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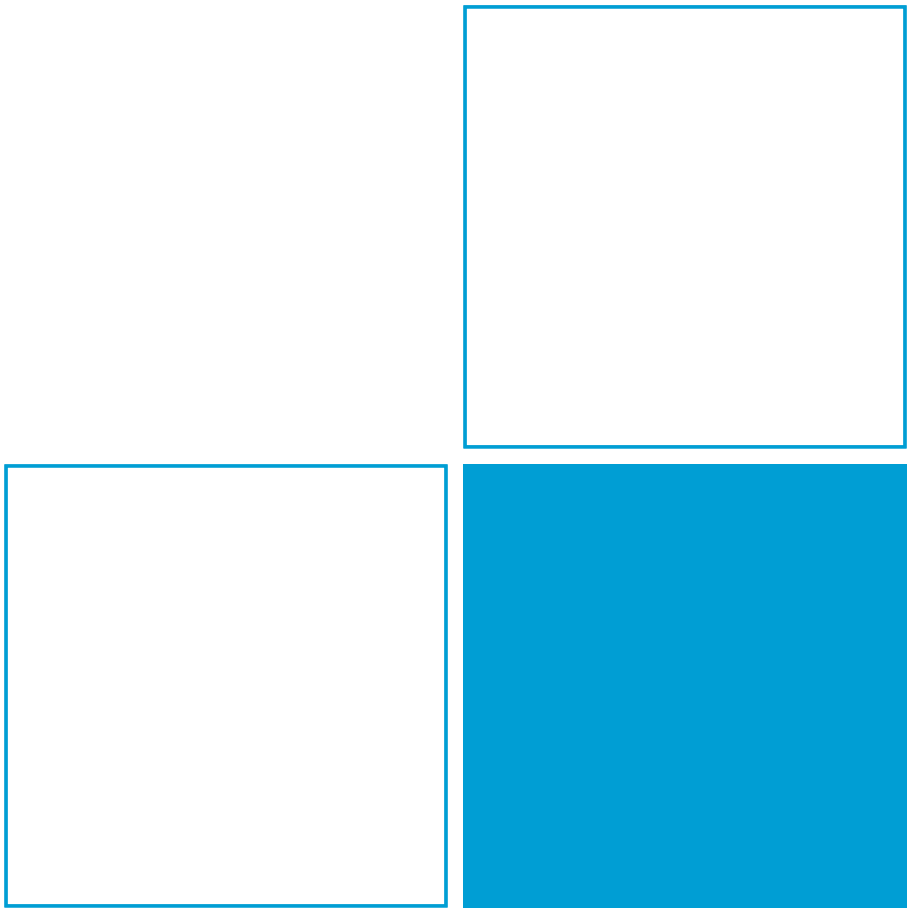
Henning Wolf

Transport properties of fuels



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Transport properties of fuels

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Fuel samples gathered throughout Germany to measure the transport quantities "density" and "viscosity"

Acknowledgement

The investigations described in this report would not have been possible without the support of external partners.

The bioethanol used was supplied by the *Südzucker* company. The different types of petrol were supplied by *Oiltanking Deutschland GmbH* through contacts with *Südzucker*. I would like to express my gratitude to Jörg Bernard for arranging this.

The different biodiesel types (among these also palm oil methyl ester imported directly from Malaysia) were supplied by *ASG Analytik-Service GmbH* thanks to negotiations by the then managing director of the association "*Arbeitsgemeinschaft Qualitätsmanagement Biodiesel*", Mr J. Haupt.

The companies *Shell Global Solutions (Germany) GmbH* and *Shell Deutschland Oil GmbH* supplied the basic fossil diesel fuels, both as winter- and as summer-grade fuels, as well as heating oil and coconut oil methyl ester. The companies *Shell* and *ADM Research GmbH* (I would like to express my particular gratitude to Jürgen Fischer) also provided diesel and biodiesel for a research project running parallel to ours at the European level (EMRP ENG09 Metrology for Biofuels). Special thanks go to Siegmar Witt (of *Shell Fuels Quality*) for his negotiating work and for the numerous very helpful conversations.

I would also like to thank Jan Ludzay from *DGMK,* the *Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V.* (*German Society for Petroleum and Coal Science and Technology*), who arranged and accompanied the large-scale collection of regional samples.

During the investigations, numerous discussions took place with representatives from the verification sector, members of the *Fachnormenausschuss Mineralöl und Brennstoffnormung* (*FAM – Technical Standardization Committee Petroleum and Fuel*) as well as with stakeholders from the petroleum industry and the petroleum trade sector who drew my attention to aspects of this field that had previously been unknown to me and, thus, influenced the course of these investigations. My thanks also go to them.

Last but not least, I would like to thank my colleague Stefan Heinsch for conducting all the measurements.

Table of Contents

1 Introduction, issues at stake

„*Vom Fachausschuß Mineralöl- und Brennstoffnormung wurde darauf hingewiesen, daß die in der Tafel 1 des Normblattes DIN 51 757 – Prüfung von Schmierölen, flüssigen Brennstoffen und verwandten Flüssigkeiten, Bestimmung der Dichte – angegebenen Dichte-Umrechnungsfaktoren nicht mehr für alle heutigen Kraftstoffe und ihre Komponenten zutreffen. Diese Tafel basiert auf den ASTM-IP-Petroleum Measurement Tables (Metric Edition) Table 53, London 1953.*

In der Physikalisch-Technischen Bundesanstalt sind auf Grund dieser Anregung Ausdehnungs-messungen an Mineralölprodukten vorgenommen worden. …“

"The Fachausschuss Mineralöl- und Brennstoffnormung's attention was drawn to the fact that the density conversion factors specified in Table 1 of the DIN 51 757 standard "Testing of mineral oils and related materials – Determination of density" no longer apply to all of today's fuels and their components. This table is based on the ASTM-IP Petroleum Measurement Tables (Metric Edition), Table 53, London 1953.

This has prompted the Physikalisch-Technische Bundesanstalt to carry out expansion measurements on petroleum products. ..."

This quotation is the introduction to a paper published in 1960 in the journal "*Erdöl und Kohle – Erdgas Petrochemie*" [1]. This statement has become topical again. Whereas in the 1950s and 1960s, everything revolved around the introduction of antiknock fuels, the preoccupation has meanwhile shifted to the introduction of "biofuels" that are added to conventional fossil fuels in order to reduce CO_2 emissions into the atmosphere.

The name "biofuel" has now established itself (although a more correct designation would be "agrofuel" which is, however, not particularly marketable) and will be used in this report to designate fuels which are generated by means of crops and then technically modified. An example of such a fuel is, on the one hand, "bioethanol" which, in Europe, is commonly produced on the basis of the sugar extracted from sugar beets, but also from cereals or potatoes. "Biodiesel", on the other hand, is produced by esterifying vegetable oils or animal fat/grease. In Europe, especially rapeseed methyl ester (RME), which is made from rapeseed oil, and soy methyl ester (SME), which is made from soybean oil, are relevant. On the European market, small amounts of palm oil methyl ester (PME) and of coconut methyl ester (CME) can also be found; other types of methyl ester are marginal niche products. Also, ethyl esters, which were first preferred to methyl esters, particularly in France, are widely underrepresented.

Fuels are usually measured volumetrically; since the volume is temperature-dependent, the values are converted to a standard temperature of 15 °C for trade. This temperature conversion requires the thermal expansion coefficient to be known. The easiest way to determine this coefficient is to measure the temperature-dependence of the density.

The technical product called "fuel" comes from a fossil source of natural origin; its composition therefore depends on the composition of the original natural product which varies from region to region. Standardization, based on a long tradition, has placed high requirements on the quality of the product and has set strict limits to the bandwidth of material parameters. It is therefore possible to

characterize fuels of nominally the same kind by indicating their density and by indicating a conversion factor – and by applying these values – to indicate the volume of the fuel (converted to 15 °C) within the prescribed limits of the maximum permissible errors prescribed by legal metrology.

Fuels from different origins, however, have slightly different compositions; this leads to a certain scattering of their density and thermal expansion coefficients.

The introduction of new fuel mixtures has raised the question – especially for the verification authorities – of whether the material parameters, the density and its temperature-dependence used to date for the verification of the volume measurement devices of shipping facilities and transport vehicles could still be used. These two parameters are very important for the conversion of amounts of substance measured gravimetrically into amounts of substance measured volumetrically and for the so-called "temperature conversion" – the conversion of a volume measured at a temperature t into a volume measured at the reference temperature 15 °C. In petroleum trade, quantities are determined both gravimetrically and volumetrically; legislations and EC directives now use the energy content to indicate quantities. Conversion requires the energy content per mass unit or per volume unit to be known. This issue will **not** be dealt with in this report.

The verification authorities' request for PTB to carry out measurements of the parameters mentioned led to a project within the scope of which thorough investigations of the density of various fuels and their mixtures with biofuels were conducted.

The measurements covered a temperature range from (as a rule) -20 °C to +50 °C; all measurements were carried out at atmospheric conditions. The temperature range chosen covers the temperature range which is necessary in Germany for considerations under the verification law (-10 °C to +50 °C); the results allow the thermal expansion coefficient to be stated for this temperature range.

In the case of petrol samples, it was necessary to limit the temperature range, since the vapour pressure of some of them lay above the ambient pressure at 50 °C, which caused them to boil. In the case of diesel samples, solid components were precipitated in the lower temperature range, which limited the density measurement.

Parallel to the density measurements, also the viscosity was measured. Knowing the viscosity is important in order to be able to characterize the transport behaviour of fuels, but also to optimize the spraying process inside the engine. Another motivation for measuring the viscosity was justified by the fact that the indication of the measured value of numerous volumetric instruments depends on the viscosity; for very accurate measurements, a correction for the viscosity value is therefore necessary – this applies to, among other things, helical turbine meters and turbine meters. As in the case of the density measurements, the temperature range aimed at also for the viscosity measurements was partly limited by boiling processes in the upper temperature range for petrol samples. For diesel samples, the viscosity measurements are strongly restricted in the lower temperature range due to precipitation processes; for this reason, the measurements were, as a rule, carried out at temperatures above 0 °C only.

Deviations in the measurement results from different fuel samples often originate from the chemical composition of the samples. It is not possible to perform accompanying chemical analyses of the analysed fuels at PTB. Due to the numerous samples, we also dispensed with having such investigations conducted at the same time at an external laboratory. Statements

made in the present report on the chemical behaviour and possible changes in the composition are therefore meant as indications for potential processes, but are not based on measurements we carried out.

2 Measurands, measuring ranges, measurement methods, measurement uncertainty

2.1 Density

The liquid's density was measured with a so-called "oscillation-type density meter" – an electronic densimeter.

In an oscillation-type density meter, a capillary tube (which is often U-shaped) is caused to oscillate mechanically. The resonance frequency of the oscillation depends, among other things, on the mass of the oscillating capillary tube. This mass changes when a liquid is filled into the tube. If it is ensured (by clamping the ends of the tube) that it is always the same section of the tube that oscillates, then also the oscillating inner volume inside the capillary tube remains the same. The change in the resonance frequency is, thus, a measure of the mass of the system tube + liquid which is changed by the liquid filled into the tube. If the volume is known, then the density of the liquid can be indicated directly. The volume, in turn, can easily be determined by means of two measurements with media of known density (in practice, mostly ultra-pure water and air).

Modern oscillation-type density meters are equipped with a temperature-control device for the measuring cell so that also the temperature dependence of the density can be measured automatically.

In the experiments described here, a modified DMA 5000 from the manufacturer *Anton Paar* was used. This instrument has a modified thermal decoupling of the measuring cell from the environment and is therefore well-suited for operation even at temperatures below 0 °C.

The temperature range covered by the measurements described here lies between -20 °C and +50 °C. For the considerations below, however, only the legally relevant range between -10 °C and +50 °C will be taken into account.

The measurement uncertainty is estimated to be 0.020 kg/m³. Hereby, the fact that no viscosity correction of the density values has been performed, since the viscosities of the measured fuels usually lie below 10 mPa s, has been taken into account.

Since at the time of the investigations, PTB was not yet equipped with calibration capabilities for the temperature range below 0 °C, it was necessary to extrapolate into this range so that the measurement uncertainty should be set at 0.050 kg/m³ in that range.

The quantity of liquid needed for each measurement is approx. 2 ml only. In order to be able to add more liquid into the device in case of doubt (e.g. if air bubbles have formed inside the instrument), we always worked with fully filled 10 ml syringes to inject the liquid into the measuring cell. When using plastic syringes, partial solution may occur if the liquid remains in the syringe for too long; we therefore used glass syringes.

The outlet of the measuring cell is connected with a thin hose of approx. 0.5 m in length which ends in a vessel filled with a fuel supply. The pressure compensation against the environment is ensured by a hole of 0.5 mm in diameter in the lid of the vessel. The hose and the vessel collect the sample when it is pressed out of the measuring cell upon completion of the measurement. The inlet of the measuring cell remains sealed by the syringe during the measurement. This arrangement minimizes the evaporation of parts of the sample. At the same time, the measuring cell of the oscillation-type

density meter is open against the environment via its outlet, which allows pressure compensation in the event of temperature variations. A change in the sample inside the measuring instrument (period spent: approx. 3 hours) due to evaporation can, thus, be precluded.At the beginning of the experiment, an additional check consisted in measuring the temperature dependence of the density by means of a measurement carried out at 20 °C, both at the beginning and at the end of the measurement series.

When filling the measuring instruments (which was done as described above, namely by drawing the liquid into a syringe and then injecting it into the instrument), changes in the liquid were minimized by handling it appropriately but could, however, not be fully ruled out. The opening of the syringe is open to the ambient air for the short way from the supply vessel to the measuring instrument and is hereby moved; therefore, evaporation in this opening cannot be fully prevented. The influence is minimized due to the fact that the liquid in the syringe opening is pressed through the measuring cell and is located behind the cell.

As an example of such a measurement series, Figure 2-1 shows the temperature dependence of pure mineral diesel ("B0", summer grade).

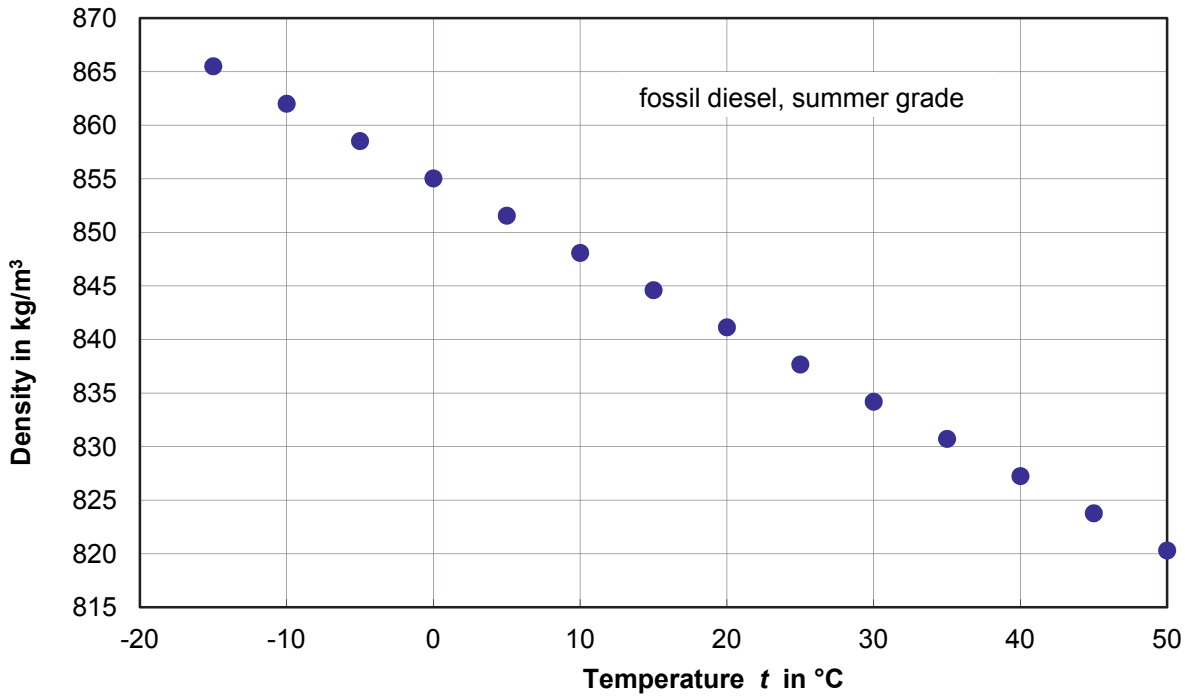


Fig. 2-1: Temperature dependence of the density of summer-grade fossil diesel. The measurement uncertainty is 0.02 kg/m³ (0.05 kg/m³ for temperatures below 0 °C) and is not visible in this plot.

2.2 Viscosity

The viscosity was measured using an SVM 3000 of the manufacturer Anton Paar. This instrument relies on an external rotating tube which is filled with the liquid to be measured; a cylinder is located in its axis so that the cylinder is "driven" by the liquid which is rotating together with the external tube. The revolution speed of this cylinder is read out electromagnetically. This attenuates the rotation of the

cylinder; the difference between the revolution speeds of the external tube and that of the cylinder is a measure of the viscosity of the coupling liquid.

The instrument used is able to cover the same temperature range as that used for the density measurement. Here too, the amount of liquid needed is approx. 10 ml. The filling procedure and the arrangement used to prevent evaporation and for pressure compensation are similar to those described for the density measurement.

The measurement uncertainty of the instrument was estimated as being 1 %; in the measuring range below 0 °C, an uncertainty of 3 % is to be expected.

As an example, Figure 2-2 shows the temperature dependence of the viscosity using the same sample as that in Fig. 2-1.

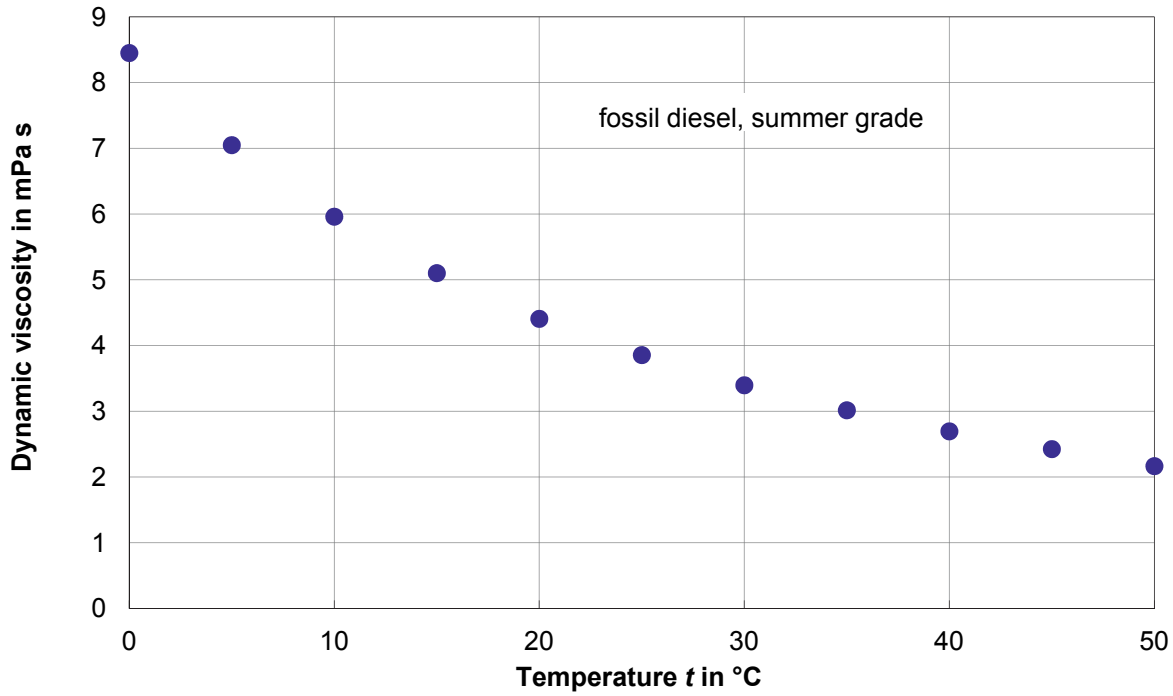


Fig. 2-2: Temperature dependence of the viscosity of summer-grade fossil diesel. The measurement uncertainty amounts to 1 % and is not visible in this plot.

3 Density and viscosity of pure alkanes

We will first describe fundamental dependences between the density and the thermal expansion coefficient and/or the viscosity using pure alkanes.

3.1 Density

The density of alkanes increases when the length of the carbon chain increases. In good approximation, the density is proportional to the reciprocal number of carbon atoms per molecule of alkane (see also Fig. 3-1).

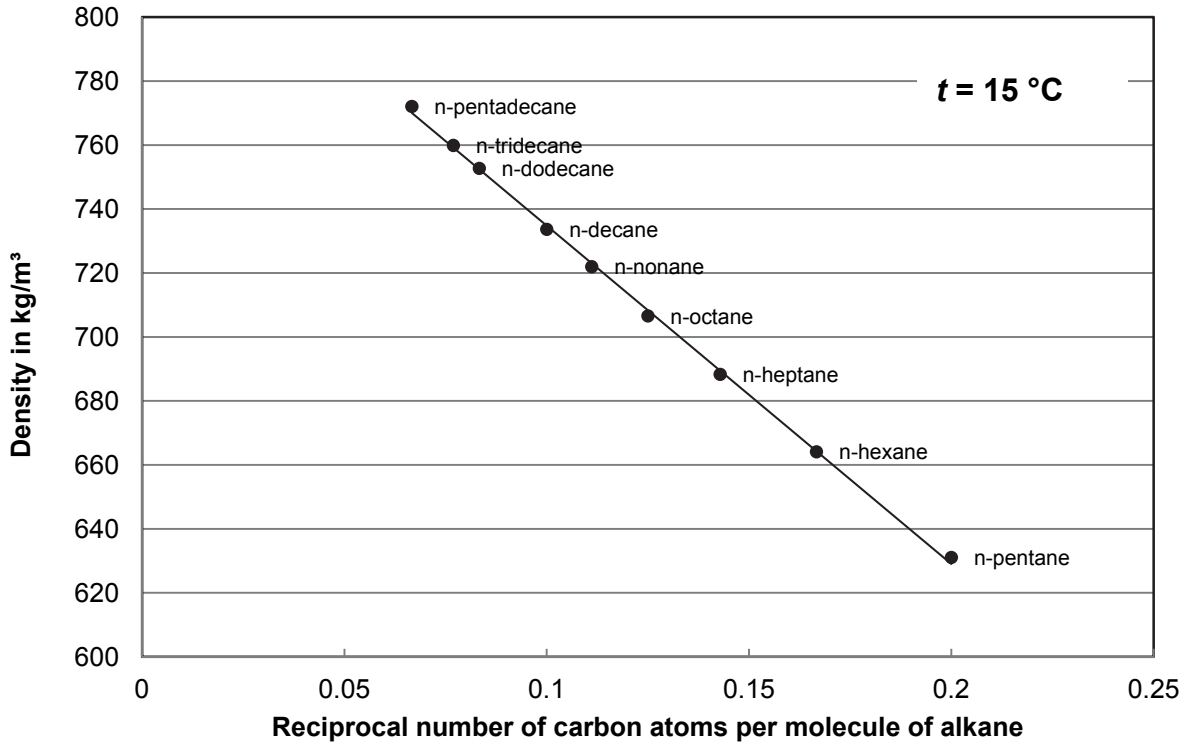


Fig. 3-1: Dependence of the density of alkanes on the carbon chain length. The functional relation can be represented in good approximation by a straight which is reciprocal to the carbon chain length.

The data in Fig. 3-1 are described by means of

ρ [kg/m³] = 840.51 - 1057.4 · n^{-1} n = number of carbon atoms per molecule of alkane

with a coefficient of determination R^2 = 0.9991.

It has also been common knowledge for a long time that the thermal expansion coefficient decreases when the length of the carbon chains increases [1]. This is shown in Figure 3-2.

In addition to the pure n-alkanes, also values for iso-octane and for two oils are plotted which are kept available at PTB as calibration oils for viscometers. These oils are mixed from alkanes (paraffins) with longer carbon chains; their exact composition is, however, unknown. These liquids, too, follow the fundamental relation between the density and the thermal expansion coefficient.

This fundamental relation can be used to compute the thermal expansion coefficient of a fuel from its density. This is done using the normalized "Procedure 2" which is a calculation rule [2, 3, 4].

