Reliability Tools

What does the tool achieve?

Why use the tool?

When to use the tool?

Where to use the tool?

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Tools

Reliability Tools				
Accelerated Testing	Design Review	HALT	Monte Carlo	Reliability Engineering
Availability	Effectiveness	HASS	Normal Distribution	Reliability Growth
Bathtub Curves	Electronic Components	Life Cycle Cost	OEE	Reliability Policies
Block Diagram Models	ESS	Life Units	Pareto Distribution 2	Reliability Testing
Capability	Events/Incidents	Load-Strength	Poisson Distribution	Simultaneous Testing
Configuration Control	Exponential	Lognormal	Probability Plots	Software Reliability
Contract For Reliability	Failure	Maintainability	Process Reliability	Sudden Death Testing
Cost Of Unreliability 3	Failure Forecast	Maintenance	QFD	TPM
Critical Items List	Failure Rates	Maintenance Engineering	Reliability 1	Weibayes Estimates
Data 5	Fault Tree Analysis	Management's Role	Reliability Audits	Weibull Analysis
Decision Trees	FMEA 4	Mean Time	RBDs	Weibull Corrective Action
Dependability	FRACAS Systems	Mechanical Component Interactions	Reliability-Centered Maintenance	Weibull Database

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Reliability

- **What:** Reliability is the probability that a device, system, or **process** will perform its prescribed duty **without failure** for a given time when operated correctly in a specified environment. **In the end reliability is about $'s.**
- Reliability is concerned with the probability of future failures based on what has occurred with past observations--**we predict the future based on the past**.
- **Why:** Reliability has two broad ranges of meanings:
  1) **qualitatively**—operating without failure as advertised,
  2) **quantitatively**—life is predictable and long, from test data
- Reliability is concerned with **failure-free operatio**n for **periods of time**.
  It is **different than quality** which is concerned with avoiding non-conformances.
  It is **different than availability** which measures % of uptime.
  It is **different than maintainability** which measures restoration time.

Reliability-Cont’d

- **When:** Reliability is expected for equipment to start, run, and continue to function for long periods of time without failure.

  Reliability is **expected** when dormant equipment is called to duty.

  Reliability is **expected** after service or restoration and resumption duty.

  Reliability is **designed** into the system by up-front activities.

  Reliability is **sustained** by careful operation of the system along with careful nurturing of the system with sustaining maintenance activities.
- **Reliability always terminates in a failure** and roots of failure can be due to design, fabrication, installation, operation, maintenance (repair and periodic servicing), and management of the system.
- There are **many ways and means to kill** the system but **few ways to keep is operating without failure**.
- **Where:** The adage “the proof of the pudding is in the eating,” and, **for reliability, the proof of the system is in the long failure-free interval**.
- Reliability tools are used from stem to stern to demonstrate and achieve high reliability with a few tools described below.

Pareto Distribution

- **What:** Vilfredo Pareto, an Italian economist, studied unequal distribution of wealth in 1906 where **~20% of the population owns ~80% of the property** in Italy and it's true around the world.
- The Pareto concept was improved and brought to the factory floor by **Dr. Joseph M. Juran** for manufacturing operations.
- **The Pareto principle, as explained by Juran, said: It's the "80-20 rule", where 80% of the problems come from 20% of the causes thus concentrate on the vital few causes.** The same concept works for money issues—you must **separate the vital few issues from the trivial many issues**.
- **Pareto distribution listed in order of money lost (including the risk for money lost) it set the work priority for attacking business problems having the greatest enterprise impact.**
- **Winners in the organization work on the vital few important items (the 10-20%), as they put their reputations at stake.** Losers in the organization work on the trivial many problems (the 60-80% of the problem list), which have little financial impact on the enterprise.

He really said: 10-20% of the issues will drive 60-80% of the $!

Pareto Distribution-Cont'd

- The gear-head approach is to build the Pareto list based on **number** of failures. This is usually not too productive. Would you really prefer to solve 90% of:
  1) 100 failures that cost a total of $1000, or
  2) 1 failure that costs $1,000,000?

  The gear-head approach goes for the 1000 small problems.
- **The business approach says go for the big $ items in the list—in the end, it's all about the money!**
- Build Pareto **$** list based on the total amount of **money spent or at risk** (maintenance costs + lost profit opportunity + rework costs + scrap costs + … + ….include all appropriate business costs)
- Avoid working on trivial money and love affairs that keep people busy but do not generate financial returns for the business.
- **The most important reliability tool is a Pareto distribution based on $'s to set work priorities for attacking the vital few problems as a method of separating important issues from the trivial many issues**.

Pareto Distribution-Cont'd

- **Why:** Pareto distributions, **based on $'s,** set work priorities, and if you want a one-year payback period, it tells how much money can be spent to resolve the issues. Most reliability engineers need to be working on the top 5 or 6 items, **based on $'s.**
- The mentality is to think like a bank robber—**go for where the big money is located and get it back—and get it back fast**.
- **When:** Reshuffle Pareto distributions at least quarterly. Know who has solved what problems and define what new targets have come over the horizon that require immediate attention.
- **Where:** Use Pareto distributions throughout the organization to keep attention on the vital few $ issues.
- **Pareto distributions help set work priorities and avoid focusing on love affairs with equipment or process.**

