

Changes in quality parameters during the aging of commercial motor gasolines containing ethanol and/or ethers

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Original article

Abstract

This publication presents the results of the assessment of the tendency to form deposits in the combustion chamber of fuel determined by the TGA FLTM BZ-154-01 method for commercial motor gasolines with a research octane number (RON) 95, 100 and 98, produced by Polish leading fuel producers, in the context of changing the quality parameters resulting from aging of fuel, specified by the subject standard for motor gasoline EN 228: 2013-04 such as density, distillation, vapour pressure, induction period and the content of unwashed gums. Aging of commercial motor gasolines, containing ethanol and/or ethers (MTBE, ETBE) available at Polish fuel stations, with a minimum research octane number 95, 100 and 98 for a period of four months under the assumed conditions, did not increase their tendency to form deposits in the combustion chamber of the engine, determined by the TGA FLTM BZ-154-01 method. However, the aging of gasolines was accompanied by a change (deterioration) of other properties important from the point of view of the consumer, e.g. density, vapour pressure, gums content and distillation parameters.

Keywords

- commercial gasoline
- bio-components
- aging of gasoline

Authors' contributions

A – Preparation of the research project
B – Assembly of data for the research undertaken
C – Conducting of statistical analysis
D – Interpretation of results
E – Manuscript preparation
F – Literature review
G – Revising the manuscript

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Conflict of interest

None declared.

Introduction

Research on the relationship between gasoline composition, oxidation stability and deposit formation in spark-ignition engines remains an important research topic. Recent work on European gasoline containing 10% v/v ethanol has demonstrated relationships between fuel oxidation stability and deposit formation during engine-relevant testing, while studies of fuel storage have addressed the loss of oxidation stability and gum formation during prolonged storage [1,2]. Standardized laboratory and engine-based methods are available for assessing deposit formation, oxidation stability, gum content, distillation characteristics, oxygenates, research octane number and overall gasoline quality [3-13]. Current approaches to fuel-quality assessment combine regulatory requirements with standardized laboratory and engine tests. ASTM D6201-25 provides a dynamometer method for evaluating intake-valve deposit formation, whereas ASTM D525 and ASTM D381 are used to assess gasoline oxidation stability and gum content, respectively [3-5]. These methods complement the physicochemical parameters specified for marketed unleaded petrol by EN 228:2025 [10]. The interpretation of gum measurements requires caution because the measured residue may include oxidation products as well as non-volatile components originating from fuel additives. ASTM D381-25 explicitly notes that the test measures gum formed in or present in the sample under the test conditions and that the result is not, by itself, a direct predictor of induction-system deposits [5]. For this reason, laboratory measurements of oxidation stability and gum content should be interpreted together with deposit-formation tests when the objective is to assess the operational consequences of fuel aging [1,3-5]. Recent research has also shown that the oxidation stability of ethanol-containing European gasoline can be related to deposit formation under engine-relevant conditions, supporting the use of accelerated oxidation tests as complementary indicators of fuel degradation [1]. This publication presents the results of the assessment of the tendency to form deposits in the combustion chamber of fuel determined by the TGA FLTM BZ-154-01 method for commercial motor gasolines with a research octane number (RON) 95, 100 and 98, produced by leading fuel producers, in the context of changes in fuel quality during aging. The quality parameters investigated in this study are compared with the requirements of the standard applicable at the time of the study [13] and, where relevant, with current European and Polish fuel-quality requirements [10-12].

Materials and methods

Characteristics of motor gasolines

The subject of the research were samples of unleaded gasoline in the RON grade ≥ 95 (two gasolines) and RON ≥ 98 (five gasolines), produced by leading Polish fuel producers and offered on the Polish market. Table 1 shows the labelling of the samples with a brief description given by the manufacturer.

