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Analysis Of Motor Chiller Safety System In Store Building

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ABSTRACT

Security of the chiller is very necessary, especially to protect the motor from interference so that it can also protect the chiller from damage that occurs, in addition to protecting the surrounding environment and living things (humans). Disturbances that arise in the chiller can be caused by current and voltage, unstable loads on the motor or from its environment; This can cause damage to the motor, fire and death. The safety equipment used in the chiller motor safety system can be in the form of circuit breakers (MCCB and ELCB) or Phase Failure Relay (Motor Saver). MCCB is used as short circuit, overload and overcurrent protection; ELCB for leakage current; while the Motor Saver is used for safety of less/over voltage, asymmetrical voltage.

Keywords:
System, safety, motor, chiller

INTRODUCTION

There are high-rise buildings in various cities in Indonesia, none of which has the characteristics of a tropical climate building, let alone designed with Indonesian architecture. These buildings are generally designed based on Western architectural patterns[1]. Where in reality it is not easy to apply tropical architecture to high-rise buildings in Indonesia, because on the floors at the top of the building, the windows must be tightly closed to prevent the entry of strong winds. As a result, the air in the interior of the room will become more stuffy[2]. The solution that can be done is to use air conditioning (AC). Thus, to overcome the stuffy air temperature, the air conditioner/AC must be turned on so that the use of air conditioning in buildings is a primary need to ensure the comfort of its residents in carrying out various work activities.[3][4]. In general, this air conditioning equipment functions to regulate air temperature, regulate air circulation, regulate air humidity and regulate air cleanliness to make it comfortable.[5].

In general, the air conditioning system used in shopping centers, hotels and office buildings uses a central air conditioning system, where in buildings that use a central air conditioning system it can be ensured to use a chiller.[6]. This is because operational costs and maintenance are cheaper and easier, where this facility is designed to fulfill one of the factors that can help make you feel comfortable. Because of the importance of using chillers in buildings where the price of the chiller itself is still relatively expensive; In addition, to maintain the comfort of the occupants in their activities, a good and reliable safety system is needed to protect the chiller from disturbances that can occur, especially on the motor.[7].

The purpose of security measures in electrical installations is to protect living things and their equipment, including electrical installation systems that are secured from disturbance conditions due to abnormal conditions that occur, where these disturbances can be in the form of short circuits, overloads, over currents, leakage currents, over voltages/ undervoltage, reverse voltage, phase current asymmetry, voltage asymmetry or one phase break for three phase electrical circuits[8]. This safety equipment is used to detect disturbances that occur in electrical installations and to disconnect electrical circuits that are experiencing disturbances so that damage does not occur/reduces damage that occurs to electrical equipment, in addition to locating disturbed areas so that uninterrupted equipment can operate normally.[9].

What is dangerous for living things from electrical energy is the amount of electric current that flows and the length of time the electric current flows in the bodies of living things. Often we misunderstand that high-voltage power sources provide a high risk, but in fact even if the voltage is high as long as there is no potential difference that can cause electricity to flow, then the voltage is safe for living things.[10]. The most common example we encounter is when a bird is perched on a live electric wire, this bird will not experience an electric shock as long as both legs are on one wire. What becomes dangerous is when the bird is standing between two wires, a potential difference will arise and an electric current will flow through its body. The dangers caused by electric shocks vary, ranging from minor hazards such as triggering contractions of the body's muscles to the highest risk, namely death[11][12].

Touch voltage is the voltage obtained as a result of touching the active part of the electrical installation. The active part of the electrical installation is the conductive part (line or neutral) which is part of the electrical circuit. The thing that causes current to flow when the body is in contact with voltage is the footrest on the ground, where the ground functions as a zero conductor which is constantly being sought by electrical energy to discharge its charge[13]. While on the other hand the human body has a resistance value and electric charge tends to find its way through a smaller charge value. The touch voltage is said to be high if the touch voltage exceeds 50V except in wet places, work spaces in the agricultural industry, and work spaces that require safety with safety insulation or safety separators. In a place like this the touch voltage is said to be high if it exceeds 25V.

