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PRIVACY PRESERVING ASSOCIATION RULE MINING APPLIED TO WEB USAGE DATA

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In this research, a method for privacy preserving association rule mining is appliedto mining web usage data. Two algorithms for hiding informative association rules are compared and experiments performed on a real-life web usage data set for various confidence/support thresholds. The effectiveness of the two algorithms is considered with respect to preserving the database state. It is theoretically and experimentally shown that one algorithm outperforms the other in all test cases, assuming thatthe properties of each sensitive rule are considered out of the context of the sensitive rule set as a whole.

Key words: *Privacy preserving data mining, association rule mining, informative association rules*

INTRODUCTION

Privacy preserving data mining is a novel research direction in data mining, where data mining algorithms are analyzed and enhanced to avoid revealing potentially sensitive information [7]. The goal of privacy preserving data mining is to hide sensitive information so that it cannot be revealed through the data mining process [8,9].

Association rule mining is one of the populardata mining methods, where the task is to discover allpatterns of the form "If a market basket contains items from the set X it likely also contains items from the set Y" [1]. Association rules can be used for predictive purposes, defining types of customers, potentially increasing the efficiency of marketing campaigns. When the items contained in an associationrule are potentially sensitive, asmay be the case when applied to the pharmaceutical or other sensitive type of data, the rules may potentially reveal sensitive information about individuals or groups of individuals, usually unauthorized for usage [7].

In this work, we apply privacy preserving association rule mining method to the web usage data. While website visitors browse the sites, the web servers store immense volumes of data, which can be mined to discover potentially valuable information about the visitor behavior [6]. In the context of web usageassociation rule mining, a web object (usually a web page)is considered an item, while a website visitor session,defined as a set of web resources requested during an event of browsing,is considered a transaction [2,3,5]. Association rules discovered from the web usage data have the form "If a visitor session contains the set of web objects X, it likely also contains the set of web objects Y".Data analysts and web masters can use such rules for marketing purposes, recommendation, user profiling and personalization.

In this work, wetest and analyze twoalgorithms designedfor hiding sensitive "informative" association rules proposed in [8]. For the purpose of the research, the algorithms were implemented within our web usage mining system [4]. We test their success in transforming the database in order to hide the sensitive association rules as little as possible,on a real-life web usage data set.The experiments confirmed that one of the algorithms outperforms the other, making fewer transformations in the database, in all tests. We explain this behavior and prove that one algorithm always makes fewer database transformations than the other does, assuming that each sensitive rule is considered out of the context of the sensitive association rule set. In order to precisely define the optimal selection of the algorithm to use, a more thorough research is recommended for future work,which would include the consideration of the properties of the sensitive association ruleset as a whole.

The rest of the paper is organized as follows. The underlying definitions are given in the following section. The section Experiments outlines the experiments when the sensitive rule hiding algorithms are applied on a real life web usage data set. The discussion of the results and the properties of the two algorithms are outlined in the session Discussion. Finally, the section Conclusions gives final remarks.

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BACKGROUND DEFINITIONS

Association rules

Let $I= \{i_1, ..., i_n\}$ be a set of items, $T= \{t1, ..., tm\}$ a set of transactions where $t_i \subseteq I$. An association rule is an implication of the form:

$$X \to Y,\ X, Y \subseteq I, X \cap Y = \emptyset$$

The support of an association rule $X \to Y$ in the set of transactions T is defined as the probability of item sets X and Y co-occurring in the same transaction.

$Supp(X \to Y) = Count(X \cup Y)/n = P(X \cup Y)$, where $Count(A)$ is the number of transactions in T that contain the set of items A , and n is the total number of transactions in T.

The confidence of the rule R in the set of transactions T is defined as the conditional probability of Y occurring in a transaction that contains X.

$$Conf(X \to Y) = \frac{Count(X \cup Y)}{Count(X)} = P(Y|X)$$

The support measures the percentage of transactions covered by the rule, while the confidence is one of the measures of how reliable an association rule is in the set of transactions. The problem of association rule mining is to generate all such rules that satisfy minimal support and minimal confidence threshold constraints.

Hiding informative association rules

Informative association rules are a subclass of association rules. They are single-target rules, such that there is no subset rule with higher confidence and for any non-informative single-target rule, there is an informative association rule with higher confidence [8].

Wang et al. propose a method to modify database so that the informative association rules containing sensitive predicting items cannot be inferred through association rule mining. The two proposed algorithmsare based on increasing the support of the left hand side (algorithm “ISL”), and decreasing the support of the right hand side of the sensitive rules (algorithm “DSR”). One of the main parameters measuring the success of the hiding process by this methodis the percentage of transformed transactions in the database, as the goal is to keep the database state as close as possible to the original. For details about the two algorithms, see [8].

For the purpose of this research, we have implemented the algorithms ISL and DSR within our web usage association rule mining system [4]. We applied the algorithms on the real-life web usage data as described in the following section.

EXPERIMENTS

Data set

The method was appliedon real-life web usage data containing the actual visits to the web site of the Higher Education Technical School of Professional Studieswww.vtsns.edu.rsduring 10 successive days in December 2013. After performing the pre-processing steps (removal of irrelevant web object requests, removal of robot requests, browsing session identification), the web log file contained 30,324 relevant web object requests, grouped into10,304 browsing sessions. A browsing sessionwas defined as a set of requests coming from the same IP, while the time between two requests did not exceed the threshold of 5 minutes.

Association rule generation and hiding

We generated association rules using ourweb usage association rule mining system, which implements a version of well-known Apriori algorithm for frequent set generation. The systemsupports all phases of web usage association rule discovery (web usage data pre-processing, association rule

generation, association rule hiding). For the purpose of this study, we extended the systemby the implementation of ISL and DSR association rule hiding algorithms.

We chose four items that could be potentially sensitive, and tried to hide the informative association rules that contain those items, using ISL and DSR algorithms.

Tables1and 2 show the results of hiding the rules using ISL and DSR respectively, when minimum support threshold was set to 0.005. The process was repeated for various levels of confidence threshold, as shown in the tables. Total numbers of generated rules for various confidence thresholdsare shown in the tablesin the column "Rules". The column "To Hide" shows the number of sensitive rules that need to be hidden for each confidence threshold.

Many rules were hidden automaticallywhiletransforming the database to hide other rules, which is shown in the column "Auto". The numbers of rules that required transformations of the database for each confidence threshold are shown in the column "Transform". As expected, the numbers of rules hidden automatically are somewhat higher for ISL than for DSR. This is due to the nature of informative association rules, where many rules have common antecedents. Since ISL changes the support of the antecedent in order to decrease the confidence of the rule, hiding one rule may cause hiding other rules that have the same antecedent.

The number of sessions transformed by adding or deleting an item for ISL and DSR respectively, and the percentage of transformed sessions out of all sessions are shown in the columns "Sessions" and "Sessions(%)" respectively. The column "Sessions/Rule" shows the average number of transformed sessions per sensitive rule that was hidden, for each confidence level. Those values increase dramatically with lower confidence thresholds, since the algorithmsneed to transform more sessions in order to decrease the confidence enough to reach a low threshold.

Similarly, Tables 3 and 4 show the results of hiding the rules using ISL and DSR respectively, when minimum support threshold was set to 0.001. As expected, the numbers of generated rules are higher as the support threshold is lower. However, the trends observed in Tables 1 and 2 for the minimum support threshold of 0.005 are the same as those for the minimum support threshold of 0.001 in Tables 3 and 4, which confirms the validity of the results.

Table 1: Hiding rules with ISL, Support = 0.005

Confidence	Rules	ToHide	Auto	Transform	Sessions	Sessions(%)	Sessions/Rule
0.5	14	1	0	1	10	0.1	10
0.4	22	4	2	2	42	0.41	10.5
0.3	36	6	3	3	284	2.76	47.33
0.2	56	11	3	8	2183	21.19	198.45
0.15	66	12	3	9	7448	72.28	620.67

Table 2: Hiding rules with DSR, Support = 0.005

Confidence	Rules	ToHide	Auto	Transform	Sessions	Sessions(%)	Sessions/Rule
0.5	14	1	0	1	5	0.05	5
0.4	22	4	0	4	22	0.21	5.5
0.3	36	6	1	5	68	0.66	11.33
0.2	56	11	3	8	343	3.33	31.18
0.15	66	12	2	10	541	5.25	45.08

Table 3: Hiding rules with ISL, Support = 0.001

Confidence	Rules	ToHide	Auto	Transform	Sessions	Sessions(%)	Sessions/Rule
0.5	118	1	0	1	10	0.1	10
0.4	166	4	2	2	42	0.41	10.5

0.3	257	10	5	5	297	2.88	29.7
0.2	427	23	14	9	2068	20.07	89.91
0.15	585	31	21	10	6141	59.6	198.1

Table 4: Hiding rules with DSR, Support = 0.001

Confidence	Rules	ToHide	Auto	Transform	Sessions	Sessions(%)	Sessions/Rule
0.5	118	1	0	1	5	0.05	5
0.4	166	4	0	4	22	0.21	5.5
0.3	257	10	1	9	86	0.83	8.6
0.2	427	23	4	19	440	4.27	19.13
0.15	585	31	5	26	696	6.75	22.45

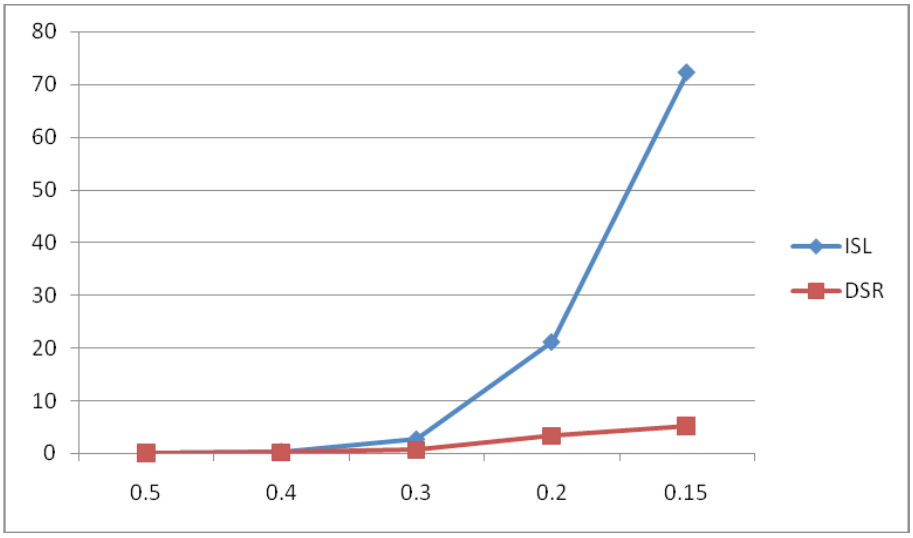

Fig 1: The percentages of sessions transformed for min support 0.005

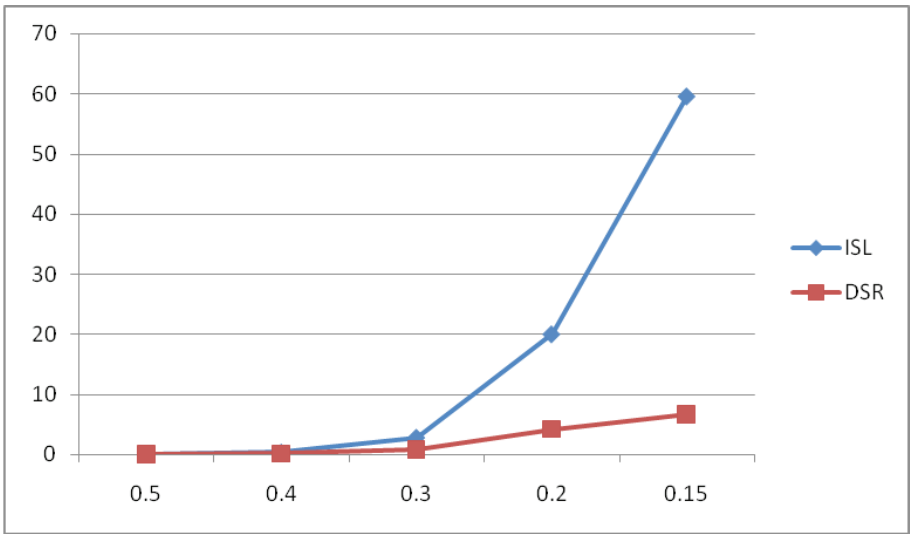

Fig 2: The percentages of sessions transformed for min support 0.001

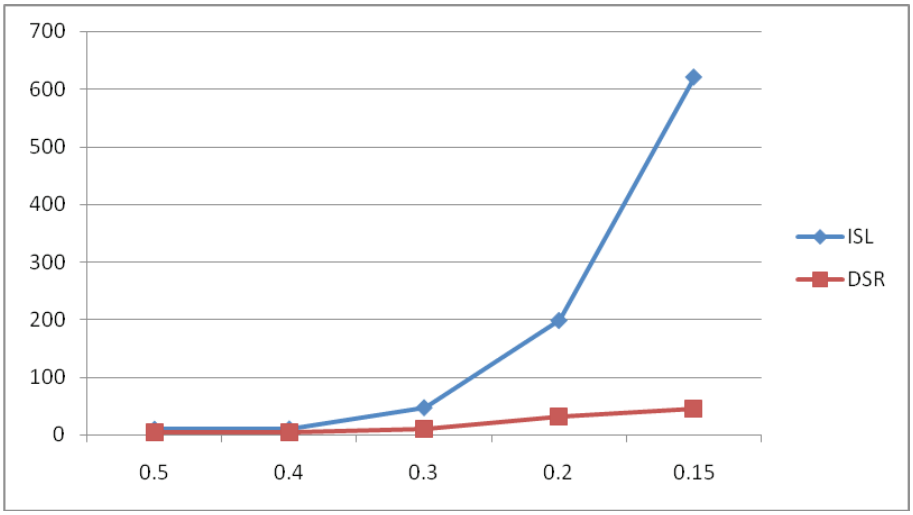

Fig 3: The numbers of sessions transformed per sensitive rule for min support 0.005

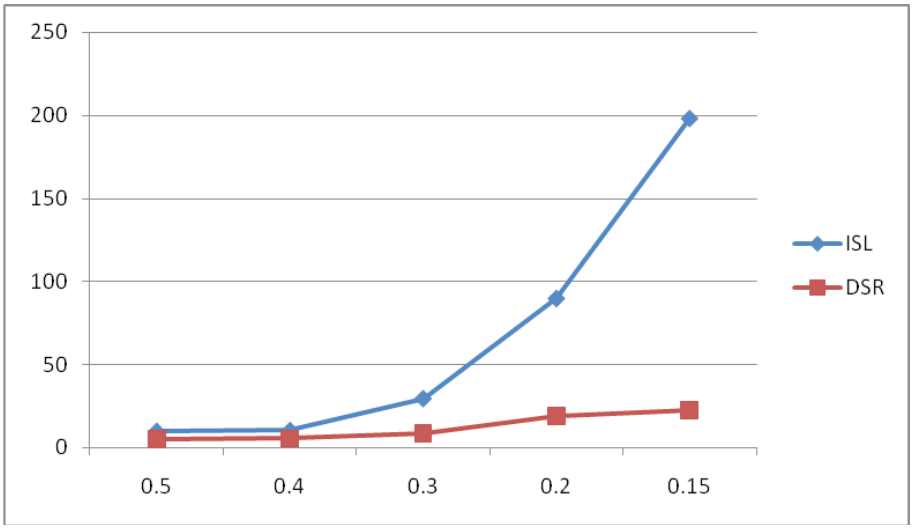

Fig 4: The numbers of sessions transformed per sensitive rule for min support 0.001

Figures 1 and 2 show the percentages of sessions transformed by ISL and DSR for various confidence thresholds, for the minimal support thresholds 0.005 and 0.001 respectively. The figures show consistent trends where the number of sessions (i.e. percentage of all sessions in the database) transformed grows with the decrease of confidence levels, regardless of the support threshold. This is expected, since it is harder to hide the rules by decreasing their confidence when the minimal confidence threshold is low. However, the number of sessions transformed grows at a much higher rate for ISL then for DSR for all combinations of support/confidence thresholds.

