ROQUET presentation on:

WP6-Testing

(and related: T1.1 Risk analysis, T1.2 Definition of categories, T2.1 Structural design, T2.2 Fluid dynamic design, T3.1 Cast iron, T3.2 Seals, T3.4 Coatings, T4.1 Honing and T4.2 Welding,)

4th Reporting Period General meeting ,

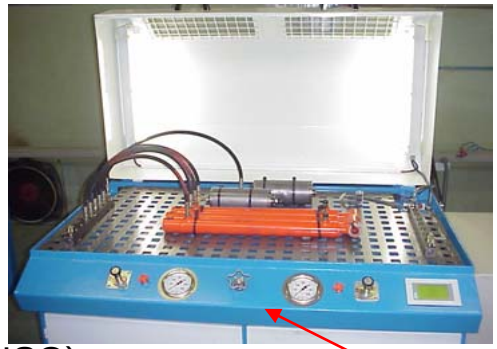
VIC (Barcelona-Spain),

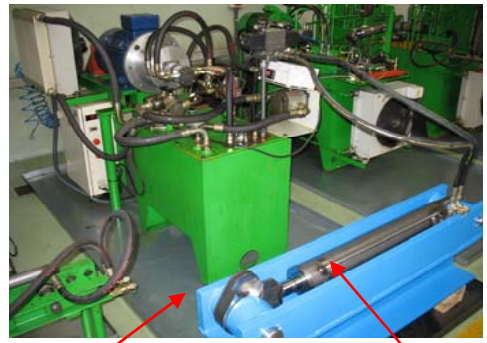
on 26th and 27th May 2008

Research performed – 4th RP- **stress lab tests results**

<u>95 stress lab tests</u> have been carried out in the Roquet's stress test benches during the 4th Reporting Period.

- 25 Cast iron cylinders (provided by FRoda)
- 15 MAG welded Tubes as oil port. (samples)
- 11 MAG welded Oil ports.(samples)
- 7 MAG welded Rods.
- 4 Friction welded Rods (provided by Scaglia).
- 3 Laser welded Oil ports (provided by ISQ).
- 3 Electron beam welded Oil ports (provided by ISQ).
- 2 Hybrid welded Rods (provided by ISQ).
- 10 complete cylinders in Stress Test bench nº2 (oil ports and rod ends)
- 15 ceramic rupture disks – fatigue tests





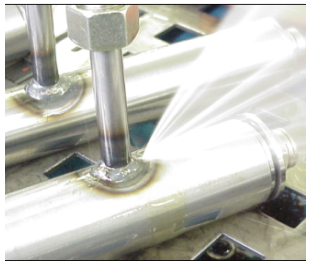
2 different Test benches

<u>NEW ! On 4th RP</u>

Ceramic rupture disks

Partners involved: Roquet, FRoda, Scaglia, ISQ, BCE

MAG



MAG

MAG

Friction

Laser , Electron Beam **Cast iron**

Research performed – 4th RP- **crack propagation**

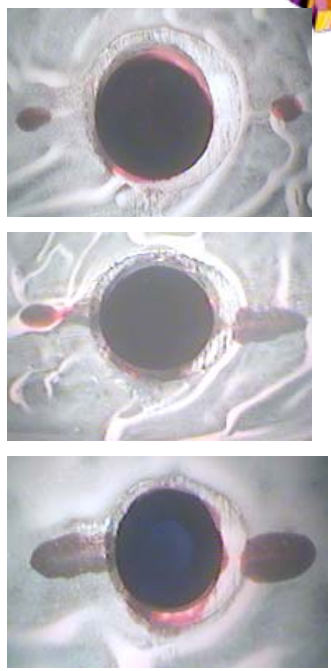
Roquet has carried out an experimental investigation on the crack propagation on the oil port zone under different pressures.

8 samples and 200 inspections by now (still going on)

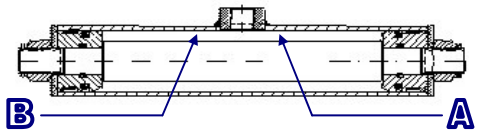
With the purpose of finding the first indications of crack, having previously calculated his estimated life by means of other experimental results, and by means of CFD simulations (crack propagation – CENAERO).

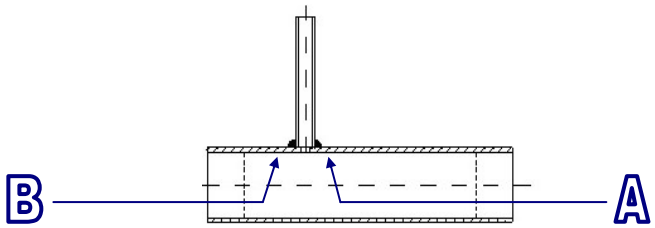
- 2 samples Ø45xØ52 with oil port at 440 bar
- 2 samples Ø45xØ52 with welded tube at 440 bar
- 2 samples Ø45xØ52 with welded tube at 275 bar
- 2 samples Ø50xØ57 with welded tube at 275 bar

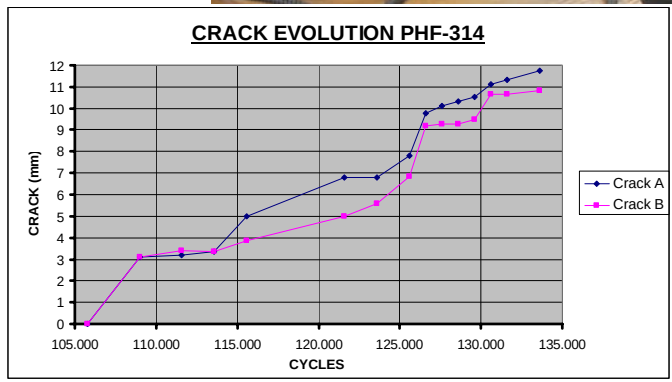
Partners involved: Roquet, Cenaero



Crack evolution







Graphic of sample Ø50xØ57 welded tube 275 bar..

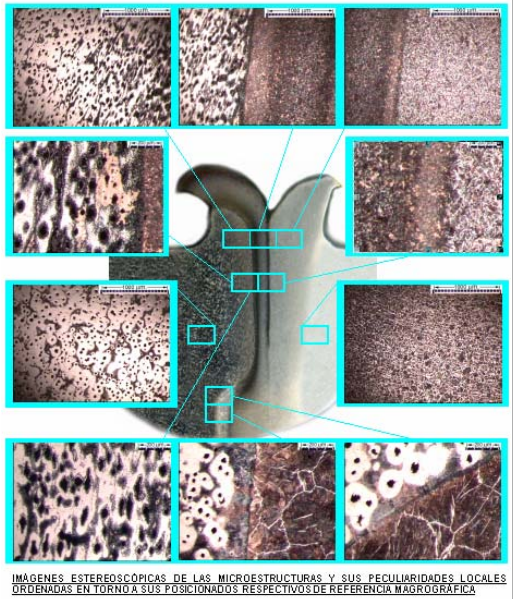
Stress cracks revealed by the inside bore, under the oil port hole.

Research performed–4thRP-**Metallurgical Laboratory reports**

80 Metallurgical Laboratory reports have been done. **Partners involved: Roquet, FRoda, Scaglia, ISQ**

Analysing: breakages, cracks, welds, seals, etc.

