Determining and investigating of oil storage in Ahvaz-Nezamiye using by FMECA and FAHP

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Abstract

Today, the main issue of concern for the safety and industrial hygiene, Identify and eliminate risks that threaten the health and lives of workers and the public and also can damage to tools, assets, equipment and products. When the risk of such hazards cannot be completely eliminated (which is often the same thing). The expert's duty is safety that suggests recommendations for control of danger and reduces the risk to acceptable level. The main goal of risk assessment is determine necessary actions by the organization in order to equality of health and safety regulations so the result is reduction of Injuries and occupational diseases. Risk assessment helps employers to obey the health and safety regulations and also keep their workforce. The goal of this paper is looking for answersto this question which are affecting factors on risk and crisis in oil storages and what is the impact of these factors on risk and crisis? On the other hand identify and prioritize risk and crisis indexes using by FAHP and FMECA method in oil storage that the result is listed below.

Introduction

Actually National Iranian Oil Products Distribution Company(NIOPDC) is one of the most equipped and responsibility of oil ministry by actively pursuing efforts boarding staff, responsible for monumental task of distributing petroleum products required by the various departments. Distributing based on accurate models of consumption with savings, the main objectives of the National Broadcasting Company.

The maximum operating load of National Oil Products Distribution Company of Khuzestan region is Nezamiye oil storage which is any defeat or failure cause accident and cut or reduction of producing, so this storage to check the hazards and risk analysis was selected.

Nowadays systems have become more sophisticated, safety is also being critical.Safety can be defined as a property of a system that is free from unacceptable risks.

So it's necessary to reduce risks to acceptable level with reasonable risk management activities. Risk analysis is one of the best known approaches to avoid improper action and accident.

FMECA risk analysis technique (Critically analysis failure modes and effects), is a method for detecting any analyzing of all potential failure modes of the system. The effects that these failures may have on the system, how to prevent or reduce the impact of these failures on the system.

Actually FMECA was an expanded FMEA that CA in FNECA represents critically different affection.

The aim of this research, study the safety and risk assessment and determine and identify of major defects in Ahvaz area Nezamiye oil storage using byanalyzing critically failure modes method and its effects (FMCEA). Moreover, the proposed control strategies for defect were created.

The overall objective of the project

Present risk assessment model in National Broadcasting Company Nezamiye oil storage Ahvaz area using by critically analysis of failure modes method and its affect (FMECA) and combining it with FAHP.

Especial Goals

1. Determine the defects (failures) in the Nezamiye oil storage.
2. Compare results obtained through quantitative and qualitative methods.
3. Identify and prioritize all critical failures in order to take corrective actions.
4. Provide a method for assessing controls in order to improve safety and prevent failures
5. Combined with the decomposition method and fuzzy analytical hierarchy process (FAHP).

FMECA

FMECA is a reliable method to design a system in which all break the rules specified underlying documents. Using by failure mode analysis determine any effect of failure on operating system. Identify the single point of failure, it means that identifies critical failures beyond operation success or employee safety and rank any failure based on critically of failure mode and the likelihood.

If FMECA process is a timely repeated action, that is an effective tool to make decision, although FMECA is a primary reliable duty. It provides the necessary information and supports safety, keeping, procurement, testing, failure detection, and separationand compensation design. FMEECA is an important tool for evaluation the reliability of the initial design stage.

Actually FMECA was a methodology for identifying and analyzing:

- All potential failure modes from different components of system
- The affection of these failures may have on system
- How to prevent or reduce these failures and their effect on system

FMECA is a technique that is used to identify, prioritize and eliminate potential failures of the system design or the process before getting the users.

FMECA is a technique for solving potential problems in system before they happen.

FMECA is fundamentally consists of 8 stages:

1. Define System
2. Identify Failures Mode
3. Determine Effects
4. Assess Effects
5. Make Classification
6. Estimate Probability
7. Calculate Critically Index
8. Determine Corrective Action

Define and methods of FAHP

Fuzzy Analytic Hierarchy Process method widely used to solve problem in multivariate decision (Cha & Kumar, 2007). For the first time FAHP methodsuggested by Satty (1980), a process of hierarchical structures to solve complex problems.