Figures 3 and 4 show the average numbers of sessions transformed per sensitive rule by ISL and DSR for various confidence thresholds, for the minimal support thresholds 0.005 and 0.001 respectively. The number of sessions transformed per rule grows at a much higher rate for ISL then for DSR, which is consistent with the trends shown in Figures 1 and 2.

DISCUSSION

One of the measures of success of the association rule hiding algorithms is the percentage of transformed transaction (sessions in the context of web usage mining) in the database. The fewer transac-

tions the algorithm transforms, the more successful it is in preserving the database state. Moreover, the time efficiency of the algorithm is higher, as it accesses the database fewer number of times. The tests presented in the previous section clearly demonstrate that DSR transforms fewer transactions than ISL for all confidence/support parameter combinations.

Lemma 1: Given a sensitive association rule $X \rightarrow Y$, and a minimum confidence threshold, DSR algorithm transforms fewer or equal number ofsessionsthan ISL algorithm when hidingthe rule $X \rightarrow Y$.

Proof: Let *Count(X)* denote the number of sessions that support the item set *X*.

Let *a* and *b* be positive integers, denoting *Count(XY)* and *Count(X)* in the database, respectively, before the transformation by *ISL* or *DSR*. Then, we denote$Conf(X \rightarrow Y) = {}^{a}/_{b}$

Obviously, $a \leq b$ holds. In extreme rare cases, when confidence of the rule equals 1, the equation holds. Otherwise, $a < b$ holds.

In each step ISL algorithm adds the item *X* to a session that does not contain it, which increases *b* exactly by 1. The confidence of the rule after one transformation by ISL becomes

$$c1 = Conf(X \rightarrow Y) = \frac{a}{b+1}$$

In each step DSR algorithm removes *Y* from a session that contains both *X* and *Y*, which decreases bexactly by 1. The confidence of the rule after the transformation becomes

$$c2 = Conf(X \rightarrow Y) = \frac{a-1}{b}$$

It can easily be shown that $c2 < c1$, *when* $a < b$.

Thus, the confidence of each sensitive association rule after one session transformation of DSR algorithm is smaller than the confidence of the same rule after one session transformation of ISL algorithm, assuming that the database state before the transformation was the same. In other words, the confidence of the rule decreases faster by DSR algorithm, then by ISL algorithm. Hence, DSRalgorithm transforms fewer sessions than ISL algorithm until it reaches minimum confidence threshold for the sensitive association rule.

On the other hand, depending on the number of sensitive rulesthat contain common antecedent, it may be possible that more other sensitive rules will be automatically hidden after hiding a particular sensitive rule by ISL, than after hiding the same rule by DSR. If that is the case, it might be possible that ISL makes fewer database transformations than DSR. Indeed, our experiments confirmed that more rules that are sensitivewere automatically hidden by DSR than by ISL (column "Auto" in Tables 1, 2, 3 and 4). However, the overall number of sessions transformed in all our experiments was still far lower for DSR than ISL, making DSR still a better choice than ISL (Figures 1, 2, 3 and 4).

Wang et al. do not completely explain the difference in the extent of database transformations between DSR and ISL. The results of their experiments performed on synthetic data are consistent with our results on real life data, showing that DSR outperforms ISL with respect to transforming fewer sessions in all test cases. However, in their analysis, Wang et al. find that "DSR outperforms ISL for low support item-sets". They base this fact on the total number of sessions trans formed by DSR and ISL. They estimatethe number of sessions transformed by ISL to be *Count(XY)*, and the number of sessions transformed by DSR to be $|D| - Count(XY)$, *where* $|D|$ is the database size. However, these numbers are actually the estimated maximal limits of the number of sessions that could potentially be transformed by each algorithm for any sensitive association rule $X \rightarrow Y$, and not the actual numbers of the transformed sessions. Further, Wang et al. suggest that ISL should be used when the support of a predicting item is low. On the contrary, our experiments and the proof of Lemma 1 show that DSR in fact outperforms ISL in all cases, regardless of the predicting item support.

However, the optimal choice between DSR and ISL may depend on the form of the sensitive rules that need to be hidden, i.e. the number of sensitive rules that share the same antecedent. If we consider each sensitive association rule separately, DSR is a better choice in all cases.

We conclude that a more thorough analysis should be performed to define the cases in which ISL could be a better choice than DSR, if such cases indeed exist. Such analysis should focus on the properties of the antecedents and consequents of all sensitive rules, i.e. consider the properties of the sensitive rule set as a whole, as opposed to the properties of each sensitive association rule separately.

CONCLUSION

In this research, we tested the methods for hiding informative association rules based on the two algorithms proposed by Wang et al. [8]. We applied the method on a real-life web usage data set and performed experiments for various confidence/support thresholds, using our implementation of the two algorithms. In our experiments,DSR outperformed ISL for all test cases. We expanded the research by Wang at al. and proved that DSR always makes fewer database transformations than ISL, when each sensitive rule is considered out of the context of the sensitive association rule set as a whole. For future work, a more thorough research should be conducted in order toprecisely define the cases in which ISL might outperform DSR, and prove whether such cases actually exist. The recommendations on applying each algorithm should consider the properties of the sensitive association rule set as a whole.

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TESTING METHOD OF SAFE USE HVT WHEN CUTTING OF COLUMN B DURING TRAFFIC ACCIDENT ON THE CHOOSEN CAR AND WORKING EFFECTIVENESS OF HYDRAULIC RESCUE EQUIPMENTS

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The Fire-rescue crew performs on-site intervention in road accidents as the initial team of first intervention. The resulting incident creates a space in which fire, police and ambulance service - the core of the main components of the IRS must quickly efficiently and safely provide assistance to injured persons. To the fore the question of deliverance often gets disabled. Author deals with the topic relating to use of hydraulic extrication tools at technical interventions in the field of person extrication and closer characterizes individual technical items. He characterizes material and technical equipage of responding units and emphasizes a need of systematic solving of each extraordinary emergency situation relating to persons extrication. The aim of paper is research of safe use of a method of DVT when cutting column B within the intervention of a traffic accident on the selected car. For the purpose of research are realized of comparison of times required for opening and closing of selected types of hydraulic. There are use hydraulic cutters Holmatro ® CU 3040 NCTM, hydraulic cutters Holmatro ® CU 4035 C, hydraulic cutters Weber Hydraulik S-260.

The second aim of paper is research of safe use of a method of DVT when cutting column B within the intervention of a traffic accident on the selected car. For the purpose of research are realized cutting tests on cars Fiat Bravo and VW-POLO by hydraulic cutters. For the purpose of cutting were use hydraulic cutters Holmatro ® CU 3040 NCTM, hydraulic cutters Holmatro ® CU 4035 C, hydraulic cutters Weber Hydraulik S-260. The highest cutting time value during cutting column B of the Opel had hydraulic cutters Weber Hydraulik S-260.

Key words: *Hydraulic extrication tool, hydraulic spreader/expander, hydraulic cutter, B-piller of car, hydraulic elevating ram jacks, power unit, emergency situation, material and technical equipage*

INTRODUCTION

Present trend of the automobile industry are still more modern, economical stronger, more perfect and more stable faster vehicles. [1] This represents a challenge to bear rate with a modern epoch not only for rescuers but also for used extrication equipment. Moreover, a vehicle that a man buys with a pleasure is in some cases also the last place where a man makes his last breathing and this is reached also by typical human inconsiderateness and hazarding of other drivers. Demandingness of rescue activities is thus every year more difficult. Rescue activities are complicated by new automobile vehicles that leave factories. Intervening units must overcome laminated glazing, high strong steel reinforcement that is able to cause damage or even eliminate hydraulic tools from operation.

Legal regulations concerning use of extrication equipment and technical tools at traffic accidents are in two levels – legal acts solving this topic only in a general way and standards directly concerning the extrication equipment and its operation. Among them it is important to list namely European standard EN 13204:2004 "Double acting hydraulic rescue tools for fire and rescue service use. Safety and performance requirements". This standard involves firefighting equipment, rescue equipment, cutting tools, hydraulic equipment, hydraulically powered equipment, hazards, equipment safety, safety measures, testing of performance characteristics, checks, emergency equipment, risk assessment, operation and maintenance. This standard is used also manufacturers of hydraulic extrication equipment. Requirements laid on extrication equipment are the same in all European countries and producers have to fulfill all actual requirements concerning performance, characteristics, properties, safety and maintenance according to this standard. [2] These requirements of course change in accordance with vehicle development. For vehicle frames nowadays are used alloys with high resistance. Subject of new vehicle construction are mainly new deformation zones in the front vehicle part in case of frontal impact. Restraint rods against side-on impact are located in side vehicle doors. At the frontal impact, the size and system of wheels and engine deviation are important for protection of lower limbs of

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transported persons. During recent years, a discussion on high alloy steel for bodywork frames and on Titanium steel or reinforcement of the most important bodywork parts (pillars) by so-called steel strip that sometimes cannot be cut by hydraulic extrication equipment produced before 2002. Each automobile production plant has own designing studios where safety engineers design bodyworks consisting of extremely hard safety frame that is understood as a safe area for travelers and that is surrounding by deformation zones capturing impact energy. Deformation zones absorbing impact energy help to minimize unwanted impact consequences. Side-on deformation zones located between outer door panel and inner cladding disperse impact energy on large area while shockproof stiffeners are intended for minimalizing danger in case of side impact. To secure that bodywork doors are not weak protected zones, protective stiffeners are inserted into doors (Fig. 1) and door space is filled by absorption foam that decreases injury probabilities.

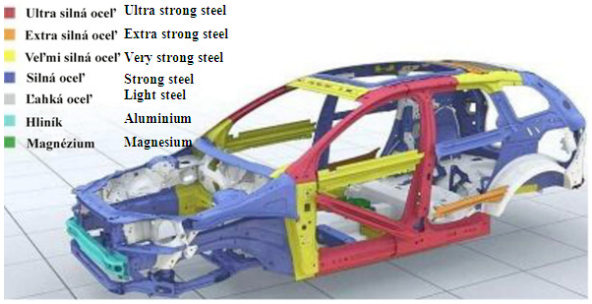


Fig. 1 - Material used for Volvo SX60 vehicle production.

Description and technical possibilities of hydraulic extrication equipment Creation and development of extrication equipment was connected with development of automobile industry and transport. It was just an increasing vehicle number as well as strengthened transport on transporting roads that brought also increasing number of accidents and injured persons. New technologies and materials development directly was connected with increasing of speed and performance of transporting vehicles what besides clear advantages had also effect on accidents seriousness. [3].

The important fact is that relatively large percentage of all traffic accidents number is caused by lorries. It is necessary to take into account that mass and size of the vehicle gas a great effect on traffic accident seriousness and consequences. Also development of high way and whole road network where increased traffic velocity as well as traffic density lead to many traffic accidents. It is necessary to mention also several railway accidents and crashes of vehicles and trains. [4] All of these mentioned factors lead to the fact that many injured persons were captured in crashed transport means and it was necessary to extricate them as soon as possible. [5]

Extrication equipment is a significant technical tool required at traffic accident involving injured persons. Use of extrication equipment significantly shortens time for reaching victims in a crashed vehicle what fastens first aid rendering. Due to increased number and seriousness of traffic accidents, it was necessary to increase technical equipage, and speed and flexibility of responding members of firefighting and rescue units. Solution was represented in progressive putting in place of special extrication equipment required mostly at traffic accident response into the Fire and Rescue Corps units' equipage. Technical tools intended for direct extrication of persons can be classified in three basic groups: hydraulic extrication equipment; pneumatic extrication equipment; mechanic extrication equipment. Hydraulic extrication equipment represents the most significant part of the equipage of responding Fire and Rescue Corps units. Its force operational ranges and mutual compatibility of individual items allow large use as regards extrication of captured persons. It can be divided into several parts that together assembly one unit. [6]

Engine power unit serves as a source for pressure energy production. It consists of:

- Hydraulic pump
- Tank for hydraulic oil
- Safety valve
- Manifold distribution valves
- Loading frame

Hydraulic piston radial two-stage pump creates in the hydraulic circuit a pressure 1.5 MPa at the first stage and 72 MPa in the second stage.

Power units (table 1) are divided according to number of pressure outlets to the one-branch power units and the two-branch ones that can supply a power for [3]:

- one tool (STO - Single Tool Operation),
- two tools simultaneously (MTO - Multiple Tool Operation),
- two tools alternatively (ATO – Alternative Tool Operation).

Another possible division way is according to engine powering:

- powered by combustion engine,
- powered by electric engine.

For better handling with power units, a hose reel is installed as a part thereof with two pairs of 20 m high pressure hoses with quick action couplings or single hose line. The hose reel can be operated independently but also with pressured hoses. It can be affirmed on the side or front frame wall of the power unit. The disadvantage is an increasing mass of the power unit.

Pressure hoses and hose reel serve for pressure energy transport from engine unit to an adapter of extrication equipment. One or two pairs of 20 m pressure hoses distinguished by colours are assembled to the hose reel. One hose from the pair always supplies oil to the working part of the extrication equipment and the second one this oil takes off. Another possibility is a pressure energy distribution by one hose line. For connecting pressure hoses are used quick action couplings with safety locking.

Table 1 Technical data of power units

Aggregate	E 330 L	V 330	V 40 Silent	V 50 Turbo
Motor	Electric motor 220V/50Hz	four-stroke petrol engine	four-stroke petrol engine	four-stroke petrol engine
Oil volume	2 l	2 l	2 l	4 l
Output power	0.5 kW	1.3 kW	1 kW	2.6 kW
Operation pressure	630/700 bar	630/700 bar	630/700 bar	630/700 bar
EN - class	STO	STO	ATO	MTO
Mass	19 kg	18 kg	24 kg	28 kg

Working tools of hydraulic extrication equipment is part is a terminal working part of hydraulic extrication equipment. It serves for direct extrication of persons. This working tool can be divided into several types according to operational performance possibilities. Hydraulic spreader serves for expansion, opening door deformed at traffic accident, squeezing of frame pillars and their removing, lifting the loads and for approach. Chain parts with quick action couplings significantly spreading use of hydraulic spreader tool are important accessories (Table 2). They are divided according to force magnitude by which they act on spreading path.

Table 2 Technical data of spreading tools

Spreader	SP 35	SP 40	SP 60	SP 80
Spreading force	42 – 93 KN	48 – 118 KN	68 – 245 KN	90 – 470 KN
Tensile force	38 KN	48 KN	77 KN	105 KN
Spreading	615 mm	710 mm	815 mm	620 mm
Mass	17.7 kg	19.4 kg	24.9 kg	25 kg
EN- class	AS 35	LHS 40	BS 63/810-25	CS 87/600-25

Hydraulic cutter (Table 3) is intended exclusively for cutting and separating of bodywork parts, e.g. roof using cutting blades. It can be used for flat or profiled section materials. They cannot be used for axles, leaf springs, or steering wheel where cutter damage threats. Hydraulic cutters are divided according to power and maximal opening of cutting blades.

Hydraulic combined tool is a combination of hydraulic cutter and hydraulic spreader in a one tool. It can be used for spreading, cutting, squeezing, elevating and approaching. Special cutting knives are equipped with blades enabling cutting metal sheets as well as profiled materials. [6]

Table 3 Technical data of hydraulic cutters

Cutters	S 140	S 180	S 260	S 270	RS 165	RS-170
Opening	140 mm	180 mm	260 mm	270 mm	165 mm	170 mm
Maximal round bar diameter	Ø 22 mm	Ø 30 mm	Ø 32 mm	Ø 36 mm	Ø 36 mm	Ø 43 mm
Mass	9,1 kg	13,5 kg	14,9 kg	17,4 kg	16,8 kg	18,9 kg
EN - class	D	G	H	H	BC-165-F	BC 170-H

When using combined tools, a combination with chain harness or spreader adapter is possible. They are divided according to performance (Table 4) and power unit – with engine or mechanical power energy.

