Analysis of Breaker Open/Closed Probability

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1.0 Purpose

This analysis will derive a conditional probability spurious operation for the DC control circuit for a breaker circuit.

2.0 Background

Analysis of single spurious operation for DC circuits is performed separately by each expert. For my analysis, the following was obtained for a single target:

> *The analysis used values in the given data table of 43/87; 0.49 (0.39, 0.49, 0.60). Additionally, the testing was source centered and should be lowered by 20% (see previous recommendation) to 0.39 (0.3, 0.39, 0.6). Note UB is not reduced. Additionally, see below.*

> *Based on review of the data, the non-breaker data is 10/24 for SOVs, and 17/34 for others. This gives a total of 27/58 = 0.47 (0.33, 0.47, 0.60). This number is revised by 20% downward; to 0.38 (0.26, 0.38, 0.60).*

> *For DC Breakers, the data shows (43-27)/(87-58) = 16/29 = 0.55 (0.36, 0.55, 0.74), with a 20% reduction for source centered to 0.44 (0.3, 0.44, 0.7).*

> *Given the valves and breakers are similar, it is recommended to keep these combined above.*

> *Additionally, for MOVs, the MOV modifier can be applied, if accepted.*

As a result, a conditional probability for breaker spurious operation, given fire damage, is estimated above at 0.39.

The following was also included in the double break analysis:

> *Ungrounded DC TS Cable: Most of the DC testing involved circuits with a single target. However, the DC MOV included multiple targets with 2 possible spurious actuations. The data is as follows for the DC MOVs:*

> - *13 Intermediate Scale (IS) Tests and 12 Penlight Tests*
> - *6 IS tests with 1 or more actuations and 9 penlight tests.*
> - *2 IS tests with both targets actuated and 1 penlight with both actuated.*

- *Conditional probability of the second actuation given the first is 3/15 = 0.2*

Based on this review, the second event is considered independent of the first for DC circuits.

A similar review for TP shows no IS tests with a second actuation and 3 penlight test out of 17 total tests (12 Actuations). For armored, there is a 1 of 2 actuation of both targets, and for metal foil cable, there were no actuations in two tests. Overall, the evidence is the second target is independent of the first.

3.0 Discussion and Analysis

The above analysis, which shows a second spurious operation is independent of the first spurious operation, is much different than for AC Power (See the separate MOV analysis). For AC Circuits, the probability of a second spurious operation, given the first target is spuriously operated, is estimated at 0.8. In the case of DC power, we are estimating the second target to be impacted at a 0.39 probability, given the first is impacted.

Given the breaker is open, and spurious operation is to close the breaker, the following would be estimated to occur:

1) Breaker is closed, and no second spurious occurs – breaker ends up closed = 1-0.39 = 0.61
2) With an anti-pump circuit: the breaker initially closes and an open spurious occurs – breaker ends up open. Given the circuit is set up with the anti-pump relay; the initial closed signal will be interlocked out once the closure occurs, and the open actuation will occur when that occurs. However, a re-closure is not expected.
3) Without an anti-pump circuit: breaker will cycle open and closed unit the hot shorts are cleared (or the breaker fails. In this case; this means a 50/50 probability of ending up either closed or open. Without anti-pump circuit; the conditional probability of being opened is then calculated as 0.5 * 0.39 ~ 0.2.

4.0 Results

It is recommended to conservatively assume the circuit does not have an anti-pump circuit. As a result, a 20% reduction is recommended for the conditional spurious operation given fire damage. This changes (for this expert) the conditional probability from 0.39 to 0.31 (0.2, 0.31, 0.5).