KM3NeT Qualification Penetrator Base Module OFP
Report of the tests

KM3NeT_QUAL_2019_002

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CPPM

Abstract

This document reports the qualification tests applied to the OFP base penetrator for the KM3NeT project. The 12 fibres ribbon MPO connectors was also tested following the same procedure.

Recipients

The KM3NeT PSC

Document Status

Revision	Date	Comment	Reviewed by	Approved by
			XX	YY

Revision History

Revision	Date	Description
Draft	30/08/2019	First draft
V0	11/09/2019	Added 2 RD and various feedback

1 Table of Contents

2 Documentation

2.1 Abbreviations

Abbreviation	Description
DU	Detection Unit
DOM	Digital Optical Module
TRR	Test Readiness Review

2.2 Reference Documents

Abbreviation	Title	Reference
RD1	KM3NeT TDR	KM3NeT_DS_TDR
RD2	KM3NeT CRD	KM3NeT_DS_CDR
RD3	KM3NeT Qualification Plan	KM3NeT_QUAL_2018_001
RD4	KM3NeT Qualification Procedures	KM3NeT_QUAL_2018_002
RD5	OFP_Base_Penetrator tests procedures	KM3NeT_QUALIF_2019_001
RD6	SOPAVIB report – Mechanical part	2E18734-1
RD7	SOPAVIB report – Climatic part	2E18734-2

3 Introduction

This document describes the results of qualification tests as defined in the RD5 document and agreed in the related Test Readiness Review (TRR).

Note: all the mechanical tests carried out at SOPAVIB were done at room temperature i.e. around 20°C.

In RD6 and RD7, one can find the SOPAVIB reports including the tests procedure as well as the monitoring of the parameters.

This document includes the following topics:

- Material configuration
- Tests, measurements and criteria

The planning of the tests was the following:

Day 1 – August 20th	Shipping to SOPAVIB Vibrations and shocks in the transversal direction Vibrations and shocks in the axial direction
Day 2 – August 21th	Vibrations and shocks in the vertical direction
Day 3 - August 22th	Climatic test
Day 4 – August 23th	Climatic test
Day 5 – August 24th	Climatic test
Day 6 – August 25th	Climatic test
Day 7 – August 26th	Climatic test + thermal shock + shipping back to CPPM

4 Material configuration

4.1 Mechanical support of the penetrators

The penetrator were mounted on an ORCA cylinder flange. This configuration is strictly nominal for the base module penetrator while this is a convenience on which we agreed during the TRR for the DOM penetrator. This flange is then mounted on its cylinder. The mechanical support of the cylinder aims to reproduce the way it is done on the anchor of the DU (i.e. 3 cradle-shaped plastic supports fixed on 3 L-shaped anchor bars). See Figure 1 and Figure 2.

Figure 1: interface plate

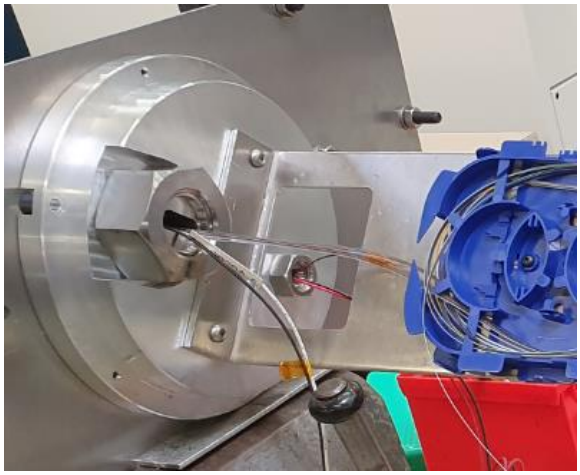

Figure 2: inside view of the penetrators mounted on the flange

The 2 BoB attached to the penetrators were mounted on a plate which is directly fixed on the flange. Then these 2 BoB were also submitted to all the stress tests. See Figure 3

Figure 3: cylinder mounted on the interface plate

4.2 Mechanical support of the MPO connectors

Inside the cylinder, there is an internal support plate in order to mount the different supports for the penetrator fibres and wires.
The fibres length were managed in a fibre cassette (in blue) before to reach the connectors.

The single DOM fibre was equipped with a FC-APC connector on both side of the penetrator. On the interior side this connector is mounted in a I-shaped adaptor fixed on the inner frame (visible in green on the bottom-right side on the picture). This connector allows connecting the fibre to the outside of the cylinder using a long fire cord.

