COMPONENTS OF FMEA DATABASE FOR THE MEASUREMENT PROCESS

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ABSTRACT. Quality is one of the most important problems of production. In today's production it is not enough to just do a final quality check and thus quality must be integrated in the production process even from the conception stage. Quality tools, such as the FMEA analysis, are used to prevent the occurrence of errors starting with the design step. Although the FMEA was initially conceived for the manufacturing process, it can be applied to other processes, such as the measurement process. This article presents the components of databases that can be used by modern software for applying the FMEA to a measurement process.
KEYWORDS: FMEA, web based FMEA, FMEA database, FMEA for the measurement process.

1. INTRODUCTION

Since the industrial revolution, the demands for quality have been increasingly stricter. As a result the good practices gathered along the way have materialized in a set of quality tools. One of these tools is the Failure Mode and Effects Analysis (FMEA). This method is commonly used for avoiding potential non-conformities by quantifying and prioritizing the risk of them arising [1] while at the same time establishing a balance between the development and the manufacturing of a product.

The implementation of FMEA was standardized by the use of MIL-STD-1629A in the United States of America, BS EN 60812:2006 in Great Britain, VDA-4 in Germany and IEC 60812 worldwide. A successful FMEA can yield qualitative improvements of 15% to 45% [2], as well as a reduction in costs.

This type of analysis is mainly used in manufacturing processes but its use can be extended to other fields. One very important application is the FMEA for the measuring process.

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2.THE FMEA ANALYSIS

The FMEA analysis can be summarized by the following stages: Definition, Analysis, Measurement, Implementation and Communication of results. This model is abbreviated DMAIC.

In the definition stage the purpose of the analysis is established. The analysis can focus on a process, a piece of equipment or it can be an update of a previous analysis. At this stage the team structure is established, each member's responsibilities and their communication channels are determined and all the necessary resources and documents are determined and procured.

The analysis stage is maybe the most complex of them all. During this step the structure and elements of the process are analyzed, its limitations and constraints are identified and a first FMEA form is generated. The next step is the analysis of errors, identification of erroneous processes, establishing the causes and determining the effects of the errors.

In the measurement stage, corrective and detection measures are established for the identified errors. All of these elements are quantified through the use of indexes, namely the occurrence (A), importance (B) and detection (E) indexes, which are used for calculating the risk labeled with the RPZ index.

The fourth stage is the implementation. Once the errors have been identified and quantified, corrective measures need to be put in place. Each team member takes on the responsibility of implementing the corrective measures before the agreed upon deadlines. The evolution of the implementation is documented by use of a form similar to that presented in Fig. 1. The whole implementation process is monitored by the project coordinator. After the implementation of the corrective measures, the A, E and RPZ indexes are reevaluated. If the resulting RPZ index is still above accepted limits (RPZ>125), the whole process is reiterated until an acceptable RPZ value is obtained.

POSSIBLE ERROR AND EFFECTS ANALYSIS FMEA No. : ________ Pag. ____

Proc. Resp. ________________

Equip. name : ________________ Moderator : ________________

Stock no. : ________________ Part Name : __________ Responsible Dept. : __________ Approved: ________________

Equip. state : new ___, revision ___, repair Part No. : __________ Program Design (No./Date) : __________ Date : ________ Planned date:

Meas. Pr. type: sample __, pre-series __, se Revision __________ Program Rev. (No./Date): __________ Rev. date : ________

Team : ________________________________

Operation No.	Measurement process operation / phase	Potential effects of measurement errors	Importance	Potential measurement errors	Potential measurement error causes	Preventive measures	Occurrence	Detection measures	Detection	RPZ	Improvement measures	Responsible / Date	Improvement results				
													Undertaken measures	Importance	Occurance	Detection	RPZ
			B				A		E					B	A	E	
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Fig.1. Form used for the FMEA analysis [3]

In the final stage the obtained results are communicated to the analysis team as well as to the management of the company. The results and documents of the whole analysis are archived and will be the starting point for future analyses.

3.FMEA ANALYSIS SOFTWARE PACKAGES

Conventionally FMEA is done by using printed tables or spreadsheet software, like Microsoft Excel. This method has the advantage of being simple to use – the user needs basic Excel skills – and there are few or no format restrictions when saving the data. Even so, there are considerable drawbacks in using these methods. Documents stored in hardcopy are not active documents that can be updated, modified or reused easily and require a lot of time for upkeep and consultation. The access to the documents is not done very easily if the analysis team isn't in the same physical location. Aggregating data from multiple analyses can take up a lot of time and considerable effort from the team.