Although experts to assess multi-criteria use traditional FAHP method, but this method is not able to fully reflect human judgment because it deals with accurate numerical value.

As some of the evaluation criteria for the qualitative and subjective nature, the fuzzy analytic hierarchy process (FAHP) as an alternative was introduced to eliminate shortages and adapt more easily to life the classic FAHP.

Differentmethodsused inFAHP,systematicmethodsaredeveloped for betterchoicesbased onfuzzytheoryandhierarchicalstructure analysis. From the viewpoint ofdecision-makers, generallyrelativejudgment is more reliable thanspecific judgment.Fuzzynature ofthecomparisonindicates that thefinaljudgments ofdecision makersare not sufficientto explain thepreferencesandtastes (Kahraman & Ulukan, 2003).

Oil Products DistributionIndustry

Actually National Iranian Oil Products Distribution Company (NIOPDC) is one of the most important and responsibility of oil ministry that consistently and activelypursuedwithday and nightefforts of staff, they responsible for distributing of oil products needed for different parts.

Distributedbased onaccurate usagemodelscombinedwith saving areobjectives of theNationalBroadcastingCompany (NationalOil Products DistributionCompanyinKhuzestan - 1391). Also Khuzestan region is one of thebiggest areas and first gradedof the NationalOil Products DistributionCompany which consist of almost 1200 employees and its responsibility delivering production from Abadan refinery, pipelineand the portof exportMahshahr and distributing, procurement, coordination and Planningof timelydelivery ofproductstoallstores, sitessellingproductsin the province andneighboring provinces such Ilam and Kohkiloye va Boyer Ahmad.

The designprocedure

There are different methods for analyzing of FMECA risk.

A. U.S.militarystandards (Mil-STD-1629) suggests 2 approaches for performing a FMECA:
1. Quantitative Approach
2. Qualitative Approach
B. In 1988, Ford Engine Company suggested RPN method for performing FMECA.

According to military standard, for performing a FMECA analysis initially can perform FMEA analysis. The following information from FMEA sheets should be transmitted to FMECA.

1. Item number
2. Item ID
3. Failure modes
4. Failure Mechanism
5. Failure effects (Qualitative)
6. Grade of severity

Then, critically analysis performed.

Critically analysis (CA)

For calculating CA:

1. Quantitative Approach
2. Qualitative Approach

Availability of information failure rate of each component will determine the analysis approach. Generally, when real data and useful are the quantitative approach is used and when the general information available, the qualitative approach is used.

According toavailable information, theanalyzermust determinewhatapproachwillbe usedto calculateCA.

Requiredvariablesto quantitative approach

Amount of β happen according to failure modes that represent the conditional probability or possibility. The consequence is failurein specific critical classification.

For majority of items β is 1.

α is adecimal fraction, and expressed as probability thatagivenpartor item fail inaspecifiedcondition. Thisnumberoffloating-pointformat shows inwhichthecomponentis expected tofailina certaincase. Totalalphasarealwaysequal to1.

λ_p: is failure rate or item and define as ratio of failures number per unit of time and usually as the number of failures per million hours or per 106 hours.

C_m: is the number of critically failure mode, a relative measure number of failure modes.In fact, that was amathematical toolto provide a number in order to importance of numeric scale based on failure rate.

$$C_m = (\beta_\alpha \lambda_p t)$$

T: is time duration or operational phaseapplication (Expressedinhours orcyclesof operation)

Cr: Critically item number

$$Cr = \sum (Cm)$$

Procedure

To perform the planforthe first set necessary coordinationwiththemanagement andstafftraining(TQM) NationalOil Products DistributionCompanyinAhwazregion.

After introductiontothehealth,safety and environmentbyeducation, primarilywaspresentedtheNezamiyeoil storage archive for the familiarity ofeach stocks parts.

Then, FMECA team

Then FMECAteamwas formed in cooperation withthesafety, health and environment, head ofwarehouse, warehouseEngineering.

The goal is assessing risks and identifiesfailures and defects of Nezamiye oil storage and prioritizing them for corrective actions by FMECA and FAHP risk analysis method.

