Maintenance program in the cooling circuit. DW case

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Engineering Division

Computerized Maintenance Management Syst.

Software PRISMA 3

For the maintenance management the commercial software **PRISMA 3** has been selected as the adequate CMMS (Computerized Maintenance Management System). Functions:

3 Sections

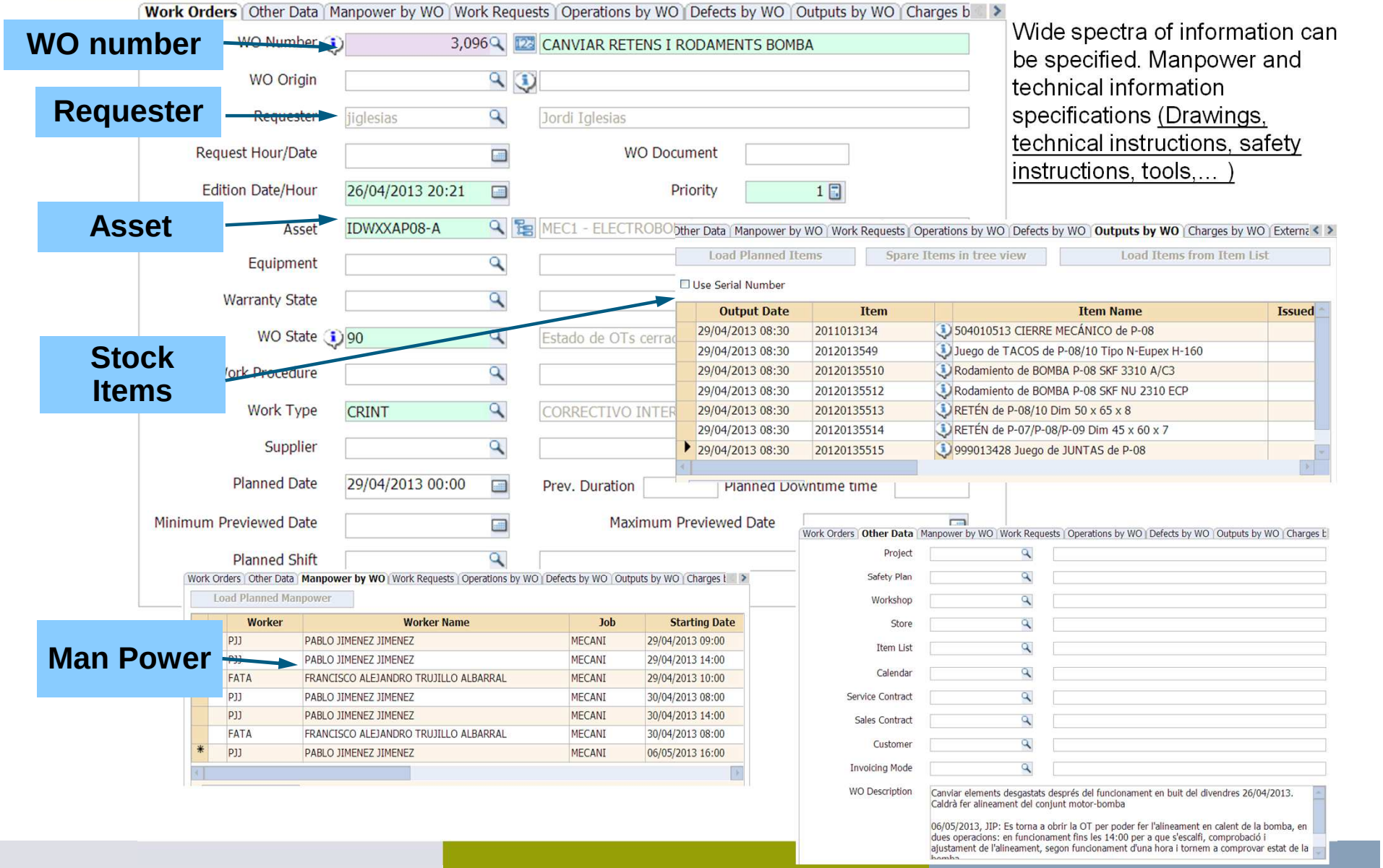
Customization
Parametrization
General Masters
Resources
Equipment
Maintenance Policy
Stocks
Purchases
Diagnosis
Energy Managment
Events, Indicators and Targets
Utilities

Operation
Resources
Equipment
Work Order
Preventive and Predictive
Sales Services
RCM
Capture and Dispatching
Stocks
Purchases
Prism@NET
Diagnosis
Energy Managment
Events, Indicators and Targets

Analysis
Resources
Equipment
Work Order
Preventive
Safety
External Services
Sales Services
Continuous Improvement
Stocks
Purchases
Diagnosis
Energy Managment
Events, Indicators and Targets
Utilities

Installation description implemented **in 6 levels**: **Facility, Building, Zone, Installation, Asset (main) and Element (part of Asset)**

Work Order Example



Wide spectra of information can be specified. Manpower and technical information specifications (Drawings, technical instructions, safety instructions, tools,…)

Work Procedure Example

Range Document: GABC example

Range code

Specialization

Tools

Regulation

LIBRO DE GAMAS

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Gama	GABC	GAMA ANUAL BATERIA CONDENSADORES	
Fecha Últ.Modif.	04/03/13 15:50	Tiempo Parada Previsto	1:30

Oficios

Oficio	Nº Operarios Previstos	Tiempo Previsto
ELECTR - ESPECIALISTA ELECTRICISTA	1	1:30

Herramientas

Herramienta	Tpo.Feedback Herram.
01 - CASCO / GORRA DE SEGURIDAD	1:30
02 - TAPONES	1:30
03 - GAFAS DE PROTECCIÓN	1:30
04 - MASCARILLA HOMOLOGADA	1:30
05 - GUANTES DE TRABAJO MECANICO/ELECTRICO	1:30
20 - CÁMARA TERMOGRÁFICA	1:30

Normas

Norma

NPSEGUR - NORMA SEGURIDAD EPIS

EPI's obligatorias para realizar el trabajo: 1.Casco/Gorra de Seguridad, 2. Tapones, 3. Gafas de Protección, 4. Mascarilla antipolvo, 5. Guantes de trabajo Mecánico/Eléctrico

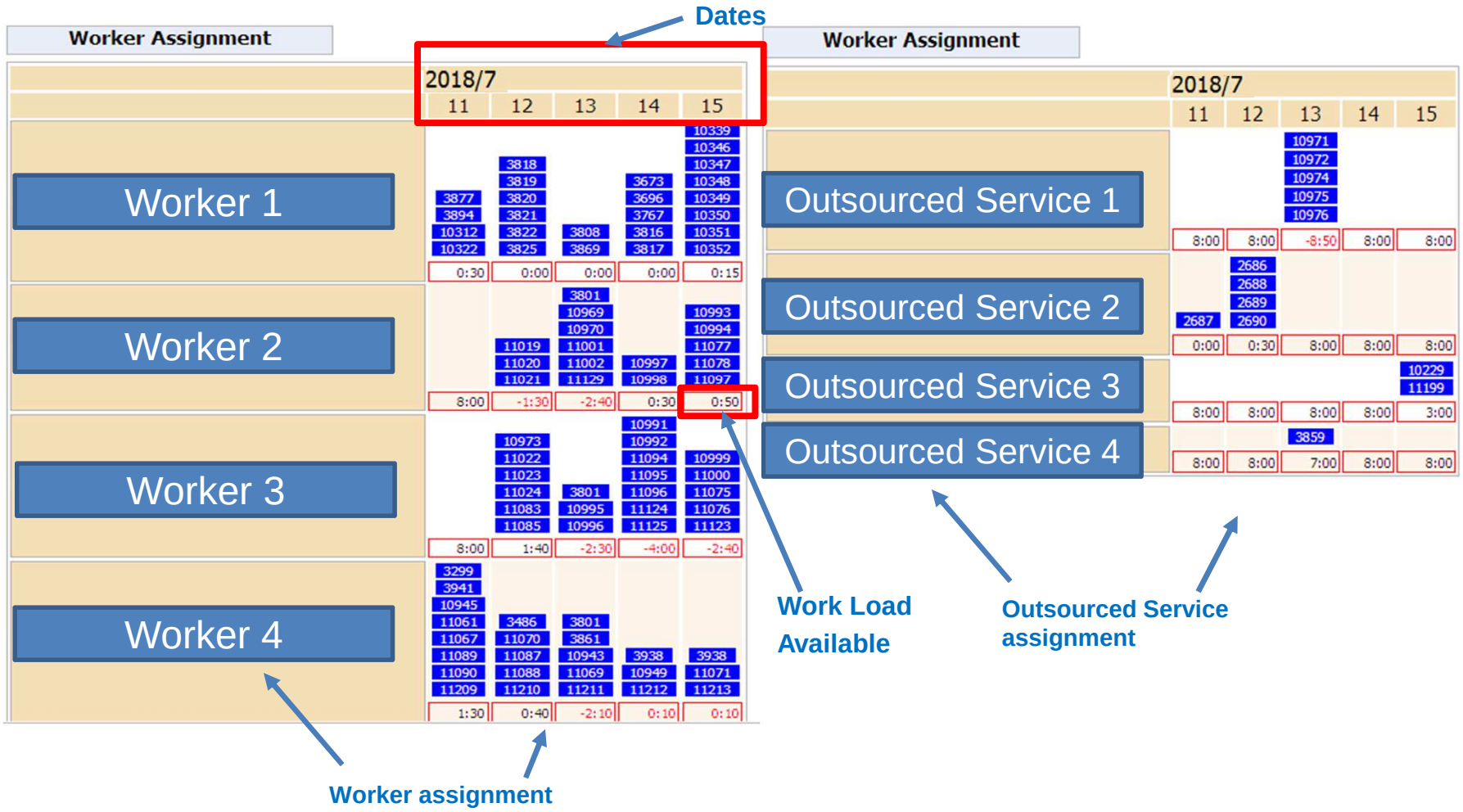
NPABC - NORMA PREVENTIVA ANUAL BATERÍA CONDENSAD

01.- Rellenar la tabla de mediciones adjunta.
02.- Revisar que no existe nivel de polución interno en la batería, manteniendo limpios los bornes y aisladores de los condensadores.
03.- Comprobar el correcto funcionamiento de todos los condensadores y revisar su consumo.
04.- Comprobar que los contactores realizan las maniobras de forma correcta.
05.- Revisar los elementos de protección.
06.- Efectuar reapriete de conexiones y realizar termografía.
07.- Comprobación de la correcta compensación del cos-fi.