Table 1. Characteristics of motor gasoline samples

Labeling of the samples	Characteristics of unleaded gasolines, according to the manufacturer's data
A (95)	Contains a package of additives that protect the car engine against the formation of deposits and helps in more efficient burning of fuel.
B (95)	Contains a proprietary package of additives, which includes special ingredients with high efficiency in removing impurities and preventing the formation of deposits in the engine.
C (100)	Contains a proprietary package of additives with a friction modifier and a double-action formula that actively cleans and protects the engine.
D (98)	Contains: • friction modifier to improve the engine's efficiency; • detergents that keep the engine clean; • corrosion inhibitors to protect the engine against corrosion and wear.
E (98)	Contains oxygen compounds (up to 5 vol. % ethanol and up to 15 vol. % ethers) and additives with antioxidant and washing properties.
F (98)	Contains particles that remove impurities in the following way: • particles adhere to impurities, pulling them away from the essential parts of the engine; • particles adhere to the clean metal surfaces of the engine, creating a protective layer that prevents the re-deposition of pollutants.
G (98)	Contains carefully selected additives with performance: • washing (detergent) – ensuring maintenance of the inlet and injection system of the engine, guaranteeing the elimination of deposits created during the use of fuel of unknown origin and without detergents; • anticorrosive – protecting elements of the supply, combustion and exhaust systems against corrosion; • antioxidant – protecting the fuel against degradation during storage.

Test methods

The work involved testing gasoline samples produced during the period of validity of the EN 228: 2013 standard, hence the testing methods given in the older version of the EN 228: 2013 [13] standard were used. It should be noted that in the latest version of the standard, references to international standards (e.g. ISO/EN procedures for determining fractional composition, oxide content or volatility) were updated, replacing the older measurement procedures with newer, more precise variants [10]. In order to evaluate the change in physicochemical and functional properties of motor gasolines in the grades RON $\geq$ 95 (unleaded gasoline 95) and RON $\geq$ 98 (unleaded gasoline 98), two series of tests were carried out. The first series concerned non-aged motor gasolines. In the second series, motor gasoline aged for a period of 4 months was tested. The aging of gasolines was carried out in transparent, clear glass bottles, 2000 ml (DURAN in accordance with DIN ISO 4796), filled with 50% gasoline (1000 ml). The bottles were not hermetically sealed but opened by unscrewing the stopper (1 turn). During the aging process bottles were stored in a bright storage room, but not exposed directly to sunlight. The room temperature was constant at 25°C, humidity 55%–65% and atmospheric pressure prevailed. The sample loss after aging was monitored. The test methods listed in Table 2 were used to evaluate the tendency of gasolines to form deposits in the combustion chamber of the engine and the quality parameters of the gasoline samples.

Table 2. Test methods

Properties	Test method
Vapour pressure	ASTM D 4953 procedure B
Distillation characteristics	EN ISO 3405
Density at 15°C	EN ISO 3675
Oxygenates content	EN 1601
Induction period	ISO 7536
Unwashed and existent gum content	EN ISO 6246
Tendency of gasoline to form deposits in the combustion chamber of the engine – TGA residue at 450°C (%)	Ford Method TGA FLTM BZ 154-01

Results and discussion

The obtained results of the tests of motor gasolines properties before aging (initial samples) are given in Tables 3 and 4, while the obtained results of the tests of the gasoline aged properties (after 4 months of storage) are given in tables 5 and 6. Quality parameters determined in this work, including vapour pressure, distillation, density, oxygen/oxygenate content, induction period and existent gums, were evaluated against the requirements of the standard applicable at the time of the study [13]. For comparison with current market requirements, the results can also be interpreted in relation to EN 228:2025 and the current Polish quality requirements for liquid fuels [10,11]. The current ORLEN specification for unleaded petrol 95 provides an example of how these requirements are applied by a major fuel supplier in Poland and lists, among others, limits for density, oxidation stability, washed gums, oxygen content, vapour pressure and distillation parameters [14].

Table 3. Properties of motor gasoline RON $\geq$ 95 before aging

Properties	A (95)	B (95)	Requirements acc. to EN 228:2013-04 [38]
Vapour pressure, DVPE, kPa	58.6	59.1	max. 60.0 summer period
Distillation, recovered vol. % at °C			
Initial boiling point (IBP)	37.1	37.4	–
5	48.6	48.2	–
10	51.7	50.2	–
20	56.3	54.9	–
30	64.9	59.9	–
40	81.8	72.8	–
50	98.8	89.7	–
60	114.7	106.6	–
70	129.3	125.6	–
80	146.1	144.4	–
90	166.8	166.1	–
95	183.4	185.4	–
Final boiling point (FBP)	202.7	204.1	max. 210
Distillation residue, vol. %	1.1	1.1	max. 2.0

