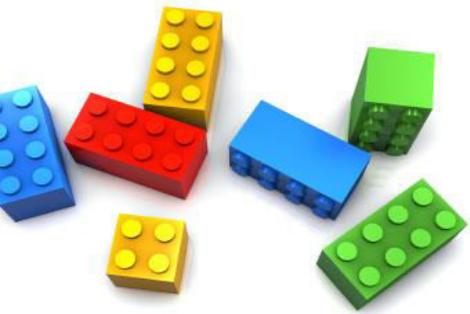APPLYING BASIC EQUIPMENT CARE AS PART OF THE PREVENTIVE MAINTENANCE STRATEGY IN ASPROPYRGOS-GREECE HELLENIC PETROLEUM REFINERY

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Athens, 31.05.2016

Motivation – The RCM Culture

A series of Generic Equipment Maintenance Strategies (**GEMS**) have been developed throughout the 3 HELPE refineries so as to structure the preventive maintenance activities per equipment type.

Focusing on the PREDICTIVE region:

• The *Reliability Team* measures equipment vibration and performs vibration analysis every 2 or 6 weeks based on its criticality.

• *Basic Equipment Care* (BEC) works supplementary to the Condition Based Maintenance (CBM) program applied in the plant.
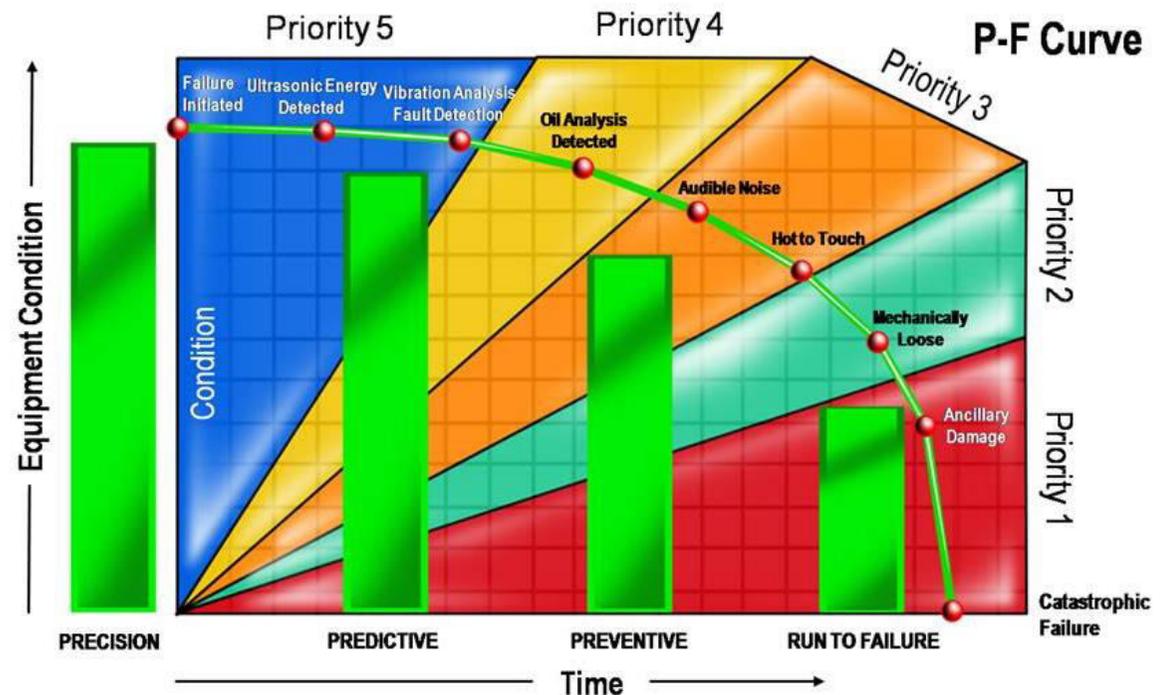
BEC as Part of CBM

- **WHAT?**

Basic Equipment Care is a formal inspection program that records the *condition* (sight, smell, touch, sound) of the assets in a plant.

- **WHO?**

This requirement refers to the *operator*, who routinely works with the equipment, to use human senses and tools to identify changes and possible problems.

