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QUALITY OF MOTOR FUELS IN SLOVAKIA

Summary

Directives of the European Parliament and of the Council relating to the quality of petrol and diesel fuels, and monitoring of their quality in the filling station network in accordance with the European Standards 14274 and 14275 [1, 2] represent a part of the European Union legislation which was implemented into the law system of Slovak Republic in the year 2004. The requirements of this legislation were transposed into the Directive of Ministry of Environment of Slovak Republic No. 53/2004. In the same time STN EN 14274 and STN EN 14275 were issued, so the law platform for performing of motor fuel quality monitoring system in the filling station network in Slovakia was formed.

The paper presents information concerning the applied monitoring system of filling stations, basic data about Slovak motor fuels market and especially results of petrol and diesel fuel quality, which were acquired in 2004 and 2005 in the scope of monitoring system application.

1. Introduction

The requirements for quality of motor fuels are continually increased in all European Union member states. The ecology, protection of the environment on one hand and illegal manipulation with the chemical composition of fuels at which the customer loses mainly on the other hand are moving powers of all this evolution. The quality of motor fuels is determined by unified European standards. The requirements for quality of motor fuels were established not only with reference to their negative effect at their combustion on environment, but also with reference to secure car operation, reliability and operational life of engine and catalytic converter as well.

Although the Slovak Inspection of Environment and Slovak Trade Inspection regularly take some samples and evaluate quality of petrol and diesel fuels, above-mentioned fact and admission of Slovak Republic into European Union led to introduction of compulsory motor fuel quality monitoring system in the filling station network in Slovakia in accordance with the European Union legislation.

Obligation to perform quality monitoring of petrol and diesel fuels at the filling stations in the territory of each European Union member state, in Slovakia from 1.5.2004, originates from EU Directive 98/70/EC and Directive 2003/17/EC [3].

Directive of Ministry of Environment of Slovak Republic No. 53/2004, in which a part of the European Union legislation was implemented, was issued before introduction of motor fuel quality monitoring system. Slovak Inspection of Environment as a coordinator for Slovak Republic was determined by the Directive of Ministry of Environment of Slovak Republic and in such a way the Commission Decision 2002/159/EC was implemented in Slovak Republic legislation. Slovak Inspection of Environment manages and performs all the monitoring process. The Ministry of Environment of Slovak Republic is responsible for working-out and sending of year reports for Slovak Republic to competent authority of European Union.

Slovnaft VURUP, Inc., on the base of competition performed in May 2004 in accordance with the Law No. 523/2003 on public competition, was chosen as organization, which realizes sampling of motor fuels at the filling stations in cooperation with competent department of the Slovak Inspection of Environment and performs analyses of motor fuels samples in accredited testing laboratories. Slovnaft VURUP, Inc. disposes with the special arranged van for the purpose of minimization of light fraction losses at transport of petrol samples between filling stations and testing laboratories, which meets the requirements of the European Standard 14275.

2. Monitoring range

Monitoring range is determined according to the European Standard 14274, which describes fuel quality monitoring system (FQMS) for evaluation of petrol and diesel fuels quality in the market of all European Union member states. Because the specifications for fuels contain requirements for different climatic conditions, monitoring is performed twice a year, during winter and summer period. The range of petrol and diesel fuel properties, necessary for monitoring needs, is given in tab. 1. The enormous decrease of limit for sulphur content to 50 mg/kg came into force in case of petrol and diesel from 1.1.2005. These fuels are called as „low-sulphur fuels“. The decrease of limit for aromatics content in petrol from 42 % (V/V) to 35 % (V/V) came into force together with the sulphur content limit. Absolute change relating to the motor fuels with sulphur content max. 10 mg/kg („sulphur-free fuels“) has to be performed till 1.1.2009 at the latest.

In accordance with the requirement of EN 14274 the database of all filling stations in Slovakia and identification of each filling nozzle for individual petrol and diesel fuel type was worked out. The database, which is updated every year, contains all the necessary information about owner of filling station and region, in which filling station is placed. The system of code was created from mentioned data and it enables to identify explicitly every filling nozzle, from which sample of individual motor fuel grade for analysing was taken. The code is always written on the sampling can together with other information such as place, date and time of sampling, motor fuel grade and the same code is referred in the testing report for each motor fuel sample.