Properties	A (95)	B (95)	Requirements acc. to EN 228:2013-04 [38]
Distillation loss, vol. %	1.4	1.3	–
Evaporated at 70°C, E70, vol. %	34.7	39.5	Summer period 20.0–48.0 (E5)*
Evaporated at 100°C, E100, vol. %	52.1	57.3	Summer period 46.0–71.0 (E5)*
Evaporated at 150°C, E150, vol. %	83.4	84.0	min.75.0
Density at 15°C, kg/m ³	753	752	720.0–775.0
Oxygenates content, vol. %			
methyl tert-butyl ether (MTBE)	0.6	<0.17	max. 15.0 (E5)*
ethyl tert-butyl ether (ETBE)	1.6	5.0	
ethanol (EtOH)	2.1	1.6	max. 5.0 (E5)*
Oxygen content, wt. %	1.12	1.37	max. 2.7 (E5)*
Induction period, minute	>360	>360	>360
Existent gum content, mg/100 ml	<1	<1	max. 5
Unwashed gum content, mg/100 ml	29	33	max. 30**
Tendency of gasoline to form deposits in the combustion chamber of the engine, TGA residue at 450°C, %	7.23	12.43	max. 20**

* E5 – unleaded gasoline with oxygen content.

** – according to WWFC [15] for 3, 4, 5 fuel category.

Changes in the gasoline parameters studied, which are the result of aging, are discussed below.

The vapour pressure

At the beginning of the storage period, the vapour pressure of the motor gasoline samples was 55.3–59.1 kPa. After 4 months of storage, a significant decrease was observed, with values of 16.8–45.7 kPa (Fig.1). The main reason for this decrease was most probably the loss of light fractions resulting from the lack of full encapsulation of the containers. A volume loss of approximately 9–15 ml (maximum 1.5%) was observed and was consistent with the changes in distillation characteristics. The current European and Polish fuel specifications define volatility requirements that are important for the usability of gasoline [10,11,13].

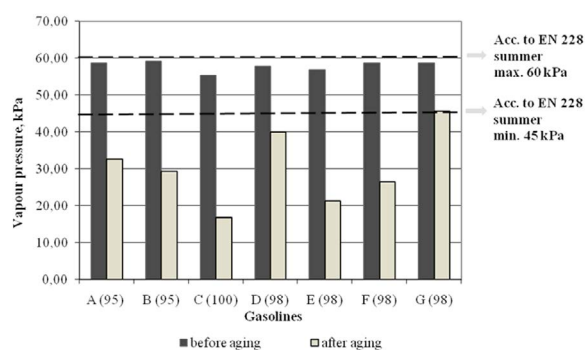


Figure 1. Changes in the vapour pressure of motor gasoline pairs RON≥95 and RON≥ 98 during 4 months of storage

Table 4. Properties of motor gasolines RON ≥ 98 before aging

Properties	C (100)	D (98)	E (98)	F (98)	G (98)	Requirements acc. to EN 228:2013-04 [38]
Vapour pressure, DVPE, kPa	55.3	57.9	56.8	58.6	58.6	45.0–60.0 summer period
Distillation, recovered vol. % at °C						
Initial boiling point (IBP)	36.0	35.9	35.7	37.1	36.6	–
5	50.6	47.8	49.1	49.1	49.0	–
10	55.6	51.6	53.0	52.3	52.0	–
20	63.8	58.5	58.7	57.1	56.5	–

Properties	C (100)	D (98)	E (98)	F (98)	G (98)	Requirements acc. to EN 228:2013-04 [38]
30	72.1	66.7	65.0	64.1	63.6	–
40	82.3	77.7	73.4	81.0	79.6	–
50	94.1	80.4	84.3	98.1	97.2	–
60	109.0	104.7	99.0	111.4	111.1	–
70	126.5	118.9	118.4	122.8	122.6	–
80	143.6	133.3	135.1	135.8	136.5	–
90	162.0	151.8	150.5	155.6	155.3	–
95	174.8	166.7	162.9	173.0	170.2	–
Final boiling point (FBP)	192.3	186.2	183.9	188.2	190.5	max. 210
Distillation residue, vol. %	1.0	1.0	1.0	1.0	1.0	max. 2.0
Distillation loss, vol. %	1.7	1.5	1.6	1.9	1.6	–
Evaporated at 70°C, E70, vol. %	29.3	34.7	37.9	36.1	36.1	summer period 20.0–48.0 (E5)
Evaporated at 100°C, E100, vol. %	55.9	58.2	62.2	53.1	53.4	summer period 46.0–71.0 (E5)
Evaporated at 150°C, E150, vol. %	85.1	90.7	91.3	89.8	88.8	min. 75.0
Density at 15°C, kg/m ³	749	747	745	754	752	720.0–775.0
Oxygenates content, vol. %						
methyl tert-butyl ether (MTBE)	<0.17	0.4	<0.17	<0.17	<0.17	max. 15.0 (E5)*
ethyl tert-butyl ether (ETBE)	13.5	9.3	14.3	4.8	4.3	
ethanol (EtOH)	<0.17	1.1	<0.17	1.9	4.1	
Oxygen content, wt. %	2.13	1.91	2.24	1.44	2.17	max. 2.7 (E5)*
Induction period, minute	>360	>360	>360	>360	>360	min. 360
Existent gum content, mg/100 ml	<1	<1	<1	<1	<1	max. 5
Unwashed gum content, mg/100 ml	93	37	36	49	20	max. 30**
Tendency of gasoline to form deposits in the combustion chamber of the engine, TGA residue at 450°C, %	9.61	12.98	12.44	9.96	8.10	max. 20**

