American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-9, Issue-6, pp-106-111
www.ajer.org
Research Paper Open Access

Evaluation of Overcurrent Protection Devicesfor Electric Motor in the Underground Mine Company XYZ Indonesia

Haramaini, Muhammad N.
[1](PPSDM KEBTKE, Jakarta, Indonesia

ABSTRACT :*Gold Mining Company XYZ in West Java Indonesia uses cut and fill underground mining system. Gold-contained ores are exploited by drilling them to make explosive holes, then blasted so the ore are easily transported to the processing plant. The activities except processing plant are done in the underground which protected by supporting system. After one mining area has been exploited, the former mining pit will be refilled with filling material.Those process uses many mining machines, such as jumbo drills, compressors, pumps to drain, and fan machines to supply fresh air.All mining machines use electric motors with large power. Electricity from powerplant outside is transmitted and distributed inside the mine using cables and switchgear made specifically for underground mines. So the reliable electric protection is needed to meet safety aspects, be able to support production and be able to overcome operational disruptions in the mine. The purpose of this research is to study the protection system used at XYZ to protect the electric motors of mining machine.Does the equipment used meet the electrical safety aspects in underground mines and meet certain standard?The method of data collection is done through direct measurement in the field by measuring several parameters of the circuit breaker, conductor of cable and operating wattage of the electric motor.The calculation is done to compare the actual measured parameters with those that should be applied according to the standards in. The results obtained that XYZ company has not implemented certain electrical standards and the electric motors in underground are not protected using the right size circuit breaker.*

KEYWORDS:over-current circuit breaker, underground mine electricity.

Date of Submission: 25-05-2020 Date of acceptance: 10-06-2020

I. INTRODUCTION

Gold mine company XYZ is located in the West Java Province of Indonesia. This mine is a gold mine that uses the cut and fill method, one type of underground mining method.Mine tunnel is made by drilling and blasting methods to reachthe ore containing gold. Along the development the tunnel supported to prevent collapse. Then the ore is exploited by also drilling and blasting methods.The empty part of the rock will be filled again with filling materials to create safety.

This underground mine methods requires a lot of mining machinery, most of which are driven by electric motors.The machines used include drilling machines, ventilation machines, pumping machines, and compressors.

The machines are driven by large capacity electric motors. The electric motor was controlled and protected by a series of connecting and control panels.This panel has two main components (1) circuit breaker such as air circuit breaker (ACB) or molded case circuit breaker (MCCB), and (2) feeder cable.In order for the circuit breaker to function optimally, it must be installed with certain current settings so that if there is an overload, the circuit breaker will trip, cut the machine from the incoming current. If the current setting used is improper, then if there is an overload disturbance (the most frequent disturbance at the mine due to the larger load of work), then the breaker will not function and consequently the motor coil will be burnt.Also, the feeder cable must be installed according to the amount of current used (cable amperage).

Indonesia has a standard that applies to electrical safety installations in general, namely the General Electrical Installation Requirements 2011 (PUIL 2011), or Indonesian National Standard (SNI) No 0225: 2011. Calculation of the size of the circuit breaker and the cable amperage is explained in that SNI.Mining companies in Indonesia can adopt this standard, or just apply other international standards such as NEC (national electrical code) orstandard from IEC (International Electrotechnical Commission).

The issues to be discussed through this research are

1) Conditions of existing circuit breaker protection (applied) in the underground mine of XYZ, and the electrical standards used for the underground mining electrical installations
2) Re-calculate the circuit breaker protection that should be installed based on the PUIL 2011 standard.

The methodology used in this study is direct data collection through direct measurement in the field to obtain parameter of circuit of electric motor.1st problem is solved by getting data on the value of current and the value of circuit breaker protection on each mining equipment. Also,the single line diagram and layout drawing of existing mining equipment will be provided. 2nd problem willsolved using the basic formula from PUIL 2011 as a reference to calculate the ideal amount of protection (ACB and MCCB). The results of this calculation are then compared with the installed quantity to determine whether the protection of mining equipment has been installed correctly.

Because of the vast mining area, the research will be carried out in selected regions only at Level 500, which shows a fairly complete equipment as a sampling for underground mining electrical equipment at XYZ. Level 500 itself consists of several area, namely: Ciurug 1 L500, Ciurug 2 L500, Ciurug 3 L500, Ciurug L450, and Ciurug L452.