Table 1: Requirements for petrol and diesel fuel

Parameter	Unit	Limits		Test
		Minimum	Maximum	Method
Petrol				
Research Octane Number	Petrol 91 Petrol 95 Petrol 98	91 (90,6) 95 (94,6) 98 (97,6)	-	EN ISO 5164
Motor Octane Number	Petrol 91 Petrol 95 Petrol 98	81 (80,5) 85 (84,5) 88 (87,5)	-	EN 25163
Vapour Pressure, DVPE summer period only	kPa	-	60 (61,8)	EN 13019-1
Distillation:				ISO 3405
- evaporated at 100°C	% (V/V)	46 (43,6)	-	
- evaporated at 150°C	% (V/V)	75 (72,6)	-	
Hydrocarbon types:				
Olefins	% (V/V)	-	18 (20,7)	ASTM D 1319
Olefins (Petrol 91 RON)	% (V/V)	-	21 (24,0)	ASTM D 1319
Aromatics till 1.1.2005	% (V/V)	-	42 (44,2)	ASTM D 1319
since 1.1.2005	% (V/V)	-	35 (37,2)	
Benzene	% (V/V)	-	1 (1,1)	EN 228
Oxygen content	% (m/m)	-	2,7 (2,9)	EN 1601
Oxygenates:				EN 1601
Methanol	% (V/V)	-	3 (3,2)	
Ethanol	% (V/V)	-	5 (5,2)	
Iso-propyl alcohol	% (V/V)	-	10 (10,5)	
Terc-butyl alcohol	% (V/V)	-	7 (7,4)	
Iso-butyl alcohol	% (V/V)	-	10 (10,5)	
Ethers with ≥ 5 carbon atoms / molecule		-	15 (15,6)	
Other oxygenates	% (V/V)	-	10 (10,5)	EN 1601
Sulphur content till 1.1.2005	mg/kg	-	150 (165,1)	EN ISO 20846
from 1.1.2005			50 (55,7)	
from 1.1.2009			10 (11,6)	
Lead content	g/l	-	0,005 (0,0054)	EN 237
Diesel				
Cetane number		51 (48,5)	-	EN ISO 5165
Density at 15°C	kg/m ³	-	845 (845,3)	EN ISO 12185
Distillation: 95 % Point	°C	-	360 (365,9)	ISO 3405
Polycyclic aromatic hydrocarbons (PAH)	% (m/m)	-	11 (13,2)	EN 12916
Sulphur content till 1.1.2005	mg/kg	-	350 (373,6)	EN ISO 20846
from 1.1.2005			50 (54,0)	
from 1.1.2009			10 (11,3)	

Notice: In the brackets there are limited values for assessment, if motor fuel sample meets the requirements of the EN 228 or EN 590

Minimal number of taken samples for petrol and diesel fuel types (for parent fuel grades) is defined by EN 14274 in dependence from sold fuel amount in year. Limited value is 15 millions t/y. The country which has total consumption more than 15 millions tons of motor fuels per year is declared as a big country, in opposite case, the country is declared as a small one. Slovak Republic ranks among the small countries on the base of information about the sold motor fuel amount in Slovakia in 2003. Minimal number of filling stations in the country, which is necessary to sample and analyse for fuel types with the sale share 10% and more, are presented in tab. 2. The petrols Super 95, Normal 91 with the additive VSRA (VSRA – Valve Seat Recession Additive) and diesel were defined as basic (parent) types of motor fuels. Required sample number for SuperPlus 98 was calculated from the ratio of his total sale amount and total sale amount of basic petrol type - Super 95.

The real number of taken samples of petrol - SuperPlus 98 was higher for creation of opportunity of result statistical analysis. Procedure for taking of petrol and diesel fuel samples from filling stations is specified in the European Standard 14275.

Table 2: Sample numbers for each fuel grade in winter and summer period in Slovakia in 2004 and 2005

Fuel type	Normal 91	Super 95	SuperPlus 98	Diesel
Summer period 2004				
<i>Planned sample number</i>	50	50	3	50
Real number of taken samples	53	56	3	57
Winter period 2004				
<i>Planned sample number</i>	50	50	3	50
Real number of taken samples	61	58	7	50
Summer period 2005				
<i>Planned sample number</i>	50	50	3	50
Real number of taken samples	55	53	15	52
Winter period 2005				
<i>Planned sample number</i>	50	50	3	50
Real number of taken samples	50	50	13	50

3. Situation on Slovak motor fuels market

The created database of filling stations offers a lot of useful information, which have never been at disposal in such a complex form. Database contains apart from SAPPO members (Slovak Association of Petroleum Industry and Trade) data about other, predominantly smaller companies operating filling station networks or even only one filling station. The 79 companies operating 676 filling stations were registered in Slovakia at the turn of the years 2003/2004. The 112 registered companies operated 769 filling stations at the turn of the years 2004/2005. These numbers do not include the companies, which declared consumption of fuels only for own, internal needs. Distribution of companies according to the number of filling stations is shown in Fig. 1 and Fig. 2. Relatively much private companies, which own

only one or less than 5 filling stations, take part in the fuel sale besides “the big four” (Slovnaft, OMV, Shell and Jurki). Share of companies on total number of filling stations in 2004 and 2005 is shown in Fig. 3 and Fig. 4.

