

A FMEA Primer

Learn How to Plan and Perform a FMEA

What is a FMEA?

A FMEA (Failure Mode and Effects Analysis) is an inductive bottom-up method of analyzing a system design or manufacturing process in order to evaluate the potential for failures. It consists of defining what can fail and the way it can fail (failure modes) and determining the effect of each failure mode on the system.

An important part of a FMEA also includes analyzing the criticality, which is how harmful the effects of a failure mode are on system operation. When criticality is considered in a FMEA, the name is changed to Failure Mode, Effects, and Criticality Analysis (FMECA).

While performing a FMEA, you examine failure modes and causes of potential item failures and determine the product response to the failure. You can then take steps to change the design or process to eliminate the failure, reduce its impact, or compensate for the failure should it occur.

In a very simple FMEA of a system design, you might have a computer monitor that has a capacitor as one of its components. By looking at the design, you determine that if the capacitor fails "open" (one failure mode), the monitor would display wavy lines (the failure effect). If the capacitor fails "shorted" (second failure mode), the monitor would go blank (the failure effect). You would rank the second failure mode to be more critical than the first because the monitor becomes completely unusable. At this point, you would attempt to find ways to prevent this failure or at least lessen its severity or impact.

A FMEA is potentially one of the most beneficial and productive tasks in a well-structured reliability program. It can be used as a stand-alone tool or as part of comprehensive quality programs such as ISO9000, QS-9000, Advanced Product Quality Planning (APQP), and Six Sigma.

FMEA Standards

There are several different standards available for FMEAs. Some examples are the Military Standard (Mil-Std-1629A), the Society of Automotive Engineers Ground Vehicle Recommended Practice (SAE J1739), and the Society of Automotive Engineers Aerospace Recommended Practice (ARP5580).

- Mil-Std-1629A is a long-recognized standard that describes a method of performing a FMECA. It is used by government, military, and commercial organizations worldwide. Mil-Std-1629A provides calculations for criticality and allows ranking of failure modes dependent on severity classification.
- SAE J1739 is based on a Ford Motor Company procedure. It defines the procedure used by the major automobile companies and their suppliers.
- ARP5580 combines the capabilities of both Mil-Std-1629A and the Automotive standards. The most notable difference in this standard is the support of fault equivalencies. Fault equivalencies allow you to focus on management of failure consequences rather than managing individual failure modes.

All three of the above standards provide general FMEA forms and documents, identify criteria for the quantification of risk associated with potential failures, and offer general guidelines on the mechanics of completing FMEAs.

Many people use a combination of all these different standards, modifying them to suit their needs for their particular applications.

Types of FMEAs

There are four basic types of FMEAs:

- System FMEAs
- Design FMEAs
- Process FMEAs
- Functional FMEAs

System FMEAs can be used to analyze a system at any level, from the piece-part level up to the system level. At the lowest level, a FMEA can be performed by looking at each component in the system to determine the ways in which it can fail and how these failures affect the system. The lowest-level FMEA is sometimes referred to as a piece-part FMEA. The system FMEA needs to go down only to the desired level of detail.

Design FMEAs are performed on a product or service at the design level, during the design phase. The purpose is to analyze a system design and determine how failure modes affect the system operation. Once the anticipated design deficiencies have been uncovered, solutions can be considered to correct the design or reduce the impact of failure modes. This FMEA is generally used before the product is released to manufacturing operation.

Process FMEAs are performed on the manufacturing processes. They highlight possible failure modes in the manufacturing process, limitations in equipment, tooling gauges, operator training, or potential sources of error. This information can then be used to determine the corrective actions that need to be taken.

Functional FMEAs are also known as "Black Box" FMEAs. This type of FMEA focuses on the intended function, or use, of a component or subsystem. As an example, a functional FMEA would consider that a capacitor is intended to regulate the voltage and then analyze the effect of the capacitor not regulating the voltage rather than considering what occurs if the capacitor fails open or fails shorted.

