

## EXPERIMENTAL RESULTS OBTAINED IN A PROACTIVE MAINTENANCE OF INDUSTRIAL EQUIPMENT OPERATING IN LUKOIL REFINERY

Authors: Ionel RUSA<sup>1</sup>, Cornel MARIN<sup>2</sup>

<sup>1</sup>BIT INVEST Romania email: [ionelrusa@gmail.com](mailto:ionelrusa@gmail.com),

<sup>2</sup>VALAHIA University of Târgoviște, FIMM, email: [marin\\_cor@yahoo.com](mailto:marin_cor@yahoo.com)

**Abstract:** *In the engineering practice, knowing the technical condition of industrial equipment under operating results shortening of repairs, repairs machinery to smart planning based on the time evolution of bearing wear, detect and correct errors on their installation or repair. This is one of the most important objectives of proactive maintenance; maintenance engineer must follow and monitor the wear of equipment with moving parts to prevent damage and removing them permanently from service, ensuring repair costs as low as possible. The aim of this paper is to present a particular case study on vibro acoustic diagnosis of equipment and components subject to wear during operation to prevent catastrophic damage, as well as human and material losses.*

**Keywords:** *proactive maintenance, bearing wear, vibro acoustic diagnosis*

### 1. INTRODUCTION

Proactive maintenance activities have become a necessity today, even if to start its implementation involves high cost. The software used for surveillance and maintenance planning within the firm LUKOIL produced by "International VMI AB Sweden - SPECTRA PRO" is professional software dedicated to a proactive maintenance program. Proactive maintenance activity aims to limit and eliminate accidental defect, growth productivity in manufacturing equipment, always knowing the technical condition of equipment, planning current and general repairs without affecting the operation of the main installations.

### 2. PROACTIVE MAINTENANCE OF NEW EQUIPMENT

Example proactive maintenance presented in this article is a case of better functioning of new equipment put into operation after installation and proper alignment of the elements in motion.

This example is an electric pump that serves a supply power having a boiler flow with a capacity 240t / h (shown in Figure 1 and Figure 2); the equipment was installed in March 2015. The main features of this equipment (the electric power - EPA no. 3) are as follows:

- Engine power = 1.7 Mw,
- Supply voltage = 6000 V
- Nominal pump (Q) = 2985 l / min,
- Working pressure = 140 bar,
- Temp water supply > 1500 C

Figure 1 shows the placement of electric motor and pump produced by ELECTROPUTERE Romanian company.

Figure 2 shows the location of the equipment seen from another angle from which we can observe the supply pump and motor, local control panel.



Fig. 1. The electric motor and pump No. 3



Fig. 2 – The electric motor, local control panel.

#### 2.1. Evolution wear in the bearing No.1.

Figure 3 presents the variation wear of mounted bearing No. 1 measured in units of gravitational acceleration  $g$ , depending on the rotation speed of the machine  $RPM$ . According to the four diagrams of Figure 3, the bearing wear of mounted bearing no. 1 is  $0.11 g$  - this is a very good value, considering that was acquired after equipment operating longer than one year (measured on the period 27.05.2015 - 28.06.2016).

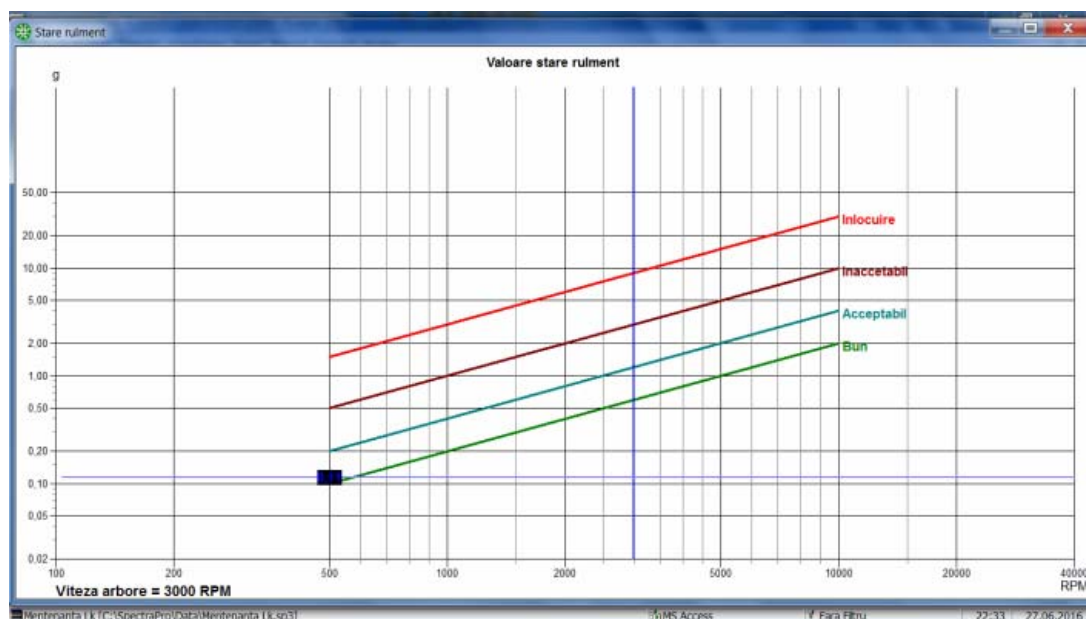


Fig. 3 – EPA nr.3 : The bearing wear of mounted bearing no. 1

Standard ISO-10816-3				
Viteza de vibrație mm/s (RMS)	Clasa I Mașini cu putere > 10 Mw	Clasa II Mașini cu putere > 300 Kw	Clasa III Motoare electrice 15 Kw – 75 Kw	Clasa IV Motoare electrice < 15 Kw
0.28	A	A	A	A
0.45				
0.71				
1.12	B	B	B	B
1.8				
2.8	C	C	C	C
4.5				
7.1	D	D	D	D
11.2				
18				
28	D	D	D	D
45				

Fig. 4 – The international standard for vibration ISO - 10816.

