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ENVIRONMENTAL RISK ASSESSMENT OF LOW DENSITY POLYETHYLENE UNIT USING THE METHOD OF FAILURE MODE AND EFFECT ANALYSIS

The ninth olefin plant of Arya Sasol Petrochemical Company (A.S.P.C.) is regarded as the largest gas Olefin Unit located on Pars Special Economic Energy Zone (P.S.E.E.Z). Considering the importance of the petrochemical unit, its environmental assessment seems necessary in order to identify and reduce potential hazards. For this purpose, after determining the scope of the study area, identification and measurement of the environmental parameters, environmental risk assessment of the unit was carried out using Environment Failure Mode and Effect Analysis (EFMEA). Using the noted method, sources causing environmental risks were identified, rated and prioritized. The impacts of the environmental aspects derived from the unit activities, as well as their consequences, were also analyzed. Furthermore, the identified impacts were prioritized based on Risk Priority Number (RPN) and severity level of the consequences imposed on the affected environment. After performing statistical calculations, it was found that the environmental aspects owing the risk priority number higher than 15 have a high level of risk. Results obtained from Low Density Polyethylene Unit revealed that the highest risk belongs to the emergency vent system with risk priority number equal to 48. It occurs due to imperfect performance of the reactor safety system leading to the emissions of ethylene gas, particles, and radioactive steam as well as air and noise pollutions. Results derived from secondary assessment of the environmental aspects, through difference in calculated RPN and activities risk levels showed that employing modern methods and risk assessment have remarkably reduced the severity of risk and consequently detracted the damages and losses incurred on the environment.

Keywords: risk assessment; risk priority number; low density polyethylene; environmental failure modes and effects analysis; emergency vent system.

Nowadays, regarding the increasing difficulties caused by environmental issues, environmental risk assessment has been considered more than ever [1--3]. The application of managerial tools and quality engineering such as the Environment Failure Mode and Effect Analysis (EFMEA) is widespread through the world [4-6]. Implementation of risk identification, prioritization and assessment plans using EFMEA is among progressive methods used in risk assessment and management of oil, gas and petrochemical industries. The EFMEA method has been applied in various industries like automotive, electronics, aerospace, etc., to identify, assess and prioritize defects and errors that have tremendous potential to create hazards particularly at different stages before offering the product, *i.e.*, designing stage [7-9]. Environmental risk assessment is a qualitative analysis process of risk potentialities that actualizes a coefficient of the potential risks available in the project as well as the sensitivity or vulnerability of its surrounded environ-

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ment. Accordingly, in addition to analysis of various aspects of risk, the sensitivity of the affected environment and the values of the regional environment are considered using a full understanding of the environment [10-12]. The study ahead aims to identify the important environmental aspects affected by the Low Density Polyethylene Unit (LDPU) based on different production processes [13]. Recently, there have been some studies published regarding the application of FMEA in identification and assessment of environmental aspects as well as the introduction of EFMEA method. The results indicate that EFMEA is an appropriate qualitative method to assess environmental consequences derived from production processes. It aims at providing a suitable tool to facilitate the tasks of the companies so that their development would be accompanied by environmental considerations [14-17]. In 2002, Paul and Van [18] carried out a research study about pipeline risk management. The purpose of the study was to reduce of the adverse impacts of pipelines on the environment, increase the positive impacts of the process on the society, enhancement of the equipment, facilities and employees' safety and reduction of damage caused by leaking pipelines. The authors were looking to reach an alternative to minimize adverse impacts to their lowest possible extent by eliminating unsafe conditions and protecting the environment as much as possible. There have also been many research studies conducted regarding risk assessment of petrochemical industries. Gharabagh *et al.* [19] conducted a comprehensive risk assessment and management for petrochemical feed and product transportation pipelines. Heavy Gas Dispersion Model was applied in environment of ALOHA software for the consequence analysis of chlorine gas at different concentrations. In 2000, Khan and Abbasi [20] presented a new tool called TORAP for conducting rapid risk-assessments in petrochemical industries.

