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Analyzing (Condition Based Maintenance) Level 1 On Substation Equipment PT. PLN Persero Berastagi

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Abstract

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Condition Based Maintenance (CBM) is a proposed maintenance program based on a decision to collect data from factory condition measurements. CBM is an attempt to save money by carrying out essential inspections only when something odd happens in production. Data acquisition (information gathering) refers to the process of capturing and storing data or information that is useful for CBM purposes during the data acquisition (information gathering) stage. This is the most basic step in implementing a CBM program to identify and predict equipment failures. This study aims to see Condition Based Maintenance (CBM) level 1 on substation equipment. CBM applications are used to streamline the storage and monitoring of inspection data equipment by observing machine/work equipment parameters, such as vibration measurement, oil level, temperature, pressure, flow and ultrasonic flow detectors. The research approach used in this study consisted of three steps, namely literature review, testing, and observation by processing data using the mean life Calculator (LM). There are two types of treatment and condition data collected in the CBM program. Based on the results of monitoring with CBM at the PT PLN Persero Berastagi substation, incident data consists of information about what happened (damage, installation, inspection, etc.) and what has been done (repair, prevention, oil change, etc.).) in less than a month.

Keywords : Based Maintenance, Level 1, Substation, Electrical, PT. PLN

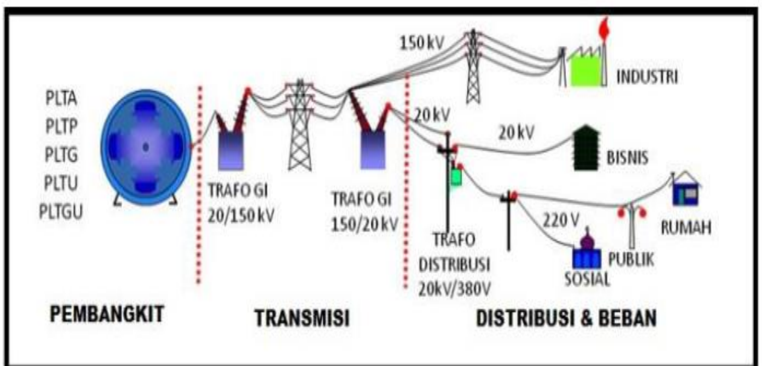
1. Introduction

The transmission network is part of the system of the electric power system whose job it is to distribute electric power, from power plants to substations through the transmission network to substations to reduce it to distribution to all consumers who use electricity, Alsimeri (2008). All equipment used in the process Production requires maintenance including electrical equipment at the substation. The damage that occurs becomes statistical data or the trend (trend) of equipment due to use, this is normal for every line. For example, the temperature characteristics of the power transformer, the condition of the SF6 gas pressure on the Circuit Breaker, the condition of the oil level in the transformer, the condition of the insulator in areas that are often struck by lightning, and so on. Recording is carried out periodically using equipment data recording devices, either daily, weekly, or monthly so that statistical data is obtained and then the trend of electrical equipment is obtained. Special applications that can store and process inspection data so that conclusions can be drawn on the proper condition of the equipment. The CBM (Condition Based Maintenance) application is an application that is useful for performing inspection, testing, and analysis functions on equipment at substations.

Based on the background of the problem, this study analyzes Condition Based Maintenance level 1 on substation equipment, because replacement or maintenance will be carried out if the results of prediction, analysis, monitoring, and testing of materials/spare parts are out of standard, but if they are still in good condition. , the material/component is still worth maintaining.

2. Literature Review

A complete electric power system consists of four elements, namely electric power generation, transmission lines, distribution lines and the use of electric power or loads. The working principle in the electric power system starts from the generator and then is channelled through the transmission network system to the substation and from this substation, it is distributed to consumers through distribution channels, or consumers receive direct service from the transmission line. Usually, these consumers require large voltage and large power. Here is a picture of the electric power system:



Source: Author

Figure 1 Electric Power System

In the electric power system, there is a power plant, which is one part of the electric power system at the power plant there are electrical, mechanical, and work building equipment (Hartono, 2015). There are main components of the generator, namely generators turbines which function to convert mechanical (potential) energy into electrical (potential) energy (Hartono, 2015). The voltage coming out of the generator must be increased first in order to reduce the amount of current flowing in the transmission line, with low current flowing in the transmission line it can reduce power.

