

Development of Implementation Guidelines for Maintenance and Treatment Work of Electrical Components in University of Indonesia Buildings and Area based on Work Breakdown Structure (WBS)

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Abstract: Maintenance and treatment work of buildings is important in maintaining the reliability of buildings. the absence of standards for the implementation of electrical maintenance and treatment work in buildings at the University of Indonesia is also one of the causes of building fires, electrical short circuit, and damage to building transformers in the last 4 years. The purpose of this study is to develop standards for the implementation of maintenance and treatment work of electrical components in buildings at the University of Indonesia based on Work Breakdown Structure (WBS) using literature studies and the Delphi method. The independent variable in this study is Work Breakdown Structure (WBS) includes the work type, work package, alternative design, implementation requirements, activities, resources, and material specifications, while the dependent variable in this study is the implementation standard. The results of this study are in the form of developing an implementation standard based on Work Breakdown Structure (WBS) which can be used as a reference for the maintenance and treatment of electrical components in buildings at the University of Indonesia, which is expected to increase building user safety and convenience as well as effectiveness and efficiency in building management.

1 INTRODUCTION

Based on the Regulation of the Minister of Public Works No. 24 / PRT / M / 2008, maintenance of the building is the activity of maintaining the reliability of the building along with the infrastructures and the ingredients so that the building is always worthy function. While the treatment is an activity building treatment replace parts of buildings, components, construction materials, and / or infrastructure and facilities in order to remain eligible buildings function. Building maintenance is defined as work to maintain, restore or repair every part of the building, to maintain the performance of building and service fabric and its surroundings, meet standards and maintain the utility and value of buildings. This includes repairs, improvements, and repairs to works from existing facilities (Plavina & Geipele, 2013). Building performance can be measured from 4 (four) requirements, namely: functional requirements, performance requirements, legality requirements and compliance with regulations, and user requirements (Son & Yuen, 2002). In the case of maintaining

function-worthy requirements, maintenance, maintenance and inspection work must be carried out on building buildings on a regular basis (Republik Indonesia, 2002)

The University of Indonesia must have a source of funds and resources are sufficient and reliable for research activities and community services so that research activities and community services can generate new discoveries that benefit humanity and contribute to the accumulation of knowledge (BPMA, 2007), Buildings used to support the achievement of the objectives and main functions of an organization optimally users, and is expected to follow the changes that may occur in its organization (Achmada, 2013).

Based on an interview with Mr. Budi Prayitno as Head of Management of Energy Saving Sustainable UI and Mr. Beny Rahman, Head of Section for Planning and Care and Maintenance of Mechanical, Electrical, and Transportation UI in October 2018, there were 5 phenomenon of fire, short circuit, as well as damage to substations and transformers in the last 4 years on the job of maintenance and

upkeep of buildings and electrical components of the University of Indonesia region which causes kerugaian material up to 40 billion rupiah.

Besides avoiding damage incidents that may occur, maintenance and treatment work of electrical component can also increase the level of satisfaction of building occupants (Au-Yong, 2014), Research This will produce guidelines for the implementation of maintenance and treatment of electrical work in the building at the University of Indonesia based Work Breakdown Structure (WBS) to be structured, managed, measured, and scheduled.

The novelty of this research is the implementation guidelines are made based on Work Breakdown Structure and the addition of the University of Indonesia area components to electrical maintenance and treatment work package such as power house, telephone, and backup power generators. This research will contribute to the University of Indonesia in the hope that it will impact the implementation guidelines so the guidelines become structured, complete, and avoid all components mistakes of maintenance and treatment electrical work, where electrical work is very important because of all building facilities supported by electrical components. Also become a reference in making guidelines for maintenance and treatment work of buildings, especially for electrical components for other institution. For academic purpose, this provides knowledge about the process of making WBS-based implementation standards.