The two 12x fibres ribbon coming from the base penetrator were also passing through the cassette before to reach 2 adaptors which connect them to the outside of the cylinder (visible in yellow on the top-right side on the picture)

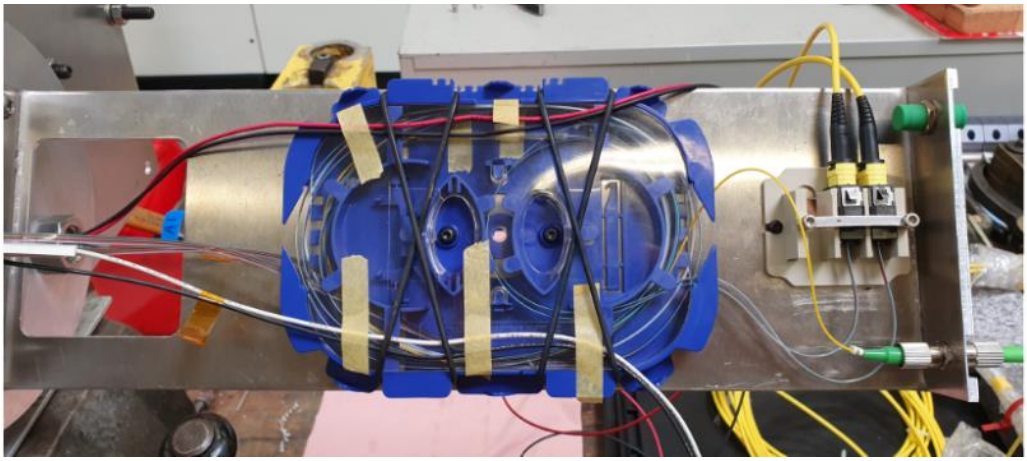

Figure 4: internal support

The PMO connectors, that were also included in the qualification tests, were mounted on the internal support by using 3D printed piece as shown on the Figure 5. This mechanical configuration, defined for the qualification tests, is not the final one, which will be used for the base module integration.

Figure 5: details of the MPO adaptors mounting

It should be noted the two following points:

- The optical components needed to pass from the 12 fibres ribbon to the 12 individuals fibres that come with the MPO connectors to be operated in the base module (MPO/APC -12 LC/APC - as described in the next part) were included in the climatic test but not in the mechanical test)
- The MPO connectors mechanical supports shown in Figure 5 are not the final design that could be used in the ARCA or ORCA base modules

5 Stress tests and related checks and measurements

5.1 How the test were done

The material used for the tests will be: laser source, optical power meter, gigaohm meter
For the base penetrator, which has 2 fibre ribbons of 12 fibres each, the fibres were spliced one by one in the BoB. The BoB was closed so that all the fibres were accessible only by the interior side if the base module. In order to facilitate the diagnostic all of them were connected to each other to form a single loop including the 24 fibers.
For the DOM penetrator, the single fiber passing through the penetrator was accessible from both side of the flange.

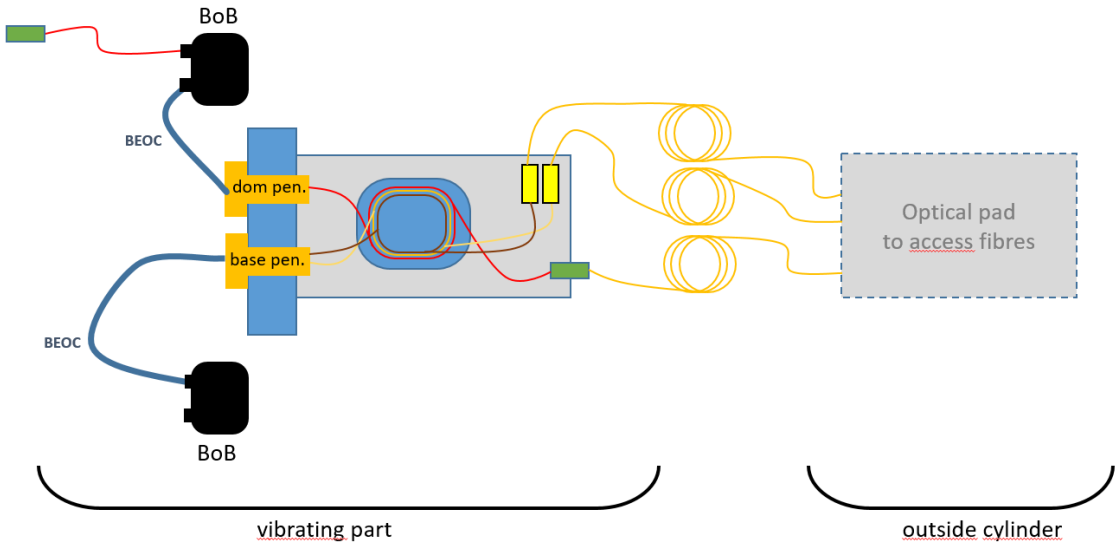

Figure 6: schematic of the optical configuration

The optical measurements were done using a laser emitter (JDSU model TLS-55C tuned to emit a -6dBm signal at 1550nm) and a power meter (F2H model FHM 2A01). The value reported in the tables are the attenuation in dB of the optical signal passing through the set up.
The electrical measurements were done using a Giga-Ohm meter (CHAUVIN ARNOUX model CA 6525). This one was tuned at 500V for the base penetrator and 250V for the DOM penetrator.