- **WHEN?**

Twice a week

BENEFITS:

- Introduce the concept of *autonomous maintenance* and change an organization's culture to a proactive mindset.
- In a very short time, an asset basic care program will develop an *equipment database* populated with information—moving the organization from "fire-fighting" to streamlined maintenance.
- An effective BEC program *partners* maintenance and reliability with production, it offers time to perform different tasks and it results in better trained mechanics and operators with higher levels of expertise.
- For the organization, it improves *operational efficiency*, quality and reduction of *maintenance costs*.

The real benefit is bonded to the development and growth of a *holistic RCM* culture in the plant.

Methodology

The BEC program defines a *minimum* of certain actions to be performed by operators during a pre-defined equipment route.

- **Historical data that need be recorded are:**

  - *Vibration* and *temperature* measurements at the bearings of the pump-motor trains with the use of vibration pens. Operators are asked to record velocity vibration and the point measurements are obtained solely in the horizontal direction. The points of measurement at a **horizontal** pump are shown. In the case of **vertical** pumps, 2 points are measured at the motor and 1 at the pump bearings, while in the **rotary** pumps, only the 2 points at the motor are measured.
  - The indications of *local instruments*.

- **Observation-related tasks:**

  - *Monitoring* for potential leaks, spills, signs of excessive wear, vibration, noise levels, lubrication levels followed by oil refill if necessary, condition of cooling lines, or unusual smells.
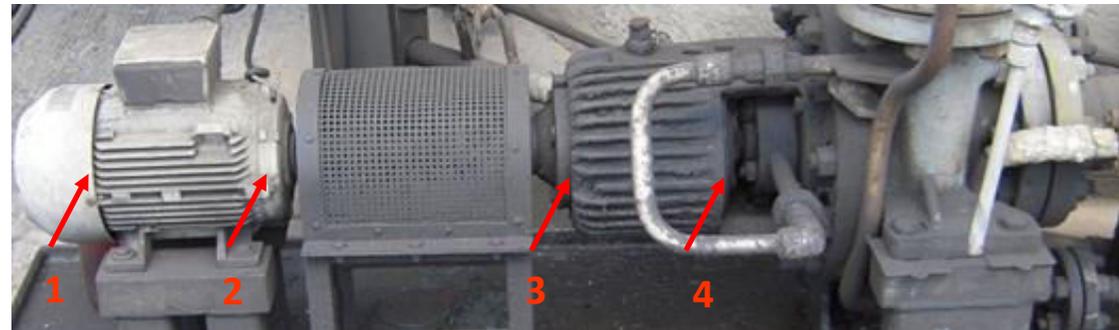
Overhung pump: The 4 points of measurement

