

AusNet Transmission Group Pty Ltd

Transmission Revenue Review 2017-2022

Appendix 7A: Fitting probability distributions to Service Component data

Submitted: 30 October 2015



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| 1 | 14/08/2015 | Initial issue | Rob Ball | Tom Hallam |
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ISSUE/AMENDMENT STATUS

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Contact

This document is the responsibility of the Regulation and Network Strategy Division of AusNet Services. Please contact the undersigned or author with any inquiries.

Rob Ball AusNet Services Level 31, 2 Southbank Boulevard Melbourne Victoria 3006 Ph: (03) 9695 6281

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| 3 | Addendum 28 October 2015 | 40 |
| 3.1 | Correction of input data | |

1 Service Component Parameters

This Appendix sets out the information used to calculate AusNet Services' proposed Service Component caps and collars, as presented in section 7.3.2 of the Revenue Proposal. This information was obtained using the @RISK product, a risk analysis and simulation add-in tool for Microsoft Excel.

For each parameter, proposed caps and collars have been set equal to the 5th and 95th percentiles, respectively, of the probability distribution that provides the best fit to the relevant historical data. This approach aligns with that adopted by the AER in AusNet Services' current determination and in recent determinations for TransGrid and TasNetworks.

For two sub-parameters (loss of supply event frequency (>0.30 system minutes) and incorrect operational isolation of primary or secondary equipment), the IntUniform distribution was found to be the best fit. However, to align with the AER's approach for the current determination , the Poisson distribution has instead been used to set caps and collars for these sub-parameters.

The following table summarises the probability distributions and percentiles underpinning the proposed caps and collars.

Table 1.1: Summary of probability distributions and percentiles

| Parameter | Preferred Distribution | 5th percentile | 95th percentile |
|--|------------------------|----------------|-----------------|
| Line outage rate (fault) | Erlang | 0.1592 | 0.3571 |
| Line outage rate (forced) | Lognorm | 0.1232 | 0.1730 |
| Reactive plant outage rate (fault) | LogLogistic | 0.2173 | 0.5570 |
| Reactive plant outage rate (forced) | Erlang | 0.1336 | 0.4414 |
| Transformer outage rate (fault) | Rayleigh | 0.0469 | 0.3585 |
| Transformer outage rate (forced) | Weibull | 0.0620 | 0.1537 |
| Number of events >0.05 system minutes | Hypergeometric | 0.0000 | 5.0000 |
| Number of events >0.30 system minutes | Poisson | 0.0000 | 2.0000 |
| Average outage duration | Weibull | 1.7200 | 253.8200 |
| Failure of protection equipment | Poisson | 20.0000 | 38.0000 |
| Material failure of SCADA system | Geometric | 0.0000 | 6.0000 |
| Incorrect operational isolation of primary or secondary equipment | Poisson | 2.0000 | 10.0000 |

The remainder of this document sets out the rationale for selecting each distribution and the underlying percentile data as calculated by @RISK.

1.1 Service parameter 1 – average circuit outage rate

1.1.1 Lines outage rate – fault (continuous)

Findings:

- A-D fit statistic: Erlang distribution best fit, standard deviation 0.0606
- K-S fit statistic: Weibull distribution best fit, standard deviation 0.0583
- A-D preferred (Erlang) due to data falling in both middle and tails of distribution

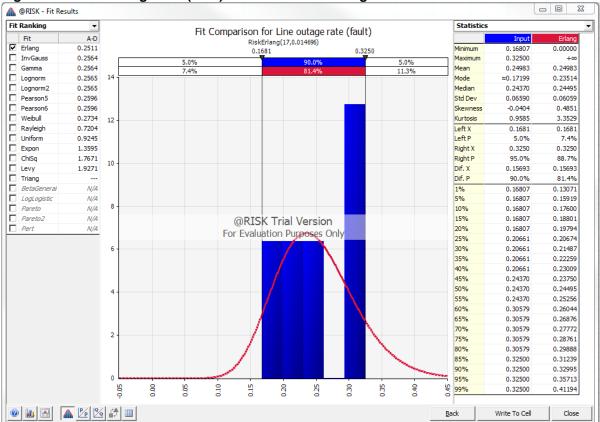
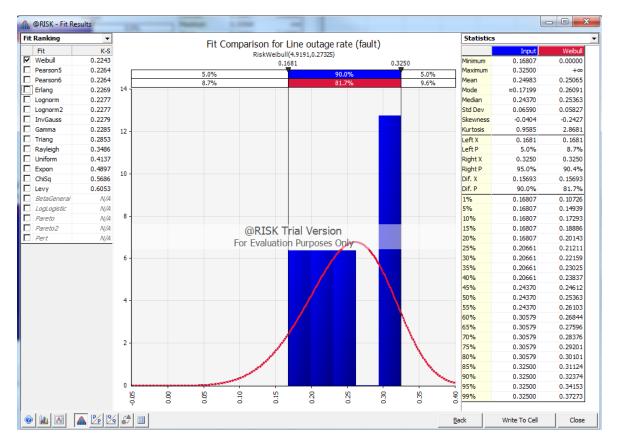


Figure 1.1: Lines outage rate (fault) – distribution fit using A-D

| it Ranking | • | | Input | Erlang | InvGauss | Gamma | Lognorm | Lognorm2 | Pearson5 | |
|----------------------|--------|---|--|-----------|-----------|-----------|-----------|-----------|-----------|----|
| Fit | A-D | - Rankings By Fit Statisti | c [14 Valid Fits] | I | | | | | | |
| Erlang | 0.2511 | Akaike (AIC) | | #6 | #7 | #5 | #8 (Tie) | #8 (Tie) | #10 | |
| InvGauss | 0.2564 | Bayesian (BIC) | | #4 | #5 | #3 | #6 (Tie) | #6 (Tie) | #8 | |
| Gamma | 0.2564 | Chi-Sq Statistic | | #1 (Tie) | |
| Lognorm | 0.2565 | K-S Statistic | | #4 | #7 | #8 | #5 (Tie) | #5 (Tie) | #2 | |
| Lognorm2 | 0.2565 | A-D Statistic | | #1 | #2 | #3 | #4 | #5 | #6 | |
| Pearson5 Pearson6 | 0.2596 | Parameters - [* Values | and the second states of the s | | | #5 | *** | #5 | #0 | |
| Weibull | 0.2396 | | | | | | | | | |
| Rayleigh | 0.7204 | Num. Est. Parameters | | 2 | 2 | 2 | 2 | 2 | 2 | |
| Uniform | 0.9245 | Fitted Parameter #1 | | m | mu | alpha | mu | mu | alpha | |
| Expon | 1.3595 | Fitted Value | | 17 | 0.2498 | 17.276 | 0.25002 | -1.4162 | 16.672 | 1 |
| ChiSq | 1.7671 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| Levy | 1.9271 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| Triang | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| BetaGeneral | N/A | Fitted Parameter #2 | | beta | lambda | beta | sigma | sigma | beta | - |
| LogLogistic | N/A | Fitted Value | | 0.0147 | 4.0744 | 0.0145 | 0.062129 | 0.24479 | 3.9246 | |
| Pareto | N/A | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| Pareto2 | N/A | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| Pert | N/A | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| | | Fitted Parameter #3 | | NA | N/A | NA | N/A | NA | N/A | |
| | | | | | | | | | | - |
| | | Fitted Value | | | | | | | | 2. |
| | | 95% Lower Limit* | | | | | | | | |
| | | 95% Upper Limit* | | | | | | | | |
| | | Conf. Interval Width* | | | | | | | | |
| | | Distribution Statistics | | | | | | | | |
| | | Minimum | 0.1681 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | Maximum | 0.3250 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | Mean | 0.2498 | 0.2498 | 0.2498 | 0.2498 | 0.2500 | 0.2500 | 0.2504 | 0. |
| | | Mode | 0.1720 [est] | 0.2351 | 0.2279 | 0.2354 | 0.2285 | 0.2285 | 0.2221 | 0. |
| | | Median | 0.2437 | 0.2450 | 0.2424 | 0.2450 | 0.2426 | 0.2426 | 0.2402 | 0. |
| | | Std. Deviation | 0.0659 | 0.0606 | 0.0619 | 0.0601 | 0.0621 | 0.0621 | 0.0654 | 0. |
| | | Skewness | -0.0404 | 0.4851 | 0.7429 | 0.4812 | 0.7608 | 0.7608 | 1,1207 | 0. |
| | | | 0.9585 | 3.3529 | 3.9198 | 3.3473 | 4.0467 | 4.0467 | 5,5060 | |
| | | Kurtosis | 0.9585 | 3.3529 | 3.9198 | 3.3473 | 4.0467 | 4.0467 | 5.5060 | |
| | | • | | | | | | | | Þ |

Figure 1.2: Lines outage rate (fault) – statistics table using A-D

Figure 1.3: Lines outage rate (fault) – distribution fit using K-S



| Fit Ranking | - | | Input | Weibull | Pearson5 | Pearson6 | Erlang | Lognorm | Lognorm2 | |
|----------------------|---------------|---|-------------------------------------|-----------|-----------|-------------|-----------|-----------|-----------|---|
| Fit | K-S | - Rankings By Fit Statist | c [14 Valid Fits] | | | | | | | |
| Veibull | 0.2243 | Akaike (AIC) | | #4 | #10 | #14 | #6 | #8 (Tie) | #8 (Tie) | |
| Pearson5 | 0.2264 | Bayesian (BIC) | | #2 | #8 | #9 | #4 | #6 (Tie) | #6 (Tie) | |
| Pearson6 | 0.2264 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | |
| Erlang | 0.2269 | K-S Statistic | | #1 | #2 | #3 | #4 | #5 (Tie) | #5 (Tie) | |
| Lognorm | 0.2277 | A-D Statistic | | #8 | #6 | #7 | #1 | #4 | #5 | |
| Lognorm2 InvGauss | 0.2277 | | and the second state and the second | | | | #1 | #1 | #5 | |
| Gamma | 0.2279 | - Parameters - [* Values | unavaliable without | | - | - | - | - | | |
| Triang | 0.2253 | Num. Est. Parameters | | 2 | 2 | 3 | 2 | 2 | 2 | |
| Rayleigh | 0.3486 | Fitted Parameter #1 | | alpha | alpha | alpha 1 | m | mu | mu | |
| Uniform | 0.4137 | Fitted Value | | 4.9191 | 16.672 | 13423160.2 | 17 | 0.25002 | -1.4162 | |
| Expon | 0.4897 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| ChiSq | 0.5686 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| Levy | 0.6053 | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| BetaGeneral | N/A | Fitted Parameter #2 | | beta | beta | alpha2 | beta | sigma | sigma | |
| LogLogistic | N/A | Fitted Value | | 0.2733 | 3.9246 | 16.672 | 0.0147 | 0.062129 | 0.24479 | |
| Pareto | N/A | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| Pareto2 | N/A | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| Pert | N/A | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | N/A | |
| | | Fitted Parameter #3 | | 17/0 | 17/0 | beta | 17/0 | | 17/0 | |
| | | Fitted Value | | | | 2.92373E-07 | | | | |
| | | | | | | | | | | |
| | | 95% Lower Limit* | | | | N/A | | | | |
| | | 95% Upper Limit* | | | | N/A | | | | |
| | | Conf. Interval Width* | | | | N/A | | | | |
| | | Distribution Statistics | | | | | | | | |
| | | Minimum | 0.1681 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | Maximum | 0.3250 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | Mean | 0.2498 | 0.2507 | 0.2504 | 0.250419328 | 0.2498 | 0.2500 | 0.2500 | |
| | | Mode | 0.1720 [est] | 0.2609 | 0.2221 | 0.222078473 | 0.2351 | 0.2285 | 0.2285 | |
| | | Median | 0.2437 | 0.2536 | 0.2402 | 0.240183745 | 0.2450 | 0.2426 | 0.2426 | |
| | | Std. Deviation | 0.0659 | 0.0583 | 0.0654 | 0.065376818 | 0.0606 | 0.0621 | 0.0621 | |
| | | Skewness | -0.0404 | -0.2427 | 1,1207 | 1,1207 | 0.4851 | 0.7608 | 0.7608 | |
| | | Kurtosis | 0.9585 | 2.8682 | 5.5060 | 5,5060 | 3.3529 | 4.0467 | 4.0467 | |
| | | itur tusis | 0.9303 | 2,0002 | 5.5000 | 3.3000 | 3.3329 | 1.0107 | 1.040.1 | |
| | ا کا اکر ا | • | | | | | | | | • |

Figure 1.4: Lines outage rate (fault) – statistics table using K-S

1.1.2 Lines outage rate – forced (continuous)

Findings:

- A-D fit statistic: Gamma distribution best fit, standard deviation 0.01507
 - Erlang very close. Slightly worse fit, slightly better std dev (0.01505)
- K-S fit statistic: Lognorm distribution best fit, standard deviation 0.01518
- K-S preferred (Lognorm) due to data concentrated in middle of distribution

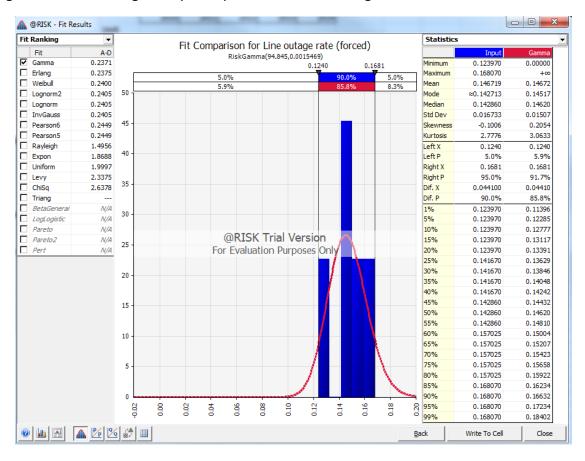


Figure 2.1: Lines outage rate (forced) – distribution fit using A-D

Figure 2.2: Lines outage rate (forced) - statistics table using A-D

| Fit | Ranking | • | | Input | Gamma | Erlang | Weibull | Lognorm | 2 Lognorm | |
|-----|----------------------|---------|---|--------------------|-----------|-----------|-----------|----------|---------------|-------|
| | Fit | A-D | Rankings By Fit Statist | c [14 Valid Fits] | | | | | | |
| ☑ | Gamma | 0.2371 | Akaike (AIC) | | #1 | #2 | #6 | #4 (Tie |) #4 (Tie) | |
| Γ | Erlang | 0.2375 | Bayesian (BIC) | | #1 | #2 | #6 | #4 (Tie |) #4 (Tie) | |
| | Weibull | 0.2400 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie | | |
| | Lognorm2 | 0.2405 | K-S Statistic | | #4 | #5 | #8 | #2 (10 | | |
| | Lognorm | 0.2405 | A-D Statistic | | #1 | #2 | #3 | # | | |
| - | InvGauss | 0.2405 | | | | | #3 | # | + #3 | |
| | Pearson6 Pearson5 | 0.2449 | Parameters - [* Values | unavailable withou | | - | | | | |
| | Rayleigh | 1.4956 | Num. Est. Parameters | | 2 | 2 | 2 | | 2 2 | |
| | Expon | 1.8688 | Fitted Parameter #1 | | alpha | m | alpha | mu | | |
| | Uniform | 1.9997 | Fitted Value | | 94.845 | 95 | 11.179 | -1.924 | 5 0.14673 | |
| | Levy | 2.3375 | 95% Lower Limit* | | N/A | N/A | N/A | N// | N/A | |
| | ChiSq | 2.6378 | 95% Upper Limit* | | N/A | N/A | N/A | N// | N/A | |
| Γ | Triang | | Conf. Interval Width* | | N/A | N/A | N/A | N// | N/A | |
| | BetaGeneral | N/A | Fitted Parameter #2 | | beta | beta | beta | sigma | a sigma | |
| | | N/A | Fitted Value | | 0.00155 | 0.00154 | 0.1535 | 0.1032 | 0.015182 | |
| | Pareto | N/A | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | Pareto2 Pert | N/A | 95% Upper Limit* | | N/A | N/A | N/A | N// | | |
| | Pert | N/A | Conf. Interval Width* | | N/A | N/A | N/A | N// | | |
| | | | Fitted Parameter #3 | | NA | N/A | N/A | 14/7 | | |
| | | | Fitted Parameter #3 | | | | | | | |
| | | | | | | | | | | |
| | | | 95% Lower Limit* | | | | | | | |
| | | | 95% Upper Limit* | | | | | | | |
| | | | Conf. Interval Width* | | | | | | | |
| | | | Distribution Statistics | | | | | | | |
| | | | Minimum | 0.1240 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | |
| | | | Maximum | 0.1681 | +Infinity | +Infinity | +Infinity | +Infinit | / +Infinity | |
| | | | Mean | 0.1467 | 0.14672 | 0.14672 | 0.1467 | 0.146 | 0.1467 | |
| | | | Mode | 0.1427 [est] | 0.14517 | 0.14517 | 0.1522 | 0.144 | 0.1444 | |
| | | | Median | 0,1429 | 0.14620 | 0.14620 | 0.1485 | 0.145 | | |
| | | | Std. Deviation | 0.0167 | 0.01507 | 0.01505 | 0.0159 | 0.015 | | |
| | | | Skewness | -0.1006 | 0.2054 | 0.2052 | -0.6835 | 0.013 | | |
| | | | | | | | | | | |
| | | | Kurtosis | 2.7776 | 3.0633 | 3.0632 | 3.6911 | 3.173 | 3.1730 | |
| | | | • | m | | | | | | • |
| 0 | 1 | 1 1% 19 | 2 🗊 🔳 | | | | | Back | Write To Cell | Close |

