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Glossary of Vehicle Networks for Multiplexing and Data Communications

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HIGHWAY
VEHICLE
REPORT

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GLOSSARY OF VEHICLE NETWORKS
FOR MULTIPLEXING AND DATA COMMUNICATIONS

Acknowledgment: A type of response which is used to indicate whether a message has been received properly. Acknowledgments can be positive, indicating the message was received, or negative, indicating the message was not received.

Arbitration: Making a decision relative to a controversy using the inputs of the units involved. In an arbitration-based protocol, arbitration is the process of awarding the communications medium (signal bus) to one of the nodes contending for it.

Arbitration-Based Protocol: A form of contention-based protocol where contention is bit-by-bit and non-destructive, such that the communications medium (signal bus) is successfully awarded to the node with the highest priority information, even at 100% bus utilization. Arbitration-based protocols typically require that the physical length of the signal bus be sufficiently short such that the propagation time for signal transmission is significantly less than one information bit.

Availability: The decimal fraction of the time during which a system is capable of performing all or nearly all of its intended functions. Availability is determined from reliability (Mean Time Between Failures) and repair time (Mean Time to Restore) by the relationship A = MTBF / (MTBF + MTTR). To avoid ambiguity, it is possible to define different levels or modes of operation and to determine an availability for each level or mode.

Baseband: The band of frequencies occupied by unmodulated signals. The ratio of the information bandwidth (upper limit minus the lower limit of the frequency band) to the center frequency is typically larger than unity.

Baseband Communications: A communications method in which the transmitted signal is in its unmodulated form and not changed by modulation.

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Bridge: A node used to connect two networks that use similar protocols, as differentiated from a gateway.

Broadband Communications: A communications method in which the transmitted signal is the original signal modulated onto a carrier. The form of modulation can be amplitude, frequency, or phase.

Broadcast Communications: The transmission of information to more than one receiver, as differentiated from node-to-node communications.

Carrier: A wave suitable for modulation by an information bearing signal to be transmitted over a communications medium. For a waveform to be considered to include a carrier, it shall have a separate carrier, as in amplitude and frequency modulation, rather than an inherent carrier, as in pulse width modulation.

Carrier Sense: The ability of a receiver to sense if another node is transmitting (providing a listen before talking capability) or to sense if any node is transmitting (adding a listening while talking capability). These capabilities permit the design of contention based protocols.

Carrier Sense Multiple Access (CSMA) Protocol: A protocol in which a node on a multiple node signal bus waits for an idle bus before attempting to transmit.

Carrier Sense Multiple Access With Collision Detection (CSMA/CD) Protocol: A type of CSMA protocol whereby when a node which is attempting to transmit detects that another node is also attempting to transmit, it delays for a time determined by a predefined contention algorithm.

Centralized Control: An organization of a control system whereby a central control element exercises control over the remainder of the system (see also master/slave).

Closed System: A system, consisting of nodes interconnected by a common communications medium (signal bus) according to established standards, which does not permit the easy addition of modules developed by another manufacturer and temporary connection to other networks, as in an open system.

Coaxial Cable: A communications medium (signal bus) with two concentric conductors separated by dielectric material(s) resulting in low losses and a relatively constant specific impedance over a wide range of frequencies.

Collision Avoidance Protocol: A protocol in which a node waits a fixed period of time after the end of the last message or after detecting that another node is also attempting to transmit before trying to transmit or to transmit again. Each node in a network is assigned a different fixed period of time.

Contention-Based Protocol: A protocol or organization of communications data where the nodes providing the data seek the use of the communications medium (signal bus) and the bus is awarded based upon the application of a predefined algorithm (typically a priority structure) to the information the nodes provide.

Data Communications (Class B System): A potential multiplex system usage whereby data is transferred between nodes to eliminate redundant sensors and other system elements. The nodes in this form of a multiplex system typically already existed as stand-alone modules in a conventionally wired vehicle.

Data Consistency: A feature of communications in some multiplex wiring systems whereby it is determined and ensured that all required recipients of a message have received the message accurately before acting upon it simultaneously. This feature is desirable in, for example, ensuring that all four lamps are turned on at once or that all four brakes are energized simultaneously.

Distributed Control: An organization of a control system whereby control logic elements of comparable capability and authority are physically located in several different places, as differentiated from a centralized organization of control.

Driver: A solid state device used to transfer electrical power to the next stage, which may be another driver, an electrical load (power driver), a wire or cable (line driver), a display (display driver), etc.

Fiber Optics: A communications medium (signal bus) consisting of either individual fibers or an assemblage of transparent glass or plastic fiber(s) bundled together parallel to one another. This fiber or bundle of fibers has the ability to transmit light along its axis by a process of total internal reflection.

Fiber Optics Receiver: An assembly which accomplishes the receive function in fiber optics communications, typically consisting of a photodetector (either a photodiode or a phototransistor) and a preamplifier.

Fiber Optics Transmitter: A unit which accomplishes the driver function in fiber optics communications, typically consisting of a light emitting diode (LED) and an LED drive circuit. In contrast with the preamplifier of a fiber optics receiver, the LED drive circuit is not required to be, and typically is not, packaged with the LED.

Flexible System: A system, consisting of nodes interconnected by a common communications medium (signal bus) according to established standards, to which nodes manufactured by another supplier can be added.

Gateway: A node used to connect networks that use different protocols, as differentiated from a bridge. A gateway acts as a protocol converter.

Ground Bus: The portion of the wiring serving all multiplex system nodes which provides ground potential and a return path for the current drawn by the node.

High Data Rate Controls (Class C System): A potential multiplex system usage whereby high data rate signals typically associated with real time control systems, such as engine controls and anti-skid brakes, are also sent over the signal bus to facilitate distributed data processing and further reduce vehicle wiring.

Latency: The time required by a system to access the medium so as to begin the delivery of information. Latency is measured from the time that a node is ready to send specific information to the time of the start of the transmission of this information which will ultimately be successful. Thus, the total time required to successfully send a desired message will be the sum of the latency and the message transmission time.

Line Driver: A solid state device (driver) used to transfer electrical energy to a wire or cable communications medium (signal bus), performing the transmit portion of the transceive function.

Line Receiver: A solid state device used to receive electrically transmitted signals from a wire or cable communications medium (signal bus), performing the receive portion of the transceive function.

Link: A relatively simple communications system which is capable of supporting communications between exactly two nodes, typically located at the physical ends of the system.

Master/Slave: A type of system (system architecture) whereby one node (a module) acts as a master or central unit and controls the actions of the other nodes, designated as slaves or remote units.

Message Administration: The portion of the protocol dealing with the procedures for establishing and controlling transmissions on the multiplex signal bus. Message administration deals with what messages must be sent and when they must be sent in accomplishing the desired communications.

Message Transfer: The portion of the protocol dealing with the organization, meaning, and timing associated with the bits of data. Message transfer deals with what bits must be sent and when they must be sent in accomplishing the transmission of a message.

Module: A subassembly with intelligence which typically accepts inputs from switches and/or sensors and provides outputs to actuators, lamps, and/or displays. In a multiplex system, a module is one type of node.

Multiplex: To interleave or simultaneously transmit two or more messages on a single channel.

Multiplex Bus: The wiring serving all multiplex system nodes and including the signal, power, and ground buses.

Multiplexed Body Wiring (Class A System): A potential multiplex system usage whereby vehicle wiring is reduced by the transmission and reception of multiple signals over the same signal bus between nodes that would have been accomplished by individual wires in a conventionally wired vehicle. The nodes used to accomplish multiplexed body wiring typically did not exist in the same or similar form in a conventionally wired vehicle.

Multiplexing: The process of combining several messages for transmission over the same signal path. There are two widely-used methods of multiplexing: time division and frequency division. Time division utilizes the principle of time sharing among information channels. Frequency division utilizes the principle of frequency sharing among information channels where the data from each channel are used to modulate sinusoidal signals called subcarriers so that the resultant signal representing each channel contains only frequencies in a restricted narrow frequency range. Multiplex radio transmission, for instance, is the simultaneous transmission of two signals over a common carrier wave.

Network: A system capable of supporting communications by three or more nodes. In a network, nodes can be attached at any position along the multiplex bus.

Node: Any subassembly of a multiplex system which communicates on the signal bus. In addition to modules, nodes may include other devices which contain the intelligence necessary to support these communications. A node includes a transceiver.

Node-To-Node Communications: The transmission of information to a single receiver, as differentiated from broadcast communications.

Non-Return To Zero (NRZ): A data bit format where the voltage or current value (typically voltage) determines the data bit value (typically one or zero).

Open System: A system, consisting of nodes interconnected by a common communications medium (signal bus) according to established standards, which will support temporary connections to manufacturing networks, diagnostics, and other local area networks.

Physical Layer: The properties of the communications medium (signal bus) which can be determined by electrical measurements, such as voltages, currents, impedances, rise times, etc.

Power Bus: The portion of the wiring serving all multiplex system nodes which provides the electrical power to the nodes, providing the electrical energy used by the node and its associated electrical loads.

Power Driver: A solid state device (driver) capable of turning on and off electrical loads requiring electrical power significantly in excess of semiconductor logic levels. A power driver can drive actuators, lamps, motors, etc. A power driver provides the output function typically provided by a switch in a conventional automotive wiring system, but does not provide its input function.

Protocol: A formal set of conventions or rules for the exchange of information between nodes, including the procedures for establishing and controlling transmissions on the multiplex signal bus (message administration) and the organization, meaning, and timing associated with the bits of data (message transfer).

Pulse Width Modulation: A data bit format in which the width of a pulse of constant voltage or current determines the value (typically one or zero) of the data transmitted.

Receiver: A device that converts electrical or optical signals used for transmission back to information or data signals.

Response: A message or portion of a message initiated by a receiving node as a result of a message transmitted by a different node. A response can be an acknowledgment or response data, and it can be appended to the original message (immediate response) or a unique message (separate response).

Response Data: A response to a message which provides the data (information) requested in the message.

Ring Topology: A bus topology with the ends of the bus (line or group of lines) tied together.

Security: Safe from adverse contingencies.

Signal Bus: The wire(s) in the portion of the wiring serving all multiplex system nodes which are dedicated to communications between the nodes.

Star Topology: Nodes connected by links to a central unit which acts as a central processor or switching point.

Switch: A mechanically-operated device for making, breaking, or changing the connections in an electrical circuit. In a conventional automotive wiring system, a switch serves as both the input device and the output device which provides electrical energy to the load. In a multiplex system, the input device is designated as a switch, and the output device is designated as a driver.

System Architecture: The organization of a multiplex system including, but not necessarily limited to, the location and ranking of logic or decision making elements, and the types and methods of communications between these elements.

System Elasticity: The capability to easily add or delete nodes and functions, permitting the multiplex wiring system to be easily expanded or contracted as required. Reprogramming of units not added or deleted should be minimized in an elastic system. This expansion and contraction may be due to model to model variations, year to year changes, or the desire for new features and accessories.

Time Division Multiplex Protocol: A protocol where the meaning of a bit of information on the signal bus is determined by its relationship (first, second, third, etc.) to the start of the message or bit stream. In a time division multiplex protocol, data is interleaved on a bit-by-bit basis.

Token: In a token-passing protocol, the symbol of authority passed between nodes indicating which node is currently in control of the medium.

Token-Passing Protocol: A protocol where a node which has communicated passes the control of the bus, including the right to communicate to another node, at the end of the message.

Topology: The configuration or physical location of the interconnecting elements of a system. This term can be used to describe the wiring of the multiplex bus.

Transceiver: An electrical circuit which both transmits (line driver portion) and receives (line receiver portion). In a multiplex system using an arbitration-based protocol, the transmitting and receiving takes place over the signal bus and a transceiver is typically a part of a node.

Transmitter: A device that converts information or data signals to electrical or optical signals so that these signals can be sent over a communications medium (signal bus).

Twisted Pair: A cable composed of two insulated conductors twisted about one another.

RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

Not applicable.

APPLICATION:

This is a glossary of vehicle networks for multiplexing and data communications.

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Glossary of Reliability Terminology Associated with Automotive Electronics

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an American National Standard

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HIGHWAY VEHICLE REPORT

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GLOSSARY OF RELIABILITY TERMINOLOGY ASSOCIATED WITH AUTOMOTIVE ELECTRONICS

1. INTRODUCTION:

This glossary has been compiled to assist, by serving as a reference, in the communication between the automotive electronics engineer and the reliability engineer.

2. SCOPE:

This compilation of terms, acronyms and symbols was drawn from usage which should be familiar to those working in automotive electronics reliability. Terms are included which are used to describe how items, materials and systems are evaluated for reliability, how they fail, how failures are modeled and how failures are prevented. Terms are also included from the disciplines of designing for reliability, testing and failure analysis as well as the general disciplines of Quality and Reliability Engineering. This glossary is intended to augment SAE J1213, Glossary of Automotive Electronic Terms.

3. REFERENCES:

A listing of applicable military and other organizational reference documents, from which many of these terms and definitions were drawn, is provided as a source of alternate or related definitions.

MILITARY

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-HDBK-217D	Reliability Prediction of Electronic Equipment
MIL-STD-280A	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-414	Sampling Procedures and Tables for Inspection by Variables for Percent Defective

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3. (Continued):

MIL-STD-756B	Reliability Models and Prediction
MIL-STD-781C	Reliability Design Qualification and Production Acceptance Tests - Experimental
MIL-STD-790B	Reliability Assurance Program for Electronic Parts Specification
MIL-STD-810C	Environmental Test Methods
MIL-STD-883B	Test Methods and Procedures for Microelectronics
MIL-STD-1313	Microelectronics Terms and Definitions
MIL-Q-9858A	Quality Program Requirements
AR-92	Quality Program Requirements
MIL-S-195001	Semiconductor Devices, General Specification for
MIC M38510D	Microcircuits, General Specifications for
MIL-STD-470	Maintainability Program Requirements for Systems and Equipments
MIL-STD-471A	Maintainability Verification/Demonstration/Evaluation
MIL-HDBK-472	Maintainability Prediction
MIL-STD-891	Contractor Parts Control and Standardization Program
MIL-STD-701	Preferred and Guidance List of Semiconductor Devices
MIL-STD-198A	Selection and Use of Capacitors
MIL-STD-199B	Selection and Use of Resistors
MIL-STD-1562	List of Standard Microcircuits
MIL-STD-976	Certification Requirements for JAN Microcircuits

EIA

Reliability Bulletin No. 1	A General Guide for Technical Reporting of Electronic Reliability Measurement
Reliability Bulletin No. 4A	Reliability Qualifications
Reliability Bulletin No. 5	Equipment Reliability Specification Guideline
Reliability Bulletin No. 10	Selection and Validation of Low Population and/or State of the Art Parts
Reliability Bulletin No. 9	Failure Mode and Effects Analyses
Reliability Bulletin No. 8	Equipment Burn-In
Engineering Bulletin No. 17	User Guidelines for Quality and Reliability Assurance of LSI Components
Engineering Bulletin No. 11	User Guidelines for Microelectronic Reliability Estimation
JEDEC Standard No. 22	Test Methods and Procedures for Solid State Devices Used in Transportation/Automotive Applications

OTHER

Glossary and Tables for Statistical Quality Control - ASQC 1973
PROCUREMENT QUALITY CONTROL - 2nd Edition - ASQC
Quality Systems Terminology - ANSI/ASQC A3-1978
Terms, Symbols and Definitions for Acceptance Sampling - ANSI/ASQC A2-1978
Definitions, Symbols, Formulas and Tables for Control Charts - ANSI/ASQC A1-1978
How to Speak Fluent Quality - National Semiconductor Co.

3. (Continued):

Reliability Design Handbook	RDH 376	- Reliability Analysis Center
Analysis Techniques for Mechanical Reliability	WPS-1	- Reliability Analysis Center
1987 Desk Manual		- Microelectronic Manufacturing and Testing
Glossary of Automotive Electronic Terms		- SAE HS J1213 1982
Automotive Electronics Reliability Handbook		- SAE AE-9 1987
The American Heritage Dictionary		- 2nd College Edn. 1982 Houghton Mifflin Co.

4. RELIABILITY GLOSSARY:

ACCELERATED LIFE TEST

A life test under test conditions that are more severe than usual operating conditions. It is necessary that a relationship between test severity and the probability distribution of life be ascertainable.

ACCELERATION FACTOR

(1) The factor by which the failure rate can be increased by an increased environmental stress.

(2) The ratio between the times necessary to obtain the same portion of failure in two equal samples under two different sets of stress conditions, involving the same failure modes and mechanisms.

ACCEPT/REJECT TEST

A test, the result of which will be the action to accept or reject something, for example, an hypothesis or a batch of incoming material.

ACCEPTABLE QUALITY LEVEL (AQL)

The maximum percent defective which can be considered satisfactory as a process average, or the percent defect whose probability of rejection is designated by α.

ACCEPTANCE NUMBER

The largest number of defects that can occur in an acceptance sampling plan and still have the lot accepted.

ACCEPTANCE SAMPLING PLAN

An accept/reject test whose purpose is to accept or reject a lot of items or material.

4. (Continued):

ACCESSIBILITY

A measure of the relative ease of admission to the various areas of an item.

ACHIEVED RELIABILITY

The reliability demonstrated at a given point in time under specified conditions of use and environment.

ACTIVATION ENERGY

(1) The energy level at which a specific microelectronic failure mechanism becomes active (in electron-volts).

(2) The slope of the time-temperature regression line in the Arrhenius equation (in electron-volts).

ACTIVE ELEMENT

A part that converts or controls energy, for example, transistor, diode, electron tube, relay.

ACTIVE ELEMENT GROUP

An active element and its associated supporting (passive) parts, for example, an amplifier circuit, a relay circuit, a pump and its plumbing and fittings.

AGING

The effect whereby the probability density function of strength is changed (strength is reduced) with time.

ALLOCATION

The process of assigning reliability requirements to individual units to attain the desired system reliability.

ALPHA PARTICLE INDUCED SOFT ERRORS

Integrated circuit memory transient errors due to emission of alpha particles during radioactive decay of uranium or thorium contamination in the IC packaging material.

AMBIENT

Used to denote surrounding, encompassing, or local conditions. Usually applied to environments, for example, ambient temperature, ambient pressure.

4. (Continued):

APPORTIONMENT

Synonym of Allocation.

ARITHMETIC MEAN

The arithmetic mean of n numbers is the sum of the n numbers, divided by n.

ARRHENIUS MODEL

A mathematical representation of the dependence of failure rate on absolute temperature and activation energy. The model assumes that degradation of a performance parameter is linear with time with the failure rate a function of temperature stress. The temperature dependence is taken to be the exponential function:

$$\Theta_1 = \Theta_2 \exp [(E/k)(1/T_2-1/T_1)]$$

Θ_1 = mean time to failure at T_1
Θ_2 = mean time to failure at T_2
T = junction temperature in K
E = activation energy in eV
k = Boltzman's constant (8.617 10^5 eV/K)

ARRHENIUS ACCELERATION FACTOR

The acceleration factor F is the factor by which the time to fail can be reduced by increased temperature.

$$F = \Theta_1/\Theta_2 = \exp (E/k)(1/T_2-1/T_1)$$

ASSESSMENT

(1) A critical appraisal, including qualitative judgments about an item, such as importance of analysis results, design criticality and failure effect.

(2) The use of test data and/or operational service data to form estimates of population parameters and to evaluate the precision of these estimates.