Table 4 Technical data of combined tools

Combined tool	HANDVARIO SPS 250 H	VARIO SPS 330	VARIO.SPS 400
Opening	250 mm	330 mm	425 mm
Opening force	40 – 83 KN	36 – 90 KN	48 – 726 KN
Tensile force	-	32 KN	58 KN
Maximal round bar diameter	Ø 22 mm	Ø 25 mm	Ø 35 mm
Mass	10.4 kg	13 kg	18.5 kg
EN – class	-	F	H

Hydraulic spreading ram jack serves for pushing off, supporting and pulling off construction parts or to enlarge openings created by hydraulic spreader or combined tool. When using terminal adapters together with chain harness and changeable footing, it is a suitable accessory to increase action ability of intervening rescuers. [7]. Spreading rams are divided according to working piston into double-acting (Table 5) and telescopic.

Table 5 Technical data of double acting rams

Spreading ram	RZ 1- 850	RZ 2-1250	RZ 3-1600
Pressure force	120 KN	120 KN	120 KN
Tensile force	23 KN	23 KN	23 KN
Initial length	530 mm	750 mm	1100 mm
Piston stroke	320 mm	500 mm	500 mm
Final length	850 mm	1250 mm	1600 mm
Mass	12.5 kg	16 kg	18.5 kg

Extremely light and compact cutter intended for use in confined spaces as one-hand tool. It serves for removing pedal at foot capturing during traffic accident. They are divided according to cutting jaws size (Table 6).

Table 6 Technical data of pedal cutters

Pedal cutter	S 30	S 50
Width of jaws	33 mm	50 mm
Maximal round bar diameter	Ø 15 mm	Ø 16 mm
Mass	3,7 kg	4,5 kg

Rescue extrication equipment with 12 V direct current integrated battery electric-hydraulic power has manifold use. Due to unchangeable performance when comparing with classically powered tools, they are flexible and have unlimited action radius. They do not consume many space, are quiet and ecological (Table 7).

Hydraulic extrication equipment with mechanical power are hydraulic tools intended for special use or for efficiency increasing of used hydraulic extrication equipment; for example:

- set for opening door;
- set for stroking;

- manual hydraulic pump;
- manual combined tool.

Table 7 Technical data of hydraulic extrication equipment with accumulator power

Tool	SP 35 A	S 140 A	SPS 330 A
Spreading force	34-170 KN	-	40-90 KN
Maximal round bar diameter	-	22 mm	25 mm
Tensile force	29 KN	-	32 KN
Maximal opening	615 mm	140 mm	330 mm
Tensile distance	530 mm	-	400 mm
Mass	22 kg	13,5 kg	17 kg

Among technical tools used by the Fire and Rescue Corps units at traffic accidents belong not only equipment mentioned above but also tools that do not serve for direct extrication of persons from crashed vehicles. [8] They are prevailingly tools intended for protection responding rescuers as well as injured persons. They are:

technical tools for protection injured persons (blanket, tent canvas, etc.) enabling protection of injured persons against further injury that can be these persons be exposed during rescue activities; e.g. broken pieces and fragments, sharp edges, etc.;

- technical tools for stabilization of crashed vehicle (cascade prisms, struts, etc.) prohibiting further shakes of crashed vehicle that lead to worsening of health condition of injured persons;
- set for work with glazing;
- airbag arrester
- saw for sawing glued safety glazing;
- spring glazing breaker.

MATERIALS AND METHODS

In experiment were use tree different types of hydraulic cutters (table 8).

Table 8 Basic characteristics of tested hydraulic cuuters.

Cutters	Loss [kg]	Opening [mm]	Maximum diameter logs Ø [mm]	EN Class 13 204	Sign of samples
WEBER HYDRAULIK S 260	14,9	260	32	H	Weber S 260
HOLMATRO 3040 NCT	17,9	180	34	H	H-3040 NTC
HOLMATRO 4035 GP	14,2	237	32	H	H-4035 GP

Measurement start in the position of fully closed hydraulic cutters. The measurement was terminated when the working arm hydraulic cutters stopped in the fully open position. Measurement times of opening, we conducted five times.

Each time we entered into the table, and we calculated the average opening time working arm hydraulic cutters (Table 9).

Measurement times of closure (s) we performed five times. Measurement start in the position completely open hydraulic cutters and measurement was completed when working shoulders hydraulic cutters stopped in the completely closed position working arm hydraulic cutters.

Cutting was performed on specimens of automobile bodies VW-POLO (year 1999), FIAT BRAVO-(year 1998) and OPEL VECTRA (year 2006). There were cut columns of motor vehicles, in particular have been used columns of type B (Fig. 2).

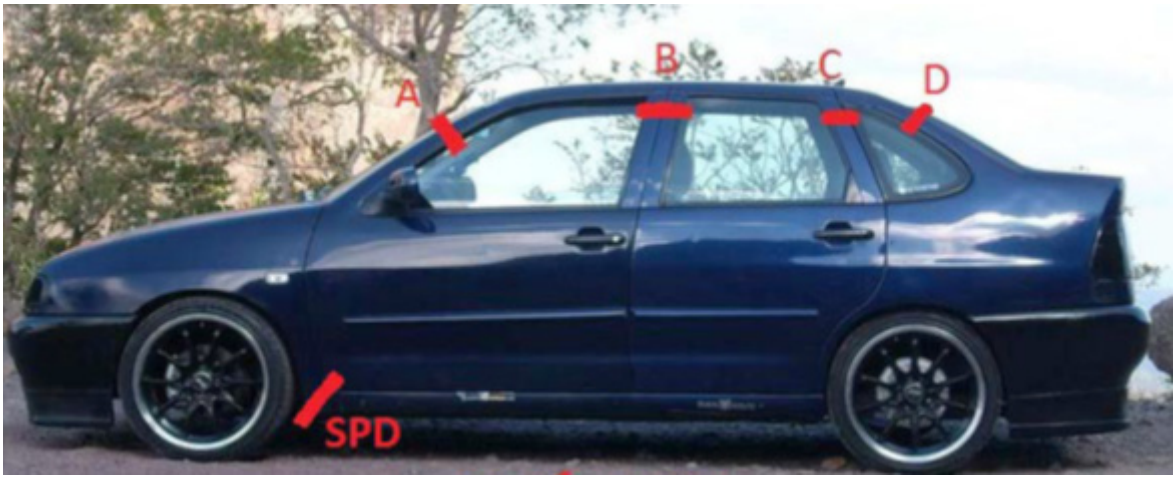


Fig. 2 Body labeled Pillars. [3]

Model cutting took place on the outer-air unit Fire and Rescue Corp. in Lučenec in the presence and assistance of professionally trained workers FRC meeting the general working conditions (pursuant to Act 124/2006 Coll.) Officers were equipped with means of personal Firefighters (according to Regulation of the Ministry of Interior of the Slovak Republic no. 26/2002 Coll), technical equipment and using other devices to research and record the measurements. (FRC Guidance Sheet No. 90.).

Endpoints

Cutting time posts were recorded from the fully open arms hydraulic cutters and measurement was stopped after cutting the test specimen in the completely closed position hydraulic cutters.

RESULTS AND DISCUSSION

Comparison of times required for opening and closing of selected types of hydraulic cutters

Based on scientific research of discussed topic, we can compare three individual types of hydraulic extrication equipment as regards working arms rate (Table 9). As shown on the Figure 3a) opening and closing times are different. It is connected with the angle φ (rad) that is calculated from adequate arm area. For closing time we can state that with decreasing φ (rad) value, the closing time increases.

Table 9 Comparison of times required for opening and closing of hydraulic cutters

Hydraulic cutter	opening time (s)	closing time (s)	φ (rad)	ω opening (rad.s-1)	ω closing (rad.s-1)
Holmatro-3040 NCT	8,448	5,278	3,142	0,372	0,595
Holmatro-4035 GCP	7,258	5,682	2,047	0,282	0,360
Weber S-260	10,47	7,252	1,734	0,166	0,239

To define actual outputs, statistic calculation was used. The mathematical software STATISTCA 7 was used for studying individual parameters influence; namely 1-factor variance analysis ANOVA with mathematical matrix in the Excel Office program. We found out statistically significant influence of the factor – angle on cutting velocity: with increasing angle the cutting velocity also increases.

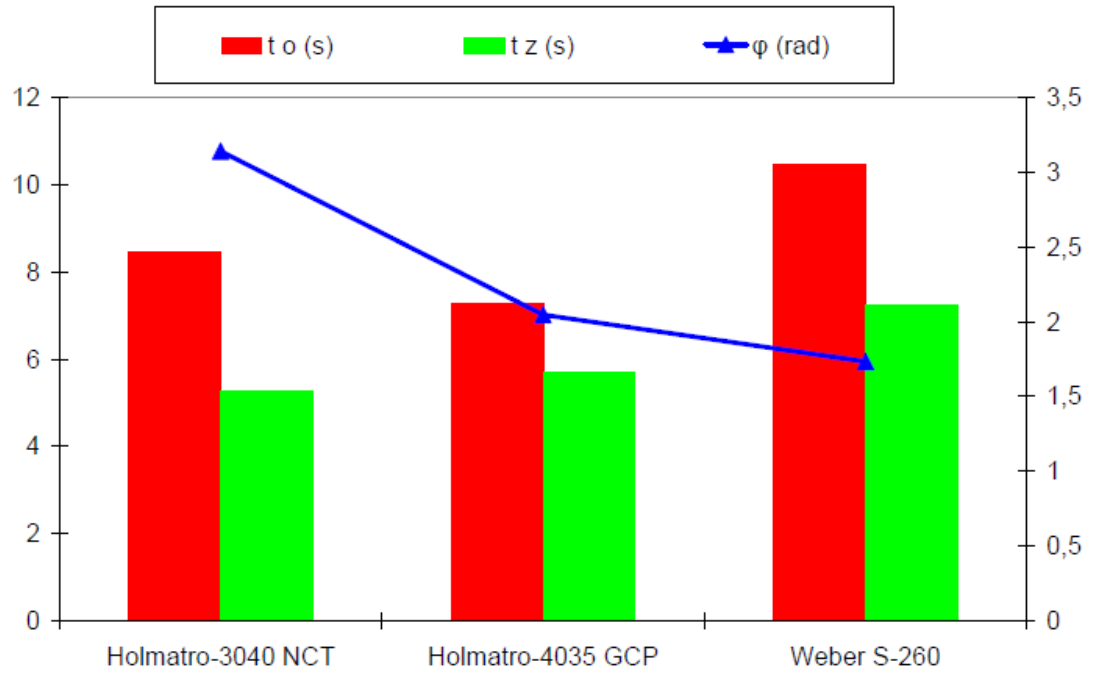


Fig. 3a) - hydraulic cutter

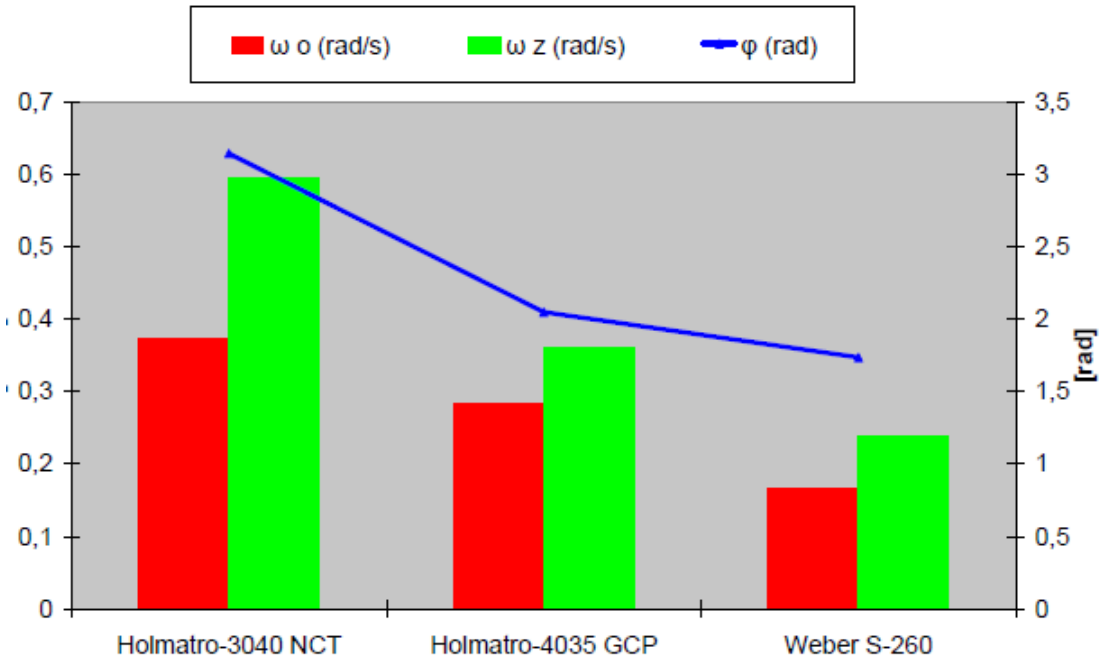


Fig. 3b) - hydraulic cutter

Fig. 3 a, b.) Mutual comparison of studied parameters for hydraulic cutters
a) opening and closing times with φ (rad), b) radian velocity

Mutual comparison of opening and closing times of hydraulic cutters and calculated radial speed

Based on our measurements (Table 8) we can state that as regards opening time the fastest is testing model H-4035 CGP hydraulic cutter, followed by the H-3040 NCT type and the last one is the

W-S 260 model. As regards closing times, the fastest is H-3040 NCT type tightly followed by the H-4035 CGP type, and the last one is the W-S 260 type. From the practical standpoint taking into account the cutter mass, as regards cutter mass and resulting physical exertion during work, the more favourable is H-4035 CGP cutter. During practical part of the experiment another positive point confirming this statement appeared- an advantage of one-hose H-4035 CGP cutter connection with power unit; while cutters H-3040 NCT and W-S 260 were connected by two-hose system. At the H-4035 CGP cutter type this connecting option was more suitable when comparing with the two-hose system as regards rescuers moving rate with the tool during cutting and cutter handling. The two-hose system used to get jammed, create loops and required greater attention at cutter moving and appeared relatively stiffly. When taking into account also time required for connecting two quick action couplings compared with time for one H-4035 CGP coupling, we can state that cutter H-4035 CGP seems to be the most suitable from this practical comparison. To make clear the total quality of operation tested tools as regards ergonomics and on basis of gained practical experience during experiments carrying out we can judge also way of operating cutters. in this case we took into account FRC members' opinions and their statements based on practical situations from responses with hydraulic extrication equipment when ergonomically more suitable is to use tools of the H type. This way is much more suitable mostly at work and at handling cutter above the shoulder height where operation is more convenient and less demanding than operation the W type cutter.