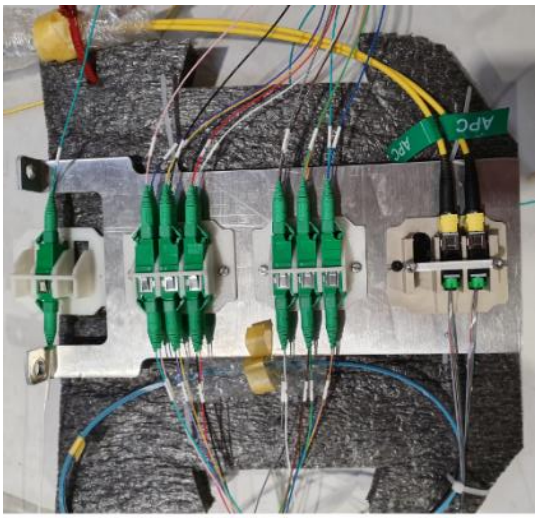

Figure 7: optical pad measurement set up

5.1.1 Initial values

- Values measured before the shipping to SOPAVIB

Item	Value	Status
Base penetrator complete loop	21.1dB	OK
DOM penetrator fibre	1.1dB	OK
Base penetrator wire insulation	white wire/black wire: ∞ Ω white wire/frame: ∞ Ω black wire/frame: ∞ Ω	OK
DOM penetrator wire insulation	red wire/black wire: ∞ Ω red wire/frame: ≈4Ω black wire/frame: ∞ Ω	OK?

- The optical attenuation values obtained are compatible with what is expected.
- It was noticed that even before the stress test the DOM penetrator showed an insulation default between the red wire and the bulk of the penetrator mechanics. It has to be compared with the value measured at NIKHEF before the shipping.

- Values measured at SOPAVIB before the stress tests

Item	Value	Status
Base penetrator complete loop	21.3dB	OK
DOM penetrator fibre	2.1dB	OK
Base penetrator wire insulation	white wire/black wire: ∞ Ω white wire/frame: ∞ Ω	OK

	black wire/frame: ∞ Ω	
DOM penetrator wire insulation	red wire/black wire: ∞ Ω red wire/frame: ≈4Ω black wire/frame: ∞ Ω	OK

5.2 Vibration and shock on the transversal axis

5.2.1 Test reminder

	Frequency range	Amplitude and acceleration	Sweep speed	Duration	Number of cycles
Frequency sweep	5 Hz to 25 Hz 25 Hz to 150 Hz	*amp.* = ±2 mm acc.= 50 m/s²	1 oct/min	1h	13

And following:

	Number of shocks	Number of axis	Description
"Hard" shocks	3	±3	acc.= 15 G /duration=11ms
"Soft" shocks	500	±3	acc.= 10G / duration=16ms

Figure 8: set up in the transversal mode

5.2.2 Result of the measurements

Item	Value	Status
Base penetrator complete loop	20.8dB	OK

DOM penetrator fibre	2.6dB	OK
Base penetrator wire insulation	white wire/black wire: ∞ Ω white wire/frame: ∞ Ω black wire/frame: ∞ Ω	OK
DOM penetrator wire insulation	red wire/black wire: ∞ Ω red wire/frame: ≈4Ω black wire/frame: ∞ Ω	OK

5.2.3 Remarks and conclusions

The vibration test was stopped after 2 minutes due to a mechanical fixation not well tight. The nuts were tightened before to resume the test.
It was noticed that the plate where the two BoBs were mounted oscillated a lot when submitted to the certain frequencies of the vibration excitation. A try have been made to limit the amplitude of these oscillation by the use of plastic collars.
No problem detected after the tests
The visual inspection does not reveal anything suspicious

5.3 Vibration and shock on the axial axis

5.3.1 Test reminder

	Frequency range	**Amplitude and acceleration**	**Sweep speed**	**Duration**	**Number of cycles**
Frequency sweep	5 Hz to 25 Hz 25 Hz to 150 Hz	*amp.* = ±2 mm acc.= 50 m/s^2	1 oct/min	1h	13

And following:

	Number of shocks	**Number of axis**	**Description**
"Hard" shocks	3	±3	acc.= 15 G /duration=11ms
"Soft" shocks	500	±3	acc.= 10G / duration=16ms

