Case study: Testing regime for 11kV Circuit Breaker

Problem description:
How frequently should functional testing be carried out on 11kV circuit breakers?

In this case the organisation was seeking reduce costs whilst maintaining performance and managing risks by optimising their maintenance strategy. Intervals for intrusive planned maintenance had been extended, with increased use being made of condition monitoring techniques to target activities where they are needed.

There was a long-established practice of annual trip-test operation of circuit breakers but the organisation wanted to ascertain whether this was a worthwhile exercise, and to determine the optimum frequency that such testing should be carried out.

Results and benefits:
The cost/risk calculations revealed that the optimal interval for testing was at 48 months, rather than the existing 12 monthly cycle. This extension of testing interval yields a c.75% reduction of overall business impact (costs and risks). For the population of 4,000 such circuit breakers this represents a potential saving of £156,000 per year.

These values take account of the risks of switchgear functional failure due to ‘hidden’ failure modes, the cumulative deterioration risks between tests, switching and other costs of the trip-test itself. And it also incorporates any beneficial effects (e.g. grease redistribution reduces ‘stiction’) or failure risks introduced by the testing activity.

Electrical distribution utilities use medium voltage networks for the distribution of electricity from primary substations to local distribution substations close to the point of load. In many parts of the world distribution utilities use 10-13kV levels as the final step down before final low voltage delivery connections.

At each of these voltage step-downs and network connecting points, circuit breakers are used for protection and switching purposes. These breakers can use a variety of technologies, such as oil or sulphur hexafluoride gas as an arcing suppression medium.

There are many circuit breakers in service in a typical network; they are highly reliable and, in a protection/isolation role, normally remain passive until called upon to operate under fault conditions.

It is clearly essential that they operate correctly and rapidly when called upon to operate to disconnect a fault. Failure to do so can result in transformer overload (potential explosion) and other hazards to people and network equipment.

The study we performed
We were called in to support a multi-disciplined team study of the optimal testing strategy using the SALVO Process. This provides a structured navigation and evaluation discipline to ensure all factors, stakeholder interests, uncertainties and scenarios were explored, quantified and evaluated on a consistent and auditable basis.

This process was supported by real-time cost/risk modelling and ‘what if?’ calculations using the DST Inspection Evaluator™ tool.
This case involved a small team comprising inspectors, operations, maintenance and process safety personnel. It needed just 2 hours to build the basic scenario, using the SALVO storyboard for inspection decision-making, and DST Inspection Evaluator™ to model of the risks and costs and operational options available, and identify the optimal strategy. The team also developed a number of alternative scenarios and explored their impact of the optimum strategy.

The study, including analysis of sensitivity to all sources of data uncertainty, revealed that the optimal strategy was to carry out functional testing every 48 months.

The major factor in determining the optimum interval proved to be the direct cost of the labour for carrying out the test. The marginal increase in risk as a result of extending the test interval was carefully explored, considered acceptable and did not impact on safety.

Finally, a formal decision-recording stage ensured the capture of the optimal strategy, the implementation actions and audit trail so that the proposed change is fully documented and future revisions can easily understand why the strategy was set to 48-monthly.

To perform the complex reliability, risk and financial ‘what if?’ calculations, this study used decision-support software called DST Inspection Evaluator™. This tool was developed as part of the international SALVO project (www.SALVOproject.org) to support the analysis of asset inspection and condition monitoring decisions. Like other modules in the DST Asset Strategy Evaluator™ suite, the tool provides:

- A structured logic, with clear ‘storyboard’ checklist to ensure all factors are considered.
- Disciplined process to capture and quantify the knowledge of cross-disciplined teams, including their uncertainty.
- State-of-the-art analytical algorithms to evaluate the life cycle cost, risk and performance of decision options.
- Sophisticated, extremely rapid sensitivity-analysis to identify which assumptions have what effect upon the decision.
- Rapid creation and evaluation/comparison of multiple scenarios, enabling the study team to compare alternatives and explore ‘what if?’ ideas - instantly.

For further information about DST Inspection Evaluator™, and the SALVO Process, please contact:

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