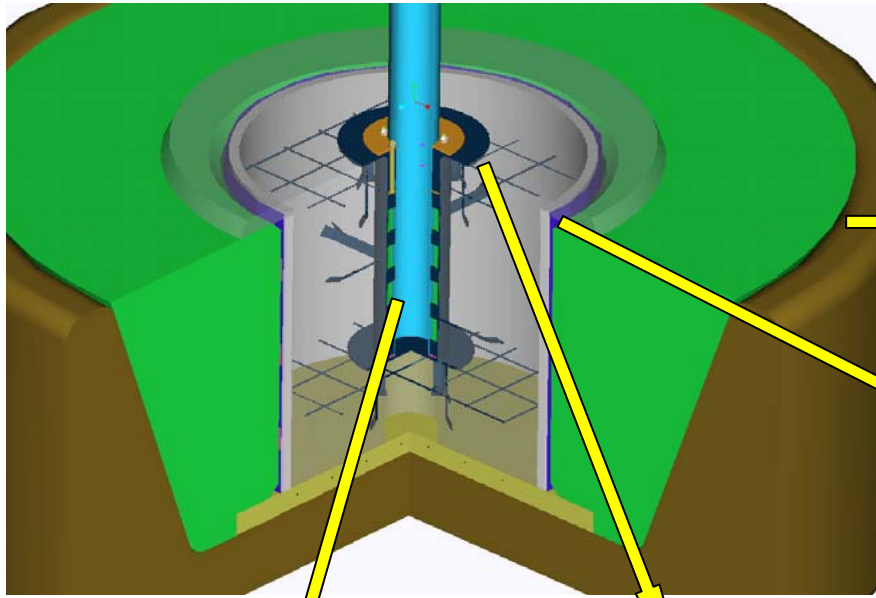


# FIELD TESTING

## Lab and Field Monitoring

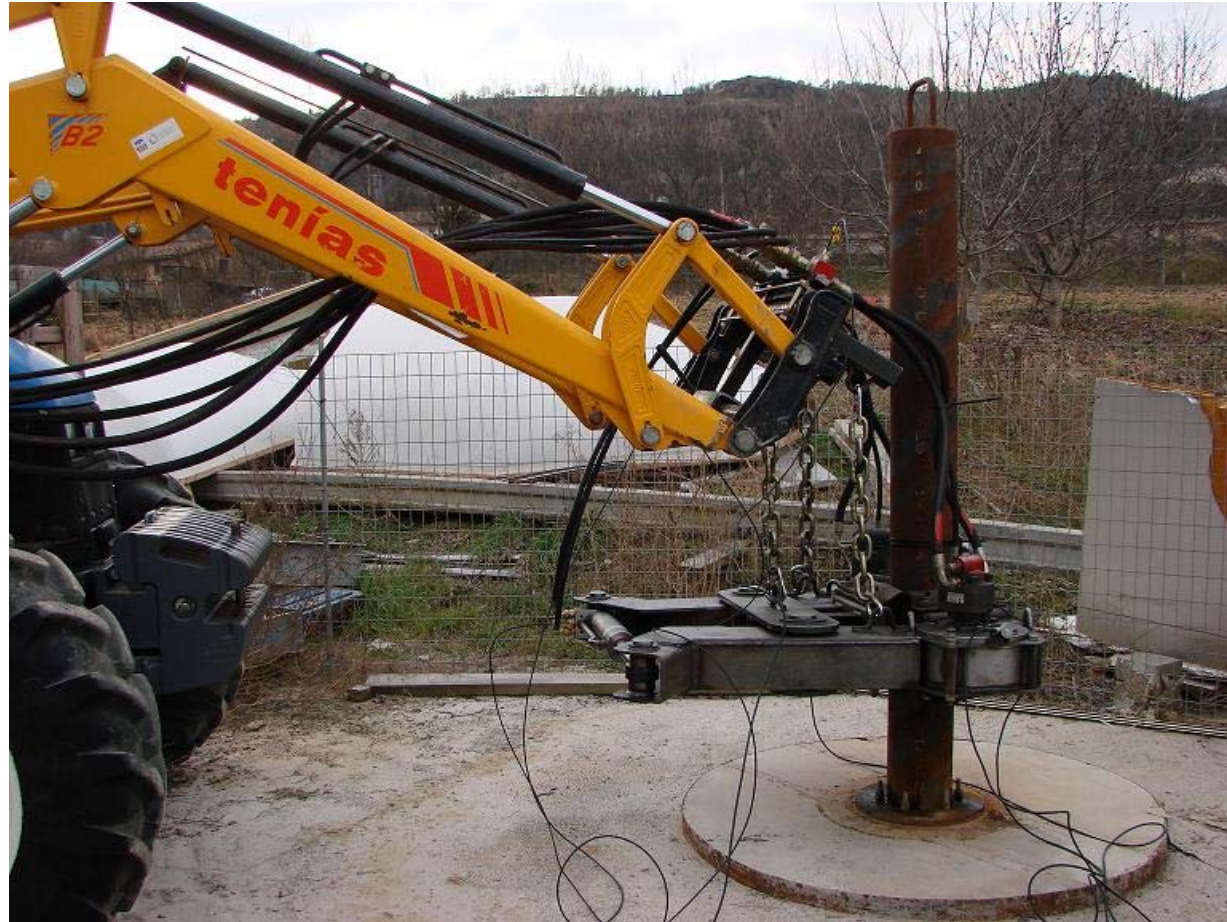
(Indoor test bench)





Example: Tree shaker  
AGRIC test bench  
(reflecting real operating systems)

