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Study of Evaluation in Maintenance to the Low Voltage Connection Device on the Feeder Db 0729

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A R T I C L E I N F O

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A B S T R A C T

One of PLN assets that can maintain the continuity of electricity distribution to consumers is the Low Voltage Connection Device. (LV-Board). Discussing the NH Fuse rating with the suitability of the type of conductor at the LV-Board distribution substation DB 0729 Discussing the estimated cost budgeted by PT. PLN South Bali in the maintenance of LV-Board distribution substation DB 0729 In conducting this research, the author carried out several data collection methods to obtain data that will be used to complete this final project where the methods used are: literature study method, observation method, and method documentation. Data processing is carried out by calculating the current carrying capacity of incoming and outgoing cables, determining the NH Fuse rating based on the current carrying capacity of outgoing cables. The NH Fuse which is used as a safety/protection device for the LV-Board DB 0729 substation before maintenance is not up to standard. Based on the method, the estimated cost budgeted by PT. PLN South Bali Customer Service Implementing Unit is a Contractor's estimate method based on the components used in the maintenance of LV-Board DB 0729 substation in order to use components that comply with the standards.

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INTRODUCTION

The vast range of energy forms that can be generated from electrical energy, combined with the rapid advancement of technology, has made every aspect of human life dependent on electricity. As a result, society's demand for electricity continues to rise. The Indonesian government has been continuously expanding the electrical grid to meet this growing demand. This can be seen from the numerous power plants that utilize various energy sources as their initial driving force. In general, the quality of power transmission and distribution systems is assessed based on the voltage quality received by consumers. Good voltage quality is characterized by a constant voltage of 230V with a service voltage variation of +5% to -10%. Service voltage variation refers to changes in service voltage under normal operating conditions in relation to nominal voltage, caused by load fluctuations and voltage regulation efforts. Voltage must always be kept constant according to the specified values, especially at the end of the distribution line. Unstable voltage can damage equipment that is sensitive to voltage fluctuations.

One of PLN assets that ensures the continuity of electricity distribution to consumers is the Low Voltage Distribution Panel. The role of the low-voltage distribution panel is crucial, as it functions as both a protective device and a current distributor for the low-voltage network. It can be said that the low-voltage distribution panel is a component of the secondary distribution network that is closest to consumers. The panel consists of several circuits that are distributed to customers. If the performance of the low-voltage distribution panel is disrupted, the electricity supply to low-voltage consumers will be automatically cut off, causing losses to PT. PLN. [1]

Disruptions in the low-voltage distribution panel can occur due to excessive load, corrosion on the ground plate, bus-bars, or bolts, faults in the NH fuse, or damage to the panel box and its components due to accidents, which subsequently lead to a decrease in substation performance. To improve substation performance, maintenance of the low-voltage distribution panel is necessary to prevent such disturbances. One of the preventive maintenance activities carried out by PT. PLN Denpasar is the replacement of the low-voltage distribution panel box and its components at the DB 0729 substation, The feeder, due to being struck by a truck entering and exiting beside a warehouse. In addition to the damage to the panel box, the protective pipes for incoming and outgoing cables were bent, causing the insulation of the NYY cables inside to peel off. If left unaddressed, this could result in losses for PT. PLN Denpasar, as the electricity supply to low-voltage consumers would be disrupted. Based on the background explanation above, the problems to be discussed can be formulated as follows: What is the NH Fuse rating in accordance with the type of conductor used in the low-voltage distribution panel of substation DB 0729? What is the service voltage supplied by the distribution transformer of substation DB 0729? What is the estimated budget allocated by PT. PLN South Bali for the maintenance of the low-voltage distribution panel of substation DB 0729?

LITERATURE REVIEW

The theory of Energy Distribution

Pramono [2] stated that after electrical power is generated by a power plant, it is then transmitted through the transmission network. From the transmission network, the electricity is further distributed to consumers via the electrical distribution network. Power plants (PTL) typically generate electricity at medium voltage, generally ranging from 6 to 20 kV. In large power systems or when power plants are located far from consumers, the voltage needs to be increased through transmission lines from medium voltage (MV) to high voltage (HV) and even extra-high voltage (EHV).

