International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:268
Vol.2, No.5, May 2013 DOI:10.15693/ijaist/2013.v2i5.68-71

Failure Modes and Effect Analysis of a Mechanical Assembly by Using Mil-Std 1629a Method

Mr. Mirza Hyder Ali Baig
Assistant Professor/Department of Mechanical Engg
Sphoorthy Engineering College, Hyderabad, India

Dr. Smt. G.Prasanthi
Professor/Department of Mechanical Engineering
JNTUACE, Anantapur, India

***Abstract*— In the present work, a mechanical valve which got its application in many fields of engineering is designed by Design for Reliability (DFR) technique. This technique is used at different phases of new product development life cycle (NPDLC). In order to improve reliability of a system, the design of the system has been analysing for its potential Failure modes and its effects on the total system. The design of mechanical valve is started with the concept of Failure Modes and Effect Analysis (FMEA) which is done by using MIL-STD 1629A Method. Along with increase in performance and Reliability on an assembly, the results are also useful to the manufacturer, designer and maintenance engineer for the evaluation of other criteria like maintainability, safety analysis, survivability and vulnerability, logistic support analysis, maintenance plan analysis for preventive maintenance, warranty estimation, failure detection and isolation subsystem design, cost estimation, ease of design, availability of technology and availability of resources for selecting the final concept before initiating the actual design and prototype for the mechanical assembly.**

Index terms - FMEA, MIL-STD 1629A, Reliability, Preventive Maintenance, DFR, Ball valve.

I. INTRODUCTION

A. General

A Ball valve is a general purpose valve. It is used in many applications such as Commercial pipelines, Aerospace, long range oil, gas and water pipelines, petrochemical, oil refining, gas, metallurgy, chemical, food, and other related industries. A general Floating ball valve is atomized by replacing hand lever with solenoid. Simple fasteners are used for assembling a solenoid.

FMEA is the process used to determine the Failures and its Effects of an item. FMEA involves identify all modes of failures and its effects within a system design or products prior to their production or modification. Successful FMEA generally requires developing a documents of all possible failures in a system within specified ground rules determines by failure modes analysis the effect of each failure on system operation, identifies single failure points, and rank each failures according to a severity classification of failure effect. The level of detail of the model will depend on the level of design detail available and detail manufacturing processes data available at that time. Data required to quantify the failure modes is obtained from sources such as company warranty records, manufacturing processes parameters, customer maintenance records, component suppliers, expert elicitation from design or field service engineers. FMEA combines rigorous analysis procedures with expert judgment to develop a realistic estimate of product performance.

B. Problem Formulation

FMEA of a mechanical valve (Floating Ball Valve) is taken up in the present work. It is used to analyse its component level as shown in fig.1 and fig.2, by using MIL-STD 1629A method. It is carried out to find the potential failure modes that are present in the design and their causes and their corresponding effects that will have on the operation of the equipment, for implementing the required design changes to ensure a fault free operation of the system to the extent possible in the real world.

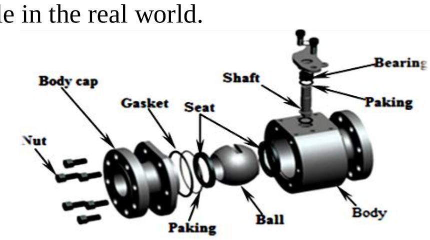

Figure 1, Shows an Exploded view of a general ball valve

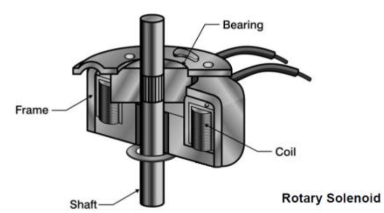

Figure 2, Shows an Exploded view of a general rotary solenoid

II. FAILURE MODES AND EFFECT ANALYSIS (FMEA)

A. Introduction

Procedures for conducting FMEA were described in US Armed Forces Military Procedures document MIL-HDBK-1629 (1949; revised in 1980 as MIL-STD-1629A). Later, it was used for aerospace/rocket development to avoid errors in small sample sizes of costly rocket technology. An example of this is the Apollo Space program. The primary push came during the 1960s, while developing the means to put a man on the moon and return him safely to earth. In the late 1970s, the Ford Motor Company introduced FMEA to the automotive industry for safety and regulatory consideration after the Pinto affair. They applied the same approach to processes of FMEA

(PFMEA) to consider potential process induced failures prior to launching production.

