Assessing the Distribution of the Probability of Spurious Operation
PROPONENT #1

Case	**P_SB_01_01** **Single Break Generic** **Grounded AC** **Intra-Cable** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	Intra-cable: 26 of 53 shorted C5 and 27 of 53 shorted C6.
Distribution obtained	Average = 26.5/53 or 0.50 (0.37, 0.50, 0.63) See adjustments below taking into account expert judgment.

Expert Judgment

EPRI TR-1003326, Section 12.1.6 provides a range for the various cable configurations (Actuation Biased, Center ground, source centered, non-actuation biased). The range for the various tests ranged from 22% to 58%, with an average of ~39%. The non-EPRI tests used the source-centered which was the 58% value. Given the non-EPRI testing (NRC testing) used the source-centered configuration; it is generally biased – roughly around 30% (~(0.58-0.4)/0.58 = 0.34). Given this constitutes around 2/3 of the testing results, an adjustment of 30% * 2/3 =20% should be applied. As a result the mean above (0.50) should be reduced by 20% to 0.40.
The range can be shown from the EPRI testing (22% to 58%). This is rounded to 20% and 60% for the LB and UB values (5^{th} and 95^{th}). The 25^{th} and 75^{th} are estimated as 0.3 and 0.5, respectively. The TP estimated value from Case 2-1 is 0.42 (0.25, 0.39, 0.5), prior to adjustment for source-centered testing. After adjustment, Case 2-1 gets 0.34 (0.2, 0.34, 0.6). When combined, the TS/TP value is the average of the two, or 0.37 (0.2, 0.37, 0.6).

Median	0.40 (see above)
Lower Quartile	0.20 (5^{th}), or 0.3 (25^{th})
Upper Quartile	0.60 (95^{th}) or 0.5 (75^{th}).
Justification of median and quartiles	See above.
Fitted distribution	Normal.

Expert's Additional Comments

For Grounded AC; recommend using the modifier for MOVs, sent through separate a white paper. See also recommendation to combine TS and TP Intra-Cable HSs.

Case	**P_SB_01_02** **Single Break Generic** **Grounded AC** **Inter-Cable** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	There were 7 inter-cable shorts reported in the EPRI/NEI tests, but all affecting single conductor cable targets. There were 26 EPRI tests. Of the 22 non-EPRI Thermoset tests where intercable was possible, there were no inter-cable hot shorts. This includes zero of 22 C5 and zero of 22 C6 opportunities. Given the EPRI and other tests are not poolable and should not be combined; the recommended approach for this is to use a Jeffries non-informative prior, using the 22 tests (e.g., ½ failure in 22+1 tests).
Distribution obtained	Using a 1/2 inter-cable hot short assumption in 22+1 tests, the following is determined: Inter-cable = 0.5/23 = 0.022 (0.0005, 0.018, 0.15). This is the statistical analysis, based on the highest expected value. Overall, the probability is expected to be less than the 0.022 value based on the previous EPRI expert panel discussion (results provided in NUREG/CR-6850). As an order of magnitude, a 0.01 value is recommended with UB of 0.1 and a lower bound of 0.0005.

Expert Judgment

Median	See above. 0.01
Lower Quartile	0.0005 (5^{th}), or 0.005 (25^{th})
Upper Quartile	0.1 (95^{th}) or 0.06 (75^{th}).
Justification of median and quartiles	5^{th} and 95^{th} for the Jeffries is listed above as 0.0005 and 0.15 for a median of 0.018. Although the median is lowered for the 0.01 estimate above, the 5^{th}/95^{th} LB/UB are assumed the same as the Jeffries value, while the 25^{th} is adjusted (since the 25^{th} LB would be above the median).
Fitted distribution	Binomial

Expert's Additional Comments

See separate white paper on MOV modifier.