2 RESEARCH OBJECTIVES

The objectives of this research are:

- To identify the work section, work type, and work package of WBS for maintenance and treatment work of electrical components in buildings and areas at Univesitas Indonesia.
- To identify alternative design/method and activity in each package of maintenance and treatment work of electrical components in buildings and areas at Univesitas Indonesia.
- To identify resources for each activity in the maintenance and treatment work of electrical components in buildings and areas at the University of Indonesia.
- To identify technical specifications used in each activity of maintenance and treatment work of electrical components in buildings and areas at the University of Indonesia.
- To identify ways to develop guidelines based on the WBS (Work Breakdown Structure) for the

maintenance and treatment work of electrical components in buildings and areas at the University of Indonesia

3 LITERATURE STUDY

3.1 University of Indonesia Buildings and Area

The University of Indonesia certainly has sufficient and reliable sources of funds and resources for research and community service activities so that research and community service activities can produce new findings that are beneficial to humanity and contribute to the accumulation of knowledge (BPMA, 2007). The building is used to support the achievement of the main goals and functions of a user organization optimally, and is expected to be able to follow changes that can occur in the user organization (Achmada, 2013). The University of Indonesia consists of 85 buildings located in an area of 320 hectares (Prayitno, 2018). To support this, good maintenance and treatment need to be done, one of which is in the electrical components of the building.

3.2 Maintenance and Treatment Work

There are four aspects that need to be considered and become the requirements for the success of maintenance and treatment of building buildings, namely the safety of buildings, the health of buildings, the comfort of buildings, ease of building (Direktorat Jenderal Cipta Karya, 2008).

3.2.1 Maintenance Work

Maintenance of building is an activity to maintain the reliability of buildings and infrastructure and facilities so that buildings are always functional. Maintenance work includes several activities such as cleaning, tidying, inspecting, testing, repairing, and replacing building materials or equipment (Direktorat Jenderal Cipta Karya, 2008).

3.2.2 Treatment Work

Treatment of building is an activity to repair and / or replace parts of a building, components, building materials, and / or infrastructure and facilities so that the building remains functionally feasible. Treatment work includes repairing and / or replacing building materials, components, building materials,

and / or infrastructure and facilities based on the technical plan for maintenance of buildings. There are three types of building maintenance work, rehabilitation, renovation and restoration.

Building damage is the non-functioning of buildings or building components due to shrinkage / expiration of the age of the building, or due to human behavior or natural behavior such as excessive functional load, fire, earthquake, or other similar causes. Based on the intensity of the damage, damage to buildings can be divided into three levels, minor damage, medium damage, and high damage. Minor damage is damage mainly to non-structural components, such as roof cover, ceiling, floor coverings and fills walls. The maximum maintenance cost is 35% of the highest unit price of the new building construction that applies, for buildings with the same class. Medium damage is damage to some non-structural components, and or structural components such as roof structures, floors. The maximum maintenance cost is 45% of the highest unit price of the new building construction that applies, for buildings with the same class. Heavy damage is damage to most building components, both structural and non-structural, which, after a repair, can still function properly. The maximum maintenance cost is 65% of the highest unit price of the new building construction that applies, for buildings with the same class (Direktorat Jenderal Cipta Karya, 2008).

3.2.3 Electrical Maintenance and Treatment Work

Regarding the Guidelines for maintenance and treatment of buildings, it is explained about the scope of building maintenance for electrical components as follows (Direktorat Jenderal Cipta Karya, 2008):

- Conduct periodic checks and maintain backup power plants.
- Conduct periodic checks and maintain on lightning protection equipment.
- Conduct periodic checks and maintain electrical installation systems, both for electric power supply and for room lighting.
- Conduct periodic checks and maintain a network of sound and communication (telephone) installation and data.
- Conduct periodic checks and maintain a network of alarm systems and alarms.

3.3 Work Breakdown Structure (WBS)

The WBS is a structured decomposition of the entire scope of work that must be done by the project team to achieve project objectives and complete the required results. The main benefit of the WBS process is to provide a framework for what needs to be done or done (Project Management Institute, 2013).

3.3.1 Power Source System

An electricity source system is an electrical system that produces, processes or temporarily stores electrical energy, and its protection so that it can be used by electrical equipment. Some of the components included in this system are a transformer, uninterruptible power supply, backup power source, and renewable power source.

3.3.2 Distribution System

This system functions to channel electrical energy so that it can be used by the electric load. The distribution system consists of several components, namely medium voltage panels and low voltage distribution panels.

3.3.3 Electric Load

The components included in this work package are equipment that consumes electrical energy for the operation of the building and its accessories. The electrical load components are load panel panels, cabling, lighting control systems, lightning rod systems, artificial lighting systems, land systems, sockets and switches, and under floor duct.

3.3.4 Electronic System

The system included in this component is equipment installed in buildings whose parts consist of electronic components such as CCTV systems, fire alarm systems and detectors, computer and internet network systems, signal amplifier systems, sound systems, and telephones.