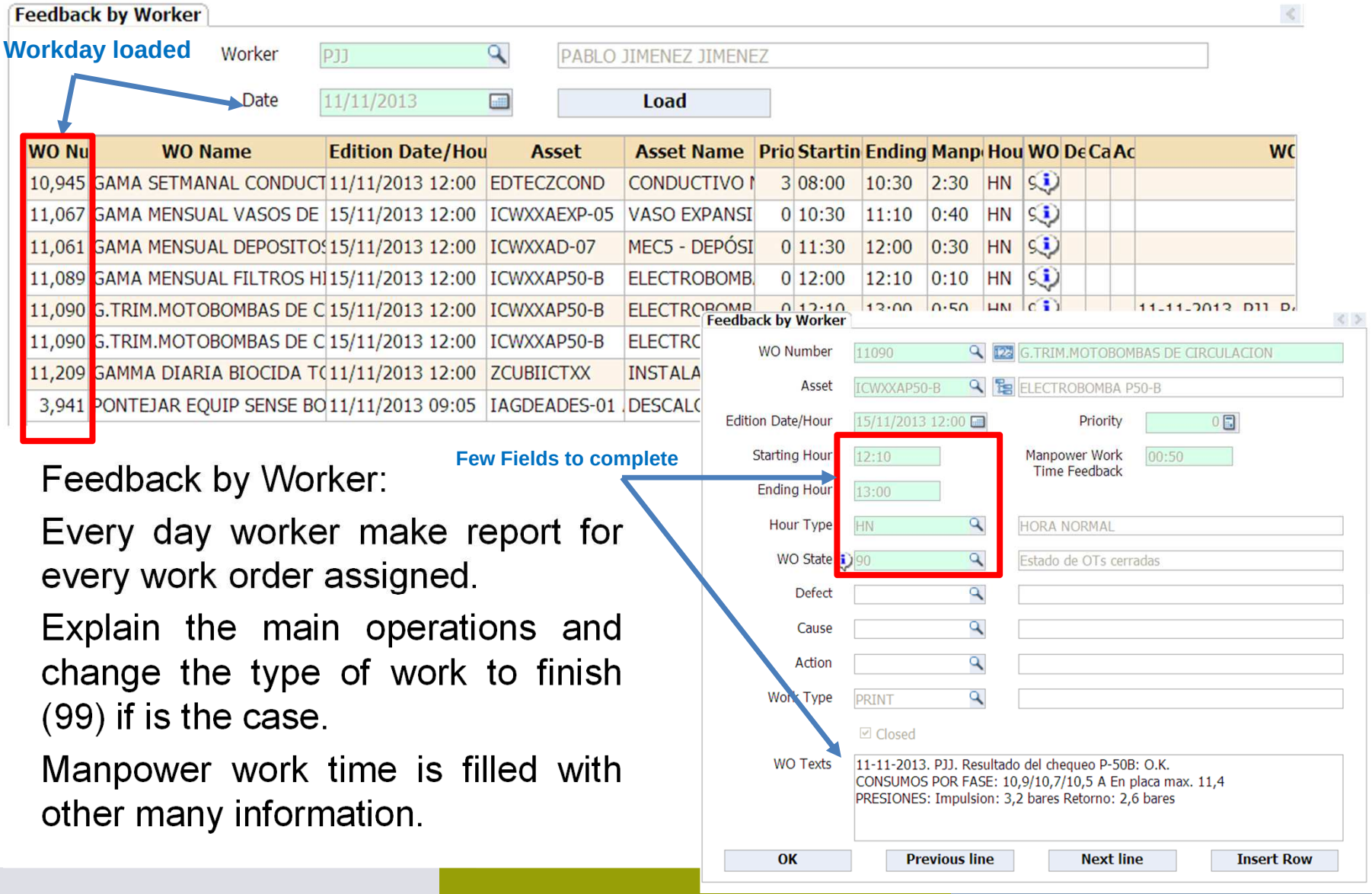
Work Order generated by schedule

(Preventive and Corrective Maintenance)

Internal and Outsourced services schedule



Work order feedback tool



Feedback by Worker:

Every day worker make report for every work order assigned.

Explain the main operations and change the type of work to finish (99) if is the case.

Manpower work time is filled with other many information.

Work Order Measurement

Work Procedure Book Page 1/1

Work Procedure	GDBIOTOR	GAMMA DIARIA BIOCIDA TORRES	
Last Modification Date	08/11/12 17:42	Planned Downtime	0:10

Jobs

Job	Planned Worker Num.	Planned Time
MECANI - ESPECIALISTA MECANICO	1	0:10

Tools

Tool	Tool Feedback Type
01 - CASCO / GORRA DE SEGURIDAD	0:10
02 - TAPONES	0:10
03 - GAFAS DE PROTECCIÓN	0:10
04 - MASCARILLA HOMOLOGADA	0:10
05 - GUANTES DE TRABAJO MECANICO/ELECTRICO	0:10

Operations

Operation
NDCTBIOC - NORMA BIOCIDA TORRES

S'ha de prendre una mostra de 10 ml d'aigua del circuit de torres, en concret, del punt de purga de la torre A i analitzar-la segons el mètode DPD. El valor de residual de biocida ha d'estar entre 0,5 i 2 ppm's.

En cas que el nivell de residual de brom estigui més alt que 2 ppm's, caldrà baixar la dosificació de producte o parar les dues bombes dosificadores dels bidons DO-01A i DO-02A, fins que el nivell de residual baixi fins a l'interval anterior.

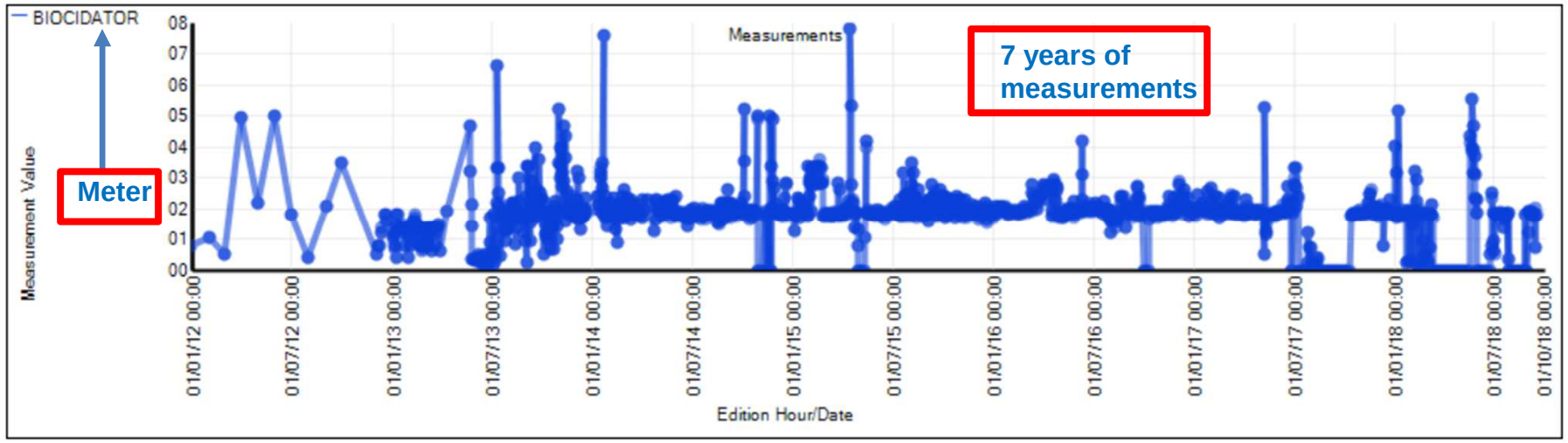
En cas que estigui per sota d'aquest nivell, caldrà revisar que la bomba dosificadora estigui funcionant correctament i que els bidons de biocida tenen producte químic.

Quan quedi poc producte químic, s'haurà d'avisar a Infraestrucutres per a reposar el producte que falti.

Work order is generated to measure criticals points in the installation. That are not yet automated.

Ex.: Operation to adquired the data.

More tha 8300 measures (with many meters) in differents equipments was done.