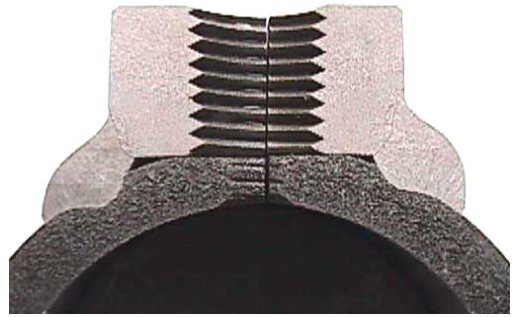
Insert type "A" cast and then friction welded


IMÁGENES ESTEREOSCÓPICAS DE LAS MICROESTRUCTURAS Y SUS PECULIARIDADES LOCALES ORDENADAS EN TORNO A SUS POSICIONADOS RESPECTIVOS DE REFERENCIA MACROGRÁFICA

Rod weld analysis

Rod weld breakage

Stress crack in oil port



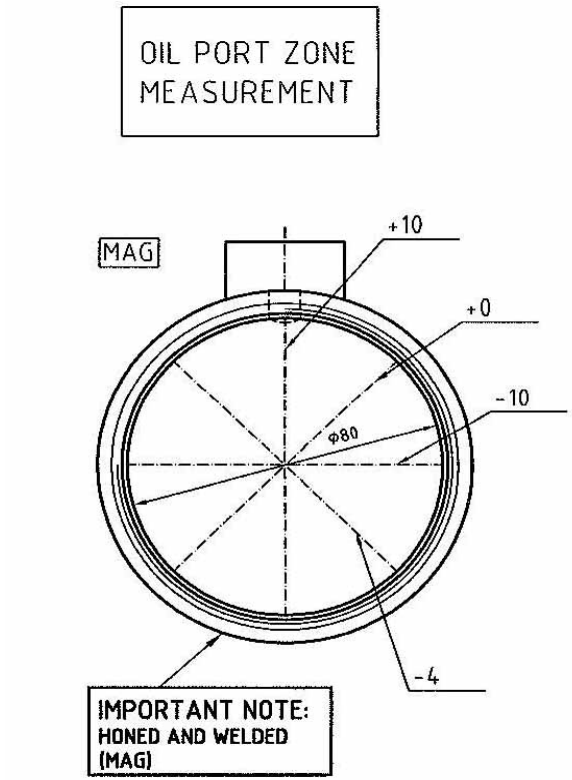
Oil port weld

Research performed – 4th RP- **Roundness distortion measurements on bore with different welding procedures**

Roquet carried out **10 tests**, measuring the bore roundness before and after different welding procedures.

- 2 -Laser welding
- 2 -Electron beam welding
- 2 -Stud welding
- 4 -MAG welding

It has been necessary to modify the Roquet manufacturing process, in order to measure the roundness distortion produced by the MAG welding process. **First honing, then welding (Not current process).**



Partners involved: Roquet, ISQ

Research performed –4th RP- **Fatigue tensile test**

Objective: Obtaining real S-N curves from smooth samples , traction loaded.

During the 4th reporting period, Roquet designed and built a new fatigue tensile test bench.

In order to obtain real and accurate data from different material properties, several tests have been carried out. Tractioning test pieces to different pressures. **(38 tests).**

Iron test piece Ø5 (CK-45) → **19 different tests**

Cast iron test piece Ø8 (GGG 40.3) → **11 different tests**

Iron test piece Ø5 (CK-15) → **8 different tests**

NEW ! On 4th RP

Fatigue tensile test bench

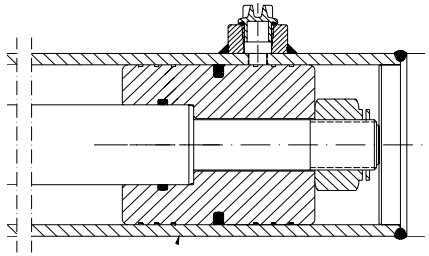
Partners involved: Roquet, FRoda

Research performed- 4th RP- **Cushioning tests**

- Roquet and UPC-Labson carried out many experimental cushioning tests in 3 different types of cushioning:

- TYPE I. Piston grooves

30 Lab cushioning tests. Varying the number of grooves and its depth, but also the geometry and the piston length.

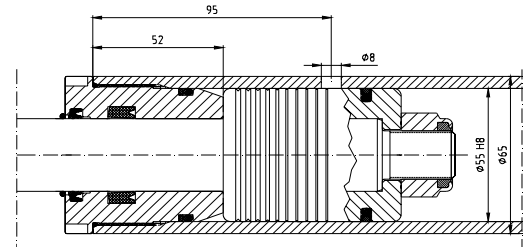


-Part num **2535.**

Grooves in both sides

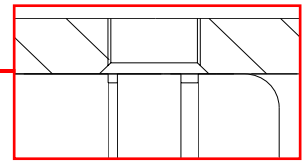
-2 types of grooves (rectangular and triangular)

-10 different piston designs - prototypes

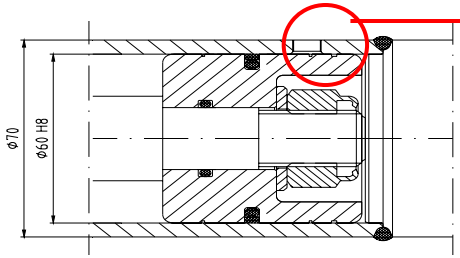


-Part num. **2972/8/4, 4599, 4601, 4896, 2652/25.**

Triangular grooves

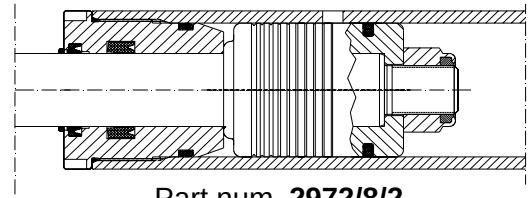


Opened grooves: 1-2.



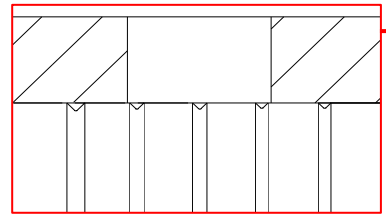
-Part num. **2283**

Rectangular grooves

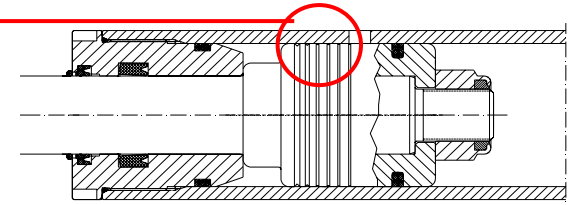


-Part num. **2972/8/2**

Triangular grooves



Opened grooves: 2-3.



-Part num. **2972/8/1**

Triangular grooves

Partners involved: Roquet, UPC-Labson, Imamoter

Research performed – 4th RP- **Cushioning tests**

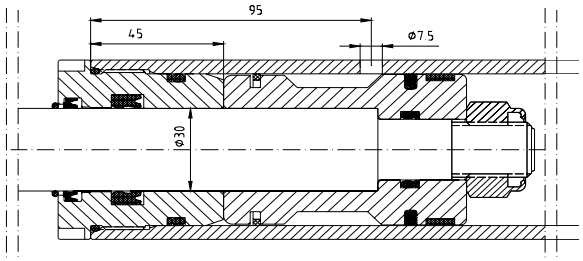
- Roquet has carried out tests in 3 different types of cushioning:

- TYPE II. Metallic Ring

24 Lab cushioning tests. Roquet has investigated in order to improve the cushioning by adding a 2nd metallic ring. The metallic ring plays a check valve role.

