ALBA Synchrotron Light Source

Infrastructure and General Services

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Agenda

1. **ALBA Infrastructures: building and utilities current maintenance approach.**
2. Conditions based maintenace introduction
3. Next steps and conclusions.

Maintenance at ALBA Infrastructures

- An accelerator maintenance singularity is the conjunction of a high complex conventional facility with an intrinsic dynamically changing scientific environment.

- The dense preventive maintenance program matches tightly with the operation plan that at the same time is going shorter in order to increase beam time hours for users.

- Shutdown periods are the best availability window to execute the critical scheduled maintenance joined to the improvements and upgrades of the whole facility.

- The Computerized Maintenance Management Systems (CMMS) are the tools to coordinate whole year process activities related to maintenance and analyze operation calendar updates and facility upgrades.

Maintenance at ALBA Infrastructures

- Objective: maximum reliability at minimum cost.
- Strategy:
  - Keep in-house all knowledge necessary to operate and maintain the facility.
  - In-house management of the whole maintenance of the facility.
  - Optimize the maintenance cost related to personnel, spares and reposition.
- Infrastructure scheme:
  - Team of in-house engineers (4) and technicians (2) trained and educated multidisciplinary with maintenance.
  - Spares and components supply framework conditions with general and specialist suppliers, price and delivery time not blind.
  - Outsourcing to specialized companies the routine preventive and normative maintenance of specific equipment's.
  - Contract with external specialized maintenance company for outsourcing personnel support during preventive and corrective maintenance (2+1 FTE). Flexibility on the contract supplier in order to absorb peak work loads at shutdown periods or critical corrective manpower necessity.

Maintenance at ALBA Infrastructures

Prisma 3®
sisteplant

- **Preventive maintenance approach by CMMS (Computerized Maintenance Management System) - Software PRISMA 3**
  - **Availability of the component database from the installation period.**
  - **Experience from installation/exploitation period.**
  - **In-house knowledge**
  - **Widely implemented in industrial and technological environments**
  - **Scalability**
  - **Integration capabilities**
  - **Potentiality**
  - **Maturity**

- **Installation description implemented in 6 levels**
  - **Facility**
  - **Building**
  - **Zone**
  - **System**
  - **Asset (main)**
  - **Element (part of Asset)**

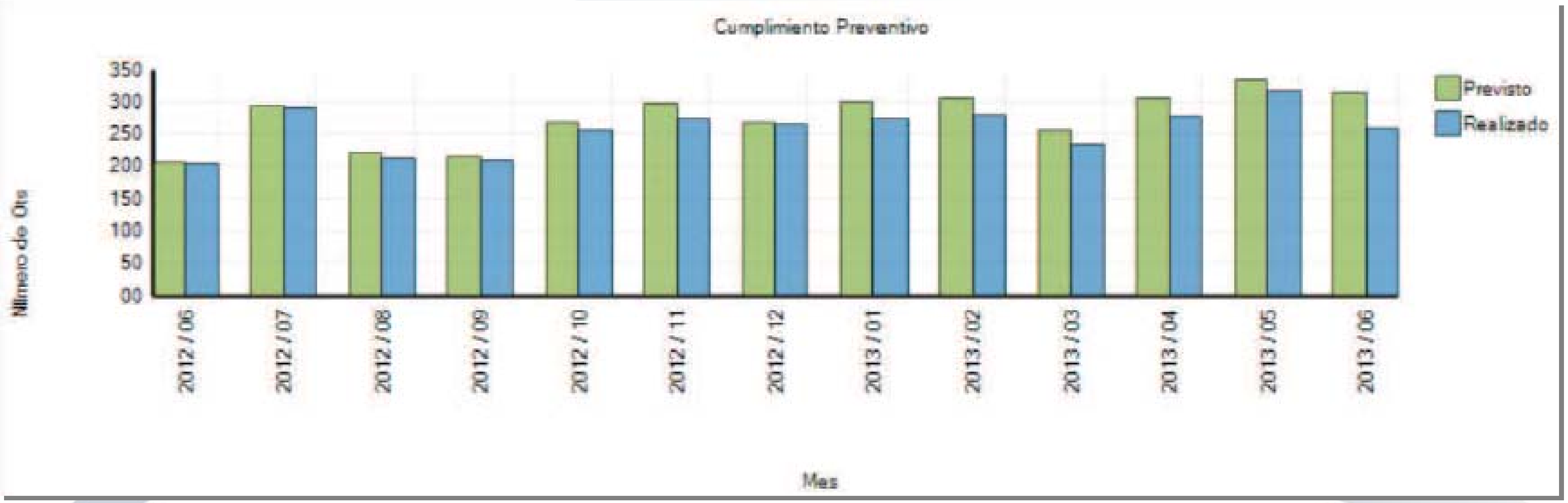
Maintenance at ALBA Infrastructures

- **<u>Key figures:</u>** From management of Normative (legal operations), Corrective, Preventive and Predictive maintenance.

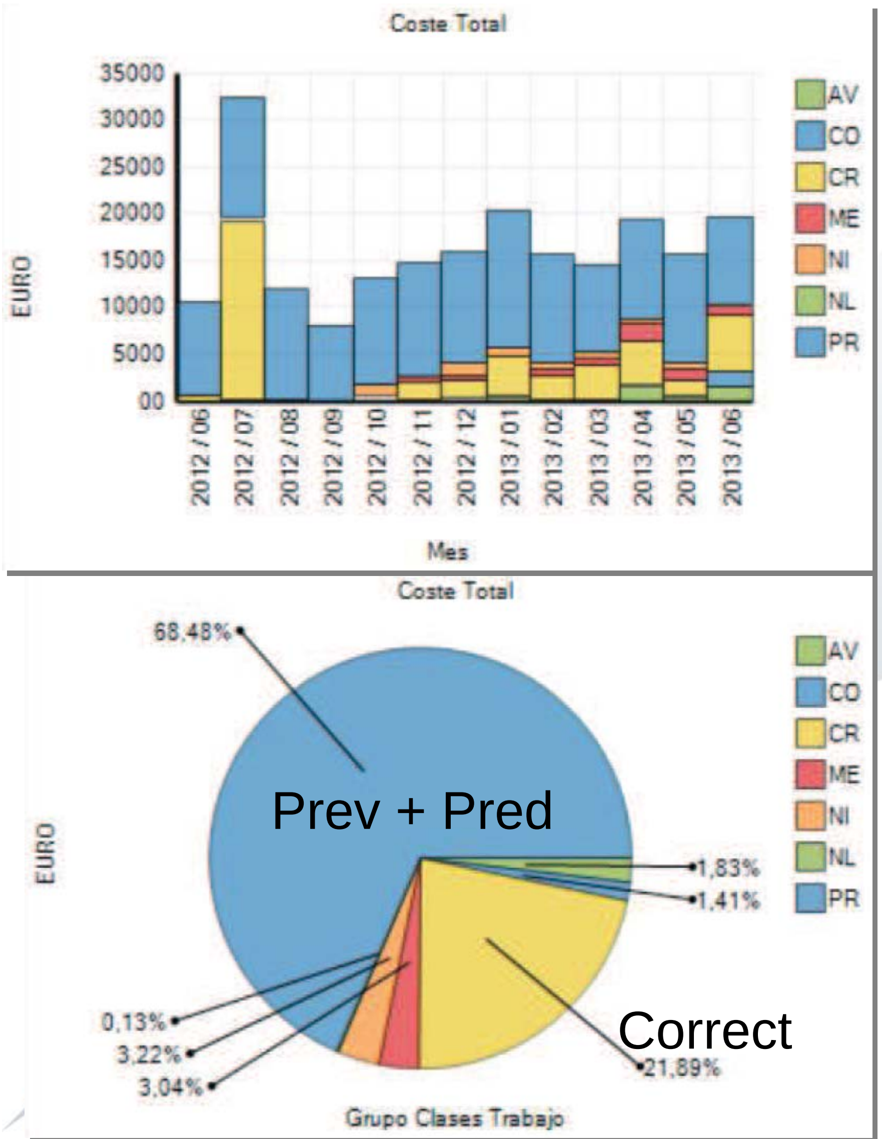
56	Contador Líneas Normas por Gama	WorkProcedureOperation	349
57	Número Solicitud Trabajo	WorkRequest	59
58	Número OT	WorkOrder	3.902
59	OTs de Preventivo	WorkOrder	11.231
60	Contador Líneas Trabajos previstos	WorkOrderPlannedLabor	11.895
61	Contador Líneas Cargos previstos	WorkOrderPlannedCharge	4
62	Contador Líneas Mat.Externos previstos	WorkOrderPlannedExtMat	0
63	Contador Líneas Normas por OT	WorkOrderOperation	29.247
64	Número Feedback Mano Obra	LaborReporting	5.525
65	Contador Líneas Feedback M.Obra	LaborReportingLine	8.073
66	Contador Líneas Ausencias	WorkerDayOff	0
67	Contador Líneas DCAs	WorkOrderDefect	0
68	Número Cargo	Charge	67.947
69	Contador Líneas Cargos	ChargeLine	67.947
70	Número Material Externo	ExternalMaterial	0
71	Contador Líneas Materiales Externos	ExternalMaterialLine	0
72	Contador Líneas Feedback Herramientas	WorkOrderTool	0
73	Número Parada	DownTime	0
74	Número Medición	Measure	1.290

Maintenance at ALBA Infrastructures

- All figures are since we launched application, (JAN-2012)
- Work order : 11.231 (PR) + 3.902 (CR) = 15.133 WOs.
- Planning Task simulated: 71.893
- Number of Operations used in Work Procedure = 349
- Number of Operations used in Work Orders = 29.247
- Number of Measurements performed = 1.290 (assets measure)



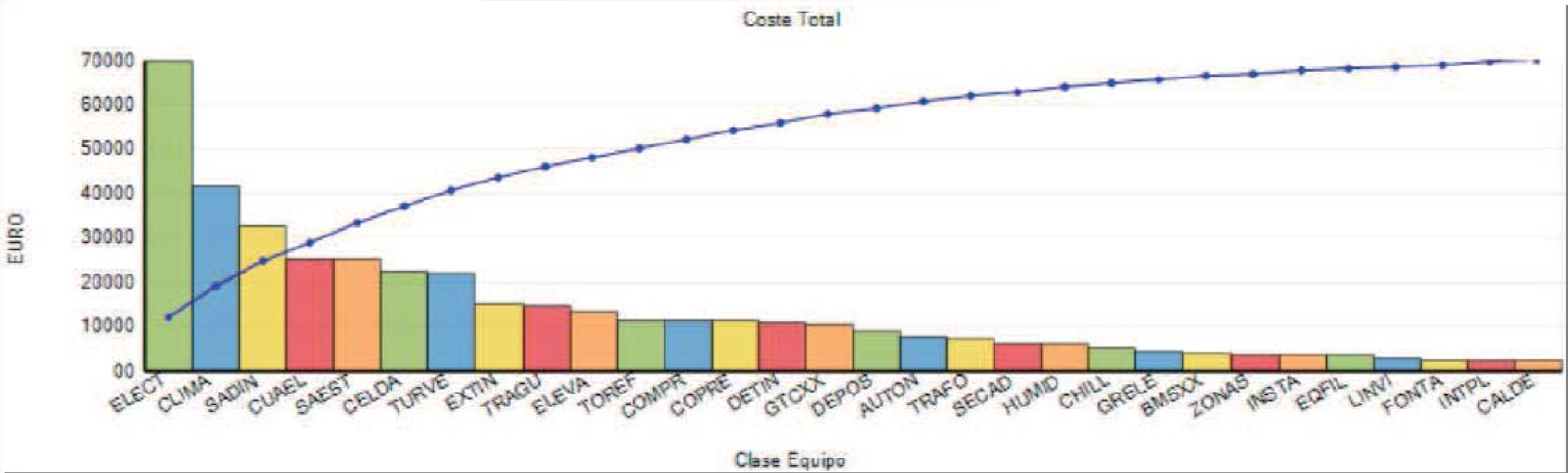
Asset/Group Type Cost Graphic



- Assets number: 2.713 assets (since Jan-2012)
- Asset procedure created: 1.353 (since Jan-2012)
- Period Analyzed in graph's: June-2012/June 2013
- Total cost versus dates, detailed Work Group types:
  - PR: Preventive+Predictive
  - CR: Corrective
  - CO: Conductive
  - NL: Legal Operations
  - ME: Improvements
  - NI: New Facilities

