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Original Article

Assessment of components of operational reliability in walk- in freezer

Evaluación de los componentes de la confiabilidad operacional en una cámara fría

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Abstract

The objective of this paper is to assess the elements integrant of operational reliability at one technical system walk-in freezer to conserve the intermediate product to do bottling. The mean time between failures was considered to analyze reliabilities equipment, process and human, as well as the mean time to repair to assess maintainability, as well as the mean time to repair to assess maintainability. Analyzing the state system on consider the failure that impact in the availability and to propose the actions to provide the make decisions for improve the operational reliability in the conservation process of pharmaceutical ingredient active. The results show the behavior of mentioned variables and the analysis of failure modes and effects, and also the actions proposed after risk assessment associated to the product conservation process.

Key words: walk-in freezer, operational reliability, reliability equipment, reliability process, reliability human, assess maintainability.

Resumen

En el trabajo se tuvo como objetivo la evaluación los elementos que conforman la confiabilidad operacional de un sistema técnico (cámara fría), para conservar un producto intermedio. Se consideró el tiempo medio entre fallas para el análisis de las confiabilidades de equipos, de procesos y humana, así como el tiempo medio de reparación para evaluar la mantenibilidad. Del análisis del estado del sistema se identificaron las insuficiencias que afectan la disponibilidad y proponer acciones que faciliten la toma de decisiones para mantener o mejorar la confiabilidad operacional en el proceso de conservación de un ingrediente farmacéutico activo. Los resultados muestran el comportamiento de las variables mencionadas y el análisis de los modos y los efectos de las fallas, así como las medidas a adoptar después de evaluar los riesgos en el proceso de conservación del producto.

Palabras clave: confiabilidad operacional, cámara fría, confiabilidad de equipo, confiabilidad proceso, confiabilidad humana, mantenibilidad.

Introduction

Actually there are a lot of new concept and technic of maintenance; between the recent organizations form is the maintenance productive overall the more important. This technic is associated to Overall Equipment Effectiveness (OEE), Reliability-centered Maintenanceand operational reliability (CO). [1]

Deepak Prabhakar in 2014 [1] publish an explanation updated about the goal of TPM as a system select to eliminate the 6 bigger waster in the equipment, the goals is facility the implementation of work form just in time by the need to integrate the maintenance department and the production department for improve the productivity and availability. For this reason the organization work in the maintenance and the improve of equipment, but leave proof the same is a system or philosophy the organization, the reliability operational is the supporting tool for the talking decisions, and can or not to do inside in this system.

The overall equipment effectiveness, (OEE) [2] is parameters which represent the percentage of the time that machine produce the quality piece to do a comparison with the time planning to do that, follow up of active systematically, improve the availability, minimize the input and maximize the output, to permit identify the sequences of the activities relate of making of the products as well as to identify the waster that are hide in the process and the efficiency waster in the production installations. The result allow self-finance the improve plan with the benefic obtained and mainly increase the personal motivation. Although for this way is possible to measure through of only parameter all the parameter of the industrial production (availability, quality and

efficiency), show us the information about the elements causal witch are responsible to reduce each one of them that witch is necessary to use other auxiliary tools for to do the analyses of these causes.

The reliability operational is the more advanced tendency in maintenance engineering. The same emerge of the growth necessity to improve the productivity minimizing the stop of main equipment, proposing the model that takes the responsibility not only in the physic process of deteriorating but in the statistic of history of fails as the goal to search the causal relation between the elements of system.

The pro-action as all the activities of improve to prognostic the human, process and equipment fails minimizing the consequence of unforeseen fails. The priority analyze give to systemic approach and the human pro-action the real direction and support. Duran [3] explain that as a relation of elements to made up but never show as can be calculate.

The new research have been change the belief most basic about the maintenance by the quantity of date that are present in a context operational determined, is difficult to establish a direct relation an unique the useful time live of the equipment and the probability of fail. As part of the new way emerge the methodology of operational reliability [4]. That is one of the works most near to the goals of the research, but the change of the context, aeronautic industry to bio technology search have some influence in the analysis.

The reliability engineering stands out as the theory framework in which the method coexist with the technic necessary to optimize the use of the physic active and to include the improvement continuous process, new technology methodology and diagnostic tools as the goal to improve the quality.[5]

The article published about this theme are most to addressed at management the active that to maintenance management and any show the analysis of the integral elements, the asses and less a model to carry for the asses.

The date were obtained of the work order in the period 2013-2014 and different method the analysis were applied for the equipment reliability was used the variable mean time between fail, the rate the fail, for process reliability was used the fail of the process and as the system is redundant for the reliability human was used the mode analysis and effect of fail and for the asses maintainability the parametric method.

