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DEVELOPING OF A APLICATION METHODOLOGY OF A FMEA ANALYSIS OF A CMM MEASURING PROCESS

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Abstract: *This paper presents the methodology of doing a FMEA analysis for a measurement process with a coordinate measuring machine (CMM) by using the DAMIC model. It follows the steps of the analysis process and presents the documentation used with the purpose of underlining the particularities of applying this kind of analysis to a measurement process.*
Key words: *FMEA, measurement process, DAMIC model, CMM, risk analysis.*

1. INTRODUCTION

The FMEA (Failure Cause and Effects Analysis) method was developed for the first time in the United States, in the mid 60's, by NASA for the Apollo project (the first lunar landing). After being used in satellite development as well as in the building of nuclear plants, it was used in the automotive industry and by its suppliers. Today it is an important tool in the quality management system. [5]

In general manufacturing is a sequence of manufacturing and control operations. Quality assurance in manufacturing focuses more on the manufacturing rather than on the control part focusing on the errors that can occur, their causes and the detection and prevention measures that can be taken.

The control of the manufacturing process can be looked at as a single process, its operations occurring in sequence. By doing so the focus is on errors that can occur, their causes and the detection and prevention measures that can be taken.

As a result a FMEA analysis can be applied to the whole control process or to specific part of the process like coordinate measuring.

Developing a FMEA analysis for the measuring process requires that parts be selected by certain criteria like:

- Parts that have had complaints from clients;
- Parts with measuring errors for the manufacturing processes;
- Parts that are new, have known issues, or have a new measurement strategy;

The parts for which the measurement processes will be analyzed with the FMEA method can be selected by using a selection matrix on the following criteria:

- If a new measurement program was used;
- The components are critical from a safety point of view;
- The components are functional ones;
- The measurement strategy suffered modifications;
- The measurement conditions have changed;
- The parts have influences on manufacturing process adjustment;
- Customer complaints have been received.

2. THE DAMIC MODEL IN THE FMEA ANALYSIS OF THE CONTROL PROCESS

The FMEA analysis is done in accordance with the DAMIC model: Definition – Analysis – Measures – Implementation – Communication (Figure 1).

Definition – Acknowledgement and system definition. This step has the following activities:

- Determination of the scope: FMEA for the control process, for a specific equipment, update of an existing analysis etc.;
- Definition of responsibilities for each team member;
- Establishment of communication channels;
- Identification of necessary resources;
- Provision of resources;
- Establishment of result recording method;
- Provision of the necessary documentation.

Analysis – Collaborative FMEA

The FMEA analysis is done in accordance with Figure 2.

An analysis form and the results must be presented to the management of the firm. The results contain information about the undergone activities, risk assessment and optimization and the necessary improvement measures.

Measures – Establishment of corrective measures

If the resulting Risk Priority Index (RPZ) or either of the occurrence (A) or the detection (E) indexes have high values, improvement measures are necessary. The RPZ can be lowered by:

- Modifying the measurement strategy as to exclude the sources of the errors;
- Improving the measurement strategy as to lower the error occurrence probability;
- Improving the error prevention methods;
- Improving the error detection methods (by avoiding adding extra verifications);

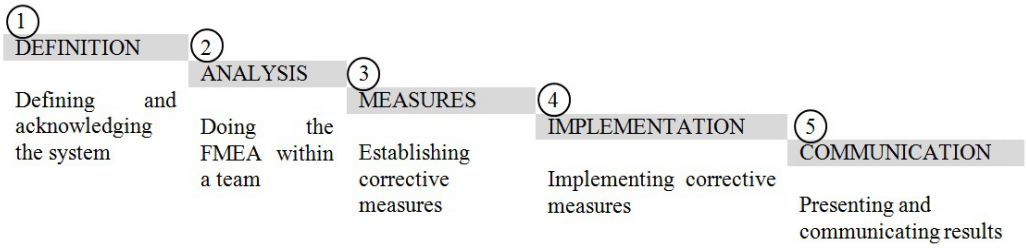

Fig. 1. The DAMIC model

Fig. 2. Steps in the analysis phase

The resulting measures are inserted in a form named "*Measurement tracking for the FMEA of the measuring process*".

Implementation – Implementing of corrective measures, evaluation, verification, validation and monitoring.

The corrective measures are implemented considering either the cause of the error or the error occurrence mechanism. These measures have a deadline and a person responsible associated with them.

The Measurement Tracking Form suggests that the team moderator be assigned the responsibility of ensuring that the corrective measures are implemented. The FMEA team members report the measure implementation progress to the project responsible. The team members can assign tasks to others outside the team but are responsible for the implementation of the measures.

