Failure Mode Effects Analysis

Sample FMEA Template

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.	Actions Taken	SEV	OCC	DET	RPN
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0
								0							0

Example of a template for use in a Failure Modes Effects Analysis

Function

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Functions should be written in verb-noun context if practical.**
- **An associated measurable metric is desirable.**

As an example:

The problem is to design an automotive HVAC system which must *defog windows* and *heat or cool cabin* to 70 degrees in all operating conditions (-40 degrees to 100 degrees) within 3 to 5 minutes.

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Functions

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- Therefore in this example, the functions are…
  - Defog windows
  - Heat cabin
  - Cool cabin

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Failure Modes

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Identify Failure Modes. A failure mode is defined as the manner in which a component, subsystem, system, process, etc. could potentially fail to meet the design intent.**
  - **How can the part/system fail to meet specifications?**
  - **What would a customer consider objectionable?**

- **There are 5 classes of failure modes:**
  - **complete failure,**
  - **partial failure,**
  - **intermittent failure,**
  - **over-function, and**
  - **unintended function**

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Failure Modes, examples

- **Examples:**
  - **Complete failure**
    - **HVAC system does not heat vehicle or defog windows**
  - **Partial failure**
    - **HVAC system takes more than 5 minutes to heat vehicle**
  - **Intermittent failure**
    - **HVAC system does heat cabin to 70 degrees in below zero temperatures**
  - **Over-function**
    - **HVAC system cools cabin to 50 degrees**
  - **Unintended functions**
    - **HVAC system activates rear window defogger**

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Effect(s) of Failure

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Effects should be listed as customer would describe them (consider…)**
  - **Reduced performance**
  - **Customer dissatisfaction**
  - **Potential risk of injury**
  - **Product liability**
- **Effects should include (as appropriate) safety / regulatory body, end user, internal customers (manufacturing, assembly, service)**
- **For example:**
  - **Cannot see out of front window**
  - **Air conditioner makes cabin too cold**
  - **Does not get warm enough**
  - **Takes too long to heat up**

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Severity

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

Determine the *severity* of the failure effects (as a rating value)

Severity values may be available from governing bodies. In this example AIAG and SAE.

If severity is based upon internally defined criteria or is based upon standard with specification modifications, rating tables should be included with the analysis.

Examples:

- **Cannot see out of front window: severity 9**
- **Air conditioner makes cab too cold: severity 5**
- **Does not get warm enough: severity 5**
- **Takes too long to heat up: severity 4**

Example of a Severity Table

Rating	Severity Description
1	The effect is not noticed by customer
2	Very slight effect noticed by customer, does not annoy or inconvenience customer
3	Slight effect that causes customer annoyance, but they do not seek service
4	Slight effect, customer may return product for service
5	Moderate effect, customer requires immediate service
6	Significant effect, causes customer dissatisfaction; may violate regulation or design code
7	Major effect, system may not be operable; elicits customer complaint; may cause injury
8	Extreme effect, system is inoperable and a safety problem. May cause severe injury.
9	Critical effect, complete system shutdown; safety risk
10	Hazardous; failure occurs without warning; life threatening

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Cause(s) of Failure

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Causes must be identified for a failure mode**
- **Brainstorm causes (man, machine, material, method, environment…)**
- **Causes should be limited to design issues (what you can control)**
- **There is usually more than one cause of failure for each failure mode**

For our example:

  - **Poor vent location**
  - **Routing of vent hoses (too close to heat source)**
  - **Inadequate coolant capacity for application**

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Occurrence (or Probability)

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Occurrence ratings for design FMEA are based upon the likelihood that a cause may occur, based upon past failures, and/or performance of similar systems in similar applications**
- **Occurrence rating values may be standardized (AIAG, SAE in this example)**
- **If occurrence values are based upon internally defined criteria, a rating table should be included in FMEA (with explanation for use)**
- **Occurrence values of 1 should have objective data to provide justification for inclusion (since failure level so low…)**

Examples

- **Poor vent location: occurrence 3**
- **Routing of vent hoses (too close to heat source): occurrence 6**
- **Inadequate coolant capacity for application : occurrence 2**

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Sample of an Occurrence Table