In order to monitor the status of technical equipment necessary for adequate monitoring / recording and processing vibration levels, which is a method of non-invasive which is achieved through the placement of transducers for measuring vibration levels in three directions: vertical, horizontal and axial.

To determine the technical condition of equipment under operating continuously measured values must be compared with standard values established by the international standard for vibration ISO - 10816.

This standard includes different values of vibration speeds RMS for four classes according to power plant their (Figure 4) colors represented for each area of vibration speeds RMS OVERALL values reflect the

technical condition of equipment: green - very good; yellow - good; orange - carefully; red - failure.

In Figures 5, 6, 7 are bearing mounted on the observed evolution of the wear of the bearing no. 1 values are measured on the period 27.05.2015 - 28.06.2016.

- In the horizontally direction: RMS OVERALL = 1.823 mm / s , , the bearing wear = 0.11 g (Figure 5). We can observe the trend of variation in amplitude is an almost constant during the period of one year after start up.

- In the vertical direction: RMS OVERALL = 0.438 mm / s, (Figure 6).

- In the axial direction: RMS OVERALL = 0.641 mm / s, (Figure 7). We can observe the trend of variation in time is an almost constant during the same period .

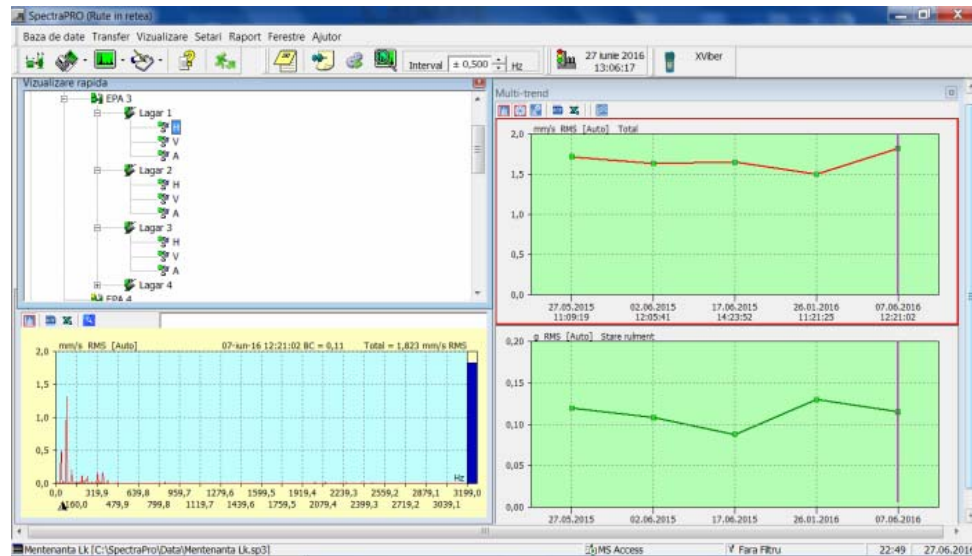


Fig. 5 – EPA No.3 : Bearing No 1- horizontally direction

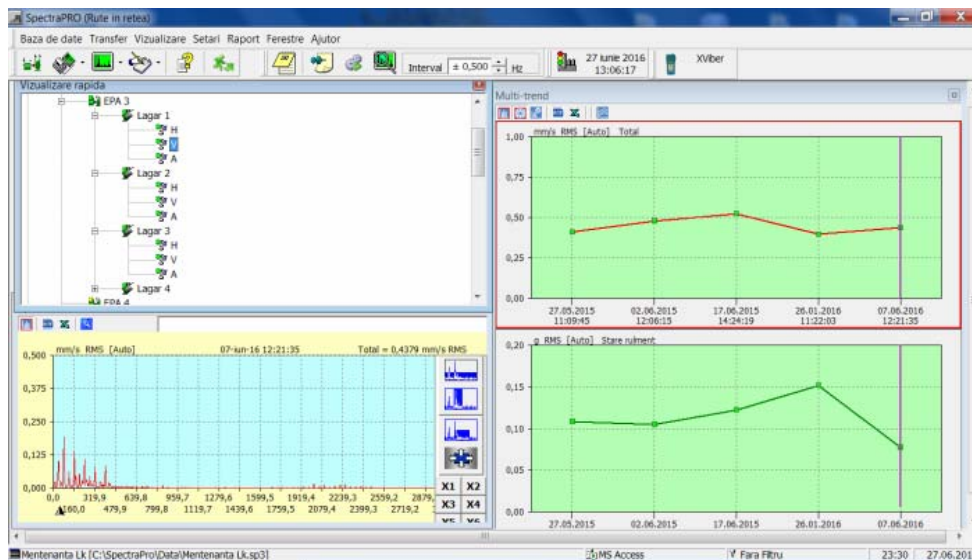


Fig. 6 – EPA No.3 : Bearing No 1- vertical direction

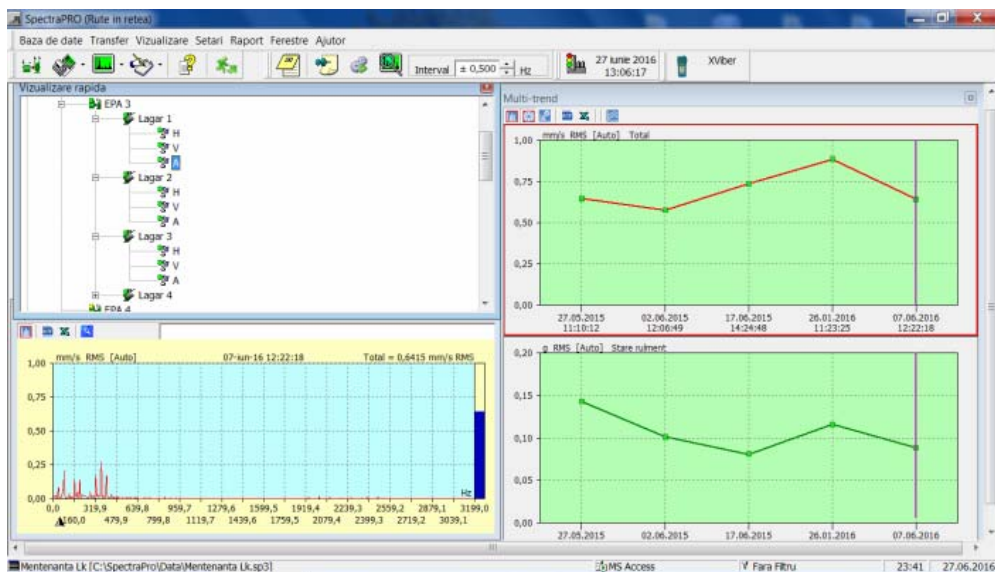


Fig. 7 – EPA No.3 : Bearing No 1- axial direction



## 2.2. Evolution wear in the bearing No.2.

Figure 8 presents the variation wear of mounted bearing No. 2 measured in units of gravitational acceleration  $g$ , depending on the rotation speed of the machine RPM.

According to the four diagrams of Figure 8, the bearing wear of mounted bearing no. 2 is  $0.18 g$  - this is a very good value, considering that was acquired after equipment operating longer than one year (values are measured on 27.06.2016).

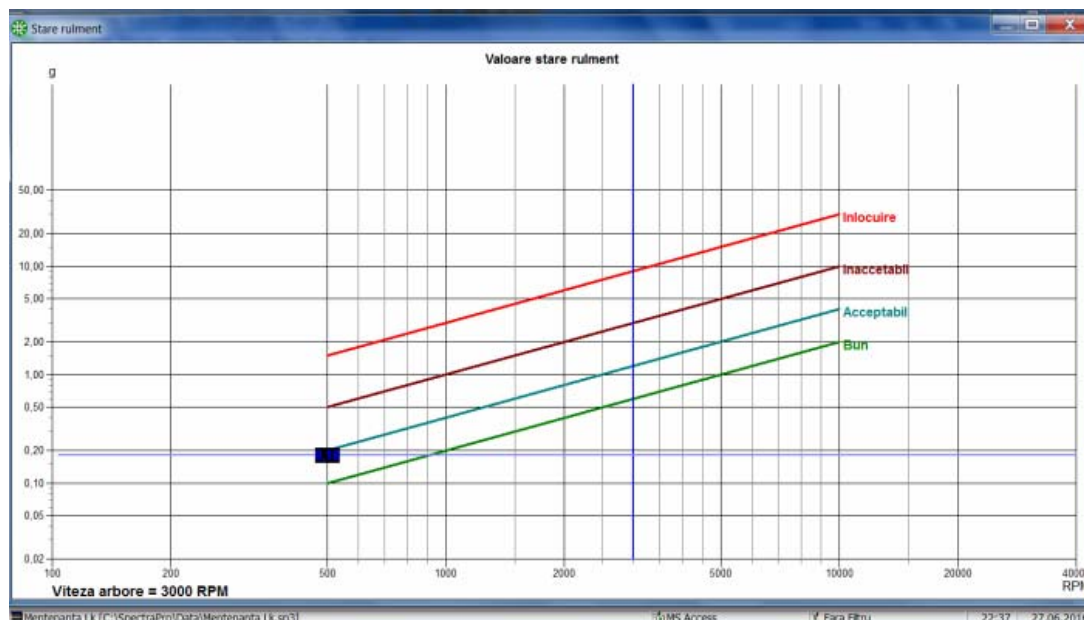


Fig. 8 – EPA No.3 : The bearing wear of mounted bearing no. 2

In Figures 9, 10, 11 are bearing mounted on the observed evolution of the wear of the bearing no. 2 values are measured on 27.06.2016:

- In the horizontally direction: RMS OVERALL=1.015 mm / s, the bearing wear=  $0.18 g$  (Figure 9).

- The vertical direction: RMS OVERALL =  $0.5005 mm / s$ , the bearing wear =  $0.21 g$  (Figure 10).

- In the axial direction: RMS OVERALL=  $0.5479 mm / s$ , the bearing wear =  $0.13 g$  (Figure 11).

