FMEA-ranking-scales

Machinery-FMEA - Overview

Severity (S)

Effect	Criteria: Severity of Effect	S
Health and life of humans is endangered	Very high severity ranking – Affects the safety of the vehicle, operator, plant, or maintenance personnel. Health and life of humans is endangered. It could lead to an existence threatening company risk.	10
Noncompliance with government regulation	High severity ranking – Affects the noncompliance with government regulation. Humans are not endangered. Unacceptable cost overrun is possible.	9
Very high	Vehicle inoperable, loss of the primary function. The customer is extraordinary dissatisfied. (walk home) Downtime of more than 8 hours or the production of defective parts for more than 4 hours.	8
High	Vehicle operable, but at a reduced level. The customer is very dissatisfied. (limp home) Downtime of between 4 and 8 hours or the production of defective parts between 2 and 4 hours.	7
	Vehicle operable, but comfort functions are not available. The customer is dissatisfied. Downtime of between 1 and 4 hours or the production of defective parts for between 1 and 2 hours.	6
Low	Vehicle operable, but comfort functions are working at a reduced level. The customer is somewhat dissatisfied. Downtime of between 30 minutes and 1 hour or the production of defective parts for up to 1 hour.	5
Very low	Fit & appearance / noises are very disturbing. Failure is noticed by most customers (more than 75%). Downtime of between 10 and 30 minutes but no production of defective parts.	4
Minor	Fit & appearance / noises are disturbing. Failure is noticed by many customers (round about 50%). Downtime of up to 10 minutes but no production of defective parts.	3
	Fit & appearance / noises are hardly disturbing. Failure is noticed by some discriminating customers (less than 25%). Process parameter variability not within specification limits. Adjustment or other process controls need to be taken during production. No downtime and no production of defective parts.	2
No effect	No discernible effect to the customer. Process parameter variability within specification limits. Adjustment or other process controls can be done during normal maintenance.	1

Occurrence (O)

Criteria: Possible number of failures within cycles of operation	Criteria: Possible number of failures within hours of operation	Criteria: The reliability based on the users required time.	O
Failure occurs every hour.	1 failure in 1 hour	R(t) < 1%: MTBF is about 10% of the user`s required time.	10
Failure occurs every shift.	1 failure in 8 hours	R(t)= 5%: MTBF is about 30% of the user`s required time.	9
Failure occurs every day.	1 failure in 24 hours	R(t)= 20%: MTBF is about 60% of the user`s required time.	8
Failure occurs every week.	1 failure in 80 hours	R(t)= 37%: MTBF is equal to the user`s required time.	7
Failure occurs every month.	1 failure in 350 hours	R(t)= 60%: MTBF is 2 times greater than the user`s required time.	6
Failure occurs every 6 months.	1 failure in 2,500 hours	R(t)= 85%: MTBF is 6 times greater than the user`s required time.	5
Failure occurs every 1 year.	1 failure in 5,000 hours	R(t)= 90%: MTBF is 10 times greater than the user`s required time.	4
Failure occurs every 2 years.	1 failure in 10,000 hours	R(t)= 95%: MTBF is 20 times greater than the user`s required time.	3
Failure occurs every 5 years.	1 failure in 25,000 hours (210d-24h-5y)	R(t)= 98%: MTBF is 50 times greater than the user`s required time.	2
Failure is eliminated through preventive control.			1

Detection (D)