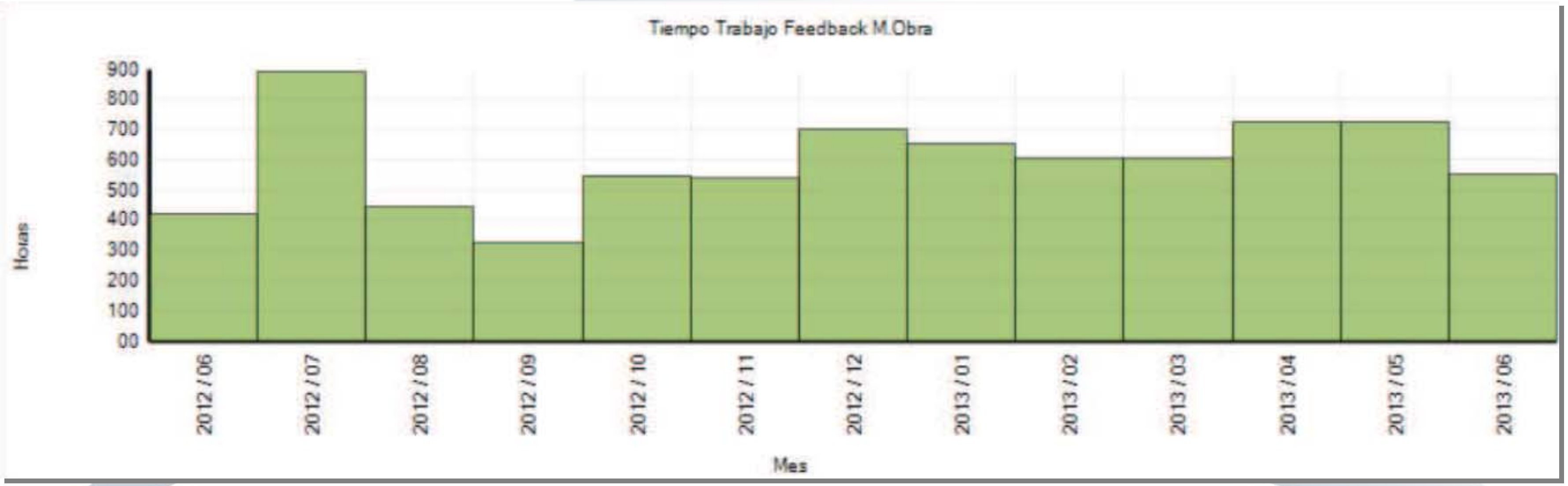
Equipment Type Cost Graphic

- Major costs by type of equipment:
  - ELECT: Electric Motor Pump
  - CLIMA: Heat, Ventilation and Air Conditioning, HVAC
  - SADIN: Rotary UPS, Specific Outsourced Services
  - CUAEL: Power Cabinets, (Maintenance Legal Operations)
  - ….

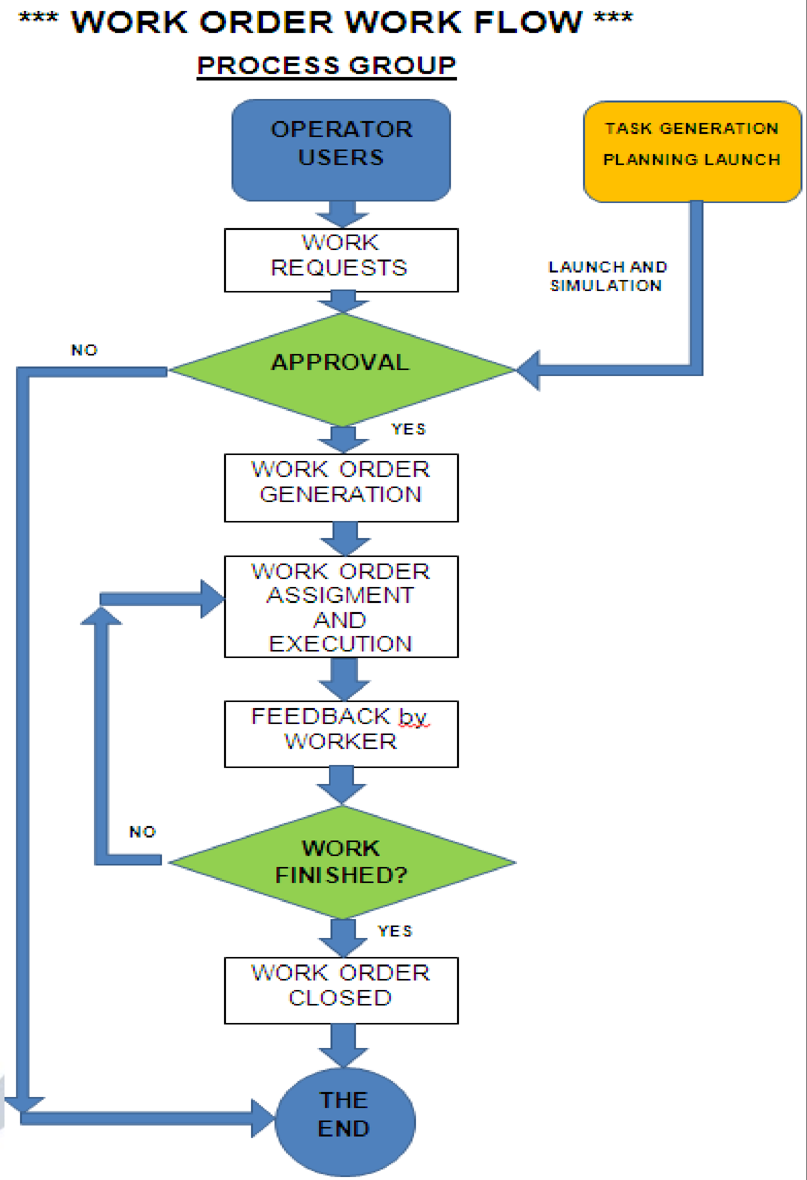


Labor Reporting

- Total Labor Reporting lines since we launched application: 8.191 lines (manpower line counter feedback)

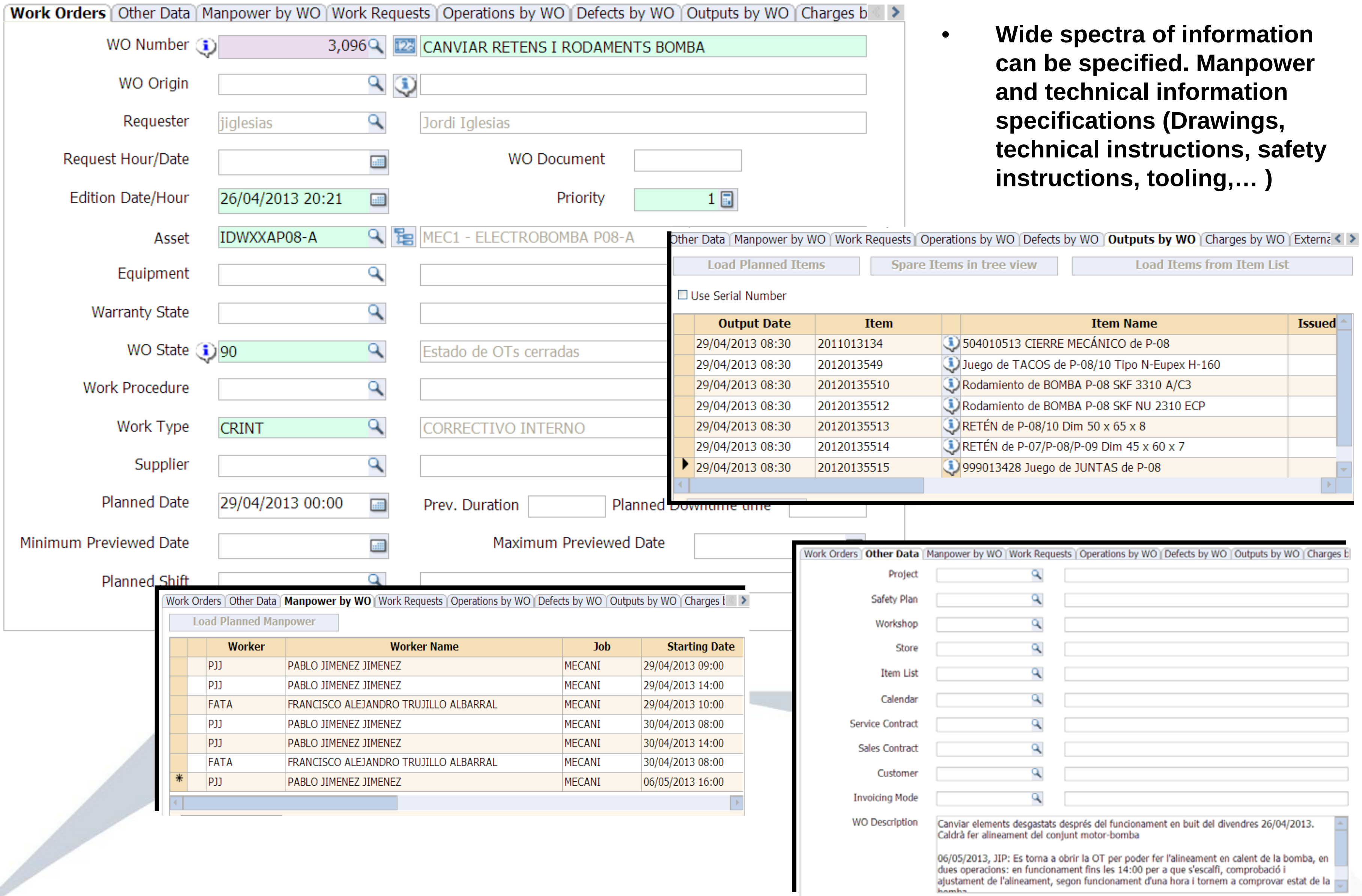


Work Flow Order Process



- **Work flow orders generated by :**
  - **Operator user**
  - **Schedule**
  - **Preventive maintenance program due to indicators**

Work order (WO) example



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

Work order generated by schedule

- Internal and Outsourced services schedule

Worker Assignment

	2013/11				
	11	12	13	14	15
ECM - ESTEBAN CRIADO MARTINEZ	3877 3894 10312 10322 0:30	3818 3819 3820 3821 3822 3825 0:00	3808 3869 0:00	3673 3696 3767 3816 3817 0:00	10339 10346 10347 10348 10349 10350 10351 10352 0:15
LMC - LUIS MORILLAS CREMADES	8:00	11019 11020 11021 -1:30	3801 10969 10970 11001 11002 11129 -2:40	10997 10998 0:30	10993 10994 11077 11078 11097 0:50
MATA - MIGUEL ANGEL TORO ALCARAZ	8:00	10973 11022 11023 11024 11083 11085 1:40	3801 10995 10996 -2:30	10991 10992 11094 11095 11096 11124 11125 -4:00	10999 11000 11075 11076 11123 -2:40
PJJ - PABLO JIMENEZ JIMENEZ	3299 3941 10945 11061 11067 11089 11090 11209 1:30	3486 11070 11087 11088 11210 0:40	3801 3861 10943 11069 11211 -2:10	3938 10949 11212 0:10	3938 11071 11213 0:10