* E5 – unleaded gasoline with oxygen content.

** – according to WWFC [15] for 3, 4, 5 fuel category.

Table 5. Properties of motor gasolines RON ≥ 95 after 4 months of aging

Properties	A (95)	B (95)	Requirements acc. to EN 228:2013-04 [38]
Vapour pressure, DVPE, kPa	32.7	29.4	45.0–60.0 summer period
Loss of volume during aging, ml/4 month	11	14	–
Distillation, recovered vol. % at °C			–
Initial boiling point (IBP)	49.5	51.3	–
5	63.7	67.8	–
10	71.6	76.1	–
20	86.1	89.2	–
30	98.0	99.9	–
40	109.2	110.8	–
50	119.8	122.2	–
60	130.5	133.2	–
70	142.6	145.5	–

Properties	A (95)	B (95)	Requirements acc. to EN 228:2013-04 [38]
80	155.6	157.7	–
90	171.8	175.1	–
95	187.2	192.0	–
Final boiling point (FBP)	208.6	215.2	max. 210
Distillation residue, vol. %	1.1	1.1	max. 2.0
Distillation loss, vol. %	1.1	1.1	–
Evaporated at 70°C, E70, vol. %	9.2	8.1	summer period 20.0–48.0 (E5)*
Evaporated at 100°C, E100, vol. %	32.6	30.0	summer period 46.0 – 71.0 (E5)*
Evaporated at 150°C, E150, vol. %	77.3	77.6	min. 75.0
Density at 15°C, kg/m ³	780	788	720.0 – 775.0
Induction period, minute	>360	>360	min. 360
Existent gum content, mg/100 ml	<1	<1	max. 5
Unwashed gum content, mg/100 ml	49	58	max. 30**
Tendency of gasoline to form deposits in the combustion chamber of the engine, TGA residue at 450°C, %	8.32	12.49	max. 20**
Oxygenates content, vol. %			
methyl tert-butyl ether (MTBE)	0.6	<0.17	max. 15.0 (E5)*
ethyl tert-butyl ether (ETBE)	1.6	5.0	
ethanol (EtOH)	2.1	1.6	max. 5.0 (E5)*
Oxygen content, wt. %	1.12	1.37	max. 2.7 (E5)*

* E5 – unleaded gasoline with oxygen content.

** – according to WWFC [15] for 3, 4, 5 fuel category.

Table 6. Properties of motor gasolines RON ≥ 98 after 4 months of aging

Properties	C (100)	D (98)	E (98)	F (98)	G (98)	Requirements acc. to EN 228:2013-04 [38]
Vapour pressure, DVPE, kPa	16.8	40.0	21.4	26.5	45.7	45.0–60.0 summer period
Loss of volume during aging, ml/4 month	15	10	15	12	9	
Distillation, recovered vol. % at °C						
Initial boiling point (IBP)	60.8	41.7	56.5	52.8	41.2	–
5	82.5	59.4	77.6	69.2	55.1	–
10	88.2	65.6	83.8	78.0	58.3	–
20	95.4	76.0	91.1	91.1	65.7	–
30	103.0	86.6	98.6	101.1	79.6	–
40	112.6	97.9	108.1	109.6	94.7	–
50	123.4	109.5	118.9	117.5	107.5	–
60	134.3	119.9	129.3	124.5	117.7	–
70	144.7	130.0	138.0	133.8	128.0	–
80	155.8	142.2	145.9	145.9	141.0	–
90	167.4	156.8	156.9	161.3	157.1	–
95	180.1	169.5	167.5	174.2	171.8	–
Final boiling point (FBP)	202.2	193.8	194.5	195.4	193.9	max. 210
Distillation residue, vol. %	1.0	1.0	1.0	1.0	1.0	max. 2.0
Distillation loss, vol. %	1.4	1.2	1.2	1.1	1.2	–