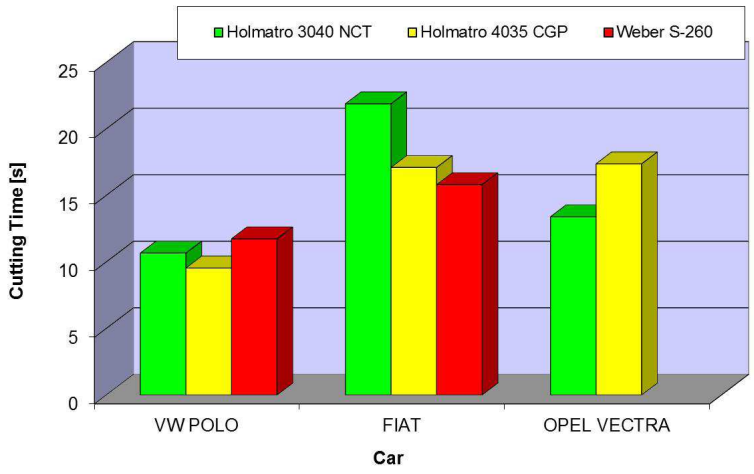
The results of cutting pillars Type B with hydraulic cutters

The results obtained by experiments with scissors cutting the B-pillars by Weber S 260, H-3040 NCT and H-4035 GCP the for WV POLO CLASSIC for FIAT BRAVO and for OPEL VECTRA are presented in Table 10 and mutual compared in Fig. 4.

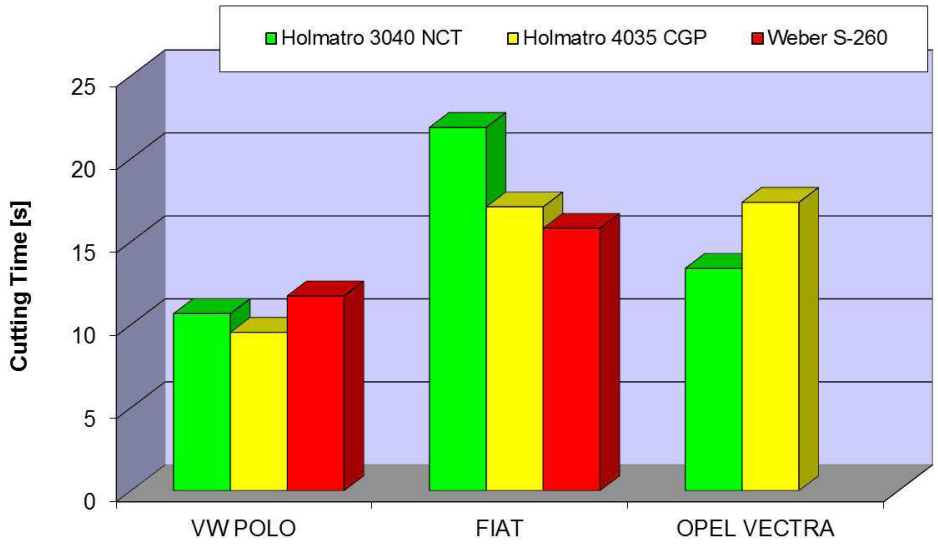
Tab. 10 Results of testing hydraulic cutters cutting the B-pillars on selected vehicles.

Pillar	Cutters	FIAT BRAVO		WV POLO		OPEL VECTRA	
		Time cutting	Maximum pressure cutting	Time cutting	Maximum pressure cutting	Time cutting	Maximum pressure cutting
		[s]	[MPa]	[s]	[MPa]	[s]	[MPa]
B	WS-260	15,804±0,13	35,6±0,18	11,734±0,18	15,9±0,18	120,102±0,09	45,5±0,22
	H-3040 NCT	21,878±0,38	32,1±0,38	16,5±0,2	16,5±0,27	13,3880,05	30,6±0,18
	H-4035 CGP	17,046±0,33	32,5±0,15	13,4±0,05	13,4±0,05	17,37±0,05	33,70,25

In the results is to see the difference between cutting the B-pillars VW POLO cars, FIAT and OPEL VECTRA. The most notable cutting time is 120 s for OPEL VECTRA. It should be noted that the shortest times all three hydraulic cutters exhibit at the WV POLO.



4 a)



4 b)

Figure 4 a, b.) Mutual comparison of studied parameters for hydraulic cutters
a) cutting times with testing hydraulic cutters, b) Maximum pressure cutting with testing hydraulic cutters

To define actual outputs, statistic calculation was used. The mathematical software STATISTCA 7 was used for studying individual parameters influence; namely 2-factor variance analysis ANOVA with mathematical matrix in the Excel Office program. We found out statistically significant influence of the factor (Figure 4) – If older vintage of hydraulic cutters and the newer the car, the bigger problems with cutting the body (hypothesis).

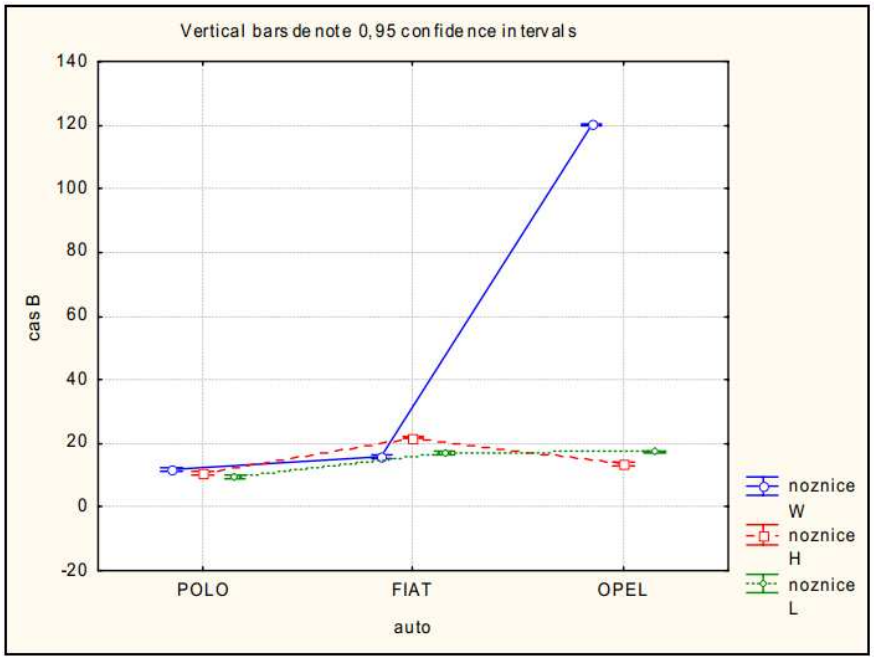


Fig. 5 Graphical representation of two-factor analys is of factors influence car (FIAT and OPEL POLO) and hydraulic cutters for cutting time B-pillars hydraulic cutters. Legend: W - Weber S260, H H-3040 Holmatro NCT and L - Holmatro 4035-GCP.

As seen in Fig. 5, the difference in times for the cars are minimal, cutting times are different for hydraulic cutters Weber S 260 with OPLA. OPEL is the youngest from experimental vehicles and hydraulic cutter Weber S 260 is the older generation in comparison with scissors Holmatro. Our hypothesis was confirmed.

CONCLUSIONS

Rescue of involved persons trapped in vehicles at traffic accidents is a continuously developing topic. [9]. Every rescue response is specific and unique. [10] The choice of rescue equipment and tools always depends on the intervention commander who is fully responsible for situation seriousness evaluation and consequently for choice of rescue tools. The equipment used in an actual situation is affected also by other factors. Safety of vehicle crew is on a value pedestal but new vehicles seem to be a threat for extrication equipment. Modernization of hydraulic extrication equipment should be growing arithmetically wit new vehicles production. Saving of human lives represents seconds that can be prolonged even into several minutes which can cause even fatality for a human being due to more complicated vehicle bodywork combined together with passive safety elements. If a human has not got oxygen input up to 5 minutes, a non-reversible damage of brain cells occurs resulting in physical organism damage or even with a fatality phenomenon.

For the purposes of environmental protection, it is necessary to develop hydraulic device that effectively and safely quick will cut of elements of the vehicle body. This reduces not only the time of extrication disabled or victims but also reduces the flow time working fluids and motor oils that penetrate the environmental components.

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THE PERFORMANCE OF FIREFIGHTERS IN RESCUING PERSONS IN TRAFFIC ACCIDENTS USING EXCTRICATION EQUIPMENT

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Firefighters 'legal responsibility is to rescue people, animals and property from fires, car accidents or when other emergency situations arise. An urgent situation is any case that endangers the life or health of a person, animals or property.

Key words: *traffic accident, risk, firefighter*

TRAFFIC ACCIDENT

Traffic accident is an event in road traffic that occurs in direct connection with the operation of a motor vehicle and involves fatality or injury of an individual, damage to the road or roadside infrastructure, leakage of dangerous substances, damage to some of the vehicles involved in the road accident as well as goods carried in them, or damage to other property exceeding one and a half times the damage pursuant to the Criminal Code - Act No 300/2005 Coll.

Rescue and recovery operations require cooperation of all elements of the Integrated Rescue System (road traffic control, removal of an obstruction to traffic, road rideability etc.).

Measures taken at the scene of an accident include the rescuing of endangered people and reduction of the consequences of road traffic accidents to the environment. [3]

Upon arrival to the site of the accident, it is important to properly set up the appropriate machines and equipment to ensure the safety of the rescue team. Bumper-to-bumper positioning of firefighting vehicles is a good solution to shield rescue workers from the passing traffic.

Table 1 gives a brief overview of the risks associated with rescue work after traffic accidents:

• Incomplete information about a traffic accident and its scene,
• The scene of the accident rescue work is not clearly visible multiple-vehicle and chain accidents, inaccessible terrain , ...)
• Impossible to remove batteries and crashed vehicles (under seats, in inaccessible space, several batteries in one vehicle)
• A large number of the injured, difficult communication with them, (foreigners, disabled, elder people, unpredictable behaviour of the injured people affected by the shock, alcohol, narcotics, increased aggressively),
• Threat to rescue workers from passing traffic ,
• Release of a large amount of fuel and operation liquids,
• Unanticipated occurrence and presence of dangerous substance,
• Different types, ageing and technical condition of crashed vehicles,
• Insufficient equipment to carry out emergency rescue operations,
• Necessity to use heavy machinery and other special equipment ,
• Risk of further traffic accidents

Table1 - Risks associated with rescue work after traffic accidents[3]

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EXTRICATION OF CASUALTIES FROM CRASHED VEHICLES

The aim of rescue work is to get access to give help to those injured in a road traffic accident. Part of the rescue operation is to provide sufficient space for emergency workers to safely rescue persons, animals and property. The extrication work is carried out in cooperation with the emergency medical rescue service. Table 2 shows two phases of the rescue work.

PHASES OF RESCUE OPERATION	RESCUE WORK AT A GIVEN PHASE
ARRIVAL AT THE SCENE OF THE TRAFFIC	✓ Positioning firefighting machines and equipment, ✓ Marking the scene of a traffic accident, ✓ Assessment of an accident scene , ✓ Traffic management arrangement at the site of an accident, ✓ Providing of fire extinguishing agent.
Elimination of potential hazards from damaged objects	✓ Prevention of fuel and other fluids spills and leakages, ✓ Disconnection of the vehicle battery , ✓ Removal of sparking parts, ✓ Stabilization on wheels, ✓ Stabilization on side, ✓ Stabilization on the roof.
INITIAL ENTRY INTO THE VEHICLE	✓ Opening the doors, ✓ Removal of glass panels, ✓ Removal of doors , ✓ Deactivation of the elements of the passive safety of a vehicle, ✓ Cutting seat belts, ✓ First aid to casualties.
Providing space for extrication of casualties	✓ Removal of the car roof , ✓ Making a third door , ✓ Removal of the vehicle side , ✓ Enlarging the space inside the vehicle ,
EXTRICATION AND TRANSPORTATION OF CASUALTIES	✓ Assessment of health condition, ✓ Extrication of casualties from a wrecked vehicle, ✓ Giving medical treatment to the injured person , ✓ Transportation of casualties to health care facilities,
Clearing the scene of the traffic accident	- Removal of the leaked oil and other vehicle liquids , - Removal parts of the car bodies, - Ensure road trafficability

Table2 -Phases of a rescueoperation [4]

EXTRICATION EQUIPMENT

A vehicle is fitted with the equipment and devices supplied as part of the vehicle. Fig. 1-6 show extrication tools.

Figure1-High pressure hydraulic hosesFigure2 -High pressure piston pump

High pressure piston pump is the source of pressure for dual-acting hydraulic devices. The pump is driven by a petrol combustion engine or electric motor. The connection to the device is by means of high pressure hydraulic hoses to transfer hydraulic oil depending on the operation of the device.

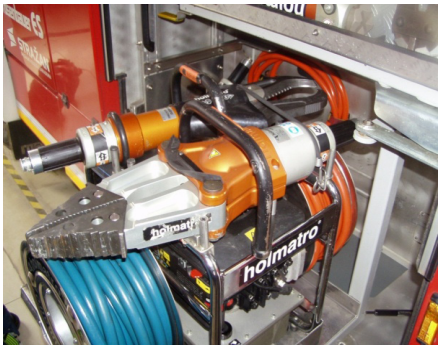

Fig. 3- Positioning of the extrication equipment

Fig. 4 -Positioning of the extrication equipment in the firefighting vehicle

Safety at work in the fire and rescue service is of the highest priority, therefore it is necessary to pay particular attention to safety considerations when training rescue squad members.

Fig. 5 - Extrication tools

A dual-acting hydraulic device with arms is used for spreading, squeezing and lifting. Drawbar chains with hooks clamped on the top of the arms of the device allows generating drawbar force, e.g., for pushing the steering wheel column.

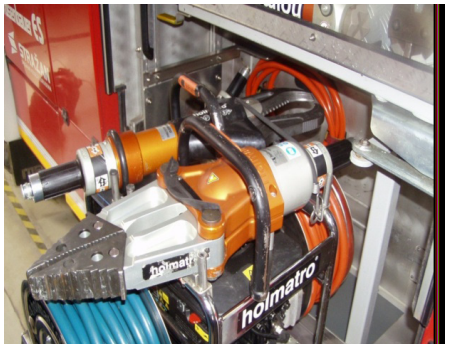

Fig. 6 - Hydraulic pulling cylinder

Dual-acting hydraulic device operating on the principle of a piston is used for separation of components or lifting them.

2.2 SAFETY AT WORK WITH EXTRICATIONTOOLS

Safety at work with extrication tools is governed by Art 16, sec. 1-3 of Act No 26/2002 of the Ministry of Interior of the Slovak republic (No 54/2003 of 27 October 2003). Safety at work with extrication tools sets out for instance the following requirements:

Rescue tools can be used only by an employee who has successfully completed training prescribed by the manufacturer and practical training. A record of the use of rescue tools and the training given shall be kept.

When working with the above-mentioned tools the designated employee shall use personal protective equipment, especially a helmet with a shield and gloves.

An employee who has not worked with hydraulic or other rescue tools for at least 3 months shall complete a 2 hour training session in using these tools if the manufacturer does not specify otherwise.

Rescue work at a traffic accident site	Per cent
✓Disconnection of the battery	20
✓Removal of sparking parts	1
✓Stabilization on the wheels	7
✓Stabilization on the side	5
✓Stabilization on the roof	1
✓Opening the doors	20
✓Removal of glass panels	5
✓Removal of doors	18
✓Searching for airbag gas generators	10
✓Deployment of airbags	5
✓Cutting seat belts	5
✓Removal of the roof	1
✓Removal of the side part of the vehicle	2

Table3 -The use of extrication tools at accident scenes in percent

An example of the assessment of risks involved in a rescue operation after an accident is given in the risk graph below [2], after the conclusion.

3. CONCLUSION

The fire service training personnel who are responsible for training of firefighters must strictly follow the guidelines of the training program and educate them about the potential dangers and risks. Firefighting equipment and fire protection devices used for training purposes must meet the specified technical requirements. Both physical and mental condition of the firefighters during the training has a significant impact on the proper course of the preparation and practical training. Good physical and mental health is one of essential prerequisites required for becoming a firefighter in order to properly perform physically demanding and dangerous tasks.

