

FMEA AIAG-VDA - Commentary and Case Study

Edly F. Ramly

Certification Director
EFR Certification Sdn Bhd, Malaysia
e.ramly@efrcertification

Hood Atan

IATF Auditor
Exergy Management Consultant Malaysia
hood.atan@yahoo.com

Abstract

Automotive Industry Action Group (AIAG) and *Verband der Automobilindustrie* (VDA) jointly published a FMEA handbook to be used by automotive suppliers to assist them in development of FMEA. Since the handbook newly published in June 2019, there are several issues in adopting the reference manual. This paper explores the common issues and benefits in developing the Process FMEA by using the the AIAG-VDA handbook through two case study. The output of this paper provide the commentary of strength, benefit and issues in developing PFMEA through AIAG-VDA FMEA handbook.

Keywords:

Risk Assessment, Risk Management, FMEA, Operation Management, IATF.

1. Introduction

The reference manual that outline the guideline for Failure Mode Effect Analysis (FMEA) published by Automotive Industry Action Group (AIAG) 4th edition in year 2008, has been updated with new handbook. The new handbook was published jointly by AIAG which is based in United States of America and Verband der Automobilindustrie (VDA) which is based in Germany in June 2019. In 2017-2018, we conducted case study in implementation of FMEA and determined that there are seven issues in implementation of FMEA and concluded as followed (Ramly and Atan, 2018):

PFMEA is proven risk assessment methodology to prevent defects. However, there are seven issues that face by the organization and the team that develop the PFMEA for their manufacturing process. The issues include determining whether to develop the design FMEA or process FMEA, setting up the objectives of PFMEA, determining the processes, determining the severity score, listing the causes, determining occurrence score, determining control and prioritizing the improvement. Each of the issue have the proposed solution as discussed in previous paper. The future research should focus on linking the PFMEA and other quality improvement tools such as cause and effect diagram, control plan and application of PFMEA in quality improvement initiatives such as six sigma and lean manufacturing.

Hence this paper conducted additional case study with two organization in order to study and provide commentary:

- The main difference between the AIAG 4th Edition FMEA handbook vs AIAG-VDA 1st edition handbook;
- The benefit of implementing the PFMEA according to AIAG-VDA FMEA handbook;
- The issues and limitation of the AIAG-VDA FMEA handbook;

- Recommended solution to minimise the issues and limitation in implementing the PFMEA according to AIAG-VDA FMEA handbook.

AIAG-VDA FMEA handbook provide guideline for Design FMEA (DFMEA), Process FMEA (PFMEA), and Monitoring system response (MSR FMEA). However, since both organizations in the case study are not design responsible, hence the study and commentary are limited to Process FMEA (PFMEA) as prescribed in section III of the AIAG-VDA FMEA handbook.

2.0 Improvement of AIAG/VDA PFMEA framework

From the 2017-2018 study of FMEA develop by Ramly and Atan (2018), the AIAG/ VDA FMEA framework complement and improve 6 out of seven issues recommended in the from the papers as followed:

1. Product or process – Addressed
2. Defect Prevention – Partially Addressed
3. Process Flow – Not addressed
4. Effects to determine severity score - Addressed
5. Top three causes – Partially Addressed
6. Determining occurrence score - Addressed
7. Continual Improvement Prioritization - Addressed

2.1 Product or Process

The previous reference manual (AIAG, 2008) not clearly addressed the context of organization in developing the FMEA. Hence, the recommended solution is to include the clear context in risk management as recommended in ISO31000 Risk Management guideline (Ramly and Atan, 2018). The 2019 AIAG/ VDA FMEA handbook have clearly addressed the context in section 1.1. The section 1.1 stated that the context of the FMEA framework is cover only technical risk and exclude the financial risk, time risk and strategy risk.

2.2 Defect Prevention

For FMEA, mandate and commitment as required by ISO31000 should be “Defect Prevention” as proposed by the previous case study. The 2019 AIAG/ VDA FMEA handbook provide more lengthy explanation and example of objective of FMEA such as defect free launch in section 1.2. However, the defect prevention should be highlighted as main goal of FMEA that will lead to achievement of other objectives such as reducing warranty and goodwill costs, increasing of customer satisfaction and building knowledge base in the company.