As a solution to these shortcomings, a lot of FMEA software packages have emerged. The benefits claimed by their developers include: they make flows more rational, reduce costs, unburden employees, shorter FMEA processing time, reuse of basic FMEAs, parent FMEAs, and all knowledge, information from complaints due to automatic detection of new defects [4], they create a keyword-searchable knowledge base of reliability-related information for the designs, establish consistency throughout the organization's FMEA process and make it easy for multiple users to cooperate on the analyses [5], they reduce the engineering time to prepare the FMEA and leave a professional impression to customers [6]

Furthermore, web-based applications have been developed that bring other advantages compared to stand-alone versions: the team can remain connected even if its members aren't all in the same physical location, the ongoing analysis can be accessed from multiple platforms (PC, tablet, smartphone), no need of installing other software, exporting and importing documents can be done from any device [7].

Many of these packages/services have the main disadvantage of the high cost. As a result, many low-cost solutions have emerged from researchers and developers in the field [8] [9] [10].

The general architecture of these web-based systems has three main components: a FMEA web server, a database and the FMEA clients. The FMEA web server manages the HTML pages necessary for viewing the information, it processes client requests and queries the FMEA database. The database is usually a relational type database that stores its information in tables. Each table keeps information on different aspects of the analysis. The FMEA client is the interface between the user and the FMEA system and it is usually represented by the browser on the user's computer or a specially developed app for the interaction with the FMEA server, in the case of mobile devices.

4.DATABASES FOR THE FMEA OF A MEASURING PROCESS

Of all the components of a web based FMEA system, we will focus on the FMEA database and what are its differences when used for the measurement process. The database stores information on the elements necessary for the analysis. In the case of a FMEA for the measuring process, the database should contain at least the following information: the causes of the errors, discovery and prevention methods and the effects of the errors.

Applying a FMEA to the measurement process has some particularities compared with applying the analysis to a manufacturing process. One of these is that all the intermediate control operations are intertwined with the manufacturing operations and to be able to do the analysis, one must regard the control process as one single continuous flow (Fig. 2.). The tools and equipment used in the manufacturing process are replaced with control equipment and devices. These have different lifecycles and require a more thorough control because of the precision requirements.

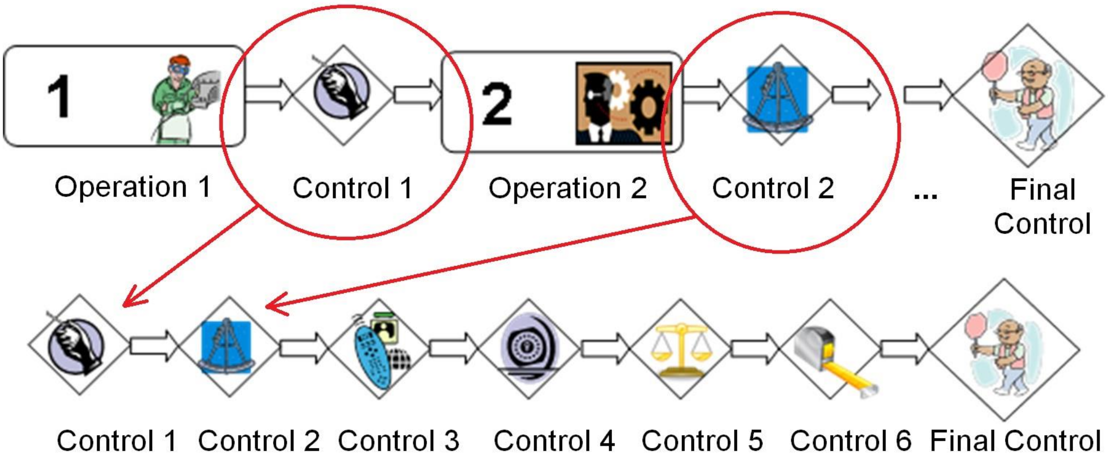

Fig. 2. Visualizing the control process as one continuous flow [10]

Taking into account the particularities of the measurement process, the FMEA analysis system must be adapted accordingly; the differences between the causes of non-conformities are presented in Tab. 1.

Tab. 1. Comparison of non-conformities causes

Causes for non-conformities for	
a manufacturing process	**a measuring process**
Worker	Operator / Quality Analyst
Machine Tool	Measuring equipment
Method	Measuring Strategy
Part material	Work-piece
Environment	Environment

When it comes to errors, their causes can be grouped by source. One easy way to visualize error causes are with an Ishikawa diagram (Fig. 3). Each category is represented in the database by a table. Each table is populated with the found causes. With each analysis the database becomes more and more complex and complete.

