PARTIAL DISCHARGE ASSESSMENT WITH ULTRASOUND AND TEV (TRANSIENT EARTH VOLTAGE) IN MEDIUM VOLTAGE SUBSTATION FOR POWER DISTRIBUTION SYSTEMS RELIABILITY OF 18TH ASIAN GAMES 2018

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ABSTRACT

Jakarta as the capital city of Indonesia as well as the center of government, business district and hosting the 18th Asian Games 2018 requires a good power distribution reliability and continuity of electricity.

This paper will describe the application of Condition Based Maintenance in Jakarta with an online partial discharge assessment. With the assessment of partial discharge accompanied by maintenance of Time Base Maintenance, it can minimize the occurrences of breakdown due to anomalies that occur in the cubicle.

INTRODUCTION

The medium voltage equipment is an important key in power distribution systems reliability in Jakarta. Having the chance to host the 18th Asian Games 2018, PLN (Perusahaan Listrik Negara, a state-owned electrical utility company) must be prepared for electrical supply reliability in Jakarta.

In Fig. 1, in 2017, 40% of incoming 20 kV transformer trip (unscheduled shutdown) were having medium voltage cubicle breakdown failure as its root cause. Incoming 20 kV transformer are connecting the secondary winding of the power transformer to the medium voltage busbar 20 kV which supplies the feeders in the substation. If the incoming 20 kV transformer trips, then the feeders that supply to the customer will experience power blackout.

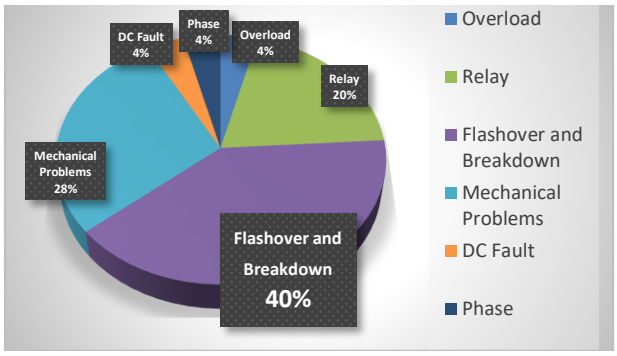

Fig.1. Identified Root Cause of Incoming 20 kV Transformer Trip

From the last few years, the parts of the cubicle which often experienced a breakdown are the cable termination, circuit breaker, current transformer, voltage transformer, and busbar. From the post-breakdown observations, 80% were examined from medium voltage cubicle failure. There were several physical signs found around the point of breakdowns, such as traces of white powder and chaffing found at termination cable. These physical signs might indicate that these equipment were having a partial discharge as a potential failure, before actual equipment breakdown occurred (functional failure).

TIME-BASED MAINTENANCE (TBM) AND CONDITION-BASED MAINTENANCE (CBM)

Time-Based Maintenance (TBM) is the default maintenance strategy in PLN-maintained Medium Voltage Substations. Time-Based Maintenance is a set of scheduled inspection and maintenance task which consist of cleaning, lubrication, and assessment (such as functional test and operational check of equipment components contained in cubicles). These inspections and/or maintenance tasks interval are scheduled based on cubicle age. For every aging component inside the cubicle, additional tasks are added, or the interval may be shorter compared to earlier components. The equipment/components on cubicles that must be maintained are a circuit breaker, current transformer, voltage transformer, busbar, relay, lightning arrester, heater, and grounding.

There are several challenges when implementing TBM. Most of the consumers in Jakarta are classified as VIP categories. Availability and reliability on electrical supply are reserved for these consumers, thus it is named “Very Importance Party”. Most of these consumers are factories, industries, malls, and business centers. Unfortunately, scheduled maintenance as planned in TBM were often postponed, in compromise for their demand on uninterruptable electrical supply. This was happened since consumers load were needed to be turned off (shut down) on completion of tasks mentioned in TBM. As a result, several cubicles might have ended in a deteriorated condition, which could lead to unscheduled downtime for corrective maintenance. In addition, cubicle health quality can’t be completed: adding more uncertainty on planning needs.

To minimize unscheduled downtime, altogether with careful planning and equalizes several maintenance tasks,

a Condition-Based Maintenance (CBM) is needed. Following the investigation results mentioned in the introduction, the condition needed to be captured is partial discharge. Partial discharge preceding total breakdown failure is occurred in a certain interval, on which can be detected using several methods.

With TBM and CBM, the 'health quality' of the cubicle can be continuously monitored even if it is online. Any discrepancies or functional failure can be detected early so prevention can be carried out to minimize the occurrence of the damage caused by the anomaly.