Between the result most important was obtained a value the reliability of the elements relative low but really is tall if is considered the period in witch was estimated those values, the mean repair time real was 50 % lower to planned.

Method

To management to do a high operational reliability is necessary that the processes are characterized by securing the required production with reasonable total costs due to minimal occurrence of failures, plans to ensure the established production, risks to an acceptable level and a highly motivated [6] .To evaluate the operational reliability of a system or process any is necessary the analysis of the elements that form, on which to act if we want to achieve long-term continuous improvement is necessary. In the figure 1 to supply a representation of these elements.

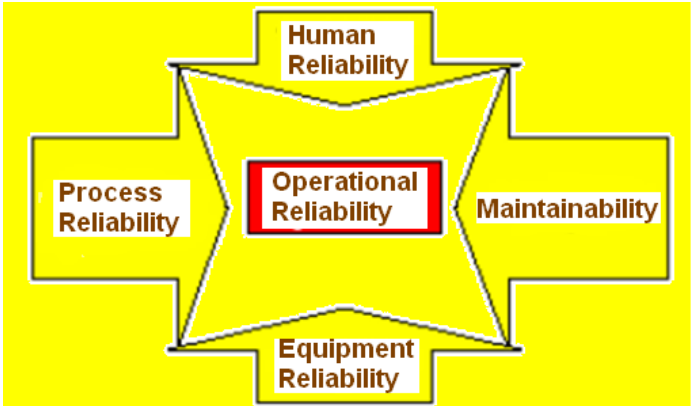

Fig. 1. Representation of the elements of operational reliability.
Source: García-Palencia [8]

The reliability of equipment is defined as the probability of a equipment, system or component satisfactorily perform the functions for which it was designed for a defined period of time under given operating conditions. Process reliability is the probability that a set of activities or events (coordinated or organized) made or happen (alternatively or simultaneously) under certain circumstances with a particular purpose. Ensure the reliable operation of the processes within the design parameters under an operational context set, using operational procedures and good operating practices to expire business objectives.

Human reliability is connected to the involvement, commitment and skills available to individuals in connection with the activities they perform and corresponding organizational structure to achieve it. It includes

elements that improve labor skills associated with knowledge, skills and abilities of each of the members of the organization in the workplace in order to generate intellectual capital [7]

Maintainability is the probability of being able to perform a certain operation maintenance repair times prefixed with the planned conditions. It is associated with the speed with which the failure or malfunction in equipment are diagnosed and corrected or scheduled maintenance is executed successfully. It is linked to the design of equipment, logistical support, and reduction in the average time to repair, maintenance strategies equipment and maintenance effectiveness for increasing its mean time between failures.

Figure 2 shows the interaction of the elements explained aforementioned and their application to technical system studied, it was the walk-freezer used in the manufacture of an intermediate product (IFA) belonging to a production of bio-pharmaceutical products shown. The type of components, quantity, quality and how they are arranged has a direct effect on system reliability.