Figure 1: Distribution of companies according to number of filling stations in 2004

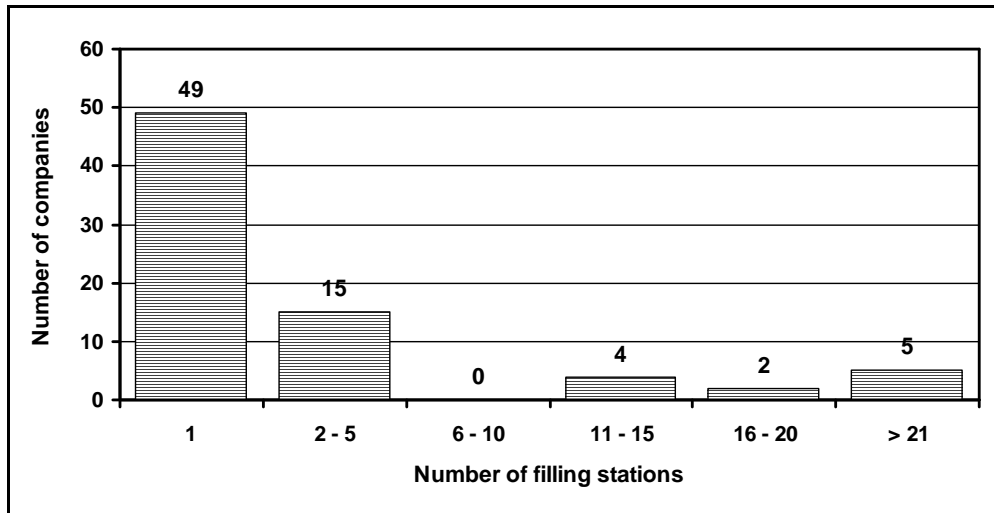


Figure 2: Distribution of companies according to number of filling stations in 2005

