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

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)	AIAG&VDA, 1st edition (status: 06/2019) - Impact to Your Plant - Impact to Ship to Plant - Impact to End User	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.	**High:** Failure may result in an acute health and/or safety risk for the manufacturing or assembly worker. Failure may result in an acute health and/or safety risk for the manufacturing or assembly worker. Affects safe operation of the vehicle and/or other vehicles, the health of driver 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.	**High:** 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 regu-lations 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	**Moderately high:** 100% of production run affected may have to be scrapped. Failure may result in in-plant regulatory noncompliance or may have a chronic health and/or safety risk for the manufacturing or assembly worker. 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. Failure may result in in-plant regulatory noncompliance or may have a chronic health and/or safety risk for the manufacturing or assembly worker. **Loss** of primary 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	**Moderately high:** Product may have to be sorted and a portion(less than 100%) scrapped; deviation from primary process; decreased line speed or added manpower. Line shutdown from 1hour up to full production shift; stop shipment possible; field repair or replacement required (assembly to end user) other than for regulatory noncompliance. **Degradation** of primary 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	**Moderately low:** 100% of production run may have to be reworked off line and accepted. Line shutdown up to one hour **Loss** of secondary vehicle 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	**Moderately low:** 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 secondary vehicle 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	**Moderately low:** 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. Very objectionable appearance, sound, vibration, harshness, or haptics.	**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	**Low:** 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. Moderately objectionable appearance, sound, vibration, harshness, or haptics.	**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	**Low:** 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. Slightly objectionable appearance, sound, vibration, harshness, or haptics.	**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	**Very low:** No discernible effect. No discernible effect or no effect. 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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OCCURRENCE – 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	**AIAG&VDA, 1st edition (status: 06/2019)** - Prediction of Failure Cause Occurring - Type of Control - 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)	**Extremely high:** None No prevention controls.	**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:** Behavioral Prevention controls will have little effect in preventing failure causes.	**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)	**Very high:** Behavioral Prevention controls will have little effect in preventing failure causes.	**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)	**High:** Behavioral or Technical Prevention controls somewhat effective in preventing failure causes.	**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)	**High:** Behavioral or Technical Prevention controls somewhat effective in preventing failure causes.	**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:** Behavioral or Technical Prevention controls are effective in preventing failure causes.	**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)	**Moderate:** Behavioral or Technical Prevention controls are effective in preventing failure causes.	**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

(*) Potential Failure Causes rated according to the criteria below (Editor's note: In this case, "top".). Consider Prevention Controls when determining the best Occurrence estimate. Occurrence is a predictive qualitative rating made at the time of evaluation and may not reflect the actual occurrence. The occurrence rating number is a relative rating within the scope of the FMEA (process being evaluated). For Prevention Controls with multiple Occurrence Ratings, use the rating that best reflects the robustness of the control.

Prevention Control Effectiveness: Consider if prevention controls are technical (rely on machines, tool life, tool material, etc.), or use best practices (fixtures, tool design, calibration procedures, error- proofing verification, preventive maintenance, work instructions, statistical process control charting, process monitoring, product design, etc.) or behavioral (rely on certified or non-certified operators, skilled trades, team leaders, etc.) when determining how effective the prevention controls will be.

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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:** Best Practice: Behavioral or Technical Prevention controls are highly effective in preventing failure causes.	**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:** Best Practice: Behavioral or Technical Prevention controls are highly effective in preventing failure causes.	**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)	**Extremely low:** Technical Prevention controls are highly effective in preventing failure causes from occurring due to design (e.g. part geometry) or process (e.g. fixture or tooling design). Intent of prevention controls – Failure Mode cannot be physically produced due to the Failure Cause.	**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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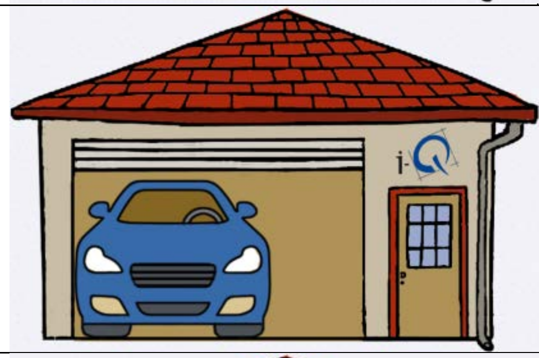
C_p/ C_{pk}	$C_{pk} < 1{,}0$	$C_{pk} = 1{,}0$	$C_{pk} = 1{,}33$	$C_{pk} = 1{,}67$	$C_{pk} = 2{,}0$
$C_p < 1{,}0$		Impossible because $C_p \geq C_{pk}$ have to be!	Impossible because $C_p \geq C_{pk}$ have to be!	Impossible because $C_p \geq C_{pk}$ have to be!	Impossible because $C_p \geq C_{pk}$ have 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!
$C_p = 2{,}0$					

