Summary of Action Strategies to Reduce risk

Action Strategies to Reduce Severity Risk

Design for fail-safe

A *fail-safe* design is one that, in the event of failure, responds in a way that will cause minimal harm to other devices or danger to personnel. Fail-safe does not mean that failure is improbable; rather that a system’s design mitigates any unsafe consequences of failure. In FMEA language, fail-safe reduces the severity of the effect to a level that is safe.

Design for fault-tolerance

A *fault-tolerant* design is a design that enables a system to continue operation, possibly at a reduced level (also known as “graceful degradation”), rather than failing completely, when some part of the system fails. In FMEA language, fault-tolerance reduces the severity of the effect to a level that is consistent with performance degradation.

Design for redundancy

A *redundant* design provides for the duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe. This means having backup components that automatically “kick in” should one component fail. In FMEA language, redundant design can reduce the occurrence of system failure and reduce system severity to a safe level.

Provide early warning

Failures that occur without warning are more dangerous than failures with warning. Catastrophic effects can be avoided by adding a warning device to system design. In FMEA language, adding early warning reduces the severity of the effect, potentially reduces the occurrence of system failure, and increases likelihood of detection of failure mode/cause during in-service usage.

Action Strategies to Reduce Occurrence Risk

As noted above, *redundant design* can reduce the occurrence of system failure.

Also noted above, an *early warning* device can reduce the occurrence of system failure.

Change the design to eliminate the failure mode or cause
It is possible to eliminate the failure mode or cause by changing the design of the product or the process. In FMEA language, eliminating the failure mode or cause will reduce the likelihood of occurrence to the lowest possible level.

**Design for robustness and other design optimization techniques**

The objective of *Robust Design* is to optimize design parameters to make the product design less sensitive to the effects of variation that is present in the system’s input variables and parameters. *Taguchi methods* are statistical methods using analysis of variance with the objective of identifying design factors responsible for degradation of performance. *Design of Experiments* is a technique for studying the factors that may affect a product or process in order to identify significant factors and optimize designs. All of these techniques are powerful strategies to improve the quality and reliability of products and processes. In FMEA language, Robust Design and other design optimization techniques improve performance and can significantly reduce the frequency of the cause of failure.

**Reduce stress-strength interference**

When product stress exceeds product strength (a condition called *stress-strength interference*), failures occur. There is *variation* in both the strength of a product and the stress that a product experiences during customer usage. Reducing variation in product strength, reducing variation in stress (how a product is used and the environment it experiences), and increasing the design margin between stress and strength will all reduce the stress-strength interference and the frequency of failure. In FMEA language, these strategies reduce the frequency of the cause of the failure mode. See the “factor of safety” section directly below for more information on increasing design margins as an FMEA action strategy.

**Use physics-of-failure modeling of failure mechanisms**

Higher risk failure mechanisms can be analytically modeled to reduce failures and obtain an accurate advanced warning of impending failures. Chapter 15, section 15.5, covers a type of FMEA called Failure Mode, Mechanism and Effects Analysis (FMMEA) that prioritizes failure mechanisms for physics-of-failure modeling.

**Use a Factor of safety**

One of the most effective action strategies to prevent failures is to design in a safety factor, also known as factor of safety. For structural applications, this is the ratio of the maximum stress that a structural part or other piece of material can withstand to the maximum stress it is anticipated to experience in the use for which it is designed. Essentially, how much stronger the system is than it usually needs to be for an intended load. The greater the safety factor, the lower the likelihood of structural failure. In FMEA language, increasing the factor-of-safety reduces the frequency of the cause of the failure mode.
A similar approach, often applied to electrical parts, is called *derating*. Derating is a technique wherein devices are operated at less than their rated maximum power dissipation, taking into account the case/body temperature, the ambient temperature and the type of cooling mechanism used. Derating increases the margin of safety between part design limits and applied stresses, thereby providing extra protection for the part. By applying derating in an electrical or electronic component, its degradation rate is reduced. The reliability and life expectancy are improved.

**Change the design to reduce the likelihood of occurrence of the cause**

The FMEA team can recommend changes to the design of the product or the process in order to reduce the likelihood of occurrence of the cause.

**Change the way the product or process interacts with the environment**

The FMEA team can recommend changes in the way the product or process interacts with the environment, which can reduce the frequency of the cause of failure.

**Change the way the user interacts with the product or process**

The FMEA team can recommend changes to the way the user or operator interacts with the product or process, which can reduce the frequency of the cause of failure.

