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Analysis of the Fire Incident on Electrical Distribution Transformer at Tunnel P3 Underground Gold Mining "Pt Xyz"

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ABSTRACT: *A lot of equipments those used at underground mining operation at PT. XYZ are powered by electrical that supplied from surface power housing. And to make secure for electrical power circuit, it needs an electrical protection system and suitability determination transformer capacity based on the load being served.. One way to obtain the reliability of an electric power system is to implement a system of protection to protect equipment from disturbances that occurred in the system. The selection of protection used should not be less than the value of the Current Rate Capability (CRC) and must not exceed the value of the maximum setting protective devices. The electrical distribution panel "P3" The main protection that's installed in this panel is using ACB and for each mining equipments are protected using MCCB. For the effectiveness of ACB and each MCCB to protect a transformer and electrical system must be recalculated to find out the appropriate value. After recalculating, current setting value obtained as follows: for the electrical equipment load that has power 15 kW needs MCCB 30A, for the electrical equipment load that has power 37 kW needs MCCB 75A, for the electrical equipment load that has power 75 kW needs MCCB 150A, for the electrical equipment load that has power 110 kW needs MCCB 225A, for the electrical equipment load that has power 132 kW needs MCCB 250A. And for the additional of mining equipment that needed for solving technically problem, it is necessary to recalculated the transformer capasity.*

Keywords: *transformator, current setting, electrical load, protection system*

I. INTRODUCTION

Gold is one type of metal with high economic value because it has a distinctive trending compared to other metals. Gold is categorized as one type of precious metal that has been used since the past until today. Utilization of gold metal is the most common as jewelry. However, along with the development of technology, the use of gold metal is now starting expanded in electronic, electrical equipment and another technologies. In nature, gold is generally found as a native Au, rounded shape (nuggets) or plates (flakes) listed as veins breaking through a rock. Aside from being a pure metal, gold can also be found in the form of minerals "tellurides" associated with quartz and pyrite. Generally the presence of gold mineralization found in magmatic rocks (frozen plutonic, volcanic) called "pluto vulkanisma", which is shown by the results of activities magmatisma be intrusive and volcanic rocks (Sunarya & Yudawinata, 1996)[1].

To get the gold or other mineral materials effectively and efficiently needs to be done appropriate mining method selection. Selection of mining method is based on the location of the deposition on the surface of the shallow or deep. According to Morrison and Russel (1973) and Boshkov and Wright (1973) in Suyono (2011)[2], the main rules of exploitation of the mine is selecting a mining method that best suits the unique characteristics (nature, geology, environment and etc) of mineral deposits mined within the bounds of safety, technology and the economy, to achieve lower costs and maximum profit. In general, mining method is divided into three parts, namely: open pit mining methods, underground mining methods and underwater mining method (hartman, 1987)[3].

PT. ABC is an Indonesian state-owned enterprise which conducts exploration and exploitation of gold. Mining is done with a system of underground mines using the "Cut and Fill" and "Shrinkage Stopping", where the main equipments are jumbo drill, load haul dump, wheel loader, back hoe, dump truck, mine truck, excavator, and etc. Beside of those equipment, there are equipments those used for supporting mining operation, for example: main fan for ventilation, pump for draining the water, and etc.

Gold is one of the non-renewable mining materials, so in mining operations mining equipment always moves along the existence of material to be mined. Mining equipment used for underground mining operations at PT. XYZ is supplied by electric power, so the electrical appliances used to supply electricity also move around. In addition, mining also creates complex technical problems, such as the problem of water discharge that must be overcome by drainage process, which is pumping water out of the mine. And it adds electric power that used. A lot of equipments those used at underground mining operation at PT. ABC are powered by electrical. More reliable supply of electricity, it will be more safe in mining operations. And the continuity of power supply should be designed to be reliable and economical. Aspects of concern for electric power design are the arrangement of protective devices that when the full load of the motor (Prasetyo, 2009)[4], and the suitability of the transformer capacity determination based on the load served, ie the percentage of loading should be close to 80% of the transformer capacity (Warman, 2004)[5].