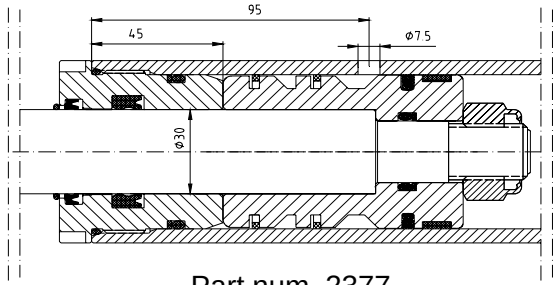
- 3 types (1 metallic ring, 2 metallic rings, progressive cushioning (single ring))

- 8 prototypes



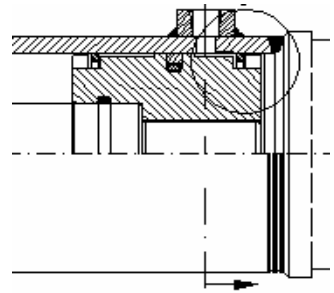
-Part num. 2377

1 metallic ring



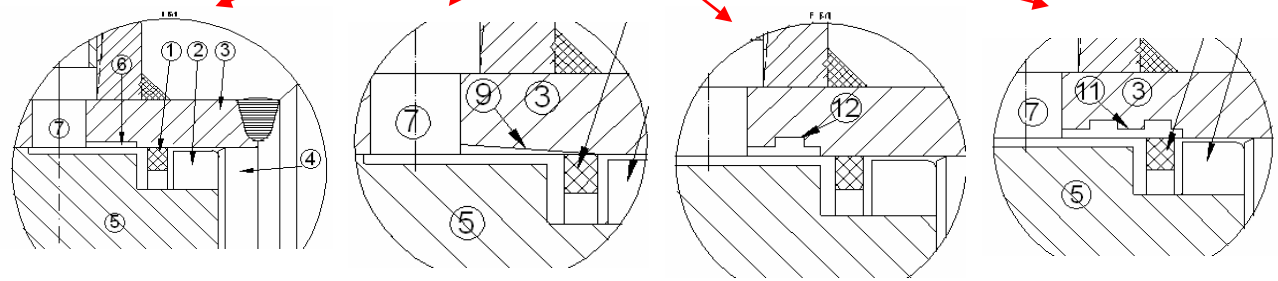
-Part num. 2377

2 metallic rings



Progressive cushioning (single ring)

Partners involved: Roquet, UPC-Labson, Imamoter



-Type a) -Type b) -Type c) -Type d)

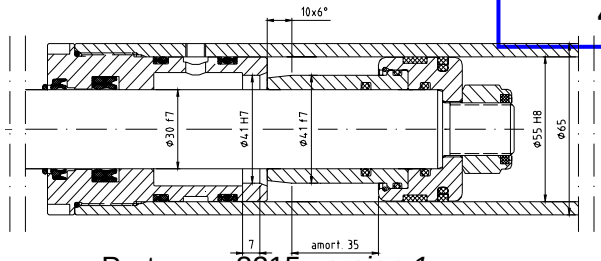
Research performed- 4th RP- **Cushioning tests**

- Roquet and UPC-Labson have carried out tests in 3 different types of cushioning:

- TYPE III. Conic cushioning

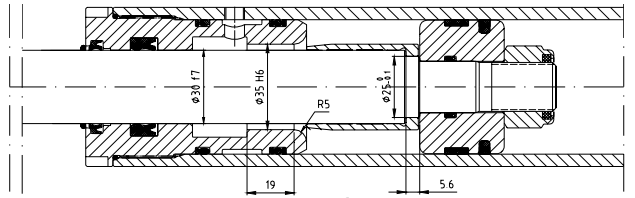
49 Lab cushioning tests

- 15 prototypes (different designs)



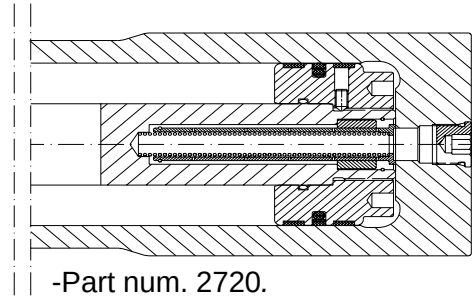
-Part num. 3215 *version 1*

Short Guiding bush. Conic part fixed



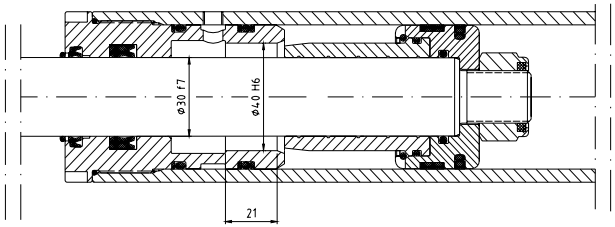
-Part num. 3215 *version 4*

Check valve function backward. Conical part movil.



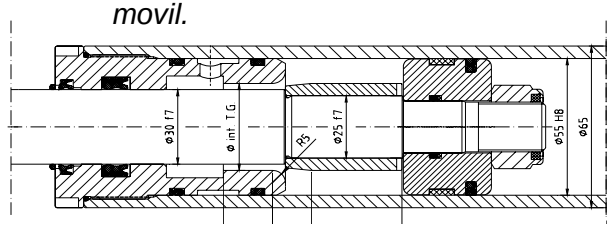
-Part num. 2720.

By floating ring and floating conical cushion part



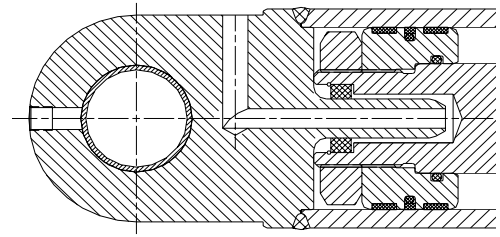
-Part num. 3215 *version 2*

Long Guiding bush. Conic part fixed



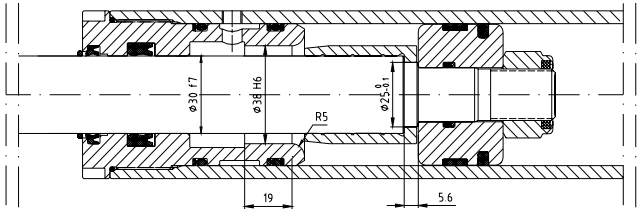
-Part num. 3215 *version 5*

Check valve function frontal. Conical part movil



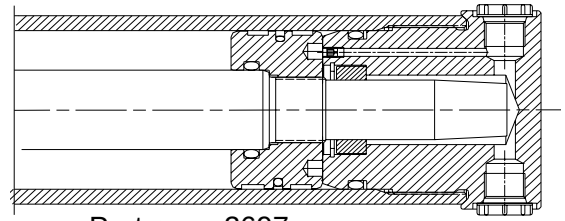
-Part num. 4909.

Cushioning by floating ring



-Part num. 3215 *version 3*

Check valve function backward.



