Ranking Scales for Process-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q

SEVERITY – Process-FMEA

S	SAE J1739 (Status: 01/2009) - effects on product - effects on process	AIAG, FMEA 4th edition (Status: 06/2008) - effects at customer - effects at machining / assembly	VDA volume 4-II (Status: 06/2012)	VDA/AIAG yellow volume (Status: 11/2017) - Your Plant - Ship to Plant - Customer	Proposal i-Q Schacht & Kollegen GmbH (Status: 03/2018)
10	**Safety and / or Regulatory Compliance** Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation without warning. May endanger operator (machine or assembly) without warning.	**Failure to Meet Safety and / or Regulatory Requirements** Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation without warning.	**Very high** Extremely severe failure that affects the safety and / or violates the compliance to legal regulations. Existence-endangering risk to the company. For quality reasons the product cannot be delivered. Unacceptable cost overruns.	Failure may endanger operator (machine or assembly), possible long-term effects on health of production associates. Failure may endanger operator (machine or assembly), possible long-term effects on health of production associates. Affects safe operation of the vehicle and / or other vehicles, the health of operator or passenger(s) or road users or pedestrians.	**Health and life of humans are endangered:** Failure affects safe vehicle operation. Health and life of passengers / road users / operator / other operators are endangered. It could lead to an **existence threatening company risk**.
9	**Safety and / or Regulatory Compliance** Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation with warning. May endanger operator (machine or assembly) with warning.	**Failure to Meet Safety and / or Regulatory Requirements** Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation with warning.	**Very high** Extremely severe failure that affects the safety and / or violates the compliance to legal regulations. Existence-endangering risk to the company. For quality reasons the product cannot be delivered. Unacceptable cost overruns.	Failure may result in in-plant regulatory noncompliance. Failure may result in in-plant regulatory noncompliance. Noncompliance with regulations	**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**.
8	**Primary Function – Essential** Loss of primary function (vehicle inoperable, does not affect safe vehicle operation). 100% of product may have to be scrapped. Line shutdown or stop shipment.	**Loss or Degradation of Primary Function** Loss of primary function (vehicle inoperable, does not affect safe vehicle operation).	**High** Highly delayed delivery High amount of reworking Production line standstill Tool wear or damage is high High cost overruns High amount of scrap	100% of product affected may have to be scrapped. Line shut down greater than full production shift. Stop shipment possible. Field repair or replacement required (assembly to end user) other than for regulatory noncompliance. **Loss** of essential vehicle function necessary for normal driving during expected service life.	**Loss of Primary Function:** Driving is not possible. The customer is extraordinary dissatisfied. (Loss of primary function – walk home – vehicle stands still => driver has to walk. Vehicle slows down, no hazard of an accident.) **Major disruption of production:** System cannot be assembled / flashed at the final assembly at the OEM (line stopper). 100% of products may have to be scrapped – delivery stop.
7	**Primary Function – Essential** Degradation of primary function (vehicle operable, but at reduced level of performance) A portion of the production run may have to be scrapped. Deviation from primary process; decreased line speed or added manpower.	**Loss or Degradation of Primary Function** Degradation of primary function (vehicle operable, but at reduced level of performance).	**High** Highly delayed delivery High amount of reworking Production line standstill Tool wear or damage is high High cost overruns High amount of scrap	A portion of the production run may have to be scrapped. Deviation from primary process; decreased line speed or added manpower. Line shutdown one hour up to full production shift. Stop shipment possible. Field repair or replacement required (assembly to end user) other than for regulatory noncompliance. **Degradation** of essential vehicle function necessary for normal driving during expected service life.	**Degradation of Primary Function:** The vehicle is operable, but at a reduced level. 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:** System cannot be assembled / programmed at the final assembly at the tier 1 (line stopper). A portion of the production run may have to be scrapped. Deviation from primary process; decreased line speed or added manpower.
6	**Secondary Function – Convenient** Loss of secondary function (vehicle operable, but comfort / convenience functions inoperable). 100% of the production run may have to be reworked off line and accepted.	**Loss or Degradation of Secondary Function** Loss of secondary function (vehicle operable, but comfort/ convenience functions inoperable).	**Moderate** Delayed delivery Moderate amount of reworking Process disruptions Moderate tool wear or damage Moderate cost overruns Moderate amount of scrap	100% of production run may have to be reworked off line and accepted. Line shutdown up to one hour **Loss** of convenience function.	**Loss of Secondary Function:** The vehicle is operable, but comfort functions are not available. The customer is dissatisfied. (Air condition is not working, window cannot be opened, hybrid has no function.) **Moderate disruption of production:** System cannot be assembled at the pilot belt or fails at the end of line test at the Tier 1. 100% of the production run may have to be reworked off line and accepted.