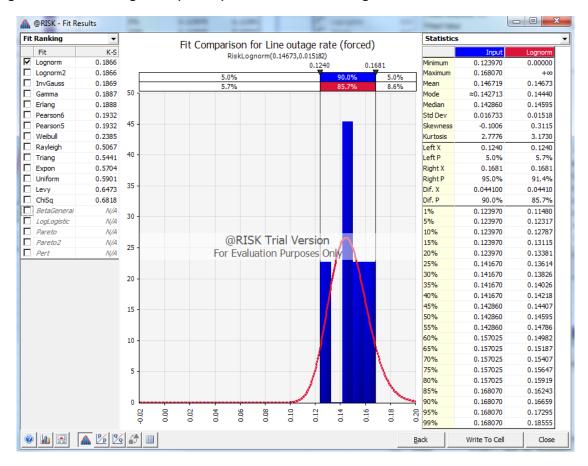


Figure 2.3 Lines outage rate (forced) – distribution fit using K-S

Figure 2.4: Lines outage rate (forced) – statistics table using K-S

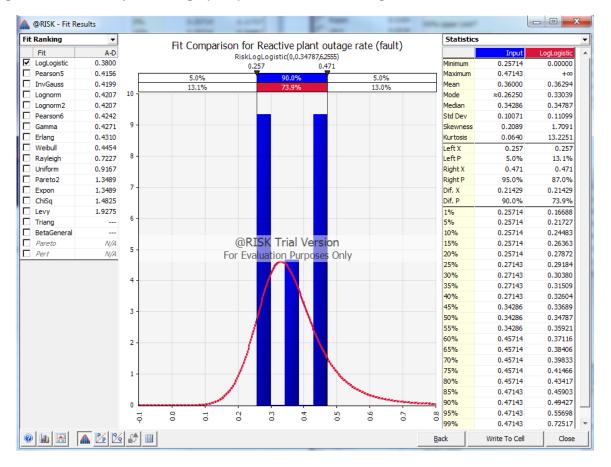
| it Ranking | • | | Input | Lognorm | Lognorm2 | InvGauss | Gamma | Erlang | |
|---------------------|--------|---------------------------|--------------------|-----------|-----------|-----------|-----------|-----------|-----|
| Fit | K-S | - Rankings By Fit Statist | ic [14 Valid Fits] | | | | | | |
| Lognorm | 0.1866 | Akaike (AIC) | | #4 (Tie) | #4 (Tie) | #3 | #1 | #2 | |
| Lognorm2 | 0.1866 | Bayesian (BIC) | | #4 (Tie) | #4 (Tie) | #3 | #1 | #2 | |
| InvGauss | 0.1869 | Chi-Sg Statistic | | #1 (Tie) | |
| Gamma | 0.1887 | K-S Statistic | | #1 | #2 | #3 | #4 | #5 | |
| Erlang | 0.1888 | A-D Statistic | | #1 | #2 | #5 | #1 | #3 | |
| Pearson6 | 0.1932 | | | | | #0 | #1 | #2 | |
| Pearson5 Weibull | 0.1932 | Parameters - [* Values | unavailable withou | - | - | | | | |
| Ravleigh | 0.2385 | Num. Est. Parameters | | 2 | 2 | 2 | 2 | 2 | |
| Triang | 0.5067 | Fitted Parameter #1 | | mu | mu | mu | alpha | m | |
| Expon | 0.5704 | Fitted Value | | 0.14673 | -1.9245 | 0.1467 | 94.845 | 95 | 39 |
| Uniform | 0.5901 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Levy | 0.6473 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| ChiSq | 0.6818 | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| BetaGeneral | N/A | Fitted Parameter #2 | | sigma | sigma | lambda | beta | beta | - |
| LogLogistic | N/A | Fitted Value | | 0.015182 | 0,10320 | 13.7156 | 0.00155 | 0.00154 | |
| Pareto | N/A | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Pareto2 | N/A | 95% Upper Limit* | | | | | | | |
| Pert | N/A | | | N/A | N/A | N/A | N/A | N/A | |
| | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | Fitted Parameter #3 | | | | | | | |
| | | Fitted Value | | | | | | | 3.3 |
| | | 95% Lower Limit* | | | | | | | |
| | | 95% Upper Limit* | | | | | | | |
| | | Conf. Interval Width* | | | | | | | |
| | | - Distribution Statistics | | | | | | | |
| | | Minimum | 0.1240 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | Maximum | 0,1681 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | Mean | 0.1467 | 0.1467 | 0.1467 | 0.1467 | 0.14672 | 0,14672 | 0.1 |
| | | Mode | 0.1427 [est] | 0.1444 | 0.1444 | 0.1444 | 0.14517 | 0.14517 | 0.1 |
| | | Median | 0.1429 | 0.1459 | 0.1459 | 0.1459 | 0.14620 | 0.14517 | 0.1 |
| | | | | | | | | | |
| | | Std. Deviation | 0.0167 | 0.0152 | 0.0152 | 0.0152 | 0.01507 | 0.01505 | 0.0 |
| | | Skewness | -0.1006 | 0.3115 | 0.3115 | 0.3103 | 0.2054 | 0.2052 | |
| | | Kurtosis | 2.7776 | 3.1730 | 3.1730 | 3.1605 | 3.0633 | 3.0632 | |
| | | • | | | | | | | • |

1. Reactive plant outage – fault (continuous)

Findings:

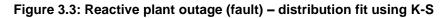
- A-D fit statistic: LogLogistic distribution best fit, standard deviation 0.1110
- K-S fit statistic: LogLogistic distribution best fit, standard deviation 0.11099
- A-D preferred (LogLogistic) due to data concentrated near tails of distribution

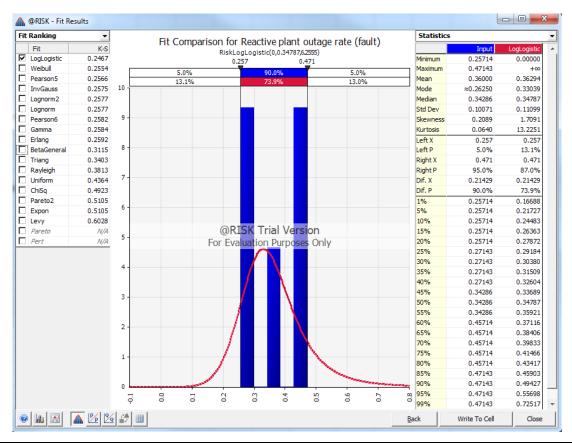
Figure 3.1: Reactive plant outage (fault) – distribution fit using A-D



| Fit | Ranking | - | | Input | LogLogistic | Pearson5 | InvGauss | Lognorm | Lognorm2 | |
|-----|---------------------|--------|---------------------------|------------------|-----------------------|------------------|-----------------|------------------|------------------|-----------|
| | Fit | A-D | - Fit | | | | | | | |
| ~ | LogLogistic | 0.3800 | Function | | =RiskLogLogistic(0 | =RiskPearson5(15 | =RiskInvGauss(0 | =RiskLognorm(0.3 | =RiskLognorm2(-1 | =RiskPear |
| | Pearson5 | 0.4156 | Method | | MLE | MLE | MLE | MLE | MLE | MLE |
| | InvGauss | 0.4199 | - Rankings By Fit Statist | ic [17 Valid Fit | a] | | | | | |
| | Lognorm | 0.4207 | Akaike (AIC) | | -, #11 | #5 | #4 | #6 (Tie) | #6 (Tie) | |
| | Lognorm2 | 0.4207 | Bayesian (BIC) | | #9 | #3 | #2 | #4 (Tie) | #4 (Tie) | |
| | Pearson6 | 0.4242 | | | | | | | | |
| | Gamma | 0.4271 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | |
| | Erlang | 0.4310 | K-S Statistic | | #1 | #3 | #4 | #6 | #5 | |
| | Weibull Rayleigh | 0.4454 | A-D Statistic | | #1 | #2 | #3 | #4 (Tie) | #4 (Tie) | |
| | Uniform | 0.7227 | - Parameters - [* Values | unavailable v | vithout running a boo | tstrap] | | | | |
| | Pareto2 | 1.3489 | Num. Est. Parameters | | 2 | 2 | 2 | 2 | 2 | |
| | Expon | 1.3489 | Fitted Parameter #1 | | beta | alpha | mu | mu | mu | |
| | ChiSg | 1.4825 | Fitted Value | | 0.3479 | 15.981 | 0,3600 | 0,36007 | -1.0535 | |
| | Levy | 1.9275 | 95% Lower Limit* | | | | | | | |
| | Triang | | | | N/A | N/A | N/A | N/A | | |
| | BetaGeneral | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | Pareto | N/A | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | Pert | N/A | Fitted Parameter #2 | | alpha | beta | lambda | sigma | sigma | |
| | | | Fitted Value | | 6.2555 | 5.3997 | 5.4971 | 0.092578 | 0.25301 | |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | | |
| | | | | | N/A | NA | NA | NA | N/A | |
| | | | Fitted Parameter #3 | | | | | | | |
| | | | Fitted Value | | | | | | | |
| | | | 95% Lower Limit* | | | | | | | |
| | | | 95% Upper Limit* | | | | | | | |
| | | | Conf. Interval Width* | | | | | | | |
| | | | - Distribution Statistics | | | | | | | |
| | | | Minimum | 0.2571 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | | Maximum | 0.4714 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | | Mean | 0.3600 | 0.3629 | 0.3604 | 0.3600 | 0.3601 | 0.3601 | |
| | | | | | | | | | | |
| | | | Mode | 0.2625 [est] | 0.3304 | 0.3180 | 0.3264 | 0.3271 | | |
| | | | Median | 0.3429 | 0.3479 | 0.3450 | 0.3486 | 0.3487 | | |
| | | | Std. Deviation | 0.1007 | 0.1110 | 0.0964 | 0.0921 | 0.0926 | 0.0926 | |
| | | | Skewness | 0.2089 | 1.7091 | 1.1522 | 0.7677 | 0.7883 | 0.7883 | |
| | | | Kurtosis | 0.0640 | 13.2248 | 5.6582 | 3.9823 | 4.1250 | 4.1250 | Þ |

Figure 3.2: Reactive plant outage (fault) – statistics table using A-D





| Fit | Ranking | • | | Input | LogLogistic | Weibull | Pearson5 | InvGauss | Lognorm2 | |
|-----|----------------------|--------|---|------------------------|--------------------|-------------------|------------------|-----------------|------------------|-----------|
| | Fit | K-S | _ Fit | | | | | | | |
| | LogLogistic | 0.2467 | Function | | =RiskLogLogistic(0 | =RiskWeibull(4.55 | =RiskPearson5(15 | =RiskInvGauss(0 | =RiskLognorm2(-1 | =RiskLogr |
| | Weibull | 0.2554 | Method | | MLE | MLE | MLE | MLE | MLE | |
| - | Pearson5 InvGauss | 0.2566 | Rankings By Fit Statist | ic [17 Valid Fit | s] | | | | | |
| - | Lognorm2 | 0.2575 | Akaike (AIC) | | #11 | #10 | #5 | #4 | #6 (Tie) | |
| | Lognorm | 0.2577 | Bayesian (BIC) | | #9 | #8 | #3 | #2 | #4 (Tie) | |
| | Pearson6 | 0.2582 | Chi-Sg Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | |
| Γ | Gamma | 0.2584 | K-S Statistic | | #1 | #2 | #3 | #4 | #5 | |
| Γ | Erlang | 0.2592 | A-D Statistic | | #1 | #9 | #2 | | | |
| | BetaGeneral | 0.3115 | - Parameters - [* Values | u navailable u | | | #L | #0 | # 1 (11c) | |
| _ | Triang | 0.3403 | Num, Est, Parameters | u lavaliable v | 2 | | 2 | 2 | 2 | |
| | Rayleigh | 0.3813 | Fitted Parameter #1 | | | | | | | |
| | Uniform ChiSg | 0.4364 | Fitted Parameter #1 Fitted Value | | beta | alpha | alpha | mu | | |
| | Pareto2 | 0.4923 | | | 0.3479 | 4.5562 | 15.981 | 0.3600 | | |
| _ | Expon | 0.5105 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | | |
| | Levy | 0.6028 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | | |
| | Pareto | N/A | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| Γ | Pert | N/A | Fitted Parameter #2 | | alpha | beta | beta | lambda | sigma | |
| | | | Fitted Value | | 6.2555 | 0.3955 | 5.3997 | 5.4971 | 0.25301 | |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Fitted Parameter #3 | | | | | | | |
| | | | Fitted Value | | | | | | | |
| | | | 95% Lower Limit* | | | | | | | |
| | | | 95% Upper Limit* | | | | | | | |
| | | | Conf. Interval Width* | | | | | | | |
| | | | Distribution Statistics | | | | | | | |
| | | | Minimum | 0.2571 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | | Maximum | 0.4714 | | +Infinity | +Infinity | +Infinity | | |
| | | | Mean | 0.3600 | 0.3629 | 0.3612 | 0.3604 | 0.3600 | | |
| | | | Mode | 0.2625 [est] | 0.3304 | | 0.3180 | 0.3264 | | |
| | | | Median | 0.2625 [est] 0.3429 | 0.3479 | 0.3650 | 0.3180 | 0.3486 | | |
| | | | | | | | | | | |
| | | | Std. Deviation | 0.1007 | 0.1110 | 0.0901 | 0.0964 | 0.0921 | | |
| | | | Skewness | 0.2089 | 1.7091 | | 1.1522 | | | |
| | | | Kurtosis | 0.0640 | 13.2248 | 2.8158 | 5.6582 | 3.9823 | 4.1250 | |

Figure 3.4: Reactive plant outage (fault) – statistics table using K-S

2. Reactive plant outage - forced (continuous)

Findings:

- A-D fit statistic: LogLogistic distribution best fit, standard deviation 0.12073
 - Erlang distribution very close. Slightly worse fit, better std dev (0.09495)
- K-S fit statistic: LogLogistic distribution best fit, standard deviation 0.12073
- A-D preferred due to data concentrated near tails of distribution, however prefer the second best fit (Erlang) which has a superior standard deviation

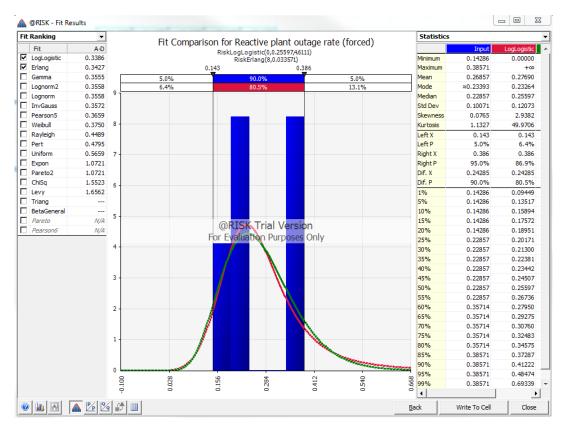


Figure 4.1: Reactive plant outage (forced) – distribution fit using A-D (two best fits)