Work Order generated by indicator

Assets Work Procedure | Other Data | Permissions | Hazards | Preventive Actions | Skills | Documents | Queries

Asset	ICWXXAE06A	INTERCAMBIADOR DE PLACAS E06A	
Equipment			
Work Procedure	GINTSEC	GAMA INTERCAMBIADOR LIMPIEZA SECUNDARIO	
Interval Type	Meter Level	Check Equipment Measurer / F_ISEQUIPMENTPREVENTIVE	
Sequence	Entry	Priority	3
Measurer Type	SECDIF	MEDIDOR PRESIÓN DIFERENCIAL SECUNDARIO	
Starting Date	05/03/2013	Intial Measurement Value	0
Measurer Interval		Launch WO with Interval	
Tolerance -	0	Tolerance +	360
Min.Num.Days		Max.Num.Days	
Lower Limit	0	Upper Limit	0.54
Excluded Days	☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☑ Saturday ☑ Sunday		
Calendar			
Preventive Plan			
Last Modification Date	05/03/2013 01:27	Planned Tasks	

Measurer

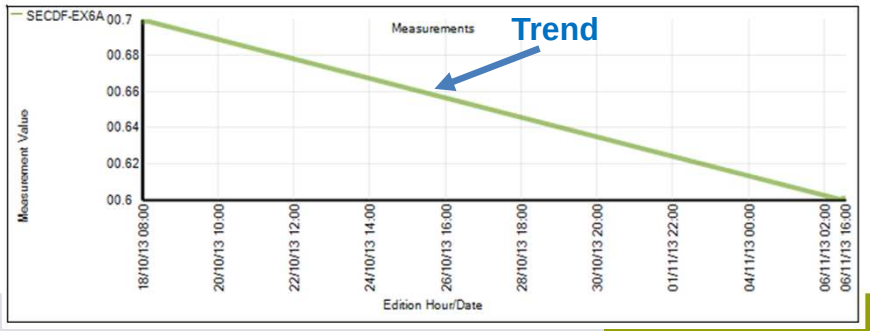
Inictial Value (if was necesary)

Value to trigger Work Order

Work order generated by indicator:

Planning launch work order to clean exchanger secondary side.

Differential pressure 0.60 bar > 0.54 bar, cleaning is required



Preventive Calendar

Asset	ICWXXAE06A	INTERCAMBIADOR DE PLACAS E06A
Equipment		
Work Procedure	GINTSEC	GAMA INTERCAMBIADOR LIMPIEZA SECUNDARIO
	☐ F_ISEQUIPMENTPREVENTIVE	
From Date	11/11/2013	
	Load	

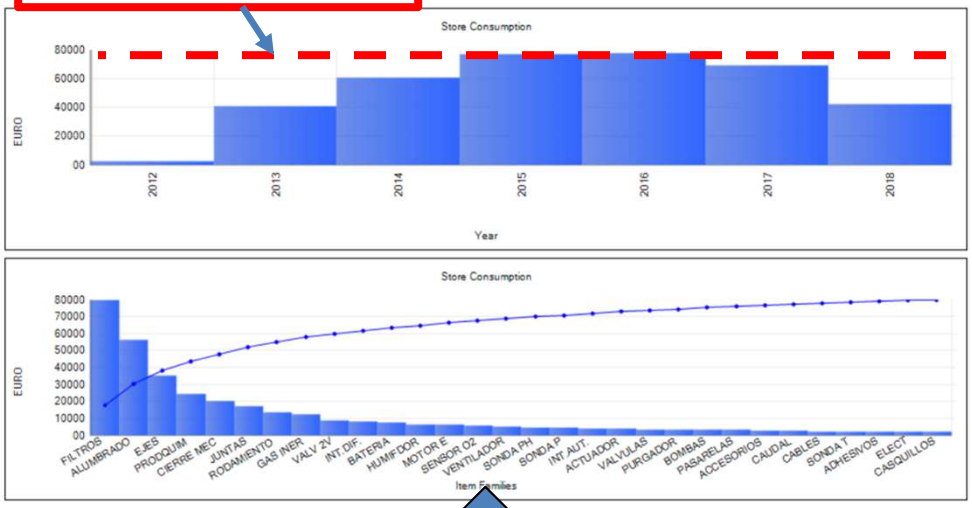
Predicted date

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	3
2013/11																															
2013/12																															

Spare parts

Managed by Prisma3 (CMMS).

Around 80.000 €/ last years



Take Item and WO register

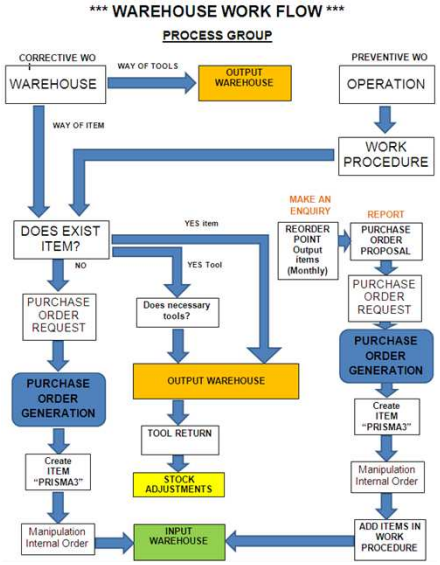
Spare parts Main Information (2013-2018):

Different Families: **1.849** (bearings, filters, screw, seals, etc)

Quantity of items: **24.310**

StoreShelf (positions): 3.666

StockMov: 15.920



Stocks Work Flow

Maintenance Key figures

A total of 3830 Assets

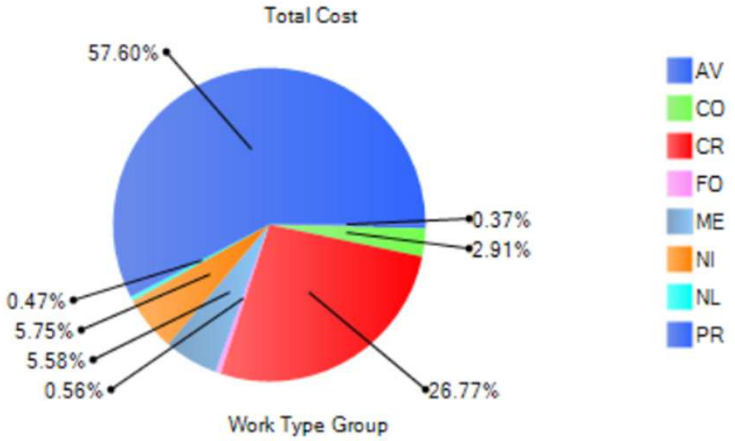
Assets: 3800

Preventive Work Order:	**49.909**
Corrective Work Order:	**13.885**
Total Work Orders:	**63.794**
Planning Task simulated:	**183.401**

Number of Measurements performed: 8.321 (assets measure)

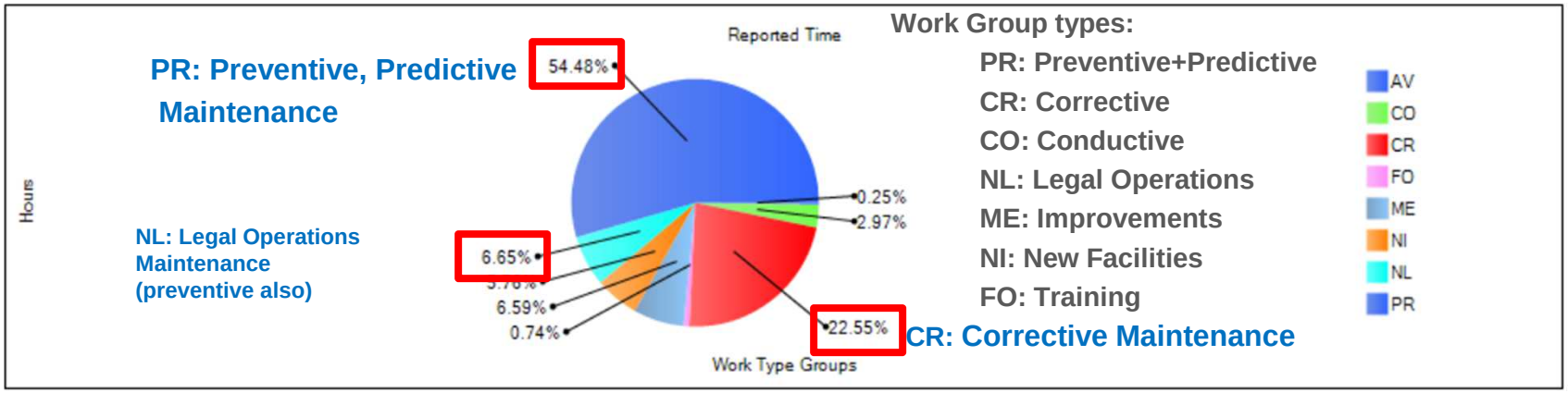
Since launched application, (2012)

Work Type Group



Work Type Reported Graphic (time)

All figures are since we launched application, (gen-2012)