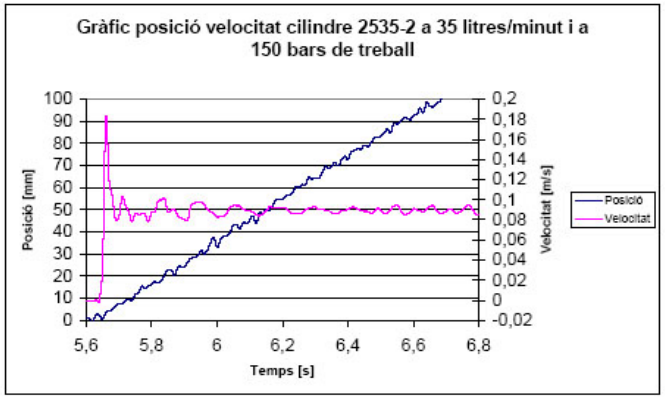
-Part num. 2697

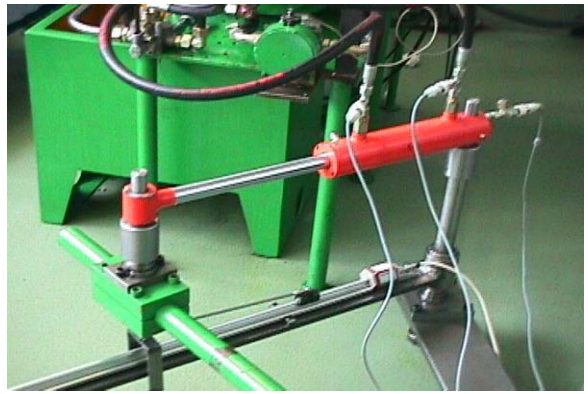
Cushioning by floating ring

Partners involved: Roquet, UPC-Labson, Imamoter

Research performed – 4th RP- **Cushioning tests**

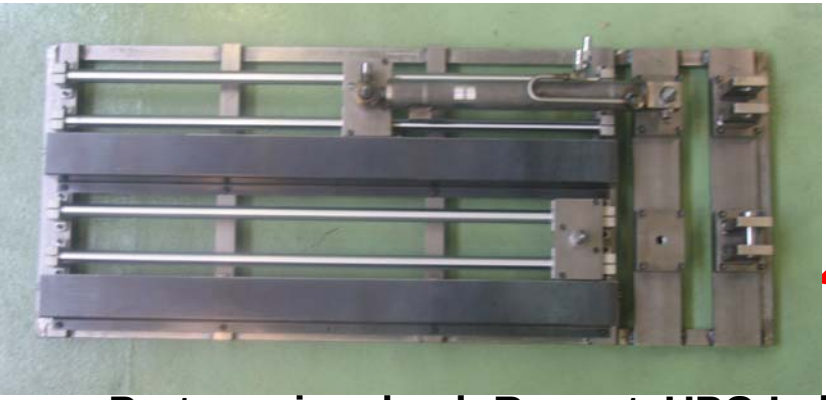
- **Cushioning tests: The cylinders are tested in the cushioning testing bench, <u>monitoring the displacement, speed and pressure within both chambers</u> . All cushioning tests have been recorded for <u>pressures 100, 200, 270 Bar</u>.**





New ! (4th RP)

<u>3 Test benches on cushioning – 2 NEW ! (4th RP)</u>



<u>5 fatigue-cushioning tests</u>

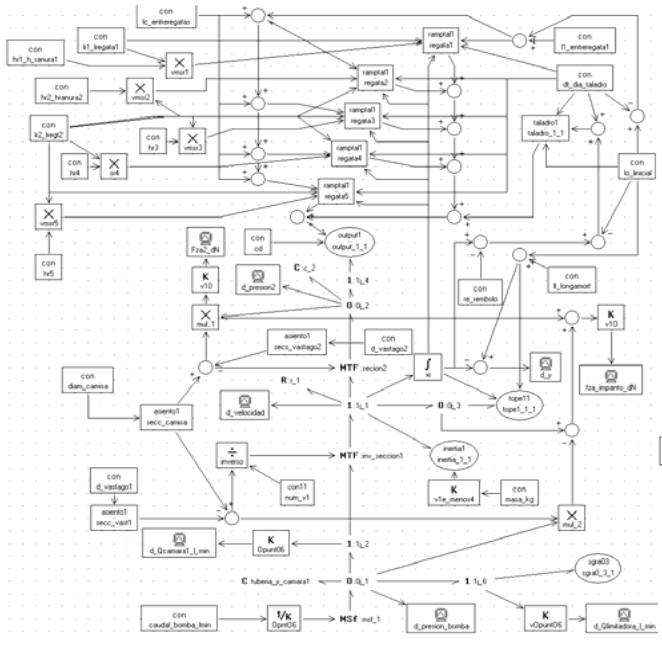
New ! (4th RP)

Partners involved: Roquet, UPC-Labson , Imamoter

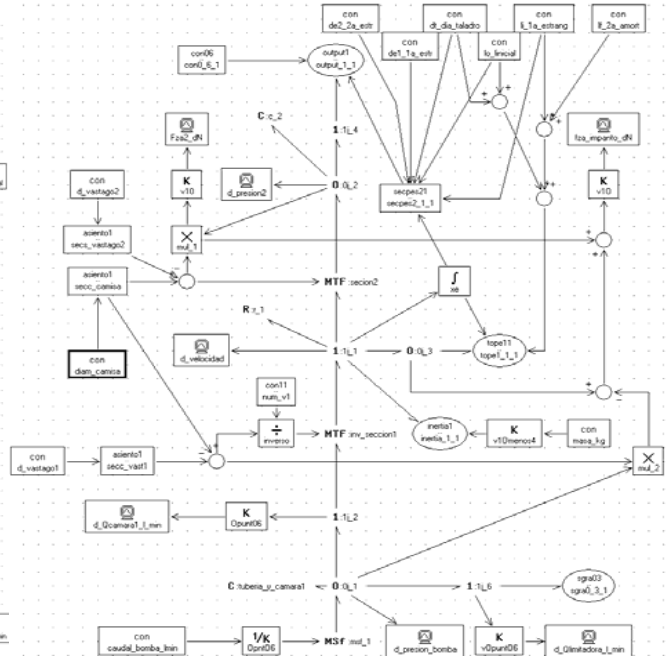
Research performed – 4th RP- **Cushioning tests**

Performed cushioning Bond-graph simulations: **Partners involved: Roquet, UPC-Labson , Imamoter**

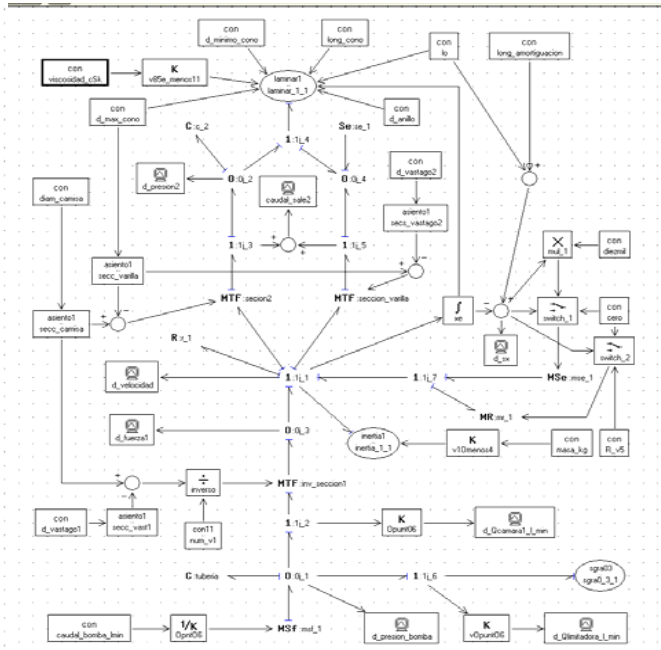
Performing also the necessary comparative between simulation and Lab experimental tests results.



