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Vibration Analysis for Monitoring the Condition of Hydraulic Powerpack for Underground Mining Supporting Simulation at Education and Training Unit of Underground Mining (Etuum)

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Abstract: *Hydraulic power pack is a hydraulic power unit used to assist in the installation of underground mine supporting. The main component of this is pump reciprocating. This pump is an alternating pump designed to produce a large enough capacity, commonly used for pumping viscous liquids and oil wells. This has several advantages, like: simple construction, ease of installation, high capacity and head, easy of operation and maintenance. But in the operation, it is often found failure, one cause is the vibration generated by coupling the clutch as the successor of rotation and power. These vibrations can damage the shaft, damage the bearing, cause noise, decreased head, decreased capacity and decreased pump efficiency.To detect the presence of damage to the reciprocating pump, a study was conducted at The Education and Training Unit of Underground Mining (ETUUM) via vibration analysis. The method of analysis used in this research by monitoring the condition of the machine through the overall vibration data, then compared with the category fault based on ISO 10816-3. Furthermore the data is processed using software Omnitrend to look for trending vibration spectrum to know the typical failure of a machine.From the whole point of measurement, there is nothing measured under normal conditions. At the point of measurement of M2V, P3H, and P3V increased over 2.3 mm/s, identified in prewarning conditions. At the point of measurement of M1A, M2H, and P4A increased over 4.5 mm/s, identified in warning conditions. While at the point of measurement the remainder increased over 7.1 mm/s, identified in alarm conditions. And the average peak (peak spectrum) of vibration occurs at 24.67 Hz and it can be said that there is a 1x vibration on the Reciprocating Pump Powerpack, and it identified unbalance or excessive clearance on bearings*

Keywords: *vibration analysis, monitoring condition, power pack, underground mining*

I. INTRODUCTION

Underground mining has very high risks associated with safety of both miners and mining equipment. One of them is the stability of the tunnel. At the time of digging the tunnel, the rock will expand due to be released from main rock. This condition is causing rock cracks and rock escapes from the main rock, and arising stress relief zone. Due to the growth of this zone, the volume of rock increases and it is pushing out into the tunnel which can narrow the tunnel's cross section or become a load that can cause the rock to collapse. Therefore the tunnel that has been dug as far as possible want to be maintained so as not to narrow. One solution is to apply the tunnel supporting for retrofitting tunnel from rock collapse (Saepulloh, 2006)[1].

Based on tunnel supporting properties, there are two types of supporting, namely: 1) passive support that supports rocks that will collapse and limits the movement of the rock, such as steel support, timbered support and concrete support. and 2) active support, reinforcement of rocks directly, such as rock bolt, hydraulic prop and powered roof support (PRS).

Underground miners are required to be able to install the tunnel support appropriately. So, before plunging into an underground mine, miners are educated and trained on underground mine supporting. The Education and Training Unit of Underground Mining (ETUUM) has technical and operational tasks in conducting underground mine education and training. In the implementation of the training, ETUUM is equipped with facilities for the support of authenticity, such as hydaulic power pack facility which is used as an underground mine supporting practice equipment.

Hydraulic power pack is a hydraulic power unit used to assist in the installation of underground mine supporting (prasojo, 2012)[2]. The installation of underground mine supporitng that require hydraulic power pack aids are active supports, such as hydraulic prop and powered roof support, which are operated with the help of pressurized fluid. This pressure is obtained from a reciprocating pump driven by an electric motor.

The pump is one of the fluid engines used to move the fluid from one place to another by increasing the pressure of the fluid. The reciprocating pump is a type of positive displacement pump that using displacement action. This pump is an alternating pump designed to produce a large enough capacity, commonly used for pumping viscous liquids and oil wells. This pump has several advantages, like: simple construction, ease of installation, high capacity and head, easy of operation and maintenance. But in the operation, it is often found failure, one cause is the vibration generated by coupling the clutch as the successor of rotation and power. These vibrations can damage the shaft, damage the bearing, cause noise, decreased head, decreased capacity and decreased pump efficiency.

