



Journal logo

Analysis of the cable system layout for an underwater detector

Antonio D'Amico for the NEMO Collaboration.

Laboratori Nazionali del Sud-INFN, Catania, Italy

Elsevier use only: Received date here; revised date here; accepted date here

Abstract

A general cable system layout was designed and the project of all the main components of the detector was realized. The aim was to design a low cost and high reliability detector having the required physics performances. According with R&D philosophy of NEMO phase1 the NEMO collaboration proposes an alternative to the standard design of housings operating in seawater environment for a long lifetime, de-coupling the pressure problem from the corrosion problem. The design characteristics of the cabling system proposed for the detector is presented.

© 2001 Elsevier Science. All rights reserved

Keywords: Type your keywords here, separated by semicolons ;

1. Introduction

Electro-optical distribution is a significant component of the cost of underwater neutrino detectors, particularly when it must serve many users in large detector structure. The effort of the design is to minimize the cost of the cabling in order to reduce the unit cost of the instrumented detector line, meanwhile maintaining the design robust and reliable.

2. Design criteria

According to the philosophy of the R&D of NEMO phase 1 the design criteria adopted during the definition of the cable system layout for the detector were:

- Fault tolerance;
- Modularity;
- Simplicity;
- Ease of assembly;
- Ease of management;
- Costs.

In order to have a system that is fault tolerant the design should avoid the usage of connectors at interface points since they can be single point failures

for the system. Although a complex cable system requires the use of connectors to facilitate the assembly the number of them should be minimized.

Another relevant characteristic is the ease of management, it means that the system must use easy to test subsystem and easy to repair cables. Taking into account that the more interfaces a system has the more difficult is to perform test, the goal is to minimize the connection interfaces. Moreover a cable system for an underwater detector should be easy to upgrade to larger detector lines and easy to handle during the assembly. The usage of penetrators should be preferred and connectors should be used only at subsystem interfaces or when the assembly procedure suggests dividing one subsystem in two or more subsystems in order to have an easier to assembly system. In the perspective to have a fault tolerant system the usage of lightweight standard cables is another important aspect of the system design; moreover it will reflect on the connectors or penetrator layout and cost since the lightweight cable termination is simpler respect to the armored cable termination.

3. Detector line structure

The detector line for NEMO phase1, called tower, is based on a modular structure composed by:

- Aluminum alloy beams;
- Retention ropes;
- Buoy.

The beam, called floors, aim is to keep in position the optical modules containing the PMTs and the DAQ boards and to host the instrumentation and the electronics for the Floor Control Module (FCM) and Power Module (PM). The retention ropes and the buoy are devoted to configure the beams in the operating position. The beams and the ropes offer a support for a lightweight cable system. Moreover the beams offer a very good and protected route for the floor cable system to distribute power and signals to the detector sensors and instrumentations.

The fact that the cable can be routed along the retention ropes allows the have a lightweight cable since it is not under stress.

4. Cabling Structure

The main subsystems of the cabling structure for the tower are:

- Base cabling;
- Backbone cabling;
- Floor cabling.

The base of the tower will host the Tower Base Module (TBM) that interconnects the tower cabling system to the Junction Box of NEMO phase 1; moreover the TBM distributes the power supply for the acoustic position system components installed on the tower base. The TBM is composed by an external oil filled plastic container and internal pressure vessel. The pressure vessel has four interfaces:

- Two hybrid penetrators;
- Two electrical connectors.

One hybrid penetrator aims the connection of the backbone cabling and the other one aims the connection to the Junction Box. The electrical connectors are used to supply power and signal to the acoustic positioning subsystem of the tower base.

The external plastic container has four interfaces:

- One feed through;
- One hybrid connector;
- Two electrical connectors.

The feed through is positioned on the link to the backbone. The hybrid connector is used to interface the TBM to the ROV jumper cable that allows the interconnection of the tower to the Junction box by means of an ROV. The two electrical connectors are for the acoustic positioning subsystem.