For each risk analysis the system should be well known and it can be defined.

Then thework sheetswerepreparedaccording to thetype of analysis approach. Risk analysiswasdoneby two methods.

1. Qualitative method according to U.S military standard qualitative method (MIL-STD-1629)
2. RPN (Risk Priority Number)method

Due tothetimeconstraints, this projectis used toquantitative approach.

RPN (Risk Priority Number) approach

In this method use 3 items for calculating RPN:

1. Severity
2. Probability of occurrence
3. Detectability

Severity, Probability of occurrence and detectability consist of separated tables in the scale of 1 to10.

RPN = (Severity × Probability of occurrence × Detectability)

For determining each items of severity, probability of occurrenceanddetectionwere usedthefollowing tables which each of them are separatelymeasured on a scaleof 1 to10.

Table of probability occurrence approach

Effect	**Criteria: Effect of intensity**	**Grade**
Very Risky	Failure is very dangerous and happens without warning. Operation of the system is suspended and not acceptable by government regulation.	10
Serious Risk	Consequences of failure are very dangerous and not acceptable by government standards and regulations.	9
Risky	Productor systemis non-operable thorough reduction of primary and mainly operation the system will non-operable.	8
Major risk	The product operation is strongly damaged except duties, the system may not operate.	7
Meaningful risk	The product operation is reduced; duties and usual operations may not operate.	6
Medium Risk	It's a medium effect on product operation; The product needs to repair.	5
Low Risk	It's a small effect on product operation; The product doesn't need to repair.	4
Small Risk	Smalleffecton the performance ofthe product orsystem	3
Very smallrisk	Very Smalleffecton the performance ofthe product orsystem	2
No Risk	No effect	1

Table intensity of event

Tracing (discovery)	Probability of detection by design control	Grade
Totally unclear	Control designed doesn't discover potential cause of failure or subsequent failure modes and there in no design control.	10
Very unlikely	Averyunlikelychance in order to discoverpotentialfailure modeof design control or subsequent failure modes.	9
unlikely	Anunlikelychance in order to discover potentialfailure mode of design control or subsequent failure modes.	8
Very Low	Averylow chance in order to discover potentialfailure mode of design control or subsequent failure modes.	7
Low	Alow chance in order to discover potentialfailure mode of design control or subsequent failure modes.	6
Medium	A medium chance in order to discover potentialfailure mode of design control or subsequent failure modes.	5
Above average	Anabove average chance in order to discover potentialfailure mode of design control or subsequent failure modes.	4
High	Ahigh chance in order to discover potentialfailure mode of design control or subsequent failure modes.	3
Very High	Averyhigh chance in order to discover potentialfailure mode of design control or subsequent failure modes.	2
Almost Clear	Design control discovers potential causes offailure	1

	orsubsequentfailuremodes as almost clear.	

Traceabilitytable(discovery) of PRN approach

Worksheetsareselected. Becauseit's take a lot spaceandtimeofeachworksheetusingFMEA,qualitativeandRPN,a complete worksheetwas selected thatincludesall three ofthem.

The analysis performs according to related worksheet to RPN. In the first column of this approach there is an identifying number which is the sign of part identifier code or except for possiblefailure modes.The second column related to investigated part and the third column shows the responsibilities of that part. The fourth, fifth and sixth,respectively, present possiblefailuremodes, causesandeffects and possible effects on system.In the failurecolumnmodesforeach componentis triedif thereis more than onepossible failure, Englishalphabetisusedfor identificationofdefectstates.Seventh column presented existence methods and for detectingdefectsandfailuremodes and eighth and ninth and tenth related to calculating factor of RPN, c D, S and D. the eleventh column, RPN is calculated and twelfth column is presented proposedcontrolactionsto correct or eliminate or control ofdefects and in the last column the value of RPN corrected that presented as subjectively after corrective measures.

FMECA worksheet with PRN method

Identification Number	Part	Task	Failure Mode (Defect)	Failure Reason	Failure Affections	Failure Discovery Method	D	O	S	RPN	Suggested Actions	Corrected RPN	Description

Reliability of qualitative analysis in this study is followed by functional analysis of FMECA.