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5	**Secondary Function – Convenient** Degradation of secondary function (vehicle operable, but comfort / convenience functions at reduced level of performance). A portion of the production run may have to be reworked offline and accepted.	**Loss or Degradation of Secondary Function** Degradation of secondary function (vehicle operable, but comfort/convenience functions at reduced level of performance).	**Moderate** Delayed delivery Moderate amount of reworking Process disruptions Moderate tool wear or damage Moderate cost overruns Moderate amount of scrap	A portion of the production run may have to be reworked off line and accepted. Less than 100% of product affected. Strong possibility for additional defective product – sort required. No line shutdown **Degradation** of convenience function.	**Degradation of Secondary Function**: The vehicle is operable, but comfort functions are working at a reduced level. 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:** System cannot be assembled at the prototype building / set into function or fails at the function test. A portion of the production run may have to be reworked offline and accepted.
4	**Annoyance** Appearance or Audible Noise, vehicle operable, item does not comfort. Defect noticed by most customers (>75%). 100% of the production run may have to be reworked in station before it is processed.	**Annoyance** Appearance or Audible Noise, vehicle operable, item does not conform and noticed by most customers (>75%).	**Moderate** Delayed delivery Moderate amount of reworking Process disruptions Moderate tool wear or damage Moderate cost overruns Moderate amount of scrap	100% of production run may have to be reworked in station before it is processed. Defective product triggers significant reaction plan. Additional defective products not likely. Sort not required. Perceived quality of appearance, sound or haptics unacceptable to most customers.	**Fit & appearance / noises are disturbing:** Failure is noticed by most customers (>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:** 100% of the production run may have to be reworked in station before it can be processed.
3	**Annoyance** Appearance or Audible Noise, vehicle operable, item does not comfort. Defect noticed by many customers (50%). A portion of the production run may have to be reworked in station before it is processed.	**Annoyance** Appearance or Audible Noise, vehicle operable, item does not conform and noticed by many customers (50%).	**Low** Little reworking Low process disruption Low cost overruns Low amount of scrap	A portion of the production run may have to be reworked in station before it is processed. Defective product triggers minor reaction plan. Additional defective products not likely. Sort not required. Perceived quality of appearance, sound or haptics unacceptable to many customers.	**Fit & appearance / noises are disturbing:** Failure is noticed by many customers (>50%). (On average every second customer will notice the failure.) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting) **Low inconvenience of production:** A portion of the production run may have to be reworked in station before it can be processed.
2	**Annoyance** Appearance or Audible Noise, vehicle operable, item does not conform. Defect noticed by discriminating customers (<25%). Slight inconvenience to process, operation or operator.	**Annoyance** Appearance or Audible Noise, vehicle operable, item does not conform and noticed by discriminating customers (<25%).	**Low** Little reworking Low process disruption Low cost overruns Low amount of scrap	Slight inconvenience to process, operation, or operator. Defective product triggers no reaction plan. Additional defective products not likely. Sort not required. Requires feedback to supplier. Perceived quality of appearance, sound or haptics unacceptable to some customers.	**Fit & appearance / noises are rarely disturbing:** Failure is noticed by some customers (<25%). (Those customers can hear the grass growing. ☺) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting) **Very low inconvenience of production**: Slight inconvenience to process, operation or operator.
1	**No effect** No discernible effect.	**No effect** No discernible effect.	**Very Low** Very low, acceptable cost overrun	No discernible effect. Defective product triggers no reaction plan. Additional defective products not likely. Sort not required. Feedback to supplier not required. No discernible effect.	**No discernible effect:** Only identifiable by qualified personnel. (But out of tolerances; at this point the tolerances have to be considered.) **No inconvenience in production.**

