FMEA

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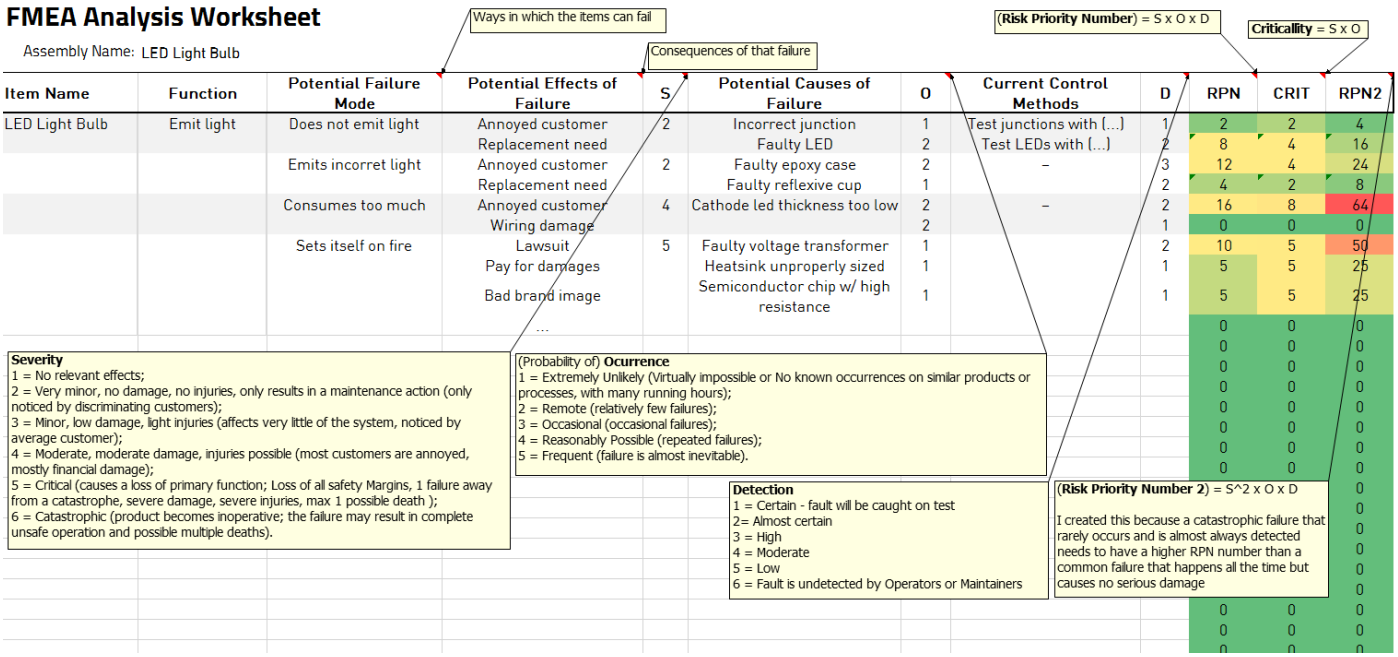
FMEA = Failure Modes and Effects Analysis. FMEA is an approach to identify all possible failures in a design, a manufacturing or assembly process, or a product or service. “Failure modes” means the ways, or modes, in which something might fail. FMEA is used during design to prevent failures.

Example FMEA worksheet

FMEA Ref.	Item	Potential failure mode	Potential cause(s) / mechanism	Mission Phase	Local effects of failure	Next higher level effect	System Level End Effect	(P) Probability (estimate)	(S) Severity	(D) Detection (Indications to Operator, Maintainer)	Detection Dormancy Period	Risk Level P*S (+D)	Actions for further Investigation / evidence	Mitigation / Requirements
1.1.1.1	Brake Manifold Ref. Designator 2b, channel A, O-ring	Internal Leakage from Channel A to B	a) O-ring Compression Set (Creep) failure b) surface damage during assembly	Landing	Decreased pressure to main brake hose	No Left Wheel Braking	Severely Reduced Aircraft deceleration on ground and side drift. Partial loss of runway position control. Risk of collision	(C) Occasional	(VI) Catastrophic (this is the worst case)	(1) Flight Computer and Maintenance Computer will indicate "Left Main Brake, Pressure Low"	Built-In Test interval is 1 minute	Unacceptable	Check Dormancy Period and probability of failure	Require redundant independent brake hydraulic channels and/or Require redundant sealing and Classify O-ring as Critical Part Class 1