WO Number: 11088 - G.TRIM.MOTOBOMBAS DE CIRCULACION

Asset: ICWXXAP50-A - ELECTROBOMBA P50-A
Priority: 0
WO State: 00 - Estado inicial por defecto

Edition Date/Hour: 15/11/2013 12:00
Planned Date: 15/11/2013 12:00
Minimum Previewed Date: 12/10/2013 12:00
Maximum Previewed Date: 02/12/2013 12:00
Starting Date: 12/11/2013 00:00
Planned Time: 2:00

Worker Assignment

	2013/11				
	11	12	13	14	15
AIRMATIC - ESPECIALISTA AIRMATIC	8:00	8:00	10971 10972 10974 10975 10976 -8:50	8:00	8:00
ELECNOR - ESPECIALISTA ELECNOR	2687 0:00	2686 2688 2689 2690 0:30	8:00	8:00	8:00
ODYL - ESPECIALISTA ODYL, S.A.	8:00	8:00	8:00	8:00	10229 11199 3:00
VICTRON - ESPECIALISTA VICTRON	8:00	8:00	3859 7:00	8:00	8:00

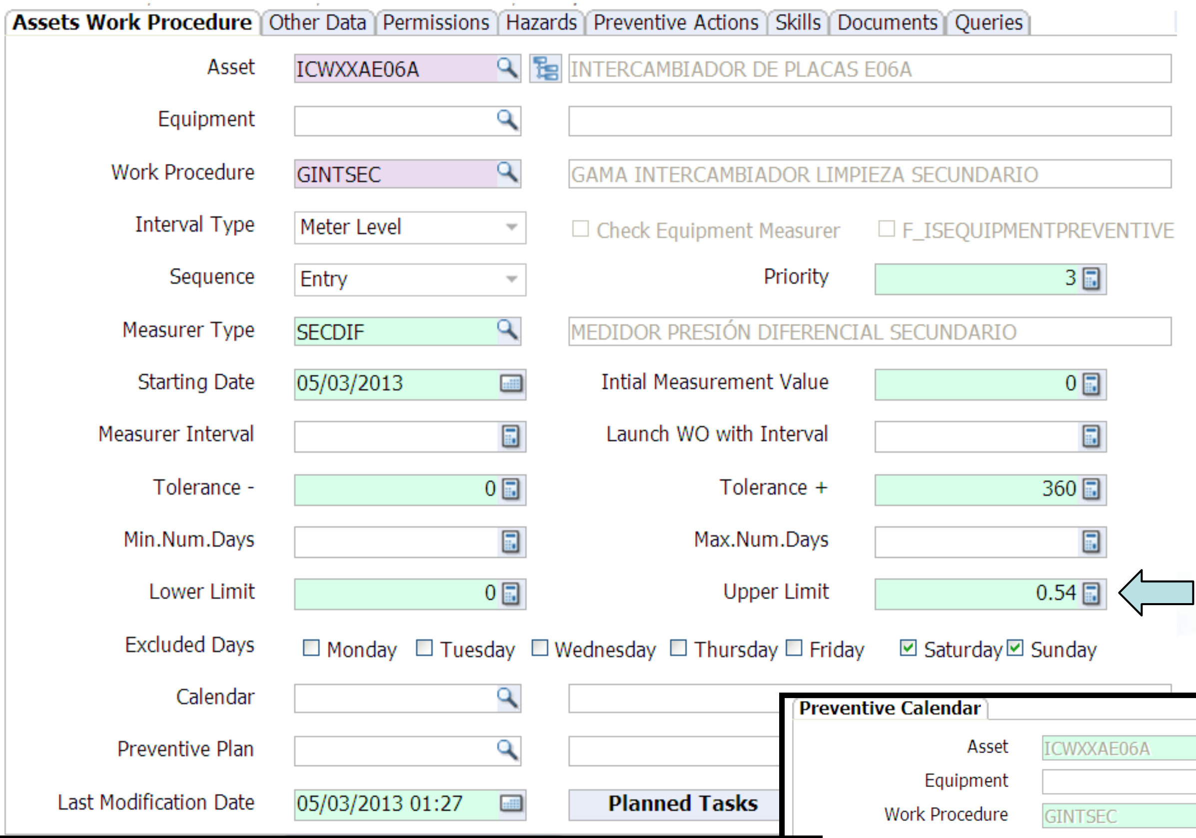
WO Number: 3859 - SUSTITUCIÓN BATERÍA UPS06

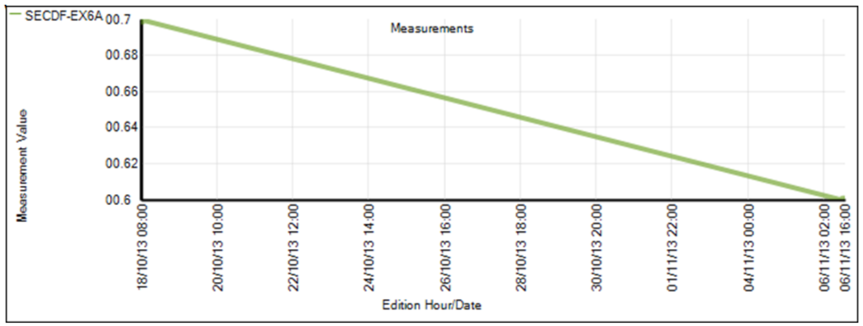
Asset: ISUINASAI6 - SAI BEAMLINES
Priority: 3
WO State: 00 - Estado inicial por defecto

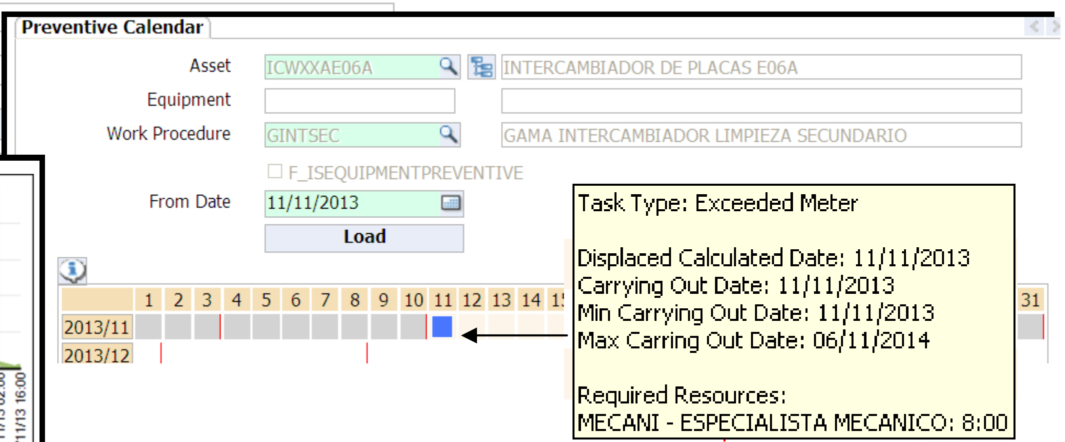
Edition Date/Hour: 21/10/2013 14:00
Planned Date: 13/11/2013 12:00
Starting Date: 13/11/2013 12:00
Planned Time: 1:00

Real screen shoot of current week activity

Work order generated by indicator

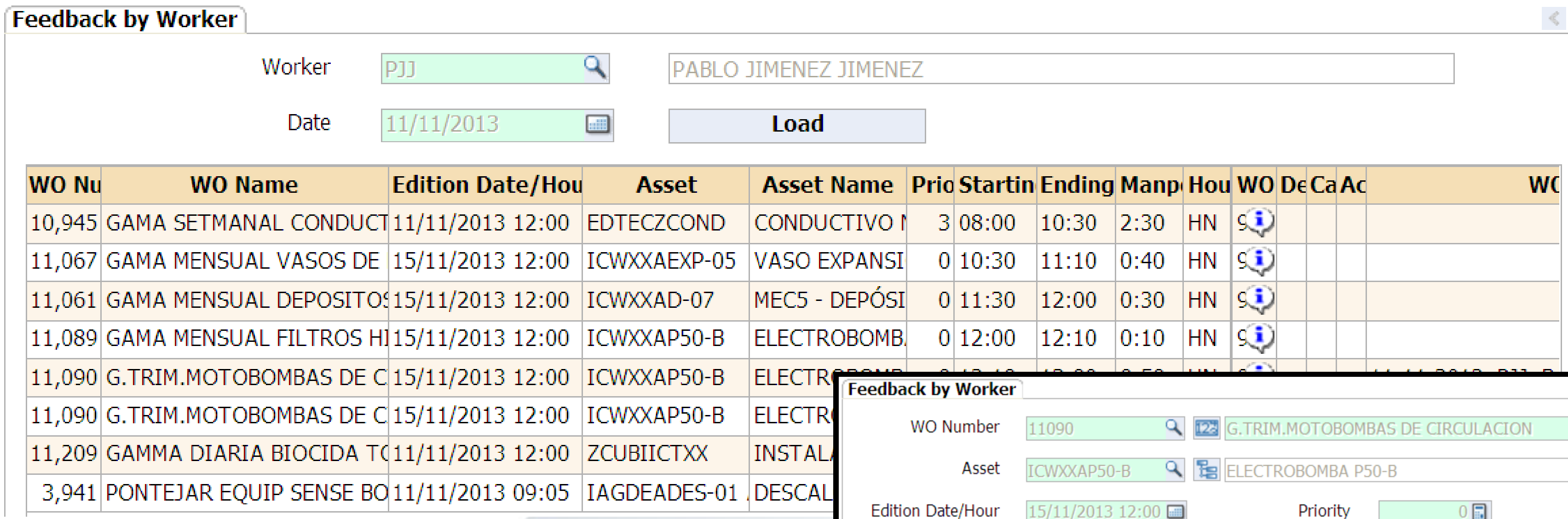


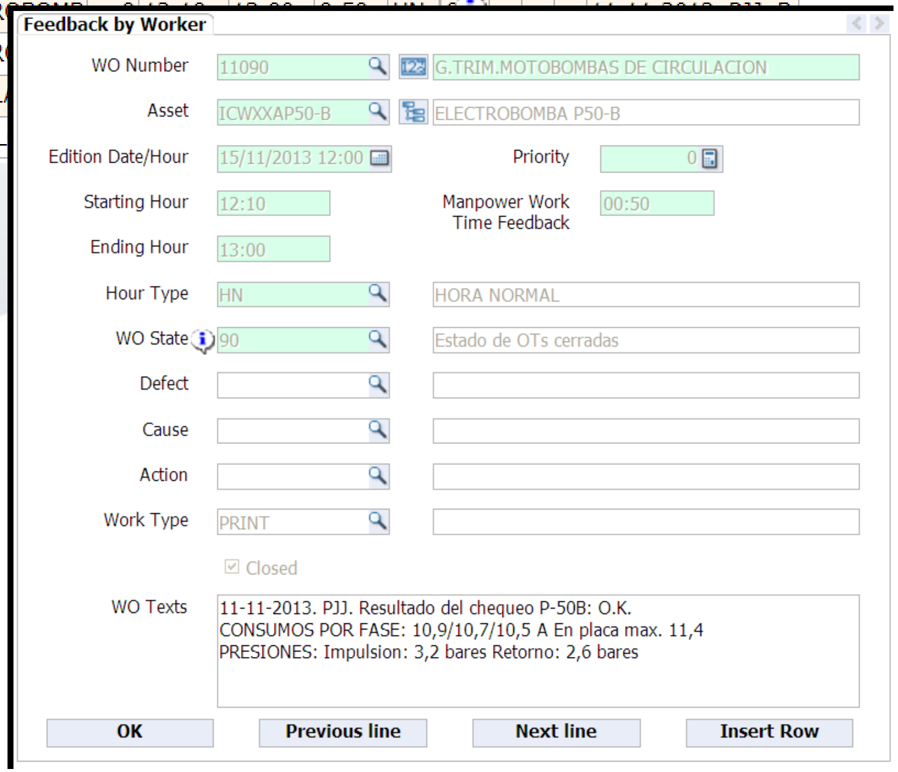




- Work order generated by indicator:
- November planning launch work order to clean exchanger secondary side.
- Differential pressure 0.60 bar > 0.54 bar, cleaning is required

