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THE ANALYSIS OF THE INDUSTRIAL SECURITY LEVEL ACCORDING TO THE INTEGRAL CRITERION IN A BELARUSSIAN OIL REFINERY

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The following systematized data about frequency of accidents and their reasons (incidents, work injuries and occupational diseases) at one of the oil refineries of the Republic of Belarus over the period of 1967 – 2015are based on the official statistical reporting. The analysis of the industrial security level was carried out according to the integral criterion. The obtained results could be the base for the prediction of the number of accıdents and the reference point on addressing the regulated causes.

Introduction. The modern oil refinery is a complex technological unity, including process equipment, infrastructure and associated structures. It is characterized by the high threat level due to the use of toxic chemicals, hazardous chemicals, causing fire and explosion during the technological process, which can be the reason for accidents and incidents, work injuries and occupational diseases, with severe consequences like human losses, material-technical and financial losses and harm to region's ecology.

Methods of research. The accidents (incidents, work injuries and occupational diseases) were analyzed, which had been subjected to statistical recording in the largest oil refinery of the Republic of Belarus in terms of the processing of raw materials. The archival materials and accounting over the period of 1967 – 2015 were explored using the statistical method of analysis. The pıcture below shows the dynamics of crude oil distillation's volume and the number of accidents at the oil refinery.

Results, their discussion and perspectives. Over the indicated period of time 5 accidents, 8 occupational diseases, 513 work injuries and 614 incidents (refusals, injures and violations referred to incidents) were registered at the factory(Fig. 1).

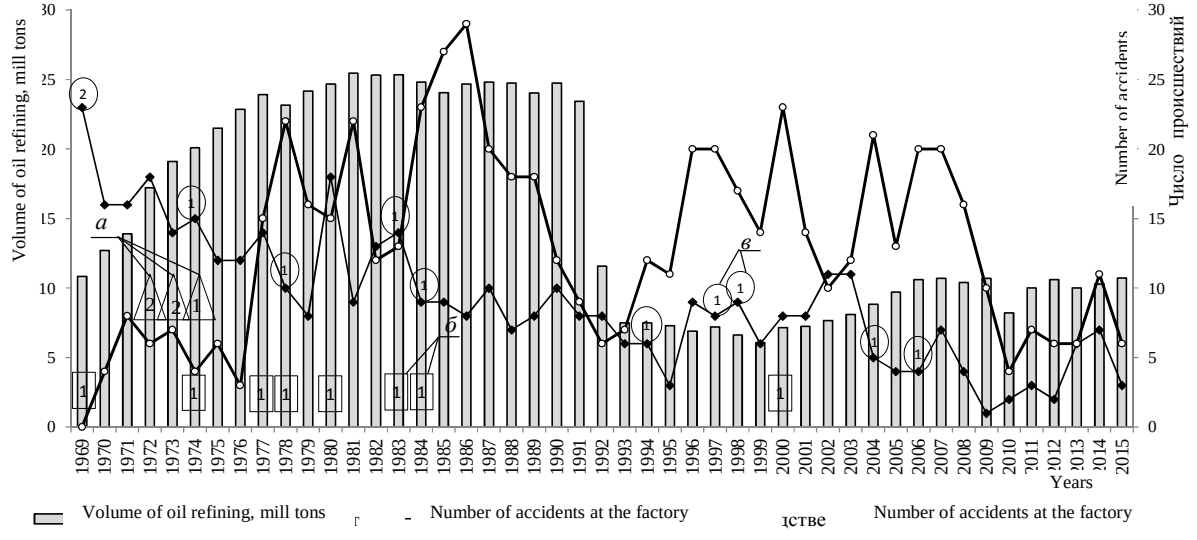

Fig. 1.The dynamics of crude oil distillation's volume and the number of accidents. Years with number of: *a* – accidents; *b* – occupational diseases; *c* – fatal accidents

The retrospective analysis of the causes of accidents and incidentswas carried out. The results are presented in Table 1.From Table 1 it is seen that the most frequent causes of accidents and incidents (about 30%) are connected with 'human factor', such as unskilled and erroneous activities of the staff, erroneous command transmission, un-cooperation, low-quality assembling and repairing workviolations ofinstruction or plan of the execution of works, implementation of hot works in an unprepared place. But the number of accidents and incidents caused by these reasons tend to reduce over a ten year period of observation. Causes connected with equipment failure due to its physical aging and conditioned by failure of electricity supply due to short circuit and insulation faults of supply cables are on the 2nd and 3rd places.