The aim to deliver and distribute power and data transmission signals to and from the tower floors is assigned to the backbone cabling system. The cable is a lightweight standard type by NEXANS and it is equipped with four electrical conductors for the AC power supply and twelve optical fibers inside one steel tube.

The splitting of the cable is performed by means of breakouts positioned at each floor level. The breakouts are pressure vessels, with two penetrators for the backbone cable and one hybrid connector to connect the floor cabling system (as shown in Fig. 1).

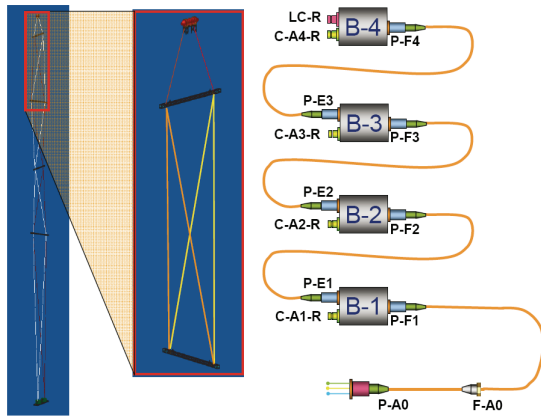


Fig. 1. The detector tower line and the backbone cabling structure for a four floors tower.

The need to have a pressure vessel for the backbone breakout is protect from the effect of the pressure the two passive optical devices that perform the Add&Drop functions for the optical data transmission signals of the out coming and incoming data flows.

The floor cabling subsystem is interfaced by means of a hybrid connector with the backbone breakout. The main components of the floor cabling are the FCM and the PM. The FCM is the core of the system and it is composed by two containers. The external container is a plastic silicone oil filled vessel; the internal container is a pressure vessel. The usage of oil prevents the corrosive effects of the seawater on the metallic pressure vessel and allows the use of cheaper alloys. The PM is a silicone oil filled plastic container since the power supply subsystem that is hosted inside has been tested to operate under pressure.

The electronics of the FCM has not been tested to work under pressure so that is necessary to protect it with a pressure vessel. The FCM pressure vessel has five interfaces:

- One optical penetrator;
- Four electrical connectors.
- The penetrator interfaces the electronics to the backbone and to the optical modules by means of optical fibers protected inside steel tubes. The

electrical connectors distribute the supply to the floor users.

The FCM plastic container has four interfaces:

- Three feed through;
- One electrical connector.

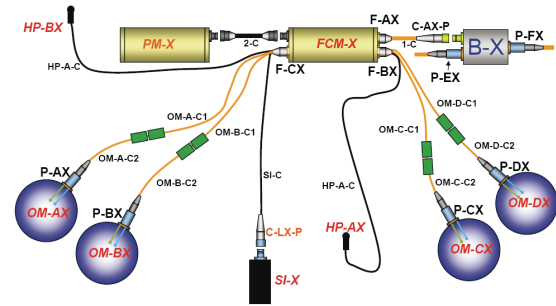


Fig. 2. The floor cabling structure and the serviced users.

The feed through are positioned on the links to the backbone and to the floor users. The connector aim is to connect the FCM to the PM in a way that the two subsystems can be assembled and positioned inside the beam separately for an easy assembly. The AC three-phase supply incoming from the backbone is routed inside the FCM plastic container through the PM where is converted into DC low voltage supply and rerouted the FCM pressure vessel where it is distributed to the users.

5. Conclusions

In an easy to assemble cabling system the connectors should be positioned at the subsystems interfaces and at users interfaces, it allows to have few connectors reducing the cost of the apparatus and permits to individually test the subsystem in pressure tanks since the their resulting sizes are relatively small compared to the full cabling system. Moreover using penetrators instead of connectors minimizes the optical loss allowing a higher link budget for the data transmission system and permitting to test the optical links by means of OTDR since there are no refractive interfaces along the optical paths.

References

- [1] M. Musumeci, Proceedings of the VIVnT Workshop
“Technical Aspects of a Very Large Volume Neutrino
Telescope in the Mediterranean Sea”, Amsterdam (2003) 153.