Planning for a FMEA

Planning for a FMEA involves a series of considerations. At the minimum it includes:

- *Selecting appropriate applications for the analysis.* A FMEA may be authorized by individuals at various levels within an organization or may be required by ISO9000, QS-9000, APQP, or Six Sigma methodologies; internal quality programs; or customer requirements. Whether authorized or required, a FMEA is expensive to complete; a FMEA should be completed only in instances where the benefits outweigh the costs.
- *Identifying and allocating resources.* These resources include FMEA team members, physical space to conduct the analysis and store documentation, hardware such as computers for communications and performing analysis, and time.
- *Defining scope.* Because a FMEA can be conducted at a high level (system level)

or a very detailed level (part level) and because a high-level FMEA can lead to additional FMEAs at a more detailed level, it is very important to set the scope of the analysis before it begins.

- *Expectations and deliverables.* FMEA team members will have multiple responsibilities and reporting structures. Because they will have other tasks that are not FMEA-related, it is critical that performance expectations for all FMEA team members be clearly defined and communicated directly to supervisory or managerial personnel. Managers need to be aware of the FMEA tasks their staff are to perform and how much time these tasks will take. It is equally important that all FMEA team members understand what deliverables will result from the analysis and their respective roles in developing those deliverables. Effectively communicating roles, responsibilities, and time demands upfront will ensure that resource conflicts do not occur.
- *Establishing milestones, due dates, and deadlines.* Key milestones for a FMEA include authorization for the analysis, establishment of a reporting structure, allocation of resources, gathering input for the analysis, completing the analysis, taking and monitoring corrective action, preparing documentation, creating final reports, and debriefings. To ensure effectiveness, a FMEA should be conducted like any other important project, meaning that a schedule should be established and due dates and deadlines specified.

Basic Steps in Performing a FMEA

Complexity and the number of steps involved in performing a FMEA are directly related to the type and level of FMEA being performed. However, all FMEAs consist of the same discrete steps given below:

- *Define the system to be analyzed.* Complete system definition includes identification of internal and interface functions, expected performance at all indenture levels, system restraints, and failure definitions.
- *Construct block diagrams.* Functional and reliability block diagrams that illustrate the operation, interrelationships, and interdependencies of functional entities should be obtained or constructed for each item configuration involved in the system's use.
- *Identify all potential item and interface failure modes.* Define the effect of the failure mode on the immediate function or item, on the system, and on the mission to be performed.
- *Evaluate each failure mode.* Analyze the worst potential consequence that may result due to the failure mode and assign a severity classification category.
- *Identify failure detection methods.* Identify compensating provisions for each failure mode.
- *Identify corrective actions.* Determine the design or other actions required to eliminate or control the risk.
- *Identify effects of corrective actions.* Establish the outcomes that occur from implementing corrective actions.
- *Iterate or repeat the analysis until all potential failures pose an "acceptable" level of risk.* What constitutes an "acceptable" risk must be clearly defined by the individual or agent authorizing the FMEA.
- *Document the analysis.* Summarize the problems that could not be corrected by

design and identify the special controls that are necessary to reduce failure risk.

Software Tools for FMEAs

FMEAs tend to be tedious and time-consuming when performed manually. Several techniques can be used to reduce the overall cost of performing a FMEA. For example, failure mode distribution standards such as FMD97, NPRD3 Modes, RADC-TR-84-244 Modes, and MIL-HDBK-338 modes can be used to assign common failure modes. Standard reports and input formats can be created to streamline the data collection and reporting process. Custom failure mode libraries can be created and reused for a future application. The Relex FMEA module from Relex Software Corporation uses all the techniques mentioned above and many more to reduce the overall cost of performing a FMEA.

A FMEA is a tool to help cross-functional teams identify, eliminate, and/or reduce the negative effects of potential failure before they happen. FMEAs are widely used as stand-alone tools or as parts of a comprehensive quality program. Software tools such as the [Relex FMEA module](#) can greatly reduce the overall cost of performing a FMEA. For additional information on the Relex FMEA module, go to the [Relex web site](#) or contact your Relex Application Consultant.