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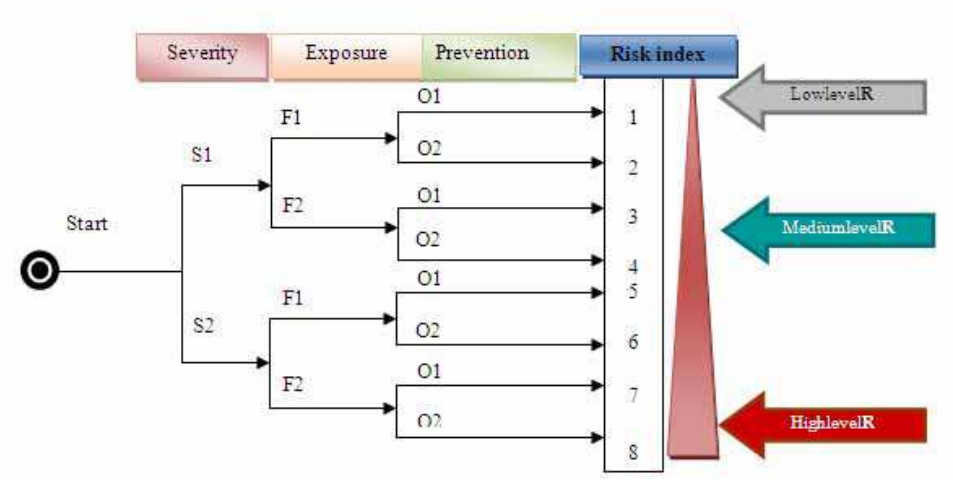

S	Severity of injury /damage
S1	Minor (slight injuries, reversible), e.g. scratching, cutting wound, bruise
S2	Severe and serious injury (usually irreversible, including death), fracture, detachment or crushing injury of a limb,...
F	**Frequency and/or duration of exposure (exposure E)**
F1	Twice or less during a working shift (rarely) or shorter than a 15 –minute exposure (short period of exposure)
F2	More than twice during a working shift or longer than15 minutes
O	**Possibility to prevent or reduce the damage**
O1	Possible under certain conditions (e.g. if parts move at a speed of less than 0, 25 m/s, employees are notified,...
O2	Impossible.

Figure 9 -Riskgraph

ACKNOWLEDGMENT

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Activitydescription : Extrication of casualties after a traffic accident						Date: 28/4/2014
Activity	**Estimation of risk – calculation of the risk index**					
	Hazardous situation	**Potential damage**	**Severity S1/S2**	**Frequency duration F1/F2**	**Possible prevention O1/O2**	**Risk index 1-6**
Extrication of persons after a road traffic accident	Injuries when using hydraulic cutters for cutting pedals of vehicles, steering wheel columns, steering rods.	Cuts	S2	F1	O1	**5**
	Injuries suffered by a firefighter caused by breaking glass or cutting seat belts.	Cuts	S1	F2	O1	**3**
	Burns caused by sparks and hot material.	Burns	S1	F2	O1	**3**
	Injury caused by a retainer of the airbag when it gets torn.	Striking a firefighter in the face	S1	F1	O2	**2**
	Leaking of oil from the hydraulichose.	Failure to control the device	S1	F1	O2	**2**
	Inappropriate use of chocks, loss of stability, fuel and oil can leak out.	Slipping on the leaked oil	S1	F1	O1	**1**

Table 4-Example of the assessment of risks involved with the rescue operation of the injured in a traffic accident using a risk graph [2]

Cut or partially damaged wiring harness can cause an increase in current flow, rising temperature and subsequently ignition of the nearby substances in the tank	Explosion	S2	F1	O1	**5**
Bursting flames while passing through the smoky area in close proximity to the fire-stricken zone. Contact with a flame or hot object.	Burns	S2	F1	O1	**5**
Physical and metal stress of firefighters, their exhaustion, toxication, overheating in summer months.	Unconscious-ness	S2	F1	O1	**5**
At a gathering of a larger number of people, if basic hygiene principles are not followed or breached, infections due to whirling of dust particles, removal of stalk materials where there were small rodents.	Infection can be transmitted to living tissues or blood by i direct exposure toinfected blood, saliva or other infected excretions via cuts or stab wounds when handling extrication tools.	S2	F1	O1	**5**

continuation of Table 4 - Example of the assessment of risks involved with the rescue operation of the injured in a traffic accident using a risk graph [2]

ANALYSIS OF VIOLATIONS OF NORMS AND REGULATIONS OF FIRE SAFETY WHICH INFLUENCE ON LIFE AND HEALTH OF PEOPLE IN CASE OF FIRE

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The work analyses the system of fire safety of objects and observes research in the field of fire development, influence of fire dangerous factors on people in buildings and provision of safe evacuation of people from buildings.

The research permits to the state fire inspection who check fire safety regulations to estimate fire safety state more objectively.

Key words: *fire safety, fire development*

According to the acting law one of the main tasks of the fire inspection of ficers is proof and justification of danger to life and health of people in case of fire.

According to the p.1, article 3.12 of the Code of administrative offences of Russian Federation (CoAO RF) in case of danger to life and health of the people suspension of activity is used as an administrative punishment. The same punishment is provided by p.5, art.20.4 of the CoAO "Violation of fire safety rules".

Considering the tacts do not contain definition "danger to life and safety of people in case of fire", the aim of the paper is to analyze elements of fire safety system that influence life and health of people in case of fire.

The requirements to developmentoff iresafety systems are provided by the State Standard 12.1.004-91 "Fire Safety. General Requirements" and the Federal Act № 123-ФЗ "Technical Regulations of Fire Safety Requirements".

According to the p.5 of the Federal Act №123-ФЗeach protected object should have a system of fire safety. The aim of the system is fire prevention, safety of people and property in case of fire which includes system of fire prevention, fire protection and complex of organization and technical fire safety measures.

According to the State Standard 12.1.004-91 the required level of fire safety of people provided by the above systems should be not less than 0,999999 of dangerous factors prevention per year per person, and a permissible level of fire safety for people shouldn`t be more than10-6 of fire dangerous factors impact воздействия, which exceed marginal permissible values per year per person.

The standard settles main fire safety requirements to the protected objects of various designations at every stage of life circle: research, elaborating of norms, construction, design, building, services (works), testing, import production procurement, selling of products (including export), storage, transporting, setting, arrangement, adjustment, technical service, repairing (reconstruction), exploitation (using) and utilization.

For the objects which do not comply to actingnorms the standard requires to elaborate recompensing means and systems of fire safety at the stage of building, reconstruction and exploitation of objects. The standard requirements are obligatory.

There are three stages of fire development in an apartment:

– beginning of fire;

– full development of fire;

– fading of fire.

How ever as the "standardfire" equation shows [3], the temperature in the fire seat of fire reaches 365 °C in 1,125 minutes. Thus it is obvious that the possible evacuation time can not exceed the period of the initial stage of fire.

Evacuationisnotonlytheindividualhumanneed, but also the first requirement of fire safety in build-

ing norms and regulations.

The majority of people who have to evacuate from the buildings ta you to the room where fire sets, and they cannot personally observe the moment of fire beginning and development. According to research based on questionnaires of people who survived a fire, people find out about a fire from verbal communication (35 %), seeing a flame (21 %) or smelling a smoke (18 %), others – some other way [4]. Smell of smoke is not always considered as a signal of danger and first is explained by other reasons for example burnt food in nearby rooms, or burning of trash near the building. Even verbal communication is not always considered a signal of areal danger.

Are search [5] was made of behavior of an cillary workers in retailers to resofabig company demonstrated that if training evacuations are not announced, in case of fire alarm only 37,2 % of workers acted according to the instruction despite regular trainings. That is why to provide safe evacuation it is necessary to elaborate and fulfill a complex of activities on people preparedness of how to act in fires – the evacuation plan.

For example, one of the first researchers of people`s streams says [6], that during a cinema show he watched in Leningrad cinema "Molnia" someone cried quietly. This was enough for dozens of people to run outside. The people rushed to the doors, jumped on the chairs clogging pathways and exits. The tragedy was avoided because one of the ushers switched the light on and the people saw that there is no reason to panic. The incident resulted in several bruises, faints and broken chairs.

The escape from the burning building should be considered as an adequate behavior to the rapid spread of dangerous factors of fire. It is much worse if people do not hurry to escape: the minutes lost at the beginning of evacuation are equivalent to the lacking seconds in the end. It is natural that the main mass of the evacuated consists from the people involved in the "mass run", able to the reasonable esteem of the situation and actions [7]. The escape from the burning building is the natural behavior of people according to the emerging circumstances[8].

The other reasons stay behind the third category of cases. The appearance of the "jam"during evacuation in factdemonstrates the lack of capacity of evacuation ways and exits. Unfortunately it is a wide spread case.

The observed content of action scommitted by people after alarm is discovered and the process of discovery of the alarm demonstrate that there exists a time interval from the moment of beginning of fire to the moment of beginning of evacuation tev. Its value depends on psychophysical qualities of a person, on his occupation and location atthemoment, whether he/she sees beginning of fire or finds out about the fire by indirect signs or alarm system which has a certain part of persistence. This time interval forms a psychic condition of a person where he/she starts evacuation and enters the main flow.

The third stage of evacuation (for the people located higher than the ground floor) goes by stairs either opened or located in staircases. The movement of people by stair scan be dangerous even in normal conditions.

Although accidents during movement by stairs occurdue to multiple reasons, the research shows that many of them are due to mistakes of architectural and building mistakes. For example, many accidents occur because person cannot clearly see and feel the edge of a stair.

To provide a constant rhythm of movement it is important that all stairs have the same height of risers. That is why inaccuracy is impossible at the stage of design and building of staircase where one step has a bigger or a smaller riser. While moving in emergency one in accurate size can cause an accident.

In the text books on building design the Blondel Law says: "Size of the stairs correspond with the length of a step. If the average step length is about 60 cm, thenduring walking by stairs the step length should be equal to the length of two risers and one going. Therefore at inclination 1:2 the size of a stair woulld be: riser – 15 cm; going – 30 cm".

For the multi-story buildings there were elaborated three types of desanfumable stair cases: H1 – with entrance to staircase from the stage via external aerial zone by opened pathways, H2 – with head of air to the staircase in case of fire, H3 – with entrance to the staircase from the stage via chamber with head of air.

Exit of people from the staircase or lobby outside means the end of the third evacuation stage but not the end of evacuation. The people need to move away from the building on a distance enough to avoid impact of other dangerous factors of fire such as shiver of glass, fragments of destroyed constructions, devices and flowing from them radioactive or toxic substances, or to get to a shelter.

Movement of people from the building towards the safe place is the fourth stage of evacuation.

Modern knowledge of structure of the people flow where distance between people changes constantly [11], require at modelling of movement to consider all kinematic and psychophysics rules. Depending on the sefactors the reares everal models of people flow.

The most simpleis "Model of movement (without spreading) of people flow of homogenous mass". This model has a significant practical meaning because this model is implemented in the Russian standards: State Standard 12.1.004–91* [5] appendix 2 (obligatory).

The fuller reproduction of kinematic rules is in the model of a flow with possibility of its spreading. It considers change of the flow structure and presence in the slow of the more energetic and mobile people who find themselves in the head of a flow. However the model considers that all peopl einflow have the sequalities.

Both first and second models use determined description of rules between the flow parameters and thus declares homogeneity of people in the flow.

The fullest reproduction of arandom and irregular flow where distance between people change can be fulfilled in imitation models.

According to are search main stages of evidence collection during fire inspections can be elaborated. These are:

Analysis of structural-spacial concepts and construction concepts of buildings, fire resistance, fire danger class of a building and its premises. For this analysis it is necessary to get a plan of a building with explication of premises.

Analysis of technological processes at the inspected object, collection of data about fire and explosion danger of premises, of quantity and physic and chemical qualities of substances and materials used in technological process.

Examination of an object and making a report. During examination it is necessary to note condition and geometric characteristics of fire exits, technical fire safety means, fire protection materials, fire barriers.

Considering that for the reliable note of characteristics and conditions off iresafety system it is necessary to use special devices, measure apparatus which usually fire officers do not have. It is necessary to use special knowledge and laboratory base of expert organizations accredited for fire safety control.

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THE USE OF MODERN INFORMATION TECHNOLOGY IN THE MANAGEMENT OF RESOURCES AND PROCESSES OF COMPLEX MANUFACTURING SYSTEMS

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The opportunities to improve resource management and processes through the use of information technology, the types of information technologies used in the process control of complex manufacturing systems.

Key words: *Process technology, information technology, resources, complex manufacturing systems, reliability, planning, automated control system*

In modern society the threats and consequently the dangers of man-made cause primarily related to the solidity of technical systems.

Solidity, stability of production systems can be considered as state of the most efficient use of resources and technology process control for prevention of unsustainable situation and ensuring of stable functioning and development of the production system.

The appearance, development and distribution of complex technical systems, like computer systems, communication systems, automated control systems, suggest new approaches to improving level opportunities of resource management and technology processes of complex technical systems.

It is actual to consider opportunities for improving resource management and technology processes through the use of information technology thereby make a focus on the application of information technology at the planning level, distribution and use of resources.

To information technology include automated control system (ACS), intelligent control systems. ACS is a set of hardware and software for controlling the various processes within the production (technological) process, production facility in accordance with the intended purpose.

Different types of automated systems are used in modern conditions. In the context of complex technology systems the automated control system means a system that uses advanced automatic data processing resources, as well as technical and economic methods for regular solving of basic problems of management for industrial and economic activities of the facility. Automated control systems are differentiated into separate groups depending on its management sectors of the economy, the volume of data processing [1, p. 227] including ACSIF - Automated control systems of industry facilities, ACSTP - automated control system of technological processes with the regulation of their parameters.

Automated control systems of industry facilities and automated control system are designed with its own characteristic for each kind of production and the products manufacturing and design.

ACSIF and ACSTP design is carried out in several stages: selection of tasks that are settled in this system, development of the algorithm to solve them, setting of technical means, design of automatic control system [1, p. 227].

In complex production systems the manufacturing process is a set of natural and human processes for production of the raw materials of the complete product.

Information support production stage of products is carried with ACSIF and ACSTP.

ACSIF include the planning and management systems of the facility ERP, production planning and material requirements MRP-2 and systems SCM - Supply Chain Management System. Intermediate position between the ACSIF and ACSTP is production executive system MES. ACSTP system includes SCADA, performing dispatch functions. The system CNC used for direct software control of technological equipment.

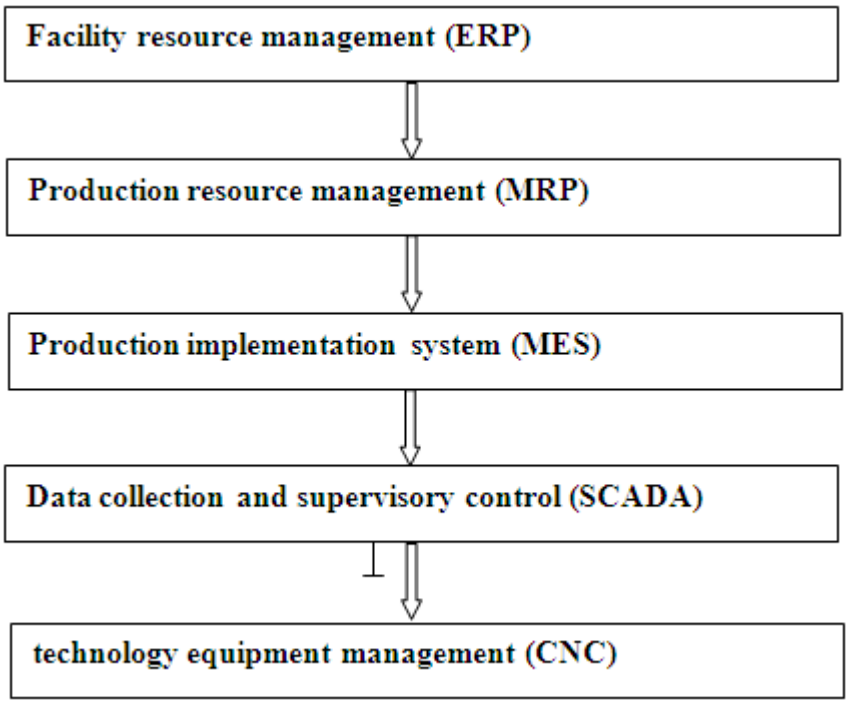

Figure 1- Global management structure [2, p. 338]

Data management in a single information space in all stages of the life cycle of any product remains on the system PLM. PLM is the process of information control of product throughout the lifecycle. PLM-system is interpreted in two ways: either as a set of automated systems CAE\CAD\CAM\PDM and ERP\CRM\SCM, or only as a set of information support of product and integration of facility automated systems, which practically coincides with the definition of CALS. [2 , p. 336]

Modern production system must have flexible and clear structure of the production technology process for the most effective use of available resources by using automated control systems. Application of the so-called products information support (CALS-technology) - the technology is the possibility of an effective distribution and use of facility resources using modern automated systems and computer technologies.