Function	Potential Failure Mode	Potential Effects(s) of Failure	S	Potential Cause(s) of Failure	O	Current Process Controls	D	RPN	CRIT	Recommended Action(s)	Responsibility and Target Completion Date	Action Results					
												Action Taken	S	O	D	RPN	CRIT
Dispense amount of cash requested by customer	Does not dispense cash	Customer very dissatisfied	8	Out of cash	5	Internal low-cash alert	5	200	40								
		Incorrect entry to demand deposit system		Machine jams	3	Internal jam alert	10	240	24								
		Discrepancy in cash balancing		Power failure during transaction	2	None	10	160	16								
	Dispenses too much cash	Bank loses money	6	Bills stuck together	2	Loading procedure (riffle ends of stack)	7	84	12								
		Discrepancy in cash balancing		Denominations in wrong trays	3	Two-person visual verification	4	72	18								
	Takes too long to dispense cash	Customer somewhat annoyed	3	Heavy computer network traffic	7	None	10	210	21								
				Power interruption during transaction	2	None	10	60	6								

Fig. 1 *Example of FMEA table of an ATM machine.*



FMEA Analysis Worksheet

Assembly Name: LED Light Bulb

Ways in which the items can fail

Consequences of that failure

(**Risk Priority Number**) = S x O x D

Criticality = S x O

Item Name	Function	Potential Failure Mode	Potential Effects of Failure	S	Potential Causes of Failure	O	Current Control Methods	D	RPN	CRIT	RPN2
LED Light Bulb	Emit light	Does not emit light	Annoyed customer	2	Incorrect junction	1	Test junctions with (...)	1	2	2	4
			Replacement need		Faulty LED	2	Test LEDs with (...)	2	8	4	16
		Emits incorret light	Annoyed customer	2	Faulty epoxy case	2	-	3	12	4	24
			Replacement need		Faulty reflexive cup	1		2	4	2	8
		Consumes too much	Annoyed customer	4	Cathode led thickness too low	2	-	2	16	8	64
			Wiring damage			2		1	0	0	0
		Sets itself on fire	Lawsuit	5	Faulty voltage transformer	1		2	10	5	50
			Pay for damages		Heatsink unproperly sized	1		1	5	5	25
			Bad brand image		Semiconductor chip w/ high resistance	1		1	5	5	25
			...						0	0	0
									0	0	0
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Severity
1 = No relevant effects;
2 = Very minor, no damage, no injuries, only results in a maintenance action (only noticed by discriminating customers);
3 = Minor, low damage, light injuries (affects very little of the system, noticed by average customer);
4 = Moderate, moderate damage, injuries possible (most customers are annoyed, mostly financial damage);
5 = Critical (causes a loss of primary function; Loss of all safety Margins, 1 failure away from a catastrophe, severe damage, severe injuries, max 1 possible death);
6 = Catastrophic (product becomes inoperative; the failure may result in complete unsafe operation and possible multiple deaths).

(Probability of) **Ocurrence**
1 = Extremely Unlikely (Virtually impossible or No known occurrences on similar products or processes, with many running hours);
2 = Remote (relatively few failures);
3 = Occasional (occasional failures);
4 = Reasonably Possible (repeated failures);
5 = Frequent (failure is almost inevitable).

Detection
1 = Certain - fault will be caught on test
2= Almost certain
3 = High
4 = Moderate
5 = Low
6 = Fault is undetected by Operators or Maintainers

(**Risk Priority Number 2**) = S^2 x O x D

I created this because a catastrophic failure that rarely occurs and is almost always detected needs to have a higher RPN number than a common failure that happens all the time but causes no serious damage

Fig. 2 *Example of simple FMEA analysis for a LED light bulb.*

Steps:

1. Identify the functions and the purpose of the thing. “What do our customers expect it to do?” Then divide the item into separate assemblies/parts/process steps and identify each one’s function.
2. For each function, identify all the ways it could fail. To fail means to lose their function or make other items lose theirs.
3. Then for each failure mode identify all the consequences it can have everywhere – system, related systems, process, related processes, product, service, customer or regulations. These are potential effects of failure. Ask, “What does the customer experience because of this failure? What happens when this failure occurs?”
4. Determine how serious each effect is. This is the severity rating, or S. Severity is usually rated on a scale from 1 to 10, where 1 is insignificant and 10 is catastrophic. If a failure mode has more than one effect, write on the FMEA table only the highest severity rating for that failure mode.
5. For each failure mode, determine all the potential root causes. Use tools classified as cause analysis tool, as well as the best knowledge and experience of the team. List all possible causes for each failure mode on the FMEA form.
6. For each cause, determine the occurrence rating, or O. This rating estimates the probability of failure occurring for that reason during the lifetime of your scope. Occurrence is usually rated on a scale from 1 to 10, where 1 is extremely unlikely and 10 is inevitable. On the FMEA table, list the occurrence rating for each cause.
7. For each cause, identify current process controls. These are tests, procedures or mechanisms that you now have in place to keep failures from reaching the customer. These controls might prevent the cause from happening, reduce the likelihood that it will happen or detect failure after the cause has already happened but before the customer is affected.
8. For each control, determine the detection rating, or D. This rating estimates how well the controls can detect either the cause or its failure mode after they have happened but before the customer is affected. Detection is usually rated on a scale from 1 to 10, where 1 means the control is absolutely certain to detect the problem and 10 means the control is certain not to detect the problem (or no control exists). On the FMEA table, list the detection rating for each cause.