# Indoor TEST BENCH

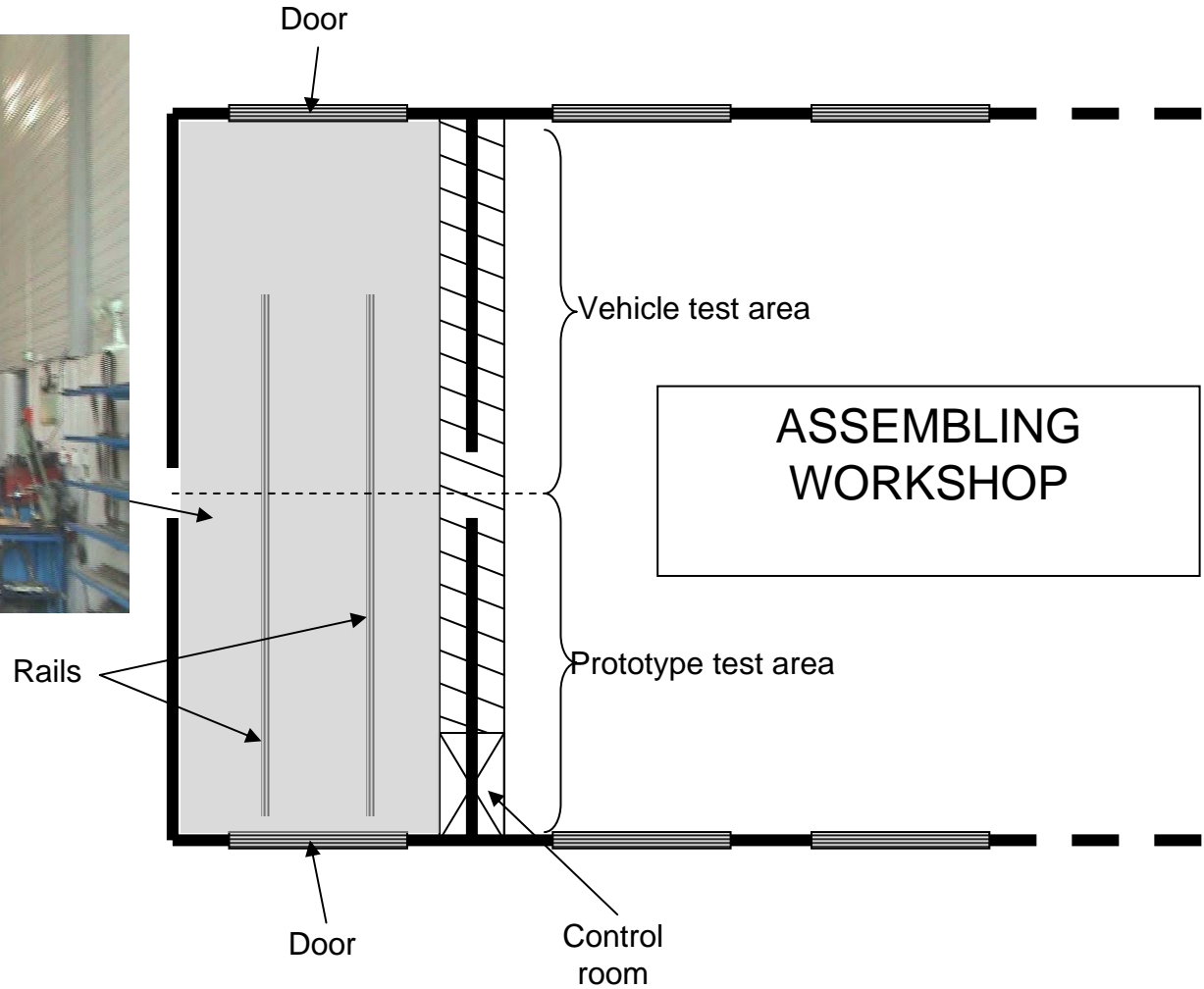


**AGRIC**

Example: Tree shaker  
AGRIC test bench  
(reflecting real operating systems)



# Indoor TEST BENCH



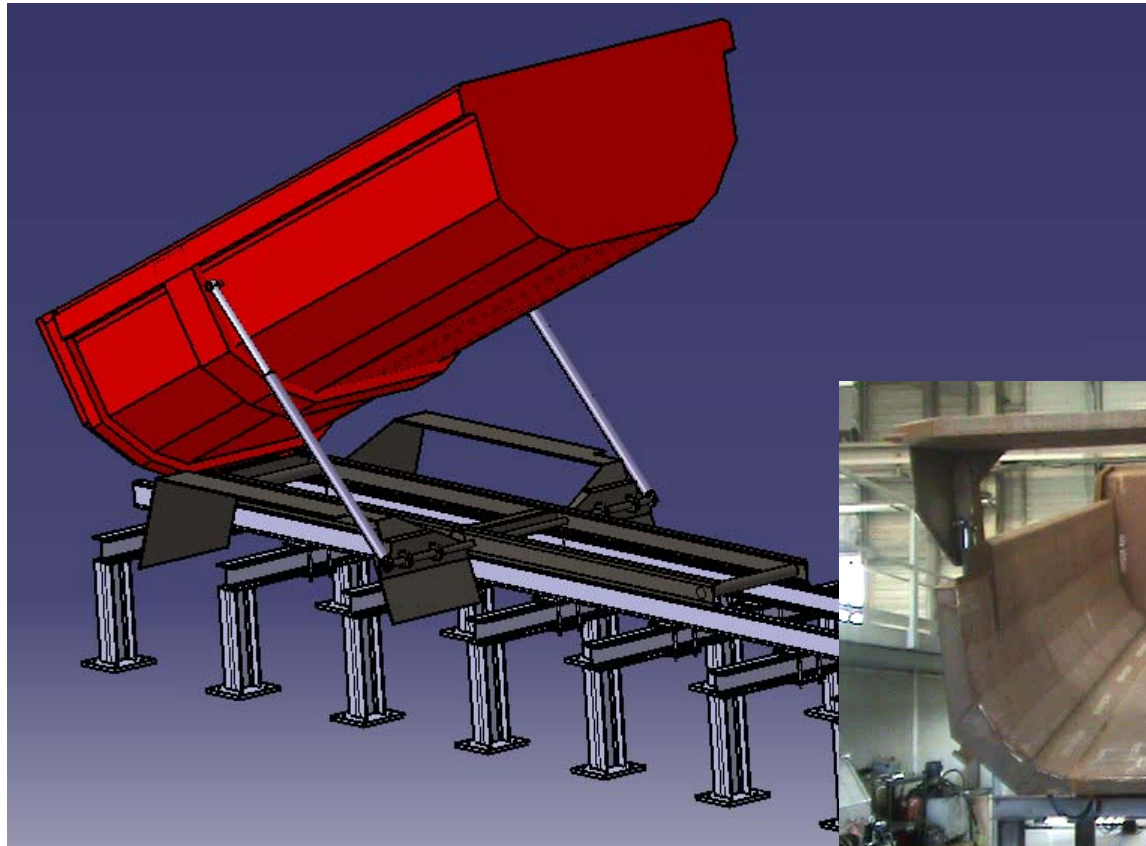
Example: Dumper Truck  
Sempere test bench  
(reflecting real operating systems)







# Indoor TEST BENCH



Example: Dumper Truck  
Sempere test bench  
(reflecting real operating systems)