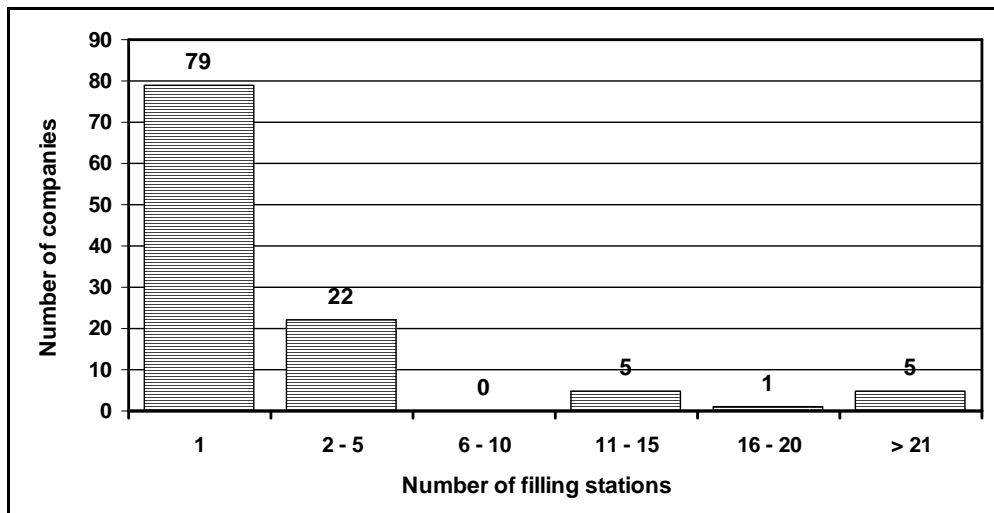


Figure 3: Share of companies on total number of filling stations in 2004

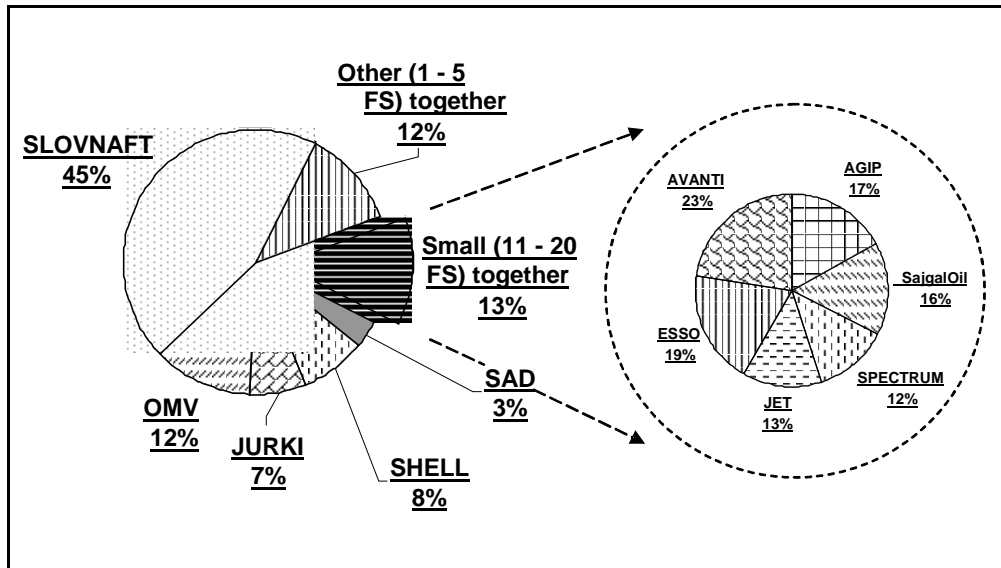
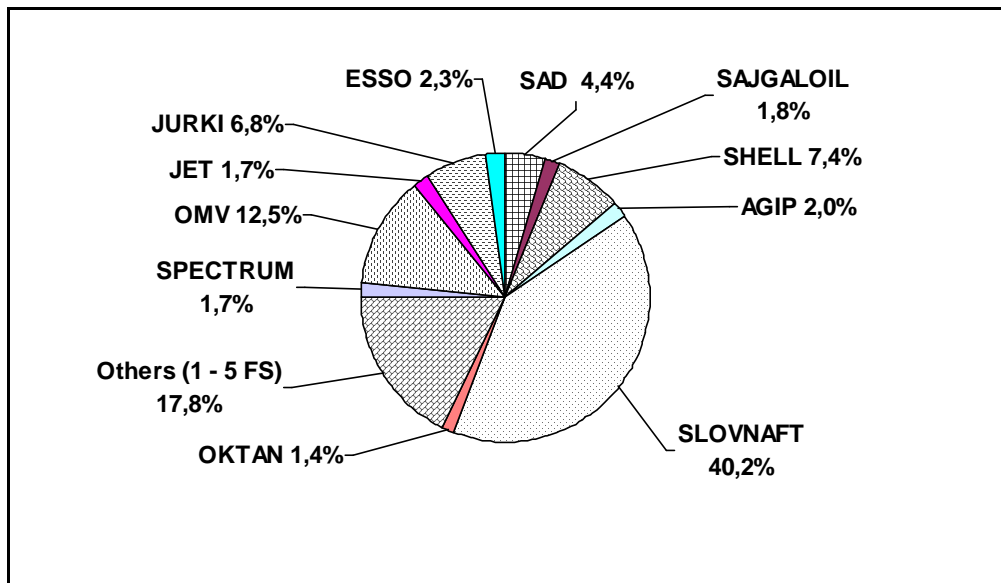


Figure 4: Share of companies on total number of filling stations in 2005



4. Results of monitoring in Slovakia

The results of properties evaluation of individual motor fuel types in summer and winter period in 2004 and 2005 are presented in tables 3 – 6. Sampling of petrol and diesel fuels was realized in August and September 2004 in view of need of legislation acts publishing and realisation of organizing actions connected with performing of monitoring, which are mentioned in the introduction part of this paper. Winter period samples were taken in November and December. In this period, companies operating filling stations have been already prepared for change to motor fuels fulfilling the requirements of EN 228: 2004 and EN 590: 2004 valid from 1.1.2005, and therefore the part of samples can be marked as “mixture” samples. This fact can be documented by the fall in the sulphur content in diesel from mean value 189,2 mg/kg in summer period to 34,5 mg/kg in samples taken in winter period. Sampling of petrol and diesel fuels in 2005 in summer period was realised in May – September and in winter period was realised in January, February, November and December. Sampling of petrol and diesel fuels was not realised in so-called „intermediate” period.