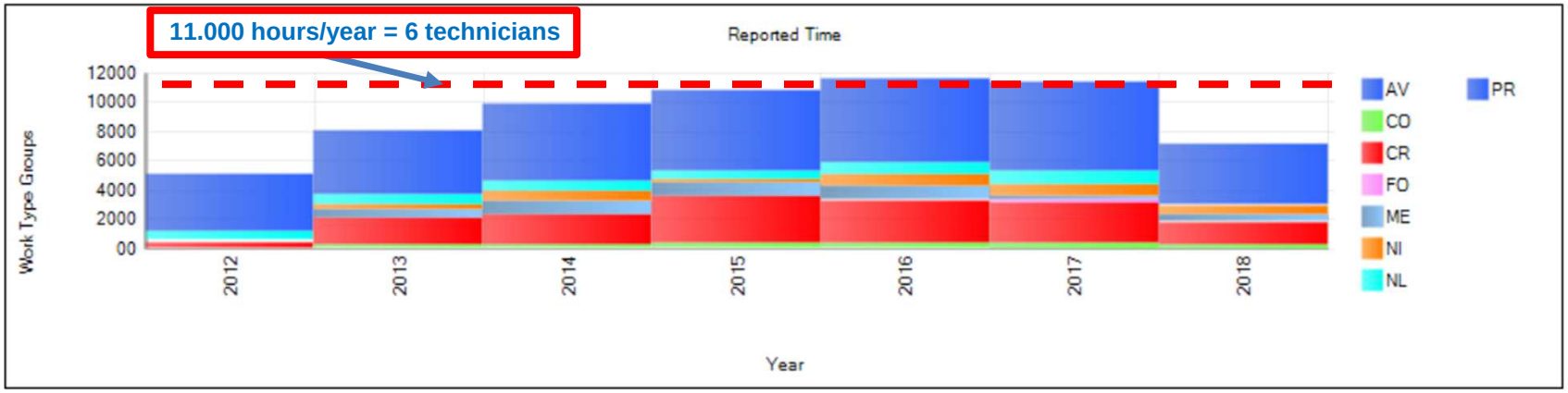
PR: Preventive, Predictive Maintenance

NL: Legal Operations Maintenance (preventive also)

Work Group types:

- **PR: Preventive+Predictive**
- **CR: Corrective**
- **CO: Conductive**
- **NL: Legal Operations**
- **ME: Improvements**
- **NI: New Facilities**
- **FO: Training**

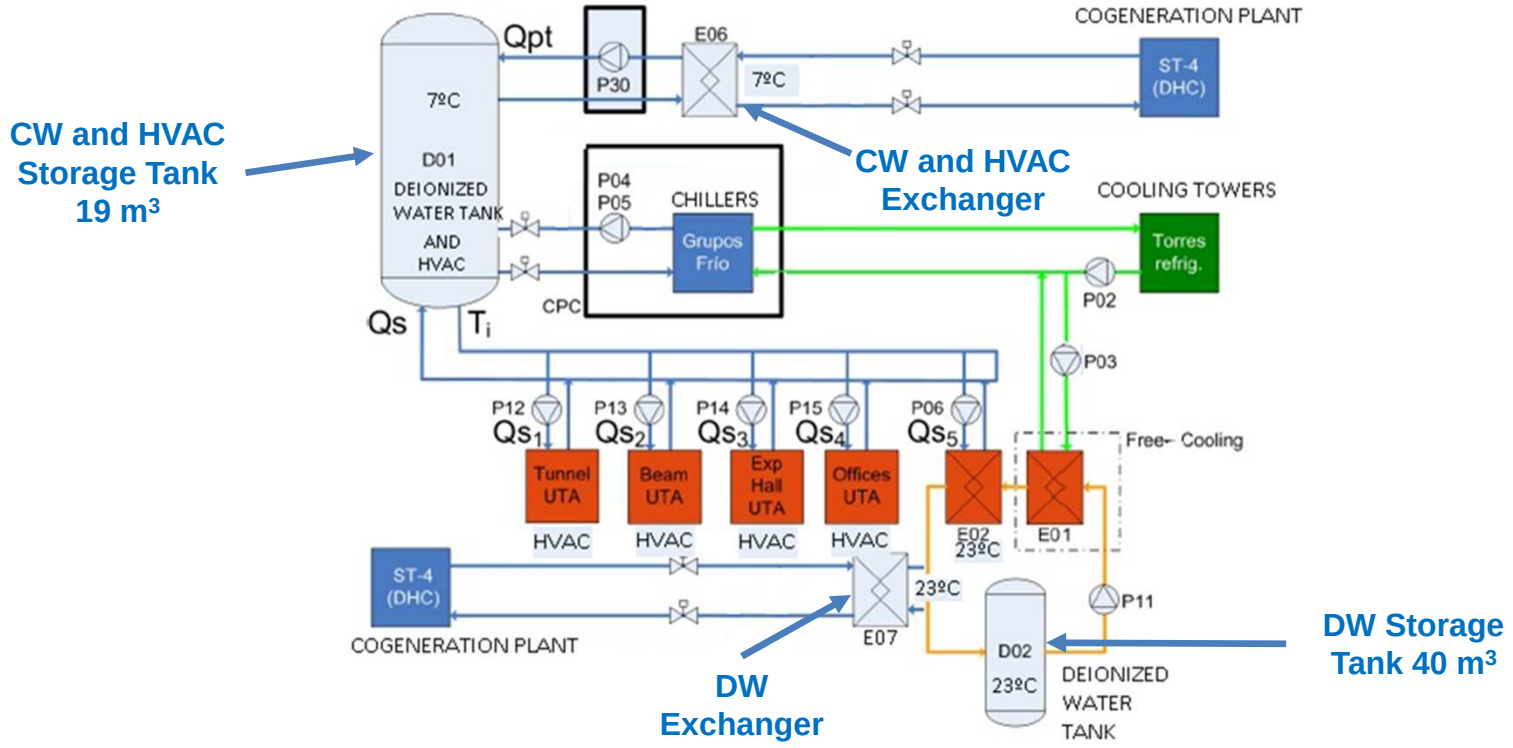
CR: Corrective Maintenance



Water Cooling Systems Pumps

Water Cooling Systems and Distribution (4 circuits)

1. Hot water at 50±0,5ºC used for comfort air conditioning.
2. Cold Water at 7±0,5ºC, used mainly for HVAC (air conditioning) and cooling
3. Deionized water at 23±0,2ºC, to refrigerate science equipment's and accelerator rings.
4. Cooling towers for chillers and Free-Cooling.



Water Pumps

Some pumps pictures from differents areas

Deionized Water Pumps 23ºC

Hot Water Pumps 50ºC

64 Main Pumps of different sizes

Cooling Tower Water Pumps 25ºC

Cooling Production Water Pumps 7ºC

HVAC and Cooling Water Pumps 7ºC

Pumps Predictive Maintenance

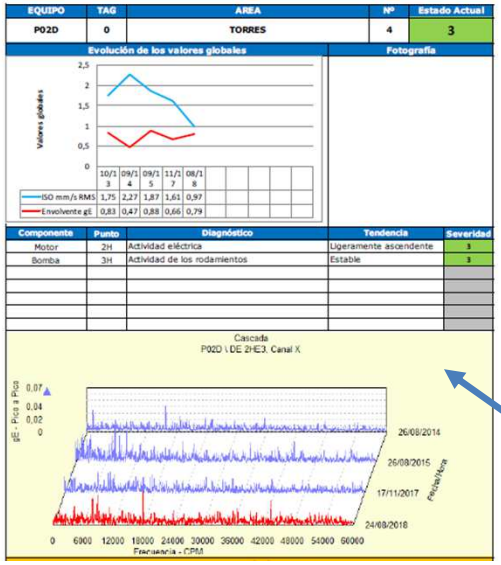
Reference Standard Severity ISO 10816

Severity		Range Limits and Machine Classes ISO Standard 10816-3 (2009)				Severity	
r.m.s. displacement µm	r.m.s. velocity mm/s	Group 2: Medium Sized Machines		Group 1: Large machines		r.m.s. velocity mm	r.m.s. displacement µm
		Rigid	Flexible	Rigid	Flexible		
22	1,4	A	A	A	A		
37	2,3					2,3	29
45	2,8	B	B	B		3,5	46
71	4,5	C			B	4,5	57
113	7,1		C	C		7,1	90
		D	D	D	C	11,0	140
					D		

Acceleration

Displacement, Velocity

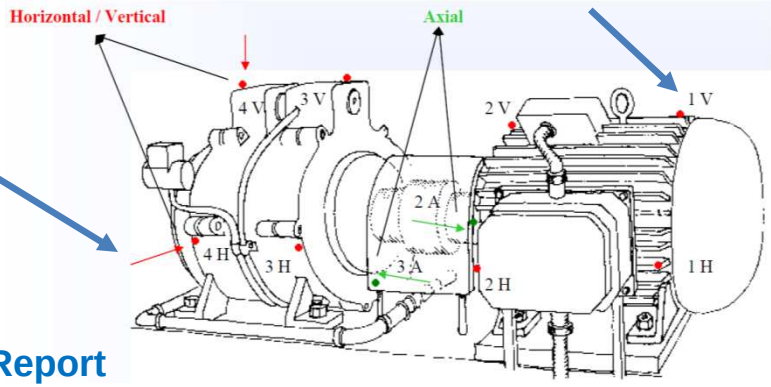
Severidad de vibración (gE's)		Velocidad y diámetros de ejes REF SKF 2372-1974		
Frecuencia Máxima		200 & 500 mm	50 & 300 mm	20 & 150 mm
500 Hz	1.000 Hz	< 500 rpm	500 & 1800 rpm	1800 & 3600 rpm
0,075	0,1	Bueno	Bueno	Bueno
0,35	0,5			
0,55	0,75	Satisfactorio		
0,75	1		Satisfactorio	
1,5	2	Insatisfactorio (alerta)		Satisfactorio
3,5	4	Inaceptable (peligro)	Insatisfactorio (alerta)	
7,5	10		Inaceptable (peligro)	Insatisfactorio (alerta)
> 7,5	> 10			Inaceptable (peligro)