3.4 Alternative Design/Method

The method chosen or used in each component and / or work package depends on the requirements of the building. In this study will consider the requirements of the Ministry Regulation of PUPR No. 24 of 2008, Ministry Regulation of PUPR no. 45 of 2007, DKI

Governor Regulation no. 38 of 2012. Alternative designs are chosen based on literature studies.

3.5 Activities

Forms of activities related to systems and electrical equipment that are in a building, in principle, are divided by phase. The phase is divided into development phases with maintenance and treatment phases. In the development phase there are two main activities, namely design, installation and testing. In design activities, electronic equipment is determined by specifications and performance. The installation aims to install equipment and systems in accordance with their specifications while testing functions to ensure that the system and equipment work in accordance with the desired performance. While in the maintenance and treatment phase there are activities of inspection, service, replacement of parts, and testing.

3.6 Resources

Every maintenance and treatment work requires resources to complete its objectives. The resources needed can be grouped into human resources, tool resources, and material resources. Each resource must be fulfilled both in terms of quantity and quality.

4 METHODOLOGY

To answer questions in research and determine the method used, it is recommended to use a strategy (Yin, 2013). According to the form, there are several kinds of instruments that can be used in general research, namely Questionnaire / Questionnaire, Interview, Observation, Documentation, Test (Arikunto, 2000). To achieve the research objectives, a qualitative method was used with inputs consisting of primary data there are ministerial regulations, Explanation of General Requirements for Electrical Installation document, SNI, and previous research. As for secondary data, researchers used questionnaire instruments, expert judgment, and interviews. Validity test is a step of testing carried out on the content or content of an instrument (Sugiyono, 2006). Validity is divided into three, namely content validity, construct validity, and criterion-related validity (Kerlinger, 1973).

Data analysis is the most important part of the scientific method, because data analysis is used to solve research problems (Basrowi & Suwandi,

2012). After that the data is analyzed, processed and validated again by experts using the Delphi method. The delphi method is a systematic method of gathering opinions from a group of experts through a series of questionnaires, where there is a feedback mechanism through a round of questions held while maintaining the anonymity of respondents' responses (Foley, 1972). There are 10 steps to the theory of the Delphi method (Hills & Fowles, 1975). The following figure is a flow diagram that shows the stages of how this research will be carried out:

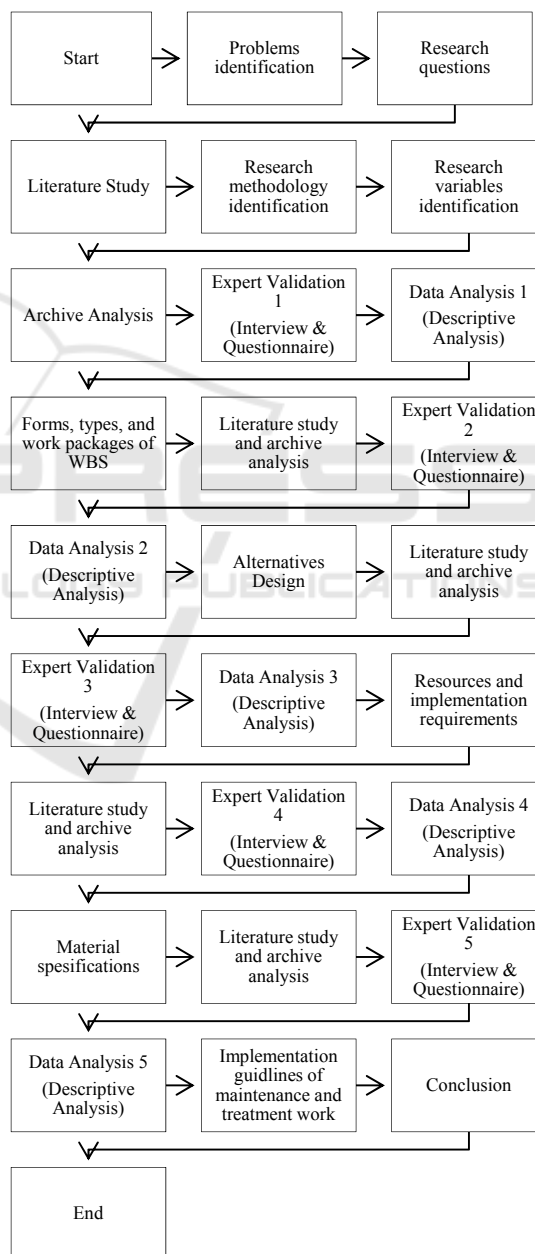


Figure 1: Research Process.

