MIL-HDBK-217 Equation References

217 Reliability Prediction Equations

MIL-HDBK-217 is divided into sections based on part type. The following equations are organized based on the structure of MIL-HDBK-217. Under each part type heading, you will find the various equations used to calculate failure rate for that part type. You will also find a description of each of the items included in the equation. This information is intended to be a guide. It is not intended to replace MIL-HDBK-217 as a reference. For that reason, specific values for many of the Pi factors are not included. You will still need to reference MIL-HDBK-217 if you want to verify all values.

Note: All 217 Equations are based on MIL-HDBK-217 F Notice 2.

217 Microcircuit Equations

217 Gate/Logic Arrays and Microprocessor Equations

$$\lambda_P = (C_1\pi_T + C_2\pi_E)\pi_Q\pi_L$$

where:

$C_1 =$	Die Complexity Failure Rate
$\pi_T =$	Temperature Factor
$C_2 =$	Package Failure Rate
$\pi_E =$	Environment Factor
$\pi_Q =$	Quality Factor
$\pi_L =$	Learning Factor

217 Memories Equations

$$\lambda_P = (C_1\pi_T + C_2\pi_E + \lambda_{cyc})\pi_Q\pi_L$$

where:

$C_1 =$	Die Complexity Failure Rate
$\pi_T =$	Temperature Factor
$C_2 =$	Package Failure Rate
$\pi_E =$	Environment Factor
$\lambda_{cyc} =$	EEPROM Read/Write Cycling Induced Failure Rate
$\pi_Q =$	Quality Factor
$\pi_L =$	Learning Factor

217 VHSIC/VHSIC-Like and VLSI CMOS Equations

$$\lambda_P = \lambda_{BD}\pi_{MFG}\pi_T\pi_{CD} + \lambda_{BP}\pi_E\pi_Q\pi_{PT} + \lambda_{EOS}$$

where:

$\lambda_{BD} =$	Die Base Failure Rate
$\pi_{MFG} =$	Manufacturing Process Correction Factor
$\pi_T =$	Temperature Factor
$\pi_{CD} =$	Die Complexity Correction Factor
$\lambda_{BP} =$	Package Base Failure Rate
$\pi_E =$	Environment Factor
$\pi_Q =$	Quality Factor
$\pi_{PT} =$	Package Type Correction Factor
$\lambda_{EOS} =$	Electrical Overstress Failure Rate

217 GaAs MMIC and Digital Devices Equations

$$\lambda_P = (C_1\pi_T\pi_A + C_2\pi_E)\pi_L\pi_Q$$

where:

$C_1 =$	Die Complexity Failure Rate
$\pi_T =$	Temperature Factor
$\pi_A =$	Device Application Factor
$C_2 =$	Package Failure Rate
$\pi_E =$	Environment Factor
$\pi_L =$	Learning Factor
$\pi_Q =$	Quality Factor

217 Hybrid Equation

$$\lambda_P = [\sum N_C \lambda_C](1+.2\pi_E)\pi_F \pi_Q \pi_L$$

where:

$N_C =$	Number of Each Particular Component
$\lambda_C =$	Failure Rate of Each Particular Component
$\pi_E =$	Environment Factor
$\pi_F =$	Circuit Function Factor
$\pi_Q =$	Quality Factor
$\pi_L =$	Learning Factor

217 SAW Device Equation

$$\lambda_P = 2.1\ \pi_Q \pi_E$$

where:

$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Magnetic Bubble Memories Equation

$$\lambda_P = \lambda_1 + \lambda_2$$

where:

$\lambda_1 =$	Failure Rate of the Control and Detection Structure $\lambda_1 = \pi_Q[N_C C_{11}\pi_{T1}\pi_W + (N_C C_{21} + C_2)\pi_E]\pi_D \pi_L$
$\lambda_2 =$	Failure Rate of the Memory Storage Area $\lambda_2 = \pi_Q N_C (C_{12}\pi_{T2} + C_{22}\pi_E)\pi_L$
$\pi_Q =$	Quality Factor
$N_C =$	Number of Bubble Chips per Packaged Device
C_{11} & $C_{21} =$	Device Complexity Failure Rate for Control & Detection Structure
$\pi_T =$	Temperature Factor
$\pi_W =$	Write Duty Cycle Factor
C_{12} & $C_{22} =$	Device Complexity Failure Rate for Memory Storage Structure
$C_2 =$	Package Failure Rate
$\pi_E =$	Environment Factor
$\pi_D =$	Duty Cycle Factor
$\pi_L =$	Learning Factor