A.S.P.C. is one of the major petrochemical complexes in Iran. In 2006, the petrochemical complex was put into operation in an area with extent of 72 ha located on P.S.E.E.Z (situated in Bushehr Province) within the Assaluyeh Port. The complex includes low, medium and high-density polyethylene as well as C2 Cracker Units. The section under study includes the low-density polyethylene unit with a production capacity of 300,000 ton/year. Assaluyeh is regarded as Iran's main economic base and the world's largest energy production region [21,22]. The area, situated near a village in adjacent the Persian Gulf, is located 276 km southeast of Bushehr. It is the nearest terrestrial spot of the Persian Gulf northern margin to the South Pars Gas Field. It is worth noting that Gonbade Shomali sphere (belonged to Qatar) is located along the study area. Approximate area of the Assaluyeh industrial zone is equal to 14000 ha, in which the construction capability is almost equal to 10000 ha regarding deduction of alluvial lands and environmental buffer zones [23,24]. The nearest protected area to the considered petrochemical complex is Nayband Protected Area situated approximately 30 km away from the complex. The location of Arya Sasol Petrochemical Company is shown in Figure 1.

MATERIAL AND METHODS

EFMEA is a method that helps examine environmental demands and legal requirements systematically and focuses on the most important activities to

Figure 1. The location of Arya Sasol Petrochemical Company.

improve the environment [26]. The method takes into account the most serious environmental aspects and facilitates conscious implementation of environmental activities. Implementation stages of the research are presented in Figure 2.

In this study, parameters related to air pollution including O_3, CO_2, CO, NO, NO_2, NO_x, SO_2, H_2S and THC (total hydrocarbon) were measured. Initially, the exact location of the chimneys was investigated, and then chimneys No. 101, 102, 103, 106 and 109 available through the unit were specified for sampling. It is noteworthy that the exact sampling locations were identified using the EPA1 Method. Afterward, the output flow rate and diameter of the chimney were determined. In this regard, three points were appointed on the chimney at distances of 50.7, 16 and 83.3 m away from the chimney. Subsequently, the device prop was fixed in each of the mentioned points to record the measured values on the screen accurately. To measure the sound level, the exact location of the measuring stations was determined based on the sources, distances, periods and emissions of the sound, as well as the noise coherence. After conducting the required investigations, places including the northwest corner (next to the exit door), northeast side (in front of the Olefin Unit), southeastern side (in front of the effluent pond), the south side (in front of the TK--51602 Tank) and west side (next to the entrance) were selected as noise measurement locations. The microphone of the device was directly placed towards the sound source without any angle. It should be noted that the placement height of the device was determined based on the sound barriers. Acoustic and electric calibrations were done using the device construction. Meanwhile, the sound level meter was set on the A-weighting frequency network, and then, the results were recorded. The clean air standard measuring was examined in places such as the HSE Building roof, east side of the site, the southern side of the site, the west side of the site (along with heat exchangers). Initially, particulate matter (PM10) of the site was measured based on the BS-EN-12341 stan-

