

Asset Failure Rate Table

When evaluating the failure rate associated with physical components, and empirical data is not available at the time of the analysis, the following reference table can be used to set the *minimum* Likelihood of occurrence (e.g., probability of catastrophic failure).

AFR

Demand refers to the number of cycles. If demand is unknown, use 12,500 cycles per 8,760 hours, or 1.4 cycles per hour. **Count** refers to the number of failures during continuous operation over 8,760 hours. Use the equation $F(t) = \lambda t$. **Mean-Time-Between-Failures (MTBF)** is based on 8,760 hours and calculated for 1 Asset. Multiply the Count by the number of assets to recalculate MTBF for multiple assets within the same period.

COMPONENT	FAILURE EFFECT	FAILURE RATE (λ)	COUNT	MTBF (hrs)
Bearings	Fatigue	$2 \times 10^{-5}/\text{hr}$	0.1752	50,000
Belts (Drive)	Fatigue	$3.33 \times 10^{-5}/\text{hr}$	0.28908	30,303
Circuit Breakers	Failure to Operate	$1 \times 10^{-3}/\text{demand}$	12.264	714
	Premature Transfer	$1 \times 10^{-6}/\text{hr}$	0.00876	1,000,000
Controllers (Solid State)	Failure to Operate	$1 \times 10^{-5}/\text{hr}$	0.0876	100,000
Couplings (Flexible)	Fatigue	$1.33 \times 10^{-5}/\text{hr}$	0.116508	75,188
Cylinders (Hydraulic)	Failure to Operate	$1.1 \times 10^{-6}/\text{hr}$	0.009636	909,091
Diaphragm (Metal)	Fatigue	$1.53 \times 10^{-5}/\text{demand}$	0.1876392	46,685
Diaphragm (Rubber)	Fatigue	$1.66 \times 10^{-5}/\text{demand}$	0.2035824	43,029
	Failure to Start	$3 \times 10^{-2}/\text{hr}$	262.8	33
Diesel (Complete System)	Fails to Run (Emergency)	$3 \times 10^{-3}/\text{demand}$	36.792	238
	Fails to Run (Engine Only)	$3 \times 10^{-4}/\text{hr}$	2.628	3,333
	Failure to Start	$3 \times 10^{-4}/\text{demand}$	3.6792	2,381
Electric Motors (Motor, AC)	Fails to Run	$1 \times 10^{-5}/\text{hr}$	0.0876	100,000
	Fails to Run (Extreme Environment)	$1 \times 10^{-3}/\text{hr}$	8.76	1,000
Fans/Blowers/Compressors	Failure to Start	$1 \times 10^{-3}/\text{demand}$	12.264	714
	Fails to Run	$3 \times 10^{-5}/\text{hr}$	0.2628	33,333
Flanges/Closures/Elbows	External Leak – Rupture	$3 \times 10^{-7}/\text{hr}$	0.002628	3,333,333
Filters (Fluid)	No Output – Clogged	$4 \times 10^{-5}/\text{hr}$	0.3504	25,000
Fuses	Premature Open	$1 \times 10^{-6}/\text{hr}$	0.00876	1,000,000
	Failure to Open	$1 \times 10^{-5}/\text{demand}$	0.12264	71,429
Gears (Gearbox)	Fatigue	$1.33 \times 10^{-5}/\text{hr}$	0.116508	75,188