"Failure modes" means the ways, or modes, in which something might fail. Failures are any errors or defects, especially ones that affect the customer, and can be potential or actual. "Effects analysis" refers to studying the consequences of those failures.

Failure Modes and Effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service.

Failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. The purpose of the FMEA is to take actions to eliminate or reduce failures, starting with the highest-priority ones.

Failure modes and effects analysis also documents current knowledge and actions about the risks of failures, for use in continuous improvement. FMEA is used during design to prevent failures. Later it's used for control, before and during ongoing operation of the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service.

B. When to use FMEA

- When a process, product or service is being designed or redesigned, after quality function deployment.
- When an existing process, product or service is being applied in a new way.
- Before developing control plans for a new or modified process.
- When improvement goals are planned for an existing process, product or service.
- When analyzing failures of an existing process, product or service.
- Periodically throughout the life of the process, product or service.

C. FMEA overview and ground rules

The floating ball valve is being developed to the Airbus Development Assurance level "D". This system is considered a mitigating feature against threat intrusion. The dispatch risk is beyond the scope of the document and is left for Airbus to determine.

The FMEA describes the precise failure modes, their consequences on the item equipment functions and the associated failure rate. This equipment does not affect the safety of flight for the aircraft. Therefore, this FMEA is provided for Airbus to determine logistical impacts related to equipment support and dispatch availability. Of these failure modes only "hard" failures are considered (e.g. open/short).

D. FMEA worksheet columns

- **Mechanical Valve**

Mechanical Valve, e.g. Floating Ball Valve in which she/he analysed system/ subsystem/ component, is analysed.

- **Function**

Brief description of the function performed on the analyzed system/subsystem/component.

- **Specification**

Number of the customer's specification of the system/subsystem/component.

- **Documents, Drawings, Functional Diagrams**

List of all documentation (e.g. descriptions, drawings, functional diagrams) used in preparing the FMEA.

- **Severity Rank criteria**

Severity rank criteria is a pre define ranks that indicates how much effect that will produce by a single component fails on total system or sub-system.

- **Occurrence failure rate criteria**

An occurrence failure rate criterion is a probabilistic occurrence failure rate is based on prediction results that how many failures will occur at specific given period of time or operations.

- **Detection rate criteria**

Detection rate criteria is a pre define detection rate of a failures of a components that indicates how easily detect the failures of a components.

- **Issue**

Indicates the FMEAs revision.

- **Supplier**

Name of Supplier

- **Prepared by**

Name of the person preparing the FMEA.

- **No.**

Consecutive numbering.

- **Functional Block**

Functional Block being analyzed.

- **Function**

Statement of the function the corresponding item performs.

- **Failure mode**

Possible defect or failure types of the item.

- **Failure cause**

Possible failure cause associated with each postulated failure mode. Since a failure mode can have more than one cause, all potential independent causes for each failure mode must be identified and described.

- **Failure Rate**

The dimension per Million hours.

- **Failure effects**

The effects on the following levels:

1. Component.
2. Subsystem.
3. System.

- **Recognition of failure**

Statement indicating a latent failure condition.

- **Remarks**

Conditions which influence the effects of the Failure compensation provisions and other information that would aid in understanding the failure mode and its effects.

E. FMEA template

In FMEA first and most important step is to give ranks for severity, occurrence and detection through which each and every technical person can easily understand FMEA work sheet without confusion. The rank, rate and criteria in this project are describe below tables. First rank for severity and is effect is shown in table 1, similarly other ranks for occurrence and detection is shown in table 2 and table 3, and RPN number is equal to severity rank x occurrence rank x detection rank.