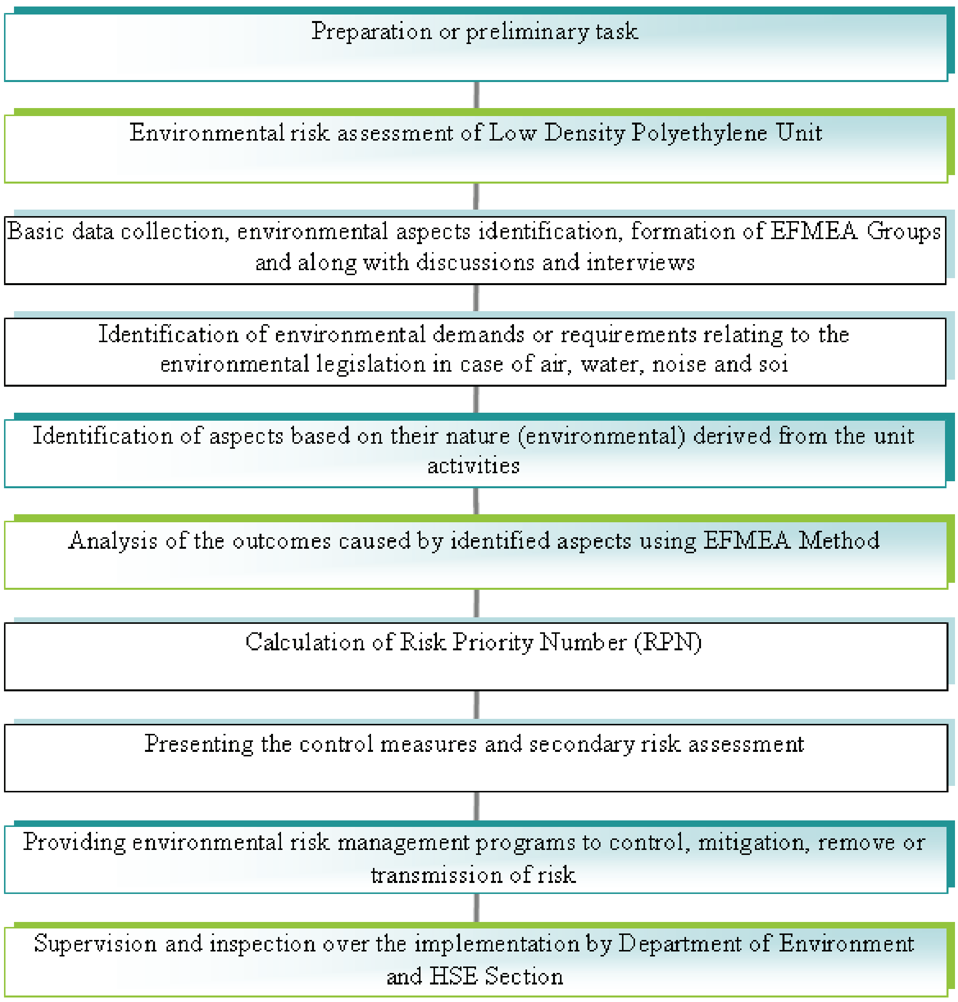

Figure 2. Workflow process in Low Density Polyethylene Unit.

dard method using a DUST TRAK photometer. The amount of the particles was shown by an aerosol photometer by measuring the amount of light released from them. The light intensity released from the particles is a function of the size, shape and analytical parameters of light. The amount and intensity of light in the Dust Trak Monitor were recorded for various suspended particles and aerosols and it was shown that the obtained data is a function of particle size at the same concentration. Fine particles (less than 1 μm) (fine particles) released more light per volume unit than larger particles. In this method the device was initially calibrated and placed in the appropriate position, 1.5 m above the ground level. The device flow was regulated and sampling was performed in a specific duration. Considering the capabilities of the device, the maximum, minimum and mean numbers of air-suspended particles per unit volume were measured. After measuring the suspended particles, the indoor air gases were evaluated. The model of the device used to measure gases including O_3, CO, NO, NO_2 and SO_2 was BABUC/A equipped by a replaceable electrochemical sensor. The parameters were transported from the sensor into the system based on voltage change and displayed in terms of the standard unit. Meanwhile, to measure the hydrocarbon compounds a PhoCheck 5000 device was applied based on PID (photo-ionization detector) with 2% precision. Parameters measured in effluent samples are included COC (continuously oily contaminated), POC (potentially oily contaminated), sea water olefin, sea water offsite, electrical connectivity (EC), pH, COD (chemical oxygen demand), BOD (biological oxygen demand), ammonium, phosphate, alkalinity, sulfide, detergent, oil, total dissolved solid (TDS), total suspended solids (TSS), lead, iron, copper, cadmium and trivalent chromium as well as the total amount of coli forms in the consumed drinking water samples. Finally, the results of the measurements were compared with the standards announced by Environmental Protection Agency (EPA). Subsequently, according to EFMEA Method, a checklist was designed to assess the environmental degradation coefficient. In the checklist, variables such as process identification, potential failure mode (environmental aspects), potential effects of the failure (outcomes), potential causes of the failure, the initial assessment of the environmental aspects (severity, probability of occurrence, pollution extent or recycling possibility, RPN and risk level), control measure and the secondary assessment of the environmental aspects (severity, occurrence probability, pollution extent or recycling possibility, RPN and risk level) were investigated. The checklist had required justifiability whereas it was prepared by participation and opinion of expertise in the field of occupational health, Health Safety and Environment (HSE), environment, chemical and process engineers at the Low Density Polyethylene Unit. After gathering required information, the environmental degradation coefficient assessment was performed using EFMEA.

