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Component/Train Unavailability Summaries

1 MSPI Unavailability Data

Table 1-1. MSPI UA data and fitted distributions.

EDG UA (219 Trains, 2002 - 2004)			HPCS EDG UA (8 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)	Statistic	Train Data	Beta Distribution (note a)
Mean	0.0134	0.0134	Mean	0.0133	0.0133
SD	0.0079	0.0070	SD	0.0054	0.0055
95%	0.0257	0.0267	95%	-	0.0235
50%	0.0121	0.0122	50%	-	0.0126
5%	0.0048	0.0043	5%	-	0.0057
EF	2.12	2.18	EF	-	1.87
α		3.586	α		5.761
β		263.3	β		426.1
HPSI MDP UA (196 Trains, 2002 - 2004)			HPCS MDP UA (8 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)	Statistic	Train Data	Beta Distribution (note a)
Mean	0.00412	0.00412	Mean	0.0131	0.0131
SD	0.0031	0.0027	SD	0.0163	0.0104
95%	0.0100	0.0093	95%	-	0.0336
50%	0.0034	0.0036	50%	-	0.0104
5%	0.0009	0.0009	5%	-	0.0016
EF	2.93	2.61	EF	-	3.22
α		2.348	α		1.537
β		567.5	β		115.9
AFWS MDP UA (122 Trains, 2002 - 2004)			NSW MDP UA (6 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)	Statistic	Train Data	Beta Distribution (note a)
Mean	0.00395	0.00395	Mean	0.0164	0.0164
SD	0.0023	0.0025	SD	0.0068	0.0065
95%	0.0082	0.0088	95%	-	0.0283
50%	0.0037	0.0034	50%	-	0.0156
5%	0.0005	0.0009	5%	-	0.0074
EF	2.20	2.59	EF	-	1.82
α		2.387	α		6.278
β		602.2	β		376.1
ESW MDP UA (223 Trains, 2002 - 2004)			RHRSW MDP UA (8 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)	Statistic	Train Data	Beta Distribution (note a)
Mean	0.0130	0.0130	Mean	0.00576	0.00576
SD	0.0226	0.0128	SD	0.0061	0.0050
95%	0.0507	0.0387	95%	-	0.0156
50%	0.0060	0.0091	50%	-	0.0044
5%	0.0002	0.0007	5%	-	0.0005
EF	8.41	4.26	EF	-	3.55
α		1.000	α		1.320
β		75.9	β		227.9

Table 1-1. (continued).

CCW MDP UA (133 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00591	0.00591
SD	0.0073	0.0052
95%	0.0184	0.0162
50%	0.0037	0.0045
5%	0.0006	0.0005
EF	4.99	3.61
α		1.288
β		216.7

All MDP UA (696 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00751	0.00751
SD	0.0141	0.0075
95%	0.0226	0.0224
50%	0.0041	0.0052
5%	0.0006	0.0004
EF	5.54	4.28
α		1.000
β		132.2

HPCI TDP UA (24 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.0130	0.0130
SD	0.0061	0.0071
95%	0.0229	0.0264
50%	0.0130	0.0117
5%	0.0047	0.0039
EF	1.77	2.25
α		3.288
β		249.9

RCIC TDP UA (30 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.0107	0.0107
SD	0.0046	0.0049
95%	0.0181	0.0198
50%	0.0109	0.0099
5%	0.0039	0.0041
EF	1.66	1.99
α		4.703
β		435.9

AFWS TDP UA (69 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00544	0.00544
SD	0.0034	0.0037
95%	0.0116	0.0125
50%	0.0050	0.0046
5%	0.0006	0.0011
EF	2.31	2.70
α		2.177
β		398.0

AFWS DDP UA (5 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00970	0.00970
SD	0.0035	0.0029
95%	-	0.0149
50%	-	0.0094
5%	-	0.0054
EF	-	1.59
α		10.946
β		1117.7

SWS DDP UA (5 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.02950	0.0295
SD	0.0131	0.0117
95%	-	0.0510
50%	-	0.0280
5%	-	0.0131
EF	-	1.82
α		6.134
β		201.8

FWR Injection UA (4 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.0160	0.0160
SD	0.0093	0.0100
95%	-	0.0352
50%	-	0.0140
5%	-	0.0037
EF	-	2.52
α		2.500
β		153.7

Table 1-1. (continued).