Electrical equipment needs to be protected from interference with the system. This is done where when the disturbance occurs there will be heat both in the disturbed system and in the equipment. IEV 441 explains that a short circuit between two or more points in a circuit through an impedance that is very small or close to zero. Fuse is used as a safety for equipment and electrical installations in the event of a short circuit because the fuse works to cut the price of short circuit current. Miniature Circuit Breaker (MCB) has a double function as a safety where it can protect electrical equipment and installations against overcurrent with bimetal and also against short circuit with electro magnet[14][10].

METHOD

The methodology used in this paper include:

a. Field/Observation Methods, namely collecting data and information by conducting comparative studies by directly reviewing and asking people who are experienced in their fields.
b. The library method is collecting data and information by searching for reference books and literatures, as well as collecting catalogs related to this writing.
c. Discussion method, namely collecting data and information by conducting dialogues and discussions. This is done by consulting with the supervisor, with teaching staff and fellow colleagues.

RESULTS AND DISCUSSION

Both safety and load have unique characteristics, therefore, to determine the safety, the type of load being secured must also be considered. For example, an electric motor when it starts to rotate requires a starting current of 6 times its nominal current, therefore if the safety working limit is only the nominal current of the motor, the safety will always trip when the motor is started. In Menara Sudirman there are three chiller motors that are used where one chiller unit is used every day according to the needs which are carried out alternately, but if needed, two chiller units can be used every day. This chiller motor safety system uses the MCCB Merlin Gerin Compact NS2000 type with a nominal current of 2000A with a Breaking Capacity of 70-85KA at a voltage of 380/415V as the main safety. As a motor safety, use MCCB Merlin Gerin Compact NS800 type with a nominal current of 800A with Breaking Capacity 50KA at a voltage of 380/415V which is equipped with an Electronic Trip Unit type STR43ME as a safety for short circuits, overloads and asymmetrical phase currents on the motor. This MCCB Compact NS800 is paired with an ELCB type Vigi module (Vigicompact) with a breaker current rating of 30mA which is used as a touch voltage safety from leakage current due to insulation failure that occurs in the motor. As for the safety equipment over/under voltage and reverse voltage from the chiller motor and asymmetrical voltage/loss of one phase in the circuit, Phase Failure Relays (PFR) are used in the form of a motor saver, where the contacts of the motor saver are attached to the chiller motor control circuit so that when motor failure occurs; This saver motor will work to disconnect the control circuit on the chiller motor which causes the KM motor contact to detach and disconnect the circuit on the chiller motor so that the motor stops without causing the MCCB to trip.

Setting the magnitude of the MCCB rating value for a three-phase induction motor is protected by a circuit breaker that uses a triangular star system starting with a ratio of 1:2.5 to its full load current, however, because this chiller motor is a motor with a rotor winding drive (sliding ring induction motor) due to the power of this chiller motor is 360HP, besides that when the chiller motor starts it works without a load so that at start the current only reaches 1.5 times its full load current so that for setting the MCCB rating a ratio of 1:1.5 is used. Then the setting for the nominal current rating of the MCCB is the current setting of 800 A. Meanwhile, to be able to find out the rating value of the MCCB which is used as the main safety of the chiller motor, it can be done with the following calculations,

Human Security

Direct touch voltage has the potential to be felt by living things because this voltage will be felt at any time as long as the system is active without the need to feel an insulation failure. For this reason, we need a way to overcome the danger of direct touch voltage, at least minimizing the risk of touching the active parts of an installation when living things are around the work area. There are various ways of dealing with the danger of direct contact, and these methods are classified in PUIL 2000 as follows: insulation is used to prevent contact with live parts. In PUIL 2000 section 3.4.1.1 states that live parts must be completely covered with insulation which can only be removed by damaging them.