-Software simulating piston grooves cushioning (triangular – rectangular)
TYPE I



-Software simulating metallic ring cushioning (single – doble)
TYPE II



-Software simulating conic cushioning
TYPE III

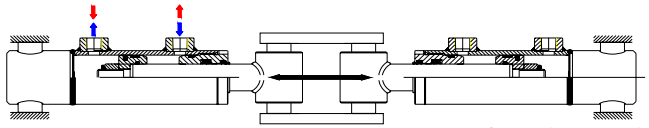
Research performed – 4th RP - **on wearing dynamic bench**

50 tests to evaluate the seals, the bushing and the honing results

Partners involved: Roquet, Trelleborg, Honingtec, UPC

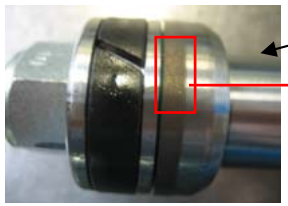
-**32 Tests** dynamic bench

-**Dynamic test bench**

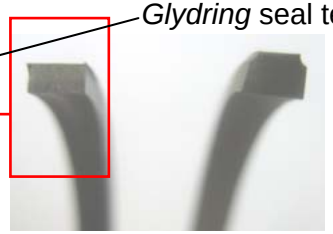


Wynseal seal tested

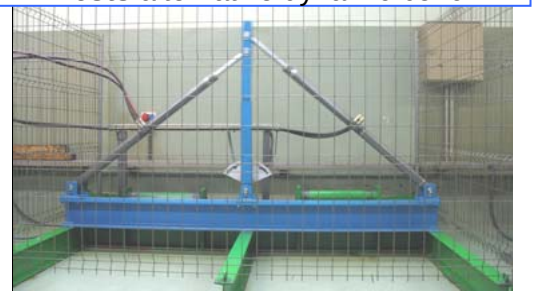
Mainly focused on getting real characteristics on developed seals but also on developed honing processes (honing but also plateau-honing)



Glydring seal tested

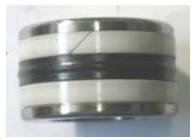


-**12 Tests** alternative dynamic bench



-**Alternative dynamic test bench**

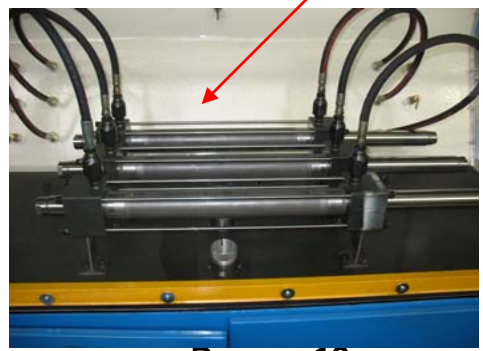
In order to obtain more experimental data to investigate in seals and bushing wear, an alternative dynamic bench has been developed (designed and built)



-**6 Tests** new dynamic bench

-**New dynamic test bench**

New ! (4th RP)



Work performed – 4th RP – **Designing and manufacturing cylinders prototypes (other than the ones for fatigue tests)**

30 Cylinders with cushioning system for Lab and in field tests:

- 10 cushioning Type I
- 8 cushioning Type II
- 12 cushioning type III

Several have been tested in field.
Partners involved: Roquet, UPC-Labson, Hidrar and Sempere.

31 Cylinders for buckling tests:

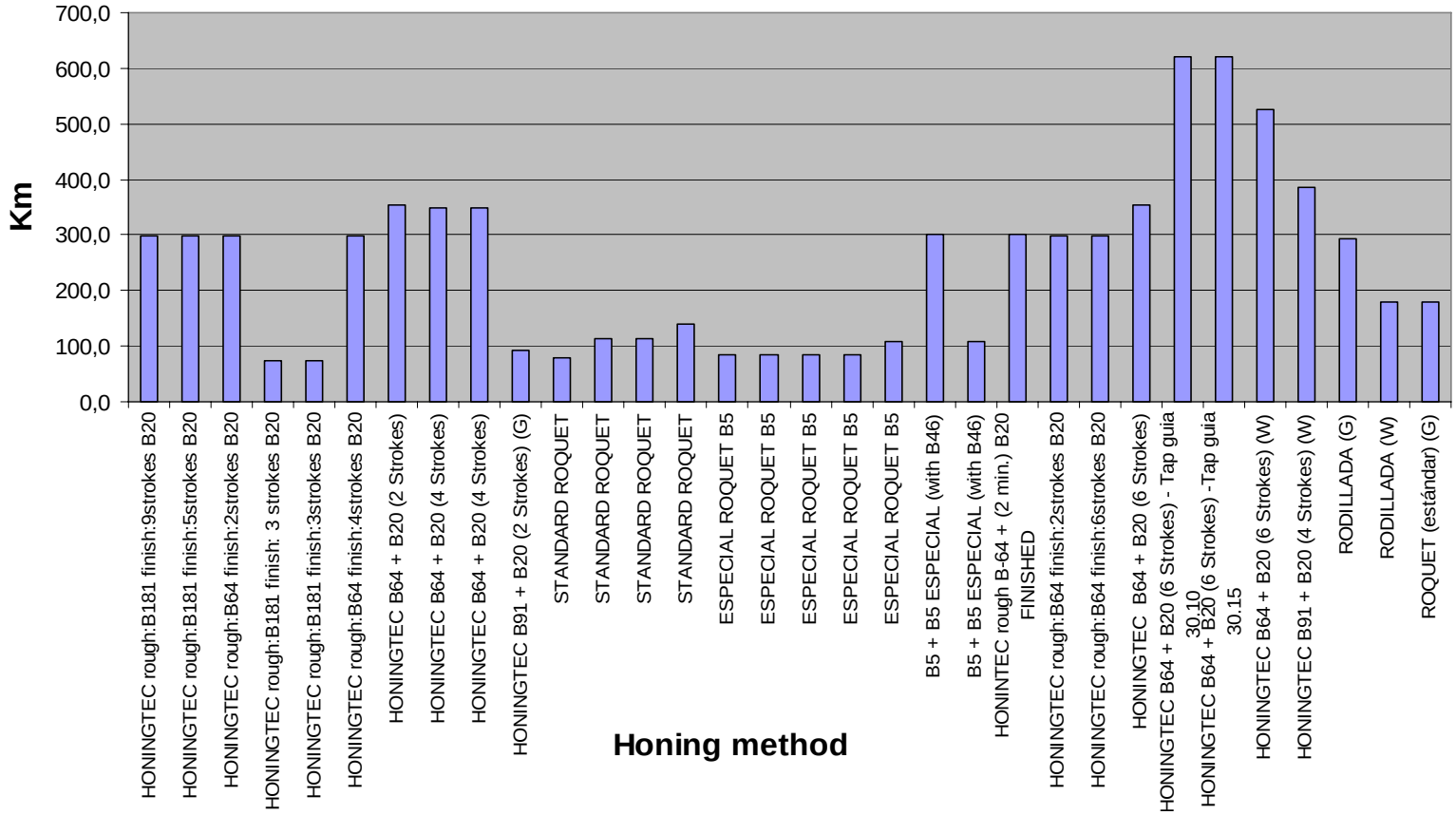
- 2 for “in field” buckling tests (loader – BMH/Hidrar)
- 4 for Lab buckling tests on back-hoe (UPC-Labson/Hidrar)
- 25 rods (and tubes as rods) for Lab buckling tests (UPC-Labson) – (several diameters and thickness)

Partners involved: Roquet, UPC-Labson, Hidrar.