FMECA analysis was performed and showed that the phase of the IRCC is the most critical equipment in the plant.

Triangular fuzzy numbers used in this study for calculating fuzzy AHP pair-wise comparison of the criteria (Table 1) are also

Triangular fuzzy numbers to calculate the fuzzy AHP pair-wise comparison of the criteria used in this study shown as table 1:

Compare the comparisons of making quantity of qualitative criteria

LinguisticPreference to set preference	Triangular Fuzzy Numbers
Priorityor complete importance	(5.2 , 3 , 7.2)
Priorityor very strong importance	(2 , 5.2 , 3)
Priorityor strong importance	(3.2 , 2.5 , 2)
Priorityor little importance	(1 , 3.2 , 2)
Priorityor almost equal importance	(1.2 , 1 , 3.2)

Priorityor accurate equal importance	(1 , 1 , 1)

Afterthematrixes of pairwise comparisons were prepared asdecisivephase, the finalphaserelativeweightsarecalculatedas follows. The range of fuzzy numbers that is determined for each parameter is shown in table2.

Paired comparisons matrix of the original risk assessment

Risk Assessment Criteria	Sanitary	Safety	Environment
Sanitary	(1,1,1)	(1,3.2,2)	(1.2,2.3,1)
Safety	1.2,2.3,1)	(1,1,1)	(2.5,1.2,2.3)
Environment	(1,3.2,2)	(3.2,2,5.2)	(1,1,1)

First step: For each of the rows of paired comparisons matrix that has been developed like above, the value of Sk is a triangular fuzzy number calculate as follows:

$$S_k = \sum_{j=1}^{n} M_{kl} \times \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} \right]^{-1}$$

S1=(2.5, 3.17, 4)*(.082, .102, .127)=(.105, .322, .506)

S2=(1.9, 2.17, 2.67)*(.082, .102, .127)=(.156, .22, .338)

S3=(.3.5, 4.5, 5.5)*(.082, .102, .127)=(.288, .458, .696)

Second Step: After calculating Si, themagnitudeofthemcanbe obtainedas follows

V (S1≥S2) = 1 V (S1≥S3) = 0.617

V (S2≥S1) = 0.565 V (S2≥S3) = 0.173

V (S3≥S1) = 1 V (S3≥S2) = 1

Third Step: For calculating of weight index according to second step in pairwisecomparisonmatrix, we have:

Min V (S1≥ S2,S3) = Min (1,0.617) = 0.617

Min V (S2$\geq$ S1,S3) = Min(0.565,0.173) = 0.173

Min V (S3$\geq$ S1,S2) = Min(1,1) = 1

Fourth Step: At last, the weightvector obtained from thirdstep isnormalizedusingthe following equation and weight vector of criteria is shown in table 3:

$w_i = \frac{w'_i}{\sum w'}$ W' = (0.617, 0.173, 1)**W = (**0.345, 0.096, 0.558**)**

Weightofthemain and prioritization component ofrisk assessmentand

Row	Risk Assessment Criteria	Weight	Priority
1	Sanitary	0.345	2
2	Safety	0.096	3
3	Environment	0.558	1

Risk assessmentofrangeoffuzzy numbers criteria assessment of sanitary, safety and the environmentare showninTable4.

Paired wisecomparisonsmatrix offuzzy numbersbased on the rangeof thecomponentmeasuresof sanitary, safety and environment

Risk Criteria				Safety			Environment		
	O	S	D	O	S	D	O	S	D
O	(1,1,1)	(1 ، 3.2 ، 2)	(1.2,2.3, 1)	(1,1, 1)	(1,1, 1)	(1.2,2. 3,1)	(1,1, 1)	(1.3, 2.5, 1.2)	(1.2, 2.3, 1)
S	(1.2,2. 3,1)	(1,1, 1)	(2.5,1.2, 2.3)	(1,1, 1)	(1,1, 1)	(1.2,2. 3,1)	(2 ، 5.2 ، 3)	(1,1,1)	(3.2 ،2 ، 5.2)

