

## Design-FMEA - Overview

Severity (S)		
Effect	Criteria: Severity of Effect	Rank
Endangerment of health and life of humans	Very high severity: Potential failure mode affects safe vehicle operation. Health and life of humans are endangered. It could lead to an existence threatening company risk.	10
Noncompliance with government regulation	Very high severity: Potential failure mode involves noncompliance with government regulation. Humans are not endangered.	9
Very high	Vehicle / Function inoperable (Loss of primary function – walk home).	8
High	Vehicle / Function operable, but at a reduced level. The customer is very dissatisfied. (limp home)	7
Moderate	Vehicle / Function operable, but comfort functions are not available. The customer is dissatisfied.	6
Little	Vehicle / Function operable, but comfort functions are working at a reduced level. The customer is somewhat dissatisfied.	5
Very little	Fit & appearance / noises are disturbing. Failure is noticed by most customers (more than 75%).	4
Low	Fit & appearance / noises are disturbing. Failure is noticed by many customers (more than 50%).	3
Very low	Fit & appearance / noises are disturbing. Failure is noticed by some discriminating customers (less than 25%).	2
No effect	No discernible effect.	1

Occurrence (O)		
Likelihood	Criteria: Potential Failure Rates	Rank
Very high: Permanent failure	New Development of systems / components without operating experience and / or under unexplained operating conditions. It is almost sure that failures will occur on a large scale.	10
	Very high occurrence of the cause of the failure, unusable, inappropriate design concept or known system with problems.	9
High: Frequent failure	New development of systems / components using new technologies and / or previously problematic technologies.	8
	Design generally conforms to designs that have repeatedly caused difficulties in the past. Cause of failure occurs repeatedly, problematic, immature design.	7
Moderate: Occasional failure	New development of systems / components with experience and / or detail changes to previous developments under comparable operating conditions.	6
	Cause of failure occurs repeatedly, not yet mature design.	5
	Design generally conforms to earlier designs that occasionally but not to a large extent failed.	4
	Occasional cause of failure, suitable, stage of maturity with advanced design.	4
Low: Relative low failures	New development of systems / components with positively completed appropriate verification procedure.	3
	There are appropriate measures with a documented, positive result, e.g. simulations (FEM, etc.), tolerance calculations, specific tests and measurements etc.	2
Very low: Failure is unlikely	Design generally complies with earlier designs for which low failure rates were reported.	2
Very low: Failure is unlikely	Proven mature system / components with experience under comparable operating conditions with positively completed verification procedure. Proven mature system / components with long-term, faultless series production experience under comparable operating conditions. Design is similar to previous designs for which no failures are known.	1

Detection (D)		
Detection	Criteria: Likelihood, that test procedure will detect the failure	Rank
NOT detected	The test procedure within the range of design will not / cannot detect the potential cause / following failure or there is no check for this characteristic.	10
Discovered coincidentally only	Very little chance that the test procedure can detect the failure or the cause, since no detection method is specified.	9
Accidentally discovered	Little chance that the test procedure can detect the failure or the cause, since detection methods are uncertain or no experience with the established detection methods exist. Failures are more likely to be discovered by accident.	8
Very low probability	Very few chances that the test measure can detect the failure or the cause, since detection methods are not certain or have little experience with the established detection methods.	7
Low probability	Few chances that the test measure can detect the failure or the cause. Proven detection method from comparable products under completely new operational / general conditions.	6
Moderate probability	Medium opportunities that the test measure can detect the failure or cause. Proven detection method from comparable products under changed operational / general conditions.	5
Reasonable probability	Moderately high chances that the test measure can detect the error or the cause. Proven detection method from comparable products under similar operational / general conditions.	4
High probability	High chances that the test measure can detect the error or the cause. Proven detection method, efficacy has been demonstrated for this product under similar conditions.	3
Very high probability	Very high chances that the test measure can detect the error or the cause. Proven detection method, efficiency has been demonstrated for this product.	2
Certainly	The test procedure within the range of design will almost certainly detect the fault or the cause. Proven detection method, the efficiency has been proven for this product already in the previous generation.	1