II. STANDARD FOR ELECTRICAL MOTOR IN INDONESIA

The electric motor used in a mine applicationmostly is an induction motor. This type of motor is very widely used because of its easy operation and maintenance. Also, the speed is relatively stable.XYZ applies 3 phase voltage of 380 V. In a 3-phase electric circuit, the nominal current (In, amperes) of the electric motor can be known using a formula:

$$I_n = \frac{P}{\sqrt{3}\,.\,V\,.\,\cos\theta}\ , \qquad \text{formula 1.}$$

where V is the motor working voltage (volts) and P is the motor power (watts). V, P and cos ɵ can be determined from the motor nameplate.

PUIL 2011 is the electrical standard that applies limited to low voltages up to 1000 volts of alternating current. Mining electric motors generally work in 3 phase 380 V voltage, so calculations from PUIL 2011 can be used.

Here are some standard formulas in PUIL 2011 used in this paper.

PUIL 2011: 510.5.3.1 End of circuit conductors having a single motor may not have a cable amperage (CA) of less than 125% of the nominal full load rated current (In).

$$CA = 125\%\ x\ I_n, \qquad \text{formula 2.}$$

PUIL 2011: 510.5.4.3 motor overload protection devices consisting of overcurrent protection device (OCPD) and short-circuit protection devices (SCPD). OCPD rated current (Ip) must at least 100% - 115% of the motor nominal current rating (In).

$$I_p = 115\%\ x\ I_n \qquad \text{formula 3.}$$

PUIL 2011: 510.5.3.2explained that "The final circuit conductor, which supplies two or more motors, must not have a CA less than the sum of the full load currents of all motors plus 25% of the largest motor full load current in the group. What is considered the biggest motor is the one that has the highest nominal full load current.

$$CA\ (group) = \sum I_n + 25\% \qquad \text{formula 4.}$$

III. DATA FINDINGS

Here presented the measurement results and single line electrical diagram from every area. At the Ciurug L500 location, the protection devices used for electric motor equipment are MCCB and ACB.

The types of mining equipment, the wattage and protection of the MCCB (ampere) used are shown in the following table:

Table 1. Mining equipment, motor power and GPAL installed

Type of Equipment	Motor Power (kW)	MCCB installed (A)
Pumps	37	250
	75	250
	110	400
Blow Fan	22	100

	37	250
Exhaust Fan	15	100
Compressor	132	400
Junction Box	60	

Wiring diagrams and attached loads for each location are shown in the following figuresand tables.

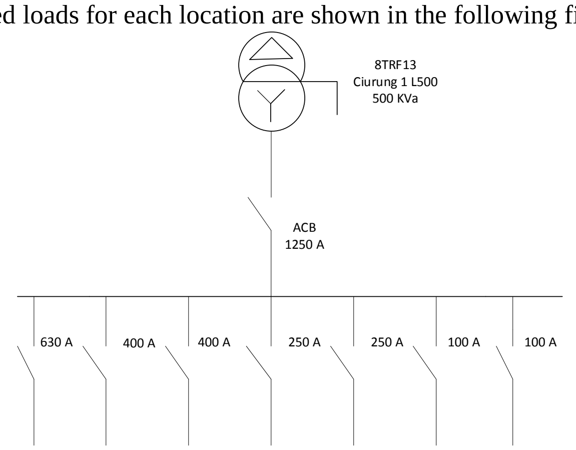

Figure. 1. Wiring diagram of OCPD in the Ciurug 1 L500 area

Table2. Loads in the Ciurug 1 L500

No	Equipment	Power (Kw)	Unit
1	Blow Fan	37	2
2	Junction Box	60	1
3	Pump Warman	110	1
4	Fan	75	1
5	Fan	37	1

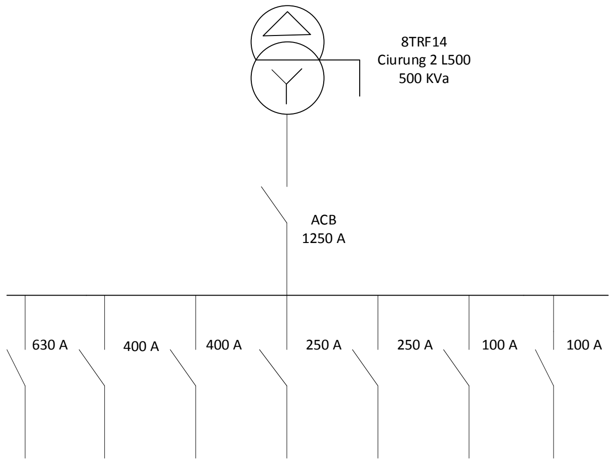

Figure 2. Wiring diagram of OCPD in the area Ciurug 2 L500

Table3. Loads in the areaCiurug 2 L500

No	Equipment	Power (Kw)	Unit
1	Pump	22	1
2	Pump	37	2
3	Blow Fan	37	1
4	Exhaust	15	1
5	Compressor	132	1