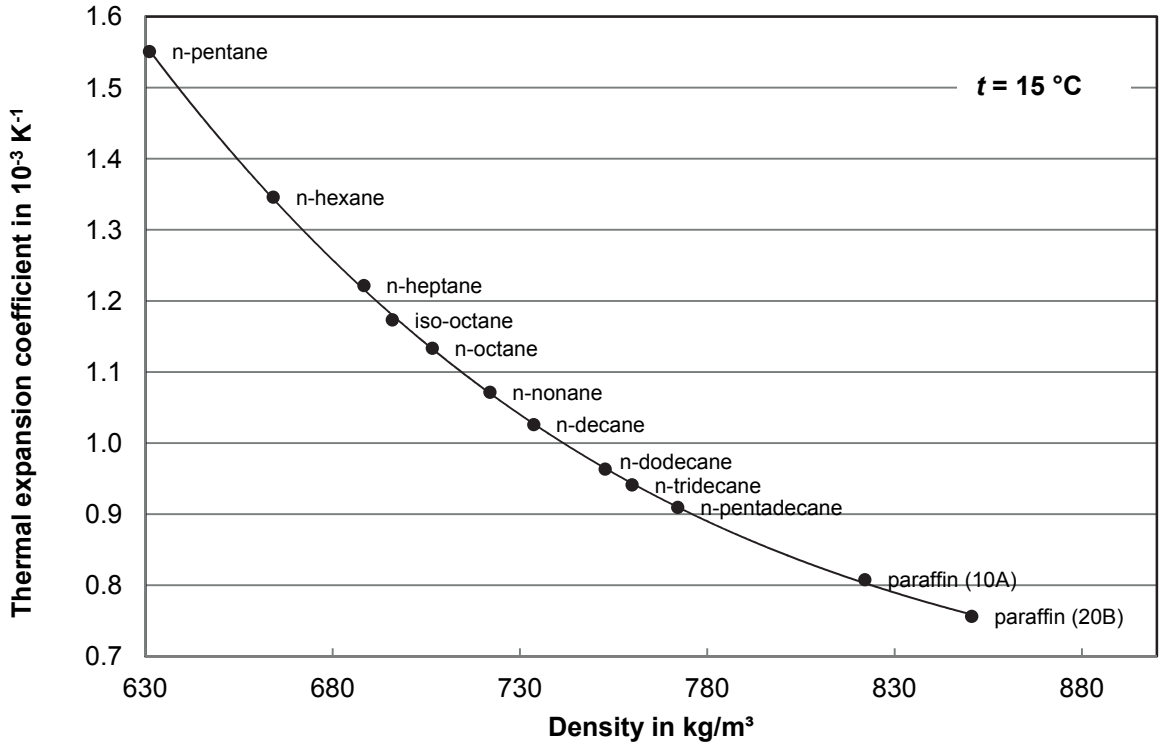


Fig. 3-2: Dependence of the thermal expansion coefficient of alkanes on their density. The substances designated as "paraffin 10A" and "paraffin 20B" describe substances that are used at PTB as viscosity calibration fluids (oils); they consist of a mixture of different alkanes, but their exact composition is unknown.

Fuels, however, not only contain alkanes, but also large amounts of aromatic hydrocarbons. Compared to alkanes, aromatic hydrocarbons (arenes), despite having the same thermal expansion coefficient, however, exhibit a clearly greater density. By mixing alkanes and arenes, it is therefore possible to change the density, with the thermal expansion coefficient remaining constant. The functional relation between the density and the thermal expansion coefficient is thus also changed. This behaviour is demonstrated in Figure 3-3 by using the example of mixtures consisting of the aromatic hydrocarbon toluol and the alkanes n-hexane and n-nonane, respectively.

The example of the mixture n-nonane/toluol is a particularly good example. N-nonane and toluol have a very similar thermal expansion coefficient ($1.071 \cdot 10^{-3}\ K^{-1}$ and $1.064 \cdot 10^{-3}\ K^{-1}$) but clearly different densities. By mixing these two components, the density can be varied between 722 kg/m³ and 871 kg/m³, with the thermal expansion coefficient remaining almost the same.

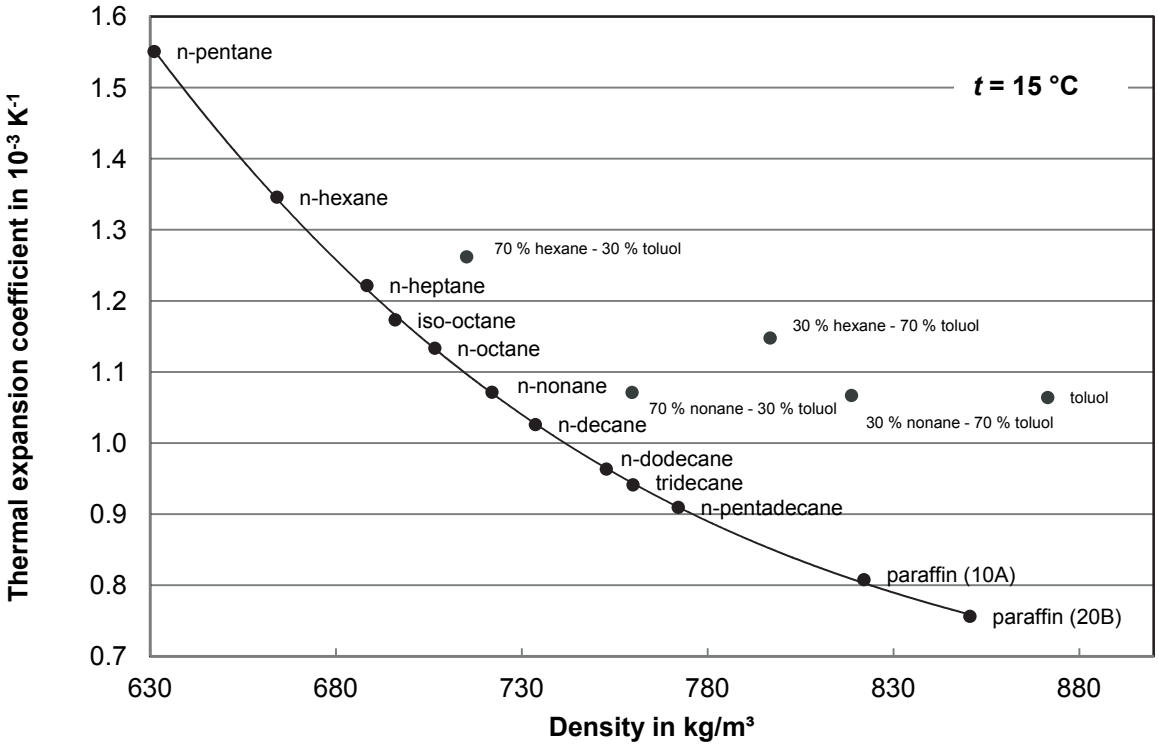


Fig. 3-3: Change in the density of the alkanes n-hexane and n-nonane by mixing them with the aromatic hydrocarbon toluol. In both cases, the density and the thermal expansion coefficient vary approximately linearly with the mixing ratio.

Since petrols are usually mixtures of alkanes, arenes and further components, and since the shares of each individual component may vary regionally or temporally, it is not possible to attribute the thermal expansion coefficient unambiguously to a specified density. A certain scattering of the values is to be expected. The approximatively linear behaviour allows a rough calculation of the values for a mixture if the input values of the components and the mixing ratio are known. Within the scope of these studies, we could, however, not investigate whether this is also possible for mixtures consisting of several various components.

Based on this finding, the question is which influence the admixture of biofuels has on the relation between the thermal expansion coefficient and the density. This question is the main motivation of our work. The thermal expansion coefficient, in turn, is the base for converting the volume into a volume at base conditions of 15 °C.

Two procedures have established themselves for temperature conversion; these differ in terms of the representation of the temperature dependence. The first procedure uses a linear equation with a pre-defined thermal expansion coefficient for the functional description of the temperature dependence of the density. The second procedure ("Procedure 2"), an exponential representation, which has mostly replaced the linear description due to the introduction of electronic conversion devices, calculates the thermal expansion coefficients from the density. An extensive comparison of these two representations is given in the attachments "Functional description of the temperature dependence of the density ...". It must be pointed out that the linear representation describes the temperature dependence of the density very well in the range in question (between -10 °C and +50 °C) and

guarantees results that lie within the maximum permissible errors. This is thus the method that will be used in the following, unless otherwise specified.

3.2 Viscosity

Similar to the density, also the viscosity of alkanes increases when the length of the hydrocarbon chains increases. The increase in viscosity is, however, clearly greater than the increase in density. When plotting the viscosity against the reciprocal number of carbon atoms per molecule of alkane, similar to the representation shown in Figure 3-1, the linear increase is no longer visible. For small reciprocal values, i.e. for long carbon chains, there is a much stronger increase in viscosity.

This is shown in Figure 3-4 with the example of the series of alkanes, which has also been used to measure the dependence of the thermal expansion coefficient on the density. Whereas the density increases by approx. 25 %, the viscosity of pentadecane is 12.8 times higher than that of pentane.

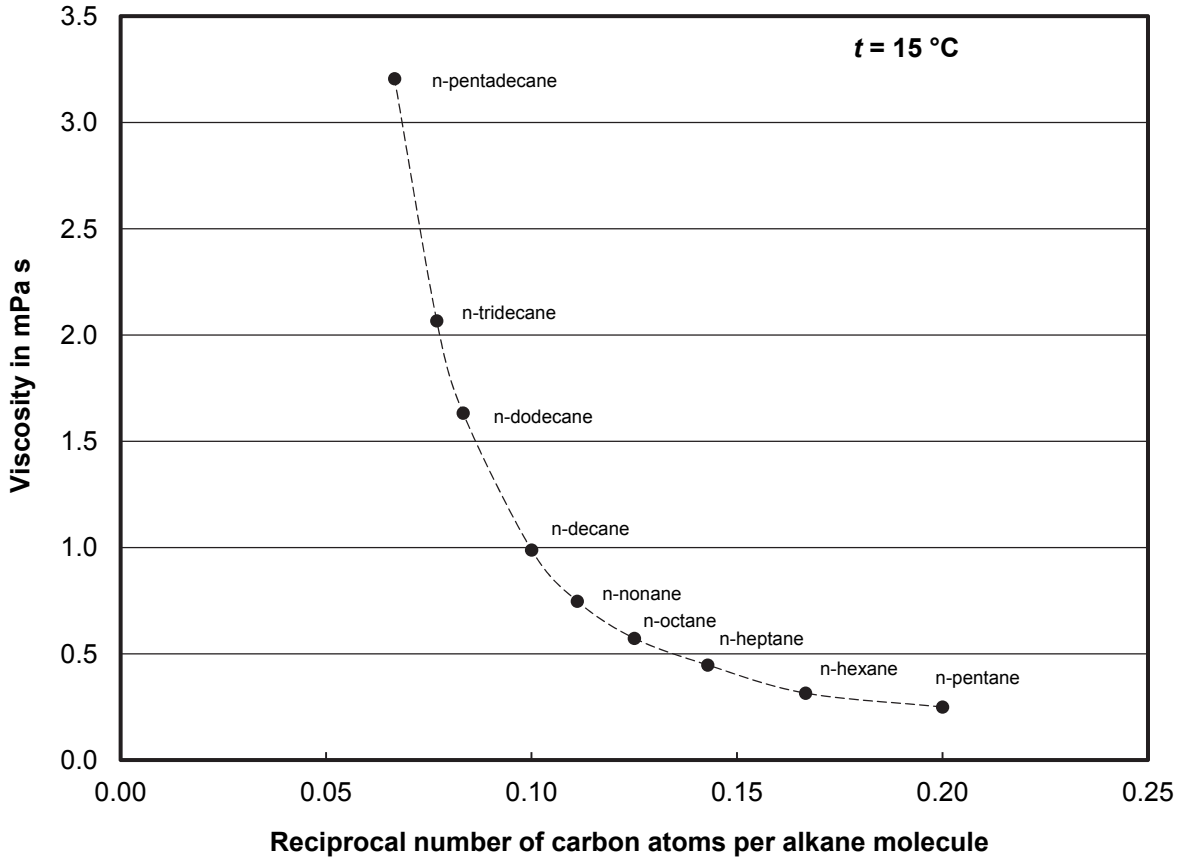


Fig. 3-4: Dependence of the viscosity of alkanes on the carbon chain length.

This stronger dependence seems to suggest that the viscosity, similar to the thermal expansion coefficient, be plotted against the density. This is shown in Figure 3-5.

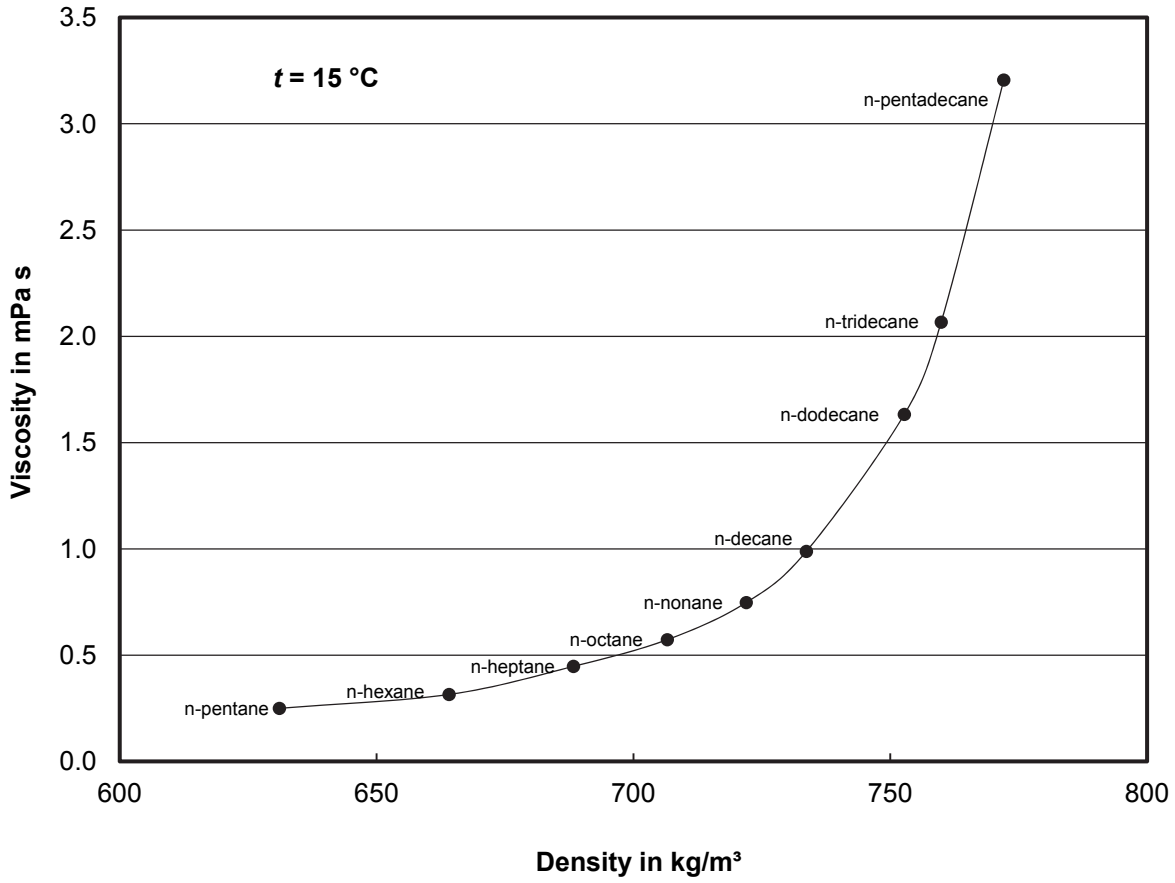


Fig. 3-5: Dependence of the viscosity of alkanes on their density.

Similar to the relation between the thermal expansion coefficient and the density, the influence of aromatic admixtures is to be shown also with regard to the viscosity. For this purpose, we will again consider the series of mixtures of toluol with n-hexane and n-nonane, respectively (Fig. 3-6).

As for the thermal expansion coefficient, here too, a shifting of the values towards higher densities is visible in the viscosity/density diagram, without the viscosity strongly changing. Here, a linear description of the series of mixtures is, however, only a very rough approximation.

We can therefore assume that variations in the density of fuels will also have an influence on the viscosity; hereby, a much greater range of variation is to be expected for the viscosity, compared to that of the density. The relation shown in Figures 3-5 and 3-6 allows a rough estimation of the relation between the density and the viscosity. When applying this to fuels, however, it must be taken into account that several aromatic compounds may be contained at various concentrations; the data stated here can therefore only be used as a guideline. For this reason, we have deliberately refrained from indicating a numerical relation.

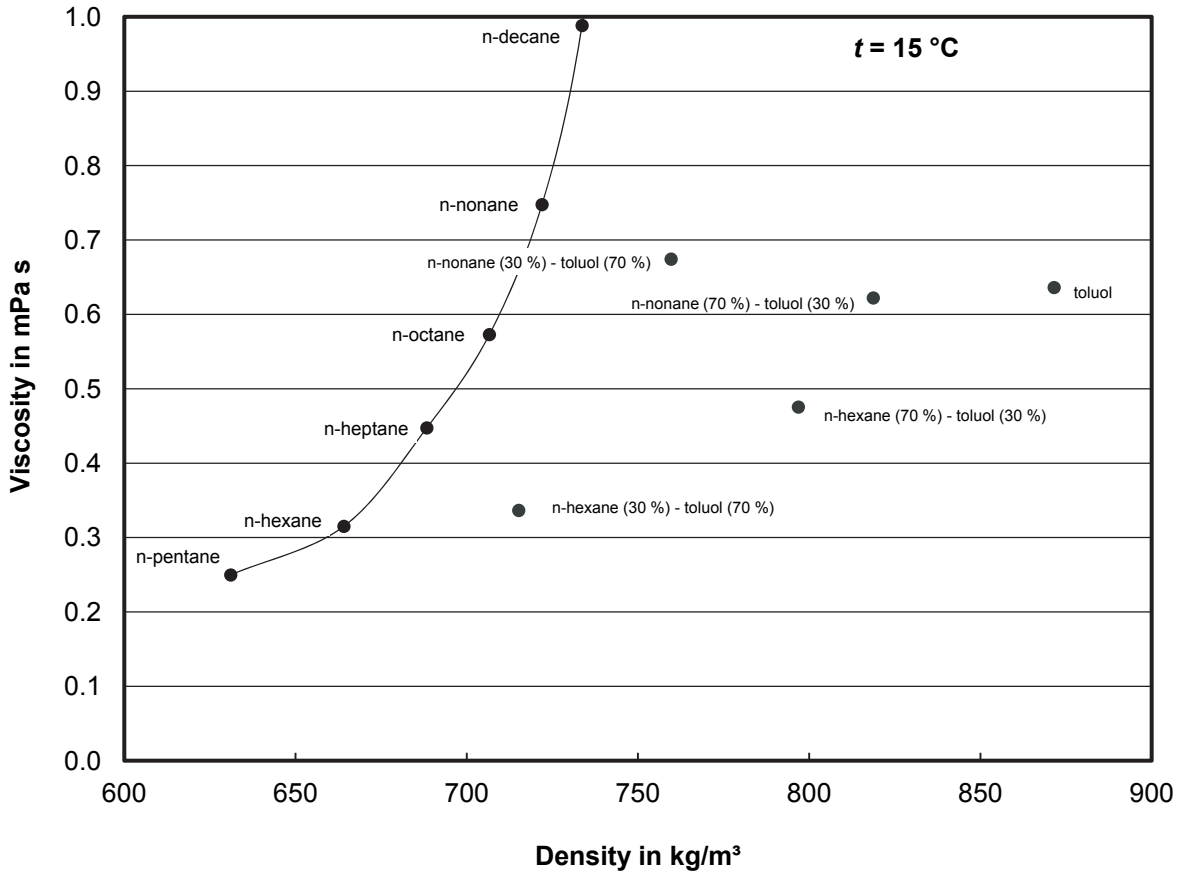


Fig. 3-6: Change in the viscosity of the alkanes n-hexane and n-nonane by mixing them with the aromatic hydrocarbon toluol. In this case, the change cannot be described satisfactorily with a linear relation.

4 Sample stability

4.1 Long-term stability

The measurement uncertainty must be evaluated as a function of the sample stability. As a rule, fuels are, from a chemical viewpoint, no pure substances, but a mixture of various components with very different material parameters. Therefore, changes in the composition due to chemical conversions must be expected; especially, light-induced crack processes and oxidation processes may occur. Among the physical processes, the evaporation of highly volatile components, which may occur, e.g., during the filling process, is worth mentioning.

The samples used for the measurements described here arrived in different types of containers (metallic and plastic jerrycans, glass bottles, metallic bottles). The filling level of the containers was different, too. Changes that might have occurred in the fuels while they were being filled into these containers, as well as during their transport and storage, must therefore be taken into account.

Especially petrols are – due to their high vapour pressure – particularly prone to evaporating, which makes their filling into other containers a problem. But also diffusion through the container caps plays a considerable role during the storage period.

In the case of diesels, this influence of evaporation is considerably lower; especially fossil diesels have proved rather stable. Biodiesels, in contrast, may undergo changes due to oxidation processes. Another problem is that the outside of the containers for biodiesel was often covered in a greasy film after a certain period of storage; this can only be explained by diffusion through the plastic walls of the container or through plastic seals. This can, of course, have an influence on the composition and, thus, on the material properties.

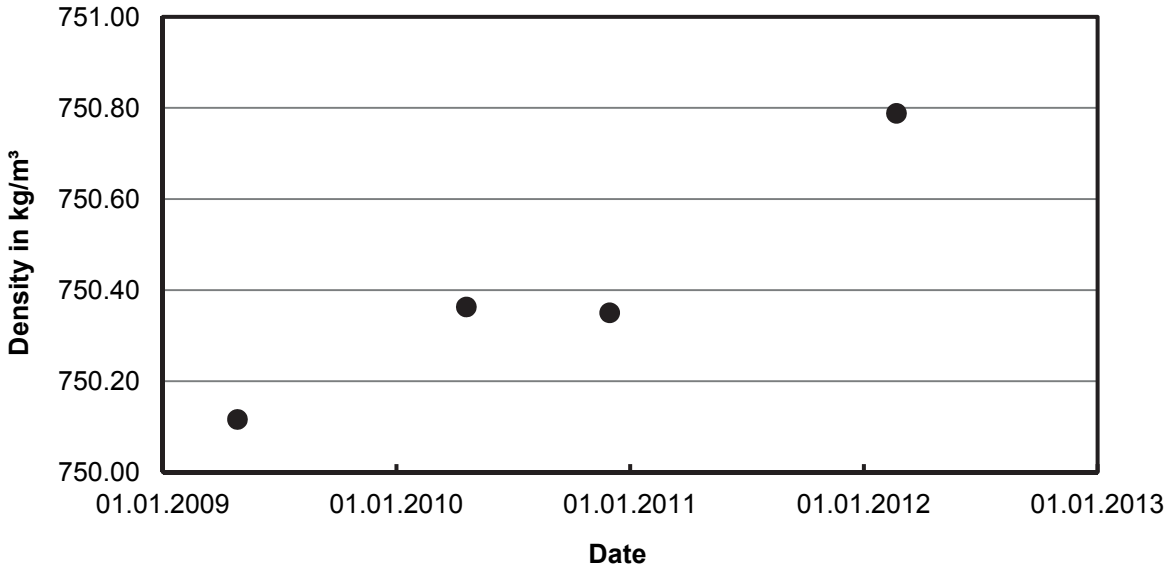


Fig. 4-1: Time-dependent change in the density of summer-grade fossil petrol OK98; value at 15 °C

The **change in the density of fuels – which is unavoidable, despite appropriate storage conditions –** is illustrated in Figures 4-1 to 4-5 by means of five different examples. For these long-term measurements, samples were stored in 500 ml bottles made of brown glass, with plastic seals, at room temperature, in the dark. The filling level was more than 400 ml. Once a year, a sample of 10 ml was drawn and analysed.

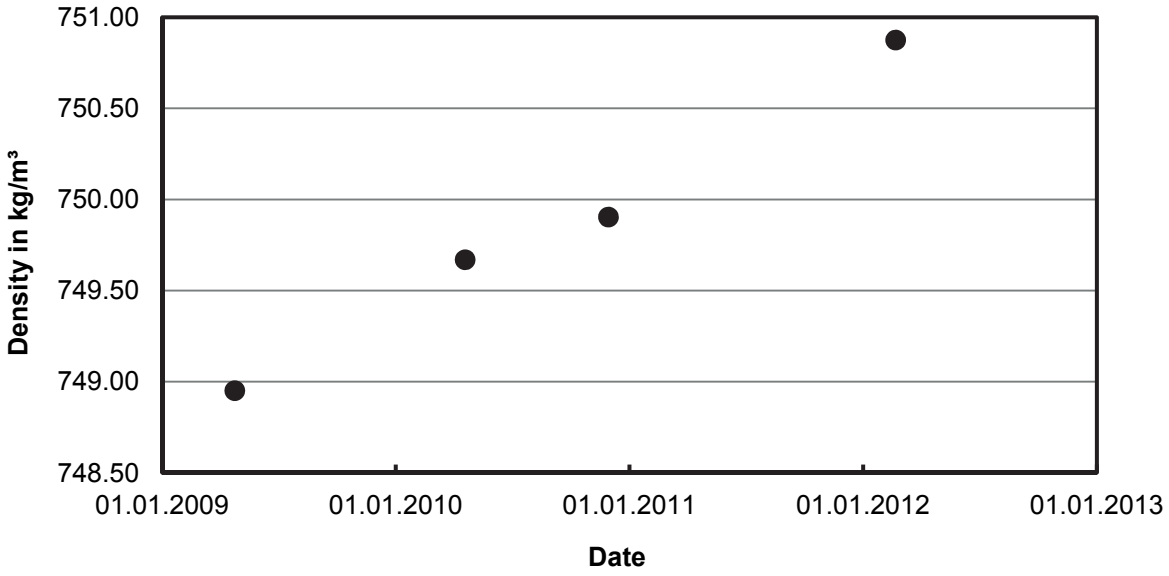


Fig. 4-2: Time-dependent change in the density of winter-grade fossil petrol OK98; value at 15 °C

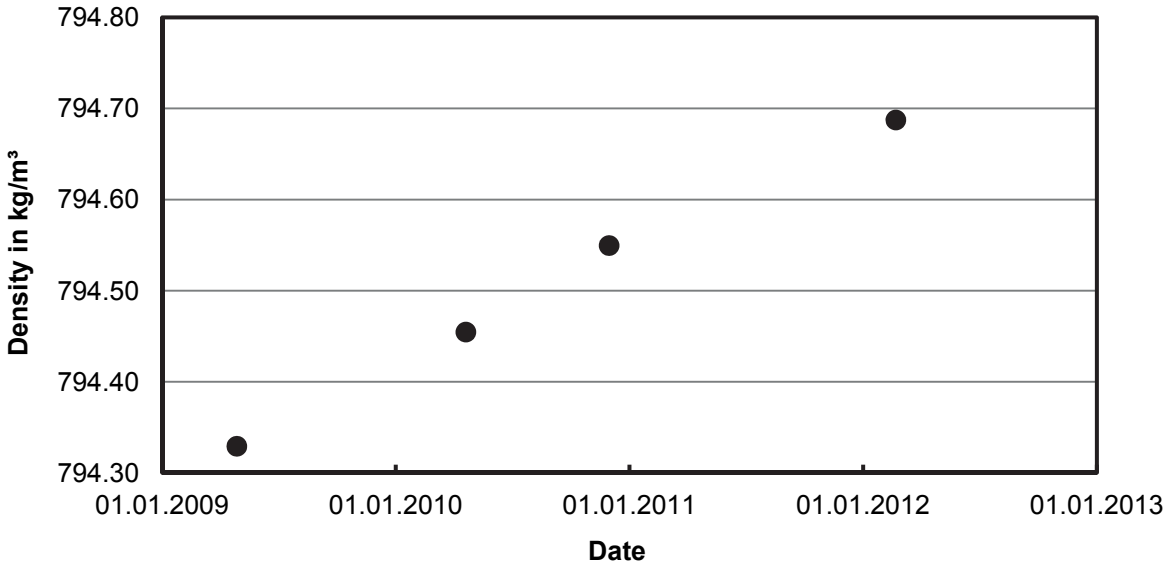


Fig. 4-3: Time-dependent change in the density of bioethanol; value at 15 °C

Whereas the density of summer-grade petrol changed by only less than 1 kg/m³ over the observation period of 3 years, this value is more than twice as high for winter-grade petrol:

approx. 2 kg/m³. The evaporation of low-boiling hydrocarbons, which have a lower density, can be assumed to be the cause for this. In the case of winter-grade fuel, the considerably higher fraction of low-boiling hydrocarbons with their higher vapour pressure becomes noticeable; the evaporation rate is correspondingly higher.