In the mining area of tunnel P3, the electric power used for the operation of mining equipment and supporting mining activities is supplied through a transformer 400V / 20,000V and 800KVA / 680KW located in the electric room at tunnel P3. The transformer is installed to supply 538KW of all equipment for mining operation. Due to the geological conditions, the direction of mining through the aquiver, that resulting in complex technical problems, which causes the water flow covered the tunnel. This problem disrupts the mining process, and must be overcome by drainage process, which is pumping water out of the mine. Thera are 2 electric pumps that used, 132 KW and 110 KW. This causes an increase in load on the distribution system at the mining area tunnel P3, burning of the transformer. Seeing this incident, it is necessary to analyze the causes of burner transformers to be able to replan again if there is additional load for mining activities, and to avoid the same incident.

For analyze the overload on the transformer can be done by evaluating at the nominal current of the electrical load, current rate capability (CRC), maximum setting protective devices, and load capacity of the transformer. Referring to The Indonesian National Standard SNI 0225: 2011 (2011)[6] on General Requirements for electrical installations in 2011 (PUIL 2011), that the selection of protection used should not be less than the value of the Current Rate Capability (CRC) and must not exceed the value of the maximum setting protective devices. Here are the equations to determine the value of the CRC and the maximum value of the protective device settings:

1. The equation to calculate the In (nominal current) of the electric load

$$I_n = \frac{P}{V \, x \sqrt{3} \, x \cos\theta} \quad \ldots\ldots (1)$$

I_n : Full Load Current (A)
P : Power Load at The Name Plate (kW)
V : Inter Phase Voltage (V)
$Cos\ \theta$: Power Factor of The Electrical Load

2. The equation for determining the CRC flowing on the electrical load

CRC = In x 125% …… (2)

3. The equation for determining the maximum setting protective devices on the power load

Protective Max = In x 115% …… (3)

4. The equation for calculating the load transformator load

$S_{(VA)} = P_{(W)} / Cos\ \theta$ …… (4)

II. MATERIAL AND METHOD

This research was conducted at PT. XYZ, located in West Java Province, Indonesia. The method used in this research is descriptive qualitative method, that is to analyze the fire incident occurring in the transformer installation in electrical distribution system at tunnel P3 of underground gold mining "PT. XYZ ". Researchers got the incident's data by reading chronological reports of events and see the installation electrical distribution system at tunnel P3. The primary data obtained are the protection system that used and the suitability of the electrical distribution system at tunnel P3. And the secondary data that collected are a single line diagram of the electrical distribution circuit at tunnel P3 and the specifications of mining equipment that used. The presentation of data is done by making tabulation which contains: electrical load from mining equipment and calculation result of electrical system reliability in accordance with SNI 0225: 2011 on General Requirements for electrical installation in 2011.

III. RESULTS AND DISCUSSION

3.1 Research results

The main source of electrical power in PT. ABC came from Indonesian Electricity Company (PLN) with a capacity of 10,400 KVA. The electricity from PLN using the air duct system transmission (line to line) 20 KV with a current of 300 A. The electricity supply back up is from the generator set with a capacity of 6,325 KVA.

The electricity of PT. ABC are supply to offices, tunnels, gold processing plant, etc. There are 17 tunnels, and the electricity distribute to all tunnels. Each tunnels have electrical distribution panel, namely: electrical distribution panel "A" for Tunnel A, to electrical distribution panel "Q" for Tunnel Q.

In the Tunnel P, the electricity supplies from electrical distribution panel "P". In this tunnel, there are 5 (five) mining areas, namely: Tunnel P1, Tunnel P2, Tunnel P3, Tunnel P4, and Tunnel P5. In each mining area there is a transformer unit to optimize the electrical power to the load, each mining area has different capacities of transformer, depending on the electrical power required by the load.

Mining activities at Tunnel P3 use some mining equipmentsthat totally have power are among 538 KW (base on name plate). For this equipments, the electrical suplly is using a transformer with a capacity of 800 KVA connected to the electrical distribution panel P3 with the main protection installed using an ACB with a capacity of 2500 A.