According to William in sihombing (2009)[3], vibrations arise when capacity, rotation, cavitation, imperfection of the pump drive system leads to instability and amplitude of vibration enlarging where the frequency of its excitation is close to the personal frequency.With the advance of machine tool maintenance techniques, the failure symptoms of the machine can be predicted from several analyzes such as vibration analysis, temperature analysis and equipment wear analysis. According to Travner and Penman in Bahkri (2013)[4], vibration analysis can be used not only to measure the event of vibration due to mechanical forces, but also some phenomena of hydraulic or electrically potentially destructive cases of pump structures by extracting vibration signals through processing techniques signal. This signal is the frequency spectrum signal that will be a unique marker that distinguishes the types of damage to one another.

The use of the vibration response from the mechanical aspect as the maintenance indicator provides the easy of testing and the exact testing point on the driving force, as well as the maximum information and testing done without connecting and disrupting the operation of mechanical equipment. With advances in mechanical equipment maintenance technology of predictive maintenance system as mechanical equipment maintenance management, vibration mechanical vibration testing is needed as an indicator of care (Kelly, 2000)[5].

According to Taylor in Harjono et al. (2013)[6], to know the general condition of machine feasibility required analysis of motor vibration spectrum by using RMS boundary velocity of vibration and analysis of characteristic of vibration spectrum. Vibration overalls, or vibration velocity, with units of mm/s or inch/s RMS (root-mean-square), are used to determine the general condition of machine feasibility based on the standard used, ISO 10816-3. Vibration spectra, with units of amplitude mm/s (or inch/s) and cpm (= cycle per minute) or Hz frequency, are used to diagnose (analyze) the dominant source of the vibrations of a machine. The measurement result is a graph of spectrum characteristic, so it can be known the typical failure of a machine, for example: Un-balance / Excessive Bearing Clearance, Mechanical Looseness, Misalignment, Oil Whirl, Electrical Problems, Torque Pulses, Bad Gears / Aerodynamic Forces, or Bad Anti-Friction Bearings.

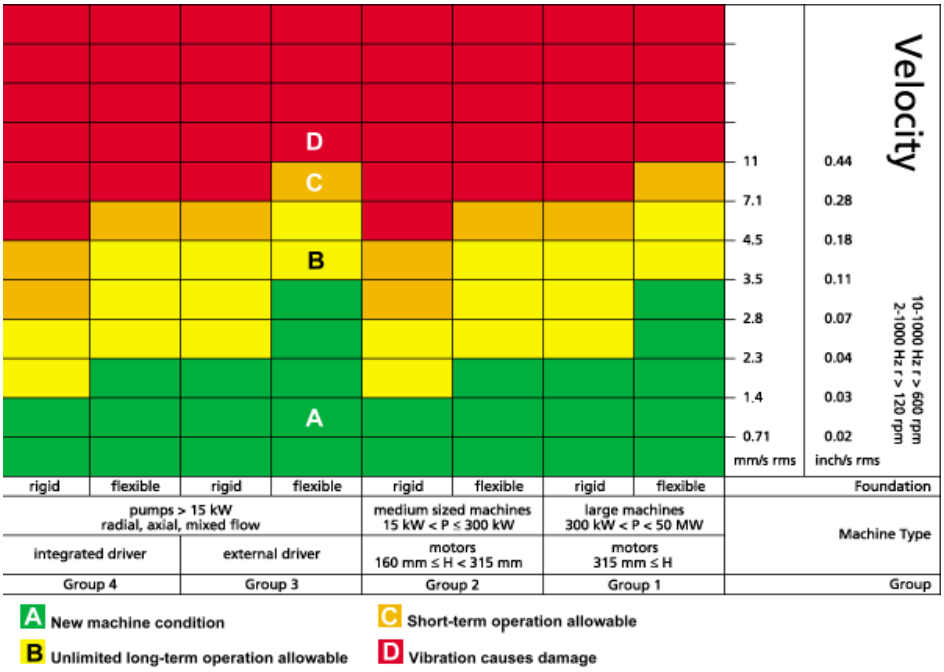


Fig. 1 Standart ISO 10816-3 for vibration

Table 1: Type of Damage The System Based on The Frequency Spectrum

Frequency on RPM	Caused
1 x RPM	Un-balance Excessice Bearing Clearance
2 x RPM	Mechanical Looseness
3 x RPM	Misalignment
Less than 1 x RPM	Oil Whirl (<1/2 RPM)
Synchrounous (A.C. Line Frequency)	Electrical Problems
2 x Synchrounous Frequency	Torque Pulses
Many times RPM (Harmonically Related Freq.)	Bad Gears Aerodinamic Forces
High Frequency (Not Harmonically Related)	Bad Anti-Friction Bearing