The density of bioethanol also increased during the observation period; the change in density amounted to approx. 0.5 kg/m³. This increase can be attributed to the increase in the water content due to the absorption of water vapour from the ambient air. The water content of the sample shown in Figure 4-3 increased from 0.18 % at the beginning of the investigation to 0.35 % at the time of the last measurement. The water content was determined by means of Karl Fischer titration; we estimate the measurement uncertainty to lie below 0.01 %. According to the official alcohol tables, an increase in density of 0.5 kg/m³ corresponds to an increase in the water content of 0.16 %. Both the density, which was measured in 2009 and was increased compared to the density value of pure ethanol, and the value measured in 2012 are in good agreement with the water contents measured.

A more precise investigation would have to include also the measurement of the fractions of higher alcohols and of methanol, but this was not possible within the scope of our work. Here, the higher evaporation rate of small amounts of methanol, but also the accumulation of higher alcohols which is due to the evaporation of the ethanol itself, could play a role.

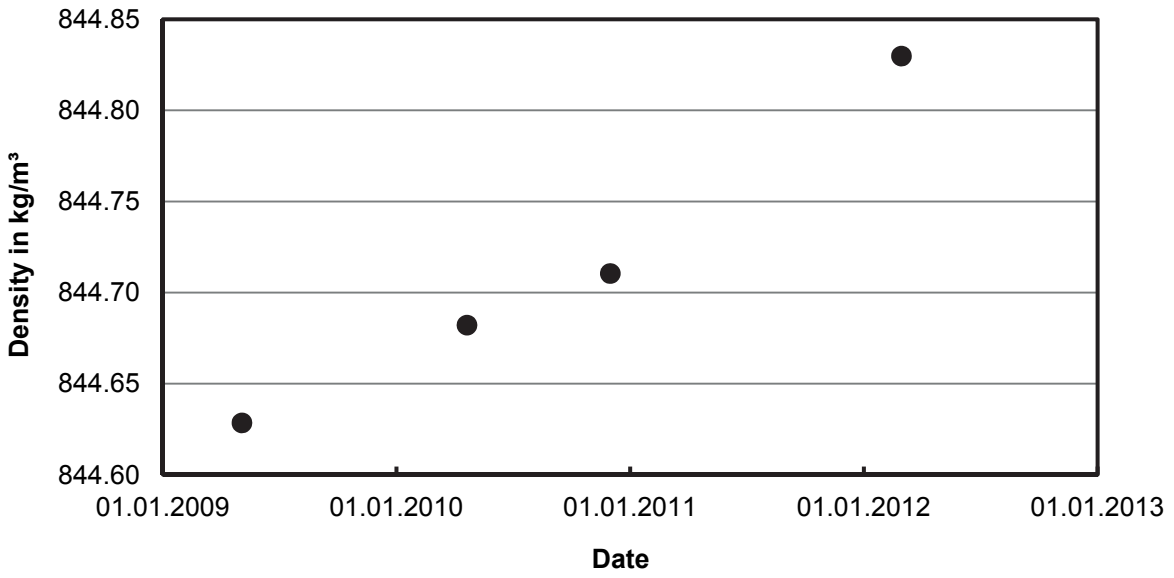


Fig. 4-4: Time-dependent change in the density of winter-grade diesel; value at 15 °C

The density changes of fossil diesel and of the biodiesel *rapeseed methyl ester* measured during the observation period were far lower than those of the petrols. This value is approx. 0.20 kg/m³ for fossil diesel and approx. 0.25 kg/m³ for biodiesel. Besides the evaporation (which is, in this case, rather low), oxidation processes are probably the main cause for the changes in density.

When comparing values measured on samples from the same source, these alteration processes must be taken into account. Strategies to reduce these effects – such as enclosing the fuel in

hermetically sealed glass vials or storing it at temperatures below 10 °C – will often fail due to lacking technical possibilities and are, of course, only feasible for laboratory samples.

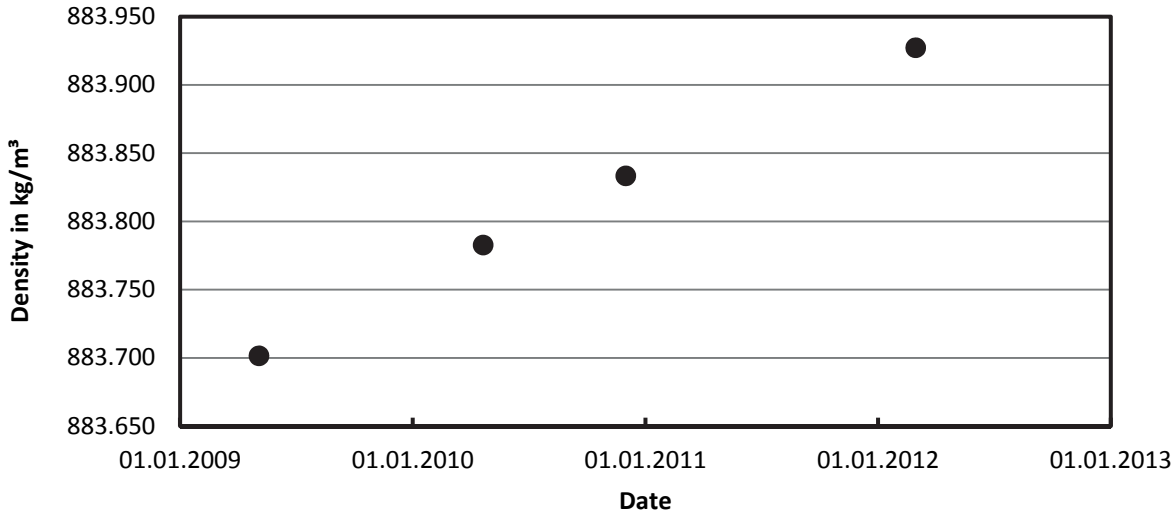


Fig. 4-5: Time-dependent change in the density of biodiesel (rapeseed methyl ester, RME); value at 15 °C

4.2 Reproducibility of the measurement results

On each fuel sample, two measurements were carried, each covering the total temperature range, in order to detect any possible misfilling or maloperations. The differences in the results typically lie around 0.050 kg/m³ for petrol samples, but may attain 0.100 kg/m³ in individual cases. This can be assumed to be caused by evaporation during the filling/drawing processes. In contrast, in the case of the diesel samples, the differences between two measurements are absolutely negligible; they usually lie below 0.005 kg/m³.

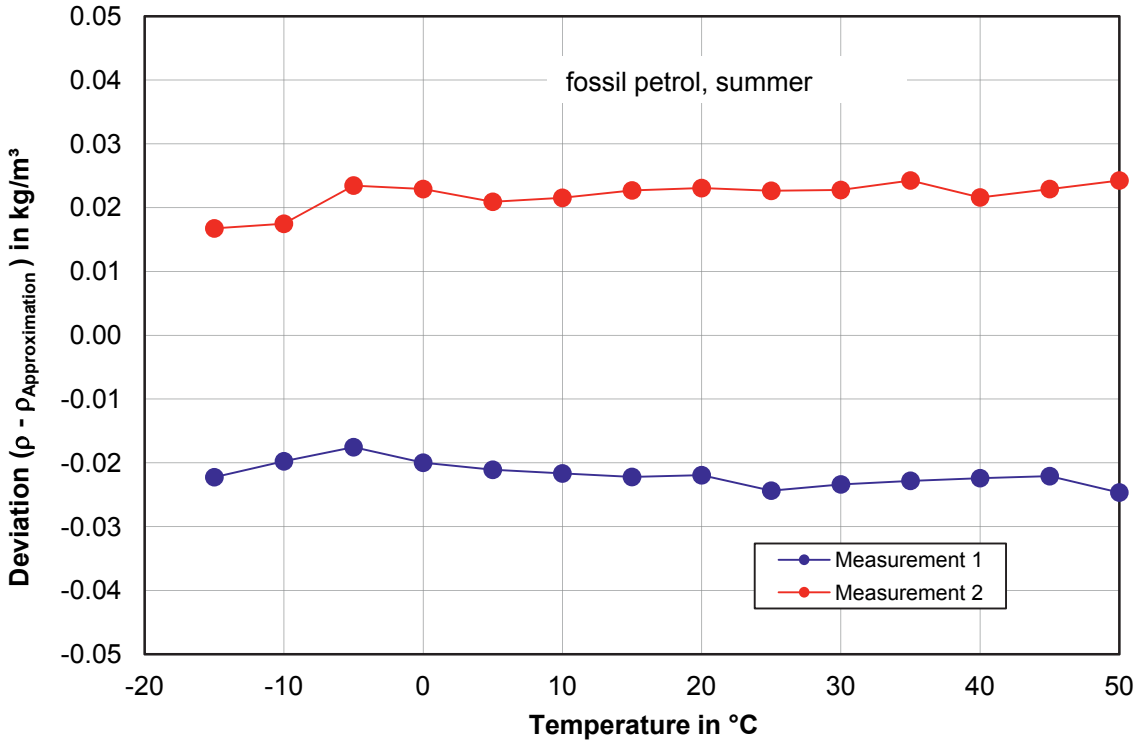


Fig. 4-6: Reproducibility of the measurement results, fossil petrol, OK98. Deviation of the measured data from the shared mean value.

Figure 4-6 shows, as an example, this deviation for summer-grade fossil petrol, OK 95. Figure 4-7 shows the same plot for the measurement carried out on pure fossil diesel as was already shown in Figure 2-1. The plotted parameters are: the deviation of the data points of the two measurement series from a polynomial fit through all data points. In this case, the fit is done by means of a third-order polynomial, since in this way, the high reproducibility can be better represented.

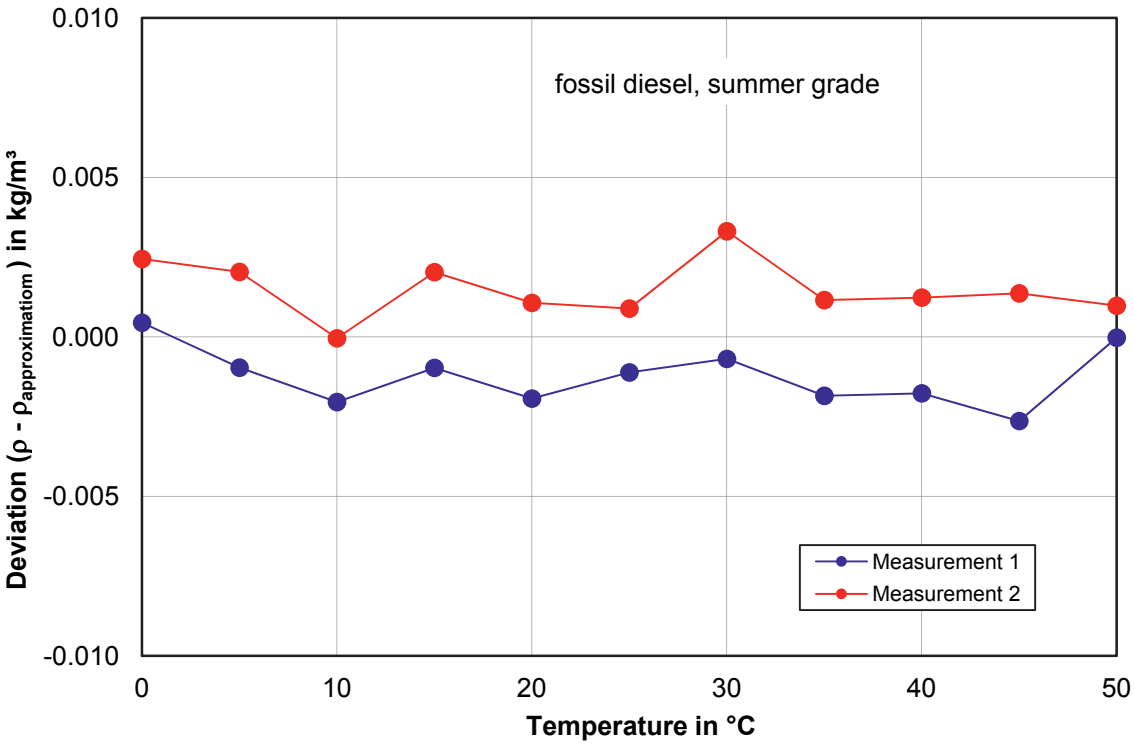


Fig. 4-7: Reproducibility of the measurement results, summer-grade fossil diesel. Deviation of the measured data from a polynomial fit of all data points.

Both representations can be deemed representative of their respective fuel class. The representation of the diesel sample is limited to the temperature range above 0 °C.

Fossil diesel starts precipitating at around 0 °C (in the case of biodiesel, this may even occur at higher temperatures). The solid phase has a slightly higher density. The moment at which solid particles start forming therefore becomes visible in the form of a bending of the density/temperature curve towards higher densities because the measuring instrument measures the density which is composed of the fluid density and of the particle density.

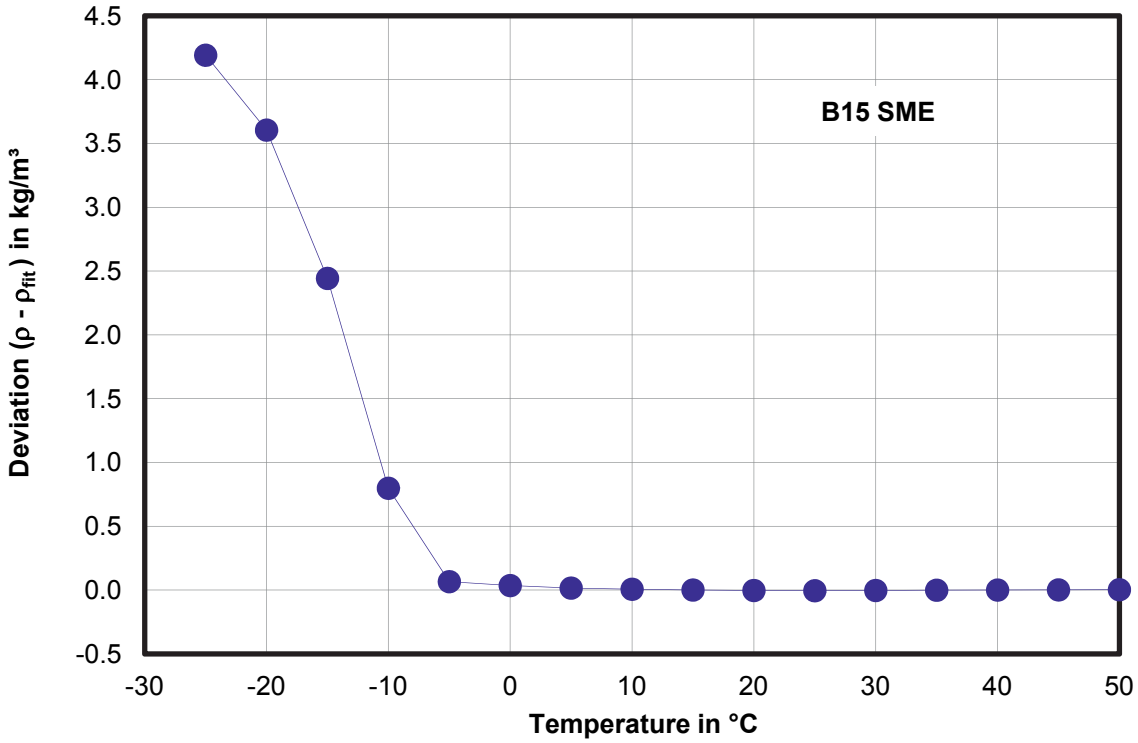


Fig. 4-8: Dependence of the density of B15 SME (the fossil share is summer-grade diesel) on the temperature with a linear fit considering the values measured above 10 °C. The density increase due to the precipitation processes is approx. 2.5 kg/m³ at t = -15 °C.

Figure 4-8 shows the influence of such a precipitation process on the density using the example of a B15 SME mixture. The designation "B15" corresponds to the usual nomenclature, i.e. the mixture contains 15 percent by volume of biodiesel, related to the reference temperature of 15 °C. In the case of this measurement, the fuel was filled into the measuring instrument at 20 °C, then heated up to 50 °C and then left to cool down in successive steps of 5 K each for the measurement. To have an enhanced resolution, the representation shows the deviation of the measurement results from a linear approximation. To calculate this approximation, only the measured values which had been measured at a temperature above 5 °C were used. This type of plotting always would yield 0 as the deviation if a linear temperature dependence of the density is given. If we now – reasonably – assume that the linear change in density along with the temperature that applies at higher temperatures would also apply at lower temperatures if no precipitation occurred, then this plot only shows the increase in density which have been generated by the precipitation processes. This is clearly visible below 0 °C and reaches 2.5 kg/m³ at -15 °C.

The values measured in this range, in which precipitation processes occur, are not as well reproducible as the measurements carried out on purely liquid material. This is, to a small extent, due to the measuring instrument. The movement of the solid particles in the oscillation field of the oscillation-type density meter leads to slight instabilities. A far greater influence is exerted, however, by the time-dependent behaviour of the precipitation process, which is probably strongly influenced by the presence of condensation nuclei and by temporal behaviour of nuclei growth and diffusion

processes and therefore exhibits rather poor reproducibility. The measurements performed allow no conclusions to be drawn as to the velocity of the reactions observed, since the cooling speed is too low. Investigating the density evolution on a longer time scale is, however, possible.

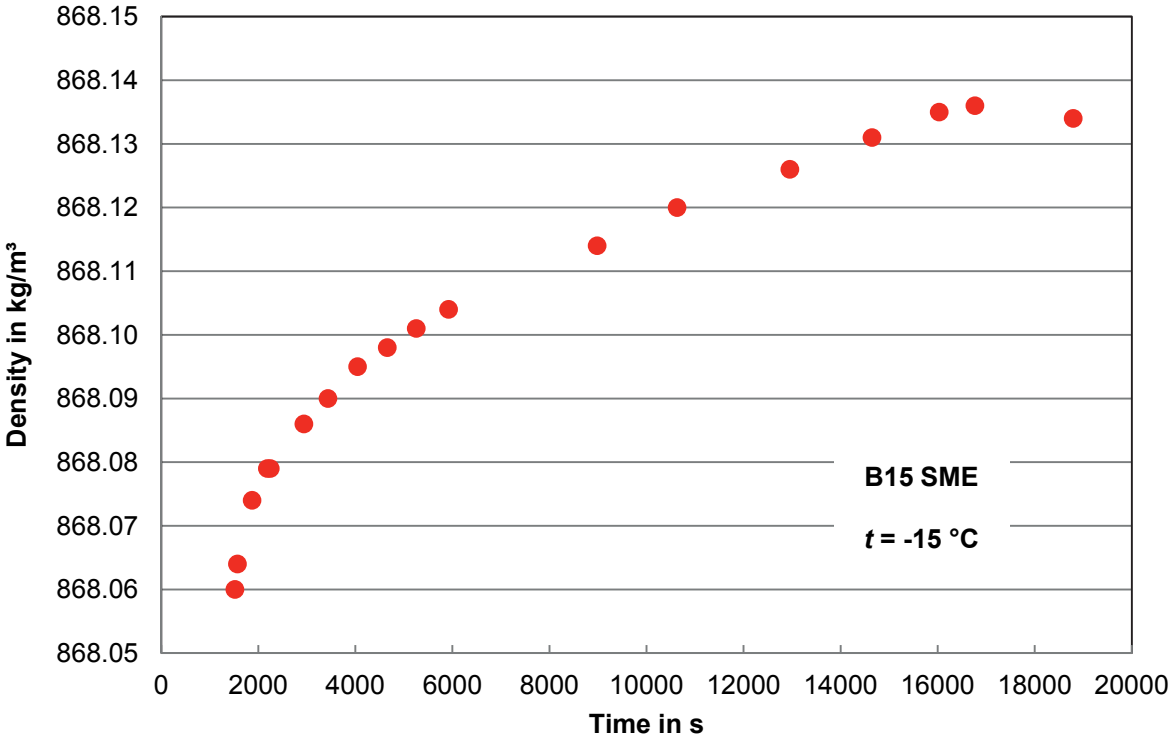


Fig. 4-9: Time-dependent variation of the density of a diesel blend containing 15 % of soy methyl ester (B158 SME, fossil share: summer grade) kept at a constant temperature of -15 °C.

For the purpose of this measurement, the fuel (in this case a mixture with the biodiesel soy methyl ester (SME)) was filled into the measuring instrument at 20 °C and then cooled down to -15 °C as fast as possible to be later kept at this temperature. The cooling time until stabilization of the target temperature was approx. 1500 seconds. Only from this moment on did the oscillation-type density meter receive a stable measurement signal and could the density measurement start. According to our experience, a delayed temperature adjustment must be expected inside the liquid due to the fast cooling (in a time span of 1500 seconds to 1800 seconds). For this reason, it cannot be ruled out that a density increase may, in addition, be caused by the temperature adjustment. After 1800 seconds (this corresponds to the 3rd measurement point in Figure 4-9), temperature stability can be assumed also inside the liquid. The density increase shown in Figure 4-9 can thus be attributed solely to the increase in the number and in the size of solid precipitations. In the following 5 hours, the density still increases by approx. 0.1 kg/m³; after 5 hours, saturation is still not in sight. This measurement only shows the "echo" of the precipitation processes, but it also denotes the kinetics of the evolution of the processes very well. A more detailed investigation of the solidification processes was, as mentioned earlier, not possible with the equipment we had at our disposal. Of course, the majority of precipitation processes takes place in the initial phase (at the beginning of the cooling), which is visible here in the form of a steep rise of the first data points.

The density measured in this range can be considered as a material parameter only to a limited extent, since it describes a two-phase mixture. If this fact is ignored, then in this range a clearly greater measurement uncertainty (higher than 0.5 kg/m³) should at least be assigned to the density measurement.

5 Regional samples

Besides the reproducibility of the measurement results due to measurement uncertainties and the stability of the available samples, a question remains – namely what the distribution of the material parameters looks like when samples coming from different regions are measured. In other words: how much do fuels differ which – nominally – have the same density and viscosity?

In order to find an answer to this question, samples were collected from up to 18 different refineries in Germany with the support of DGMK (Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V., *German Society for Petroleum and Coal Science and Technology*, Hamburg). The samples were taken directly from the production chain, i.e. they reflect fuels which are really sold in Germany. With regard to the geographical source of the samples, we made a point of covering, as far as possible, the whole German territory. The samples were made anonymous by DGMK and then sent to PTB, since not all suppliers were willing to reveal their fuel data openly. For this reason, the samples collected for the purposes of this report are simply designated as numbers 1 to 18.

For each sample, the density and the viscosity were measured in the way described above.

The investigated fuels were supplied, on the one hand, as summer-grade fuel: diesel fuel (SDK), petrol OK95 and OK98 (SOK), heating oil HEL and low-sulphur heating oil (SHEL and SHEL-Sarm). On the other hand, also winter-grade fuels were supplied and investigated: diesel fuel (WDK), petrol OK95 and OK98 with different ethanol concentrations (WOK), and heating oil HEL and low-sulphur heating oil HEL (WHEL and WHEL-Sarm). A list of the supplied samples is given in Tables 1a (for summer-grade fuels) and 1b (for winter-grade fuels). If certain fields are not filled in, this means that this particular source did not supply any corresponding sample.

Here, we only want to deal with the distribution of the measured values at 15 °C (as representative data). Table 2 provides a list of all arithmetic mean values of the individual product groups. For a more detailed individual representation of all results for the different groups of fuels/heating oils, please refer to Annex 3 and Annex 4, where both individual diagrams and a list of all measured data in the form of a table can be found. For reasons of clarity, this list is however, limited to the first of the two measurements (see also Chapter 4.2).

To assess the conversion in accordance with the verification law, it is not sufficient to indicate just a mean value and its standard deviation. Indicating the extreme values and the difference between these is, in our case, also very meaningful. In this way, we can state whether "outliers" can still be correctly realised within the scope of the verification law. These data, too, are included in Table 2; the diagrams included in Annex 3 indicate the relative difference between the maximum and the minimum value. This value is normalized to the corresponding mean value and designated as "span" in the diagrams.

The relative standard deviations of all densities of products of the same group lie between 0.6 % and 1.4 %. The fuels and heating oils are thus very homogeneous with regard to their density. The spans (i.e. the differences between the maximum and the minimum density) vary between 1.9 % and 5.2 %, which is often due to only one or two samples having a density clearly different from the majority of the samples investigated.