**Error proof a product design**

It is possible to change the product design so that errors in manufacturing or assembly processing are reduced or eliminated.

**Error proof the manufacturing process**

The manufacturing or assembly process can be changed so that processing errors are reduced or eliminated. In FMEA language, error proofing a product design or a manufacturing process reduces the frequency of the cause of the failure mode.

**Error proof the product use**

The operation of products or equipment can be designed so that unsafe operation is not possible.

**Use statistical process control (SPC) to monitor and control manufacturing processes**

Statistical process control (SPC) is the application of statistical methods to measure and analyze the variation in manufacturing (or other) processes, with the objective of getting and keeping processes under control and producing conforming products. SPC will not improve a poorly designed product's
reliability, but can be used to maintain the consistency of how the product is made. Properly used, SPC can significantly reduce defects in the manufacturing process.

**Action Strategies to Reduce Detection Risk**

As noted above, adding an *early warning* device can increase the likelihood of detection of a failure mode/cause during in-service usage.

**Utilize existing detection-type controls to increase the likelihood of detection of the cause**

The FMEA team may decide to utilize detection-type controls that already exist but were not currently used to detect the failure mode or cause being analyzed. If selected properly, the detection-type controls can increase the likelihood of detection of the cause of failure.

**Modify existing detection-type controls to increase the likelihood of detection of the cause**

The FMEA team can recommend changes to the existing detection-type controls to increase the likelihood of detection of the cause.

**Develop new detection-type controls to increase the likelihood of detection of the cause**

The FMEA team may decide to develop new detection-type controls that do not currently exist. In FMEA language, by adding the newly developed detection-type controls, the likelihood of detecting the cause of the failure can be increased.

**Use improved test strategies, such as degradation testing, accelerated testing and/or test-to-failure**

The risk due to inadequate design controls can be reduced by changing the type of test. Traditional pass-fail testing introduces risk by not detecting or understanding the cause of failure. Where possible it is important to test to failure, and use degradation testing to understand the progression of failure. Strategies such as Highly Accelerated Life Testing (HALT), Accelerated Life Testing (ALT) and degradation testing can markedly improve detection risk.

**Common Action Strategy Mistakes to Avoid**

Knowing how to identify effective action strategies to reduce risk is important, but it is also essential to avoid the most common mistakes. Here are some of the more common mistakes that FMEA practitioners make when recommending actions to reduce risk.

**Using a single action to address high risk when multiple actions are needed**
In most cases, when addressing high risk, the FMEA team will need to identify more than one action strategy. The mistake is to rely on a single recommended action when trying to address high risk. This is applicable when the team is targeting one category of risk, such as frequency of occurrence; and it is certainly applicable when addressing multiple levels of risk (severity, occurrence, and/or detection.) The key is to use multiple effective actions when addressing high risk.

“Hobby horsing” one particular action strategy

Some practitioners or teams have a favorite strategy (called a “hobby horse”) that is recommended more often than appropriate. Even if this favorite strategy is very effective when applied to the right set of circumstances, it is not useful to apply it broadly as a solution when selection criteria are not met. Avoid “hobby horsing” a single action strategy.

Focusing on only one type of risk

Some teams tend to focus on only one of the three types of risk, such as detection risk. They end up recommending many changes to testing regimens, for example, but miss the opportunity to reduce severity or occurrence risk, and make designs more robust. FMEA teams should review the actions being recommended and ensure they are reducing all three types of risk, as needed.

Actions that are unspecific

FMEA teams can develop the right action strategy during team meetings and yet document the recommended action verbiage too generally. They may have the right concept in mind, yet fail to identify the specific actions to implement the concept. Refer to section 7.5 in this chapter for guidelines on writing effective actions.

Tampering

Variation is present in all natural systems. The challenge is to differentiate between variations due to “common causes” versus “special causes.” The differentiation requires knowledge of statistical process controls and control charts, which is why it is essential to have a quality or reliability expert as part of the FMEA team. Dr. W. Edwards Deming cautioned against tampering with systems that are “in control,” which increases variation.

The field of quality control teaches the correct use of control charts in achieving stable and capable manufacturing processes. Process FMEA teams should familiarize themselves with quality control resources and ensure they recommend effective strategies to improve manufacturing process and avoid tampering.

This summary is from the book “Effective FMEAs”, written by Carl S. Carlson, published by John Wiley & Sons, ©2012, all rights reserved