II. MATERIAL AND METHOD

Monitoring of powerpack hydraulic conditions for simulation of underground mooring system is done at The Education and Training Unit of Underground Mining (ETUUM), Sawahlunto City, Indonesia. Monitoring of hydraulic powerpack conditions is focused on monitoring the reciprocating pump conditions as a major part of the powerpack hydraulic component (fig.2). To measure the level of vibration that occurs in the pump is used vibration signal measuring instrument, namely vibexpert equipment and supported by omnitrend software applications. This tool is capable as vibration analyzer, diagnostics, data collector (fig.3). Monitoring of reciprocating pump conditions on hydraulic powerpack for simulation of underground buffering system is done in Balai Diklat Tambang Bawah Tanah, conducted by observation on 2 (two) variables, namely: vibration of overall and vibrational spectrum.

1. Overall Vibration Measurement.
   Used to know the general condition of machine feasibility based on ISO 10816-3 standard.
2. Vibration Spectrum
   Then the whole vibration data is processed using Omnitrend software to look for vibration vibration trending. What is meant by spectrum analysis here is an attempt to find the problem and its causes by studying the pattern of comparison of the magnitude of the vibration amplitude at all possible frequencies. From the frequency (and amplitudes) that can be known typical of a machine failure, for example: rotor unbalance, rotor eccentricity, misalignment shaft, mechanical looseness, and others.

Fig. 2. Recrocating pump: main component ofhydraulic powerpack

Table 2: The Specification of Reciprocating Powerpack Pump

	Tipe	Speed(Rpm)	Power (KW)	Voltase	Pondasi
Type of Driver	3-Phase Induction motor	1480	55	380 V	Flexibel
Type of Pump	Reciprocating	1480	55	380 v	Flexibel

Fig. 3. VIBXPERT®IIEquipment

Observation of the vibration signal arising from changes in the pump is to determine the point of measurement. Measurements are made at a predetermined point by retrieving data by time domain and domain frequency. The measurement point for monitoring of pump reciprocating conditions on hydraulic powerpack is shown in Fig. 4.

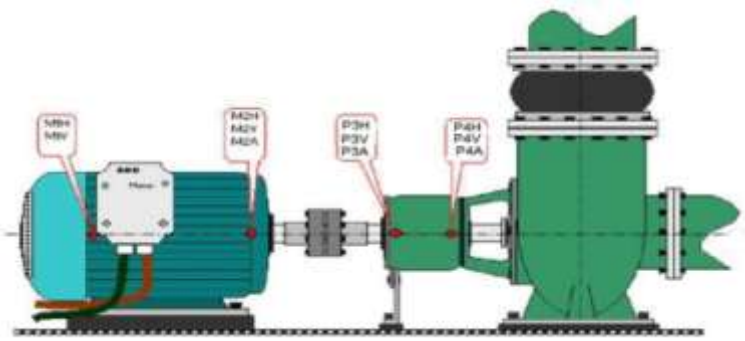


Fig. 4. Point of Measurement for Vibration's datas

The caption:
M : Motor, P : Pump, H : Horizontal, V : Vertical, A : Axial

III. RESULTS AND DISCUSSION

Vibration measurements at the pump captured the Overall Vibration data as the value of vibration (value) in (mm / s rms) and spectrum (frequency). The results of the measurements obtained are as follows:

Table 3: The Result of Overall Vibration Measurement

MEASEURMENT POINT	OVERAL VELOCITY (MM/S)	STANDART VIBRATION ISO 10816.3 (mm/s)			
		NORMAL	PREWARNING > 2.3	WARNING > 4.5	ALARM > 7.1
M1H	13,68				
M1V	12,13				
M1A	6,13				
M2H	6,59				
M2V	4,23				
M2A	10,86				
P3H	2,89				
P3V	3,69				
P3A	9,21				
P4H	7,95				
P4V	9,21				
P4A	4,84				

From the data it is known there are the increase of vibration. From the whole point of measurement, there is nothing measured under normal conditions. At the point of measurement of M2V, P3H, and P3V increased over 2.3 mm / s, in accordance with the ISO10816.3 vibration standard identified in prewarning conditions. At the point of measurement of M1A, M2H, and P4A increased over 4.5 mm / s, in accordance with the ISO10816.3 vibration standard identified in warning conditions. While at the point of measurement the remainder increased over 7.1 mm / s, in accordance with the ISO10816.3 vibration standard identified in alarm conditions.