Table 3: Monitoring results – Diesel

Property	Unit	Sample number	Min.	Max.	Mean
Year 2004					
Cetane number		107	51,0	55,2	52,9
Density at 15°C	kg/m ³	107	828,3	843,8	836,9
Distillation: 95 % Point	°C	107	335,9	359,1	346,3
Polycyclic aromatic hydrocarbons (PAH)	% (m/m)	107	0,0	5,9	3,8
Sulphur content	mg/kg	107	2,9	1167	116,9
Samples with sulphur content:					
- to 10 mg/kg		17	2,9	9,5	5,4
- over 10 and to 50 mg/kg		36	10,2	48,8	23,2
- over 50 mg/kg		54	54,3	1167	214,5
Year 2005					
Cetane number		102	49,4	56,6	52,7
Density at 15°C	kg/m ³	102	829,8	843,7	835,7
Distillation: 95 % Point	°C	102	252,1	361,3	346,6
Polycyclic aromatic hydrocarbons (PAH)	% (m/m)	102	1,5	5,1	2,7
Sulphur content	mg/kg	102	2,0	130,8	12,6
Samples with sulphur content:					
- to 10 mg/kg		49	2,0	9,9	6,3
- over 10 mg/kg		53	10,2	130,8	18,5

Table 4: Monitoring results - Petrol Normal 91

Property	Unit	Sample number	Min.	Max.	Mean
Year 2004					
Research Octane Number		114	90,5	95,2	92,5
Motor Octane Number		114	83,0	86,5	84,4
Density at 15°C	kg/m ³	114	734,0	757,1	742,9
Vapour Pressure, DVPE summer period only	kPa	53	52,6	60,3	56,7
Distillation:					
E 70 (Summer period)	% (V/V)	53	28,4	39,3	33,0
E 70 (Winter period)	% (V/V)	61	26,4	42,2	33,9
E 100	% (V/V)	114	47,9	61,0	54,0
E 150	% (V/V)	114	77,8	87,3	82,0
Hydrocarbon types:					
- Olefins	% (V/V)	114	3,8	17,8	9,6
- Aromatics	% (V/V)	114	22,2	41,3	31,2
- Benzene	% (V/V)	114	0,6	1,0	0,9
Oxygenates content	% (V/V)	114	0,0	2,6	0,5
Sulphur content	mg/kg	114	1,8	131,1	13,0
Samples with sulphur content:					
- to 10 mg/kg		75	1,8	9,9	5,4
- over 10 mg/kg		39	10,3	131,1	27,6
Year 2005					
Research Octane Number		105	90,2	95,9	92,9
Motor Octane Number		105	82,6	85,8	84,1
Density at 15°C	kg/m ³	105	736,2	756,6	744,9
Vapour Pressure, DVPE summer period only	kPa	55	44,9	63,6	51,5
Distillation:					
E 70 (Summer period)	% (V/V)	55	22,6	35,5	29,2
E 70 (Winter period)	% (V/V)	50	27,7	41,4	34,6
E 100	% (V/V)	105	46,8	60,9	53,2
E 150	% (V/V)	105	77,0	86,2	81,2
Hydrocarbon types:					
- Olefins	% (V/V)	105	4,3	18,5	11,7
- Aromatics	% (V/V)	105	27,2	35,6	31,5
- Benzene	% (V/V)	105	0,5	1,0	0,8
Oxygenates content	% (V/V)	105	0,0	4,5	0,9
Sulphur content	mg/kg	105	0,3	46,4	9,2
Samples with sulphur content:					
- to 10 mg/kg		76	0,3	9,8	5,0
- over 10 mg/kg		29	10,5	46,4	20,1

Table 5: Monitoring results – Petrol Super 95

Property	Unit	Sample number	Min.	Max.	Mean
Year 2004					
Research Octane Number		114	94,3	97,5	95,5
Motor Octane Number		114	85,8	87,2	86,5
Density at 15°C	kg/m ³	114	738,9	771,1	750,6
Vapour Pressure, DVPE summer period only	kPa	56	49,3	62,3	56,4
Distillation:					
E 70 (Summer period)	% (V/V)	56	25,8	36,1	29,0
E 70 (Winter period)	% (V/V)	58	26,6	41,6	32,3
E 100	% (V/V)	114	47,0	58,9	50,5
E 150	% (V/V)	114	77,2	88,3	81,5
Hydrocarbon types:					
- Olefins	% (V/V)	114	4,6	16,3	9,2
- Aromatics	% (V/V)	114	29,7	44,1	35,3
- Benzene	% (V/V)	114	0,5	1,0	0,8
Oxygenates content	% (V/V)	114	0,6	12,8	2,7
Sulphur content	mg/kg	114	1,7	69,3	7,1
Samples with sulphur content:					
- to 10 mg/kg		106	1,7	9,6	5,0
- over 10 mg/kg		8	14,7	69,3	34,2
Year 2005					
Research Octane Number		103	94,4	96,7	95,5
Motor Octane Number		103	85,2	87,3	86,1
Density at 15°C	kg/m ³	103	737,5	756,4	748,2
Vapour Pressure, DVPE summer period only	kPa	53	45,3	73,3	51,4
Distillation:					
E 70 (Summer period)	% (V/V)	53	24,3	38,3	29,2
E 70 (Winter period)	% (V/V)	50	26,0	40,0	32,4
E 100	% (V/V)	103	47,2	59,1	51,5
E 150	% (V/V)	103	77,3	87,3	81,3
Hydrocarbon types:					
- Olefins	% (V/V)	103	3,7	16,8	11,1
- Aromatics	% (V/V)	103	27,4	36,9	32,9
- Benzene	% (V/V)	103	0,4	1,3	0,7
Oxygenates content	% (V/V)	103	0,2	11,1	3,8
Sulphur content	mg/kg	103	0,6	37,1	6,2
Samples with sulphur content:					
- to 10 mg/kg		92	0,6	8,0	3,4
- over 10 mg/kg		11	19,7	37,1	29,7