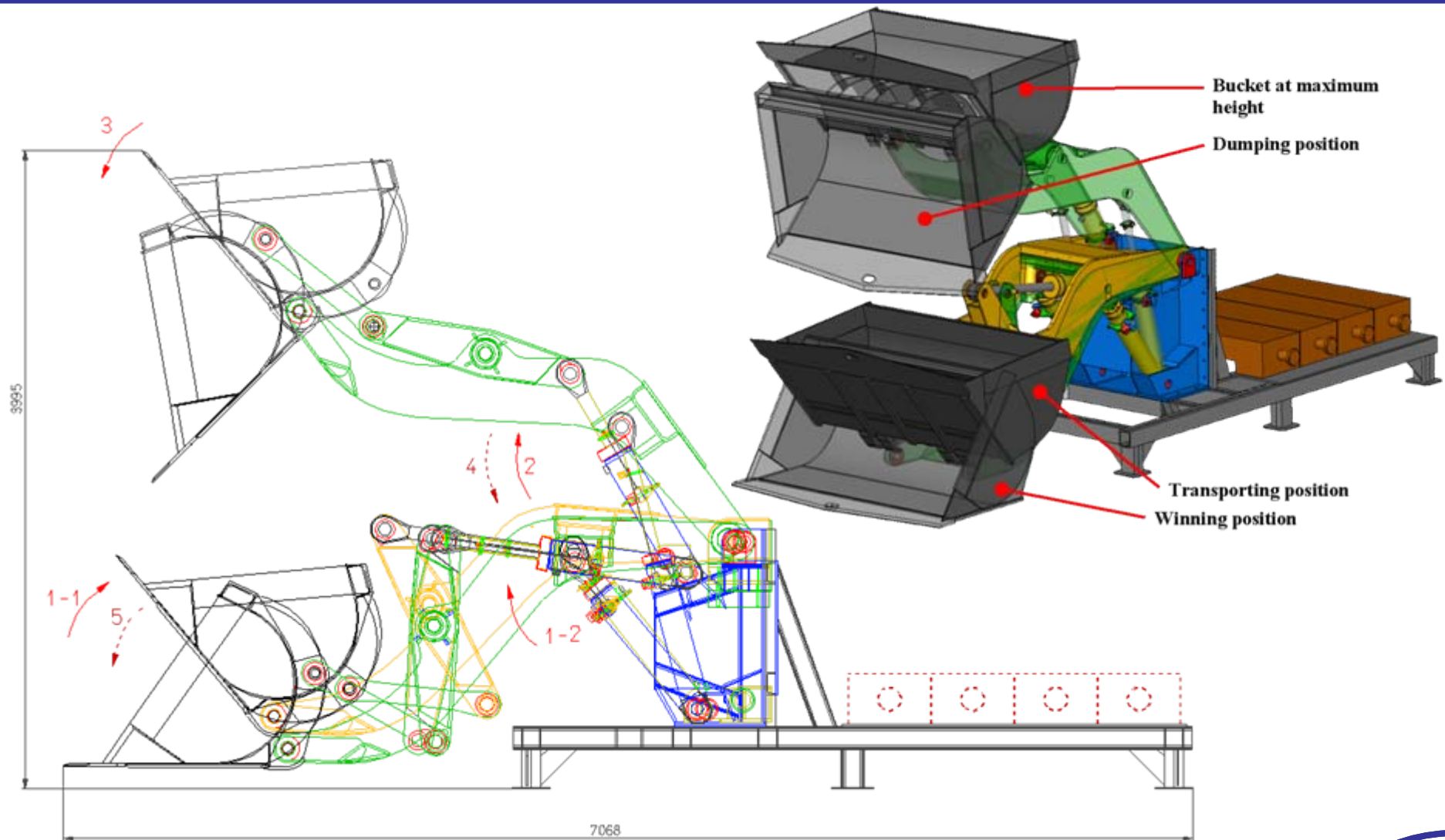
# Indoor TEST BENCH



Example: Dumper Truck  
Sempere test bench  
(reflecting real operating systems)



# Indoor TEST BENCH



**Test bench motions sequence.**

1-1, 1-2 – winning (bucket closing and boom rising), 2 – preparing to dumping (rising the boom at max height), 3 – dumping (bucket opening), 4 – preparing to winning (boom lowering and bucket closing)



# Indoor TEST BENCH



Examples: Mining Loader  
Fadroma test bench  
(reflecting real operating systems)





# Lab tests



## **Test rig H6 for Rod Seals (Endurance testing of Sealing Systems)**

Testing Conditions:

Pressure: 0 - 30 MPa

Medium: Öl HLP 46

Temperature: 60 °C

Velocity: 0,2 m/s

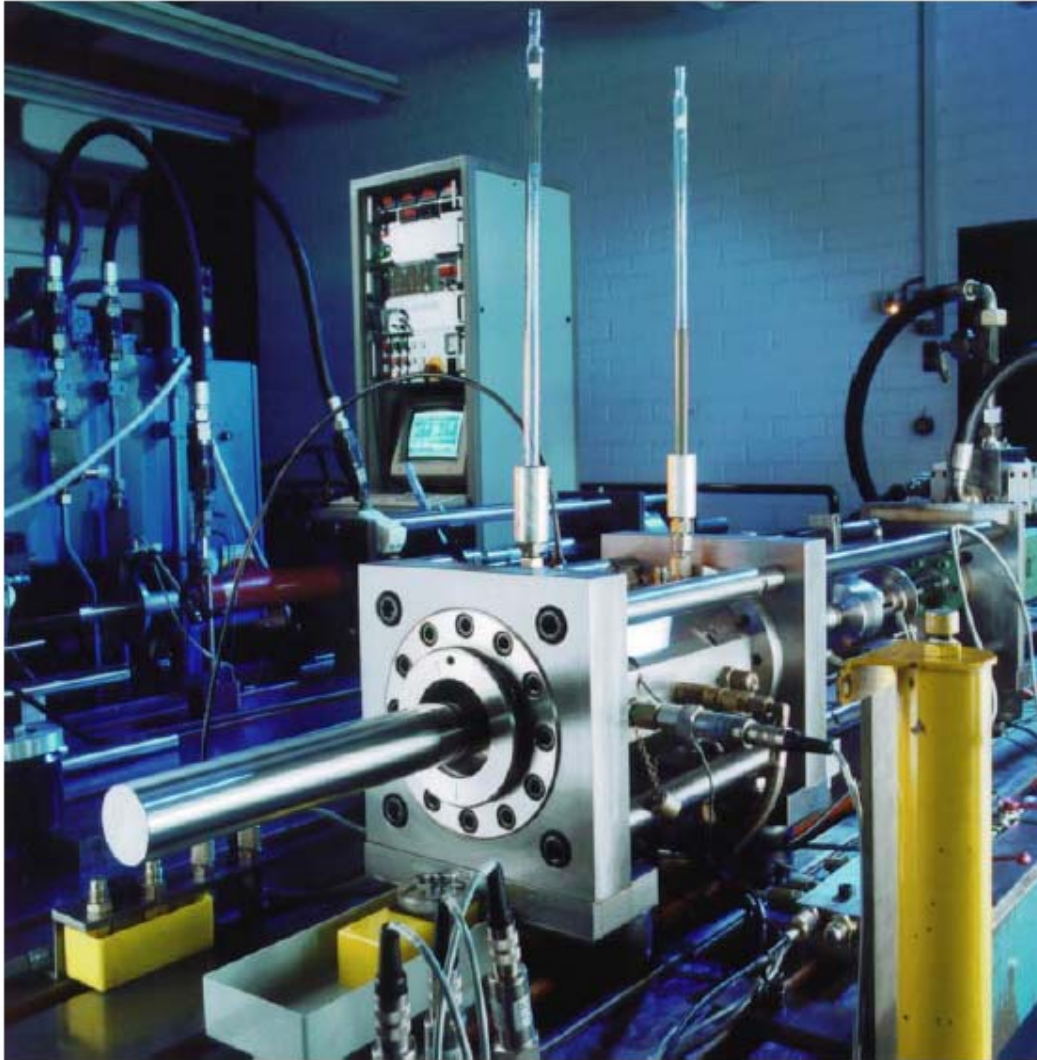
Stroke length: 280 mm

Endurance:

250.000 - 1 Mio.