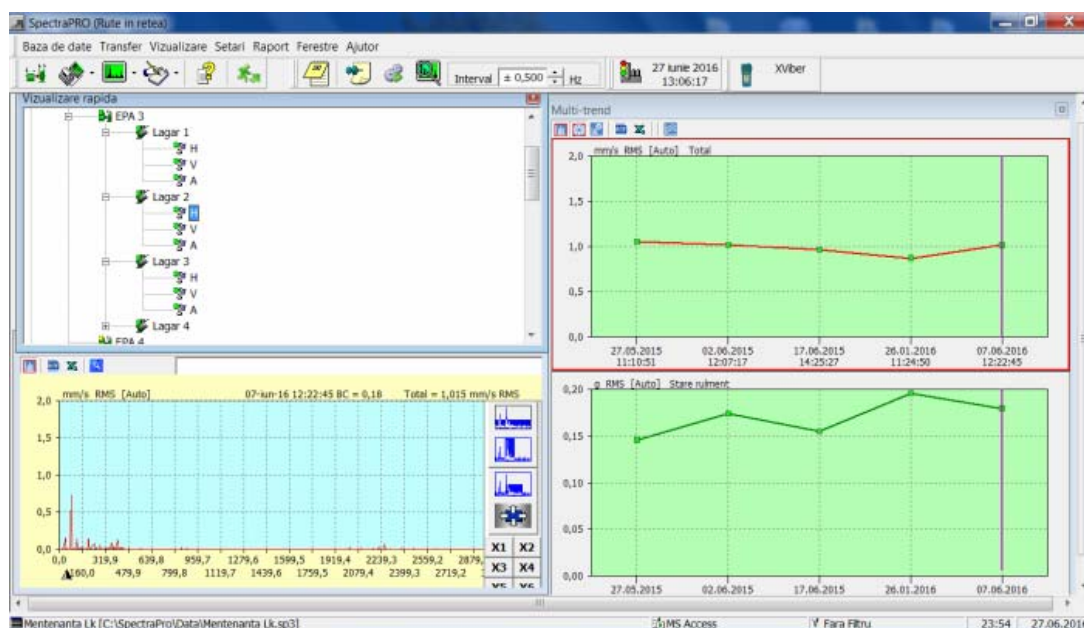


Fig. 9 – EPA no.3 : Bearing No 2 – Horizontally direction

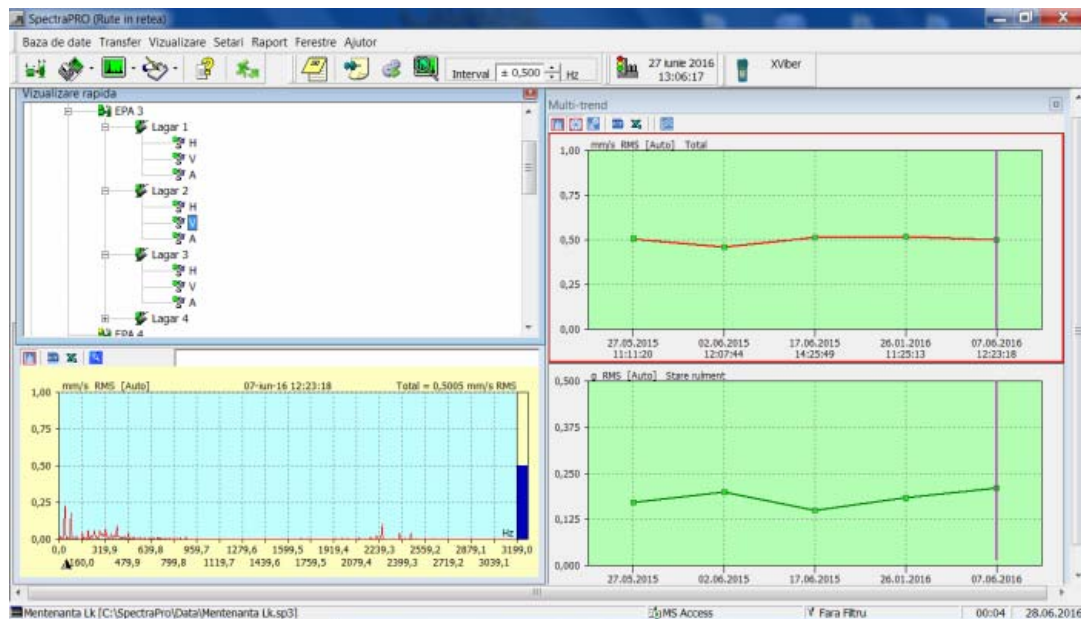


Fig. 10 – EPA no.3 : Bearing No 2 – Vertical direction

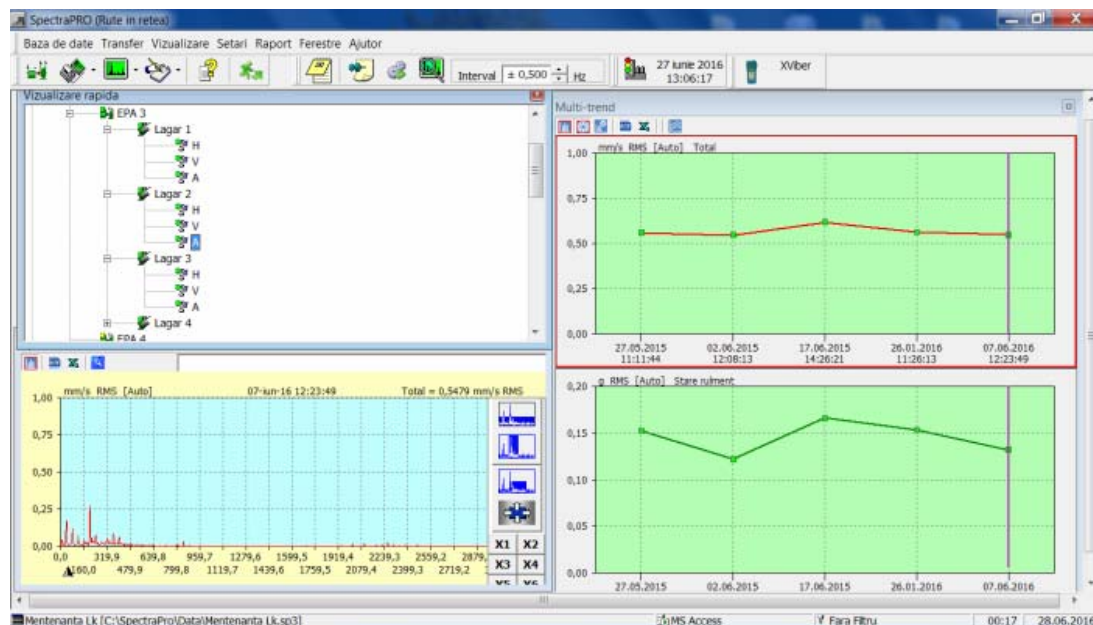


Fig. 11 – EPA no.3 : Bearing No 2 – Axial direction

### 2.3. Evolution wear in the bearing No.3.

Figure 12 presents the variation wear of mounted bearing No. 3 measured in units of gravitational acceleration  $g$ , depending on the rotation speed of the machine RPM.

According to the four diagrams of Figure 12, the bearing wear of mounted bearing no. 2 is  $0.36 g$  - this is a very good value, considering that was acquired after equipment operating longer than one year (values are measured on 28.06.2016).

In Figures 13, 14, 15 are bearing mounted on the observed evolution of the wear of the bearing no. 3 values are measured on 28.06.2016:

- In the horizontally direction: RMS OVERALL= $1.182 \text{ mm/s}$ , the bearing wear= $0.36 g$  (Figure 13).
- The vertical direction: RMS OVERALL = $0.991 \text{ mm/s}$ , the bearing wear = $0.34 g$  (Figure 14).
- In the axial direction: RMS OVERALL= $0.572 \text{ mm/s}$ , the bearing wear =  $0.61 g$  (Figure 15).

