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Assessment of the Reliability ofFractionator Column of the Kaduna Refinery using Failure Modes Effects and Criticality Analysis (FMECA)

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Abstract—*The reliability of a process equipment is the probability that an item will perform a required function under stated condition(s). It is an important issue in any process industry. Failure to assess the reliability of most process equipment had led to huge financial losses. As a result, this research aims at assessing the reliability of the Fractionator column of the Kaduna Refining and Petrochemicals (KRPC), Fluid Catalytic Cracking Unit (FCCU), using the Failure mode, effects and criticality analysis (FMECA). The failure mode effects analysis (FMEA) was firstused to identify failure modes, mechanisms, cause, effects severity of the fractionator column through its fourteen (14) sub-units(fractionator primary condenser, bottoms product cooler, debutanizer oil condenser, main fractionator, main fractionator oil drum, main fractionator reflux drum, heavy naphtha exchanger, heavy cycle oil exchanger, bottoms exchanger, BFW heater, steam generator, stripper reboiler, debutanizer reboiler, top reflux pumps). Both quantitative and qualitative criticality analyses (CA) were used to determine the effectiveness and reliability of the unit (Fractionator column). For the qualitative analysis, items risk priority number (RPN) were computed and it was found that, six (6) of the sub-units (feed/ main fractionator bottoms exchanger, main fractionator reflux drum, main fractionator bottoms pumps, feed/ heavy naphtha exchanger, main fractionator, and main fractionator bottoms/BFW heater) had their RPN>300, with feed/ main fractionator bottoms exchanger having the highest RPN of 460. For the quantitative analysis, items criticality number (Cr) were computed and it was found that most of the sub-units had their Cr>0.002. In addition, the results of the criticality matrix showed that, fifteen (15) out of the twenty nine (29) failure modes identifiedwere above or closely below the criticality line. Therefore, the effectiveness and reliability of the unit is low. As such, sub-units with RPN>300 and failure modes above or closely below the criticality line were recommended for replacement or predictive maintenance.*

Keywords—*FCCU; Fractionator column; reliability; FMEA/FMECA; risk priority number, criticality number; and criticality matrix.*

I. INTRODUCTION

The negligence of most process industries not assessing the reliability of their process equipment had led to huge financial losses across the globe[1]; this is as a result of their process equipment failure. In Nigeria today, the failure rate of FCCU is high resulting to huge financial losses[2]. FCCU is one of the most important conversion processes used in petroleum refineries. It is widely used to convert high-boiling, high-molecular weight hydrocarbon fractions of petroleum crude oils to more valuable gasoline, olefinic gases, and other products. The feedstock to an FCC is usually heavy gas oil (HVGO) from atmospheric distillation or vacuum distillation. It has an initial boiling point of at least 340 °C at atmospheric pressure and an average molecular weight ranging between 200 to 600. The cracking is done in the presence of a finely divided catalyst which is maintained in an aerated or fluidized state at a temperature and pressure of 700 °C and 2.4bar respectively[3]. The objective of the Fractionator unit is to distilled into FCC end products of cracked naphtha, fuel oil and off gas. The failure of the this unit may lead to accumulation of cracked product from the reactor – regeneration unit, which may lead to shutdown of the entire units. As such, the reliability analysis of the unit is of great importance. Therefore, the basic input for finding the optimal maintenance tasks comes from Failure mode, effects and criticality analysis (FMECA) of the equipment [4]. FMECA is a step-by-step approach for identifying all possible failures in a design, manufacturing or assembly process, product or service [5]. It identifies and carries out corrective actions to address the most serious concerns.