5 RESULT AND DISCUSSION

5.1 Level 1 to 4 WBS

To get the results in the first phase, the researcher used SNI 0225:2011, Ministry Regulation of PUPR no.24 of 2008, electrical WBS, and literature study for inputs. Then for the analysis, I used the delphi method to collect opinions from several experts using questionnaires. After expert validation, Work Breakdown Structure in table 1 is detailed every work package concerning the work and maintenance of electrical components in dungung and regional buildings at the University of Indonesia. The difference in WBS between office buildings and University of Indonesia buildings is in the electricity sources that are power house consisting of three work packages. There are liquid transformers, LVMDb, and medium voltage chambers.

Table 1: Work Breakdown Structure Level 1-4.

Project Name	Work Section	Work Type	Work Package
Level 1 WBS	Level 2 WBS	Level 3 WBS	Level 4 WBS
Maintenance and Treatment Work of University of Indonesia Buildings and Area	Electrical	Electrical Sources	Power house
			Backup Power Generator
			Renewable Power
		Distribution System	Uninterruptable Power Supply
			LVMDb Panel
		Electrical Load	MV Panel
			Load Panel
			Cable
			Lightning Control System
			Lightning Protection
			Lightning
			Grounding System
			Receptacle and Switch
			Under Floor Duct
		Electronics	CCTV System
			Fire Alarm and Detector

			Internet and Computer
			Signal Repeater
			Sound System
			Telephone

From table 1, there are 4 components at WBS level 3 and 19 components on WBS level 4. Furthermore the work package will be more detailed in alternative designs / methods and activities. The implementation of the work package can be a control account. Control accounts are a control point for management where scope, budget, and schedule are compared with earned values for performance measurement.

5.2 Alternatives Design/Method and Level 5 WBS

To get the results in the second phase, the researcher used Ministry Regulation of PUPR no.24 of 2008, electrical WBS, and literature study for inputs. Then for the analysis, I used the delphi method to collect opinions from several experts using questionnaires. The list of alternative design / method in table 2 covers all the scope of the work package in electrical work. Then each alternative design / method is implemented into more specific activities which consist of inspection, maintenance, treatment, and testing.

Inspection is cover surveillance and monitoring the device to find a defect or anomaly during normal operation. Maintenance work includes several activities such as cleaning, tidying, inspecting, testing, repairing, and replacing building materials or equipment. While the treatment is an activity building treatment and / or replace parts of buildings, components, construction materials, and / or infrastructure and facilities in order to remain eligible buildings function. Testing is a process that aims to ascertain whether all devices functions work properly and look for errors that might occur in the system.

From table 2, there are 41 components in alternative designs/methods and 61 components in activities. Furthermore, alternative designs/methods will be more detailed in the resources. The implementation of alternative designs/methods is a method used to select alternative types of use of work functions such as transformers, diesel generators, and solar panels.

Table 2: Alternatives Design / Method.

Work Package	Alternative Design / Method	Activity
WBS Level 4		WBS Level 5
Power House	MV Cubicle	Inspection
		Maintenance
		Treatment
		Testing
	LVMDB	Inspection
		Maintenance
		Treatment
		Testing
	Transformer	Inspection
		Maintenance
		Treatment
		Testing
Backup Power Generator	Diesel Generator	Inspection
		Maintenance
		Treatment
		Testing
Renewable Energy	Solar Panel	Inspection
		Maintenance
		Treatment
		Testing
Uninterruptable Power Supply	UPS Central	Inspection
		Maintenance
		Treatment
	UPS Lokal	Testing
		Inspection
		Maintenance
LVMDB Panel	LVMDB	Treatment
		Testing
		Inspection
		Maintenance
	Sub Distribution Panel	Treatment
		Testing
		Inspection
		Maintenance
	Connecting Board	Treatment
		Testing
		Inspection
		Maintenance
	Mini Circuit Breaker	Treatment
		Testing
		Inspection
		Maintenance
	Molded Case Circuit Breaker	Treatment
		Testing
Inspection		
Maintenance		
MV Panel	Vaccum Circuit Breaker	Testing
		Maintenance
		Treatment

