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# CONSTRUCTION OF A DEVICE TO TEST CREEP BEHAVIOUR OF SYNTHETIC MULTIFILAMENTS, SUBMERGED IN COLD WATER, USED IN OFFSHORE MOORING SYSTEMS, AND RESULTS.

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***Abstract:*** *This article presents the equipment developed at POLICAB (Stress Analyses Laboratory) and the preliminary experimental results. The project objective was to develop equipment to approaching the test condition to the work condition and characterize the creep behavior of synthetic multifilaments, applied to offshore mooring systems for ultra deep waters. The equipment developed is able to test wet multifilaments simulating the ocean deep water temperature.*

***Key words:*** *Creep, synthetic multifilament, cold water*

## 1. Introduction

In Brazil, the oil exploration is made each more time in deep and ultra-deep water (above 2000 meters of deep), like as *Pre Salt* petroleum basin in the coast of Sao Paulo State. This situation had created new challenges to mooring systems and materials to offshore applications.

Synthetic ropes are used in the mooring system called "Taut-Leg". With the increasing exploration deep, new synthetic materials are being developed to improve the mechanical characteristics and to possibility the exploration in deeper waters.

A characteristic to be improved is the creep behaviour, because the creep is a possible fail mode. The main tool to verify the creep behaviour of these materials is the experimental analyses. Therefore, is important to develop devices that reproduce the similar conditions when applied to anchorage petroleum platforms.

This work presents the equipment and the preliminary testing results of synthetic fibber of HMPE submerged in cold water.

## 2. Creep

Creep is the tendency of a material to deform permanently under the influence of static loads. In the study case, it occurs when the synthetic rope is exposed in a very low variation of amplitude solicitation for a long time, mainly caused by ocean waves.

The phenomenon of creep is divided into three phases until it reaches the break. The determination of the time in which phases transition occur is very important for a complete understanding of the creep behaviour of material to be used.

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For to show an imminent danger of crash, the third phase should be avoided in any applications of the material.

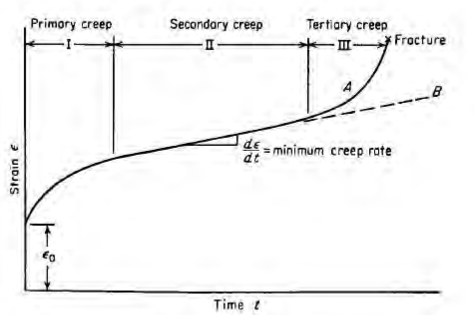


Fig. 1. *Creep phases*

## 3. Equipment design

The equipment was projected to support the static loads and the low temperatures, near the ocean temperature in deep water.

The equipment is mainly comprises of a main structure, thermally insulated tank, independent cooling system, sensors and loads support. To c ontrol the multifilament displacement is used a linear transducer and to control the tem perature is used a thermocouple together with a controller.

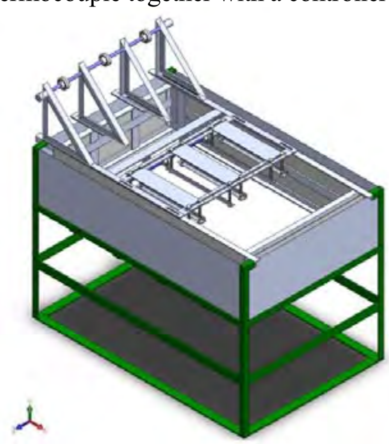

Fig. 2. *Equipment design*

### 3.1. Main structure

The main structure was built with steel material and the parts were joined by welding. The structure was projected using the finite element analyses method. The main structure can be seen the next figure.

Fig. 3. *Main structure*

### 3.2. Thermally insulated tank and cooling system

The tank was built using stainless steel plates on the outside and aluminium plates on the inside. To thermal isolation wa s used polystyrene between the plates.