In order to deliver electrical energy, a transmission line is needed, which is the medium used to transmit electrical power from the generator station/power generator to the distribution line to consumers who use electricity. Electric power is transmitted by a conductor material that carries electric power based on the category of transmission line (Suhadi, 2008). The overhead line system transmits electric power through conductors suspended on transmission poles by means of insulators, while the underground transmission line system distributes electric power through underground cables (Lagolan, 2012).

In the distribution of electric power, there is a voltage generated by the generator which must be increased with a step up power transformer to hundreds of kilovolts, which aims to reduce the amount of current flowing in the transmission line, so that power losses can be reduced and all equipment installed after the transformer (secondary side) must be able to bear high stresses (Sulasno, 2010).

Substation Work System

The electric power distribution system from the substation is part of the electrical equipment system between bulk power (bulk power source, BPS) and customer service switches. In addition, a distribution system is usually composed of several pieces of equipment and other supporting components such as distribution substations, sub-transmission systems, feeders and distribution transformers, as well as customer service (Logahan, 2012). The continuity of the distribution system distribution is closely related to the network configuration and the medium voltage components installed on the network. In addition, in order for the distribution network function to run properly, efforts are needed to overcome disturbances that often occur in the distribution network quickly, efficiently, and in a short time. Then these elements can affect the level of reliability of the distribution system in distributing quality electric power. The electric power distribution network system is divided into 2 systems: the primary distribution network system (medium voltage distribution network) and the secondary distribution network system (low voltage distribution network).

Condition Based Maintenance

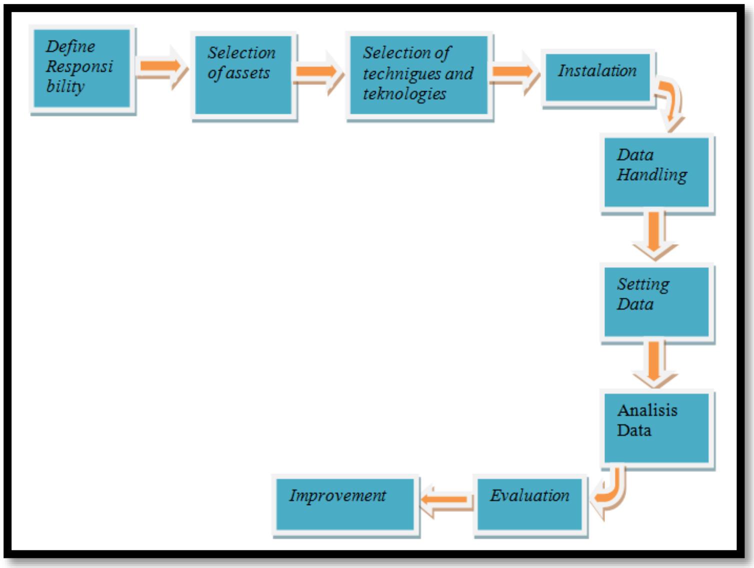
Condition Based Maintenance, abbreviated as CBM is an attempt to reduce maintenance schedule that is not really needed, which is only done when something abnormal happens to the plant to reduce maintenance costs (Jardine et al, 2005). Condition Based Maintenance is a recommended maintenance program based on decisions to collect information from the measurement conditions of a plant (Cahyono, 2009). Data from condition measurements, data caused by sensor errors (Kwan, 2003). The principle of the type K thermocouple as output from the sensor is in the form of output voltage, which is then processed with a signal conditioning circuit to obtain a program whose treatment decision recommendations are based on gathering information from conditions (Jardine et al, 2005).

CBM Application Program Level 1

The CBM (Condition Based Maintenance) level 1 application program is an application that functions to store and display data on inspection results of substation equipment so that it can be monitored by the direct supervisor (PLN Team, 2009). The CBM Inspection Level 1 application is a desktop application that can be run by copying application files so there is no need to install (Cahyono, 2008). Applications can be run, stored and run via flash. Damage to facilities will endanger workers, both their health and safety. CBM level 1 can deal damage that occurs suddenly. This is because CBM can detect and capture signals when a system will fail and determine when a system requires service (repair) (Chen, 2017).