IC Injection UA (6 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00586	0.00586
SD	0.0062	0.0052
95%	-	0.0161
50%	-	0.0044
5%	-	0.0005
EF	-	3.65
α		1.265
β		214.5

ESW Header UA (53 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00865	0.00865
SD	0.0132	0.0086
95%	0.0331	0.0258
50%	0.0052	0.0060
5%	0.0000	0.0004
EF	6.39	4.28
α		1.000
β		114.7

RHRSW Header UA (38 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00363	0.00363
SD	0.0032	0.0027
95%	0.0105	0.0090
50%	0.0031	0.0030
5%	0.0000	0.0005
EF	3.45	3.02
α		1.747
β		480.1

RHR BWR HTX UA (70 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00762	0.00762
SD	0.0040	0.0039
95%	0.0147	0.0150
50%	0.0068	0.0070
5%	0.0031	0.0025
EF	2.16	2.15
α		3.759
β		489.7

RHR PWR HTX UA (145 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00518	0.00518
SD	0.0036	0.0031
95%	0.0118	0.0111
50%	0.0044	0.0046
5%	0.0014	0.0013
EF	2.68	2.43
α		2.748
β		527.7

CCW HTX UA (73 Trains, 2002 - 2004)		
Statistic	Train Data	Beta Distribution (note a)
Mean	0.00723	0.00723
SD	0.0073	0.0072
95%	0.0248	0.0216
50%	0.0039	0.0050
5%	0.0000	0.0004
EF	6.40	4.29
α		1.000
β		137.3

Acronyms – AFWS (auxiliary feedwater system), BWR (boiling water reactor), EDG (emergency diesel generator), EF (error factor), FWCI (feedwater coolant injection), HPCS (high-pressure core spray), HPCI (high-pressure coolant injection), HPSI (high-pressure safety injection), HTG (hydro turbine generator), IC (isolation condenser), PWR (pressurized water reactor), RCIC (reactor core isolation cooling), RHR (residual heat removal), SD (standard deviation), UA (unavailability)
Note a - Maximum likelihood estimate approach. For cases with fewer than 5 trains, an average α of 2.5 was assumed.

2 Other Unavailability Estimates

Table 2-1. Comparison of IPE and ROP SSU UA estimates.

System Train	IPE UA (1980s) (61 Plants)	MSPI UA (2002 - 2004) (103 Plants)	IPE/MSPI	ROP SSU UA (1998 - 2002) (103 Plants)	IPE/ROP
EDG	0.0270	0.0134	2.01	0.0090	3.00
HPCI TDP	0.0310	0.0130	2.38	0.0112	2.77
HPSI MDP	0.0094	0.0041	2.28	0.0050	1.88
HPCS MDP	0.0140	0.0131	1.07	0.0068	2.06
RCIC TDP	0.0280	0.0107	2.62	0.0129	2.17
AFWS MDP	0.0100	0.0040	2.53	0.0050	2.00
AFWS TDP	0.0240	0.0054	4.41	0.0050	4.80
AFWS DDP	0.0030	0.0097	0.31	0.0050	0.60
RHR BWR	0.0100	0.0076	1.31	0.0073	1.37
RHR PWR	0.0089	0.0052	1.72	0.0052	1.71
		Average	2.06	Average	2.24

Acronyms - AFWS (auxiliary feedwater system), BWR (boiling water reactor), DDP (diesel-driven pump), EDG (emergency diesel generator), HPCI (high-pressure coolant injection), HPSI (high-pressure safety injection), IPE (Individual Plant Examination), MDP (motor-driven pump), MSPI (mitigating systems performance index), PWR (pressurized water reactor), RCIC (reactor core isolation cooling), RHR (residual heat removal), ROP (Reactor Oversight Process), SSU (Safety System Unavailability), TDP (turbine-driven pump), UA (unavailability)

Table 2-2. IPE UA estimates.