In a power plant, the voltage generated by the generator is 16 kV. This voltage is then increased by a step-up transformer at an extra-high voltage substation (GITET) to 500 kV. The electricity is then transmitted through extra-high voltage overhead lines (SUTET) to high-voltage consumers. Before reaching high-voltage consumers, the voltage is first stepped down from EHV to HV, around 150 kV, using a step-down transformer located at a main substation (GI). After that, electricity flows through high-voltage overhead lines (SUTT) towards medium-voltage consumers. Before reaching medium-voltage (MV) consumers, the voltage is further stepped down by the main substation using a step-down transformer from HV to MV, which is around 20 kV.

As the electricity approaches common consumption centers, the electrical energy transmitted through the medium-voltage network is reduced from MV to low voltage (LV) by a step-down transformer at the distribution substation. The voltage is then stepped down to 230V and 380V, which is subsequently distributed to consumers via the low-voltage network through the distribution substation.

The Theory of A Distribution Substation

A distribution substation is one of the components of PLN distribution system that functions to connect the network to consumers or to distribute electrical power to consumers or customers, whether they are medium-voltage or low-voltage customers. An electrical distribution substation is a facility that contains or consists of medium-voltage distribution panel (PHB-TM), a distribution transformer, and low-voltage distribution panel (PHB-TR) to supply electrical power to both medium-voltage (MV 20kV) and low-voltage (LV 230/380V) customers.

In a distribution substation, a distribution transformer is typically used to reduce the electrical voltage from the high-voltage distribution network to a usable voltage for the low-voltage distribution network (step-down transformer), for example, from 20kV to 380/230V. Meanwhile, transformers used to increase electrical voltage (step-up transformers) are only utilized in power generation plants to ensure that the voltage distributed through long transmission lines does not experience significant voltage drops, meaning that it does not exceed the allowable voltage drop limit of 5% from the initial voltage [3].

The Theory of Distribution Panel

The low-voltage distribution panel (PHB-TR) is a combination of one or more low-voltage distribution panel units along with control equipment, measuring instruments, protection devices, and control systems that are interconnected. The entire assembly is fully equipped with wiring and mechanical systems mounted on supporting structures. Generally, for indoor installations, an open-type design is used. The indoor low-voltage switchgear is installed in concrete distribution substations.

The open-type low-voltage switchgear is an assembly consisting of support structures for protective equipment and switching devices, where all live components are installed without insulation. Each transformer or distribution substation can have a maximum of eight circuits, depending on the transformer capacity and the current-carrying capacity (KHA) of the low-voltage distribution network (JTR) conductors used. A single-line diagram, rated current of protective and control devices, and the names of JTR circuits must be indicated on the low-voltage switchgear [4].

Hartanti [1] stated that the function of low-voltage switchgear is to serve as a connector and distributor of electrical power from the secondary side (LV) of the transformer output to the distribution busbar and then to the low-voltage network (JTR) via outgoing feeder cables (Opstyg Cable), which are protected by individual fuse protections. Arifin [5] stated that low-voltage switchgear can be found in various types of distribution substations, including portal substations, pole-mounted substations, concrete substations, and kiosk substations. Inside the low-voltage switchgear panel, there are several components, each with its own role and function. The following are the equipment, components, and parts present in the low-voltage switchgear (PHB-TR) of a distribution substation.

Figure 1. *Distribution Panel Box*

The Theory of The current-carrying capacity

The current-carrying capacity (KHA) of a conductor refers to the maximum amount of electric current that can flow through an electrical conductor. A conductor's capacity is limited and determined based on various factors, including environmental conditions, material properties, and construction constraints, such as ambient temperature, type of conductor, initial ambient temperature, final conductor temperature, thermal limit of insulation capacity, wind cooling factor, heat dissipation in the surrounding medium. If any deviation from these specified limits occurs, the current-carrying capacity (KHA) of the conductor must be corrected accordingly. The cable conductor between the transformer and the low-voltage switch gear must have a current-carrying capacity of at least 115% of the nominal current of the transformer on the secondary side, which can be calculated.

METHODOLOGY

In conducting this research, the author employed several data collection methods to obtain the necessary data for completing this final project. The methods used include the literature study method is a series of activities related to the collection of library data, reading and taking notes, as well as processing research materials. This method is conducted to reveal various theories relevant to the problem being studied, serving as a reference in discussing the research findings. Observation is one of the data collection methods carried out by carefully and directly observing or inspecting a location to understand the actual conditions or verify the accuracy of an ongoing study. The author conducted on-site visits to observe and record the necessary data for completing this final project.