Information gained by performing FMECA can be used as a basis for troubleshooting activities, maintenance, manual development and design of effective built-in test techniques[6].The analysis is characterized as consisting of two sub-analyses, the first being the failure modes and effects analysis (FMEA), and the second, the criticality analysis (CA).The method is widely used and accepted throughout the military and commercial industries [7].This tool was used by Ibrahim, A. et'al[8], 2015 to assess the reliability of a Reactor – regenerator unit. Their result showed that the reliability of the unit was found to be low. Similarly, Thangamani, G. et'al[9], 1995used this tool to assess the reliability of a FCCU. Also, Flecher, P[10]. 2012 used this tool to assess the risk of Sinopec X'ian branch FCCU. His result showed that reactor-regenerator systems have the highest potential hazard. In addition, Mahendra, P[4]. 2012 apply FMECA for ensuring reliability of process equipment. At the end of his work, highly critical systems and failure modes were identified and that the duration for which the equipment is out of work is reduced significantly. Similarly, Masoud. H. et'al[11] 2011 in their research "The application of FMEA in the oil industry in Iran: The case of four litre oil canning process of Sepahan Oil Company". The aim of their research was to show how FMEA could be applied to improve the quality of products at Sepahan Oil Company.However, after implementation of the improvement actions from FMEA, the can scrap percentage was reduced from 50000 to 5000 ppm and the percentage of the oil waste was reduced from 1 to 0.08%. Therefore, the use of FMECA to assess the reliability of FCCU will help to minimize huge financial loses as a result of equipment failure.

II. Methodology

FMEA was used to identify potential failure modes, failure mechanism, failure effects, detection method, compensation provision and severity of the reactor-regeneration unit. The FMEA data were generated from the failure logbooks, operating manuals, equipment maintenance manuals and questionnaires. After FMEA analysis, both quantitative and qualitative criticality analysis (FMECA) were performed. According to Ibrahim, A. et'al[8], 2015, Keller, P[12]. 2014, and RAC[13] 2005 equations (1), (2), (3) and (4) were used for the quantitative criticality analysis, while according to Puthillath, B. et'al[14] 2012, Yelmaz, M[15]. 2009, Sydney Water [16]2010 and Sultan, L.L[6]. 2011 equation (5) was used for the qualitative analysis.

$$Cr = \alpha * \beta * \lambda_i * t \text{ ------------------------------------ } (1)$$

Where,

α is the failure effect probability

$$\alpha = \frac{\lambda_i}{\overline{\lambda}} \text{ ------------------------------------ } (2)$$

$$\overline{\lambda} = \sum_{i=1,2,3...}^{n} \lambda_i \text{ ------------------------------------ } (3)$$

β is the failure mode ratio

λ_i is the failure rate

$$\lambda_i = \frac{Occurrence}{Operating\ time} \text{ ------------------------------------ } (4)$$

t is the operating time

$$RPN = D * O * S \text{ ------------------------------------ } (5)$$

Where,

D is the detection

O is the occurrence

S is the severity

A criticality matrix was then computed from the plot of criticality number and severity using MS-Excel spread sheet. This was used to identify critical items which were then ranked according to their level of criticality.

III. Results and Discussion

The result of FMEA for the Fractionator is shown in Table 1. It generally indicates the potential failure modes, failure mechanism, failure effects, detection method, compensation provision and severity of the sub-units (fractionator primary condenser, bottoms product cooler, debutanizer oil condenser, main fractionator, main fractionator oil drum, main fractionator reflux drum, heavy naphtha exchanger, heavy cycle oil exchanger, bottoms exchanger, BFW heater, steam generator, stripper reboiler, debutanizer reboiler, top reflux pumps) under the fractionator. The fourteen (14) sub-units under study had twenty seven (27) failure modes, twenty seven (27) failure mechanism and twenty seven(27) failure effects. The detection method involve either the use of alarming systems, flowsensors or inspections. The compensation provision used were either Supervisory Control And Data Acquisition (SCADA) indicators, redudant systems or operation overide. The severity of the twenty one (21) failure effects of the sub-units is above average, between four (4) to nine (9). That is, froma failure which may cause minor injury, minor property damage, or minor system damage which will result in delay or loss of sub-unit (marginal), to a failure which may cause death or lack of ability to carry out operation without warning (catastrophic). This values and description of the failures above were in conformity with the RAC[13], 2005 and Technical manual[17], 2006. Table 2 represents the qualitative FMECA for the fractionator unit. From the Table, six (6) sub-units (main fractionator, main fractionator reflux drum, heavy naphtha exchanger, main fractionator bottom exchanger, main fractionator bottoms/BFW heater and main fractionator bottom pumps) have their RPN greater than 300 these sub-units are critical and have low reliabilities. Eleven (11) of the sub-units (fractionator primary condenser, bottoms product cooler, debutanizer oil condenser, main fractionator oil drum, heavy cycle oil exchanger, steam generator, stripper reboiler, debutanizer reboiler, top reflux pumps, LCO product pump and heavy naphtha pump) have their RPN less than 200. These sub-units are said to be less critical and have moderate reliabilities. Ibrahim, A. et'al[8] 2015 and Puthillath, B. et'al[14] 2012 used these methods of RPN to categorize items.