Figure 4.2: Reactive plant outage (forced) - statistics table using A-D

| Fit | Ranking | • | | Input | LogLogistic | Erlang | Gamma | Lognorm2 | Lognorm | |
|-----|------------------|--------|---------------------------|--------------------|-------------------------|-----------------|----------------|------------------|------------------|---------|
| | Fit | A-D | 二 Fit | | | | | | | |
| ☑ | LogLogistic | 0.3386 | Function | = | RiskLogLogistic(0 =Ris | kErlang(8,0.0 = | RiskGamma(8.31 | =RiskLognorm2(-1 | =RiskLognorm(0.2 | =RiskIr |
| | Erlang | 0.3427 | Method | | MLE | MLE | MLE | MLE | MLE | |
| _ | Gamma | 0.3555 | - Rankings By Fit Statist | ic [17 Valid Fits] | | | | | | |
| _ | Lognorm2 | 0.3558 | Akaike (AIC) | ic [17 Valid Frid] | #13 | #7 | #6 | #9 (Tie) | #9 (Tie) | |
| _ | Lognorm | 0.3558 | | | | | | | | |
| | InvGauss | 0.3572 | Bayesian (BIC) | | #11 | #6 | #5 | #8 (Tie) | #8 (Tie) | |
| - | Pearson5 | 0.3659 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | |
| _ | Weibull | 0.3750 | K-S Statistic | | #1 | #3 | #7 | #4 | #5 | |
| | Rayleigh | 0.4489 | A-D Statistic | | #1 | #2 | #3 | #4 | #5 | |
| _ | Pert | 0.4795 | - Parameters - [* Values | unavailable wit | hout running a bootstra | p] | | | | |
| _ | Uniform Expon | 0.5659 | Num, Est, Parameters | | 2 | 2 | 2 | 2 | 2 | |
| - | Pareto2 | 1.0721 | Fitted Parameter #1 | | beta | m | alpha | mu | mu | |
| | ChiSo | 1.5523 | Fitted Value | | 0.2560 | 8 | 8.3118 | -1.3760 | 0.26939 | |
| _ | Levv | 1.6562 | 95% Lower Limit* | | | N/A | | | | |
| | Triang | | | | N/A | | N/A | N/A | N/A | |
| _ | BetaGeneral | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | Pareto | N/A | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | Pearson6 | N/A | Fitted Parameter #2 | | alpha | beta | beta | sigma | sigma | |
| | | | Fitted Value | | 4.6111 | 0.0336 | 0.0323 | 0.35887 | 0.099872 | |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Fitted Parameter #3 | | | | | | | |
| | | | | | | | | | | |
| | | | Fitted Value | | | | | | | |
| | | | 95% Lower Limit* | | | | | | | |
| | | | 95% Upper Limit* | | | | | | | |
| | | | Conf. Interval Width* | | | | | | | |
| | | | - Distribution Statistics | | | | | | | |
| | | | Minimum | 0.1429 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | | Maximum | 0.3857 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | | Mean | 0.2686 | 0.2769 | 0.2686 | 0.2686 | 0.2694 | 0.2694 | |
| | | | Mode | | 0.2326 | 0.2350 | 0.2363 | 0.2234 | 0.2234 | |
| | | | | 0.2339 [est] | | | | | | |
| | | | Median | 0.2286 | 0.2560 | 0.2575 | 0.2579 | 0.2526 | 0.2526 | |
| | | | Std. Deviation | 0.1007 | 0.1207 | 0.0950 | 0.0932 | 0.0999 | 0.0999 | |
| | | | Skewness | 0.0765 | 2.9382 | 0.7071 | 0.6937 | 1.1632 | 1.1632 | |
| | | | Kurtosis | 1.1327 | 49.9686 | 3.7500 | 3.7219 | 5.4985 | 5.4985 | |
| | | | < III | | | | | | | - F |

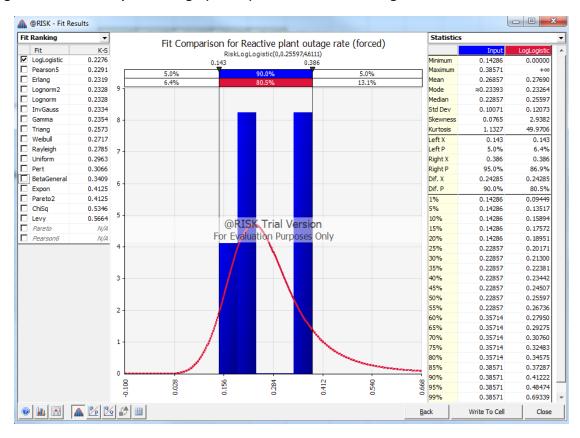


Figure 4.3: Reactive plant outage (forced) – distribution fit using K-S

Figure 4.4: Reactive plant outage (forced) – statistics table using K-S

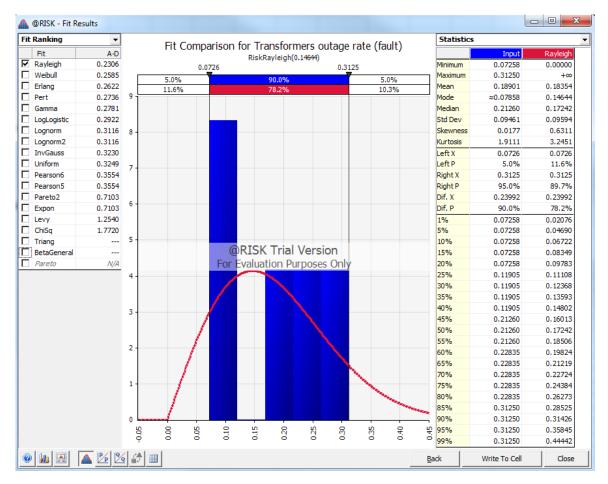
| Fit | Ranking | - | | Input | LogLogistic | Pearson5 | Erlang | Lognorm2 | Lognorm | |
|-----|---------------------|--------|---|------------------|--------------------|-----------------|-------------------|------------------|------------------|---------|
| | Fit | K-S | | | | | | | | |
| | LogLogistic | 0.2276 | Function | | =RiskLogLogistic(0 | =RiskPearson5(7 | =RiskErlang(8,0.0 | =RiskLognorm2(-1 | =RiskLognorm(0.2 | =RiskIr |
| | Pearson5 | 0.2291 | Method | | MLE | MLE | MLE | MLE | MLE | |
| | Erlang | 0.2319 | Rankings By Fit Statist | ic [17 Valid Fit | s] | | | | | |
| | Lognorm2 Lognorm | 0.2328 | Akaike (AIC) | - | #13 | #12 | #7 | #9 (Tie) | #9 (Tie) | |
| | InvGauss | 0.2328 | Bayesian (BIC) | | #11 | #10 | #6 | #8 (Tie) | #8 (Tie) | |
| | Gamma | 0.2354 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | |
| | Triang | 0.2573 | K-S Statistic | | #1 | #2 | #3 | #4 | #5 | |
| | Weibull | 0.2717 | A-D Statistic | | #1 | #7 | #2 | #4 | #5 | |
| | Rayleigh | 0.2785 | Parameters - [* Values | unavailable v | | | | | | |
| - | Uniform | 0.2963 | Num, Est, Parameters | , and valiable v | 2 | | 2 | 2 | 2 | |
| | Pert BetaGeneral | 0.3066 | Fitted Parameter #1 | | beta | alpha | | mu | | |
| | Expon | 0.3409 | Fitted Value | | 0.2560 | 7,7561 | 8 | -1.3760 | 0.26939 | |
| | Pareto2 | 0.4125 | 95% Lower Limit* | | 0.2300 N/A | N/A | N/A | -1.3760 N/A | | |
| - | ChiSq | 0.5346 | | | | | | | | |
| Γ | Levy | 0.5664 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | | |
| | Pareto | N/A | Conf. Interval Width* | | N/A | N/A | N/A | N/A | | |
| Π | Pearson6 | N/A | Fitted Parameter #2 | | alpha | beta | beta | sigma | sigma | |
| | | | Fitted Value | | 4.6111 | 1.8342 | 0.0336 | 0.35887 | | |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Fitted Parameter #3 | | | | | | | |
| | | | Fitted Value | | | | | | | |
| | | | 95% Lower Limit* | | | | | | | |
| | | | 95% Upper Limit* | | | | | | | |
| | | | Conf. Interval Width* | | | | | | | |
| | | | Distribution Statistics | | | | | | | |
| | | | Minimum | 0.1429 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | | Maximum | 0.3857 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | | Mean | 0.2686 | 0.2769 | 0.2715 | 0.2686 | 0.2694 | | |
| | | | Mode | 0.2339 [est] | 0.2326 | 0.2095 | 0.2350 | 0.2221 | | |
| | | | Median | 0.2286 | 0.2560 | 0.2470 | 0.2575 | 0.2526 | 0.2526 | |
| | | | Std. Deviation | 0.2286 | 0.1207 | 0.1132 | 0.0950 | 0.0999 | 0.0999 | |
| | | | Skewness | 0.1007 | 2.9382 | 2.0178 | 0.0930 | 1.1632 | | |
| | | | | | | | | | | |
| | | | Kurtosis | 1.1327 | 49.9686 | 12.3305 | 3.7500 | 5.4985 | 5.4985 | Þ |
| 0 | | | | | | | | | | |

3. Transformers outage – fault (continuous)

Findings:

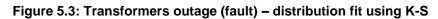
- A-D fit statistic: Rayleigh distribution best fit, standard deviation 0.0959
- K-S fit statistic: Uniform distribution best fit, standard deviation 0.11277
- A-D preferred (Rayleigh) due to data concentrated near tails of distribution

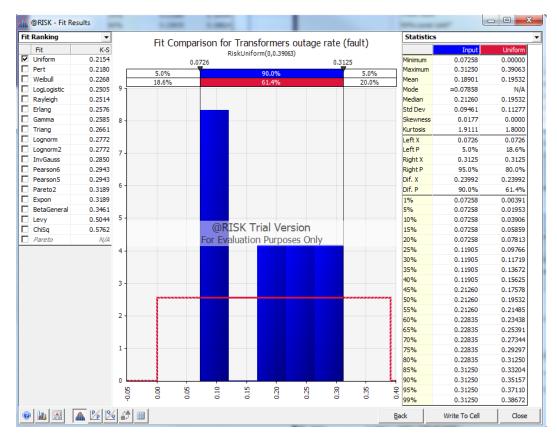
Figure 5.1: Transformers outage (fault) – distribution fit using A-D



| FIL | Ranking | • | | Input | Rayleigh | Weibull | Erlang | Pert | Gamma |
|------------|-----------------|--------|---|------------------|-------------------|-------------------|-------------------|---------------------|--------------------|
| | Fit | A-D | _ Fit | | | | | | |
| | Rayleigh | 0.2306 | Function | | =RiskRayleigh(0.1 | =RiskWeibull(2.44 | =RiskErlang(4,0.0 | =RiskPert(0,0.179 = | =RiskGamma(4.25 =R |
| | Weibull | 0.2585 | Method | | MLE | MLE | MLE | MLE | MLE |
| | Erlang | 0.2622 | Rankings By Fit Statist | ic [18 Valid Fit | s] | | | | |
| | Pert Gamma | 0.2736 | Akaike (AIC) | - | #1 | #6 | #8 | #5 | #7 |
| | LogLogistic | 0.2781 | Bayesian (BIC) | | #2 | #5 | #7 | #3 | #6 |
| | Lognorm | 0.3116 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) |
| Π | Lognorm2 | 0.3116 | K-S Statistic | | #5 | #3 | #6 | #2 | #7 |
| | InvGauss | 0.3230 | A-D Statistic | | #1 | | #3 | #4 | #5 |
| Π | Uniform | 0.3249 | | | | | #3 | #7 | #3 |
| Γ | Pearson6 | 0.3554 | Parameters - [* Values | s unavailable v | - | | | | |
| | Pearson5 | 0.3554 | Num. Est. Parameters | | 1 | | | 2 | 2 |
| | Pareto2 | 0.7103 | Fitted Parameter #1 | | b | alpha | m | M. likely | alpha |
| | Expon | 0.7103 | Fitted Value | | 0.1464 | 2.4482 | 4 | 0.1797 | 4.2577 |
| _ | Levy | 1.2540 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A |
| | ChiSq Triang | 1.7720 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A |
| | - | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A |
| | Pareto | N/A | Fitted Parameter #2 | | | beta | beta | Max | beta |
| | 101010 | | Fitted Value | | | 0.2139 | 0.0473 | 0.4114 | 0.0444 |
| | | | 95% Lower Limit* | | | N/A | N/A | N/A | N/A |
| | | | 95% Upper Limit* | | | N/A | N/A | N/A | N/A |
| | | | Conf. Interval Width* | | | N/A | N/A | N/A | N/A |
| | | | Fitted Parameter #3 | | | NA | NA | N/A | NA |
| | | | Fitted Parameter #3 | | | | | | |
| | | | | | | | | | |
| | | | 95% Lower Limit* | | | | | | |
| | | | 95% Upper Limit* | | | | | | |
| | | | Conf. Interval Width* | | | | | | |
| | | | Distribution Statistics | | | | | | |
| | | | Minimum | 0.0726 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | | Maximum | 0.3125 | +Infinity | +Infinity | +Infinity | 0.4114 | +Infinity |
| | | | Mean | 0.1890 | 0.1835 | 0.1897 | 0.1890 | 0.1884 | 0.1890 |
| | | | Mode | 0.0786 [est] | 0.1464 | 0.1726 | 0.1418 | 0.1797 | 0.1446 |
| | | | Median | 0.2126 | | 0.1841 | 0.1735 | 0,1863 | 0,1744 |
| | | | Std. Deviation | 0.0946 | | 0.0827 | 0.0945 | 0.0775 | 0.0916 |
| | | | Skewness | 0.0340 | | | 1.0000 | 0.1116 | 0.9693 |
| | | | | | | | | | |
| | | | Kurtosis | 1.9111 | 3.2451 | 2.8808 | 4.5000 | 2.3499 | 4.4092 |

Figure 5.2: Transformers outage (fault) – statistics table using A-D





| Fit | Ranking | - | | Input | Uniform | Pert | Weibull | LogLogistic | Rayleigh | |
|-----|----------------------|--------|---|------------------|-----------------------|-------------------|-------------------|--------------------|---------------------|------|
| | Fit | K-S | - Fit | | | | | | | |
| | Uniform | 0.2154 | Function | | =RiskUniform(0,0 | =RiskPert(0,0.179 | =RiskWeibull(2.44 | =RiskLogLogistic(0 | =RiskRayleigh(0.1 + | =Ris |
| | Pert | 0.2180 | Method | | MLE (Bias Correcte | MLE | MLE | MLE | MLE | |
| | Weibull | 0.2268 | Rankings By Fit Statist | ic [18 Valid Fit | sl | | | | | |
| | LogLogistic | 0.2505 | Akaike (AIC) | | #2 | #5 | #6 | #12 | #1 | _ |
| | Rayleigh | 0.2514 | Bayesian (BIC) | | #4 | | #5 | #11 | #2 | |
| _ | Erlang | 0.2576 | | | | | | | | |
| | Gamma | 0.2585 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | |
| | Triang | 0.2661 | K-S Statistic | | #1 | #2 | #3 | #4 | #5 | |
| | Lognorm | 0.2772 | A-D Statistic | | #10 | #4 | #2 | #6 | #1 | |
| | Lognorm2 InvGauss | 0.2772 | Parameters - [* Values | unavailable v | vithout running a boo | tstrap] | | | | |
| _ | Pearson6 | 0.2850 | Num. Est. Parameters | | 1 | 2 | 2 | 2 | 1 | _ |
| _ | Pearson6 Pearson5 | 0.2943 | Fitted Parameter #1 | | Max | M. likely | alpha | beta | b | |
| _ | Pearsons Pareto2 | 0.2945 | Fitted Value | | 0.3906 | 0,1797 | 2,4482 | 0.1748 | 0,1464 | |
| | Expon | 0.3189 | | | | | | | | |
| | BetaGeneral | 0.3461 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| _ | Levy | 0.5044 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | ChiSq | 0.5762 | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | N/A | Fitted Parameter #2 | | | Max | beta | alpha | | |
| | | | Fitted Value | | | 0.4114 | 0.2139 | 3.1754 | | |
| | | | 95% Lower Limit* | | | N/A | N/A | N/A | | |
| | | | 95% Upper Limit* | | | N/A | N/A | N/A | | |
| | | | Conf. Interval Width* | | | N/A | N/A | N/A | | |
| | | | | | | N/A | N/A | N/A | | |
| | | | Fitted Parameter #3 | | | | | | | |
| | | | Fitted Value | | | | | | | |
| | | | 95% Lower Limit* | | | | | | | |
| | | | 95% Upper Limit* | | | | | | | |
| | | | Conf. Interval Width* | | | | | | | |
| | | | Distribution Statistics | | | | | | | |
| | | | Minimum | 0.0726 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | | Maximum | 0.3125 | 0.3906 | 0.4114 | +Infinity | +Infinity | +Infinity | |
| | | | Mean | 0.1890 | | 0.1884 | 0.1897 | 0.2070 | 0.1835 | |
| | | | Mode | 0.0786 [est] | 0.0000 | 0.1797 | 0.1726 | 0.1424 | 0.1464 | |
| | | | Median | 0.2126 | | 0.1863 | 0.1841 | 0.1748 | 0.1724 | |
| | | | Std. Deviation | 0.0946 | | 0.0775 | 0.0827 | 0.1518 | 0.0959 | |
| | | | Skewness | 0.0340 | | 0.1116 | 0.3822 | 19.6366 | 0.6311 | |
| | | | Kurtosis | 1.9111 | | 2.3499 | 2.8808 | +Infinity | 3.2451 | |
| | | | Nul (0515 | 1.7111 | 1.0000 | 2,0499 | 2.0000 | TIMPILY | 3.2431 | |