Double strokes

Test bench by Trelleborg



**Test rig H2/H3 for Rod  
Seals  
(single seals)**

Testing Conditions:

Pressure: 0 - 20 MPa

Medium: Öl HLP 46

Temperature: 30 - 50 °C

Velocity: 0,01 - 0,4 m/s

Stroke length: 250 mm

Endurance: 66 hours

Test bench by Trelleborg



## Test bench Pedro Roquet SA

### View of dynamic Test bench



### Testing Conditions

(Master & Slave)

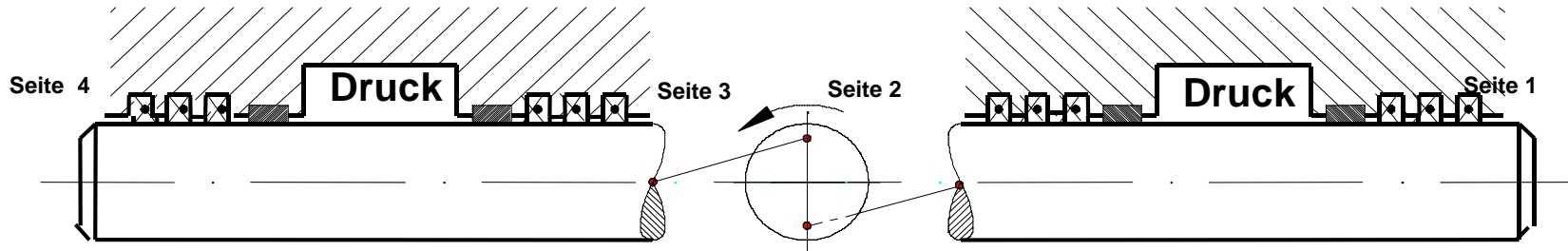
<b>Piston-Ø</b>	<b>50 mm</b>
<b>Rod-Ø</b>	<b>30 mm</b>
<b>Velocity</b>	<b>0,3 ÷ 0,47 m/s</b>
<b>Test Fluid</b>	<b>HLP46</b>
<b>Pressure</b>	<b>0 - 25 MPa</b>
<b>Stroke Length</b>	<b>270 mm</b>
<b>Oil Temperature</b>	<b>80°C</b>

### Measurable:

**Leckage (internal / external each  
50k double strokes)**

## 2. Testing of Rod Seals

### Endurance Rod Seal Test Rig



### Testing Conditions

Rod- $\varnothing$	32 mm
Velocity	0,2 m/s
Test Fluid	HLP46
Pressure	20 MPa const.
Stroke Length	200 mm
Oil Temperature	60°C

### Measurable:

Pressure  
Leakage  
Oil temperature  
Stroke Length

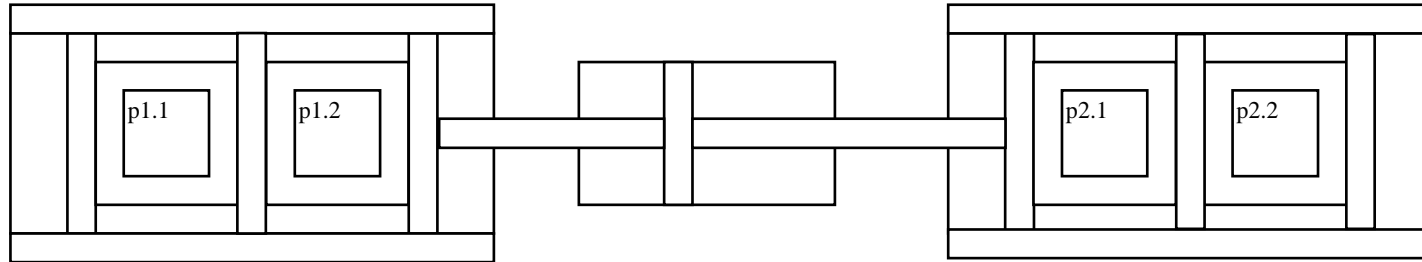


Test bench by Trelleborg

# 1. Testing of Piston Seals

## Piston Seal Test Rig

Schematic:

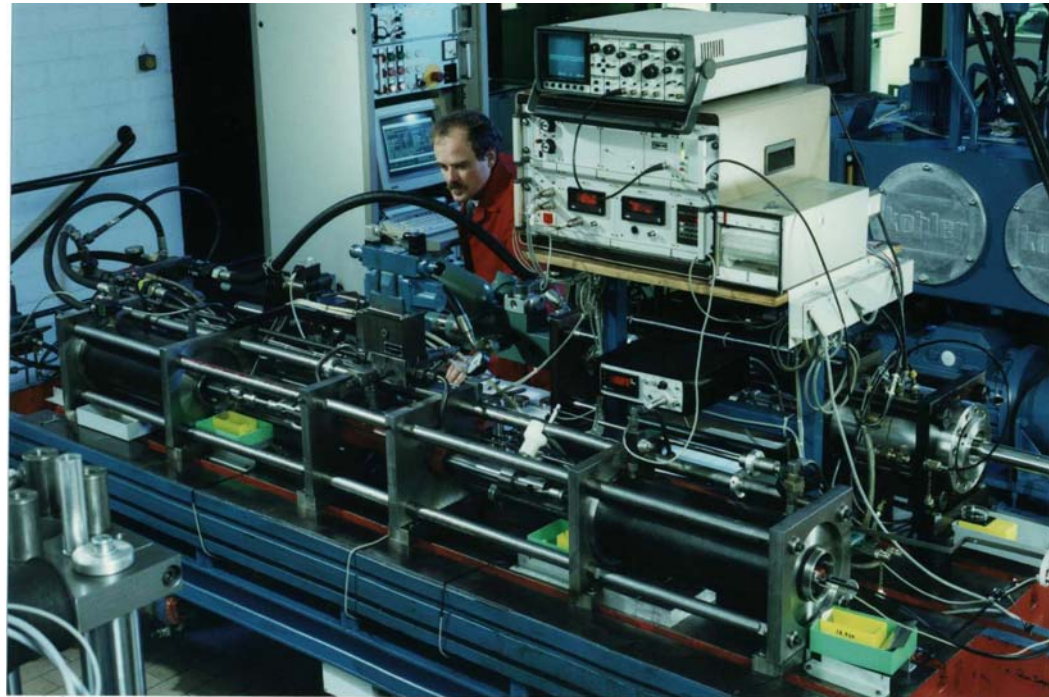


## Testing Conditions

<b>Piston-Ø</b>	<b>80 mm</b>
<b>Velocity</b>	<b>0,2 m/s</b>
<b>Test Fluid</b>	<b>HLP46</b>
<b>Pressure</b>	<b>0 - 30 MPa</b>
<b>Stroke Length</b>	<b>200 mm</b>
<b>Oil Temperature</b>	<b>60°C</b>

