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"FMEA Database for Oil and Gas Industry"

(Platforms, Subsea, Refineries, chemical and petrochemical plants)

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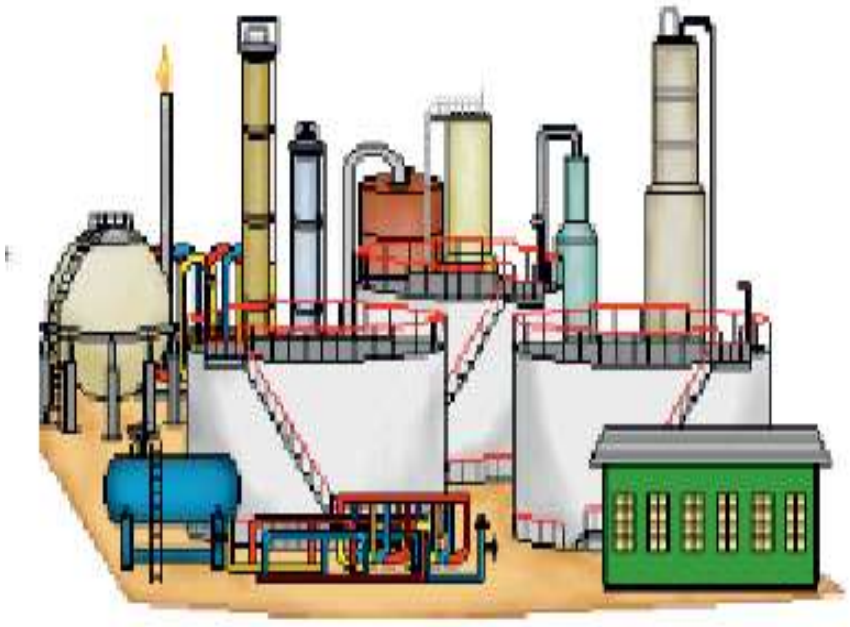

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ABBREVIATIONS

2P	Two Parameters
ETF	Expected Time to Failure
FMEA	Failure Mode and Effect Analysis
PDF	Probability Density Function
RAM	Reliability Availability and Maintainability

1. INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

The ECC FMEA database aims to provide the information of equipment failure modes, cause and effects of oil and gas and petrochemical process plants equipment and component. The FMEA database provides a guideline for support projects during concept and design phase and assessment of physical asset during operational phase. By using the ECC FMEA data base you will have the following:

- To safe time, money and effort by with standardized failuremodes, cause and consequences;
- To have the basis for RCM analysis and safe time, money and effort;
- To implement the standardized failure modes, cause and effect in the FRACAS, CMMS, Asset Management systems;
- To safe time, money and effort by with standardized failure modes, cause and consequences in safety and risk analysis;

Based on the equipment / component list defined the FMEA is described by using a general risk matrix. In order to update the FMEA database by using the different risk matrix, a re-assessment must take place.

1.2 METHODOLOGY

The FMEA database is based on the Reliability Engineer Expert Dr. Eduardo Calixto experience in hundreds of Reliability Engineering analysis including FMEA.

However, this FMEA database is defined in for equipment and component level. Because of different equipment configuration, it was considered the most critical component that affect the equipment reliability performance.

The FMEA data base is presented in level 1 (equipment) and level 2(component).

The main equipment of Oil and gas industry of downstream and upstream are divided in different types of equipment and system such as:

- Rotating;
- Static;
- Safety and Control;
- Utilities.

1.3 DATABASE STRUCTURE

The FMEA database is structured in a template divided in:

- Equipment List
- Equipment / Component Functions
- Failure Mode
- Cause

- Consequence
- Risk
- Mitigation Action/Recommendation

The “Equipment Description” describes the type of equipment, supplier, operation conditions and design specification.

The “Equipment Configuration” describes the number of equipment components in order to clarify if there is redundancy or not.

The “Equipment Function” describes the equipment objective.

The “Component” describes the type of components of the equipment.

The “Component Function” describes the objective of the components.

The “Failure Modes” describes the way that such components lose their function.

The “Failure Mode Causes” describes why failure mode happens.

The “Consequence” describes the failure modes effects on equipment/component or system.

The “Phase” describes each phase of an asset when the failure mode happens, based on its cause. The asset phases are described in the FMEA sheet as: De (design), Mo (Montage), Tra (Transportation), Ins (Installation), Prec (Pre-Commissioning), Op (Operation).

The “Risk Assessment” on the FMEA analysis, the risk is the combination of the likelihood of failure mode with the consequence of failure mode effect. In order to analyze the risk, the qualitative risk assessment was carried out based on specialist opinion, regarding a risk matrix with the likelihood and consequence criteria established. In order to simplify the FMEA template severity classification will consider the worse effect or one of the four categories (Personal Safety, Installation, Environment and Image and social).

The “Likelihood Assessment” is the frequency of the failure modes occurrence based on the risk matrix description. The failure modes frequencies classification are in line with the ECC reliability and maintainability database.

There are different configurations of risk matrix and such configuration must reflect the law and companies risk policy. The figure 2 shows an example of risk matrix with four severity categories and six frequency categories.

Figure 2 – Risk Matrix

		FREQUENCY CATEGORY					
		A (extremely remote)	B (remote)	C (Little frequence)	D (Frequent)	E (Very frequent)	F (Extremely frequent)
		At least 1 between 1000 and 100000 years	At least 1 between 50 and 1000	At least 1 betwen 30 and 50 years	At least 1 betwen 5 and 30 years	At least 1 in 5 years	At least 1 in 1 year
SEVERITY CATEGORY	IV	M	NT	NT	NT	NT	NT
	III	M	M	NT	NT	NT	NT
	II	T	T	M	M	M	M
	I	T	T	T	M	M	M

In addition, severity classification must describe all parties affected in the case of an accident like employees, community and environment as well as company installations cost. The figure 3 shows an example of severity category.