Data collection at 10 Points of measure:

Horizontal, Vertical Axial in each pump

Position of accelerometers

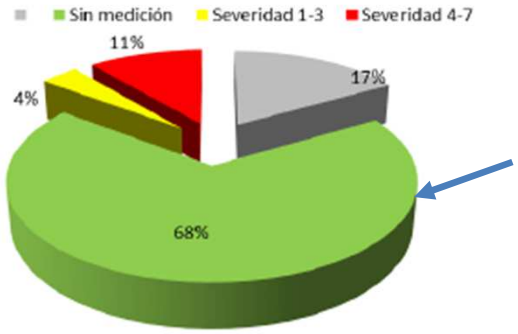


Vibration Analysis Report

Pumps Predictive Maintenance

Results Pumps Vibration Analysis

Measurement on more than 60 Pumps

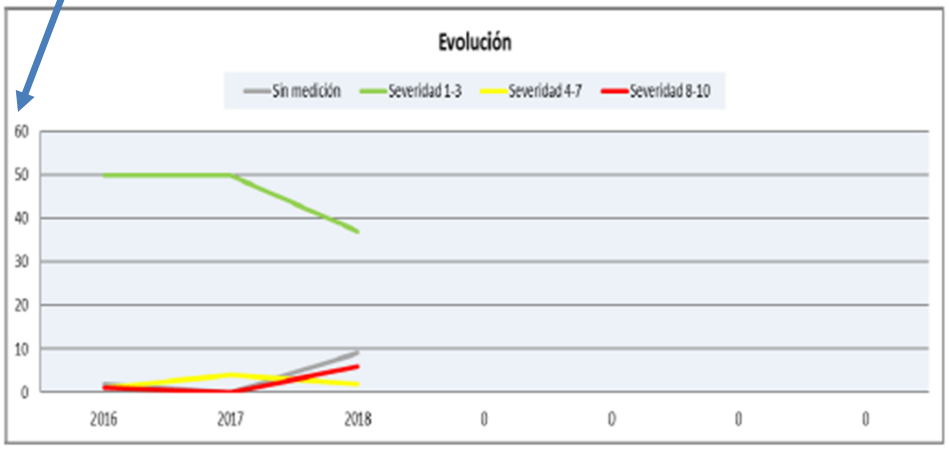


Number of measure Pumps

Degree of Severity:

Red: Bad

Green: Good



Report of 6 years of measures

EQUIPO	AREA	2013 OCT	2014 SEP	2015 SEP	2016 SEP	2017 AGO	2018 AGO
P02A	TORRES	3	3	3	3	3	3
P02B	TORRES	3	3	3	3	3	8
P02C	TORRES	3		3	3	3	3
P02D	TORRES	3	3	3		3	3
P02E	TORRES	3	3	3	3	6	8
P02F	TORRES	3	3	3	3	5	8
P02G	TORRES	3	6	3	3	3	
P02H	TORRES	3	3	3	3	3	8
P03A	INTER TORRES	3	3	3	3	3	
P03B	INTER TORRES	3	8	8	3	3	
P03C	INTER TORRES		3	3	3	3	
P04A	TURBO COMPRESORES	3	3	3	3	3	3
P04B	TURBO COMPRESORES	3	3	3	3	3	3
P04C	TURBO COMPRESORES	3	3	3	3	3	8
P04D	TURBO COMPRESORES	3	3	3		3	3
P04E	TURBO COMPRESORES	3	3	3	3	3	3
P04F	TURBO COMPRESORES	3	3	3	3	3	3
P05A	GRUPO FRED CARGOL	3	3	3	3	3	3
P05B	GRUPO FRED CARGOL	3		3	3	3	8
P05C	GRUPO FRED CARGOL	3	3	3	3	3	3
P05D	GRUPO FRED CARGOL	3	3	3	3	3	3
P06A	DESIONITIZADAS	3	3	3	3	3	3
P06B	DESIONITIZADAS	3	3	3	3	3	3
P06C	DESIONITIZADAS	3	3	3	3	3	3
P12A	UTA'S TUNEL	3	3	3	3	3	3
P12B	UTA'S TUNEL	3	3	3	3	3	3
P14A	UTA'S EXP	3	3	3	3	7	3
P14B	UTA'S EXP	3	3	3	3	3	3
P15A	UTA'S LABS OFF	3	3	3	3	6	3
P15B	UTA'S LABS OFF	3	3	3	8	3	3
P15C	UTA'S LABS OFF	3	3	8	3	3	3
P16A	CIRCUITO PRIMARIO CALDERA	3	3	3	3	3	3
P16B	CIRCUITO PRIMARIO CALDERA	3	3	3	3	3	3
P16C	CIRCUITO PRIMARIO CALDERA	3	3	3	3	3	
P16D	CIRCUITO PRIMARIO CALDERA	3	3	3	3	3	3
.							
.							
.							
P52	AGUA DEIONITZADA			3	3	3	
P50A	FRED EMERGENCIA			3	3	3	7
P50B	FRED EMERGENCIA			3	3	3	3

Equipment type cost

Major costs by type of equipment:

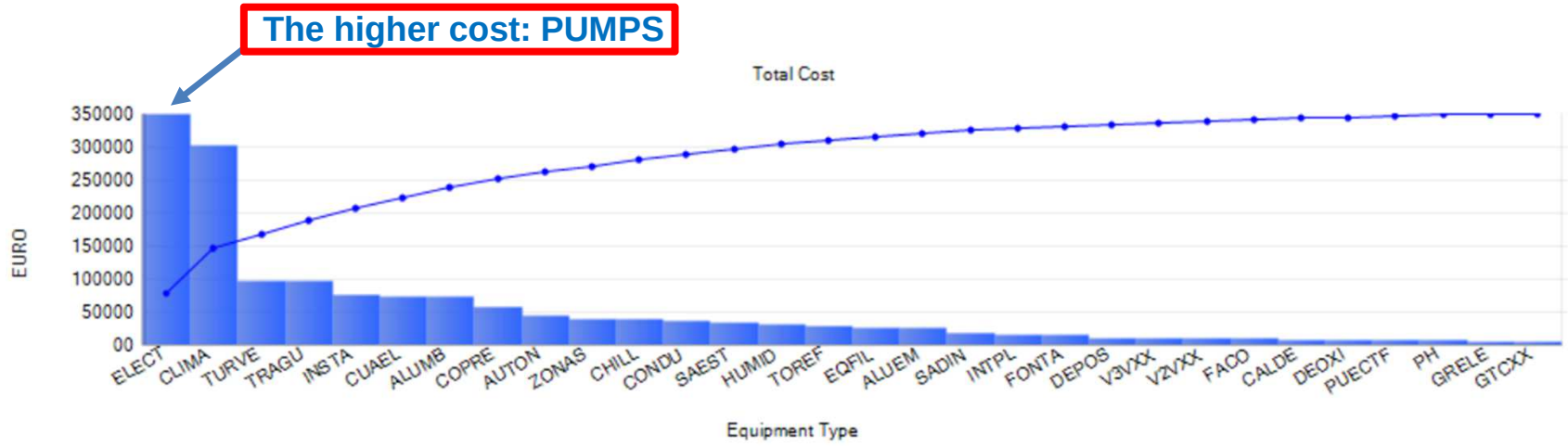
ELECT: Electric Motor and Pump

CLIMA: Heat, Ventilation and Air Conditioning, HVAC

TURVE: Turbine Extraction and Impulsion

TRAGU: Water treatments

etc…



Deionized Water Pumps Case

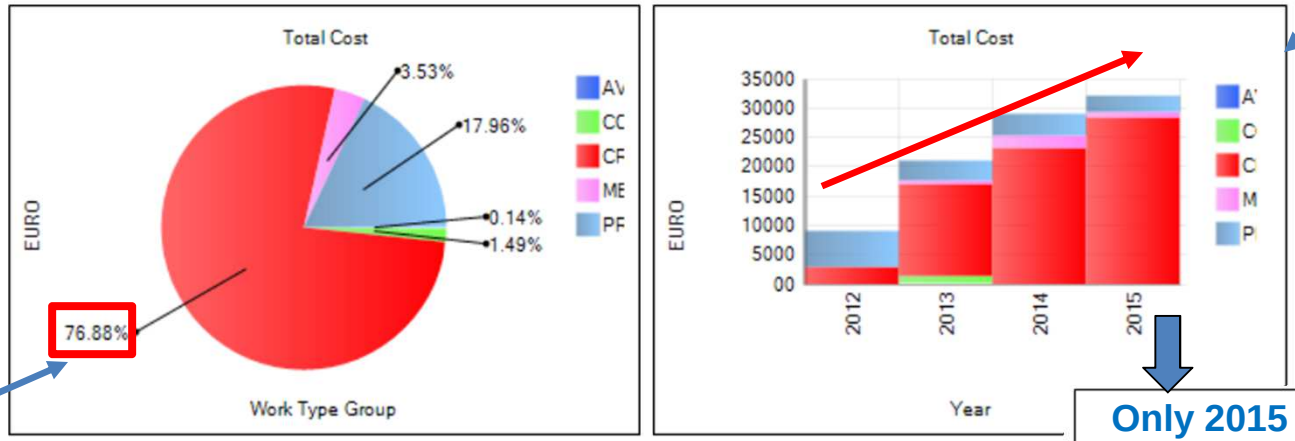
12 Deionized water pumps

1. Service Area: 3 Pumps (2 working + 1 backup)
2. Booster Ring: 2 Pumps (1 working + 1 backup)
3. Storage Ring: 3 Pumps (2 working + 1 backup)
4. Experimental Hall: 2 Pumps (1 working + 1 backup)