Load Panel	AC Panel	Testing
		Inspection
		Maintenance
		Treatment
	Lighting Panel	Testing
		Inspection
		Maintenance
		Treatment
	Utility Panel	Testing
		Inspection
		Maintenance
		Treatment
Cable	Medium Voltage Cable	Testing
		Inspection
		Maintenance
	Low Voltage Cable	Treatment
		Testing
		Inspection
Lightning Control System	Time Sensor	Maintenance
		Testing
		Treatment
		Inspection
Lightning Protection	Lightning Rod - Tight Wire	Maintenance
		Testing
		Treatment
	Lightning Rod - Meshed Cage	Inspection
		Maintenance
		Treatment
Lightning	LED Lamp	Testing
		Inspection
		Maintenance
	Fluorescent Lamp	Treatment
		Testing
		Inspection
Grounding System	Solid Grounding	Maintenance
		Testing
		Treatment
		Inspection
Receptacle and Switch	Switch	Maintenance
		Testing
		Treatment
	Receptacle	Inspection
		Maintenance
		Treatment

Table 2: Alternatives Design / Method. (cont.)

Under Floor Duct	Under Floor Duct	Inspection
		Maintenance
		Treatment
		Testing
CCTV System	DVR	Inspection
		Maintenance
		Treatment
		Testing
	CCTV Camera	Inspection
		Maintenance
		Treatment
		Testing
	Recorder	Inspection
		Maintenance
		Treatment
		Testing
Fire and Alarme Detector	Smoke Detector	Inspection
		Maintenance
		Treatment
		Testing
	Heat Detector	Inspection
		Maintenance
		Treatment
		Testing
	Fire Panel	Inspection
		Maintenance
		Treatment
		Testing
	Fire Alarm	Inspection
		Maintenance
		Treatment
		Testing
Internet and Computer	Ethernet Server	Inspection
		Maintenance
		Treatment
		Testing
	Wifi	Inspection
		Maintenance
		Treatment
		Testing
Signal Repeater	Telephone Signal Repeater	Inspection
		Maintenance
		Treatment
		Testing
Sound System	Mic	Inspection
		Maintenance
		Treatment
		Testing
	Speaker	Inspection
		Maintenance
		Treatment
		Testing

	Tape Recorder	Inspection
		Maintenance
		Treatment
		Testing
Telephone	PABX	Inspection
		Maintenance
		Treatment
		Testing

While the implementation of activities is to identify and document specific actions that will be carried out to produce a deliverable project. The main benefit of this process is the decomposition of work packages into activity schedules that provide the basis for estimating, scheduling, implementing, monitoring and controlling project work. This process is carried out throughout the project.

5.3 Level 6 WBS

To get the results in the third phase, the researcher used Ministry Regulation of PUPR no.24 of 2008, PUIL documents about Electrical Instalation, and Standard for Maintenance Testing Spesification for inputs. Then for the analysis, I used the the delphi method to collect opinions from several experts using questionnaires. Every maintenance and treatment activity requires resources to complete its objectives. Resources consist of materials, equipment, and men. In this case, the researcher took the example of the work package and transformer alternative design.

The implementation of good resource planning is in accordance with the logical needs of the project that will help achieve project suggestions and objectives maximally.

5.4 Technical Specification

To get the results in the fourth phase, the researcher used Ministry Regulation of PUPR no.24 of 2008, PUIL documents about Electrical Instalation, and Standard for Maintenance Testing Spesification for inputs. Then for the analysis, I used the the delphi method to collect opinions from several experts using questionnaires. Technical specifications are needed so that all materials used in maintenance and treatment work are of equal quality. This makes it easy for workers to choose the material used. Technical specifications can also be used as inspection activities and tested back to initial performance.

Table 3: Work Breakdown Structure Level 5 & 6.