ATTRIBUTE

A term used to designate a method of measurement whereby units are examined by noting the presence (or absence) of some characteristic or attribute in each of the units in the group under consideration and by counting how many units do (or do not) possess it. Inspection by attributes can be of two kinds - either the unit of product is classified simply as defective or nondefective, or the number of defects in the unit of product is counted, with respect to a given requirement or set of requirements.

4. (Continued):

ATTRIBUTE TESTING

Testing to evaluate whether or not an item possesses a specified attribute.

AUTOMATIC TEST EQUIPMENT (ATE)

Test equipment that contains provisions for automatically performing a series of pre-programmed tests.

AVAILABILITY (OPERATIONAL READINESS)

The probability that at any point in time the system is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions.

AVERAGE

A general term. It often means arithmetic mean, but can refer to s-expected value, median, mode, or some other measure of the general location of the data values.

AVERAGE OUTGOING QUALITY (AOQ)

The average quality of outgoing product after 100% inspection of rejected lots, with replacement by good units of all defective units found in inspection.

AVERAGE OUTGOING QUALITY LIMIT (AOQL)

The maximum average outgoing quality (AOQ) for a sampling plan.

BAKE-OUT

To subject an unsealed item to an elevated temperature to drive out moisture and unwanted gases prior to other process or sealing.

BATHTUB CURVE

A plot of failure rate of an item (whether repairable or not) vs. time. The failure rate initially decreases, then stays reasonably constant, then begins to rise rather rapidly. It has the shape of a bathtub. Not all items have this behavior.

BIAS

(1) The difference between the s-expected value of an estimator and the value of the true parameter.

(2) Applied voltage.

4. (Continued):

BINOMIAL DISTRIBUTION

The probability of r, or fewer successes in n independent trials, given a probability of success p in a single trial, is given by the cumulative binomial distribution:

$$\Pr (x \leq r) = F(r; p, n) = \sum_{x=0}^{r} \binom{n}{x} p^{x} (1-p)^{n-x}$$

BINOMIAL FUNCTION

The probability of exactly x successes in n independent trials, given a probability of success p in a single trial, is given by the binomial probability function:

$$f(x; p, n) = \binom{n}{x} p^{x} (1-p)^{n-x}, \quad x = 0, 1, 2, \ldots n, \quad 0 \leq p \leq 1$$

BOND

(1) An interconnection which performs a permanent electrical and/or mechanical function.

(2) To join with adhesives.

BOND LIFT OFF

The failure mode whereby the bonded lead separates the surface to which it was attached.

BOND STRENGTH

In wire bonding, the pull force at rupture of the bond interface.

BREADBOARD MODEL

A preliminary assembly of parts to test the feasibility of an item or principle without regard to eventual design or form. Usually refers to a small collection of electronic parts.

BURN-IN

The initial operation of an item to stabilize its characteristics, and to minimize infant mortality in the field.

4. (Continued):

CAPABILITY

(1) A measure of the ability of an item to achieve mission objectives given the conditions during the mission.

(2) The spread of performance of a process in a state of statistical control; the amount of variation from common causes identified after all special causes of variation have been eliminated.

C CHART

Control chart for number of nonconformities observed in some specified inspection. The units should be alike in size and in the apparent likelihood of the existence of the nonconformity, in order that the area of opportunity for nonconformity be constant from unit to unit.

CENTRAL LINE

The line on a control chart that represents the average or median value of the items being plotted. It is shown as a solid line.

CHECKOUT

Tests or observations on an item to determine its condition or status.

COEFFICIENT OF VARIATION

The standard deviation divided by the mean, multiplied by 100 and expressed as a percentage.

COMPLEXITY LEVEL

A measure of the number of active elements required to perform a specific system function.

COMPONENT

A self-contained combination of parts, subassemblies, or assemblies which perform a distinctive function in the overall operation of an equipment. Often used interchangeably with (electronic) part.

CONFIDENCE

A specialized statistical term referring to the reliance to be placed in an assertion about the value of a parameter of a probability distribution.

4. (Continued):

CONFIDENCE COEFFICIENT

(1) A measure of assurance that a statement based upon statistical data is correct.

(2) The probability that an unknown parameter lies within a stated interval or is greater or less than some stated value.

CONFIDENCE INTERVAL

The interval within which it is asserted that the parameter of a probability distribution lies.

CONFIDENCE LEVEL

Equals $1-\alpha$ where α = the risk (%).

CONFIDENCE LIMIT

A bound of a confidence interval.

CONSISTENCY

A statistical term relating to the behavior of an estimator as the sample size becomes very large. An estimator is consistent if it converges to the population value as the sample size becomes large.

CONSTANT FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the middle, or "useful life" period of the Bathtub Curve model of item life.

(2) A term characterizing the hazard rate, $h(t)$, of an item having an exponential reliability function.

CONTAMINATION

A general term used to describe an unwanted material that adversely affects the physical or electrical characteristics of an item.

CONTINUOUS SAMPLING PLAN

In acceptance sampling, a plan intended for application to a continuous flow of individual units of product that involves acceptance or rejection on a unit-by-unit inspection and sampling. Continuous sampling plans are usually characterized by requiring that each period of 100% inspection be continued until a specified number of consecutively inspected units are found clear of defects.

4. (Continued):

CORRECTIVE ACTION

A documented design, material or process change to correct the true cause of a failure. Part replacement with a like item does not constitute appropriate corrective action. Rather, the action should make it impossible for that failure to happen again.

CORRELATION

A form of statistical dependence between two variables. Unless stated otherwise, linear correlation is implied.

CORRELATION COEFFICIENT

A number between -1 and +1, which indicates the degree of linear relationship between two sets of numbers. Coefficients of -1 and +1 represent perfect linear agreement between two variables, while a coefficient of zero implies none.

CORRODE

To dissolve or wear away gradually, especially by chemical action.

CORROSION

The deterioration of a substance (usually a metal) because of a reaction with its environment, or with a corroding agent.

COSMETIC DEFECT

A variation from the conventional appearance of an item such as a slight change in its color, not necessarily detrimental to service performance.

COST-EFFECTIVENESS

A measure of the value received for the resources expended.

CRACK

Evidence of a full or partial break without separation of parts.

CRAZE

A network of fine cracks in the surface.

CREEP

(1) Elongation or fracture resulting from loads sustained over relatively long time at high temperatures.

(2) The dimensional change with time of a material under load.

4. (Continued):

CRITICALITY

A relative measure of the consequences of a failure.

CRITICALITY ANALYSIS

A procedure by which each potential failure mode is evaluated and ranked according to the combined influences of severity and probability of occurrence.

CUMULATIVE DISTRIBUTION FUNCTION (CDF)

The probability that the random variable takes on any value less than or equal to a value x, that is,

$$\mathrm{Cdf}(x) = \mathrm{pr}(X \leq x)$$

The unreliability function with regard to failures

$$F(t) = \mathrm{Pr}(T \leq t)$$

CUT SET

In a Fault Tree, any basic event or combination of basic events whose occurrence will cause the top event to occur.

DEBUGGING

The period of "shakedown operation" of a finished equipment performed prior to placing it in use. During this period, defective parts and workmanship errors are corrected under test conditions that closely simulate field operation.

DECAP

To de-encapsulate. To remove the cover or plastic encapsulant on an item.

DECREASING FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the first or "infant mortality" period of the Bathtub Curve model or product life.

(2) A term characterizing the hazard rate $h(t)$ of an item having a Weibull reliability function with slope $B < 1$.

DEFECT

A deviation of an item from some ideal state. The ideal state is usually given in a formal specification.

4. (Continued):

DEFECT, CRITICAL

A defect that could result in hazardous or unsafe conditions for individuals using, maintaining or depending on the item.

DEFECTIVE

A unit of product which contains one or more defects.

DEGRADATION

A gradual deterioration in performance as a function of time.

DELTA LIMITS

THe difference between initial and final readings usually associated with the difference between the zero time readings on a life test and the final readings. Determine how much parameters shift during the test.

DEMONSTRATED

That which has been proven by the use of concrete evidence gathered under specified conditions.

DEPENDABILITY

A measure of the item operating condition at one or more points during the mission, including the effects of Reliability, Maintainability and Survivability, given the item condition(s) at the start of the mission. It may be stated as the probability that an item will (1) enter or occupy any one of its required operational modes during a specified mission and (2) perform the functions associated with those operational modes.

DERATING

The intentional reduction of stress/strength ratio in the application of an item, usually for the purpose of reducing the occurrence of stress-related failures.

DESIGN ADEQUACY

The probability that the system will satisfy effectiveness requirements, given that the system design satisfied the design specification.

DEVICE

Any subdivision of a system; synonym for ITEM.

4. (Continued):

DISCRIMINATION RATIO

A measure of the distance between two specific points of the operating characteristic curve which are used to define the acceptance sampling plan.

DISSOCIATION

The breakdown of a substance into two or more constituents.

DISTRIBUTION

Generally short for Cumulative Distribution Function.

DOWNTIME

The total time during which the system is not in condition to perform its intended function.

DURABILITY

The probability that an item will operate as specified under stated conditions without a wearout failure; a special case of reliability.

DUTY CYCLE

The ratio of the time "on" of a device or system divided by the total cycle time. For a device that normally runs intermittently rather than continuously, the amount of time a device operates as opposed to its idle time.

EARLY FAILURE PERIOD

That period of life, after assembly, in which failures occur at an initially high rate because of the presence of defective parts and workmanship defects.

EDX SPECTROMETER

Generally used with a scanning electron microscope (SEM) to provide elemental analysis of X-rays generated on the region being hit by the electron beam.

EFFECTIVENESS

The capability of the system or device to perform its function.

EFFICIENCY

A statistical term relating to the dispersion in values of an ESTIMATOR. It is between zero and one.

4. (Continued):

ELECTROMAGNETIC COMPATABILITY (EMC)

The capability of electronic equipment to function in the intended electromagnetic environment at designed levels of efficiency.

ELECTROMIGRATION

Dendritic or filamentary growth of a metal (for example, silver) in an electric field.

EMISSION SPECTROGRAPH

An instrument which identifies the presence of elements by burning the sample in an air plasma and analyzing the resultant optical spectrum.

ENGINEERING, HUMAN

The science of studying the man-machine relation in order to minimize the effects of human error and fatigue and thereby provide a more reliable operating system.

ENGINEERING, RELIABILITY

The science of including those factors in the basic design which will assure the required degree of reliability.

ENVIRONMENT

The aggregate of all external conditions and influences affecting the life and development of the product.

ELECTRICAL OVERSTRESS (EOS)

The electrical stressing of electronic components beyond specifications.

ELECTROSTATIC DISCHARGE (ESD)

The transfer of electric charge between bodies at different electrostatic potentials caused by direct contact or by an electrostatic field.

ESTIMATOR

A statistic, which is derived from a sample, used to infer a value of a parameter of an assumed distribution model.

4. (Continued):

EXPECTED VALUE

The mean or average, defined as: If x is a random variable and F(x) is its CDF

$E(x) = \int x dF(x)$, where the integration is over all x.

For continuous variables with a pdf, this reduces to

$E(x) = \int x \, pdf(x) \, dx$.

For discrete random variables with a pmf, this reduces to

$E(x) = \Sigma x_n \, p(x_n)$ where the sum is over all n.

EXPONENTIAL DISTRIBUTION

The probability density function

$$f(t) = \lambda \exp(-\lambda t)$$

where λ, the failure rate is constant.

EXPONENTIAL MODEL

In reliability engineering, a model based on the assumption that times t between successive failures are described by the exponential distribution.

EVALUATION

A broad term used to encompass prediction, measurement and demonstration.

EXTREME VALUE DISTRIBUTION

The asymptotic distribution of the smallest extreme from a statistical distribution; used to model capacitor breakdown voltage, time to failure of corrosion, etc. The pdf is $p(x) = \exp(x) \exp[-\exp(x)]$.

EYRING MODEL

An accelerated life test model in which failure rate is related to temperature. Given by $\lambda = T\exp(A-B/T)$.

FAILURE

The termination of the ability of an item to perform its required function.

4. (Continued):

FAILURE ANALYSIS

The identification of the failure mode, the failure mechanism and the cause. Often includes physical dissection.

FAILURE, CATASTROPHIC

A sudden change in the operating characteristics of an item resulting in a complete loss of useful performance.

FAILURE, DEGRADATION

A failure that occurs as a result of a gradual or partial change in the operating characteristics of an item.

FAILURE EFFECT

The consequences a failure mode has on the operation, function or status of an item.

FAILURE, INCIPIENT

A degradation failure which is just beginning to exist.

FAILURE, INDUCED

A failure caused by a physical condition external to the failed item.

FAILURE, INFANT

A failure that occurs during the early life of an item.

FAILURE, INHERENT

A failure basically caused by a physical condition or phenomenon internal to the failed item.

FAILURE, INITIAL

The first failure to occur in use.

FAILURE, LATENT

A malfunction that occurs as a result of a previous exposure to a condition that did not result in an immediately detectable failure.

FAILURE MECHANISM

The mechanical, chemical or other process that results in a failure.

4. (Continued):

FAILURE MODE

The effect or manner by which a failure is observed. Generally describes the way the failure occurs.

FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

A systematic, organized procedure for evaluating potential failures in an operating system.

FAILURE MODES, EFFECTS AND CRITICALITY ANALYSIS (FMECA)

An analysis of possible modes of failure, their causes, effects, their criticalities and expected frequencies of occurrence.

FAILURE, NONRELEVANT

A failure not applicable to the computation or reliability.

FAILURE, PRIMARY

A failure whose occurrence is not caused by other failures.

FAILURE, RANDOM

A failure whose occurrence is not predictable in an absolute sense but is predictable in a probabilistic sense.

FAILURE RATE

(1) The conditional probability that an item will fail just after time t, given the item has not failed up to time t.

(2) The number of failures of an item per unit measure of life (cycles, time, miles, events, etc.) as applicable for the item.

FAILURE, RELEVANT

A failure attributable to a deficiency of design, manufacture or materials of the failed device, applicable to the computation of reliability.

FAILURE, SECONDARY

A failure caused directly or indirectly by the failure of another item.

FAILURE, WEAROUT

A failure whose time of occurrence is governed by rapidly increasing failure rate.

4. (Continued):

FATIGUE

Cracking or fracture from cyclic loads.

FAULT

An attribute which adversely affects the reliability of a device.

FAULT TREE ANALYSIS (FTA)

A method of reliability analysis in which a logical block diagram is used to indicate contributing lower level events.

FIT

A contraction of <u>F</u>ailure un<u>IT</u>, having a value of failures per 10^9 component-hours.

FORCED DEFECT

A failure induced by stress testing.

FOREIGN MATERIAL

The presence of an object or material which comes from some source external to the part or system.

FREEDOM, DEGREE OF

The number of observations that are free to vary at random, regardless of the restrictions imposed by the mathematics describing the statistic.

FUNCTIONAL FAILURE

A failure whereby a device does not perform its intended function when the inputs or controls are correct.

GAMMA DISTRIBUTION

An important distribution in statistical queuing theory. Given by:

$$\mathrm{pdf}(x) = \frac{\lambda(\lambda t)^{k-1} e^{-\lambda t}}{\Gamma(k)}, \text{ where } \Gamma(k) = \int_0^\infty u^{k-1} e^{-u} du$$

$$\lambda,\ \beta,\ t > 0$$

4. (Continued):

GAUSSIAN DISTRIBUTION (See NORMAL DISTRIBUTION)

A 2-parameter distribution with

$$\mathrm{pdf}(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp - \left[\frac{1}{2}\left(\frac{x-u}{\sigma}\right)\right]^2$$

GEOMETRIC MEAN

The geometric mean of n numbers is the nth root of their product.

GLASS TRANSITION TEMPERATURE

The temperature at which an amorphous polymer changes from a hard and relatively brittle condition to a viscous or rubbery condition.

GO, NO-GO

The result of a test of an attribute. It is either good or bad.

GOODNESS OF FIT

A statistical term that quantifies how likely a sample was to have come from a given probability distribution.

HAZARD RATE h(t)

(1) At a particular time, the rate of change of the number of items that have failed divided by the number of items surviving.

(2) Represents the probability that an item still functioning at time t will fail in the interval (t, t+Δt), where Δt is an infinitesimal time increment. Hazard rate is synonymous with conditional failure rate or instantaneous failure rate.

$$h(t) = \lim_{t \to 0} \frac{R(t)-R(t+\Delta t)}{t\ R(t)}$$

$$h(t) = f(t)/R(t)$$

HERMETICITY

The effectiveness of the seal of microelectronic and semiconductor devices with designed internal cavities.

HOMOGENEOUS

Of the same or similar nature. Uniform in structure or composition.

4. (Continued):

HUMAN FACTORS

A body of scientific facts about human characteristics. The term covers all biomedical and psychosocial considerations. It includes but is not limited to principles and applications in the areas of human engineering, personnel selection, training, life support, job performance aids and performance evaluation.

HYPOTHESIS, NULL

An hypothesis that there is no difference between some characteristics of the parent populations of several different samples, that is, that the samples come from similar populations. A conjecture about the true state of nature, that if true, will only rarely be rejected as the outcome of an experiment or measurement.

INCREASING FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the third or "wearout" period of the Bathtub Curve model of product life.

(2) A term characterizing the hazard rate h(t) of an item having a Normal reliability function, for instance.

INFANT MORTALITY

Premature catastrophic failures occurring at a much greater rate than during the useful life period prior to the onset of substantial wearout.

INSPECTION

The examination and testing of supplies and services (including, when appropriate, raw materials, components and intermediate assemblies) to determine whether they conform to specified requirements.

INSPECTION BY ATTRIBUTES

Inspection whereby either the unit of product or characteristic thereof is classified simply as defective or nondefective, or the number of defects in the unit or product is counted with respect to a given requirement.

INSPECTION BY VARIABLES

Inspection wherein certain quality characteristics of a sample are evaluated with respect to a continuous numerical scale and expressed as precise points along this scale. Variable inspections record the degree of conformance of the unit with specified requirements for the quality characteristics involved.

4. (Continued):

INSPECTION LEVEL

An indication of the relative size of the sample to the size of the lot.

INSPECTION LOT

A collection of units of product bearing identification and treated as a unique entity from which a sample is to be taken and inspected to determine conformance with the acceptability criteria.

ITEM

An all-inclusive term, to include assemblies, subassemblies accessories, parts, equipment and services, applied to what is being discussed.

LIFE TEST

A test, usually of several items, made for the purpose of estimating some characteristic(s) of the probability distribution of life.

LOG NORMAL DISTRIBUTION

The model of a random variable whose logarithm follows the Normal function with parameters μ and σ. It is a life model for a process whose value results from the multiplication of many small errors. Its pdf-

$$f(x:\mu,\sigma) = 1/(\sigma x\sqrt{2\pi})\ \exp\ [-1/_{2\sigma}2(\ln x-\mu)^2]$$

$$x > 0$$
$$\sigma > 0$$
$$-\infty < \mu < \infty$$

LONGEVITY

Length of useful life of a product to its ultimate wearout requiring complete rehabilitation. This is a term generally applied in the definition of a safe, useful life for an equipment or system under the conditions of storage and use to which it will be exposed during its lifetime.

LOT

A group of units from a particular device type submitted each time for inspection and/or testing is called a lot.

LOT QUALITY

The true fraction defective in a lot.

4. (Continued):

LOT REJECT RATE (LRR)

The lot reject rate is the percentage of lots rejected from the lots evaluated.

LOT TOLERANCE PERCENT DEFECTIVE (LTPD)

The percent defective which is to be accepted a minimum or arbitrary fraction of the time, or that percent defective whose probability of rejection is designated by ß.