Program Implementation

The Program

1. Covers ~1,000 Pump Tag.Nos :
   - Centrifugal horizontal - 75%
   - Centrifugal vertical - 15%
   - Rotary pumps - 10%
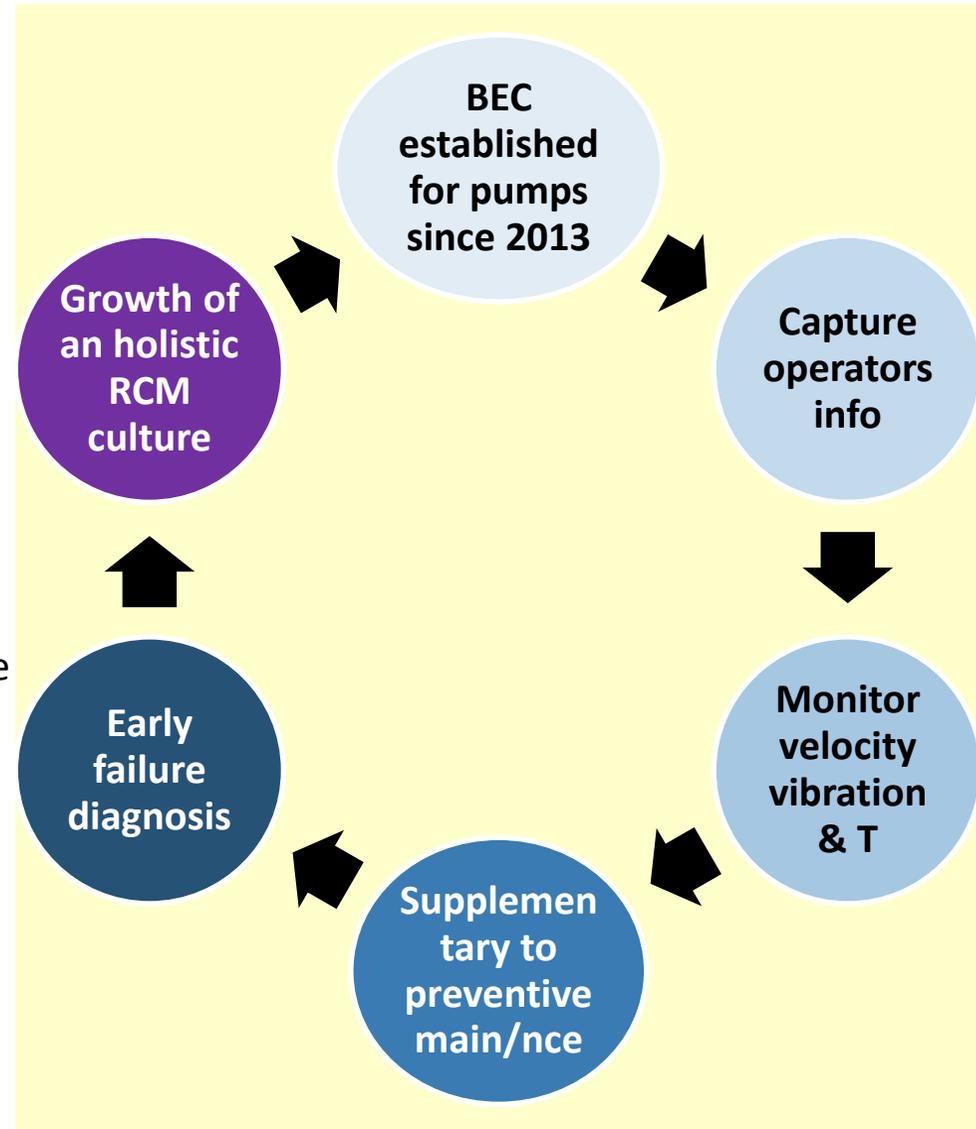2. Recordings of local instruments
3. Observation-related tasks

The Challenge

1. Plethora of BEC users & measurements ~*7,000* weekly
2. Need for evaluation of the quality and significance of the measured data
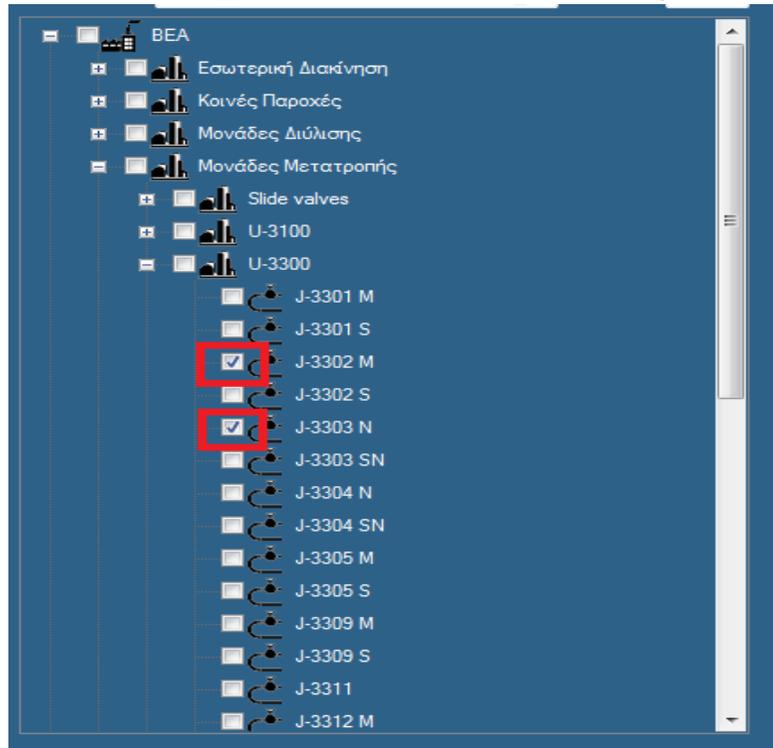
The Action

