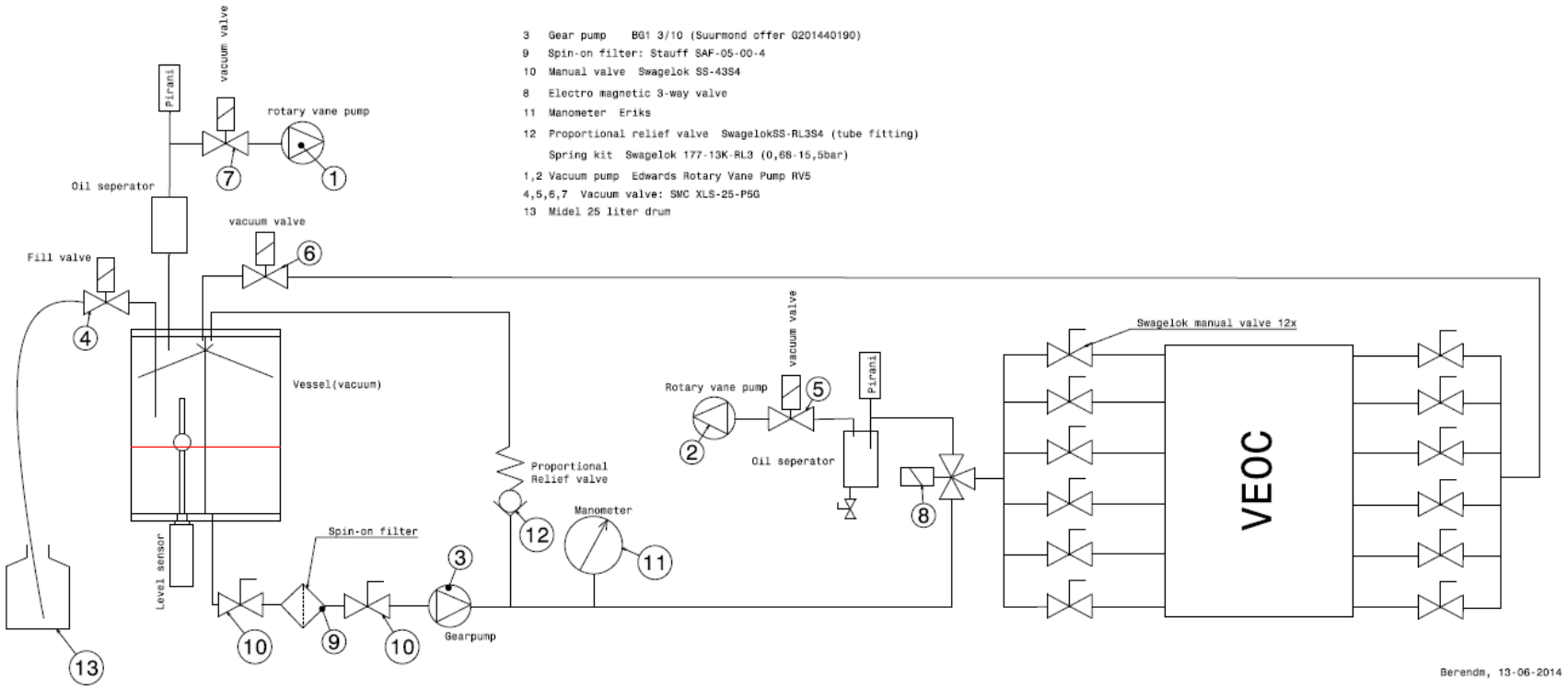
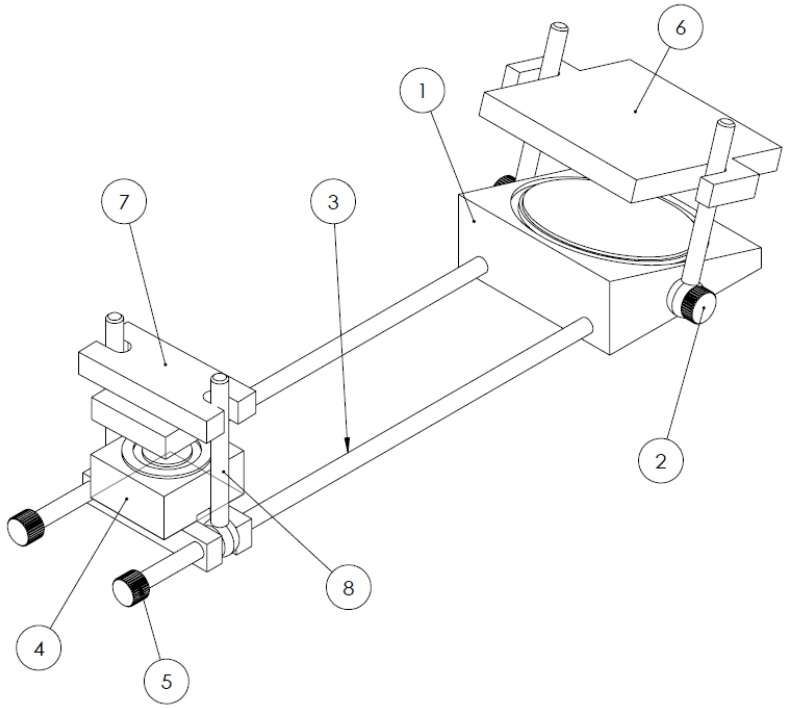