After implementing the improvement measures, the A, E and RPZ indexes are reevaluated while the B index remains unchanged. If the RPZ index is still too high, the improvement process is repeated until the index is in limits.

Communication – Presentation, information and communication

The acquired knowledge must be put at the firm's disposal:

- Informing of the involved parties;
- Presenting of the FMEA results;
- Updating of knowledge base;
- Updating of the study database;
- Redefining of new responsibilities.

2.1. The FMEA analysis team for measurement process

The team has an important role in the FMEA analysis of the measurement process (Figure 3).

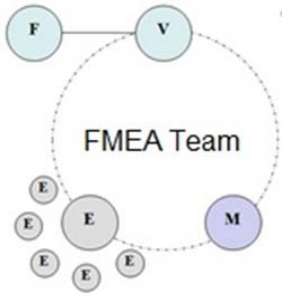

Fig. 3. The FMEA team

The team is composed of: - A project coordinator with the following responsibilities; - Decisions regarding the measurement process execution; - Ensuring support for information gathering; - FMEA approval; -

A FMEA responsible with the following tasks: Co-participating at FMEA preparation; Providing information about the known measurement processes based on experience; Taking part in the selection of improvement measures;

- A moderator from the Quality Department with the following tasks:

- Taking part in the planning of the FMEA analysis;
- Preparing/organizing of the analysis;
- Moderating the work team;
- Documenting the analysis;
- Evaluating and presenting the results;
- Ensuring methodological correctness;
- Taking part in improving the efficiency;
- Experience exchange;

- Experts with the following duties:

- Presenting of the current state of the measuring process
- Providing information about the known measurement processes based on experience;
- Implementing the improvement measures.

2.2. The procedure for the FMEA analysis of the measurement process

For risk evaluation the A, B and E indexes are assigned the values in Table 1, 2 and 3.
The analysis process is shown in Figure 4. For each operation or phase the causes and effects are determined and improvement and detection measures are conceived. The risk is evaluated and the measures are implemented. If the RPZ index is not low enough, the process is repeated.

Table 1

Classification of the importance index B (5)

Imp.	Importance criteria	Cls.
Very high	Deviation from critical/ security characteristic and regulation, assembly clearances, improper fitting, erroneous approval of manufacturing process	10
	Positioning errors of assembly components, noise while in operation	9
High	The manufacturing process is not approved, Part declared compliant, it being scrap	8
	Influences on the measurement equipment capability, improper CMM calibration	7
Moderate	Collision of probe head	6
	Influences on process capability on a short/long term, improper styli calibration	5
	Styli deterioration (breakage), part declared scrap, it being compliant, influences on manufacturing process adjustment	4
Low	Blockage on machine guideways, premature machine wear (pneumatic guideways)	3
	Deviation of less important characteristics, long manufacturing process approval times	2
Not important	No effect on measurement result	1