I.P. Norenkov defines CALS-technology as a modern approach to the design and production of high-tech products, consisting in the use of computer equipment and modern information technologies at all stages of the product life cycle, and providing a consistent way to manage processes of interaction of all participants in this cycle; products customers, suppliers/manufacturers of products, operations and maintenance personnel. CALS-technology developed in accordance with the requirements of international standards system that make the rules of interaction via electronic data interchange. [3. 52]

CALS-technologies designed to provide integration of the industrial automation systems into a single powerful system. The purpose of integration of design and management automated systems is to improve efficiency of the creation and use of complex equipment.

Industrial automation systems can operate autonomously. However, the efficiency of automation will be considerably higher if the data generated by one of the systems will be available to other systems.

Building of open distributed automated systems for design and management in the industry is the basis of modern CALS-technologies.

Stability and solidity of resource area of the production system is characterized by the possibility of resource provision and planning its operation activity.

Illustrative examples of practical application of the principle of solidity and stability of structural model can be the production planning systems JITM and MRP. [4, p.47]

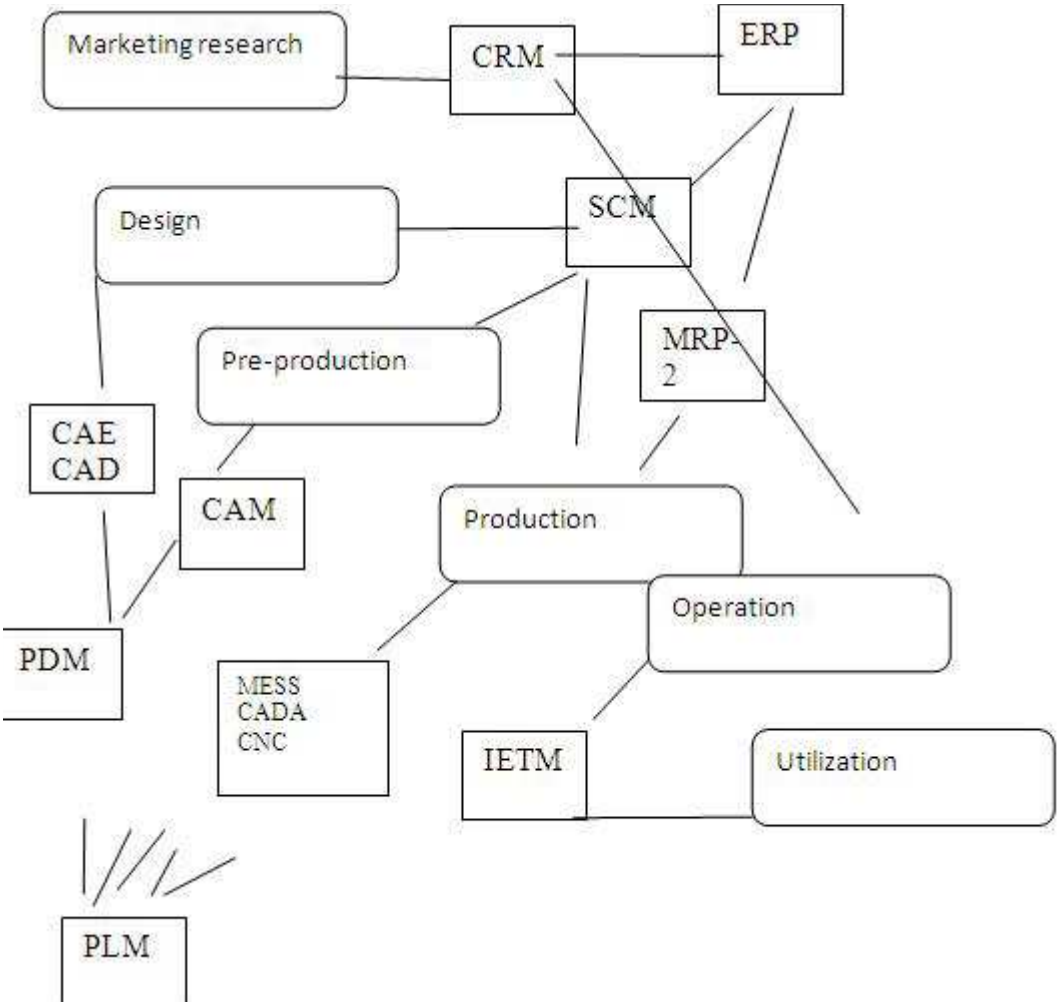

Figure 2 - Lifecycle of industrial products and used automated systems [2, p. 335]

Planning in MRP system is centralized, so each production unit receives a specific task for the planning period and report on its implementation to the central planning agency of the facility, but each unit at these conditions exists in isolation. As a result, the number of uncertain parameters increases for the production units that apply MRP system. The number of feedbacks highly grows which correct the production plans of individual departments of the facility. [5, p.47]

JITM system defined as a system of production of products necessary components in the required amounts exactly at the time when they are needed. This model of management systems can be attributed to an absolutely stable. [9, p.47]

The application of the intelligent systems technology (intelligent distribution systems) of decision support for assessment, forecasting and resource generation of production systems is possible to change the stability level of the production system as the characteristic of resource potentials of possible.

Intelligent system is a powerful tool for assessment and forecasting of inventory and projected orders. The system represents the set of specialized intelligent systems, interacting by the local and global networks. Specialized systems as part of an integrated system are composed of database for inventories, orders, equipment, components, etc. Intelligent system provides science-based assessment for inventories and forecasts of valid orders.

Calculation and forecasting are performed on the basis of long-term data processing, expert knowledge and integrated decision-making tools.

From the above we can conclude:

Complex production system exists in risky conditions. After all, in modern society any purposeful activity associated with random and uncertain. [6. 57].

The evolution of information technology is determined by different factors of production and economic system changes, as the integration of businesses, the need for adequately respond to any changes of the external environment, dynamically reallocating resources of the facility. [7]

Effective automatic control system supports the organization of stable production process and solidity at various stages.

As it was noted earlier the information technologies applied to different levels of management are implemented using automated control systems (ACS), and intelligent systems (ICS).

In turn, the development of ICS uses the idea of MRP/ERP technology - the idea of "horizontal" management of production facility. [8]

The ICS composition includes subsystem of information support of production, supply, sales, warehousing and technical, material, financial security, etc. Having this information allows us to pose the optimizing problem of material and financial flows at the facility, optimizing of business processes and their structure, costs cutting.

Of course, the use of CALS-technologies, MRP/ERP systems allows more efficient production management through control of financial resources and storage costs; evaluating reliability of the orders feasibility, according to available production capacity; costs and time reduce by optimizing of production processes; reducing the duration of the production cycle.

The presence of a distributed system for data collection from each structural unit of the facility for further processing in the administrative center is a serious competitive advantage.

For this purpose, the model construction of production management system must include the so-called intellectual elements [9,10], responsible for supporting management decisions. As these elements can act optimization models of planning and resource allocation at the tactical and operational levels of management. It is possible to prove optimal production plan, ensuring stability of the production system with these elements. [6]

Use of modern information technology is the environment which allows increasing of the solidity for the production system, so it refers to the stability of production systems at the non-simultaneity work of units, available consequences of failures, planning and use of resources.

The automated system can be used according to the production needs, to make good management decisions.

Information technology in resource management should provide decision-making under uncertainty, situational decision support, and should automate the search process of control decisions based on the accumulated data.

Any complex production system can be represented as a sequence of operations, which includes manufacturing, organizational processes, planning processes, raw materials and financial support, etc. Today there are developed management information technology and are implemented in the form of powerful tools such as a tool for planning and resource allocation. With its help it is possible to automate these operations.

Not appropriate information technology resource management entails many negative effects, such as violation of products delivery terms, more expensive products due to additional costs of finished goods at storages, reducing of technical and economic indicators of production, since the disturbance breaks an established mode of production work, increasing the possibility of defects.

These information technology may be used to improve the stability of production system at the level of production area, by improving of solidity of the production process and management planning (formation and resource allocation).

Advanced high-tech complex production systems can implement information technology, the abilities of production and resource potentials to neutralize the threat, initiated with the external and internal environments.

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USE OF CALCULATION METHODS FOR DETERMINING A SEAT OF FIRE

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The possibilities of using computational methods to determine the source of the fire. Disclosure of the most commonly used calculation methods for the determination of the fire. Proposed a procedure to correct the calculations using mathematical modeling.

Key words: *seat of fire, calculation methods, the reconstruction of fire development*

One of the main objectives of a judicial fire technical expertise is to define the seat of fire. During the process of identification of the fire seat it is necessary to consider the following circumstances:

due to the fact that the seat of the fire is a place of initial rise of burning, for its determination it is necessary to discover the zone of the longest duration of burning;

in the process of rather equal distribution of fire load, due to longer burning, in zone of the fire growth the degree of constructions and materials` thermal lesion is higher, than in other zones;

the nature of burning development in a great measure depends on the location of initial rise of burning;

during the searching of the zones of the fire growth it is necessary to consider the features of the fire processes which can influence on its rise and development.

Nowadays in the most cases the mentioned factors are considered by the expert subjectively without using the calculation techniques. At the same time, the using of the calculation methods in the mentioned cases allows to increase veracity and quality of the conducted researches about the determination of the seat of fire.

To the main calculation methods, which can be applied in the case of determination of the seat of the fire, is needed belong the following:

- calculations of the reconstruction of fire development (temporary characteristics of a fire);
- calculations of temperature patterns on the enclosures (temperature characteristics of a fire);
- calculations of processes parameters during the rise of a fire.

Performing these calculations has to accompany with traditional methods of the seat of fire establishment, based on the thermal lesions of materials and constructions` appraisal, identification of signs of the fire growth and signs of the direction of distribution of burning, the analysis of indications of witnesses, etc.

Let us consider in detail the practical use of the mentioned calculation methods for the seat of fire definition.

1 The seat of the fire determination with performing calculations based on reconstruction of fire development

The main point of calculation performs in specifying the place of the assumed seat of fire, the source of ignition and reconstruction under these conditions of a fire. The place of the seat of fire can be considered established if the fire development calculations in time, space and its consequences coincide with actuals.

For this purpose it is necessary to implement the following main stages:

- to develop the fire scenarios which are based on the available data about the fire behavior including both objective and subjective data;
- to define basic data (initial conditions) for modeling on the base of the developed scenario and the

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presented materials and perform modeling;
- to estimate the data gained as a result of modeling with available objective and subjective data about fire development;
- in the case of coincidence of data one should accept the version about the fire break-out in this place. Otherwise one should develop the alternative scenario and repeat calculation.

As software of performing calculations on the base of field modeling the FDS package (Fire Dynamics Simulator) can be used. To the main advantages of this package belongs: free distribution, possibility of performing the distributed calculations, etc.

The calculation of fire parameters performs by the method similar to a method, stated in a technique [1].

During the developing of the fire scenario the borders of the subject, distribution of fire load by object and sequence of events during the fire are determined, about which relevant data exists (the location of the seat of fire, operation of fire extinguishing systems, smoke removals, conditions of windows, doors, etc.). At the same time the physical assignment of task is carried out, i.e. the formulation of initial and boundary conditions is performing, and also creation of the information field about properties of fire load (thermophysical characteristics of substances and materials, characteristics of the objects burning) is performing.

The result of this work is creation of the inbound file containing the mentioned information, which is necessary for the correct work of FDS package. As a result of performing calculation the aggregate of fields of speeds, temperatures and concentration of gases for all time interval of process of burning is determined. Considering that this information is difficult for perception because of its volume, it needs to be visualized. The special software – the SmokeView postprocessor is used for this purpose.

In such a way, the expert gets the detailed visualized picture of the burning development. If the reconstructed picture in any aspect (dynamics or an orientation of the burning development, fire consequences, etc.) does not conforms authentically known circumstances of a fire and other actuals (in the case of all characteristics and boundary and initial conditions are indicated correctly), then the expert should consider other scenarios concerning characteristics of sources of ignition and the location of seats of fire.

The received results of calculation can be used by the expert for the formulation of answers to the questions and also can be included to the expert`s signing for the illustration of conclusions.

For the calculation of dangerous fire factors in general it is possible to use the generalized data according to [2].

However one should take into account that fire modeling with the help of computational methods (field modeling) doesn't reflect exactly the real events of process that is caused by impossibility of the accounting of all available details and events. In this case a direct dependence takes place: the more exact is the basic data for production of modeling and the higher is the knowledge of the expert, than the reconstructed scenario of a fire will correspond to real process is more precise. Besides the use of such software calculated packages is expedient for the fires on difficult objects, and also on the fires which are followed by death of people or big material damage that is connected with carrying out a big ground work on preparation of basic data for calculation.

2 Determination of the seat of fire with the use of calculations of temperature fields on protecting constructions

The essence of calculation lies in the fact that the probable location of the seat of fire can be assumed by taking into consideration the geometry of rooms, distribution of fire load, papers of a case. After carrying out the fire modeling, the received results of calculation can be compared to the real thermal damages, and then the conclusion about the relevancy of opinion about the estimated location of the seat of fire is pronounced. Thus the sequence of actions which is necessary for determination of the seat of fire by this way, usually, coincide with sequence of the actions specified for the previous method.

One of the most important aspects on which it is necessary to pay special attention in using the given calculation way of definition of the seat of fire, is the correctness of the zones of thermal defeats determination. From this it is also following that application of a considered method is needed only when the possibility of establishment of one or several pronounced zones of thermal damages takes place, and performing the calculations for them will allow the confidence of confirming the version about of the seat of fire location in one of them.

During the determination of the zones of thermal damages in most cases the visual methods of definition of thermal damages are used. However one should pay attention to the fact that by their simplicity and availability they are less exact. Traditionally in using a visual method, such parameters, as deformations, burning out, exfoliation of a protective layer of concrete, plaster, existence or lack of a soot and others are estimated.

Also for the increasing of reliability of the data gained during the estimation of zones of thermal damages which in the future will be used for performing the calculations it is necessary to aim for the use of the most exact methods, which are available for the expert, in a combination with visual methods.

In most cases it is usually supposed that the sizes, which are characterizing the degree of thermal damage of a material during the fire, are physical parameters describing structure, composition and qualities of a material which monotonously change with the increasing of the temperature and duration of thermal influence and also which can be precisely measured with the help of the modern instrument equipment. To this parameters can be taken: the size of coercive field strength for the cold-deformed steel products, electrical resistivity for the carbonized remains of wood and polymeric materials, correlation of characteristic strips in infra-red spectrum or x-ray diffraction maxima, the residual maintenance of labile to temperature components for the stone inorganic materials made by an fired method and some others.

