Failure Mode and Effect Analysis

FMEA

- An analytical technique
- experience of people
- foresee failure modes product or process
- effect on customer
- plan its elimination
- Design, Process FMEA

Benefits

- Review of component failure modes
- Its effect on product or process function

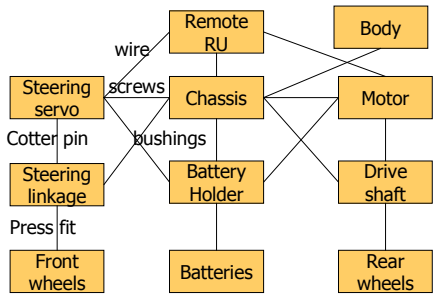
Start with Block Diagram

- List all system components
- Eg: Toy Car
  - Chassis, Body, Steering servo, Motor, Steering linkage, Battery Holder, Drive shaft, Front and rear wheels, Battery, Remote sending and receiving units

Block Diagram...

- Identify how they are connected or attached
- Eg: Toy Car
  - Screws, Snap fit, Press fit, Compressive fit, Cotter pins, Wires, Bushings, Shaft couplings

Block Diagram



FAILURE MODE AND EFFECT ANALYSIS Rev 0
(DESIGN FMEA)

Item: Design Responsibility: FMEA Number
Model Number / Year: Key Date: Page of
Core Team: Prepared By
FMEA Date (Orig.) (Rev.)

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S	CLASS	Potential Cause(s) / Mechanisms of Failure	O	Current Design Controls	D	RPN	Recommended Actions	Responsibility and Target Completion Dates	Action Results: Actions Taken	S	O	D	RPN

Four Stages

❶Specifying Possibilities
❷Quantifying Risk
❸Correcting High Risk Causes
❹Re-evaluation of Risk

Potential Failure Mode

- Fail to meet design criteria
- Cause failure in higher level system
- Result of failure in lower level system
- All possible modes should be considered
- Consider range beyond normal usage
- Describe in technical terms: cracked, deformed, etc

Item / Function	Potential Failure Mode
Write smoothly	*Ink dried up*
	Ink gurgling out

Potential Effect(s) of Failure

- Effect of failure -customer view
- internal or external
- Describe how noticed or experienced
- Safety? Regulations?
- Effect on other systems or subsystems

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure
Write smoothly	*Ink dried up*	*Will not write*
	Ink gurgling out	*Ink spreading over paper, hands*

Severity

- Seriousness of the effect
- Not to failure mode
- Reduction can come only be change in design
- Different methods of ranking
- 10 - most severe
- 1 - least severe

Rankings of Severity of Effect for Design FMEA

Effect	Criteria	Ranking
Hazardous without warning	Very high ranking when potential failure mode affects safe operation and / or regulation noncompliance. Failure occurs without warning.	10
Hazardous with warning	Very high ranking when potential failure mode affects safe operation and / or regulation concompliance. Failure occurs with warning.	9
Very High	Item or product is inoperable, with loss of function. Customer very dissatisfied	8
High	Item or product is operable, but with loss of performance. Customer dissatisfied.	7
Moderate	Item or product is operable, but with loss to comfort / convenience items inoperable. Customer experiences discomfort.	6

Rankings of Severity of Effect for Design FMEA ...

Effect	Criteria	Ranking
Low	Item or product is operable, but with loss of performance of comfort / convenience items inoperable. Customer has some dissatisfaction.	5
Very Low	Certain item characteristics do not conform. Noticed by most customers.	4
Minor	Certain item characteristics do not conform. Noticed by average customers.	3
Very Minor	Certain item characteristics do not conform. Noticed by discriminating customers.	2
None	No effect	1

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S
Write smoothly	*Ink dried up*	*Will not write*	*8*
	Ink gurgling out	*Ink spreading over paper, hands*	*6*

Classification (CLASS)

- Any special product characteristics for components, subsystems, or systems that may require additional process controls

Potential Cause(s) / Mechanism(s) of Failure

- List completely and concisely
- Some failure modes - More than one cause and/or mechanism
- Eg:
  - Causes - Incorrect material specified, Inadequate life assumption, Over-stressing
  - Mechanisms - Yield, creep, fatigue

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S	CLASS	Potential Cause(s) / Mechanisms of Failure
Write smoothly	*Ink dried up*	*Will not write*	*8*		*Stored for a long time* *Solvent fraction less*
	Ink gurgling out	*Ink spreading over paper, hands*	*6*		*Solvent fraction more* *Ball dia less*

Occurrence

- The chance that one of the specific causes / mechanisms may occur
- every cause and mechanism
- Reduction only by direct change in design
- 1 - least chance
- 10 - Highest chance