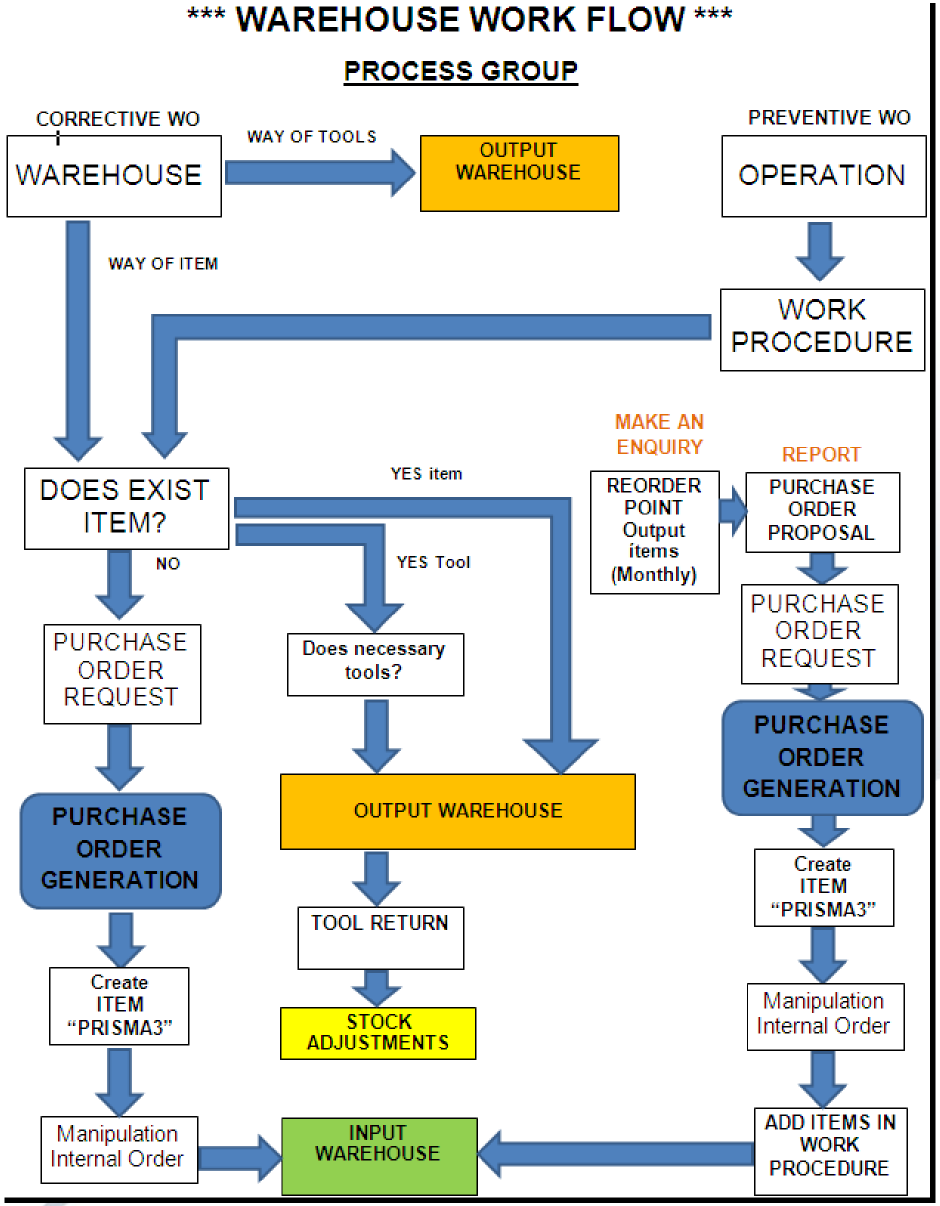
Work order feedback tool





- 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.

Spares warehouse management



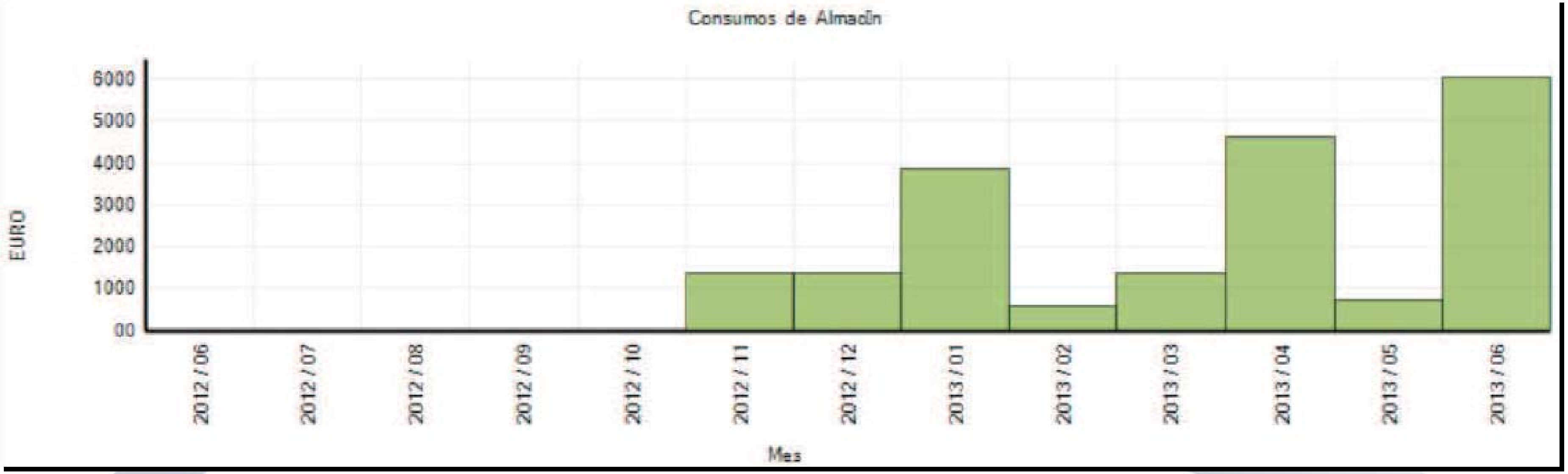
- WAREHOUSE STOCK COUNT
  - Stock Movement: 1.915 items
  - Purchase order through Purchase order proposal: 1.537 items

102	Nº Sugerencia	OrderProposal	22
103	Contador Líneas Sugerencias de Pedido	OrderProposalItem	1.537

82	Contador lineas Almacén Estante	StoreShelf	729
83	Número Movimiento Almacén	StockMov	1.915
84	Número Ajuste	StockAdjust	147
85	Contador Líneas Ajustes	StockAdjustItem	506
86	Número Entrada	StockEntry	234
87	Contador Líneas Entradas	StockEntryItem	538
88	Número Salida	StockIssue	706
89	Contador Líneas Salidas	StockIssueItem	701
90	Contador Líneas Salidas Generadas	StockIssueGenItem	0
91	Número Transferencia	StockTransfer	43
92	Contador Líneas Transferencias	StockTransferItem	85

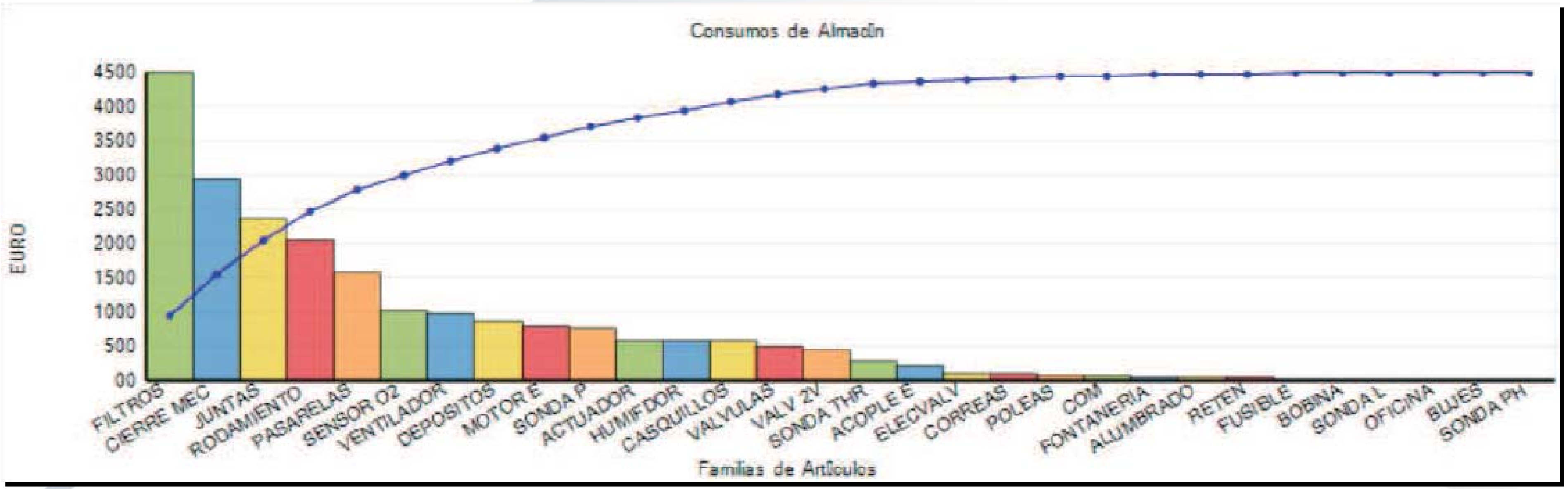
Store Valuation

- In 2012 november, starts activity from warehouse.
- Warehouse usage depends on the preventive maintenance plan and corrective operations and other types work orders.



Valuation by Fammily

- Main item familys:
  - FILTROS: Filters for HVAC.
  - CIERRE MEC: Mechanicals seals for Motor Pumps.
  - JUNTAS: Joints for Motor Pumps
  - RODAMIENTO: Bearings for Motor Pumps, Ventilation, etc.
  - ……



Agenda

1. ALBA Infrastructures: building and utilities current maintenance approach.
2. **Conditions based maintenace introduction**
3. Next steps and conclusions.