PARTIAL DISCHARGE ASSESSMENT

Partial discharge assessment is consists of two methods of measurement: measurement with ultrasonic sound wave propagation to detect surface discharge and measurement of TEV (Transient Earth Voltage) to detect internal discharge. Surface discharge activity is indicated by the jump of electric charges into the air, causing ultrasonic sound waves propagation. This ultrasonic wave generates audible sound, measured in dBµV, on a certain level it can be recognized as a partial discharge.

Partial discharge assessment with Ultrasound and TEV was commenced in the second semester of 2018 at several substations used to supply 18th Asian Games 2018.

In Fig. 2, there were partial discharge findings using the ultrasound method in Kasti Feeder, Ketapang Substation. An indication of partial discharge was found on the cable box. The sound was identified as a crackling sound in the headphones. As shown in the instrument, partial discharge was measured on 20 dBµV, which indicates that the equipment lies behind was critically severed by partial discharge. Thus, it needs immediate investigation (open access panel is required).

In Fig. 3, after further investigation, partial discharge findings were localized in the wounds on the main-spare jumper cable. The cable was repaired in accordance with proper maintenance standard and indication partial discharge was decreased.

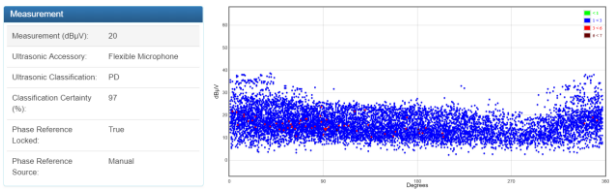

Fig.2. Ultrasound PD in Kasti Feeder

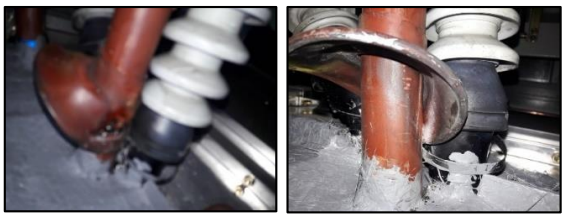

Fig.3. Investigation in Kasti Feeder, main-spare jumper cable conditions

Another partial discharge case was detected with ultrasound detection method in the cable box of Canda Feeder, Kemayoran Substation. Figure 4 shows that the classification shown on the measuring instrument has indicated partial discharge with a measurement value of 5 dBµV. Even though the value is still relatively small, it is necessary to check further on the cable box.

After inspection, a crack was found in the indoor cable terminations, as shown in figure 5. A replacement was then deemed necessary.

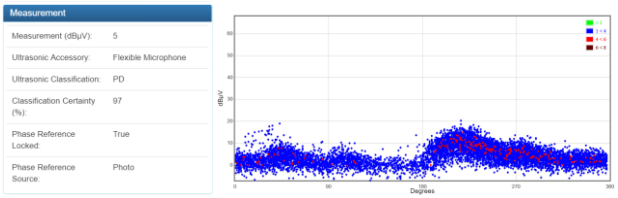

Fig.4. Ultrasound PD in Canda Feeder

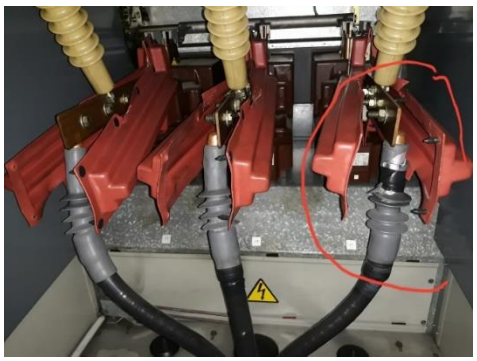

Fig.5. Crack in Indoor Cable Terminations Canda Feeder

Fig.6. Replacing Cable Terminations Canda Feeder

As for internal discharge activity, it is characterized by the propagation of electromagnetic waves from internal discharge. When this electromagnetic wave hit the outer surface of equipment (such as cubicle case, or any other equipment enclosure), it will produce a substantial amount of Transient Earth Voltage (TEV). In Fig. 7, in the method of using TEV in SN38 which supplies electricity to Gelora Bung Karno Stadium.

The causes of partial discharge with TEV is difficult to be determined because it is often regarded as "hidden failure". In Fig. 8, the waveforms indicates that there is an indication of TEV on the cubicle. This method only gives suggestions for parts that have a high measurement of TEV but it cannot determine the details of damage caused by the internal discharge. Nevertheless, the TEV method can provide early warning for the next step.