Research performed- 4th RP - **Honing methods tests**

Roquet has carried out an investigation in honing methods (honing and Plateau-honing), this graphic is a summary of the results**, (32 tests).**

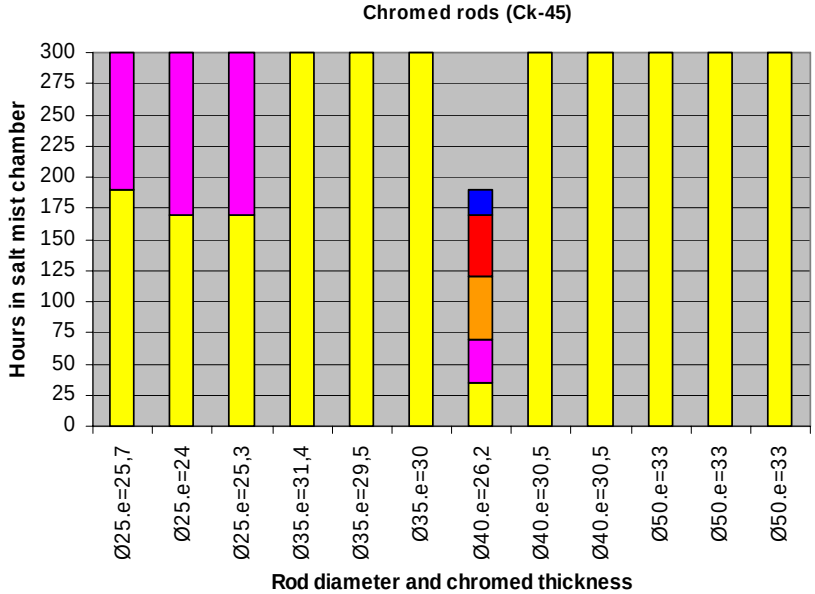
All tests done in the dynamic test bench have been recorded and analyzed.

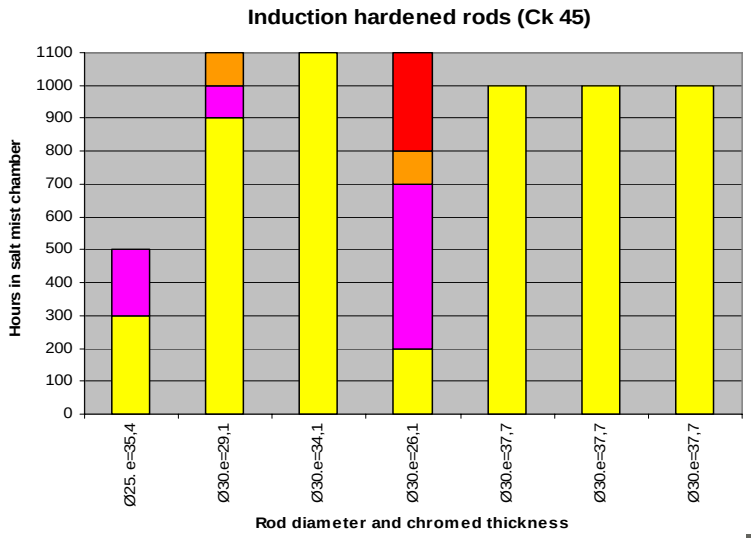


Partners involved: Roquet, Trelleborg, Honingtec

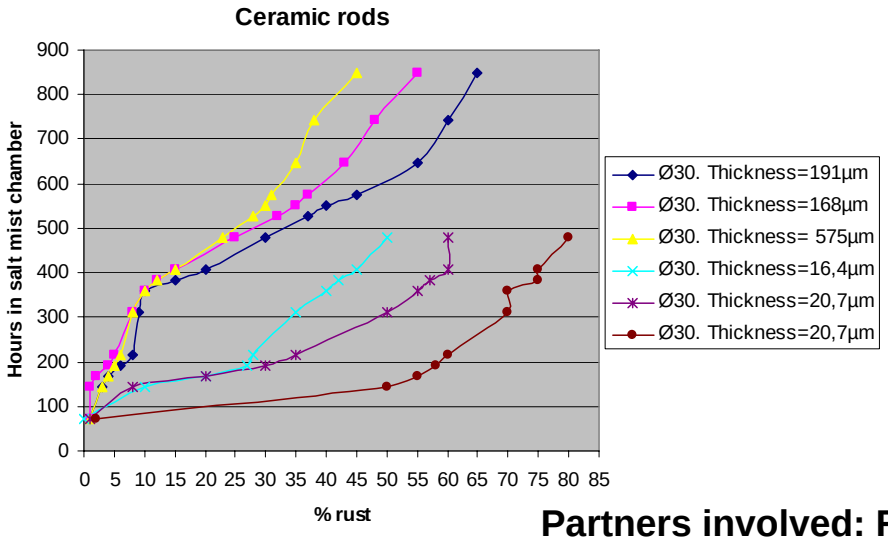
Research performed – 4th RP - **Corrosion tests –**

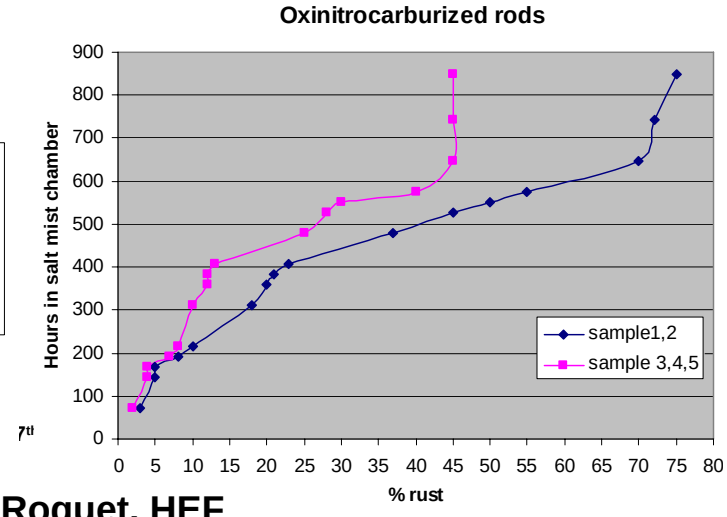
NSS (Neutral Salt Spray)- CASS





RATING	10	9	8	7	6
COLOR					





-NSS test chamber.

Partners involved: Roquet, HEF

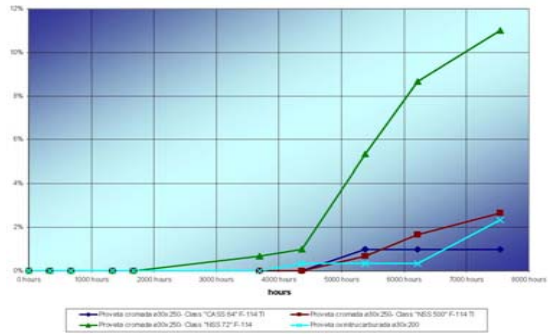
Research perform – 4th RP - **Corrosion as "in field" tests**

- Roquet carried out (but still going on) tests in several rod samples (40) to evaluate the corrosion in different field environments.