**Measurable:**

**Pressure**  
**Leakage**  
**Oil temperature**  
**Stroke Length**  
**Friction Force**



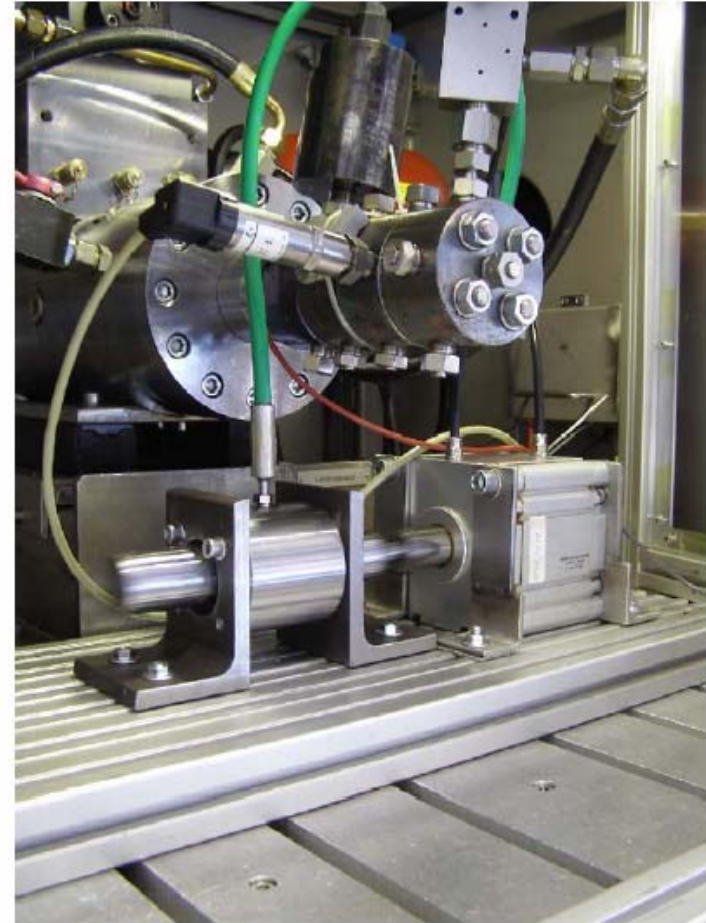
Test bench by Trelleborg



# ROD SEALS (High pressure)

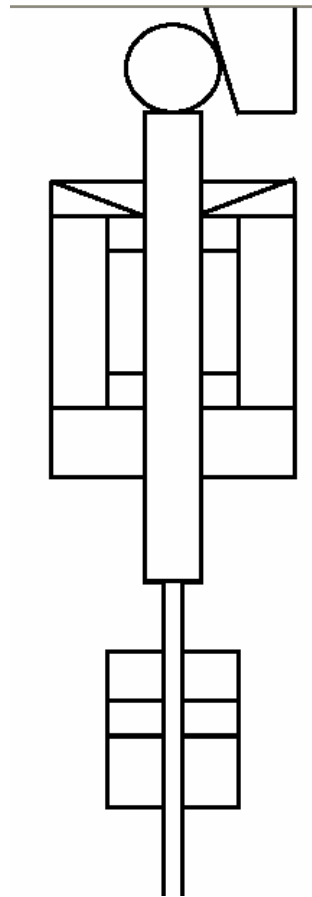
## Conditions:

Seal	RL17N0040-Z20 (40 x 60 x11)
Pressure	600 / 0 bar (2sec. each)
Frequency	0,125 Hz
Stroke	40 mm
Fluid	HLP 46
Temperature	ambient
Cycles	30.000
Duration	70 hrs.



Test bench by Trelleborg

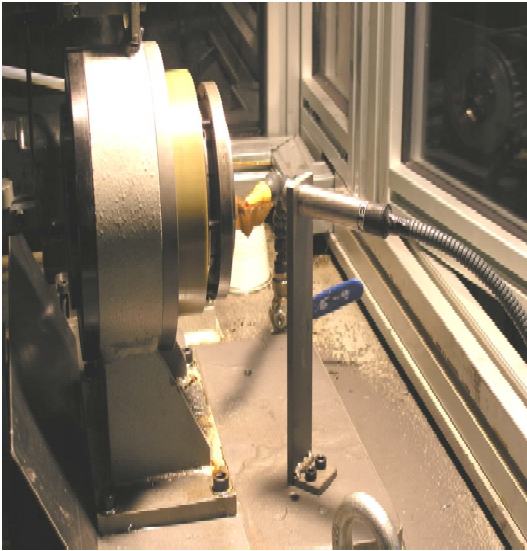
# WIPER ENDURANCE TEST



Test bench by Trelleborg

Stangen-Ø / ROD-Ø	10 - 50	mm
Stangengeschwindigkeit / ROD VELOCITY	0,01 – 0,5	m/s
Prüfflüssigkeit / TEST FLUID	HLP46 + Arizona Sand	
Prüfdruck / PRESSURE	0 - 5	MPa
Hublänge / STROKE LENGTH	200	mm
Öltemperatur / OIL TEMPERATURE	25 - 50	°C
Stangenauslenkung / ROD DEFLECTION	0 – 0,5	mm

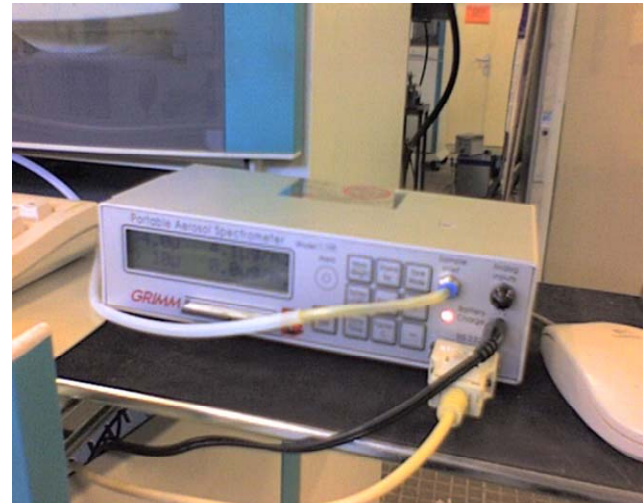
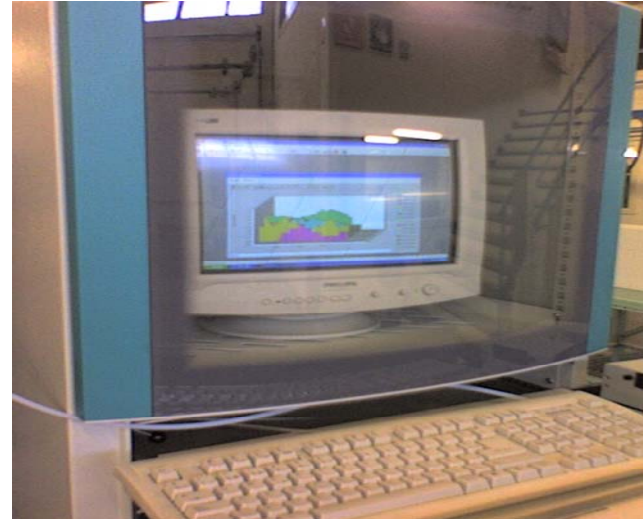
# Honing test bench