Implementation of Condition Based Maintenance

Implementing CBM is carried out with the proposed work process for the implementation phase of using Condition Based Maintenance. First, it is important to select the appropriate type of CBM technology to be applied, critical analysis and maintenance audits help to assess the possibility of CBM implementation techniques. The second stage determines the responsibilities, including making decisions, discussing the implementation of ideas, developing existing needs, and selecting tools, techniques, and technologies. The next stage is the training stage. Different technologies have different training and skills, so measurements must be made online (real time) or offline (by handling instrument) based on the type of technology used. In simple terms, the stages in implementing CBM can be described in the following picture:



Source: Isrofi, 2018
Figure 2 Implementing CBM

CBM Application Programs
When doing CBM applications, there are several programs including:
1. OPGI One of the implementations of the CBM program running in Indonesia is the Substation Information System (SIGI), now known as OPGI.
2. CBM Application Program (Condition Based Maintenance) level 1 CBM application is an application that functions to store and display data on inspection results of substation equipment online so that the direct supervisor can monitor it.

3. Methods

This study analyzes Condition Based Maintenance (CBM) level 1 on substation equipment. The research method carried out in this study uses three ways: literature study, testing, and observation with data processing using the calculation of the mean life (LM) carried out with the equation:

$$LM = \frac{1}{\pi} \text{ Where: LM= Mean life, dan } \pi = data\ obtained$$

Then the determination of Remaining Useful Life (LR) where LR is the component's remaining life under the operating conditions used. The LR value is obtained from the results of subtracting LM and LA. This data omission is based on the Upper Control Limit (UCL) and Lower Control Limit (LCL) values obtained using the following equation:

$$\text{Mean } (\times) = \frac{n1+n2+n3+n....}{n}$$

Meanwhile to get LCL= X- 3σ dan UCL= X + 3σ Where:

$$\sigma(standartDeviasi) = n\frac{\sum_x 2 - \sum_x 2}{n\,(n-1)}$$

Furthermore, the determination of LA can be done after the variables that affect the age of the tool are determined. The determination of the LA equation uses the general linear regression equation as follows :

$$\gamma = \alpha + mx$$

Where : γ = the estimated value of the variable for a given value of x,
Where γ a old aktualy (LA).
α= axis intersection Y, which is the estimated Y value for the variable x to be zero (x=0).
M = the slope of the line (gradient) or the change in y for each one unit change in the independent variable x.

4. Results And Discussion

Field Observation Results

Maintenance of substation installations is essential to optimize equipment function, worker safety and distribution of the electricity industry. The results of level 1 observations on substation equipment to determine CBM At the PT PLN Persero Berastagi substation, researchers can describe as follows.

Table 1. Observation On Grounding

Grounding	Initial Condition	Observation result
Grounding Wire	Normal	Loose
Grounding Terminal	Normal	Loose

Source: Research Results, 2021

Based on researchers' observations in the field on grounding and based on existing data, the initial conditions of the grounding wire and grounding terminal are in normal condition. However, after direct observation, the grounding condition is a little loose. In the opinion of researchers, this can occur due to land shifts due to high rainfall and fast-flowing water, plus the occurrence of earthquakes due to the eruption of Mount Sinabung. So that there is a shift in the ground, which results in looseness in the grounding equipment.

Table 2. Observation On Insulator

Isolator	Initial Condition	Observation result
cleanliness	Clean	Clean
Rift	There is not any	Slightly cracked

Source: Research Results, 2021

The results of observations of researchers in the field on the insulator based on available data that the initial condition of the insulator is clean and not cracked, this can occur due to changing air temperatures, where when conditions are cold, it feels cold, but due to the hot temperature from the eruption of Mount Sinabung, it appears hot weather.

Table 3. Observation on the Separation Handlebar

Separation Handlebar	Initial Condition	Observation result
Knives	Normal	Normal
Contacts	Normal	Normal

Source: Research Results, 2021

The results of observations in the field on the handlebar separator based on available data that the initial conditions of the handlebar separator are in normal conditions as well as the results of observations under

normal circumstances both the blades and the contacts on the handlebar separator, so there is no need for maintenance or replacement on the handlebar separator. .
Furthermore, observing the tightness of the bolts, observing the tightness of the bolts based on the results of observations of the tightness of the bolts, the researchers found that the bolts attached to each machine and electrical equipment at the PT PLN Persero Berastagi substation could be described as follows:

Table 4. Observation on Bolt Tightness

Bolt Tightness	Initial Condition	Observation result
Main Terminal	Tight	Tight
Drive Tank	Tight	Tight

Source: Research Results, 2021

The results of observations by researchers in the field on the bolts attached to the PT. PLN Persero Berastagi substation based on existing data that the initial conditions of the main terminal were tightly tied as were the results of the researchers' observations, then the drive tank was still tightly tied.