Development of the *BEC tool*:
1. Expansion of a dynamic database
2. Criteria of Statistical Quality Control
3. Monitoring-alarming system
4. Recording of Maintenance Calendar

BEC established for pumps since 2013

Capture operators info

Monitor velocity vibration & T

Supplementary to preventive main/nce

Early failure diagnosis

Growth of an holistic RCM culture

BEC Tool*: The Database

The fundamental aspect of the platform is its user-friendliness, achieved through an interactive and iterative process at its development stage, with the users, the operators.


Massive Data Upload : The equipment is stored in a tree form. Here, Pumps J-3302 and J-3303 are selected for new data storage.
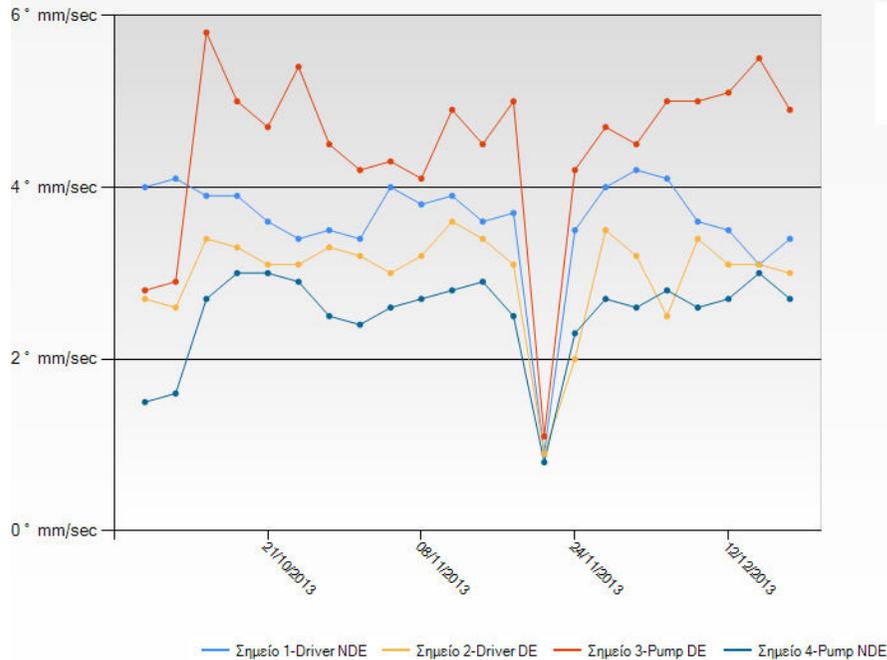

New entry overview: Except for the date, time and user information, the actual 4 measurements for vibration and temperature are stored, along with the local instrument indications (if available), namely discharge Pressure and Amperes.

*The Tool has been developed in house by developer A. Gkoutis

Vibration & Temperature Trends
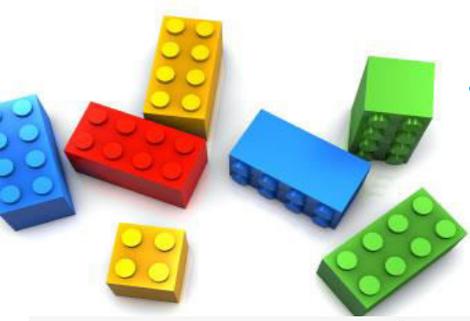
In the plots, each one of the 4 lines corresponds to a different measuring point and the x-axis can be filtered down to the desired time frame

