INFOKUM
Volume 13, Number 06, 2025, DOI 10.58471/infokum.v13i06
ESSN 2722-4635 (Online)
https://infor.seaninstitute.org/index.php/infokum

Analysis of Low Voltage Cable Insulation Resistance Test in PT. PLN (Persero) UPP Sumbagut 1 Building

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Article Info
Keywords:
Insulation resistance
low voltage cables
megger
PUIL 2011
electrical installations.

ABSTRACT
Insulation resistance testing is an important part of electrical installation system maintenance to ensure system safety and reliability. This study aims to analyze the condition of low-voltage cable insulation in the PT. PLN (Persero) UPP Sumbagut 1 building through insulation resistance testing using a megger. Measurements were conducted at several distribution panel points by comparing the results with the 2011 PUIL standard. The test results showed a decrease in insulation quality at several points, especially in the generator panel area, which has the potential to cause disruption to the power distribution system. The decrease in insulation resistance can be influenced by various factors such as cable age, environmental humidity, and installation conditions. This study provides recommendations for preventive measures in the form of cable replacement at critical points and the implementation of periodic testing to maintain the performance of the electrical system. In addition, evaluation of installation design and environmental control is also needed to increase cable service life and overall system efficiency.

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INTRODUCTION

In everyday life, electricity is essential. It can be used for lighting (lamps) and as a power source for other electrical devices. As technology advances, the need for electrical loads increases with the advancement of technology. This need for electrical loads is often not matched by maintenance and upgrades to electrical installations. To transmit electrical energy, electrical conductors are required. One commonly used electrical conductor is a cable. Cables consist of several components: a core or conductor, insulation, filler, binding material, mechanical load protection, and an outer protective sheath. Cables play a crucial role in transmitting electrical power. As conductors are used for a long time and frequently, their insulation resistance decreases. This degradation of insulation quality can lead to current leakage in the conductor. This is caused by exposure to heat from the flow of electric current over a period of time. If the conductor wire is too small, the insulation can be damaged or melted by the heat from the current. Damaged insulation can cause short circuits, which can lead to fires. According to Ministerial Regulation Number 12 of 2015

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concerning Electrical Occupational Safety and Health, Article 11, paragraphs (1) and (2), "periodic inspections of electrical installations must be conducted at least once a year, and periodic testing must be conducted at least once every five (5) years." These inspections are activities that assess and measure electrical installations, equipment, and tools to ensure they meet electrical standards and statutory requirements. Testing is the assessment, calculation, testing, and measurement of electrical installations, equipment, and tools to ensure they meet electrical standards and statutory requirements. Inspections and testing are mandatory during planning, installation, use, modification, and maintenance for electricity generation, transmission, distribution, and utilization. Therefore, it can be concluded that inspections and testing are necessary for electrical installations that are more than five years old.

A good electrical installation must use installation cables that comply with SNI/SPLN standards, such as cables with PVC insulation. PVC insulators have characteristics that meet the needs of home/building electrical installations and meet standard requirements. They also offer several advantages over other materials, including lighter weight, better mechanical properties, lower dielectric loss, a lower dissipation factor, and higher volume resistivity. Therefore, the authors were interested in conducting insulation resistance tests on low-voltage cables at the PT PLN (Persero) UPP Sumbagut 1 building. The cables tested in this study were consumable cables used in multi-storey buildings. The researchers' purpose in sampling consumable cables was to examine consumable cables to determine the degree of insulation resistance obtained compared to new cables, which generally have good insulation resistance values. This will facilitate the study of cable characteristics and the factors influencing their insulation resistance. Based on the above description, the researchers intend to conduct research on "Insulation Resistance Testing of Low-Voltage Cables Based on SPLN 42-2:1992 and SNI 04-6629:2011." Electrical cables function as conductors of electrical energy from the source to the load. In the operation of an electric power system, distribution system reliability is significantly influenced by the quality of cable insulation. Deterioration in insulation quality can lead to leakage currents, short circuits, and even fires. Therefore, regular insulation resistance testing is crucial to prevent electrical disturbances and maintain system safety and efficiency. The PT. PLN (Persero) UPP Sumbagut 1 building is one of the strategic electricity project management centers in the northern Sumatra region. Given the importance of electrical system reliability in this building, low-voltage cable insulation resistance testing was conducted to assess actual conditions and detect potential disturbances early. This research is expected to serve as a reference for preventative maintenance and improve the quality of electrical installation systems in electrical office environments.

METHOD

Test Location and Objects

The test was conducted at the PT. PLN (Persero) UPP Sumbagut 1 building in Medan, North Sumatra. The test objects included low-voltage cables from five main distribution panels: the Main Panel (P1), the 1st Floor Distribution Panel (P2), the 2nd Floor Distribution Panel

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(P3), the Server Area Panel (P4), and the Generator Panel (P5).

Tools and Materials

a. MIT420 Megger with 1000 VDC test voltage
b. Digital multimeter for power-off voltage verification
c. Insulating gloves and personal protective equipment (PPE)
d. Field documentation camera
e. Test result recording form

Testing Steps

1. Preparation: Conduct a work safety briefing and ensure the test area is safe from users.
2. Source Outage: Ensure all panels are de-energized using a multimeter.
3. Disconnecting Cables from the Load: The cables are removed from the load terminals and the grounding is temporarily removed.
4. Connecting the Measuring Instrument: The megger is connected to the test cables between phase-to-ground and phase-to-phase.
5. Data Collection: The resistance value is read after it has stabilized for 60 seconds and recorded in the test results table.
6. Analysis and Validation: The data is compared with the threshold values of the PUIL 2011 standard.
7. System Recovery: The cable is returned to its original position and the system is restarted.