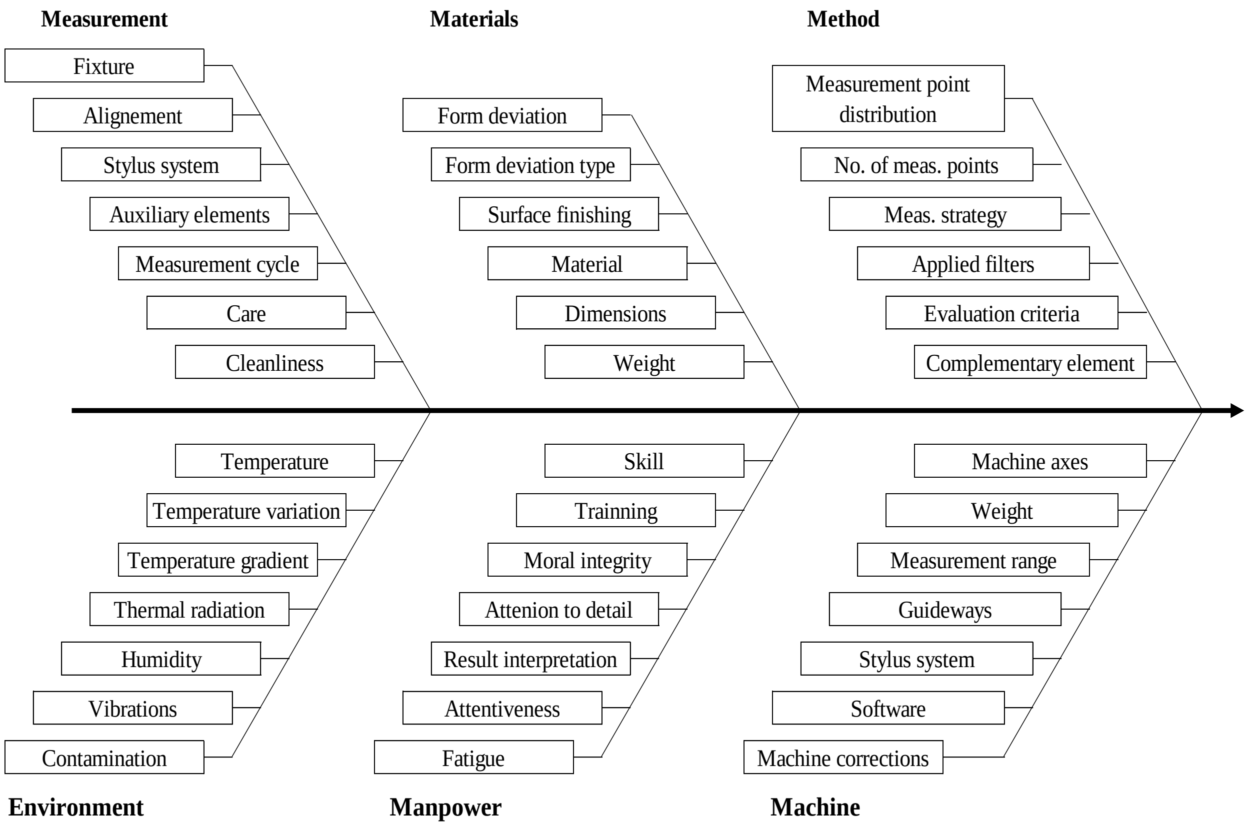

Fig. 3. The Ishikawa diagram of the error causes

In the case of a measuring process, the worker is in fact the operator/quality analyst in the control room. He can have different skill and training levels as well as his own internal motivation for fulfilling the job requirements.

A quality analyst must be able to recognize problems, take measurements and interpret results, perform visual inspections of products and fill out the necessary documentation. The job requires a special attention to detail, moral integrity and communication skills [11]. Any shortcoming in any of these attributes coupled with strain from the work schedule can represent a source of errors.

In many cases the measuring process is done by use of coordinate measuring machines (CMMs). Because of the demand for high precision, the periodical calibration and maintenance of CMMs is paramount. A machine that doesn't conform to the precision requirements can lead to completely erroneous results. As important is choosing the correct type of machine, positioning devices and fixtures.

The measuring method can have a great influence on the measurement results. In the case of CMMs, the measuring strategy can be quite diverse and have a great influence on the outcome of the measurement. The strategy must be chosen with regard to the measured feature, the evaluated characteristics and the restrictions of the part geometry. Depending on the functionality of the part, some strategies can yield better or worse results.