Table 1: A FMEA sheet for Fractionator

	FAILURE MODE EFFECT ANALYSIS (FMEA)						
	STUDY AREA: Area 3 (KRPC)						
	SYSTEM : Fractionator						
	OBJECTIVE: To distilled into the FCC end products of cracked naphtha, fuel oil and off gas						
ITEM ID	FUNCTIONAL ID	POTENTIAL FAILURE MODE(S)	FAILURE MECHANISM	FAILURE EFFECTS	DETECTION METHOD	COMPENSATION PROVISION	SEVERITY
A01	fractionator primary condenser	ineffective overhead product cooling	tube blockage	low gasoline yield	alarm system	SCADA Indicator	3
		electric motor failure	motor winding open	over heating	alarm system	SCADA Indicator	8
A03	fractionator bottoms product cooler	improper product cooling	tube blockage	hot product sent to tank	alarm system	SCADA Indicator	7
		electric motor or fan failure	motor winding open	over heating	alarm system	SCADA Indicator	4
A05	debutanizer oil condenser	improper product cooling	tube blockage	hot product sent to tank	alarm system	SCADA Indicator	8
		electric motor or fan failure	motor winding open	over heating	alarm system	SCADA Indicator	4
C01	main fractionator	flooding of the column	tray collaps	improper seperation of product	alarm system	level indicator	2
		poor distillation	tray collaps	more of bottom product	alarm system	level indicator	5
D03	main fractionator oil drum	high level in seperator	P04 blockage	lost of product to drain to lower level	alarm system	level indicator	9
D04	main fractionator reflux drum	bad reflux in main fractionator	upstream blockage	improper seperation of product	alarm system	level indicator	9
		low level	P03 cavitation	high C01 over head temperature	alarm system	level indicator	8
E02A/B	feed/ heavy naphtha exchanger	ineffective heat transfer	tube blockage	low H02 outlet temperature	alarm temperature sensor	SCADA Indicator	5
		leakage	tube rupture	low outlet temperature	alarm temperature sensor	SCADA Indicator	5
		accumulated dirt	filament blockage	lube oil flow restriction	alarm temperature sensor	SCADA Indicator	7
		loss of vacuum	tube rupture	compressor might trip off	alarm temperature sensor	SCADA Indicator	6
E04	feed/ heavy cycle oil exchanger	ineffective heat transfer	tube blockage	low H02 outlet temperature	alarm temperature sensor	SCADA Indicator	5
		leakage	tube rupture	low outlet temperature	alarm temperature sensor	SCADA Indicator	5
E05	feed/ main fractionator bottoms exchanger	ineffective heat transfer	tube blockage	low H02 outlet temperature	alarm temperature sensor	SCADA Indicator	5
		leakage	tube rupture	low outlet temperature	alarm temperature sensor	SCADA Indicator	8
E07	main fractionator bottoms/BFW heater	improper heat recovery	tube blockage	low or no steam generation	alarm temperature sensor	SCADA Indicator	3
		poor BFW line-up	tube coking	low outlet temperature	alarm temperature sensor	SCADA Indicator	8
E08	main fractionator bottoms steam generator	improper heat recovery	tube blockage	bad cooling of slurry and no steam generation	alarm temperature sensor	SCADA Indicator	4
E11	stripper reboiler	bad or no heat transfer	tube blockage or leakage	ineffective reboiling	alarm temperature sensor	SCADA Indicator	2
E12	debutanizer reboiler	ineffective reboiling	tube blockage	poor seperation of gasoline/LPG	alarm temperature sensor	SCADA Indicator	5
P03A/B	main fractionator top reflux pumps	low level in reflux drum	improper column refluxing	poor seperation of product	flow sensor	Redundant System	2
		low suction head pressure	suction strainer dirty	poor discharged head pressure	flow sensor	Redundant System	8
		leakage	tube rupture	insufficient over head reflux	flow sensor	Redundant System	3