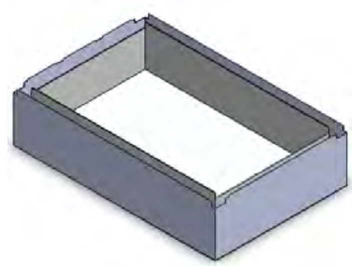

Fig. 4. *Thermally insulated tank*

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The cooling system consists of a compression cycle steam and wa s adapted from a simple refrigerator.

### 3.3. Sensors and loads support

This par pa rt of the equipment was projected to position the sensors and the loads, with special attention, to the int eraction between equipment and the specim en. Therefore, were projected pulleys with ball bearings to reduce the friction between the components. This can be seen in the next figure.

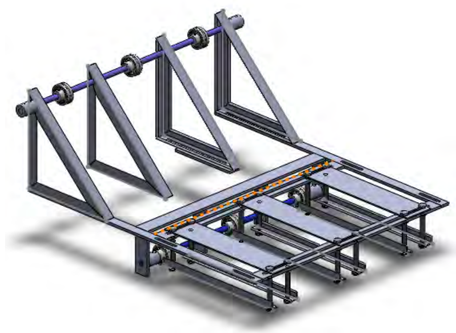

Fig. 5. *Sensors and loads support*

The sensor used to control the multifilament displacement is a li near transducer brand Balluf® (Transducer Micropulse AT, Profile BTL6 A1), using the measuring principle magnetostrictivo, this transducer is used together a magnet.

To control the water t emperature is used a thermocouple (model Pt 100) c onnected to a temperature controller brand Novus® (model N480d). This controller is resp onsible to turn on or off the cooling system, when necessary (follow next pictures).

**5. Equipment built**

The next pictures show the det ails of the equipment built and working.

Fig. 5. *Equipment built*

Fig. 5. *Sensors and loads bearing*

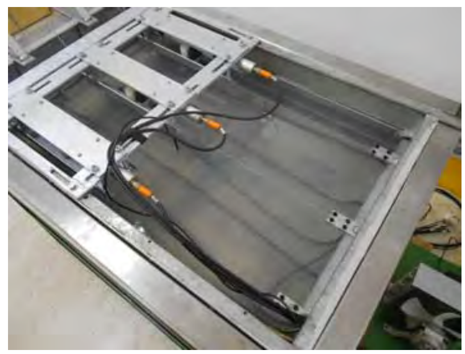

Fig. 5. *Sensors*

Fig. 5. *Loads*

**6. Tests**

In extreme storm conditions, the cable s showed that suffer a maximum load of 45% of a te nsile strength (**YBL** = **Y**arn **B**reak **L**oad), following the owners-Petrobras recommendations. But for study usual conditions of work in quasi-static loads, the

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study of creep behaviour is necessary. In this case we consider a long period of time where the loads didn´t passing 35% YBL limit. The tests in subm erged cold water became necessary to sim ulate as near as possible the real conditions o f work. So, the tests were performed submerged in water at 4 ± 1 ° Celsius (approximately the minimum temperature of the bottom of the ocean) and the constant loads used was 15%, 25% and 35% YBL, for a lo ng period of t ime just to characterize the second creep phase.

### 6.1 Specimens

The HMPE specimen length is 500 *mm*, and the equipment is ab le to test three specimens simultaneously. The next picture shows the specimens preparation.

Fig. 5. *Specimens preparation*

### 6.2 Loads

Steel balls are used as for the test loading. Is used steel ball, because is easier to control the right load test. Th e load-bearings can be seen in the next picture.