The material of the work-piece is determined by the design team and as a result the styli must be chosen accordingly. Some materials can have a chemical affinity for the stylus' material which can lead to deposits on the surface of the stylus resulting in measurement errors.

At the start of the measurement the styli must be qualified. This way, errors that might occur because of stylus wear can be compensated. If the styli have a high degree of wear, the results of the measurement are erroneous.

Although the environment where the measurements are usually done is a controlled one, factors like work-piece or stylus cleanliness or differences in temperature between the work-piece and measuring equipment have a significant influence on the measuring process.

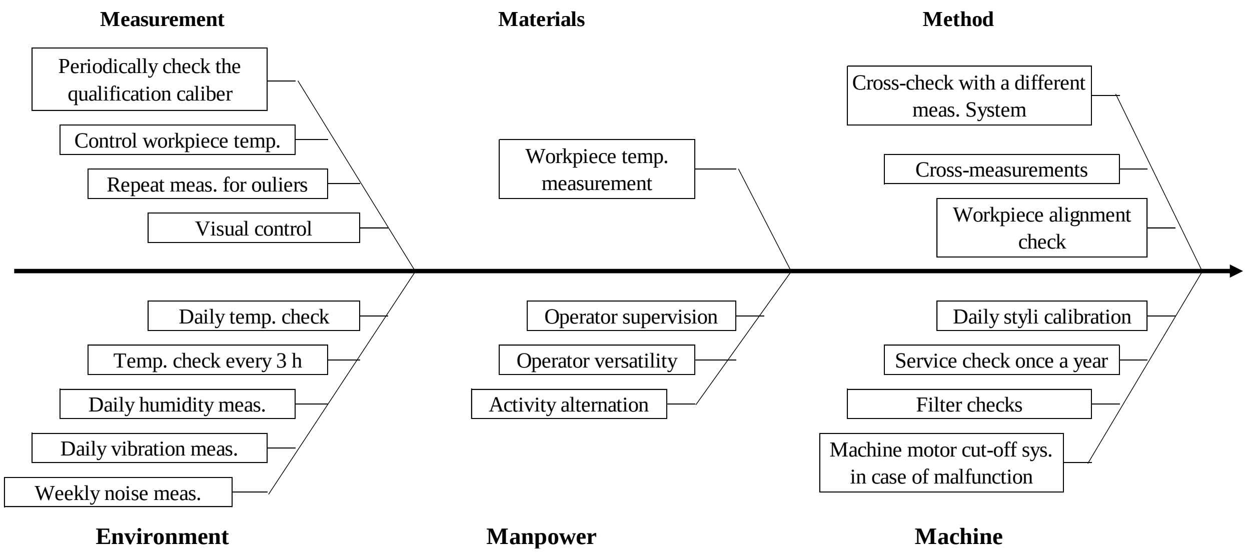

Fig. 4. The detection measures for the identified causes

All these causes require adequate detection methods. Fig. 4 shows these methods grouped by the six described categories. Each category represents a different table in the FMEA database and may include more or less items.

