Failure mode and effects analysis

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A **Failure mode and effects analysis (FMEA)** is a procedure for analysis of potential failure modes within a system for the classification by severity or determination of the failure's effect upon the system. It is widely used in the manufacturing industries in various phases of the product life cycle. Failure causes are any errors or defects in process, design, or item especially ones that affect the customer, and can be potential or actual. *Effects analysis* refers to studying the consequences of those failures.

Contents

Basic terms

Failure mode: "The manner by which a failure is observed; it generally describes the way the failure occurs."
Failure effect: The immediate consequences a failure has on the operation, function or functionality, or status of some item
Local effect: The Failure effect as it applies to the item under analysis.
Next higher level effect: The Failure effect as it applies at the next higher indenture level.
End effect: The failure effect at the highest indenture level or total system.
Failure cause: Defects in design, process, quality, or part application, which are the underlying cause of the failure or which initiate a process which leads to failure.
Severity: "The consequences of a failure mode. Severity considers the worst potential consequence of a failure, determined by the degree of injury, property damage, or system damage that could ultimately occur."
Indenture levels: An identifier for item complexity. Complexity increases as the levels get closer to one.
[1]

History

The FMEA process was originally developed by the US military in 1949 to classify failures "according to their impact on mission success and personnel/equipment safety". FMEA has since been used on the 1960s Apollo space missions. In the 1980s it was used by the Ford Motor Company to reduce risks after one model of car, the Pinto, suffered a design flaw that failed to prevent the fuel tank from rupturing in a crash, leading to the possibility of the vehicle catching fire.[2]

Implementation

In FMEA, Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. A FMEA also documents current knowledge and actions about the risks of failures, for use in continuous improvement. FMEA is used during the design stage with an aim to avoid future failures. Later it is used for process control, before and during ongoing operation of the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service.

The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones. It may be used to evaluate risk management priorities for mitigating known threat-vulnerabilities. FMEA helps select remedial actions that reduce cumulative impacts of life-cycle consequences (risks) from a systems failure (fault).

It is used in many formal quality systems such as QS-9000 or ISO/TS 16949. The basic process is to take a description of the parts of a system, and list the consequences if each part fails. In most formal systems, the consequences are then evaluated by three criteria and associated risk indices:

- Severity (*S*),
- Likelihood of occurrence (*O*), and (Note: This is also often known as probability (*P*))
- Inability of controls to detect it (*D*)

An FMEA simple scheme would be to have three indices rated from 1 (lowest risk) to 10 (highest risk). The overall risk of each failure would then be called *Risk Priority Number (RPN)* and equal to the product of Severity (*S*), Occurrence (*O*), and Detection (*D*), or $RPN = SxOxD$. It should be noted that for the Detection index, a rating of 1 means the control is absolutely certain to detect the failure and a rating of 10 means the control is certain not to detect the problem (or no control exists). The *RPN* (ranging from 1 to 1000) is used to prioritize all potential failures to decide upon actions leading to reduce the risk, usually by reducing likelihood of occurrence and improving controls for detecting the failure.

Disadvantages

If used as a top-down tool, FMEA may only identify major failure modes in a system. Fault tree analysis (FTA) is better suited for "top-down" analysis. When used as a "bottom-up" tool FMEA can augment or complement FTA and identify many more causes and failure modes resulting in top-level symptoms. It is not able to discover complex failure modes involving multiple failures within a subsystem, or to report expected failure intervals of particular failure modes up to the upper level subsystem or system.

Additionally, the multiplication of the severity, occurrence and detection rankings may result in rank reversals, where a less serious failure mode receives a higher RPN than a more serious failure mode. The reason for this is that the rankings are ordinal scale numbers, and multiplication is not a valid operation on them. The ordinal rankings only say that one ranking is better or worse than another, but not by how much. For instance, a ranking of "2" may not be twice as bad as a ranking of "1," or an "8" may not be twice as bad as a "4," but multiplication treats them as though they are. See Level of measurement for further discussion.

Software

The usage of software will improve the documentation process of FMEA. A number of software packages exist. When selecting the software package which best suits your company's needs, it is important to choose one that is easy to learn and promotes consistent updating of your documentation. It is not necessary to spend a lot of money to have an effective, user-friendly system. Some FMEA software companies provide free upgrades, free support, and software with unlimited licenses. This is especially helpful in ensuring the long-term acceptance, understanding, and implementation of FMEAs.

See also

- Failure Mode, Effects, and Criticality Analysis (FMECA)
- Causal layered analysis
- Futures techniques
- Failure mode
- Failure rate
- High availability
- Process decision program chart
- Hazard Analysis and Critical Control Points
- Reliability engineering
- Risk assessment
- Safety engineering
- Six sigma
- DRBFM
- FMEA Worksheet (xls format)

Notes

1. ^ Langford, J. W., *Logistics: Principles and Applications*, McGraw Hill, 1995, pp-488. (in paraphrase)
2. ^ Quality Associates International's History of FMEA

References

- "Failure Modes and Effects Analysis (FMEA)"
- "FMEA and FMECA Information"
- "Free FMEA Presentation - 'Criteria for a Successful FMEA' (requires Flash player)"

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