COMPONENT	FAILURE EFFECT	FAILURE RATE (λ)	COUNT	MTBF (hrs)
Instrumentation (Amplification, Annunciators, Transducers, Calibration, Combination)			0.438	20,000
	Failure to Operate	5x10 ⁻⁵ /hr		
	Improper Output	3x10 ⁻⁵ /hr	0.2628	33,333
Lubricants (Oils, Greases)	Fatigue	1x10 ⁻⁴ /hr	0.876	10,000
Magnets (Powered, Unmanned)	Failure to Operate	2x10 ⁻⁷ /hr	0.001752	5,000,000
Pipes >3" (High Quality)	Rupture (per Section)	1x10 ⁻¹⁰ /hr	0.000000876	10,000,000,000
Pipes <3" (High Quality)	Rupture (per Section)	1x10 ⁻⁹ /hr	0.00000876	1,000,000,000
Power Supplies	No Output	3x10 ⁻⁶ /hr	0.02628	333,333
	No Output	6.66x10 ⁻⁶ /hr	0.0583416	150,150
Pumps (Centrifugal)	Fails to Run	3x10 ⁻⁵ /hr	0.2628	33,333
	Fails to Run (Extreme Environment)	1x10 ⁻³ /hr	8.76	1,000
Pumps (Reciprocating)	No Output	2x10 ⁻⁵ /hr	0.1752	50,000
	Failure to Energize	1x10 ⁻⁴ /demand	1.2264	7,143
	Failure NO Contact to Close	3x10 ⁻⁷ /hr	0.002628	3,333,333
Relays	Short Across NO/NO Contacts	1x10 ⁻⁸ /hr	0.0000876	100,000,000
	Open NC Contact	1x10 ⁻⁷ /hr	0.000876	10,000,000
Seals (Mechanical)	Fatigue	4x10 ⁻⁵ /hr	0.3504	25,000
Solid State Devices (High Power Applications)	Failure to Function	3x10 ⁻⁶ /hr	0.02628	333,333
	Shorts	1x10 ⁻⁶ /hr	0.00876	1,000,000
Solid State Devices (Low Power Applications)	Failure to Function	1x10 ⁻⁶ /hr	0.00876	1,000,000
	Shorts	1x10 ⁻⁷ /hr	0.000876	10,000,000
Transformers	Open	1x10 ⁻⁶ /hr	0.00876	1,000,000
	Shorts	1x10 ⁻⁶ /hr	0.00876	1,000,000
	Limit - Fails to Operate	3x10 ⁻⁴ /demand	3.6792	2,381
	Torque - Fails to Operate	1x10 ⁻⁴ /demand	1.2264	7,143
Switches	Pressure - Fails to Operate	1x10 ⁻⁴ /demand	1.2264	7,143
	Manual - Fails to Transition	1x10 ⁻⁵ /demand	0.12264	71,429
	Manual - Contact Shorts	1x10 ⁻⁸ /hr	0.0000876	100,000,000
	Fails to Operate	1x10 ⁻³ /demand	12.264	714
Valves: MOV (Motorized)	Fails to Remain Open (plugged)	1x10 ⁻⁴ /demand	1.2264	7,143
	External Leak – Rupture	1x10 ⁻⁸ /hr	0.0000876	100,000,000
Valves: SOV (Solenoid Operated)	Fails to Operate	1.33x10 ⁻⁵ /demand	0.1631112	53,706
	Fails to Operate	3x10 ⁻⁴ /demand	3.6792	2,381

COMPONENT	FAILURE EFFECT	FAILURE RATE (λ)	COUNT	MTBF (hrs)
Valves: AOV (Air Operated)	Fails to Remain Open (plugged)	1×10^{-4} /demand	1.2264	7,143
	External Leak – Rupture	1×10^{-8} /hr	0.0000876	100,000,000
	Fails to Operate	1×10^{-4} /demand	1.2264	7,143
Valves: Check	Reverse Leak	3×10^{-7} /hr	0.002628	3,333,333
	External Leak – Rupture	1×10^{-8} /hr	0.0000876	100,000,000
Valves: Control	Fails to Operate	1×10^{-5} /demand	0.12264	71,429
Valves: Vacuum	Fails to Operate	3×10^{-5} /demand	0.36792	23,810
	Rupture	1×10^{-8} /hr	0.0000876	100,000,000
Valves: Orifices, Flow Meters	Rupture	1×10^{-8} /hr	0.0000876	100,000,000
Valves: Manual	Fails to Remain Open (plugged)	1×10^{-4} /demand	1.2264	7,143
Valves: Relief	Fails to Open	1×10^{-5} /demand	0.12264	71,429
	Premature Open	1×10^{-5} /hr	0.0876	100,000
Welds	Leaks	3×10^{-9} /hr	0.00002628	333,333,333
	Open	3×10^{-6} /hr	0.02628	333,333
Wires	Short to Ground	1×10^{-7} /hr	0.000876	10,000,000
	Short to Power	1×10^{-8} /hr	0.0000876	100,000,000

Human Error Rates

Type of Activity	Probability of Human Error
Lowest probability of any single task performed by an individual and not verified by another individual.	0.0001
A simple, routine inspection task performed by a single individual.	0.001
Failure to follow procedures for any routine task or routine operation.	0.003
Error of commission like misreading a gauge or selecting the wrong setting as part of the performance of a routine task.	0.003
A manual operation that does not provide immediate feedback, like entering a setpoint, adjusting a valve, or tightening a fastener as part of the performance of a routine task.	0.01
Any non-routine task performed without a written procedure and not verified by another individual.	0.03
Any non-routine startup or shutdown task performed during an abnormal process condition.	0.1
Any task performed under dangerous conditions , like working from an elevated position or under extreme physical conditions.	0.3
Any task performed within 1 minute of a serious incident , like an emergent response after a failure, spill, or even an alarm.	0.9