The data collection took place at substation DB 0729, which is located on the Cokro feeder. The data obtained includes distribution Substation DB 0729 and measurement Data. The collected data will then be processed according to the references obtained. The data used in this final project consists of the inspection results of the low-voltage switch gear components before and after maintenance, which were gathered during the low-voltage switch gear maintenance activities at substation DB 0729 on the Cokro feeder. Data processing involves calculating the current-carrying capacity of the incoming and outgoing cables, determining the NH fuse rating based on the current-carrying capacity of the outgoing cable, and comparing these calculations with the NH fuse used in the low-voltage switch gear before and after maintenance

RESEARCH RESULT

Steps to test results

The evaluation of the low-voltage switch gear replacement was conducted at substation DB 0729, located on Denpasar City, Bali. The author chose this location because preventive maintenance was required due to severe damage to the low-voltage switch gear, which was caused by a truck repeatedly entering and exiting near the warehouse on Cokro aminoto.

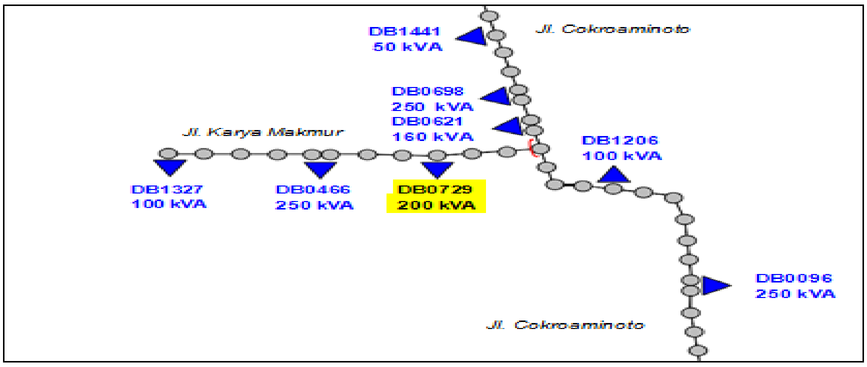

Figure 2. *Location of Substation*

Based on the minimum current-carrying capacity of the conductor used as the incoming conductor for the low-voltage switch gear at substation DB 0729, it is determined that the type of incoming conductor used before and after maintenance is an NYY 150 mm² cable. According to Table 1, if an NYY 150 mm² cable is installed in the air, its current-carrying capacity is 442 A.

Therefore, it can be concluded that the type of conductor used as the incoming conductor for the low-voltage switch gear at substation DB 0729 is appropriate and meets the standard requirements. The primary cable type used in the low-voltage distribution network (JTR) for portal substations is either NYY or NYFGbY cables [8]. Based on this statement, the current-carrying capacity of the feeder conductor in the low-voltage switch gear must be greater than the current of each circuit in the low-voltage switch gear.

Table 1. Comparison Rating NH Fuse Before and After

Rating NH Fuse (A)	Quadran 1			Quadran 2		
	R	S	T	R	S	T
Before	200	160	400	160	160	160
After	200	200	200	200	200	200

The selection of the NH Fuse must also be based on the current-carrying capacity of the outgoing cable in the low-voltage switch gear. The outgoing cable used in the low-voltage switch gear is of the NYY type with a diameter of 70 mm² and a current-carrying capacity of 269 A. The calculation of the NH Fuse rating for a distribution substation with a 200 kVA transformer and two feeder circuits.

DISCUSSION

The vast range of energy forms that can be generated from electrical energy, combined with the rapid advancement of technology, has made every aspect of human life dependent on electricity. As a result, society's demand for electricity continues to rise. The Indonesian government has been continuously expanding the electrical grid to meet this growing demand. This can be seen from the numerous power plants that utilize various energy sources as their initial driving force.

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In conducting this research, the author employed several data collection methods to obtain the necessary data for completing this final project. The methods used include Handriani [12] stated that the literature study method is a series of activities related to the collection of library data, reading and taking notes, as well as processing research materials. This method is conducted to reveal various theories relevant to the problem being studied, serving as a reference in discussing the research findings.