The thermal expansion coefficients show, as a matter of principle, a similar behaviour. It must be pointed out that the general functional relation "an increase in density means a decrease in the thermal expansion coefficient" (see Chapter 2) is valid here as well. Here, the standard deviations and spans are almost always clearly (by a factor of 2) higher than in the case of the density values.

For thermal temperature conversion, German verification legislation prescribes a maximum permissible error of 0.2 %. A simple exemplary calculation allows the determination of the thermal expansion coefficient span that does not exceed this maximum permissible error.

For this purpose, let us consider a temperature conversion of $t = +50\ °C$ to $t_0 = +15\ °C$, i.e. a conversion covering the greatest temperature difference prescribed within the scope of the verification law.

A linear approach for thermal expansion yields:

$$V_{15} = V_{50}\,(1 - k_0 \cdot \Delta t) = V_{50}\,(1 - k_0 \cdot 35\ \mathrm{K})$$

For further simplification, let us assume a thermal expansion coefficient $k_0 = 1.25 \cdot 10^{-3}\ \mathrm{K}^{-1}$ for petrols and $k_0 = 0.84 \cdot 10^{-3}\ \mathrm{K}^{-1}$ for diesel fuels, i.e. values that correspond to approximately the mean values of all the coefficients measured.

For petrols, this results in:

$V_{15}/V_{50} = 0.95625$; but with the maximum permissible error of 0.2 % it is allowed to have $V_{15}/V_{50} = 0.95625 \pm 0.002$.

This is met for $k = k_0\,(1 \pm 4.57\ \%)$.

The same calculation for diesel fuels results in:

$V_{15}/V_{50} = 0.9706$; but with the maximum permissible error of 0.2 % it is allowed to have $V_{15}/V_{50} = 0.9706 \pm 0.002$.

This is met for $k = k_0\,(1 \pm 6.80\ \%)$.

The larger span allowed in k_0 for diesel fuels results from the smaller thermal expansion coefficient. When using the “Procedure 2” (exponential representation), slightly smaller spans of 4.47 % and 6.70 % are obtained.

Compared to the density values, the viscosity values show clearly increased standard deviations and differences between the maximum and the minimum value. Whereas the standard deviations fluctuate between 3.7 % and 19.7 %, the differences for the "spans" can amount to up to 60.9 %. As described earlier, this value refers to the common mean value; in this case, the absolute minimum and maximum values amount to 3.06 mPa s and 5.55 mPa s. The reason for these strong differences in viscosity is the stronger dependence of the viscosity on the length of the carbon chains described in Chapter 3. Correspondingly, the viscosity reacts clearly more strongly to – even small – variation in the fuel composition. Branched carbon chains and aromatic compounds enhance this effect even further.

Table 1a: List of the samples (summer-grade fuels) collected to investigate the scattering of the material parameters. The serial numbers designate the sample suppliers. The admixture of biofuel is indicated in brackets.

Diesel	Heating oil HEL	Heating oil HEL, low-sulphur	Petrol OK98	Petrol OK98	Petrol OK95	Petrol OK95
SDK-01 (B7)		SHEL-Sarm-01 (B7)	SOK98-01 (E5)		SOK95-01 (E5)	
SDK-02 (B7)		SHEL-Sarm-02 (B7)			SOK95-02 (E5)	
SDK-03 (B7)	SHEL-03 (B7)	SHEL-Sarm-03 (B7)			SOK95-03 (E5)	
SDK-04 (B7)		SHEL-Sarm-04 (B7)	SOK98-04 (E5)		SOK95-04 (E5)	
SDK-05 (B7)	SHEL-05 (B7)	SHEL-Sarm-05 (B7)	SOK98-05 (E5)		SOK95-05 (E5)	
SDK-06 (B7)	SHEL-06 (B7)		SOK98-06 (E5)		SOK95-06 (E5)	
SDK-07 (B7)		SHEL-Sarm-07 (B7)	SOK98-07 (E5)		SOK95-07 (E5)	
SDK-08 (B7)	SHEL-08 (B7)	SHEL-Sarm-08 (B7)	SOK98-08 (E5)		SOK95-08 (E5)	
SDK-10 (B7)		SHEL-Sarm-10 (B7)	SOK98-10 (E5)		SOK95-10 (E5)	
SDK-11 (B7)	SHEL-11 (B7)				SOK95-11 (E5)	
SDK-12 (B7)		SHEL-Sarm-12 (B7)	SOK98-12 (E5)		SOK95-12 (E5)	
SDK-13 (B7)		SHEL-Sarm-13 (B7)	SOK98-13 (E5)		SOK95-13 (E5)	
SDK-14 (B7)		SHEL-Sarm-14 (B7)	SOK98-14 (E5)		SOK95-14 (E5)	
SDK-15 (B7)	SHEL-15 (B7)	SHEL-Sarm-15 (B7)	SOK98-15 (E5)		SOK95-15 (E5)	
SDK-16 (B7)	SHEL-16 (B7)	SHEL-Sarm-16 (B7)	SOK98-16 (E5)		SOK95-16 (E5)	
SDK-17 (B7)	SHEL-17 (B7)	SHEL-Sarm-17 (B7)	SOK98-17 (E5)		SOK95-17 (E5)	
SDK-18 (B7)	SHEL-18 (B7)	SHEL-Sarm-18 (B7)	SOK98-18 (E5)		SOK95-18 (E5)	

Table 1b: List of the samples (winter-grade fuels) collected to investigate the scattering of the material parameters. The serial numbers designate the sample suppliers. The admixture of biofuel is indicated in brackets. At the time the samples were collected, E10 was being introduced in Germany. Therefore, also a certain number of E10 samples could be investigated. Most suppliers provided OK98 as E0.

Diesel	Heating oil HEL	Heating oil HEL, low-sulphur	Petrol OK98	Petrol OK98	Petrol OK95	Petrol OK95
WDK-01 (B7)		WHEL-Sarm-01 (B7)	WOK98-01 (E0)		WOK95-01 (E5)	
WDK-02 (B7)		WHEL-Sarm-02 (B7)	WOK98-02 (E0)			
WDK-03 (B7)	WHEL-03 (B7)				WOK95-03 (E5)	
WDK-04 (B7)		WHEL-Sarm-04 (B7)	WOK98-04 (E0)		WOK95-04 (E5)	
WDK-05 (B7)	WHEL-05 (B7)	WHEL-Sarm-05 (B7)	WOK98-05 (E0)		WOK95-05 (E5)	
WDK-06 (B7)		WHEL-Sarm-06 (B7)			WOK95-06 (E5)	
WDK-07 (B7)		WHEL-Sarm-07 (B7)	WOK98-07 (E0)		WOK95-07 (E5)	
WDK-08 (B7)	WHEL-08 (B7)	WHEL-Sarm-08 (B7)		WOK98-08 (E5)	WOK95-08 (E5)	WOK95-08 (E10)
WDK-09 (B7)		WHEL-Sarm-09 (B7)				
WDK-10 (B7)		WHEL-Sarm-10 (B7)	WOK98-10 (E0)		WOK95-10 (E5)	WOK95-10 (E10)
WDK-11 (B7)		WHEL-Sarm-11 (B7)	WOK98-11 (E0)		WOK95-11 (E5)	
WDK-12 (B7)		WHEL-Sarm-12 (B7)		WOK98-12 (E5)	WOK95-12 (E5)	WOK95-12 (E10)
WDK-13 (B7)		WHEL-Sarm-13 (B7)	WOK98-13 (E0)		WOK95-13 (E5)	
WDK-14 (B7)		WHEL-Sarm-14 (B7)		WOK98-14 (E5)	WOK95-14 (E5)	
WDK-15 (B7)		WHEL-Sarm-15 (B7)	WOK98-15 (E0)		WOK95-15 (E5)	
WDK-16 (B7)		WHEL-Sarm-16 (B7)	WOK98-16 (E0)		WOK95-16 (E5)	
WDK-17 (B7)	WHEL-17 (B7)	WHEL-Sarm-17 (B7)	WOK98-17 (E0)		WOK95-17 (E5)	
WDK-18 (B7)		WHEL-Sarm-18 (B7)			WOK95-18 (E5)	

Table 2: Mean value of the data for each group of fuel/combustible

ρ density, unit: kg/m³,

γ thermal expansion coefficient, unit: 10^{-3} K^{-1},

η dynamic viscosity, unit: mPa s

Material		Mean value	Standard deviation	Min	Max	Max-Min
SDK	ρ	838.267	5.058	825.884	844.914	19.029
	γ	0.838	0.010	0.827	0.868	0.041
	η	4.18	0.51	2.87	4.92	2.05
WDK	ρ	836.030	5.106	827.626	843.535	15.909
	γ	0.843	0.009	0.829	0.864	0.035
	η	4.00	0.47	3.03	4.64	1.61
SHEL	ρ	846.359	7.640	837.849	858.949	21.100
	γ	0.834	0.007	0.821	0.844	0.023
	η	4.18	0.49	3.67	5.33	1.66
WHEL	ρ	852.410	8.309	840.221	858.865	18.644
	γ	0.834	0.004	0.830	0.838	0.007
	η	4.10	0.51	3.42	4.63	1.22
SHEL-Sarm	ρ	839.001	10.063	813.856	857.417	43.561
	γ	0.837	0.014	0.814	0.866	0.052
	η	4.15	0.75	2.84	5.32	2.48
WHEL-Sarm	ρ	842.752	7.067	833.970	858.464	24.494
	γ	0.837	0.011	0.812	0.852	0.040
	η	4.08	0.80	3.06	5.55	2.48
SOK95	ρ	751.260	6.151	741.833	765.332	23.499
	γ	1.227	0.018	1.193	1.268	0.075
	η	0.46	0.02	0.43	0.49	0.06
WOK95	ρ	739.763	9.957	725.931	760.654	34.723
	γ	1.271	0.029	1.207	1.300	0.094
	η	0.43	0.03	0.40	0.50	0.10
WOK95-E10	ρ	745.758	10.758	735.258	756.756	21.499
	γ	1.259	0.031	1.226	1.287	0.061
	η	0.46	0.04	0.42	0.50	0.07
SOK98	ρ	751.679	6.084	744.280	764.495	20.215
	γ	1.218	0.021	1.181	1.246	0.065
	η	0.46	0.02	0.43	0.50	0.08
WOK98	ρ	743.450	8.598	726.822	755.025	28.204
	γ	1.247	0.020	1.209	1.285	0.076
	η	0.44	0.02	0.40	0.47	0.07

5.1 Functional relationship between the density and the thermal expansion coefficient

A summary is given by the diagram of the thermal expansion coefficient as a function of the density already used in Figure 3-2. In Figures 5-1 and 5-2, this is shown for all petrols and all diesels as well as for all heating oils measured.

Both representations confirm the principle which is already known from Figure 3-2 and according to which the thermal expansion coefficient decreases when the density increases. The individual composition of the fuels and heating oils shown (which we do not know), however, leads to clear deviations from this ideal behaviour and, thus, to a widening of the data line which becomes a cloud. For better orientation, arrows have been included in both figures to identify the 5 % and the 10 % span, respectively.

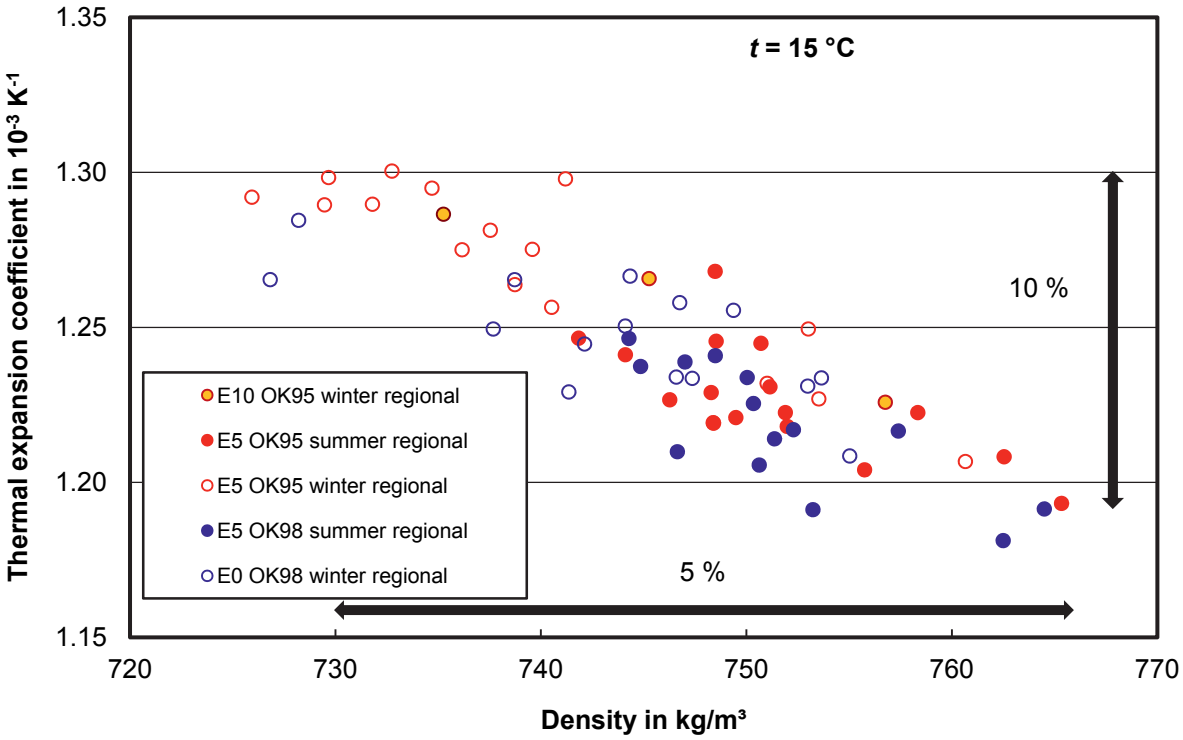


Fig. 5-1: Dependence of the thermal expansion coefficient of the petrols on the density.

In the case of the petrols, small differences occur between OK95 and OK98. For the summer grade, this difference is negligible; for the winter grade, however, it reaches half of the experimental standard deviation. We will study the change in the density and the thermal expansion coefficient due to the variation of the ethanol fraction in more depth in the next chapter.

What is more clearly visible is a shift towards lower densities in the transition from summer- to winter-grade fuels. In connection with this, we also observed an increase in the thermal expansion coefficient. All samples taken together cover a density range of slightly more than 5 %. The thermal expansion coefficient varies within a range of slightly more than 10 %. This is a little more than the ±4.57 % that are permitted in the above mentioned calculation. The fuels whose parameters are

located at the edge of the field shown here would exceed the maximum permissible error for temperature conversion as soon as the full temperature range of $\Delta t = 35$ K – i.e. temperature conversion from 50 °C to 15 °C – is fully used. This is, for instance, the case for the sample WOK95-03. In the following chapter, we will show that this cannot be explained by the admixture of 5 % to 10 % of ethanol.

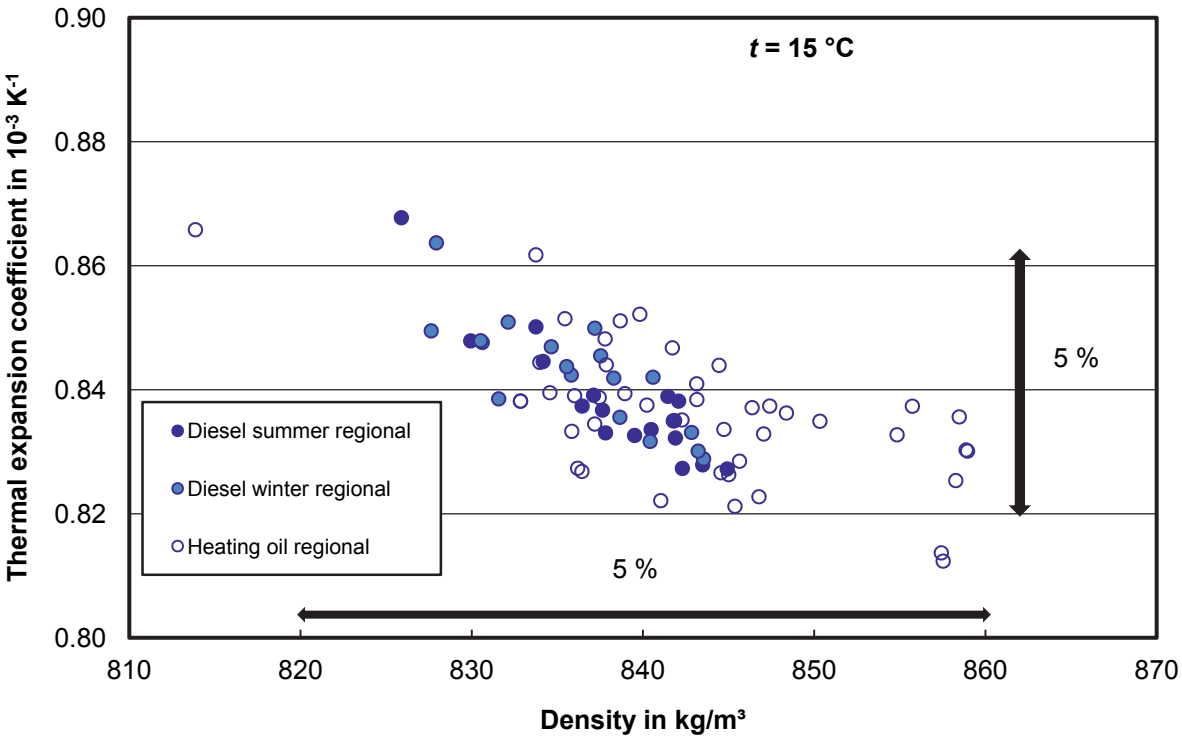


Fig. 5-2: Dependence of the thermal expansion coefficient of diesels and heating oils on the density.

In the case of diesel fuels, the spans amount to approx. 2.5 % for the density range and to approx. 5 % for the range of the thermal expansion coefficient. Including the heating oils (as shown in Fig. 5-2) leads to a 100 % increase in the density range. Heating oils also cover the density core range of diesels which extends from 825 kg/m³ to 845 kg/m³, but there are also many heating oils with densities of up to 860 kg/m³. One sample exhibited an unusually low density of 813.8 kg/m³. Contrary to the density range, the range of values of the thermal expansion coefficient is not significantly enlarged (only to 6 %) when including the heating oil samples. Only two samples exhibited values which lay outside this range; when taking those into account as well, the range covered increases to 7 %. Contrary to petrols, diesel fuels never exceed the maximum permissible error for temperature conversion due to the bandwidth of the thermal expansion values. The span measured here only accounts for approx. 50 % of the permitted span.

5.2 Viscosity

The results of the viscosity measurements will also be represented here as a function of the density (Figure 5-3 for petrols and 5-4 for diesel and heating oils).

This dependence of the viscosity on the density is also clearly visible here, however, the viscosities measured on petrols were significantly lower (approximately by a factor of 3) than those of the alcanes with the same density. In the density range of the diesel fuels, we could not measure any pure alcane; extrapolation of the viscosity values exceeding the value of pentadecane towards a higher density allowed us to expect a viscosity of approx. 15 mPa s for 850 kg/m³. Here, too, there is a factor of approximately 3 between the values of the pure alcanes and those of the fuels. Here, admixtures of arenes and, in particular, drag-reducing agents (DRAs), are noticeable.

The variation span of the viscosity compared to that of the thermal expansion coefficient is significantly increased. In the case of the petrols, it amounts to 20 %; for diesels and heating oils, the span reaches 65 %.

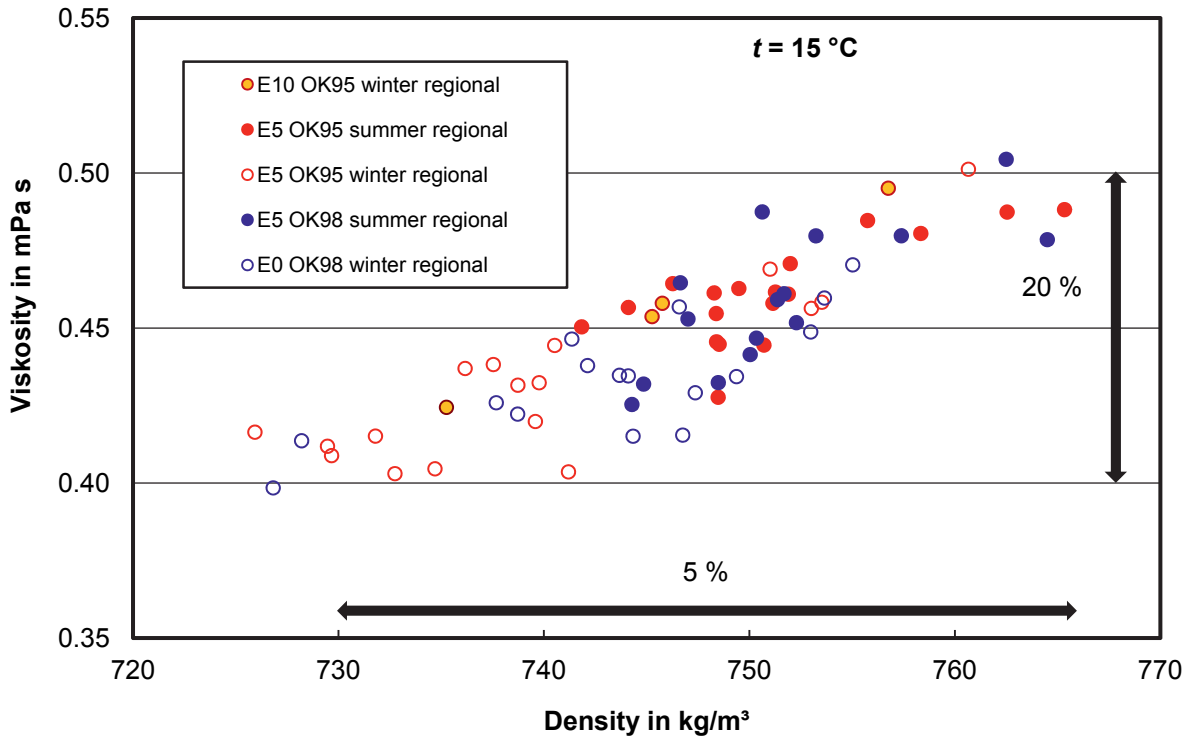


Fig. 5-3: Dependence of the viscosity of the petrols on the density.

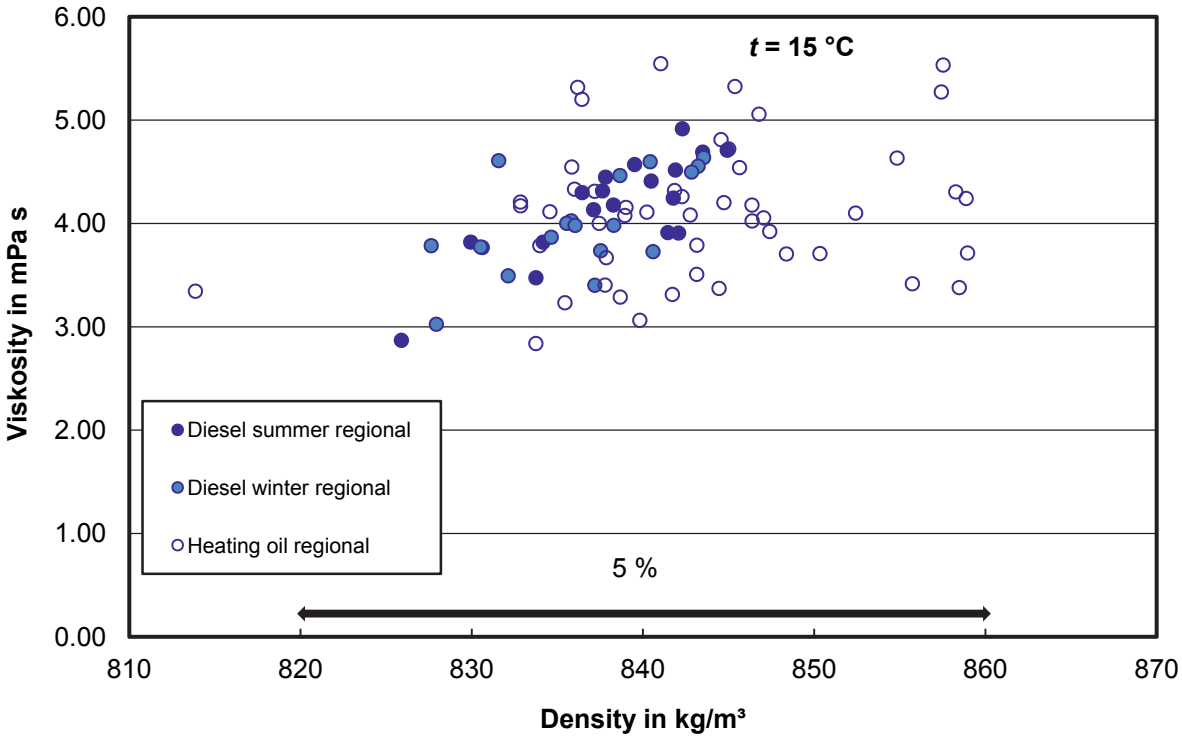


Fig. 5-4: Dependence of the viscosity of diesels and heating oils on the density.

6 Mixtures containing biofuel components

In the previous chapter 5, we have shown that fuels from regionally different sources exhibit a certain bandwidth of values with regard to their density and their thermal expansion coefficient. In the case of the petrols, this bandwidth slightly exceeds the legally prescribed limits, which can, in certain cases, lead to an exceeding of the maximum permissible error for thermal temperature conversion.