Summary

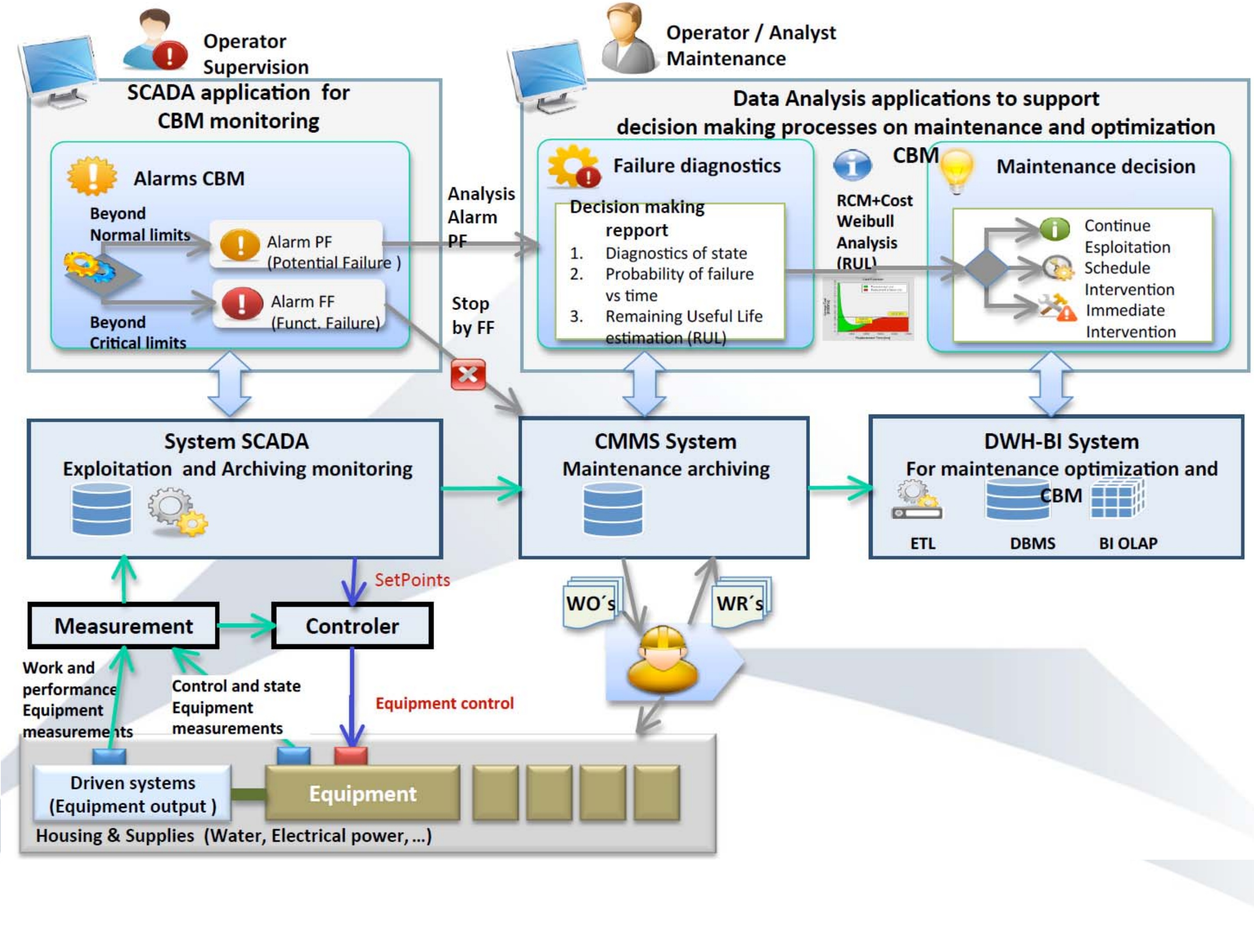
- Particularities of the scientific research facilities operation and design (fast variable load, high availability, redundancy,..) brings to an scenario where the conventional industrial approach to maintenance should be improved.

- Motivation to explore the viability of CBM approach implementation:
  - Increase reliability.
  - Decrease cost.
  - Decrease at minimum not programmed shutdowns.
  - Increase predictability to optimize the programmed shutdown activities

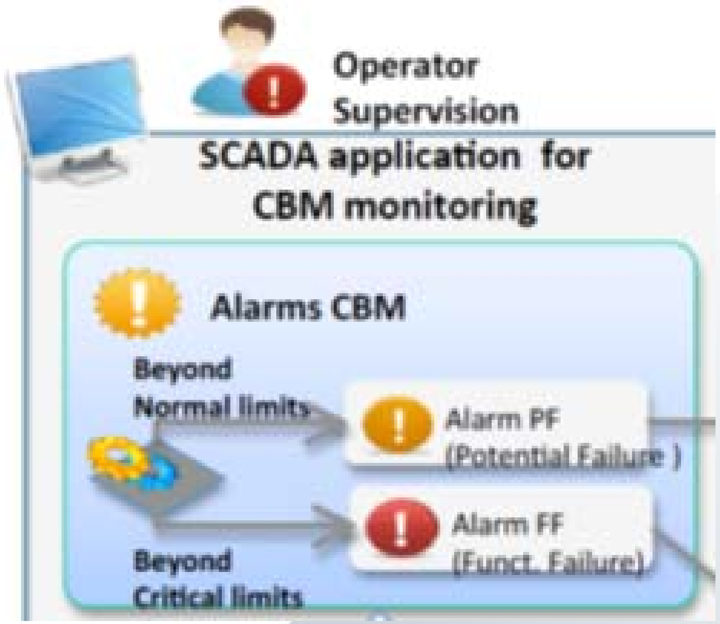
CBM architecture system

- Main requests to the centralized managemetn system:
  - Measure
  - Control
  - Alarm generation
  - Archiving
  - Diagnostic
  - Support to maintenance decisions
- Modules to be implemented in the framework of the operations (SCADA) and maintenance (CMMS) ALBA scheme. Three modules are defined:
  - Measure system
  - Alarm and diagnostic system
  - Support to decision system
- The pumps of the cooling and HVAC systems are choose as study case.
- Motivation
  - critical for the facility
  - literature availability
  - real data availability

CBM architecture system

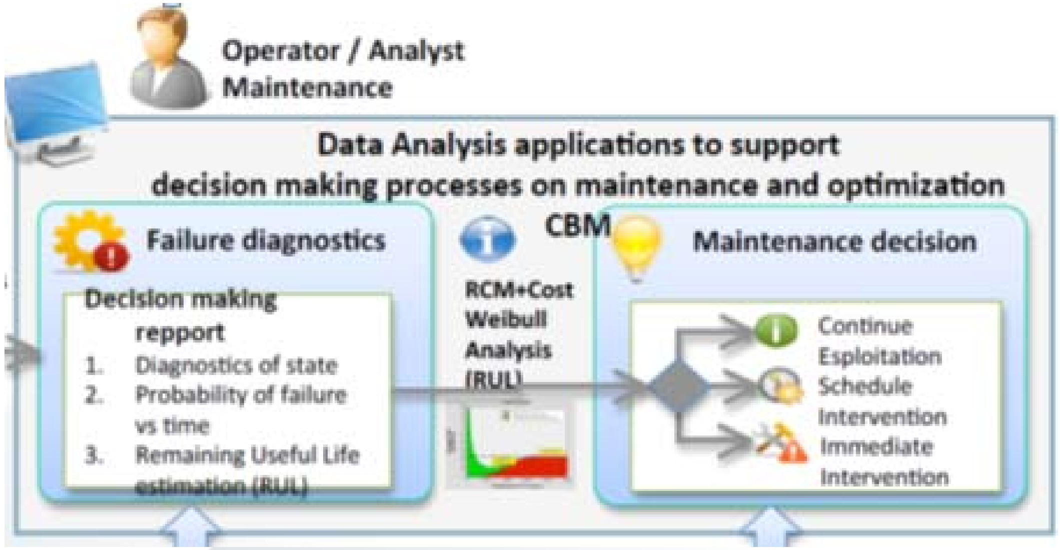


Alarm and diagnostic system



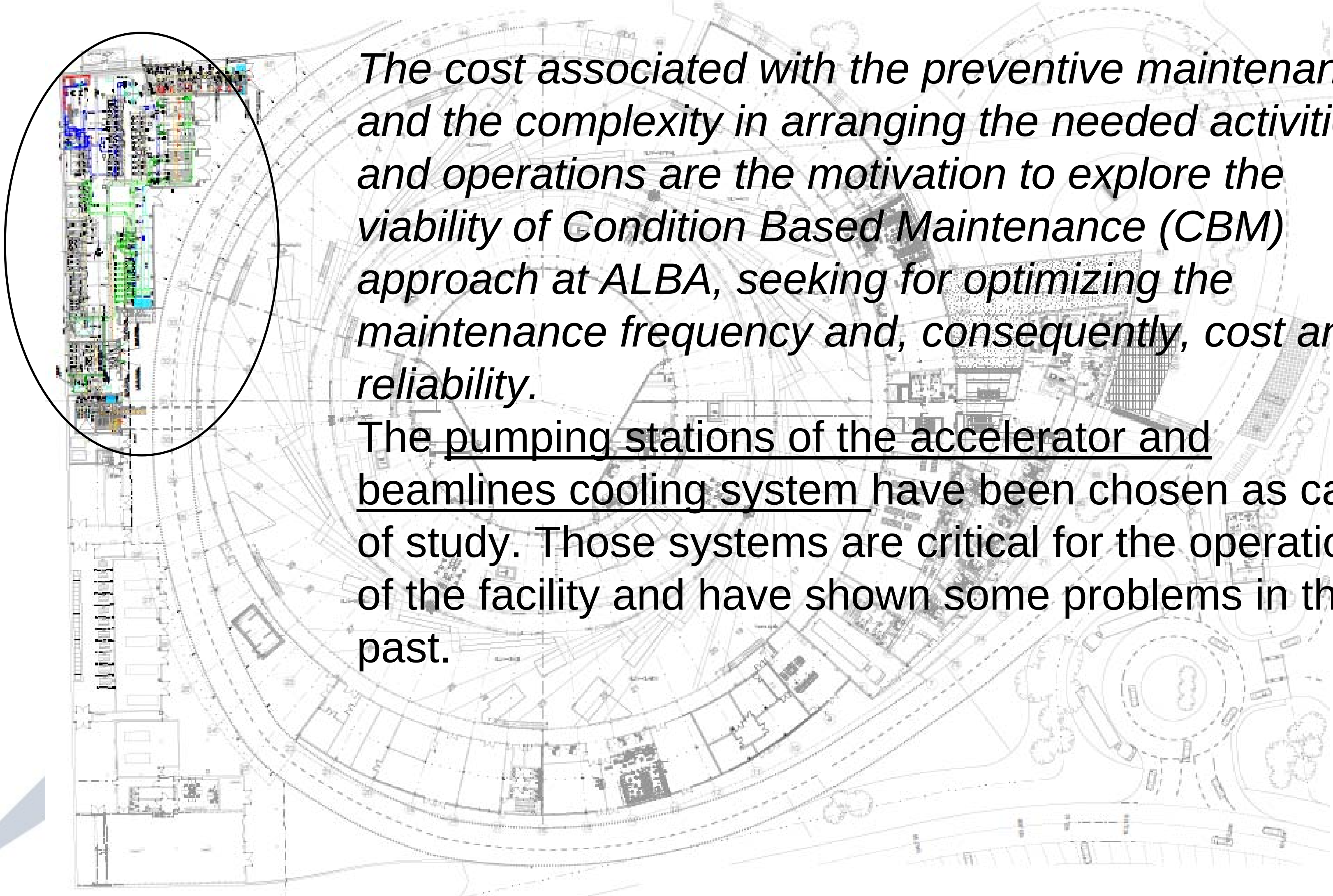
- Alarm generation embedded in in the control system, generated from internal and external parameters.
- The limits of the parameters deviate from the control range, a potential failure alarm is generated. The alarm shall be considered with the historical data from the CMMS (work orders knowledge) and RCM (Reliability Condition Maintenance, reliability knowledge).
- The limits of the parameters deviate from the control range up to a critical level, a functional failure alarm is generated that implies the emergency stop of the equipment.