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)	AIAG&VDA, 1st edition (status: 06/2019) - Detection Method Maturity - Opportunity for Detection	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.	Very low: No testing or inspection method has been established or is known. The failure mode will not or cannot be detected.	**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 low: It is unlikely that the testing or inspection method will detect the failure mode. The failure mode is not easily detected through random or sporadic audits.	**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.	Low: Test or inspection method **has not been** proven to be effective and reliable (e.g. plant has little or no experience with method, gauge R&R results marginal on comparable process or this application etc.) Human inspection (visual, tactile, audible), or use of manual gauging (attribute or variable) that should detect the failure mode or failure cause.	**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.	Low: Test or inspection method **has not been** proven to be effective and reliable (e.g. plant has little or no experience with method, gauge R&R results marginal on comparable process or this application etc.) Machine-based detection (automated or semi-automated with notification by light, buzzer, etc.), or use of inspection equipment such as a coordinate measuring machine that should detect failure mode or failure cause.	**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.	Moderate: Test or inspection method **has been** proven to be effective and reliable (e.g. plant has experience with method, gauge R&R results acceptable on comparable process or this application etc.) Human inspection (visual, tactile, audible), or use of manual gauging (attribute or variable) that will detect the failure mode or has failure cause (including product sample checks).	**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: Test or inspection method **has been** proven to be effective and reliable (e.g. plant has experience with method, gauge R&R results acceptable on comparable process or this application etc.) Machine-based detection (semi-automated with notification by light, buzzer, etc.), or use of inspection equipment such as a coordinate measuring machine that will detect failure mode or failure cause (including product sample checks).	**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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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.	**High:** System has been proven to be effective and reliable (e.g. plant has experience with method on identical process or this application), gauge R&R results are acceptable, etc. Machine-based automated detection method that will detect the failure mode **downstream**, prevent further processing or system will identify the product as discrepant and allow it to automatically move forward in the process until the designated reject unload area. Discrepant product will be controlled by a robust system that will prevent outflow of the product from the facility.	**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:** System has been proven to be effective and reliable (e.g. plant has experience with method on identical process or this application), gauge R&R results are acceptable, etc. Machine-based automated detection method that will detect the failure mode **in-station**,, prevent further processing or system will identify the product as discrepant and allow it to automatically move forward in the process until the designated reject unload area. Discrepant product will be controlled by a robust system that will prevent outflow of the product from the facility.	**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.	**High:** Detection method has been proven to be effective and reliable (e.g. plant has experience with method, error-proofing verifications etc.) Machine-based detection method that will detect the cause and prevent the failure mode (discrepant part) from being produced.	**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.	**Very high:** Failure mode cannot be physically produced as-designed or processed, or detection methods proven to **always** detect the failure mode or failure cause.	**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 / AIAG&VDA / proposal i-Q GmbH

With our (i-Q GmbH) proposed rankings and statements we reference to the following tables (status: August 2019):

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** (https://www.aiag.org/store/publications/details?ProductCode=FMEAAV-1)

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, which are certainly very easy to comprehend in the production area.
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 / AIAG&VDA / proposal i-Q GmbH

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.
And by that I mean faultlessly produced parts and not ppm values of the 0km failures at the customer. Such numbers (below 1ppm) are quite possible!