In PUIL 2000 section 3.4.2.1 discloses that the protection provided by enclosures against direct contact with hazardous parts is human protection against contact with dangerous low-voltage live parts, contact with hazardous mechanical parts and approaching dangerously high-voltage live parts under a defined clearance. adequate in the enclosure.

The purpose of providing this barrier is to prevent accidental approach of the body to live parts and also to prevent touching of live parts during normal operation of active parts. This is as stated in PUIL 2000 section 3.4.3. In PUIL 2000 section 3.4.4.1 it is stated that potentially different parts that can be reached simultaneously must be separated, where this simultaneous separation occurs when the two parts are not more than 2.5m apart. If the normally occupied position is obstructed in the horizontal direction by an obstacle providing a level of protection less than IP 2X, then the reach of the hand shall be measured starting from the obstacle, upwards of the reach is 2.5m. If the load resistance is large, we take 17□ with reference to the magnitude of the ground fault resistance, and the ground resistance of 5□, then using the above formula will get the value of the touch voltage of 50 Volts. This value is still permitted because it can still be borne by the body. One type of leakage current switch that is often used is the ELCB with a nominal drop current of 30 mA. This switch is quite safe because it will work when it senses a leakage current of 30 mA, and we know that currents below 50mA if felt by the body can still be borne by the body without causing dangerous symptoms.

Electric Motor Security

The impact given from the disruption of motor work in general is the emergence of heat in the windings which will cause the motor to burn. For that we need an action that secures the electric motor when there is a disturbance in the motor, with the hope that the motor will not experience too high heat, so that it burns out. Electric motors must not only be protected from fault currents, they must also be protected from other objects or water that can cause interference, for this reason their use must be adapted to the work environment. In this case what is needed is the protection index (IP / Index Protection) of the motor. Motor grounding is also required in an electrical installation, because with grounding if there is a leakage current in the motor, the current will be channeled directly to the earth.

This is the case for three-phase motors, where voltage asymmetry can occur due to a break in one of the phases. The potential difference between the phases is 380 Volts for a low voltage of 220/380 Volts, and when one phase is disconnected, the neutral part will become live. The result of this situation is that the motor will not work because there is a motor winding that does not get a supply due to the small potential difference due to the neutral voltage. In other parts of the motor windings that are still supplied, heat energy will be continuously received by the coil, with the condition that the coil does not work to move the motor so that heat accumulation occurs again which will endanger the motor.

Phase Failure Relays (PFR) are connected to a three-phase circuit, this device is used as a safety device or as a signal. Phase Failure Relays detect a decrease or increase in voltage in one or more phases and a voltage difference between the phases. The properties of Phase Failure Relays are to keep the 3-phase circuit functioning at a nominal voltage of 10%. In the chiller motor, the safety equipment used to detect phase imbalance in the motor network is a motor saver. This motor saver is set to work if there has been a phase imbalance in the motor network, where when the motor saver works the contacts will break the control circuit which will cause the motor to stop working.