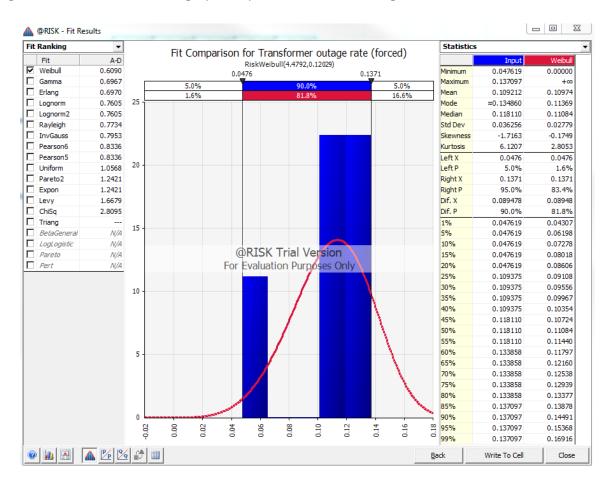
Figure 5.4: Transformers outage (fault) – statistics table using K-S

4. Transformers outage – forced (continuous)

Findings:

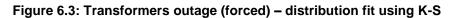
- A-D fit statistic: Weibull distribution best fit, standard deviation 0.02779
- K-S fit statistic: Weibull distribution best fit, standard deviation 0.02779
- A-D preferred (Weibull) due to data concentrated near tails of distribution

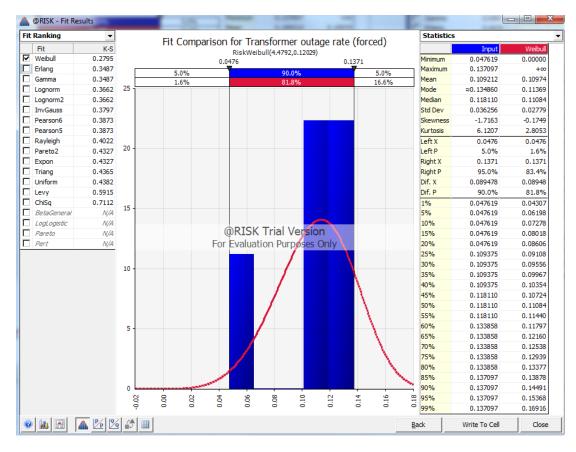
Figure 6.1: Transformers outage (forced) – distribution fit using A-D



| it Ranking | - | | Input | Weibull | Gamma | Erlang | Lognorm | Lognorm2 | |
|---|------------|---|--------------------|-----------|-----------|-----------|-------------------|-----------|---|
| Fit | A-D | - Rankings By Fit Statist | ic [15 Valid Fits] | | | | | | |
| ✓ Weibull | 0.6090 | Akaike (AIC) | | #4 | #6 | #7 | #8 (Tie) | #8 (Tie) | |
| Gamma | 0.6967 | Bayesian (BIC) | | #2 | #5 | #6 | #7 (Tie) | #7 (Tie) | |
| Erlang | 0.6970 | Chi-Sg Statistic | | #1 | #2 (Tie) | #2 (Tie) | #2 (Tie) | #2 (Tie) | |
| Lognorm | 0.7605 | K-S Statistic | | #1 | #3 | #2 | #4 (Tie) | #4 (Tie) | |
| Lognorm2 Rayleigh | 0.7605 | A-D Statistic | | #1 | #2 | #3 | #4 (Tie) | #4 (Tie) | |
| Rayleigh InvGauss | 0.7953 | Parameters - [* Values | underlievenu | | | | <i>»</i> • (••••) | # · (| |
| Pearson6 | 0.8336 | Num, Est. Parameters | | 2 | 2 | 2 | 2 | 2 | |
| Pearson5 | 0.8336 | | | _ | | 2 | 2 | | |
| Uniform | 1.0568 | Fitted Parameter #1 | | alpha | alpha | m | mu | mu | |
| Pareto2 | 1.2421 | Fitted Value | | 4.4792 | 7.9915 | 8 | 0.11063 | -2.2783 | |
| Expon | 1.2421 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Levy | 1.6679 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| ChiSq | 2.8095 | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| Triang | | Fitted Parameter #2 | | beta | beta | beta | sigma | sigma | |
| BetaGeneral | N/A | Fitted Value | | 0.1203 | 0.0137 | 0.0137 | 0.045073 | 0.39188 | |
| LogLogistic Pareto | N/A N/A | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Pert | N/A | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| , creater and the second se | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | Fitted Parameter #3 | | | | | | | |
| | | Fitted Value | | | | | | | |
| | | 95% Lower Limit* | | | | | | | |
| | | 95% Upper Limit* | | | | | | | |
| | | Conf. Interval Width* | | | | | | | |
| | | | | | | | | | |
| | | Distribution Statistics | | | | | | | |
| | | Minimum | 0.0476 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | Maximum | 0.1371 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | Mean | 0.1092 | 0.1097 | 0.1092 | 0.1092 | 0.1106 | 0.1106 | |
| | | Mode | 0.1349 [est] | 0.1137 | 0.0955 | 0.0956 | 0.0879 | 0.0879 | |
| | | Median | 0.1181 | 0.1108 | 0.1047 | 0.1047 | 0.1025 | 0.1025 | |
| | | Std. Deviation | 0.0363 | 0.0278 | 0.0386 | 0.0386 | 0.0451 | 0.0451 | |
| | | Skewness | -1.7163 | -0.1749 | 0.7075 | 0.7071 | 1.2899 | 1.2899 | |
| | | Kurtosis | 6.1207 | 2.8053 | 3.7508 | 3.7500 | 6.0973 | 6.0973 | |
| | | | | | | | | | Þ |

Figure 6.2: Transformers outage (forced) – statistics table using A-D





| Fit Ranking | - | | Input | Weibull | Erlang | Gamma | Lognorm | Lognorm2 | |
|------------------------|------------|---|-------------------|-----------|-----------|-----------|-----------|-----------|---|
| Fit | K-S | Rankings By Fit Statist | c [15 Valid Fits] | | | | | | |
| Veibull | 0.2795 | Akaike (AIC) | | #4 | #7 | #6 | #8 (Tie) | #8 (Tie) | _ |
| Erlang | 0.3487 | Bayesian (BIC) | | #2 | #6 | #5 | #7 (Tie) | #7 (Tie) | |
| Gamma | 0.3487 | Chi-Sq Statistic | | #1 | #2 (Tie) | #2 (Tie) | #2 (Tie) | #2 (Tie) | |
| Lognorm | 0.3662 | K-S Statistic | | #1 | #2 | #3 | #4 (Tie) | #4 (Tie) | |
| Lognorm2 | 0.3662 | A-D Statistic | | #1 | #3 | #2 | #4 (Tie) | #4 (Tie) | |
| Pearson6 | 0.3797 | - Parameters - [* Values | فيحطف والمامات | | | #2 | # 1 (11c) | #1(112) | |
| Pearson5 | 0.3873 | | | | - | | 2 | 2 | |
| Rayleigh | 0,4022 | Num. Est. Parameters | | 2 | 2 | 2 | 2 | 2 | |
| Pareto2 | 0.4327 | Fitted Parameter #1 | | alpha | m | alpha | mu | mu | |
| Expon | 0.4327 | Fitted Value | | 4.4792 | 8 | 7.9915 | 0.11063 | -2.2783 | |
| Triang | 0.4365 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Uniform | 0.4382 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Levy | 0.5915 | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| ChiSq | 0.7112 | Fitted Parameter #2 | | beta | beta | beta | sigma | sigma | |
| BetaGenera | | Fitted Value | | 0.1203 | 0.0137 | 0.0137 | 0.045073 | 0.39188 | |
| LogLogistic Pareto | N/A N/A | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Pareto | N/A | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | 19/4 | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | Fitted Parameter #3 | | | | | | | |
| | | Fitted Value | | | | | | | |
| | | 95% Lower Limit* | | | | | | | |
| | | 95% Upper Limit* | | | | | | | |
| | | Conf. Interval Width* | | | | | | | |
| | | | | | | | | | |
| | | Distribution Statistics | | | | | | | |
| | | Minimum | 0.0476 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| | | Maximum | 0.1371 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | Mean | 0.1092 | 0.1097 | 0.1092 | 0.1092 | 0.1106 | 0.1106 | |
| | | Mode | 0.1349 [est] | 0.1137 | 0.0956 | 0.0955 | 0.0879 | 0.0879 | |
| | | Median | 0.1181 | 0.1108 | 0.1047 | 0.1047 | 0.1025 | 0.1025 | |
| | | Std. Deviation | 0.0363 | 0.0278 | 0.0386 | 0.0386 | 0.0451 | 0.0451 | |
| | | Skewness | -1.7163 | -0.1749 | 0.7071 | 0.7075 | 1.2899 | 1.2899 | |
| | | Kurtosis | 6.1207 | 2.8053 | 3.7500 | 3.7508 | 6.0973 | 6.0973 | |
| | | 1 | | | | | | | Þ |

Figure 6.4: Transformers outage (forced) – statistics table using K-S

1.2 Service parameter 2 – loss of supply event frequency

5. Number of events >0.05 system minutes (discrete)

Findings:

- Chi Squared fit statistic: Geometric distribution best fit, standard deviation 2.2450.
- Large variance in standard deviations of better fitting distributions
- Best fit distribution (Geometric) preferred, noting variability in std dev.

Figure 7.1: Number of events >0.05 system minutes – geometric distribution

| Fit Ranking | - | | | Eth Comm | | E | | | Statistics | | |
|-------------|--------|-------|--------|----------|------------|--------------------------|-----------|-------|------------|--------|--------|
| Fit | Chi-Sq | | | Fit Comp | | EVENUS > iet(0.35714) | 0.05 mins | | | Input | Geomet |
| Geomet | 0.0300 | | 0.00 | | | 00 | | | Minimum | 0.0000 | 0.000 |
| NegBin | 0.0711 | | 5.0% | 90.0% | | <u> </u> | 5.0% | | Maximum | 5.0000 | +00 |
| HyperGeo | 0.0923 | | 35.7% | 57.2% | | | 7.1% | | Mean | 1.8000 | 1.800 |
| Poisson | 0.1001 | 45% | 55.776 | 57.27 | | | 7.175 | | Mode | 1.0000 | 0.000 |
| IntUniform | 1.8000 | | | | | | | | Median | 1.0000 | 1.000 |
| Binomial | N/A | | | | | | | | Std Dev | 1.9235 | 2.245 |
| | | 40% | | | | | | | Skewness | 1.5175 | 2.0490 |
| | | | | | | | | | Kurtosis | 5.6077 | 9.1984 |
| | | | | | | | | | Left X | 0.00 | 0.00 |
| | | | | | | | | | Left P | 5.0% | 35.7% |
| | | 35% | | | | | | | Right X | 5.00 | 5.00 |
| | | | | | | | | | Right P | 95.0% | 92.9% |
| | | | | | | | | | Dif. X | 5.0000 | 5.000 |
| | | 30% - | | | | | | | Dif. P | 90.0% | 57.2% |
| | | | | | | | | | 1% | 0.0000 | 0.000 |
| | | | | | | | | | 5% | 0.0000 | 0.000 |
| | | 25% - | | | | | | | 10% | 0.0000 | 0.000 |
| | | | | 6 | RISK Tr | ial Versi | on | | 15% | 0.0000 | 0.000 |
| | | | | | Evaluation | | | | 20% | 0.0000 | 0.000 |
| | | 2007 | | 1011 | | Purposes | Only | | 25% | 1.0000 | 0.000 |
| | | 20% | | | | | | | 30% | 1.0000 | 0.000 |
| | | | | | | | | | 35% | 1.0000 | 0.000 |
| | | | | | | | | | 40% | 1.0000 | 1.000 |
| | | 15% - | | | | | | | 45% | 1.0000 | 1.000 |
| | | | | | | | | | 50% | 1.0000 | 1.000 |
| | | | | | | | | | 55% | 1.0000 | 1.000 |
| | | 10% - | | | | | | | 60% | 1.0000 | 2.000 |
| | | | | | | | | | 65% | 2.0000 | 2.000 |
| | | | | | | | | | 70% | 2.0000 | 2.000 |
| | | 500 | | | | | | | 75% | 2.0000 | 3.000 |
| | | 5% - | | | | | | | 80% | 2.0000 | 3.000 |
| | | | | | | | | | 85% | 5.0000 | 4.000 |
| | | | | | | | | | 90% | 5.0000 | 5.000 |
| | | 0% | | | | | | 14 E4 | 95% | 5.0000 | 6.000 |
| | | Ϋ́ | 0 | 0 | 4 | 9 | 00 | 9 | 99% | 5.0000 | 10.000 |

| it Ranking | • | | Input | Geomet | NegBin | HyperGeo | Poisson | IntUniform |
|------------|--------|---|------------------|-----------|-----------|----------|-----------|------------|
| Fit | Chi-Sa | - Rankings By Fit Statistic | | | | | | |
| Geomet | 0.0300 | Akaike (AIC) | | #1 | #3 | #5 | #2 | #4 |
| NegBin | 0.0711 | Bayesian (BIC) | | #1 | #3 | #5 | #2 | #4 |
| HyperGeo | 0.0923 | Chi-Sq Statistic | | #1 | #2 | #3 | #4 | #5 |
| Poisson | 0.1001 | Parameters - [* Values un | available withou | | | #5 | #1 | #5 |
| IntUniform | 1.8000 | Num. Est. Parameters | | 1 1 | 2 | 3 | 1 | 2 |
| Binomial | N/A | Fitted Parameter #1 | | | | | lambda | |
| | | | | p | s | n | | Min |
| | | Fitted Value | | 0.35714 | 3 | 57 | 1.8000 | 0 |
| | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A |
| | | Fitted Parameter #2 | | | p | D | | Max |
| | | Fitted Value | | | 0.62500 | 1026 | | 5 |
| | | 95% Lower Limit* | | | N/A | N/A | | N/A |
| | | 95% Upper Limit* | | | N/A | N/A | | N/A |
| | | Conf. Interval Width* | | | N/A | N/A | | N/A |
| | | Fitted Parameter #3 | | | | М | | |
| | | Fitted Value | | | | 32675 | | |
| | | 95% Lower Limit* | | | | N/A | | |
| | | 95% Upper Limit* | | | | N/A | | |
| | | Conf. Interval Width* | | | | N/A | | |
| | | Distribution Statistics | | | | | | |
| | | Minimum | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | Maximum | 5.0000 | +Infinity | +Infinity | 57.0000 | +Infinity | 5.0000 |
| | | Mean | 1.8000 | 1.8000 | 1.8000 | 1.7898 | 1.8000 | 2,5000 |
| | | Mode | 1.0000 | 0.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 |
| | | Median | 1.0000 | 1.0000 | 1.0000 | 2.0000 | 2.0000 | 2,0000 |
| | | Std. Deviation | 1.9235 | 2.2450 | 1.6971 | 1.3155 | 1.3416 | 1.7078 |
| | | Skewness | 1.5175 | 2.0490 | 1.2964 | 0.7100 | 0.7454 | 0.0000 |
| | | Kurtosis | 5.6077 | 9, 1984 | 5.3472 | 3,4673 | 3.5556 | 1.7314 |
| | | NULTOSIS | 3.0077 | 3, 1304 | 3.3472 | 3,4073 | 2,2220 | 1.7314 |

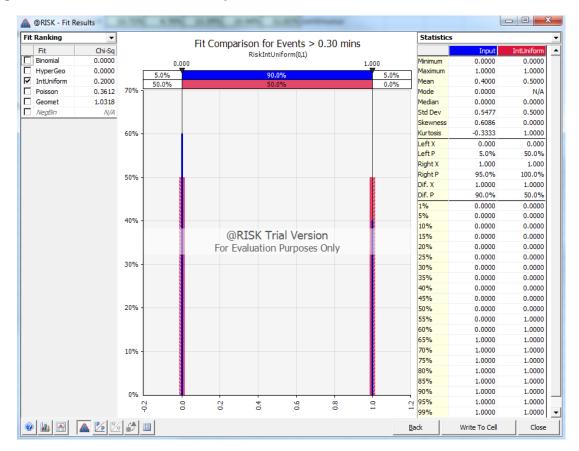
Figure 7.2: Number of events >0.05 system minutes – statistics table

6. Number of events >0.30 system minutes (discrete)

Findings:

- Chi Squared fit statistic: input data does not lend itself easily to statistical analysis, as it is comprised of either zero or one events, suggesting a binomial or hypergeometric distribution. However, more than one event is possible (in 2009 there were two events).
- Since the 9 out of the last 10 years have resulted in either zero or one events, recommend using the IntUniform distribution with a mean of 0.5 and standard deviation of 0.5, noting the difficulty in fitting a curve to this data.