Maintenance History & Dashboard
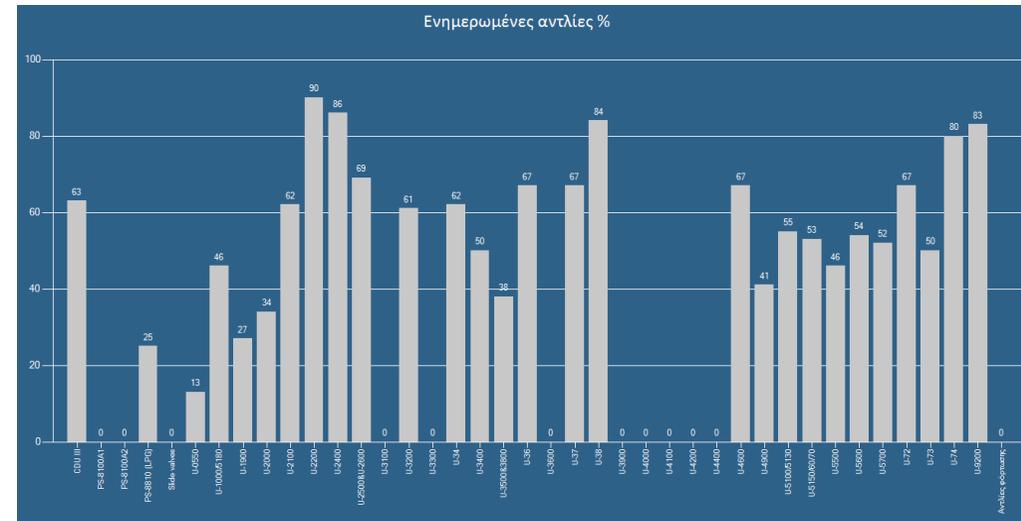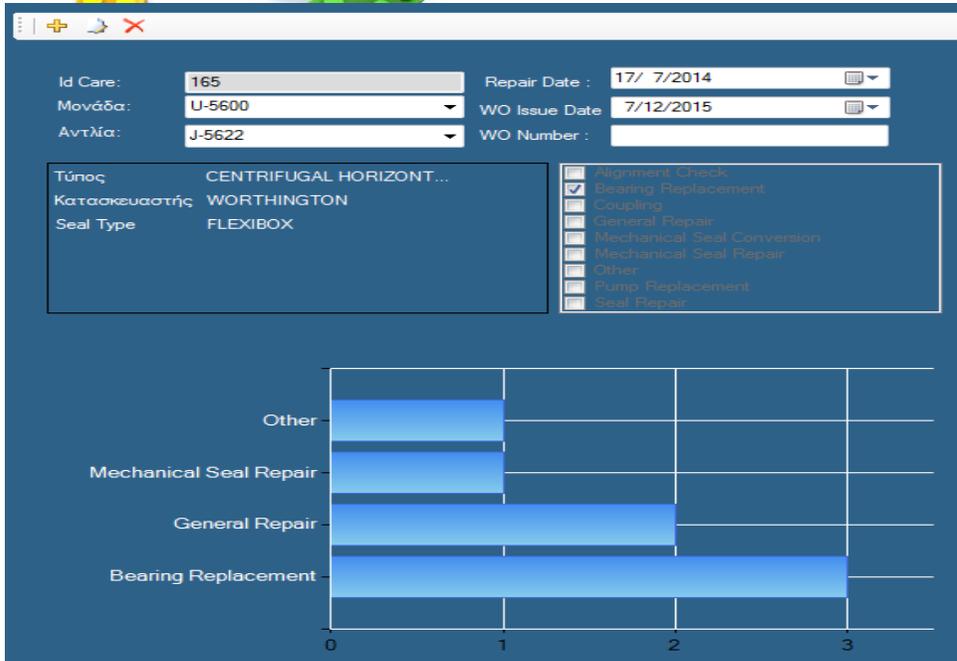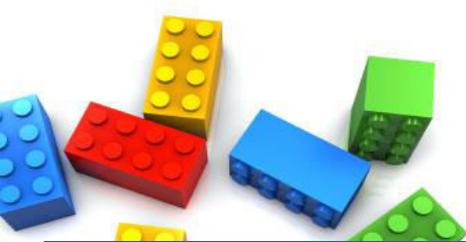
Maintenance History: Statistical information is gathered per pump, concerning its failures. This information is uploaded by the Reliability team. In this example, within 1.5 years, the pump has been through one MS repair, 2 GR, 3 BR and one repair due to other reasons.

Dashboard: A quick overview of the BEC program implementation is provided. This is performed per Unit and assists the Reliability team to focus on areas that might need assistance with the program. An acceptable implementation would be close to 60%.