SEVERITY		
Rank	**Effect rate**	**Criteria**
10	Hazardous-without warning	Very high severity ranking when a potential failure mode affects personal safety, safe item operation and/or involves non-compliance with government regulation without warning
9	Hazardous-with warning	Very high severity ranking when a potential failure mode affects safe item operation and/or involves non-compliance with government regulation with warning
8	Very High	Item inoperable, with loss of primary function.
7	High	Item operable, but at reduced level of performance. Customer dissatisfied.
6	Moderate	Item operable, but Comfort/ Convience item(s) inoperable. Customer experiences discomfort.
5	Low	Item operable, but Comfort/ Convience item(s) operable at reduced level of performance. Customer experiences some dissatisfaction.
4	Very low	Fit & finish/Squeak & Rattle item does not conform. Defect noticed by average customers.
3	Minor	Fit & finish/Squeak & Rattle item does not conform. Defect noticed by most customers.
2	Very minor	Fit & finish/Squeak & Rattle item does not conform. Defect noticed by discriminating customers.
1	None	No effect.

Table 1, Gives the severity rank, severity effect rate and severity criteria.

OCCURRENCE			
Rank	**CPK**	**Failure Rate**	**Criteria**
10	$\leq$ 0.33	< 1 in 2	**Very High:**
9	$\geq$ 0.33	1 in 3	Failure almost inevitable
8	$\geq$ 0.51	1 in 8	**High:**
7	$\geq$ 0.67	1 in 20	Repeated failures
6	$\geq$ 0.83	1 in 80	**Moderate:**
5	$\geq$ 1.00	1 in 400	Occasional failures
4	$\geq$ 1.17	1 in 2000	
3	$\geq$ 1.33	1 in 15 000	**Low:**
2	$\geq$ 1.50	1 in 150 000	Relatively few failures
1	$\geq$ 1.67	$\leq$ 1 in 1 500 000	**Remote:** Failure is unlikely

Table 2, Gives the occurrence rank, occurrence failure rate and Occurrence criteria.

DETECTION		
Rank	**Detection rate**	**Criteria**
10	Absolute uncertainty	Design Control will not and/or cannot detect a potential cause/ mechanism and subsequent failure mode; or there is no Design Control.
9	Very remote	Very Remote chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.
8	Remote	Remote chance the Design Control will detect a potential cause/ mechanism and subsequent failure mode.
7	Very low	Very Low chance the Design Control will detect a potential cause/ mechanism and subsequent failure mode.
6	Low	Low chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.
5	Moderate	Moderate chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.
4	Moderately high	Moderately High chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.
3	High	High chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.
2	Very high	Very High chance the Design Control will detect a potential cause/mechanism and subsequent failure mode.
1	Almost certain	Design Controls will almost certainly detect a potential cause/mechanism and subsequent failure mode.

Table 3, Gives detection rank, detection rate and detection criteria.

The FMEA template is designed according to the instructions given in the customers' guideline document. The columns that are present in template will change from company to company depending on their requirements. The following FMEA templates shown in Excel Template represent the FMEA process done in this project

III. COMPONENTS TECHNICAL DATA

A. *Floating ball valve* [1]

The main function of floating ball valve is to cut off or allow the flow passage along the pipeline. In this manually operated hand lever is replaced with solenoid to atomize their operation. The solenoid drives the ball to cut off or allow the flow passage.

Rotate solenoid 90 degrees clockwise to close the valve and cut off the flow. Turn the solenoid 90 degrees counterclockwise to open the valve and allow the flow.

Bill of material of a stainless steel series 3" floating ball valve, *ref 3*, is shown in table: 4.

The predicted MTBF of a given floating ball valve is found to be 9.22 failures/ million operations [1].

SL NO	DESCRIPTION	MATERIAL	ASTM STANDARD	NUMBER OF PARTS
1	Body	Stainless steel	A182-F304 / F304L	1
2	Ball	Stainless steel	A182-F304 / F304L	1
3	Stem	Stainless steel	A182-F304 / F304L	1
4	Seat	RPTFE	RPTFE	2
5	Packing	PTFE	PTFE	2
6	Gasket	PTFE	PTFE	2

7	Bearing	PTFE	PTFE	2
8	Fasteners	Stainless steel	A193, Grade B8	12
9	Solenoid	Copper winding	Copper	1

Table 4, Bill of material of a 3” floating ball valve

IV. CONCLUSION

Design for Reliability process will ensure that high quality products are delivered at the right costs with minimal warranty exposure and that mistakes are not repeated in future designs. Today's challenges are to deliver quality products in less time for less cost and the DFR process is a good way to achieve it.