Furthermore, vibration data on the alarm condition is processed using software Omnitrend to look for vibration trending. What is meant by spectrum analysis here is an attempt to find the problem and its cause by studying the pattern of comparison of the magnitude of the vibration amplitude at all possible frequencies. As for the vibrational spectrum image which is the result of processing the overall vibration data by using software Omnitrend can be seen in the picture below.

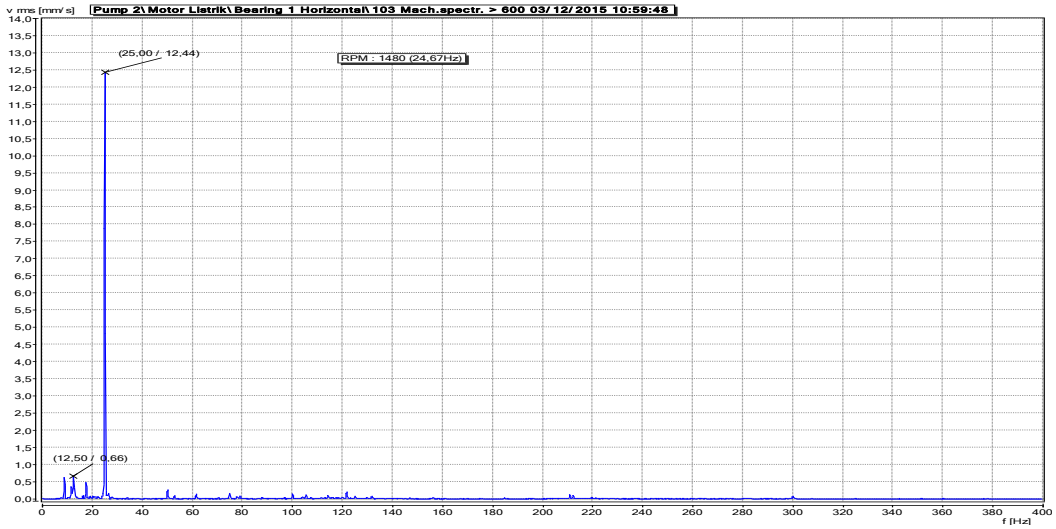
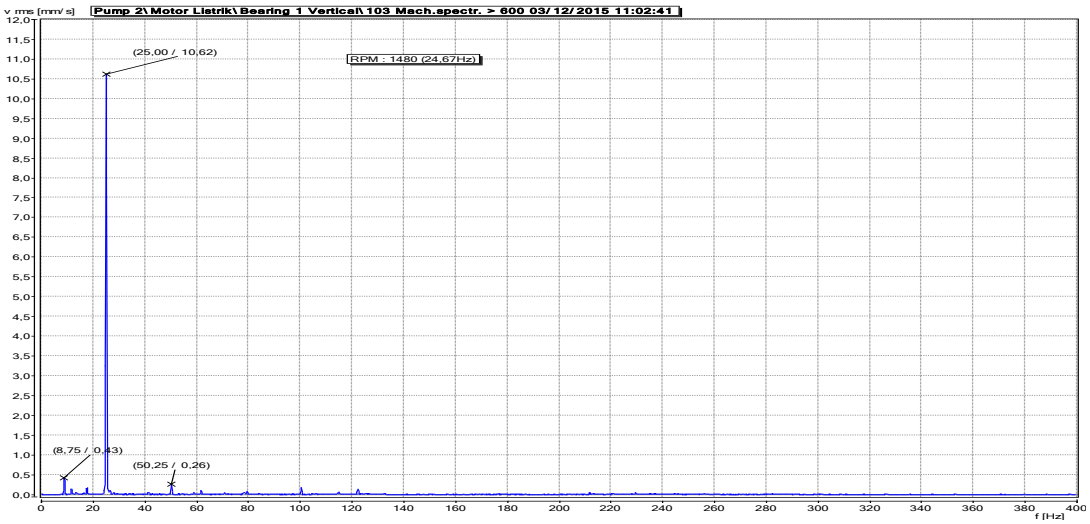