217 Discrete Semiconductors Equations

217 Diodes, Low Frequency Equations

$$\lambda_P = \lambda_b \pi_T \pi_S \pi_C \pi_Q \pi_E$$

where:

$\lambda_b =$ Base Failure Rate

$\pi_T =$ Temperature Factor

$\pi_S =$ Electrical Stress Factor

$\pi_C =$ Contact Construction Factor

$\pi_Q =$ Quality Factor

$\pi_E =$ Environment Factor

217 Diodes, High Frequency (Microwave, RF) Equations

$$\lambda_P = \lambda_b \pi_T \pi_A \pi_R \pi_Q \pi_E$$

where:

$\lambda_b =$ Base Failure Rate

$\pi_T =$ Temperature Factor

$\pi_A =$ Application Factor

$\pi_R =$ Power Rating Factor

$\pi_Q =$ Quality Factor

$\pi_E =$ Environment Factor

217 Transistors, Low Frequency, Bipolar

$$\lambda_P = \lambda_b \pi_T \pi_A \pi_R \pi_S \pi_Q \pi_E$$

where:

$\lambda_b =$ Base Failure Rate

$\pi_T =$ Temperature Factor

$\pi_A =$ Application Factor

$\pi_R =$ Power Rating Factor

$\pi_S =$ Voltage Stress Factor

$\pi_Q =$ Quality Factor

$\pi_E =$ Environment Factor

217 Transistors, Low Frequency, Si FET Equations

$\lambda_P = \lambda_b \pi_T \pi_A \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_A =$	Application Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Transistors, Unijunction Equations

$\lambda_P = \lambda_b \pi_T \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Transistors, Low Noise, High Frequency, Bipolar Equations

$\lambda_P = \lambda_b \pi_T \pi_R \pi_S \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_R =$	Power Rating Factor
$\pi_S =$	Voltage Stress Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Transistors, High Power, High Frequency, Bipolar Equations

$$\lambda_P = \lambda_b \pi_T \pi_A \pi_M \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_A =$	Application Factor
$\pi_M =$	Matching Network Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Transistors, High Frequency, GaAs FET Equations

$$\lambda_P = \lambda_b \pi_T \pi_A \pi_M \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_A =$	Application Factor
$\pi_M =$	Matching Network Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Transistors, High Frequency, Si FET Equations

$$\lambda_P = \lambda_b \pi_T \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Thyristors and SCRs Equations

$$\lambda_P = \lambda_b \pi_T \pi_R \pi_S \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_R =$	Current Rating Factor
$\pi_S =$	Voltage Stress Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Optoelectronics, Detectors, Isolators, Emitters Equations

$$\lambda_P = \lambda_b \pi_T \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Optoelectronics, Alphanumeric Displays Equations

$$\lambda_P = \lambda_b \pi_T \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Optoelectronics, Laser Diode Equations

$\lambda_P = \lambda_b \pi_T \pi_Q \pi_I \pi_A \pi_P \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_Q =$	Quality Factor
$\pi_I =$	Forward Current Factor
$\pi_A =$	Application Factor
$\pi_P =$	Power Degradation Factor
$\pi_E =$	Environment Factor

217 Tubes Equations

217 Tubes, All types except TWT and Magnetron Equations

$\lambda_P = \lambda_b \pi_L \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_L =$	Learning Factor
$\pi_E =$	Environment Factor

217 Tubes, Traveling Wave Equations

$\lambda_P = \lambda_b \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_E =$	Environment Factor

217 Tubes, Magnetron Equations

$\lambda_P = \lambda_b \pi_U \pi_C \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_U =$	Utilization Factor
$\pi_C =$	Construction Factor
$\pi_E =$	Environment Factor

217 Lasers Equations

217 Lasers, Helium and Argon Equations

$$\lambda_P = \lambda_{MEDIA}\pi_E + \lambda_{COUPLING}\pi_E$$

where:

$\lambda_{MEDIA} =$	Lasing Media Failure Rate
$\lambda_{COUPLING} =$	Coupling Failure Rate
$\pi_E =$	Environment Factor

217 Lasers, Carbon Dioxide, Sealed Equations

$$\lambda_P = \lambda_{MEDIA}\pi_O\pi_B\pi_E + 10\pi_{OS}\pi_E$$

where:

$\lambda_{MEDIA} =$	Lasing Media Failure Rate
$\pi_O =$	Gas Overfill Factor
$\pi_B =$	Ballast Factor
$\pi_E =$	Environment Factor
$\pi_{OS} =$	Optical Surface Factor

217 Lasers, Carbon Dioxide, Flowing Equations

$$\lambda_P = \lambda_{COUPLING}\pi_{OS}\pi_E$$

where:

$\lambda_{COUPLING} =$	Coupling Failure Rate
$\pi_{OS} =$	Optical Surface Factor
$\pi_E =$	Environment Factor

217 Lasers, Solid State, ND:YAG and Ruby Rod Equations

$$\lambda_P = (\lambda_{PUMP} + \lambda_{MEDIA} + 16.3\pi_C\pi_{OS})\pi_E$$

where:

$\lambda_{PUMP} =$	Pump Pulse Failure Rate
$\lambda_{MEDIA} =$	Media Failure Rate
$\pi_C =$	Coupling Cleanliness Factor
$\pi_{OS} =$	Optical Surface Factor
$\pi_E =$	Environment Factor

217 Resistors Equations

$$\lambda_P = \lambda_b \pi_T \pi_P \pi_S \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_P =$	Power Factor
$\pi_S =$	Power Stress Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Capacitors Equations

$$\lambda_P = \lambda_b \pi_T \pi_C \pi_V \pi_{SR} \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_C =$	Capacitance Factor
$\pi_V =$	Voltage Stress Factor
$\pi_{SR} =$	Series Resistance Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Inductive Devices Equations

217 Transformers Equations

$$\lambda_P = \lambda_b \pi_T \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Coils Equations

$$\lambda_P = \lambda_b \pi_T \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Rotating Devices Equations

217 Motors Equations

$$\lambda_P = \frac{\lambda_1}{A\alpha_B} + \frac{\lambda_2}{B\alpha_W}$$

where:

$\lambda_1 =$	Base Bearing Failure Rate
$\lambda_2 =$	Base Winding Failure Rate
$A =$	Based on Motor Type
$\alpha_B =$	Weibull Characteristic Life for Motor Bearing
	$\alpha_B = \left[10^{\left(2.534 - \frac{2357}{T_A + 273}\right)} + \frac{1}{10^{\left(20 - \frac{4500}{T_A + 273}\right)} + 300} \right]^{-1}$
$B =$	Based on Motor Type
$\alpha_W =$	Weibull Characteristic Life for the Motor Windings
	$\alpha_W = 10^{\left[\frac{2357}{T_A + 273} - 1.83\right]}$
$T_A =$	Ambient Temperature (°C)

217 Synchros and Resolvers Equations

$$\lambda_P = \lambda_b \pi_S \pi_N \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_S =$	Size Factor
$\pi_N =$	Number of Brushes Factor
$\pi_E =$	Environment Factor

217 Elapsed Time Meters Equations

$\lambda_P = \lambda_b \pi_T \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Stress Factor
$\pi_E =$	Environment Factor

217 Relays Equations

217 Mechanical Relays Equations

$\lambda_P = \lambda_b \pi_L \pi_C \pi_{CYC} \pi_F \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_L =$	Load Stress Factor
$\pi_C =$	Contact Form Factor
$\pi_{CYC} =$	Cycling Factor
$\pi_F =$	Application and Construction Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Solid State and Time Delay Relays Equations

$\lambda_P = \lambda_b \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Switches Equations

$\lambda_P = \lambda_b \pi_L \pi_C \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_L =$	Load Stress Factor
$\pi_C =$	Contact Configuration Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Switches, Circuit Breakers Equations

$\lambda_P = \lambda_b \pi_C \pi_U \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_C =$	Configuration Factor
$\pi_U =$	Use Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Connectors Equations

217 General Connectors Equations

$\lambda_P = \lambda_b \pi_T \pi_K \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_T =$	Temperature Factor
$\pi_K =$	Mating/Unmating Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Socket Connectors Equations

$$\lambda_P = \lambda_b \pi_P \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$\pi_P =$	Active Pins Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Interconnection Assemblies with Plated Through Holes Equations

$$\lambda_P = \lambda_b [N_1 \pi_C + N_2 (\pi_C + 13)] \pi_Q \pi_E$$

where:

$\lambda_b =$	Base Failure Rate
$N_1 =$	Number of PTHs Factor
$\pi_C =$	Complexity Factor
$N_2 =$	Number of PTHs Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Interconnection Assemblies, Surface Mount Technology Equations

As per Page 16-2 of MIL-HDBK-217F Notice 2, "The SMT model was developed to assess the life integrity of leadless and leaded devices. It provides a relative measure of circuit card wearout due to thermal cycling fatigue failure of the ‘weakest link’ SMT device. An analysis should be performed on all circuit board SMT components. The component with the largest failure rate value (weakest link) is assessed as the overall board failure rate due to SMT. The model assumes the board is completely renewed upon failure of the weakest link and the results do not consider solder or lead manufacturing defects. This mode is based on the techniques developed in Reference 37."