Table 6: Monitoring results - Petrol SuperPlus 98

Property	Unit	Sample number	Min.	Max.	Mean
Year 2004					
Research Octane Number		10	98,0	100,0	98,8
Motor Octane Number		10	89,0	90,2	89,5
Density at 15°C	kg/m ³	10	749,8	774,5	760,3
Vapour Pressure, DVPE summer period only	kPa	3	51,6	58,4	55,5
Distillation:					
E 70 (Summer period)	% (V/V)	3	24,7	37,3	32,3
E 70 (Winter period)	% (V/V)	7	25,3	37,5	31,5
E 100	% (V/V)	10	48,0	59,3	53,8
E 150	% (V/V)	10	77,3	87,9	82,1
Hydrocarbon types:					
- Olefins	% (V/V)	10	2,1	8,5	4,1
- Aromatics	% (V/V)	10	33,0	42,0	36,9
- Benzene	% (V/V)	10	0,3	0,7	0,5
Oxygenates content	% (V/V)	10	9,3	14,0	11,7
Sulphur content	mg/kg	10	0,8	5,6	3,4
Year 2005					
Research Octane Number		28	96,8	100,2	98,8
Motor Octane Number		28	88,0	90,7	89,3
Density at 15°C	kg/m ³	28	745,3	757,5	751,1
Vapour Pressure, DVPE summer period only	kPa	15	44,8	68,1	53,7
Distillation:					
E 70 (Summer period)	% (V/V)	15	25,7	42,0	31,4
E 70 (Winter period)	% (V/V)	13	27,3	43,5	36,9
E 100	% (V/V)	28	49,5	64,9	56,0
E 150	% (V/V)	28	78,5	93,6	84,3
Hydrocarbon types:					
- Olefins	% (V/V)	28	2,7	11,7	6,1
- Aromatics	% (V/V)	28	28,4	37,7	32,8
- Benzene	% (V/V)	28	0,4	0,8	0,5
Oxygenates content	% (V/V)	28	8,8	14,7	11,6
Sulphur content	mg/kg	28	0,2	7,4	2,7

The presentation of the distribution of parameter values in the framework of taken samples set provides histograms, which were created from selected test data. Distribution of research octane number (RON) and motor octane number (MON) for all samples of Super 95 in 2004 (totally 114 samples) and 2005 (totally 103 samples) is illustrated in Fig. 5 and Fig. 6. The similar data for cetane number of diesel is shown in Fig. 7 and Fig. 8. Distributions of cetane number at summer and winter diesel samples are different, and therefore this data is reported separately.

Figure 5: Distribution of Research Octane Number values for all Super 95 samples in summer and winter period of 2004 and 2005