MAINTAINABILITY

A characteristic of design and installation which is expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

MAINTENANCE, PREVENTIVE

The maintenance performed in an attempt to retain an item in a specified condition by providing systematic inspection, detection and prevention of incipient failure.

MARGIN TESTING

Testing in which item environments such as line voltage or temperature are changed to reversibly worsen the performance. Its purpose is to find how much margin is left in the item for its degradation.

MEAN

(1) The expected value of a random variable.

(2) The first moment of a probability distribution about its origin. As specifically defined and modified, for example, the arithmetic mean (sums), the geometric mean (products), the harmonic mean (reciprocals), logarithmic mean, etc.

MEAN LIFE (Θ)

The arithmetic average of lifetimes of all items considered.

$$\Theta = \int_0^T R(t)dt = \int_0^T t\,pdf(t)dt$$

where R(t) = the s-reliability of the item
T = the interval over which the mean life is desired, usually the useful life

4. (Continued):

MEAN-LIFE-BETWEEN-FAILURES

This concept is the same as Mean Life except that it is for repaired items and is the mean up-time of the item. The formula is the same as for Mean Life except that R(t) is interpreted as the distribution of up-times.

MEAN-TIME-BETWEEN-FAILURES (MTBF)

For a particular interval, the total functioning life of a population of an item divided by the total number of failures within the population during the measurement interval. The definition holds for time, cycles, miles, events or other measure of life units. A basic measure of reliability of repairable items.

MEAN-TIME-BETWEEN-MAINTENANCE (MTBM)

The mean of the distribution of the time intervals between maintenance actions (either preventive, corrective or both).

MEAN-TIME-TO-FAILURE (MTTF)

For nonrepaired items, the mean life.

MEAN-TIME-TO-REPAIR (MTTR)

The total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

$$\text{MTTR} = \int_0^T G(t)dt$$

where G(t) = Cdf of repair time
T = Maximum allowed repair time

MEDIAN

The median of a distribution of one random variable X of the discrete or continuous type is a value of x such that $\Pr(X \leq x) = 1/2$ and $\Pr(X \geq x) = 1/2$, the middle value.

4. (Continued):

MISSION

The objective or task, together with the purpose, which clearly indicates the action to be taken.

MISSION RELIABILITY

The probability of success of an item to perform its required function for the duration of its intended mission.

MISSION PROFILE

The mission profile describes the events and conditions, including times and time spans, associated with a specific operational usage of an item. It is one segment of the operational cycle.

MODE

The mode of a distribution of one random variable X of discrete or continuous type is a value of x that maximizes the pdf f(x).

MODEL

A mathematical representation of a process. In Reliability there are two primary modeling concepts.

(1) A statistical function describing a life characteristic.

(2) A description of the reliability connectivity of the parts of a system.

MODEL, PARALLEL

A representation of the connection of the parts in a system such that the failure of all parts so connected is required for failure of that section of the system.

MODEL, SERIES

A representation of the connection of parts of a system such that failure of any part so connected will cause failure of that section of the system.

MODULE

An item which is packaged and is part of the next higher level of assembly.

4. (Continued):

NORMAL DISTRIBUTION (See GAUSSIAN)

The most prominant continuous distribution in statistics, frequently referred to as the Gaussian or bell-shaped distribution. Its density function is

$$f(x;\mu,\sigma) = \frac{1}{\sigma \quad 2\pi} \exp - \frac{(x-\mu)^2}{2\sigma^2} , \quad -\infty < x < \infty, \ -\infty < \mu < \infty, \ \sigma > 0$$

with mean μ and variance σ^2. The theoretical justification for the normal distribution lies in the central-limit theorem, which shows that under very broad conditions the distribution of the average of n independent observations from any distribution approaches a normal distribution as n becomes large.

NORMAL VARIABLE

A random variable that is normally distributed. In situations where the random variable represents the total effect of many "small" independent causes, each with mutually independent errors, the central limit theorem leads to the prospect the variable will be normally distributed.

OPERATING CHARACTERISTIC (OC CURVE)

A curve showing the relation between the probability of acceptance and either lot quality or process quality, whichever is applicable.

OPERATIONAL READINESS

The probability that, at any point in time, the system is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions, including stated allowable warning time. Thus, total calendar time is the basis for computation of operational readiness.

OVERCOAT

A thin film of insulating material over micro-circuit elements to provide mechanical protection or prevention of contamination.

OVERSTRESS

A condition wherein the severity levels of operation are more than usual or more than the specification.

PART

(1) An item that will not be disassembled for maintenance.
(2) The least subdivision of a system.
(3) An item which cannot ordinarily be disassembled without being destroyed.

4. (Continued):

PARTS PER MILLION (PPM)

Describing fractional defective, PPM is obtained by multiplying percent defective by 10 000; for example, 0.01% = 100 ppm.

PASSIVE ELEMENT

An element that is not active, that is, does not control energy; for example, a resistor, capacitor or an inductor.

PERCENTAGE DEFECTIVE

That proportion of a lot which is defective. This is the figure of merit in the population domain which characterizes quality control measurements and differentiates it from reliability.

PHYSIOCHEMICAL INSTABILITY

Change from an initial material bulk property, such as strength, resiliency, volume, composition, etc., as a result of age, pressure, temperature, etc.

PIN HOLE

A microscopic hole through an insulating (glass) layer. A defect.

POPULATION

The totality of the set of items, units, measurements, etc., real or conceptual, that is under consideration.

PROBABILITY

(1) Classical: If an event can occur in N equally likely and different ways, and if n of these ways have an attribute A, then the probability of the occurrence of A, denoted Pr(A) is defined as n/N.

(2) Frequency: If an experiment is conducted N times, and outcome A occurs n times, then the limit of n/N as N becomes large, is defined as the probability of A, denoted as Pr(A).

(3) Subjective: The probability Pr(A) is a measure of the degree of belief one holds in a specified proposition A.

PROBABILITY DENSITY FUNCTION

A continuous f(x) is a pdf if $f(x) \geqslant 0, -\infty < x < \infty$ and

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

4. (Continued):

PROBABILITY MASS FUNCTION

A discrete f(x) is a pmf if f(x) = 0 for all x, except for a finite countable set of values of x for which f(x) > 0, and

$$\sum_x f(x) = 1, \text{ for all } x \text{ such that } f(x) > 0$$

PROBABILITY FUNCTION

The probability function is defined in terms of its pdf or pmf. If there is a pdf, F(x) is continuous and is defined by

$$F(x) = \int_{-\infty}^{x} f(x)dx$$

If there is a pmf, F(x) is discrete and is defined by

$$F(x) = \sum_x f(x)$$

PROBABILITY DISTRIBUTION

A mathematical function with specific properties which describes the probability that a random variable will take on a value or a set of values. If the random variable is continuous and well-behaved enough, there will be a pdf. If the random variable is discrete, there will be a pmf.

PROBABILITY PAPER

Graph paper constructed so that cumulative distribution curves plot as straight lines. Paper is available for normal, log-normal, Weibull, and several other distributions.

PROCESS AVERAGE (PA)

The total number of units rejected over an extended period of time divided by the total number of units produced over the same period of time.

PULL TEST

A test to determine the bond strength of a lead to an interconnecting surface, usually perpendicular to the surface, by pulling to failure.

4. (Continued):

PURPLE PLAGUE

One of several gold-aluminum compounds formed when bonding gold to aluminum and activated by exposure to moisture and high temperature, resulting in brittle, time-based bond failure.

QUALIFICATION

The entire process by which products are obtained from manufacturers or distributors, examined and tested, and then identified on a Qualified Products List.

QUALITY

(1) The composite of all characteristics or attributes, including performance, of an item.

(2) A measure of the degree to which an item conforms to applicable specification and workmanship standards.

(3) A property which refers to the tendency of an item to be made to specific specifications or the customer's express needs, or both. See current publications by Juran, Deming, Crosby, et al.

QUALITY ASSURANCE

A system of activities whose purpose it is to provide assurance that the overall quality control job is, in fact, being done effectively.

QUALITY CHARACTERISTICS

Those properties of an item or process which can be measured, reviewed or observed and which are identified in the drawings, specifications or constructual requirements. Reliability becomes a quality characteristic when so defined.

QUALITY CONTROL (QC)

The overall system of activities whose purpose is to provide a quality of product or service which meets the needs of users; also, the use of such a system.

RANDOMNESS

The occurrence of an event in accordance with the laws of chance.

RANDOM EVENT

The occurrence of an event affected by chance alone. For example, heads or tails on a flipped coin occurs at random.

4. (Continued):

RANDOM SAMPLE

As commonly used in acceptance sampling theory, the process of selecting sample units in such a manner that all units under consideration have the same probability of being selected.

RANDOM VARIABLE (r.v.)

A function defined on a sample space, or a transformation which associates a real number with each point in a sample space.

REDUNDANCY

The existence of more than one means for accomplishing a given function.

REDUNDANCY, ACTIVE

A type of redundancy where all items in the group are operating simultaneously.

REDUNDANCY, STANDBY

A type of redundancy where the alternative means of performing the function is inoperative until needed and is switched on upon failure of the primary means of performing the function.

REGRESSION ANALYSIS

A mathematical means to fit an assumed model to data containing errors by minimizing the sum of squared deviations from the fit.

RELIABILITY

The probability that a device will function without failure over a specified time period or amount of usage at stated conditions.

RELIABILITY GROWTH

The increase in reliability as a result of the effort, the resource commitment to improve design, purchasing, production, and inspection procedures.

RELIABILITY, INHERENT

The potential reliability of an item present in its design.

RELIABILITY, INTRINSIC

The probability that a device will perform its specified function, determined on the basis of a statistical analysis of the failure rates and other characteristics of the parts and components which comprise the device.

4. (Continued):

RELIABILITY, PREDICTED

The process of quantitatively assessing whether a proposed or actual equipment design will meet a specified reliability requirement.

RELIABILITY WITH REPAIR

The reliability that can be achieved when preventive maintenance is allowed.

REPAIRABILITY

The probability that a failed system will be restored to operable condition in a specified active repair time.

RISK

The probability of rendering a wrong decision based on inadequate data or analysis. The probability of an undesired outcome.

RISK, CONSUMER'S (ß)

For a given sampling plan, the probability of acceptance for a designated numerical value of relatively poor submitted quality.

RISK, PRODUCER'S (α)

For a given sampling plan, the probability of rejection for a designated numerical value of relatively good submitted quality.

RISK PRIORITY NUMBER

In an FMEA, the product of the Occurrence Ranking, the Severity Ranking and the Detection Ranking.

SAFETY

The conservation of human life and its effectiveness, and the prevention of damage to items, consistent with mission requirements.

SAMPLE

A random selection of units from a lot, usually made for the purpose of evaluating the characteristics of the lot.

SCANNING ELECTRON MICROSCOPE (SEM)

An instrument which provides a visual image of the surface of an item. It scans an electron beam over the surface of a sample held in a vacuum and measures any of several resultant particle counts or energies. Provides depth of field and resolution significantly exceeding light counts microscopy and may be used at magnifications exceeding 50 000 times.

4. (Continued):

SCREENING

The process of performing 100% inspection, or exposure to stress, on product lots and removing the defective units from the lots.

SCREENING TEST

A test or combination of tests intended to remove unsatisfactory items or those likely to exhibit early failures.

SERVICEABILITY

A measure of the degree to which servicing of an item will be accomplished within a given time under specified conditions.

SERVICING

The replenishment of consumables needed to keep an item in operating condition, but not including any other preventive maintenance or any corrective maintenance.

SEVERITY LEVEL

A general term implying the degree to which an environment will cause damage or shorten life, or both.

SHEAR TEST

Test of the shear strength of various attachments, for example, die attach, wire bond, wire weld, contact weld, etc. by application of force in the plane.

SHORT CIRCUIT

An abnormal connection of relatively low impedance, whether made intentionally or accidentally between two points of different electric potential.

SIGNIFICANCE

Results that show deviations between an hypothesis and the observations used as a test of the hypothesis greater than can be explained by random variation or chance alone, are called statistically significant.

SIGNIFICANCE LEVEL

The probability of rejecting the null hypothesis when it is actually true.

4. (Continued):

SNEAK CIRCUIT

An unexpected path or logic flow within a system which, under certain conditions, can initiate an undesired function or inhibit a desired function.

SOFT ERROR

Temporary memory content error due to intrusion of an alpha particle, for instance.

STANDARD DEVIATION

The square root of the variance.

STATISTIC

A value calculated from a sample which is used to estimate some characteristic of a population.

STATISTICAL CONTROL

Control of a process by statistical methods. A process is said to be in a state of statistical control if the variations among the sampling results from it can be attributed to a stable pattern of chance causes.

STATISTICAL MODEL

A probability distribution as a representation of time to failure.

STEP STRESS TEST

A test consisting of several stress levels applied sequentially for periods of equal duration to a sample. During each period, a stated stress level is applied, and the stress level is increased from one step to the next.

STORAGE LIFE (SHELF LIFE)

The length of time an item can be stored under specified conditions and still meet specified requirements.

STRESS

A general and ambiguous term used as an extension of its meaning in mechanics as that which could cause failure. It does not distinguish between those things which cause permanent damage (deterioration) and those things which do not.

4. (Continued):

STRESS RELIEF

A design means to minimize the effects of stress, for example, a cable clamp or a conformal coat.

STRESS, COMPONENT

The stresses on component parts during testing, assembly or use which affect the failure rate and hence the reliability of the parts. Voltage, power temperature and thermal environmental stress are included.

SUBASSEMBLY

A replaceable combination of parts which is an element of an assembly.

SUBSYSTEM

A major subdivision of a system which performs a specified function in the overall operation of a system.

SURVIVABILITY

The measure of the degree to which an item will withstand hostile man-made environment and not suffer abortive impairment of its ability to accomplish its designated mission.

SURVIVOR FUNCTION Sf(t)

The Reliability distribution function. The probability that an item will survive to time t.

$$Sf(t) = Pr(T>t) \qquad t > 0, \ T \text{ a r.v.}$$

SUSPENDED ITEM

An item removed from test prior to failure.

SYSTEM

A combination of complete operation equipments, assemblies, components, parts or accessories interconnected to perform a specific operational function.

SYSTEM EFFECTIVENESS

A measure of the degree to which an item can be expected to achieve a set of specific mission requirements and which may be expressed as a function of availability, dependability and capability.

4. (Continued):

TEMPERATURE CYCLE

A stress test where the temperature of the medium (usually air) surrounding the test items is varied in a predetermined manner over the temperature range in such a way that the internal item temperature is kept at a fixed minimal increment from the medium temperature.

TEST TO FAILURE

The practice of inducing increased electrical and mechanical stresses in order to determine the maximum capability of a device so that conservative use in subsequent applications will, thereby, increase its life through the derating determined by these tests.

THERMAL ENDURANCE

The time at a selected temperature for a material or system of materials to deteriorate to some predetermined level of electrical, mechanical or chemical performance under prescribed conditions of test.

THERMAL FATIGUE

The failure of materials subjected to alternating heating and cooling.

THERMAL SHOCK

A stress test in which the temperature of the medium surrounding the test items is varied as rapidly as possible in order to create large, cyclic temperature gradients in the test items.

TIME, ACTIVE

That time during which an item is operational.

TIME, DOWN

That element of time during which the item is not in condition to perform its intended function.

TIME, MISSION

That element of uptime during which the item is performing its designated mission.

TIME, UP

That element of active time during which an item is either alert, reacting or performing a mission.

4. (Continued):

VARIABLE

In testing, the characteristic under examination which can have many values.

VARIANCE

The average of the squares of the deviations of individual values from their average. It is a measure of dispersion of a random variable. The second moment about the mean of a pdf given by

$$\text{var} = \int_{-\infty}^{\infty} (x-\mu)^2\, f(x)dx$$

WARRANTY

A written guarantee of the performance of a product in which the maker for a specific period of time or other variable will be responsible for the repair or replacement of defective items.

WEAR

The mechanical removal of surface material by adhesion or abrasion.

WEAROUT

The process of attrition which results in an increase of hazard rate with increasing age (cycles, miles, events or time) as applicable for the item.

WEIBULL DISTRIBUTION

A general distribution, which is suitable for describing the life characteristic of a large group of problems. The general expression for the Weibull cumulative distribution function is defined, for F(t=o)=0 as

$$F(t) = 1 - e^{-\left(\frac{t}{\Theta}\right)^{\beta}}$$

β = Weibull Slope - The shape parameter of the distribution and equal to the slope of the line drawn through the failure data plotted on Weibull probability paper.

Θ = Characteristic Life - The scale parameter of the distribution and always equal to the life at 63.2% cumulative failure.

X CHART

Control chart for averages X of values in a subgroup.

4. (Continued):

X-RAY SPECTROMETER

Spectrographic analysis to characterize elements which are present.

YIELD

Elongation or fracture resulting from a single application of load in a relatively short period of time.

5. ACRONYMS, ABBREVIATIONS AND SYMBOLS:

AGREE	Advisory Group on Reliability of Electronic Equipment
AOQ	Average Outgoing Quality
AOQL	Average Outgoing Quality Limit
AQL	Acceptance Quality Level
ATE	Automatic Test Equipment
BITE	Built-In Test Equipment
Cdf	Cumulative Distribution Function
CFR	Constant Failure Rate
COO	Cost of Ownership
C_p	Process Potential Index
C_{pk}	Process Performance for Two-Sided Spec Limits
DECAP	De-encapsulation
DFR	Declining Failure Rate
EDX	Energy Dispersive X-Ray
EDS	Energy Dispersive Spectrometer
EMC	Electromagnetic Compatability
EMI	Electromagnetic Interference
EOM	Ease of Maintenance
EOS	Electrical Overstress
ESD	Electrostatic Discharge

5. (Continued):

ESS	Environmental Stress Screening
FAR	Failure Analysis Request/Report
FIT	Failure Unit
FMA	Failure Modes Analysis
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes and Effects Criticality Analysis
FRACAS	Failure Reporting, Analysis and Corrective Action System
FTA	Fault Tree Analysis
HAST	Highly Accelerated Stress Test
h(t)	Hazard Function
IFR	Increasing Failure Rate
JAN	Joint Army Navy
LCC	Life Cycle Cost
LSC	Logistic Support Cost
LTPD	Lot Tolerance Percent Defective
MRB	Material Review Board
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
NPF	No Problem Found
NTF	No Trouble Found
OC	Operating Characteristic (Curve)
ORLA	Optimum Repair Level Analysis
PA	Product Assurance / Process Average
PDA	Process Defect Average

5. (Continued):

pdf	Probability Density Function
pmf	Probability Mass Function
PPL	Preferred Parts List
PPM	Parts Per Million
PRST	Probability Ratio Sequential Test
QA	Quality Assurance
QC	Quality Control
QPL	Qualified Products List
R	Reliability
RAC	Reliability Analysis Center
RPM	Reliability Planning and Management
r.v.	Random Variable
s	Sample Standard Deviation
s-	Statistical (Prefix)
SCA	Sneak Circuit Analysis
SEM	Scanning Electron Microscope
Sf(t)	Survivor Function
SPC	Statistical Process Control
TNI	Trouble Not Identified
z(t)	Hazard Function
α	Producer's Risk
β	Weibull Slope, Consumer's Risk
λ	Failure Rate
μ	Mean
Θ	Mean Life
σ	Standard Deviation

RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

MILITARY

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-HDBK-217D	Reliability Prediction of Electronic Equipment
MIL-STD-280A	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-414	Sampling Procedures and Tables for Inspection by Variables for Percent Defective
MIL-STD-756B	Reliability Models and Prediction
MIL-STD-781C	Reliability Design Qualification and Production Acceptance Tests - Experimental
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MIL-STD-810C	Environmental Test Methods
MIL-STD-883B	Test Methods and Procedures for Microelectronics
MIL-STD-1313	Microelectronics Terms and Definitions
MIL-Q-9858A	Quality Program Requirements
AR-92	Quality Program Requirements
MIL-S-195001	Semiconductor Devices, General Specification for
MIC M38510D	Microcircuits, General Specifications for
MIL-STD-470	Maintainability Program Requirements for Systems and Equipments
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REFERENCE SECTION (Continued):

Engineering Bulletin No. 11	User Guidelines for Microelectronic Reliability Estimation
JEDEC Standard No. 22	Test Methods and Procedures for Solid State Devices Used in Transportation/Automotive Applications

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Glossary and Tables for Statistical Quality Control		- ASQC 1973
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Quality Systems Terminology		- ANSI/ASQC A3-1978
Terms, Symbols and Definitions for Acceptance Sampling		- ANSI/ASQC A2-1978
Definitions, Symbols, Formulas and Tables for Control Charts		- ANSI/ASQC A1-1978
How to Speak Fluent Quality		- National Semiconductor Co.
Reliability Design Handbook	RDH 376	- Reliability Analysis Center
Analysis Techniques for Mechanical Reliability	WPS-1	- Reliability Analysis Center
1987 Desk Manual		- Microelectronic Manufacturing and Testing
Glossary of Automotive Electronic Terms		- SAE HS J1213 1982
Automotive Electronics Reliability Handbook		- SAE AE-9 1987
The American Heritage Dictionary		- 2nd College Edn. 1982 Houghton Mifflen Co.