Motor Fault Analysis

If a motor is given a load that is too large mechanically, this load will cause a large coupling moment, which can cause the motor to not rotate optimally due to excessive load. The electrical impact caused when overloaded is the generation of overcurrent in the motor which is required by the motor to rotate normally. If this continues to occur, it can cause the motor to be damaged/burned because excessive current will cause the motor windings/coils to receive excessive heat which can damage the insulation. To prevent this, safety equipment is needed to secure the motor from overcurrent where the safety equipment can be in the form of an over current relay (OCR). In the chiller motor, the safety equipment used is in the form of an MCCB which functions to detect the overcurrent that arises in the motor. The rise and fall of the coupling moment caused by an unstable load can cause the current flowing in the motor to be unstable, so that the motor winding/coil gets an unstable supply as well, where this unstable current can damage the insulation on the motor winding/coil if it occurs accidentally. continuously so that it can cause the motor to burn/damage. Therefore, in order to prevent this, it is necessary to ensure that the load received by the motor is stable. When a motor is started, for example when the motor is started Y- where this unstable current can damage the insulation on the windings/coils of the motor if it occurs continuously so that it can cause the motor to burn/damage. Therefore, in order to prevent this, it is necessary to ensure that the load received by the motor is stable. When a motor is started, for example when the motor is started Y- where this unstable current can damage the insulation on the windings/coils of the motor if it occurs continuously so that it can cause the motor to burn/damage. Therefore, in order to prevent this, it is necessary to ensure that the load received by the motor is stable. When a motor is started, for example when the motor is started Y-□, the motor starting current will be less than the starting current without starting. Times like this will cause the motor power to be small, so it can be seen that when it is started the motor is in an abnormal condition because the windings / coils of the motor get a large supply voltage. If this is done frequently and the starting time is too long, it can damage the insulation of the motor windings/coils, so safety equipment is needed that can protect the motor from overvoltage, as well as for braking the motor too often and for too long. When the motor is braked, the current flowing in the motor remains while the power output is small, so that the windings / coils of the motor will heat up due to excessive current. The heat generated in the windings / coils of this motor can damage the insulation,

In the chiller this motor is used as a compressor motor which functions to compress the refrigerant in the form of gas in the compressor where this refrigerant comes from the suction line of the evaporator so that the temperature and pressure of this refrigerant will increase. This refrigerant will be used to cool the water flowing in the evaporator and the amount of refrigerant that will be compressed by the compressor is regulated by the vanes where these vanes work based on the temperature in the evaporator, so that the current flowing in the motor can be adjusted. Therefore, this motor is relatively safe against disturbances from large loads and load instability because the amount of refrigerant that will be compressed by this compression motor is relatively stable or if there is a refrigerant addition/reduction it will be done gradually because it has been regulated by the vanes automatically. Likewise for the start where the starting time has been set to less than 10 seconds. Meanwhile, the braking is relatively non-existent because this motor is designed to operate continuously without braking.

To prevent overcurrent in the motor due to undervoltage, safety equipment against undervoltage is needed which can be an under voltage relay (UVR) or overcurrent. If the supply voltage on the motor is too high, the motor will still be able to rotate where the current required is small. However, a voltage that is too high on the motor can cause damage to the insulation of the motor windings/coils which can cause the motor to be damaged/burned due to receiving a voltage above the nominal voltage, so to prevent this, safety equipment is needed that can protect the motor from overvoltage which can be in the form of relay over voltage (OVR).). To prevent the occurrence of a voltage that is too low / high on the motor, you can use a stabilizer to stabilize the voltage.

On a motor with a line to line voltage specification of 380V, if one of the three phases gets an unequal supply voltage, the motor cannot rotate optimally (the motor rotates intermittently) and will cause a current to occur in the neutral conductor. If this condition occurs continuously, it can cause the motor to be damaged/burned due to damage to the motor insulation caused by overcurrent that occurs in the windings/coils due to unequal phase voltages; and can endanger living things and the surrounding environment, especially humans because of the current flowing in the neutral conductor. To prevent the occurrence of voltage asymmetry, safety equipment is needed that can detect asymmetrical phase voltages in the circuit which can be in the form of a phase failure relay.

When one phase of the motor breaks, it causes a large current to occur in the neutral conductor, so that the potential difference between the phases will decrease. This condition causes the motor to buzz and spin not optimally (the motor rotates broken) because one of the phases is not active and both phases bear all the load that should be borne by all phases so that the current in the windings/coils is large and can cause the motor to be damaged/burned. where the insulation breakdown is caused by a large overcurrent. In addition, the current flowing in a neutral conductor can harm living things and the surrounding environment, especially humans because of the large current flowing. Therefore we need safety equipment that can secure the motor against breaking the wrong phase on the motor, where the equipment used can be a phase failure relay. In the chiller motor this has been overcome because the circuit has installed safety equipment in the form of a motor saver that functions as an under voltage relay (UVR), over voltage relay (OVR), phase failure relay (PFR), as well as to detect reverse voltage from the motor (Phase Reversal); which is used to detect disturbances that occur in the motor circuit. This motor saver works when the voltage in the circuit is reduced by 10% of the nominal voltage (380V) in the event of an undervoltage, while the overvoltage is set at 405 V. Likewise, when there is a reverse voltage from the motor where the chiller motor will produce a voltage that can interfere with the supply voltage from the PLN / Generator and when there is asymmetric voltage or a break in one of the phases, this motor saver will work. Where the work of the motor saver will cause the control circuit of the motor to be disconnected and the motor will stop without causing the MCCB to trip because the contacts of this motor are attached to the control circuit.

