ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Genova

INFN-18-11/GE
17 Ottobre 2018

The system to fill with oil the empty Break Out Boxes (BOBs) of the KM3NeT Detection Units

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Abstract

The KM3NeT collaboration aims to construct the largest underwater neutrino telescope in the Mediterranean sea. The detector is located in two sites, one in front of Toulon at 2500m sea depth and one SE Capo Passero in Sicily at 3500m depth. On both sites, one or two blocks of 115 Detection Units (DU) are connected to shore , each Du being composed by a Vertical Electro-Optical Cable (VEOC) connecting 18 Digital Optical Modules (DOMs). In this report we describe the integration of the DU carried out in our INFN laboratory in Genova, in particular one important phase of the process where some components in the VEOC have to be carefully filled with oil before connection to the DOMs.

PACS:07.10.-h;07.09.+c

Published by
Laboratori Nazionali di Frascati

1 Introduction

During integration each DOM must be connected to the vertical electro optical cable (VEOC) through a plastic tubing connecting its penetrator cap to the open top part of the break out box (BOB) in the VEOC. The tubing contains the optical fibers and the electrical conductors while the open portion of the BOB houses the plastic reel to wind the fibers after splicing. When the connection is completed, the BOB is sealed and the empty volume is filled with oil, the one chosen by the collaboration being MIDEL 7131.

Here we describe the procedure to follow once the BOBs are sealed and have to be filled with oil like the rest of the VEOC:

- make the vacuum in the tube and in the BOB,
- fill with oil the empty space,
- repeat the operation two or more times : de-gassing and refill with oil,
- use compressed air at 1 atm to test the system and reshape the BOB.

To perform these operations we have realized a system equivalent to the one used in NIKHEF, arranged in a slightly different way but with the same principle of operation. The system is different with respect to the one described in the DU integration Manual where a syringe is used to fill the BOB with oil. The solution we have adopted, in fact, includes a vacuum pump, a series of plastic tubing to drive the oil from a vessel to the BOBs and various valves. This solution, requires a dedicated set-up but makes the filling operation more under control and easy to perform.

2 The components

The scheme of the system is reported in Fig.1 It includes a low vacuum pump, a vacuum buffer of 10 liters, a set of transparent vessels rated for both vacuum and pressure up to 5 atm and various hydraulic components. Fig.2 shows how the system is installed: pumping system and vacuum buffer (left), the tubing (right).

The various components of the system are the following:

- a low vacuum pump Mod Leybold Trivac D 25 B
- a vacuum gauge: -76 - 0 cm Hg range
- various plastic pipes got from NIKHEF from the terminating valves n.11,12, to the DOM penetrator inlet. These pipes are mild, 20 cm long and terminate with a dedicated connector to fit the penetrator cap, D 6/4 mm- M6 model AIGNEP cod. 01021 00 002
- various 6 mm outer ⌀, 4 mm inner ⌀ pipes for compressed air systems, mini Brass Ball Valves.

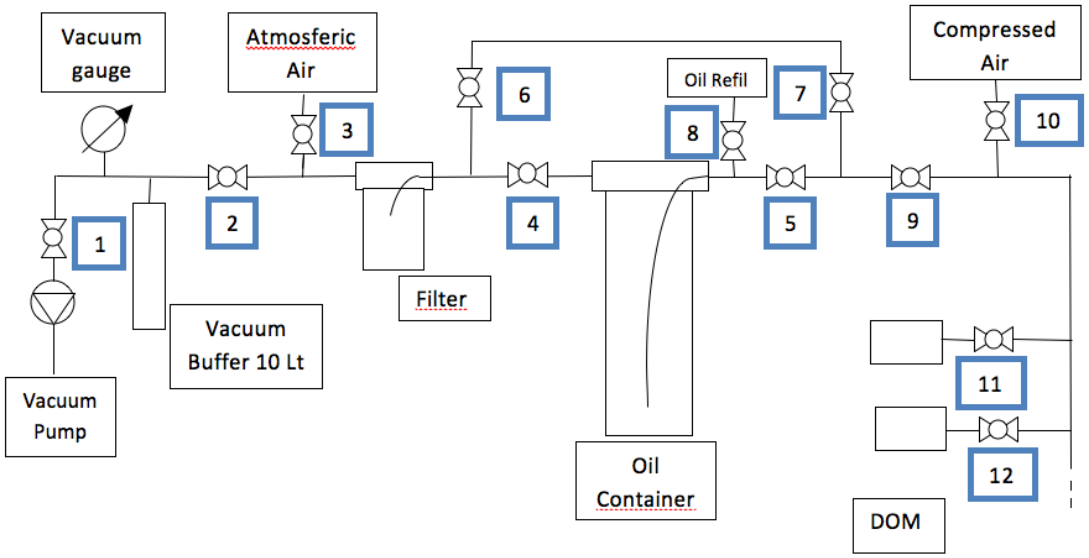

Figure 1: Schematic of the oil filling system

- The oil filter and the oil container were obtained from commercial water filters, removing the filtering core and re-machining the top in order to fit to the valves. The oil container has a volume of roughly 1.2 l, the filter of 0.5 l. The complete assembly was tested during several cycles alternating vacuum and 8 Atm pressure followed by a 10 days connection to the vacuum buffer.