APPLICATION:

This compilation of terms, acronyms and symbols was drawn from usage which should be familiar to those working in automotive electronics reliability. Terms are included which are used to describe how items, materials and systems are evaluated for reliability, how they fail, how failures are modeled and how failures are prevented. Terms are also included from the disciplines of designing for reliability, testing and failure analysis as well as the general disciplines of Quality and Reliability Engineering. This glossary is intended to augment SAE J1213, Glossary of Automotive Electronic Terms.

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REPORT

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GLOSSARY OF RELIABILITY TERMINOLOGY ASSOCIATED WITH AUTOMOTIVE ELECTRONICS

1. INTRODUCTION:

This glossary has been compiled to assist, by serving as a reference, in the communication between the automotive electronics engineer and the reliability engineer.

2. SCOPE:

This compilation of terms, acronyms and symbols was drawn from usage which should be familiar to those working in automotive electronics reliability. Terms are included which are used to describe how items, materials and systems are evaluated for reliability, how they fail, how failures are modeled and how failures are prevented. Terms are also included from the disciplines of designing for reliability, testing and failure analysis as well as the general disciplines of Quality and Reliability Engineering. This glossary is intended to augment SAE J1213, Glossary of Automotive Electronic Terms.

3. REFERENCES:

A listing of applicable military and other organizational reference documents, from which many of these terms and definitions were drawn, is provided as a source of alternate or related definitions.

MILITARY

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-HDBK-217D	Reliability Prediction of Electronic Equipment
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3. (Continued):

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3. (Continued):

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Automotive Electronics Reliability Handbook		SAE AE-9 1987
The American Heritage Dictionary		2nd College Edn. 1982 Houghton Mifflin Co.

4. RELIABILITY GLOSSARY:

ACCELERATED LIFE TEST

A life test under test conditions that are more severe than usual operating conditions. It is necessary that a relationship between test severity and the probability distribution of life be ascertainable.

ACCELERATION FACTOR

(1) The factor by which the failure rate can be increased by an increased environmental stress.

(2) The ratio between the times necessary to obtain the same portion of failure in two equal samples under two different sets of stress conditions, involving the same failure modes and mechanisms.

ACCEPT/REJECT TEST

A test, the result of which will be the action to accept or reject something, for example, an hypothesis or a batch of incoming material.

ACCEPTABLE QUALITY LEVEL (AQL)

The maximum percent defective which can be considered satisfactory as a process average, or the percent defect whose probability of rejection is designated by α.

ACCEPTANCE NUMBER

The largest number of defects that can occur in an acceptance sampling plan and still have the lot accepted.

ACCEPTANCE SAMPLING PLAN

An accept/reject test whose purpose is to accept or reject a lot of items or material.

4. (Continued):

ACCESSIBILITY

A measure of the relative ease of admission to the various areas of an item.

ACHIEVED RELIABILITY

The reliability demonstrated at a given point in time under specified conditions of use and environment.

ACTIVATION ENERGY

(1) The energy level at which a specific microelectronic failure mechanism becomes active (in electron-volts).

(2) The slope of the time-temperature regression line in the Arrhenius equation (in electron-volts).

ACTIVE ELEMENT

A part that converts or controls energy, for example, transistor, diode, electron tube, relay.

ACTIVE ELEMENT GROUP

An active element and its associated supporting (passive) parts, for example, an amplifier circuit, a relay circuit, a pump and its plumbing and fittings.

AGING

The effect whereby the probability density function of strength is changed (strength is reduced) with time.

ALLOCATION

The process of assigning reliability requirements to individual units to attain the desired system reliability.

ALPHA PARTICLE INDUCED SOFT ERRORS

Integrated circuit memory transient errors due to emission of alpha particles during radioactive decay of uranium or thorium contamination in the IC packaging material.

AMBIENT

Used to denote surrounding, encompassing, or local conditions. Usually applied to environments, for example, ambient temperature, ambient pressure.

4. (Continued):

APPORTIONMENT

Synonym of Allocation.

ARITHMETIC MEAN

The arithmetic mean of n numbers is the sum of the n numbers, divided by n.

ARRHENIUS MODEL

A mathematical representation of the dependence of failure rate on absolute temperature and activation energy. The model assumes that degradation of a performance parameter is linear with time with the failure rate a function of temperature stress. The temperature dependence is taken to be the exponential function:

$$\Theta_1 = \Theta_2 \exp[(E/k)(1/T_2 - 1/T_1)]$$

Θ_1 = mean time to failure at T_1
Θ_2 = mean time to failure at T_2
T = junction temperature in K
E = activation energy in eV
k = Boltzman's constant ($8.617\ 10^5$ eV/K)

ARRHENIUS ACCELERATION FACTOR

The acceleration factor F is the factor by which the time to fail can be reduced by increased temperature.

$$F = \Theta_1/\Theta_2 = \exp(E/k)(1/T_2 - 1/T_1)$$

ASSESSMENT

(1) A critical appraisal, including qualitative judgments about an item, such as importance of analysis results, design criticality and failure effect.

(2) The use of test data and/or operational service data to form estimates of population parameters and to evaluate the precision of these estimates.

ATTRIBUTE

A term used to designate a method of measurement whereby units are examined by noting the presence (or absence) of some characteristic or attribute in each of the units in the group under consideration and by counting how many units do (or do not) possess it. Inspection by attributes can be of two kinds - either the unit of product is classified simply as defective or nondefective, or the number of defects in the unit of product is counted, with respect to a given requirement or set of requirements.

4. (Continued):

ATTRIBUTE TESTING

Testing to evaluate whether or not an item possesses a specified attribute.

AUTOMATIC TEST EQUIPMENT (ATE)

Test equipment that contains provisions for automatically performing a series of pre-programmed tests.

AVAILABILITY (OPERATIONAL READINESS)

The probability that at any point in time the system is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions.

AVERAGE

A general term. It often means arithmetic mean, but can refer to s-expected value, median, mode, or some other measure of the general location of the data values.

AVERAGE OUTGOING QUALITY (AOQ)

The average quality of outgoing product after 100% inspection of rejected lots, with replacement by good units of all defective units found in inspection.

AVERAGE OUTGOING QUALITY LIMIT (AOQL)

The maximum average outgoing quality (AOQ) for a sampling plan.

BAKE-OUT

To subject an unsealed item to an elevated temperature to drive out moisture and unwanted gases prior to other process or sealing.

BATHTUB CURVE

A plot of failure rate of an item (whether repairable or not) vs. time. The failure rate initially decreases, then stays reasonably constant, then begins to rise rather rapidly. It has the shape of a bathtub. Not all items have this behavior.

BIAS

(1) The difference between the s-expected value of an estimator and the value of the true parameter.

(2) Applied voltage.

4. (Continued):

BINOMIAL DISTRIBUTION

The probability of r, or fewer successes in n independent trials, given a probability of success p in a single trial, is given by the cumulative binomial distribution:

$$Pr\ (x \leq r) = F\ (r;\ p,\ n) = \sum_{x=0}^{r} \genfrac{}{}{0pt}{}{n}{x}\ p^{x}\ (1-p)^{n-x}$$

BINOMIAL FUNCTION

The probability of exactly x successes in n independent trials, given a probability of success p in a single trial, is given by the binomial probability function:

$$f\ (x;\ p,\ n) = \genfrac{}{}{0pt}{}{n}{x}\ p^{x}\ (1-p)^{n-x},\quad x = 0, 1, 2, \ldots n \quad 0 \leq p \leq 1$$

BOND

(1) An interconnection which performs a permanent electrical and/or mechanical function.

(2) To join with adhesives.

BOND LIFT OFF

The failure mode whereby the bonded lead separates the surface to which it was attached.

BOND STRENGTH

In wire bonding, the pull force at rupture of the bond interface.

BREADBOARD MODEL

A preliminary assembly of parts to test the feasibility of an item or principle without regard to eventual design or form. Usually refers to a small collection of electronic parts.

BURN-IN

The initial operation of an item to stabilize its characteristics, and to minimize infant mortality in the field.

4. (Continued):

CAPABILITY

(1) A measure of the ability of an item to achieve mission objectives given the conditions during the mission.

(2) The spread of performance of a process in a state of statistical control; the amount of variation from common causes identified after all special causes of variation have been eliminated.

C CHART

Control chart for number of nonconformities observed in some specified inspection. The units should be alike in size and in the apparent likelihood of the existence of the nonconformity, in order that the area of opportunity for nonconformity be constant from unit to unit.

CENTRAL LINE

The line on a control chart that represents the average or median value of the items being plotted. It is shown as a solid line.

CHECKOUT

Tests or observations on an item to determine its condition or status.

COEFFICIENT OF VARIATION

The standard deviation divided by the mean, multiplied by 100 and expressed as a percentage.

COMPLEXITY LEVEL

A measure of the number of active elements required to perform a specific system function.

COMPONENT

A self-contained combination of parts, subassemblies, or assemblies which perform a distinctive function in the overall operation of an equipment. Often used interchangeably with (electronic) part.

CONFIDENCE

A specialized statistical term referring to the reliance to be placed in an assertion about the value of a parameter of a probability distribution.

4. (Continued):

CONFIDENCE COEFFICIENT

(1) A measure of assurance that a statement based upon statistical data is correct.

(2) The probability that an unknown parameter lies within a stated interval or is greater or less than some stated value.

CONFIDENCE INTERVAL

The interval within which it is asserted that the parameter of a probability distribution lies.

CONFIDENCE LEVEL

Equals $1-\alpha$ where α = the risk (%).

CONFIDENCE LIMIT

A bound of a confidence interval.

CONSISTENCY

A statistical term relating to the behavior of an estimator as the sample size becomes very large. An estimator is consistent if it converges to the population value as the sample size becomes large.

CONSTANT FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the middle, or "useful life" period of the Bathtub Curve model of item life.

(2) A term characterizing the hazard rate, h(t), of an item having an exponential reliability function.

CONTAMINATION

A general term used to describe an unwanted material that adversely affects the physical or electrical characteristics of an item.

CONTINUOUS SAMPLING PLAN

In acceptance sampling, a plan intended for application to a continuous flow of individual units of product that involves acceptance or rejection on a unit-by-unit inspection and sampling. Continuous sampling plans are usually characterized by requiring that each period of 100% inspection be continued until a specified number of consecutively inspected units are found clear of defects.

4. (Continued):

CORRECTIVE ACTION

A documented design, material or process change to correct the true cause of a failure. Part replacement with a like item does not constitute appropriate corrective action. Rather, the action should make it impossible for that failure to happen again.

CORRELATION

A form of statistical dependence between two variables. Unless stated otherwise, linear correlation is implied.

CORRELATION COEFFICIENT

A number between -1 and +1, which indicates the degree of linear relationship between two sets of numbers. Coefficients of -1 and +1 represent perfect linear agreement between two variables, while a coefficient of zero implies none.

CORRODE

To dissolve or wear away gradually, especially by chemical action.

CORROSION

The deterioration of a substance (usually a metal) because of a reaction with its environment, or with a corroding agent.

COSMETIC DEFECT

A variation from the conventional appearance of an item such as a slight change in its color, not necessarily detrimental to service performance.

COST-EFFECTIVENESS

A measure of the value received for the resources expended.

CRACK

Evidence of a full or partial break without separation of parts.

CRAZE

A network of fine cracks in the surface.

CREEP

(1) Elongation or fracture resulting from loads sustained over relatively long time at high temperatures.

(2) The dimensional change with time of a material under load.

4. (Continued):

CRITICALITY

A relative measure of the consequences of a failure.

CRITICALITY ANALYSIS

A procedure by which each potential failure mode is evaluated and ranked according to the combined influences of severity and probability of occurrence.

CUMULATIVE DISTRIBUTION FUNCTION (CDF)

The probability that the random variable takes on any value less than or equal to a value x, that is,

$$Cdf(x) = pr(X \leq x)$$

The unreliability function with regard to failures

$$F(t) = Pr(T \leq t)$$

CUT SET

In a Fault Tree, any basic event or combination of basic events whose occurrence will cause the top event to occur.

DEBUGGING

The period of "shakedown operation" of a finished equipment performed prior to placing it in use. During this period, defective parts and workmanship errors are corrected under test conditions that closely simulate field operation.

DECAP

To de-encapsulate. To remove the cover or plastic encapsulant on an item.

DECREASING FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the first or "infant mortality" period of the Bathtub Curve model or product life.

(2) A term characterizing the hazard rate h(t) of an item having a Weibull reliability function with slope $B < 1$.

DEFECT

A deviation of an item from some ideal state. The ideal state is usually given in a formal specification.

4. (Continued):

DEFECT, CRITICAL

A defect that could result in hazardous or unsafe conditions for individuals using, maintaining or depending on the item.

DEFECTIVE

A unit of product which contains one or more defects.

DEGRADATION

A gradual deterioration in performance as a function of time.

DELTA LIMITS

THe difference between initial and final readings usually associated with the difference between the zero time readings on a life test and the final readings. Determine how much parameters shift during the test.

DEMONSTRATED

That which has been proven by the use of concrete evidence gathered under specified conditions.

DEPENDABILITY

A measure of the item operating condition at one or more points during the mission, including the effects of Reliability, Maintainability and Survivability, given the item condition(s) at the start of the mission. It may be stated as the probability that an item will (1) enter or occupy any one of its required operational modes during a specified mission and (2) perform the functions associated with those operational modes.

DERATING

The intentional reduction of stress/strength ratio in the application of an item, usually for the purpose of reducing the occurrence of stress-related failures.

DESIGN ADEQUACY

The probability that the system will satisfy effectiveness requirements, given that the system design satisfied the design specification.

DEVICE

Any subdivision of a system; synonym for ITEM.

4. (Continued):

DISCRIMINATION RATIO

A measure of the distance between two specific points of the operating characteristic curve which are used to define the acceptance sampling plan.

DISSOCIATION

The breakdown of a substance into two or more constituents.

DISTRIBUTION

Generally short for Cumulative Distribution Function.

DOWNTIME

The total time during which the system is not in condition to perform its intended function.

DURABILITY

The probability that an item will operate as specified under stated conditions without a wearout failure; a special case of reliability.

DUTY CYCLE

The ratio of the time "on" of a device or system divided by the total cycle time. For a device that normally runs intermittently rather than continuously, the amount of time a device operates as opposed to its idle time.

EARLY FAILURE PERIOD

That period of life, after assembly, in which failures occur at an initially high rate because of the presence of defective parts and workmanship defects.

EDX SPECTROMETER

Generally used with a scanning electron microscope (SEM) to provide elemental analysis of X-rays generated on the region being hit by the electron beam.

EFFECTIVENESS

The capability of the system or device to perform its function.

EFFICIENCY

A statistical term relating to the dispersion in values of an ESTIMATOR. It is between zero and one.

4. (Continued):

ELECTROMAGNETIC COMPATABILITY (EMC)

The capability of electronic equipment to function in the intended electromagnetic environment at designed levels of efficiency.

ELECTROMIGRATION

Dendritic or filamentary growth of a metal (for example, silver) in an electric field.

EMISSION SPECTROGRAPH

An instrument which identifies the presence of elements by burning the sample in an air plasma and analyzing the resultant optical spectrum.

ENGINEERING, HUMAN

The science of studying the man-machine relation in order to minimize the effects of human error and fatigue and thereby provide a more reliable operating system.

ENGINEERING, RELIABILITY

The science of including those factors in the basic design which will assure the required degree of reliability.

ENVIRONMENT

The aggregate of all external conditions and influences affecting the life and development of the product.

ELECTRICAL OVERSTRESS (EOS)

The electrical stressing of electronic components beyond specifications.

ELECTROSTATIC DISCHARGE (ESD)

The transfer of electric charge between bodies at different electrostatic potentials caused by direct contact or by an electrostatic field.

ESTIMATOR

A statistic, which is derived from a sample, used to infer a value of a parameter of an assumed distribution model.

4. (Continued):

EXPECTED VALUE

The mean or average, defined as: If x is a random variable and F(x) is its CDF

$E(x) = \int x dF(x)$, where the integration is over all x.

For continuous variables with a pdf, this reduces to

$E(x) = \int x \, pdf(x) \, dx$.

For discrete random variables with a pmf, this reduces to

$E(x) = \Sigma x_n \, p(x_n)$ where the sum is over all n.

EXPONENTIAL DISTRIBUTION

The probability density function

$$f(t) = \lambda \exp(-\lambda t)$$

where λ, the failure rate is constant.

EXPONENTIAL MODEL

In reliability engineering, a model based on the assumption that times t between successive failures are described by the exponential distribution.

EVALUATION

A broad term used to encompass prediction, measurement and demonstration.

EXTREME VALUE DISTRIBUTION

The asymptotic distribution of the smallest extreme from a statistical distribution; used to model capacitor breakdown voltage, time to failure of corrosion, etc. The pdf is $p(x) = \exp(x) \exp[-\exp(x)]$.

EYRING MODEL

An accelerated life test model in which failure rate is related to temperature. Given by $\lambda = T\exp(A-B/T)$.

FAILURE

The termination of the ability of an item to perform its required function.

4. (Continued):

FAILURE ANALYSIS

The identification of the failure mode, the failure mechanism and the cause. Often includes physical dissection.

FAILURE, CATASTROPHIC

A sudden change in the operating characteristics of an item resulting in a complete loss of useful performance.

FAILURE, DEGRADATION

A failure that occurs as a result of a gradual or partial change in the operating characteristics of an item.

FAILURE EFFECT

The consequences a failure mode has on the operation, function or status of an item.

FAILURE, INCIPIENT

A degradation failure which is just beginning to exist.

FAILURE, INDUCED

A failure caused by a physical condition external to the failed item.

FAILURE, INFANT

A failure that occurs during the early life of an item.

