

Developing process FMEA for centrifugal pump: a case study in Loji Air Bertam, SAMB

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ABSTRACT – The Failure Modes and Effects Analysis (FMEA) is a systematic method for identifying those possible failures that pose the greatest overall risk for the product/system by analysing the ways a process can fail, the possible causes of each failure, and its consequences. In this study, a Process FMEA (PFMEA) was to be developed for the centrifugal pumps at Loji Air Bertam under Syarikat Air Melaka Berhad (SAMB), who has not implemented any risk assessment methodology. Interviews, surveys, and brainstorming are among methods used to gather and analyse common issues related to the centrifugal water pump. Through literature research, a PFMEA template and ranking scale was developed, followed by the fitting of data collected into the template. A Standard Operating Procedure (SOP) was also developed during the implementation phase of the PFMEA to act as a guideline.

1. INTRODUCTION

Failure Modes and Effects Analysis (FMEA) is currently one of the world's most widely known reliability tool used to systematically identify and prevent product and process problems before they occur. It is "focused on preventing defects, enhancing safety, and increasing customer satisfaction." [1] At present, Syarikat Air Melaka Berhad (SAMB) has not implemented the use of FMEA in the administration of the organisation. Due to the nature of the organisation, the effects of any centrifugal pump breakdown will also cause devastating loss in service quality. This study aims to develop a Process FMEA (PFMEA) [2] for the centrifugal pump at Loji Air Bertam, SAMB, to enable the engineering team to tackle issues in the order of the highest to lowest risk. [3] To achieve that, 3 study objectives were identified:

- i) Analysing the common problems and issues related to the centrifugal water pump,
- ii) Developing a PFMEA up to determination of the Risk Priority Numbers (RPN),
- iii) Implementing the PFMEA developed at Loji Air Bertam using a Standard Operating Procedure (SOP).

2. METHODOLOGY

In accordance to the objectives, the case study was carried out in 3 stages – gathering and analysis of data, development of the PFMEA itself, and implementation.

Data Collection

Library research was mainly used as a reference for the development of the PFMEA, using established methods as a benchmark. [1] The expertise of the engineering team at the site of the case study was also consulted. The remainder of the required information were gathered via observations and analysis of existing documentation.

Development of the PFMEA

Through referencing data collected through literature review, a PFMEA template was first developed, followed by the development of Severity, Occurrence, and Detection rating scales. [4] Then, data was inserted and the RPN for each failure mode calculated to complete the PFMEA. Finally, the RPN numbers between failure modes were compared to identify their respective priority levels.

Implementation of the PFMEA

Existing SOP in circulation within SAMB and within Loji Air Bertam itself were first referenced to ensure that the newly developed SOP followed the same format in order to standardise the documentation.

3. RESULT AND DISCUSSION

The Severity, Occurrence, and Detection ranking scales to be used at Loji Air Bertam were customised based on the processes found in the water processing facility. Great consideration has been given during the establishment of descriptions for each point on the ranking scales to make sure that there exists no ambiguity during the interpretation of the scales, allowing a more standardised view among the PFMEA team members during discussions.

As a water processing facility, it is assumed that the processed water may end up being consumed directly off the tap. This means that the severity of failures involved in the process not only has to be identified and analysed in terms of physical hazards, but also chemical and biological risks. The severity of a failure also involves the loss in efficiency, and defects based on the perception of the consumer.

On the other hand, the Occurrence scale was a simple linear scale using numerals as performance indicators. This was largely because the perception of "more" or "few" can vary greatly among people.

In the case of Detection, it is more qualitative than quantitative in nature, hence no numerals could be

assigned. As such, despite an attempt to detail each description on the rating scale as much as possible, slight disagreements among team members at the brainstorming stage are still expected.

The description for each point was intentionally written to be slightly more general so that the same ranking scales could be applied on most processes, enables the resulting RPN to be compared across different PFMEAs, encouraging further prioritisation of risk reduction activities.

The analysis of common issues found in the centrifugal pumps started with the application of the 6M Method [5], however, only Machine, Man, and Material were relevant in this case. While failure modes in the Man and Material categories were based on observations and the experience of the engineering team, failure modes in the Machine category involved an in-depth study and analysis of the components and working principles of the centrifugal pump itself.

The implementation of an entirely new risk assessment methodology at Loji Air Bertam was executed in stages to avoid overwhelming the related personnel through the delivery of a huge amount of data to be processed in a relatively short span of time. Taking the understanding of the engineering team as priority, an SOP was drafted to act as a handbook for reference. Interestingly, it was noted that the SOP currently in circulation were written in the Malay language, which is also the main spoken language among employees. However, the PFMEA as a ISO9001:2015 risk assessment tool, is based in English. As such, the Malay language was used to write the SOP, but English terminology aided with Malay translations applied where needed. A flowchart dictating the courses of action required at various stages was also added to clarify any doubts.

4. CONCLUSIONS

In a similar case study carried out by Wicaksono & Karnaningroem [6], the FMEA was applied to determine the main risk for poor water quality from a list of 4 possible factors. The Severity scales which was established at the expertise of the city health office allowed for a proper comparison across different water processing facilities. However, due to time constraints, the Occurrence and Detection scores were based on the Severity and Occurrence scores respectively instead of independent observations, leading to the all RPN, and in turn all FMEA, being reliant on only one source of judgement and very prone to bias.

In contrast, this case study was focused on the application of the PFMEA in only one water processing facility. The lack of an industry-wide standard limits the ability to perform benchmarking activities with other organisations of similar functions, yet this tailored approach provides the engineering team with a better understanding of the possible risks that may be unique to their own organisation. In addition, due to the FMEA being customised specifically for the site of study, it may also serve as a documentation of risks and actions for future reference.

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REFERENCES

- [1] McDermott, R., Mikulak, R., & Beauregard, M, The Basics of FMEA, 2nd ed. New York: CRC Press; 2009.
- [2] Stamatis, D., Failure Mode and Effect Analysis: FMEA from Theory to Execution, 2nd ed. Milwaukee, Wisc.: ASQ Quality Press; 2003.
- [3] Kmenta, S., Advanced Failure Modes and Effects Analysis: A Method for Predicting and Evaluating Failures in Products and Processes, Stanford University, 2000.
- [4] Aguiar, D., Souza, H., & Salomon, V., An AHP application to evaluate scoring criteria for failure mode and effect analysis (FMEA), International Journal Of The Analytic Hierarchy Process, vol. 2, no. 1, pp., 2010.
- [5] Hessing, T. (2017). 6M's in Six Sigma (Six Ms or 5Ms and one P or 5M1P) | Six Sigma Study Guide. Retrieved 11 January 2020, from <https://sixsigmastudyguide.com/six-ms-6ms-or-5ms-and-one-p-5m1p/>
- [6] Wicaksono, A., & Karnaningroem, N., Minimizing failure risk of refill drinking water production in Rungkut district Surabaya using Failure Mode and Effect Analysis (FMEA). IOP Conference Series: Earth And Environmental Science, 259, pp. 012013, 2019.