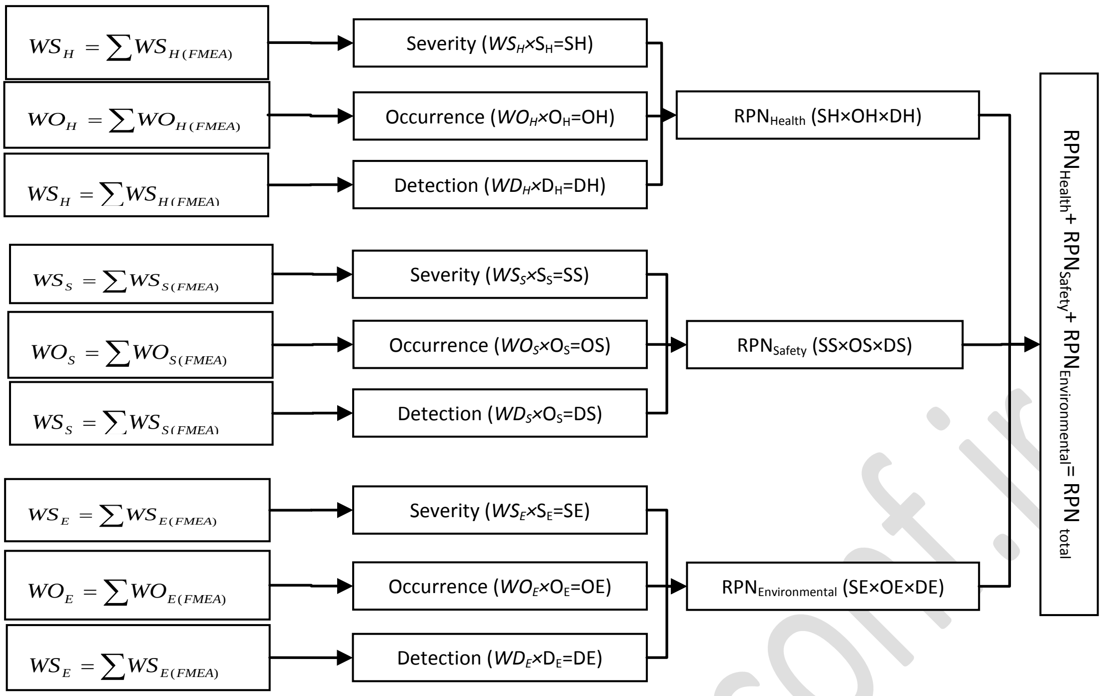
D	(1 ،3.2 ،2)	(3.2 ،2 ، 5.2)	(1,1,1)	(1 ، 3.2 ، 2)	(1 ، 3.2 ، 2)	(1,1,1)	(1 ، 3.2 ، 2)	(2.5,1.2, 2.3)	(1,1, 1)

Weight ofthefinal threemain risk assessment criteriasanitary, safety andenvironmentalbreakdownis showninTable5.

Priority of related criteria to sanitary criteria

$Risk_{(FMEA)}$	Environmental		Safety		Health	
	FAHP	FMEA	FAHP	FMEA	FAHP	FMEA
$O_{(E,S,H)}$	0.13	1.3	0.227	2.27	0.345	3.45
$S_{(E,S,H)}$	0.72	7.2	0.227	2.27	0.096	0.96
$D_{(E,S,H)}$	0.15	1.5	0.545	5.45	0.558	5.58

Based onthe results oftherisk assessmentconceptual model of oil storageis shownin Figure 2. According to presented conceptual model the result that obtained from this model, moreover showing of system weakness, it can compare systems with risk criteria and prioritize them. In order todeterminethedegreeofrisk,whichthemodelpresented inTable9 is obtainedexpert opinion, can beused.