FAILURE, INHERENT

A failure basically caused by a physical condition or phenomenon internal to the failed item.

FAILURE, INITIAL

The first failure to occur in use.

FAILURE, LATENT

A malfunction that occurs as a result of a previous exposure to a condition that did not result in an immediately detectable failure.

FAILURE MECHANISM

The mechanical, chemical or other process that results in a failure.

4. (Continued):

FAILURE MODE

The effect or manner by which a failure is observed. Generally describes the way the failure occurs.

FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

A systematic, organized procedure for evaluating potential failures in an operating system.

FAILURE MODES, EFFECTS AND CRITICALITY ANALYSIS (FMECA)

An analysis of possible modes of failure, their causes, effects, their criticalities and expected frequencies of occurrence.

FAILURE, NONRELEVANT

A failure not applicable to the computation or reliability.

FAILURE, PRIMARY

A failure whose occurrence is not caused by other failures.

FAILURE, RANDOM

A failure whose occurrence is not predictable in an absolute sense but is predictable in a probabilistic sense.

FAILURE RATE

(1) The conditional probability that an item will fail just after time t, given the item has not failed up to time t.

(2) The number of failures of an item per unit measure of life (cycles, time, miles, events, etc.) as applicable for the item.

FAILURE, RELEVANT

A failure attributable to a deficiency of design, manufacture or materials of the failed device, applicable to the computation of reliability.

FAILURE, SECONDARY

A failure caused directly or indirectly by the failure of another item.

FAILURE, WEAROUT

A failure whose time of occurrence is governed by rapidly increasing failure rate.

4. (Continued):

FATIGUE

Cracking or fracture from cyclic loads.

FAULT

An attribute which adversely affects the reliability of a device.

FAULT TREE ANALYSIS (FTA)

A method of reliability analysis in which a logical block diagram is used to indicate contributing lower level events.

FIT

A contraction of <u>F</u>ailure un<u>IT</u>, having a value of failures per 10^9 component-hours.

FORCED DEFECT

A failure induced by stress testing.

FOREIGN MATERIAL

The presence of an object or material which comes from some source external to the part or system.

FREEDOM, DEGREE OF

The number of observations that are free to vary at random, regardless of the restrictions imposed by the mathematics describing the statistic.

FUNCTIONAL FAILURE

A failure whereby a device does not perform its intended function when the inputs or controls are correct.

GAMMA DISTRIBUTION

An important distribution in statistical queuing theory. Given by:

$$\mathrm{pdf}(x) = \frac{\lambda(\lambda t)^{k-1} e^{-\lambda t}}{\Gamma(k)}, \quad \text{where } \Gamma(k) = \int_0^\infty u^{k-1} e^{-u} du$$

$$\lambda,\ \beta,\ t > 0$$

4. (Continued):

GAUSSIAN DISTRIBUTION (See NORMAL DISTRIBUTION)

A 2-parameter distribution with

$$\mathrm{pdf}(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp - \left[\frac{1}{2}\left(\frac{x-u}{\sigma}\right)\right]^2$$

GEOMETRIC MEAN

The geometric mean of n numbers is the nth root of their product.

GLASS TRANSITION TEMPERATURE

The temperature at which an amorphous polymer changes from a hard and relatively brittle condition to a viscous or rubbery condition.

GO, NO-GO

The result of a test of an attribute. It is either good or bad.

GOODNESS OF FIT

A statistical term that quantifies how likely a sample was to have come from a given probability distribution.

HAZARD RATE h(t)

(1) At a particular time, the rate of change of the number of items that have failed divided by the number of items surviving.

(2) Represents the probability that an item still functioning at time t will fail in the interval (t, t+Δt), where Δt is an infinitesimal time increment. Hazard rate is synonymous with conditional failure rate or instantaneous failure rate.

$$h(t) = \lim_{t \to 0} \frac{R(t)-R(t+\Delta t)}{t\,R(t)}$$

$$h(t) = f(t)/R(t)$$

HERMETICITY

The effectiveness of the seal of microelectronic and semiconductor devices with designed internal cavities.

HOMOGENEOUS

Of the same or similar nature. Uniform in structure or composition.

4. (Continued):

HUMAN FACTORS

A body of scientific facts about human characteristics. The term covers all biomedical and psychosocial considerations. It includes but is not limited to principles and applications in the areas of human engineering, personnel selection, training, life support, job performance aids and performance evaluation.

HYPOTHESIS, NULL

An hypothesis that there is no difference between some characteristics of the parent populations of several different samples, that is, that the samples come from similar populations. A conjecture about the true state of nature, that if true, will only rarely be rejected as the outcome of an experiment or measurement.

INCREASING FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the third or "wearout" period of the Bathtub Curve model of product life.

(2) A term characterizing the hazard rate h(t) of an item having a Normal reliability function, for instance.

INFANT MORTALITY

Premature catastrophic failures occurring at a much greater rate than during the useful life period prior to the onset of substantial wearout.

INSPECTION

The examination and testing of supplies and services (including, when appropriate, raw materials, components and intermediate assemblies) to determine whether they conform to specified requirements.

INSPECTION BY ATTRIBUTES

Inspection whereby either the unit of product or characteristic thereof is classified simply as defective or nondefective, or the number of defects in the unit or product is counted with respect to a given requirement.

INSPECTION BY VARIABLES

Inspection wherein certain quality characteristics of a sample are evaluated with respect to a continuous numerical scale and expressed as precise points along this scale. Variable inspections record the degree of conformance of the unit with specified requirements for the quality characteristics involved.

4. (Continued):

INSPECTION LEVEL

An indication of the relative size of the sample to the size of the lot.

INSPECTION LOT

A collection of units of product bearing identification and treated as a unique entity from which a sample is to be taken and inspected to determine conformance with the acceptability criteria.

ITEM

An all-inclusive term, to include assemblies, subassemblies accessories, parts, equipment and services, applied to what is being discussed.

LIFE TEST

A test, usually of several items, made for the purpose of estimating some characteristic(s) of the probability distribution of life.

LOG NORMAL DISTRIBUTION

The model of a random variable whose logarithm follows the Normal function with parameters μ and σ. It is a life model for a process whose value results from the multiplication of many small errors. Its pdf-

$$f(x:\mu,\sigma) = 1/(\sigma x\sqrt{2\pi}) \exp [-1/2\sigma^2(\ln x-\mu)^2]$$

$$x > 0$$
$$\sigma > 0$$
$$-\infty < \mu < \infty$$

LONGEVITY

Length of useful life of a product to its ultimate wearout requiring complete rehabilitation. This is a term generally applied in the definition of a safe, useful life for an equipment or system under the conditions of storage and use to which it will be exposed during its lifetime.

LOT

A group of units from a particular device type submitted each time for inspection and/or testing is called a lot.

LOT QUALITY

The true fraction defective in a lot.

4. (Continued):

LOT REJECT RATE (LRR)

The lot reject rate is the percentage of lots rejected from the lots evaluated.

LOT TOLERANCE PERCENT DEFECTIVE (LTPD)

The percent defective which is to be accepted a minimum or arbitrary fraction of the time, or that percent defective whose probability of rejection is designated by ß.

MAINTAINABILITY

A characteristic of design and installation which is expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

MAINTENANCE, PREVENTIVE

The maintenance performed in an attempt to retain an item in a specified condition by providing systematic inspection, detection and prevention of incipient failure.

MARGIN TESTING

Testing in which item environments such as line voltage or temperature are changed to reversibly worsen the performance. Its purpose is to find how much margin is left in the item for its degradation.

MEAN

(1) The expected value of a random variable.

(2) The first moment of a probability distribution about its origin. As specifically defined and modified, for example, the arithmetic mean (sums), the geometric mean (products), the harmonic mean (reciprocals), logarithmic mean, etc.

MEAN LIFE (Θ)

The arithmetic average of lifetimes of all items considered.

$$\Theta = \int_0^T R(t)dt = \int_0^T t\,pdf(t)dt$$

where R(t) = the s-reliability of the item
T = the interval over which the mean life is desired, usually the useful life

4. (Continued):

MEAN-LIFE-BETWEEN-FAILURES

This concept is the same as Mean Life except that it is for repaired items and is the mean up-time of the item. The formula is the same as for Mean Life except that R(t) is interpreted as the distribution of up-times.

MEAN-TIME-BETWEEN-FAILURES (MTBF)

For a particular interval, the total functioning life of a population of an item divided by the total number of failures within the population during the measurement interval. The definition holds for time, cycles, miles, events or other measure of life units. A basic measure of reliability of repairable items.

MEAN-TIME-BETWEEN-MAINTENANCE (MTBM)

The mean of the distribution of the time intervals between maintenance actions (either preventive, corrective or both).

MEAN-TIME-TO-FAILURE (MTTF)

For nonrepaired items, the mean life.

MEAN-TIME-TO-REPAIR (MTTR)

The total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

$$\mathrm{MTTR} = \int_0^T G(t)dt$$

where G(t) = Cdf of repair time
T = Maximum allowed repair time

MEDIAN

The median of a distribution of one random variable X of the discrete or continuous type is a value of x such that $\Pr(X \leq x) = 1/2$ and $\Pr(X \geq x) = 1/2$, the middle value.

4. (Continued):

MISSION

The objective or task, together with the purpose, which clearly indicates the action to be taken.

MISSION RELIABILITY

The probability of success of an item to perform its required function for the duration of its intended mission.

MISSION PROFILE

The mission profile describes the events and conditions, including times and time spans, associated with a specific operational usage of an item. It is one segment of the operational cycle.

MODE

The mode of a distribution of one random variable X of discrete or continuous type is a value of x that maximizes the pdf f(x).

MODEL

A mathematical representation of a process. In Reliability there are two primary modeling concepts:

(1) A statistical function describing a life characteristic.

(2) A description of the reliability connectivity of the parts of a system.

MODEL, PARALLEL

A representation of the connection of the parts in a system such that the failure of all parts so connected is required for failure of that section of the system.

MODEL, SERIES

A representation of the connection of parts of a system such that failure of any part so connected will cause failure of that section of the system.

MODULE

An item which is packaged and is part of the next higher level of assembly.

4. (Continued):

NORMAL DISTRIBUTION (See GAUSSIAN)

The most prominant continuous distribution in statistics, frequently referred to as the Gaussian or bell-shaped distribution. Its density function is

$$f(x;\mu,\sigma) = \frac{1}{\sigma \quad 2\pi} \exp \; - \frac{(x-\mu)^2}{2\sigma^2} \;, \quad -\infty < x < \infty, \; -\infty < \mu < \infty, \; \sigma > 0$$

with mean μ and variance σ^2. The theoretical justification for the normal distribution lies in the central-limit theorem, which shows that under very broad conditions the distribution of the average of n independent observations from any distribution approaches a normal distribution as n becomes large.

NORMAL VARIABLE

A random variable that is normally distributed. In situations where the random variable represents the total effect of many "small" independent causes, each with mutually independent errors, the central limit theorem leads to the prospect the variable will be normally distributed.

OPERATING CHARACTERISTIC (OC CURVE)

A curve showing the relation between the probability of acceptance and either lot quality or process quality, whichever is applicable.

OPERATIONAL READINESS

The probability that, at any point in time, the system is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions, including stated allowable warning time. Thus, total calendar time is the basis for computation of operational readiness.

OVERCOAT

A thin film of insulating material over micro-circuit elements to provide mechanical protection or prevention of contamination.

OVERSTRESS

A condition wherein the severity levels of operation are more than usual or more than the specification.

PART

(1) An item that will not be disassembled for maintenance.
(2) The least subdivision of a system.
(3) An item which cannot ordinarily be disassembled without being destroyed.

4. (Continued):

PARTS PER MILLION (PPM)

Describing fractional defective, PPM is obtained by multiplying percent defective by 10 000; for example, 0.01% = 100 ppm.

PASSIVE ELEMENT

An element that is not active, that is, does not control energy; for example, a resistor, capacitor or an inductor.

PERCENTAGE DEFECTIVE

That proportion of a lot which is defective. This is the figure of merit in the population domain which characterizes quality control measurements and differentiates it from reliability.

PHYSIOCHEMICAL INSTABILITY

Change from an initial material bulk property, such as strength, resiliency, volume, composition, etc., as a result of age, pressure, temperature, etc.

PIN HOLE

A microscopic hole through an insulating (glass) layer. A defect.

POPULATION

The totality of the set of items, units, measurements, etc., real or conceptual, that is under consideration.

PROBABILITY

(1) Classical: If an event can occur in N equally likely and different ways, and if n of these ways have an attribute A, then the probability of the occurrence of A, denoted Pr(A) is defined as n/N.

(2) Frequency: If an experiment is conducted N times, and outcome A occurs n times, then the limit of n/N as N becomes large, is defined as the probability of A, denoted as Pr(A).

(3) Subjective: The probability Pr(A) is a measure of the degree of belief one holds in a specified proposition A.

PROBABILITY DENSITY FUNCTION

A continuous f(x) is a pdf if $f(x) \geqslant 0$, $-\infty < x < \infty$ and

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

4. (Continued):

PROBABILITY MASS FUNCTION

A discrete f(x) is a pmf if f(x) = 0 for all x, except for a finite countable set of values of x for which f(x) > 0, and

$$\sum_x f(x) = 1, \text{ for all } x \text{ such that } f(x) > 0$$

PROBABILITY FUNCTION

The probability function is defined in terms of its pdf or pmf. If there is a pdf, F(x) is continuous and is defined by

$$F(x) = \int_{-\infty}^{x} f(x)dx$$

If there is a pmf, F(x) is discrete and is defined by

$$F(x) = \sum_x f(x)$$

PROBABILITY DISTRIBUTION

A mathematical function with specific properties which describes the probability that a random variable will take on a value or a set of values. If the random variable is continuous and well-behaved enough, there will be a pdf. If the random variable is discrete, there will be a pmf.

PROBABILITY PAPER

Graph paper constructed so that cumulative distribution curves plot as straight lines. Paper is available for normal, log-normal, Weibull, and several other distributions.

PROCESS AVERAGE (PA)

The total number of units rejected over an extended period of time divided by the total number of units produced over the same period of time.

PULL TEST

A test to determine the bond strength of a lead to an interconnecting surface, usually perpendicular to the surface, by pulling to failure.

4. (Continued):

PURPLE PLAGUE

One of several gold-aluminum compounds formed when bonding gold to aluminum and activated by exposure to moisture and high temperature, resulting in brittle, time-based bond failure.

QUALIFICATION

The entire process by which products are obtained from manufacturers or distributors, examined and tested, and then identified on a Qualified Products List.

QUALITY

(1) The composite of all characteristics or attributes, including performance, of an item.

(2) A measure of the degree to which an item conforms to applicable specification and workmanship standards.

(3) A property which refers to the tendency of an item to be made to specific specifications or the customer's express needs, or both. See current publications by Juran, Deming, Crosby, et al.

QUALITY ASSURANCE

A system of activities whose purpose it is to provide assurance that the overall quality control job is, in fact, being done effectively.

QUALITY CHARACTERISTICS

Those properties of an item or process which can be measured, reviewed or observed and which are identified in the drawings, specifications or constructual requirements. Reliability becomes a quality characteristic when so defined.

QUALITY CONTROL (QC)

The overall system of activities whose purpose is to provide a quality of product or service which meets the needs of users; also, the use of such a system.

RANDOMNESS

The occurrence of an event in accordance with the laws of chance.

RANDOM EVENT

The occurrence of an event affected by chance alone. For example, heads or tails on a flipped coin occurs at random.

4. (Continued):

RANDOM SAMPLE

As commonly used in acceptance sampling theory, the process of selecting sample units in such a manner that all units under consideration have the same probability of being selected.

RANDOM VARIABLE (r.v.)

A function defined on a sample space, or a transformation which associates a real number with each point in a sample space.

REDUNDANCY

The existence of more than one means for accomplishing a given function.

REDUNDANCY, ACTIVE

A type of redundancy where all items in the group are operating simultaneously.

REDUNDANCY, STANDBY

A type of redundancy where the alternative means of performing the function is inoperative until needed and is switched on upon failure of the primary means of performing the function.

REGRESSION ANALYSIS

A mathematical means to fit an assumed model to data containing errors by minimizing the sum of squared deviations from the fit.

RELIABILITY

The probability that a device will function without failure over a specified time period or amount of usage at stated conditions.

RELIABILITY GROWTH

The increase in reliability as a result of the effort, the resource commitment to improve design, purchasing, production, and inspection procedures.

RELIABILITY, INHERENT

The potential reliability of an item present in its design.

RELIABILITY, INTRINSIC

The probability that a device will perform its specified function, determined on the basis of a statistical analysis of the failure rates and other characteristics of the parts and components which comprise the device.

4. (Continued):

RELIABILITY, PREDICTED

The process of quantitatively assessing whether a proposed or actual equipment design will meet a specified reliability requirement.

RELIABILITY WITH REPAIR

The reliability that can be achieved when preventive maintenance is allowed.

REPAIRABILITY

The probability that a failed system will be restored to operable condition in a specified active repair time.

RISK

The probability of rendering a wrong decision based on inadequate data or analysis. The probability of an undesired outcome.

RISK, CONSUMER'S (β)

For a given sampling plan, the probability of acceptance for a designated numerical value of relatively poor submitted quality.

RISK, PRODUCER'S (α)

For a given sampling plan, the probability of rejection for a designated numerical value of relatively good submitted quality.

RISK PRIORITY NUMBER

In an FMEA, the product of the Occurrence Ranking, the Severity Ranking and the Detection Ranking.

SAFETY

The conservation of human life and its effectiveness, and the prevention of damage to items, consistent with mission requirements.

SAMPLE

A random selection of units from a lot, usually made for the purpose of evaluating the characteristics of the lot.

SCANNING ELECTRON MICROSCOPE (SEM)

An instrument which provides a visual image of the surface of an item. It scans an electron beam over the surface of a sample held in a vacuum and measures any of several resultant particle counts or energies. Provides depth of field and resolution significantly exceeding light counts microscopy and may be used at magnifications exceeding 50 000 times.

4. (Continued):

SCREENING

The process of performing 100% inspection, or exposure to stress, on product lots and removing the defective units from the lots.

SCREENING TEST

A test or combination of tests intended to remove unsatisfactory items or those likely to exhibit early failures.

SERVICEABILITY

A measure of the degree to which servicing of an item will be accomplished within a given time under specified conditions.

SERVICING

The replenishment of consumables needed to keep an item in operating condition, but not including any other preventive maintenance or any corrective maintenance.

SEVERITY LEVEL

A general term implying the degree to which an environment will cause damage or shorten life, or both.

SHEAR TEST

Test of the shear strength of various attachments, for example, die attach, wire bond, wire weld, contact weld, etc. by application of force in the plane.

SHORT CIRCUIT

An abnormal connection of relatively low impedance, whether made intentionally or accidentally between two points of different electric potential.

SIGNIFICANCE

Results that show deviations between an hypothesis and the observations used as a test of the hypothesis greater than can be explained by random variation or chance alone, are called statistically significant.

SIGNIFICANCE LEVEL

The probability of rejecting the null hypothesis when it is actually true.

4. (Continued):

SNEAK CIRCUIT

An unexpected path or logic flow within a system which, under certain conditions, can initiate an undesired function or inhibit a desired function.

SOFT ERROR

Temporary memory content error due to intrusion of an alpha particle, for instance.

STANDARD DEVIATION

The square root of the variance.

STATISTIC

A value calculated from a sample which is used to estimate some characteristic of a population.