Table 5. Observation on the Mechanical Box

Mechanical Box	Initial Condition	Observation result
Gears	Well	Start Thirsty
Drive Motor	Well	Well

Source: Research Results, 2021

The results of observations in the field on the mechanical box based on available data that the initial conditions of the mechanical box are in good condition as well as the results of observations on the driving motor, but the gears in the initial conditions are still good, but the observations are starting to get thirsty, so something needs to be done gear replacement.

Data Collection Through CBM Level 1

Based on the data obtained by the researchers at PT PLN Persero Berastagi, the CBM data obtained were:

Table 6. Data CBM Level 1

No	Observation	Bulan														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Grounding Wire	N	N	L	L	N	N	N	L	N	N	L	R.G	N	N	L
2	Grounding Terminal	N	N	N	L	N	N	L	N	N	N	L	N	N	L	L
3	Insulator Cleanliness	K	B	K	K	K	K	K	K	K	K	K	K	K	K	K
4	Insulator Adhesion	A	A	R	G	A	A	A	R	G	A	A	A	R.T	G	A
5	Handlebar Knife Separator	N	N	N	N	N	R.G	N	N	N	N	N	R.G	N	N	N
6	Separator Handlebar Contact	N	N	N	N	R	G	N	N	N	N	R	G	N	N	N
7	Main Terminal	K	K	L	K	K	K.	L	K.	K.	L	K.	K.	L	K.	K.

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		. C	. C		. C	. C	C		C	C		C	C		C	C
8	Drive Tank	K . C	L	K C	L	K . C	L	K. C	L	K. C	L	K. C	L	K. C	L	K. C
9	Gears	B . K	B . K	M .H	G	B . K	B. K	B. K	M .H	G	B. K	B. K	B. K	G	B. K	M. H
10	Drive Motor	B . K	B . K	G	B . K	B . K	B. K	B. K	G	B. K	B. K	B. K	B. K	G	B. K	B. K

Keterangan:

N : Normal RT : Crack L : Loose
G : Replace RG : Broken / Replace KC : Tight
K: Dirty BK: Fine B : Clean
MH : Getting thirsty A: Safe

1. Calculation of Mean Life (LM), Calculation of Mean Life is done with the equation: LM $=\frac{1}{\pi}$, then the calculation is:

LM ground wire $= \frac{6}{15} =$ 0,4
LM Grounding Terminal $= \frac{5}{15} =$ 0,3
LM Insulator Cleanliness $= \frac{14}{15} =$ 0,94
LM Insulator Cracks $= \frac{6}{15} =$ 0,4
LM Split Handlebar Blade $= \frac{2}{15} =$ 0,13
LM Separation Handlebar Contacts $= \frac{4}{15} =$ 0,26
LM Main Terminal $= \frac{4}{15} =$ 0,26
LM Drive Tank $= \frac{7}{15} =$ 0,46
LM Gears $= \frac{6}{15} =$ 0,4
LM Drive Motor $= \frac{3}{15} =$ 0,2

2. The next step is to determine the remaining useful life (LR). The LR value is obtained from the results of subtracting LM and LA. This data omission is based on the Upper Control Limit (UCL), and Lower Control Limit (LCL) values obtained using the following equations:

Mean (×) $= \frac{n1+n2+n3+n....}{n}$

So : (X) $= \frac{0,4+0,3+0,94+0,4+0,13+0,26+0,26+0,46+0,4+0,2}{10}$

(×) $= \frac{3,75}{10}$

(×) = 0,375 dibulatkan menjadi 0,4

Next determine $\sigma(standartDeviasi)$= n$\frac{\sum_x 2-\sum_x 2}{n\ (n-1)}$

σ= 10$\frac{3,75^2-3,75^2}{10\ (10-1)}$

$\sigma = 10\frac{14{,}0625 - 14{,}0625}{10\ (9)}$

$\sigma = \frac{140{,}625 - 14{,}0625}{10\ (9)}$

$\sigma = \frac{126{,}5625}{90}$

σ= 1,40625 rounded to 1,4

Furthermore, the calculation results are confirmed by:

LCL= X- 3σ
LCL= 0,4- 3(1,4)
LCL= 0,4- 3(1,4)
LCL= 0,4- 4,2
LCL= -3,8

The next step is :

UCL= X + 3σ
UCL= 0,4+ 3(1,4)
UCL= 0,4+ 3(1,4)
UCL= 0,4+ 4,2
UCL= 4,6

3. Next is to determine the LA, the determination of LA can be done after the variables that affect the age of the tool are determined. The determination of the LA equation uses the general linear regression equation as follows:

$$\gamma = \alpha + mx$$

Where *Y*: = the estimated variable value for a certain x value, where is the actual age (LA).
α = the Y-intercept, which is the estimated Y value when the variable x is zero (x=0).
M = the Y-intercept, which is the estimated Y value when the variable x is zero (x=0).