## Design-FMEA – Severity

Effect	Criteria: Severity of Effect	Rank
Endangerment of health and life of humans	<b>Very high severity: Potential failure mode affects safe vehicle operation. Health and life of humans are endangered.</b> It could lead to an existence threatening company risk.	10
Noncompliance with government regulation	<b>Very high severity: Potential failure mode involves noncompliance with government regulation.</b> Humans are not endangered.	9
Loss of Primary Function Walk Home	<b>The vehicle is inoperable. Driving is not possible. The customer is extraordinary dissatisfied.</b> ( <i>Loss of primary function – walk home – vehicle stands still =&gt; driver has to walk. Vehicle slows down, no hazard of an accident</i> ) <b>System cannot be assembled / flashed at the final assembly at the OEM (line stopper).</b>	8
Degradation of Primary Function Limp Home	<b>The vehicle is operable, but at a reduced level. The customer is very dissatisfied. Immediate stay in the garage is imperatively necessary.</b> ( <i>limp home – vehicle can be driven in reduced mode only, e.g. limitation of maximum revolution</i> ) <b>System cannot be assembled / flashed at the final assembly at the tier 1 (line stopper).</b>	7
Loss of convenience function	<b>The vehicle is operable, but comfort functions are not available. The customer is dissatisfied.</b> ( <i>Air condition is not working, window cannot be opened, Hybrid has no function.</i> ) <b>System cannot be assembled at the pilot belt or fails at the end of line test at the Tier 1.</b>	6
Degradation of convenience function	<b>The vehicle is operable, but comfort functions are working at a reduced level. The customer is somewhat dissatisfied. Immediate stay in the garage is not necessary.</b> ( <i>Air condition is not working properly, window opens slowly, Hybrid has no full function.</i> ) <b>System cannot be assembled at the prototype building / set into function or fails at the function test.</b>	5
Sensory disturbance (high)	<b>Fit &amp; appearance / noises are disturbing. Failure is noticed by most customers – more than 75%. (Almost all customers will notice the failure, even non-critical representatives!)</b> Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting)	4
Sensory disturbance (moderate)	<b>Fit &amp; appearance / noises are disturbing. Failure is noticed by many customers – more than 50%. (On average every second customer will notice the failure.)</b> Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting)	3
Sensory disturbance (low)	<b>Fit &amp; appearance / noises are disturbing. Failure is noticed by some customers – less than 25%. (Those customers can hear the grass growing ☺)</b> Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting)	2
None	<b>No discernible effect. Only identifiable by qualified personnel.</b> ( <i>But out of tolerances; at this point the tolerances have to be discussed!</i> )	1

Rankings of failure effects have to be aligned common between manufacturer and customer (next recipient).

If failure effects are not known, severity has to be ranked with S = 10!

## Design-FMEA – Likelihood of Occurrence

Likelihood of failure	Criteria: Potential Failure Rates	Rank
Very high: Permanent failure	<b>New Development of systems /</b> components <b>without operating experience</b> and / or under <b>unexplained operating conditions</b> . It is almost sure that failures will occur on a large scale.	10
Very high: Permanent failure	<b>New Development of systems /</b> components <b>without operating experience</b> and / or under <b>unexplained operating conditions</b> . <b>Highly frequent occurrence</b> of the cause of the failure, unusable, inappropriate design concept or known system with problems.	9
High: Frequent failure	<b>New development of systems /</b> components <b>using new technologies</b> and / or <b>previously problematic technologies</b> . Design generally conforms to designs that have repeatedly caused <b>difficulties in the past</b> .	8
High: Frequent failure	<b>New development of systems /</b> components <b>using new technologies</b> and / or <b>previously problematic technologies</b> . Cause of failure occurs repeatedly, <b>problematic, immature design</b> .	7
Moderate: Occasional failure	<b>New development of systems /</b> components with experience and / or detail changes to previous developments under <b>comparable operating conditions</b> . Cause of failure occurs repeatedly, <b>not yet mature design</b> .	6
Moderate: Occasional failure	<b>New development of systems /</b> components with experience and / or detail changes to previous developments under <b>comparable operating conditions</b> . Design generally conforms to earlier designs that <b>occasionally</b> but not to a large extent <b>failed</b> .	5
Moderate: Occasional failure	<b>New development of systems /</b> components with experience and / or detail changes to previous developments under <b>comparable operating conditions</b> . Occasional cause of failure, suitable, <b>stage of maturity with advanced design</b> .	4
Low: Relative low failures	<b>New development of systems /</b> components with <b>positively completed appropriate verification procedure</b> . There are appropriate measures with a documented, positive result, e.g. simulations (FEM, etc.), tolerance calculations, specific tests and measurements etc.	3
Low: Relative low failures	<b>Detail changes of proven mature systems /</b> components with long-term, faultless series production experience under comparable operating conditions. Design generally complies with <b>earlier designs</b> for which <b>low failure</b> rates were reported.	2
Very low: Failure is unlikely	<b>Proven mature system /</b> components with experience <b>under comparable operating conditions with positively completed verification procedure</b> . Proven mature system / components with long-term, <b>faultless series production experience</b> under comparable operating conditions. Design is similar to previous designs for which <b>no failures are known</b> .	1