Case	**P_SB_01_03** **Single Break Generic** **Grounded AC** **Aggregate** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	See separate analysis for Intra-Cable and Inter-Cable.
Distribution obtained	Total = 0.40 (0.2, 0.40, 0.6) + 0.01 (0.0005, 0.01, 0.1) = 0.41 (0.2, 0.41, 0.64)

Expert Judgment

Median	0.41
Lower Quartile	0.2 (5^{th}), or 0.3 (25^{th})
Upper Quartile	0.64 (95^{th}) or 0.53 (75^{th})
Justification of median and quartiles	Median and uncertainty Bounds for inter-cable and intra-cable are both adjusted using engineering judgment. LB/UB values are based on the Boolean sum of each. For example, the 75^{th} bound = 0.5 + (1-0.5)*0.06 = 0.53.
Fitted distribution	

Case	**P_SB_01_04** **Single Break Generic** **Ungrounded AC** **Intra-Cable** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	Intra-cable: 6 of 8 shorted C5 and 6 of 8 shorted C6. Average = 6/8 or 0.75 (0.35, 0.75, 0.97) **(See recommendation below).** See also case 1-1, which recommends adjusting the point estimate to account for source-centered configuration for testing. As a result, the point estimate is 0.75 * (1-.2) = 0.6. UB and LB are also adjusted to get (0.3, 0.6, 0.9).
Distribution obtained	**Recommendation:** Given TS and TP are so close, and given the low amount of tests; it is recommended to combine the two into a single HS probability = (6+3.5)/ (8+5) = 9.5/13 = 0.73 (0.46, 0.73, 0.91). However, this is modified below based on engineering judgment (source-centered configuration) by 20% to 0.58 (0.3, 0.58, 0.8).

Expert Judgment

Median	0.58 (assuming T-Set and T-Plastic are combined)
Lower Quartile	0.3 (5^{th}) or 0.5 (25^{th})
Upper Quartile	0.8 (95^{th}) or 0.7 (75^{th}).
Justification of median and quartiles	Based on discussions in the Grounded AC TS case; a source-centered test bias is judged to affect the results. As a result, a 20% reduction in the failure rate is applied to TS cable. Also, LB and UB are adjusted based on the 20% reduction, but with a smaller reduction on the UB. For example, the 75^{th} UB is 0.80 before the 20% reduction, and is adjusted to 0.7 (versus 0.8 * 0.8 = 0.64).
Fitted distribution	

Expert's Additional Comments

Overall, the statistical uncertainty appears to be conservative.

Case **P_SB_01_05**
Single Break Generic
Ungrounded AC
Inter-Cable
TS source cable
TS target cable

Statistical Analyses

Description of Analyses	0 of 8 occurrences for both C5 and C6. However, considered no test data during the data analysis due to inadequate opportunity for inter-cable spurious operation.
Distribution obtained	None (see below)

Expert Judgment

Discussion: None occurred in 8 tests. Additionally, a review of the failure modes for this circuit indicate that the spurious operation would require either two hot shorts between two multi-conductor cables, or a single hot short and a ground on the negative side of the target. This is considered less likely, and is judged to be less than the Base Case inter-cable.
Based on this, an estimate of 1E-03 is recommended with an UB of 0.01 and a LB of 1E-04. The UB and LB are based on engineering judgment, but are similar to other low probability spurious operation probabilities in the analysis.

Mean (not median).	Inter-cable = 0.001
Lower Quartile	1E-04
Upper Quartile	0.01
Justification of median and quartiles	See above

Case	**P_SB_01_06** **Single Break Generic** **Ungrounded AC** **Aggregate** **TS source cable** **TS target cable**

Statistical Analyses

If you carry out statistical analyses, please document your evaluation in the following table.

Description of Analyses	Total of Proponent 1 Intra-Cable 0.58 (0.3, 0.58, 0.8) and Inter-Cable 0.001 (0.0001, 0.001, 0.01)
Distribution obtained	0.58 (0.3, 0.58, 0.8)

Expert Judgment

If you use expert judgment, please document your evaluation in the following table.

See above. Expert Judgment is used for the Inter-cable value, and a 20% reduction in the intra-cable value based on testing bias (source centered testing). Also includes the recommendation to combine T-Set and T-Plastic Cables. Would be slightly higher (0.3, 0.6, 0.9) if not combined.

Case	**P_SB_01_07** **Single Break Generic** **Ungrounded DC** **Intra-Cable** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	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.
Distribution obtained	See below

Expert Judgment

Median	0.39
Lower Quartile	0.3 (5^{th}), 0.35 (25^{th})
Upper Quartile	0.60 (95^{th}), 0.5 (75^{th})
Justification of median and quartiles	LB based on statistical Binomial confidence intervals with 20% reduction for source centered. UB based on original UB confidence intervals without reduction (rounded).

Expert's Additional Comments

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.