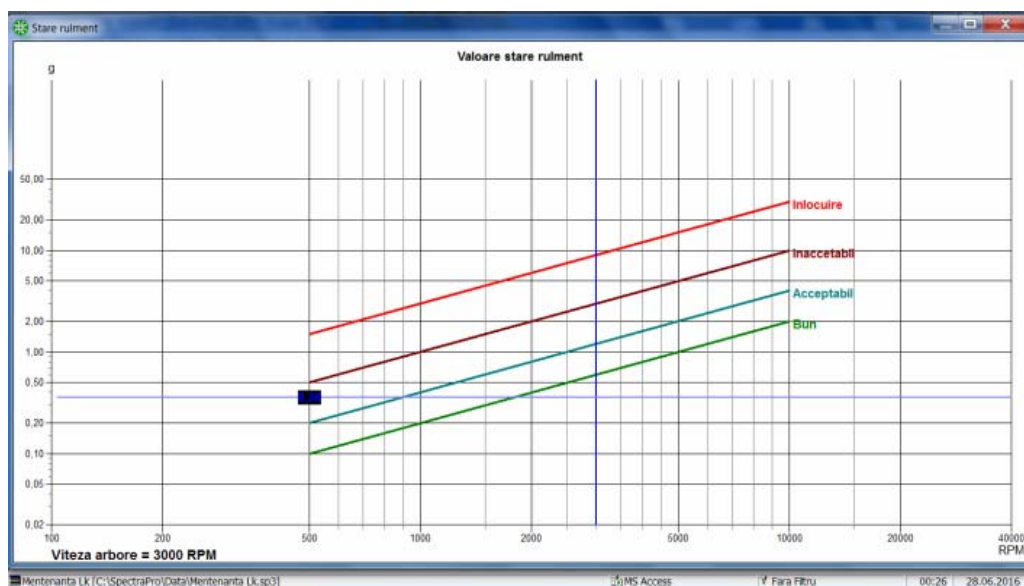


Fig. 12 – EPA No.3 : The bearing wear of mounted bearing no. 3

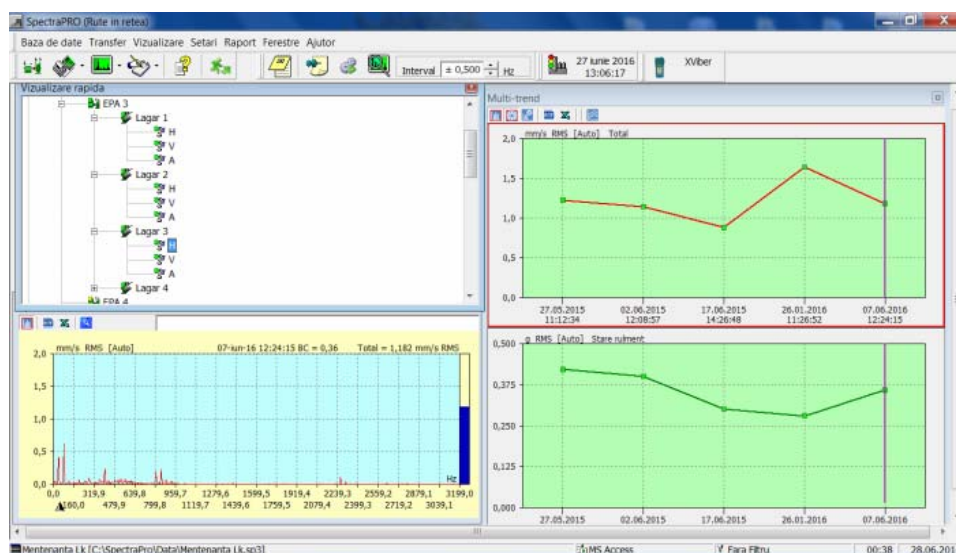


Fig. 13 – EPA no.3 : Bearing No 3 – Horizontally direction

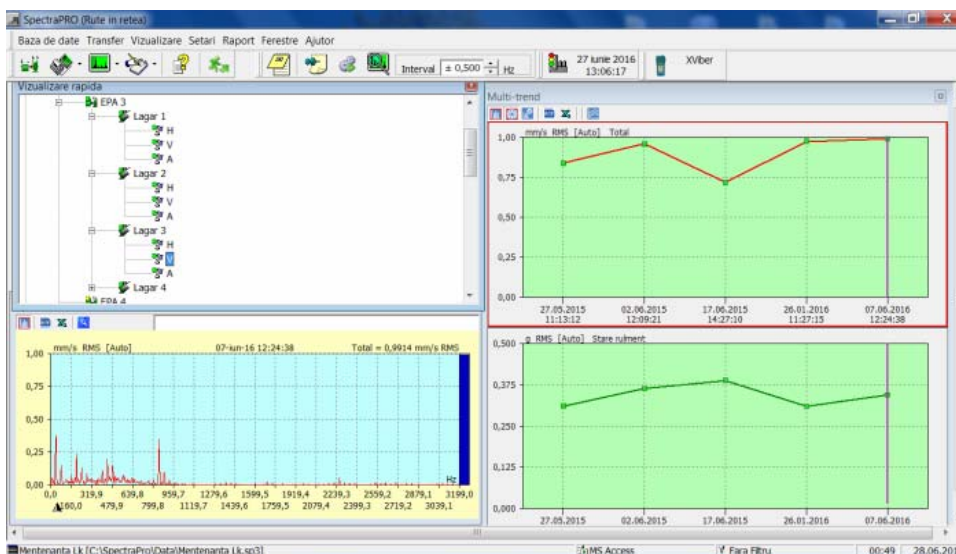


Fig. 14 – EPA no.3 : Bearing No 3 – Vertical direction



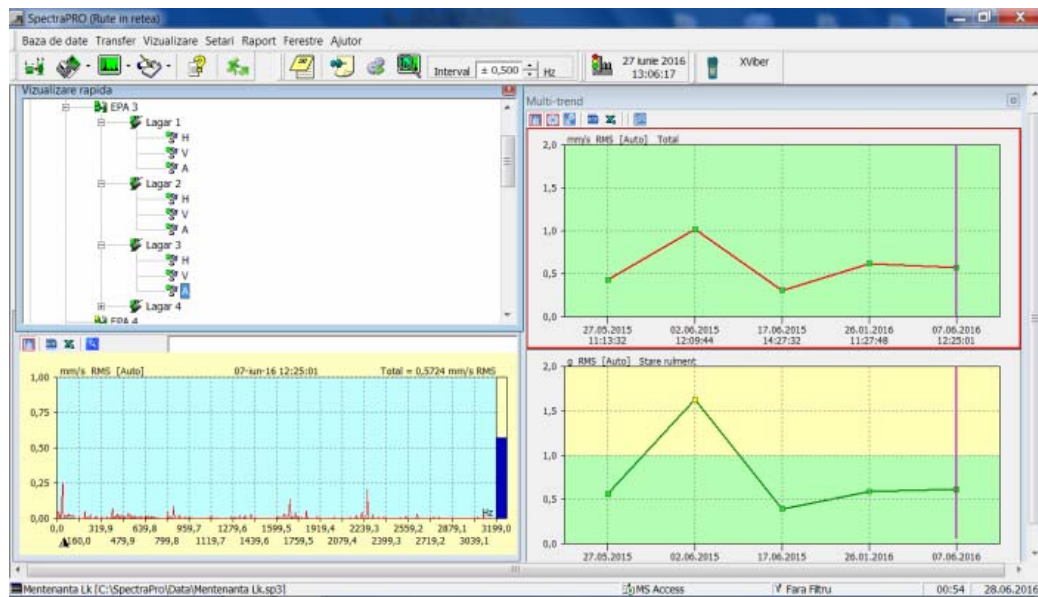


Fig. 15 – EPA no.3 : Bearing No 3 – Axial direction

#### 2.4. Evolution wear in the bearing No.4.

Figure 16 presents the variation wear of mounted bearing No. 4 measured in units of gravitational acceleration  $g$ , depending on the rotation speed of the machine RPM.

According to the four diagrams of Figure 12, the bearing wear of mounted bearing no. 4 is  $0.57 g$  - this is a very good value, considering that was acquired after equipment operating longer than one year (values are measured on 28.06.2016).