Example: Occurrence Rankings

Probability of Failure	Possible Failure Rates	Ranking
Very High: Failure is almost inevitable	> 1 in 2 1 in 3	10 9
High: Repeated failures	1 in 8 1 in 20	8 7
Moderate: Occasional failures	1 in 80 1 in 400 1 in 2000	6 5 4
Low: Relatively few failures	1 in 15000 1 in 150,000	3 2
Remote: Failure is unlikely	< 1 in 1,500,000	1

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S	CLASS	Potential Cause(s) / Mechanisms of Failure	O
Write smoothly	*Ink dried up*	*Will not write*	*8*		*Stored for a long time* *Solvent fraction less*	*6* *4*
	Ink gurgling out	*Ink spreading over paper, hands*	*6*		*Solvent fraction more* *Ball dia less*	*4* *6*

Current Design Controls

- Prevent the cause / mechanism or failure mode effect from occurring or reduce the rate of occurrence
- Detect the cause / mechanism and lead to corrective actions
- Detect only the failure mode

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S	CLASS	Potential Cause(s) / Mechanisms of Failure	O	Current Design Controls
Write smoothly	*Ink dried up*	*Will not write*	*8*		*Stored for a long time*	*6*	*NIL*
					Solvent fraction less	*4*	*Receiving inspection*
	Ink gurgling out	*Ink spreading over paper, hands*	*6*		*Solvent fraction more*	*4*	*Receiving inspection*
					Ball dia less	*6*	*Receiving inspection*

Detection

- A relative measure of the ability of the design control to detect either a potential cause / mechanism or the subsequent failure mode

Detection	Criteria	Ranking
Absolute Uncertainty	Design control will not and/or cannot detect a potential cause/mechanism and subsequent failure mode: or there is no design control	10
Very Remote	Very remote chance the design control will detect a potential cause/mechanism and subsequent failure mode	9
Remote	Remote chance the design control will detect a potential cause/mechanism and subsequent failure mode	8
Very Low	Very low chance the design control will detect a potential cause/mechanism and subsequent failure mode	7
Low	Low chance the design control will detect a potential cause/mechanism and subsequent failure mode	6

Detection	Criteria	Ranking
Moderate	Moderate chance the design control will detect a potential cause/mechanism and subsequent failure mode	5
Moderately High	Moderately high chance the design control will detect a potential cause/mechanism and subsequent failure mode	4
High	High chance the design control will detect a potential cause/mechanism and subsequent failure mode	3
Very High	Very high chance the design control will detect a potential cause/mechanism and subsequent failure mode	2
Almost Certain	design control will almost certainly detect a potential cause/mechanism and subsequent failure mode	1

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S	CLASS	Potential Cause(s) / Mechanisms of Failure	O	Current Design Controls	D
Write smoothly	*Ink dried up*	*Will not write*	*8*		*Stored for a long time*	*6*	*NIL*	*9*
					Solvent fraction less	*4*	*Receiving inspection*	*2*
	Ink gurgling out	*Ink spreading over paper, hands*	*6*		*Solvent fraction more*	*4*	*Receiving inspection*	*2*
					Ball dia less	*6*	*Receiving inspection*	*2*

Risk Priority Number

RPN = Severity X Occurrence X Detection
= S X O X D

- Can range from 1 to 1000
- 1 is the smallest possible risk
- For high RPN, corrective action required
- Severity high, low RPN not sufficient

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S	CLASS	Potential Cause(s) / Mechanisms of Failure	O	Current Design Controls	D	RPN
Write smoothly	*Ink dried up*	*Will not write*	*8*		*Stored for a long time*	*6*	*NIL*	*9*	*432*
					Solvent fraction less	*4*	*Receiving inspection*	*2*	*64*
	Ink gurgling out	*Ink spreading over paper, hands*	*6*		*Solvent fraction more*	*4*	*Receiving inspection*	*2*	*48*
					Ball dia less	*6*	*Receiving inspection*	*2*	*72*

Recommended Actions

- Attack the highest RPN
- Attack high severity
- Additional Design Controls can reduce detection ranking
- Design improvements can reduce occurrence ranking

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	S	CLASS	Potential Cause(s) / Mechanisms of Failure	O	Current Design Controls	D	RPN	Recommended Actions
Write smoothly	*Ink dried up*	*Will not write*	*8*		*Stored for a long time*	*6*	*NIL*	*9*	*432*	*Introduce sealed cover*
					Solvent fraction less	*4*	*Receiving inspection*	*2*	*64*	
	Ink gurgling out	*Ink spreading over paper, hands*	*6*		*Solvent fraction more*	*4*	*Receiving inspection*	*2*	*48*	
					Ball dia less	*6*	*Receiving inspection*	*2*	*72*	

Resulting RPN

- Re-estimate after corrective action
- Leave blank if no action taken
- Keep document alive

Process FMEA

- Very similar to Design FMEA
- For all manufacturing operations
- Assumes Design is OK
- Does not rely on product design to overcome process weakness

FMEA

- A tool for preventive action