Rating	Approx. Probability of Failure	Description of Occurrence
1	$\leq 1 \times 10^{-5}$	Extremely remote
2	1×10^{-5}	Remote, very unlikely
3	1×10^{-5}	Very slight chance of occurrence
4	4×10^{-4}	Slight chance of occurrence
5	2×10^{-3}	Occasional occurrence
6	1×10^{-2}	Moderate occurrence
7	4×10^{-2}	Frequent occurrence
8	0.20	High occurrence
9	0.33	Very high occurrence
10	≥ 0.50	Extremely high occurrence

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Current Design Controls

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Identify the existing controls that identify and reduce failures**

- **Controls may be *Preventive (designed in)* or *Detective (found by functional testing, etc.)***
  - **Preventive controls are those that help reduce the likelihood that a failure mode or cause will occur (affect occurrence value)**
  - **Detective controls are those that find problems that have been designed into the product (assigned detection value)**
  - **If detective and preventive controls are not listed in separate columns, they must include an indication of the type of control**

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Current Design Controls

- **Examples:**

  Engineering specifications provide preventive control (P)

  Historical data provide preventive control (P)

  Functional testing provides detective control (D)

Detection

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Detection values should correspond any existing standards (AIAG, SAE)**
- **If detection values are based upon internally defined criteria, a rating table should be included in FMEA (with explanation for use)**
- **Detection is the value assigned to each of the detective controls.**
- **Detection values of 1 mean the potential for failure is eliminated due to design solutions.**

Examples:

Engineering specifications:	**no detection value**
Historical data:	**no detection value**
Functional testing:	**detection 3**
General vehicle durability:	**detection 5**

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RPN (Risk Priority Number)

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **Risk Priority Number is the product of the severity, occurrence and detection ratings. (RPN = S*O*D)**
  Note: Lowest detection rating is used to determine RPN

- **RPN threshold should not be used as the primary trigger for definition of recommended actions**

From previous examples:

Cannot see out of front window	**(S = 9)**
Incorrect vent location	**(O = 2)**
Detection by functional testing	**(D = 3)**

RPN = 54

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Recommended Actions

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **The RPN is used to identify items which require attention and assign a priority to them.**
- **All critical or significant failures should have recommended actions associated with them.**
- **Recommended actions should be focused on design, and directed toward mitigating the cause of failure, or eliminating the failure mode.**

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Recommended Actions

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- Recommended Actions (examples)
  - Try to eliminate the failure mode (some failures are more preventable than others)
  - Minimize the severity of the failure
  - Reduce the occurrence of the failure mode
  - Improve the detection

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Responsibility & Target Completion Date

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **All recommended actions should have a person assigned responsibility for completion of the action**
- **There should be a completion date accompanying each recommended action**

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Action Results

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Recommended Actions	Target Complete Date	Actions Taken	SEV	OCC	DET	RPN

- **"Action taken" must detail what actions occurred, and the results of those actions**
- **Actions must be completed by the target completion date**
- **Update S, V, and O to reflect actions taken**
  - **Unless the failure mode has been eliminated, severity should not change**
  - **Occurrence may or may not be lowered based upon the results of actions**
  - **Detection may or may not be lowered based upon the results of actions**
  - **If severity, occurrence or detection ratings are not improved, additional recommended actions must to be defined**

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Example of FMEA Table

Item / Function	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes Mechanism(s) of Failure	OCC	Current Controls	DET	RPN	Actions Recommended	Resp.	Actions Taken	SEV	OCC	DET	RPN
Defog windows	HVAC system does not defog windows	Cannot see out of front window	9	Poor vent location	3	Functional testing	3	81	None						0
								0							0
Heat cabin	HVAC system does not heat vehicle	Cabin does not heat up	5	Insufficient capacity	2	In house standards	2	20	None						0
	HVAC system takes more than 5 minutes to cool vehicle	Cabin does not cool soon enough	4	Routing of hoses (too close to heat source)	6	Consumer complaint	6	144	Increase on-site inspection at assembly			4	2	3	18
			4	Vent location	3		3	24	None						0
Cool cabin	HVAC system cools cabin to 50 degrees	Cabin gets too cold	5	excessive capacity	2	In house standards	2	20	None						0
								0							0

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