STATISTICAL CONTROL

Control of a process by statistical methods. A process is said to be in a state of statistical control if the variations among the sampling results from it can be attributed to a stable pattern of chance causes.

STATISTICAL MODEL

A probability distribution as a representation of time to failure.

STEP STRESS TEST

A test consisting of several stress levels applied sequentially for periods of equal duration to a sample. During each period, a stated stress level is applied, and the stress level is increased from one step to the next.

STORAGE LIFE (SHELF LIFE)

The length of time an item can be stored under specified conditions and still meet specified requirements.

STRESS

A general and ambiguous term used as an extension of its meaning in mechanics as that which could cause failure. It does not distinguish between those things which cause permanent damage (deterioration) and those things which do not.

4. (Continued):

STRESS RELIEF

A design means to minimize the effects of stress, for example, a cable clamp or a conformal coat.

STRESS, COMPONENT

The stresses on component parts during testing, assembly or use which affect the failure rate and hence the reliability of the parts. Voltage, power temperature and thermal environmental stress are included.

SUBASSEMBLY

A replaceable combination of parts which is an element of an assembly.

SUBSYSTEM

A major subdivision of a system which performs a specified function in the overall operation of a system.

SURVIVABILITY

The measure of the degree to which an item will withstand hostile man-made environment and not suffer abortive impairment of its ability to accomplish its designated mission.

SURVIVOR FUNCTION Sf(t)

The Reliability distribution function. The probability that an item will survive to time t.

$$Sf(t) = Pr(T>t) \qquad t > 0,\ T \text{ a r.v.}$$

SUSPENDED ITEM

An item removed from test prior to failure.

SYSTEM

A combination of complete operation equipments, assemblies, components, parts or accessories interconnected to perform a specific operational function.

SYSTEM EFFECTIVENESS

A measure of the degree to which an item can be expected to achieve a set of specific mission requirements and which may be expressed as a function of availability, dependability and capability.

4. (Continued):

TEMPERATURE CYCLE

A stress test where the temperature of the medium (usually air) surrounding the test items is varied in a predetermined manner over the temperature range in such a way that the internal item temperature is kept at a fixed minimal increment from the medium temperature.

TEST TO FAILURE

The practice of inducing increased electrical and mechanical stresses in order to determine the maximum capability of a device so that conservative use in subsequent applications will, thereby, increase its life through the derating determined by these tests.

THERMAL ENDURANCE

The time at a selected temperature for a material or system of materials to deteriorate to some predetermined level of electrical, mechanical or chemical performance under prescribed conditions of test.

THERMAL FATIGUE

The failure of materials subjected to alternating heating and cooling.

THERMAL SHOCK

A stress test in which the temperature of the medium surrounding the test items is varied as rapidly as possible in order to create large, cyclic temperature gradients in the test items.

TIME, ACTIVE

That time during which an item is operational.

TIME, DOWN

That element of time during which the item is not in condition to perform its intended function.

TIME, MISSION

That element of uptime during which the item is performing its designated mission.

TIME, UP

That element of active time during which an item is either alert, reacting or performing a mission.

4. (Continued):

VARIABLE

In testing, the characteristic under examination which can have many values.

VARIANCE

The average of the squares of the deviations of individual values from their average. It is a measure of dispersion of a random variable. The second moment about the mean of a pdf given by

$$\mathrm{var} = \int_{-\infty}^{\infty} (x-\mu)^2 \, f(x)dx$$

WARRANTY

A written guarantee of the performance of a product in which the maker for a specific period of time or other variable will be responsible for the repair or replacement of defective items.

WEAR

The mechanical removal of surface material by adhesion or abrasion.

WEAROUT

The process of attrition which results in an increase of hazard rate with increasing age (cycles, miles, events or time) as applicable for the item.

WEIBULL DISTRIBUTION

A general distribution, which is suitable for describing the life characteristic of a large group of problems. The general expression for the Weibull cumulative distribution function is defined, for F(t=o)=0 as

$$F(t) = 1 - e^{-\left(\frac{t}{\theta}\right)^{\beta}}$$

β = <u>Weibull Slope</u> - The shape parameter of the distribution and equal to the slope of the line drawn through the failure data plotted on Weibull probability paper.

θ = <u>Characteristic Life</u> - The scale parameter of the distribution and always equal to the life at 63.2% cumulative failure.

X CHART

Control chart for averages X of values in a subgroup.

4. (Continued):

X-RAY SPECTROMETER

Spectrographic analysis to characterize elements which are present.

YIELD

Elongation or fracture resulting from a single application of load in a relatively short period of time.

5. ACRONYMS, ABBREVIATIONS AND SYMBOLS:

AGREE	Advisory Group on Reliability of Electronic Equipment
AOQ	Average Outgoing Quality
AOQL	Average Outgoing Quality Limit
AQL	Acceptance Quality Level
ATE	Automatic Test Equipment
BITE	Built-In Test Equipment
Cdf	Cumulative Distribution Function
CFR	Constant Failure Rate
COO	Cost of Ownership
C_p	Process Potential Index
C_{pk}	Process Performance for Two-Sided Spec Limits
DECAP	De-encapsulation
DFR	Declining Failure Rate
EDX	Energy Dispersive X-Ray
EDS	Energy Dispersive Spectrometer
EMC	Electromagnetic Compatability
EMI	Electromagnetic Interference
EOM	Ease of Maintenance
EOS	Electrical Overstress
ESD	Electrostatic Discharge

5. (Continued):

ESS	Environmental Stress Screening
FAR	Failure Analysis Request/Report
FIT	Failure Unit
FMA	Failure Modes Analysis
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes and Effects Criticality Analysis
FRACAS	Failure Reporting, Analysis and Corrective Action System
FTA	Fault Tree Analysis
HAST	Highly Accelerated Stress Test
h(t)	Hazard Function
IFR	Increasing Failure Rate
JAN	Joint Army Navy
LCC	Life Cycle Cost
LSC	Logistic Support Cost
LTPD	Lot Tolerance Percent Defective
MRB	Material Review Board
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
NPF	No Problem Found
NTF	No Trouble Found
OC	Operating Characteristic (Curve)
ORLA	Optimum Repair Level Analysis
PA	Product Assurance / Process Average
PDA	Process Defect Average

5. (Continued):

pdf	Probability Density Function
pmf	Probability Mass Function
PPL	Preferred Parts List
PPM	Parts Per Million
PRST	Probability Ratio Sequential Test
QA	Quality Assurance
QC	Quality Control
QPL	Qualified Products List
R	Reliability
RAC	Reliability Analysis Center
RPM	Reliability Planning and Management
r.v.	Random Variable
s	Sample Standard Deviation
s-	Statistical (Prefix)
SCA	Sneak Circuit Analysis
SEM	Scanning Electron Microscope
Sf(t)	Survivor Function
SPC	Statistical Process Control
TNI	Trouble Not Identified
z(t)	Hazard Function
α	Producer's Risk
β	Weibull Slope, Consumer's Risk
λ	Failure Rate
μ	Mean
Θ	Mean Life
σ	Standard Deviation

RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

MILITARY

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-HDBK-217D	Reliability Prediction of Electronic Equipment
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MIL-Q-9858A	Quality Program Requirements
AR-92	Quality Program Requirements
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MIC M38510D	Microcircuits, General Specifications for
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REFERENCE SECTION (Continued):

Engineering Bulletin No. 11	User Guidelines for Microelectronic Reliability Estimation
JEDEC Standard No. 22	Test Methods and Procedures for Solid State Devices Used in Transportation/Automotive Applications

OTHER

Glossary and Tables for Statistical Quality Control		– ASQC 1973
PROCUREMENT QUALITY CONTROL – 2nd Edition		– ASQC
Quality Systems Terminology		– ANSI/ASQC A3-1978
Terms, Symbols and Definitions for Acceptance Sampling		– ANSI/ASQC A2-1978
Definitions, Symbols, Formulas and Tables for Control Charts		– ANSI/ASQC A1-1978
How to Speak Fluent Quality		– National Semiconductor Co.
Reliability Design Handbook	RDH 376	– Reliability Analysis Center
Analysis Techniques for Mechanical Reliability	WPS-1	– Reliability Analysis Center
1987 Desk Manual		– Microelectronic Manufacturing and Testing
Glossary of Automotive Electronic Terms		– SAE HS J1213 1982
Automotive Electronics Reliability Handbook		– SAE AE-9 1987
The American Heritage Dictionary		– 2nd College Edn. 1982 Houghton Mifflen Co.

APPLICATION:

This compilation of terms, acronyms and symbols was drawn from usage which should be familiar to those working in automotive electronics reliability. Terms are included which are used to describe how items, materials and systems are evaluated for reliability, how they fail, how failures are modeled and how failures are prevented. Terms are also included from the disciplines of designing for reliability, testing and failure analysis as well as the general disciplines of Quality and Reliability Engineering. This glossary is intended to augment SAE J1213, Glossary of Automotive Electronic Terms.

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SAE J1213/2

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GLOSSARY OF RELIABILITY TERMINOLOGY ASSOCIATED WITH AUTOMOTIVE ELECTRONICS

1. INTRODUCTION:

This glossary has been compiled to assist, by serving as a reference, in the communication between the automotive electronics engineer and the reliability engineer.

2. SCOPE:

This compilation of terms, acronyms and symbols was drawn from usage which should be familiar to those working in automotive electronics reliability. Terms are included which are used to describe how items, materials and systems are evaluated for reliability, how they fail, how failures are modeled and how failures are prevented. Terms are also included from the disciplines of designing for reliability, testing and failure analysis as well as the general disciplines of Quality and Reliability Engineering. This glossary is intended to augment SAE J1213, Glossary of Automotive Electronic Terms.

3. REFERENCES:

A listing of applicable military and other organizational reference documents, from which many of these terms and definitions were drawn, is provided as a source of alternate or related definitions.

MILITARY

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-HDBK-217D	Reliability Prediction of Electronic Equipment
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3. (Continued):

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3. (Continued):

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Automotive Electronics Reliability Handbook		- SAE AE-9 1987
The American Heritage Dictionary		- 2nd College Edn. 1982 Houghton Mifflin Co.

4. RELIABILITY GLOSSARY:

ACCELERATED LIFE TEST

A life test under test conditions that are more severe than usual operating conditions. It is necessary that a relationship between test severity and the probability distribution of life be ascertainable.

ACCELERATION FACTOR

(1) The factor by which the failure rate can be increased by an increased environmental stress.

(2) The ratio between the times necessary to obtain the same portion of failure in two equal samples under two different sets of stress conditions, involving the same failure modes and mechanisms.

ACCEPT/REJECT TEST

A test, the result of which will be the action to accept or reject something, for example, an hypothesis or a batch of incoming material.

ACCEPTABLE QUALITY LEVEL (AQL)

The maximum percent defective which can be considered satisfactory as a process average, or the percent defect whose probability of rejection is designated by α.

ACCEPTANCE NUMBER

The largest number of defects that can occur in an acceptance sampling plan and still have the lot accepted.

ACCEPTANCE SAMPLING PLAN

An accept/reject test whose purpose is to accept or reject a lot of items or material.

4. (Continued):

ACCESSIBILITY

A measure of the relative ease of admission to the various areas of an item.

ACHIEVED RELIABILITY

The reliability demonstrated at a given point in time under specified conditions of use and environment.

ACTIVATION ENERGY

(1) The energy level at which a specific microelectronic failure mechanism becomes active (in electron-volts).

(2) The slope of the time-temperature regression line in the Arrhenius equation (in electron-volts).

ACTIVE ELEMENT

A part that converts or controls energy, for example, transistor, diode, electron tube, relay.

ACTIVE ELEMENT GROUP

An active element and its associated supporting (passive) parts, for example, an amplifier circuit, a relay circuit, a pump and its plumbing and fittings.

AGING

The effect whereby the probability density function of strength is changed (strength is reduced) with time.

ALLOCATION

The process of assigning reliability requirements to individual units to attain the desired system reliability.

ALPHA PARTICLE INDUCED SOFT ERRORS

Integrated circuit memory transient errors due to emission of alpha particles during radioactive decay of uranium or thorium contamination in the IC packaging material.

AMBIENT

Used to denote surrounding, encompassing, or local conditions. Usually applied to environments, for example, ambient temperature, ambient pressure.

4. (Continued):

APPORTIONMENT

Synonym of Allocation.

ARITHMETIC MEAN

The arithmetic mean of n numbers is the sum of the n numbers, divided by n.

ARRHENIUS MODEL

A mathematical representation of the dependence of failure rate on absolute temperature and activation energy. The model assumes that degradation of a performance parameter is linear with time with the failure rate a function of temperature stress. The temperature dependence is taken to be the exponential function:

$$\Theta_1 = \Theta_2 \exp [(E/k)(1/T_2-1/T_1)]$$

Θ_1 = mean time to failure at T_1
Θ_2 = mean time to failure at T_2
T = junction temperature in K
E = activation energy in eV
k = Boltzman's constant ($8.617\ 10^5$ eV/K)

ARRHENIUS ACCELERATION FACTOR

The acceleration factor F is the factor by which the time to fail can be reduced by increased temperature.

$$F = \Theta_1/\Theta_2 = \exp (E/k)(1/T_2-1/T_1)$$

ASSESSMENT

(1) A critical appraisal, including qualitative judgments about an item, such as importance of analysis results, design criticality and failure effect.

(2) The use of test data and/or operational service data to form estimates of population parameters and to evaluate the precision of these estimates.

ATTRIBUTE

A term used to designate a method of measurement whereby units are examined by noting the presence (or absence) of some characteristic or attribute in each of the units in the group under consideration and by counting how many units do (or do not) possess it. Inspection by attributes can be of two kinds - either the unit of product is classified simply as defective or nondefective, or the number of defects in the unit of product is counted, with respect to a given requirement or set of requirements.

4. (Continued):

ATTRIBUTE TESTING

Testing to evaluate whether or not an item possesses a specified attribute.

AUTOMATIC TEST EQUIPMENT (ATE)

Test equipment that contains provisions for automatically performing a series of pre-programmed tests.

AVAILABILITY (OPERATIONAL READINESS)

The probability that at any point in time the system is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions.

AVERAGE

A general term. It often means arithmetic mean, but can refer to s-expected value, median, mode, or some other measure of the general location of the data values.

AVERAGE OUTGOING QUALITY (AOQ)

The average quality of outgoing product after 100% inspection of rejected lots, with replacement by good units of all defective units found in inspection.

AVERAGE OUTGOING QUALITY LIMIT (AOQL)

The maximum average outgoing quality (AOQ) for a sampling plan.

BAKE-OUT

To subject an unsealed item to an elevated temperature to drive out moisture and unwanted gases prior to other process or sealing.

BATHTUB CURVE

A plot of failure rate of an item (whether repairable or not) vs. time. The failure rate initially decreases, then stays reasonably constant, then begins to rise rather rapidly. It has the shape of a bathtub. Not all items have this behavior.

BIAS

(1) The difference between the s-expected value of an estimator and the value of the true parameter.

(2) Applied voltage.

4. (Continued):

BINOMIAL DISTRIBUTION

The probability of r, or fewer successes in n independent trials, given a probability of success p in a single trial, is given by the cumulative binomial distribution:

$$\Pr\ (x \le r) = F\ (r;\ p,\ n) = \sum_{x=0}^{r} \binom{n}{x} p^{x}\ (1-p)^{n-x}$$

BINOMIAL FUNCTION

The probability of exactly x successes in n independent trials, given a probability of success p in a single trial, is given by the binomial probability function:

$$f\ (x;\ p,\ n) = \binom{n}{x} p^{x}\ (1-p)^{n-x},\quad x = 0, 1, 2, \ldots\ n \quad 0 \le p \le 1$$

BOND

(1) An interconnection which performs a permanent electrical and/or mechanical function.

(2) To join with adhesives.

BOND LIFT OFF

The failure mode whereby the bonded lead separates the surface to which it was attached.

BOND STRENGTH

In wire bonding, the pull force at rupture of the bond interface.

BREADBOARD MODEL

A preliminary assembly of parts to test the feasibility of an item or principle without regard to eventual design or form. Usually refers to a small collection of electronic parts.

BURN-IN

The initial operation of an item to stabilize its characteristics, and to minimize infant mortality in the field.

4. (Continued):

CAPABILITY

(1) A measure of the ability of an item to achieve mission objectives given the conditions during the mission.

(2) The spread of performance of a process in a state of statistical control; the amount of variation from common causes identified after all special causes of variation have been eliminated.

C CHART

Control chart for number of nonconformities observed in some specified inspection. The units should be alike in size and in the apparent likelihood of the existence of the nonconformity, in order that the area of opportunity for nonconformity be constant from unit to unit.

CENTRAL LINE

The line on a control chart that represents the average or median value of the items being plotted. It is shown as a solid line.

CHECKOUT

Tests or observations on an item to determine its condition or status.

COEFFICIENT OF VARIATION

The standard deviation divided by the mean, multiplied by 100 and expressed as a percentage.

COMPLEXITY LEVEL

A measure of the number of active elements required to perform a specific system function.

COMPONENT

A self-contained combination of parts, subassemblies, or assemblies which perform a distinctive function in the overall operation of an equipment. Often used interchangeably with (electronic) part.

CONFIDENCE

A specialized statistical term referring to the reliance to be placed in an assertion about the value of a parameter of a probability distribution.

4. (Continued):

CONFIDENCE COEFFICIENT

(1) A measure of assurance that a statement based upon statistical data is correct.

(2) The probability that an unknown parameter lies within a stated interval or is greater or less than some stated value.

CONFIDENCE INTERVAL

The interval within which it is asserted that the parameter of a probability distribution lies.

CONFIDENCE LEVEL

Equals $1-\alpha$ where α = the risk (%).

CONFIDENCE LIMIT

A bound of a confidence interval.

CONSISTENCY

A statistical term relating to the behavior of an estimator as the sample size becomes very large. An estimator is consistent if it converges to the population value as the sample size becomes large.

CONSTANT FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the middle, or "useful life" period of the Bathtub Curve model of item life.

(2) A term characterizing the hazard rate, h(t), of an item having an exponential reliability function.

CONTAMINATION

A general term used to describe an unwanted material that adversely affects the physical or electrical characteristics of an item.

CONTINUOUS SAMPLING PLAN

In acceptance sampling, a plan intended for application to a continuous flow of individual units of product that involves acceptance or rejection on a unit-by-unit inspection and sampling. Continuous sampling plans are usually characterized by requiring that each period of 100% inspection be continued until a specified number of consecutively inspected units are found clear of defects.

4. (Continued):

CORRECTIVE ACTION

A documented design, material or process change to correct the true cause of a failure. Part replacement with a like item does not constitute appropriate corrective action. Rather, the action should make it impossible for that failure to happen again.

CORRELATION

A form of statistical dependence between two variables. Unless stated otherwise, linear correlation is implied.

CORRELATION COEFFICIENT

A number between -1 and +1, which indicates the degree of linear relationship between two sets of numbers. Coefficients of -1 and +1 represent perfect linear agreement between two variables, while a coefficient of zero implies none.

CORRODE

To dissolve or wear away gradually, especially by chemical action.

CORROSION

The deterioration of a substance (usually a metal) because of a reaction with its environment, or with a corroding agent.

COSMETIC DEFECT

A variation from the conventional appearance of an item such as a slight change in its color, not necessarily detrimental to service performance.

COST-EFFECTIVENESS

A measure of the value received for the resources expended.

CRACK

Evidence of a full or partial break without separation of parts.

CRAZE

A network of fine cracks in the surface.

CREEP

(1) Elongation or fracture resulting from loads sustained over relatively long time at high temperatures.

