

FMEAs Promote Improved Product Reliability

Anticipate Problems and Minimize Their Occurrence and Impact

Failure Modes and Effects Analysis (FMEA) is one of the most widely used and effective tools for developing quality designs, processes, and services.

NOTE: When criticality is considered, a FMEA is often times referred to as a FMECA (Failure Modes, Effects, and Criticality Analysis). In this document, the term FMEA is used in a general sense to include both FMEAs and FMECAs.

Developed during the design stage, FMEAs are procedures by which:

- Potential failure modes of a system are analyzed to determine their effects on the system.
- Potential failure modes are classified according to their severity (FMEAs) or to their severity and probability of occurrence (FMECAs).
- Actions are recommended to either eliminate or compensate for unacceptable effects.

When introduced in the late 1960s, FMEAs were used primarily to assess the safety and reliability of system components in the aerospace industry. During the late 1980s, FMEAs were applied to manufacturing and assembly processes by Ford Motor Company to improve production. Today, FMEAs are being used for the design of products and processes as well as for the design of software and services in virtually all industries. As markets continue to become more intense and competitive, FMEAs can help to ensure that new products, which consumers demand be brought to market quickly, are both highly reliable and affordable.

The principle objectives of FMEAs are to anticipate the most important design problems early in the development process and either to prevent these problems from occurring or to minimize their consequences as cost effectively as possible. In addition, FMEAs provide a formal and systematic approach for design development and actually aid in evaluating, tracking, and updating both design and development efforts. Because the FMEA is begun early in the design phase and is maintained throughout the life of the system, the FMEA becomes a diary of the design and all changes that affect system quality and reliability.

Types of FMEAs

All FMEAs focus on design and assess the impact of failure on system performance and safety. However, FMEAs are generally categorized based on whether they analyze product design or the processes involved in manufacturing and assembling the product.

- **Product FMEAs.** Examine the ways that products (typically hardware or software) can fail and affect product operation. Product FMEAs indicate what can be done to prevent potential design failures.
- **Process FMEAs.** Examine the ways that failures in manufacturing and assembly processes can affect the operation and quality of a product or service. Process

FMEAs indicate what can be done to prevent potential process failures prior to the first production run.

Although FMEAs can be initiated at any system level and use either a top-down or bottom-up approach, today's products and processes tend to be complex. As a result, most FMEAs use an inductive, bottom-up approach, starting the analysis with the failure modes of the lowest level items of the system and then successively iterating through the next higher levels, ending at the system level. Regardless of the direction in which the system is analyzed, all potential failure modes are to be identified and documented on FMEA worksheets (hard copy or electronic), where they are then classified in relation to the severity of their effects.

In a very simple product FMEA, for example, a computer monitor may have a capacitor as one of its components. By looking at the design specifications, it can be determined that if the capacitor is open (failure mode), the display appears with wavy lines (failure effect). And, if the capacitor is shorted (failure mode), the monitor goes blank (failure effect). When assessing these two failure modes, the shorted capacitor would be ranked as more critical because the monitor becomes completely unusable. On the FMEA worksheet, ways in which this failure mode can either be prevented or its severity lessened would be indicated.

Approaches to FMEAs

Product and process FMEAs can be further categorized by the level on which the failure modes are to be presented.

- **Functional FMEAs.** Focus on the functions that a product, process, or service is to perform rather than on the characteristics of the specific implementation. When developing a functional FMEA, a functional block diagram is used to identify the top-level failure modes for each functional block on the diagram. For a heater, for example, two potential failure modes would be: "Heater fails to heat" and "Heater always heats." Because FMEAs are best begun during the conceptual design phase, long before specific hardware information is available, the functional approach is generally the most practical and feasible approach by which to begin a FMEA, especially for large, complex products or processes that are more easily understood by function than by the details of their operation. When systems are very complex, the analysis for functional FMEAs generally begins at the highest system level and uses a top-down approach.
- **Interface FMEAs.** Focus on the interconnections between system elements so that the failures between them can be determined and recorded and compliance to requirements can be verified. When developing interface FMEAs, failure modes are usually developed for each interface type (electrical cabling, wires, fiber optic lines, mechanical linkages, hydraulic lines, pneumatics lines, signals, software, etc.). Beginning an interface FMEA as soon as the system interconnections are defined ensures that proper protocols are used and that all interconnections are compliant with design requirements.
- **Detailed FMEAs.** Focus on the characteristics of specific implementations to ensure that designs comply with requirements for failures that can cause loss of end-item function, single-point failures, and fault detection and isolation. Once individual items of a system (piece-parts, software routines, or process steps) are uniquely identified in the later design and development stages, FMEAs can assess the failure causes and effects of failure modes on the lowest level system items. Detailed FMEAs for hardware, commonly referred to as piece-part FMEAs, are the most common FMEA applications. They generally begin at the lowest piece-part level and use a bottom-up approach to check design verification, compliance, and validation.

Variations in design complexity and data availability will dictate the analysis approach to be used. Some cases may require that part of the analysis be performed at the functional level and other portions at the interface and detailed levels. In other cases, initial requirements may be for a functional FMEA that is to later progress to an interface FMEA, and then finally progress to a detailed FMEA. Thus, FMEAs completed for more complex systems often include worksheets that employ all three approaches to FMEA development.

If you would like additional information about FMEAs and all types and approaches have been implemented in Relex, please email info@relex.com. _____