The work of the motor saver is backed up by the electronic trip unit contained in the MCCB where the electronic trip unit will work when the phase current imbalance reaches 40% or more, while for the over/under voltage it reaches 10% of the nominal voltage. When the motor saver is working, the motor saver will disconnect the control circuit from the motor which causes the motor to stop, while when the electronic trip unit is working, the electronic trip unit will cause the working MCCB to disconnect the circuit where the electronic trip unit is attached to the MCCB as well as on the ELCB Vigi Compact.

The electric motor is designed with a construction that has ventilation to be a means of air circulation between the hot air from the motor coil when the motor is running and the air around the environment as a coolant. For this reason, electric motors have protection by using insulation which can only be damaged by excessive temperatures. If this insulation is damaged, the ambient temperature and heat in the motor winding/coil can cause the motor winding/coil to burn out. The class of motor insulation can be shown in table 1.

Table 1. Motor Insulation Class

Insulation Class	A	E	B	F
Maximum allowable temperature (°C)	105	120	130	155

The environment where the chiller motor is placed has been equipped with fresh air fan and exhaust fan facilities that operate for 24 hours which function as air circulation so that the chiller motor is relatively safe against disturbances from the surrounding temperature which could interfere with the performance of the chiller where the air temperature is always maintained, In addition, this chiller motor has been equipped with class F motor isolation which means this motor can withstand temperatures up to 155°C for the windings/coils. In addition, to reduce the vibrations that arise from the chiller motor when the motor is working which can cause the motor to shift from its position, a spring/spring is used at the foundation to stabilize the position of the chiller motor, where this spring/spring can be adjusted in height.

Discussion

When the chiller motor has a disturbance caused by an overload, the safety equipment that works is MCCB800A where this MCCB functions as an overload safety, as well as when there is an overcurrent where excessive current can cause an overload so that the safety that works is this MCCB800A. For overload safety, the current rating (Ir) of this MCCB is set at 110% of the nominal current (110%In) or at 67% of the setting current (67%Is) which is 536A, where the nominal current (In) of this motor is 490A and the current is 490A. setting (Is) for this MCCB is 800A.

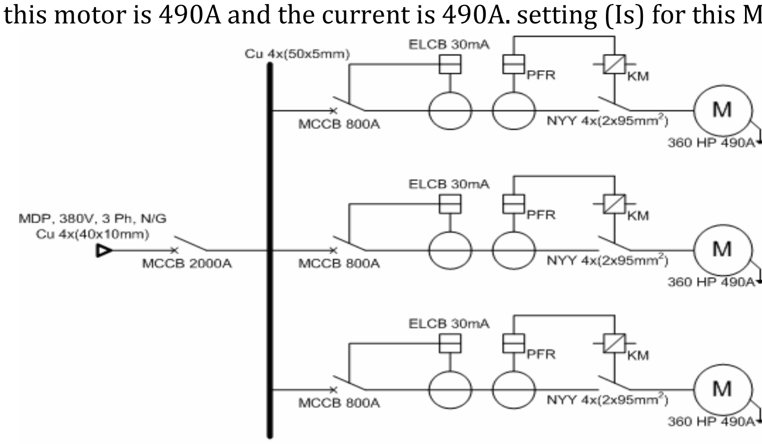

Figure 1 Single Line Chiller Motor Safety System

When the overload is 110%In, the electronic trip unit works which causes the MCCB800A to trip within 700s, while for an overload of 120%In, the MCCB800A will trip within 450s. For more details regarding the trip time of the MCCB during overload, see table 3.2. At the time of overload, the tripping type used by MCCB is thermal.