However the functional dependences of the mentioned parameters are very different from conditions of thermal influence, moreover, one of them with the increasing of temperature and heating duration increase gradually, others – decrease gradually. For the purpose of compensation of this effect it is viable to use the dependences defining relative degrees of thermal damages of any material of a fire which can be calculated relatively to the minimum and maximum degree of destruction considered material on this fire. At that the result has to be in the range from 0 to 1.

The sequence of making the scenario of the fire for performing the modeling is similar to the mentioned above. Thus as the parameter defining the rise of thermal defeats it is possible to use temperature, production of temperature on the influence duration, on the thermal stream or others.

After performing the modeling and receiving fields of values it is necessary to perform comparison of the gained data with the real ones.

During the determination of the seat of fire by the reconstructive method of burning process one can compare the real thermal defeats with the calculated ones. At their coincidence it is possible to make a conclusion on correctness of the scenario of development of a fire and on location of the seat of fire.

During the determination of the seat of fire by the comparative method of thermal defeats with distribution of fire load, the identification of signs of the seat of fire by the comparative method can be made as follows. It is assumed that with equal degree of probability that any parts of the room can become the seat of fire. Therefore at the calculation one should use the model of simultaneous burning of the fire load on a surface with calculation of distribution of temperature zones (nondimensional temperatures).After that by comparing it with the distribution of the degree of thermal defeats it is possible to discover the zones of considerable virtually thermal defeats, thus there are no high values of calculated thermal defeats. Therefore, burning in these zones was much longer than in others that caused the stronger heating of these zones, and, therefore, stronger thermal defeats.

Thus, in the result of performing the comparison the expert can make a conclusion on relevancy of the supposition about the finding of the seat of fire on this place.

During the determination of the seat of fire by the comparative method of thermal defeats with distribution of fire load, the signs identification of the seat of fire by the comparative method can be made as follows. It is assumed that with equal degree of probability any parts of the room can become the seat of fire. Therefore performing the calculation one should use the model of simultaneous burning of the fire load on a surface with the calculation of distribution of temperature zones (nondimensional temperatures). After that by comparing it with the distribution of the degree of thermal defeats it is possible to reveal zones of considerable virtually thermal defeats, thus there are no high values of the calculative thermal defeats. Therefore, burning in these zones was much longer than in others that caused stronger heating of these zones, and, therefore, stronger thermal defeats.

For the determination of such zones it is offered to use the seat of fire criterion expressing the difference between nondimensional degrees of measured and calculated thermal defeat which should be counted on a formula:

$$Fc = (Sfact - Scalc)/Sfact$$

The zones, in which the criterion of Fc has the maximum value, have to correspond to the most probable location of the seat of fire.

As for the illustration of the applications of the definition technique of the seat of fire with the use of calculations of temperature fields on protecting constructions it is possible to give the following example of a fire in the flat of the multi-storied building.

The supersonic sounding in the burning room discovered 4 zones of the maximum thermal defeats of concrete constructions (picture 1b). But where the seat of fire is located and which are the centers of burning caused by concentration of fire load was difficult to define without extra analysis.

The initial distribution of fire load in the room is given at picture 1a. The calculation of a temperature field for the developed technique was performed which showed that the maximum thermal defeats on a ceiling of the room have to be in the zone of a bed, near a zone III (picture 1v) that is coordinated with the important thermal defeats in this zone. The value of criterion of Fc is maximum in a zone I (picture 1g). Here one should assume the seat of fire. Here the seat of fire is assumed.

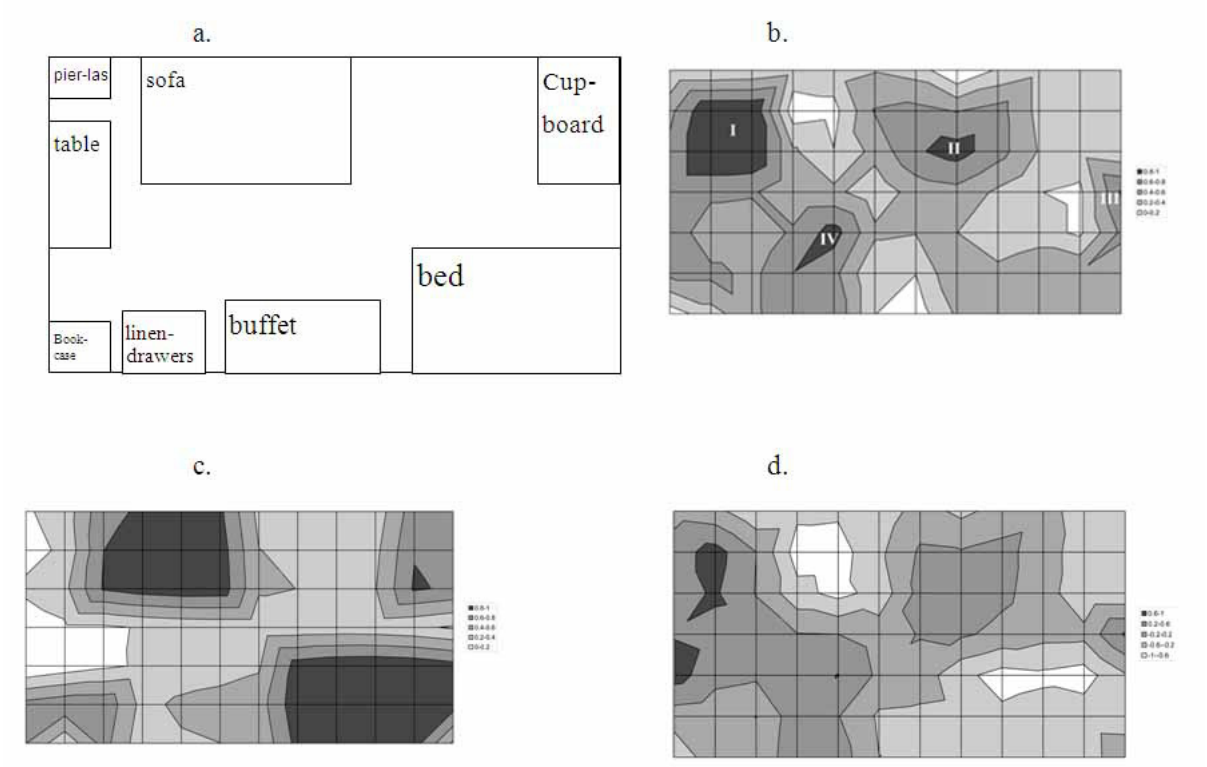

Fig. 1 - The results of the data processing and settlement of fire number 1

a - the floor plan; b - measured dimensionless degree thermal injuries; c - the calculated dimensionless degree thermal injuries; d - the criterion Fc

3 Ancillary mathematical modeling methods used in determining the seat of fire

The calculations of the heat transfer conductivity

Heat may be transferred by conduction, convection and radiant heat transfer. The calculation of these processes can be carried out by different methods. However, it is recommended to make the payment by means of specialized packages of mathematical modeling (FDS).

The aim of the study in the seat of fire determination by using heat transfer calculations is to obtain the values of temperature on the nonheated surface and to compare it with the critical value for evaluating possibility of the material ignition by heating.

This calculation can be made, for example, for the characterization of the possibility of deck structures which are adjacent to the furnace chimney while heating by conduction and others.

For the simulation, for example, burning of wood the burning wood materials from database FDS can be used. For temperature measurements virtual sensors in the gas and solid phase can be used. For visualization and analysis of the results sections (SLICES) and graphs can be used which indicate the sensor values at different times.

Calculations of heat transfer by convection and radiant heat exchange

The aim of the calculation is to determine the surface object temperature heated by radiant and convective heat transfer, in order to compare it with the critical and evaluate the possibility of material ignition by heating.

This calculation can be made, in particular, for the characterization of the possibility of firing in other constructions, and thus the fire development to form the secondary seats.

For the simulation the fire in a FDS package data the fire information about the load can be used. For the result`s visualization and analysis the sections and the virtual sensors of the heat flow in the gas phase can be used.

It should be also noted that the same way the fire of electrical or friction sparks and hot elements produced by fire may be considered.

Calculations for the flashover

To estimate the time of a fire the various influencing factors on the rate of fire should be considered. Thus, the same fire may pass different developmental stages in which the burning rate may vary. To simulate these processes in solving problems of determining the source of the fire and the analysis of the fire growth the FDS package can be also used.

As is well-known, in terms of the ratio of oxygen and fire load (combustible substances and materials) in the room two basic modes of the fire can be distinguished - the load-controlled fire (LCF) and the ventilation-controlled fire (VCF) [1].

In LCF occurs, the amount of oxygen, inside the closed space which is enough for the maintaining the combustion and seat of fire is limited by the amount involved in the process of fire load burning. Therefore, in LCF occurs, the air flow has no noticeable effect on the combustion process.

In VCF occurs, oxygen, on the contrary, is not enough to full involvement of the fire load and gaseous combustion products of its thermal decomposition in the combustion process. The seat of fire is limited by the oxygen supply. Therefore, in VCF occurs, air flow increases the rate of combustion.

In the FDS package the mechanism of intensification of combustion is modeled as follows. The virtual sensors that respond to the raise of temperature should be placed. When a certain temperature is reached, window or door “breaks” and, as a result of the flow of oxygen, intensification of combustion occurs. Due to the simulation of the fire growth time parameters one can understand for how fast the burn front of the fire reaches the certain points recorded instrumentally or by indications, which allows a more accurate determination of the fire, pathways and dynamics of combustion expansion.

Calculations of the flame running

This phenomenon is attributed to the fact that as a result of exposure to elevated temperature on the fire load and the lack of ventilation in rooms gaseous products of pyrolysis (incomplete combustion) can be accumulated, which may ignite under certain conditions. The burn front can spread on them from the fire bed for a very short time after a certain pause which is necessary for the accumulation of pyrolysis products. The consideration of these factors and the correct calculation of the fire time parameters can also help for the correct definition of the fire.

For simulation of the flame running one should indicate the specific parameters of the pyrolysis. For the simulation of pyrolysis process sufficiently small computational grid is required. After setting the necessary processes the mathematical modeling FDS package should be carried out. The results of the passage of the flame front through the gaseous pyrolysis products can be visualized by using the HRRPUV parameter. The color settings can be settled in the tab Dialog of Smokeview program.

During the simulation of the fire time parameters one can understand which way and how fast the burn front of the fire reaches the certain points recorded instrumentally or by proceeding from testimony.

Features of modeling of the fires caused by ignition and deflagration burning of the steam-gas-air mixture

In calculation of temporary parameters of the fire growth it is necessary to consider that the fastest mechanism of distribution of a flame is its distribution on a steam or gas phase. As a rule, it takes place in a mode of a deflagration on condition that concentration of vapors (gas) is between bottom and top limits of distribution of a flame. The calculation of these limits can be made according to a technique [1]. Opportunities and features of explosion the steam-gas-air mixtures, bringing to a fire and arising during the fire are considered in literature [2].

Thus, carrying out calculations by using the considered methods will allow the expert to prove by means of objective information the correctness of the conclusions about the seat of fire. Thus it should be noted that adequacy of the data obtained as a result of calculation depends on quality of the held events for preparation of basic data for calculation, i.e. on qualification of the expert.

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ASSESSMENT OF FIRE AND ECOLOGICAL DANGERS BY PREVALENCE OF OIL POLLUTION IN ARCTIC

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The main problem of spread ofoil pollution in soil depositis described in this article. There is considered from a position of the theory of a percolation the possible mechanism of formation of artificial underground deposits of man-made oil products due to processes of an infiltration of oil. There is identified type of soil with specified processes. The research provides fire risk assessment ofoil-saturated soil systems.

Key words: *soil, percolation theory, oil pollution, indicators of fire danger*

The Northern regions are the most vulnerable when the negative impact of oil products. The soil depth in the tundra is 20-30 cm, while the depth of cover in soddy-podzolic soil is up to 2.5 m, and chernozem soil depth is more than 3 m Permanent natural impact (unless the major and catastrophic), is compensated by the self-regulating capacity of ecosystems. However, the self-cleaning ability of the soil of the tundra is much lower than of soddy-podzolic soil and Chernozem soil. This is due to low microbiological activity.

Meanwhile, the greatest Russian oil and gas companies and the intensive search for new hydrocarbon deposits are located in the North area. There are revealed in total more than 20 thousand hectares of contaminated areas in Western Siberia with depth of soil at least 5 cm.

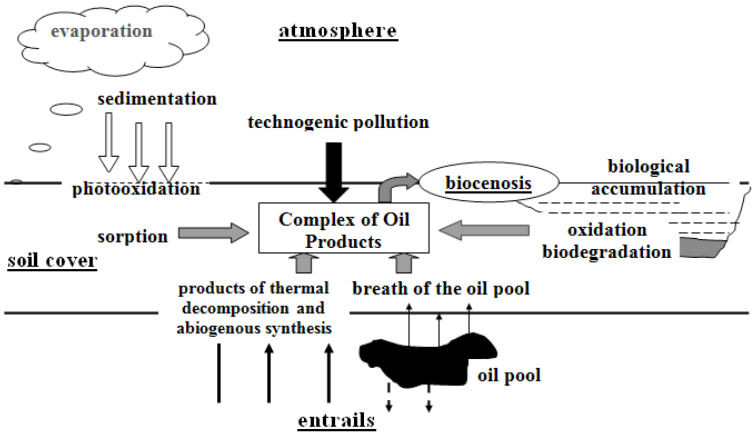
Petroleum product plumes are formedafter oil leakage to ground water table. While migrating oil products plumes can cause pollution of water intake areas and ground waters. An example of this situation is an accident near the city Grozny (Chechen Republic). Infiltration of oil products caused the formation of large underground oil pools in Angarsk, Mozdok, Tuapse, Yeisk, Oryol, Novokuibyshevsk, Ufa, Komsomolsk-on-Amur and other cities [1].

The large number accidents concerning Infiltration of oil products are well-known the USA. However, the soils of region of Grozny city in Chechnya are one of the largest human-created oil deposits in the world. The reserves evaluation is at the rate of about one million tons. The obvious result is poisoned ground waters that seep into Sunzha River, toxic fumes into the air.

Thesameproblemsrevealnearoilrefineries, oil products reservoirs.

There arethe following problems when investigating the prevalence of pollution in soil deposits.

The first problem.The soil cover is the most important depositing element of the biosphere. The soil keeps a long-term condition and transfer of polluting substances between elements of environments.



The scheme of functioning of oil pollution in environment.

Second problem.The regulatory in the field of oil pollution of soils is insufficient developed. Regulation Principles of the amount and type of oil pollutionof soils differ significantly from those for atmosphere air and natural waters, as the entry of toxic substances in the organism of human and animals directly from the soil occurs in exceptional cases and in small quantities.

Rationing of oil pollution based on values of maximum permissible concentration by reason of limited regulation listof norms of maximum permissible concentration for soil and oil products.

Third problem.There are a lot of types of soils compared to water and air, which are hard to standardize. There are no principles of identification of types of soil deposits concerning to oil pollution.

There are 4 types of soils in the world:

1) humid tropics - tropical red and yellow earth;
2) rich soils of savanna and moor;
3) poor and extremely unstable ground of deserts and semideserts;
4) barren soils oftemperate zone forests – podsolic brown and grey forest soils.

There are 3 last mentioned types of soils in Russia (highlighted in orange in the tab.).

Fourth problem.When studying dynamics of oil pollution it is necessary to take in accountself-purification capacity of soils.

By the estimates based on the approximate admissible concentration (AAC) of oil products in soils, it is offered to consider as the low pollution standardwhich provides resoiling during a year. Such way the toppermissible limit of TPH – in – soil.There are a list of approxible permissible concentration of dangerous compounds in soils in Russia. Because of large variety of soil typesthere are nouniversal indicator of AAC of soil for the whole territory of Russia, as far as scouring velocity od soils in different natural zones and soil types at the same level of pollution will be different (table 1) [3].