Figure 8.1: Number of events >0.30 system minutes – IntUniform distribution



| Fit | Ranking | - | | Input | Binomial | HyperGeo | IntUniform | Poisson | Geomet |
|-----|-------------------|-----------|---|-------------------|----------------------|----------|------------|---------------|-----------|
| | Fit | Chi-Sq | Rankings By Fit Statistic | [5 Valid Fits] | | | | | |
| | Binomial | 0.0000 | Akaike (AIC) | | #3 | #5 | #4 | #1 | #2 |
| | HyperGeo | 0.0000 | Bayesian (BIC) | | #2 | #5 | #4 | #1 | #3 |
| | | 0.2000 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #3 | #4 | #5 |
| | Poisson Geomet | 0.3612 | Parameters - [* Values u | navailable withou | t running a bootstra | p] | | | |
| | NegBin | N/A | Num. Est. Parameters | | 2 | 3 | 2 | 1 | 1 |
| | | | Fitted Parameter #1 | | n | n | Min | lambda | p |
| | | | Fitted Value | | 1 | 1 | 0 | 0.40000 | 0.71429 |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A |
| | | | Fitted Parameter #2 | | p | D | Max | | |
| | | | Fitted Value | | 0.40000 | 2 | 1 | | |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | | |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | | |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | | |
| | | | Fitted Parameter #3 | | | М | | | |
| | | | Fitted Value | | | 5 | | | |
| | | | 95% Lower Limit* | | | N/A | | | |
| | | | 95% Upper Limit* | | | N/A | | | |
| | | | Conf. Interval Width* | | | N/A | | | |
| | | | Distribution Statistics | | | | | | |
| | | | Minimum | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | | Maximum | 1.0000 | 1.0000 | 1.0000 | 1.0000 | +Infinity | +Infinity |
| | | | Mean | 0.4000 | 0.4000 | 0.4000 | 0.5000 | 0.4000 | 0.4000 |
| | | | Mode | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | | Median | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | | Std. Deviation | 0.5477 | 0.4899 | 0.4899 | 0.5000 | 0.6325 | 0.7483 |
| | | | Skewness | 0.6086 | 0.4082 | 0.4082 | 0.0000 | 1.5811 | 2.4054 |
| | | | Kurtosis | -0.3333 | 1.1667 | 1.1667 | 1.0000 | 5.5000 | 10.7857 |
| 6 | | 1 1/2 1/2 | | | | | Back | Write To Cell | Close |

Figure 8.2: Number of events >0.30 system minutes – statistics table

1.3 Service parameter 3 – average outage duration

7. Average outage duration (continuous)

Findings:

- A-D fit statistic: LogLogistic distribution best fit, however this returns an undefined standard deviation
 - The Lognorm distribution is also a close fit to the data and is very close to the LogLogistic distribution (0.2278 v. 0.2190) and returns a standard deviation of 211.4355.
 - The Weibull distribution is also a close fit and compares well to LogLogistic (0.2435 v. 0.2190). The Weibull distribution has the advantage of a far superior standard deviation of 91.3057.
- K-S fit statistic: Lognorm distribution best fit, standard deviation 211.4355.
- A-D preferred due to data falling near tails of distribution. There is some question as to which distribution is the most appropriate to use (Lognorm or Weibull), however on balance, Weibull is preferred due to its standard deviation.

🛕 @RISK - Fit Results Fit Ranking Statistics • Fit Comparison for Average outage duration A-D Fit RiskLogLogistic(0,33.642,1.1989) Input LogLogistic 0.2190 0.00 Minimum 4.00 230 Lognorm Lognorm2 0.2278 230.00 Maximum 5.0% 0.2278 Mean 74.08 177.05 7.2% 9.1% 0.025 Weibull 0.2435 Mode ≈20.95 4.53 Gamma 0.2633 Median 24.00 33.64 Levy 0.2760 93.55 Std Dev N/A InvGauss 0.3306 Skewness 1.6124 N/A Pareto2 0.4646 5.2855 N/A Kurtosis Expon 0.4646 Left X 4.0 4.0 0.020 Γ Pert 0.7036 Left P 5.0% 7.2% Γ Triang 1.4335 230.0 230.0 Right X Uniform 2.6974 Right P 95.0% 90.9% Rayleigh 3.8708 Dif. X 226.00 226.00 ChiSa Dif. P 90.0% 83.7% BetaGenera N/A 1% 4.00 0.728 0.015 4.00 Erlang N/A 5% 2.89 Γ Pareto N/A 10% 4.00 5.38 **@RISK Trial Version** Pearson5 N/A 15% 4.00 7.92 For Evaluation Purposes Only Pearsone N/A 20% 4.00 10.59 19.90 25% 13.46 0.010 30% 19.90 16.59 35% 19.90 20.07 40% 19.90 23.99 45% 24.00 28,46 50% 24.00 33.64 55% 24.00 39.77 0.005 60% 92.50 47.18 65% 92.50 56.38 70% 92.50 68.20 75% 92.50 84.11 80% 92.50 106.92 85% 230.00 142.97 0.000 90% 230.00 210.29 ន ន 8 ស្ន 8 ស្ត õ ត្ត 95% 230.00 392.18 🛛 🜆 🖻 🕋 🖾 🖉 🔳 <u>B</u>ack Write To Cell Close

Figure 9.1: Average outage duration- distribution fit using A-D (LogLogistic)

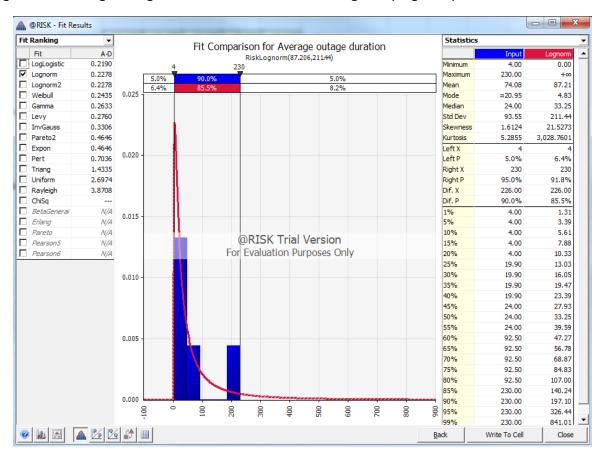
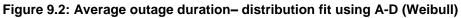
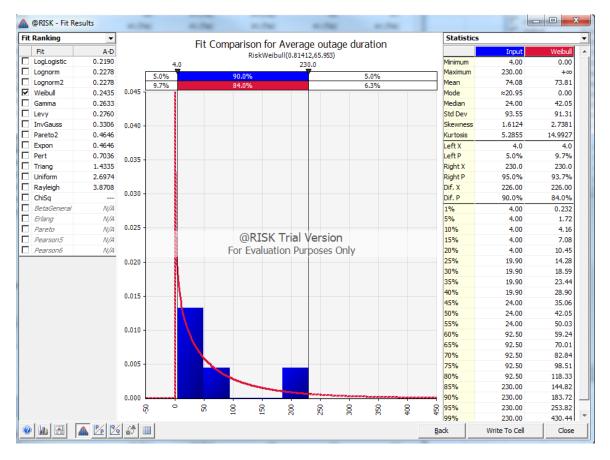


Figure 9.2: Average outage duration- distribution fit using A-D (Lognorm)

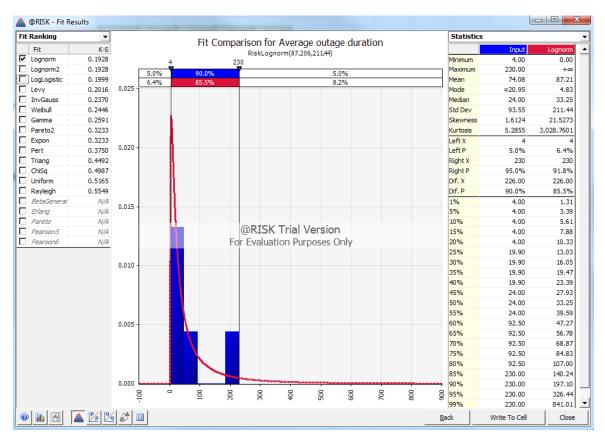




| Fit | Ranking | - | | Input | LogLogistic | Lognorm | Lognorm2 | Weibull | Gamma | |
|-----|----------------------|------------|----------------------------|-------------------|-------------|-----------|--------------------------|-------------|-----------|---|
| | Fit | A-D | - Rankings By Fit Statisti | c [14 Valid Fits] | | | | | | |
| | LogLogistic | 0.2190 | Akaike (AIC) | | #9 | #5 (Tie) | #5 (Tie) | #7 | #8 | |
| | Lognorm | 0.2278 | Bayesian (BIC) | | #8 | #4 (Tie) | #4 (Tie) | #6 | #7 | |
| | Lognorm2 | 0.2278 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | |
| | Weibull | 0.2435 | K-S Statistic | | #3 | #1 (Tie) | #1 (Tie) | #6 | #7 | |
| | | 0.2633 | A-D Statistic | | #1 | #2 (Tie) | #2 (Tie) | #4 | #5 | |
| 늡 | InvGauss | 0.2760 | Parameters - [* Values | uppublic witho | | • • | <i>**</i> 2 (112) | | | |
| 늡 | Pareto2 | 0.3500 | Num, Est, Parameters | | 2 | 2 | 2 | 2 | 2 | _ |
| Ē | Expon | 0.4646 | | | | | | - | - | _ |
| Ē | | 0.7036 | Fitted Parameter #1 | | beta | mu | mu | alpha | alpha | |
| | Triang | 1.4335 | Fitted Value | | 33.6423 | 87.206 | 3.5041 | 0.81412 | 0.74761 | |
| Π | Uniform | 2.6974 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Γ | Rayleigh | 3.8708 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| Γ | ChiSq | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | BetaGeneral | N/A | Fitted Parameter #2 | | alpha | sigma | sigma | beta | beta | - |
| 므 | | N/A | Fitted Value | | 1.1989 | 211.44 | 1.3887 | 65.9534 | 99.0888 | |
| - | Pareto Pearson5 | N/A | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | Pearson5 Pearson6 | N/A N/A | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A | |
| | Pedisono | Түүн | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A | |
| | | | Distribution Statistics | | | | | | | |
| | | | Minimum | 4.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | _ |
| | | | | | | | | | | |
| | | | Maximum | 230.0000 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | |
| | | | Mean | 74.0800 | 177.0523 | 87.2058 | 87.2058 | 73.8132 | 74.0800 | |
| | | | | 20.9500 [e | 4.5335 | 4.8340 | 4.8340 | 0.0000 | 0.0000 | |
| | | | Median | 24.0000 | 33.6423 | 33.2505 | 33.2505 | 42.0456 | 44.7806 | |
| | | | Std. Deviation | 93.5482 | +Infinity | 211.4355 | 211.4355 | 91.3057 | 85.6767 | |
| | | | Skewness | 1.6124 | +Infinity | 21.5264 | 21.5264 | 2.7381 | 2.3131 | |
| | | | Kurtosis | 5.2855 | +Infinity | 3028.4072 | 3028.4072 | 14.9926 | 11.0255 | |
| | | | • | 111 | | | | | | Þ |
| 0 | | | | | | | Back | Write To Ce | | |

Figure 9.4: Average outage duration – statistics table using A-D

Figure 9.5: Average outage duration – distribution fit using K-S



| it | Ranking | - | | Input | Lognorm | Lognorm2 | LogLogistic | Levy | InvGauss |
|----|---------------------|--------|---|---|-----------|-----------|-------------|-----------|-----------|
| | Fit | K-S | - Rankings By Fit Statisti | c [14 Valid Fits] | | | | | |
| | Lognorm | 0.1928 | Akaike (AIC) | | #5 (Tie) | #5 (Tie) | #9 | #2 | #4 |
| | Lognorm2 | 0.1928 | Bayesian (BIC) | | #4 (Tie) | #4 (Tie) | #8 | #2 | #3 |
| | LogLogistic | 0.1999 | Chi-Sq Statistic | | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) | #1 (Tie) |
| | Levy | 0.2016 | K-S Statistic | | #1 (Tie) | #1 (Tie) | #3 | #4 | #5 |
| _ | InvGauss Weibull | 0.2370 | A-D Statistic | | #2 (Tie) | #2 (Tie) | #1 | #6 | #7 |
| _ | Gamma | 0.2446 | Parameters - [* Values | and the last state of the second state of the | | • • | #1 | #0 | #7 |
| | Pareto2 | 0.3233 | | unavaliable withou | - | | | | |
| | Expon | 0.3233 | Num. Est. Parameters | | 2 | 2 | 2 | 1 | 2 |
| | Pert | 0.3750 | Fitted Parameter #1 | | mu | mu | beta | c | mu |
| | Triang | 0.4492 | Fitted Value | | 87.206 | 3.5041 | 33.6423 | 14.0026 | 74.0800 |
| | ChiSq | 0.4987 | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A |
| 1 | Uniform | 0.5165 | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A |
| 1 | Rayleigh | 0.5549 | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A |
| | BetaGeneral | N/A | Fitted Parameter #2 | | sigma | sigma | alpha | | lambda |
| | Erlang | N/A | Fitted Value | | 211.44 | 1.3887 | 1, 1989 | | 17.2663 |
| | Pareto | N/A | 95% Lower Limit* | | N/A | N/A | N/A | | N/A |
| | Pearson5 | N/A | 95% Upper Limit* | | N/A | N/A | N/A | | N/A |
| | Pearson6 | N/A | Conf. Interval Width* | | N/A | N/A | N/A | | N/A |
| | | | | | NA | N/A | N/A | | NA |
| | | | Distribution Statistics | | | | | | |
| | | | Minimum | 4.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | | Maximum | 230.0000 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity |
| | | | Mean | 74.0800 | 87.2058 | 87.2058 | 177.0523 | +Infinity | 74.0800 |
| | | | Mode | 20.9500 [e | 4.8340 | 4.8340 | 4.5335 | 4.6675 | 5.7211 |
| | | | Median | 24.0000 | 33.2505 | 33.2505 | 33.6423 | 30.7792 | 24.7198 |
| | | | Std. Deviation | 93.5482 | 211.4355 | 211.4355 | +Infinity | +Infinity | 153.4448 |
| | | | Skewness | 1.6124 | 21.5264 | 21.5264 | +Infinity | +Infinity | 6.2140 |
| | | | Kurtosis | 5.2855 | 3028.4072 | 3028,4072 | +Infinity | +Infinity | 67.3567 |
| | | | 4 | | | | | | |

Figure 6.4: Transformers outage (forced) – statistics table using K-S

1.4 Service parameter 4 – Proper operation of equipment

8. Failure of protection system (discrete)

Findings:

- Chi Squared fit statistic: Hypergeometric distribution best fit, standard deviation 4.9336
- Poisson distribution next best fit
- Best fit distribution (Hypergeometric) preferred.