Case	**P_SB_01_08** **Single Break Generic** **Ungrounded DC** **Inter-Cable** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	Zero failures in 53 (estimated) opportunities using the penlight data (zero in 45 without), although not all are likely opportunities.
Distribution obtained	Based on Jeffries non-informative prior; = 0.5/54 = 0.009. However, see below. Recommended value of 0.001 (0.0005, 0.001, 0.01).

Expert Judgment

Median	Considered unlikely (0.001). See below
Lower Quartile	0.0005 (5^{th})
Upper Quartile	0.01 (95^{th})
Justification of median and quartiles	Since it is a single failure (hot to target), multi-conductor to multi-conductor, this is similar, but less likely than Case 1-2.
Fitted distribution	

Expert's Additional Comments

Given there is significant data, with no inter-cable HSs for ungrounded DC, and given it takes a specific set of failures; the TS inter-cable HS is considered unlikely. This is considered less likely than the 1-2 case (inter-cable, TS, grounded AC).

Case	**P_SB_01_09** **Single Break Generic** **Ungrounded DC** **Multiple Shorts Ground** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	See the Updated Table Counts 12-06-12
Distribution obtained	= 14/87 =0.16 (0.09, 0.16, 0.26). 25th = 0.13, 75th = 0.20 This is assuming penlight is included. However, with penlight removed; = 9/49 = 0.18 (0.09, 0.18, 0.30). Recommend including penlight, since there is not a lot of difference. However, modifying the UB based on the penlight removed. Result = (0.09, 0.16, 0.30)

Case	**P_SB_01_10** **Single Break Generic** **Ungrounded DC** **Aggregate** **TS source cable** **TS target cable**

Statistical Analyses

Description of Analyses	See updated table counts 6-20 Intra cable = 0.39 (0.30, 0.39, 0.60), inter-cable less than 1E-03, multiple grounds = (0.09, 0.16, 0.30). Summation is based on the Boolean Sum.
Distribution obtained	= 0.39 + 0.001* (1-0.39) + 0.16 * (1-.391) **= 0.49 (0.36, 0.49, 0.72)** with 5th and 95th listed based on Boolean Sum. For example, UB = 0.60 + 0.01 * (1-0.6) + 0.30 * (1-0.604) = 0.72

Case	**P_SB_02_01** **Single Break Generic** **Grounded AC** **Intra-Cable** **TP source cable** **TP target cable**	**P_SB_03_01** **Single Break Generic** **Grounded AC** **Intra-Cable** **TS source cable – Note Source cable doesn't matter here…** **TP target cable**

These two cases were combined into a single case.

Statistical Analyses

Description of Analyses	15 of 32 shorted C5 and 12 of 32 shorted C6. Average = 13.5/32
Distribution obtained	Average = 0.42 (0.2, 0.42, 0.6) – Upper and Lower bound based on Engineering Judgment, which is wider than the statistical uncertainty. See also below for source centered modification and combination of TS and TP.

Expert Judgment

Median	= 0.42 * 0.8 = 0.34 – adjusted for source centered testing. See case 1-1.
Lower Quartile	0.16 (5^{th}) or 0.30 (25^{th}) – adjusted from the statistical value above by ~20%
Upper Quartile	0.6(95^{th}) or 0.40 (75^{th}) - 95^{th} not adjusted (kept at .6), while 75^{th} adjusted by 20%.
Justification of median and quartiles	See below.
Fitted distribution	

Expert's Additional Comments

Recommend combining Intra-cable TS and TP data; TS ~ 0.40, and TP ~ 0.34 (after adjustment for source-centered testing). When combined, the TS/TP value is the average of the two, or 0.37 (0.2, 0.37, 0.6)

Case **P_SB_02_02**
Single Break Generic
Grounded AC
Inter-Cable
TP source cable
TP target cable

Statistical Analyses

Description of Analyses	0 C5 and 0 C6 of 24 tests. 9 EPRI are not counted, since they are single to multi-conductor inter-cable interactions (no Multi-conductor to multi-conductor). The recommended approach for this is to use a Jeffries non-informative prior, using the 24 tests (e.g., ½ failure in 24+1 tests).
Distribution obtained	Average = 0.5/25 = 0.02 (0.002, 0.02, 0.1). This is the statistical analysis, based on the highest expected value. Overall, similar to case 1-2, the probability is expected to be less than the 0.02 value. As an order of magnitude, a 0.01 value is recommended with UB of 0.1 and a lower bound of 0.0005. This is similar to the TS case 01-02.

Expert Judgment

See above

If you use expert judgment, please document your evaluation in the following table.