Some of the methods that come under design for reliability techniques were Reliability prediction, failure modes effect analyses, fault tree analysis, accelerated life testing etc.

The floating ball valve is presently used in many engineering applications for controlling of fluid flow through pipes.
For this valve, reliability prediction is done to assure its reliability and analyze its potential failure modes so as to use it in aircraft as a fuel control valve.

Modes that are causing failure in the design can be verified and rectified by carrying out FMEA. For carrying out FMEA, military handbook MIL-HDBK-1629A is followed. This handbook provides certain procedures to conduct FMEA process. In this project, taking guidelines from military handbook and from vendor’s documents, an FMEA template is designed. The details filled in this template will provide information about the failure modes, their causes and their effects on component level, sub system level and on the system level. Not only this, it provides failure rate for each failure mode. The modes that have more failure rate have to be concentrated more, in order to mitigate that failure, to achieve high reliability.

REFERENCES

[1]. Dr.Smt.G.Prasanthi & Mr. Mirza Hyder Ali Baig, *“Reliability Prediction of A Mechanical Valve By Using NSWC Method”* (2012) *Int. J. Adwance Mechanical Engineering*, Research India Publication, 2012, pp.35-42.

[2]. Charles E. Ebeling, *“An introduction to* reliability *and maintainability* engineering*”* (2004). *“Design for reliability”*, Tata mcgrahill 2nd, ch 7, pp. 145-188.

[3]. MIL-STD 1629A *"Handbook for reliability procedures for performing a failure mode, effect and criticality analysis,"* (24-Nov-1980), *Department of defense USA*, ch. 3,4,5 and Task 101,105. pp. 5-11, 101-1, 101-5 and 101-11.

[4]. Quanterian solutions, Inc., *ReliabilityPredictionsQSI.pdf*, (2008), *"Reliability predictions"*, pp. 1-27.

Authors Profile

Mirza Hyder Ali Baig received the **D.M.E.** Diploma in Mechanical Engineering from the Vasavi Polytechnic College, Banaganapalli, SBTET A.P, Hyderabad, India, in 2006. **B.Tech.** degree in Industrial and Production Engineering from the G.Pulla Reddy Engineering College (Autonomous), Kurnool, Sri Krishnadevaraya University, Anantapuram, India, in 2009. **M.Tech.** degree in Product Design, from the JNTUA College of Engineering (Autonomous), Anantapuram, Jawaharlal Nehru Technological University Anantapuram (JNTUA), Anantapuram, India, in 2012.Currently Working as a Assistant Professor in Mechanical Engineering Department, Sphoorthy Engineering College, Hyderabad, Jawaharlal Nehru Technological University Hyderabad (JNTUH), Hyderabad, India. His research interest includes Reliability Prediction and Analysis of a Mechanical Assemblies, FRP Composite Materials, Product Design, Short Bamboo Fibers.

Dr.Smt.G.Prasanthi received the **B.Tech.** degree in Mechanical Engineering from the JNTU College of Engineering, Anantapur, Jawaharlal Nehru Technological University (JNTU), Hyderabad, India, in 1992.Curre. **M.E.** in Mechanical Engineering From the Birla Institute of Technology & Science (BITS), Pilani, India. **Doctor of Philosophy (Ph.D.).** Doctorate Degree in Mechanical Engineering from the Jawaharlal Nehru Technological University (JNTU), Hyderabad, India. Currently Working as a Professor in Mechanical Engineering Department, JNTUA College of Engineering (Autonomous), Anantapur, Jawaharlal Nehru Technological University Anantapur (JNTUA), Her research interest includes CAD/CAM, IC Engines, Manufacturing Systems Engineering, Energy Systems, Reliability.