Figure 10.1: Failure of protection system – hypergeometric distribution

| Fit Ranking | - | | | Eit Com | oprison f | or Folly | re of p | rotoctio | | | Statistics | | | |
|------------------------------|------------|----------------|-------|---------|-----------|-----------------------|-----------|----------|---------|----|-------------------|---------|----------|----|
| Fit | Chi-Sq | | | Fit Com | | UF Fallu lyperGeo(| | | n syste | em | | Input | HyperGeo | |
| HyperGeo | 0.00433562 | | 17 | 37 | RISKE | iyperGeo(| /9/,105/, | 320/5) | | | Minimum | 12.000 | 0.00 | 11 |
| Poisson | 0.0069 | Г | 5.0% | Y | | | 5.0% | | | | Maximum | 37.000 | 797.00 | |
| IntUniform | 0.2000 | ŀ | 0.2% | | | | 1.2% | | | | Mean | 25.800 | 25.78 | |
| NegBin | 0.7315 | 45% | 01270 | | | | 212.70 | | | | Mode | 32.000 | 25.00 | |
| Geomet | 7.1676 | | | | | | | | | | Median | 32.000 | 26.00 | |
| Binomial | N/A | | | | | | | | | | Std Dev | 11.054 | 4.93 | |
| | | 40% - | | | | | | | | | Skewness | -0.5206 | 0.1803 | |
| | | | | | | | | | | | Kurtosis | 0.3725 | 3.0284 | |
| | | | | | | | | | | | Left X | 12 | 12 | 1 |
| | | 35% - | | | | | | | | | Left P | 5.0% | 0.2% | |
| | | 33 %] | | | | | | | | | Right X | 37 | 37 | |
| | | | | | | | | | | | Right P | 95.0% | 98.8% | |
| | | | | | | | | | | | Dif. X | 25.000 | 25.00 | L |
| | | 30% - | | | | | | | | | Dif. P | 90.0% | 98.6% | |
| | | | | | | | | | | | 1% | 12.000 | 15.00 | 1 |
| | | | | | | | | | | | 5% | 12.000 | 18.00 | L |
| | | 25% - | | | | | | | | | 10% | 12.000 | 20.00 | L |
| | | | | | @RI | SK Tri | ial Ver | sion | | | 15% | 12.000 | 21.00 | |
| | | | | | For Eva | luation | Purpos | es Only | | | 20% | 12.000 | 22.00 | |
| | | 20% - | | | | | | | | | 25% | 16.000 | 22.00 | |
| | | | | | | | | | | | 30% | 16.000 | 23.00 | |
| | | | | | | | | | | | 35% | 16.000 | 24.00 | L |
| | | 15% - | | | | | | | | | 40% | 16.000 | 24.00 | L |
| | | 1370] | | | | | | | | | 45% | 32.000 | 25.00 | L |
| | | | | | | | | | | | 50% | 32.000 | 26.00 | L |
| | | | | | | | | | | | 55% | 32.000 | 26.00 | |
| | | 10% - | | | | | | | | | 60% | 32.000 | 27.00 | |
| | | | | | | | | | | | 65% | 32.000 | 28.00 | |
| | | | | | | | | | | | 70% | 32.000 | 28.00 | |
| | | 5% - | | | | | | | | | 75% | 32.000 | 29.00 | |
| | | | | | | | | | | | 80% | 32.000 | 30.00 | |
| | | | | | | | | | | | 85% | 37.000 | 31.00 | |
| | | 0% L | | | | | | | | | 90% | 37.000 | 32.00 | |
| | | Ę | , - | 8 | 8 | ĝ | ê. | 8 | 009 | 20 | 8 95% | 37.000 | 34.00 | |
| | | - 7 | • | 11 | 2 | ē | 4 | ū | 9 | 7 | ⁶⁰ 99% | 37.000 | 38.00 | |

| it Ranking | • | | Input | HyperGeo | Poisson | IntUniform | NegBin | Geomet |
|------------|---------------|---|--------------------|------------------------|-----------|------------|---------------|-----------|
| Fit | Chi-Sq | - Rankings By Fit Statistic | [5 Valid Fits] | | | | I | |
| HyperGeo | 0.00433562 | Akaike (AIC) | | #5 | #4 | #1 | #3 | #2 |
| Poisson | 0.0069 | Bayesian (BIC) | | #5 | #4 | #1 | #2 | #3 |
| IntUniform | 0.2000 | Chi-Sq Statistic | | #1 | #2 | #3 | #4 | #5 |
| NegBin | 0.7315 | Parameters - [* Values u | inavailable withou | it running a bootstrag | 1 | | | |
| Geomet | 7.1676 N/A | Num, Est, Parameters | | 3 | 1 | 2 | 2 | 1 |
| Diriomai | Түн | Fitted Parameter #1 | | - n | lambda | Min | s | P |
| | | Fitted Value | | 797 | 25.800 | 12 | 8 | 0.037313 |
| | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A |
| | | | | | N/A | | | 17/6 |
| | | Fitted Parameter #2 Fitted Value | | D | | Max | P | |
| | | | | 1057 | | 37 | 0.23669 | |
| | | 95% Lower Limit* | | N/A | | N/A | N/A | |
| | | 95% Upper Limit* | | N/A | | N/A | N/A | |
| | | Conf. Interval Width* | | N/A | | N/A | N/A | |
| | | Fitted Parameter #3 | | м | | | | |
| | | Fitted Value | | 32675 | | | | |
| | | 95% Lower Limit* | | N/A | | | | |
| | | 95% Upper Limit* | | N/A | | | | |
| | | Conf. Interval Width* | | N/A | | | | |
| | | Distribution Statistics | | | | | | |
| | | Minimum | 12.0000 | 0.0000 | 0.0000 | 12.0000 | 0.0000 | 0.0000 |
| | | Maximum | 37.0000 | 797.0000 | +Infinity | 37.0000 | +Infinity | +Infinity |
| | | Mean | 25.8000 | 25.7821 | 25.8000 | 24.5000 | 25.8000 | 25.8000 |
| | | Mode | 32.0000 | 25.0000 | 25.0000 | 12.0000 | 22.0000 | 0.0000 |
| | | Median | 32.0000 | 26.0000 | 26.0000 | 24.0000 | 25.0000 | 18.0000 |
| | | Std. Deviation | 11.0544 | 4.9336 | 5.0794 | 7.5000 | 10.4405 | 26.2952 |
| | | Skewness | -0.5206 | 0.1803 | 0.1969 | 0.0000 | 0.7136 | 2.0004 |
| | | Kurtosis | 0.3725 | 3.0284 | 3.0388 | 1.7964 | 3.7592 | 9.0014 |
| | | - Percentiles | | | | | | |
| 0 | | | | | | Back | Write To Cell | Close |

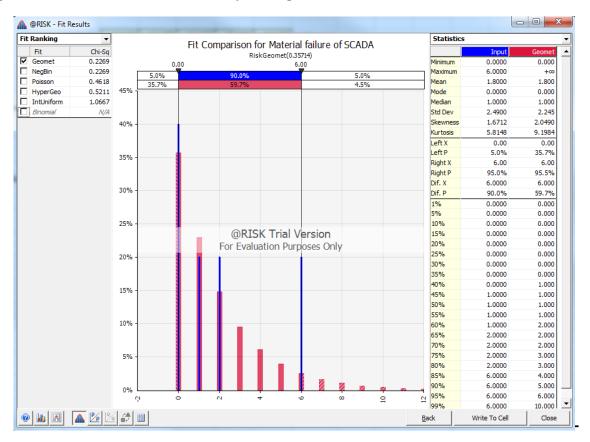
Figure 10.2 Failure of protection system- statistics table

9. Material failure of SCADA system (discrete)

Findings:

- Chi Squared fit statistic: Tie between geometric and NegBin distributions for both best fit (0.2269) and standard deviation 2.245
- Identical results on all other parameters and statistics
- No preference between Geometric and NegBin distributions.

Figure 11.1: Material failure of SCADA system –geometric distribution



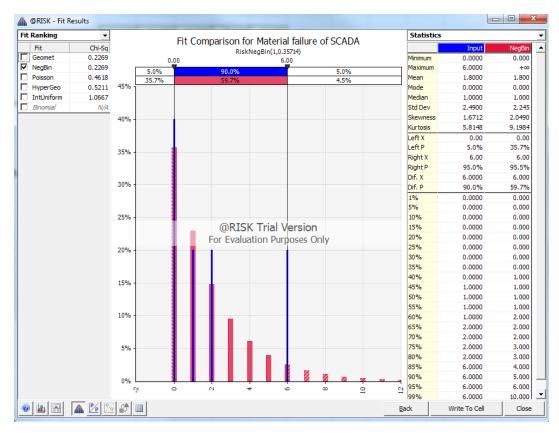


Figure 11.2: Material failure of SCADA system– NegBin distribution

Figure 11.3: Material failure of SCADA system- statistics table

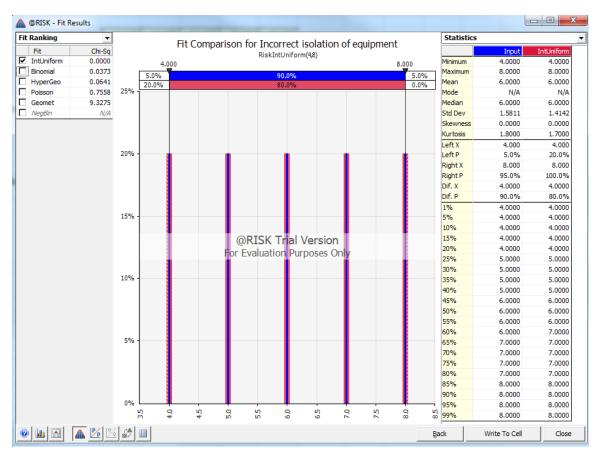
| Poisson 0.4618 International Piece Pie | Fit | Ranking | • | | Input | Geomet | NegBin | Poisson | HyperGeo | IntUniform |
|--|----------|----------|--------|---|-----------------|----------------------|---------------|-------------------|--------------------|------------------|
| VegBin 0.0.269 Method MLE MLE MLE (Approximate) MLE HyperGeo 0.411 | | Fit | Chi-Sq | _ Fit | | | | | | |
| Poisson 0.4618 International Piece Pie | | | 0.2269 | Function | = | RiskGeomet(0.35 =Ris | kNegBin(1,0.3 | =RiskPoisson(1.80 | =RiskHyperGeo(5 =F | RiskIntUniform(0 |
| Image Price Image Price Presented (ST) Presented (ST | V | - | | Method | | MLE | MLE | MLE | MLE (Approximate) | MLE |
| Imperate 0.001 Atalac (ALC) #1 #3 #2 #5 #4 Brunnia/ M/A Bayesian (BLC) #1 #2 #4 #5 #4 Brunnia/ M/A Bayesian (BLC) #1 #2 #4 #5 #4 Brunnia/ M/A Brunnia/ #1 #1 #2 #4 #5 #4 Brunnia/ M/A Brunnia/ #1 #2 #4 #5 #4 Brunnia/ M/A Brunnia/ #1 #2 #4 #5 #4 Brunnia/ M/A Brunnia/ #1 #1 #2 #4 #5 Parameters - [* Values unavailable without running a bootstrap Image: Main MA N/A N/A N/A Sisk Lower Limit* N/A N/A N/A N/A N/A Sisk Lower Limit* N/A N/A N/A N/A N/A Sisk Lower Limit* N/A N/A N/A N/A N/A | <u> </u> | | | - Rankings By Fit Statistic [| 5 Valid Fits] | | | | | |
| Internation 1.00007 # 2 # 4 # 5 # 4 Branewid (N/A) (N/A) # 1(Tie) # 11(Tie) # 3 # 4 # 5 Branewid (N/A) # 1(Tie) # 11(Tie) # 3 # 4 # 5 Immedia (N/A) # 1(Tie) # 10(Tie) # 3 # 4 # 5 Immedia (N/A) # 1(Tie) # 10(Tie) # 3 # 4 # 5 Immedia (N/A) # 10(Tie) # 3 # 4 # 5 # 5 Immedia (N/A) Immedia 1 1000 57 1 1 3 7 0 State (N/A) (N/A) N/A N/A </td <td>_</td> <td></td> <td></td> <td></td> <td></td> <td>#1</td> <td>#3</td> <td>#2</td> <td>#5</td> <td>#4</td> | _ | | | | | #1 | #3 | #2 | #5 | #4 |
| L | | | | | | | | | | |
| Parameters - [* Values unavailable without running a bootstrap] Num. Est. Parameters 1 2 1 3 3 Fitted Parameter #1 p s lambda n Mrin Fitted Parameter #1 p s lambda n Mrin 95% Lower Limit* N/A N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A N/A Fitted Value 0.35714 1027 0 Maxin Maxin N/A Fitted Value 0.35714 1027 0 Maxin Maxin N/A N/A N/A 95% Lower Limit* N/A | | Diriomia | N/A | | | | | #3 | | |
| Num. Est. Parameters 1 2 1 3 2 Fitted Parameter #1 p s lambda n Mini Fitted Value 0.35714 1 1.0000 57 0 95% Lower Limit* N/A N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A N/A Conf. Interval Width* N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A 95% Lower Limit* N/A N/A N/A 7 Conf. Interval Width* N/A N/A N/A 7 Fitted Value N/A N/A 95% Lower Limit* N/A N/A Conf. Interval Width* | | | | · · | navailable with | | | | | |
| Fitted Value 0.35714 1 1.8000 57 0 95% Lower Limit* N/A N/A N/A N/A N/A N/A N/A 95% Loper Limit* N/A N/A N/A N/A N/A N/A N/A 95% Loper Limit* N/A N/A N/A N/A N/A N/A Fitted Value 0 0.35714 1027 0 0 95% Lower Limit* N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A Fitted Value 0 N/A N/A N/A N/A 95% Lower Limit* 0 N/A N/A N/A N/A Fitted Value 0 N/A N/A N/A N/A 95% Loper Limit* 0 N/A N/A N/A Conf. Interval Width* N/A N/A <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-</td> <td>1</td> <td>3</td> <td>2</td> | | | | | | | - | 1 | 3 | 2 |
| 95% Lower Limit* N/A N/A N/A N/A N/A 95% Loper Limit* N/A N/A N/A N/A N/A 95% Loper Limit* N/A N/A N/A N/A N/A Fitted Parameter #2 p D Maximut* Fitted Value 0.35714 1027 C 95% Lower Limit* N/A N/A N/A N/A Fitted Parameter #3 N/A N/A N/A N/A Fitted Value 0 N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A Conf. Interval Width* N/A N/A N/A N/A 95% Loper Limit* N/A N/A N/A N/A Onf. Interval Width* 0.000 0.0000 | | | | Fitted Parameter #1 | | p | s | lambda | n | Mir |
| 35% Upper Limit* N/A N/A N/A N/A N/A N/A Fitted Parameter #2 p D Maxing Fitted Value 0.35714 1027 C 95% Upper Limit* N/A N/A N/A N/A Fitted Value 0.35714 1027 C C 95% Upper Limit* N/A N/A N/A N/A Fitted Value N/A N/A N/A Fitted Value N/A N/A 95% Upper Limit* N/A N/A Conf. Interval Width* N/A N/A Pistribution Statistics N/A N/A | | | | Fitted Value | | 0.35714 | 1 | 1.8000 | 57 | 0 |
| Conf. Interval Width* N/A N/A N/A N/A N/A N/A N/A Fitted Parameter #2 p 0 0 Maxa 0.35714 1027 C 95% Lower Limit* N/A N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A N/A 95% Lower Limit* N/A N/A N/A N/A N/A N/A Fitted Parameter #3 N/A N/A N/A N/A Fitted Value 32675 32675 32675 32675 32675 32675 3000 30000 0. | | | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A |
| Fitted Parameter #2 p D Max Fitted Value 0.35714 1027 66 95% Lower Limit* N/A N/A N/A Fitted Parameter #3 N/A N/A N/A Fitted Value 32675 32675 32675 95% Lower Limit* N/A N/A N/A 95% Lower Limit* 0.0000 0.0000 0.0000 Minium 6.0000 <td< td=""><td></td><td></td><td></td><td>95% Upper Limit*</td><td></td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></td<> | | | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A |
| Fitted Value 0.035714 1027 95% Lower Limit* N/A N/A N/A 95% Upper Limit* N/A N/A N/A 95% Lower Limit* N/A N/A N/A 95% Lower Limit* N/A N/A N/A Fitted Parameter #3 N/A N/A N/A Fitted Value 100 32655 35% Lower Limit* M 95% Lower Limit* N/A N/A N/A 0.0000 0.0000 0.0000 N/A 95% Lower Limit* N/A N/A N/A Minimum 6.0000 0.0000 0.0000 0.0000 Maximum 1.8000 1.8000 1.8000 1.8000 1.9000 | | | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A |
| 95% Lower Limit* N/A N/A N/A N/A 95% Upper Limit* N/A N/A N/A N/A 95% Upper Limit* N/A N/A N/A N/A Fitted Parameter #3 N/A M/A N/A N/A Fitted Parameter #3 M M M/A N/A Fitted Value M M/A N/A N/A 95% Lower Limit* M M/A N/A 95% Upper Limit* M/A N/A N/A 95% Upper Limit* N/A N/A N/A 95% Upper Limit* N/A N/A N/A Ontribution Statistics N/A N/A N/A Minimum 0.0000 0.0000 0.0000 0.0000 Maximum 6.0000 1.8000 1.8000 1.8000 1.8000 1.8000 1.0000 0.0000 Maximum 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Maximum 0.0000 1.8000 </td <td></td> <td></td> <td></td> <td>Fitted Parameter #2</td> <td></td> <td></td> <td>p</td> <td></td> <td>D</td> <td>Max</td> | | | | Fitted Parameter #2 | | | p | | D | Max |
| 95% Upper Limit* 0.000 0.000 0.000 Fitted Parameter #3 M/A M/A Fitted Parameter #3 M/A M/A Fitted Parameter #3 M/A M/A Fitted Value 32675 95% Lower Limit* M/A M/A 95% Lower Limit* M/A M/A 95% Lower Limit* M/A | | | | Fitted Value | | | 0.35714 | | 1027 | e |
| Conf. Interval Width* N/A N/A Fitted Parameter #3 M Fitted Value 32675 32675 95% Lower Limit* N/A N/A 95% Lower Limit* N/A N/A 95% Lower Limit* N/A N/A 05% Lower Limit* N/A N/A Onf. Interval Width* N/A N/A Onf. Interval Width* N/A N/A Minimum 0.0000 0.0000 0.0000 0.0000 0.0000 Maximum 6.0000 1.8000 1.8000 1.8000 1.8000 1.0000 0.0000 Mode 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Mode 0.0000 1.0000 1.0000 1.0000 0.0000 3.0000 3.0000 3.0000 3.0000 3.0000 3.0000 3.0000 3.0000 3.0000 <td></td> <td></td> <td></td> <td>95% Lower Limit*</td> <td></td> <td></td> <td>N/A</td> <td></td> <td>N/A</td> <td>N/A</td> | | | | 95% Lower Limit* | | | N/A | | N/A | N/A |
| Minimum 0.0000 | | | | 95% Upper Limit* | | | N/A | | N/A | N/A |
| Number Number Number Number 95% Lower Limit* Number Number 95% Lower Limit* Number Number Number 95% Lower Limit* Number Number Number Number 0000 0.0000 | | | | Conf. Interval Width* | | | N/A | | N/A | N/A |
| 95% Lower Limit* 0.000 N/A 95% Upper Limit* N/A 0001 Conf. Interval Width* N/A Imimum 0.0000 0.0000 0.0000 0.0000 Maximum 6.0000 +Infinity +Infinity 57.0000 6.0000 Mean 1.8000 1.8000 1.8000 1.0000 0.0000 0.0000 Mode 0.0000 0.0000 0.0000 1.0000 1.0000 0.0000 0.0000 Std. Deviation 2.4900 2.2450 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.796 0.0000 | | | | Fitted Parameter #3 | | | | | М | |
| 95% Upper Limit* Image: Conf. Interval Width* N/A Image: Conf. Interval Width* 0.000 0.0000 0.0000 0.0000 Image: Distribution Statistics Image: Conf. Interval Width* 0.0000 | | | | Fitted Value | | | | | 32675 | |
| Image: Conf. Interval Width* Image: Conf. Interval Width* Image: Conf. Interval Width* Distribution Statistics Image: Conf. Interval Width* N/A Minimum 0.0000 0.0000 0.0000 0.0000 Maximum 6.0000 +Infinity +Infinity 57.0000 6.0000 Mean 1.8000 1.8000 1.8000 1.0000 1.0000 0.0000 Mode 0.0000 0.0000 0.0000 1.0000 1.0000 0.0000 Median 1.0000 1.0000 1.0000 2.0000 3.0000 Std. Deviation 2.4900 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.7096 0.0000 | | | | 95% Lower Limit* | | | | | N/A | |
| Iminum 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Maximum 6.0000 +Infinity +Infinity +Infinity 57.0000 6.0000 Mean 1.8000 1.8000 1.8000 1.8000 1.0000 0.0000 0.0000 Mode 0.0000 0.0000 0.0000 1.0000 1.0000 0.0000 0.0000 Median 1.0000 1.0000 1.0000 2.0000 3.0000 Std. Deviation 2.4900 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.7096 0.0000 | | | | 95% Upper Limit* | | | | | N/A | |
| Minimum 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Maximum 6.0000 +Infinity +Infinity +Infinity 57.0000 6.0000 Mean 1.8000 1.8000 1.8000 1.8000 1.0000 1.0000 0.0000 Mode 0.0000 0.0000 0.0000 1.0000 1.0000 0.0000 Median 1.0000 1.0000 1.0000 2.0000 3.0000 Std. Deviation 2.4900 2.2450 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.7096 0.0000 | | | | Conf. Interval Width* | | | | | N/A | |
| Maximum 6.000 +Infinity +Infinity +Infinity 57.000 6.0000 Mean 1.800 1.8000 1.8000 1.8000 1.8000 1.0000 3.0000 Mode 0.0000 0.0000 0.0000 1.0000 1.0000 0.0000 3.0000 Median 1.0000 1.0000 1.0000 2.0000 3.0000 3.0000 Std. Deviation 2.4900 2.2450 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.7096 0.0000 | | | | Distribution Statistics | | | | | | |
| Mean 1.8000 1.8000 1.8000 1.8000 1.8000 1.8000 1.916 3.0000 Mode 0.0000 0.0000 0.0000 1.0000 1.0000 0.0000 | | | | Minimum | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Mode 0.0000 0.0000 0.0000 1.0000 1.0000 0.0000 Median 1.0000 1.0000 1.0000 2.0000 2.0000 3.0000 Std. Deviation 2.4900 2.2450 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.7096 0.0000 | | | | Maximum | 6.0000 | +Infinity | +Infinity | +Infinity | 57.0000 | 6.0000 |
| Median 1.0000 1.0000 1.0000 2.0000 2.0000 3.0000 Std. Deviation 2.4900 2.2450 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.7096 0.0000 | | | | Mean | 1.8000 | 1.8000 | 1.8000 | 1.8000 | 1.7916 | 3.0000 |
| Std. Deviation 2.4900 2.2450 2.2450 1.3416 1.3162 2.0000 Skewness 1.6712 2.0490 2.0490 0.7454 0.7096 0.0000 | | | | Mode | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 1.0000 | 0.0000 |
| Skewness 1.6712 2.0490 0.7454 0.7096 0.0000 | | | | Median | 1.0000 | 1.0000 | 1.0000 | 2.0000 | 2.0000 | 3.0000 |
| | | | | Std. Deviation | 2.4900 | 2.2450 | 2.2450 | 1.3416 | 1.3162 | 2.0000 |
| Kurtosis 5.8148 9.1984 9.1984 3.5556 3.4668 1.7500 | | | | Skewness | 1.6712 | 2.0490 | 2.0490 | 0.7454 | 0.7096 | 0.0000 |
| | | | | Kurtosis | 5.8148 | 9.1984 | 9.1984 | 3.5556 | 3.4668 | 1.7500 |