In order to apply the EFMEA method for each aspect identified at "environmental aspect identifycation stage", the aspects were divided into two groups as follows:

a) Environmental aspects that cause emissions or produce various kinds of pollution, waste, and sewage in the environment.

b) Environmental aspects that cause reduction in natural resources due to indiscriminate consumption; for example, the use of a variety of fossil fuels, cooling water beds, electricity, compressed air and oxygen.

Accordingly, the considered RPN was calculated by multiplying three parameters including severity, occurrence probability, pollution extent or possibility of recycling.

For the first group of the environmental aspects the following formula was applied to obtain environmental degradation coefficient:

$$\text{Environmental degradation coefficient} = \text{Severity}\times\text{Occurrence probability}\times\text{Pollution extent}$$

For the second group, the following equation was used:

$$\text{Environmental degradation coefficient} = \text{Severity}\times\text{Occurrence probability}\times\text{Recycling possibility}$$

The scoring manner was such that for the "intensity" parameter (as presented in Table 1) the scoring range was within 1 to 5. The score 5 belonged to the most intensive state, while the score 1 was assigned to the lowest intensity case. In the case of "occurrence probability" (Table 2), a scoring number within the range of 1 to 5 was given so that for the highest and lowest occurrence probability, the scores 5 and 1 were allocated, respectively. For "pollution extent or recycling possibility" a 1-5 scoring rage was considered as well (Tables 3 and 4) so that the highest (5) and lowest score (1) were respectively assigned to the highest and lowest pollution extent or recycling possibility [13,27-29].

Finally, the hazardability degree was calculated using frequency distribution method with help of RPN Index. All calculations were performed in the environment of SPSS software. In order to perform statistical analysis, the number of the categories was computed using the following equations.

Table 1. The severity of environmental degradation [25,31]

Score	Description of severity	Severity
5	Potentially very harmful or destructive / high loss or consume of resources	Severe/catastrophic
4	Is not harmful, but potentially destructive/ high loss or consume of resources	Serious
3	Relatively hazardous / moderate loss or consume of resources	Medium
2	Low potential for harm/ low consumption or loss of resources	Low
1	Loss is slight and can be negligible/ Slight consumption or loss of resources	Slight

Table 2. The occurrence probability of environmental outcomes [25,32]

Score	Probability of occurrence
5	Very high and inevitable occurrence (it is possible to happens every day)
4	Common occurrence (it is possible to happens during the week)
3	Possible and moderate occurrence (it is possible to happens during the month)
2	Trace occurrence (it is possible to happens once a year)
1	Impossible and unlikely occurrence (it is possible to happens once every 10 years)

Table 3. Dispersion of pollution [25,33]

Score	Range of pollution
5	At regional level
4	At project level (Arya Sasol Petrochemical)
3	At workshop level (production line)
2	At workshop level (unit)
1	At workstation level

Table 4. The possibility of recycling [25]

Score	Possibility of recycling
5	Consumption of non-recyclable resources
4	Waste of non-recyclable resources
3	Waste of resources having hard recyclables and improvement
2	Waste of resources having easy recyclables and improvement
1	Consumption of recyclable resources

The category length, CL, was obtained by subtracting the smallest RPN value, S, from the greatest amount of risk priority number, L, over number of categories, K:

$$CL = \frac{L-S}{K} \tag{1}$$

where K is defined as follows:

$$K = 1 + 3.3\log n \tag{2}$$

where n is the total number of the environmental aspects.