Fig.7. PD Assessment with TEV

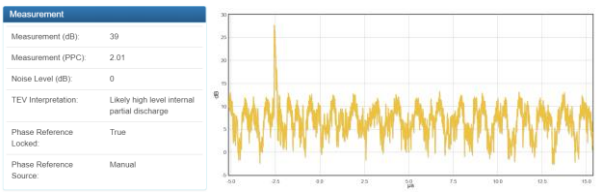

Fig.8. TEV in SN38

RESULTS OF ASSESSMENT

During the second semester in 2018, partial discharge assessment has been implemented in 27 substations which supply 18th Asian Games 2018 venues and 7 medium voltage distribution panels (power source for Gelora Bung Karno Stadium Area).

Following components were found having partial discharge potential failure. These parts include circuit breakers, voltage transformer chamber, cable box, and busbar.

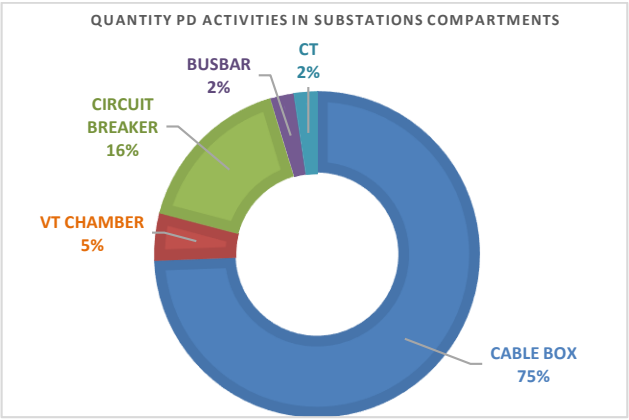

Fig.9. Quantity PD Activities in Substations Compartments

Figure 9 shows that partial discharge activity most occurs in the cable box. The main cause of the partial discharge at the cable box is due to improper procedure during the cable installation process. In addition, it is also suspected that postponed scheduled maintenance can further deteriorate.

Specific in the case of assessment using the ultrasonic wave method (Kasti Feeder and Canda Feeder cases), the source of partial discharge was derived from chaffing in the cable terminations. Having examined works performed at the cubicle, it was concluded that these defects can be traced back in commisioning phase. Limited by a commisioning deadline, the maintenance team was decided to install the cable without proper maintenance standard. Thus, making the deterioration process faster. Lesson learned from the failure and indication of partial discharge is the initial installation stage of the cubicles is a stage that requires good planning and execution so that the installed material can be in accordance with applicable standards and does not cause potential harm in the future.

As for assessment using the TEV method, our concerns are on the selection of equipment used in the cubicle, such as the quality of the current transformer, voltage transformer, busbar, and circuit breaker. It must be ensured that it is always in accordance with the engineering standard.

Having implemented partial discharge assessment started in semester 2 of 2018, breakdown failure (causing incoming 20 kV transformer trip) has lowered 40% compared with previous year achievement.

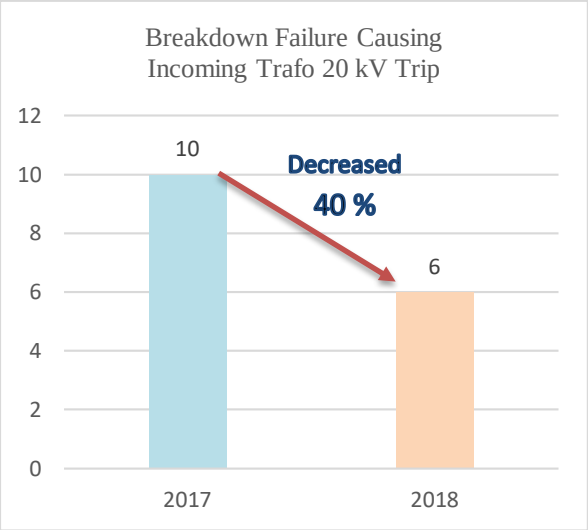

Fig.10. Breakdown Failure Causing Incoming 20 kV Transformer Trip

CONCLUSION

TBM with CBM can minimize failure during the 18th Asian Games 2018 and second semester in 2018 in substations and contribute 40% decrease in incoming 20 kV transformer trip due to a breakdown caused partial discharge.

Assessment with partial discharge measurements is preferred to prevent from failure or breakdown of medium voltage substation, without the needs to temporarily disable electricity on consumers load. Partial discharge assessment will be a sustainable business process in PLN that has a vision to periodically display health index so that the condition of each cubicle in medium voltage substation can be monitored continuously.

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