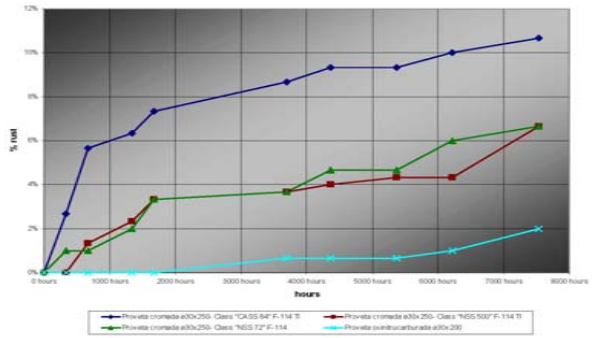
Rods treatments	**Environment (field simulation)**
-Induction hardened chromed rods	**-Buried in saline earth**
-Chromed rods	**-Saline earth atmosphere**
-Oxinitrocarburized rods	**-Marine environment**

-**Saline earth**

- 6 Induction hardened chromed rods Buried in saline earth.
- 5 Induction hardened chromed rods in Saline atmosphere
- 6 Induction hardened chromed rods in Marine environment



- 3 Chromed rods Buried in saline earth.
- 3 Chromed rods in Saline atmosphere
- 3 Chromed rods in Marine environment



- 3 Oxinitrocarburized rods Buried in saline earth
- 3 Oxinitrocarburized rods in Saline atmosphere
- 8 Oxinitrocarburized rods in Marine environment

-**Marine atmosphere**

Partners involved: Roquet, HEF, UPC-Labson

Research perform – 4th RP- **Field tests**

Partners involved: Roquet, Hidrar,UPC-Labson

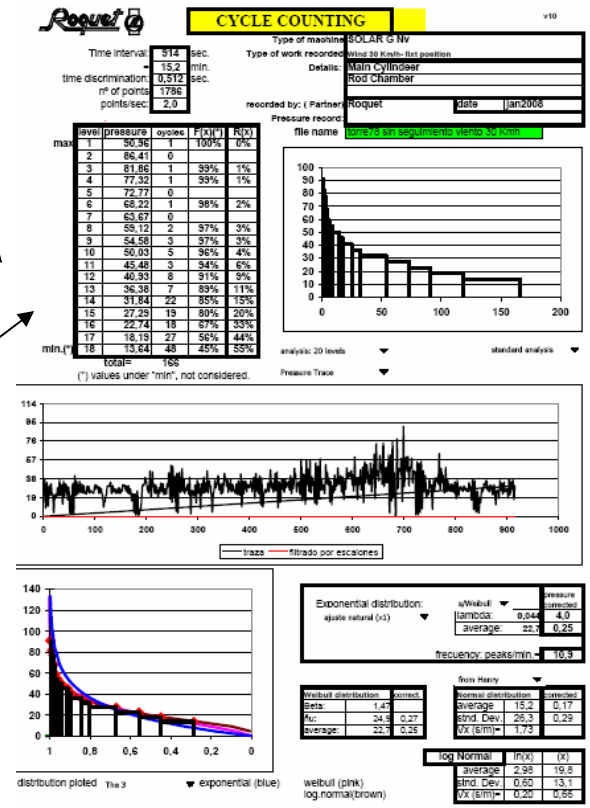
5 Field tests – 48 recorders – 48 cycle counting analysis.

The Cycle-counting program is an analysis program of the signal spectrum by the “Rainflow” method, which besides showing the spectrum, it finds the *Normal* distribution, *Lognormal*, *Exponential* and *Weibull* that better adjusts to the discreet spectrum, to transform it into a continuous spectrum.

Hydraulic solar panels

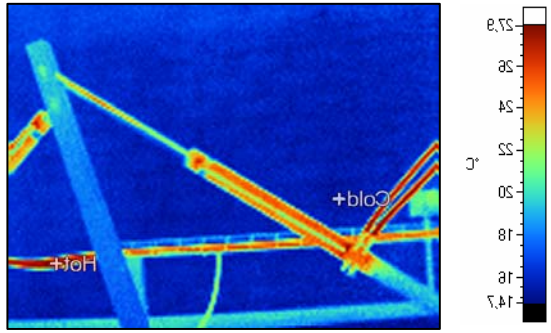
Loader

Back-hoe

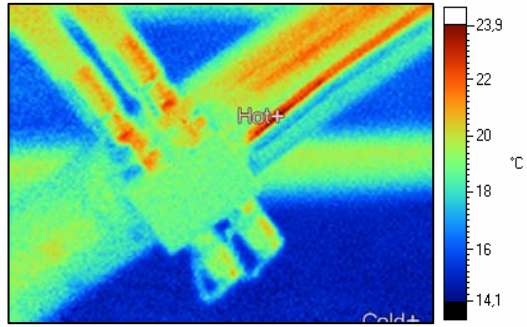


Research performed –4th RP- **Thermographic analysis**

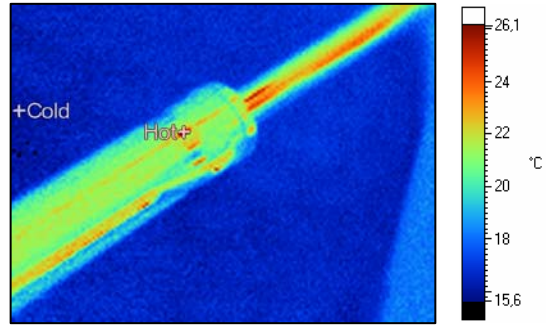
In order to investigate the possibility of monitoring the heating evolution in any part of a cylinder, Roquet has taken **<u>60 thermal photos</u>**.