Eventually, the final ranking was performed based on the hazardability degree and then the environmental risk level was determined for each activity. Sequentially, the aspects having RPN higher than the considered hazardability degree were counted as critical activities required the mitigation measures.

RESULT AND DISCUSSION

Results obtained from the environmental parameters of A.S.P.C. (given in Table 5) revealed that the amount of CO and other gases in all measured outputs is acceptable and less than standard limits.

Noise pollution was assessed two times, during the day and night, based on Leq (30). The results are presented in Table 6. The measurement results indicate that the intensity level of the environmental noise in all stations is less than the standard limit. It is worth noting that the Leq (30) standard determined by the Department of the Environment of Iran is equal to 75 dB during the day and and 65 dB at night.

The measurement results for the suspended particles (Table 7) show that the amount of suspended particles in all stations was within the standard limit but the roof of HSE Building and the eastern side of

Table 5. Emissions from chimneys

No	Chimney name	0.3% O_2 CO ppm	Permissible standard limits, 0.3% O_2 CO	0.3% O_2 NO_x ppm	Permissible standard limits, 0.3% O_2 NO_x	0.3% O_2 SO_2 ppm	Permissible standard limits, 0.3% O_2 SO_2
1	101	0	150	90.72	350	1.26	800
2	102	0	150	116.54	350	0	800
3	103	0	150	83.6	350	0	800
4	106	0	150	113.3	350	0	800
5	109	0	150	120	350	0	800

the site. However, the mentioned amounts will be decreased in order to optimize the production process and reduce pollution.

The measurements results of the effluent sample for various parameters show that the amount of COC, COD, BOD and TDS were higher than the standard limits (Table 8). It should be mentioned that the amount of COD and TDS offsite and at the Olefin Unit were beyond the standard limits. The overall rate of the coli forms in drinking water was within the standard limit.

After examination of 23 devices, a total of 116 environmental risk aspects was identified using EFMEA Method in production line of L.DP.U. After calculation of risk prioritization number it was determined that the highest (48) RPN belonged to the Emergency Vent System. Afterward, statistical calculations were performed based on equations presented in material and methods. Table 9 shows the results obtained from the statistical calculations. It demonstrates the number and length of the categories equal to eight and to six. The limits of the categories are presented in Table 10.

After determining the limit of the categories, the frequency of each category was gained so that 67 cases were placed within the 3-8 category limit, *i.e.*, out of 116 RPNs, 67 cases were located within the category of 3-8. Accordingly, by calculation of two numbers, 3 and 8 (lower and upper limits) of the mentioned category, the hazardability degree was found to be equal to five. According to statistics obtained from the initial assessment of the environmental aspects, the risks presented in Table 11 were classified. As stated in the classification stage, the aspects having less than five initial RPN were ignored and displayed as low-level risks with (L) symptom. The first category related to the activities in the range of 5 to 10 were considered as aspects with moderate and acceptable risk level and displayed using (M) symptom. For these kinds of activities, there is no neces-

Table 6. Noise pollution

Position	Max. intensity of sound, dB		Min. intensity of sound, dB		The continuous equivalent noise level over a 30 min interval (Leq (30))		Environmental standard of Iran for the continuous equivalent noise level over a 30 min interval (Leq (30))	
	Day	Night	Day	Night	Day	Night	Day	Night
Northwest corner (next to the exit doors)	69.5	65.1	63.5	61.1	64.9	63.1	75	65
North side (in front of the Quality Control Building)	66.4	65.4	64	59.6	65	60.5	75	65
Northeast side (in front of the Olefin Unit)	66.7	64.3	62.1	61.8	63.5	62.5	75	65
Southeastern side (in front of the effluent pond)	70.1	65.6	62.3	60.8	66.8	62.2	75	65
South side (in front of the TK-51602 Tank)	66.4	62.3	60.8	56.1	63.8	58.6	75	65
West side (near the entrance)	68.7	70.6	66.2	63.9	66.6	64.5	75	65

Table 7. Suspended particles (PM10) measurement test based on clean air standard; time: 15 min, suction volume: 25.5 dm^3; discharge: 0.102 m^3/h; standard amount: 150 μg/m^3