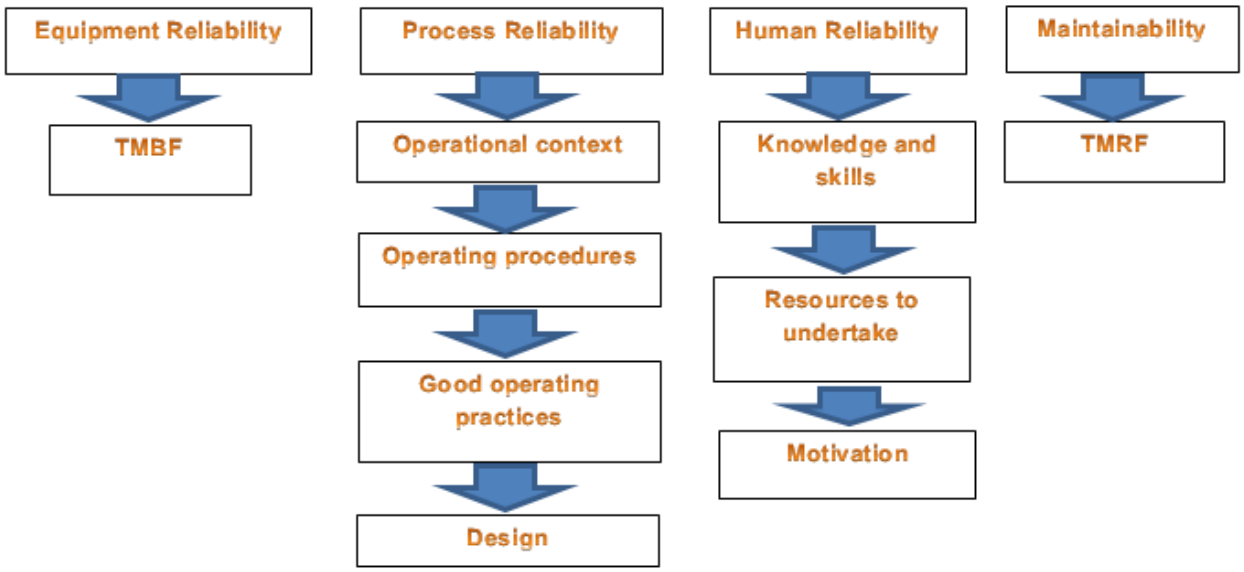

Fig. 2. Model for calculating the elements of reliability Operational in the walk freezer intermediate

In figure 3 the system shows schematically the walk-freezer intermediate which comprises:

- A system with an active redundant parallel configuration.
- A mixed system consists of a controller and active redundant parallel system.

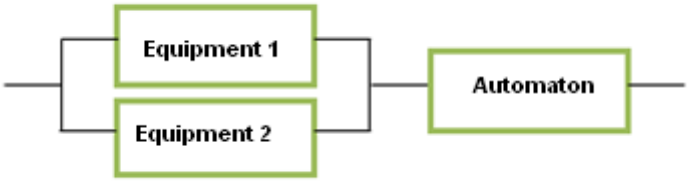

Fig. 3. Configuration of the walk-freezer

Maintenance management in the company that owns the system under study is focused on the processes and is done through an automated program maintenance management which, through work orders, collects information related to the active both unforeseen as planned actions.

They based work orders generated for reactive corrections in a period of two years (both before the study years), they were classified as equipment failures, failures of processes and technological and human failure, identifying one total of 11 faults distribution as shown in table 1.

Table 1. Failures identified

FAULTS TYPE	QUANTITY
Equipment failures	4
technological failures	5
human failings	2
TOTAL	11

Results and Discussion

Evaluation of equipment reliability

From the data obtained and the analysis, in table 2 the values of equipment reliability and system for a period equivalent to analyzed from the variable mean time between failures (MTBF) period and the failure rate is (λ) corresponding.

Table 2. Values obtained for calculating the reliability of equipment

	hours MTBF	λ	R (t) equipment	R (t) system
Equipment 1	8746,50	1,1433*10-4	0,1349	0,2512
Equipment 2	8732,50	1,1451*10-4	0,1345	0,2512
Automaton	54945,05	0,182*10-4	0,7270	0,1826

Reliability Assessment Process

Table 3 shows the result of calculating the reliability of a redundant system process (Team 1 and Team 2) and mixed regarding the programmer. By being configured in series and present 5 trouble shooting, system reliability decreases to 6% for the same time considered.

Table 3. Values obtained for calculating the reliability of the process

Equipment	TMEF hours	R(t)	R (redundant system)
Equipment 1	8746,5	0,135	0,2500
Equipment 2	8732,5	0,134	
PLC	12648	0,250	R (mixed system)
			0,0625

Assessment of human reliability

Failures may originate in natural or human causes. Ignorance, emotional or moods, willingness to perform an activity, working conditions or the worker are likely causes of human error. The literature raises among the main methodologies for human reliability analysis methods called (by its acronym in English) SHARP, ATHENEA, Therp, SHERPA and HFMEA. Of these, it was decided to choose the latter because of its simplicity, being feasible for probabilistic risk analysis and ease in implementation.

Analysis of modes and effects of human failures (HFMEA)

To implement this method, the steps are:

- Establish a method for analyzing and quantifying human failures mean time between human errors (MTBE).Characterize the errors and the root causes of human failures.
- Develop a risk assessment matrix.
- Defining risk levels and acceptance criteria. Then the development of the analysis is presented done with reference to the above sequence raised.

Table 4 shows the classification of the likelihood of human error and the corresponding definition to each base for later risk analysis.

Table 4. Classification of the probabilities of occurrence of human failings

Code	Description	Definition
Remote	1	Event that occurs very rarely (once every five years)
Low	2	Event is not expected that (once every three years) occurs
Average	3	Event is not expected that (once years) occurs
High	4	Event that is likely to occur (more than three times a year)

In the case it analyzed it was determined that the failure occurs once a year and corresponds to an average occurrence probability of receiving 3 codes as assigned value. [8]

Table 5 shows the classification of the severity of human error and corresponding to each definition basis also for later risk analysis.