Table 2: A qualitative FMECA for Fractionator

	QUALITATIVE FAILURE MODES EFFECTS AND CRITICALITY ANALYSIS (FMECA)					
	STUDY AREA: Area 3 (KRPC)					
	SYSTEM : Fractionator					
	OBJECTIVE: To distilled into the FCC end products of cracked naphtha, fuel oil and off gas					
ITEM ID	**FUNCTIONAL ID**	**SEVERITY**	**OCCURRENCE**	**DETECTION**	**RPN1**	**RPN2**
A01	fractionator primary condenser	3	2	2	12	212
		8	5	5	200	
A03	fractionator bottoms product cooler	7	2	8	112	192
		4	4	5	80	
A05	debutanizer oil condenser	8	2	8	128	208
		4	4	5	80	
C01	main fractionator	2	8	3	48	328
		8	5	7	280	
D03	main fractionator oil drum	9	6	3	162	162
D04	main fractionator reflux drum	9	6	3	162	442
		8	5	7	280	
E02A/B	feed/ heavy naphtha exchanger	5	2	7	70	381
		5	3	7	105	
		7	1	8	56	
		6	5	5	150	
E04	feed/ heavy cycle oil exchanger	5	3	6	90	170
		5	2	8	80	
E05	feed/ main fractionator bottoms exchanger	5	9	4	180	460
		8	5	7	280	
E07	main fractionator bottoms/BFW heater	3	1	8	24	304
		8	5	7	280	
E08	main fractionator bottoms steam generator	4	6	7	168	168
E11	stripper reboiler	2	3	7	42	42
E12	debutanizer reboiler	5	3	8	120	120
P03A/B	main fractionator top reflux pumps	2	3	1	6	184
		8	5	4	160	
		3	2	3	18	
P05A/B	main fractionator heavy naphtha pumps	3	2	3	18	178
		8	5	4	160	
P09A/B	main fractionator bottoms pumps	8	5	7	280	424
		9	8	2	144	
P10A/B	main fractionator bottoms LCO product pumps	3	1	2	6	294
		8	5	6	240	
		8	3	2	48	

Table 3 shows the prioritized items for corrective action based on the fractionator RPN. Item with the highest RPN showed item to be considered first for either replacement, repair or maintenance. This is to ensured safety and reliability of the unit. The feed/ main fractionator bottoms exchanger has the highest RPN of 460 this means highest priority for corrective action, the order follows up to stripper reboiler with the least RPN value of 42. This means least priority for corrective action.In terms of selection criteria for maintenance program, Puthillath, B. et'al[14] 2012 also adopted this system of item ranking.

Table 3: A prioritized item ranking for fractionator

	ITEM RANKING QUALITATIVE (FMECA)	
	STUDY AREA: Area 3 (KRPC)	
	SYSTEM : Fractionator	
ITEM ID	FUNCTIONAL ID	ITEM RPN
E05	feed/ main fractionator bottoms exchanger	460
D04	main fractionator reflux drum	442
P09A/B	main fractionator bottoms pumps	424
E02A/B	feed/ heavy naphtha exchanger	381
C01	main fractionator	328
E07	main fractionator bottoms/BFW heater	304
P10A/B	main fractionator bottoms LCO product pumps	294
A01	fractionator primary condenser	212
A05	debutanizer oil condenser	208
A03	fractionator bottoms product cooler	192
P03A/B	main fractionator top reflux pumps	184
P05A/B	main fractionator heavy naphtha pumps	178
E04	feed/ heavy cycle oil exchanger	170
E08	main fractionator bottoms steam generator	168
D03	main fractionator oil drum	162
E12	debutanizer reboiler	120
E11	stripper reboiler	42