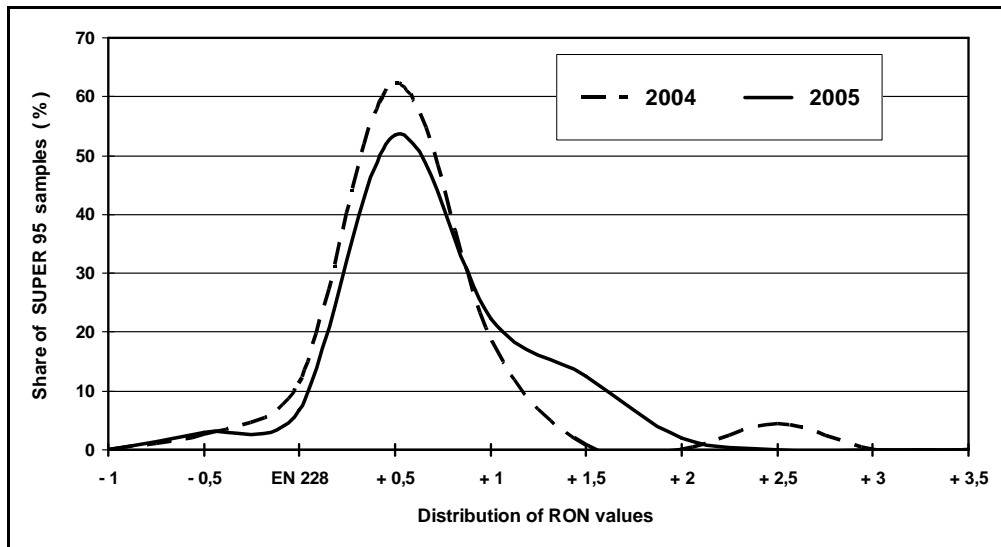


Figure 6: Distribution of Motor Octane Number values for all Super 95 samples in summer and winter period of 2004 and 2005

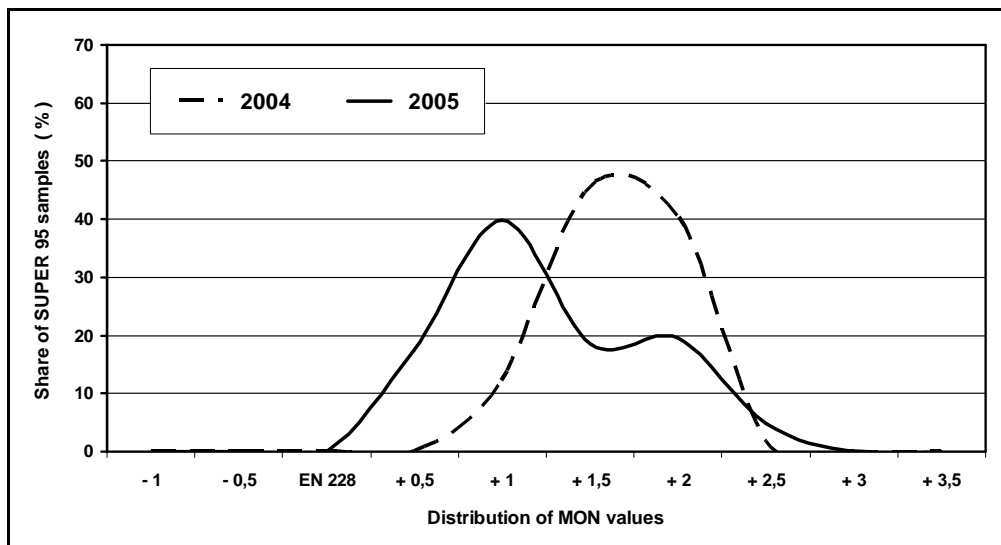


Figure 7: Distribution of cetane number values of all taken diesel samples in summer (S) and winter (W) period of 2004

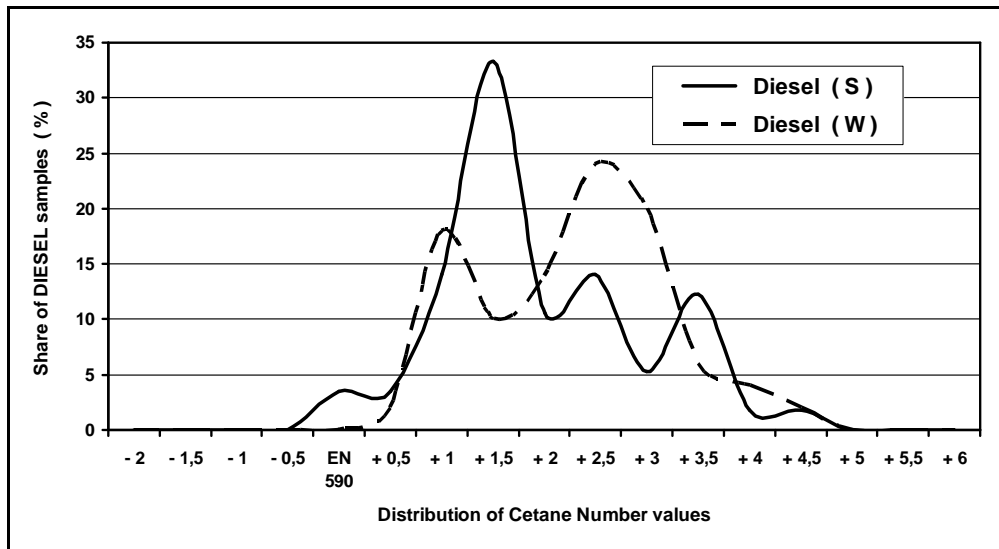


Figure 8: Distribution of cetane number values of all taken diesel samples in summer (S) and winter (W) period of 2005

