

SECTION 7: RELIABILITY ENGINEERING DESIGN GUIDELINES

TABLE 7.8-1: FAILURE MODE DISTRIBUTION OF PARTS⁶

DEVICE TYPE	FAILURE MODE	MODE PROBABILITY (α)
Accumulator	Leaking	.47
	Seized	.23
	Worn	.20
	Contaminated	.10
Actuator	Spurious Position Change	.36
	Binding	.27
	Leaking	.22
	Seized	.15
Alarm	False Indication	.48
	Failure to Operate	.29
	Spurious Operation	.18
	Degraded Alarm	.05
Antenna	No Transmission	.54
	Signal Leakage	.21
	Spurious Transmission	.25
Battery, Lithium	Degraded Output	.78
	Startup Delay	.14
	Short	.06
	Open	.02
Battery, Lead Acid	Degraded Output	.70
	Short	.20
	Intermittent Output	.10
Battery, Ni-Cd	Degraded Output	.72
	No Output	.28
Bearing	Binding/Sticking	.50
	Excessive Play	.43
	Contaminated	.07
Belt	Excessive Wear	.75
	Broken	.25
Brake	Excessive Wear	.56
	Leaking	.23
	Scored	.11
	Corroded	.05
	Loose	.05
Bushing	Excessive Wear	.85
	Loose	.11
	Cracked	.04
Cable	Short	.45
	Excessive Wear	.36
	Open	.19
Capacitor, Aluminum, Electrolytic	Short	.53
	Open	.35
	Electrolyte Leak	.10
	Decrease in Capacitance	.02

⁶ Reliability Analysis Center, "Failure Mode/Mechanism Distributions" (FMD-91)

SECTION 7: RELIABILITY ENGINEERING DESIGN GUIDELINES

TABLE 7.8-1: FAILURE MODE DISTRIBUTION OF PARTS (CONT'D)

DEVICE TYPE	FAILURE MODE	MODE PROBABILITY (α)
Capacitor, Ceramic	Short	.49
	Change in Value	.29
	Open	.22
Capacitor, Mica/Glass	Short	.72
	Change in Value	.15
	Open	.13
Capacitor, Paper	Short	.63
	Open	.37
Capacitor, Plastic	Open	.42
	Short	.40
	Change in Value	.18
Capacitor, Tantalum	Short	.57
	Open	.32
	Change in Value	.11
Capacitor, Tantalum, Electrolytic	Short	.69
	Open	.17
	Change in Value	.14
Capacitor, Variable, Piston	Change in Value	.60
	Short	.30
	Open	.10
Circuit Breaker	Opens Without Stimuli	.51
	Does Not Open	.49
Clutch	Binding/Sticking	.56
	Slippage	.24
	No Movement	.20
Coil	Short	.42
	Open	.42
	Change in Value	.16
Connector/Connection	Open	.61
	Poor Contact/Intermittent	.23
	Short	.16
Counter Assembly	Inaccurate Count	.91
	Seized	.09
Diode, General	Short	.49
	Open	.36
	Parameter Change	.15
Diode, Rectifier	Short	.51
	Open	.29
	Parameter Change	.20

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TABLE 7.8-1: FAILURE MODE DISTRIBUTION OF PARTS (CONT'D)

DEVICE TYPE	FAILURE MODE	MODE PROBABILITY (α)
Diode, SCR	Short	.98
	Open	.02
Diode, Small Signal	Parameter Change	.58
	Open	.24
	Short	.18
Diode, Thyristor	Failed Off	.45
	Short	.40
	Open	.10
	Failed On	.05
Diode, Triac	Failed Off	.90
	Failed On	.10
Diode, Zener, Voltage Reference	Parameter Change	.69
	Open	.18
	Short	.13
Diode, Zener, Voltage Regulator	Open	.45
	Parameter Change	.35
	Short	.20
Electric Motor, AC	Winding Failure	.31
	Bearing Failure	.28
	Fails to Run, After Start	.23
	Fails to Start	.18
Fuse	Fails to Open	.49
	Slow to Open	.43
	Premature Open	.08
Gear	Excessive Wear	.54
	Binding/Sticking	.46
Generator	Degraded Output	.60
	No Output	.22
	Fails to Run, After Start	.09
	Loss of Control	.09
Hybrid Device	Open Circuit	.51
	Degraded Output	.26
	Short Circuit	.17
	No Output	.06
Injector	Corroded	.87
	Deformed	.08
	Cracked/Fractured	.05

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TABLE 7.8-1: FAILURE MODE DISTRIBUTION OF PARTS (CONT'D)