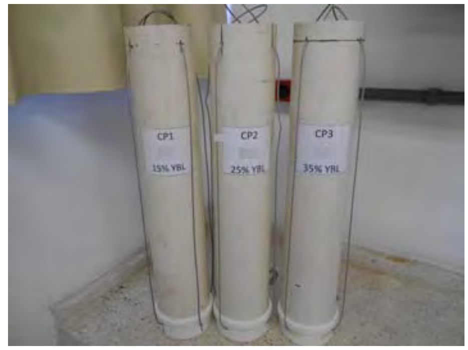

Fig. 6. *Load-Bearing*

### 5. Results

The results, of preliminary creep tests of HMPE fibers, can be seen in the Figure 3.

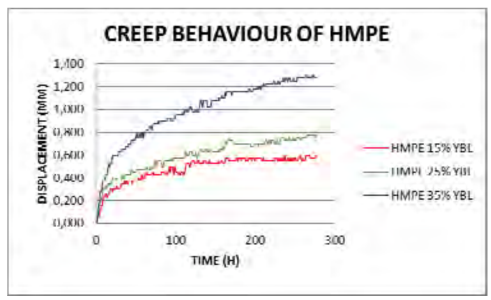


Fig.7. *Preliminary results*

For the test s at 4° C with out water, was used a de vice developed at POLICAB [1]. This equipment consists on an adapted vertical refrigerator system. In t his equipment the specimens are suspended and tensioned by applying the load on the bottom causing the creep. The next picture shows the equipment used to obtain the creep behaviour of HMPE multifilaments at 4° C without water.

Fig. 8. *Equipment used to performing tests without water.*

The next f igures show the comparative creep behaviour from tests performed at 4º C with and without water.

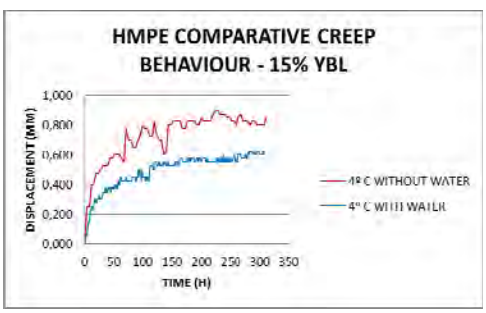


Fig.8. *Creep behaviour 15% YBL*

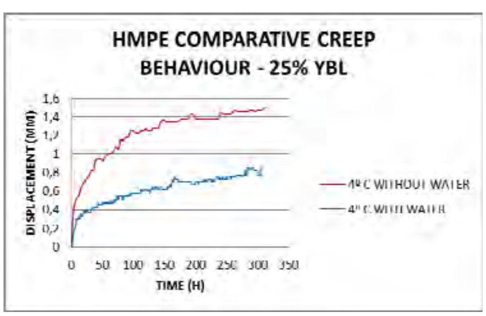


Fig.8. *Creep behaviour 25% YBL*

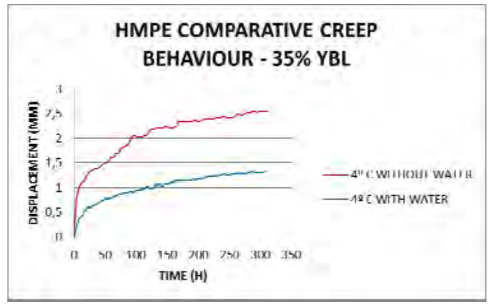


Fig.8. *Creep behaviour 35% YBL*

The results above show a difference between the test performed at 4º C with and without water. We don´t know if this difference of the results are because the water influence in the material behaviour or the different devices.

Now is necessary to perform tests in both equipment (with and without water) in the same condition and compare the resu lts to verify the influences.

## 6. Conclusions

The equipment, to characterize the creep behaviour developed works very well: retain the work temperature proposed.

After the actual project, the c onstruction of the equipment and the pr eliminary tests showed above, the next step of the research is to vali date the results for many others samples and use, in t he same conditions. Other device of the Laboratory to compare the results (verifying the possible influence of the equipment on the results), is necessary.

The tests to validate the results must be made at environmental temperature in both equipments.

## Acknowledgements

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## References

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