The Statistical Model
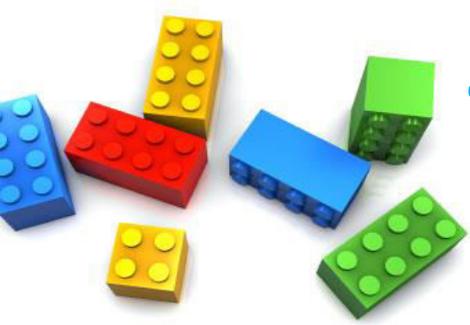
The BEC Tool is not solely a dynamic database.

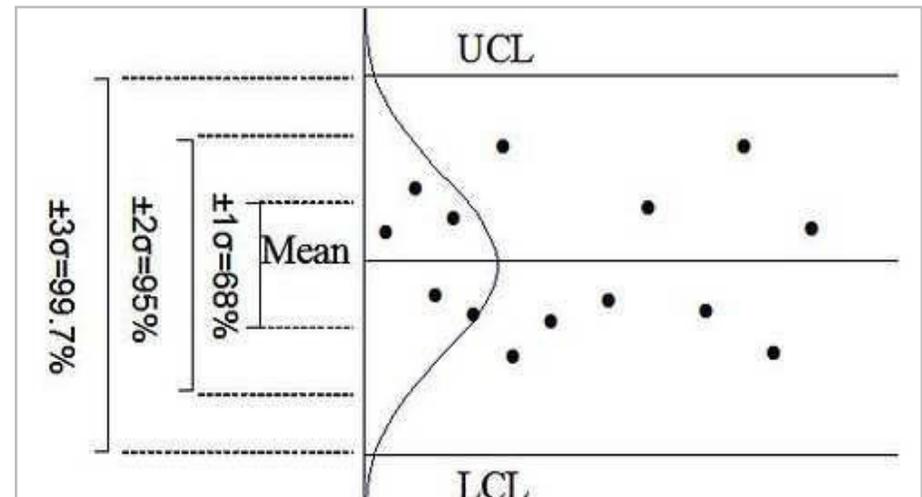It has also embedded the *monitoring mechanism* to evaluate each new stored vibration measurement and trigger the program alarming system, if necessary.

This mechanism is based on the theory of *Statistical Quality Control* and applies certain criteria in assessing the new measurement. There are three core components in a control chart*:

- The Mean of all data points
- The UCL (Upper Control Limit)
- The LCL (Lower Control Limit)

For the cases where the sampling rate is not very frequent, like in this case where the measurements are obtained twice a week, the control limits are calculated based on the moving range of 2 consequent measurements [Render et al 2011].

The control chart has the following shape:

Source: www.shmula.com

* *The Control Charts have derived from the world six sigma / process excellence.*
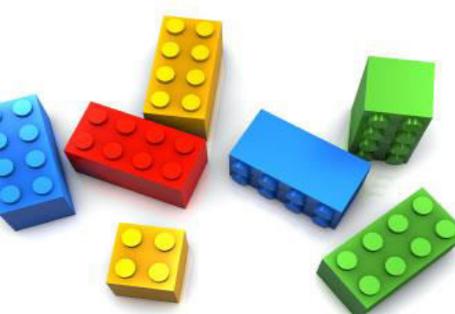
Monitoring-Alarming Criteria

For each new measurement, the program performs the above calculations and then applies the following 4 criteria:

1. The new measurement is outside the 3σ limit
2. 2 out of 3 consecutive points are located outside the 2σ limit
3. 3 out of 5 consecutive points are located outside the 1σ limit
4. 5 consecutive points are located above x

Despite the statistical model, additional monitoring is activated above 2 predefined cut-off values:

1. Vibration value is above 9mm/s.
2. Temperature value is above 75°C.

Measurements that trigger alarms in the software, are evaluated by the Reliability team. In most cases *alarms act as an extra call* and the Reliability specialist goes on site to obtain new measurements of the equipment and evaluate its condition.

* The Control Charts have derived from the world six sigma / process excellence.

Implementation Results

It is reminded that the Reliability Team measures equipment vibration every 2 or 6 weeks based on its criticality and the operator measurements twice a week work *supplementary*.