Properties	C (100)	D (98)	E (98)	F (98)	G (98)	Requirements acc. to EN 228:2013-04 [38]
Evaporated at 70°C, E70, vol. %	2.1	15.4	3.4	5.7	22.7	summer period 20.0–48.0 (E5)
Evaporated at 100°C, E100, vol. %	27.2	42.6	31.1	28.9	43.4	summer period 46.0–71.0 (E5)
Evaporated at 150°C, E150, vol. %	76.9	83.8	84.7	87.7	83.8	min.75.0
Density at 15°C, kg/m ³	796	776	799	788	767	720.0–775.0
Induction period, minute	>360	>360	>360	>360	>360	min. 360
Existent gum content, mg/100 ml	<1	<1	<1	<1	<1	max. 5
Unwashed gum content, mg/100 ml	161	55	68	80	28	max. 30**
Tendency of gasoline to form deposits in the combustion chamber of the engine, TGA residue at 450°C, %	10.75	13.30	12.78	10.36	8.87	max. 20**
Oxygenates content, vol. %						
methyl tert-butyl ether (MTBE)	<0.17	0.4	<0.17	<0.17	<0.17	max. 15.0 (E5)*
ethyl tert-butyl ether (ETBE)	13.5	9.3	14.3	4.8	4.3	
ethanol (EtOH)	<0.17	1.1	<0.17	1.9	4.1	max. 5.0 (E5)*
Oxygen content, wt. %	2.13	1.91	2.24	1.44	2.17	max. 2.7 (E5)*

* E5 – unleaded gasoline with oxygen content.

** – according to WWFC [15] for 3, 4, 5 fuel category.

Distillation

It was found that aging changed the distillation characteristics of the tested gasolines. An increase in the initial boiling point (IBP) and final boiling point (FBP) was observed. In general, the distillation curves for aged gasolines shifted towards higher temperatures at the same degree of evaporation, particularly below 150°C, indicating a loss of light fractions (Figures 2–8). Such changes are consistent with the role of distillation characteristics as a key quality parameter of spark-ignition engine fuels [6,10].

