

Problem Solving and Analysis Tools

FAILURE MODES AND EFFECTS ANALYSIS - FMEA

QUALITY TOOLS

Failure Modes and Effects Analysis

Description of Failure Modes and Effects Analysis

FMEA(Failure Modes and Effects Analysis) is an analysis tool that makes sure that all the potential problems related to product and process are predicted and addressed throughout the product and process development process.

FMEA is a methodology to analyze and discover:

- All potential failure modes of a process
- The effects these failures have on the process
- How to correct and or mitigate the failures or effects on the process

FMEA is can be used as the main phase of the design process in the early stage. FMEA provides the structural approach for root cause analysis, severity of the issue and helps to draw the actions for the prevention of the problem.

FMEA development uses the following steps to address:

Potential product / process failure to meet product specification.

- Potential failure modes
- Potential causes of the failure modes
- Enforcement of current controls
- Level of Threat or Risk
- Action for risk reduction

Team responsible for the development of FMEA must gather all related information before the development of FMEA. This will help effective and efficient FMEA development.

FMEA emerged from the US Military in the late 1940s as a tool to improve the evaluation of reliability of equipment. Its benefits quickly became apparent and it was adopted by aerospace industries and NASA during the Apollo program in the 1960s. It was later taken up by many of the larger automotive companies, including Ford in the 1970s. It has since become a core tool in product development in many organizations and is recommended as a part of an organization's quality management system.

When to use the Failure Modes and Effects Analysis

There are two main types of FMEA, Product or Design FMEA (DFMEA) and Process FMEA (PFMEA).

Product or Design FMEA

What could go wrong with a product while in service as a result of a weakness in design?

- Carried out during the early stages of a design project
- Tends to assume that the product will be produced to the required design specifications
- Aims to reduce reliance on process controls and inspection to overcome limitations in the basic design and thus, need to consider the technical and physical limitations of the manufacturing and assembly processes

Process FMEA

What could go wrong with a product during manufacture or while in service as a result of non-compliance to specification or design?

How to use the Failure Modes and Effects Analysis

Typically, the information is collated and presented in a tabular format, as shown below:

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (Process FMEA)																
ITEM:	A			PROCESS RESPONSIBILITY:	B			PREPARED BY:	C							
MODEL YEAR (S)				APP. DATE:				FMEA NUMBER:								
PROGRAM (S)								FMEA DATE (Orig):	Updated Date:							
CORE (Cross Functional) TEAM:																
Process Function, Requirements	Potential Failure Mode	Potential Effect(s) of Failure	SEVERITY	CLASS	Potential Causes / Mechanisms of Failure	OCCURRENCE	Current Process Controls (Prevention)	Current Process Controls (Detection)	DETECTION	R P N	Recommended Action(s)	Responsibility and Target Completion Date	Action Results			
													Actions Taken & Effective Date	SEV	OCC	DET
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		

Details of Elements in FMEA Table:

A. Item & Core Team Identification:

Details of the Product identification Name, Number etc., Responsible Core team involved in the development of the FMEA.

B. Date & Completed by:

To record the name of the champion and when the analysis took place.

C. FMEA number & reference information:

Reference document numbering for quick and easy traceability

1. System / component / function:

The specific name of the process function or characteristics / number of the item or element under study.

2. Potential Failure Modes:

The manner in which a component, subsystem or system could possibly fail while being

used. Team should validate the potential failure modes through a review of past things gone wrong, concerns, reports and team brainstorming.

3. Potential Effects of Failure:

Record the effects of the potential failure mode. What could go wrong? Provide as detailed description as is necessary of the potential impact of failure. An individual failure mode may have many possible effects.

4. Severity rating:

Each failure effect can be judged for its potential seriousness. Typically, this is done by scoring the effect on a 1 to 5 (or 10): scale. Team should discuss with arguments and agreed to a representative severity rating that explains the effect of failure mode.