At the meantime, the seven steps in FMEA development as outline in 2019 AIAG/ VDA FMEA handbook provide clear framework in defect prevention. The first part of “step 2 structure analysis”, “step 3 functional analysis” and “step 4 failure analysis”, provide structured methodology to define the requirements as show in table 1 that can be focused on defect prevention. From previous version of FMEA, there are column on “Requirement”. Requirements can be refer to specification or characteristic of the product such as dimension, colour, functionality and appearance. The requirements column is recommended since it can help the team to determine the potential failure mode in term of defects or opposite to the requirements such as Bent, Burred, Hole off-location, Cracked, Hole too shallow, Hole missing, Dirty, Surface too rough, Deformed, Open circuited, Short circuited and Mis-labelled. The 2019 AIAG/ VDA FMEA handbook provide the step to determine the requirement effectively under the step 3 as shown in both table 1 and table 2. The step 3 determine the function of the process item, or function of system or subsystem, or part element or process step. Hence the step 3, effectively assisted to determine the failure mode, failure effect and failure cause in step 4 of 2019 AIAG/ VDA FMEA framework.

Table 1: Sequence in analysis of parts/ components

| STRUCTURE ANALYSIS (STEP 2) | FUNCTION ANALYSIS (STEP 3) | FAILURE ANALYSIS (STEP 4) |
|--|--|--|
| 1. Process Item, System, Subsystem, Part Element | 1. Function of the Process Item Function of System, Subsystem, Part Element or Process | 1. Failure Effect (FE) to the Next Higher-Level Element and/or End User |
| Electrical Motor Assembly | <u>Your Plant:</u> Assembly of shaft into pole housing assembly <u>Ship to Plant:</u> Assembly of motor to vehicle door <u>End User:</u> Window raises and lowers | <u>Your Plant:</u> Clearance too small to assemble shaft without potential damage <u>Ship to Plant:</u> Assembly of motor to vehicle door requires additional insertion force with potential damage <u>End User:</u> Comfort closing time too long. |

2.3 Process Flow

The 2019 AIAG/ VDA FMEA handbook not clearly addressed or provide guideline in detailing the type of process. The argument from the team on “should the PFMEA include all the process such as inspection, each of movement, each of storage and work in progress?” From previous study, the team agree that the PFMEA shall include all the value-added process that change the physical of the product. The team also agreed that the inspection process should be excluded from the PFMEA due to: 1) The PFMEA is the tools to determine the inspection/ control needed; 2) The potential failure of inspection process (such as wrong decision) is control through calibration and Gage Repeatability and Reproducibility (GRR) study; 3) The risk of producing another defect during inspection should be highlighted in inspection standard or procedure. As for the move (Transfer between station) and wait process (Raw material storage, Work in progress and Finish good storage), the team decided whether to include in the analysis based on probability of defect occurred during the process. If there are minimum defect can occurred, the process can be omitted from the PFMEA.

However, the example from the 2019 AIAG/ VDA FMEA handbook, the process step determines from step 2 can be further analyse to step 3 and step 4 in more detail as shown in table 2. This methodology helps the team to determine the failure mode effectively and avoid confusion in determining the failure effect.

Table 2: Sequence in analysis of parts/ components

| STRUCTURE ANALYSIS (STEP 2) | FUNCTION ANALYSIS (STEP 3) | FAILURE ANALYSIS (STEP 4) |
|--|--|---|
| 2. Process Step | 2. Function of the Process Step and Product Characteristic (Quantitative value is optional) | 2. Failure Mode (FM) of the Focus Element |
| (OP30) Sintered Bearing Press in Process | Press in sintered bearing to achieve axial position in pole housing to max gap per print | Axial position of sintered bearing is not reached |

2.4 Effects to determine severity score

The previous AIAG FMEA reference manual (AIAG, 2008) have provide clear guideline to determine the severity score for the defects based on the effect to customer or next process. The effects can be categorized to Safety and Regulation related, Functionality including fitment related, and Appearance related. So far, the team does not face any issues in determine the effect of defect in terms of what the customer might notice or experience, remembering that the customer may be an internal customer as well as the ultimate end user. In addition, the 2019 AIAG/ VDA FMEA handbook provide three level of effect which are 1) Your Plant; 2) Ship to Plant; 3) End User as shown in table 1.