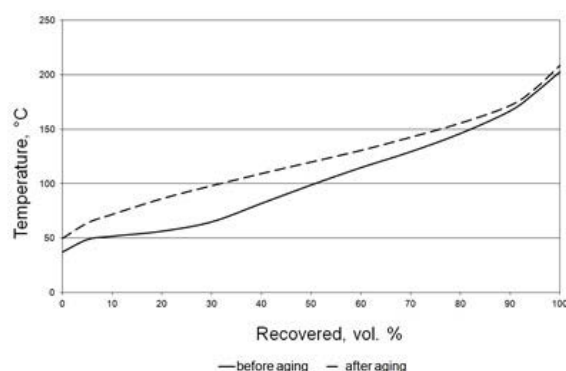


Figure 2. Distillation curves for A (95) gasoline

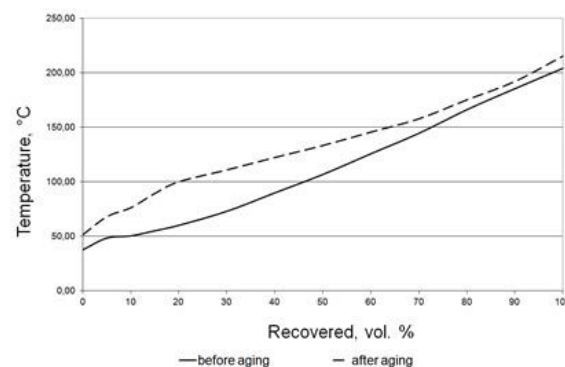


Figure 3. Distillation curves for B (95) gasoline

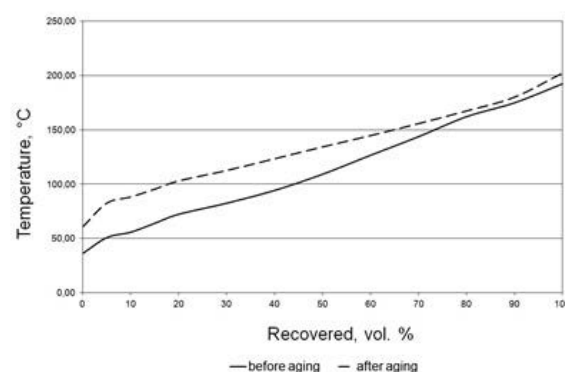


Figure 4. Distillation curves for C (100) gasoline

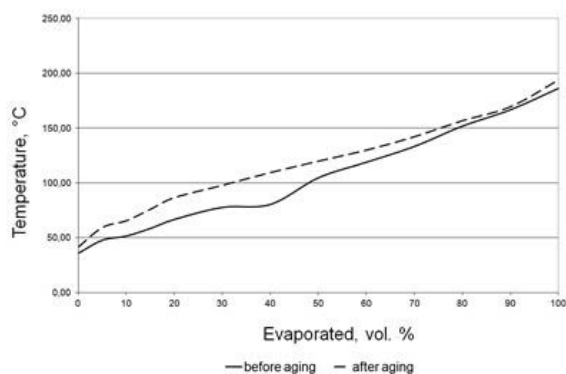


Figure 5. Distillation curves for D (98) gasoline

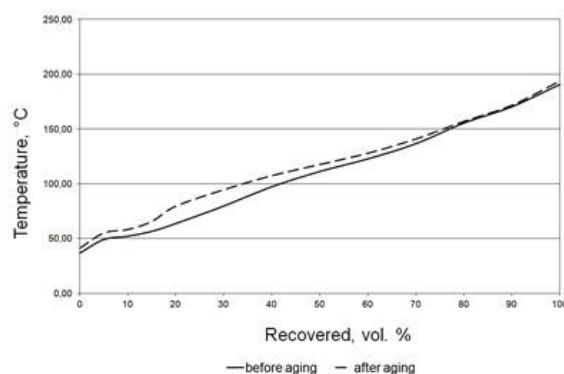


Figure 8. Distillation curves for G (98) gasoline

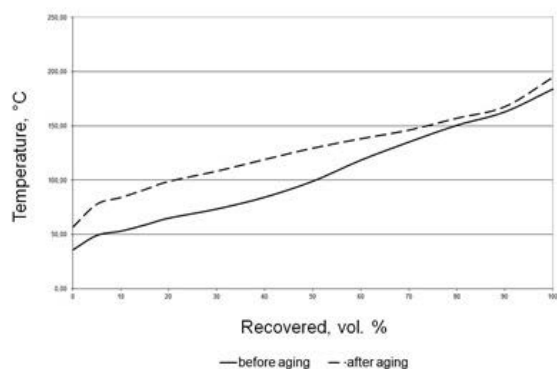


Figure 6. Distillation curves for E (98) gasoline

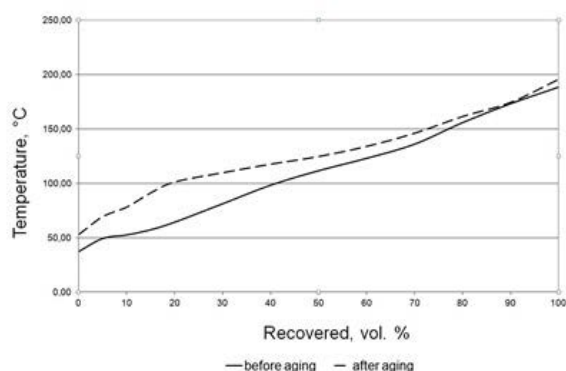


Figure 7. Distillation curves for F (98) gasoline

The loss of light fractions during aging significantly influenced parameters describing gasoline volatility, including E70, E100 and E150. These parameters decreased in relation to non-aged gasoline (Figures 9–11). After aging, most samples no longer met the relevant volatility requirements used for the gasoline grade evaluated in this study. The current European standard EN 228:2025 and Polish requirements specify volatility-related limits for marketed unleaded petrol [10,11]. In the case of distillation residue, all motor gasolines before and after aging remained below 2 vol. %. The current EN 228 framework also includes distillation residue among the quality parameters used for unleaded petrol [10].