Deionized Water Pumps Case

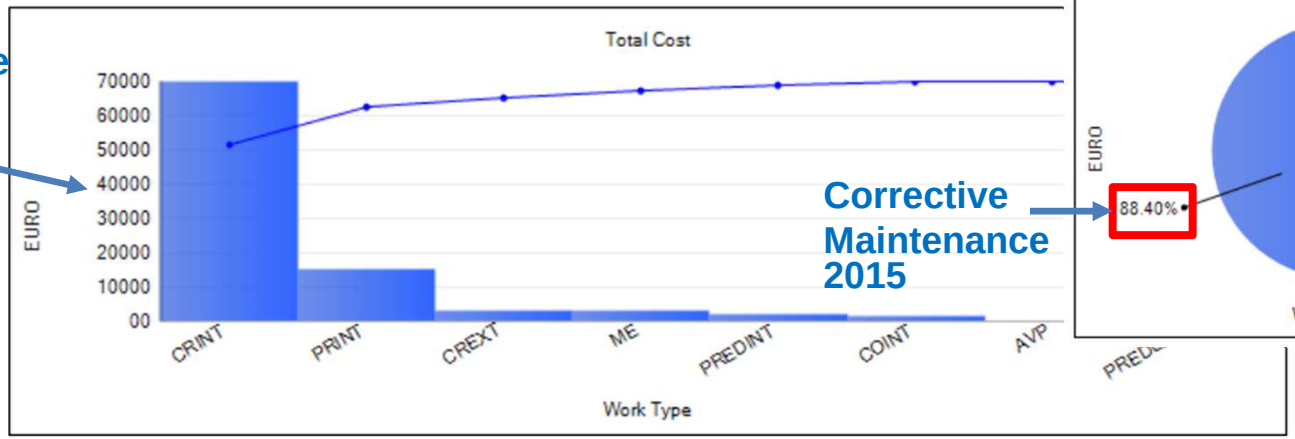
Maintenance Cost (only in 12 Deionized Water Pumps)

The maintenance costs were growing until 2015

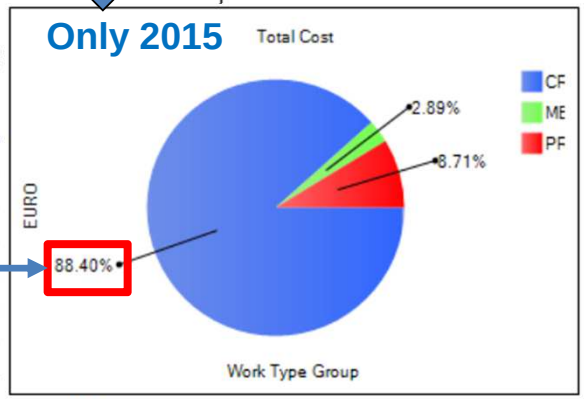


¡We had a problem with DW Pumps!

Corrective Maintenance 2012-2018



Only 2015



Corrective Maintenance 2015

¡Too much recurrent unexpected reparations!

Deionized Water Pumps Case

Meanwhile the time between repairs was decreasing

¡Yes, we had a problem with DW Pumps!

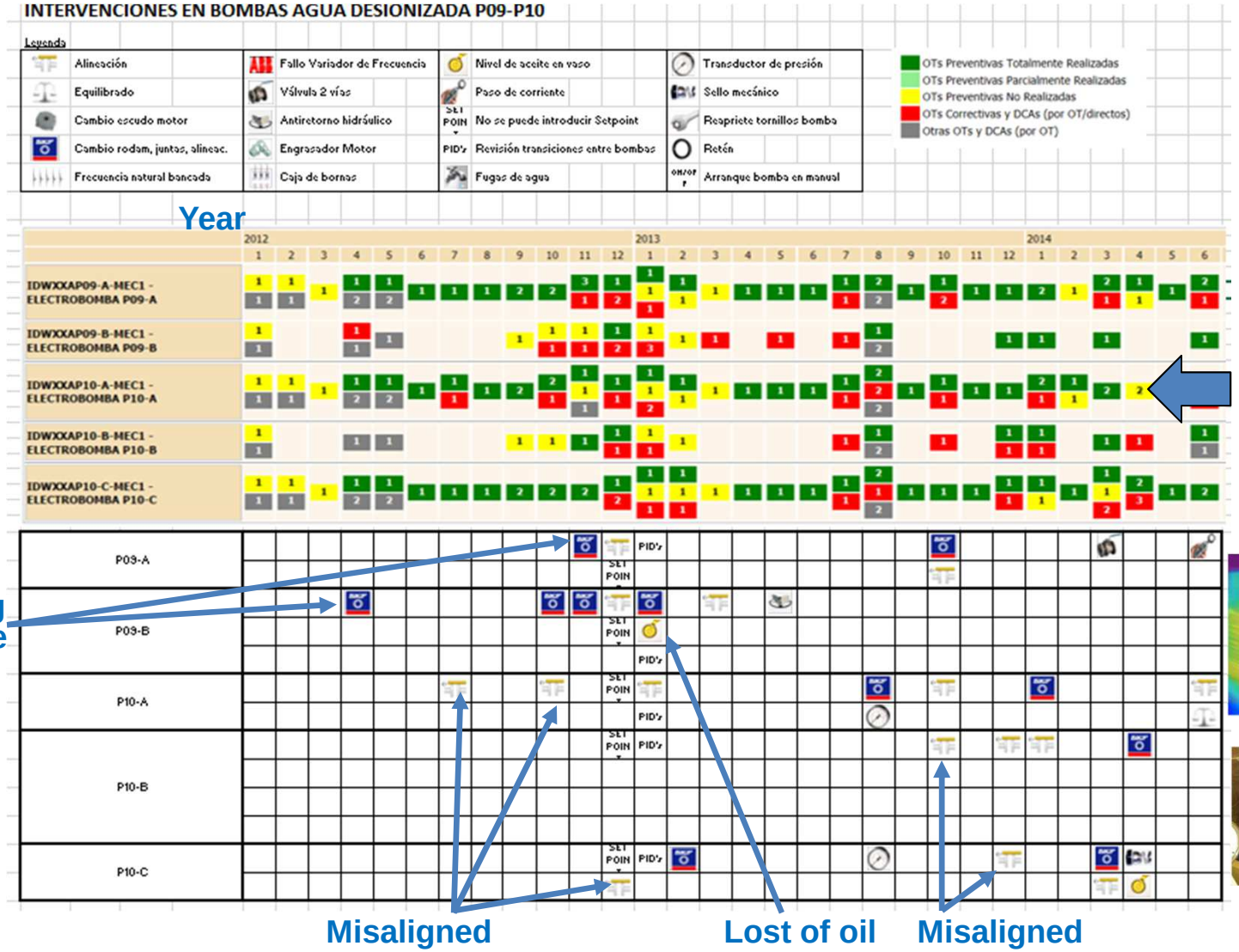
Only 2-3 months between big repairs!!!

MTBF by days

Asset	WO Number	MTBF
AP08-AEBOMB - BOMBA HIDRÁULICA P08A	1	547.50
ICWXXAP13-A - MEC1 - ELECTROBOMBA P13-A	3	273.75
IDWXXAP07-A - MEC1 - ELECTROBOMBA P07-A	12	84.23
IDWXXAP07-B - MEC1 - ELECTROBOMBA P07-B	4	219.00
IDWXXAP08-A - MEC1 - ELECTROBOMBA P08-A 7114747	10	99.55
IDWXXAP08-B - MEC1 - ELECTROBOMBA P08-B 7114739	18	57.63
IDWXXAP08-C - MEC1 - ELECTROBOMBA P08-C 7114754	16	64.41
IDWXXAP09-A - MEC1 - ELECTROBOMBA P09-A	6	156.43
IDWXXAP09-B - MEC1 - ELECTROBOMBA P09-B	9	109.50
IDWXXAP10-A - MEC1 - ELECTROBOMBA P10-A	17	60.83
IDWXXAP10-B - MEC1 - ELECTROBOMBA P10-B	11	91.25
IDWXXAP10-C - MEC1 - ELECTROBOMBA P10-C	11	91.25
IDWXXAP11-A - MEC1 - ELECTROBOMBA P11-A	7	136.88
IDWXXAP11-B - MEC1 - ELECTROBOMBA P11-B	7	136.88

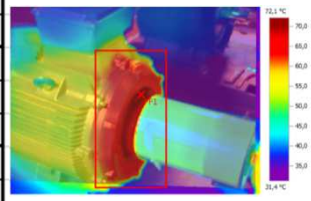
Deionized Water Pumps Case

Differents Problems:



Many and repetitive problems

CMMS: Prisma3, allowed us to analyze, identify and categorize the problems



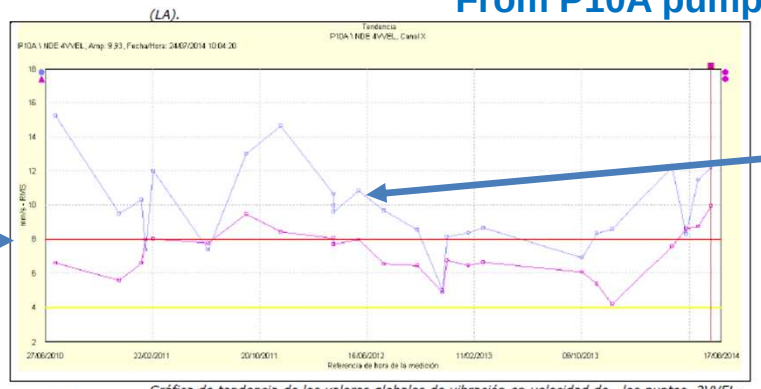
Deionized Water Pumps Case

The diagnosis and more questions:

1. Predictive Analysis: Very high velocity values for pump size and type. Maintained in time.

From P10A pump

High Severity value ISO Velocity: (8 mm/sg)



Usual values always higher than worse severity ISO

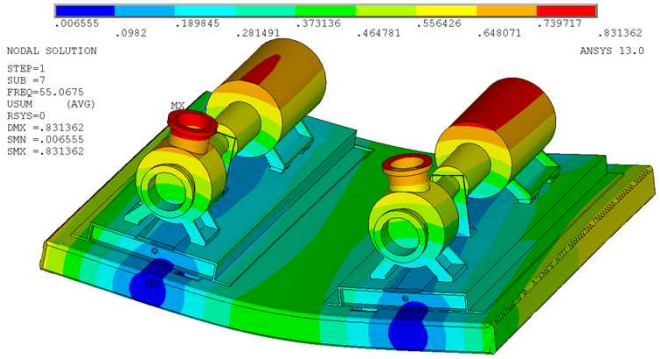
Figura 26: Gráfica de tendencia de los valores globales de vibración en velocidad de los puntos 3VVEL-4VVEL rodamientos de la bomba lado accionamiento (LA) y lado opuesto al accionamiento

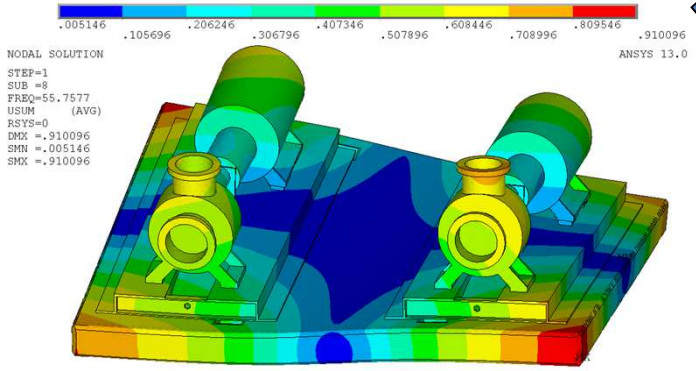
2. Consequently, high values occur in acceleration also and finally damage.
3. What about harmonic excitations?
4. The design of the bench is the best to avoid them?
5. What about of the rigidity of the bench (deformation amplitudes)?

Deionized Water Pumps Case

Simulation, design, construction and test: New design of the bench

1. We had the need to study the solution
2. Bench simulation to discover natural frequencies in different vibration modes shapes.

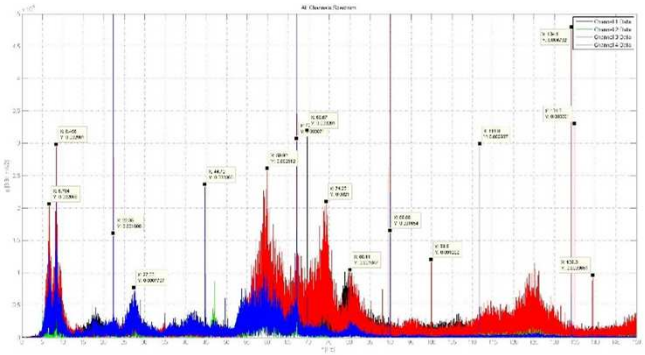




Modes shapes summary

Mode	Simulated [Hz]	Measured [Hz]
f_0	4	8,45
f_1	55,1	59,92
f_2	55,8	74,25
f_3	127,5	125,1
f_4	128,8	129,1

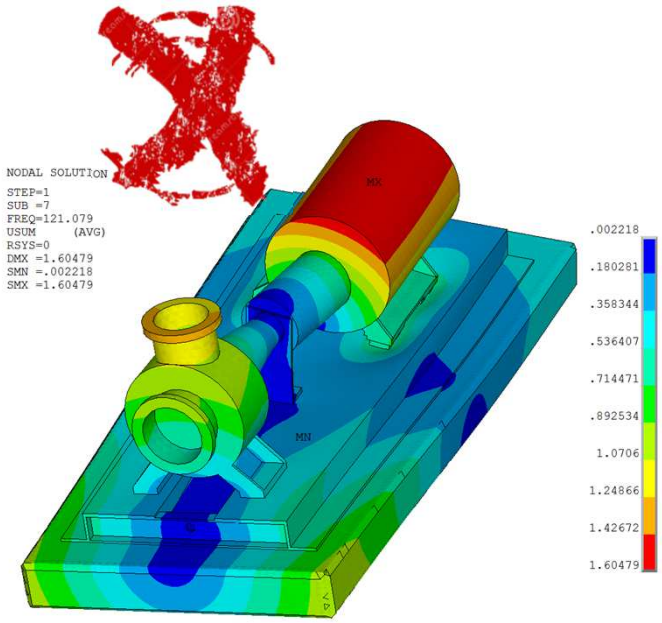
Fundamental frequencies and harmonics



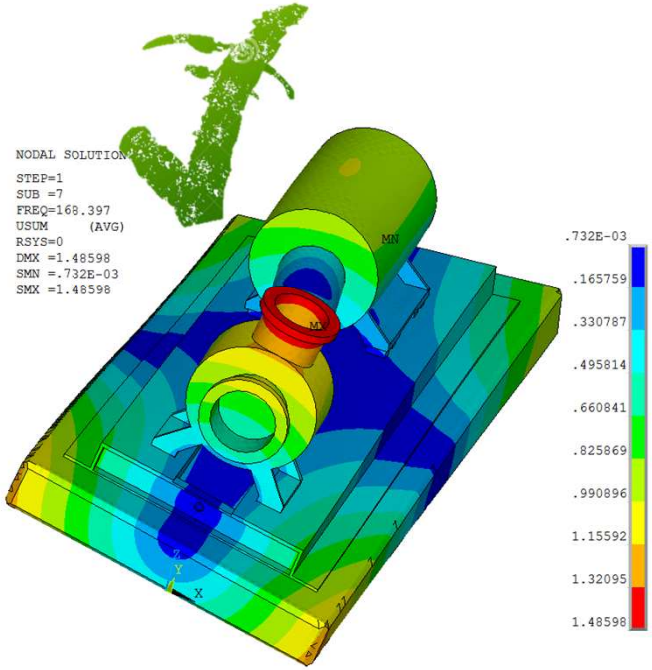
Deionized Water Pumps Case

Push the resonance modes to higher frequencies far away of the harmonic

3. Dynamic Electro-pump loads coinciding with a natural frequency, can cause resonance, the design looking for push this frequencies far away the natural ones and his harmonics.