Reference Standards

The test refers to:

a. PUIL 2011: Minimum insulation resistance of 1 MΩ
b. IEC 60364: Minimum resistance of 1 MΩ per LV system
c. General recommendation: ≥100 MΩ for new building installations

Testing Procedure

1. Ensure the system is de-energized using a multimeter.
2. Isolate the cable from the load and temporarily disconnect the ground.
3. Connect the megger to the test points (phase-to-ground and phase-to-phase).
4. Record the insulation resistance value after the reading is stable for 60 seconds.
5. Compare the results with the 2011 PUIL standard.

Table 1. Insulation Resistance Test Results

No	Titik Panel	Fasa-Tanah (MΩ)	Fasa-Fasa (MΩ)
1	P1	600	580
2	P2	530	510
3	P3	420	400
4	P4	210	190
5	P5	90	85

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Figure 1. Testing Process with Megger

RESULTS AND DISCUSSION

Field Data Analysis

Measurement values for P1 to P3 indicate excellent insulation conditions, well above the minimum standard. P4 has an intermediate result, which is still safe but shows signs of degradation. Meanwhile, P5 has the lowest value and is approaching the critical limit, indicating a decline in insulation quality due to cable age, humidity, or imperfect installation.

Test Results Graph

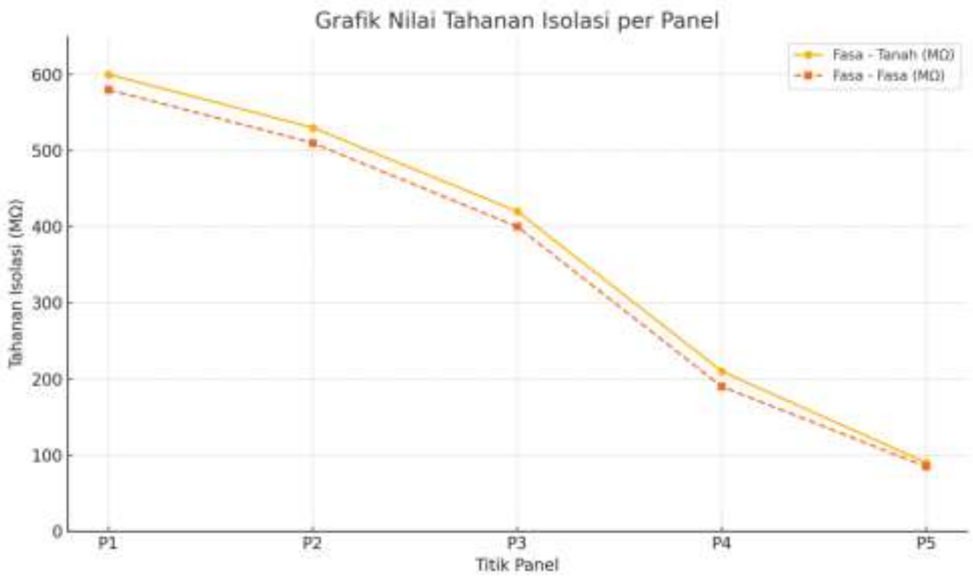

Figure 2. Graph of Insulation Resistance Values per Panel

Evaluation against Standards

Based on the PUIL 2011 and IEC 60364 standards, the minimum insulation resistance value is 1 MΩ. However, for low-voltage systems, a good value is usually above 100 MΩ. P1 to P3 are categorized as "Very Good," P4 as "Sufficient," and P5 is categorized as "Poor" and requires further action.

Technical Discussion

Environmental factors such as temperature, humidity, and the presence of water vapor around the cable significantly affect insulation performance. Furthermore, cables that are more than 10 years old generally show a decline in insulation value. Installing cables too tightly without ventilation can also cause overheating, accelerating insulation degradation. In the case of panel P5, the cable's age, which is more than 12 years old, and the panel's location close to the generator area, have the potential to accelerate damage. Therefore, technical interventions such as cable replacement, dehumidifier installation, and regular inspections are necessary to prevent a more serious system failure.

Damage Risk Simulation

The simulation was conducted using a probabilistic approach based on insulation resistance data and cable age. Panel P5, with a resistance below 100 MΩ and an age of more than 12 years, is predicted to have a 72% risk of failure within the next two years if no repairs are made.

Cable Life Prediction

Referring to the insulation degradation curve, cables in P1–P3 are estimated to have a remaining operational life of >10 years. P4 is approximately 5–7 years. The P5 cable is recommended for immediate replacement as it has exceeded the critical age and performance thresholds.

Replacement Cost Analysis

The estimated cable replacement cost for the P5 panel includes:

3×70 mm² NYY cable: Rp 175,000/m (length ±30 m) = Rp 5,250,000

Labor and installation costs: Rp 3,000,000

Retesting and commissioning costs: Rp 1,000,000

Total estimated cost: Rp 9,250,000

This cost is lower than the potential losses due to system disruptions and equipment damage due to short circuits.

CONCLUSION

Insulation resistance test results indicate that the low-voltage distribution cable system at the PT. PLN (Persero) UPP Sumbagut 1 building is largely in good condition. However, there are indications of insulation degradation in panels P4 and P5. Therefore, it is recommended: Cable replacement at the point with the low value (P5), Periodic re-inspection every 6 months, Evaluate the panel environment to reduce humidity, Documentation of test results for long-term trends.

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