Maintenance Decision



- Support to decision system. Once a potential failure alarm has been generated the system shall combine the following information
  - component diagnostics based on the operative measurements of the component and the process.
  - information about the lifetime behaviour of the component (CMMS historical data)
  - Failure probability in the future. Weibull analysis.
  - Estimation of remaining lifetime
  - Data on the cost associated to unexpected failure and preventive maintenance.
- Graphs are to be generated to asses the decision making process

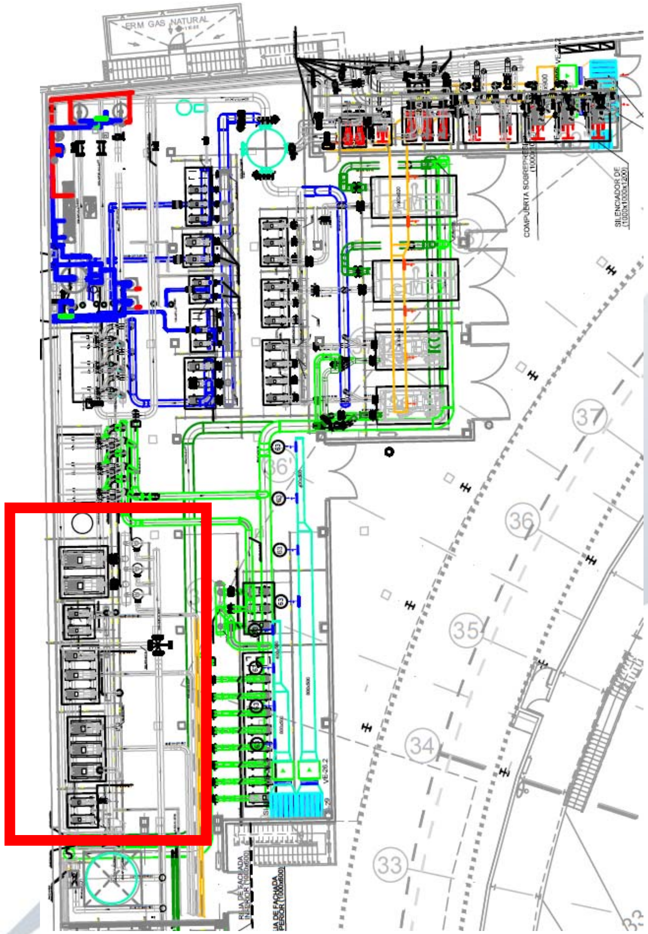
General layout of DW cooling circuit



The cost associated with the preventive maintenance and the complexity in arranging the needed activities and operations are the motivation to explore the viability of Condition Based Maintenance (CBM) approach at ALBA, seeking for optimizing the maintenance frequency and, consequently, cost and reliability.

The pumping stations of the accelerator and beamlines cooling system have been chosen as case of study. Those systems are critical for the operation of the facility and have shown some problems in the past.

The cooling circuit pumps



	FLOW (m3/h)	High (Kpa)	Power Kw	Config num.	Models	Inlet (mm)	Outlet (mm)	Vel rpm
P07	84	1010	45	1+1	NM-65/250B	100	65	3000
P08	127	1340	90	2+1	INP-80/315C	125	80	3000
P09	38	1150	37	1+1	NM-50/315BR	80	50	3000
P10	104	1030	75	2+1	NM-65/315BR	100	65	3000
P11	646	230	75	1+1	INP-250/300C	250	250	1500

There is a problem at pumps

Asset	Name for Related Asset	WO Number	WO Name	Edition Date/Hour
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	966	ALINEACIÓN	27/07/2010 15:42
IDWXXAP11-A	MEC1 - ELECTROBOMBA P11-A	969	ALINEACIÓN	27/07/2010 15:42
IDWXXAP11-B	MEC1 - ELECTROBOMBA P11-B	972	ALINEACIÓN	11/10/2010 15:42
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	973	ALINEACIÓN	05/11/2010 15:42
IDWXXAP10-B	MEC1 - ELECTROBOMBA P10-B	974	ALINEACIÓN	05/11/2010 15:42
IDWXXAP10-B	MEC1 - ELECTROBOMBA P10-B	975	REPARACIÓN	28/11/2010 15:42
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	976	ALINEACIÓN	20/04/2011 15:42
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	977	ALINEACIÓN	20/04/2011 15:42
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	978	ALINEACIÓN	20/04/2011 15:42
IDWXXAP10-B	MEC1 - ELECTROBOMBA P10-B	1259	ALINEACIÓN	20/04/2011 15:42
IDWXXAP09-A	MEC1 - ELECTROBOMBA P09-A	1260	ALINEACIÓN	19/05/2011 15:42
IDWXXAP10-C	MEC1 - ELECTROBOMBA P10-C	1261	ALINEACIÓN	20/10/2011 15:42
IDWXXAP10-C	MEC1 - ELECTROBOMBA P10-C	1263	ALINEACIÓN	20/10/2011 15:42
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	1410	EQUILIBRADO EJE Y RODETE	22/06/2012 00:00
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	1401	EQUILIBRADO RODETE Y EJE BOMBA	22/06/2012 10:54
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	1402	ALINEACIÓN	29/06/2012 10:36
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	1403	REALIZAR ALINEACIÓN Y ANAL.VIBRACIONES	03/07/2012 14:33
IDWXXAP11-A	MEC1 - ELECTROBOMBA P11-A	1404	REVISIÓN Y REAPRIETE BOMBA Y MOTOR	04/07/2012 15:12
IDWXXAP08-A	MEC1 - ELECTROBOMBA P08-A	1412	CAMBIO RODAMIENTO MOTOR LA	09/07/2012 14:47
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	1416	REPARACIÓN RODAMIENTO LA MOTOR	10/07/2012 15:21
IDWXXAP08-A	MEC1 - ELECTROBOMBA P08-A	1421	SUSTITUCIÓN ESCUDO LA MOTOR Y VENTILADOR	17/07/2012 11:39
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	1423	SUSTITUIR ESCUDO MOTOR LA	17/07/2012 15:13
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	1424	ALINEACIÓN	18/07/2012 11:01
IDWXXAP09-B	MEC1 - ELECTROBOMBA P09-B	2311	SUSTITUIR RODAMIENTOS BOMBA	17/10/2012 11:51
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	2328	ALINEACIÓN	23/10/2012 13:19
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	2329	ALINEACION	23/10/2012 13:44
IDWXXAP09-A	MEC1 - ELECTROBOMBA P09-A	2499	CAMBIAR SELLO MECÁNICO POR PÉRDIDA DE AG	26/11/2012 14:26
IDWXXAP09-B	MEC1 - ELECTROBOMBA P09-B	2505	CAMBIAR RETÉN DE BOMBA PÉRDIDA ACEITE	28/11/2012 00:00
IDWXXAP07-A	MEC1 - ELECTROBOMBA P07-A	2527	ALINEACIÓN	01/12/2012 15:34
IDWXXAP11-A	MEC1 - ELECTROBOMBA P11-A	2529	REAPRIETE DE TORNILLOS PLANO 2	03/12/2012 23:57
IDWXXAP11-A	MEC1 - ELECTROBOMBA P11-A	2557	REALIZAR ALINEACIÓN CONJUNTO	14/12/2012 00:00
IDWXXAP10-C	MEC1 - ELECTROBOMBA P10-C	2551	REALIZAR ALINEACIÓN PREVENTIVA	14/12/2012 02:06
IDWXXAP09-A	MEC1 - ELECTROBOMBA P09-A	2552	ALINEACIÓN	14/12/2012 11:52
IDWXXAP09-B	MEC1 - ELECTROBOMBA P09-B	2553	ALINEACIÓN	14/12/2012 11:52
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	2610	CAMBIAR RODAMIENTOS MOTOR	02/01/2013 10:51
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	2647	ALINEACIÓN	18/01/2013 14:00
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	2677	CANVIAR RETENS	22/01/2013 15:44
IDWXXAP09-B	MEC1 - ELECTROBOMBA P09-B	2678	NORMA ANUAL 2 MOTOBOMBAS DE CIRCULACION	22/01/2013 15:52
IDWXXAP11-A	MEC1 - ELECTROBOMBA P11-A	2681	CANVIAR RETEN TRASERA	22/01/2013 17:34
IDWXXAP09-B	MEC1 - ELECTROBOMBA P09-B	2697	CANVIAR RODAMENTS BOMBA	28/01/2013 18:29
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	2698	REALITZAR ALINEAMENT CONJUNT MOTOR-BOMBA	28/01/2013 18:34
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	2745	MODIFICAR FRECUENCIA NATURAL BANCADA	11/02/2013 09:24
IDWXXAP10-C	MEC1 - ELECTROBOMBA P10-C	2746	SUBSTITUCIÓ RODAMENTS	11/02/2013 09:27
IDWXXAP11-B	MEC1 - ELECTROBOMBA P11-B	2879	PÉRDIDA DE ACEITE POR RETÉN	04/03/2013 18:19
IDWXXAP09-B	MEC1 - ELECTROBOMBA P09-B	3006	ALINEACIÓN	27/03/2013 17:21
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	3011	CANVI RETENS I SEGELLS MECANICS	02/04/2013 17:03
IDWXXAP08-A	MEC1 - ELECTROBOMBA P08-A	3096	CANVIAR RETENS I RODAMENTS BOMBA	26/04/2013 20:21
IDWXXAP08-A	MEC1 - ELECTROBOMBA P08-A	3222	INCIDENCIA DW 20130603	04/06/2013 10:04
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	3224	INCIDENCIA DW 20130603	04/06/2013 16:43
IDWXXAP07-A	MEC1 - ELECTROBOMBA P07-A	3226	INCIDENCIA DW 20130603	04/06/2013 16:48
IDWXXAP11-B	MEC1 - ELECTROBOMBA P11-B	3225	INCIDENCIA DW 20130603	04/06/2013 16:48
IDWXXAP11-B	MEC1 - ELECTROBOMBA P11-B	3007	ALINEACIÓN EN CALIENTE BOMBA	10/06/2013 00:00
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	3234	REALIZAR ALINEACIÓN EN CALIENTE	10/06/2013 16:58
IDWXXAP07-A	MEC1 - ELECTROBOMBA P07-A	3235	REPARACIÓN RODAMIENTOS MOTOR	10/06/2013 17:39
IDWXXAP08-C	MEC1 - ELECTROBOMBA P08-C	3397	Comprobar estado bomba P-8C	09/07/2013 00:00
IDWXXAP07-A	MEC1 - ELECTROBOMBA P07-A	3473	MONTAR VOLUTA Y BOMBA EN BANCADA	22/07/2013 16:26
IDWXXAP08-A	MEC1 - ELECTROBOMBA P08-A	3481	REPARACIÓN COMPLETA BOMBA	24/07/2013 16:52
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	3495	UTILITZAR EQUIP CONTRAST OLI	26/07/2013 12:13
IDWXXAP07-A	MEC1 - ELECTROBOMBA P07-A	3521	RECTIFICAR EIX BOMBA	07/08/2013 17:36
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	3568	CANVI SEGELL MECÀNIC	14/08/2013 16:02
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	3572	CANVIAR TRANSMISSOR BOMBES	14/08/2013 16:39
IDWXXAP10-C	MEC1 - ELECTROBOMBA P10-C	3573	CANVIAR TRANSMISSOR BOMBES	14/08/2013 16:39
IDWXXAP11-B	MEC1 - ELECTROBOMBA P11-B	3647	ARRANQUE DE BOMBA ESTANDO EN MANUAL	26/08/2013 09:30
IDWXXAP07-A	MEC1 - ELECTROBOMBA P07-A	3651	ALINEACIÓN	26/08/2013 11:35
IDWXXAP10-A	MEC1 - ELECTROBOMBA P10-A	3830	ALINEAMENT CONJUNT MOTOR-BOMBA	14/10/2013 17:47
IDWXXAP08-B	MEC1 - ELECTROBOMBA P08-B	3862	CANVIAR ENGRASSADOR MOTOR BOMBA	21/10/2013 17:59
IDWXXAP09-A	MEC1 - ELECTROBOMBA P09-A	3885	CANVI RODAMENTS COSTAT BOMBA	28/10/2013 11:29
IDWXXAP09-A	MEC1 - ELECTROBOMBA P09-A	3887	ALINEACIÓN	28/10/2013 11:29
IDWXXAP10-B	MEC1 - ELECTROBOMBA P10-B	3888	COMPROVAR ALINEAMENT	28/10/2013 11:29