Median	0.01
Lower Quartile	0.0005 (5th)
Upper Quartile	0.1 (95th)
Justification of median and quartiles	See Case 1-2 above. Similar judgment used for estimating the Median (lower than the Jeffries), and estimating the UB/LB.
Fitted distribution	

Case **P_SB_02_03**
Single Break Generic
Grounded AC
Aggregate
TP source cable
TP target cable

Statistical Analyses

If you carry out statistical analyses, please document your evaluation in the following table.

Description of Analyses	Intra-Cable: 0.37 (0.2, 0.37, 0.6) – including source-centered adjustment, and **combination with TS** Inter-Cable TP Source = 0.01 (0.0005, 0.01, 0.1)
Distribution obtained	Total = 0.38 (0.2, 0.38, 0.64) If not combined with TS; should be the arithmetic mean of the two cases 2-1 and 2-2.

Case	**P_SB_02_04**	**P_SB_03_04**
	Single Break Generic	**Single Break Generic**
	Ungrounded AC	**Ungrounded AC**
	Intra-Cable	**Intra-Cable**
	TP source cable	**TS source cable**
	TP target cable	**TP target cable**

These two cases were combined into a single case.

Statistical Analyses

Description of Analyses	3 of 5 shorted C5 and 4/5 shorted C6. Average = 3.5 of 5. **(See recommendation below).** See also case 1-1, which recommends adjusting the point estimate to account for source-centered configuration for testing. As a result, the point estimate is 0.70 * (1-.2) = 0.56. UB and LB are also adjusted to get (0.2, 0.56, 0.8).

Distribution obtained	If Recommendation not accepted: 0.56 (0.2, 0.56, 0.8). **Recommendation:** Given TS and TP are so close, and given the low amount of tests; it is recommended to combine the two into a single HS probability = (6+3.5)/ (8+5) = 9.5/13 = 0.73 (0.46, 0.73, 0.91). However, this is modified below based on engineering judgment (source-centered configuration) by 20% to 0.58 (0.3, 0.58, 0.8).

Expert Judgment

Median	0.58 (assuming T-Set and T-Plastic are combined)
Lower Quartile	0.3 (5^{th}) or 0.5 (25^{th})
Upper Quartile	0.8 (95^{th}) or 0.7 (75^{th}).
Justification of median and quartiles	Based on discussions in the Grounded AC TS case; a source-centered test bias is judged to affect the results. As a result, a 20% reduction in the failure rate is applied to TS cable. Also, LB and UB are adjusted based on the 20% reduction, but with a smaller reduction on the UB. For example, the 75^{th} UB is 0.80 before the 20% reduction, and is adjusted to 0.7 (versus 0.8 * 0.8 = 0.64).
Fitted distribution	

Case	**P_SB_02_05** **Single Break Generic** **Ungrounded AC** **Inter-Cable** **TP source cable** **TP target cable**

Statistical Analyses

Description of Analyses	Zero failures in 5 tests, listed as no test data in the table.
Distribution obtained	N/A – See below

Expert Judgment

Median	0.01
Lower Quartile	0.0005 (5^{th})
Upper Quartile	0.1 (95^{th})
Justification of median and quartiles	See below
Fitted distribution	

Expert's Additional Comments

Similar to the TS, there were zero inter-cable hot shorts in 5 tests for both C5 and C6 contacts. However, this may be due to the high number of intra-cable HSs. It is recommended to use a

higher value than the Inter-cable failure rate calculated for the ungrounded case; as a result, an unlikely recommendation is provided, similar to grounded AC:

Inter-cable = 0.01 (0.0005, 0.01, 0.1)

Case	**P_SB_02_06** **Single Break Generic** **Ungrounded AC** **Aggregate** **TP source cable** **TP target cable**

Statistical Analyses

Description of Analyses	Intra-Cable: 0.58 (0.3, 0.58, 0.8) Inter-cable (based on grounded) = 0.01 (0.0005, 0.01, 0.01)
Distribution obtained	Aggregate = 0.59 (0.4, 0.71, 0.81)

Case	**P_SB_02_07** **Single Break Generic** **Ungrounded DC** **Intra-Cable** **TP source cable** **TP target cable**	**P_SB_03_07** **Single Break Generic** **Ungrounded DC** **Intra-Cable – Doesn't make sense (intra cable with TS-TP?)** **TS source cable** **TP target cable**

These two cases were combined into a single case.