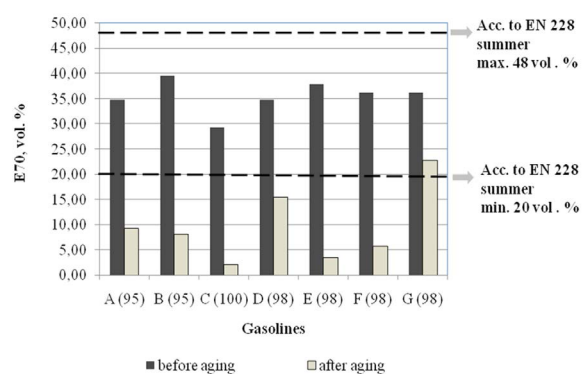


Figure 9. Parameter E70 for motor gasolines

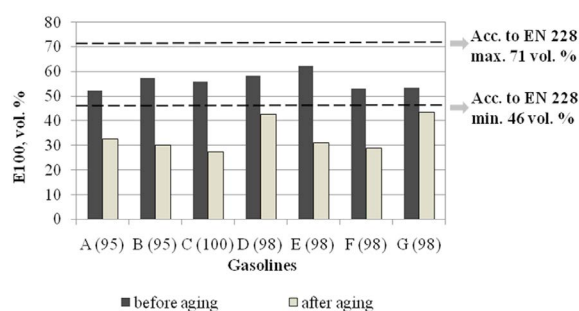


Figure 10. Parameter E100 for motor gasolines

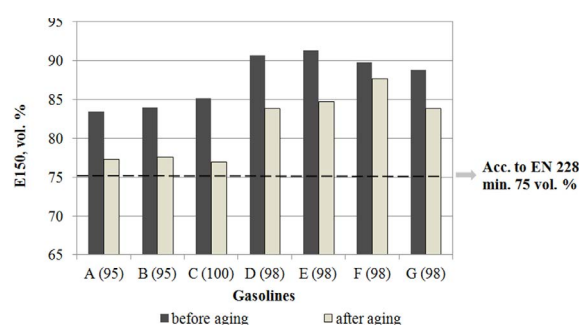


Figure 11. Parameter E150 for motor gasolines

Density

An increase in density was observed for all gasoline samples during 4 months of storage. The most probable explanation is the preferential evaporation of light fractions. For gasoline G (98) and D (98), density remained within the upper limit used in the applicable requirements, whereas the other samples exceeded 775.0 kg/m³, as present at Figure 12. Density is also a regulated quality parameter in the current Polish requirements and in the specifications of marketed gasoline [11,13].

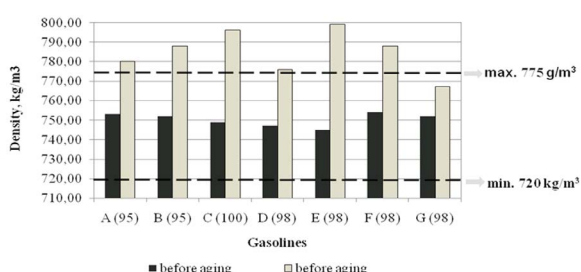


Figure 12. Changes in the density of gasolines RON≥95 and RON≥ 98 during 4 months of storage

Induction period

For all gasoline samples, both before and after aging, the induction period remained above 360 minutes. Thus, the samples met the corresponding requirement used in the study [13] and the current Polish minimum requirement for oxidation stability [11]. ASTM D525-12a(2025) confirms that the induction period is used as an indicator of the tendency of motor gasoline to form gum during storage, while noting that the correlation depends on fuel and storage conditions [4].

Content of unwashed existent gums and washed with n-heptane existent gums

For all tested non-aged motor gasolines, the content of unwashed gums was assessed (Fig. 13). After aging, this parameter increased for all gasolines except gasoline G (98), for which the value remained at 28 mg/100 ml. In general, the content of unwashed gums increased by approximately 25–100% compared with non-aged gasoline. Because EN 228:2013 specifies washed/existent gum rather than a 30 mg/100 ml limit for unwashed gums, this value should be treated as a comparative research criterion rather than as a current regulatory limit [5,10,11,15].