Train Unavailability Event	Description	Data Source	Data	Recommended Probability Distribution				
			IPE (Ref. B-3)	Distribution (note a)	Mean	α	β	Error Factor
AHU-TM	Air Handling Unit Test or Maintenance	IPEs	Table C-1, CFC-FAN-TM	Beta (IPEs, SCNID)	2.48E-03	0.50	2.01E+02	8.4
BAC-TM	Bus (ac) Test or Maintenance	IPEs	Table C-1, ACP-BAC-TM	Beta (IPEs, SCNID)	2.15E-04	0.50	2.33E+03	8.4
BCH-TM	Battery Charger Test or Maintenance	IPEs	Table C-1, CDP-BCH-TM	Beta (IPEs, SCNID)	2.20E-03	0.50	2.27E+02	8.4
CHL-TM	Chiller Test or Maintenance	IPEs	Table C-1, EHV-FAN-TM-TRN	Beta (IPEs/2, SCNID)	1.98E-02	0.50	2.48E+01	8.2
CTF-TM	Cooling Tower Fan Test or Maintenance	IPEs	Table C-1, OLW-FAN-TM	Beta (IPEs, SCNID)	1.86E-03	0.50	2.68E+02	8.4
CTG-TM	Combustion Turbine Generator Test or Maintenance	IPEs	Table C-1, GTG-TM	Beta (IPEs/2, SCNID)	5.00E-02	0.50	9.50E+00	7.7
EOV-TM	Explosive-Operated Valve Test or Maintenance	IPEs	Table C-1, SLC-EPV-TM	Beta (IPEs, SCNID)	5.52E-04	0.50	9.05E+02	8.4
FAN-TM	Fan Test or Maintenance	IPEs	Table C-1, EHV-FAN-TM	Beta (IPEs, SCNID)	2.00E-03	0.50	2.50E+02	8.4
HTX-TM	Heat Exchanger Test or Maintenance	IPEs	Table C-1, RHR-HTX-TM	Beta (IPEs, SCNID)	2.74E-03	0.50	1.82E+02	8.4
MDC-TM	Motor-Driven Compressor Test or Maintenance	IPEs	Table C-1, IAS-MDC-TM	Beta (IPEs/2, SCNID)	1.30E-02	0.50	3.80E+01	8.3
PDP-TM	Positive Displacement Pump Test or Maintenance	IPEs	Table C-1, CVC-PDP-TM	Beta (IPEs, SCNID)	3.19E-03	0.50	1.56E+02	8.4

Acronyms - AHU (air-handling unit), BAC (bus ac), BCH (battery charger), CHL (chiller), CNID (constrained noninformative distribution), CTF (cooling tower fan), CTG (combustion turbine generator), EOV (explosive-operated valve), FAN (fan), HTX (heat exchanger), IPE (Individual Plant Examination), LL (lower limit), MDC (motor-driven compressor), PDP (positive displacement pump), SCNID (simplified constrained noninformative distribution), TM (test or maintenance)

Note a - The format for the distributions is the following: distribution type (source for mean, source for α factor). If the source for the mean indicates IPE/2, these are cases in which the IPE value was divided by two to reflect more current performance.

3 References

1. U.S. Nuclear Regulatory Commission, "Mitigating Systems Performance Index (MSPI)," http://nrc.gov/NRR/OVERSIGHT/ASSESS/mspi.html.
2. U.S. Nuclear Regulatory Commission, "Reactor Oversight Process (ROP)," http://nrc.gov/NRR/OVERSIGHT/ASSESS/index.html.
3. M.S. DeHaan et al., "Generic Test and Maintenance Unavailabilities Based on Data from the IPEs," September 1999, attached to letter from M.B. Sattison, Idaho National Laboratory, to E.G. Rodrick, U.S. Nuclear Regulatory Commission, MBS-02-99, September 20, 1999.