When considering the question as to whether the admixture of biofuels changes the material parameters in such a way that a new assessment within the scope of the verification law is necessary (particularly by indicating new temperature conversion coefficients), these values should be considered as reference values. The investigations described in the following are based on such an approach.

When investigating the dependence of the density and of the thermal expansion coefficient as well as of the viscosity on the fraction of biofuel components in the fuel, limitations must be put up with as far as the number of samples measured is concerned. Measurement series were carried out with sample mixtures consisting of fossil petrol with ethanol and of fossil diesel fuel with the biodiesels *rapeseed methyl ester* (RME), *soy methyl ester* (SME), *palm oil methyl ester* (PME) and *coconut oil methyl ester* (CME), respectively. In addition, also some mixtures of fossil heating oil with RME were investigated. Hereby, mixture series consisting of 0 % biofuel content (= pure fossil fuel) up to 100 % biofuel (= pure biofuel) were made with each of the combinations mentioned above. For the main series (super petrol/ethanol, diesel/RME, and diesel/SME), a 10 % pattern was aimed at, enhanced, in the edge ranges, by further mixtures. The other mixture series were mixed according to a rougher pattern.

The fossil primary material was, for all series, the same petrol or the same diesel fuel; the only change was the modification undergone by the material during the storage period (see Chapter 4). Two mixture series were made, one with summer-grade fuel and one with winter-grade fuel as the fossil basis. The biofuel contents were always taken from the same batch.

In this way, we created a data field which, of course, cannot reflect all possible mixture variants, but which can, however, be deemed representative of all mixtures that are possible. The possible variation width of the fossil components corresponds to approximately that described in Chapter 5. The low concentrations of biofuel components did not significantly influence the bandwidth of the material parameters reflected there, as will be shown in the following.

We could not measure the bandwidth of the material parameters in the case of recently produced bio-ethanol and biodiesels from several different sources. The density difference in two existing RME samples of different origin amounted to 0.5 kg/m³, that of two SME samples amounted to 1 kg/m³. Therefore, we assume that the span of the material parameters in the biofuel components is no larger than that encountered in fossil components. Also for bio-ethanol, we do not expect any higher scattering of the density values.

All indications about the admixtures refer to the volume at 15 °C. The mixtures were produced gravimetrically, i.e. the masses of the base components necessary for the desired mixture were calculated from the previously measured densities at 15 °C and they were poured together while being weighed on a balance. The two fuel components to be mixed were poured into the mixing bottle using

a syringe in such a way that the contact area with air was kept as small as possible. Free fall of the liquids by pouring was also avoided. The uncertainty of the mixing ratio achieved solely due to the gravimetric measurement is lower than 0.01 %, but the total uncertainty of the mixing ratio was estimated as being 0.1 % due to the contact of the liquids with air and the association evaporation that cannot be fully ruled out.

Table 3 lists the number of all mixtures produced and measured.

Table 3: Number of samples produced to investigate the influence of biofuels on the material parameters "density" and "viscosity".

Class of substance	Number of mixtures measured
Summer-grade super petrol/ethanol	14
Winter-grade super petrol/ethanol	13
Nonane, hexane/ethanol	33
Summer-grade diesel/RME	18
Winter-grade diesel/RME	17
Summer-grade diesel/SME	15
Winter-grade diesel/SME	15
Summer-grade diesel/PME	9
Winter-grade diesel/PME	8
Summer-grade diesel/CME	12
Winter-grade diesel/CME	12
Heating oil/RME	6

6.1 Behaviour of a pure alcane when adding ethanol

Table 3 also lists the mixture series of hexane/ethanol and nonane/ethanol. These two alcanes hexane and nonane with a purity of 99 % each were selected to represent the fundamental behaviour when adding bio-ethanol. The question is whether a certain behaviour could possibly be caused by a small admixture of an additive contained in one of the petrol samples we used (e.g. ETBE) which would, however, not occur when modifying the admixtures. The two pure substances reflect, on the one hand, the behaviour of petrols; on the other hand, they ensure that such admixtures of additives do not already exist (as mentioned earlier, we did not have any analytical capabilities at our disposal for this purpose).

Based on the mixture series ethanol/hexane, the change in density and thermal expansion coefficient when adding bio-ethanol will be addressed in detail in the following.

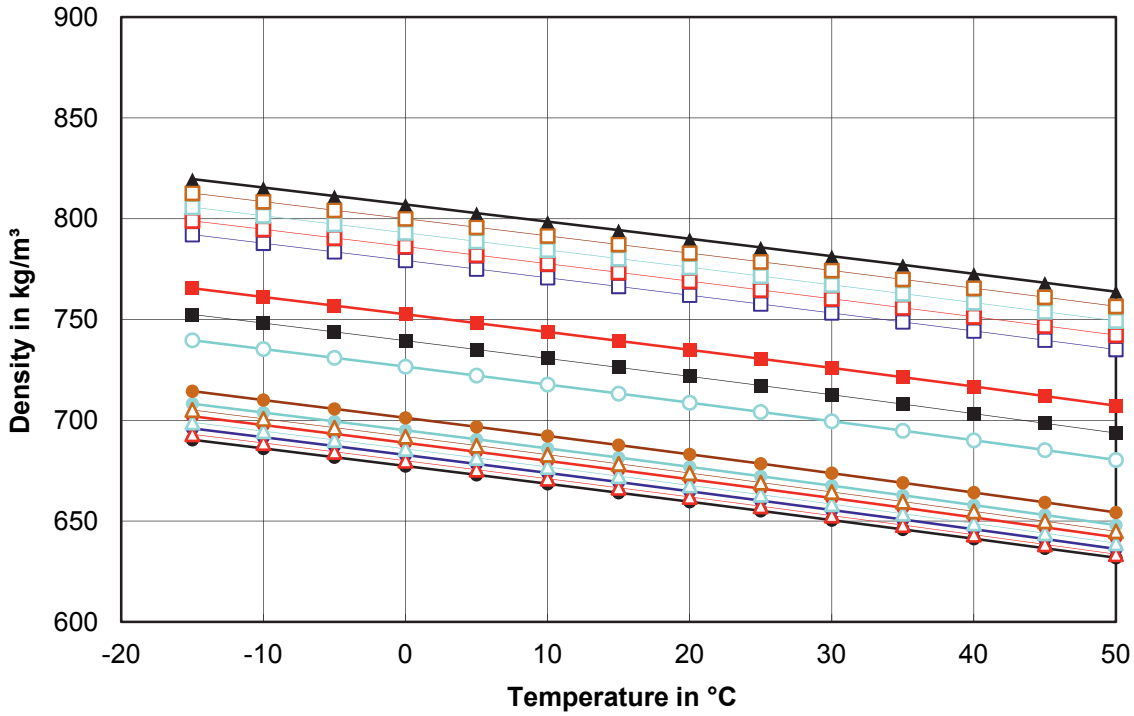
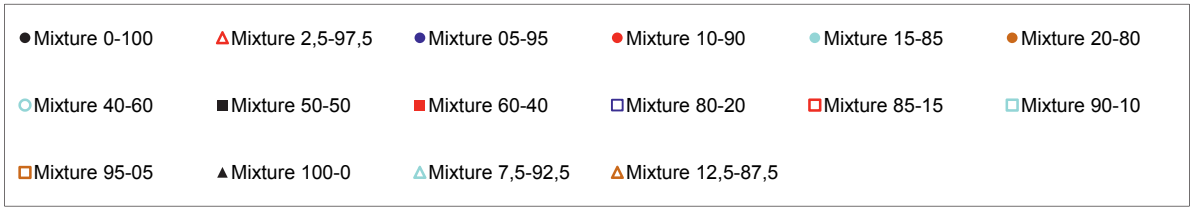


Fig. 6-1: Dependence of the density on the temperature for various ethanol/hexane mixtures.



The figures indicate the mixing ratio in % volume, with the former being ethanol and the latter being hexane (e.g.: 20-80 means 20 % ethanol and 80 % hexane). The volume fractions apply at the reference temperature of 15 °C. The diagram shows the measured data and an approximation curve obtained from these data.

Measurement series of density as a function of the mixing ratio can be extracted from these measured data. Figure 6-2 shows this for the following temperatures: -15 °C; 0 °C; 15 °C; 30 °C, and 50 °C.

A more meaningful means would be a representation showing the deviation of the measured densities from a density interpolated linearly from the mixing ratio, as shown in Figure 6-3. We would expect a perfectly linear behaviour if the mixing were done without any interaction between the different types of molecules; in this case, the respective volumes of the two liquid components would simply add up. If there is – in contrast – a deviation from the linear behaviour, then this is an indication of such interactions.

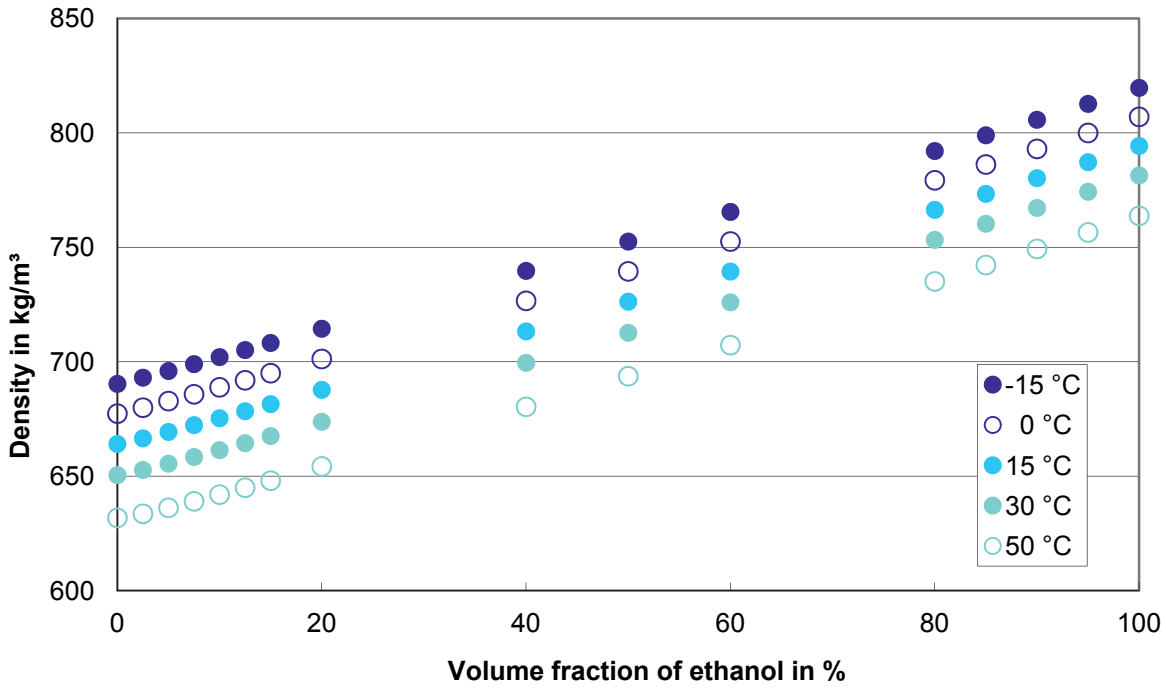


Fig. 6-2: Dependence of the density on the mixing ratio for various ethanol/hexane mixtures.

Figure 6-3a shows a density reduction, i.e. a volume increase when mixing – an excess volume which is often encountered when mixing non-polar and polar liquids. In order to make this excess volume more palpable, Figure 6-3b is a reiteration of this representation, this time in relative values. At low temperatures, the maximum of the excess volume occurs at an ethanol fraction of approx. 50 % and shifts to a lower ethanol concentration of approx. 40 % when the temperature increases. Due to the rough 10 % pattern, it would not make sense to try and indicate the volume fractions with greater accuracy; determining the density decrease via an approximation of the data requires a detailed investigation of the functional relation, which is not the subject of this work.

What is remarkable is that this excess volume turns out to be strongly temperature-dependent even at very small ethanol admixtures, whereas the temperature dependence on the high-ethanol side of the curve is very low. Obviously, the excess volume is, to a considerable extent, caused by the admixture of the – compared to hexane – very small ethanol molecule; at low ethanol concentrations, a masking of the ethanol molecules by the hexane molecules can be expected, so that their polarity cannot lead to interactions with other ethanol molecules. This is the reason why these small molecules make the volume of the mixture increase. This effect is obviously strongly temperature-dependent. At higher ethanol concentrations, the OH group of the ethanol is no longer sufficiently masked, and the properties of pure ethanol become increasingly determinative for the overall properties of the mixed liquid.

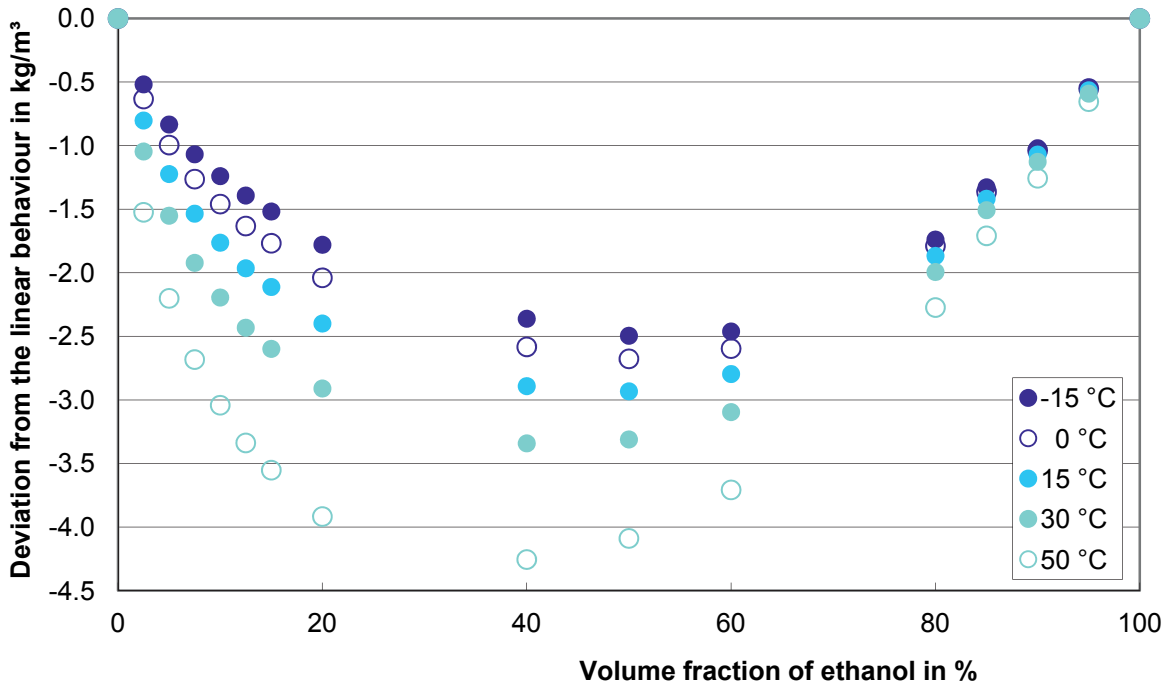


Fig. 6-3a: Dependence of the density on the mixing ratio for various ethanol/hexane mixtures. Absolute deviation from a linear behaviour.

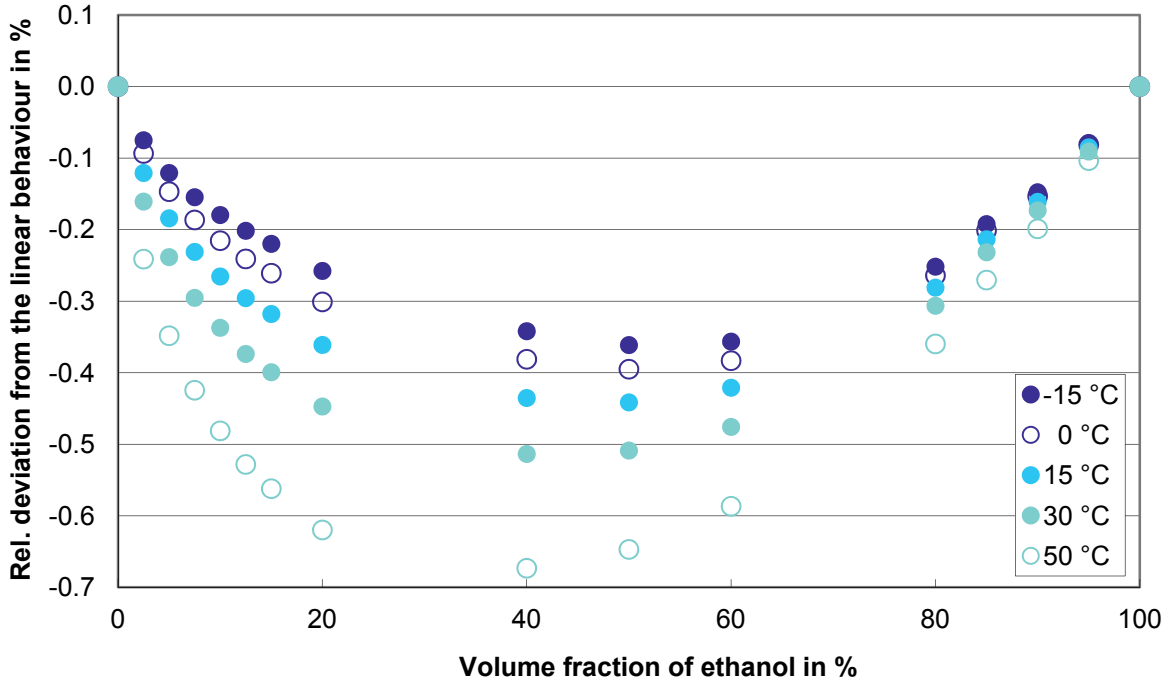


Fig. 6-3b: Dependence of the density on the mixing ratio for various ethanol/hexane mixtures. Relative deviation from a linear behaviour.

A temperature dependence can therefore no longer be observed in the selected data plot, since it refers to the ethanol density at the respectively selected temperature.

The masking of the small polar ethanol molecules by the non-polar hexane must also be considered as the cause for the known vapour pressure increase observed in petrol blends containing small ethanol concentrations.

The dependence of the density of fuels on the temperature cannot be described with sufficient accuracy with a function which is determined by a physical model. It is therefore described by means of mathematical approximation, in this precise case, by means of a third-order polynomial. This is a compromise between good adjustment (the deviations between the measured values and the approximated values usually lie around less than 0.003 kg/m³) and a "smooth" curve which does not oscillate between the data points used for the approximation. The thermal expansion coefficient can then be obtained by simple differentiation. Figure 6-4 illustrates the thermal expansion coefficients obtained in this way from the ethanol/hexane mixture series.

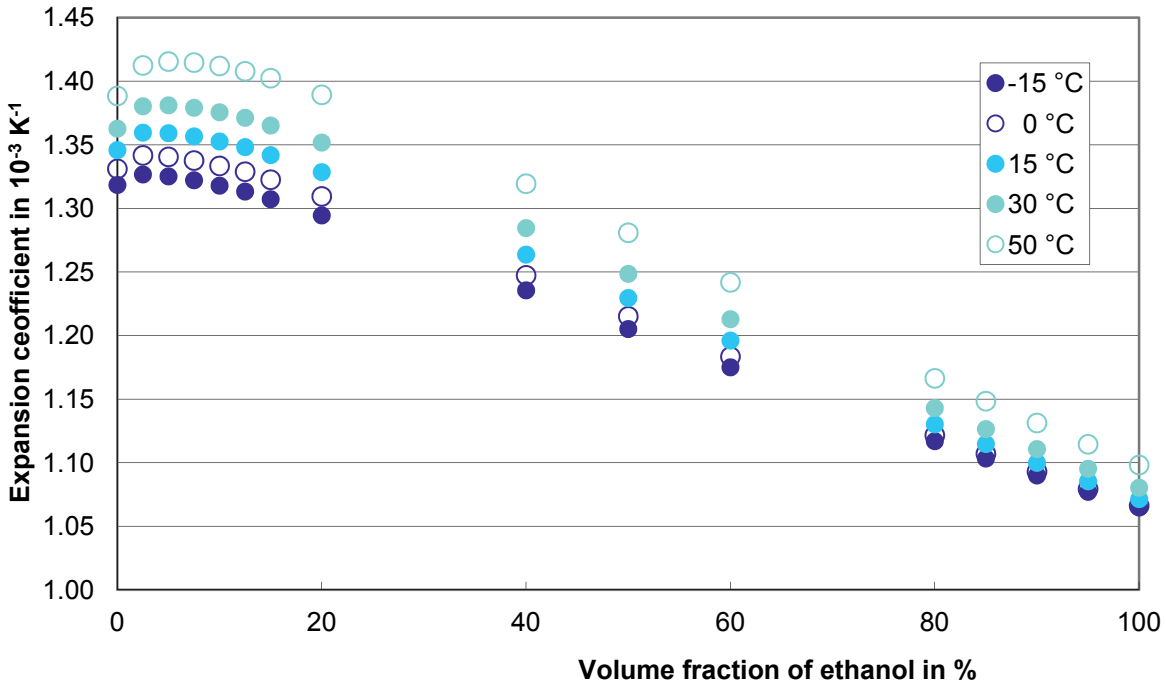


Fig. 6-4: Dependence of the thermal expansion coefficient on the mixing ratio for ethanol/hexane mixtures. For this purpose, the dependence of the density on the temperature was described using a third-order polynomial.

When indicating the thermal expansion coefficient, the statistical relative uncertainty calculated from the adjustment to the measured data lies, depending on the order of the adjustment polynomial, between $5 \cdot 10^{-3}$ for a first-order polynomial and $5 \cdot 10^{-5}$ for a third-order polynomial. The measurement uncertainties of the density and the temperature do not cause these values to increase significantly. This uncertainty must be compared with the permitted variation of the thermal expansion coefficient of 4.5 % derived in Chapter 5 for compliance with the legal verification requirements.

As a rough approximation, the thermal expansion coefficient evolves linearly from the value for pure fossil fuel to the value for pure bio-ethanol. Upon closer inspection, however, it turns out that at low ethanol concentrations of up to 7.5 %, the thermal expansion coefficient first increases before it starts decreasing again. This peak increases together with increasing temperature. A possible cause for this is the already described masking of the small polar ethanol molecules which, due to their small size, would have a considerably higher thermal expansion coefficient if their polarity were deactivated. The span between the minimum thermal expansion coefficient (the value for pure ethanol) and the maximum thermal expansion coefficient (approx. E7, 7 % ethanol concentration) amounts to 27 % at t = 15 °C (as a function of the minimum value) and even to 29 % at t = 50 °C. If the values for pure hexane are taken as a reference, the span obtained is 25 % for both temperatures.

In Chapter 5, it was demonstrated by means of a model calculation that the maximum permissible span for a petrol is 9 % to comply with the maximum permissible error if a mean temperature conversion coefficient is used instead of the real thermal expansion coefficient. This value is clearly exceeded in the ethanol/hexane series when considering the whole mixture range. In the low-ethanol range (up to approx. 20 %), the maximum span is, however, not attained. It is thus possible to use the same temperature conversion coefficient for all mixtures.

6.2 Behaviour of petrols when adding ethanol

The dependence of the density and of the thermal expansion coefficient when adding ethanol to fossil fuels was investigated as described in Chapter 6.1. Hereby, two mixture series – one with summer-grade fuel and one with winter-grade fuel – were produced and measured. We would like to emphasize again that the base fuel used is only one of the list mentioned in Chapter 5. The bandwidth described in Chapter 5 therefore suggests that using a different base fuel would lead to different results. The ethanol component was taken from the same batch for all mixtures.

The indications specified in Chapter 6.1 with regard to the uncertainty of the thermal expansion coefficient can all be transferred to all ethanol/petrol blends. They also amount to $5 \cdot 10^{-3}$ in the case of a linear approximation and to approx. $5 \cdot 10^{-5}$ in the case of an approximation with a third-order polynomial.

The results obtained here are shown in Figures 6-5 to 6-8 for the mixtures series with summer-grade fuel, and in Figures 6-9 to 6-12 for the mixtures series with winter-grade fuel.

In these mixture series, too, the density increases, in a rough approximation, linearly with the concentration of ethanol added. What is striking, however, is that the excess volume behaves in a fully different manner than in the ethanol/hexane mixture series. For summer-grade fuel, the density increases at low temperatures on the high-fuel side; a clear correlation, however, cannot be established. Only at high temperatures the density is decreasing in a way similar to the ethanol/hexane series; a clear correlation can also not be found here. The relative deviations from the linear interpolation at the maximum are less than half the size of those of the ethanol/hexane mixtures series.

The mixture series with winter-grade petrol shows a strong density increase of up to 2 % when adding up to 20 % ethanol; the effect indicated in summer-grade petrol is very distinct here. We tried to reproduce this effect with other samples, but we failed. The effect seems to be strongly dependent on

the chemical composition of the particular petrol sample. During our investigations, these measurements could not be pursued due to the lack of chemical analysis capacities.

Similar to the ethanol/hexane mixture series, the thermal expansion coefficient has its maximum at an admixture concentration of around 10 % ethanol. The maximum increase is 2.1 % in summer-grade fuel and 1.7 % in winter-grade fuel. In both grades of fuel, the maximum is very broad; therefore, it can be calculated in good approximation for admixtures between 2.5 % and 15 % ethanol with these specified values.

Based on these data, it is possible to estimate how large the natural scattering of the thermal expansion coefficient described in Chapter 5 – which covers a range of approx. 10 % (cf. Fig. 5-1) – would be if only fossil fuels (without ethanol admixture) had been available. In default of sufficient data, we assume that the difference between the summer-grade and the winter-grade fuels is also a measure of the additional scattering caused by adding ethanol to the fossil petrol. The scattering described in Chapter 5 can thus be back-calculated to a probable scattering for samples without added ethanol; this yields a value of 10.1 % - 0.4 % = 9.7 %. This value exceeds the 9.14 % specified in Chapter 5 which allows a temperature conversion of all measured fuels from 50 °C to 15 °C without exceeding the maximum permissible error. It is therefore assumed that some petrol batches are occasionally put on the market which may slightly exceed the maximum permissible error when using the maximum temperature conversion value.

