ANALYSIS OF RUSTY CLOSED TYPE SWITCHGEARS

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ABSTRACT

As for pole-mounted switchgears (SWs), rust caused by aging is the major factor of deterioration. By analyzing progress of rust, it is revealed that deterioration by rust on SWs does not depend on the number of passing years, but color of rust and corrosion blister. In this paper, we show the result of our analysis based on replaced SWs examination.

1. INTRODUCTION

We have utilized pole-mounted closed type switchgears as sectionalizing SWs in distribution automation system since 1976. We operate and maintain approximately 170 thousand closed type SWs as a total, and we have experienced distribution system faults due to deterioration of closed type SWs about 30 times per year. In this paper, we show the result of the analysis for SWs deterioration.

2. ISSUES ON SWITCHGEARS

(1) Structure of Switchgear

Fig.1 shows structure of SW we commonly use. This SW has a handle and a connector. The handle is used to operate SW status (open/close) by manual operation; the connector is used to connect remote terminal unit to control SW by remote control. As arc extinguishing mechanisms of SW, we adopted vacuum valve type, gas insulation type, and air insulation type. The structure of SW shown in Fig.1 is the example which has vacuum valves. To maintain durability of the internal mechanism and prevent electronic parts from breaking down by rainwater inundation and foreign substances, SWs' housing have been sealed air tightly.
The pointer which indicates SW's status is equipped on the other side of the handle; field technicians can confirm the switch status (open/close) from the ground.

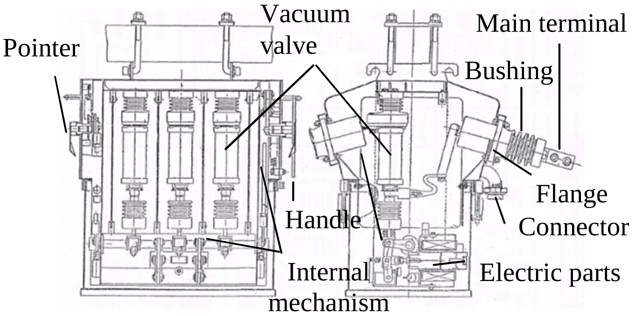


Fig.1: Structure of SW

(2) Issues on Aging SWs

Because of cost and process ability, housing of most closed type SWs are made of iron, and a part of early introduced SWs are made of aluminum.
Those materials and coating applied to the surface ensure material durability, however, once the coating is peeled off, it rusts easily (shown in Fig.2). Rust is mainly caused by the salt in air, wide range of temperature change and ultraviolet absorption. In the case rust affects air tightness of SWs, the inside become moist; internal mechanisms are rusted by accumulated moisture or water, as a result SWs doesn't work properly. As other cases, water breaks electronic parts of SWs. In the worst case, it causes dielectric breakdown or malfunction. Recently the number of SWs malfunctions tends to increase. Therefore, it is important to investigate and analyze the causes of SWs deterioration in order to estimate SW's lifecycle and improve SW specification.

Fig.2: Rusty SW

3. EXAMINING REPLACED SWITCHGEARS

We visually inspect all of each distribution facility every five years. In the case heavily damaged SWs are found, we replace and investigate some of them in details. Based on past investigation result, we have analyzed the causes of SWs deterioration. Fig.3 shows the broken points of SWs. Rusty SWs accounts for 64%, therefore, we focus on rust and investigate the progress of degradation.

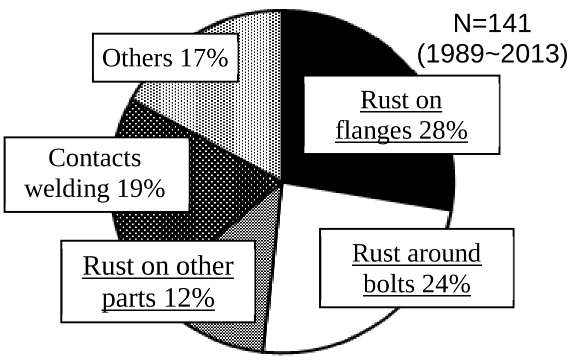


Fig.3: Broken Points on SWs

4. EVALUATION OF RUST CONDITION

(1) Observation of the SW Appearance (Flange)

Fig.4 and Fig.5 show two SWs to compare rust condition, one is totally rusty, and the other is partially rusty. Each corrosion range are different, but both SWs have severe rust on flange parts. Flange around bushings is the rustiest point on SWs; significant thinning and holes are confirmed on them.