Table 1 – The dynamics of accidents and incidents' causes in the factory

Accidents and incidents' causes	% of the accidents and incidents number over the period of					
	1970–1979	1980–1989	1990–1999	2000–2009	2010–2015	1967–2015
Violations of production procedures' rules, instructions requirements, fallacious activities	46.15	27.92	24.22	17.61	4.55	*24.51*
Equipment failure and aging of equipment	4.40	24.87	18.75	13.21	11.36	*15.68*
Insufficient operating conditions of electrical equipment	4.40	15.74	10.16	25.16	4.55	*13.70*
Corrosion and erosion of equipment	2.20	4.57	7.03	6.29	15.91	*5.63*
Malfunction of control equipment and automation	6.59	2.03	7.81	6.92	6.82	*5.18*
Faulty installation and repair of equipment	8.79	8.12	3.13	1.89	2.27	*4.87*
Natural phenomena	3.30	4.57	3.91	6.92	2.27	*4.41*
Gasketdamage	6.59	4.06	3.91	5.03	4.55	*4.41*
Shafts burnout because of localized overheating and coke deposits	4.40	3.05	3.13	2.52	13.64	*3.65*
Constructional defects	6.59	3.05	1.56	2.52	6.82	*3.20*
Low quality of welds	-	4.06	2.34	1.26	9.09	*2.59*
The safety valve disruption	2.20	2.03	2.34	1.26	6.82	*2.13*
Overflow of tanks and industrial savage systems	4.40	3.05	0.78	1.26	-	*2.13*
Plugs, ingress of solid particles, accumulation of resinous compounds	3.30	1.02	2.34	3.14	-	*1.98*
Hydraulic shock, ingress of liquid in compressor cylinder	-	0.51	2.34	2.52	2.27	*1.37*
Project faults of process	1.10	1.02	2.34	0.63	-	*1.07*
Self-ignition of substances	1.10	-	4.69	-	-	*1.07*
Others	2.20	1.02	2.34	3.14	9.09	*2.44*

Moreover the dynamics of accidents and incidents number growthconnected with insufficient operating conditions of electricity supply, as well as with corrosion of equipment is noticed.

Technological plants with the highest frequency of accidents and incidents rise are determined during the topographical analysis.

And 17.61% of incidents occurre in a complex of crude oil distillation plants (EDP (Electrical Desalting Plant) AVD (Atmospheric Vacuum Destillation)-6, EDP AVD-2, AT(Single-flash pipe still)-3, AT-8, VT(Vacuum pipe still)-1, 'Purification', etc.), 13.57% are at the catalytic reformer.12.92% are at the hydrofining of fuels plants.7.43 % are in the complex 'Hydrocracking'andinstallation of soft hydrocracking.6.46% areat plants complex on receipt of single aromatic hydrocarbons (releases of gross xylols, 'Tatoray Unit', 'Detol', isomerization of xylols, receit of paraxylene, orthoxylene, pseudocumene, ethylbenzene, etc.). 5.82% are at the electricity supply shop. 5.49% are at the commodity shop. 2,75% are at the plants for receit of additives, sulfuric acid and in the recirculated water unit. 2.42% are at the plant 'Visbreaking-Thermal craking'. Deasphalting plant (3.23%), oils dewaxing plant (2,42%), oils selective treatment plants (1.94%) and bitumens production (1.62%) are singled out among other plants of oil lubricants and bitumens' production in frequency of accidents and incidents' causes.

The correlated connection between the size of primary oil distillation and the amount of work injuryat the factorywas fixed, the linear dependence between the lowering of the absolute number of accidents over the showed follow-up period (R_2 = 0,67) and the low operating effectiveness of work safety system between 1996 and 2003was confirmed.

The analysis of the structure of industrial injures by kinds of accidents showed that 72.51% of accidents were brought by mechanical rammers, thermal burnsaccount for 17.93% and chemical burns – 7.02%.

Distribution analysis of industrial injures for petroleum-refining industry showed available lines and places with high injury risk and on the first place is the Oil fuel and aromatic hydrocarbon industry (19.16% of accidents), on the second place is the industry of Lubricating oils and bitumens (18.96% accidents), on the third and the fourth places are ancillary proceedings - Repair's proceeding (13.37%) and Commodity department (12.58%).

The highest number of victims at the factory was fixed among processing stations operators. That is 19.88% injures of the total number, metalworkers – 18.32% and 8.58%. This can be explained by the fact that these workers make up the greater part of the labour force at the plant. In Table №2 are the results of analysisofreasons ofinjures for the period between 1963 and 2015.

The retrospective study of the industrial injures at the factory shows, that about 80% of the industrial injures have organizational disruptions, linked to the human element and about 20% - to technical reasons.The safety engineering violation by the workers and victims' personal carelessness are the main reasons for industrial injures at the factory (23.11% and 19.72% of the total industry injuries number). The analysis of every ten years can tell the downtrend of the number of injures because ofsafety engineering violation by victims or by other people and because of application of dangerous work performance. It can be related to the rise in workers preparation level, in their competence in the protection of labour area and the improving of work by their study, instruction and administrative control toughening. Over the investigated periods attention was paid to the growing number of injuries because of victims personal carelessness, for the most part, because of dropping on the surfaces at the time of transportation.