Cost Of Unreliability

- **What:** The cost of unreliability is a **big-picture view** of system failure costs, described in annual terms, for a manufacturing plant or operation as if the key elements were reduced to a series block diagram for simplicity.
- It looks at the production system and reduces the complexity to a simple series system where failure of a single item /equipment /system/processing-complex causes the loss of productive output along with the **total cost incurred for the failure**.
- If the system **IS** sold out, then the cost of unreliability must include all appropriate business costs such as lost gross margin plus repair costs, scrap incurred, etc. **You'll need high reliability!**
- If the system **IS NOT** sold out, and make-up time is available in the financial year, then lost gross margin for the failure cannot be counted. The cost of unreliability is a management concern connected to management's two favorite metrics: time and money. **For the NOT SOLD OUT case you don't need high reliabilty.**

Cost Of Unreliabiilty-Cont'd

- **Why:** In private enterprise, **failures must be concerned from a financial viewpoint** and not simply counting the number of failures.
- You must speak the language of the enterprise. Describe events by **monetary measures** over a period of time.
- The annual cost for failures is usually **NOT** stated in a clear-cut manner nor are failure costs summarized by a system/sub-system to **identify the weak links** in a monetary fashion so that appropriate action is taken.
- The issue is to **reduce the annual cost of <u>un</u>reliability by building a clear Pareto distribution to attack the vital (high cost) areas** with action plans to stop failures (unreliability) and **reduce the cost of <u>un</u>reliability**.

Cost Of Unreliability-Cont'd

- **When:** For a new plant, COUR can be a design criteria to limit costs of unreliability for competitive reasons. You must **make the hidden costs of failures obvious** as **a portion of the strategic plan**.
- For an existing plant, COUR can help build a long-term plan to reduce COUR as a **portion of the tactical plan**.
- **Where:** Calculate COUR with **high-level involvement** of the management team for fundamental understanding of the "icebergs" that rip out the underbelly of the plant.
- A single number for COUR **involves the organization** in a plan to reduce the costs so that profits are pushed upward because of the improvements.
- If COUR cannot be reduced, then **COUR costs become extra weight for the saddlebags** in the race for survival.

COUR = Cost of Unreliability

FMEA

- **What:** Failure mode and effect analysis (**FMEA**) is the study of potential failure occurrences in any part of a system and probable effects of each failure on operational success.
- In the automotive world, FMEA is a required portion of the quality systems, where it is also known as **PFMEA** for potential failure mode and effect analysis.
- FMEA helps prevent failures with a simple and cost-effective analysis **drawing on collective information of the team** to **find problems before they occur**.
- **Why:** FMEA analysis is known as a bottom-up (inductive) approach to finding and preventing failures that might occur for every component of a system.
- FMEA determinines **each failure mode** and ranks results of seriousness for a single **risk priority number**.

FMEA-Cont'd

- FMEA is used from **different viewpoints** such as safety, mission success, availability, repair costs, failure modes, reliability reputation, production processes, service, etc.
- **When:** The FMEA is **most productive during the design process** to eliminate potential failures. It **used most often on existing systems** where operations personnel and maintainers are made team members to add real-life experiences to educate the team in a problem-solving forum to eliminating existing problems.
- **Where:** FMEA is a **great tool for sharing experiences for details** known to one person but seldom shared with the team. FMEA educates young engineers, maintainers, and operators for details that kill the system.

People fail to use FMEA--thinking any system this this simple and based on arithmetic is too simple to be useful

Data

- **What:** Data is the **informational energy** that runs the reliability improvement machine.
- Data is acquired at **great cost**—thus use it wisely.
- Retain data and **use it to prevent future failure events**.
- Proper use of **data provides an understanding of failure mechanisms and helps prevent reoccurrence** of failures causing safety or high-cost failures to occur.
- **Reliability data requires definition of a failure**. Failures can be catastrophic failures or slow degradation—**you decide by defining the failures**. Units of measure for the data must be in **units of the degradation**— it can be hours, miles, cycles, and so forth—in short, **whatever motivates the failure**.
- Removal of aged items without failure generates a category of data called a **suspension** or **censored** data.

Data-Cont'd

- Data is info in the form of facts, figures, or engineering databases. **It comes from engineering tests, experiments, or actual operating conditions.**
- Reliability data is often incomplete as the exact times to failure are rarely known/recorded precisely so **only imperfect information is available for analysis**.
- Reliability data comes in two forms: 1) **age-to-failure data**, and 2) **censored/suspended data** as when unfailed items are removed from service or when they fail from different failure modes than we are studying. **Suspended data is useful information and part of the data set**.
- Some data is better than no data for resolving reliability issues. **All data is deficient but some data is very useful!**

Data-Cont'd

- **Why:** Data helps **prevent repetition of bad history** and allows an enlightened approach to rationally solving a reliability issue using facts and figures.
- Reliabililty data/tools provides **objective evidence** for helping to solve the **root cause of failures.**
- **When:** Reliability data helps predicting future failure events and is particularly valuable if retained in a Weibull database with shape factor beta (**failure mode**) and scale factor eta (**durability**).
- **Where:** Data is useful for **predicting future failures** with subsequent increases in the aging of equipment.
- **The role of the reliability engineer is to acquire the failure data and convert the data into useful information for both current and future use.**

Summary

- So many **reliability tools**—so little time to discuss!
  - **Reliability**: Operate without failure to save **$'s**
  - **Pareto**: Define the vital few **$** issues for work priorities
  - **Cost of unreliability**: Quantify **$'s** for management
  - **FMEA**: Simple tool for team involvement/solutions
  - **Data**: Facts, not opinions, when used with reliability tools will help avoid repeating the same old bad history
- **Reliability is substance not style!**
  Learn and use the tools. See other useful tools at:
  http://www.barringer1.com/nov07prb.htm