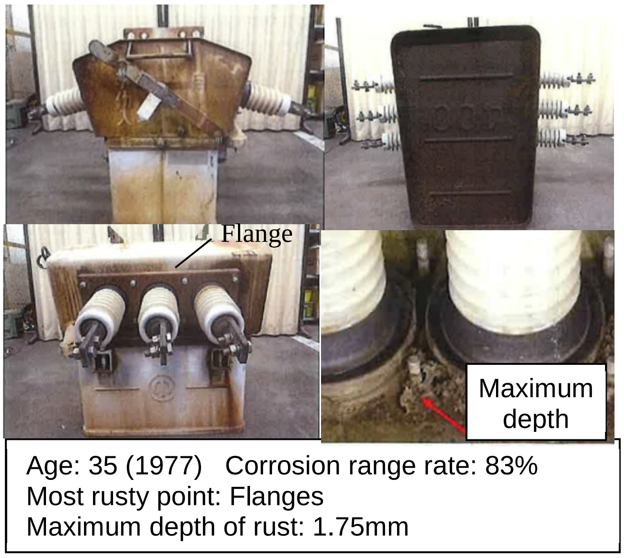


Fig.4: an Example of Totally Rusty SW

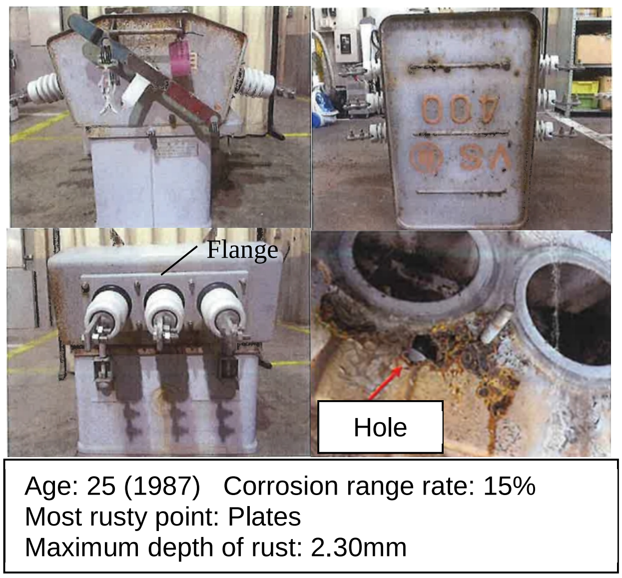


Fig.5: an Example of Partially Rusty SW

(2) Factors of Rust on Flanges

Rust on flanges covering bushings have been observed most frequently on rusty SWs. Because SWs had been exposed to rain and wind including sea breeze, the salt content had remained at the flanges; this rusted them, and affected SWs' airtightness. (Fig.6, 7)

Fig.6: Flange Covering Bushing

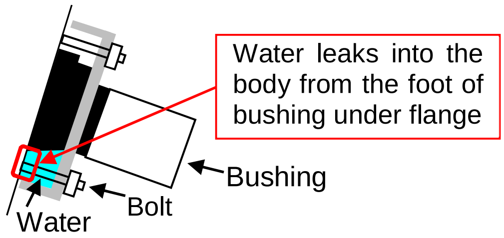


Fig.7: Water Leaking at Flange

(3) Analyzing Deterioration Process due to Rust

1) Relevance between age and corrosion range rate

It is generally thought that corrosion range increases in proportion to SW's age. In the largest case, 80% of the surface are rusted, which was 35 years old. On the other hand, there are SWs that rarely rust even 25 years after installation. The strong relevance is not observed between the passing years and corrosion range rate.

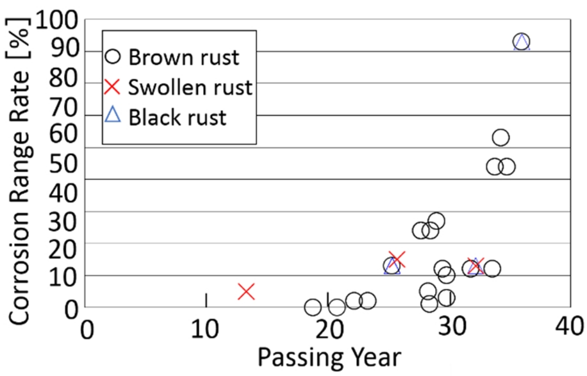


Fig.8: Corrosion Range Rate across Passing Years

2) Relevance between depth of rust and age

We examined relevance between the depth of corrosion and outlook of rust such as area and color. Black rust is much worse than brown rust. In addition, swollen rust is confirmed as bad as black rust, corrosion by swollen rust reaches almost as same depth as black rust. (Fig.9, 10)