For more explanation we list some notes:

1. the terminating valves n.11,12, .. are not strictly necessary but we found them useful in various step of the operation

2. de-gassing may be performed in different configurations:

   a) by-passing the oil container: valves 1,2,6,7,9, 11,12,.. are opened, the rest is closed. This configuration may be used to maximize pumping speed when the pipes are free from oil residuals.

   b) through the oil container : valves 1,2,4,5,9, 11,12,.. are opened and the rest closed. This configuration may be used when the pipes to the DOMs contains oil residuals (usually after each oil filling operation). On this configuration there is a separation of air from oil by bubbling the flow in the oil container

   c) through the by-pass and the oil container: valves 1,2,4,5,6,7,9, 11,12,.. are opened and the rest closed. This configuration is usually used after configuration B.

3. Opening 3,4,5,9,11,12,.. valves we allow the intake of atmospheric air to push smoothly the oil from the container to the DOMs.

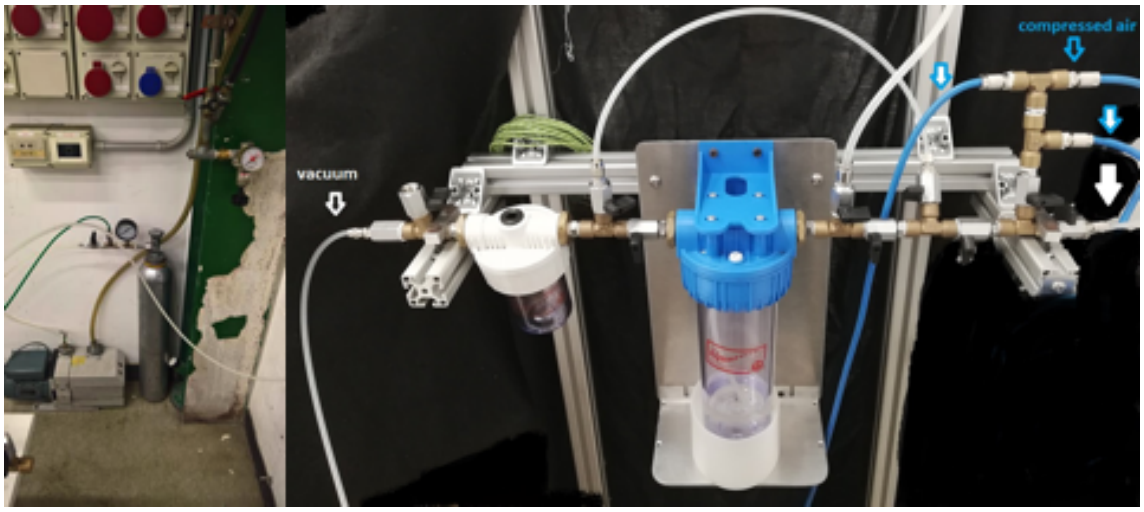

Figure 2: How the system was assembled in the integration room: the pump (left) and the oil container (right)

4. Opening only valve n.10, 11,12,.. we pressurize DOM at 1 atm for test and reshaping.

5. Opening only valve n. 8 we fill up the oil container from the external storage.

6. de-gassing operation can also operate with the pump off. In this case valve 1 is closed, 24,5,9,11,12,.. opened and the vacuum buffer is directly connected to the line.