Table 2. – Analysis of the industrial injuries causes

Cause	% of the whole injures number	% of theinjuries from the NS numberover the definite period					
		before 1969	1970–1979	1980–1989	1990–1999	2000–2009	2010–2015
Safety specification's violation by the victim	23.11	27.47	24.82	25.74	20.72	16.18	7.41
Victim's personal carelessness	19.72	15.32	10.28	20.88	18.57	33.83	62.96
Safety specification's violation by other people	8.96	9.01	10.64	15.05	11.43	8.83	3.70
Unsatisfactory work organization	8.57	8.11	12.77	5.34	11.43	10.29	-
Application of dangerous work performance	8.76	7.66	6.74	2.91	2.14	1.47	14.81
Disrepair of facilities, mechanism and devices (including corrosion and aging equipment)	8.17 (1.67)	3.6 (0.90)	7.09 (0.71)	6.79 (1.94)	7.85 (2.14)	7.35 (2.94)	3.70 (3.70)
Personal protection equipment non-use	5.38	6.31	5.67	3.88	3.57	7.35	3.70
Unsatisfactory work places keeping	2.99	2.70	2.48	4.37	5.00	2.94	-
Careless and criminal activity by other people	1.79	0.90	-	0.97	2.86	2.94	-
Unsatisfactory wheeling and territory state	2.72	0.90	2.84	2.91	5.71	0.00	-
Design defects of means of production	2.72	6.31	2.84	2.91	6.43	4.41	-
Deficient victim's informing	2.39	8.11	10.99	4.37	1.43	-	-
Flowsheets imperfection	1.39	2.70	2.84	2.91	-	2.94	-
Personalprotectionequipment'sneediness	1.00	0.90	-	-	-	1.47	-
Others	1.00	-	-	0.97	2.86	-	3.7

By these materials since the start of production activities of the factory, eight cases of occupation diseases were officially registered. The professional chronic intoxication with petrochemicals (hydrocarbons, benzol and it's homologue etc.) was diagnosed in 75% of cases, one incident was bronchial asthma and one – functional hand overstrain. The main occupational disease cause in 62.5% of incidents is long contact with petrochemicals in high resistances.

Analysis of the state of accident rate, occupational diseases and traumatism at a factory was the basis for the valuation of the safety at a factory by the integral criterion that took into account production and number of expressed accidents:

$$K_{ПБ} = \frac{Д}{\sum_{i=1}^{n} N_i \alpha_i} \quad (1)$$

$K_{ПБ}$ – the level of safety at a factory;
Д – production, mln. tons / year;
N_i– number of parameter;
α_i – coefficient of parameter concernment. $\alpha_i = \overline{N}_{ин} / \overline{N}_i$ ($\overline{N}_{ин}$ – average number of accidents over the definite period; $\overline{N}_i$ – average number of accidents over the same period).

Index of dynamics of safety level at a factory over the period of 1969 and 2015 is onfigure 2.

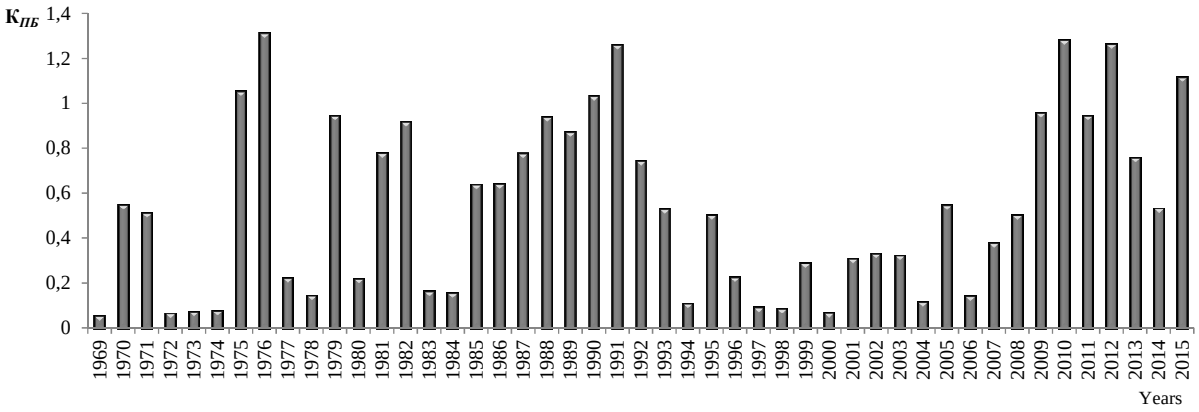

Fig. 2. Dynamic of safety level in factory

Conclusion. We can see that safety level at a factory has risen for the last ten years. These results can be basis to prediction of the number of accidents and to reference point to elimination dirigible causes of their rise.

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