2.5 Top three causes

2019 AIAG/ VDA FMEA handbook provided the need to determine the cause, start from step 2 by determining the process work element of 4M (Man, Material, Machine, Method).

From the previous study, the potential cause of failure is defined as how the failure could occur, described in terms of something that can be corrected or can be controlled. The team list every cause assignable to each of potential defect (potential failure mode). The FMEA development team attempted to determine the potential cause through cause and effect (defect) diagram (fishbone diagram) and five why analysis. However, the teams were unable to document all the causes due to limited space (column and row) in the AIAG PFMEA sheet. The same issues occurred with 2019 AIAG/ VDA FMEA recommended form. Hence the recommendation to document only top three causes in the sheet through team consensus and the copy of each cause and effect (defect) diagram is recommended to be documented for future reference.

2.6 Determining occurrence score

From previous study, the team have difficulties in deciding whether the occurrence should be reflected on the “defect” or the occurrence of “cause”. For the first organization, the team selected to use the “defect” as indicator for occurrence score. While the second organization, develop the occurrence score rating which are “defect score rating” and cause occurrence score rating”. 2019 AIAG/ VDA FMEA handbook have cleared the team from the previous difficulties. The handbook outline in the 5th step of FMEA as risk analysis that the occurrence score should be determine by the type of prevention control. Hence the occurrence score determines from the prevention control of either the failure mode (defect) or failure cause. Occurrence is the likelihood that a specific failure will occur. The likelihood of occurrence ranking number has a relative meaning rather than an absolute value. Preventing or controlling the causes/mechanisms of failure through a design or process change is the only way a reduction in the occurrence ranking can be affected as shown in table 3.

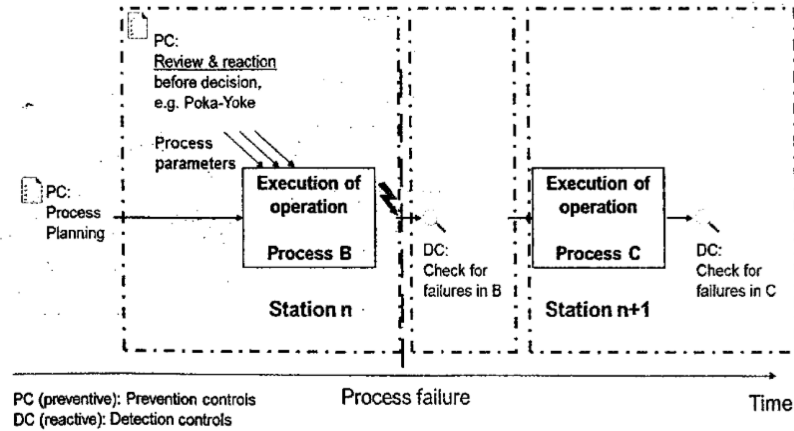
3.6 Determine control

Na2019 AIAG/ VDA FMEA handbook Current Process Controls are descriptions of the controls that either prevent to the extent possible the failure mode or cause/mechanism of failure from occurring, or detect the failure mode or cause/mechanism of failure should it occur. Two types of Process Controls to consider: 1) Prevention: Eliminate (prevent) the cause of the failure or the failure mode from occurring, or reduce their rate of occurrence, 2) Detection: Identify (detect) the cause of failure or the failure mode, leading to the development of associated corrective action (s) or counter measures. The preferred approach is to first use prevention controls, if possible. The initial occurrence rankings will be affected by the prevention controls provided they are integrated as part of the process. The initial rankings for detection will be based on process controls that either detect the cause/mechanism of failure, or detect the failure mode.