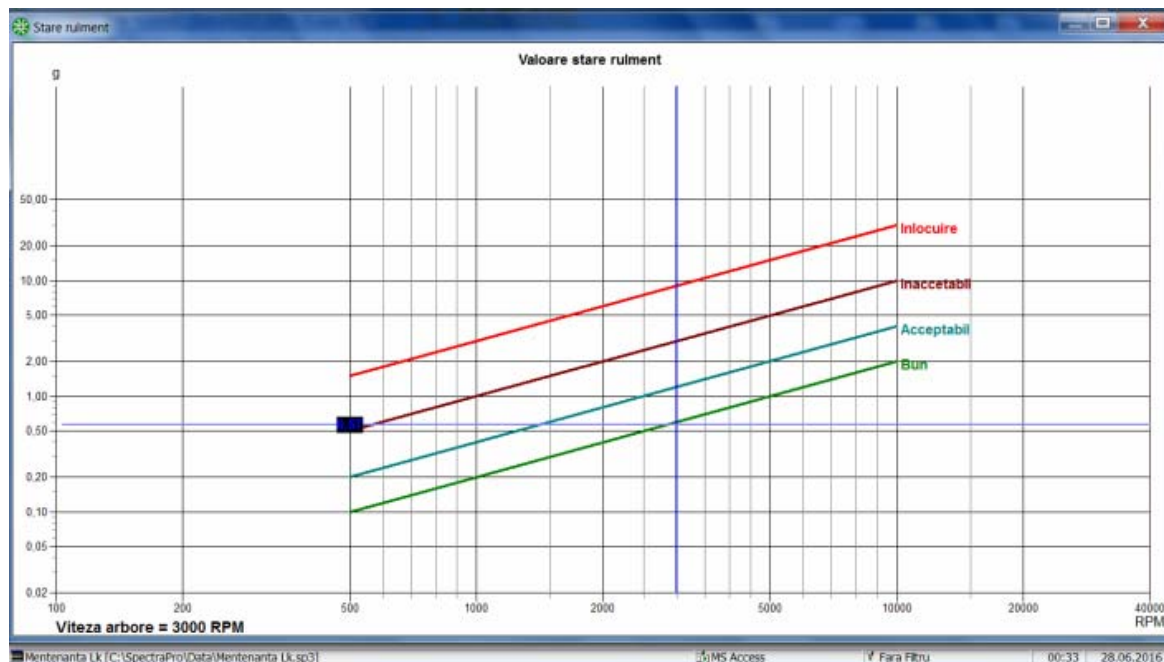


Fig. 16 – EPA No.3 : The bearing wear of mounted bearing no. 4

In Figures 17, 18, 19 are bearing mounted on the observed evolution of the wear of the bearing no. 4 values are measured on 28.06.2016:

- In the horizontally direction: RMS OVERALL= $0.6142 mm/s$ , the bearing wear =  $0.57 g$  (Figure 17).

- The vertical direction: RMS OVERALL =  $0.8525 mm/s$ , the bearing wear =  $0.71 g$  (Figure 18).

- In the axial direction: RMS OVERALL =  $0.656 mm/s$ , the bearing wear =  $0.64 g$  (Figure 19).