10. Incorrect operational isolation of primary or secondary equipment (discrete)

Findings:

- Chi Squared fit statistic: IntUniform distribution best fit, standard deviation 1.4142
- This is due to the nature of the data (five years with results of 4,5,6,7,8)
- Binominal and hypergeometric are the next best fits, with the same standard deviation to IntUniform
- Best fit distribution (IntUniform) preferred

Figure 12.1: Incorrect operational isolation of equipment –geometric distribution



| Fit F | Ranking | - | | Input | IntUniform | Binomial | HyperGeo | Poisson | Geomet |
|-------|-------------------|------------------|---|------------------|---------------------|------------------|-------------------|-----------------|------------------|
| | Fit | Chi-Sq | - Fit | | | | | | |
| - | IntUniform | 0.0000 | Function | = | RiskIntUniform(4 = | RiskBinomial(9,0 | =RiskHyperGeo(1 | =RiskPoisson(6) | =RiskGeomet(0.14 |
| - | Binomial | 0.0373 | Method | | MLE | MLE | MLE (Approximate) | MLE | MLE |
| | HyperGeo | 0.0641 | Rankings By Fit Statistic | [5 Valid Fits] | | | | | |
| _ | Poisson Geomet | 0.7558 9.3275 | Akaike (AIC) | | #2 | #3 | #5 | #1 | #4 |
| | NegBin | N/A | Bayesian (BIC) | | #1 | #2 | #4 | #3 | #5 |
| | | | Chi-Sq Statistic | | #1 | #2 | #3 | #4 | #5 |
| | | | - Parameters - [* Values u | unavailable with | out running a boots | trap] | | | |
| | | | Num. Est. Parameters | | 2 | 2 | 3 | 1 | 1 |
| | | | Fitted Parameter #1 | | Min | n | n | lambda | p |
| | | | Fitted Value | | 4 | 9 | 10 | 6.0000 | 0.14286 |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | N/A | N/A |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | N/A | N/A |
| | | | Fitted Parameter #2 | | Max | | | | |
| | | | Fitted Value | | 8 | 0.66667 | 33 | | |
| | | | 95% Lower Limit* | | N/A | N/A | N/A | | |
| | | | 95% Upper Limit* | | N/A | N/A | N/A | | |
| | | | Conf. Interval Width* | | N/A | N/A | N/A | | |
| | | | Fitted Parameter #3 | | | | M | | |
| | | | Fitted Value | | | | 55 | | |
| | | | 95% Lower Limit* | | | | N/A | | |
| | | | 95% Upper Limit* | | | | N/A | | |
| | | | Conf. Interval Width* | | | | N/A | | |
| | | | Distribution Statistics | | | | | | |
| | | | Minimum | 4.0000 | 4.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | | Maximum | 8,0000 | 8.0000 | 9.0000 | 10.0000 | +Infinity | +Infinity |
| | | | Mean | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 |
| | | | Mode | 4.0000 | 4.0000 | 6,0000 | 6.0000 | 5.0000 | 0.0000 |
| | | | Median | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 4.0000 |
| | | | Std. Deviation | 1.5811 | 1.4142 | 1.4142 | 1.4142 | 2.4495 | 6.4807 |
| | | | Skewness | 0.0000 | 0.0000 | -0.2357 | -0.0934 | 0.4082 | 2.0059 |
| | | | Kurtosis | 1.8000 | 1.7000 | 2.8333 | 2.8643 | 3,1667 | 9.0238 |
| | | | | 1.0000 | 1.,000 | 2.0000 | 210010 | 0.2007 | 5.5250 |

Figure 12.1: Incorrect operational isolation of equipment -statistics table

2 Addendum 14 September 2015

Since the initial version of this report, a number of changes or requests for additional information have been received. These are addressed below.

2.1 Correction of Typographical Errors

2.1.1 Error in standard deviation for parameter 'Number of events >0.05 system minutes'

The first version of this report contained two typographical errors relating to the standard deviation of the 'number of events >0.05 system minutes' parameter in which the text in the report did not reflect the outcome of the analysis. The standard deviation in the first report should have been noted as 2.2450 instead of 0.0606. The correct standard deviation has been updated in this document (sections 7 and 13), however an error in the input data as originally provided has rendered this analysis redundant. See the discussion under 'Correction of input data', below, for an updated analysis of this parameter.

2.2 Additional Data Required

2.2.1 Additional parameters for 'Reactive plant outage rate (forced)'

Subsequent to the first report, the 5th and 95th percentiles of each performance parameter were added to the data required, instead of just the standard deviation. The screenshots for each parameter contained the 5th and

95th percentiles, except the 'reactive plant outage rate (forced)' parameter. The 5th and 95th percentiles for this parameter are included in Figure A.1:

| Fit Ranki | ng 💌 | | Input | LogLogistic | Erlang | Gamma | Lognorm | Lognorm2 | InvGauss | Pearson5 | Weibull |
|-------------|-----------|--|--------------|-------------|-------------|-----------|-------------|-------------|-------------|------------|--------------|
| Fit | A-D | - Fit | | Disk and a | DiskTalana | Diskonne | Diald a sea | Dield a sea | Diskteringe | DiskDasas | Dislatistics |
| LogLogistic | 0.3386 | Function | | =RISKLOGLO | =RiskErlang | =RISKGamm | =RISKLOGNO | =RISKLOGNO | =RISKINVGa | =RiskPears | =RISKWEIDU |
| Erlang | 0.3427 | Distribution Statisti Minimum | 0.1429 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Gamma | 0.3555 | Maximum | 0.3857 | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity | +Infinity |
| Lognorm | 0.3558 | Mean | 0.2686 | 0.2769 | 0.2686 | 0.2686 | 0.2694 | 0.2694 | 0.2686 | 0.2715 | 0,2697 |
| Lognorm2 | 0.3558 | Mode | 0.2339 [est] | 0.2769 | 0.2888 | 0.2000 | 0.2094 | 0.2094 | 0.2000 | 0.2715 | 0.2097 |
| InvGauss | 0.3572 | Median | 0.2339 [est] | 0.2526 | 0.2550 | 0.2363 | 0.2221 | 0.2221 | 0.2194 | 0.2095 | 0.2/06 |
| Pearson5 | 0.3659 | Std. Deviation | 0.2286 | 0.2560 | 0.2575 | | 0.2526 | 0.2526 | 0.2517 | | 0.2694 |
| Weibull | 0.3750 | | 0.1007 | 2.9382 | 0.7071 | | | | | 0.1132 | 0.0882 |
| Rayleigh | 0.4489 | Skewness Kurtosis | | | 3.7500 | 0.6937 | 1.1632 | 1.1632 | 1.1049 | | |
| Uniform | 0.5659 | - Percentiles | 1.5332 | 49.9686 | 3.7500 | 3.7219 | 5.4985 | 5.4985 | 5.0348 | 12.3305 | 2.7105 |
| Expon | 1.0721 | 5% | 0.1429 | 0.1352 | 0.1336 | 0.1358 | 0.1400 | 0.1400 | 0.1403 | 0.1429 | 0.1246 |
| Pareto2 | 1.0721 | 10% | 0.1429 | 0.1352 | | | | | | 0.1429 | |
| ChiSq | 1.5523 | 10% | 0.1429 | 0.1589 | 0.1563 | 0.1582 | 0.1595 | 0.1595 | 0.1392 | 0.1599 | 0.1542 |
| BetaGeneral | +Infinity | 20% | | | | | | | | | |
| Triang | +Infinity | 20% | 0.1429 | 0.1895 | 0.1872 | | 0.1867 | 0.1867 | 0.1859 | 0.1843 | 0.1926 |
| Pareto | N/A | | 0.2286 | 0.2017 | 0.2000 | 0.2013 | 0.1983 | 0.1983 | 0.1974 | 0.1949 | 0.2076 |
| Pearson6 | N/A | 30% | 0.2286 | 0.2130 | 0.2119 | 0.2131 | 0.2093 | 0.2093 | 0.2083 | 0.2051 | 0.2213 |
| | | 35% | 0.2286 | 0.2238 | 0.2234 | | 0.2200 | 0.2200 | 0.2190 | 0.2153 | 0.2340 |
| | | 40% | 0.2286 | 0.2344 | 0.2347 | 0.2355 | 0.2306 | 0.2306 | 0.2296 | 0.2255 | 0.2461 |
| | | 45% | 0.2286 | 0.2451 | 0.2460 | 0.2466 | 0.2414 | 0.2414 | 0.2405 | 0.2360 | 0.2579 |
| | | 50% | 0.2286 | 0.2560 | 0.2575 | | 0.2526 | 0.2526 | 0.2517 | 0.2470 | 0.2694 |
| | | 55% | 0.2286 | 0.2674 | 0.2693 | | 0.2642 | 0.2642 | 0.2634 | 0.2587 | 0.2809 |
| | | 60% | 0.3571 | 0.2795 | 0.2817 | 0.2816 | 0.2766 | 0.2766 | 0.2759 | 0.2714 | 0.2926 |
| | | 65% | 0.3571 | 0.2928 | 0.2948 | 0.2945 | 0.2900 | 0.2900 | 0.2894 | 0.2853 | 0.3047 |
| | | 70% | 0.3571 | 0.3076 | 0.3092 | 0.3086 | 0.3049 | 0.3049 | 0.3043 | 0.3011 | 0.3173 |
| | | 75% | 0.3571 | 0.3248 | 0.3251 | 0.3242 | 0.3218 | 0.3218 | 0.3213 | 0.3194 | 0.3308 |
| | | 80% | 0.3571 | 0.3457 | 0.3435 | 0.3422 | 0.3416 | 0.3416 | 0.3413 | 0.3416 | 0.3458 |
| | | 85% | 0.3857 | 0.3729 | 0.3658 | 0.3640 | 0.3664 | 0.3664 | 0.3661 | 0.3701 | 0.3630 |
| | | 90% | 0.3857 | 0.4122 | 0.3952 | 0.3927 | 0.4001 | 0.4001 | 0.3996 | 0.4104 | 0.3845 |
| | | 95% | 0.3857 | 0.4847 | 0.4414 | 0.4379 | 0.4558 | 0.4558 | 0.4545 | 0.4815 | 0.4157 |
| | | • | | | | | | | | | • |

| Figure 2.1: Reactive plant of | outage (forced) – statistics | table using A-D |
|-------------------------------|------------------------------|-----------------|
|-------------------------------|------------------------------|-----------------|

2.3 Correction of input data

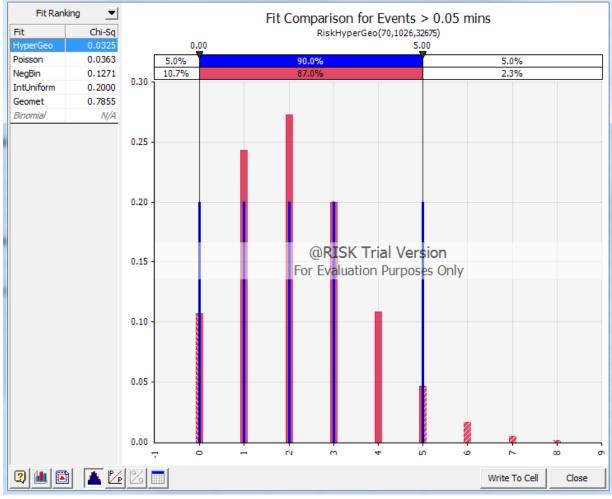
2.3.1 Error in input data for 'Number of events >0.05 system minutes'

The input data received for this parameter contained an error in the final year of data. A corrected data set was provided, in which the final year value was 3, rather than 1. The distribution fitting exercise was performed on the new data, which suggested the HyperGeo distribution was the best fit, with a standard deviation of 1.4576. The detailed results are included below.