Position	Amount of suspended particles (PM10), μg/m^3		
	Max.	Min.	Average
HSE Building roof	149	130	165
Eastern side of the site	143	115	218
Southern side of the site	96	85	131
Western side of the site (next to the heat exchangers)	9	87	116

Table 8. The results obtained from wastewater samples analysis

Parameter	Sample effluent COC	Sample effluent POC	Effluent seawater samples		Output standard		
			Olefin unit	Offside unit	Discharge to the surface water	Discharge to the absorber wells	Agricultural and irrigation purposes
Electrical connectivity (EC), µS/cm	22340	13850	8340	9820	—	—	—
pH	6.88	7.28	6.48	7.31	8.5—6.5	9.0—5.0	8.5—6.0
Chemical oxygen demand (COD), mg/l (Clause 3)	253.2	162.8	1342	1968	60 (momentary 100)	60 (momentary 100)	200
Biochemical oxygen demand (BOD), mg/l (Clause 3)	181	15	10	8	30 (momentary 50)	30 (momentary 50)	100
Ammonium, mg/l	3.36	1.84	0.19	<0.1	5.2	1	—
Phosphate, mg/l	1.0	0.07	0.09	0.13	6	6	—
Alkalinity, mg/l	67.5	0	15.5	130	—	—	—
Sulfide, mg/l	<0.1	<0.1	<0.1	<0.1	3	3	3
Detergent, mg/l	<0.1	6.6	<0.1	<0.1	1.5	0.5	0.5
Oil, mg/l	<0.1	<0.1	<0.1	<0.1	10	10	10
Total dissolved solid (TDS), mg/l	19320	10030	6950	7655	—	—	—
Total suspended solid (TSS), mg/l	2	10	4	2	40	—	100
Lead, mg/l	0.19	0.23	0.23	0.7	1	1	1
Iron, mg/l	2.18	1.14	1.14	0.45	3	3	3
Copper, mg/l	<0.1	<0.1	<0.1	<0.1	1	1	0.2
Cadmium, mg/l	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.05
Trivalent chromium, mg/l	<0.1	<0.1	<0.1	<0.1	2	2	2

Table 9. The statistical results obtained from initial RPN

The category length	The largest RPN	The smallest RPN	Number of the categories	Number of data
6	48	3	8	116

sary need to consider control and mitigation measures. The second category is related to activities in the range between 10 and 15, which are considered as high-level but tolerable risks aspects. H1 character was applied to show them. It is worth noting that for such activities, it is preferable to consider mitigation and control measures. The last class is related to the activities with RPN greater than 15. They were regarded as aspects with very high-level risk and H2 symptom was used to display them. It should be noted that the list of H2 risks is inserted in Table 12. For the activities categorized in this level it is necessary to consider control and mitigation measures. The main purpose of such a classification was providing an appropriate basis for prioritization of risks needed to be controlled.

Table 10. Calculation of the category limit

Calculation	Limit
3+6 = 9	L1 = 3-8
9+6 = 15	L2 = 9-14
15+6 = 21	L3 = 15-20
21+6 = 27	L4 = 21-26
27+6 = 33	L5 = 27-32
33+6 = 39	L6 = 33-38
39+6 = 45	L7 = 39-44
45+6 = 51	L8 = 45-50

Table 11. The category of the risk limit in EFMEA Method

Category	Risk type	Risk limit
First	Medium level risks	$5 \leq RPN \geq 10$
Second	High level risks	$10 < RPN \geq 15$
Third	Very high level risks	RPN > 15

After initial assessment of the environmental aspects in A.S.P.C. it was revealed that some activities have high level of risk. Out of 116 investigated aspects, 37 cases were placed within the category with low level risk, 8 cases were allocated to the high level risk category and 32 cases were assigned to the very