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OCCURENCE – Process-FMEA

0	SAE J1739 (Status: 01/2009) (incidents per 1.000 items/ vehicles)	AIAG, FMEA 4th edition (Status: 06/2008) (incidents per items/ vehicles)	VDA volume 4-II (Status: 06/2012) (Process design) (Process design failure rate in ppm)	VDA/AIAG yellow volume (Status: 11/2017) - Estimated Occurrence - Process Experience - Prevention Controls	Proposal i-Q Schacht & Kollegen GmbH (Status: 03/2018)
10	**Very High** ≥ 100 per thousand pieces ≥ 1 in 10	**Very High** ≥ 100 per thousand ≥ 1 in 10	**Very High** New process without experience. (500,000 ppm)	Occurrence during manufacturing or assembly cannot be determined, no preventive controls, or occurrence during manufacturing or assembly is extremely high. New process without experience. New product application. Best practices and procedures do not exist.	**Always:** New process without experience. 100.000 ppm / 1 failure per 10 parts / C_{pk}=0,43 Permanent failure
9	**High** 50 per thousand pieces 1 in 20	**High** 50 per thousand 1 in 20	**Very High** New process without experience. (100,000 ppm)	Very high occurrence during manufacturing or assembly. Limited experience with the process. Application significantly different from previous application. Not targeted to specific failure cause. Newly developed for this process. First application of new procedures with no experience.	**Very high:** New process without experience. 50.000 ppm / 1 failure per 20 parts / C_{pk}=0,55 Multiple failures per hour
8	**High** 20 per thousand pieces 1 in 50	**High** 20 per thousand 1 in 50	**High** New process with known but problematic procedure. (30,000 ppm)	High occurrence during manufacturing or assembly. Known but problematic process. Application presents significant process challenges. Not a reliable prevention of the failure cause. Few existing procedures and best practices, not directly applicable for this process.	**High:** New process with known but problematic procedure. 20.000 ppm / 1 failure per 50 parts / C_{pk}=0,68 One failure per hour
7	**High** 10 per thousand pieces 1 in 100	**High** 10 per thousand 1 in 100	**High** New process with known but problematic procedure. (10,000 ppm)	Moderately high occurrence during manufacturing or assembly. Similar process with evidence of non-conformance in excess of acceptance rate. No experience with this application in the company. Provides limited use in preventing a failure cause. Procedures and best practices apply to the baseline process, but not the innovations.	**Significant:** New process with known but problematic procedure 10.000 ppm / 1 failure per 100 parts / C_{pk}=0,77 One failure per shift
6	**Moderate** 2 per thousand pieces 1 in 500	**Moderate** 2 per thousand 1 in 500	**Moderate** New process carrying over known procedure. Mature process with positive production experience under altered conditions. (5,000 ppm)	Moderate occurrence during manufacturing or assembly. Similar process with some evidence of non-conformance. Limited experience with this application in the company. Provides some ability to prevent a failure cause. Procedures and best practices exist but are insufficient to ensure that the failure will not occur.	**Moderate:** New process carrying over known procedure. Mature process with positive production experience under altered conditions. 2.000 ppm / 1 failure per 500 parts / C_{pk}=0,96 Multiple failures per day
5	**Moderate** 0.5 per thousand pieces 1 in 2.000	**Moderate** 0.5 per thousand 1 in 2.000	**Moderate** New process carrying over known procedure. Mature process with positive production experience under altered conditions. (2,000 ppm)	Moderate occurrence during manufacturing or assembly. Similar process with some evidence of non-conformance. Limited experience with this application in the company. Capable of finding deficiencies in the process. Process Design addresses lessons learned from previous designs. Best practices re-evaluated for this process, but have not yet been proven. Provides some indication that the process will not have problems.	**Moderate:** New process carrying over known procedure. Mature process with positive production experience under altered conditions. 500 ppm / 1 failure per 2.000 parts / C_{pk}=1,1 One failure per week
4	**Moderate** 0.1 per thousand pieces 1 in 10.000	**Moderate** 0.1 per thousand 1 in 10.000	**Moderate** New process carrying over known procedure. Mature process with positive production experience under altered conditions. (500 ppm)	Moderately low occurrence during manufacturing or assembly. New setup based on proven process. Application does not introduce significant risk of process challenges. Capable of finding deficiencies in the process related to the failure. Predecessor process and changes for new processes conforms to best practices and procedures. Indicates likely process conformance.	**Minor:** New process carrying over known procedure. Mature process with positive production experience under altered conditions. 100 ppm / 1 failure per 10.000 parts / C_{pk}=1,24 One failure per month

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3	**Low** 0.01 per thousand 1 in 100.000	**Low** 0.01 per thousand 1 in 100.000	**Low** Changes to detail on mature processes with positive production experience under comparable conditions. (100 ppm)	Low occurrence during manufacturing or assembly. Process has been tried and tested with successful results in series production. History of capability within control limits. Similar application. Capable of finding deficiencies in the process related to the failure. Process expected to conform to best practices and procedures, considering lessons learned from previous processes. Predicts conformance of production design.	**Low:** Changes to detail on mature processes with positive production experience under comparable conditions. 10 ppm / 1 failure per 100.000 parts / C_{pk}=1,42 One failure per quarter
2	**Low** ≤ 0,001 per thousand pieces 1 in 1.000.000	**Low** ≤ 0,001 per thousand 1 in 1.000.000	**Low** Changes to detail on mature processes with positive production experience under comparable conditions. (10 ppm)	Very low occurrence during manufacturing or assembly. Process has been tried and tested with successful results in series production. History of capability within control limits. Carryover application. Capable of finding deficiencies in the process related to the failure. Process expected to conform to best practices, considering lessons learned from previous processes, with significant margin of confidence. Indicates confidence in design conformance	**Very low:** Changes to detail on mature processes with positive production experience under comparable conditions. 1 ppm / 1 failure per 1.000.000 parts / C_{pk}=1,58 One failure per year
1	**Very Low** Failure is eliminated through preventative control.	**Very Low** Failure is eliminated through preventive control.	**Very Low** New process under altered conditions with positively completed proof of machine and process capability. Mature process with positive production experience under comparable conditions and comparable machines. (1 ppm)	Possibility of failures is eliminated through preventative control and history of failure-free series production. The failure cannot occur in series production. Cause cannot occur because failure is eliminated through demonstrated preventative control. Failure cannot occur in series production. Process proven to conform to procedures and best practices, considering lessons learned.	**Unlikely:** New process under altered conditions with positively completed proof of machine and process capability. Mature process with positive production experience under comparable conditions and comparable machines. ≤ 1 ppm / ≤ 1 failure per 1.000.000 parts Less than 1 failure per year