DEVICE TYPE	FAILURE MODE	MODE PROBABILITY (α)
Keyboard Assembly	Spring Failure	.32
	Contact Failure	.30
	Connection Failure	.30
	Lock-up	.08
Lamp/Light	No Illumination	.67
	Loss of Illumination	.33
Liquid Crystal Display	Dim Rows	.39
	Blank Display	.22
	Flickering Rows	.20
	Missing Elements	.19
Mechanical Filter	Leaking	.67
	Clogged	.33
Meter	Faulty Indication	.51
	Unable to Adjust	.23
	Open	.14
	No Indication	.12
Microcircuit, Digital, Bipolar	Output Stuck High	.28
	Output Stuck Low	.28
	Input Open	.22
	Output Open	.22
Microcircuit, Digital, MOS	Input Open	.36
	Output Open	.36
	Supply Open	.12
	Output Stuck Low	.09
	Output Stuck High	.08
Microcircuit, Interface	Output Stuck Low	.58
	Output Open	.16
	Input Open	.16
	Supply Open	.10
Microcircuit, Linear	Improper Output	.77
	No Output	.23
Microcircuit, Memory, Bipolar	Slow Transfer of Data	.79
	Data Bit Loss	.21
Microcircuit, Memory, MOS	Data Bit Loss	.34
	Short	.26
	Open	.23
	Slow Transfer of Data	.17

SECTION 7: RELIABILITY ENGINEERING DESIGN GUIDELINES

TABLE 7.8-1: FAILURE MODE DISTRIBUTION OF PARTS (CONT'D)

DEVICE TYPE	FAILURE MODE	MODE PROBABILITY (α)
Microwave Amplifier	No Output	.90
	Limited Voltage Gain	.10
Microwave, Connector	High Insertion Loss	.80
	Open	.20
Microwave Detector	Power Loss	.90
	No Output	.10
Microwave, Diode	Open	.60
	Parameter Change	.28
	Short	.12
Microwave Filter	Center Frequency Drift	.80
	No Output	.20
Microwave Mixer	Power Decrease	.90
	Loss of Intermediate Frequency	.10
Microwave Modulator	Power Loss	.90
	No Output	.10
Microwave Oscillator	No Output	.80
	Untuned Frequency	.10
	Reduced Power	.10
Microwave VCO	No Output	.80
	Untuned Frequency	.15
	Reduced Power	.05
Optoelectronic LED	Open	.70
	Short	.30
Optoelectronic Sensor	Short	.50
	Open	.50
Power Supply	No Output	.52
	Incorrect Output	.48
Printed Wiring Assembly	Open	.76
	Short	.24
Pump, Centrifugal	No Output	.67
	Degraded Output	.33
Pump, Hydraulic	Leaking	.82
	Improper Flow	.12
	No Flow	.06
Relay	Fails to Trip	.55
	Spurious Trip	.26
	Short	.19

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TABLE 7.8-1: FAILURE MODE DISTRIBUTION OF PARTS (CONTD)

DEVICE TYPE	FAILURE MODE	MODE PROBABILITY (α)
Resistor, Composition	Parameter Change	.66
	Open	.31
	Short	.03
Resistor, Film	Open	.59
	Parameter Change	.36
	Short	.05
Resistor, Wirewound	Open	.65
	Parameter Change	.26
	Short	.09
Resistor, Network	Open	.92
	Short	.08
Resistor, Variable	Open	.53
	Erratic Output	.40
	Short	.07
Rotary Switch	Improper Output	.53
	Contact Failure	.47
Software	Design Changes	.46
	Design Errors	.41
	User Error	.07
	Documentation Error	.06
Solenoid	Short	.52
	Slow Movement	.43
	Open	.05
Switch, Push-button	Open	.60
	Sticking	.33
	Short	.07
Switch, Thermal	Parameter Change	.63
	Open	.27
	No Control	.08
	Short	.02
Switch, Toggle	Open	.65
	Sticking	.19
	Short	.16
Synchro	Winding Failure	.45
	Bearing Failure	.33
	Brush Failure	.22

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TABLE 7.8-1: FAILURE MODE DISTRIBUTION OF PARTS (CONT'D)

DEVICE TYPE	FAILURE MODE	MODE PROBABILITY (α)
Transducer	Out of Tolerance	.68
	False Response	.15
	Open	.12
	Short	.05
Transformer	Open	.42
	Short	.42
	Parameter Change	.16
Transistor, Bipolar	Short	.73
	Open	.27
Transistor, FET	Short	.51
	Output Low	.22
	Parameter Change	.17
	Open	.05
	Output High	.05
Transistor, GaAs FET	Open	.61
	Short	.26
	Parameter Change	.13
Transistor, R.F.	Parameter Change	.50
	Short	.40
	Open	.10
Tube, Traveling Wave	Reduced Output Power	.71
	High Helix Current	.11
	Gun Failure	.09
	Open Helix	.09
Valve, Hydraulic	Leaking	.77
	Stuck Closed	.12
	Stuck Open	.11
Valve, Pneumatic	Leaking	.28
	Stuck Open	.20
	Stuck Closed	.20
	Spurious Opening	.16
	Spurious Closing	.16
Valve, Relief	Premature Open	.77
	Leaking	.23