Before performing LA calculations, first determine the value of a obtained from:

M = r $\frac{sy}{sx}$, end a = y-mx
M = 1 $\frac{1{,}4}{0{,}4}$
M = 3,5

Then the next step is to determine:a = y-mx
a = 1,4-3,5. 0,4
a = 1,4- 1,4
a = 0

Then the next step is to find the value of Y with the following equation::

$\gamma = \alpha + mx$
$\gamma = 0 + 3{,}5.\,0{,}4$
$\gamma = 1{,}4$

Based on the results of these calculations, the LA value of 1,4 is obtained. The results of this calculation can then be used as a reference in calculating the CBM at the PT PLN Persero Berastagi substation. The first step is to carry out the measurement stage using the equation LR = LM-LA. as follows:

Ground wire LR = 0.4- 1.4= -1
LR Earthing Terminal = 0.3- 1.4 = -1.1
Isolator CleanlinessLR = 0.94 - 1.4 = -0.46
Isolator CrackLR = 0.4 - 1.4 = -1

Handlebar Blade Separator LR = 0.13 - 1.4 = -1.27
LR Separation Handlebar Contact = 0.26 - 1.4 = -1.14
Main Terminal LR = 0.26 - 1.4 = -1.14
LR Drive Tank = 0.46- 1.4 = -0.94
Gears LR = 0.4 - 1.4 = -1

LR Drive Motor = 0.2 - 1.4= -1.2 While the treatment time is the same as the Mean Life (LM) calculation, the Mean Life calculation has been carried out at the beginning:

LM ground wire $= \frac{6}{15} =$ 0,4

LM Grounding Terminal $= \frac{5}{15} =$ 0,3

LM Insulator Cleanliness $= \frac{14}{15} =$ 0,94

LM Insulator Cracks $= \frac{6}{15} =$ 0,4

LM Split Handlebar Blade $= \frac{2}{15} =$ 0,13

LM Separation Handlebar Contacts $= \frac{4}{15} =$ 0,26

LM Main Terminal $= \frac{4}{15} =$ 0,26

LM Drive Tank $= \frac{7}{15} =$ 0,46

LM Gears $= \frac{6}{15} =$ 0,4

LM Drive Motor $= \frac{3}{15} =$ 0,2

Based on the calculations and maintenance time at the PT PLN Persero Berastagi substation, it can be analyzed with the results of monitoring with CBM at the PT PLN Persero Berastagi substation that the maintenance that must be carried out on each substation item must be carried out in less than one month.

4. Discussion

The results of the maintenance of the separator equipment at the substation both on grounding (grounding), grounding wire, grounding terminal, insulator, separation handlebar, bolt tightness, the main terminal of drive shaft, mechanical box, namely gear motor drive, foundation and others that the results of checking it can be seen that the initial conditions or the final conditions on the separator obtained good and quite good results, this is because there is no significant damage, then inspections on the separator need to be carried out routinely. The results of field observations, researchers also found preventive maintenance, i.e. the damage suddenly occurs. This is because CBM level 1 can also detect and capture signals when a system will fail and determine when a system requires service (repair). Therefore, PLN needs to maintain records of individual processes, machines, or equipment with good reporting techniques.

Replacement or maintenance will be carried out if the results of prediction, analysis, monitoring, and testing of materials/spare parts are out of standard, but if they are still in good condition, the materials/components are still worth maintaining. So in terms of costs, increased productivity and efficiency, this pattern is clearly more profitable. In field observations, researchers also found that the condition of the equipment can still be maintained without having to always refer to the manufacturer's instructions for vital and critical equipment by utilizing analysis, measurement and laboratory tests that are optimal and usable. However, PT PLN Persero Berastagi better understands the conditions and their effects during the operation of the machine without ignoring the instruction manual, so that equipment that is still feasible, but very vital, is immediately replaced. with the results of monitoring with CBM at the PT PLN Persero Berastagi substation that the maintenance that must be carried out on each substation item must be carried out in less than one month. That maintenance at the substation must be carried out for less than one month, both on the handlebars, the mechanical box, the tightness of the bolts, the foundation, and so on.

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