Approxible permissible concentration of light oil products in soils of different natural zones of (not operational at the present time)

Type of oil product	Landscape-geochemical areas	Soil types	Value of APC on with background taking into account mg / kg	Possible state of aggregation of matter in all types of soils
Light oil products: patrols, kerosene, diesel fuel	Permafrost tundra-taiga	Tundra gley, marshy tundra	2000	The vapor and liquid state in vapor soil. In the adsorbed state on organic and mineral particles of soil. In a free state on the soil surface.
	Taiga-forest	Middle and southern taiga podzol	4000	
	Forest-steppe and steppe, semi-desert and desert	Grey soil, forest, blackearth, chestnut soil, desert-steppe soil, brown, desert-flinty soil	8000	

The process of passing the fluid through a volume porous sample (eg, petroleum products through the soil) can be described froma perspective of percolation theory.

Individual pores of the porous structure (soil) can be represented as a cell. Together they form the pore space - a cluster. Conductive elements added to the cluster from exposure to external source, but

at first their amount is not enoughfor percolation. At the moment of percolation (during continuous conductive of a cluster) the number of conductive cells becomes sufficient to fluid seepage from one side to the other of the sample. The porous structure is permeable to liquid. The percolation threshold separates two phases: one phase clusters exist only at finite size, the other - one infinite cluster.

The values of porosity and permeability for granulometric fractions of air-dry clay-silty sands are determined experimentally. The porosity ≈ 22-25%, fraction are > 0,6 mm. The porosity in the fraction < 0,2 mm is 45% or more. Porosity of the soil is directly connected with permeability. The threshold of a percolation comes in fraction with the average size of particles of 0,4 mm, 31% having porosity and coefficient of permeability 10,4 Darci.

Fire danger assessment of soil.

System of fire characteristics, adopted in Russia and some other countries involves division of all combustible substances and materials by the aggregate state.The soilwhich form with oil productsan almostindivisible system (single isolated clusters), should be estimated by fire-danger index, adopted to solid combustibles.While segregationIn allocating of oil into a separate phase such objects assess on fire characteristics, adopted for liquids.

There are the following conclusions.The formation of large underground deposits of man-caused oil products due to the processes of infiltration belong to the areas with the second and fourth soil types(Mozdok, Tuapse, Tuapse, Oryol, Novokuibyshevsk and so on).However, there are not identified such cases in the Arabian Peninsula and in Polar Regionsof Russia where the third type of soil is dominated. Thus, the identification of the morphology of the soils for analysis of the dynamics of oil spills is of practical importance

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IDENTIFICATION OF GASOLINES BY THE RESULTS OF GAS CHROMATOGRAPHIC STUDY OF AROMATIC COMPOUNDS FOR THE PURPOSES OF FIRE INVESTIGATION

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The article is devoted to the study of potential identification of gasoline by gas chromatographic analysis of aromatic compounds. The method of presenting the results in the form of graphics on the basis of data on the relative areas of chromatographic peaks of selected aromatic compounds and their retention time was selected in this study. The analysis revealed that, on the basis of a gas chromatographic analysis of aromatic compounds it is possible to determine the manufacturer of gasoline.

Key words: *Gas-liquid chromatography, gasoline, fire-technical examination*

Modern expert methods of determining the fact of arson regard detection of additions of flammable liquids at the accident site as the main qualification feature of a given crime. However, experts often face the issue of identification of their detected residual matter. When considering the issue of identification of oil products for the purposes of fire investigation, it is necessary to determine the meaning of the term "identification". Presently, analytical chemistry treats this term as determining one specific analyte in a sample or a group of substances. At the same time, identification is understood as confirmation of assignment of characteristic properties (peak position on chromatogram or electrophoregram, line in the spectrum or on diffractogram) to a specific substance or compound group.

On the other hand, in order to prove an oil sample belonging to a specific source, one must resolve the problems of criminalistic identification, which is understood as «determining of an individual and specific identity of the element of substance context, common generic or group belonging» [6]. In criminal science, identification is determination of identity of a specific object or a person by the totality of common and individual features by way of their comparative study. The results of criminalistic identification must be expressed in procedural acts to which expert examination is related [2,4]. The tasks of criminalistic identification are determining generic, group, or individual belonging of objects. The most difficult task is establishing the identification of objects [5-6]. In order to resolve it, criminal science uses methods and approaches that are based on the last achievements of analytical chemistry.

The techniques of criminalistic identification may be based on analytical identification or consider the results of the study of objects when comparing them in the form of graphic presentation. The latter approach does not require conducting quantitative determinations and device calibration. It is sufficient to have analytical equipment and the conditions of conducting an analysis identical. Nevertheless, it is quite often that it is impossible to avoid quantitative determination of compounds, atoms, and separate molecular structures that are contained in samples.

We made an attempt to identify gasolines of various grades on the basis of aromatic components that are present in them. Selection of this class of compounds is associated with the following circumstances:

1. these substances are not related to highly volatile gasoline components that may evaporate under the influence of the environment factors, therefore they are preserved longer;
2. they may be formed in the process of thermal influence on original gasoline, for example, in case of fire. Studying their correlation in the sample composition, one can make a judgment about the degree of their burnoff;
3. each manufacturer, in order to reach the required octane number, uses its own set of aromatic compounds. Therefore, by their composition, it is possible to resolve identification tasks.

As study samples, gasolines AI 95 (with octane number 95) of various grades from Serbia were examined together with Neste gasolines AI 92, AI 98, and AI 95.

The analysis was conducted with the use of chromatograph Kristall 5000.1 with a capillary column (length – 25 m, internal diameter – 0.2 mm, phase – OV-101) and a flame-ionization detector.

Quantitative content of aromatic substances on samples can be used for the purposes of identification. A more easy method is based on processing of chromatograms obtained without conducting quantitative determinations. In this regard, as reference data, one can use either height, or area of various peaks, both absolute and relative values, reduced to total height or peak area of aromatic compounds [1]. As reference aromatic compounds, 15 substances were selected that are represented in Table 1.

Tab. 1. Aroma compounds used for identification

№	Time, min.	Component
1	2,4 - 2,7	benzol
2	4,2 - 4,4	toluene
3	7,6 - 7,8	Ethyl benzene
4	8,0 - 8,4	Metaxylene, paraxylene
5	9,1 - 9,4	ortoxylene
6	10,3 - 10,8	isopropylbenzene
7	11,6 - 11,8	propylbenzene
8	12,0 - 12,1	1-methyl-3(4)- ethylbenzene
9	12,2 - 12,3	1,3,5- trimethylbenzene
10	13,1 - 13,2	1- methyl -2- ethylbenzene
11	13,4 - 13,5	1,2,4 trimethylbenzene
12	15,2 - 15,4	1,2,3- trimethylbenzene
13	17,4 - 17,5	1,2- dimethyl -4- ethylbenzene
14	18,6 - 18,8	1,2,4,5- tetramethyl benzene
15	18,9 - 19,1	1,2,3,5- tetramethyl benzene

When conducting identification studies, the most difficult task is the procedure of substantiating the identity of the samples of commercial oil products, since an indispensable condition of expert study of accident and illegal spills of oil products (OP) is presenting of evidentiary information that ensures visible results of chemical analysis that is required by law enforcement officers.

The most convenient ways of presenting information are various types of graphic construction when the systems of dots marked on chromatographic fingerprints are viewed as reference data. The purpose of such constructions is resolving the issue of correspondence or non-correspondence of two systems of marked characteristic dots that are inherent to compared study objects.

Theoretical presentations of criminalistic study of substances, materials, and items (CSSMI) instruct, when comparing two-dimension objects (for instance, fingertip prints) for identification, to use not less than 6 marked characteristic dots. In expert practice, the number of such characteristic dots is usually selected with a certain «reserve» - up to sixteen, not more [4].

In order to make comparisons, there was selected a method of presenting results obtained in the form of graphic constructions on the basis of data in regard to relative areas of chromatographic peaks of selected aromatic compounds and the time of their retention.

The graphic presentations of the results obtained, constructed by the values of chromatographic peak areas of 15 selected aromatic compounds reduced to total values are presented in Figure 1 and 2.

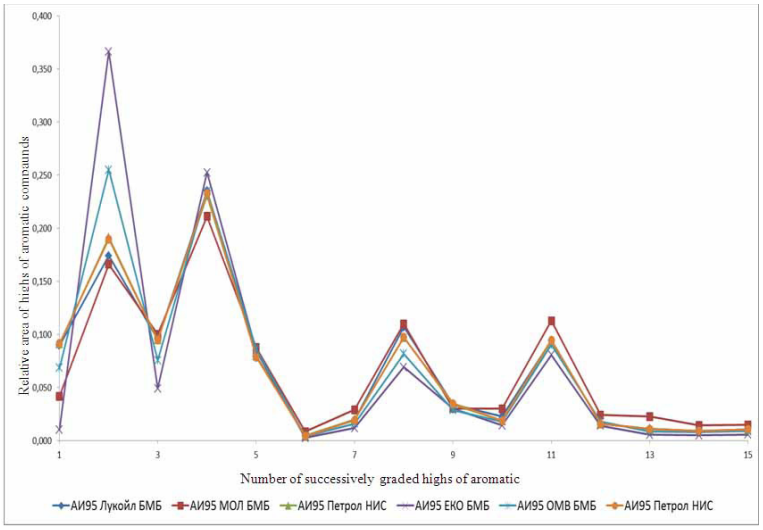

Fig. 1. The graphic presentations of aromatic content of gasolines AI 95 of different companies

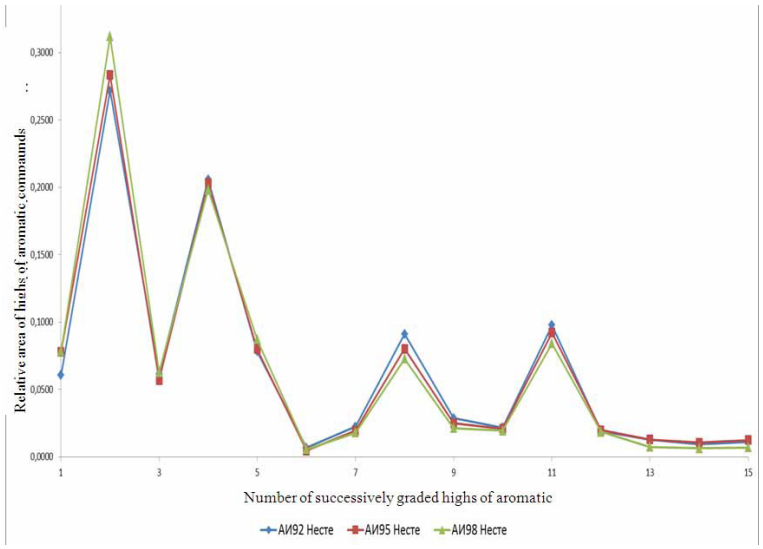

Fig. 2. Graphic presentations of the content of aromatic compounds in the gasolines of various grades produced by Neste

When comparing gasolines AI 95 of various gasoline companies, the differences are usually associated with the content of benzol, toluene, o-xylene, 1-methyl-3(4)-ethyl benzene, and tetramethyl benzenes in samples. These aromatic compounds are added to automobile gasolines in order to obtain the required octane number. The values of relative areas of aromatic compound peaks (Figures 1- 2) in relation to one another are different by orders, which affects the quality of comparison conducted. For better visual expression, we can use the logarithmic scale of relative content of various compounds. In this case, the difference is more visible (Figure 3) especially for substances that come out after the 12th minute, whose content is insignificant relating to others. The substances by which the differences are the most evident are represented in Table 2.

Table 17. Aromatic compounds, whose number is different for gasolines AI 95 of various gasoline companies.

№	Time, min.	Component
1	2,2-2,6	benzol
2	4,2-4,6	toluene
4	7,8-8,2	Metaxylene, paraxylene
6	10,1-10,3	isopropylbenzene
7	11,3-11,6	propylbenzene
8	11,9-12,2	1-methyl-3(4)- ethylbenzene
11	13,3-13,6	1,2,4 trimethylbenzene
12	15,2-15,4	1,2,3- trimethylbenzene
13	17,3-17,4	1,2- dimethyl - 4- ethylbenzene
14	18,6-18,7	1,2,4,5- tetramethyl benzene
15	18,9-19,1	1,2,3,5- tetramethyl benzene

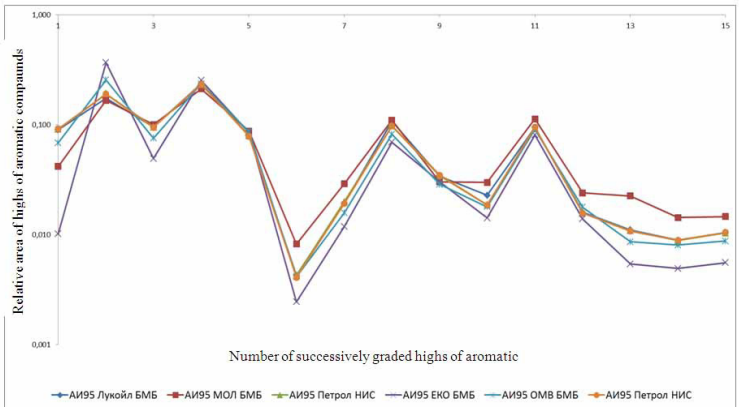

Fig. 3 Graphic presentations for the content of aromatic compounds in gasolines AI 95 of various companies

The differences in the composition of aromatic compounds can be used when determining gasolines of various fuel companies. The study of gasolines of different grades produced by one company allowed to detect insignificant differences with the help of building graphic constructions (Figure 14). Even when using a logarithmic scale of relative content of aromatic compounds, differences are not that visible (Figure 16). As seen in Figure 4, gasolines of Neste trade mark of various grades vary only by the content of various tetramethyl benzenes.

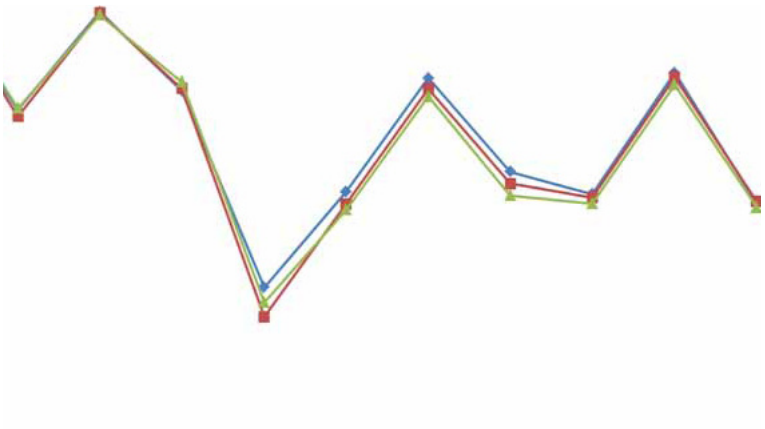

Fig. 4. Graphic presentations of the content of aromatic compounds in the gasolines of various grades produced by Neste

The studies conducted and subsequent processing of their results showed that usage of gasoline grade for diagnostics only by the content of aromatic hydrocarbons is not sufficient. In order to provide a more detailed evaluation, it is necessary to use design criteria that allow to perform numeric evaluation of various samples by way of building graphic constructions. For instance, we can use calculation of Euclidean distance.

In the future, it is planned to conduct a study of a larger number of commercial oil products, both reference and after thermal influence. That study was conducted in the framework of developing a technique for search and detection of highly-flammable liquids and flammable liquids residue at the accident site when conducting investigations of arsons, held at the department of criminal science and forensic engineering.

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[3] http://www.vanguard.edu/psychology/apa.pdf (retrieval date) *(for web content)*

[4] Regulation on the mode and procedure of risk assessment in the workplace and in the work environment ("Official Gazette of RS". No. 72/06, 84/06 and 30/10) *(for the document without the author)*

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