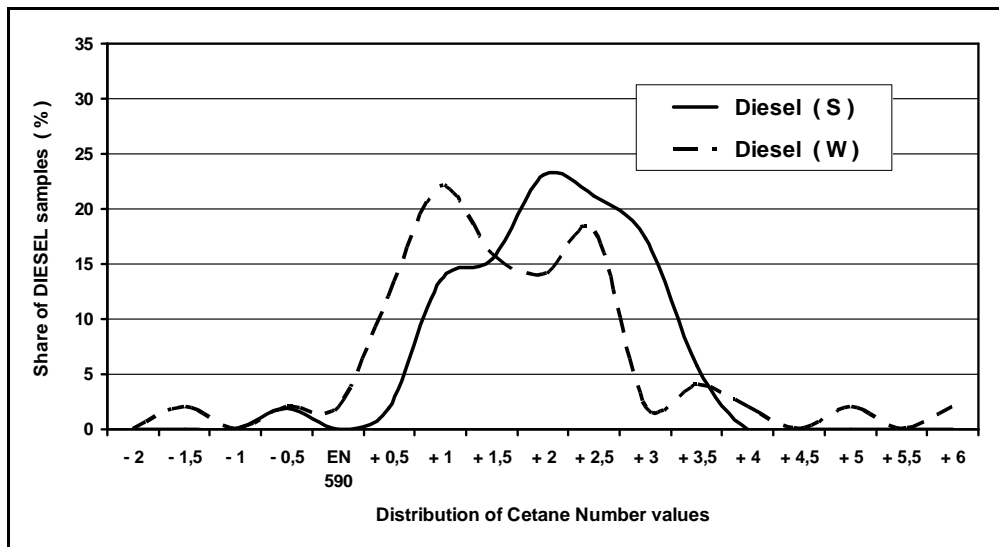


Table 7: Percentage share and values of motor fuel samples in Slovak filling station network in 2004 and 2005, which breached the tolerance limits

Fuel grade	Property	Value	Share (%)
Summer period of 2004			
Super 95	Research octane number	94,3	3,57
Super 95	Research octane number	94,5	
Super 95	Vapour Pressure, DVPE	62,3 kPa	1,79
Diesel	Sulphur content	438,7 mg/kg	3,51
Diesel	Sulphur content	1167 mg/kg	
Winter period of 2004			
Normal 91 AVSRA	Research octane number	90,5	1,64
Super 95	Research octane number	94,4	1,72
Summer period of 2005			
SuperPlus 98	Research octane number	96,8	6,67
Super 95	Research octane number	94,4	3,77
Super 95	Research octane number	94,4	
Normal 91 AVSRA	Research octane number	90,2	1,82
SuperPlus 98	Vapour Pressure, DVPE	68,1 kPa	13,33
SuperPlus 98	Vapour Pressure, DVPE	64,6 kPa	
Normal 91 AVSRA	Vapour Pressure, DVPE	63,6 kPa	3,64
Normal 91 AVSRA	Vapour Pressure, DVPE	62,7 kPa	
Winter period of 2005			
Super 95	Research octane number	94,5	2,00
SuperPlus 98	Aromatics content	37,7 % (V/V)	7,70
Super 95	Benzene content	1,3 % (V/V)	2,00
Diesel	Sulphur content	130,8 mg/kg	2,00

5. Conclusion

Fuel quality monitoring system of petrol and diesel fuels sold at filling stations in Slovakia was introduced and completely realized in 2004 after admission of Slovak Republic into European Union. Monitoring was performed also in 2005 in accordance with European Union legislation transposed into the Directive of Ministry of Environment of Slovak Republic No. 53/2004 and with the European Standards 14274 and 14275.

On the base of the reported data in the tables it is possible to assert that at the time being majority of sold motor fuels fulfils the requirement in term of sulphur content limit 10 mg/kg and therefore according to trend in Slovakia "sulphur-free fuels" will be available on market in full range before required term 1.1.2009.

Results reported in tables 3 - 7 show that percentage share of samples which after including of test reproducibility and standard enactments EN ISO 4259 [4] do not

fulfil the requirements of the Directive of Ministry of Environment of Slovak Republic No. 53/2004, was relatively low.

The percentage share of unfit samples in 2005 shows a slight increase and in the case of one parameter (vapour pressure) overreached 10 % level, but is completely comparable with analogous results of European Union member states, which apply obligatory monitoring system [5, 6].

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UDK	ključne riječi	key words
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