Figures 6-8 and 6-12 show the dynamic viscosities of the measured mixtures. The value of the viscosity increases at low temperatures by a factor of 5 when considering the whole mixtures series; at high temperatures, this factor has approximately the value 3. The behaviour is not linear in the mixing ratio. The mixtures with winter-grade fuel do not allow measurements at temperatures ranging above 30 °C, since cavitation effects already occur due to the high vapour pressure which lead to a gas/liquid mixture making it impossible to carry out the measurement.

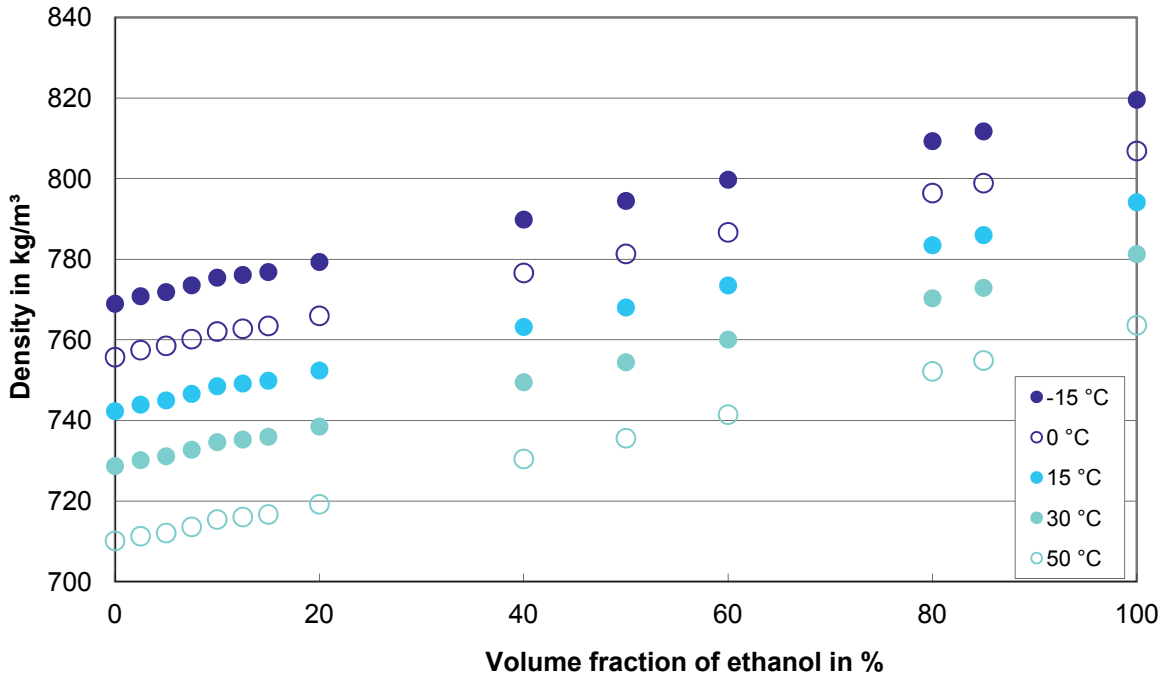


Fig. 6-5: Dependence of the density on the mixing ratio for various ethanol/petrol mixtures. Summer-grade petrol.

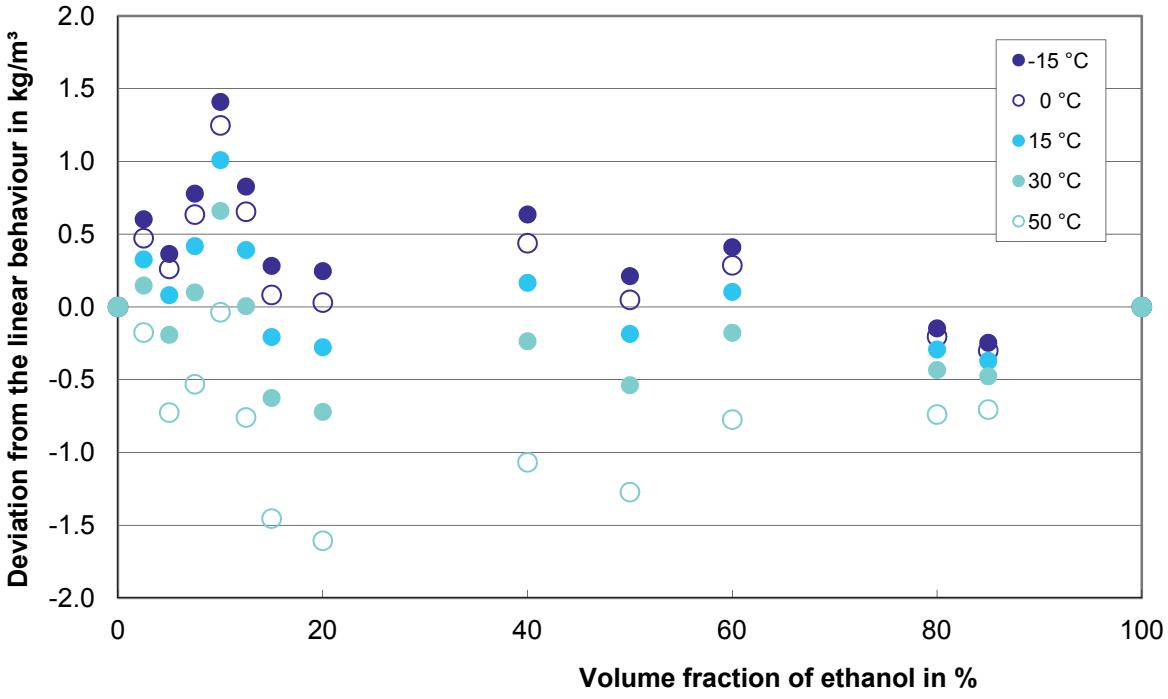


Fig. 6-6: Dependence of the density on the mixing ratio for various ethanol/petrol mixtures. Summer-grade petrol. Deviation from a linear behaviour.

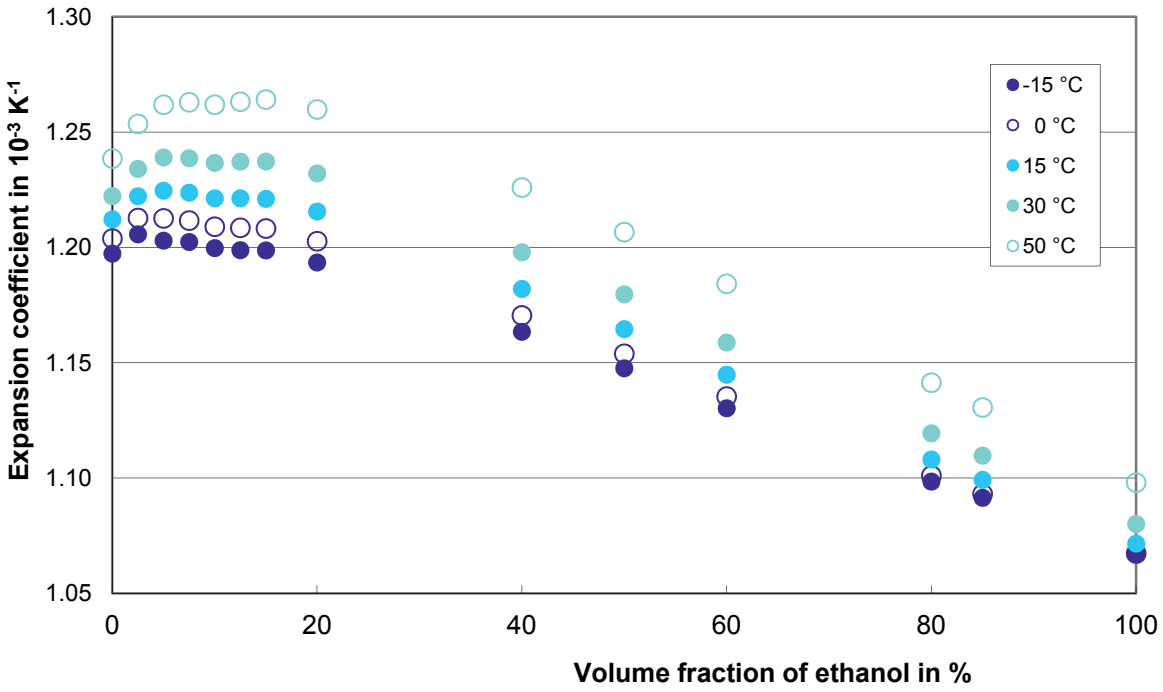


Fig. 6-7: Dependence of the thermal expansion coefficient on the mixing ratio for ethanol/petrol mixtures. Summer-grade petrol. For this purpose, the dependence of the density on the temperature was described using a third-order polynomial.

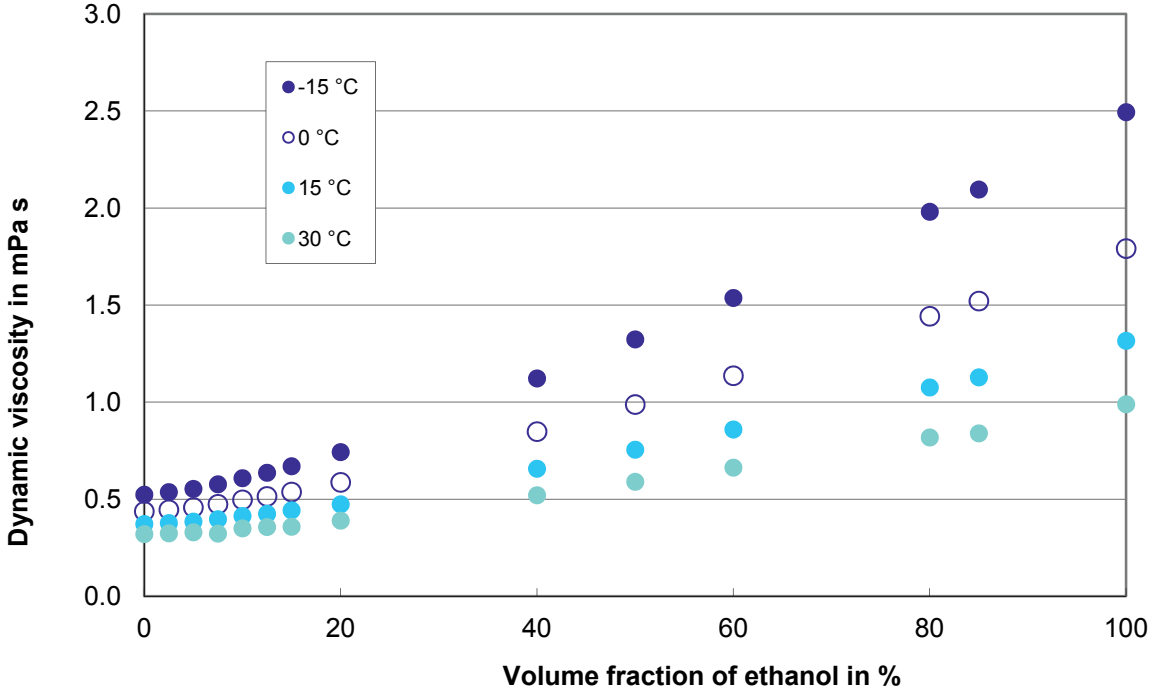


Fig. 6-8: Dependence of the viscosity on the mixing ratio for various ethanol/petrol mixtures. Summer-grade petrol.

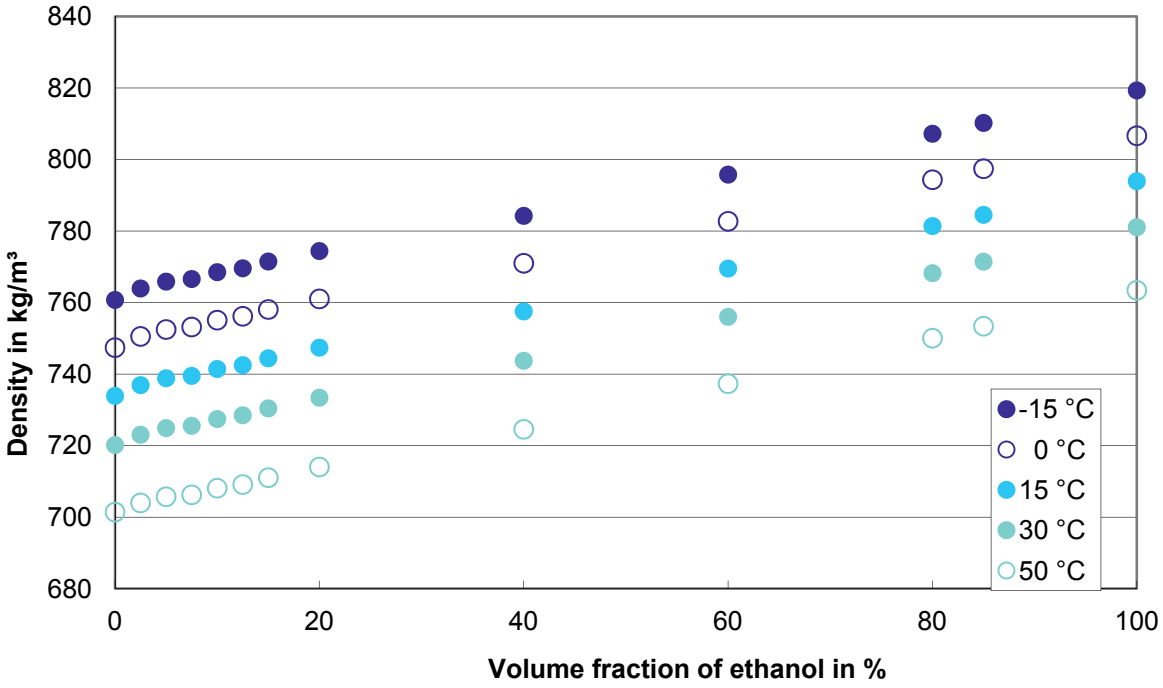


Fig. 6-9: Dependence of the density on the mixing ratio for various ethanol/petrol mixtures. Winter-grade petrol.

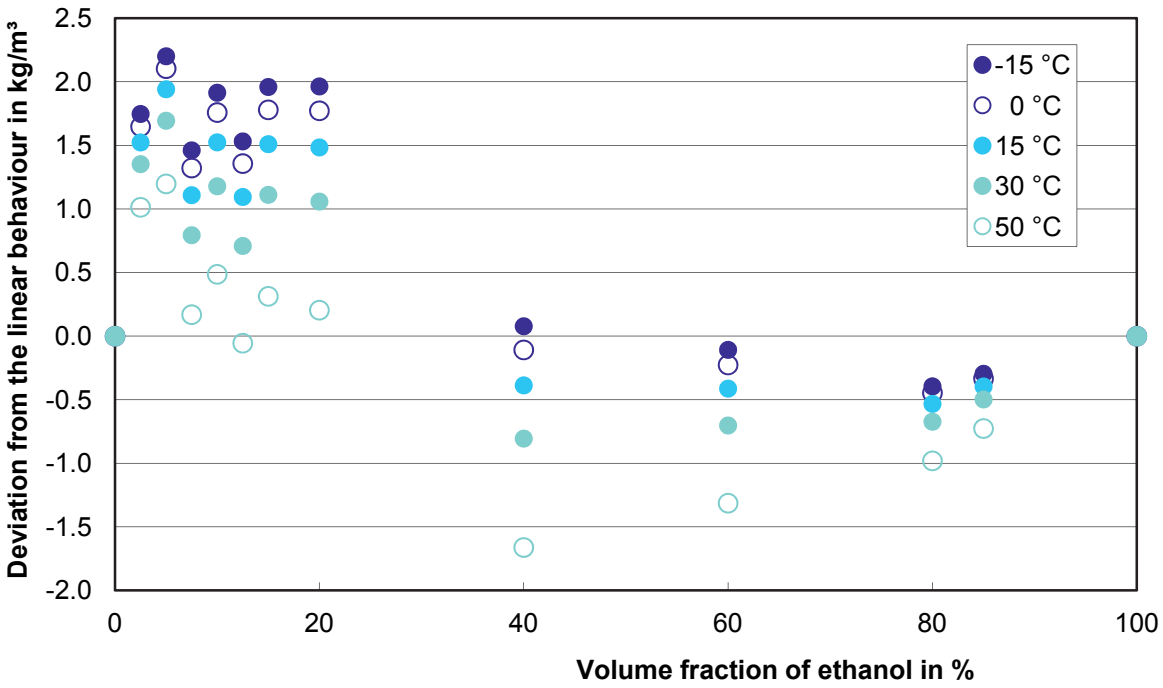


Fig. 6-10: Dependence of the density on the mixing ratio for various ethanol/petrol mixtures. Winter-grade petrol. Deviation from a linear behaviour.

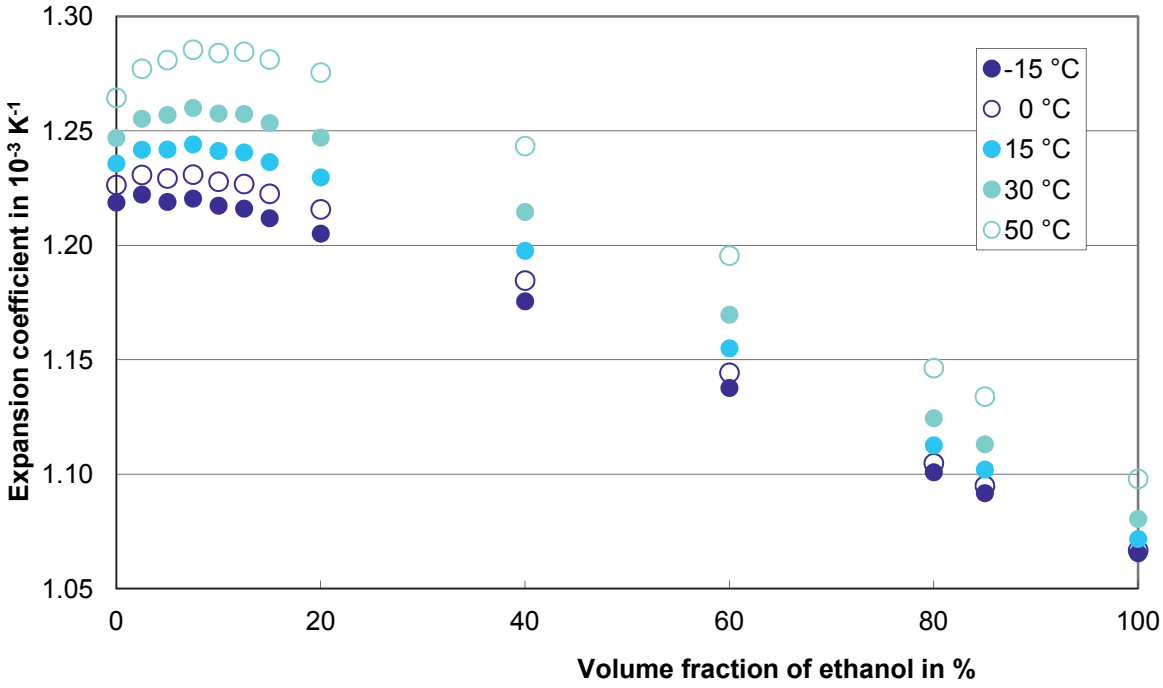


Fig. 6-11: Dependence of the thermal expansion coefficient on the mixing ratio for ethanol/petrol mixtures. Winter-grade petrol. For this purpose, the dependence of the density on the temperature was described using a third-order polynomial.

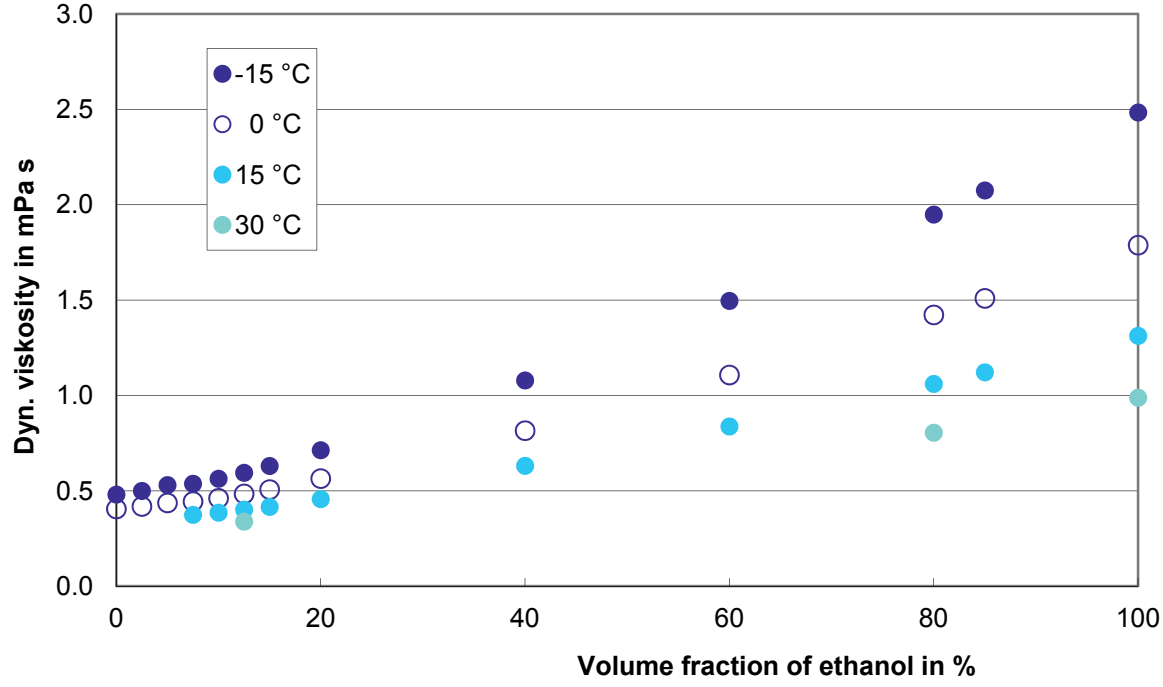


Fig. 6-12: Dependence of the viscosity on the mixing ratio for various ethanol/petrol mixtures. Winter-grade petrol.

6.3 Behaviour of diesel fuels when adding biodiesel

The dependence of the density and of the thermal expansion coefficient when adding biodiesel to fossil diesel fuel was also investigated as described in Chapter 6.1. Here too, two mixture series – one with summer-grade fuel and one with winter-grade fuel – were produced and measured. We would like to emphasize again that, here too, the base fuel used is only one of the list mentioned in Section 5. The bandwidth described in Section 5 therefore suggests that using a different base fuel would lead to different results. The biodiesel component was taken from the same batch for all mixtures. Besides mixtures using rapeseed methyl ester, also others with other types of biodiesel fuels (soy methyl ester, palm oil methyl ester and coconut oil methyl ester) were produced and measured (cf. Table 3).

Similar to Chapter 6.2, the results obtained by admixture of rapeseed methyl ester (RME) are shown in Figures 6-13 to 6-16 for the mixture series with summer-grade fuel and in Figures 6-17 to 6-20 for the mixture series with winter-grade fuel.

The indications specified in Chapter 6.1 with regard to the uncertainty of the thermal expansion coefficient are even better for biodiesel/diesel blends. Due to the "better" linearity of diesel fuels, these are smaller than $5 \cdot 10^{-4}$ in the case of a linear approximation and smaller than $5 \cdot 10^{-5}$ in the case of an approximation with a third-order polynomial.

In these mixture series, too, the density increases, in a rough approximation, linearly with the concentration of rapeseed oil methyl ester added. The excess volume exhibits a similar behaviour to the ethanol/hexane mixture series, but is considerably – by a factor of 9 – smaller.

The thermal expansion coefficient scarcely varies for the mixture series with summer-grade diesel (order of magnitude: 0.5 %). The behaviour is temperature-dependent; at -15 °C there seems to be a maximum at around 90 % RME admixture. This maximum is enhanced by increasing temperatures and simultaneously shifts towards smaller mixture concentrations of RME. For temperatures above 30 °C, the thermal expansion coefficient of pure RME is smaller than that of pure fossil diesel.

Pure winter-grade fossil diesel has, compared to summer-grade diesel, a thermal expansion coefficient that is larger by 3 %. Here, the thermal expansion coefficient of the mixture series decreases continuously; its behaviour is, in good approximation, linear in the mixing ratio.

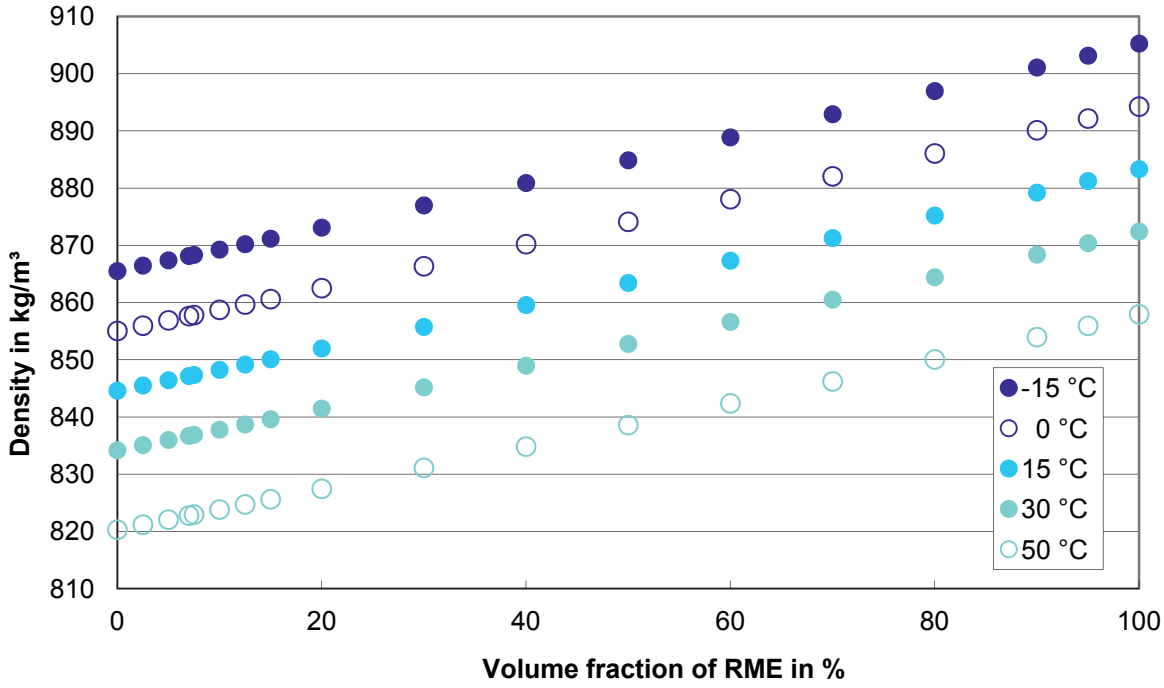


Fig. 6-13: Dependence of the density on the mixing ratio for RME/diesel mixtures. Summer-grade diesel.