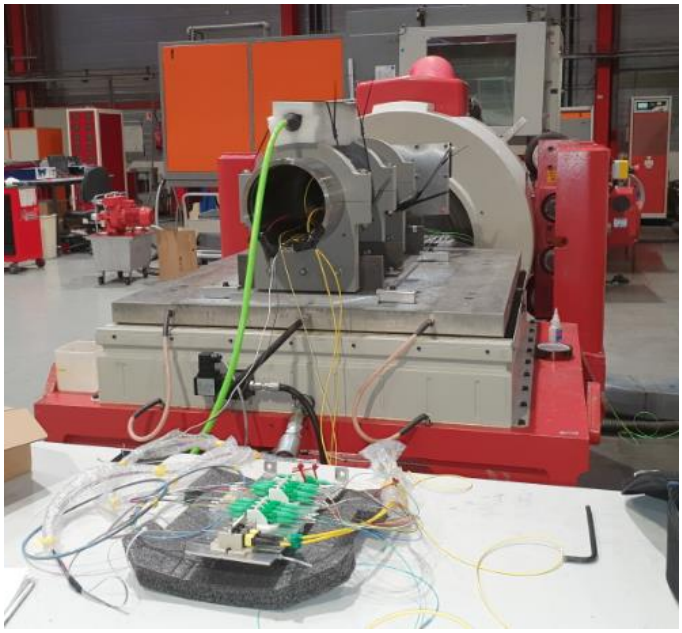

Figure 9: set up in the axial mode

5.3.2 Result of the measurements

Item	Value	Status
Base penetrator complete loop	20.4dB	OK
DOM penetrator fibre	3.0dB	OK
Base penetrator wire insulation	white wire/black wire: ∞ Ω white wire/frame: ∞ Ω black wire/frame: ∞ Ω	OK
DOM penetrator wire insulation	red wire/black wire: ∞ Ω red wire/frame: ≈4Ω black wire/frame: ∞ Ω	OK

5.3.3 Remarks and conclusions

In the middle of the shock sequence, the cylinder started to slide inside its support. So the tests was stopped around 5 minutes in order to put it back in place and tighten the fixing screws
No problem detected after the tests
The visual inspection does not reveal anything suspicious

5.4 Vibration and shock on the vertical axis

5.4.1 Test reminder

	Frequency range	Amplitude and acceleration	Sweep speed	Duration	Number of cycles
Frequency sweep	5 Hz to 25 Hz 25 Hz to 150 Hz	*amp.* = ±2 mm acc.= 50 m/s^2	1 oct/min	1h	13

And following:

	Number of shocks	Number of axis	Description
"Hard" shocks	3	±3	acc.= 15 G /duration=11ms
"Soft" shocks	500	±3	acc.= 10G / duration=16ms

Figure 10: set up in the vertical mode

5.4.2 Result of the measurements

Item	Value	Status
Base penetrator complete loop	21.1dB	OK
DOM penetrator fibre	2.5dB	OK
Base penetrator wire insulation	white wire/black wire: ∞ Ω white wire/frame: ∞ Ω black wire/frame: ∞ Ω	OK

DOM penetrator wire insulation	red wire/black wire: ∞ Ω red wire/frame: ≈4Ω black wire/frame: ∞ Ω	OK

5.4.3 Remarks and conclusions

No problem detected after the tests
The visual inspection does not reveal anything suspicious

5.5 Climatic and thermal shock test

5.5.1 Test reminder

Climatic cycling:

	Temperature & HR	**Duration**
Ramping up	20°C to 70°C HR not specified	2h
Stand	70°C 93% HR	96h
Ramping down	70°C to 20°C HR not specified	2h

And following, thermal shock:

	Temperature	**Duration**
Warm phase	50°C	2h
Cold phase	10°C	15min

5.5.2 Result of the measurements

Item	Value	Status
Base penetrator complete loop	22.6dB	OK
DOM penetrator fibre	2.8dB	OK
Base penetrator wire insulation	white wire/black wire: ∞ Ω white wire/frame: ∞ Ω black wire/frame: ∞ Ω	OK
DOM penetrator wire insulation	red wire/black wire: ∞ Ω red wire/frame: ≈4Ω black wire/frame: ∞ Ω	OK

5.5.3 Remarks and conclusions

No problem detected after the tests
The visual inspection does not reveal anything suspicious

5.6 After Shipping back to CPPM

Item	Value	Status
Base penetrator complete loop	22.9dB	OK
DOM penetrator fibre	2.1dB	OK
Base penetrator wire insulation	white wire/black wire: ∞ Ω white wire/frame: ∞ Ω black wire/frame: ∞ Ω	OK
DOM penetrator wire insulation	red wire/black wire: ∞ Ω red wire/frame: ≈4Ω black wire/frame: ∞ Ω	OK

5.7 Detailed inspection at NIKHEF

To be done as soon as possible