(2) The dimensional change with time of a material under load.

4. (Continued):

CRITICALITY

A relative measure of the consequences of a failure.

CRITICALITY ANALYSIS

A procedure by which each potential failure mode is evaluated and ranked according to the combined influences of severity and probability of occurrence.

CUMULATIVE DISTRIBUTION FUNCTION (CDF)

The probability that the random variable takes on any value less than or equal to a value x, that is,

$$\mathrm{Cdf}(x) = \mathrm{pr}(X \leq x)$$

The unreliability function with regard to failures

$$F(t) = \Pr(T \leq t)$$

CUT SET

In a Fault Tree, any basic event or combination of basic events whose occurrence will cause the top event to occur.

DEBUGGING

The period of "shakedown operation" of a finished equipment performed prior to placing it in use. During this period, defective parts and workmanship errors are corrected under test conditions that closely simulate field operation.

DECAP

To de-encapsulate. To remove the cover or plastic encapsulant on an item.

DECREASING FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the first or "infant mortality" period of the Bathtub Curve model or product life.

(2) A term characterizing the hazard rate $h(t)$ of an item having a Weibull reliability function with slope $B < 1$.

DEFECT

A deviation of an item from some ideal state. The ideal state is usually given in a formal specification.

4. (Continued):

DEFECT, CRITICAL

A defect that could result in hazardous or unsafe conditions for individuals using, maintaining or depending on the item.

DEFECTIVE

A unit of product which contains one or more defects.

DEGRADATION

A gradual deterioration in performance as a function of time.

DELTA LIMITS

THe difference between initial and final readings usually associated with the difference between the zero time readings on a life test and the final readings. Determine how much parameters shift during the test.

DEMONSTRATED

That which has been proven by the use of concrete evidence gathered under specified conditions.

DEPENDABILITY

A measure of the item operating condition at one or more points during the mission, including the effects of Reliability, Maintainability and Survivability, given the item condition(s) at the start of the mission. It may be stated as the probability that an item will (1) enter or occupy any one of its required operational modes during a specified mission and (2) perform the functions associated with those operational modes.

DERATING

The intentional reduction of stress/strength ratio in the application of an item, usually for the purpose of reducing the occurrence of stress-related failures.

DESIGN ADEQUACY

The probability that the system will satisfy effectiveness requirements, given that the system design satisfied the design specification.

DEVICE

Any subdivision of a system; synonym for ITEM.

4. (Continued):

DISCRIMINATION RATIO

A measure of the distance between two specific points of the operating characteristic curve which are used to define the acceptance sampling plan.

DISSOCIATION

The breakdown of a substance into two or more constituents.

DISTRIBUTION

Generally short for Cumulative Distribution Function.

DOWNTIME

The total time during which the system is not in condition to perform its intended function.

DURABILITY

The probability that an item will operate as specified under stated conditions without a wearout failure; a special case of reliability.

DUTY CYCLE

The ratio of the time "on" of a device or system divided by the total cycle time. For a device that normally runs intermittently rather than continuously, the amount of time a device operates as opposed to its idle time.

EARLY FAILURE PERIOD

That period of life, after assembly, in which failures occur at an initially high rate because of the presence of defective parts and workmanship defects.

EDX SPECTROMETER

Generally used with a scanning electron microscope (SEM) to provide elemental analysis of X-rays generated on the region being hit by the electron beam.

EFFECTIVENESS

The capability of the system or device to perform its function.

EFFICIENCY

A statistical term relating to the dispersion in values of an ESTIMATOR. It is between zero and one.

4. (Continued):

ELECTROMAGNETIC COMPATABILITY (EMC)

The capability of electronic equipment to function in the intended electromagnetic environment at designed levels of efficiency.

ELECTROMIGRATION

Dendritic or filamentary growth of a metal (for example, silver) in an electric field.

EMISSION SPECTROGRAPH

An instrument which identifies the presence of elements by burning the sample in an air plasma and analyzing the resultant optical spectrum.

ENGINEERING, HUMAN

The science of studying the man-machine relation in order to minimize the effects of human error and fatigue and thereby provide a more reliable operating system.

ENGINEERING, RELIABILITY

The science of including those factors in the basic design which will assure the required degree of reliability.

ENVIRONMENT

The aggregate of all external conditions and influences affecting the life and development of the product.

ELECTRICAL OVERSTRESS (EOS)

The electrical stressing of electronic components beyond specifications.

ELECTROSTATIC DISCHARGE (ESD)

The transfer of electric charge between bodies at different electrostatic potentials caused by direct contact or by an electrostatic field.

ESTIMATOR

A statistic, which is derived from a sample, used to infer a value of a parameter of an assumed distribution model.

4. (Continued):

EXPECTED VALUE

The mean or average, defined as: If x is a random variable and F(x) is its CDF

$$E(x) = \int x dF(x),$$ where the integration is over all x.

For continuous variables with a pdf, this reduces to

$$E(x) = \int x \, pdf(x) \, dx.$$

For discrete random variables with a pmf, this reduces to

$$E(x) = \Sigma x_n \, p(x_n)$$ where the sum is over all n.

EXPONENTIAL DISTRIBUTION

The probability density function

$$f(t) = \lambda \exp(-\lambda t)$$

where λ, the failure rate is constant.

EXPONENTIAL MODEL

In reliability engineering, a model based on the assumption that times t between successive failures are described by the exponential distribution.

EVALUATION

A broad term used to encompass prediction, measurement and demonstration.

EXTREME VALUE DISTRIBUTION

The asymptotic distribution of the smallest extreme from a statistical distribution; used to model capacitor breakdown voltage, time to failure of corrosion, etc. The pdf is $p(x) = \exp(x) \exp[-\exp(x)]$.

EYRING MODEL

An accelerated life test model in which failure rate is related to temperature. Given by $\lambda = T\exp(A-B/T)$.

FAILURE

The termination of the ability of an item to perform its required function.

4. (Continued):

FAILURE ANALYSIS

The identification of the failure mode, the failure mechanism and the cause. Often includes physical dissection.

FAILURE, CATASTROPHIC

A sudden change in the operating characteristics of an item resulting in a complete loss of useful performance.

FAILURE, DEGRADATION

A failure that occurs as a result of a gradual or partial change in the operating characteristics of an item.

FAILURE EFFECT

The consequences a failure mode has on the operation, function or status of an item.

FAILURE, INCIPIENT

A degradation failure which is just beginning to exist.

FAILURE, INDUCED

A failure caused by a physical condition external to the failed item.

FAILURE, INFANT

A failure that occurs during the early life of an item.

FAILURE, INHERENT

A failure basically caused by a physical condition or phenomenon internal to the failed item.

FAILURE, INITIAL

The first failure to occur in use.

FAILURE, LATENT

A malfunction that occurs as a result of a previous exposure to a condition that did not result in an immediately detectable failure.

FAILURE MECHANISM

The mechanical, chemical or other process that results in a failure.

4. (Continued):

FAILURE MODE

The effect or manner by which a failure is observed. Generally describes the way the failure occurs.

FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

A systematic, organized procedure for evaluating potential failures in an operating system.

FAILURE MODES, EFFECTS AND CRITICALITY ANALYSIS (FMECA)

An analysis of possible modes of failure, their causes, effects, their criticalities and expected frequencies of occurrence.

FAILURE, NONRELEVANT

A failure not applicable to the computation or reliability.

FAILURE, PRIMARY

A failure whose occurrence is not caused by other failures.

FAILURE, RANDOM

A failure whose occurrence is not predictable in an absolute sense but is predictable in a probabilistic sense.

FAILURE RATE

(1) The conditional probability that an item will fail just after time t, given the item has not failed up to time t.

(2) The number of failures of an item per unit measure of life (cycles, time, miles, events, etc.) as applicable for the item.

FAILURE, RELEVANT

A failure attributable to a deficiency of design, manufacture or materials of the failed device, applicable to the computation of reliability.

FAILURE, SECONDARY

A failure caused directly or indirectly by the failure of another item.

FAILURE, WEAROUT

A failure whose time of occurrence is governed by rapidly increasing failure rate.

4. (Continued):

FATIGUE

Cracking or fracture from cyclic loads.

FAULT

An attribute which adversely affects the reliability of a device.

FAULT TREE ANALYSIS (FTA)

A method of reliability analysis in which a logical block diagram is used to indicate contributing lower level events.

FIT

A contraction of Failure unIT, having a value of failures per 10^9 component-hours.

FORCED DEFECT

A failure induced by stress testing.

FOREIGN MATERIAL

The presence of an object or material which comes from some source external to the part or system.

FREEDOM, DEGREE OF

The number of observations that are free to vary at random, regardless of the restrictions imposed by the mathematics describing the statistic.

FUNCTIONAL FAILURE

A failure whereby a device does not perform its intended function when the inputs or controls are correct.

GAMMA DISTRIBUTION

An important distribution in statistical queuing theory. Given by:

$$\mathrm{pdf}(x) = \frac{\lambda(\lambda t)^{k-1} e^{-\lambda t}}{\Gamma(k)}, \quad \text{where } \Gamma(k) = \int_0^\infty u^{k-1} e^{-u}\, du$$

$$\lambda,\ \beta,\ t > 0$$

4. (Continued):

GAUSSIAN DISTRIBUTION (See NORMAL DISTRIBUTION)

A 2-parameter distribution with

$$\mathrm{pdf}(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp - \left[\frac{1}{2}\left(\frac{x-u}{\sigma}\right)\right]^2$$

GEOMETRIC MEAN

The geometric mean of n numbers is the nth root of their product.

GLASS TRANSITION TEMPERATURE

The temperature at which an amorphous polymer changes from a hard and relatively brittle condition to a viscous or rubbery condition.

GO, NO-GO

The result of a test of an attribute. It is either good or bad.

GOODNESS OF FIT

A statistical term that quantifies how likely a sample was to have come from a given probability distribution.

HAZARD RATE h(t)

(1) At a particular time, the rate of change of the number of items that have failed divided by the number of items surviving.

(2) Represents the probability that an item still functioning at time t will fail in the interval (t, t+Δt), where Δt is an infinitesimal time increment. Hazard rate is synonymous with conditional failure rate or instantaneous failure rate.

$$h(t) = \lim_{t \to 0} \frac{R(t)-R(t+\Delta t)}{t\ R(t)}$$

$$h(t) = f(t)/R(t)$$

HERMETICITY

The effectiveness of the seal of microelectronic and semiconductor devices with designed internal cavities.

HOMOGENEOUS

Of the same or similar nature. Uniform in structure or composition.

4. (Continued):

HUMAN FACTORS

A body of scientific facts about human characteristics. The term covers all biomedical and psychosocial considerations. It includes but is not limited to principles and applications in the areas of human engineering, personnel selection, training, life support, job performance aids and performance evaluation.

HYPOTHESIS, NULL

An hypothesis that there is no difference between some characteristics of the parent populations of several different samples, that is, that the samples come from similar populations. A conjecture about the true state of nature, that if true, will only rarely be rejected as the outcome of an experiment or measurement.

INCREASING FAILURE RATE

(1) A term characterizing the instantaneous failure rate in the third or "wearout" period of the Bathtub Curve model of product life.

(2) A term characterizing the hazard rate h(t) of an item having a Normal reliability function, for instance.

INFANT MORTALITY

Premature catastrophic failures occurring at a much greater rate than during the useful life period prior to the onset of substantial wearout.

INSPECTION

The examination and testing of supplies and services (including, when appropriate, raw materials, components and intermediate assemblies) to determine whether they conform to specified requirements.

INSPECTION BY ATTRIBUTES

Inspection whereby either the unit of product or characteristic thereof is classified simply as defective or nondefective, or the number of defects in the unit or product is counted with respect to a given requirement.

INSPECTION BY VARIABLES

Inspection wherein certain quality characteristics of a sample are evaluated with respect to a continuous numerical scale and expressed as precise points along this scale. Variable inspections record the degree of conformance of the unit with specified requirements for the quality characteristics involved.

4. (Continued):

INSPECTION LEVEL

An indication of the relative size of the sample to the size of the lot.

INSPECTION LOT

A collection of units of product bearing identification and treated as a unique entity from which a sample is to be taken and inspected to determine conformance with the acceptability criteria.

ITEM

An all-inclusive term, to include assemblies, subassemblies accessories, parts, equipment and services, applied to what is being discussed.

LIFE TEST

A test, usually of several items, made for the purpose of estimating some characteristic(s) of the probability distribution of life.

LOG NORMAL DISTRIBUTION

The model of a random variable whose logarithm follows the Normal function with parameters μ and σ. It is a life model for a process whose value results from the multiplication of many small errors. Its pdf-

$$f(x:\mu,\sigma) = 1/(\sigma x\sqrt{2\pi})\ \exp\ [-1/_{2\sigma}2(\ln x-\mu)^2]$$

$$x > 0$$
$$\sigma > 0$$
$$-\infty < \mu < \infty$$

LONGEVITY

Length of useful life of a product to its ultimate wearout requiring complete rehabilitation. This is a term generally applied in the definition of a safe, useful life for an equipment or system under the conditions of storage and use to which it will be exposed during its lifetime.

LOT

A group of units from a particular device type submitted each time for inspection and/or testing is called a lot.

LOT QUALITY

The true fraction defective in a lot.

4. (Continued):

LOT REJECT RATE (LRR)

The lot reject rate is the percentage of lots rejected from the lots evaluated.

LOT TOLERANCE PERCENT DEFECTIVE (LTPD)

The percent defective which is to be accepted a minimum or arbitrary fraction of the time, or that percent defective whose probability of rejection is designated by ß.

MAINTAINABILITY

A characteristic of design and installation which is expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

MAINTENANCE, PREVENTIVE

The maintenance performed in an attempt to retain an item in a specified condition by providing systematic inspection, detection and prevention of incipient failure.

MARGIN TESTING

Testing in which item environments such as line voltage or temperature are changed to reversibly worsen the performance. Its purpose is to find how much margin is left in the item for its degradation.

MEAN

(1) The expected value of a random variable.

(2) The first moment of a probability distribution about its origin. As specifically defined and modified, for example, the arithmetic mean (sums), the geometric mean (products), the harmonic mean (reciprocals), logarithmic mean, etc.

MEAN LIFE (Θ)

The arithmetic average of lifetimes of all items considered.

$$\Theta = \int_{0}^{T} R(t)dt = \int_{0}^{T} t\,pdf(t)dt$$

where R(t) = the s-reliability of the item
T = the interval over which the mean life is desired, usually the useful life

4. (Continued):

MEAN-LIFE-BETWEEN-FAILURES

This concept is the same as Mean Life except that it is for repaired items and is the mean up-time of the item. The formula is the same as for Mean Life except that R(t) is interpreted as the distribution of up-times.

MEAN-TIME-BETWEEN-FAILURES (MTBF)

For a particular interval, the total functioning life of a population of an item divided by the total number of failures within the population during the measurement interval. The definition holds for time, cycles, miles, events or other measure of life units. A basic measure of reliability of repairable items.

MEAN-TIME-BETWEEN-MAINTENANCE (MTBM)

The mean of the distribution of the time intervals between maintenance actions (either preventive, corrective or both).

MEAN-TIME-TO-FAILURE (MTTF)

For nonrepaired items, the mean life.

MEAN-TIME-TO-REPAIR (MTTR)

The total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

$$\text{MTTR} = \int_{0}^{T} G(t)dt$$

where $G(t)$ = Cdf of repair time
T = Maximum allowed repair time

MEDIAN

The median of a distribution of one random variable X of the discrete or continuous type is a value of x such that $\Pr(X \le x) = 1/2$ and $\Pr(X \ge x) = 1/2$, the middle value.

4. (Continued):

MISSION

The objective or task, together with the purpose, which clearly indicates the action to be taken.

MISSION RELIABILITY

The probability of success of an item to perform its required function for the duration of its intended mission.

MISSION PROFILE

The mission profile describes the events and conditions, including times and time spans, associated with a specific operational usage of an item. It is one segment of the operational cycle.

MODE

The mode of a distribution of one random variable X of discrete or continuous type is a value of x that maximizes the pdf f(x).

MODEL

A mathematical representation of a process. In Reliability there are two primary modeling concepts.

(1) A statistical function describing a life characteristic.

(2) A description of the reliability connectivity of the parts of a system.

MODEL, PARALLEL

A representation of the connection of the parts in a system such that the failure of all parts so connected is required for failure of that section of the system.

MODEL, SERIES

A representation of the connection of parts of a system such that failure of any part so connected will cause failure of that section of the system.

MODULE

An item which is packaged and is part of the next higher level of assembly.

4. (Continued):

NORMAL DISTRIBUTION (See GAUSSIAN)

The most prominant continuous distribution in statistics, frequently referred to as the Gaussian or bell-shaped distribution. Its density function is

$$f(x;\mu,\sigma) = \frac{1}{\sigma \quad 2\pi} \exp \quad - \frac{(x-\mu)^2}{2\sigma^2} \quad , \quad -\infty < x < \infty, \ -\infty < \mu < \infty, \ \sigma > 0$$

with mean μ and variance σ^2. The theoretical justification for the normal distribution lies in the central-limit theorem, which shows that under very broad conditions the distribution of the average of n independent observations from any distribution approaches a normal distribution as n becomes large.

NORMAL VARIABLE

A random variable that is normally distributed. In situations where the random variable represents the total effect of many "small" independent causes, each with mutually independent errors, the central limit theorem leads to the prospect the variable will be normally distributed.

OPERATING CHARACTERISTIC (OC CURVE)

A curve showing the relation between the probability of acceptance and either lot quality or process quality, whichever is applicable.

OPERATIONAL READINESS

The probability that, at any point in time, the system is either operating satisfactorily or ready to be placed in operation on demand when used under stated conditions, including stated allowable warning time. Thus, total calendar time is the basis for computation of operational readiness.

OVERCOAT

A thin film of insulating material over micro-circuit elements to provide mechanical protection or prevention of contamination.

OVERSTRESS

A condition wherein the severity levels of operation are more than usual or more than the specification.

PART

(1) An item that will not be disassembled for maintenance.
(2) The least subdivision of a system.
(3) An item which cannot ordinarily be disassembled without being destroyed.

4. (Continued):

PARTS PER MILLION (PPM)

Describing fractional defective, PPM is obtained by multiplying percent defective by 10 000; for example, 0.01% = 100 ppm.

PASSIVE ELEMENT

An element that is not active, that is, does not control energy; for example, a resistor, capacitor or an inductor.

PERCENTAGE DEFECTIVE

That proportion of a lot which is defective. This is the figure of merit in the population domain which characterizes quality control measurements and differentiates it from reliability.

PHYSIOCHEMICAL INSTABILITY

Change from an initial material bulk property, such as strength, resiliency, volume, composition, etc., as a result of age, pressure, temperature, etc.

PIN HOLE

A microscopic hole through an insulating (glass) layer. A defect.

POPULATION

The totality of the set of items, units, measurements, etc., real or conceptual, that is under consideration.

PROBABILITY

(1) Classical: If an event can occur in N equally likely and different ways, and if n of these ways have an attribute A, then the probability of the occurrence of A, denoted Pr(A) is defined as n/N.

(2) Frequency: If an experiment is conducted N times, and outcome A occurs n times, then the limit of n/N as N becomes large, is defined as the probability of A, denoted as Pr(A).

(3) Subjective: The probability Pr(A) is a measure of the degree of belief one holds in a specified proposition A.