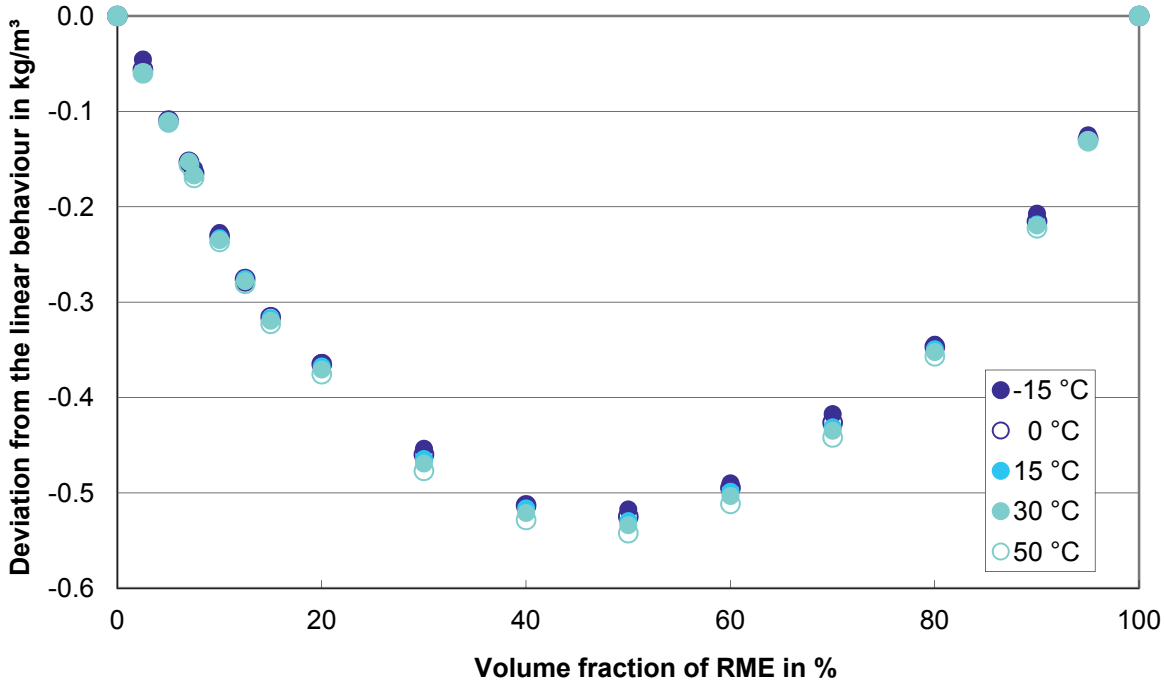


Fig. 6-14: Dependence of the density on the mixing ratio for RME/diesel mixtures. Summer-grade diesel. Deviation from a linear behaviour.

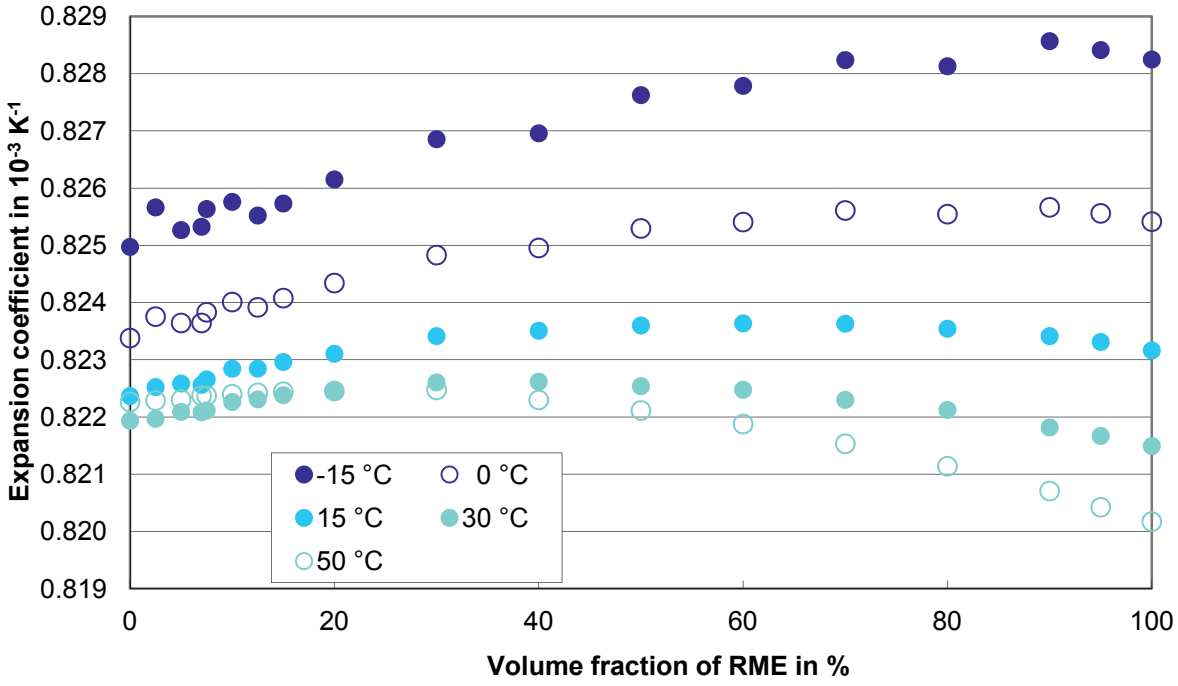


Fig. 6-15: Dependence of the thermal expansion coefficient on the mixing ratio for RME/diesel mixtures. Summer-grade diesel. For this purpose, the dependence of the density on the temperature was described using a third-order polynomial.

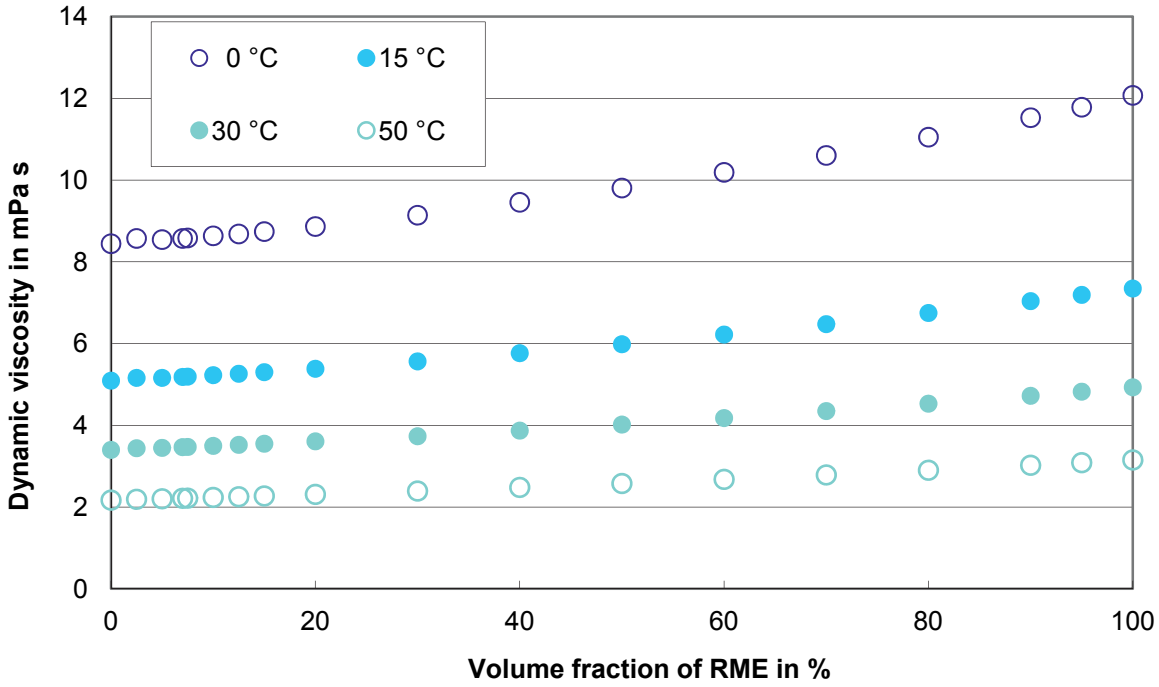


Fig. 6-16: Dependence of the viscosity on the mixing ratio for RME/diesel mixtures. Summer-grade diesel.

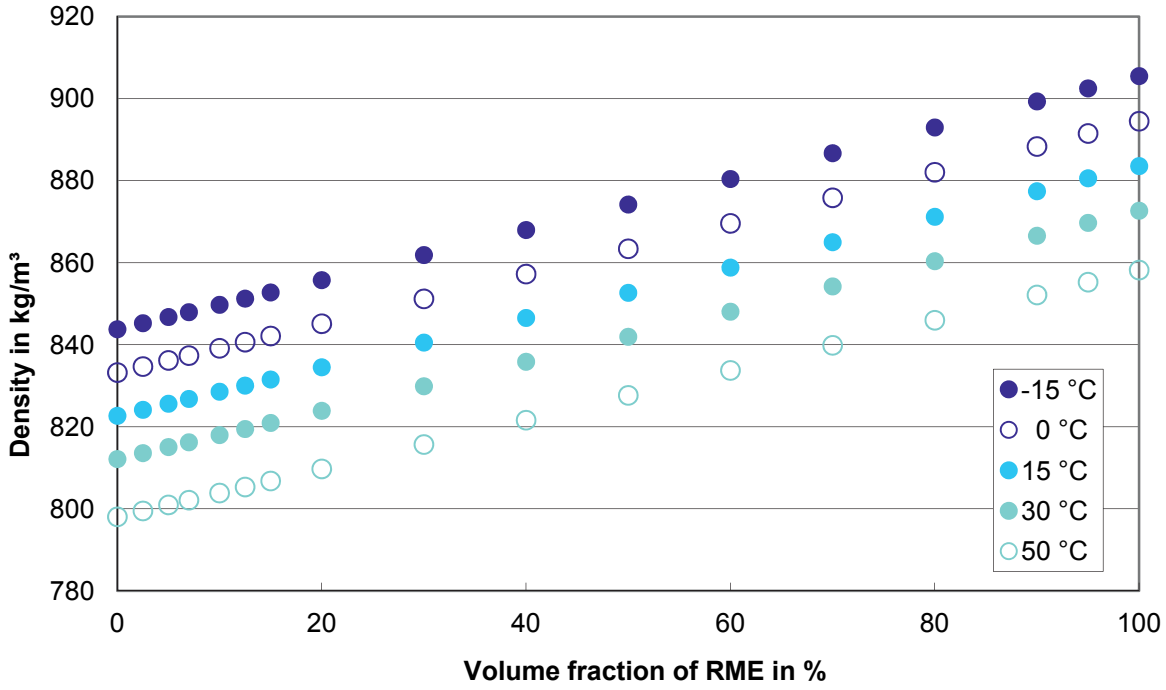


Fig. 6-17: Dependence of the density on the mixing ratio for RME/diesel mixtures. Winter-grade diesel.

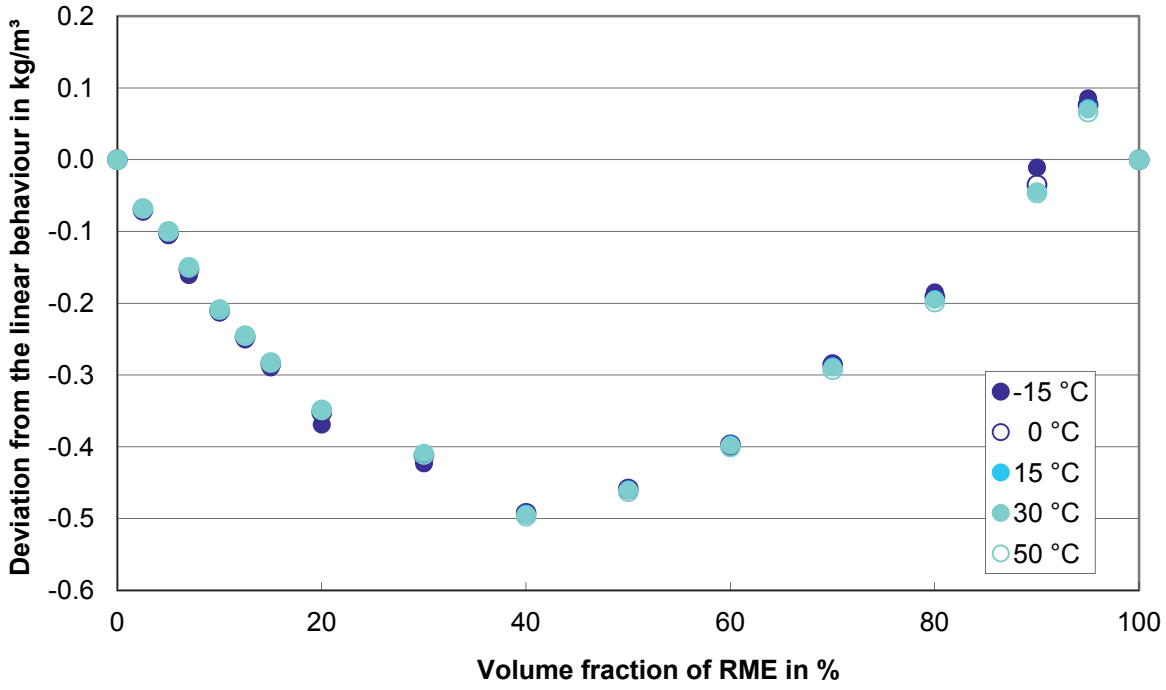


Fig. 6-18: Dependence of the density on the mixing ratio for RME/diesel mixtures. Winter-grade diesel. Deviation from a linear behaviour.

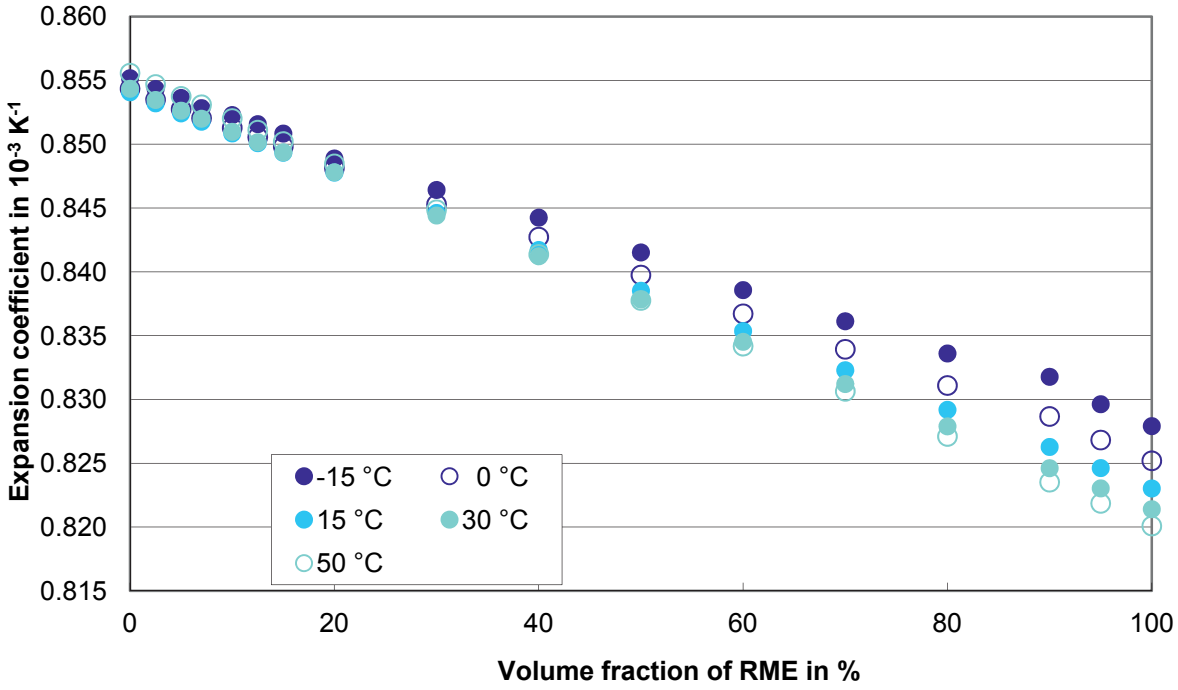


Fig. 6-19: Dependence of the thermal expansion coefficient on the mixing ratio for RME/diesel mixtures. Winter-grade diesel. For this purpose, the dependence of the density on the temperature was described using a third-order polynomial.

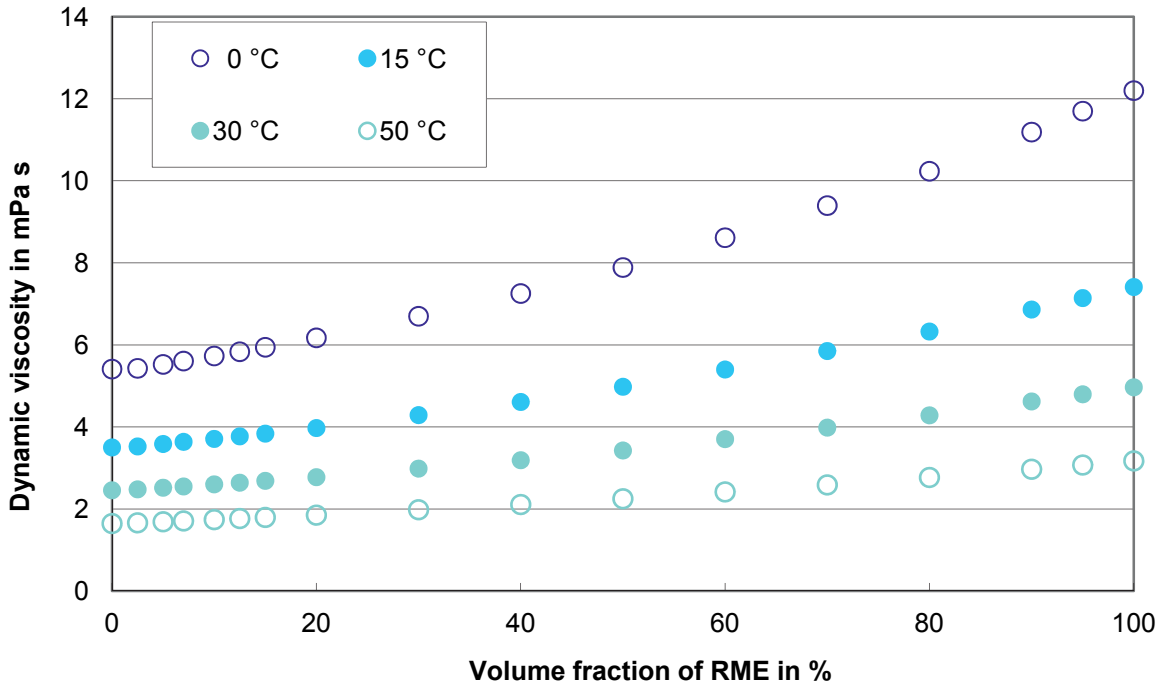


Fig. 6-20: Dependence of the viscosity on the mixing ratio for RME/diesel mixtures. Winter-grade diesel.

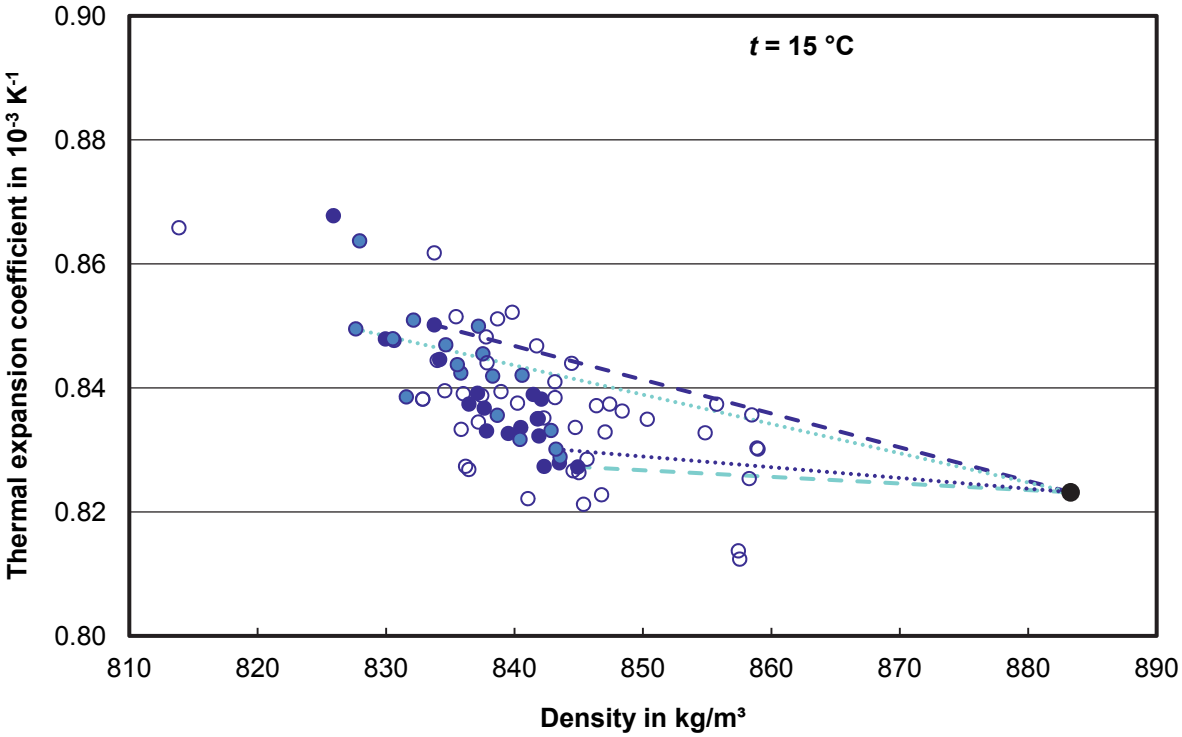


Fig. 6-21: Two of the possible variants for the curve of the dependence of the thermal expansion coefficient on the density when adding biodiesel. The black disk designates a value for pure rapeseed methyl ester. The dashed lines with the long dashes show two possible curves for the mixture with summer-grade diesel; the dashed lines with the short dashes show two possible curves for the mixture with winter-grade diesel. This figure is an extension of Figure 5-2.

Again, we would like to point out that these mixture series are based on a random selection of the base material; base material coming from another refinery must be expected to yield different results. This is clearly shown in Figure 6-21: Here are two possible curves plotted into the Figure 5-2 – which is showing the dependence of the thermal expansion coefficient on the density for regional diesel samples, indicating two different base materials used. In this example, the biodiesel component is assumed to be the same for all mixtures. The dependence on the mixing ratio shown in Figures 6-17 and 6-19 is visible in this figure as a change in density.

Due to the very small changes in the thermal expansion coefficient, there is, for either possible variants, no risk that the maximum permissible errors for temperature conversion might be exceeded when adding RME to fossil diesel.

Figures 6-16 and 6-20 show the dynamic viscosities of the measured mixtures. The value of the viscosity increases for the mixtures with winter-grade diesel approximately by a factor of 2 when considering the whole mixtures series; in mixtures with summer-grade diesel, this is approximately 1.5. The behaviour is not linear in the mixing ratio. The mixtures with winter-grade fuel do not allow measurements at temperatures below 0 °C, since solid deposition occurs which makes it impossible to carry out the measurement.

6.4 Behaviour of diesel fuels when adding SME, PME or CME

Besides the mixture series with rapeseed methyl ester (RME), also mixture series – to a lower extent – with soy methyl ester (SME), palm oil methyl ester (PME) and coconut oil methyl ester (CME) were investigated.

Here, we would like to draw a summary of the dependence of the thermal expansion coefficient on the density for all mixture series (Figure 6-22).

The behaviour of the SME mixtures is nearly the same as that of RME mixtures. The differences are negligible if the conclusions drawn in Chapter 6.3 are referred to.

PME has a thermal expansion coefficient which is higher by approx. 2 % at a density which is lower than that of RME and SME by approx. 1 %. The values, however, still lie completely within a range which does not cause any problems under legal regulations for the thermal expansion coefficient.

CME has a thermal expansion coefficient that is considerably higher than that of RME and SME; the difference amounts to 9 %. This value clearly exceeds the limit of 6.8 % described in Chapter 5. A biodiesel blend with high CME concentration thus does not comply with legal regulations. This case is, however, not particularly meaningful as the quantity of CME present on the market is very small.

The fossil diesel fuel used for the mixture series CME-WDK and PME-WDK had to be from a different jerrycan than that for the mixture series RME-WDK and SME-WDK. The values for the density and the thermal expansion coefficient of the fossil base material therefore differ slightly; this is visible in the different values of the data points on the far left in the figure which describe the pure fossil material.