- The current preventive maintenance scheme implemented showed us that there is something to improve with the cooling pumps.
  - Maintenance activity increasing yearly

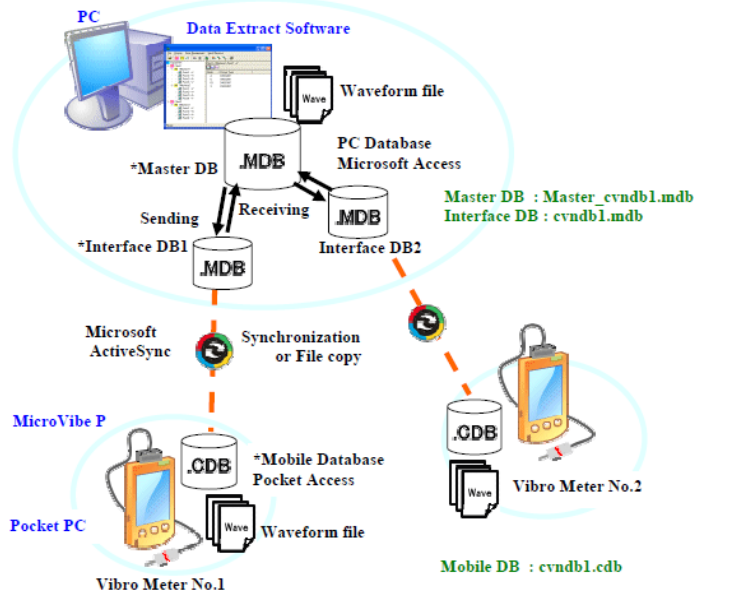
Machine vibration monitoring

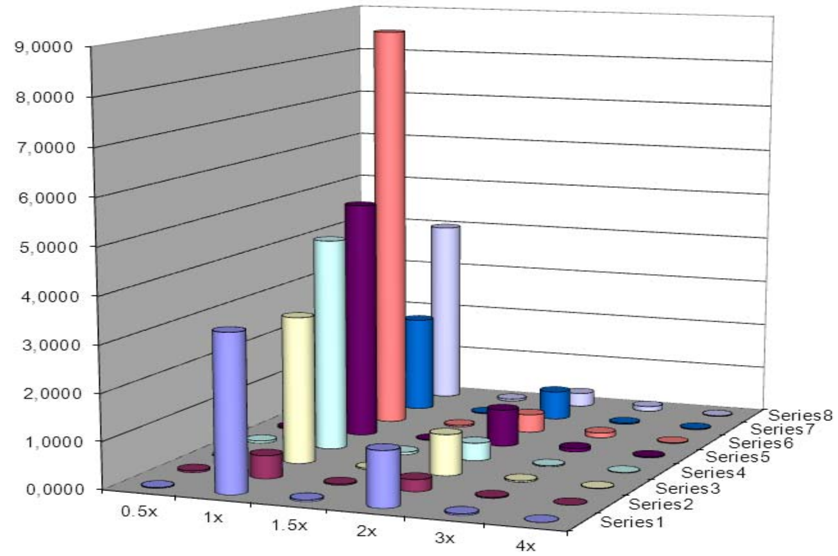
Within predictive machine maintenance, vibration monitoring is one of the most used techniques. It provides the following advantages:

- Vibration magnitude is proportional to the magnitude of the problem
- Vibration measurement is non-invasive
- Most faults show increased vibration in an early stage of the deterioration sequence
- Vibration can be measured instantaneously
- Vibration can indicate severity and deterioration rate of a fault
- Vibration can help to find the location of the fault
- Vibration can help to find the cause of the fault

Machine Vibration is generated in server ways:

- Operating machinery produces vibration due to its rotational or linear motion
- Increasing trends towards a higher level indicate emerging problems
- Typical problems arise through
  - misalignment of drive train components
  - worn or damaged bearings
  - load asymmetry due to debris adhesion on rotary parts like fans etc.
  - incorrect assembly
- Vibration generally occurs with its major component perpendicular to the rotational axis of the load transmission shaft
- The amount of vibration depends on
  - the stiffness and geometry of the machine's structure
  - the machine foundation
  - the speed of rotation of the shaft





Reference Standard ISO 10816

- The standard gives recommendations for the evaluation of machine vibration on non rotating parts.

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/s	r.m.s. displacement µm
		Rigid	Flexible	Rigid	Flexible		
22	1,4	A	A	A	A		
37	2,3	B	A	A	A	2,3	29
45	2,8	B	B	B	A		
71	4,5	C	B	B	A	3,5	45
		C	B	B	B	4,5	57
113	7,1	D	C	C	B	7,1	90
		D	D	D	C	11,0	140
		D	D	D	D		

Group 1:	Large machines with rated power above 300 kW and not more than 50 MW; electrical machines with shaft height H ≥ 315 mm. These machines normally have sleeve bearings. The range of operating or nominal speeds is relatively broad and ranges from 120 r/min to 15 000 r/min.
Group 2:	Medium-sized machines with rated power above 15 kW up to and including 300 kW; electrical machines with shaft height 160 mm ≤ H < 315 mm. These machines normally have rolling element bearings and operating speeds above 600 r/min.

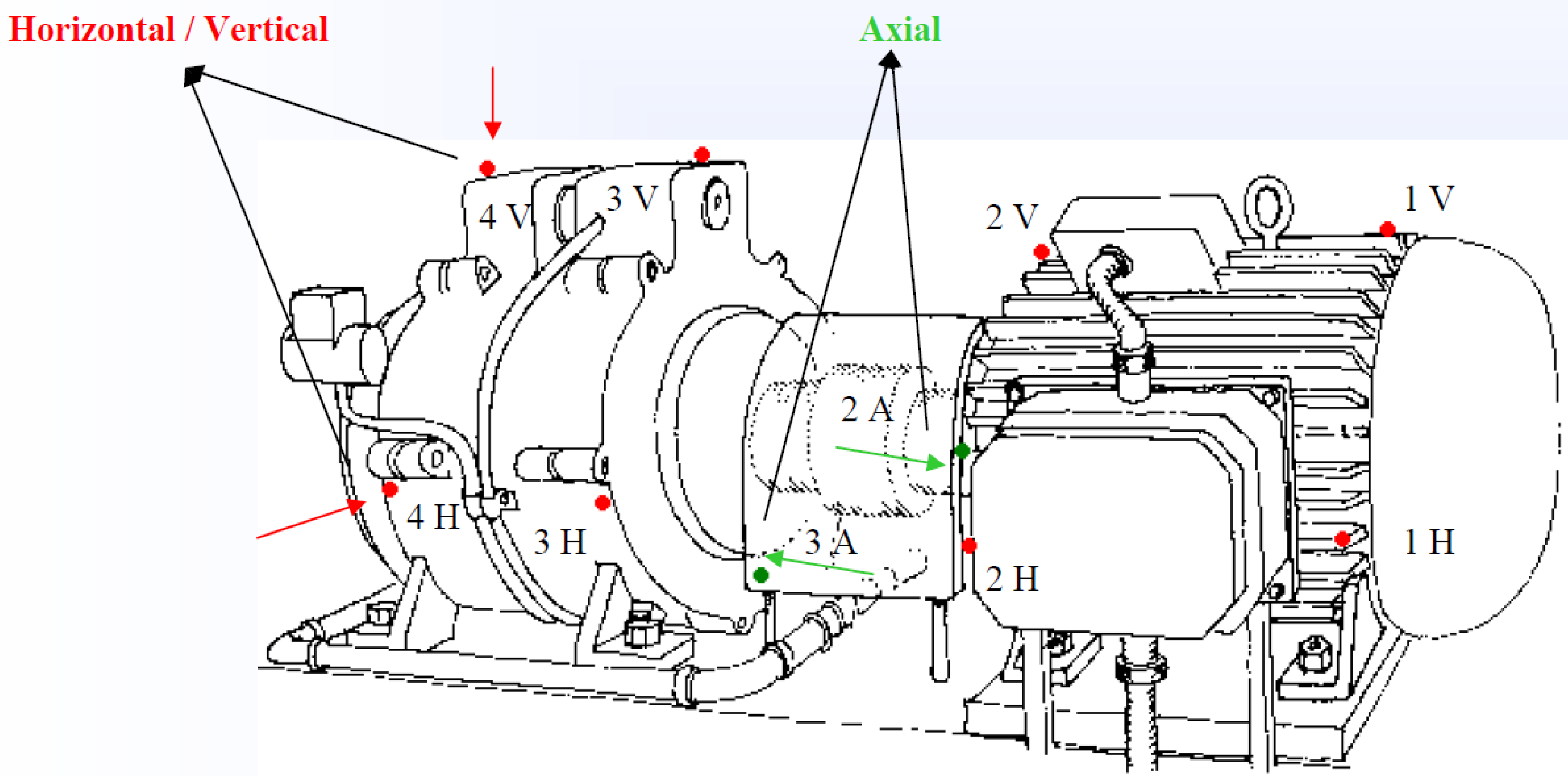
Zone A:	The vibration of newly commissioned machines normally falls within this zone.
Zone B:	Machines with vibration within this zone are normally considered acceptable for unrestricted longterm operation
Zone C:	Machines with vibration within this zone are normally considered unsatisfactory for long-termcontinuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.
Zone D:	Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine

CBM vibration pattern

Slab	1x
Imbalance	1x
Eccentricity	1x, 2x
Misalignment	1x, 2x, 3x
Double Axis	2x
Roominess	1x, 2x, 3x, 4x,
Bearings – see form	
Supports	0.5x, 1x, 1,5x
Lubrication	0.4, 0.5x
Blades	(1x)* (5=nº blades)

Measurement points

Data taken at horizontal / vertical / axial – several points each one



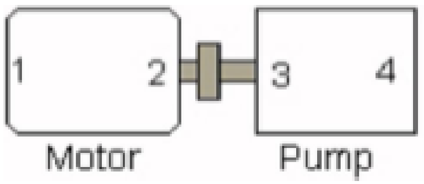
Example measurement at pumps P11

Spectra analyzer GX-70-M

Accelerometer CMSS 2200 of 100 mV/g

BOMBA P 11 B (75 KW 1485 rpm)

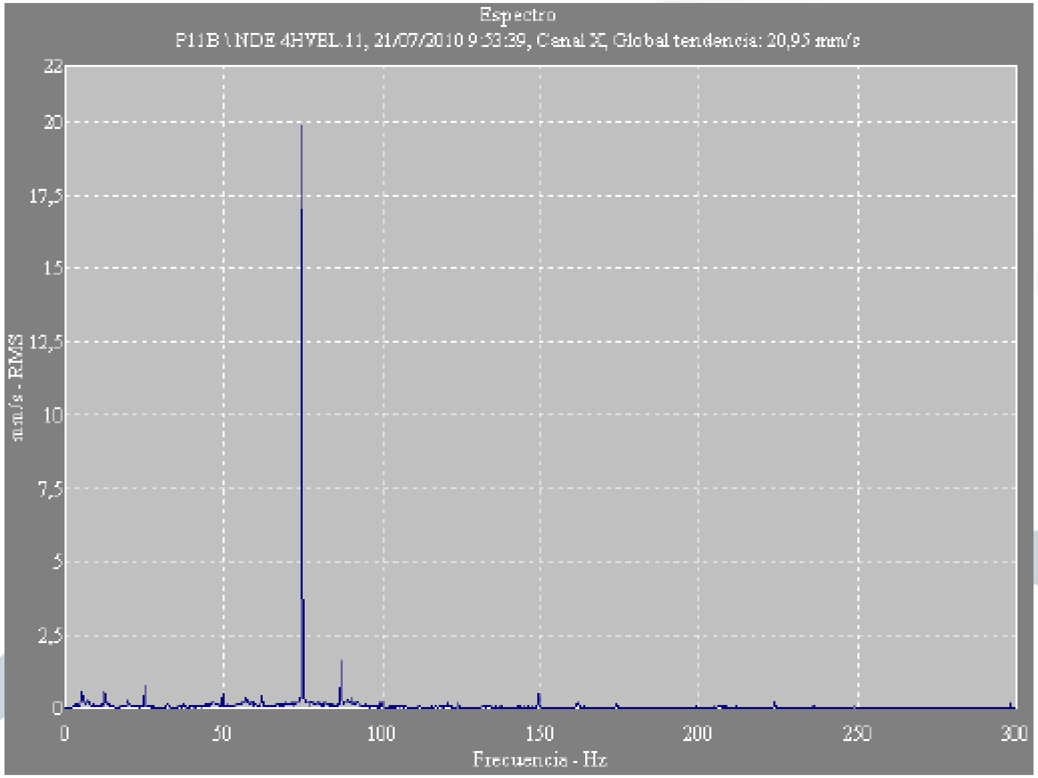
PUNTOS	1 H VEL	1 H ENV	1 V VEL	1 V ENV		
P1	3,9	0,92	5,1	0,64		
	2 H VEL	2 H ENV	2 V VEL	2 V ENV	2 A VEL	2 A ENV
P2	5,1	0,54	8,1	0,6	4,8	0,59
	3 H VEL	3 H ENV	3 V VEL	3 V ENV	3 A VEL	3 A ENV
P3	15,6	1,21	4,2	1,24	2,6	1,5
	4 H VEL	4 H ENV	4 V VEL	4 V ENV	4 A VEL	4 A ENV
P4	12,6	1,59	4	1,17	2,9	3,09



Regular monthly monitoring, no permanent monitoring.