It is reasonable to expect few achievements per year.

BEC Findings since launching

	Tag. No.	Action	Description
2013	J-2103	Repair	Coupling & Alignment Check
	J-8361	Repair	Coupling & Alignment Check
2014	J-8361	Repair	Impeller & Wear Rings Check
	J-5622-S	Repair	Pump Bearings
	1033-S	Repair	Coupling & Alignment Check
	J-3353	Repair	Coupling & Alignment Check
2015	J-3505-M	Repair	Motor Bearings
	J-8854	Repair	Pump Bearings
	J-5501-S	Repair	Impeller & Wear Rings Check
	J-5612	Repair	Impeller & Wear Rings Check
	J-2006-S	Recheck	Monitoring/Recheck

Tag. No.	Actual Repair Cost	Avg Cost General Repair	BENEFIT
J-2103	727 €	4,000 €	3,273 €
J-8361	340 €	7,500 €	7,160 €
J-8361	5,113 €	7,500 €	2,387 €
J-5622-S	15,455 €	17,200 €	1,745 €
1033-S	778 €	7,500 €	6,722 €
J-3353	1,914 €	7,500 €	5,586 €
J-3505-M	540 €	7,500 €	6,960 €
J-8854	8,828 €	17,200 €	8,372 €
J-5501-S	511 €	7,500 €	6,989 €
J-5612	13,400 €	17,200 €	3,800 €
J-2006-S	Recheck	Recheck	-
SUM			52,994 €

Economic Benefit of BEC Implementation:

The economic benefit is extracted based on the historical average of general repair costs of various size pumps.

May–June 2016

Future Elements

The continuation of the BEC program implementation is the fundamental goal for the Reliability team.

- The 1,000 Tag.Nos is a challenging amount of equipment to *sustain* in the program.

- The program *expansion* in terms of new measuring parameters by the operators is the next step:
  - Acceleration measurements could be obtained, since they can be supported by the vibration pen used,
  - Other parameters such as oil Pressure and Temperature for Sundyne pumps.

- Then, additional *equipment families* can be introduced to BEC. Hence, reciprocating pumps can be added, fans and air coolers.

- The ultimate idea is to expand the platform so as to include *equipment performance metrics*, such as online operational data plotted along with the characteristic curve of the equipment. This could provide an overview of the equipment operation over time and give insight to the users concerning its expected behavior.
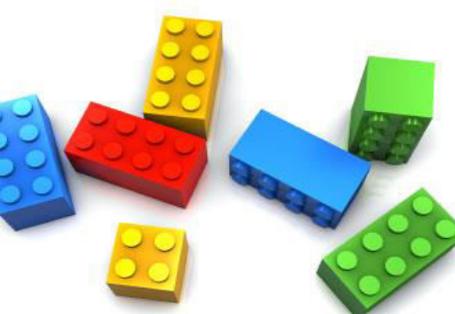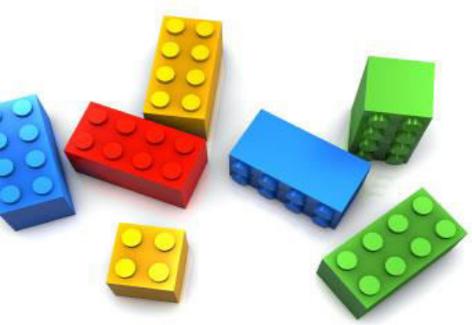
Conclusion

- **The significance of BEC implementation has primarily <u>a strong qualitative dimension</u>:**

  - The list of actions described in the program, including both observation-related steps and equipment measurements, establishes a *permanent route* for the operator.
  - This repeatability translates the route into a routine and will develop *expected conditions* for the operator, who eventually increases his skill and expertise.
  - The program targets *imprinting the routine* into the personnel's culture founding a reliability centered philosophy in the plant.

- **The <u>quantitative benefits</u> rising from BEC implementation are also noticeable:**

  - Within 2 years of the program operation, the economic benefit reached the amount of approximately *53k €.*
  - This is expected, as it corresponds to the failure findings solely by the operators, within the window between two measurements by the Reliability Team.

Thank you for your attention