Table 3: The occurrence ranking (Extracted from 2019 AIAG/ VDA FMEA handbook)

| Occurrence Potential (O) for the process | | | | |
|--|--|--|---|---|
| Potential Failure Causes rated according to the criteria below. 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. | | | | Blank until filled in by user |
| O | Prediction of Failure Cause Occurring | Type of Control | Prevention Controls | Corporate or Product Line Examples |
| 10 | Extremely High | None | No prevention controls. | |
| 9 | Very High | Behavioral | Prevention controls will have little effect in preventing failure cause. | |
| 8 | | | | |
| 7 | High | Behavioral or Technical | Prevention controls somewhat effective in preventing failure cause. | |
| 6 | | | | |
| 5 | | | | Moderate |
| 4 | | | | |
| 3 | Low | Best Practice: Behavioral or Technical | Prevention controls are highly effective in preventing failure cause. | |
| 2 | Very Low | | | |
| 1 | Extremely Low | Technical | Prevention controls are extremely effective in preventing failure cause 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. | |

The team decision from previous study have been determine effectively in 2019 AIAG/ VDA FMEA handbook as depicted in figure 1 such as the prevention control only such as error proofing to the cause of defects and include set-up verification. The detection controls cover the inspection process either during incoming, in-process or outgoing inspection. However the 2019 AIAG/ VDA FMEA handbook does not indicate any of this control should be transfer to control plan to detail up the inspection process.



PC (preventive): Prevention controls
DC (reactive): Detection controls

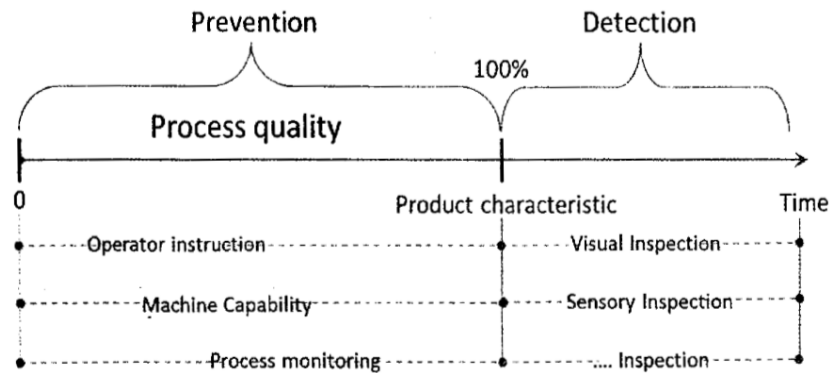


Figure 1: The prevention control vs detection control (Extracted from 2019 AIAG/ VDA FMEA handbook Figure 3.5-1 and 3.5-2)

3.7 Continual Improvement Prioritization

2019 AIAG/ VDA FMEA handbook replace the improvement prioritization through risk priority number (RPN) threshold to “action priority” risk matrix that determine the level of risk based on combination of severity, occurrence and detection ranking. This provide solution to ambiguous recommendation from previous AIAG method that required to prioritized based on highest severity first, the occurrence second and the detection third. This method has make no sense in determining the action for example the severity score is 10, while occurrence is 2 and detection is 2. It is because the occurrence and detection are already considered as low as practicable. Example of action priority risk priority table as shown in figure 2.

| Failure Effect | S | Prediction of Failure Cause Occurring | O | Ability to Detect | D | ACTION PRIORITY (AP) | Comments |
|----------------|------|---------------------------------------|-----|----------------------|------|----------------------|----------|
| | 9-10 | Moderate | 4-5 | Low – Very low | 7-10 | H | |
| | | | | Moderate | 5-6 | H | |
| | | | | High | 2-4 | H | |
| | | | | Very high | 1 | M | |
| | | Low | 2-3 | Low – Very low | 7-10 | H | |
| | | | | Moderate | 5-6 | M | |
| | | | | High | 2-4 | L | |
| | | | | Very high | 1 | L | |
| | | Very low | 1 | Very high – Very low | 1-10 | L | |

Figure 2: The example of action priority table

3. Discussion

Apart of benefit, strength and limitation in comparing with previous study result, additional strength and limitation of AIAG-VDA FMEA handbook were found. The additional strength and limitation are discussed below.

1. FMEA Success Factors

In addition, the handbook outline the success factors in section 1.3 of the handbook. Section 1.3 outline the success factors in integration of FMEA in the company that include, 1) several potential considerations of the FMEA i.e. real, true, realistic, complete; 2) Senior Management Commitment, 3) Know-How protection and 3) development of foundation and family FMEAs. However, the example is limited and further study on the FMEA development and implementation critical success factor is highly recommended.