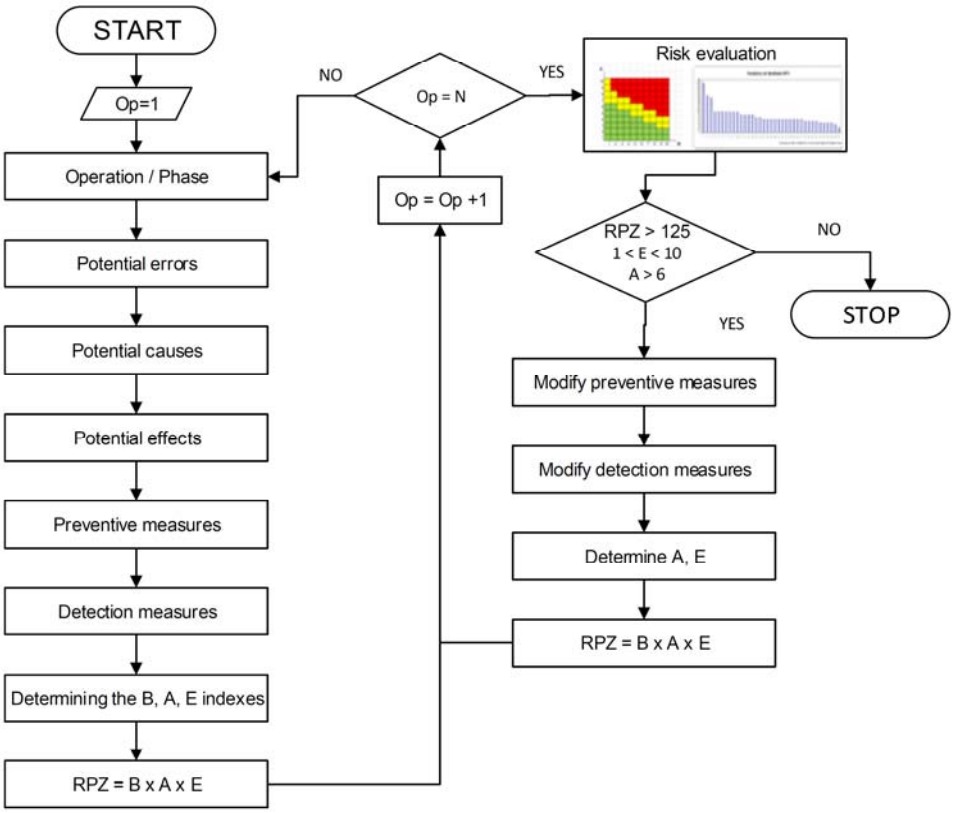

Fig.4. The FMEA process

Table 2

Classification of the occurrence index A (5)

P_o	**Occurrence criteria (Preventive measures)**	**Occ.**	**Cls**
Very high	Error occurrence is almost certain (Daily machine cleanup, verification of function keyboard, rethinking of work program, ensuring optimal work conditions)	more than 1 in 10 measurements	10
	Error occurrence is almost certain (CMM preventive maintenance plan, program simulation, workplace organization)	1 in 20 measurements	9
High	Frequent errors. The measurement process is not controlled (Log: styli change, systematic measurement errors, temperature with indication of measurement point, noise level measurement)	1 in 50 measurements	8
	Frequent errors. The measurement process is not controlled (Database with styli used for each feature and operation, ensuring measurements with or without a CAD model, measurement evaluation software licenses)		7
Moderate	Occasional errors in the measurement process (Air-conditioned room, measurement plan with less points, software upgrade)	1 in 125 measurements	6
	Occasional errors in the measurement process (Instructions regarding usage of additional devices and part temperature measurement, measurement plan with more points, adequate measurement strategy, purchasing of vibration compensators)	1 in 250 measurements	5
Low	Isolated errors in the measurement process (Instructions regarding part alignment with machine coordinate system, instructions in using the calibration gauge, comparison between drawing precision and machine precision)	1 in 500 measurements	4

	Isolated errors in the measurement process (Instructions regarding machine calibration and verification of calibration gauge, periodic machine revision, correct selection of measuring precision in accordance with the measured part's tolerances)	1 in 750 measurements	3
Very low	Measurement process is under control (Operator is trained in measuring, position correction of measurement head at machine calibration, control technologies, styli calibration periodic verification on a gauge part)	1 in 1000 measurements	2
Impossible	Error occurrence is impossible	0	1

Table 3

Classification of the detection index D (5)

P_D	**Criteria: probability of cause detection (NOK measurements) by the proposed detection measures**	**Cls**
Very unlikely	Filter check according to MIC documentation	10
	Daily check of function keyboard operation, daily verification of temperature, daily humidity check, weekly noise measurement	9
Unlikely	Visual control, daily vibration check	8
	Daily verification of temperature, temperature measurement of part at control, activity alternation	7
Moderate	Cut-off system for the motors when improper operation is detected, operator supervision, temperature verification every 3 hours, result interpretation from another operator	6
	Verification of stylus system at shift change	5
Likely	Verification of calibration gauge at regular intervals, measurement operator versatility, roughness check according to control plan	4
	Yearly service check-up, part alignment check before program start, repeat measurements for outliers	3
Very likely	Verification with a different stylus system, Cross-measurements	2
	Daily styli calibration	1

2.3. Documentation for the MMC control process FMEA

Figure 5 presents the FMEA analysis form with two states: the initial state and the state after improvement.

The initial state is documented in columns 0 to 10. The first column has the measurement operation sequence, column 4 has the potential errors and their causes (col. 5) followed by the potential error effects (col. 2).