Table 4 depict the quantitative FMECA for fractionator unit.The data(item failure rates, failure mode ratio, maintainability, and item criticality number) where computed for the fourteen (14) sub-units(fractionator primary condenser, bottoms product cooler, debutanizer oil condenser, main fractionator, main fractionator oil drum, main fractionator reflux drum, heavy naphtha exchanger, heavy cycle oil exchanger, bottoms exchanger, BFW heater, steam generator, stripper reboiler, debutanizer reboiler, top reflux pumps). The criticality number (Cr) showed the level of risk and reliability of each of the sub-unit.The higher the criticality number (Cr) the more risk involve and the lower the reliability of the item. All the sub-units with the exception of heavy cycle oil exchanger have their Cr > 0.003. Similar data were obtained by RAC[13], 2005 and Technical Manual[17], 2006 in assessing the reliability of their defence equipment.

Table 4: A quantitative FMECA sheet for Fractionator

			QUANTITATIVE FAILURE MODES EFFECTS AND CRITICALITY ANALYSIS (FMECA)					
			STUDY AREA: Area 3 (KRPC)					
			SYSTEM : Fractionator					
			OBJECTIVE: To distilled into the FCC end products of cracked naphtha, fuel oil and off gas					
FUNCTIONAL ID	Operating time (hr	OCCURRENCE	Failure rate λ (/hr	Item failure rate	Failure effect probability	Failure mode ratio α	Failure mode criticality number	Item criticality number
fractionator primary condenser	17280	2	1.15741E-07	4.05093E-07	1	0.29	0.00058	0.00413
	17280	5	2.89352E-07		1	0.71	0.00355	
fractionator bottoms product cooler	17280	2	1.15741E-07	3.47222E-07	1	0.33	0.00066	0.00334
	17280	4	2.31481E-07		1	0.67	0.00268	
debutanizer oil condenser	17280	2	1.15741E-07	3.47222E-07	1	0.33	0.00066	0.00334
	17280	4	2.31481E-07		1	0.67	0.00268	
main fractionator	17280	8	4.62963E-07	7.52315E-07	1	0.62	0.00496	0.00686
	17280	5	2.89352E-07		1	0.38	0.0019	
main fractionator oil drum	17280	6	3.47222E-07	3.47222E-07	1	1	0.006	0.006
main fractionator reflux drum	17280	6	3.47222E-07	6.36574E-07	1	0.55	0.0033	0.00555
	17280	5	2.89352E-07		1	0.45	0.00225	
feed/ heavy naphtha exchanger	17280	2	1.15741E-07	6.36574E-07	1	0.18	0.00036	0.00352
	17280	3	1.73611E-07		1	0.27	0.00081	
	17280	1	5.78704E-08		1	0.1	0.0001	
	17280	5	2.89352E-07		1	0.45	0.00225	
feed/ heavy cycle oil exchanger	17280	3	1.73611E-07	2.89352E-07	1	0.6	0.0018	0.0026
	17280	2	1.15741E-07		1	0.4	0.0008	
feed/ main fractionator bottoms exchanger	17280	9	5.20833E-07	8.10185E-07	1	0.64	0.00576	0.00756
	17280	5	2.89352E-07		1	0.36	0.0018	
main fractionator bottoms/BFW heater	17280	1	5.78704E-08	3.47222E-07	1	0.17	0.00017	0.00432
	17280	5	2.89352E-07		1	0.83	0.00415	
main fractionator bottoms steam generator	17280	6	3.47222E-07	3.47222E-07	1	1	0.006	0.006
stripper reboiler	17280	3	1.73611E-07	1.73611E-07	1	1	0.003	0.003
debutanizer reboiler	17280	3	1.73611E-07	1.73611E-07	1	1	0.003	0.003
main fractionator top reflux pumps	17280	3	1.73611E-07	5.78704E-07	1	0.3	0.0009	0.0038
	17280	5	2.89352E-07		1	0.5	0.0025	
	17280	2	1.15741E-07		1	0.2	0.0004	
main fractionator heavy naphtha pumps	17280	2	1.15741E-07	4.05093E-07	1	0.29	0.00058	0.00413
	17280	5	2.89352E-07		1	0.71	0.00355	
main fractionator bottoms pumps	17280	5	2.89352E-07	7.52315E-07	1	0.38	0.0019	0.00686
	17280	8	4.62963E-07		1	0.62	0.00496	
main fractionator bottoms LCO product pum	17280	1	5.78704E-08	5.20833E-07	1	0.11	0.00011	0.0039
	17280	5	2.89352E-07		1	0.56	0.0028	
	17280	3	1.73611E-07		1	0.33	0.00099	

