Australasian Power Technologies

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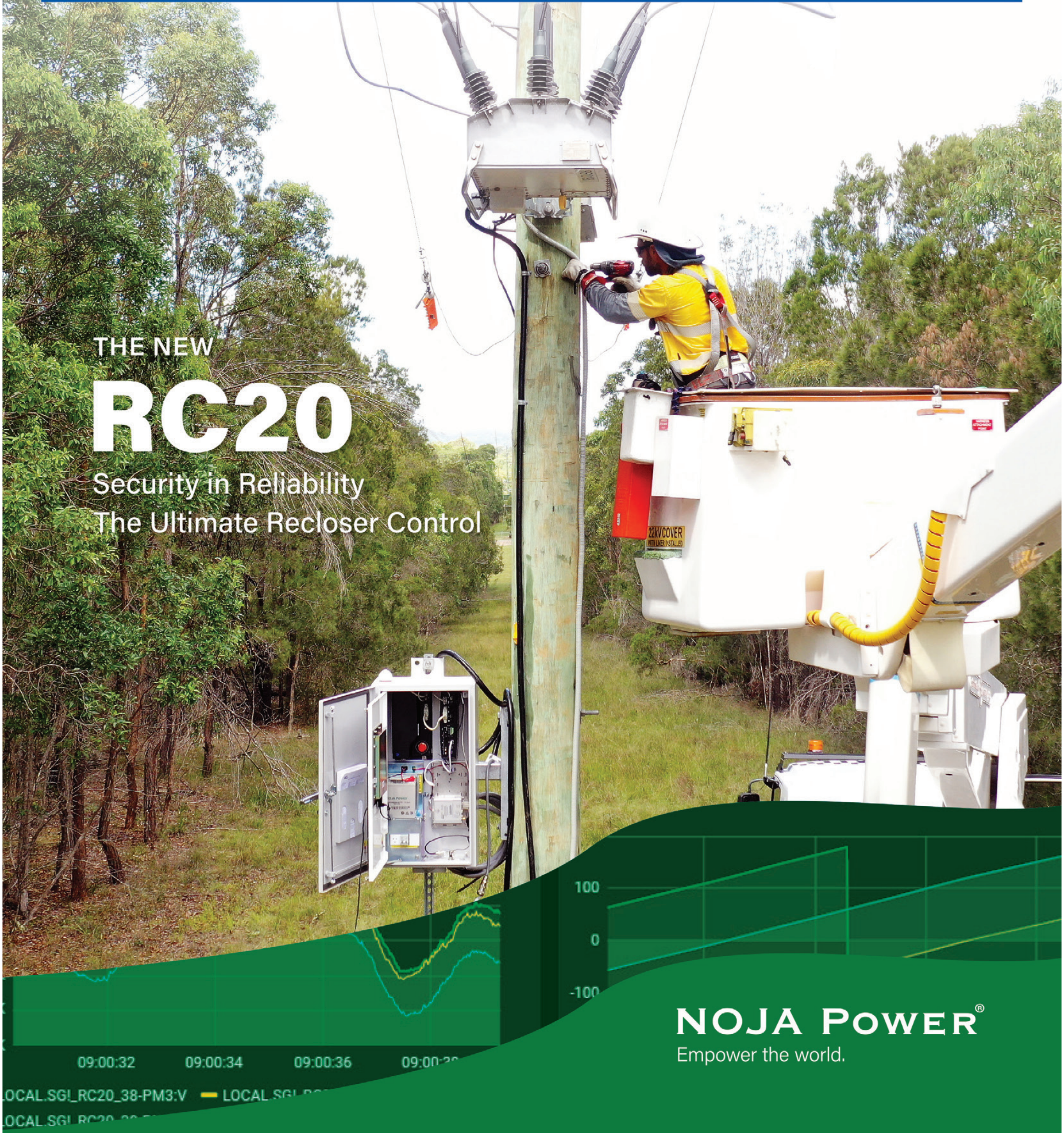
SHOWCASING MEDIUM & HIGH VOLTAGE ELECTRICITY | ISSUE 5 | OCTOBER-NOVEMBER | 2020 |



Potential Mitigation Strategies to Prevent Silver Sulphide Corrosion in a Transformer OLTC

Silver sulphide corrosion has recently been identified as one of the transformer's On-load tap changer (OLTC) failure causes. Due to the lack of understanding of silver sulphide corrosion mechanism and its impact on transformer and OLTC operation, transformer failure can occur without any early warning sign [1, 2].

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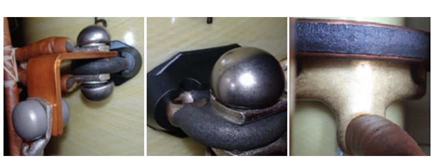
OLTC components such as tap selector contacts and current take-off rings are silver coated to improve its electrical and thermal properties. Corrosive sulphur in the transformer oil can aggressively react with those silver-coated components. As a result, conductive silver sulphide can be formed on the silver-coated surfaces [2]. The detached silver sulphide particles then suspend in the transformer oil in the vicinity of an OLTC. Since silver sulphide is conductive, it can increase the electric stress between adjacent contacts and reduce the dielectric strength of the oil between adjacent contacts [2, 3]. Consequently, electric discharge can take place between adjacent contacts, which may short circuit the regulating winding. The risk of silver sulphide corrosion is driven by several factors, among them corrosive sulphur compound and its concentration is an important one. Then other factors like oil temperature (influenced by transformer loading conditions and cooling system) and OLTC design (influenced by geometry, thickness of silver coating) are the next factors.