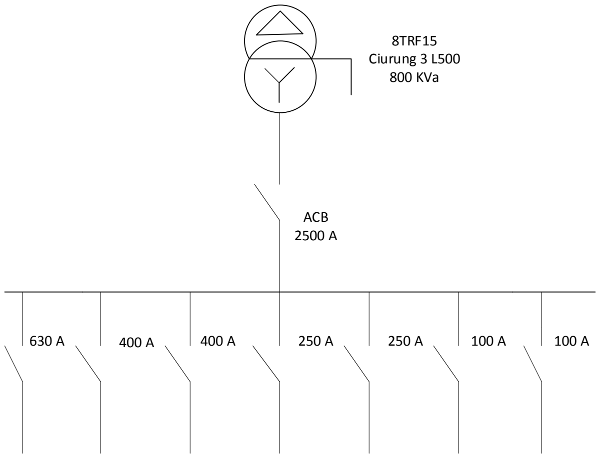

Figure 3. Wiring diagramof OCPD in the area Ciurug 3 L500

Table4.Loads in the areaCiurug 3 L500

No	Equipment	Power (Kw)	Unit
1	Blow Fan	37	1
2	Junction Box	60	1
3	Fan	132	1
4	Fan	37	1
5	Fan	15	2
6	PumpWarman	132	2
7	PumpWarman	110	2

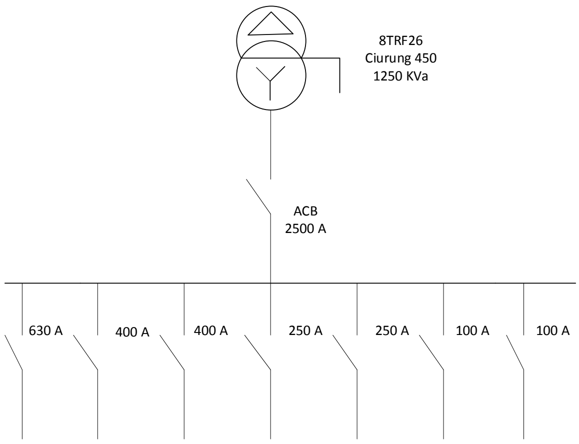

Figure 4. Wiring diagram of OCPD in the area Ciurug L450

Table5.Loads in the area Ciurug 450

No	Equipment	Power (Kw)	Unit
1	Pump Warman	110	2
2	Pump Tsurumi	75	1
3	Pump Tsurumi	37	4
4	Compressor IR	132	1
5	Blow Fan	75	1
6	Blow Fan	37	2
7	Blow Fan	22	2

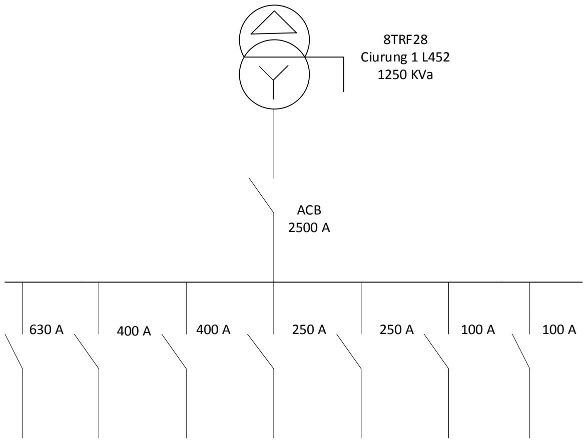

Figure 5. Wiring diagram of OCPD in the area Ciurug 1 L 452

Table6. Loads in the area Ciurug 1 L452

No	Equipment	Power (Kw)	Unit
1	Pump Tsurumi	75	2
2	Pump Tsurumi	37	3
3	Pump Warman	110	1
4	Pump Tsurumi	75	3
5	Pump Tsurumi	37	3
6	Blow Fan	37	1

IV. DATA ANALYSIS

In this section, we will calculate the correct value of protection devices should be installed for electric motors in the field in accordance with the results of calculations that refer to PUIL 2011. The working voltage of electric motors is 380 V - 3 phase.

Table7. Calculation of In, CA and Ip for each motor

Power Motor (kilowatt)	**Nominal current, I_n (ampere)**	**Cable amperage (ampere)**	**I_pSetting protection**	**MCCB calculated**
	Formula 1	Formula 2	Formula 3	
15 kW	26,8 A	33,5 A	30 A	30 A
22 kW	39,3 A	294 A	45,2 A	60 A
37 kW	66,1 A	82,6 A	76 A	80 A
75 kW	134 A	167 A	154 A	160 A
110 kW	196,6 A	245 A	226 A	225 A
132 kW	235,9 A	49,1 A	271,2 A	250 A/300 A

Analysis of Circuit Protection Devices of Electric Motor at Level 500

Based on the calculation referring to PUIL 2011: 5.5.5.2.3 it can be concluded that the installed MCCB is not appropriate.