Detection	Criteria: Likelihood of Detection by Design (Detection) Control	D
Almost impossible	Design or machinery controls will not / cannot detect a potential cause and subsequent failure, or there are no design or machinery controls for this characteristic.	10
Very remote	Very remote chance that design or machinery controls for this characteristic will detect a potential cause and subsequent failure mode. There are random checks only.	9
Remote	Remote chance that design or machinery controls for this characteristic will detect a potential cause and subsequent failure mode. Machinery control will provide indication of failure.	8
	Very low chance that design or machinery controls for this characteristic do not prevent the failure from occurring. Machinery controls will isolate the cause and subsequent failure mode after the failure has occurred.	7
Low	Low chance that design or machinery controls will detect the potential cause and subsequent failure mode. Machinery controls will provide an indicator of imminent failure.	6
Moderate	Medium chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls will prevent imminent failure.	5
Moderately high	Moderately high chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls will prevent imminent failure.	4
High	High chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls will prevent an imminent failure and isolate the cause.	3
	Very high chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls may not be required.	2
Almost certain	Detection not applicable; Failure Prevention: Failure cause of failure mode cannot occur because it is fully prevented through design solutions (e.g., proven design standards, best practice or common material, etc.). Machinery test procedure is not necessary.	1

Machinery-FMEA - Severity

Effect	Criteria: Severity of Effect	Ranking
Health and life of humans is endangered	Very high severity ranking – Health and life of humans is endangered: Potential failure mode affects safe vehicle operation. Health and life of humans is endangered (passengers / road users / operator / other operators). It could lead to an existence threatening company risk.	10
Noncompliance with govern-ment regulation	High severity ranking – Potential failure mode involves noncompliance with government regulation: Failure involves violating the compliance to legal regulations or noncompliance with government regulations. Humans (passengers / road users / operator / other operators) are not endangered. Unacceptable cost overrun is possible.	9
Very high - Loss of Primary Function Walk Home	The vehicle is inoperable, loss of the primary function. The customer is extraordinary dissatisfied. (Loss of primary function – walk home – vehicle stands still => driver has to walk. Vehicle slows down to still stand, no hazard of an accident.) Major disruption of production: Downtime of more than 8 hours or the production of defective parts for more than 4 hours.	8
High – Degrada-tion of Primary Function Limp Home	The vehicle is operable, but at a reduced level. Degradation of Primary Function: The customer is very dissatisfied. Immediate stay in the garage is imperatively necessary. (Limp home – vehicle can be driven in reduced mode only, e.g. limitation of maximum engine speed.) Significant disruption of production: Downtime of more than 4 and 8 hours or the production of defective parts between 2 and 4 hours.	7
Moderate - Loss of convenience function	The vehicle is operable, but comfort functions are not available. Loss of Secondary Function: The customer is dissatisfied. (Air condition is not working, window cannot be opened, no radio, hybrid has no function.) Moderate disruption of production: Downtime of between 1 and 4 hours or the production of defective parts for between 1 and 2 hours.	6
Low – Degrada-tion of conve-nience function	The vehicle is operable, but comfort functions are working at a reduced level. Degradation of Secondary Function: The customer is somewhat dissatisfied. (Air condition is not working properly, window opens slowly, radio disturbance, hybrid has no full function.) Moderate disruption of production: Downtime of between 30 minutes and 1 hour or the production of defective parts for up to 1 hour.	5
Very low – Sen-sory disturbance (high)	Fit & appearance / noises are very disturbing: Failure is noticed by most customers (more than 75%). (Almost all customers will notice the failure, even non-critical representatives!) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting). Minor disruption of production: Downtime of between 10 and 30 minutes but no production of defective parts.	4
Minor - Sensory disturbance (moderate)	Fit & appearance / noises are disturbing: Failure is noticed by many customers (round about 50%). (On average every second customer will notice the failure.) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting). Low inconvenience of production: Downtime of up to 10 minutes but no production of defective parts.	3
Very minor - Sensory distur-bance (low)	Fit & appearance / noises are hardly disturbing: Failure is noticed by some customers (less than 25%). (Those customers can hear the grass growing. ☺) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting) Very low inconvenience of production: Process parameter variability not within specification limits. Adjustment or other process controls need to be taken during production. No downtime and no production of defective parts.	2
None	No discernible effect to the customer: Only identifiable by qualified personnel. (But out of tolerances; at this point the tolerances have to be considered.) No inconvenience in production: Process parameter variability within specification limits. Adjustment or other process controls can be done during normal maintenance.	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!