Figure 16 Oil fil schematics

9.17 Leak tester

Figure 17 Leak testing Tool



1. BOB-onderkant (Anchor) - ALU
2. BOB geleidingsbout - RVS
3. BOB-BEOC geleidingsas - RVS
4. BEOC-onderkant - ALU
5. BOB-BEOC geleidingsdopje - ALU
6. BOB-bovenkant (Top) - ALU
7. BEOC-bovenkant - ALU
8. Knevelbout - RVS (Bestelproduct)

9.18 Drawing list

The following drawings are added to the documentation package as pdf.

Drawing list			
Drawing number	**Rev.**	**Name**	
020593	**B**	BoB Housing - Top 7mm	pdf
020592	**B**	BoB Housing 7mm	pdf
021020	**A**	BoB Housing - Middle 7mm	pdf
021017	**A**	BoB Housing - Between 7mm	pdf
020594	**A**	BoB Housing - Anchor 7mm	pdf
022254	**A**	Cover VEOC	pdf
022255	**A**	Cover BEOC	pdf
022261	**A**	End Cover DOM Ø7mm	pdf
022295	**A**	End Cover Straight Anchor Ø8mm	pdf
022250	**A**	Power Transit	pdf
022257	**A**	Fiber Transit for 1 fiber	pdf
022258	**A**	Fiber Transit for 4 fiber	pdf
022259	**A**	Sealing screw (BoB)	pdf
022260	**A**	Sealing screw (End Cover)	pdf
022268	**A**	Star 32mm	pdf
022270	**A**	Star 13mm	pdf
		Assemblies	pdf
022286	A	Assy Power transit	pdf
022341	B	Assy VEOC ARCA Tubing	pdf
022345	B	Assy VEOC ARCA Fiber into Tube	pdf
022370	B	Assy VEOC ARCA Fiber in BoB	pdf
022372	B	Assy VEOC ARCA Covers	pdf
022373	A	Assy VEOC ARCA Oil in and Oil out	pdf