1. Motor 15 Kw installed with 100 A circuit breaker,that should be enough with 30 A
2. Motor 22 Kw installed with 100 A circuit breaker,that should be enough with60 A
3. Motor 37 Kw installed with 250 A circuit breaker,that should be enough with80 A
4. Motor 75 Kw installed with 250 A circuit breaker,that should be enough with160 A
5. Motor 110 Kw installed with 400 A circuit breaker,that should be enough with225 A
6. Motor 132 Kw installed with 400 A circuit breaker,that should be enough with250 A/ 300 A

If the circuit breaker installed is too large then needed, when the motor is overloading the protection will not work immediately and if over time the motor will be damaged. Meanwhile, if the protection installed is smaller than the maximum setting that should be, so that if there is a slight increase in load that will make the protection work and will disturb the performance of the motor itself.

The CA settings and ACB protection devices in each area according to the PUIL 2011 calculation: 510.5.3.2 (formula 4) are presented on the following table.

Table 8.CA dan Ip for each branch circuit in area L500

Area ACB	Cable amperage (Ampere)	Ip (Ampere)	ACB installed	ACB calculated
Ciurug 1 L500	577	558,3	1250	630
Ciurug 2 L500	558	535,7	1250	630
Ciurug 3 L500	1344,8	1322	2500	1250
Ciurug L450	1430	1407,6	2500	1250
Ciurug 1 L452	1377,7	1358,7	2500	1250

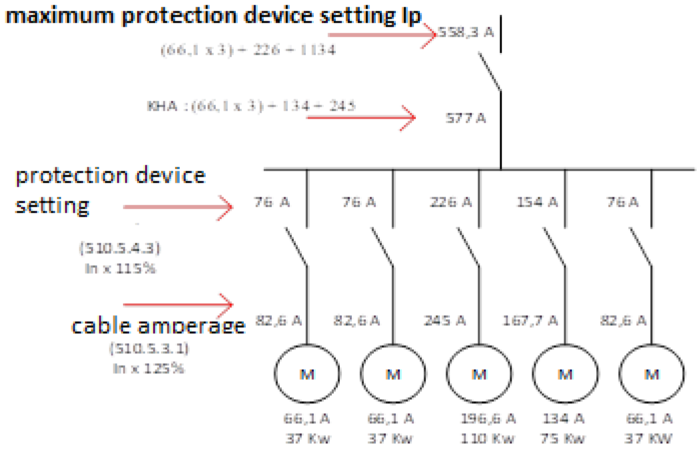

Figure 6. Calculation of CA and maximum protection device settings in the Ciurug 1 Level 500 area

It can be seen from the results of calculations that the installation of ACB also uses settings that are too large so that it is feared that if an interruption occurs the ACB does not work.

V. CONCLUSION

After analyzing the 3-phase electric motor protection circuit at underground mine company XYZ, the following conclusions can be drawn:

1. XYZ has not yet adopted the standard for the electrical installation of its mining motor. During this time the electrical installation is made based on the experience of the technicians only.Based on the single line diagram in the field, it appears that the over current protection device installed is larger than it should be so that if the electric motor is overloaded the device installed will not work because the current limiting for the circuit break is too large. This resulted in many motors burning due to heavy works.
2. Based on calculations obtained and referring to PUIL 2011, are obtained the ideal current protection setting for each equipment in the underground mine XYZ at location level 500. Furthermore, the calculation results can be installed and tested to further prove its reliability in the field. The Head of Mining Engineering of XYZ company must immediately assignelectrical installation standards for XYZ so that the safety of mining operations is guaranteed.

REFERENCES

[1]. BSN: SNI 0225: 2011 PersyaratanUmumInstalasi Listrik 2011. Badan StandardisasiNasional (2011).
[2]. Miller, R., Miller, M., A.: Audel Electric Motor 6th edition. Wiley Publishing Inc (2006).
[3]. NFPA 70: National Electric Code 2014ed. National Fire Protection Association (2014).
[4]. Rosenberg, P. :Audel Electric Course for apprentice and journeyman 4th edition. Wiley Publishing Inc (2004).

Haramaini, Muhammad N. "Evaluation of Overcurrent Protection Devicesfor Electric Motor in the Underground Mine Company XYZ Indonesia." *American Journal of Engineering Research (AJER)*, vol. 9(06), 2020, pp. 106-111.