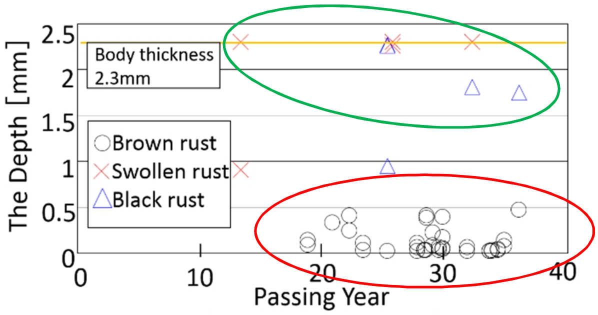


Fig.9: Depth of Rust across Passing Years

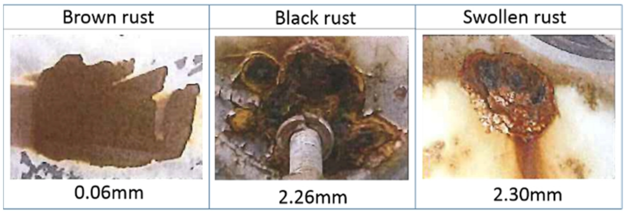


Fig.10: Aspects of Rust and Depth

3) Relevance between Depth of Rust and Corrosion Range Rate

Fig.11 shows the relevance between depth of rust and corrosion range rate. The amount of rust range is not clearly related to the depth.

Fig.11: Depth of Rust and Corossion Rate

As a result of the examination, we found that the depth of rust has correlation with not the corrosion range but the color of rust (rust condition).

5. EVALUATION OF DISSIMILAR METAL CORROSION PROGRESS

(1) Dissimilar Metal Corrosion with Aluminum (Rust around Bolts)

As mentioned above, some SWs have aluminum housing because aluminum is more resistant to rust than iron. However, stainless steel bolts are used for this type of SW; Dissimilar metal corrosion have occurred between stainless and aluminum due to ionization tendency difference.

(2) Occurrence of Dissimilar Metal Corrosion

Fig.12 shows the number of switchgears that failed airtightness due to dissimilar metal corrosion by SW age. Dissimilar metal corrosion may occur as early as 15 years after installation.

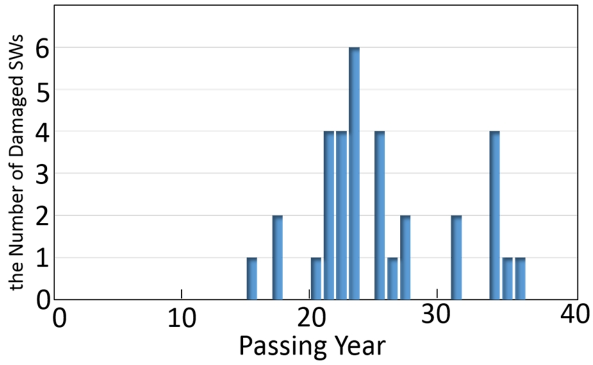


Fig.12: the Number of Dissimilar Metal Corrosion with Aluminum

(3) Appearance of SW with Dissimilar Metal Corrosion

Dissimilar metal corrosion occurs between the stainless steel bolt and the aluminum housing, therefore corrosion of the aluminum housing is promoted; this causes the damage on airtightness.

Then rainwater leaks into the inside of SW through this gap. This leads to the dielectric breakdown at bushing.

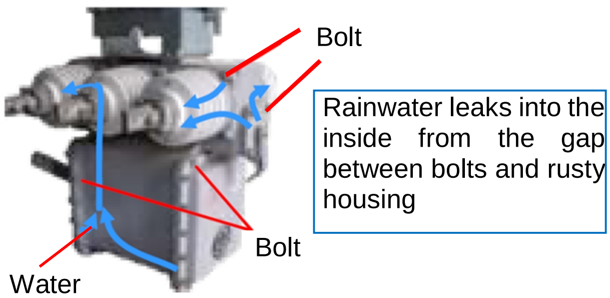
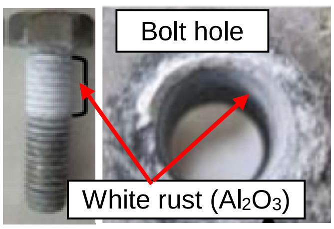


Fig.13: SW with Aluminum Housing



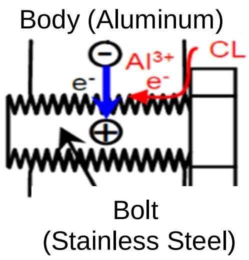


Fig.14: Bolt and Bolt Hole: Fig.15: Model of Bolt

As a result of the examination, we found that dissimilar metal corrosion occurs depending on the combination of metal materials and we must take it into consideration for the long-term durability of SW.

Accordingly, we have reflected this knowledge in our new specification of SW; the stainless steel housing and stainless steel bolts are adopted in the current type SW.

6. CONCLUSIONS

We found that the depth of corrosion due to rust on SWs related to the color and the condition of rust. This result is an important point for our visual inspection. Based on this result, we have already reflected these findings in our internal guideline for visual inspection.
In addition, as the improvement points, we found that material selection (to prevent dissimilar metal corrosion) and the structure (to prevent rainwater inundation) must be taken into consideration. As a result of this research, we could improve the specification of new sectionalizing SWs (Fig.16).
As our future work, we continue to analyze deteriorated SWs for establishing residual lifetime prediction method based on rust condition.

Fig.16: New Sectionalizing SW