Table 1: Mining Equipment Used at Tunnel P3

No	Name of Mining Equipment	Specification		MCCB Protection (A)
		Power (kW)	*Cos θ*	
1	Junction Box for Jumbo Drill Electricity Supply	75	0,85	250
2	Draining Pump 1	132	0,85	400
3	Draining Pump 2	110	0,85	400
4	Main Fan	132	0,85	400
5	Auxilary Fan 1	37	0,85	250
6	Auxilary Fan 2	37	0,85	250
7	Auxilary Fan 3	15	0,85	100
	Total Power Used	538	ACB Used	2500

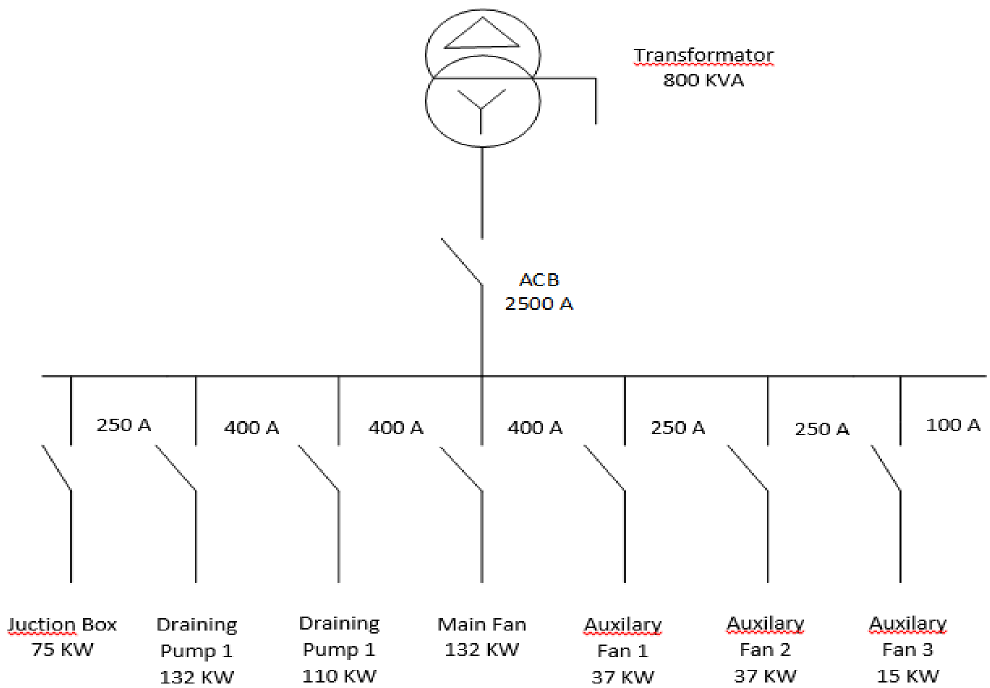

Fig. 1 Single Line Diagram of Electrical Distribution Panel at Tunnel P3

In the development of mining activity, due to the geological conditions, the direction of mining through the aquiver layer, which causes the water flow covered the tunnel. This problem disrupts the mining process. The water problem must be solved by drainage process, which is pumping water out of mine. Pumps added to overcome this problem. There were 2 electric pumps that used, 132 KW and 110 KW. The addition of pumps directly installed in the electrical distribution panel P3. These caused an increase in load on the electrical distribution system at Tunnel P3, and burned of the transformer. This below is a table of mining equipment in the Tunel P3 after the addition:

Table 2: Mining Equipment Used after Addition Load at Tunnel P3

No	Name of Mining Equiments	Specification		MCCB Protection (A)
		Power (kW)	*Cos θ*	
1	Junction Box for Jumbo Drill Electricity Supply	75	0,85	250
2	Draining Pump 1	132	0,85	400
3	Draining Pump 2	110	0,85	400
4	Draining Pump 3	132	0,85	400
5	Draining Pump 4	110	0,85	400
6	Main Fan	132	0,85	400
7	Auxilary Fan 1	37	0,85	250
8	Auxilary Fan 2	37	0,85	250
9	Auxilary Fan 3	15	0,85	100
	Total Power Used	780	Total ACB	2500