The ranking is always to be understood as a relative assessment rather than an absolute measure according to the current state of knowledge.

A confirmation or correction of the assessment may be made after the implementation of the action and its effectiveness check and the availability of new data.

## Design-FMEA – Likelihood of Detection

Detection	Criteria: Likelihood, that test procedure will detect the failure	Rank
NOT detected	The test procedure within the range of design will not / cannot detect the potential cause / following failure or there is <b>no check for this characteristic</b> . - No monitoring / no diagnosis by the system of the function to be checked	10
Discovered coincidentally only	Discovered coincidentally only: Very little chance that the test procedure can detect the failure or the cause, since <b>no detection method is specified</b> . - In the diagnosis hardly or only with great effort discoverable	9
Accidentally discovered	Little chance that the test procedure can detect the failure or the cause, since <b>detection methods are uncertain</b> or <b>no experience with the established detection methods</b> exist. Failures are more likely to be discovered by accident. - Monitoring / diagnosis of partial scopes of the functions to be monitored respectively only under certain operating conditions by the system or the user - Altered function, e.g. comfortable replacement operation	8
Very low probability	Very few chances that the test measure can detect the failure or the cause, since <b>detection methods are not certain</b> or have <b>little experience with the established detection methods</b> . - Monitoring / diagnosis of partial scopes of the functions to be monitored respectively only under certain operating conditions by the system or the user - Discoverable only with great effort during diagnosis	7
Low probability	Few chances that the test measure can detect the failure or the cause. <b>Proven detection method</b> from comparable products under <b>completely new operational / general conditions</b> . - Discoverable at diagnosis only with reasonable effort	6
Moderate probability	Medium opportunities that the test measure can detect the failure or cause. <b>Proven detection method</b> from comparable products under <b>changed operational / general conditions</b> . - Monitoring / diagnosis of partial scopes of the functions to be monitored by the system	5
Reasonable probability	Moderately high chances that the test measure can detect the error or the cause. <b>Proven detection method</b> from comparable products under <b>similar operational / general conditions</b> . - - Functional failure / replacement operation and / or warning of the user e.g. by statically controlled warning lamp	4
High probability	High chances that the test measure can detect the error or the cause. <b>Proven detection method</b> , efficacy has been demonstrated for this <b>product under similar conditions</b> . - - Functional failure and replacement operation with clearly noticeable impairment and / or warning of the user e.g. by flashing warning light	3
Very high probability	Very high chances that the test measure can detect the error or the cause. <b>Proven detection method</b> , efficiency has been demonstrated for this product. - Discoverable safely with little effort in the diagnosis, e.g. through service routine	2
Certainly	The test procedure within the range of design will almost certainly detect the fault or the cause. <b>Proven detection method</b> , the efficiency has been proven for this product <b>already in the previous generation</b> . - No common cause effects between fault cause and detection measure imaginable Functional failure / replacement operation with clearly noticeable impairment and / or with clearly perceptible warning of the user e.g. by an acoustic signal - By self-diagnosis / display without additional test equipment safely discoverable by the user or the diagnosis.	1