PROBABILITY DENSITY FUNCTION

A continuous f(x) is a pdf if $f(x) \geqslant 0$, $-\infty < x < \infty$ and

$$\int_{-\infty}^{\infty} f(x)dx = 1$$

4. (Continued):

PROBABILITY MASS FUNCTION

A discrete f(x) is a pmf if f(x) = 0 for all x, except for a finite countable set of values of x for which f(x) > 0, and

$$\sum_{x} f(x) = 1, \text{ for all x such that } f(x) > 0$$

PROBABILITY FUNCTION

The probability function is defined in terms of its pdf or pmf. If there is a pdf, F(x) is continuous and is defined by

$$F(x) = \int_{-\infty}^{x} f(x)dx$$

If there is a pmf, F(x) is discrete and is defined by

$$F(x) = \sum_{x} f(x)$$

PROBABILITY DISTRIBUTION

A mathematical function with specific properties which describes the probability that a random variable will take on a value or a set of values. If the random variable is continuous and well-behaved enough, there will be a pdf. If the random variable is discrete, there will be a pmf.

PROBABILITY PAPER

Graph paper constructed so that cumulative distribution curves plot as straight lines. Paper is available for normal, log-normal, Weibull, and several other distributions.

PROCESS AVERAGE (PA)

The total number of units rejected over an extended period of time divided by the total number of units produced over the same period of time.

PULL TEST

A test to determine the bond strength of a lead to an interconnecting surface, usually perpendicular to the surface, by pulling to failure.

4. (Continued):

PURPLE PLAGUE

One of several gold-aluminum compounds formed when bonding gold to aluminum and activated by exposure to moisture and high temperature, resulting in brittle, time-based bond failure.

QUALIFICATION

The entire process by which products are obtained from manufacturers or distributors, examined and tested, and then identified on a Qualified Products List.

QUALITY

(1) The composite of all characteristics or attributes, including performance, of an item.

(2) A measure of the degree to which an item conforms to applicable specification and workmanship standards.

(3) A property which refers to the tendency of an item to be made to specific specifications or the customer's express needs, or both. See current publications by Juran, Deming, Crosby, et al.

QUALITY ASSURANCE

A system of activities whose purpose it is to provide assurance that the overall quality control job is, in fact, being done effectively.

QUALITY CHARACTERISTICS

Those properties of an item or process which can be measured, reviewed or observed and which are identified in the drawings, specifications or constructual requirements. Reliability becomes a quality characteristic when so defined.

QUALITY CONTROL (QC)

The overall system of activities whose purpose is to provide a quality of product or service which meets the needs of users; also, the use of such a system.

RANDOMNESS

The occurrence of an event in accordance with the laws of chance.

RANDOM EVENT

The occurrence of an event affected by chance alone. For example, heads or tails on a flipped coin occurs at random.

4. (Continued):

RANDOM SAMPLE

As commonly used in acceptance sampling theory, the process of selecting sample units in such a manner that all units under consideration have the same probability of being selected.

RANDOM VARIABLE (r.v.)

A function defined on a sample space, or a transformation which associates a real number with each point in a sample space.

REDUNDANCY

The existence of more than one means for accomplishing a given function.

REDUNDANCY, ACTIVE

A type of redundancy where all items in the group are operating simultaneously.

REDUNDANCY, STANDBY

A type of redundancy where the alternative means of performing the function is inoperative until needed and is switched on upon failure of the primary means of performing the function.

REGRESSION ANALYSIS

A mathematical means to fit an assumed model to data containing errors by minimizing the sum of squared deviations from the fit.

RELIABILITY

The probability that a device will function without failure over a specified time period or amount of usage at stated conditions.

RELIABILITY GROWTH

The increase in reliability as a result of the effort, the resource commitment to improve design, purchasing, production, and inspection procedures.

RELIABILITY, INHERENT

The potential reliability of an item present in its design.

RELIABILITY, INTRINSIC

The probability that a device will perform its specified function, determined on the basis of a statistical analysis of the failure rates and other characteristics of the parts and components which comprise the device.

4. (Continued):

RELIABILITY, PREDICTED

The process of quantitatively assessing whether a proposed or actual equipment design will meet a specified reliability requirement.

RELIABILITY WITH REPAIR

The reliability that can be achieved when preventive maintenance is allowed.

REPAIRABILITY

The probability that a failed system will be restored to operable condition in a specified active repair time.

RISK

The probability of rendering a wrong decision based on inadequate data or analysis. The probability of an undesired outcome.

RISK, CONSUMER'S (ß)

For a given sampling plan, the probability of acceptance for a designated numerical value of relatively poor submitted quality.

RISK, PRODUCER'S (α)

For a given sampling plan, the probability of rejection for a designated numerical value of relatively good submitted quality.

RISK PRIORITY NUMBER

In an FMEA, the product of the Occurrence Ranking, the Severity Ranking and the Detection Ranking.

SAFETY

The conservation of human life and its effectiveness, and the prevention of damage to items, consistent with mission requirements.

SAMPLE

A random selection of units from a lot, usually made for the purpose of evaluating the characteristics of the lot.

SCANNING ELECTRON MICROSCOPE (SEM)

An instrument which provides a visual image of the surface of an item. It scans an electron beam over the surface of a sample held in a vacuum and measures any of several resultant particle counts or energies. Provides depth of field and resolution significantly exceeding light counts microscopy and may be used at magnifications exceeding 50 000 times.

4. (Continued):

SCREENING

The process of performing 100% inspection, or exposure to stress, on product lots and removing the defective units from the lots.

SCREENING TEST

A test or combination of tests intended to remove unsatisfactory items or those likely to exhibit early failures.

SERVICEABILITY

A measure of the degree to which servicing of an item will be accomplished within a given time under specified conditions.

SERVICING

The replenishment of consumables needed to keep an item in operating condition, but not including any other preventive maintenance or any corrective maintenance.

SEVERITY LEVEL

A general term implying the degree to which an environment will cause damage or shorten life, or both.

SHEAR TEST

Test of the shear strength of various attachments, for example, die attach, wire bond, wire weld, contact weld, etc. by application of force in the plane.

SHORT CIRCUIT

An abnormal connection of relatively low impedance, whether made intentionally or accidentally between two points of different electric potential.

SIGNIFICANCE

Results that show deviations between an hypothesis and the observations used as a test of the hypothesis greater than can be explained by random variation or chance alone, are called statistically significant.

SIGNIFICANCE LEVEL

The probability of rejecting the null hypothesis when it is actually true.

4. (Continued):

SNEAK CIRCUIT

An unexpected path or logic flow within a system which, under certain conditions, can initiate an undesired function or inhibit a desired function.

SOFT ERROR

Temporary memory content error due to intrusion of an alpha particle, for instance.

STANDARD DEVIATION

The square root of the variance.

STATISTIC

A value calculated from a sample which is used to estimate some characteristic of a population.

STATISTICAL CONTROL

Control of a process by statistical methods. A process is said to be in a state of statistical control if the variations among the sampling results from it can be attributed to a stable pattern of chance causes.

STATISTICAL MODEL

A probability distribution as a representation of time to failure.

STEP STRESS TEST

A test consisting of several stress levels applied sequentially for periods of equal duration to a sample. During each period, a stated stress level is applied, and the stress level is increased from one step to the next.

STORAGE LIFE (SHELF LIFE)

The length of time an item can be stored under specified conditions and still meet specified requirements.

STRESS

A general and ambiguous term used as an extension of its meaning in mechanics as that which could cause failure. It does not distinguish between those things which cause permanent damage (deterioration) and those things which do not.

4. (Continued):

STRESS RELIEF

A design means to minimize the effects of stress, for example, a cable clamp or a conformal coat.

STRESS, COMPONENT

The stresses on component parts during testing, assembly or use which affect the failure rate and hence the reliability of the parts. Voltage, power temperature and thermal environmental stress are included.

SUBASSEMBLY

A replaceable combination of parts which is an element of an assembly.

SUBSYSTEM

A major subdivision of a system which performs a specified function in the overall operation of a system.

SURVIVABILITY

The measure of the degree to which an item will withstand hostile man-made environment and not suffer abortive impairment of its ability to accomplish its designated mission.

SURVIVOR FUNCTION Sf(t)

The Reliability distribution function. The probability that an item will survive to time t.

$$Sf(t) = Pr(T>t) \qquad t > 0,\ T \text{ a r.v.}$$

SUSPENDED ITEM

An item removed from test prior to failure.

SYSTEM

A combination of complete operation equipments, assemblies, components, parts or accessories interconnected to perform a specific operational function.

SYSTEM EFFECTIVENESS

A measure of the degree to which an item can be expected to achieve a set of specific mission requirements and which may be expressed as a function of availability, dependability and capability.

4. (Continued):

TEMPERATURE CYCLE

A stress test where the temperature of the medium (usually air) surrounding the test items is varied in a predetermined manner over the temperature range in such a way that the internal item temperature is kept at a fixed minimal increment from the medium temperature.

TEST TO FAILURE

The practice of inducing increased electrical and mechanical stresses in order to determine the maximum capability of a device so that conservative use in subsequent applications will, thereby, increase its life through the derating determined by these tests.

THERMAL ENDURANCE

The time at a selected temperature for a material or system of materials to deteriorate to some predetermined level of electrical, mechanical or chemical performance under prescribed conditions of test.

THERMAL FATIGUE

The failure of materials subjected to alternating heating and cooling.

THERMAL SHOCK

A stress test in which the temperature of the medium surrounding the test items is varied as rapidly as possible in order to create large, cyclic temperature gradients in the test items.

TIME, ACTIVE

That time during which an item is operational.

TIME, DOWN

That element of time during which the item is not in condition to perform its intended function.

TIME, MISSION

That element of uptime during which the item is performing its designated mission.

TIME, UP

That element of active time during which an item is either alert, reacting or performing a mission.

4. (Continued):

VARIABLE

In testing, the characteristic under examination which can have many values.

VARIANCE

The average of the squares of the deviations of individual values from their average. It is a measure of dispersion of a random variable. The second moment about the mean of a pdf given by

$$\text{var} = \int_{-\infty}^{\infty} (x-\mu)^2 \, f(x)dx$$

WARRANTY

A written guarantee of the performance of a product in which the maker for a specific period of time or other variable will be responsible for the repair or replacement of defective items.

WEAR

The mechanical removal of surface material by adhesion or abrasion.

WEAROUT

The process of attrition which results in an increase of hazard rate with increasing age (cycles, miles, events or time) as applicable for the item.

WEIBULL DISTRIBUTION

A general distribution, which is suitable for describing the life characteristic of a large group of problems. The general expression for the Weibull cumulative distribution function is defined, for $F(t=o)=0$ as

$$F(t) = 1 - e^{-\left(\frac{t}{\Theta}\right)^{\beta}}$$

β = Weibull Slope - The shape parameter of the distribution and equal to the slope of the line drawn through the failure data plotted on Weibull probability paper.

Θ = Characteristic Life - The scale parameter of the distribution and always equal to the life at 63.2% cumulative failure.

X CHART

Control chart for averages X of values in a subgroup.

4. (Continued):

X-RAY SPECTROMETER

Spectrographic analysis to characterize elements which are present.

YIELD

Elongation or fracture resulting from a single application of load in a relatively short period of time.

5. ACRONYMS, ABBREVIATIONS AND SYMBOLS:

AGREE	Advisory Group on Reliability of Electronic Equipment
AOQ	Average Outgoing Quality
AOQL	Average Outgoing Quality Limit
AQL	Acceptance Quality Level
ATE	Automatic Test Equipment
BITE	Built-In Test Equipment
Cdf	Cumulative Distribution Function
CFR	Constant Failure Rate
COO	Cost of Ownership
C_p	Process Potential Index
C_{pk}	Process Performance for Two-Sided Spec Limits
DECAP	De-encapsulation
DFR	Declining 'Failure Rate
EDX	Energy Dispersive X-Ray
EDS	Energy Dispersive Spectrometer
EMC	Electromagnetic Compatability
EMI	Electromagnetic Interference
EOM	Ease of Maintenance
EOS	Electrical Overstress
ESD	Electrostatic Discharge

5. (Continued):

ESS	Environmental Stress Screening
FAR	Failure Analysis Request/Report
FIT	Failure Unit
FMA	Failure Modes Analysis
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes and Effects Criticality Analysis
FRACAS	Failure Reporting, Analysis and Corrective Action System
FTA	Fault Tree Analysis
HAST	Highly Accelerated Stress Test
h(t)	Hazard Function
IFR	Increasing Failure Rate
JAN	Joint Army Navy
LCC	Life Cycle Cost
LSC	Logistic Support Cost
LTPD	Lot Tolerance Percent Defective
MRB	Material Review Board
MTBF	Mean Time Between Failure
MTBM	Mean Time Between Maintenance
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
NPF	No Problem Found
NTF	No Trouble Found
OC	Operating Characteristic (Curve)
ORLA	Optimum Repair Level Analysis
PA	Product Assurance / Process Average
PDA	Process Defect Average

5. (Continued):

pdf	Probability Density Function
pmf	Probability Mass Function
PPL	Preferred Parts List
PPM	Parts Per Million
PRST	Probability Ratio Sequential Test
QA	Quality Assurance
QC	Quality Control
QPL	Qualified Products List
R	Reliability
RAC	Reliability Analysis Center
RPM	Reliability Planning and Management
r.v.	Random Variable
s	Sample Standard Deviation
s-	Statistical (Prefix)
SCA	Sneak Circuit Analysis
SEM	Scanning Electron Microscope
Sf(t)	Survivor Function
SPC	Statistical Process Control
TNI	Trouble Not Identified
z(t)	Hazard Function
α	Producer's Risk
β	Weibull Slope, Consumer's Risk
λ	Failure Rate
μ	Mean
θ	Mean Life
σ	Standard Deviation

RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

MILITARY

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-HDBK-217D	Reliability Prediction of Electronic Equipment
MIL-STD-280A	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
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MIL-STD-883B	Test Methods and Procedures for Microelectronics
MIL-STD-1313	Microelectronics Terms and Definitions
MIL-Q-9858A	Quality Program Requirements
AR-92	Quality Program Requirements
MIL-S-195001	Semiconductor Devices, General Specification for
MIC M38510D	Microcircuits, General Specifications for
MIL-STD-470	Maintainability Program Requirements for Systems and Equipments
MIL-STD-471A	Maintainability Verification/Demonstration/Evaluation
MIL-HDBK-472	Maintainability Prediction
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Reliability Bulletin No. 8	Equipment Burn-In
Engineering Bulletin No. 17	User Guidelines for Quality and Reliability Assurance of LSI Components

REFERENCE SECTION (Continued):

Engineering Bulletin No. 11	User Guidelines for Microelectronic Reliability Estimation
JEDEC Standard No. 22	Test Methods and Procedures for Solid State Devices Used in Transportation/Automotive Applications

OTHER

Glossary and Tables for Statistical Quality Control		- ASQC 1973
PROCUREMENT QUALITY CONTROL - 2nd Edition		- ASQC
Quality Systems Terminology		- ANSI/ASQC A3-1978
Terms, Symbols and Definitions for Acceptance Sampling		- ANSI/ASQC A2-1978
Definitions, Symbols, Formulas and Tables for Control Charts		- ANSI/ASQC A1-1978
How to Speak Fluent Quality		- National Semiconductor Co.
Reliability Design Handbook	RDH 376	- Reliability Analysis Center
Analysis Techniques for Mechanical Reliability	WPS-1	- Reliability Analysis Center
1987 Desk Manual		- Microelectronic Manufacturing and Testing
Glossary of Automotive Electronic Terms		- SAE HS J1213 1982
Automotive Electronics Reliability Handbook		- SAE AE-9 1987
The American Heritage Dictionary		- 2nd College Edn. 1982 Houghton Mifflen Co.

APPLICATION:

This compilation of terms, acronyms and symbols was drawn from usage which should be familiar to those working in automotive electronics reliability. Terms are included which are used to describe how items, materials and systems are evaluated for reliability, how they fail, how failures are modeled and how failures are prevented. Terms are also included from the disciplines of designing for reliability, testing and failure analysis as well as the general disciplines of Quality and Reliability Engineering. This glossary is intended to augment SAE J1213, Glossary of Automotive Electronic Terms.

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REPORT

SAE J1213B

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GLOSSARY OF RELIABILITY TERMINOLOGY ASSOCIATED WITH AUTOMOTIVE ELECTRONICS

1. INTRODUCTION:

This glossary has been compiled to assist, by serving as a reference, in the communication between the automotive electronics engineer and the reliability engineer.

2. SCOPE:

This compilation of terms, acronyms and symbols was drawn from usage which should be familiar to those working in automotive electronics reliability. Terms are included which are used to describe how items, materials and systems are evaluated for reliability, how they fail, how failures are modeled and how failures are prevented. Terms are also included from the disciplines of designing for reliability, testing and failure analysis as well as the general disciplines of Quality and Reliability Engineering. This glossary is intended to augment SAE J1213, Glossary of Automotive Electronic Terms.

3. REFERENCES:

A listing of applicable military and other organizational reference documents, from which many of these terms and definitions were drawn, is provided as a source of alternate or related definitions.

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MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
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3. (Continued):

Reliability Design Handbook	RDH 376	- Reliability Analysis Center
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1987 Desk Manual		- Microelectronic Manufacturing and Testing
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Automotive Electronics Reliability Handbook		- SAE AE-9 1987
The American Heritage Dictionary		- 2nd College Edn. 1982 Houghton Mifflin Co.

4. RELIABILITY GLOSSARY:

ACCELERATED LIFE TEST

A life test under test conditions that are more severe than usual operating conditions. It is necessary that a relationship between test severity and the probability distribution of life be ascertainable.

ACCELERATION FACTOR

(1) The factor by which the failure rate can be increased by an increased environmental stress.

(2) The ratio between the times necessary to obtain the same portion of failure in two equal samples under two different sets of stress conditions, involving the same failure modes and mechanisms.

ACCEPT/REJECT TEST

A test, the result of which will be the action to accept or reject something, for example, an hypothesis or a batch of incoming material.

ACCEPTABLE QUALITY LEVEL (AQL)

The maximum percent defective which can be considered satisfactory as a process average, or the percent defect whose probability of rejection is designated by α.

ACCEPTANCE NUMBER

The largest number of defects that can occur in an acceptance sampling plan and still have the lot accepted.

ACCEPTANCE SAMPLING PLAN

An accept/reject test whose purpose is to accept or reject a lot of items or material.

4. (Continued):

ACCESSIBILITY

A measure of the relative ease of admission to the various areas of an item.

ACHIEVED RELIABILITY

The reliability demonstrated at a given point in time under specified conditions of use and environment.

ACTIVATION ENERGY

(1) The energy level at which a specific microelectronic failure mechanism becomes active (in electron-volts).

(2) The slope of the time-temperature regression line in the Arrhenius equation (in electron-volts).

ACTIVE ELEMENT

A part that converts or controls energy, for example, transistor, diode, electron tube, relay.

ACTIVE ELEMENT GROUP

An active element and its associated supporting (passive) parts, for example, an amplifier circuit, a relay circuit, a pump and its plumbing and fittings.

AGING

The effect whereby the probability density function of strength is changed (strength is reduced) with time.

ALLOCATION

The process of assigning reliability requirements to individual units to attain the desired system reliability.

ALPHA PARTICLE INDUCED SOFT ERRORS

Integrated circuit memory transient errors due to emission of alpha particles during radioactive decay of uranium or thorium contamination in the IC packaging material.

AMBIENT

Used to denote surrounding, encompassing, or local conditions. Usually applied to environments, for example, ambient temperature, ambient pressure.