HONINGTEC



# OIL MIST



# LABSON

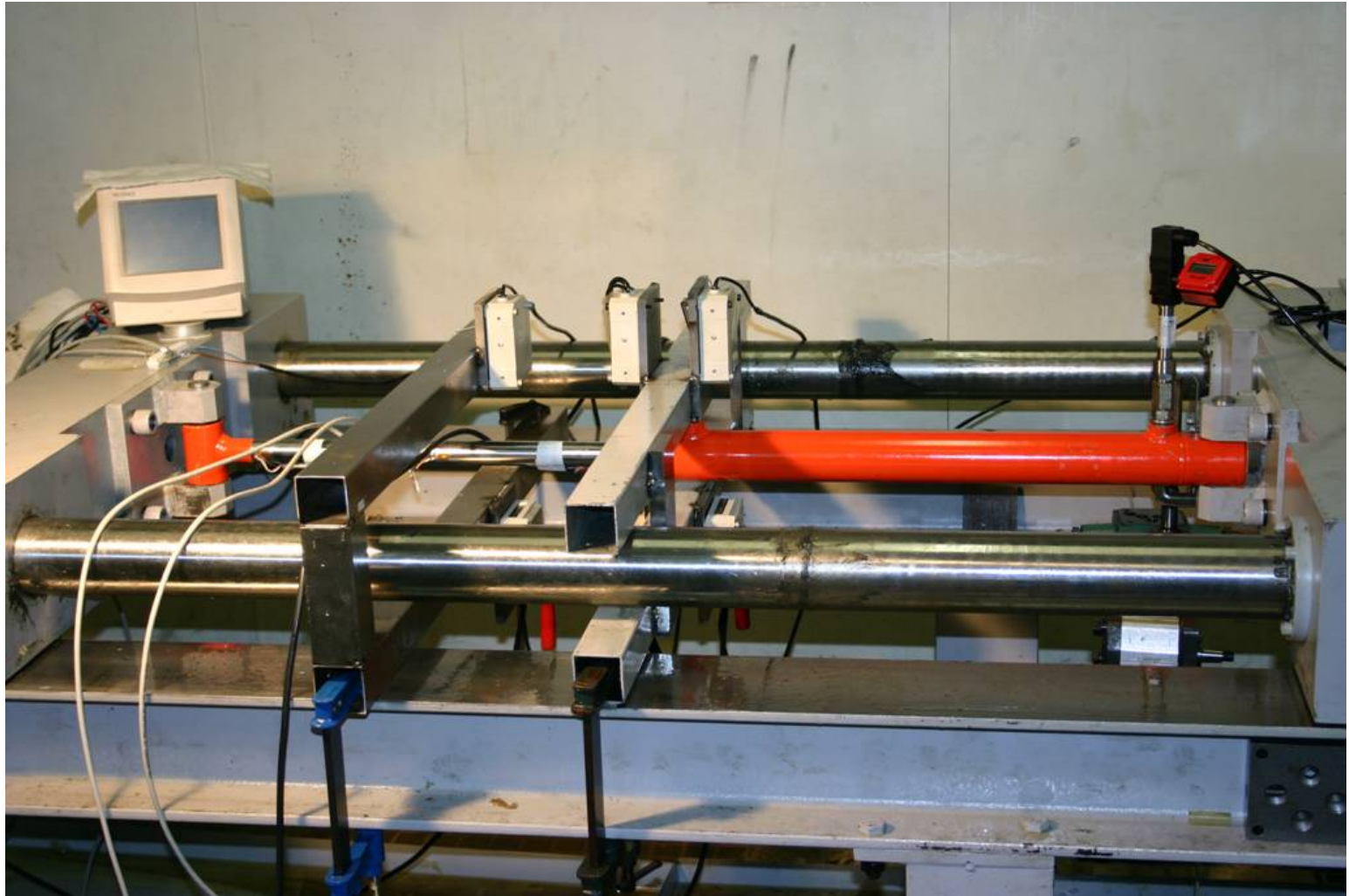
# ALTERNATIVE TEST BENCH



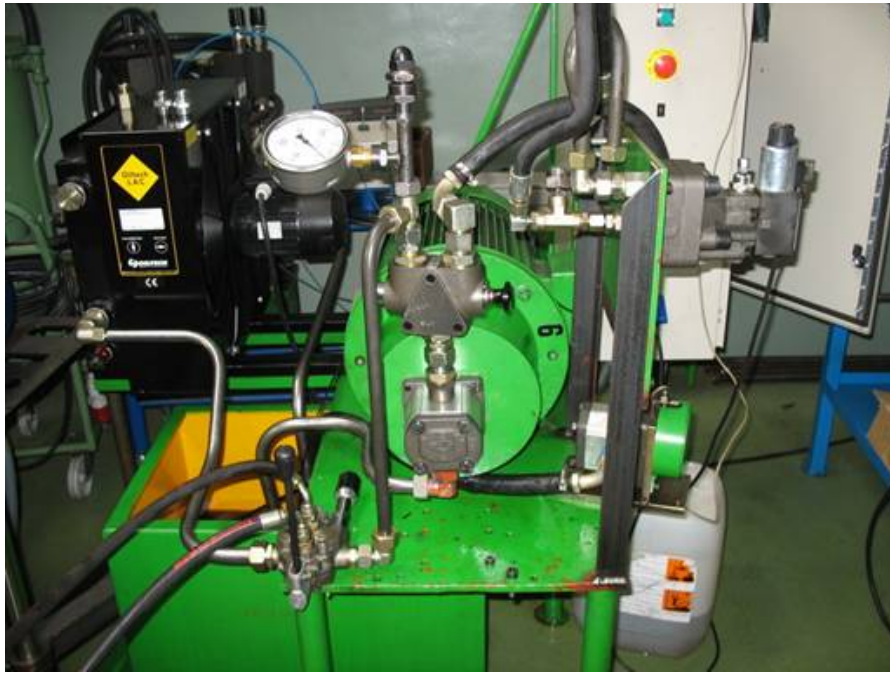
PEDRO ROQUET SA



# BUCKLING TEST BENCH



LABSON



CUSHIONING TEST BENCH



PEDRO ROQUET

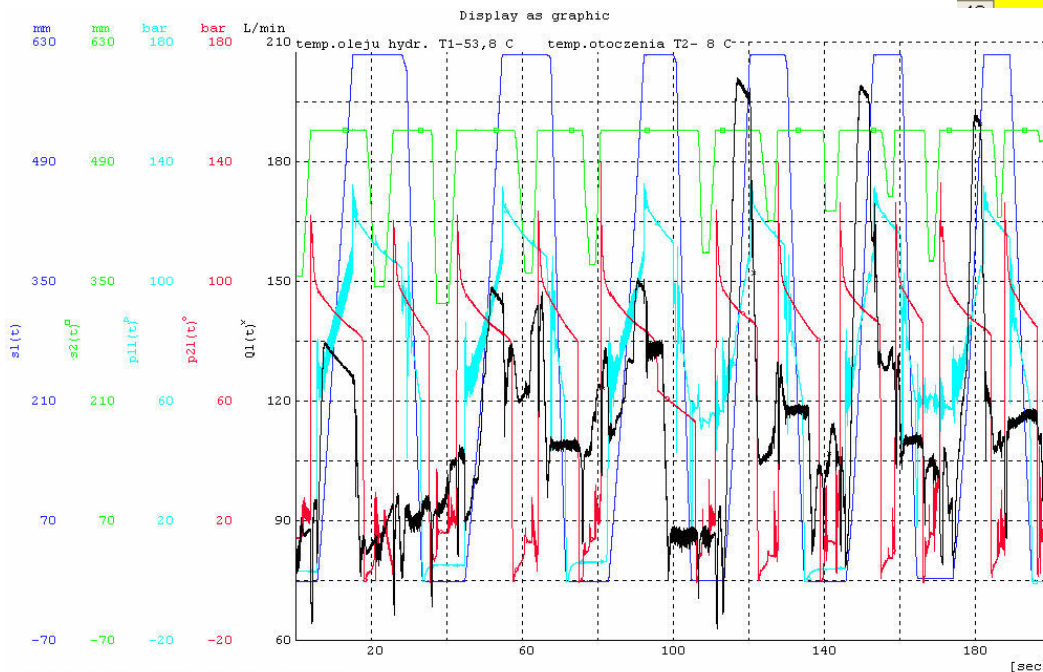


# ACQUIRED DATA

## Measured parameters:

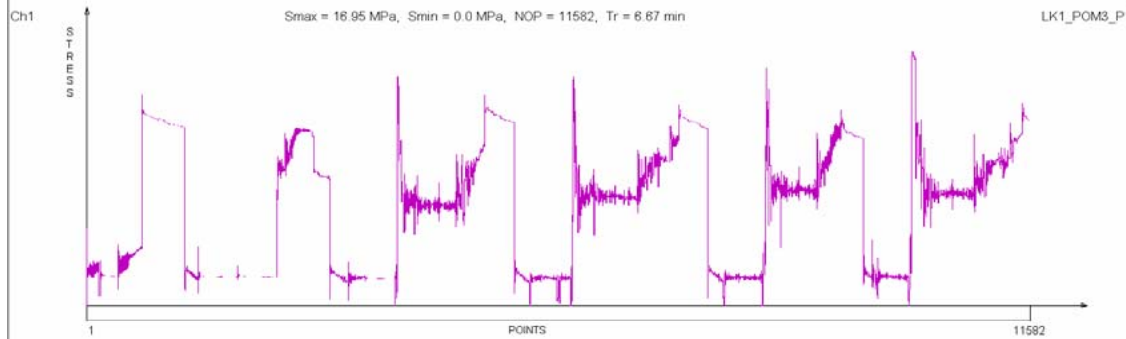
- Pressure in piston chamber
- Pressure in rod chamber
- Hydraulic oil temperature
- Ambient temperature
- Piston displacement
- Hydraulic oil cleanness
- Hydraulic oil flow

	A	B	C	D	E	F
1	<b>Several working cycles of mining loader LK1 with rated load</b>					
2	\Name of source file: 20060202_LK1_obciazniki_wysiegnik_8 <new>					
3	\Recording from 02_02_2006 16:02 POMIAR 8					
4	hydraulic oil temperature		T1= 45 C			
5	ambient temperature		T2= 8 C			
6	\Channels: 5					
7	\Scanning rate: 10 ms = 0,010 sec					
8	\Variable 1: s1(mm) displacement of boom cylinder's rod (left)					
9	\Variable 2: s3(mm) displacement of boom cylinder's rod (right)					