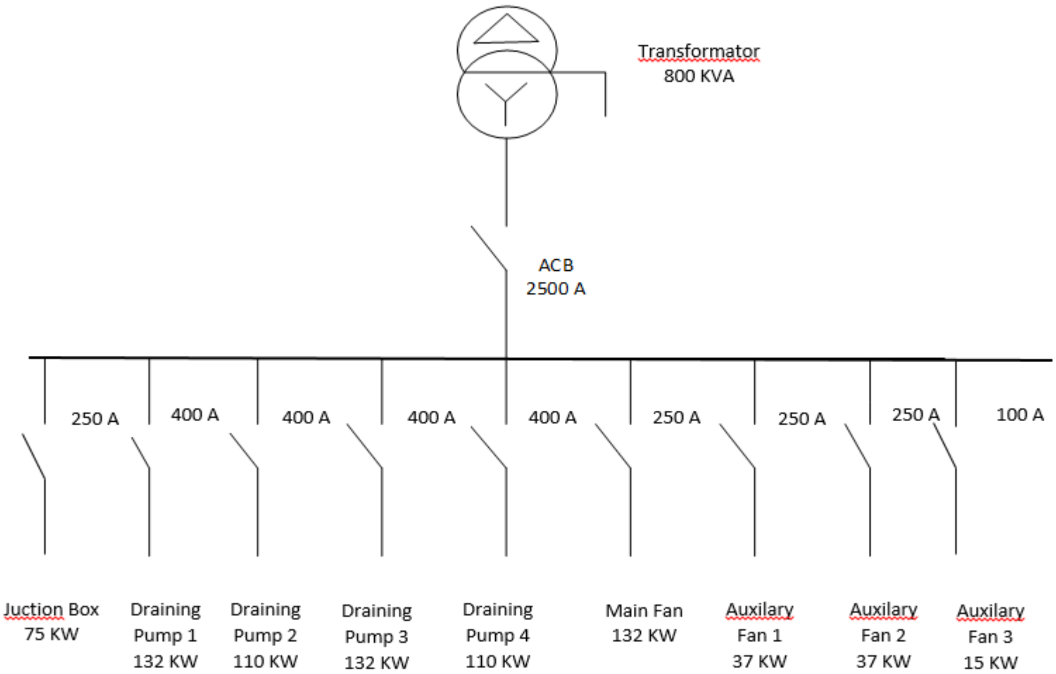

Fig. 2 Single Line Diagram of Electrical Distribution Panel after Additional Load at Tunnel P3

3.2 Discussion

Continuity of power supply should be designed to be reliable and economical. Aspects of concern to the design of electric power is the protection system and the suitability of capacity of the transformer based on the load served. The addition of pumps directly installed in the electrical distribution panel P3 caused an increase in load on the electrical distribution system at Tunnel P3, and burned of the transformer. Seeing this incident, it is necessary to analyze the causes of burner transformers to be able to replan again if there is additional load for mining activities, and to avoid the same incident. And for analyze the overload on the transformer can be done by evaluating protection system, begin from recalculating at the nominal current of the electrical load, current rate capability (CRC), maximum setting protective devices, and load capacity of the transformer

The implementation protection system si to be protect equipment from disturbances that occurred in the system, so as not to damage and disruption due to localized so as not to spread in the electrical system, and also to secure people from the hazards posed by electricity. Breaker is one of the important parts of the security system used to decide whether the burden of fault current will be like a short circuit condition, to prevent widespread interference to other networks. For the effectiveness of the protection system in an electrical system, it is necessary to evaluate the use of breaker is installed, in order to obtain reliability in protecting equipment from disturbances that occurred in the system. According to The Indonesian National Standard SNI 0225: 2011, on General Requirements for electrical installations in 2011 (PUIL 2011), that the selection of protection used should not be less than the value of the Current Rate Capability (CRC) and must not exceed the value of the maximum setting protective devices. The following are the results of the evaluation of the currrent setting for the protection of electrical load in the Tunnel P3.

The main protection that's installed in each mining area are using ACB and for each electrical equipments in each mining area are protected using MCCB. For the effectiveness of ACB and each MCCB to protect a transformer and electrical system against disturbances that occurred in the system so as not to damage and disruption due to localized so as not to spread in the system, the current setting for the protection must be recalculated to find out the appropriate value, that the value should not be less than the value of the Current Rate Capability (CRC) and must not exceed the value of the maximum setting protective devices.

As an example of the calculation example is juction box for jumbo drill electricity supply. The spesification of jumbo drill are: has voltage input 3 phasa 380 Volt, has power 75 kW with Cos θ 0,85. The step calculations are as follows:

a. Calculate the nominal current of the equipment nameplate by using equation (1)

$$I_n = \frac{P}{V\ x\ \sqrt{3}\ x\ cos\theta} = I_n = \frac{75000}{380\ x\ \sqrt{3}\ x\ 0.85} = 134{,}06\ A$$

b. Calculate the value of the Current Rate Capability (CRC) by using equation (2)

CRC = In x 125%
= 134,06 x 125%
= 167,58 A

c. Calculate the value of the maximum setting protective devices by using equation (3)

Protective Max = In x 115%
= 134,06 x 115%
= 154,17 A

In the same way, here are the results of calculation of electrical equipment that used in th Tunnel P3:

Table 3: Results of Nominal Current, CRC, and Value of Setting Protection Devices for Equipment used in Tunnel P3

No	Name of Mining Equipment	Power (kW)	Nominsl Current (A)	CRC (A)	Setting Protection (A)
1	Junction Box for Jumbo Drill Electricity Supply	75	134,06	167,58	154,17
2	Draining Pump 1	132	235,95	294,94	271,34
3	Draining Pump 3	110	196,62	245,78	226,11
4	Main Fan	132	235,95	294,94	271,34
5	Auxilary Fan 1	37	66,14	82,68	76,06
6	Auxilary Fan 2	37	66,14	82,68	76,06
7	Auxilary Fan 3	15	26,81	33,51	30,83
	Total Power Installated	538			
	Total Value for Current Setting ACB			1202,11	1105,91

By knowing the value of CRC and maximum setting protective devices, it can be determined the current setting value for MCCB of each mining equipment. And for calculating the capacity of the transformer based on the load used is using equation (4).

$S_{(VA)}$ = $P_{(W)}$ / *Cos θ*
= 538.000 / 0.85 = 632,94 KVA

Figure 3 is the result of evaluation of MCCB usage based on calculation of CRC value and protective device. Evaluation is needed to get the value of setting the termination current against the load more in the hope that if MCCB used is too large, then the damage will propagate to the electrical system. Likewise with ACB as the main breaker of the electrical system also needs to be evaluated so that damage does not propagate to the transformer. And for the capacity trasnformator with the above load is still safe in accordance with the installed capacity, which is 800 KVA.

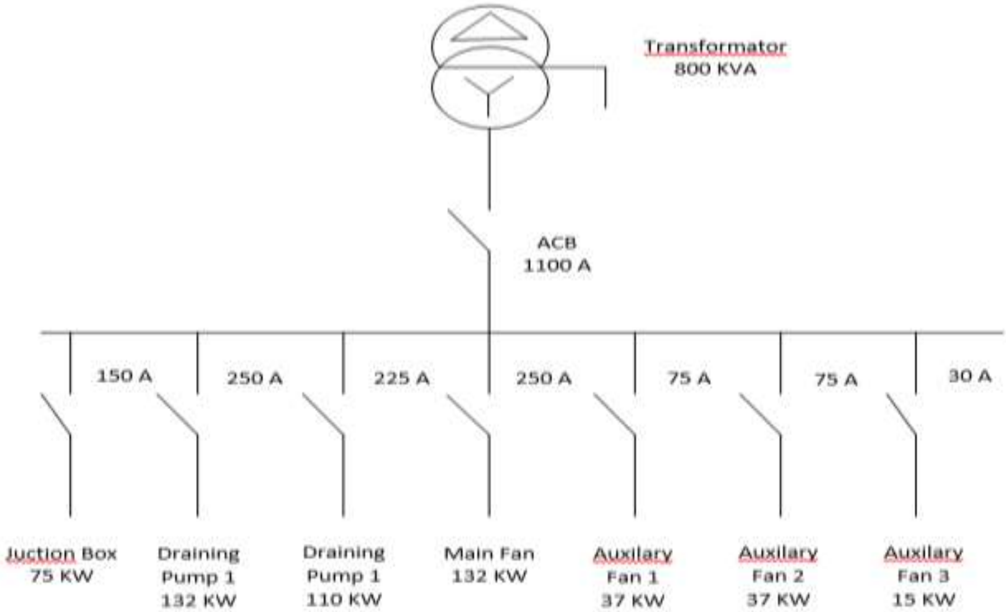

Fig.3 Evaluation of Single Line Diagram of Electrical Distribution Panel at Tunnel P3

Below is the calculation result for the addition of mining equipment due to the technical problem of water discharge which must be overcome by the addition of 2 pumps.

Table 4: Results of Nominal Current, CRC, and Value of Setting Protection Devices for Equipment after Additional Load used in Tunnel P3

No	Name of Mining Equipment	Power (kW)	Nominsl Current (A)	CRC (A)	Setting Protection (A)
1	Junction Box for Jumbo Drill Electricity Supply	75	134,06	167,58	154,17
2	Draining Pump 1	132	235,95	294,94	271,34
3	Draining Pump 2	110	196,62	245,78	226,11
4	Draining Pump 3	132	235,95	294,94	271,34
5	Draining Pump 4	110	196,62	245,78	226,11
6	Main Fan	132	235,95	294,94	271,34
7	Auxilary Fan 1	37	66,14	82,68	76,06
8	Auxilary Fan 2	37	66,14	82,68	76,06
9	Auxilary Fan 3	15	26,81	33,51	30,83
	Total Power Installated	780			
	Total Value for Current Setting ACB			1742,83	1603,36

And for calculating the capacity of the transformer based on the load used is using this equation.