Steel Base empty: f0=121 Hz

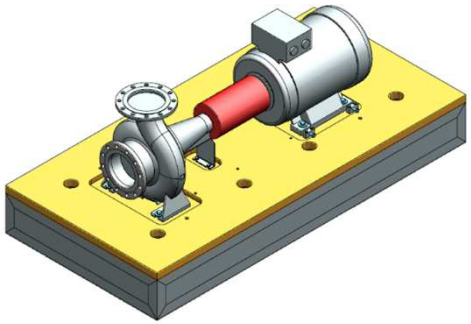


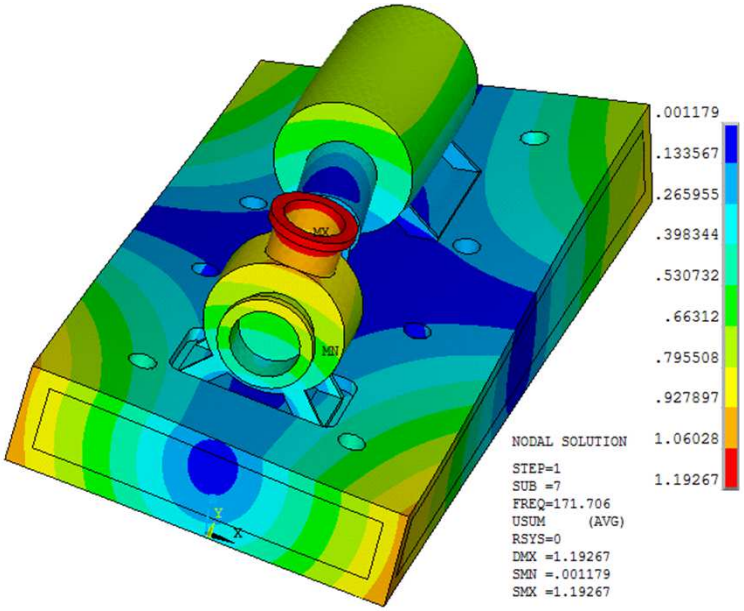
Steel Base fill (steel): f0=168 Hz

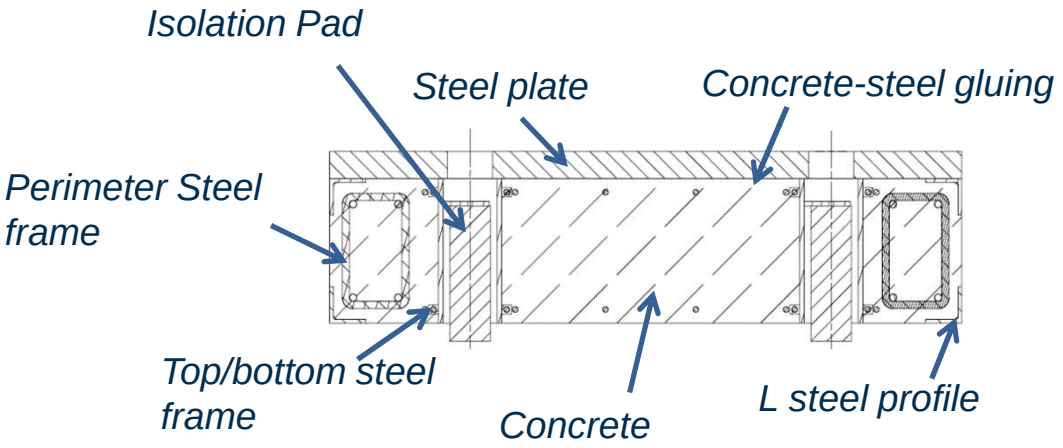
Deionized Water Pumps Case

Applied solutions

4. Split the slab in two independent one for each pumping group.
5. Concrete thick base
6. Steel base plate







Proposed Design

Deionized Water Pumps Case

Construction and Test

Frame

Complete Frame ended

Concrete Filling

30 days of concrete setting

Shaker final test

Deionized Water Pumps Case

Installation and commissioning

Cutting the concrete

Done

Moving the slab

Deionized Water Pumps Case

Installation and commissioning

Waiting the New slab

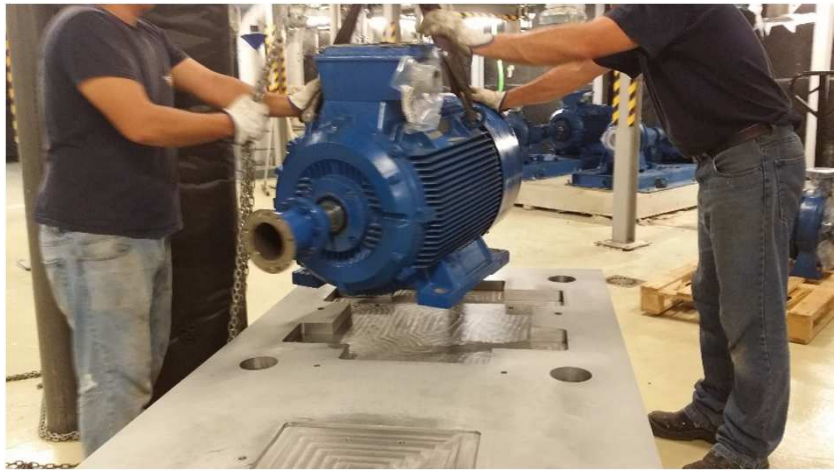
New one

Moving the slab

Final position

Deionized Water Pumps Case

Installation and commissioning



The next…

12 Pumps moving….dozens of tons

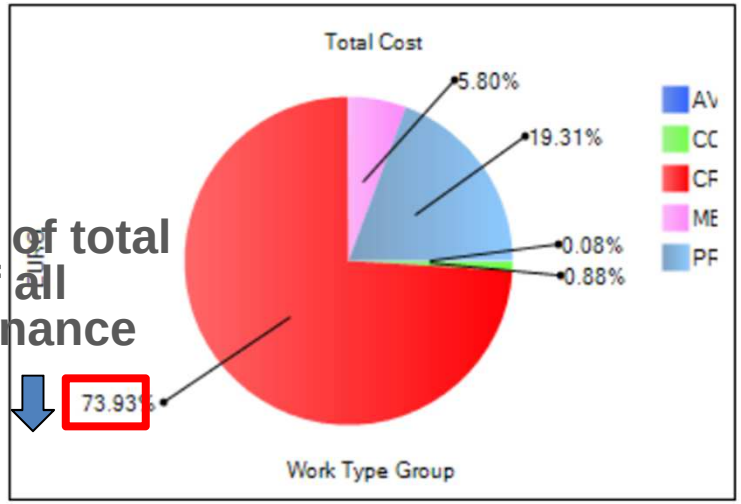
Deionized Water Pumps Case

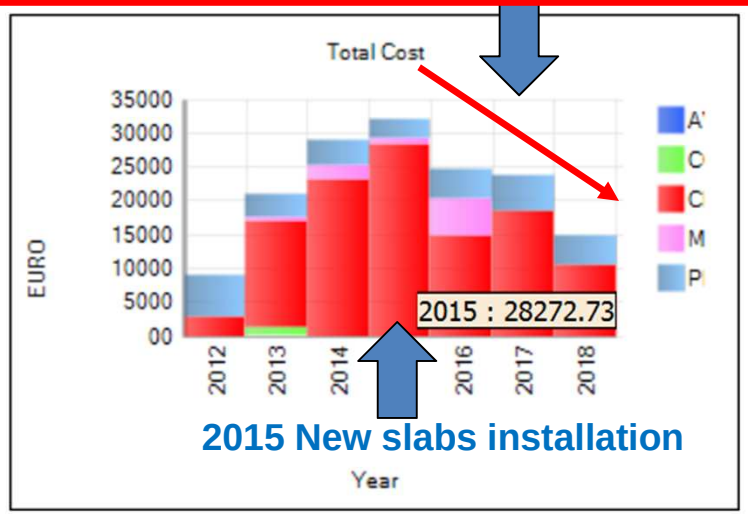
The results were as expected

The corrective in the pumps has dropped between 50% - 60%

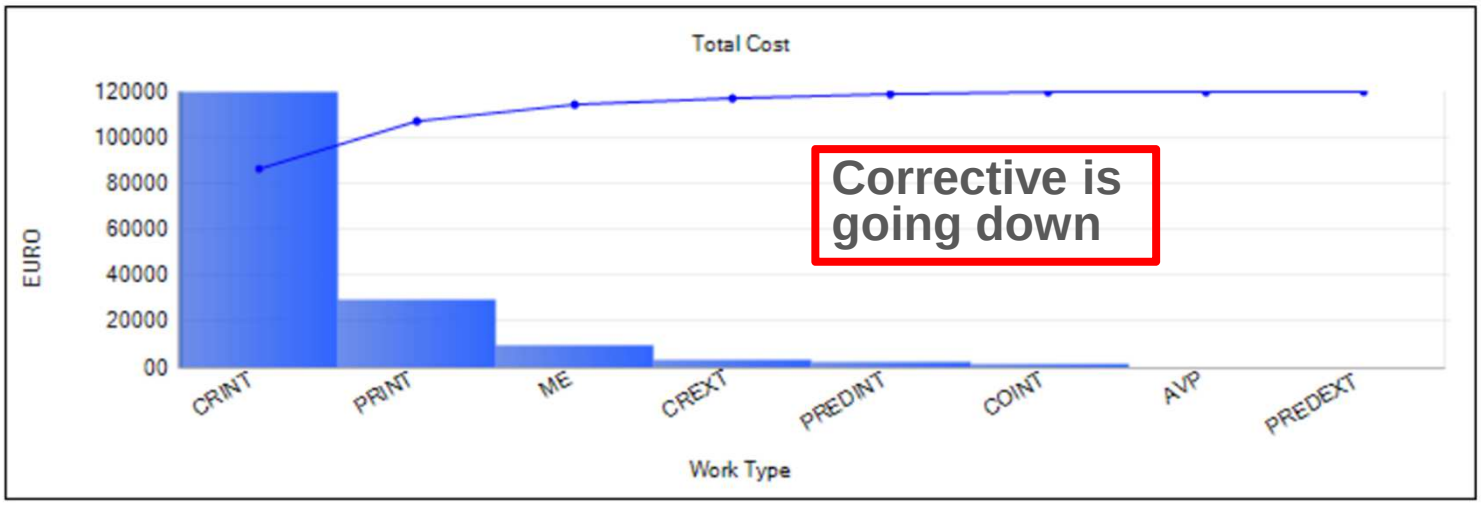
Impact of total cost of all maintenance

- 3 %





2015 New slabs installation



Corrective is going down

Deionized Water Pumps Case

Conclusions

1. This exercise it has been a very good example of how interact and work all together the multidisciplinary profiles of our engineers at CELLS Engineering Division.
2. Technician and Engineers from several fields such us Infrastructure, Workshop, Maintenance technicians, Civil Works, Survey&Alignment, Project Office, Draftsmen, Designers and Calculists.
3. After 7 year in operation the Engineering Division is working on the upgrade of their Maintenance Program.
4. According to our infrastructure growth the number of equipment pieces will increase.
5. New installation will be included on the Maintenance Program: Radio Frequency (RF) Plants at Service Area, Beam Lines, and Helium Plant.

Thank you.