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The collected data will then be processed according to the references obtained. The data used in this final project consists of the inspection results of the low-voltage switchgear components before and after maintenance, which were gathered during the low-voltage switchgear maintenance activities at substation DB 0729 on the Cokro feeder. Data processing involves calculating the current-carrying capacity of the incoming and outgoing cables, determining the NH fuse rating based on the current-carrying capacity of the outgoing cable, and comparing these calculations with the NH fuse used in the low-voltage switchgear before and after maintenance.

The evaluation of the low-voltage switchgear replacement was conducted at substation DB 0729, located on Denpasar City, Bali. The author chose this location because preventive maintenance was required due to severe damage to the low-voltage switchgear, which was caused by a truck repeatedly entering and exiting near the warehouse on Cokroaminoto.

Based on the minimum current-carrying capacity of the conductor used as the incoming conductor for the low-voltage switchgear at substation DB 0729, it is determined that the type of incoming conductor used before and after maintenance is an NYY 150 mm^2 cable. According to Table 1, if an NYY 150 mm^2 cable is installed in the air, its current-carrying capacity is 442 A. Therefore, it can be concluded that the type of conductor used as the incoming conductor for the low-voltage switchgear at substation DB 0729 is appropriate and meets the standard requirements. The primary cable type used in the low-voltage distribution network (JTR) for portal substations is either NYY or NYFGbY cables [8]. Based on this statement, the current-carrying capacity of the feeder conductor in the low-voltage switchgear must be greater than the current of each circuit in the low-voltage switchgear.

The selection of the NH Fuse must also be based on the current-carrying capacity of the outgoing cable in the low-voltage switch gear. The outgoing cable used in the low-voltage switch gear is of the NYY type with a diameter of 70 mm^2 and a current-carrying capacity of 269 A. The calculation of the NH Fuse rating for a distribution substation with a 200 kVA transformer and two feeder circuits is as follows:

Based on the method used, the cost estimation budgeted by PT. PLN (Persero) Customer Service Implementation Unit (UP3) South Bali follows the Contractor's Estimate method. This method involves a detailed and precise cost estimation conducted by the contractor company, breaking down each part of the work, including material costs, labor costs for executing the work, duration of execution for each material, profit margins, and any other potential costs that may arise during the project implementation. All these aspects must be clearly outlined to achieve the lowest possible estimated cost [9].

CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis and discussion of the maintenance of the low-voltage switchgear at the DB 0729 distribution substation, Cokro feeder, several conclusions can be drawn as follows:

During the maintenance and replacement of the low-voltage switchgear at the DB 0729 distribution substation, Cokro feeder, workers and supervisors used proper work equipment, personal protective equipment (PPE), and followed work instructions in accordance with applicable standard operating procedures.

The type of conductor used as the incoming cable for the low-voltage switchgear at the DB 0729 substation complies with the standards outlined in Book 1 of the Engineering Design Criteria for Electrical Distribution Network Construction, as shown in Table 2.6 "Current-Carrying Capacity of Cables," with a capacity of 331.97 A.

The type of conductor used as the outgoing cable for the low-voltage switchgear at the DB 0729 substation also meets the standards of Book 1 of the Engineering Design Criteria for Electrical Distribution Network Construction, as shown in Table 2.6 "Current-Carrying Capacity of Cables," with a capacity of 165.95 A.

The NH Fuse used as a protective device in the low-voltage switchgear at the DB 0729 substation was not in accordance with the SPLN D3-016-1 2010 standard before maintenance due to an excessively high NH Fuse rating. However, after maintenance and calculation of the NH Fuse rating based on cable current-carrying capacity and nominal current for each circuit, it was adjusted to comply with the SPLN D3-016-1 2010 standard, as shown in Table 2.3 "NH Fuse Ratings."

The frame components of the low-voltage switchgear at the DB 0729 substation conform to the SPLN 118-3-1-1996 standard and Book 4 "Construction Standards for Distribution Substations and Switching Substations," where the material used is 3 mm thick steel plate with dimensions of 1450x1000x400 mm.

ADVANCED RESEARCH

Each study has limitations; thus, we can describe about development of this research to integration with digital communication technology, smart system, and sustainable tourism based on local wisdom here and briefly provide suggestions for further research.

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