Relation between C_p and PPM values

C_p	0,50	0,67	0,75	0,90	1,00	1,30	1,33	1,40	1,50	1,60	1,67	2,00
PPM	133.614	44.431	24.448	6.933	2.699	96	66	26	6	1,6	0,6	0,002
Sigma					3σ		4σ				5σ	6σ

Relation between C_{pk} and PPM values

C_{pk}	0,50	0,67	0,75	0,90	1,00	1,30	1,33	1,40	1,50	1,60	1,67	2,00
PPM	66.807	22.216	12.224	3.467	1.350	48	33	13	3	0,8	0,3	0,001

At a symmetrical process distribution a C_p value 1,0 correlates to a value of 2.700 ppm.

If the process is out of range, then this will be a C_{pk} value. Producing only nOK parts on this side of tolerance zone the percentage of incorrect parts thereby will halve (approximately) in half of the C_p value, so in our case in 1.350 ppm.

Generally the C_p value is a bilateral viewing and the C_{pk} value is an unilateral viewing, at whom the inferior to either side will be used for process rating. Nevertheless it is also reasonable for C_{pk} value figuring the ppms to the "superior" side.

The bad habit of indicating a C_p value at unilateral tolerated characteristics (that isn´t mathematical logic, because of no existing tolerance range UTL-LTL resp. tolerance range is infinite) possibly had led one or the other user to a misconception. Or is it directly or indirectly written off a statistic software provider who was thinking of new (funny, but unfounded) definitions of C_p and C_{pk} values, thereby offering users a more easier life at first sight?

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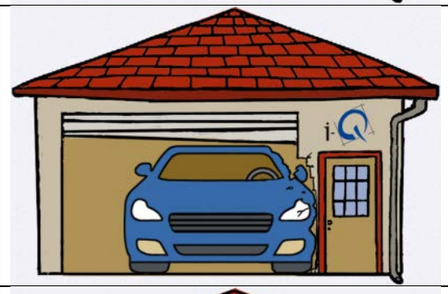
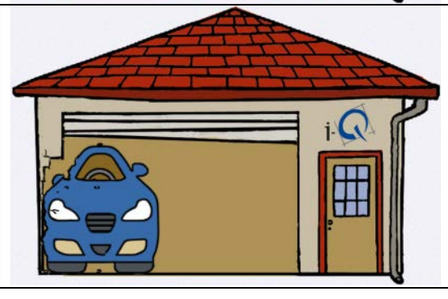
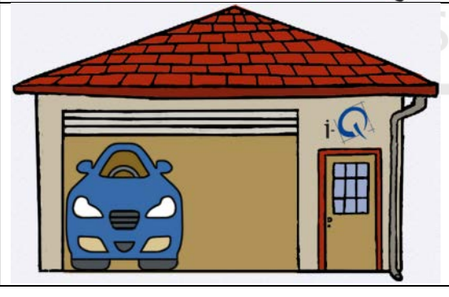
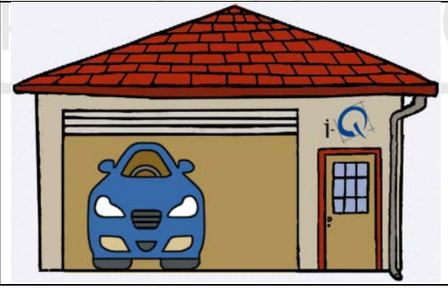
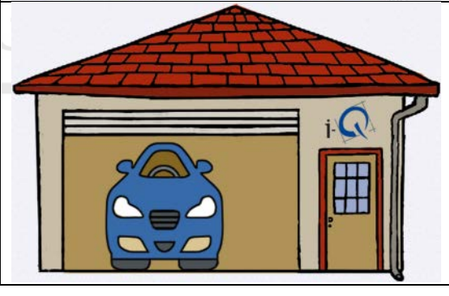
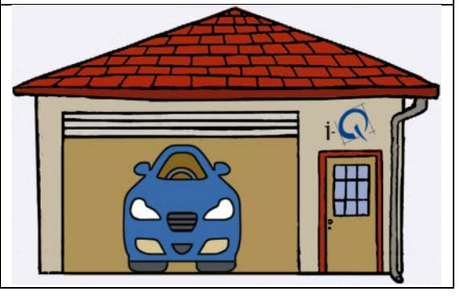
C_p/ C_{pk}	C_{pk} < 1,0	C_{pk} = 1,0	C_{pk} = 1,33	C_{pk} = 1,67	C_{pk} = 2,0
C_p < 1,0		Impossible because **$C_p \geq C_{pk}$** have to be!	Impossible because **$C_p \geq C_{pk}$** have to be!	Impossible because **$C_p \geq C_{pk}$** have to be!	Impossible because **$C_p \geq C_{pk}$** have to be!
C_p = 1,0			Impossible because **$C_p \geq C_{pk}$** have to be!	Impossible because **$C_p \geq C_{pk}$** have to be!	Impossible because **$C_p \geq C_{pk}$** have to be!
C_p = 1,33				Impossible because **$C_p \geq C_{pk}$** have to be!	Impossible because **$C_p \geq C_{pk}$** have to be!
C_p = 1,67					Impossible because **$C_p \geq C_{pk}$** have to be!
C_p = 2,0					