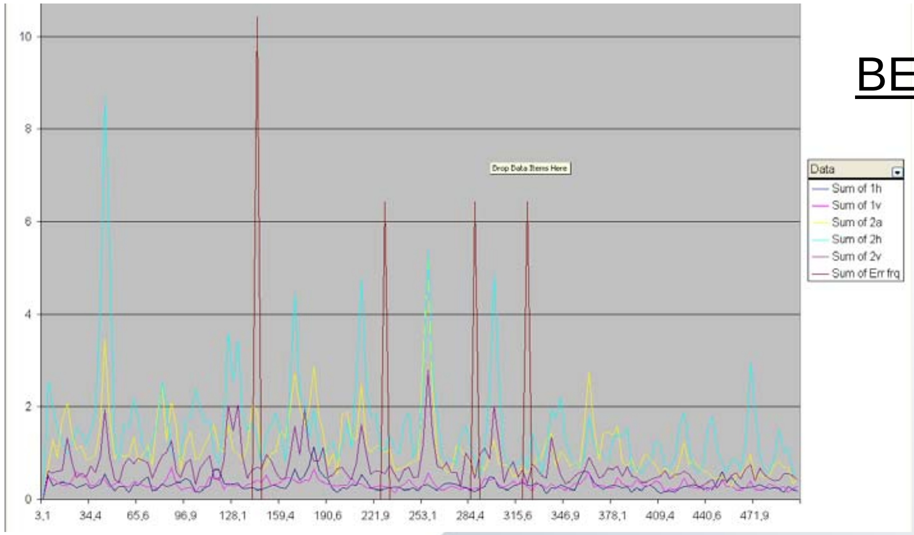
Measuring the vibration

- Every component, every fault, every hurt associated with some component generates a vibration to a certain frequency. In the example pumb P11B



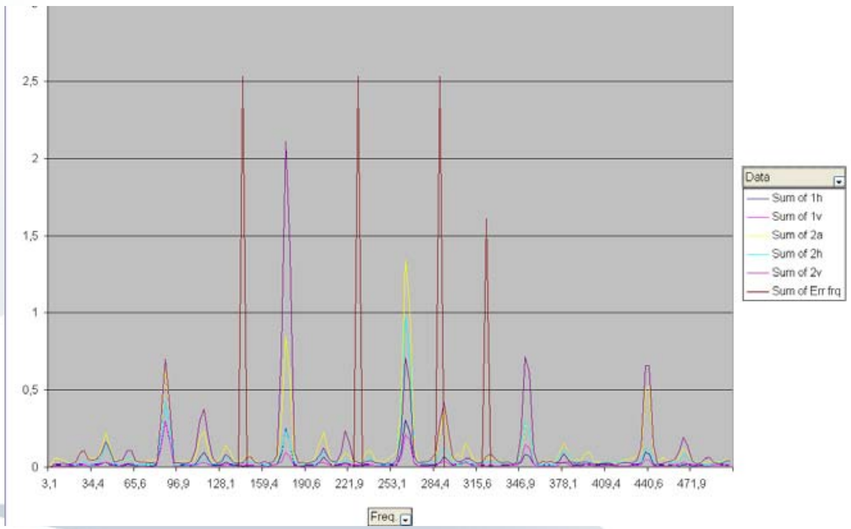
__Analysis in frequency: every band of frequency is associated with a certain fault, in this case with a misalignment of the pump P11B.__

Vibration monitoring evolution

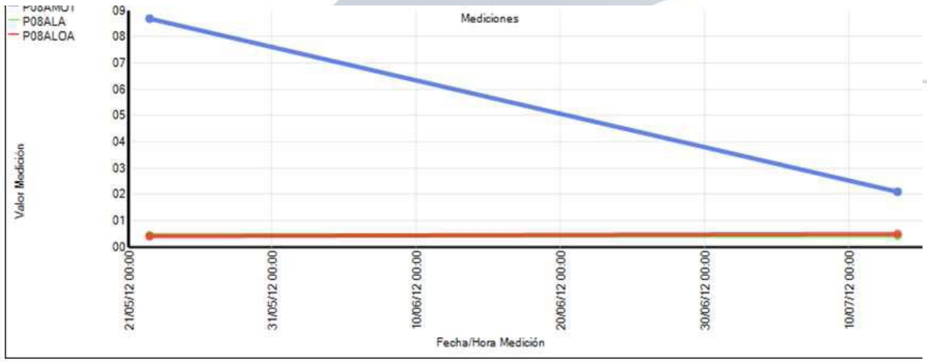


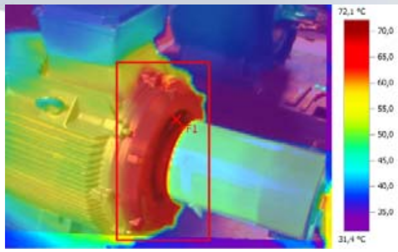
BEFORE replacement of bearings

AFTER replacement of bearings



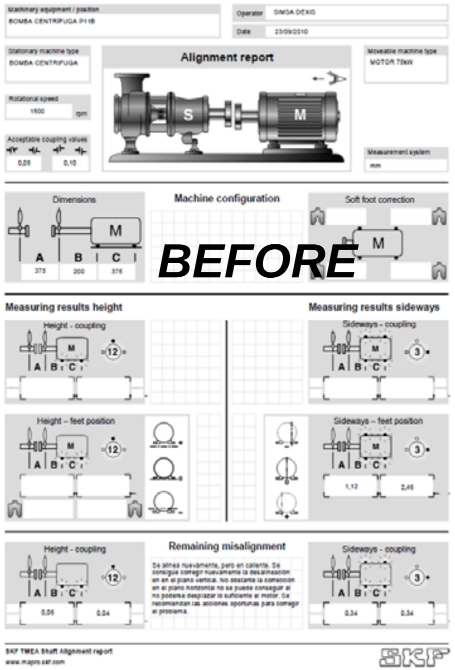
Compare data taken before and after the intervention

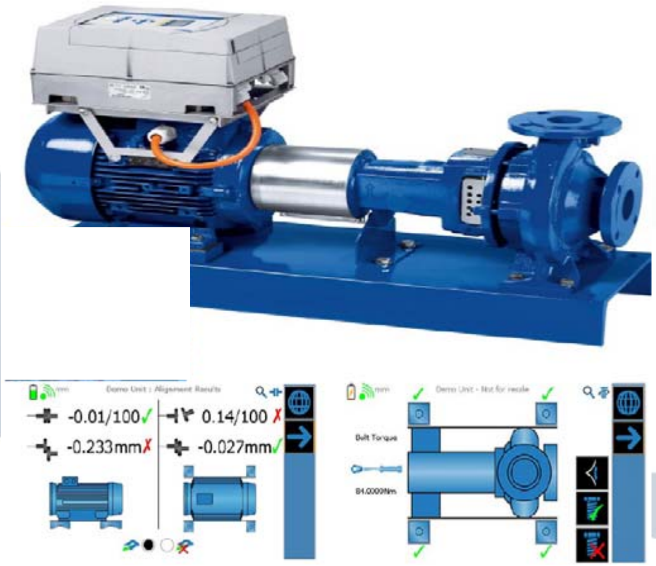


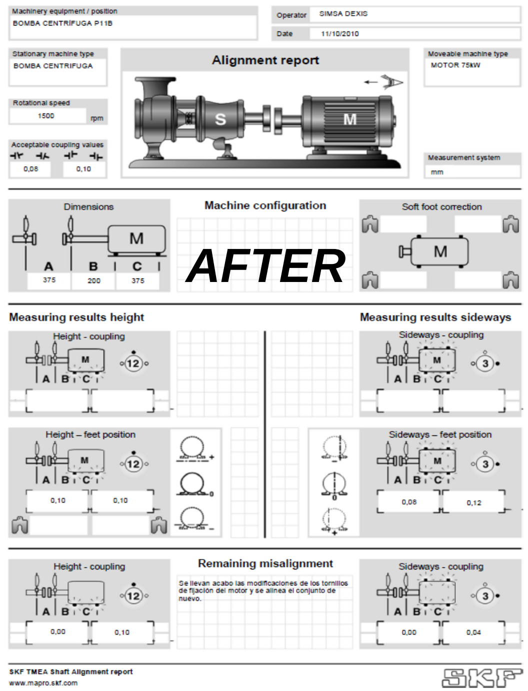


Correction of the fault

- ACTION: Alignment of the pump P11B. We move the pump horizontally and vertically to correct the misalignment.







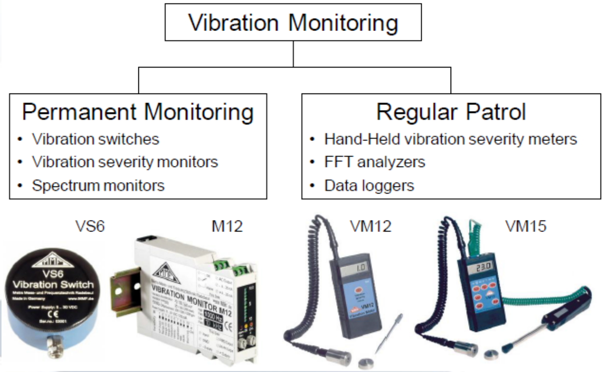
(Typical worksheets of alignment work orders)

Agenda

1. ALBA Infrastructures: building and utilities current maintenance approach.
2. Conditions based maintenace introduction
3. **Next steps and conclusions.**

Next steps

- Once the P11 circuit will be well studied and implemented permanent monitoring, move to the other circuits with same problem but different configuration (2+1 instead of 1+1).
- In a later stage, the current scada software platform that is the Centralized Management System of the conventional infrastructure facilities, will manage:
  - Monitor alarms of equipment health, and failure diagnosis support.
  - Perform health/life data analysis and maintenance decision support.
- Measure equipment status and performance in a permanent monitoring towards improvement of the preventive.
- Plans for the implementation of a predictive maintenance approach where applies and the extension of the current maintenance strategy to other scientific equipment.



Conclusions

- 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.
  - Technician and Engineers from several fields such us Infrastructure, Workshop, Maintenance technicians, Civil Works, Survey&Alignment, Project Office, Draftsmen, Designers and Calculists.

Thanks!!!