10	\Variable 3: p11(bar) pressure in piston chamber of boom cylinder (left)					
11	\Variable 4: p12(bar) pressure in rod chamber of boom cylinder (left)					
12	\Variable 5: Q1(L/min) oil flow					
13						
14	<b>t [s]</b>	<b>s1 [mm]</b>	<b>s3 [mm]</b>	<b>p11 [bar]</b>	<b>p12 [bar]</b>	<b>Q1 [L/min]</b>
15	0	0,292	-0,3	5,78	-0,612	80,438
16	0,01	0,292	-0,3	5,723	-0,612	79,981
17	0,02	0,292	0	5,665	-0,612	81,436
18	0,03	0,292	-0,3	5,723	-0,612	81,146
19	0,04	0,292	-0,3	5,723	-0,612	81,146
20	0,05	0,292	0	5,665	-0,612	81,064
21	0,06	0,292	0	5,78	-0,612	80,33
22	0,07	0,292	-0,3	5,723	-0,612	80,061
23	0,08	0,292	-0,3	5,723	-0,612	80,831
24	0,09	0,292	-0,3	5,723	-0,612	81,27
25	0,1	0,292	-0,3	5,723	-0,612	80,859
26	0,11	0,292	0	5,78	-0,612	80,859
27	0,12	0,292	0	5,665	-0,612	80,941
28	0,13	0,292	-0,3	5,78	-0,612	80,941
29	0,14	0,292	0	5,665	-0,612	80,195
30	0,15	0,292	0	5,723	-0,612	81,064
31	0,16	0,292	0	5,723	-0,612	80,424
32	0,17	0,292	-0,3	5,723	-0,612	80,424
33	0,18	0,292	-0,3	5,78	-0,612	81,298