Rating Criteria:

5 (9-10) with potential safety risk or legal problems - potential loss of life or major dissatisfaction

4 (7-8) High potential customer dissatisfaction - serious injury or significant mission disruption

3 (5-6) Medium potential customer dissatisfaction - potential small injury, mission inconvenience / delay

2 (3-4) The customer may notice the potential failure and may be a little dissatisfied -annoyance

1 (1-2) The customer will probably not detect the failure - undetectable

5. Classification:

This column may be used to identify the high priority failure modes which must be addressed (e.g. safety issues, sales issues etc.)

6. Potential Cause / Mechanisms of Failure:

Each failure mode will have an underlying root cause. Team should focus on an understanding of the failure mechanism for each failure mode. Causes are the circumstances that induce or activate a failure mechanism. Possible causes could include: Wrong tooling, poor alignment, operator error, component missing, defective components, maintenance required, environment etc.

7. Occurrence Ranking:

It is also necessary to consider the likelihood of the potential failure occurring. A consistent occurrence ranking system should be used to ensure continuity. Typically, this is done by scoring the occurrence on a 1 to 5 (or 10): scale as shown below:

Rating Criteria:

5 (9-10) Very high probability of occurrence

4 (7-8) High probability of occurrence

3 (5-6) Moderate probability of occurrence

2 (3-4) Low probability of occurrence

1 (1-2) Remote probability of occurrence

This section is critical in the FMEA procedure and each of the responses categorized as very high or high should be considered and addressed.

8 & 9. Current Process control:

There are two types of process controls to consider:

- Prevention: Aim to eliminate the potential failure? These could include labels, barriers, instructions or total redesigns.
- Detection: Identify (detect) the cause of failure followed up by the implementation of the corrective action to catch the problem.

10. Detection rating:

The final rating aims to establish how 'detectable' the potential failure will be. In order to achieve a lower ranking, generally the planned detection control has to be improved.

Suggested ratings on a scale of 1 to 5 (or 10):

Rating Criteria:

5 (9 or 10) Zero probability of detecting the potential failure cause

4 (7 or 8) Close to zero probability of detecting potential failure cause

3 (4, 5 or 6) Not likely to detect potential failure cause

2 (2 or 3) Good chance of detecting potential failure cause

1 (1) Almost certain to identify potential failure cause

11. Risk Priority Number (RPN)

The RPN is simply the product of the severity, occurrence and detection ratings:

RPN = Severity rating x Occurrence rating x Detection rating

- perhaps more easily remembered as:

RPN= S*O*D

The RPN value gives an indicator of the design risk and generally, the items with the highest RPN and severity ratings should be given first consideration.

12. Recommended actions:

The intent of any recommended action is to reduce rankings in the following order: severity, occurrence and detection.

- Only a design or process revision can bring about a reduction in the severity ranking.
- A reduction in the occurrence rating can be achieved by controlling one or more causes of the failure mode along with a revision of product and process design.
- A reduction in the detection rating can be done by applying error/mistake proofing or by the modification, automation and improvement of the detection process.

13. Responsibility:

All actions should be clearly assigned to an individual, department and/or organization with a clear target completion date. Team leader is responsible for ensuring that all recommended actions are implemented and adequately addressed.

14. Actions taken and effective date:

Brief description of the actions taken with task completion date.

15. Severity, Occurrence, Detection and RPN:

These columns identifies the result of the preventive/corrective actions and the effect of the action in terms of S, O, D rankings and new RPN for the item.

Verification of the corrective actions is needed to be completed for continual improvements.

Tips on use of Failure Modes and Effects Analysis

- Preparation is essential
- Facilitation is critical
- Customize the scales where needed
- Multiple sessions more effective
- Brainstorming rules apply
- Allocate sufficient time for an effective outcome