Table 5. Classification of the severity of human error

Code	Description	Definition
Very critical	4	Loss of more than 75 % of production
Critical	3	Loss from 35 % to 75 % of production
Moderate	2	Loss of 10 % to 35 % of production
Mild	1	Loss less than 10 % of production

In the case studied, the severity causing a failure is considered mild, causing losses to less than 10 % of production, which receives code 1 as the assigned value.

Table 6. Risk Matrix

Severity	Probability			
	Remote	Come down	Average	High
Very critique	4	8	12	16
Critique	3	6	9	12
Moderate	2	4	6	8
Mild	1	2	3	4
Risk=Severity for Probability				

Table 7 shows the 3 zones established risk limits that frame each and its corresponding definition.

Table 7. Rating risk areas

Classification	Definition
Zone H (8-16)	Corresponds to faults that have unacceptable consequences, either by the severity thereof or likely to have occurred. This area should be the highest priority for action when implementing measures for the elimination or reduction of causes that provoked it.
Zone M (3-6)	Corresponds to an undesirable faults and only tolerable risk.
Zone L (1-2)	Corresponds to faults with acceptable risk. It represents the best value from the point of view of risk-cost.

Table 8 shows that the risk of human error occurs in the area are characterized because the average value obtained is between 3 and 6.

Table 8. Risk Rating in the matrix of severity / probability

Severity	Probability			
	Remote	Come down	Average	High
Very critique	M	A	A	A
Critique	M	M	A	A
Moderate	B	M	M	A
Mild	B	B	M	M

The value of human reliability shown in table 9 corresponds to the two faults occurring in the analyzed period, it can be noted that the value is very low.

Table 9. Values obtained for the assessment of human reliability

Time between failures	TTO hours	failures	MTBE	R(t) %
1/jab/2011-2/feb/2011	766	F1	8756	0,135
2/feb/2011-5/april/2011	1488	F2		
5/ April/2011-31/dec/2012	15258			

Table 10 shows the values of time between failures and repair time observed for two years taken for the study. These data were the basis for identifying the type of distribution (see table 11) used in the subsequent calculation of the maintainability [9]

Table 10. Shows the values of time between failures and repair time observed

	Hours		Time hours	
Condition of equipment	Begin	End	TBF	TTR
In function	0	3145	3145	
In stop	3145	3148		3
In function	3148	7009	3861	
In stop	7009	7014		5
In function	7014	12648	5634	
In stop	12648	12672		24
In function	12672	13152	480	
In stop	13152	13202		50
In function	13202	17520	4318	
Total		17520		82

Tabla 11. Type of distribution

ITEM(i)	TTR hours	Empirical function	Exp	Weibull	Exp	Weibull
		$F_i = \frac{(i-0.3)}{(n+0.4)}$	$-\ln[1-F(i)]$	$\ln\left[\ln\left(\frac{1}{1-F(i)}\right)\right]$	t	ln (t)
1	3	0,159	0,173	-1,753	3	1,099
2	5	0,386	0,488	-0,718	5	1,609
3	24	0,614	0,952	-0,049	24	3,178
4	50	0,841	1,839	0,609	50	3,912

Table 12. Application of method HFMEA and action to improve identified

Analyze of mod and effect of fail					Enterprise						
Process		Human reliability			System	Walk-freezer of CIM					
Personal	Operation or function	Mode of fail	Effect the fail	S	G	Cause of failure	O	Controles actuales	D	NPR	Preventive action
Maintainer	Ensure a function Sure Of equipment and reestablish her operation in case of failure surprise	Ignorance causes loss of the physicochemical properties of the product	Installation damage, high costs for loss of the stored product	4	x	They do not possess the knowledge required	3	There are but do not have the necessary information	6	72	Training
		They have not the equipment	Installation damage causes high maintenance costs, loss of the stored product	4	x	They do not possess the necessary tooling	3	Exist the causes are identified	5	60	Buy the tools needed
		Lack of monetary motivation, moral and material. It does not respond with the necessary urgency to faults	Installation damage causes high maintenance costs, loss of the stored product	4	x	Lack of communication between managers and subordinates	2	control does not exist	5	40	Communication course for managers.
Operator	Perform the distribution of the IFA in walk-freezer according to established procedures.	Ignorance causes loss of the physicochemical properties of the product stored	Property damage and cause high losses high maintenance costs, loss of the stored product	4	x	They do not possess the knowledge required	3	Exist procedure	6	72	Training

Conclusions

The reliability of the elements may seem low (between 6 % and 13,5 %, equivalent to 2 or 3 failures in the reporting period), but is actually relatively high given the extent of the period for which it is estimating these values.

The average actual repair time is approximately 50 % lower than expected.

Teams that are not repaired within the stipulated time are successful in operation within 72 hours.

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