$\lambda_{SMT} =$ Average failure rate over the expected equipment life cycle due to surface mount device wearout. This failure rate contribution to the system is for the Surface Mount Device on each board exhibiting the highest absolute value of the strain range: $|\alpha_S \Delta_T - \alpha_{CC}(\Delta_T + T_{RISE})| \times 10^{-6}$

$$\lambda_{SMT} = \frac{ECF}{\alpha_{SMT}}$$

where:

$ECF =$ Effective cumulative # of failures over the Weibull characteristic life

$\alpha_{SMT} =$ The Weibull characteristic life. α_{SMT} is a function of device and substrate material, the manufacturing methods, and the application environment used.

$$\alpha_{SMT} = \frac{Nf}{CR}$$

$CR =$ Temperature cycling rate in cycles per calendar hour

$Nf =$ Average number of thermal cycles to failure

$$Nf = 3.5\left(\frac{d}{.65h}|(\alpha_S \Delta T - \alpha_{CC}(\Delta T + T_{RISE}))| \times 10^{-6}\right)^{-2.26}(\pi_{LC})$$

$\alpha_S =$ Circuit board substrate thermal coefficient of expansion (TCE)

$\Delta T =$ Use environment temperature extreme difference

$\alpha_{CC} =$ Package material thermal coefficient of expansion (TCE)

$T_{RISE} =$ Temperature rise due to power dissipation

$\pi_{LC} =$ Lead configuration factor

217 Connections Equations

$$\lambda_P = \lambda_b \pi_E$$

where:

$\lambda_b =$ Base Failure Rate

$\pi_E =$ Environment Factor

217 Meters, Panel Equations

$\lambda_P = \lambda_b \pi_A \pi_F \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_A =$	Application Factor
$\pi_F =$	Function Factor
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Quartz Crystals Equations

$\lambda_P = \lambda_b \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Lamps Equations

$\lambda_P = \lambda_b \pi_U \pi_A \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_U =$	Utilization Factor
$\pi_A =$	Application Factor
$\pi_E =$	Environment Factor

217 Electronic Filters, Non-Tunable Equations

$\lambda_P = \lambda_b \pi_Q \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_Q =$	Quality Factor
$\pi_E =$	Environment Factor

217 Fuses Equations

$\lambda_P = \lambda_b \pi_E$

where:

$\lambda_b =$	Base Failure Rate
$\pi_E =$	Environment Factor

217 Miscellaneous Parts Equations

$\pi_E =$ Environment Factor

217 Vibrators Equations

$\lambda_P = 15$	for 60-cycle
$\lambda_P = 20$	for 120-cycle
$\lambda_P = 40$	for 400-cycle

217 Lamps (Misc) Equations

$\lambda_P = 0.20$ for Neon Lamps

217 Fiber Optic Cables Equations

$\lambda_P = 0.1$ (per Fiber Km)

217 Single Fiber Optic Connectors Equations

$\lambda_P = 0.10$

217 Microwave Elements (Coaxial & Waveguide) Equations

Attenuators (Fixed & Variable): –See Resistors, Type RD

Fixed Elements (Directional Couplers, Fixed Stubs & Cavities): –Negligible

Variable Elements (Tuned Stubs & Cavities): $\lambda_P = 0.10$

217 Microwave Ferrite Devices Equations

Isolators & Circulators (≤100W): $\lambda_P = 0.10 \times \pi_E$

Isolators & Circulators (>100W): $\lambda_P = 0.20 \times \pi_E$

Phase Shifter (Latching): $\lambda_P = 0.10 \times \pi_E$

217 Dummy Loads Equations

<100W: $\lambda_P = 0.010 \times \pi_E$

100W to ≤1000W: $\lambda_P = 0.030 \times \pi_E$

>1000W: $\lambda_P = 0.10 \times \pi_E$

217 Terminations Equations

$\lambda_P = 0.030 \times \pi_E$