2. Implementation/ Adoption Strategy

There is no specific transition period to adopt the 2019 AIAG/ VDA FMEA framework especially for IATF certified organization. Several car makers specified to their supplier should adopt the new FMEA framework when there is a new project. From the case study conducted, both organization are not bind by their customer to adopt the new format. Hence, for the start, the team agreed to use the new framework for the purposed of solving customer complaints on their quality issued.

3. Linkage to other quality tools and techniques

2019 AIAG/ VDA FMEA handbook provide no clear linkage several important quality and techniques such as linkage to control plan, cause and effect diagram, and process approaches turtle diagram. However the handbook outline the linkages to AIAG Advance Product Quality Planning (APQP) and VDA Maturity Level Agreement (MLA). The handbook also outline in step 1 of planning and preparation to determine the tools as part of five “T” in project plan which are intent, Timing, Team, Task and Tools.

4. Level of detail in PFMEA

Due to number of steps to develop the PFMEA increase in the 2019 AIAG/ VDA FMEA framework, more space required especially if the organization used the worksheet software such as excel. The information cannot be presented on single page. Hence it is difficult to present the information in the PFMEA. Same goes to the level of detail to work elements. Even though there is no solution provide by the team, the used of guided software application is highly recommended by the team to provide clear guide to determine the information required by PFMEA and recommended the space to store the information for future use.

4. Conclusion

2019 AIAG/ VDA FMEA handbook provide the systematic framework to conduct technical product and process risk assessment to prevent defect. Potential Failure Modes and Effects Analysis in Manufacturing and Assembly Processes (PFMEA) is an important preventive method for quality assurance, and through it informed action priority methodology provide decisions based on the severity levels and probabilities of occurrences and detection of the failure modes. The framework also can be effectively applied for problem solving techniques. Both version of PFMEA have been develop according to AIAG (2009) and AIAG VDA (2019) version have been developed, review and tested in case organizations. However, there are several issues that potentially face by the organizations that implement several management systems such as there is limited specific tools and techniques provided, limited space to fill in the format provided, and limited example of intent and adoption strategy.

The future research should focus on linking the PFMEA framework with other quality tools and study the effectiveness through the result and the performance improvement after adopting the FMEA. More case study is required on different context of organization, different industry and sector, difference business process and difference size of organization.

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Biography

Edly F. Ramly is Certification Director for EFR Certification and Fellow for IEOM. He is renowned coach, auditor, consultant and trainer. With his excellent technical expert and interpersonal skills, he has conducted various high impact trainings and workshop in the area of operation management, industrial engineering, management system including quality, environment and occupational health and safety, workplace improvement, variation and waste reduction, and practical problem solving techniques including statistical tools. Apart from being trained as Lead Auditor in various management system, he is also qualified auditor for Automotive Industry IATF 16949. During his service with Pera Neville Clarke, he is also tutor for QMS lead auditor course. His industrial experience was in the automotive industry. During his stayed with the TRW Automotive, he was tasked with the responsibility of promoting and implementing Lean and Six-Sigma within the Organization. Due to his extensive exposure in Lean and Six-Sigma Management System, he was invited by Malaysia Productivity Corporation (MPC) and Asia Productivity Organization (APO) to conduct public training in the area of Six-Sigma implementation and Lean Implementation. In 2014, he been awarded as one of Malaysia Productivity Specialist by Malaysia Ministry of International Trade and Industry.

Hood Atan is a full time project consultant and qualified auditor in the fields of Quality, Health & Safety and Environmental Management system. Mr. Hood Atan holds a Bachelor of Engineering in Mechanical (Industrial) degree and a Master in Engineering (Industrial Engineering) degree from Universiti Teknologi Malaysia. Having worked as a Quality Engineer, Quality Manager, Quality and Environmental Management Representative for numerous years from bottom, middle and to top management. His industrial experience was in the manufacturing industry. During his stayed with the TRW Automotive, he was tasked with the responsibility of promoting and implementing VDA 6.3, QS-9000, ISO/TS 16949, ISO14001, ISO 13485, ISO50001, OSHAS 18001 management system and Lean Six Sigma initiatives within the organization. Besides, he also responsible for supplier audit either local or oversea such as Thailand, Singapore, Vietnam, Indonesia, China and India.