Fig.5. Spectrum Velocity at M1H



Fix.6. Spectrum Velocity at M1V

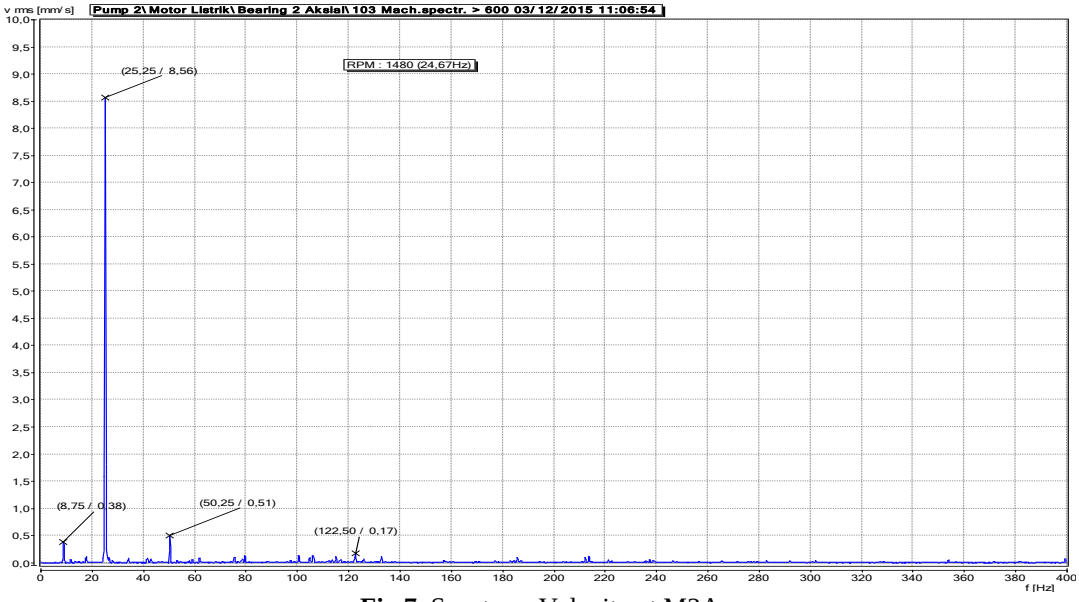


Fig.7. Spectrum Velocity at M2A

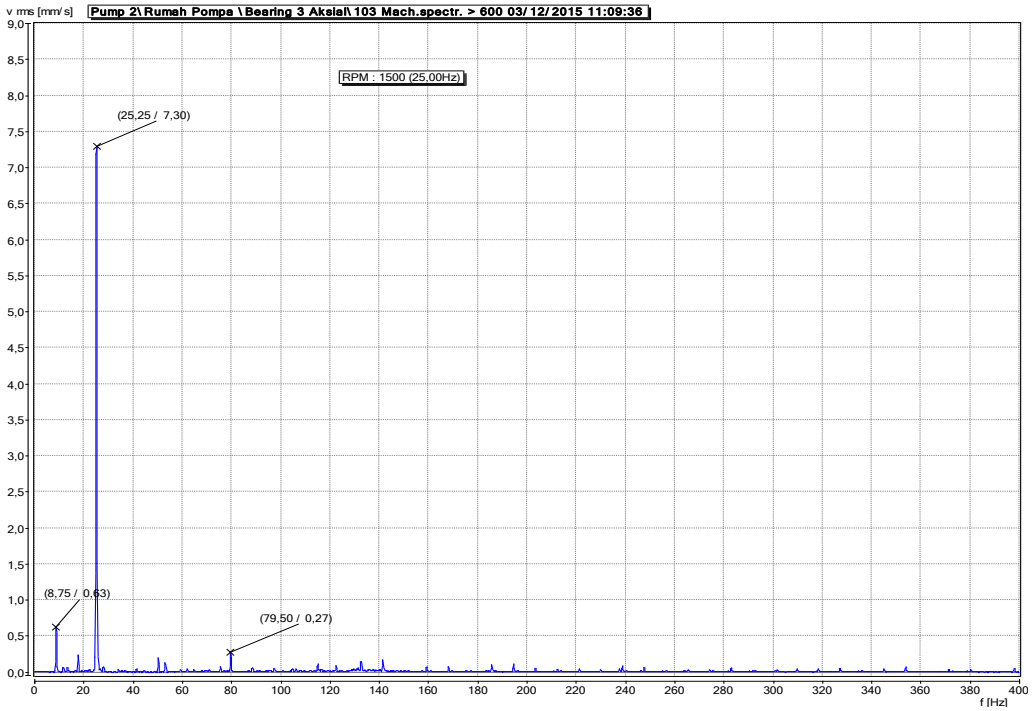


Fig.8. Spectrum Velocity atP3A

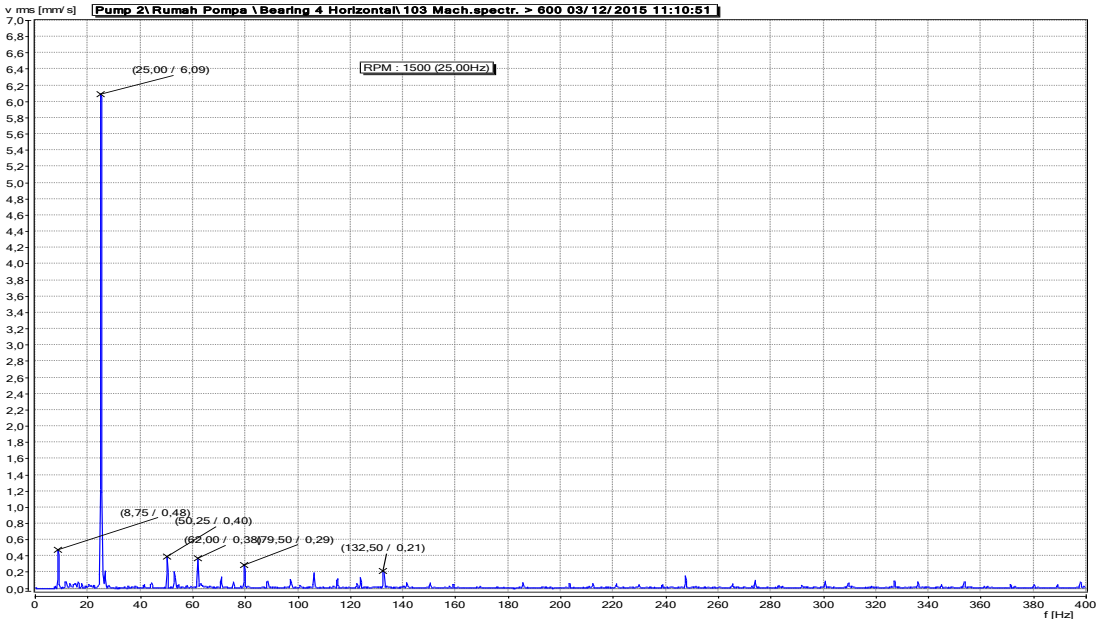


Fig.9. Spectrum Velocity at P4H

The average peak (peak spectrum) of vibration from figure 5 to 9 above occurs at 24.67 Hz (1 Hz = 1 cycle per second) and there is a lot of noise. Since the motor also rotates at a speed of 24.67 Hz (1480 RPM / 60) it can be said that there is a 1x vibration on the Reciprocating Pump Powerpack. In accordance with table 1, there will be unbalance or excessive clearance on bearings.

IV. CONCLUSION

Looking at the data obtained from the data retrieval and discussion of the analysis that has been done, it can be concluded that the damage to the rotating equipment, in this case the bearing damage on the Reciprocating Pump Powerpack can be detected with the help of the vibration spectrum. Early indication of bearing damage is indicated by the increase of vibration across the measurement point. Results of measurements with ISO10816.3 vibration standard none of which are measured under normal conditions. The measurement

points of M2V, P3H, and P3V increased over 2.3 mm/s (prewarning condition), M1A, M2H and P4A measurements increased over 4.5 mm/s (warning conditions) and the remaining measurement points increased over 7.1 mm/s (alarm condition).

After the vibration spectrum analysis, the result of the cause of the high vibration of the Reciprocating Powerpac Pump is the breakdown of the ball bearing, this is indicated by the average peak (peak spectrum) vibration occurs at 24.67 Hz (1 Hz = 1 cycle per second), there is Lots of noise, and 1x vibration occurs on the Powerpack Reciprocating Pump. Then there is unbalance or excessive clearance on bearing. From the above data that hydraulic powerpack condition for simulation of underground supporting system in *The Education and Training Unit of Underground Mining (ETUUM)*, Sawahlunto City indicated motor in condition not feasible to operate. And as a recommendation, should add lubrication to the bearings, Re-alignment shaft motors and pumps, perform balancing on the pump impeller, and perform routine vibration checking

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