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DETECTION – Process-FMEA

D	SAE J1739 (Status: 01/2009) (Detection by process control)	AIAG, FMEA 4th edition (Status: 06/2008) (Opportunity - Likelihood)	VDA volume 4-II (Status: 06/2012) (Detection in process)	VDA/AIAG yellow volume (Status: 11/2017)	Proposal i-Q Schacht & Kollegen GmbH (Status: 03/2018)
10	**Absolute Uncertainty** No current process control; Cannot detect or is not analyzed.	**No detection opportunity – Almost Impossible** No current process control; Cannot detect or is not analyzed.	**Very Low** Failure with very low detection potential, since a proof procedure is not known and / or has not been established.	**Absolute uncertainty:** The failure will not or cannot be detected as no testing or inspection method has been established or is known.	**NOT detected:** Almost Impossible: no current process control; Cannot be detected or is not analysed. 1 in 2 failures will not be detected / $C_{pk} \leq 0{,}33$ No failure detection
9	**Difficult to Detect** Defect (Failure Mode) and / or error (Cause) is not easily detected (e.g. random audits).	**Not likely to detect at any stage – Very Remote** Failure Mode and/ or Error (cause) is not easily detected (e.g. random audits).	**Very Low** Failure with very low detection potential, since a proof procedure is not known and / or has not been established.	**Very remote:** Failure is not easily detected. Random audits <100% of product. It is unlikely that the testing or inspection method will detect a possible malfunction or fault mechanism.	**Discovered coincidentally only:** Failure Mode and/ or Error (cause) is not easily detected. Only random proof procedures (audits) have been established. 1 in 10 failures will not be detected / $C_{pk} \geq 0{,}33$ 10% not detected failures
8	**Defect Detection Post-Processing** Defect (Failure Mode) detection post-processing by operator through visual / tactile / audible means.	**Problem Detection Post Processing - Remote** Failure Mode detection post-processing by operator through visual / tactile / audible means.	**Low** Failure with a low detection potential, since the proof procedure is uncertain and / or there is no experience with the established proof procedure.	**Remote:** Defect (Failure Mode) detection downstream through visual, tactile or audible means. Ability of testing or inspection method is uncertain or the company / business unit has no experience with the defined testing or inspection method. The method relies on a human for verification and disposition.	**Accidentally discovered:** Failure Mode and/ or Error (cause) is not easily detected. Detection post-processing by operator through visual / tactile / audible means. 1 in 20 failures will not be detected / $C_{pk} \geq 0{,}67$ 5% not detected failures
7	**Defect Detection at Source** Defect (Failure Mode) detection in station by operator through visual / tactile / audible means or post-processing through use of attribute gauging (go/no –go, manual torque check / clicker wrench, etc).	**Problem Detection at Source – Very Low** Failure Mode detection in-station by operator through visual / tactile / audible means or post-processing through use of attribute ganging (go/ no-go, manual torque check/clicker wrench, etc.)	**Low** Failure with a low detection potential, since the proof procedure is uncertain and / or there is no experience with the established proof procedure.	**Very low:** Defect (Failure Mode) detection in-station through visual, tactile or audible means. Ability of testing or inspection method is very low or the company / business unit has little experience with the defined testing or inspection method available. The method relies on a human for verification and disposition.	**Very low probability:** Failure Mode will be detected in-station by operator through visual / tactile / audible means or post-processing through use of attribute gauges (go/ no-go, manual torque check/clicker wrench, etc.) 1 in 50 failures will not be detected / $C_{pk} \geq 1{,}00$ 2% not detected failures
6	**Defect Detection Post-Processing** Defect (Failure Mode) detection post-processing by operator through use of variable gauging or in station by operator through use of attribute gauging (go/no –go, manual torque check / clicker wrench, etc.).	**Problem Detection Post Processing - Low** Failure Mode detection post-processing by operator through use of variable gauging or in station by operator through use of attribute ganging (go/ no-go, manual torque check/clicker wrench, etc.)	**Moderate** Failure with a moderate detection potential. Mature proof procedure from comparable products under new usage/boundary conditions.	**Low:** Defect (Failure Mode) detection downstream through use of variable gauging (e.g. calipers, dial gauge, etc.) or attribute gauging (e.g. go/no-go, manual torque check / clicker wrench, etc.). Ability of testing or inspection method not been proven for this application. The company / business unit has experience with the defined testing or inspection method. Test / inspection / measuring equipment capability is not yet proven.	**Low probability:** Failure Mode will be detected post-processing by operator through use of variable gauging or in station by operator through use of attribute gauges (go/ no-go, manual torque check/clicker wrench, etc.). 1 in 100 failures will not be detected / $C_{pk} \geq 1{,}33$ 1% not detected failures
5	**Defect Detection at Source** Defect (Failure Mode) or Error (Cause) detection in station by operator through use of variable gauging or by automated controls in station that will detect discrepant part and notify operator (light, buzzer, etc.). Gauging performed on setup and first-piece check (for setup-causes only).	**Problem Detection at Source – Moderate** Failure Mode or Error (Cause) detection in-station by operator through use of variable gauging or by automated controls in-station that will detect discrepant part and notify operator (light, buzzer, etc.). Gauging performed on setup and first-piece check (for set-up causes only).	**Moderate** Failure with a moderate detection potential. Mature proof procedure from comparable products under new usage/boundary conditions.	**Moderate:** Defect (Failure Mode) or Error (Failure Cause) detection in station through use of variable gauging (calipers, dial gauge, etc.) or attribute gauging (go / no-go, manual torque check / clicker wrench, etc.). Proven testing or inspection method for comparable products under new operating / boundary conditions. Test / inspection / measuring equipment capability for comparable processes is confirmed through gauge repeatability and reproducibility evaluations. For set-up Causes only: Confirmation of setup with first piece check and use of last piece check, as applicable.	**Moderate probability:** Error (Failure Cause) will be detected in-station by operator. Therefore variable gauges or automated controls in-station are used to detect discrepant part and to notify operator (light, buzzer, etc Gauging performed on setup and first-piece check (for set-up causes only). 1 in 200 failures will not be detected / $C_{pk} \geq 1{,}5$ 0,5% not detected failures