Statistical Analyses

Description of Analyses	Use data directly = 35/64
Distribution obtained	0.55 (0.44, 0.55, 0.65) – 5^{th}/95^{th} However; adjusted for the 20% source centered testing (see 1-1), the final recommended result is 0.56 * .8 = **0.44 (0.35, 0.45, 0.65)**

Expert Judgment

Median	0.44
Lower Quartile	0.35 (5^{th}), 0.4 (25^{th})
Upper Quartile	0.65 (95^{th}) , 0.55 (75^{th})
Justification of median and quartiles	0.34 is based on calculated value above 0.43 reduced by 20%. UB remains similar to the above, without reduction. 25^{th} and 75^{th} based on engineering judgment, based on 5^{th} and 95^{th} estimates.
Fitted	

distribution

Expert's Additional Comments

With the large amount of data; the uncertainty bounds can be based on the statistical estimates above, without significant uncertainty added.

Case **P_SB_02_08**
Single Break Generic
Ungrounded DC
Inter-Cable
TP source cable
TP target cable

Statistical Analyses

Description of Analyses	No data in 36 tests, including penlight.
Distribution obtained	Considered Unlikely (e.g., 0.01 median)

Expert Judgment

Median	0.01
Lower Quartile	0.001
Upper Quartile	0.1
Justification of median and quartiles	Used unlikely similar to the previous estimates. Based on the number of tests, would consider lower. However, since it is not clear about the number of possible interactions; the median of 0.01 seems reasonable.
Fitted distribution	

Case **P_SB_02_09**
Single Break Generic
Ungrounded DC
Multiple Shorts Ground
TP source cable
TP target cable

Statistical Analyses

Description of Analyses	See the data table; 9 failures in 64 tests, including penlight (3 in 36 if penlight is not included).
Distribution	= 9/64 = 0.14 (0.08, 0.14, 0.23) – 5^{th}/95^{th}

obtained

Expert's Additional Comments

May want to consider combining with TS failures (case 1-9) = 0.20. Average would be 0.17.

Case	**P_SB_02_10** **Single Break Generic** **Ungrounded DC** **Aggregate** **TP source cable** **TP target cable**

Statistical Analyses

Description of Analyses	See Cases 2-7 to 2-9. = 0.45 (0.35, 0.45, 0.65) + 0.01 (0.001, 0.01, 0.1) + 0.14 (0.08, 0.14, 0.23) Median = 0.45 + 0.01 * (1-0.45) + 0.14 * (1-0.451) **= 0.53 (0.40, 0.53, 0.75)**
Distribution obtained	

Case	**P_SB_04_01 (now 03-01)** **Single Break Generic** **Grounded AC** **Intra-Cable** **Cable includes a grounded metal foil shield wrap**

Statistical Analyses

Description of Analyses	Intra-Cable: 0 of 5 shorted C5 and 2 of 5 shorted C6. Average = 1/5
Distribution obtained	0.2 (0.0051, 0.20, 0.72) See below

Expert Judgment

Median	0.20
Lower Quartile	0.037 (5^{th}), 0.10 (25^{th})
Upper Quartile	0.51 (95^{th}), 0.36 (75^{th})
Justification of median and quartiles	Statistical mean appears too wide, based on 5 tests. If you use 2/10, you get much smaller uncertainty. Additionally, we believe the value is below 1-1 and 1-2, which would mean the UB should be below ~ 0.5. LB and UB values based on 2/10 using binomial confidence intervals.

Fitted distribution	

Case **P_SB_04_03 (now 03-03)**
Single Break Generic
Grounded AC
Aggregate
Cable includes a grounded metal foil shield wrap

Statistical Analyses

Description of Analyses	Same as Intra-Cable since inter- cable is considered unlikely.
Distribution obtained	0.2 (0.037, 0.20, 0.51) – 5^{th}/95^{th}.

Case **P_SB_04_04 (now 03-04)**
Single Break Generic
Ungrounded AC
Intra-Cable
Cable includes a grounded metal foil shield wrap

Statistical Analyses

Description of Analyses	N/A – See below No Direct Data.
Distribution obtained	

Expert Judgment

Mean	0.30
Lower Quartile	0.04 (5^{th})
Upper Quartile	0.70 (95^{th})
Justification of median and quartiles	See below
Fitted distribution	

Expert's Additional Comments

Given no direct data, it is recommended that the ratio of the TS for Ungrounded (0.58) and grounded (0.40) (both adjusted for source-centered) multiplied by the Grounded AC HS probability for metal foil cable (0.2 (0.037, 0.2, 0.51)). This results in the following:

Intra-Cable = 0.2 * (0.58/0.4) = 0.29 (0.008, 0.30, 0.70) – Note: LB/UB based on expert opinion.
Inter-Cable considered unlikely.