Table 12. Environmental aspects risk assessment using EFMEA Method

Equipment	Environmental aspect	Failure effect	Initial assessment of the environmental aspect (risk level: H2)				Secondary assessment of the environmental aspect				
			Intensity	Occurrence probability	Pollution extent or recycling possibility	Risk priority number, *RPN*	Intensity	Occurrence probability	Pollution extent or recycling possibility	Risk priority number, *RPN*	Risk level
Initial compressor	Oil spill	Soil pollution	2	4	2	16	2	2	2	8	M
	Oil spill	Liquid waste	2	2	2	16	2	2	2	8	M
	Ethylene gas emission	Air pollution	5	2	4	16	5	1	4	20	H2
	Vibration	Noise pollution	2	5	2	20	2	3	2	12	H1
Secondary compressor	Oil spill	Soil pollution	2	4	2	16	2	2	2	8	M
	Oil spill	Liquid waste	2	4	2	16	2	2	2	8	M
	Ethylene gas emission	Air pollution	5	2	4	40	5	1	4	20	H2
	Vibration	Noise pollution	2	5	2	20	2	3	2	12	H1
Pressure breaker valve (BPV)	Hot water consumption	Waste of resources	2	3	3	18	1	2	3	6	M
	Ethylene gas emission	Air Pollution	5	2	3	30	5	1	3	15	H1
	Vibration	Soil pollution	4	4	2	32	4	2	2	16	H2
	Primer leak	Liquid waste	4	4	2	32	4	2	2	16	H2
Extruder	Melt polymer release	Solid waste	5	2	2	20	2	3	2	12	H1
	Ethylene gas emission	Air pollution	5	2	3	30	5	1	3	15	H1
Coolers to set the temperature of air returned to the secondary compressor	Vibration	Air pollution	5	2	3	30	5	1	3	15	H1
A/B compressor	Vibration	Noise pollution	3	5	2	30	3	4	2	24	H2

high level risk category. Subsequently, based on the mentioned categories some strategies included control and mitigation measures were suggested for activities owing high potentiality for causing environmental risks. This time, the secondary assessment of the environmental aspects was performed. The contents of Table 12 show that all parameters investigated in the secondary assessment of the environmental aspects were placed within the acceptable and tolerable level.

CONCLUSION

According to the conducted ranking, 31.9% of the aspects have low level risks while 33.62% were placed on the medium level risk category. Moreover, 6.9% was allocated within high-level risk classification and 27.6% were belonged to the very high-risk level group. The results of the environmental risk aspects for each device suggested that the lowest risk priority number is equal to 3. The highest risk priority number related to the environmental risk is specified to the process of the Emergency Vent System, which was allocated a PRN tantamount to 48. Due to the safety performance of the reactor, ethylene, particles, vapors and radioactive materials are released which lead to air and noise pollution as well as the radioactive emissions. The main factor preventing the unit authorities to apply control methods for eliminating or reducing the potentiality of the risks is the application cost of such methods. However, it should always be considered that the incidence of environmental risk will be followed by more expenditure. From this viewpoint, the required control and mitigation measures should be proposed proportional to the activity type and the ongoing process with high potentiality of the environmental risk. Reformatory measures suggested at the place of ethylene gas emission include replacement or repair of device failure, use of pollutant gas control systems in the output of the chimney and ventilation outlet. Also, reformatory measures such as promotion and employees' obligation to use personal protective equipment, sound control at receiving place like the use of hearing protection devices, Silent Ear Muff and Ear Protector (models: A615 and A812) as well as installation of silencers at noise pollution sources is highly recommended to maintain the personnel's health. Cleaning the unit floor using a vacuum cleaner, application of cyclone or dry electrostatic filters to dust removal, reducing the concentration of dust and pollutants by embedding a filter, scrubber or cyclone in order to air conditioning of Production Saloon and Raw Materials Storage, usage of wet scrubber system, the application of ceiling fans for air conditioning of workshops and reducing dust concentration, the use of filtered masks during making contact with particles, the use of dirt deflector systems in place of particulate emissions and also enclosing the resources using safety guards to prevent the release of radiation in the environment are considered among the necessary mitigation measures to reduce the potential environmental risks through the unit.