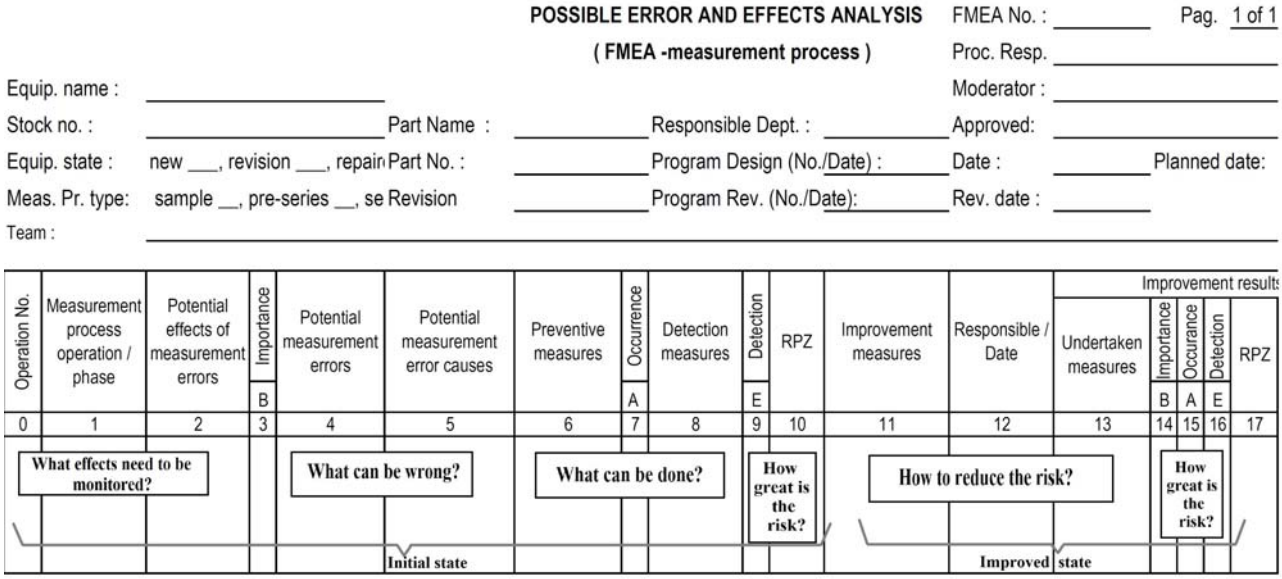

Fig. 5. The FMEA form explained

The preventive measures are part of quality assurance and the detection measures are part of quality control. Next, the importance B (col. 3), occurrence A (col. 7) and detection E (col. 9) indexes are evaluated in accordance with tables 1-3.

Lastly the RPZ risk index (col. 10) is evaluated. The risk evaluation is done by:

- Drawing the risk diagram in descending order with the RPZ value on the X axis;
- Using a risk matrix in accordance with VDA4.

The improvement stage follows, depending on the value of the RPZ index (RPZ>125) and/or the cumulated value of the A and B indexes. The Measures Tracking Form is used, which contains the needed actions and the responsible/deadlines. The moderator monitors the progress of the implementation. A new risk assessment is done with the B index remaining the same. When the RPZ cannot be lowered anymore the date is entered in the last column of the form..

The results of the FMEA analysis are communicated to the firm's management and to the participants.

A database is created which will be the basis for other FMEA analyses.

In every step of the analysis the moderator uses the questions presented in tables 4-8

3. CONCLUSION

The FMEA applied to process coordinate measurement uses the sequence: inform-analyze-use. The information regarding the measurement errors are analyzed through their causes, their effects and through the detection and prevention measures.

The main value of this analysis is applying the improvement measures and creating a database of results for future similar analyses to be based on.

4. REFERENCES

[1] AMG - Grundlagen Qualitätsmanagement. Qualitätsmanagement Methoden, Tools und Prozesse, Oktober 2005, version 1.0 Competence Center Quality

[2] Pfeifer T., Schmitt R., - Fertigungs-messtechnik, 3. Auflage, 2010, München, ISBN 978-3-486-59202-3

[3] VDA 4 Sicherung der Qualität in der Prozesslandschaft – Allgemeines, Risikoanalysen, Methoden, Vorgehensmodelle – Produkt- und Prozess – FMEA, Auflage 2009

[4] VDA 5 Prüfproyesseignung, 2.Auflage, Berlin, 2010

[5] Fulea L., Bulgaru M, Borzan M, BocăneŢ V. „Contributions regarding the application of fmea analysis to measuring with a coordinate measuring machine", 11-th International Conference MTeM 17-19 oct. 2013, Cluj-Napoca, Romania

Elaborarea unei metodologii de aplicare a analizei FMEA unui proces de măsurare cu MMC-uri

Rezumat. Această lucrare prezintă metodologia de realizare a unei analize FMEA pentru un proces de măsurare cu ajutorul unei MMC utilizând modelul DAMIC. Se urmăresc etapele procesului de analiză i documentaŢia aferentă cu scopul de a evidenŢia particularităŢile aplicării unei astfel de analize unui proces de măsurare.

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