Machinery-FMEA - Occurrence

Criteria: Possible number of failures within cycles of operation	Criteria: Possible number of failures within hours of operation	MTBF	$R(t)^{(t)}$	Criteria: The reliability based on the users required time	Ranking
Failure occurs every hour.	1 failure in 1 hour	1	0.03%	R(t) < 1%: MTBF is about 10% of the user`s required time.	10
Failure occurs every shift.	1 failure in 8 hours	8	4.98%	R(t)= 5%: MTBF is about 30% of the user`s required time.	9
Failure occurs every day.	1 failure in 24 hours	24	18.89%	R(t)= 20%: MTBF is about 60% of the user`s required time.	8
Failure occurs every week.	1 failure in 80 hours (5d x 24h = 120h)	80	36.79%	R(t)= 37%: MTBF is equal to the user`s required time.	7
Failure occurs every month.	1 failure in 350 hours (210d x 24h x 1/12y = 420h)	350	60.65%	R(t)= 60%: MTBF is 2 times greater than the user`s required time.	6
Failure occurs every 6 months.	1 failure in 2,500 hours (210d x 24h x 0,5y = 2,520h)	2,500	85.21%	R(t)= 85%: MTBF is 6 times greater than the user`s required time.	5
Failure occurs every year.	1 failure in 5,000 hours (210d x 24h x 1y = 5,040h)	5,000	90.48%	R(t)= 90%: MTBF is 10 times greater than the user`s required time.	4
Failure occurs every 2 years.	1 failure in 10,000 hours (210d x 24h x 2y = 10,080h	10,000	95.12%	R(t)= 95%: MTBF is 20 times greater than the user`s required time.	3
Failure occurs every 5 years.	1 failure in 25,000 hours (210d x 24h x 5y = 25,200h)	25,000	98.02%	R(t)= 98%: MTBF is 50 times greater than the user`s required time.	2
Failure is eliminated through preventive control.					1

The ranking is always to be understood as a relative estimate instead of an absolute measure according to the current state of knowledge. The „Failure per time unit" cannot be converted. A confirmation or correction of the estimate may be made after the implementation of the action and its effectiveness check and the availability of new data.

For calculation we come from 210 working days per year, 3 shifts per day and 5 working days per week.

More examples for calculation you will find within AIAG book „Machinery FMEA" at page 19 and Appendix D (page 34).

$R(t)^{(t)} = e^{-t/mtbf}$

MTBF: Mean Time Between Failures (The sum of the total operating time of a machine divided by the total number of occurred failures.)

Machinery-FMEA - Detection

Detection	Criteria: Likelihood, that test procedure within the range of design / of process will detect the failure	Ranking
Almost impossible	Design or machinery controls will not / cannot detect a potential cause and subsequent failure, or there are no design or machinery controls for this characteristic.	10
Very remote	Very remote chance that design or machinery controls for this characteristic will detect a potential cause and subsequent failure mode. There are random checks only.	9
Remote	Remote chance that design or machinery controls for this characteristic will detect a potential cause and subsequent failure mode. Machinery control will provide indication of failure.	8
Very low	Design or machinery controls for this characteristic do not prevent the failure from occurring. Machinery controls will isolate the cause and subsequent failure mode after the failure has occurred.	7
Low	Low chance that design or machinery controls will detect the potential cause and subsequent failure mode. Machinery controls will provide an indicator of imminent failure.	6
Moderate	Medium chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls will prevent imminent failure.	5
Moderately high	Moderately high chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls will prevent imminent failure.	4
High	High chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls will prevent an imminent failure and isolate the cause.	3
Very high	Very high chance that design controls will detect a potential cause and subsequent failure mode. Machinery controls may not be required.	2
Almost certain	Detection not applicable; Failure Prevention: Failure cause of failure mode cannot occur because it is fully prevented through design solutions (e.g., proven design standards, best practice or common material, etc.). Machinery test procedure is not necessary.	1