The study shows the effectiveness of the EFMEA method in identification of the affected environment, risk quantity estimation as well as identification of the appropriate risk mitigation measures. Since EFMEA is a qualitative method, it is effective in product development processes, identification of the structures and important aspects having priority regarding environmental outcomes throughout the life cycle of the product or process. Considering that humans are the main basis of the sustainable development, finding solutions in order to remove and reduce contaminants seems essential. In addition, applying ways with the aim of preventing waste and excessive consumption of resources is considered among the issues that special attention should be paid to in line with environmental risks management. Following industry-specific standards and environmental policies and practices as well as applying proper management techniques will increase the confidence coefficient of mitigation of the industrial activities and processes adverse effects. By examination of environmental risk assessment results of L.D.P.U. it was determined that the unit enjoys relatively high safety and environmental control systems. However, in cases where the devices have very high risk, implementation of control measures seem necessary.

Abbreviation list

A.S.P.C.	Arya Sasol Petrochemical Company
BOD	Biological Oxygen Demand
COC	Continuously Oily Contaminated
COD	Chemical Oxygen Demand
EFMEA	Environment Failure Mode and Effect Analysis
LDPU	Low Density Polyethylene Unit
POC	Potentially Oily Contaminated
P.S.E.E.	Pars Special Economic Energy Zone
PID	Photo-Ionization Detector
RPN	Risk Priority Number
TDS	Total Dissolve Solid
THC	Total Hydrocarbon
TORAP	Tool for Rapid risk Assessment.

Symbol list

CL	The category length
H1	High-level risks aspects but tolerable
H2	Aspects with very high-level risk
L	Low-level risks, the largest RPN
L1, L2,…, L8	First, second,…, eight class limits
M	Aspects with moderate and acceptable risk level
N	The number of the RPN
S	The smallest RPN.

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NAUČNI RAD

PROCENA EKOLOŠKOG RIZIKA POSTROJENJA ZA POLIETILEN MALE GUSTINE METODOM ANALIZE NAČINA I EFEKATA OTKAZA

Deveti plan petrohemijske kompanije Arya Sasol (A.S.P.C.) se tiče postrojenja gasovite olefin u specijalnoj ekonomskoj, energetskoj zoni Pars. Razmatrajući značaj ovog petrohemijskog postrojenja, čini se neophodnim da se izvrši njegova procena zaštite životne sredine da bi se identifikovale i smanjile potencijalne opasnosti. U ovu svrhu, posle određivanja cilja istraživanja, izvršene su identifikacija i merenje ekoloških parametara i procena zaštite životne sredine korišćenjem metode analize načina i efekata otkaza (EFMEA). Koristeći ovu metodu, identifikovani su i ocenjeni izvori ekoliških rizika, a zatim određeni njhovi prioriteti. Pored toga, analizirani su uticaji ekoloških aspekata koji sau rezultat rada postrojenja kao i njihovih posledica. Štaviše, napravljen je prioritet među identifikovanim uticajima na osnovu broja prioritenog rizika i nivoa ozbiljnosti posledica nametnutih okolini. Posle sprovedenih statističkih proračuna, utvrđeno je da ekološki aspekti sa brojem prioritetnog rizika većim od 15 imaju najveći nivo rizika. Dobijeni rezultati za postrojenje za dobijanje polietilena niske gustine su otkrili da najveći rizik pripada sistemu sigurnosnih ventila sa brojem prioritetnog rizika 48. Ovo je rezultat nesavršenog rada bezbedonosnog sistema reaktora koji vodi emisiji etilena, čestica I radioaktivne pare kao i zagađenju vazduhom i bukom. Rezultati dobijeni sekundarnom procenom ekoliških aspekata, kroz razliku izračunatih brojeva prioritetnog rizika i nivoa rizika aktivnosti su pokazali da je primena modernih metoda i procene rizika značajno smanjila ozbiljnost rizika i samim tim smanjile odštete i gubici kojima je izložena okolina.

Ključne reči: procena rizika; broj prioritetnog rizika; polietile niske gustine; analiza načina i efekata ekoloških otkaza; petrohemijska kompanija Arya Sasol; sistem sigurnosnih ventila.