Case **P_SB_04_06 (now 03-06)**
Single Break Generic
Ungrounded AC
Aggregate
Cable includes a grounded metal foil shield wrap

Statistical Analyses

Description of Analyses	Same as Intra-Cable
Distribution obtained	0.3 (0.04, 0.30, 0.70) – Note: LB/UB based on expert opinion.

Case **P_SB_04_07 (now 03-07)**
Single Break Generic
Ungrounded DC
Intra-Cable
Cable includes a grounded metal foil shield wrap

Statistical Analyses

Description of Analyses	Used the Updated Table Counts data directly.
Distribution obtained	= 3/7 = 0.43 (0.13, 0.43, 0.77)

Case **P_SB_04_09 (now 03-09)**
Single Break Generic
Ungrounded DC
Multiple Shorts Ground
Cable includes a grounded metal foil shield wrap

Statistical Analyses

Description of Analyses	Use the data directly.
Distribution obtained	= 2/7 0.29 (0.053, 0.29, 0.66)

Case	**P_SB_04_10 (now 03-10)** **Single Break Generic** **Ungrounded DC** **Aggregate** **Cable includes a grounded metal foil shield wrap**

Statistical Analyses

Description of Analyses	Used data directly.
Distribution obtained	= 5/7 0.71 (0.34, 0.71, 0.947)

Case	**P_SB_05_01 (now 04-01)** **Single Break Generic** **Grounded AC** **Intra-Cable** **Cable includes an un-insulated grounded drain wire**

Statistical Analyses

Description of Analyses	0 of 1 shorted C5 and 0 of 1 shorted C6.
Distribution obtained	Jeffries Non-Informative Prior would result in 0.5/2 = 0.25. LB = 0.1, UB = 0.6 (based on TS intra-cable). This appears to be around the right magnitude since it is above the shielded value (~ 0.2) and below the TS or TP unshielded value (~ 0.5). If you use both contacts; Jeffries non-informative prior would be 0.5 of 3; which gives 0.16. This appears to be too low, since it is below the Shielded case.

Expert Judgment

Median	0.25
Lower Quartile	0.1 (5^{th})
Upper Quartile	0.6 (95^{th})
Justification of median and quartiles	See above.
Fitted distribution	

Case	**P_SB_05_02 (now 04-02)** **Single Break Generic** **Grounded AC** **Inter-Cable** **Cable includes an un-insulated grounded drain wire**

Expert Judgment

If you use expert judgment, please document your evaluation in the following table.

Median	0.001
Lower Quartile	0.0001
Upper Quartile	0.01
Justification of median and quartiles	EF 10 estimated.
Fitted distribution	

Expert's Additional Comments

Inter-cable: 0.019 and 0.016 are the values for TS and TP cables above. Likely, the value for un-insulated ground drain wire will be much lower. Given the likely upperbound is likely a factor of 10 lower, a recommended value of 0.001 is estimated based on engineering judgment, EF =10. 1E-03 is the value I estimate for highly unlikely, which includes the X-ed out boxes on the table. The unlikely boxes, typically gray, are more likely ~1e-02. The case above appears to be lower than 1E-02, but there is insufficient data to validate this.

Case **P_SB_05_03 (now 04-03)**
Single Break Generic
Grounded AC
Aggregate
Cable includes an un-insulated grounded drain wire

Statistical Analyses

If you carry out statistical analyses, please document your evaluation in the following table.

Description of Analyses	Basically, using the Intra-Cable Value since inter-cable estimated as 0.001
Distribution obtained	0.2 (0.0051, 0.20, 0.73)

Case **P_SB_06_01 (now 05-01)**
Single Break Generic
Grounded AC
Intra-Cable
Armored 7/C Cable

Expert Judgment

If you use expert judgment, please document your evaluation in the following table.