Table 2. Percentage of overload and tripping time of MCCB

Over load	110%In	120%In	130%In	140%In	150%In
waktu	700s	450s	300s	200s	150s

Meanwhile, if a short circuit occurs, the safety equipment that works is MCCB800A because this MCCB is also used as a short circuit current safety, where the tripping type used is electromagnetic. The setting for the short circuit current on the MCCB is divided into two, namely instantaneous and short time. For instantaneous the rating current (Ir) is set at 13 times the nominal current (13xIn), while for short time the rating current (Ir) is set at 6 times the nominal (6xIn). To protect humans against the possibility of insulation failure that occurs in the chiller motor which can cause leakage currents in the chiller motor, where the leakage current can harm the environment and living things around it, especially humans, this chiller motor is equipped with a Vigi Compact ELCB which is integrated with the MCCB800A. This safety equipment will work if the leakage current that occurs is greater than 30 mA so that if the ELCB detects a leakage current of 30 mA the circuit will be disconnected by the MCCB800A so that the circuit will be disconnected and no current will flow to the chiller motor.

The MCCB800A has also been equipped with an electronic trip unit, which is a safety device that functions to detect the occurrence of over//less voltage or asymmetrical phase currents that occur in the circuit where the MCCB800A will trip if the voltage is less/more than 10% and or asymmetrical phase currents occur. on the circuit has reached 40% or more. The safety on this MCCB is a back-up from the motor saver. Meanwhile, to secure the motor against disturbances from over/under voltage, reverse voltage and asymmetrical phase voltages or the loss of one phase of the motor that may occur, the motor has been installed with a Phase Failure Relay in the form of a motor saver where if the motor saver detects the disappearance of one of the single phase or asymmetrical voltage,

When the motor saver works, the contact will break the control circuit on the chiller motor which causes the contact of the KM contactor to disconnect the motor circuit so that the motor will stop operating. This is different from the back up safety of the motor saver, namely the electronic trip unit found on the MCCB800A which will disconnect the circuit through the MCCB as well as the ELCB Vigi Compact, while the motor saver disconnects the circuit through the contactor contacts. This MCCB800A is backed up with MCCB2000A which serves to secure the entire circuit where if the MCCB800A cannot work if there has been a disturbance in the circuit/motor then the MCCB2000A will work and disconnect the entire circuit from the three chiller motors so that there will be a total blackout.

CONCLUSION

Based on the results of the analysis, it can be seen that the safety equipment used to secure the chiller motor consists of three types, namely MCCB, ELCB and Motor Saver. The MCCB functions as a safety for the chiller motor against overload and short circuit current as well as the main protection for the chiller motor, while the ELCB is used as a safeguard against touch voltage and leakage current caused by insulation failure. To detect the occurrence of disturbances that occur in the chiller motor, you can use a motor saver. This motor saver serves as a safety device to detect the occurrence of over/under voltage, reverse voltage and asymmetrical voltage/loss of one phase voltage on the chiller motor, where disturbances that occur in the motor can be caused by the driven device, supply network and the environment around the motor. For driven tools, it can be caused by unstable coupling (up/down) and too frequent starting which causes overcurrent to occur in the motor windings/coils; while for the supply network it can be caused by an unstable voltage and a break in one of the phases which results in over/under voltage and overcurrent in the motor windings/coils, while for the environment around the motor it can be caused by temperature and vibrations that occur. In addition, this MCCB has also been equipped with an Electronic Trip Unit which is used to detect over/under voltage and asymmetrical phase currents in the circuit, where the electronic trip unit is integrated with the MCCB as is the case with the Vigi Compac ELCB.

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