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D	SAE J1739 (Status: 01/2009) (Detection by process control)	AIAG, FMEA 4th edition (Status: 06/2008) (Opportunity - Likelihood)	VDA volume 4-II (Status: 06/2012) (Detection in process)	VDA/AIAG yellow volume (Status: 11/2017)	Proposal i-Q Schacht & Kollegen GmbH (Status: 03/2018)
4	**Defect Detection Post-Processing** Defect (Failure Mode) detection post-processing by automated controls that will detect discrepant part and lock part to prevent further processing.	**Problem Detection Post Processing-- Moderately high** Failure Mode detection post-processing by automated controls that will detect discrepant part and lock part to prevent further processing.	**Moderate** Failure with a moderate detection potential. Mature proof procedure from comparable products under new usage/boundary conditions.	**Moderately high:** Defect (Failure Mode) detection downstream through use of controls that will detect and control discrepant product. Proven testing or inspection method from comparable processes under similar operating / boundary conditions (machines, material). Test / inspection / measuring equipment capability from comparable processes confirmed through gauge repeatability and reproducibility evaluations. The required error proofing verification is performed.	**Reasonable probability:** Failure Mode will be detected post-processing by automated controls that will detect discrepant parts and lock parts to prevent further processing. 1 in 500 failures will not be detected / $C_{pk} \geq 1,67$ 0,2% not detected failures
3	**Defect Detection at Source** Defect (Failure Mode) detection in station by automated controls that will detect discrepant part and automatically lock part in station to prevent further processing.	**Problem Detection at Source – High** Failure Mode detection in station by automated controls that will detect discrepant part and automatically lock part in station to prevent further processing.	**High** Failure with a high detection potential due mature proof procedure. The required measuring equipment capability has been confirmed.	**High:** Defect (Failure Mode) detection in-station through use of controls that will detect and control discrepant product. Proven testing or inspection method from comparable processes under similar operating / boundary conditions (machines, material). Test / inspection / measuring equipment capability from comparable processes confirmed through gauge repeatability and reproducibility evaluations. The required error proofing verification is performed.	**High probability:** Error (Failure Cause) will be detected in station by automated controls that will detect the failure and prevent discrepant part from being made. 1 in 1.000 failures will not be detected / $C_{pk} \geq 1,83$ 0,1% not detected failures
2	**Error Detection and / or Defect Prevention** Error (Cause) detection in station by automated controls that will detect error and prevent discrepant part from being made.	**Error Detection and / or Problem Prevention – Very High** Error (Cause) detection in-station by automated controls that will detect error and prevent discrepant part from being made.	**High** Failure with a high detection potential due mature proof procedure. The required measuring equipment capability has been confirmed.	**Very high:** Error (Failure Cause) detection in-station through use of controls that will detect error and prevent discrepant product from being produced. Proven testing or inspection method from identical processes under the same operating / boundary conditions (machines, material). Test / inspection / measuring equipment capability from identical processes confirmed through gauge repeatability and reproducibility evaluations. The required error proofing verification is performed.	**Very high probability:** Error (Failure Cause) will be detected in station by automated controls that will detect the failure and prevent discrepant part from being made. 1 in 10.000 failures will not be detected / $C_{pk} = 2,0$ 0,01% not detected failures
1	**Detection not applicable; Error Prevention** Error (Cause) prevention as a result of fixture design, machine design or part design.	**Detection not applicable; Failure Prevention – Almost Certain** Error (Cause) prevention as a result of fixture design, machine design or part design. Discrepant parts cannot be made because item has been error-proofed by process/product design.	**Very High** Failure with a very high detection potential due to mature proof procedure of previous generation. The effectiveness was demonstrated on this product.	**Almost certain:** Discrepant product cannot be physically produced due to design (part geometry) or process (fixture or tooling design). The effectiveness was demonstrated on this product.	**Certainly:** Error (Cause) will be prevented as a result of fixture design, machine design or part design. Discrepant parts cannot be made because item has been error-proofed by process and / or product design. Failure cannot occur. / $C_{pk} \geq 2,0$ Less than 0,01% not detected failures