Fitting probability distributions to Service Component data

Figure 2.2: Number of events >0.05 system minutes – HyperGeo distribution





| Fit Ranki | ng 💌 | | | Input | HyperGeo | Poisson | NegBin | IntUniform | Geomet |
|----------------------|------------------|-----|------------------------|--------|------------|-------------|------------|-------------|-----------|
| Fit | | F | unction | | =RiskHyper | =RiskPoisso | =RiskNegBi | =RiskIntUni | =RiskGeom |
| HyperGeo | Chi-Sq 0.0325 | _0 | istribution Statistics | | | | | | |
| Poisson | 0.0323 | N | 1inimum | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 0.0363 | N | laximum | 5.0000 | 70.0000 | +Infinity | +Infinity | 5.0000 | +Infinity |
| NegBin IntUniform | 0.1271 | N | lean | 2,2000 | 2,1980 | 2.2000 | 2.2000 | 2.5000 | 2.2000 |
| | | N | lode | 0.0000 | 2.0000 | 2.0000 | 1.0000 | 0.0000 | 0.0000 |
| Geomet | 0.7855 | N | ledian | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 1.0000 |
| Binomial | N/A | S | td. Deviation | 1.9235 | 1.4576 | 1.4832 | 1.7799 | 1.7078 | 2.6533 |
| | | S | kewness | 0.3959 | 0.6403 | 0.6742 | 1.0562 | 0.0000 | 2.0352 |
| | | K | urtosis | 1.9945 | 3.3798 | 3.4545 | 4.5157 | 1.7314 | 9.1420 |
| | | _ P | ercentiles | | | | | | |
| | | 5 | % | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 1 | 0% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 1 | 5% | 0.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 2 | 0% | 0.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 |
| | | 2 | 5% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 |
| | | 3 | 0% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 |
| | | 3 | 5% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 2.0000 | 1.0000 |
| | | 4 | 0% | 1.0000 | 2.0000 | 2.0000 | 1.0000 | 2.0000 | 1.0000 |
| | | 4 | 5% | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 1.0000 |
| | | 5 | 0% | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 1.0000 |
| | | 5 | 5% | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 3.0000 | 2.0000 |
| | | 6 | 0% | 2.0000 | 2.0000 | 2.0000 | 2.0000 | 3.0000 | 2.0000 |
| | | 6 | 5% | 3.0000 | 3.0000 | 3.0000 | 3.0000 | 3.0000 | 2.0000 |
| | | 7 | 0% | 3.0000 | 3.0000 | 3.0000 | 3.0000 | 4.0000 | 3.0000 |
| | | 7 | '5% | 3.0000 | 3.0000 | 3.0000 | 3.0000 | 4.0000 | 3.0000 |
| | | 8 | 0% | 3.0000 | 3.0000 | 3.0000 | 4.0000 | 4.0000 | 4.0000 |
| | | 8 | 5% | 5.0000 | 4.0000 | 4.0000 | 4.0000 | 5.0000 | 5.0000 |
| | | 9 | 0% | 5.0000 | 4.0000 | 4.0000 | 5.0000 | 5.0000 | 6.0000 |
| | | 9 | 5% | 5.0000 | 5.0000 | 5.0000 | 6.0000 | 5.0000 | 7.0000 |
| | | -10 | hi-Squared Test | | | | | | |

Figure 2.3: Number of events >0.05 system minutes – statistics table

2.4 Updated recommendations

2.4.1 Use of Poisson distribution instead of IntUniform

In the last TRR, the AER rejected the proposal to use the IntUniform distribution for the 'number of events >0.3 system minutes' indicator and instead preferred to use the Poisson distribution. The IntUniform distribution is again the distribution that best fit the performance data in the original version of this report.

In order to be consistent with the last determination, it is now recommended that the Poisson distribution is adopted for both this parameter, and also the 'Incorrect operational isolation of primary or secondary equipment' parameter, which also led to the IntUniform parameter being recommended in the initial report. The distribution fit analysis using the Poisson distribution for both of these parameters is included below.

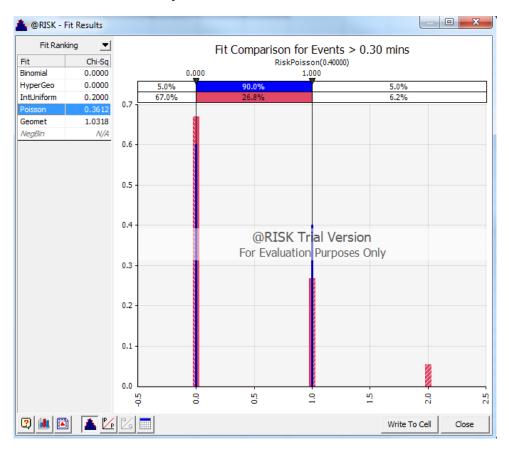


Figure 2.4 Number of events >0.30 system minutes – Poisson distribution

Figure 2.5 Number of events >0.30 system minutes - statistics table

| Fit Ranki | ng 💌 | | Input | Binomial | HyperGeo | IntUniform | Poisson | Geomet |
|------------|--------|---|--------|------------|------------|-------------|-------------|-----------|
| Fit | Chi-Sq | - Fit | | | | | | |
| Binomial | 0.0000 | Function | = | RiskBinomi | =RiskHyper | =RiskIntUni | =RiskPoisso | =RiskGeom |
| HyperGeo | 0.0000 | Distribution Statistics | | | | | | |
| IntUniform | 0.2000 | Minimum | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Poisson | 0.3612 | Maximum | 1.0000 | 1.0000 | 1.0000 | 1.0000 | +Infinity | +Infinity |
| Geomet | 1.0318 | Mean | 0.4000 | 0.4000 | 0.4000 | 0.5000 | 0.4000 | 0.4000 |
| | | Mode | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NegBin | N/A | Median | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | Std. Deviation | 0.5477 | 0.4899 | 0.4899 | 0.5000 | 0.6325 | 0.7483 |
| | | Skewness | 0.4082 | 0.4082 | 0.4082 | 0.0000 | 1.5811 | 2.4054 |
| | | Kurtosis | 1.1667 | 1.1667 | 1.1667 | 1.0000 | 5.5000 | 10.7857 |
| | | - Percentiles | | | | | | |
| | | 5% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 10% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 15% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 20% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 25% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 30% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 35% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 40% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 45% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 50% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | | 55% | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 |
| | | 60% | 0.0000 | 1.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 |
| | | 65% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 |
| | | 70% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 |
| | | 75% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | 80% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | 85% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | 90% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| | | 95% | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 2.0000 | 2.0000 |
| | | - Chi-Souared Test | | | | | | |

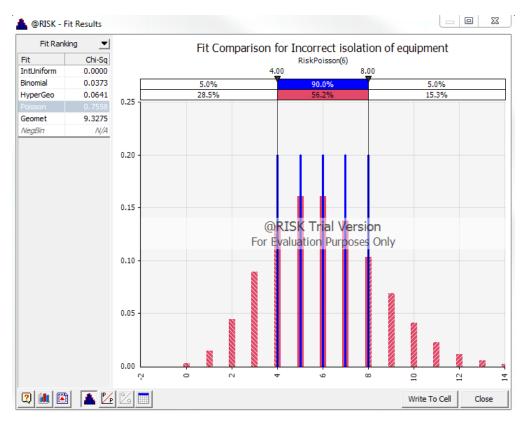


Figure 2.6: Incorrect operational isolation – Poisson distribution

Figure 2.7: Incorrect operational isolation of equipment -statistics table

| Fit Rankir | ng 💌 | | Input | IntUniform | Binomial | HyperGeo | Poisson | Geomet |
|------------|--------|--|--------|-------------|-------------|------------|---------------|-----------|
| Fit | Chi-Sq | - Fit | | | | | | |
| IntUniform | 0.0000 | Function | | =RiskIntUni | =RiskBinomi | =RiskHyper | =RiskPoisso = | =RiskGeom |
| Binomial | 0.0373 | Distribution Statistic | | | | | | |
| HyperGeo | 0.0641 | Minimum | 4.0000 | 4.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Poisson | 0.7558 | Maximum | 8.0000 | 8.0000 | 9.0000 | 10.0000 | +Infinity | +Infinity |
| Geomet | 9.3275 | Mean | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 |
| NegBin | N/A | Mode | 4.0000 | 4.0000 | 6.0000 | 6.0000 | 5.0000 | 0.0000 |
| Neguin | N/A | Median | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 4.0000 |
| | | Std. Deviation | 1.5811 | 1.4142 | 1.4142 | 1.4142 | 2.4495 | 6.4807 |
| | | Skewness | 0.0000 | 0.0000 | -0.2357 | -0.0934 | 0.4082 | 2.0059 |
| | | Kurtosis | 1.7000 | 1.7000 | 2.8333 | 2.8643 | 3.1667 | 9.0238 |
| | | - Percentiles | | | | | | |
| | | 5% | 4.0000 | 4.0000 | 4.0000 | 4.0000 | 2.0000 | 0.0000 |
| | | 10% | 4.0000 | 4.0000 | 4.0000 | 4.0000 | 3.0000 | 0.0000 |
| | | 15% | 4.0000 | 4.0000 | 5.0000 | 5.0000 | 3.0000 | 1.0000 |
| | | 20% | 4.0000 | 4.0000 | 5.0000 | 5.0000 | 4.0000 | 1.0000 |
| | | 25% | 5.0000 | 5.0000 | 5.0000 | 5.0000 | 4.0000 | 1.0000 |
| | | 30% | 5.0000 | 5.0000 | 5.0000 | 5.0000 | 5.0000 | 2.0000 |
| | | 35% | 5.0000 | 5.0000 | 6.0000 | 5.0000 | 5.0000 | 2.0000 |
| | | 40% | 5.0000 | 5.0000 | 6.0000 | 6.0000 | 5.0000 | 3.0000 |
| | | 45% | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 3.0000 |
| | | 50% | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 4.0000 |
| | | 55% | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 6.0000 | 5.0000 |
| | | 60% | 6.0000 | 7.0000 | 6.0000 | 6.0000 | 6.0000 | 5.0000 |
| | | 65% | 7.0000 | 7.0000 | 7.0000 | 7.0000 | 7.0000 | 6.0000 |
| | | 70% | 7.0000 | 7.0000 | 7.0000 | 7.0000 | 7.0000 | 7.0000 |
| | | 75% | 7.0000 | 7.0000 | 7.0000 | 7.0000 | 8.0000 | 8.0000 |
| | | 80% | 7.0000 | 7.0000 | 7.0000 | 7.0000 | 8.0000 | 10.0000 |
| | | 85% | 8.0000 | 8.0000 | 7.0000 | 7.0000 | 9.0000 | 12.0000 |
| | | 90% | 8.0000 | 8.0000 | 8.0000 | 8.0000 | 9.0000 | 14.0000 |
| | | 95% | 8.0000 | 8.0000 | 8,0000 | 8.0000 | 10.0000 | 19.0000 |

3 Addendum 28 October 2015

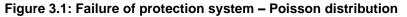
A second addendum was required to reflect the revision of some previously incorrectly stated data.

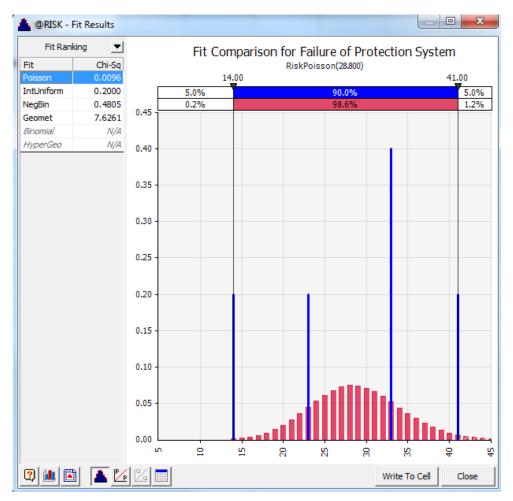
3.1 Correction of input data

3.1.1 Revised input data for parameter 'Failure of protection system'

The audit of AusNet Services' performance data resulted in changes to the input data for the 'Failure of protection system parameter' to reflect the AER's stated intent in the STPIS Version 5 final decision to include both protection and control systems in the scope of this sub-parameter.

Using the revised data, the recommended distribution has changed from the Hypergeometric distribution (standard deviation 4.9336) to the Poisson distribution (standard deviation 5.3666). The detailed results from this exercise are presented below.





| Figure 3.2: Failure of p | protection system – statistics table |
|--------------------------|--------------------------------------|
| | |

| Fit Ranki | ing 💌 | | Input | Poisson | IntUniform | NegBin | Geomet |
|------------|--------|--------------------------|---------|-------------|-------------|------------|-----------|
| | | Function | | =RiskPoisso | =RiskIntUni | =RiskNegBi | =RiskGeom |
| it | Chi-Sq | - Distribution Statistic | s | | | | |
| Poisson | 0.0096 | Minimum | 14.0000 | 0.0000 | 14.0000 | 0.0000 | 0.0000 |
| IntUniform | 0.2000 | Maximum | 41.0000 | +Infinity | 41.0000 | +Infinity | +Infinity |
| VegBin | 0.4805 | Mean | 28.8000 | 28.8000 | 27.5000 | 28.8000 | 28.8000 |
| Geomet | 7.6261 | Mode | 33.0000 | 28.0000 | 14.0000 | 26.0000 | 0.0000 |
| Binomial | N/A | Median | 33.0000 | 29.0000 | 27.0000 | 28.0000 | 20.0000 |
| HyperGeo | N/A | Std. Deviation | 10.4499 | 5.3666 | 8.0777 | 9.8955 | 29.2957 |
| | | Skewness | -0.3608 | 0.1863 | 0.0000 | 0.5861 | 2.0003 |
| | | Kurtosis | 1.8839 | 3.0347 | 1.7969 | 3.5102 | 9.0012 |
| | | - Percentiles | | | | | |
| | | 5% | 14.0000 | 20.0000 | 15.0000 | 14.0000 | 1.0000 |
| | | 10% | 14.0000 | 22.0000 | 16.0000 | 17.0000 | 3.0000 |
| | | 15% | 14.0000 | 23.0000 | 18.0000 | 19.0000 | 4.0000 |
| | | 20% | 14.0000 | 24.0000 | 19.0000 | 20.0000 | 6.0000 |
| | | 25% | 23.0000 | 25.0000 | 20.0000 | 22.0000 | 8.0000 |
| | | 30% | 23.0000 | 26.0000 | 22.0000 | 23.0000 | 10.0000 |
| | | 35% | 23.0000 | 27.0000 | 23.0000 | 24.0000 | 12.0000 |
| | | 40% | 23.0000 | 27.0000 | 25.0000 | 25.0000 | 14.0000 |
| | | 45% | 33.0000 | 28.0000 | 26.0000 | 27.0000 | 17.0000 |
| | | 50% | 33.0000 | 29.0000 | 27.0000 | 28.0000 | 20.0000 |
| | | 55% | 33.0000 | 29.0000 | 29.0000 | 29.0000 | 23.0000 |
| | | 60% | 33.0000 | 30.0000 | 30.0000 | 30.0000 | 26.0000 |
| | | 65% | 33.0000 | 31.0000 | 32.0000 | 32.0000 | 30.0000 |
| | | 70% | 33.0000 | 31.0000 | 33.0000 | 33.0000 | 35.0000 |
| | | 75% | 33.0000 | 32.0000 | 34.0000 | 35.0000 | 40.0000 |
| | | 80% | 33.0000 | 33.0000 | 36.0000 | 37.0000 | 47.0000 |
| | | 85% | 41.0000 | 34.0000 | 37.0000 | 39.0000 | 55.0000 |
| | | 90% | 41.0000 | 36.0000 | 39.0000 | 42.0000 | 67.0000 |
| | | 95% | 41.0000 | 38.0000 | 40.0000 | 47.0000 | 87.0000 |
| | | - Chi-Squared Test | | | | | |