TABLEdecisions regardingrisk

RPN(Health or safety or environmental)	RPN Total	Risk	Explain
90	270>	Acceptable	If RPN(health, Safety, Environmental)<90
90- 200	270-600	Telorable	If RPN(health, Safety, Environmental)<200
200<	600<	Un telorable	-

Conclusion

The resultssuggestthatenvironmentalfactorsweighing0.558 is thefirst priority. Regarding to sanitary factor, criteria D weighting 0.558 and regarding to safety factor, criteria D weighting 0.545 and regarding to environment factor< criteria S weighing 0.720 are in the first priority and themost importantdefects is inNezamiyeoil storage Ahvaz area. Rate ofincompatibility is 0.07 that is acceptable pairedcomparisonsof theincompatibility. One the feature ofthis paper anda hybridmodel, it ispossibleto consider theweight of thedecision. This is important because the committee may consist of different members that each of them has different positions. Byaccepting theassumption thatdifferentsites are different resulted byknowledge, experience,and workhistoryand... . Anexecutivecommittee as executivecommitteedecision can compare committee members as paired, finally, with calculating of special vector matrix, obtains decision makers weights. Then, thecalculationswill beaffected by thedecisionweight.

Refrences

Aydın Çelen,Nes¸ e Yalçın.(2012). Performance assessment of Turkish electricity distribution utilities: An application of combined FAHP/TOPSIS/DEA methodology to incorporate quality of service.Utilities Policy xxx (2012) 1-13

Chan, F. T. S., Chan, M. H., & Tang, N. K. H. (2000). Evaluation methodologies for technology selection. Journal of Materials Processing Technology, 107, 330–337.

Chan, F. T. S., & Kumar, N. (2007). Global supplier development considering risk

factors using fuzzy extended AHP-based approach. Omega, 35(4), 417–431.

H. Shakouri G., Y. Tavassoli N.(2012). Implementation of a hybrid fuzzy system as a decision support process: A FAHP–FMCDM–FIS composition. Expert Systems with Applications 39 (2012) 3682–3691.

Kahraman, C., Cebeci, U., &Ulukan, Z. (2003). Multi-criteria supplier selection using fuzzy AHP. Logistics Information Management, 16(6), 382–394.

Kahraman, C., Ruan, D., &Dogˇan, Y. (2003). Fuzzy group decision-making for facility location selection. Information Sciences, 157, 135–153.

Lee, A. H. I., Chen, W.-C., & Chang, C.-J. (2008). A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan. Expert Systems with Applications, 34(1), 96–107.

MasoudZareNaghadehi, Reza Mikaeil, Mohammad Ataei.(2009).The application of fuzzy analytic hierarchy process (FAHP) approach to selection of optimum underground mining method for Jajarm Bauxite Mine, Iran.Expert Systems with Applications 36 (2009) 8218-8226.

NeseYalcin,AliBayrakdaroglu, CengizKahraman.(2012). Application of fuzzy multi-criteria decision making methods for financial performance evaluation of Turkish manufacturing industries.Expert Systems with Applications 39 (2012) 350–364.

Saaty, T. L. (1980). The analytic hierarchy process. New York: McGraw-Hill.

Van Laarhoven, P. J. M., &Pedrycz, W. (1983). A fuzzy extension of Saaty'sprioritytheory. Fuzzy Sets and Systems, 11(1), 199–227.

Wang, L., Chu, J., & Wu, J. (2007). Selection of optimum maintenance strategies

based on a fuzzy analytic hierarchy process. International Journal of Economics, 107, 151–163.

Chen, C.-T., Lin, C.-T. and Cheng, S.-F.H., A fuzzy approach for supplier evaluation and selection in supply chain management, Int. J. of Production Economics, Vol. 102, No. 2, 2006, pp. 289-301.

Monozka R. Trent R and R.Hand ield. (1998), "purchasing and supply chain management" south western college, Cincinnati, Ohio USA

Liu, F.H. and Hai, H.L. (2005), "The voting analytic hierarchy process method for selecting suppliers", International Journal of Production Economics, Vol. 97, pp. 308-17.

- Lee, A. H. I., Chen, W.-C., & Chang, C.-J. (2009). A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan. Expert Systems with Applications, 34(1), 96–107.

Wang, T. C., & Chang, T. H. (2007). Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment. Expert Systems with Applications, 33, 870–880.

Chang, C.-W., Wu, C.-R., & Chen, H.-C. (2008). Using expert technology to select unstable slicing machine to control wafer slicing quality via fuzzy AHP. Expert Systems with Applications, 34(3), 2210–2220.)