Table 5 is the quantitative item ranking for the Fractionator unit. Items were ranked according to their level of criticality number. The main fractionator bottoms exchanger have the highest criticality number of 0.00756 while theheavy cyle oil exchanger has the least criticality number of 0.0026. However, in terms of maintenance, or repair or replacement, sub-units with the highest criticality number would be considered first.

Table 5: A quantitative FMECA item ranking for Fractionator

	ITEM RANKING QUANTITATIVE (FMECA)				
	STUDY AREA: Area 3 (KRPC)				
	SYSTEM : Fractionator				
Item ID	Functional ID	Operating time (hr)	failure rate λ (/hr)	Failure effect probability β	Item criticality number
E05	feed/ main fractionator bottoms exchanger	17280	8.10185E-07	1	0.00756
C01	main fractionator	17280	7.52315E-07	1	0.00686
P09A/B	main fractionator bottoms pumps	17280	7.52315E-07	1	0.00686
D03	main fractionator oil drum	17280	3.47222E-07	1	0.006
E08	main fractionator bottoms steam generator	17280	3.47222E-07	1	0.006
D04	main fractionator reflux drum	17280	6.36574E-07	1	0.00555
E07	main fractionator bottoms/BFW heater	17280	3.47222E-07	1	0.00432
A01	fractionator primary condenser	17280	4.05093E-07	1	0.00413
P05A/B	main fractionator heavy naphtha pumps	17280	4.05093E-07	1	0.00413
P10A/B	main fractionator bottoms LCO product pumps	17280	5.20833E-07	1	0.0039
P03A/B	main fractionator top reflux pumps	17280	5.78704E-07	1	0.0038
E02A/B	feed/ heavy naphtha exchanger	17280	6.36574E-07	1	0.00352
A03	fractionator bottoms product cooler	17280	3.47222E-07	1	0.00334
A05	debutanizer oil condenser	17280	3.47222E-07	1	0.00334
E11	stripper reboiler	17280	1.73611E-07	1	0.003
E12	debutanizer reboiler	17280	1.73611E-07	1	0.003
E04	feed/ heavy cycle oil exchanger	17280	2.89352E-07	1	0.0026

Figure 1 is the criticality matrix for the fractionator. From the figure,the plot of criticality number against severity was used to identify those critical failure modes related to the sub-units. Also, fifteen (15) out of the twenty nine (29) failure modes identified were above or closely below the criticality line while fourteen (14) values of the failure modes were below the criticality line. Those values above and closely below the criticality line showed how critical those failure modes were with respect to the unit (Fractionator). However, it means that the reliability of those sub-units is low, therefore, preventive maintenance is recommended. Ibrahim, A. et'al[8] 2015 and Rooney, et'al[18]1988 also recommended preventive maintenance for high risk, because it may eventually results in substential reduction in production periods.