$S_{(VA)} = P_{(W)} / Cos\ \theta$

$= 780.000 / 0.85 \quad = 917,65$ KVA

Figure 4 below is the evaluation result of MCCB usage based on calculation of CRC value and protective device after the addition of 2 pumps. And for the capacity trasnformator with the above load is not safe, because it exceeds the installed capacity of 800 KVA, while the required is 917.65 KVA. Thus the installed transformer capacity is 1,000 KVA.

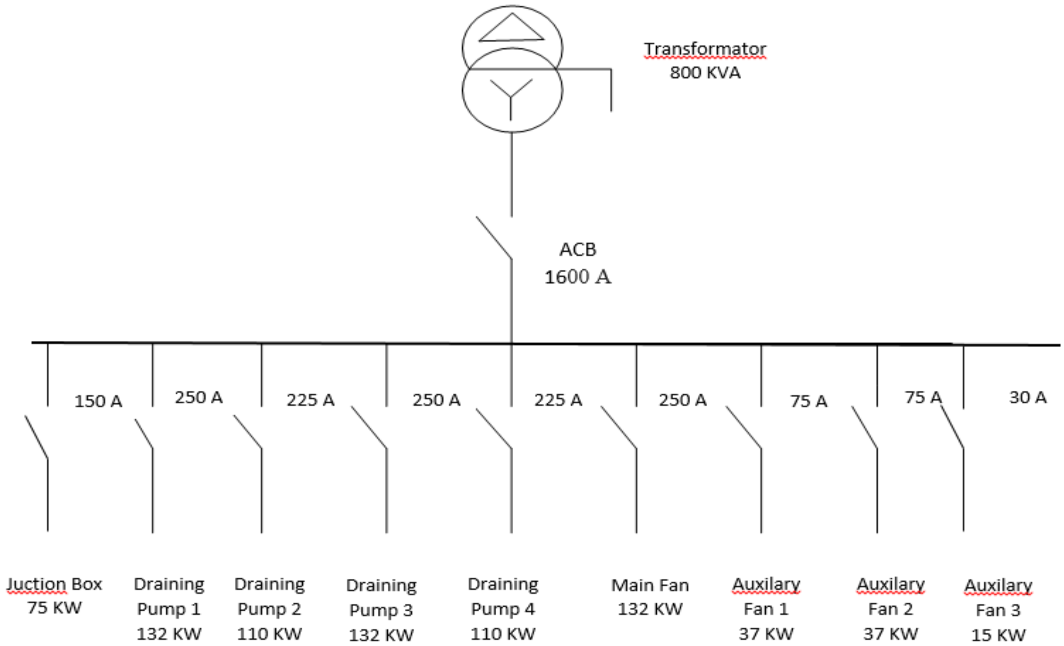

Fig. 4 Evaluation of Single Line Diagram of Electrical Distribution Panel after Additional Load at Tunnel P3

From the calculation above, transformer fire incident in electrical distribution system for electrical distribution panel P3 can be analyzed as follows:

a. The use of overload safety protection (MCCB) for each mining equipment is too large, so it will allow MCCB not to trip in case of overload.

b. The use of primary safety protection (ACB) for mining equipment systems is too large, so it will allow ACB trips in case of overload.

c. With the addition of 2 pumps, will increase electrical power. So it will overload the transformer. And if the main safety protection (ACB) does not trip, then the overload will propagate to the transformer and will cause the transformer to burn.

IV. CONCLUSION

The results of this study have demonstrated the importance of designing electrical systems, taking into account the evaluation of electrical protection systems and the suitability of capacity transformer based on the load served. Selection of protection used shall not be less than the value of the Current Rate Capability (CRC) and shall not exceed the maximum value of protective device settings. The implementation of value for the electrical load protection in the electrical distribution panel P3 of the "XYZ" underground gold mine is too large, so to protect the equipment from system disturbances needs to be recalculated to find out the appropriate value.

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