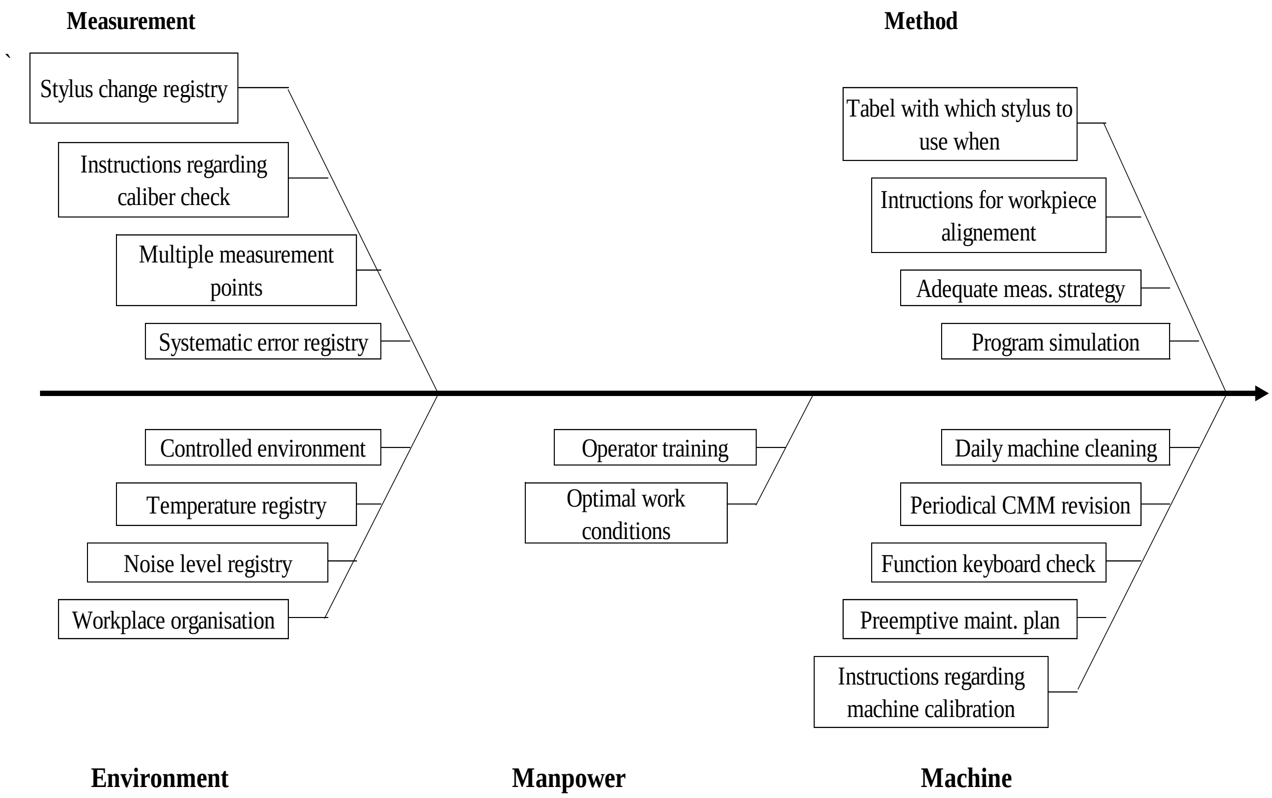

Fig. 5. The prevention methods

After the causes have been identified and detection measures have been determined, prevention methods are established (Fig. 5). The category structure is kept and the tables are populated with the established prevention methods that address the more important causes.

5.CONCLUSIONS

As quality control and assurance become more and more important in the modern production process, the tools and methods used need to be adapted to meet their demands. One of the methods used is FMEA which, conventionally, is used for the manufacturing process. The FMEA analysis can be applied to the measuring process but only after adapting the current software solutions.

The current paper proposes a structure for the FMEA database to be used with current software solutions. It should have at least tables that contain the error causes, discovery and prevention methods and error effects. The tables can be grouped by the sources of errors that can be easily visualized with Ishikawa diagrams.

6. REFERENCES

►BULGARU Marius, FULEA Lucian, BOCĂNEȚ Vlad „Development of a FMEA analysis on the coordinate measuring process”, XI-th International Scientific Conference Coordinate Measuring Technique, 2-4 apr. 2014, Bielsko-Biala, Polonia Proceedings of XIth International Scientific Conference on Coordinate Measuring Technique CMT 2014, pag. 15-19, Bielsko-Biała, 2015, Ed. Akademii Techniczno-Humanistycznej, ISBN 978-83-63713-88-1.

►Fulea L., Bulgaru M, Borzan M, Bocăneț 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

►HUANG, G.; SHI, J.; MAK, K. Failure mode and effect analysis (FMEA) over the WWW. International Journal of Advanced Manufacturing Technology, v. 16, n. 8, p.603 - 608, 2000.

►Huang G. Q., M. Nie, K.L. Mak “Web-based failure mode and effect analysis (FMEA)”, Computers & Industrial Engineering 37(1-2):177-180 · October 1999

► Huang G. Q., J. Shi and K. L. Mak, “Failure Mode and Effect Analysis (FMEA) Over the WWW”, International Journal of Advanced Manufacturing Technology (2000) 16:603–608. Springer-Verlag London Limited

► Neagoe, B.S., I. Martinescu “Web-based methodology for the management of FMEA projects”, RECENT, Vol. 13, no. 2(35), July, 2012, ISSN 1582-0246

►Information on http://www.pickert.de/en/rqm-the-optimal-caq-software/quality-planning/fmea/

►Information on http://www.reliasoft.com/xfmea/

► Information on http://www.datalyzer.com/software/fmea-software/

►Information on https://www.qaassistant.com/en/QA_Assistant_Studio_features/

►Information on http://www.onetonline.org/link/details/19-4099.01