3 The operations

- Step 1: Fill up the oil container until about half level from the external storage following note 5).
- Step 2: Connect the pipes to the penetrator of each DOM. The present configuration allows connection up to 4 DOMs. Start degassing the pipes and the BOBs in configuration A. If pipes contains some oil residual, start with configuration B. by 10 prior to A.
- Step 3: Keep de-gassing for at least 3 hours minimum in configuration A. A much more effective condition was found when leaving the vacuum pump active for at least 6 hours and then activating the vacuum buffer for one night with the pump off. To minimize the presence of bubbles during the oil filling phase, the de-gassing step2 can be extended up to 2 days compatible to the available time. Small volumes of air can, in fact, remain hidden inside the small tubes protecting the electric wires and the optic fibres in the reels of the BOB.
- Step 4: Start filling with oil at the atmospheric pressure opening valve 3 and closing valve 2 (note 3). The BOB is positioned on the support as shown in the Fig.3 to

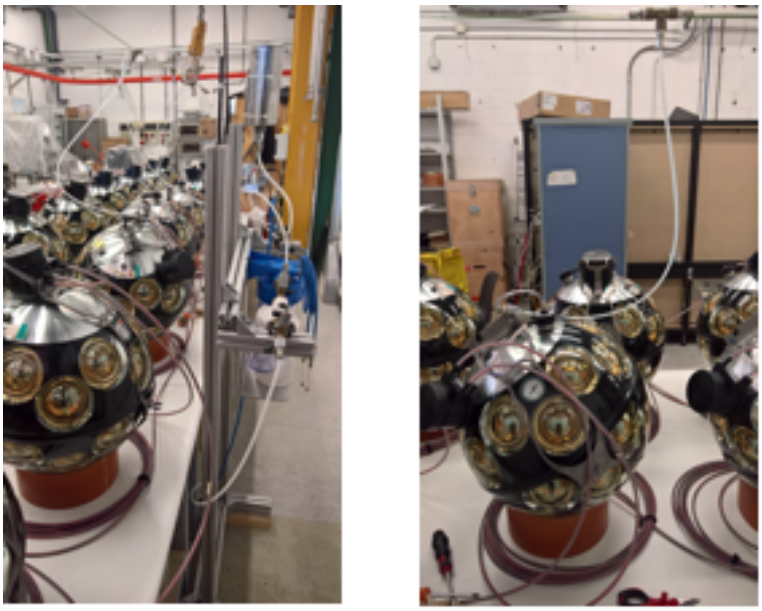

Figure 3: The completion of the integration. The oil filling system (left) and the filling pipe connected to the DOM(right)

easy the operation. The oil is automatically driven to the BOB due to the difference of pressure (atmospheric pressure in the left side of the oil container, vacuum in the pipes and in the BOBs). Keep this condition for 1 day.

- Step 5: De-gas for 6 hours in configuration B. and C.
- Step 6: Refill with oil again like in step 4.
- Step 7: Repeat the steps 5-6 more times with time lapse of 10 minutes. During the de-gassing time, hit the BOB with a plastic tool for encourage the air output. Turning the BOB slightly may also help.
- Step 8: Apply 1bar of pressure with compressed air for 5 minutes to reshape the BOBs (see note 4).
- Step 9: Return the line to the atmospheric pressure.
- Step 10: Remove the pipes, insert the screw with o-ring and close with torque of 0.4 Nm.
- Step 11: Fix the BOB with the titanium clamp (see Fig. 3).

4 Possible improvements

The connector to fit the penetrator cap model AIGNEP cod. 01021 00 002- (see Fig.6 left) should be substituted to the model AIGNEP cod. LG500 00 006 + LG410 00 003 (Fig.6

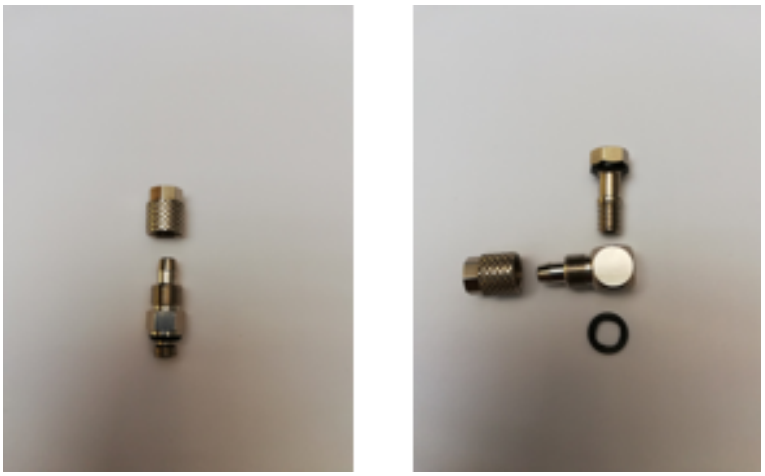

Figure 4: The connector to the DOM penetrator used during integration (left) and the suggested one (right)

right). This model makes more easy the connection of the pipe to the DOM penetrator cap. In particular, using this connector type, there is no more need to pre-turn the mild pipes as described in c) before connection to the DOM. These pipes can be therefore substituted with a more rigid type which does not shrink during the degassing operation.