9.19 Drawing VEOC ARCA

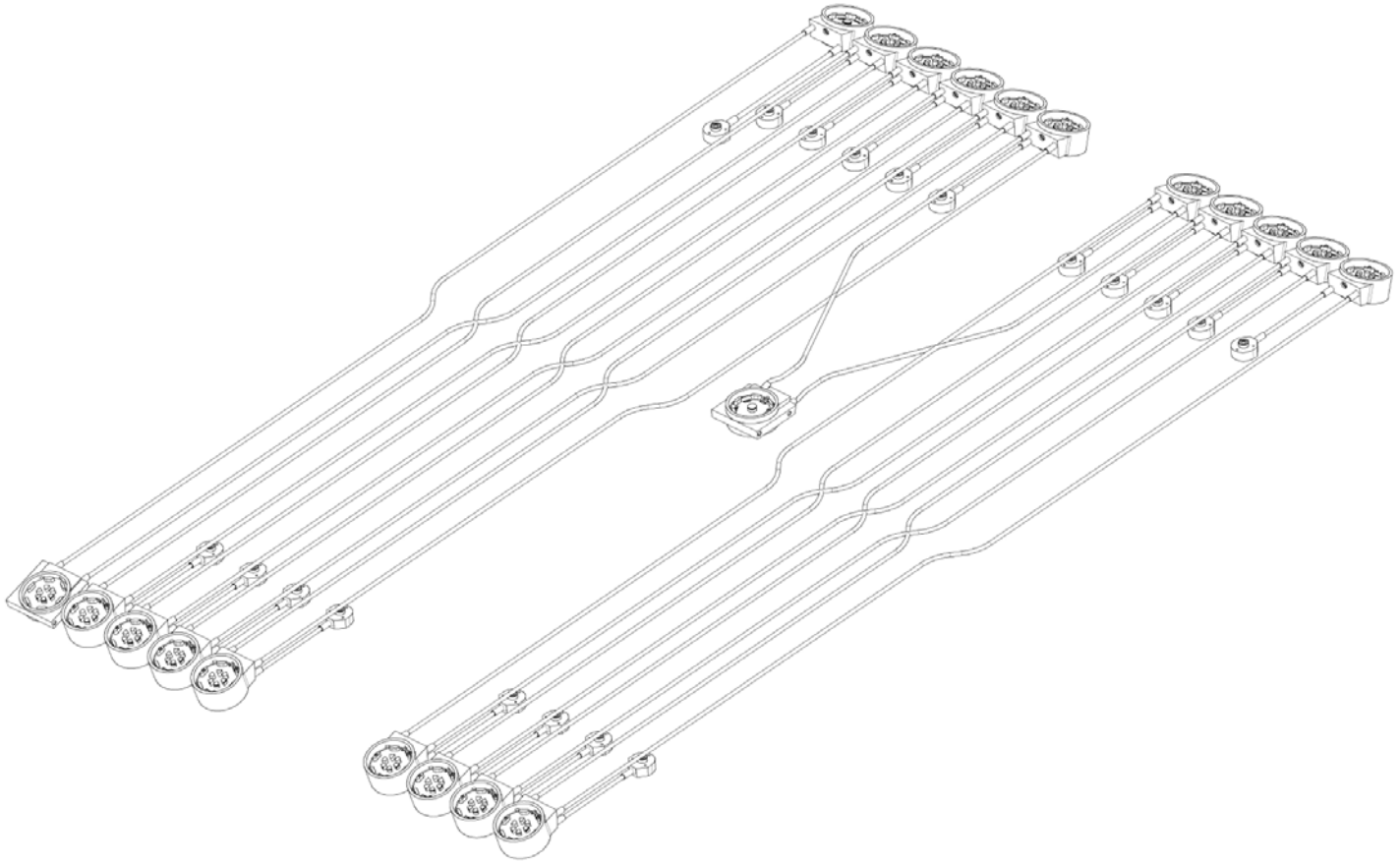


Figure 18 VEOC ARCA configuration

9.20 Drawing VEOC ORCA

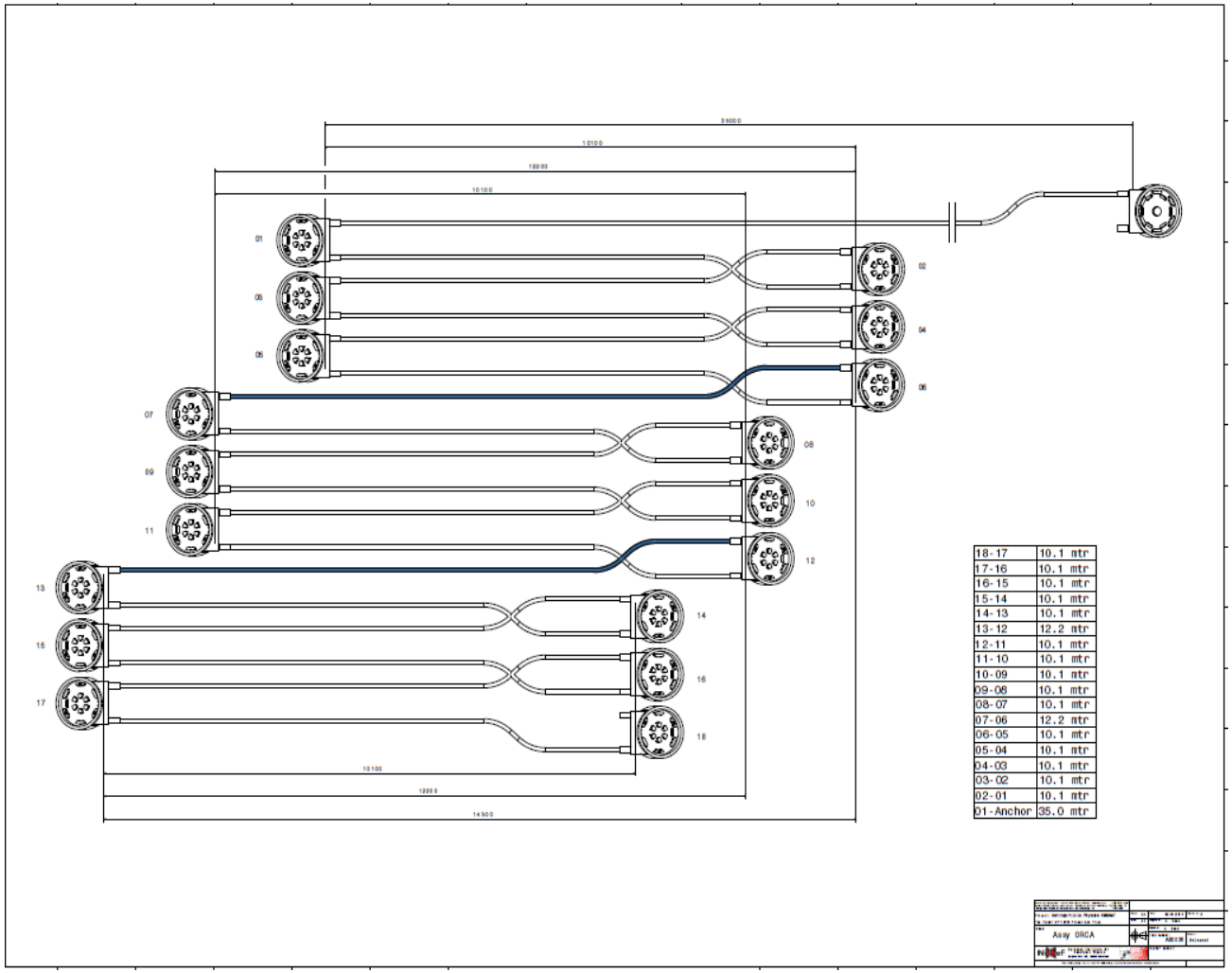


Figure 19 VEOC ORCA configuration