Application of Failure Modes and Effects Analysis

- Concept
- Design/Product
- Process
- Implementation
- Change

Attached here is an example for application of FMEA

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (Process FMEA)																
ITEM:	XYZ Assembly A				PROCESS RESPONSIBILITY:	ABC B		PREPARED BY:	AB C							
MODEL YEAR (S)	2012				APP. DATE:	27-Jan-12		FMEA NUMBER:	ABC-12-001							
PROGRAM (S)	X10						FMEA DATE (Orig):	25-Jun-12		Updated Date: 27-JUN-12						
DDRE (Cross Functional) TEAM:	AB, CD, EF, GH, IJKLWX & YZ															
Process Function, Requirements	Potential Failure Mode	Potential Effect(s) of Failure	SEVERITY	CLASS	Potential Causes / Mechanisms of Failure	OCCURRENCE	Current Process Controls (Prevention)	Current Process Controls (Detection)	DETECTION	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results			
													Actions Taken & Effective Date	SEV	OCC	DET
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
OP30 - Machining Process																
1 - Overall Length	Oversize	Final Assy and fit difficulty of transmission. Parts may rejected at assembly	8		Incorrect set-up -Improper offset Wrong tools used Tool wear/breakage Incorrect gauging	2	Gauge System Setter Training Operator Training Standard Work Instruction	First Off Inspection SPC	5	80						
	Undersize	May lead to excessive play in final assembly of transmission	8		Incorrect set-up -Improper offset Wrong tools used Incorrect gauging Parts loading onto lathe by wrong side	2	Gauge System Setter Training Standard Work Instruction	First Off Inspection SPC	5	80						
2 - Shaft Diameter	Oversize	May lead to excessive play in final assembly of transmission	8		Incorrect set-up -Improper offset Wrong tools Tool wear/breakage Incorrect gauging	2	Gauge System Setter Training Standard Work Instruction	First Off Inspection	5	96						
	Undersize	Final Assy and fit difficulty of transmission.	8		Incorrect set-up -Improper offset Wrong tools Incorrect gauging Parts loading onto	2	Gauge System Setter Training Standard Work Instruction	First Off Inspection	5	60						

Example

Following table may also be used for ranking scale for Severity, Occurrence and Detection.

FMEA Steps: Rating Scales

RATING	DEGREE OF SEVERITY	PROBABILITY OF OCCURRENCE		ABILITY TO DETECT	
			FREQUENCY (1 in ...)		Detection Certainty
1	Customer will not notice the adverse effect or it is insignificant	Likelihood of occurrence is remote	1,000,000	Sure that the potential failure will be found or prevented before reaching the next customer	100%
2	Customer will probably experience slight annoyance	Low failure rate with supporting documentation	20,000	Almost certain that the potential failure will be found or prevented before reaching the next customer	99%
3	Customer will experience annoyance due to the slight degradation of performance	Low failure rate without supporting documentation	5,000	Low likelihood that the potential failure will reach the next customer undetected	95
4	Customer dissatisfaction due to reduced performance	Occasional failures	2,000	Controls may detect or prevent the potential failure from reaching the next customer	90
5	Customer is made uncomfortable or their productivity is reduced by the continued degradation of the effect	Relatively moderate failure rate with supporting documentation	500	Moderate likelihood that the potential failure will reach the next customer	85
6	Warranty repair or significant manufacturing or assembly complaint	Moderate failure rate without supporting documentation	100	Controls are unlikely to detect or prevent the potential failure from reaching the next customer	80
7	High degree of customer dissatisfaction due to component failure without complete loss of function. Productivity impacted by high scrap or rework levels.	Relatively high failure rate with supporting documentation	50	Poor likelihood that the potential failure will be detected or prevented before reaching the next customer	70
8	Very high degree of dissatisfaction due to the loss of function without a negative impact on safety or governmental regulations	High failure rate without supporting documentation	20	Very poor likelihood that the potential failure will be detected or prevented before reaching the next customer	60
9	Customer endangered due to the adverse effect on safe system performance with warning before failure or violation of governmental regulations	Failure is almost certain based on warranty data or significant DV testing	10	Current controls probably will not even detect the potential failure	50
10	Customer endangered due to the adverse effect on safe system performance without warning before failure or violation of governmental regulations	Assured of failure based on warranty data or significant DV testing	2	Absolute certainty that the current controls will not detect the potential failure	< 50

References

- AIAG Manual for FMEA, Fourth Edition