1. ALBA Infrastructures: building and utilities current maintenance approach.

2. Conditions based maintenace introduction

3. Next steps and conclusions.
• 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.
• 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.
• 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)
**Key figures:** From management of Normative (legal operations), Corrective, Preventive and Predictive maintenance.

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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)
• 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
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

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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
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.

![Graph showing consumptions from 2012/06 to 2013/06.](image)
Valuation by Family

- Main item families:
  - FILTROS: Filters for HVAC.
  - CIERRE MEC: Mechanical 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 maintenance 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 management 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 chosen as study case.

• Motivation
  – Critical for the facility
  – Literature availability
  – Real data availability
Alarm and diagnostic system

- Alarm generation embedded 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.
• 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 assess the decision making process
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

<table>
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<tr>
<th>FLOW</th>
<th>High</th>
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<th>Models</th>
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<th>Outlet</th>
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<td>(Kpa)</td>
<td>Kw</td>
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<td>1+1 INP-250/300C</td>
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</table>
There is a problem at pumps

- The current preventive maintenance scheme implemented showed us that there is something to improve with the cooling pumps.
  - Maintenance activity increasing yearly.
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 several 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
The standard gives recommendations for the evaluation of machine vibration on non rotating parts.

**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)
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

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 pump 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)
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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!!!