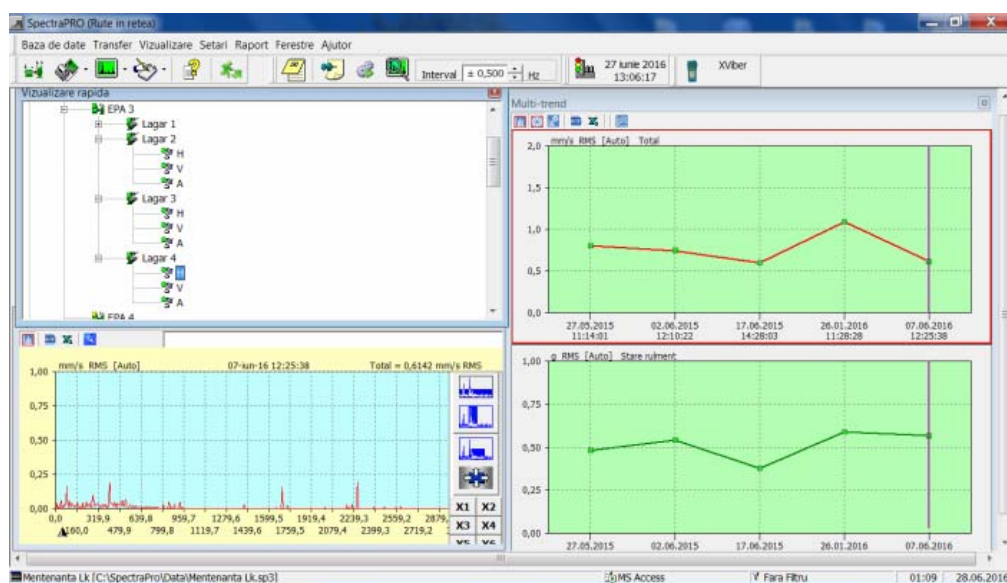


Fig. 17 – EPA no.3 : Bearing No 4 – Horizontally direction

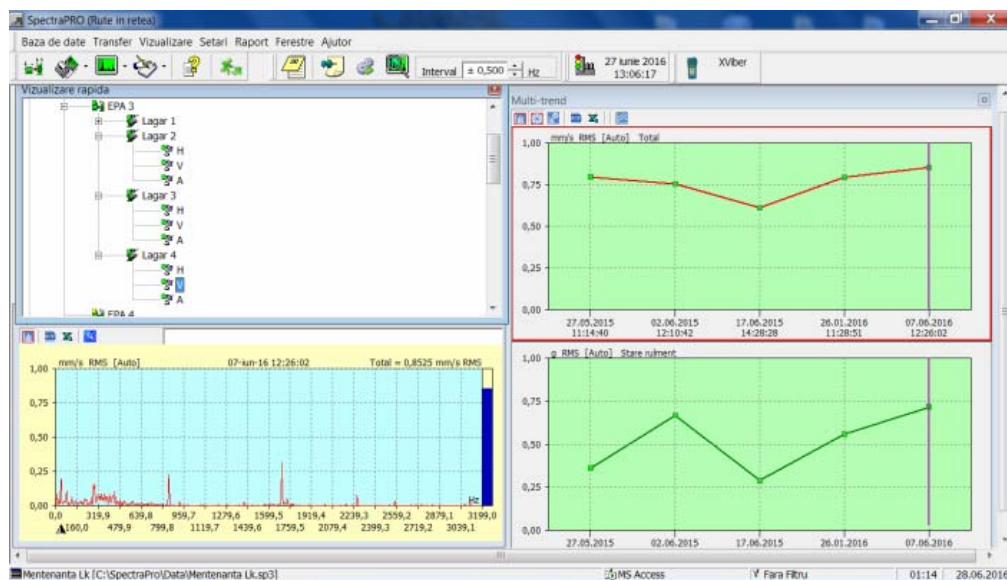


Fig. 18 – EPA no.3 : Bearing No 4 – Vertical direction

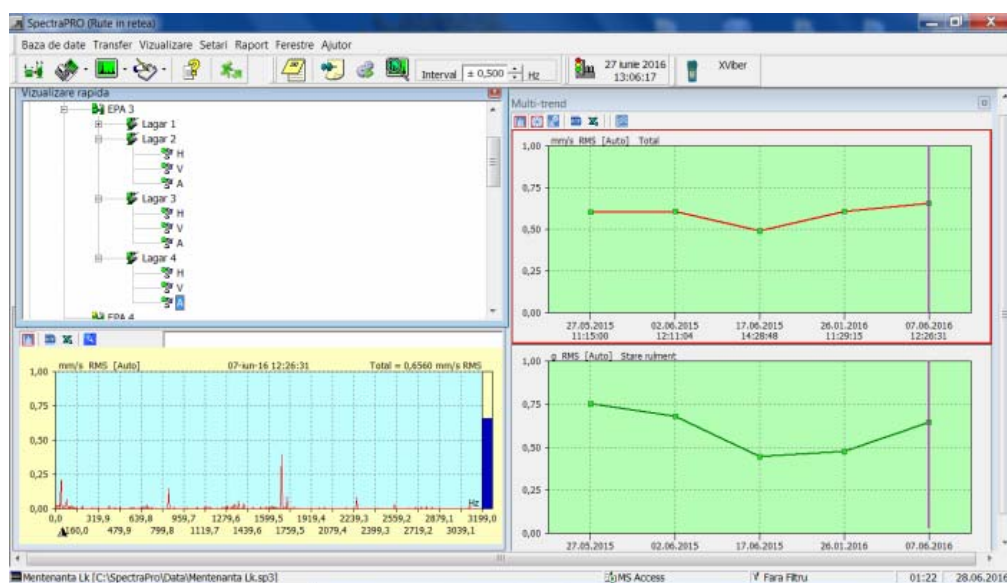


Fig. 19 – EPA no.3 : Bearing No 4 – Axial direction



### 3. CONCLUSIONS

- Appendix 1 contains the report of wear bearing of equipment studied **CET2/EPA 3** obtained on June 28, 2016 and shows the status of operation of the equipment; this report can be imported into a database containing information about wear and maintenance program to be watched.
- Due functional role in the technological and particular importance of this equipment, application program properly maintenance will lead to operation at nominal parameters of equipment, in good condition throughout the period of operation envisaged - **this is the first point of the concept of maintenance proactive;**
- Implement a software maintenance is the main component of a database containing the results of measurements for at least one year, its processing showing: history of operation equipment, the failures that have occurred and how they were resolved, as it influences plant productivity - **this is the second point of the concept of proactive maintenance**