POWER HOUSE		
TRANSFORMER		
CODE	DESCRIPTION	
WBS LEVEL 2	WORK SECTION	Electrical
WBS LEVEL 3	WORK TYPE	Electrical Sources
WBS LEVEL 4	WORK PACKAGE	Power House
	DESIGN ALTERNATIVES/METHOD	Transformer
LEVEL 5 WBS	LEVEL 6 WBS	
ACTIVITIES	RESOURCES	
Inspection	Materials	-
	Equipments	Personal protective equipment, multimeter, torque wrench, light tools, temperature gun
	Man	Electrical technician, supervisor
Maintenance	Materials	Patchwork
	Equipments	Personal protective equipment
	Man	Electrical technician, supervisor
Treatment	Materials	Spare parts
	Equipments	Personal protective equipment, multimeter, torque wrench, special tools
	Man	Electrical technician, supervisor
Testing	Materials	-
	Equipments	Personal protective equipment, multimeter, torque wrench, special tools
	Man	Electrical technician, supervisor

The implementation of technical specifications is to ensure the accuracy of measurement results obtained in accordance with what has been determined. In addition, the specifications are also arranged in a complete and clear manner regarding items, methods or final results of work that can be purchased, built or developed by other workers so that it can fulfill the wishes of all stakeholders involved.

Table 4: Technical Specification.

TECHNICAL SPECIFICATION	
1.	Meets the SNI 0225: 2011 standards or the latest on "General Requirements for Electrical Installations"
2.	Meets the SNI IEC 60076: 2012 standards or most recently on "Power Transformers"

3. Meets the ISO 14001: 2015 standards or the latest on "Environmental Management"
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5.5 Guideline Development

To get the results in the fifth phase, the researcher used the previous project name, work section, work package, work type, alternative design/method, activity, resources, and technical specification for inputs. Then for the analysis, I used the delphi method to get experts approval using questionnaires. Then after expert validation on how to develop guidelines based on the WBS (Work Breakdown Structure) for maintenance and treatment work of electrical components in buildings and areas at the University of Indonesia, there are seven stages in developing implementation guidelines. Starting from knowing the project name, work section, work type, work package, alternative design / method, resources, and technical specifications.

With the development of WBS-based guidelines, these guidelines become structured, measurable, scheduled, and complete as well as to avoid the failure to fulfill all components of maintenance and treatment of electrical components because all building facilities are supported by these components. The use of electrical components can be harmful to humans and the environment if not done carefully so that these electrical components must be safe and in their use must be in accordance with the applicable provisions and standards so that no damage can endanger the user (Suyono, et al., 2011).

6 CONCLUSION

WBS-based guidelines of maintenance and treatment electrical work are structured, complete, and can avoid the mistakes of all work components so it can make easier for users to easier and better understand the steps of each process, so the process can be more effective and efficient.

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APPENDIX

Indicators for Each Construct:

<i>Inspection</i>
Get a permit and work permit related to the activities that will be carried out
Conduct risk studies to find out the dangers that might occur
Use personal protective equipment according to the type of work
Check physical and mechanical conditions
Check anchorage, alignment and grounding
Check the condition of equipment parameters
Check the electrical bolt connection using a low-impeded ohmmeter, torque-wrench and / or conduct a thermographic survey
Check the operation of the cooling fan
Check the surge arrestor condition
Check the condition of the alarm, function of the dick, trip from the observer / protection equipment
Record all findings and anomalies as further maintenance activities
<i>Maintenance</i>
Get a permit and work permit related to activities that will be carried out
Conduct risk studies to find out the dangers that might occur
Use personal protective equipment according to the type of work
Secure equipment, turn off equipment or use LOTO
Clean the outside of the transformer (body and floor) from dust
Adjust the temperature and air condition of the transformer room
Tighten all cable strings on the terminal in the correct and strong position
Perform calibration of measuring and protection devices
Record all the troubles or anomalies as further treatment activities
<i>Treatment</i>
Get a permit and work permit related to the activities that will be carried out
Conduct risk studies to find out the dangers that might occur
Use personal protective equipment according to the type of work
Prepare all parts and materials needed
Secure equipment, turn off equipment or use LOTO
Replace parts (electrical, mechanical, measuring, and protective equipment) that are damaged, obsolete or expired
Conduct testing activities to ensure that the installed parts have the desired performance
<i>Testing</i>
Get a permit and work permit related to the activities that will be carried out
Conduct risk studies to find out the dangers that might occur
Use personal protective equipment according to the type of work
Measure resistance through the condition of a low-impeded ohmmeter bolt
Test coil insulation to coils and coils to ground
Get a permit and work permit related to the activities that will be carried out
Conduct risk studies to find out the dangers that might occur
Use personal protective equipment according to the type of work
Perform turn-ratio tests at each tap position
Excitation-current test on each phase
Test the surge arresters
Record all test results and plan maintenance and maintenance activities if there are inappropriate results.