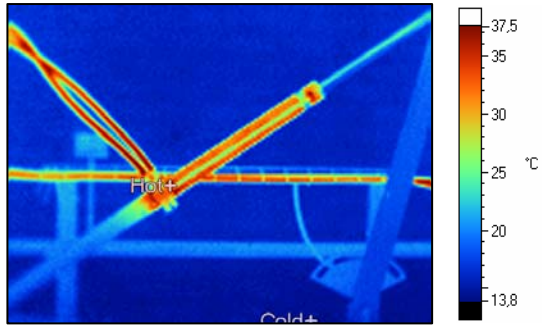
Slave cylinder **2 min** working



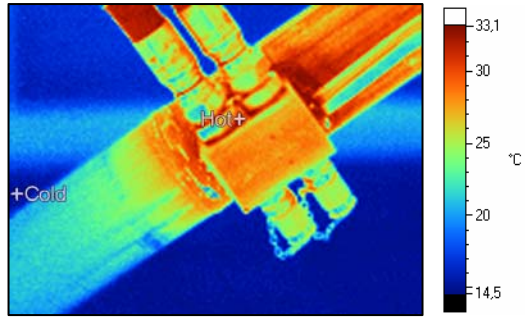
Oil port **1 min** working



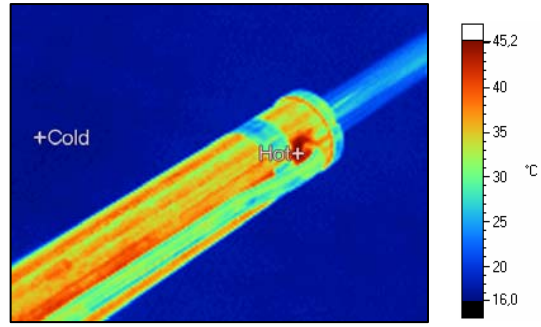
Guiding bush **1 min** working



Slave cylinder **10 min** working



Oil port **10 min** working

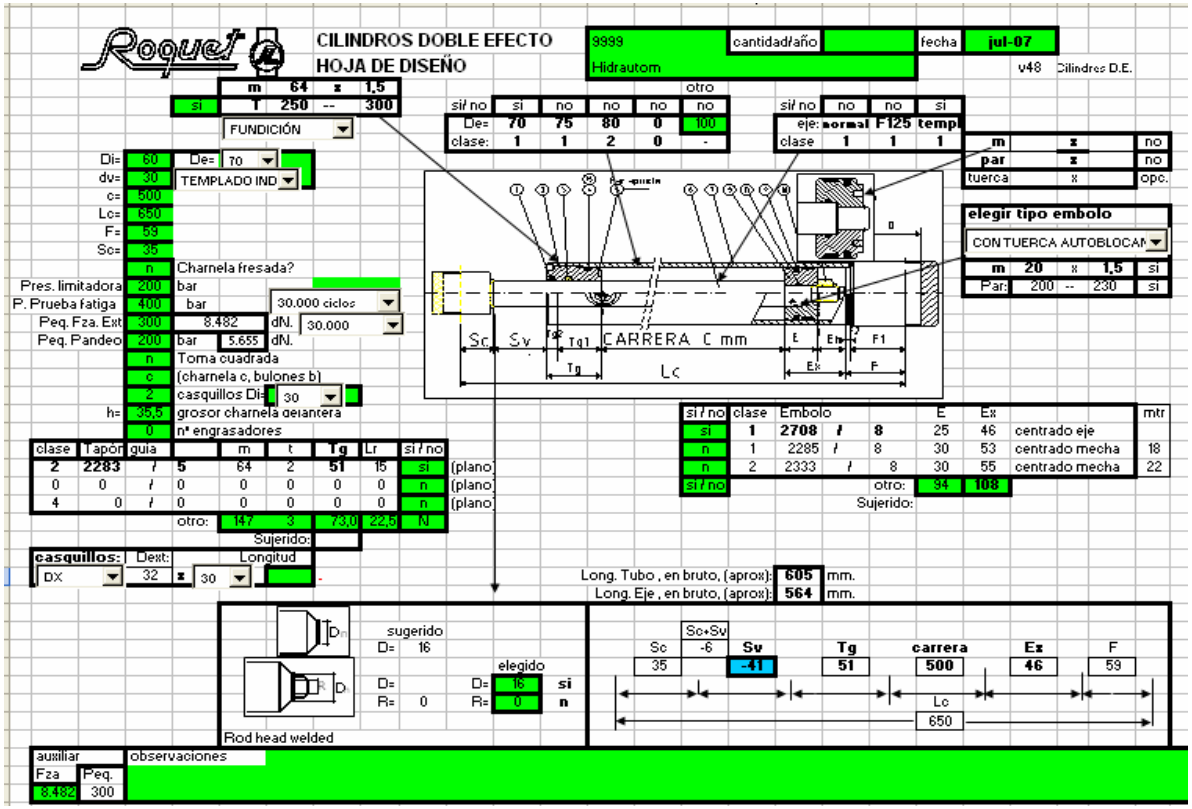


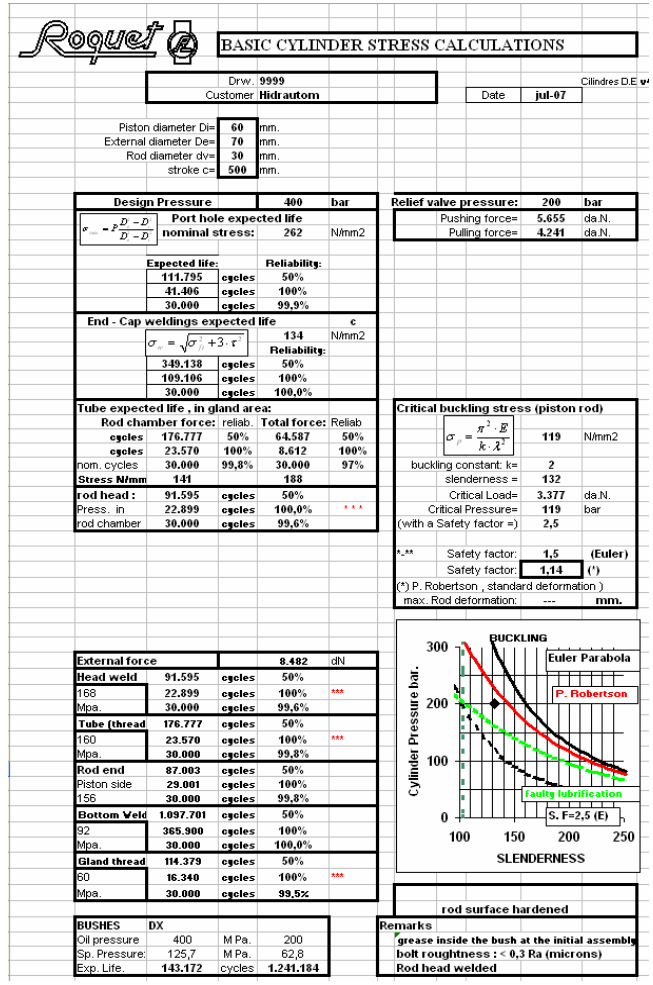
Guiding bush **11 min** working

Research perform – 4th RP- **Cylinder's calculation program**

Roquet developed a cylinder's calculation program to design correctly and efficiently, as well as to evaluate the load, buckling and stress in any critical part of a cylinder.

Data entrance

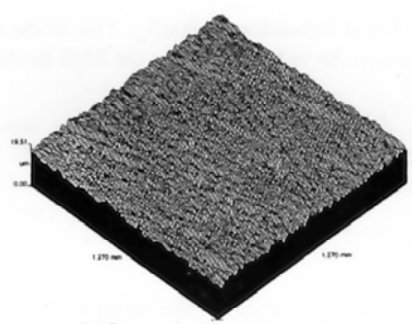




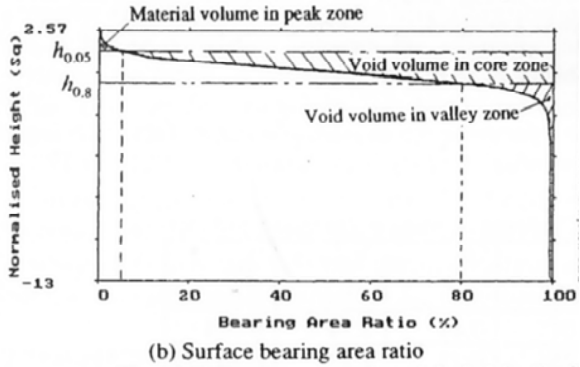
THANKS FOR YOUR ATTENTION

The figure below shows as after the honing process, the valley and plateau region is modified improving the tribological and bearing characteristics.

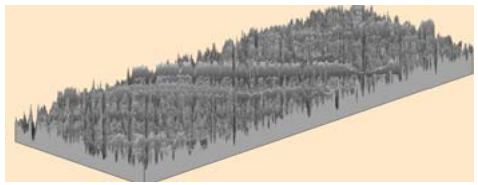
HONED SURFACE
Bearing area ratio and the height distribution of honing bore surface



(a) Isometric plot of the surface

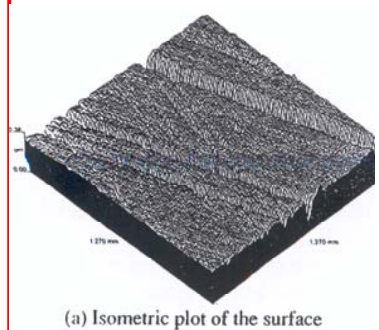


(b) Surface bearing area ratio



The figure below shows the differences with the previous process in volume of valley region where the lubricant is deposited.

PLATEAU-HONED SURFACES
Bearing area ratio and the height distribution of plateau honing surface



(a) Isometric plot of the surface