Table 6: A criticality matrix for fractionator

ITEM ID	SEVERITY	Criticality number
A01	3	0.00058
	8	0.00355
A03	7	0.00066
	4	0.00268
A05	8	0.00066
	4	0.00268
C01	2	0.00496
	8	0.0019
D03	9	0.006
D04	9	0.0033
	8	0.00225
E02A/B	5	0.00036
	5	0.00081
	7	0.0001
	6	0.00225
E04	5	0.0018
	5	0.0008
E05	5	0.00576
	8	0.0018
E07	3	0.00017
	8	0.00415
E08	4	0.006
E11	2	0.003
E12	5	0.003
P03A/B	2	0.0009
	8	0.0025
	3	0.0004
P05A/B	3	0.00058
	8	0.00355
P09A/B	8	0.0019
	9	0.00496
P10A/B	3	0.00011
	8	0.0028
	8	0.00099

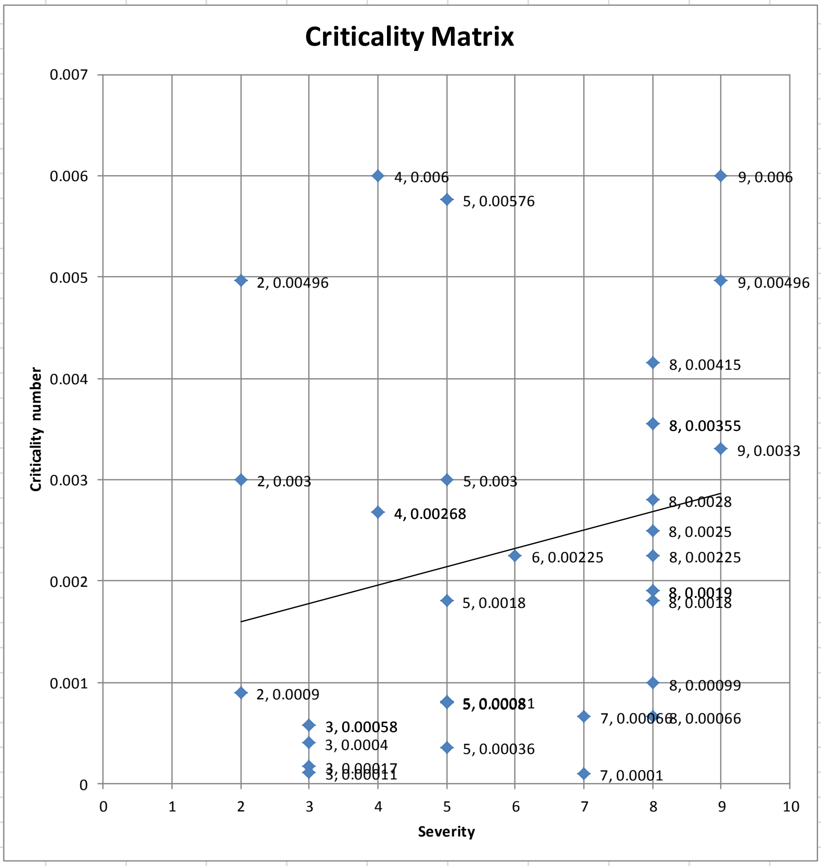

Figure 1: A criticality matrix for fractionator

IV. Conclusion

The performance behavior of fractionator unit via its sub-units (fractionator primary condenser, bottoms product cooler, debutanizer oil condenser, main fractionator, main fractionator oil drum, main fractionator reflux drum, heavy naphtha exchanger, heavy cycle oil exchanger, bottoms exchanger, BFW heater, steam generator, stripper reboiler, debutanizer reboiler, top reflux pumps) was assessed using FMECA as the reliability assessment tool.

Fromthe qualitative analysis used, the reliability of the fractionator was found to be low.This is because nine (9) sub-units (main fractionator, main fractionator reflux drum, heavy naphtha exchanger, main fractionator bottom exchanger, main fractionator bottoms/BFW heater and main fractionator bottom pumps, fractionator primary condenser, bottoms product cooler, and debutanizer oil condenser) of the fractionator unit have their RPN greater than 200, these sub-units are critical and have low reliabilities.Also, from the quantitative analysis, all the sub-units with the exception of heavy cycle oil exchanger have their Cr > 0.003.This means low reliability of the fractionator.

From the analysis of the criticality matrix, most of the values of the failure modes were either above or very close to the criticality line, as such, it can be concluded that the reliability of the fractionator unit is low. As such, preventive maintenance is recommended.

The use of FMECA to assess the reliability of fractionator unit,will help to reduce financial losses as a result of equipment damage, injury to personnel and above all loss of life.

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