Ranking Scales for Process-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q

With our (i-Q GmbH) proposed rankings and statements we reference to the following tables (status: February 2018):

A. **SAE J1739** (SAE International, https://www.sae.org/standards/content/j1739_200208/)
B. **AIAG FMEA** (FMEA, 4th Edition 06/2008)
C. **VDA** (Chapter 4: Product- and Process-FMEA, 2nd Edition 12/2006, updated 06/2012)
D. **AIAG / VDA FMEA Alignment** (VDA yellow volume, withdrawn 28.02.2018)

Explanation of why we at i-Q GmbH come to these proposals.

1) It is completely unsatisfactory if several rankings (3-4-5) are provided with the same text. How should a concrete distinction be made?
2) In the high severity rankings, we are still considering that only those items are extremely critical, at which health and life of humans are endangered (S=10) and where is a noncompliance with legal regulations (S=9). This could lead to an existence threatening company risk (as it happened in 2015). Therefore, we are making distinction in meaning for severity as follows:
   i. 10: Life and health of humans is endangered (it doesn´t matter if customer or operator)
   ii. 9: Noncompliance with legal requirements / existence threatening company risk (Call back actions for most of current production)
3) Then for us the next ranking step (8 and 7) is dedicated very consequent to the inspection of the vehicle´s primary functions (to drive from A to B).
   i. 8: Vehicle stops (no impairment of health and life of humans are endangered or government regulations)! Or we speak of a so called „Walk Home Failure" – vehicle stands still => driver has to walk home. The vehicle has to be brought into garage by service car. Line shutdown at OEM with possible delivery stop of vehicles-
   ii. 7: The vehicle is operable, but on a reduced level. That will be called „Limp Home Failure" - e.g. limited revolutions / torque / speed – vehicle can be driven in reduced mode only! So I could drive to a garage by myself (no service car necessary), but long distances would become absolute torture. Line shutdown at tier 1 with possible delivery stop of delivered systems (reduced delivery stop of vehicles is possible).
4) Let´s have a look at secondary functions / comfort functions. Similar to the primary functions we differentiate between „is not operable" and „is reduced operable". Consequential that rating will follow:
   i. 6: comfort functions are not working (Navi / window lifter / radio / air condition), but vehicle is operable without reduced level of performance. System cannot be assembled at the pilot belt or fails at the end of line test at the Tier 1.
   ii. 5: comfort functions are working on a reduced level / decelerated (Navi: decelerated reaction/ window lifter: takes a long time / radio: one radio station only / air condition: isn´t cooling with full capacity), but vehicle is operable without reduced level of performance. System cannot be assembled at the prototype building / set into function or fails at the function test.
5) In this rating area it´s not about deficient functions, but about our five (four) senses.
   - Hearing – auditive / acoustical (rattling, rubbing, knocking, squeaking, ...);
   - Seeing – visual / optical (clearance, displacement of colours, the look simply "sucks", ...),
   - Smelling - olfactory (stinky, musty, painful, ...),
   - Feeling – tactile / haptic (uncomfortable, cold, cheap, ...),
   - Tasting - gustative (that will not be relevant, because: who will lick at his car by choice!)
   i. 4: Nearly most of the drivers / users (>75%) will feel a difference. 100% of the production run may have to be reworked in station before it is processed.
   ii. 3: Circa half of the drivers / users (~ 50%) will feel disturbed / impaired. A portion of the production run may have to be reworked in station before it is processed.
   iii. 2: Only some drivers / users (<25%) will notice (even the "nitpickers "). Slight inconvenience to process, operation or operator.
6) It is a deviation to specifications, but no customer will ever notice the non-conforming.
   i. 1: Only identifiable by qualified personnel. No inconvenience of production.
7) Looking at Occurrence we will focus on original comparison figures (e.g.: 1 of 1.000) that have a high evidence within the production area. Declarations like „one failure per time unit" (day / month / year) cannot be converted into the other values directly, but can be used as additional (optional) standard of comparison.
8) As well as at Detection we refer to former comparison figures, die im Produktionsbereich sicherlich sehr gut nachzuvollziehen sind.
9) On the last page you will now find a matrix with corresponding values for O and D failures, which are allowed / might have to get to the customer. From our point of view we make some reservations as values will increase utopian at any time. For example: A=3 (1 failure / 100.000 parts) and E=3 (1 undetected failure in 1.000 present failures) that follows by pure mathematics, only ONE single failure per 100 million delivered parts would get to the customer!