Figure 3 – Severity classification

			Description and caracteristic			
			PERSONAL SAFETY	INSTALATION	ENVIROMENT AND IMAGE	SOCIAL
SEVERITY CATEGORY	IV	Catastofic	Cathastrofic injures with death, its possible to effect people outside	Losses in equipment and plant with high cost to buy the new one	Loss of ecosystem with bad nacional and international company image reputation	Economics effects in local activities, healh cost in local populatio, economics losses in turism, ecosystem local losses and quality of life losses. (Betwen R$ 101.000.000,00 and R$ 336.000.000,00)
	III	Critical	Critical injuries. Employees stay a period oftime out of workplace	Equipment serius damaged with high cost to repair	Critical effects to enviroment being hard to improve eosystem condition even with human actions. Bad nacional and international company image reputation	Economics effects in local activities, healh cost in local populatio, economics losses in turism, ecosystem local losses (Betwen R$ 2.500.000,00 and R$ 101.000.000,00)
	II	Marginal	Moderate injuries with firt aid assistence	Low equipment damaged with low repair cost	Not serius enviroment effect but its necessary human intervention and actions to improve enviroment.Bad nacional company image reputation	Economics effects in local activities, healh cost in local population, economics losses in turism, fishing and the others (Form R$ 0,00 to R$ 2.500.000,00)
	I	NOT EFFECT	Theres no injuries and health damaged	There is not damaged to equipment and plant	Insignificant enviroment effect. There is not necessity to human action to ecosystem improvment. There is not nacional company image reputation bad effect	There is not economics effects in local activities, healh cost in local population

2. ONSHORE EQUIPMENT

2.1 Rotating Equipment

2.1.1 ***Pumps*** (Components: seal, bearing, shaft, impeller, O-ring, casing, packing, shaft, coupling, nozzle)

The centrifugal pump is one of the most used pumps in Petrochemical, chemical and Oil and Gas industry, therefore, such FMEA will describe the main components failure modes. The first step in FMEA analysis is to define the equipment and components list. The main component of centrifugal pump can be described on equipment hierarchy as follows:

- Seal;
- Bearing;
- Shaft;
- Impeller;
- O-ring;
- Casing;
- Packing;
- Shaft;
- Coupling;
- Nozzle.

The next step is to define the equipment and component function, which is described on table 1 below.

Table 1 – Pump equipment and component function (FMEA)

Failure Mode and Effect analysis (FMEA)					
FMEA Leader: Dr. Eduardo Calixto			**Document: DE-xxxx-001 Rev01**	**Date:xx-xxx-xxxx**	
System: xxxxxxx			**Subsystem: xxxxxxx**	**Equipment: P-01 A/B**	
N0	**Equipment Number**	**Equipment Description**	**Equipment Function**	**Component**	**Component Function**
1	P-101 A/B	Centrifugal Pump	Transfer a given liquid at a system required flow rate of "X" and a pressure of "Y"	O-ring	Avoid leakage
2				Casing	Protect the impeller and create a chamber for the fluid be pumped through.
3				Coupling	Transmit torque to impeller
4				Impeller	Spin the fluid inside the pump chamber
5				Shaft	Transmit mechanical energy
6				Seal	Prevent external leakage
7				Bearing	Ensure shaft alignment
8				Packing	Control leakage
9				Nozzle	To direct or modify the flow of a fluid

The next step is to perform the different component FMEA Analysis as shows the tables 2 below.

Table 2 – FMEA Pump O-ring, Casing, and Coupling)

Failure Mode and Effect analysis (FMEA)												
FMEA Leader: Dr. Eduardo Calixto			**Document: DE-xxxxxx-001 Rev01**			**Date:XX-XX-2020**						
System: XXXXXXX			**Subsystem: XXXX**			**Equipment: P-01 A/B**				**Component: O-ring, Casing and Coupling**		
N0	**Component**	**Failure mode**	**Phase**	**Cause**	**O**	**Consequence**	**S**	**Risk (Pri)**	**Mitigate Action**	**O**	**S**	**Risk (Post)**
1	O-ring	Worn out	Op	Normal wear	E	Leakage and pump loss of performance	I	**EI**	N/A	D	I	**DI**
2			Op	Excessive solids in fluid causing premature wear	E			**EI**	To control fluid quality	D		**DI**
3			Ins	Impeller misaligned	E			**EI**	To verify impeller alignment	D		**DI**
4		Brittle	Op	Overheat due lack of cooling or adequate liquid flow	E			**EI**	To control fluid quality	D		**DI**
5		Deformation	OP	Excessive temperature, pressure or chemical attack	E			**EI**	To control fluid temperature	D		**DI**
6	Casing	Worn out	Op	Aged	D	Low flow (Pumps less than the required flow rate of 'X' or pressure of 'Y'.)	I	**DI**	N/A	C	I	**CI**
7			Op	Excessive solids in fluid causing premature wear	.D			**DI**	To control fluid quality	.C		**CI**
8		Distorted	Op	Excessive pipe strain caused by overload.	D			**DI**	To control process load	C		**CI**
9	Coupling	Worn out	Op	Vibration caused by Improper shaft alignment	D		II	**DII**	To verify impeller alignment	C	II	**CII**
10			Op	Improper lubrication	D			**DII**	N/A	C		**CII**
11			Op	Aged	D			**DII**	N/A	C		**CII**