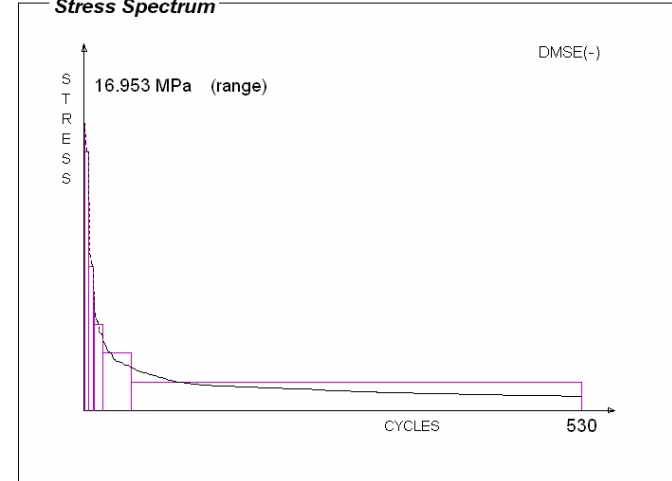


# LOAD SPECTRA

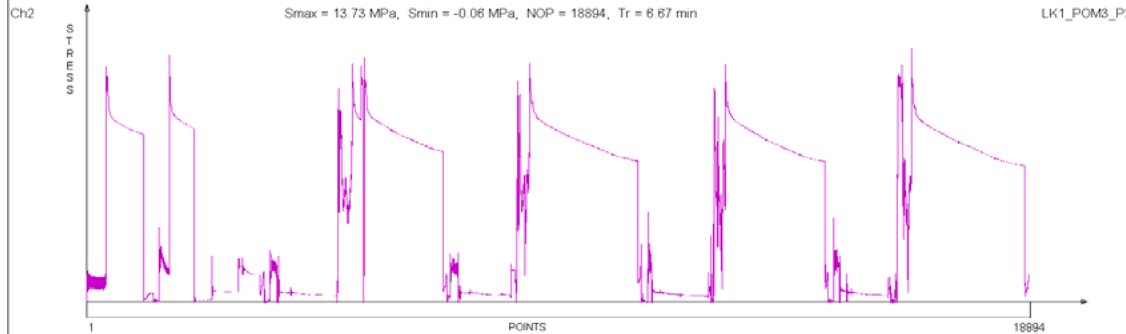
Stress History



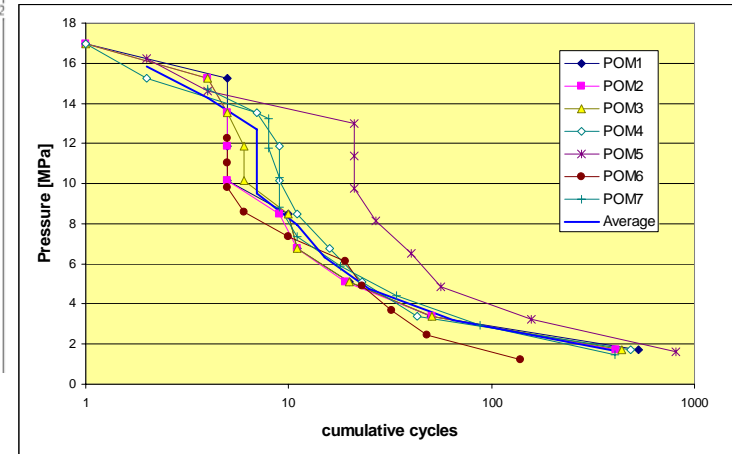
Stress Spectrum



Pressure spectra

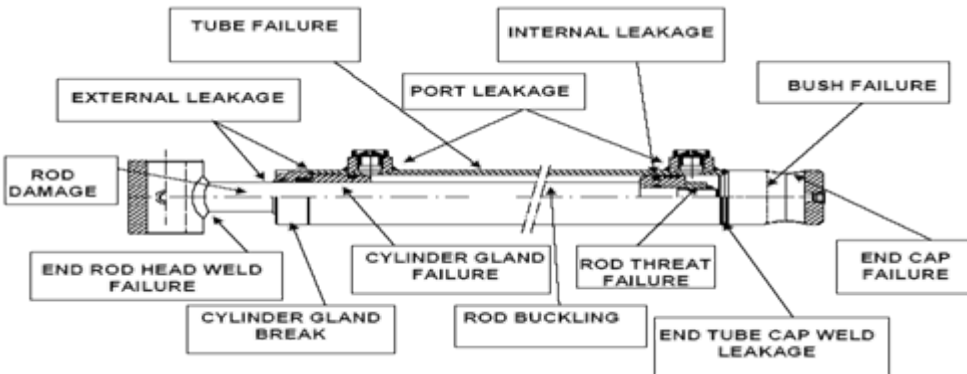


Pressure histories



Pressure spectra created for 7 measurements

# PRA analysis



Component	Failure Mode	Potential Effects	Potential Causes	Failure Prevention	Failure Detection	Failure Example
Piston rod	Red thread failure	- Rod thread failure - End rod head break - Cylinder malfunction	- Lack of wrong unscrew protection - Dynamic loads - Incorrect thread relief - Unsuitable thread profile tolerance - Overload	- Proper unscrew protection	- Screw joint clearance - Thread stripping	
End rod head	End rod head weld failure	- End rod head break - Working system damage	- Wrong cylinder selection - Inadequate technology of preparing surface to welding - Inadequate welding technology - Overload	- Appropriate technology of preparing surface to welding (heat treating, chamfering etc.) - Appropriate technology of welding - Proper weld class	- Cracked welds - End rod head break	

Component	Failure Mode	Potential Effects	Potential Causes	Failure Prevention	Failure Detection	Failure Example
Piston rod	Piston rod break	- Piston rod break - Working system damage - Cylinder drop - Load drop	- Wrong cylinder selection - Inadequate working system kinematics - Off axis loads - Stiffness of cylinder attachment - Insufficient greasing - Spherical bearing failure	- Larger cylinder with stronger piston rod - Improvement of working system kinematics - Use of articulated connection based on spherical bearing - Better lubrication	- Piston rod break - Cylinder blockage - Squashing during work	
Piston rod	Piston rod buckling	- Cylinder blockage - Cylinder malfunction	- Wrong cylinder selection - Inadequate working system kinematics - Overpressure from dynamic loads	- Larger cylinder with stronger piston rod - Improvement of working system kinematics	- Piston rod break - Cylinder blockage - Squashing during work	
Piston rod	Piston rod surface damage	- Rod rusted - Corrosion pits - External leakages - Quick seal damage	- Inadequate rod wear selection - Aggressive atmosphere - Thin chrome layer - Careless chromium cover	- Proper to working conditions and wear selection - Optimal layer thickness	- Piston rod break - Cylinder blockage - Squashing during work	

Component	Failure Mode	Potential Effects	Potential Causes	Failure Prevention	Failure Detection	Failure Example
Seals	External leakages	- Irregular operating system work - Load descends - External leakages	- Normal or abnormal seal wear - Seal damage - Wrong seal selection - Aggressive atmosphere - Harsh working conditions	- Proper to working conditions seal selection	- External leakages	
Seals	Internal leakages	- Load descends - Irregular operating system work	- Careless cleaning after machining - Wrong tube roughness - Metal impurities hydraulic system - Normal or abnormal seal - Wrong seal selection	- Careful cleaning after machining	- Load descends	

Component	Failure Mode	Potential Effects	Potential Causes	Failure Prevention	Failure Detection	Failure Example
Cylinder gland	Cylinder gland break	- Cylinder malfunction - Oil flowing out of the cylinder - Dynamic loads	- Wrong cylinder selection - Inadequate working system kinematics - Overpressure from dynamic loads	- Improvement of working system kinematics	- Piston rod break - Cylinder blockage - Squashing during work	
Cylinder gland	Cylinder gland failure	- Damaged piston rod - Damaged seals - External leakages	- Metal impurities in hydraulic system - Chromium particles from piston rods - Harsh working conditions	- Careful oil filtration	- External leakages	
End tube cap	End tube cap weld failure	- External leakages - Load drop - End tube cap break	- Wrong cylinder selection - Inadequate technology of preparing surface to welding - Inadequate welding technology - Overload	- Appropriate technology of preparing surface to welding (heat treating, chamfering) - Appropriate technology of welding	- Cracked welds - End tube cap break - External leakages	

(Extracted from PEDRO ROQUET S.A. report nr PROHPP-01-024-V01)

Loader problem	Potential effects	Potential causes	Failure prevention
Boom self lowering	- Bucket and boom lowering - Impossibility of holding the bucket in highest boom position	- Internal piston leakage, - Internal manipulator leakage, - Port leakage, - Pressure conduit failure	- Pressure check - Leakages elimination - Pressure conduits replacement
Boom drop	- Operating system damage - Cylinders damage - Pressure conduits damage	- Piston rods sealing damage	- Sealing replacement
Cracked boom welds	- Operating system damage - Cylinders damage	- Unsymmetrical bucket loads - Welding failure - Wrong cylinders selection	- Proper welding technology - Proper cylinders selection
Operating system malfunction (cylinder's bearing seize)	- Impossibility of correct work	- Cylinders bearing seize - Bearing sleeves damage - Joints break	- Proper lubrication - Overloads - Central lubrication system conduits check
Irregular loader work	- Impossibility of correct work - Quick joints wear - Oil carry-over	- End rod head stretch - Joints clearance - Careless machining of hydraulic cylinders sockets	- Quality improvement
Often loaders shutdown	- Low efficiency - Increased exploitation costs	- Quick seal wearing - Wrong seal selection - Mechanical cylinders damage	- Proper seal selection - Cylinders protective covers introduction