Compared to copper sulphide corrosion, mitigation of silver sulphide corrosion has not yet been properly researched and discussed. However, based on my experimental findings at UQ and findings by other researches, possible silver sulphide corrosion risk mitigation strategies can be outlined. Mitigation strategies are important for utilities to prevent or reduce the risk of silver sulphide corrosion in their transformers.

The oil change has been used successfully in 4% of world transformers to mitigate copper sulphide corrosion [1, 4, 5]. Moreover, experimental and field measurements have shown that oil change can significantly reduce the risk of transformer failure by permanently eliminating the source of corrosive sulphur [1, 5]. However, the main drawback is even after the oil change, 5-10% of contaminated transformer oil may remain in the transformer [1, 5]. Therefore, oil corrosivity after the oil change may vary with the residual corrosive sulphur concentration.

Transformer oil reclamation with sorbent is another potential method of silver sulphide risk mitigation. The sorbent clay used in oil reclamation can absorbs corrosive sulphur compounds from the transformer oil [1, 5]. Compared to oil change, oil reclamation is more ecofriendly. The effectiveness of oil reclamation can be improved by the oil treatment cycles and the oil treatment duration. However, it has been found that oil reclamation can effectively remove dibenzyl disulphide (DBDS) from transformer oil but not elemental sulphur [1, 5]. Moreover, oil reclamation could also be responsible for several silver sulphide corrosion failures around the world [1, 3, 4]. In those incidents elemental sulphur ingress may have happened into the transformer oil from the sorbent clay. As mentioned, sorbent clay absorbs the corrosive sulphur compounds from oil along with oxidative by products [4]. To reuse the clay, it is thermally regenerated. If the regeneration is done with poor ventilation and oxygen supply, absorbed sulphur could be converted into elemental sulphur and remain in the clay [4]. Therefore, when using oil reclamation to mitigate silver sulphide corrosion, tracking of the oil corrosivity as well as corrosive sulphur compounds in the oil may be essential.



Silver sulphide corrosion in generator transformer OLTC (courtesy: Michael L O'Brien, GE)

Transformer oil passivation is the most successful short-term mitigation technique that has been used to prevent copper sulphide corrosion. According to the standard adding 100 ppm of passivator can provide significant protection to copper [1, 6]. However, it has been reported that passivator can not prevent silver sulphide corrosion even at higher concentrations [4]. The passivator effectiveness was comprehensively studied in the UQ laboratory and it has been found that passivation become ineffective if the oil contains elemental sulphur (even for small concentrations) [6]. But if the oil contains only DBDS, adding 300-400 ppm of passivator can provide significant protection to silver [6].

In addition to oil change and oil treatment strategies, maintaining the low oil temperature can significantly reduce the corrosion rate of silver sulphide. Therefore, reducing the loading of a contaminated transformer and improving the transformer cooling may slow down the corrosivity rate and buy more time for a utility to apply short term or long-term mitigation procedures to prevent silver sulphide corrosion. Apart from that new chemical treatment technologies are emerging to remove corrosive sulphur compounds, namely sulphur deactivation, liquid to liquid extraction and silver nitrate treatment, which could be available in commercial scale in the future [5].

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Acknowledgements are due to Energy Networks Australia for their funding in this project through ASTP Scheme. Thanks are also due to Powerlink Queensland and Energy Queensland for their continuous support in this research work. T&D

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Which Innovative Power Transformer Condition Monitoring Techniques and Asset Management Strategies will Reduce Costs and Increase your Transformer Fleet Performance?

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TOPICS:

- Effective signal processing for extracting data and information from sensor measurements
- Transformation of data into useful information regarding the condition of transformer (i.e. fault type identification)
- Integration of online sensor measurement and other information (i.e. offline measurement, human experts' judgments, industry standards and practices) inspection) to determine transformer health index
- Forecasting of condition degradation for power transformers - importance of linking all available condition information and of probability of failure curves- Transformer Condition scores
- Data required and process to determine adequate number of system spare power transformers
- Background and the need for Digital Enabled Substations
- Digitisation of transformer online data and information
- Practical application of transformer AVR in advanced VOLT-VAR control schemes in modern power systems with high penetration of renewable sources
- Transformer online data for power systems analysis using Artificial Intelligence (AI) and Machine Learning (ML)
- Major utility shares key transformer condition monitoring/asset management strategies
- Asset management principles
- Economic assessment of investments and optimal project timing
- Quantifying Transformer asset risks
- Understanding risk in redundant systems
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- Asset Performance Management of Transformers through Digitalization – the "TXpert Ecosystem"
- Introduction to Monitoring & Diagnostics using the 5W's approach, with the focus on its contribution to Maintenance
- Essential Monitoring (on-line & periodic) and the 80/20 rule
- Transformer Maintenance Cycles how they can be reduced, or eliminated
- Case Histories with good and not so good results
- Response Plan and Actions resulting from monitoring outputs
- Communications and Situational Awareness
- Introduction into MR FLEETSCAN 2D transformer condition assessment methodology
- Case-study and results of a FLEETSCAN 2D project in Germany for a DNSP transformer fleet
- Introduction about tests to identify corrosive/silver sulphur in transformer oil
- Case-study about corrosive sulphur transformer risk assessment based on MR´s FLEETSCAN 2D methodology
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