Ranking Scales for Process-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q

How many failures will be delivered to the customer at the end of the day?

	Occurrence / Detection	10	9	8	7	6	5	4	3	2	1
		1 of 2 failures not detected	**1 of 10** failures not detected	**1 of 20** failures not detected	**1 of 50** failures not detected	**1 of 100** failures not detected	**1 of 200** failures not detected	**1 of 500** failures not detected	**1 of 1.000** failures not detected	**1 of 10.000** failures not detected	**Cannot occur / PokaYoke**
10	1 Failure / 10 Parts	1 of **20**	1 of **100**	1 of **200**	1 of **500**	1 of **1.000**	1 of **2.000**	1 of **5.000**	1 of **10.000**	1 of **100.000**	**0**
9	1 Failure / 20 Parts	1 of **40**	1 of **200**	1 of **400**	1 of **1.000**	1 of **2.000**	1 of **4.000**	1 of **10.000**	1 of **20.000**	1 of **200.000**	**0**
8	1 Failure / 50 Parts	1 of **100**	1 of **500**	1 of **1.000**	1 of **2.500**	1 of **5.000**	1 of **10.000**	1 of **25.000**	1 of **50.000**	1 of **500.000**	**0**
7	1 Failure / 100 Parts	1 of **200**	1 of **1.000**	1 of **2.000**	1 of **5.000**	1 of **10.000**	1 of **20.000**	1 of **50.000**	1 of **100.000**	1 of **1.000.000**	**0**
6	1 Failure / 500 Parts	1 of **1.000**	1 of **5.000**	1 of **10.000**	1 of **25.000**	1 of **50.000**	1 of **100.000**	1 of **250.000**	1 of **500.000**	1 of **5.000.000**	**0**
5	1 Failure / 2.000 Parts	1 von **4.000**	1 of **20.000**	1 of **40.000**	1 of **100.000**	1 of **200.000**	1 of **400.000**	1 of **1.000.000**	1 of **2.000.000**	1 of **20.000.000**	**0**
4	1 Failure / 10.000 Parts	1 of **20.000**	1 of **100.000**	1 of **200.000**	1 of **500.000**	1 of **1.000.000**	1 of **2.000.000**	1 of **5.000.000**	1 of **10.000.000**	1 of **100.000.000**	**0**
3	1 Failure / 100.000 Parts	1 of **200.000**	1 of **1.000.000**	1 of **2.000.000**	1 of **5.000.000**	1 of **10.000.000**	1 of **20.000.000**	1 of **50.000.000**	1 of **100.000.000**	1 of **1.000.000.000**	**0**
2	1 Failure / 1.000.000 Parts	1 of **2.000.000**	1 of **10.000.000**	1 of **20.000.000**	1 of **50.000.000**	1 of **100.000.000**	1 of **200.000.000**	1 of **500.000.000**	1 of **1.000.000.000**	1 of **10.000.000.000**	**0**
1	< 1 Failure / 1.000.000 Parts	< 1 of **2.000.000**	< 1 of **10.000.000**	< 1 of **20.000.000**	< 1 of **50.000.000**	< 1 of **100.000.000**	< 1 of **200.000.000**	< 1 of **500.000.000**	< 1 of **1.000.000.000**	< 1 of **10.000.000.000**	**0**

(Personal annotation)
Anything over 1 million faultless parts per year is out of question / out of touch with reality to me absolutely. Maybe that the number of faultless products is marginally lower, but definitely not higher!
Otherwise I would like you to show me this process quite concretely. I would be pleased to highlight it as shining exceptional case.