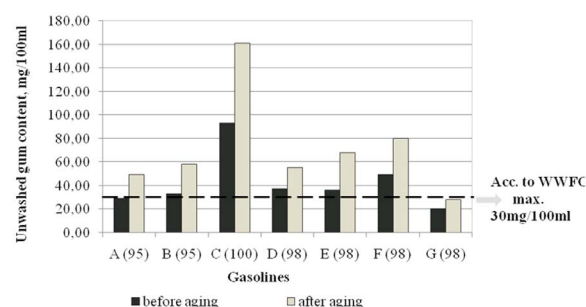


Figure 13. Content of unwashed gums in motor gasolines

Unwashed-gum measurements in commercial gasolines containing additive packages should be interpreted with caution because the measured residue may include non-volatile components originating from additives as well as products formed during storage [5]. The increase in unwashed gums after aging may therefore result from chemical changes in the fuel and/or from concentration effects associated with evaporation of light fractions. All samples of the test gasolines after washing with n-heptane obtained values of exist-

ent gums at a preferably low level well below the 5 mg/100 ml limit. As a result of aging, the parameter: induction period did not deteriorate.

The tendency to form deposits in the combustion chamber

It was a key parameter designated in this work. Based on the results of the BZ-154-01 test, it was found that all tested gasolines were characterized by a low tendency to form deposits in the combustion chamber of the engine (TGA residue at 450°C (%) below 20 %). In addition, no deterioration of this parameter was observed for gasoline samples after aging. It is noteworthy, however, that among the studied gasolines, the highest tendency to form deposits in the combustion chamber was demonstrated by gasoline D (98), both before and after aging. The obtained results are depicted in Figure 14.

Previous work on gasoline oxidation and deposit formation has demonstrated that fuel oxidation stability and deposit-forming tendency are related but not interchangeable properties [1,3,4]. The present results likewise indicate that the increase in unwashed gums during storage was not accompanied by deterioration of the TGA residue at 450°C. This suggests that the TGA response and gum-content measurement characterize different aspects of the aged fuel.

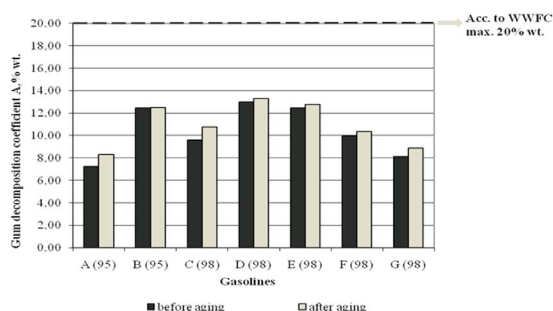


Figure 14. Tendency of gasolines to form deposits in the engine combustion chamber expressed with TGA residue at 450°C (%)

Conclusions

Despite changing requirements for motor fuels, the obtained research results can significantly contribute to increasing knowledge about the impact of gasoline aging on engine deposit formation. They allow us to

determine important parameters that change due to gasoline aging and the impact on engine deposit formation.

Aging of commercial motor gasolines, produced according to the requirements of the EN 228:2013 standard, containing ethanol and/or ethers (MTBE, ETBE) available at Polish fuel stations, with a minimum research octane number 95 and a minimum research octane number of 98 for a period of four months under the assumed conditions, did not increase their tendency to form deposits in the combustion chamber of the engine, determined by the BZ-154-01 method.

However, aging of the gasolines was accompanied by deterioration of several properties important from the consumer's point of view. The loss of light fractions resulted in changes in distillation characteristics and deterioration of E70 and E100. Other quality parameters, including density and vapour pressure, also deteriorated. These parameters remain important in current European and Polish requirements for marketed unleaded petrol [10,11].

For the non-aged gasolines, unwashed-gum contents were elevated in several samples. This parameter should not be interpreted as equivalent to the current regulatory limit for existent/washed gum. ASTM D381-25 specifically distinguishes gum measurement from a direct prediction of induction-system deposits, while current fuel requirements focus on the regulated gum parameter [5,10,11,15].

Aging increased the content of unwashed gums in all tested gasoline samples. However, for gasoline G (98) it was still in the range recommended by the Worldwide Fuel Charter (below 30 mg/100 ml). All samples of the test gasolines after washing with n-heptane obtained values of existent gums at a preferably low level well below the 5 mg / 100 ml limit. The induction period (as a parameter) did not deteriorate during aging.

It should be emphasized that inadequate sealing of containers or fuel tanks during gasoline storage can accelerate the loss of volatile components and contribute to deterioration of key fuel properties. Recent research on gasoline storage and oxidation confirms the importance of storage conditions for fuel stability, while industry guidance for marketed gasoline emphasizes controlled volatility and oxidation-stability requirements [1,2,4,13].

Data availability

The data underlying the results are available from the corresponding author upon reasonable request.

Use of AI tools

The authors declared that during the process of creating the publication they used AI tools (Google translator) for linguistic and stylistic correction.

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