Mean	0.07 (does not include and insights from the Duke Tests)
Lower Quartile	0.004 (5^{th}) and 0.04 (25^{th}).
Upper Quartile	0.4 (95^{th}) and 0.2 (75^{th})

Justification of median and quartiles	See below
Fitted distribution	

Expert's Additional Comments

1/7 for C5 and 1/7 for C6. However, the one test was from the EPRI test where the armored cable exceeded its minimum bend radius. For the resulting probability tables, this failure was removed (resulting in the estimated values in NUREG/CR-6850 of 0.075 with CPT). Several alternatives are possible; a) Use 1 of 7 as an average; which gives 0.14, b) Use 0.5 of 6+1, based on Jeffries non-informative prior; which gives 0.071 or c) some alternate method. It is recommended to use option b, given the agreement of the original expert panel that the single hot short observed occurred in a cable configuration not allowed in a plant installation.

Intra-Cable Average = 0.5/7 = 0.07 (0.004, 0.07, 0.4).

It is expected, if the Duke tests were incorporated, the value would decrease to around 0.04 or so, since there were no additional HSs for grounded AC circuits in the Duke Tests per the summary report.

Case **P_SB_06_03 (now 05-03)**
Single Break Generic
Grounded AC
Aggregate
Armored 7/C Cable

Statistical Analyses

Description of Analyses	Since Inter-Cable is considered unlikely, use Intra-cable
Distribution obtained	0.07 (0.004, 0.07, 0.4) $5^{th}/95^{th}$

Expert's Additional Comments

See Intercable discussion.

Case **P_SB_06_04 (now 05-04)**
Single Break Generic
Ungrounded AC
Intra-Cable
Armored 7/C Cable

Expert Judgment

Median	0.5
Lower Quartile	0.2 (5^{th}) and 0.4 (25^{th})
Upper Quartile	0.9 (95^{th}) and 0.6 (75^{th})
Justification of median and quartiles	Use ungrounded DC, considering Duke Tests, with some reduction for AC.
Fitted distribution	

Expert's Additional Comments

See analysis for Metal foil shielded wrap as follows:

Given no direct data, it is recommended that the ratio of the TS for Ungrounded (0.58) and grounded (0.40) (both adjusted for source-centered) multiplied by the Grounded AC HS probability for metal foil cable (0.2 (0.037, 0.2, 0.51)). This results in the following:
*Intra-Cable = 0.2 * (0.58/0.4) = 0.29 (0.008, 0.30, 0.70) – Note: LB/UB based on expert opinion.*
Inter-Cable considered unlikely.

Using a similar approach above for armored cable, grounded is (0.004, 0.07, 0.4). Result is:
Intra-cable Armored Cable = 0.10 (0.006, 0.10, 0.6).

However; based on engineering judgment; the value should be more similar to the ungrounded DC. The ungrounded DC = 9/12 = 0.75 (0.47, 0.75, 0.928). Including the Duke testing, the number is roughly 0.5 to 0.6. Based on engineering judgment, the resulting ungrounded AC is recommended to be (0.2, 0.5, 0.9).

Case **P_SB_06_06 (now 05-06)**
Single Break Generic
Ungrounded AC
Aggregate
Armored 7/C Cable

Statistical Analyses

Description of Analyses	Since inter-cable is considered unlikely, use Intra-Cable.
Distribution obtained	0.5 (0.2, 0.5, 0.9)

Case **P_SB_06_07 (now 05-07)**
Single Break Generic
Ungrounded DC
Intra-Cable

Armored 7/C Cable

Statistical Analyses

Description of Analyses	Use data from table
Distribution obtained	= 9/12 0.75 (0.47, 0.75, 0.93). The 25th and 75th are 0.6 and 0.85, respectfully.

The above does not include any of the Duke Power Test insights. Likely, the results would be slightly lower when this is accounted for in the results.

Expert's Additional Comments

UB and LB (all) bounds are based on statistical estimates.

Case **P_SB_06_09 (Now 05-09)**
Single Break Generic
Ungrounded DC
Multiple Shorts Ground
Armored 7/C Cable

Statistical Analyses

Description of Analyses	Use data directly.
Distribution obtained	= 5/12 0.42 (0.18, 0.42, 0.68) – 5th/95th

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Case **P_SB_06_10 (now 05-10)**
Single Break Generic
Ungrounded DC
Aggregate
Armored 7/C Cable

Statistical Analyses

Description of Analyses	Use Table Values
Distribution obtained	= 11/12 0.92 (0.66, 0.92, 0.996) – 5th/95th Should get similar if using Boolean Sum of the two independent values, so recommending for this case; recommend using the data directly for this case.