- Knowledge of the technical condition of equipment at any time, but especially knowing the trend for depreciation of machinery, provides predictability on the operation Equipment for the foreseeable future, and smart planning repairs to reduce production losses, reduce costs repeated, avoiding damage human and material - **this is the third point of the concept of proactive maintenance.**

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# APPENDIX 1

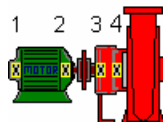
**S.C. VIROMEK SOLUTION S.R.L.**

Date: 28 .06. 2016

Time: 01:38

## Maintenance report

Lk



Equipment: CET 2/EPA 3

Horizontal mounting

Measuring point	Direction	Date	RMS/gBC Value	Measurement units	W HI	D HI
Bearing 1	H	27.06.2016	1,823	mm/s RMS	4,00	7,00
	H	27.06.2016	0,115	g	1,00	2,00
	V	27.06.2016	0,438	mm/s RMS	4,00	7,00
	V	27.06.2016	0,077	g	1,00	2,00
	A	27.06.2016	0,642	mm/s RMS	4,00	7,00
	A	27.06.2016	0,088	g	1,00	2,00
Bearing 2	H	27.06.2016	1,015	mm/s RMS	4,00	7,00
	H	27.06.2016	0,179	g	1,00	2,00
	V	28.06.2016	0,501	mm/s RMS	4,00	7,00
	V	28.06.2016	0,210	g	1,00	2,00
	A	28.06.2016	0,548	mm/s RMS	4,00	7,00
	A	28.06.2016	0,132	g	1,00	2,00
Bearing 3	H	28.06.2016	1,182	mm/s RMS	4,00	7,00
	H	28.06.2016	0,358	g	1,00	2,00
	V	28.06.2016	0,991	mm/s RMS	4,00	7,00
	V	28.06.2016	0,344	g	1,00	2,00
	A	28.06.2016	0,572	mm/s RMS	4,00	7,00
	A	28.06.2016	0,611	g	1,00	2,00
Bearing 4	H	28.06.2016	0,614	mm/s RMS	4,00	7,00
	H	28.06.2016	0,566	g	1,00	2,00
	V	28.06.2016	0,853	mm/s RMS	4,00	7,00
	V	28.06.2016	0,716	g	1,00	2,00
	A	28.06.2016	0,656	mm/s RMS	4,00	7,00
	A	28.06.2016	0,645	g	1,00	2,00