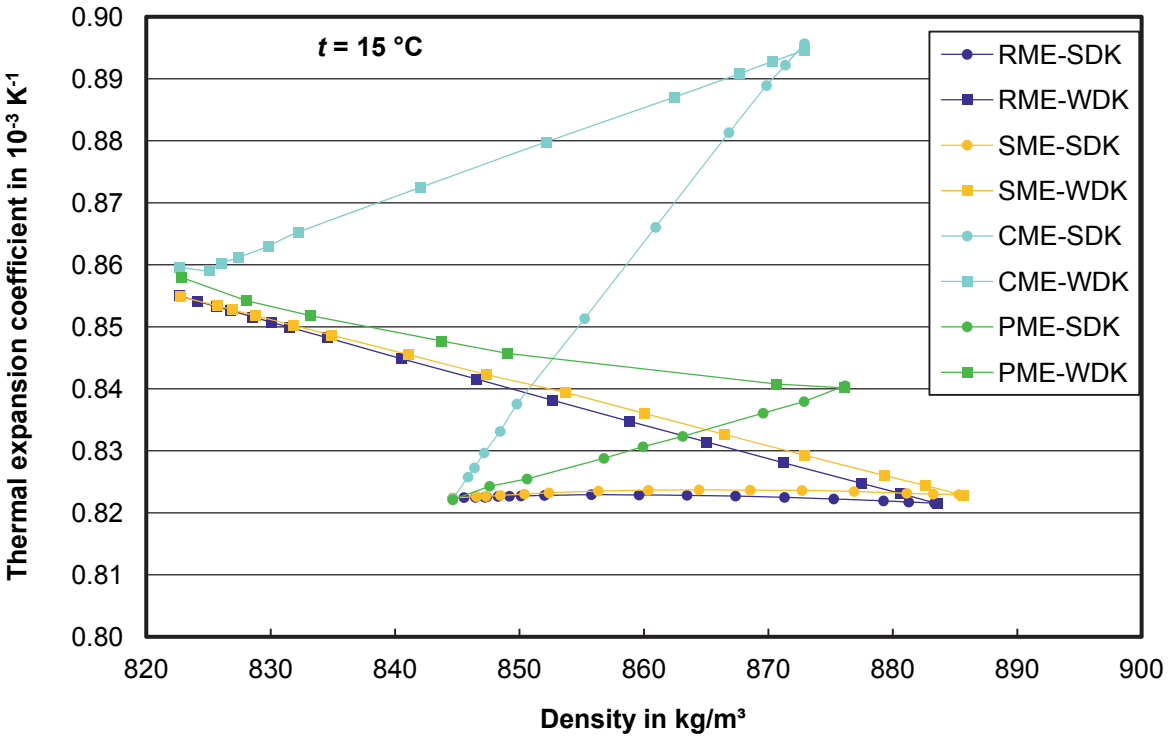


Fig. 6.22: Compared dependence of the thermal expansion coefficient on the density for the mixture series rapeseed methyl ester/summer-grade diesel (RME-SDK), rapeseed methyl ester/winter-grade diesel (RME-WDK), soy methyl ester/summer-grade diesel (SME-SDK), soy methyl ester/winter-grade diesel (SME-WDK), palm oil methyl ester/summer-grade diesel (PME-SDK), palm oil methyl ester/winter-grade diesel (PME-WDK), coconut oil methyl ester/summer-grade diesel (CME-SDK), and coconut oil methyl ester/winter-grade diesel (CME-WDK). The data points with the lowest density are the values for fossil diesels; the density increases along with an increasing volume fraction of biodiesel.

7 Impacts on legal metrology and standardization

The introduction of the new fuel mixtures has raised the issue – especially for the verification authorities – of whether the material parameters, the density and their temperature-dependence used to date for the verification of the volume measurement equipment available at shipping facilities and in transport vehicles could still be used. Similar approaches have been taken into consideration in the field of standardization.

Such an approach with regard to the impacts of the admixture of biofuels to fossil fuels on modifications that might become necessary should always take the natural scattering of the parameters into account which already existed previously. Chapter 5 therefore gives a detailed overview of the current state.

Chapter 6 is a comparison of the latter with the changes caused by the admixture of biofuels. It turns out that these changes lie within the natural scattering of the parameters "density" and "thermal expansion coefficient" in the ethanol/petrol system when relatively low quantities (below 30 %) of ethanol are added to petrol, and in the biodiesel/diesel system for all admixtures of rapeseed and soy methyl ester.

This does not make a change in the legal regulations and the corresponding standards necessary. A problem arises, however, if the thermal expansion coefficient is calculated from the density, as prescribed by the so-called "Procedure 2" (the exponential representation of the dependence of the density on the temperature). For more information on this topic, please see Annex 2.

Since the density increases in the event of admixtures, but the thermal expansion coefficient hardly changes, this calculation yields values of the thermal expansion coefficient that are too small – and thus provides a wrong temperature conversion factor. The thermal expansion coefficient calculated for diesel blends changes by 10 % when varying the biofuel fraction from 0 % to 100 %, whereas the values measured merely changes by 3 % if winter-grade diesel is used as a base fuel – and by even less than 0.5 % in the case of summer-grade diesel.

In the case of ethanol/petrol mixtures, the change in the thermal expansion coefficient measured was 14 % and 16 %, respectively, when varying the ethanol fraction from 0 % to 100 %, whereas the calculated change using (11.1) amounted to 23 %.

Both in petrol and in diesel systems, the deviations of the calculated thermal expansion coefficient from the measured value were so large that the maximum permissible error was exceeded.

With lower admixtures (up to 30 %), the maximum permissible error is, however, still complied with. Since the admixture rates used today are 10 % ethanol and 7 % biodiesel, it is not expected that the maximum permissible error could be exceeded when working with conventional procedures and numerical values. But also here, calculating the thermal expansion coefficient according to (11.1) should be avoided, as far as possible.

The admixtures of coconut oil methyl ester may already lead to large changes in the thermal expansion coefficient at low concentrations, but they are used at such a small scale that it is not really necessary to investigate them separately within the scope of this paper.

8 Proposal to clarify whether there is a need for action with regard to the re-definition of the temperature conversion coefficient for future fuel mixtures

In the present study, we have shown that a measurement series consisting of only one fossil fuel and only one biofuel, each taken from the same batch, can only provide representative results for a class of possible results. The results of such a measurement series cannot be transferred onto all possible nominally identical fuels with the same precision as that obtained in that precise measurement. It is necessary to work with mean values instead, which, due to the scattering of the material parameters in the case of materials from different origins, caused higher uncertainties.

This suggests the use of a simplified strategy for the measurements that has to be carried out in order to determine temperature conversion factors when a new kind of fuel is marketed to be mixed with conventional fuels.

The conventional material which is used as the base material should have a density which lies within the natural scattering of the base fuels, on the opposite side of the added components, in order to obtain results over a wide density range. For future new fuels, it may, of course, happen that their density is lower than that of current fuels, in which case the scenario shown in Chapter 6 would have to be inversed.

Measurements of the density and of the thermal expansion coefficient must then only be performed for the base material and for the new component. A linear interpolation between these values is usually sufficient within the scope of the accuracy required to determine the temperature conversion coefficient. The linearity can be checked using two additional mixtures, one of which roughly represents the mixture supposed to be commercialized soon. Only when there are signs of a strongly non-linear behaviour is it necessary to carry out measurements on further mixtures. Non-linear behaviour should be expected especially when mixing non-polar liquids with polar ones, as illustrated by the example of petrol/ethanol.

If the behaviour of the mixtures turns out to be conventional, mean conversion coefficients can be determined. These are not coupled to the measured value of the concretely measured mixture, but rather to the (known) mean values of all the base fuels. If it is expected that the new component will also exhibit strongly varying parameters, then a measurement series has to be carried out to determine the scattering and the mean values of the density and of the thermal expansion coefficient in the case of material coming from different sources.

9 Summary

In the present study, measurements of density and viscosity as well as their temperature dependences were described based on a series of mixtures consisting of biofuels and fossil fuels. The measurement series cover the range of the commercially available fuels used in Germany – and in most of Europe. In order to provide data also covering fuel mixtures containing larger biofuel fractions which might be put onto the market in the future, mixtures with mixing ratios between 0 % and 100 % biofuel content were produced and measured. To understand their basic behaviour, additional measurements were carried out on pure alkanes and on mixture series consisting of ethanol/hexane and ethanol/nonane.

For comparison purposes, a collection of samples was measured – supplied with the cooperation of DGMK – which represents the regional scattering of the parameters of the fuels currently available on the German market.

The density and the thermal expansion coefficient are both legally relevant quantities as they are required for temperature conversion as well as for the calculation of the volume at base conditions at 15 °C.

The viscosity is not legally relevant, but it is important as a potential correction quantity for flowrate measurements and as a significant process parameter to control the fuel flowrate in transport pipelines and for fuel injection in engines. Viscosity data were therefore also measured as far as possible.

The investigations show that the change in the density and in the thermal expansion coefficient caused by the addition of biofuels up to a fraction of 30 % lies, for all the mixtures investigated, within the natural scattering of the parameters measured during the examination of the regional samples.

In the case of biodiesel/diesel mixtures, this statement even applies to mixtures with biofuel fractions of up to 100 %. In the case of ethanol/petrol mixtures with ethanol contents larger than 30 %, the changes in the thermal expansion coefficient are larger than prescribed by the natural scattering of the values of the regional samples.

The results suggest that there is no immediate need for action in legal metrology and standardization with regard to the currently sold fuels that contain less than 10 % of biofuel. The rule normally used for temperature conversion, which prescribes a calculation of the thermal expansion coefficient from the density, can, however, lead to wrong conversion coefficients in the case of larger biofuel fractions. Here, it is recommended that the standards be adapted in view of future developments.

10 References

[1] Hans Schoeneck, Wolf Weber
Die Änderung der Dichte von Mineralölprodukten mit der Temperatur – Beitrag zu einer Änderung von DIN 51757
Erdöl und Kohle · Erdgas · Petrochemie 13 (1960) pp. 738-739

[2] DIN 51757

[3] Detlev Mencke
Einstellwerte für Temperatur-Mengenumwerter von Flüssigkeitszählern
PTB-Mitteilungen 109 (1999) pp. 385-388

[4] Gudrun Wendt, Michael Rinker
Einstellwerte für Temperatur-Mengenumwerter von Flüssigkeitszählern
PTB-Mitteilungen 114 (2004) pp. 117 - 119

Annex 1: Functional description of the dependence of the density on the temperature by means of polynomials

The thermal expansion coefficient can be obtained by approximation of a curve to the measured data and, then, by differentiation. Most liquids show in good approximation a linear dependence of the density on the temperature which, by approximation to the critical point, becomes an exponential dependence. The best-known exception is water, which exhibits its highest density at 4 °C.

A more accurate description, however, requires corrections of the linear description whose functional relation is not necessarily given. Thus, we will, in the following, investigate approximation by means of polynomials of different order, as in Equation A1.1.

We would like to repeat that the resolution of the measuring instrument is 0.001 kg/m³; the measurement uncertainties used were: 0.020 kg/m³ for the temperature range above 0 °C and 0.050 kg/m³ for the temperature range below 0 °C.

The general polynomial equation reads:

$$\rho(t) = \rho_B*(1+ \gamma\,(t - t_B)) = \rho_B*\{1+ [A_1+A_2*(t - t_B)+A_3*(t - t_B)^2+ \ldots]*(t - t_B)\} \qquad \text{(A1.1)}$$

ρ density

ρ_B reference density, here at t = 15 °C

t temperature in °C

t_B reference temperature, here t_B = 15 °C

γ thermal expansion coefficient

A_i adjustment constants

Note: The thermal expansion coefficient used here allows the density to be calculated directly if the temperature of the liquid is known; it should not be confused with the thermodynamically defined cubic thermal expansion coefficient

$$\alpha^* = \frac{1}{V_0}\frac{dV}{dT}. \qquad \textit{(A1.2)}$$

α^* can be converted into γ by integration over the temperature.

In Figures A1-1a to A1-1d, the deviation of the measured values from such a polynomial approximation is shown using the example of an ethanol/hexane mixture with a 10 % ethanol fraction. Figure A1-1a, the linear representation, shows deviations of up to 0.7 kg/m³ between the measured values and the approximation. But the deviation itself is also clearly dependent on the temperature, which suggests that an approximation by means of a high-order polynomial would improve this. Even using an approximation with a second-order polynomial (Figure A1-1b) reduces the size of these deviations down to approx. 1/10. The argumentation used for a first-order approximation also applies in this case. Finally, the approximation with a third-order polynomial (Figure A1-1c) reduces the size of the deviations again, roughly by a factor of 10; the deviations now lie clearly below the measurement uncertainty and close to the resolution of the density indication of the measuring instrument. A

structure is, however, still visible in the data. Approximation with a fourth-order polynomial (Figure A1-1d) no longer brings about a great reduction in the deviations, except for one data point, the deviation now lies below the measuring instrument's resolution. Now, the deviations are, however, statistically distributed.

Such an optimization of the approximation curve may certainly make sense for specific applications. For the representation of the temperature dependence of petrols if required for legally relevant purposes, the accuracy used should, however, be based on practical facts. These are the natural scattering of the parameters, on the one hand, and the maximum permissible error, on the other hand. The natural scattering of the thermal expansion coefficient covers a span of approx. 10 % (cf. Chapter 5). A very accurate representation may thus be a good description of an individual sample, but not necessarily of all fuels available on the market. On the other hand, the maximum deviation found in the case of the linear approximation was 0.7 kg/m³. This is an order of magnitude which corresponds to the resolution of numerous measuring instruments currently used, i.e. it can no longer be detected reliably. The relative deviation is only 0.11 % for temperature conversion from 50 °C to 15 °C; even if the measured density deviated from the calculated density by 0.14 %, the value obtained would still lie clearly below the maximum permissible error of 0.2 %.

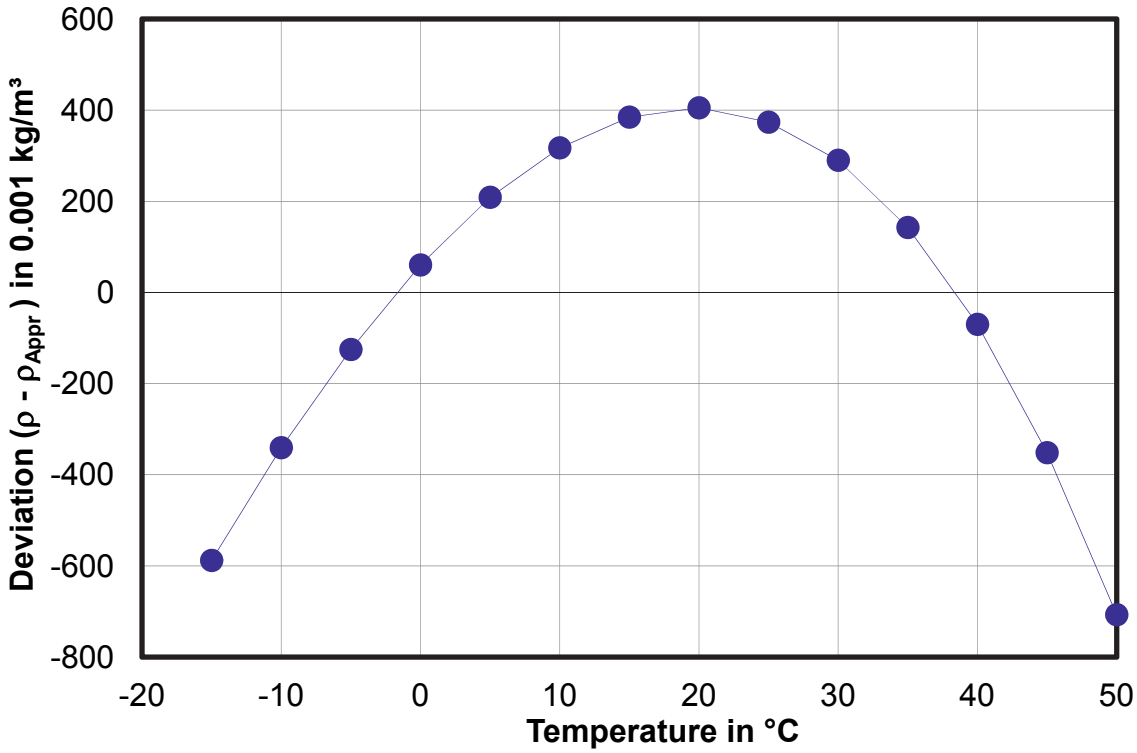


Fig. A1-1a: Deviation of the measured density values from an approximation with a first-order polynomial, ethanol/hexane mixture with 10 % ethanol.

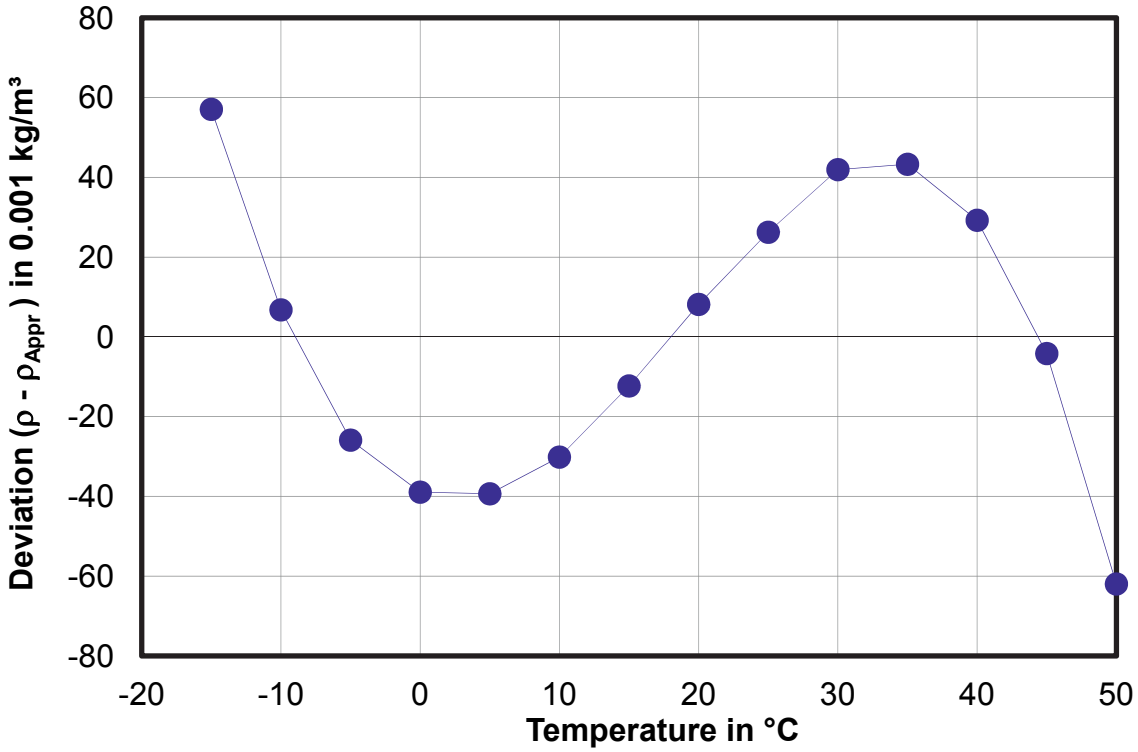


Fig. A1-1b: Deviation of the measured density values from an approximation with a second-order polynomial, ethanol/hexane mixture with 10 % ethanol.

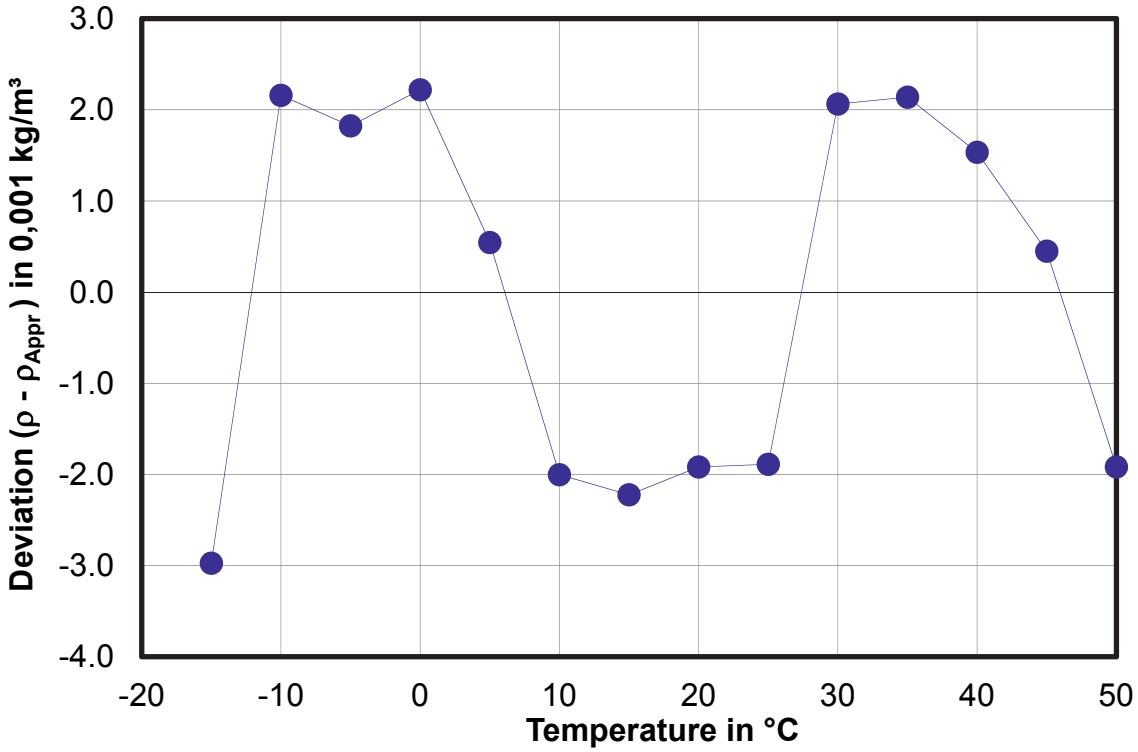


Fig. A1-1c: Deviation of the measured density values from an approximation with a third-order polynomial, ethanol/hexane mixture with 10 % ethanol.

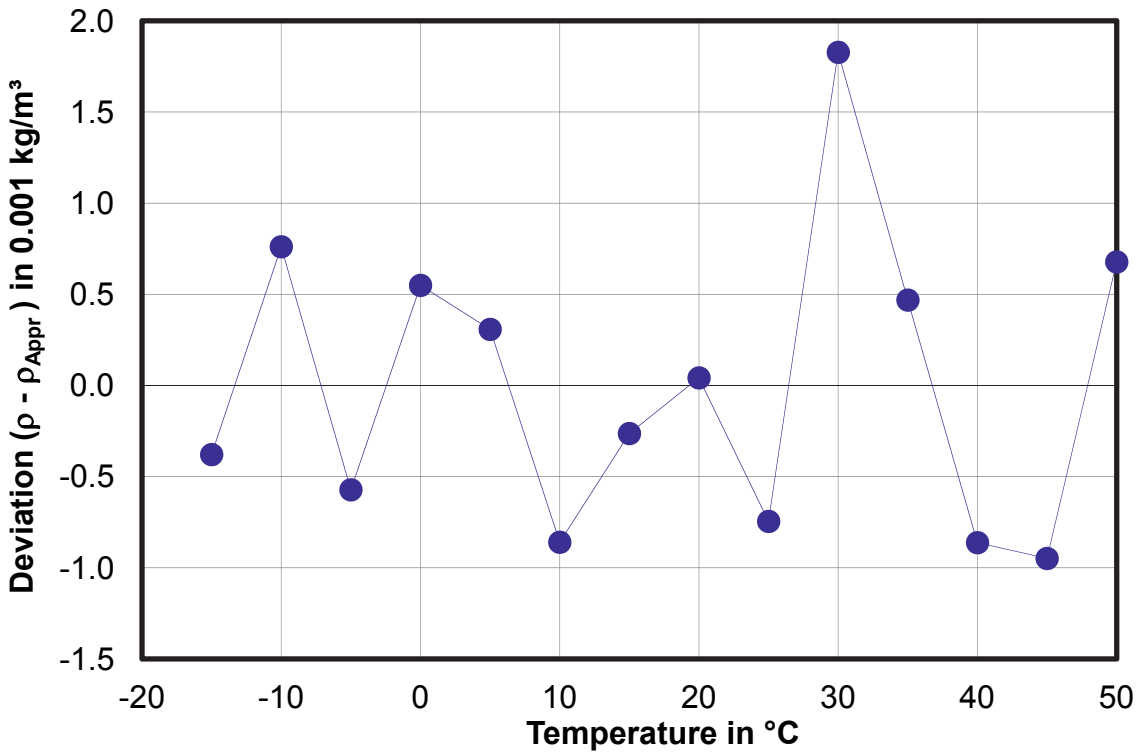


Fig. A1-1d: Deviation of the measured density values from an approximation with a fourth-order polynomial, ethanol/hexane mixture with 10 % ethanol.

The measurement results of the mixture series ethanol/nonane confirm the results described here using the ethanol/hexane series. The thermal expansion coefficient becomes smaller, as expected due to the general dependence of the thermal expansion coefficient on the density (see Chapter 2). The curvature of the $\gamma(t)$ curve – i.e. the deviation from a straight line – also becomes smaller, since the critical point for nonane shifts towards higher temperatures.

Diesels have an even higher critical temperature so that the linear approximation is already very accurate; deviations are generally smaller than 0.01 kg/m³. Figure 10-2 illustrates this very well. The bending of the curve at temperatures below 5 °C – and thus deviation from this linear behaviour – is explained by solidification processes, as described in Chapter 4.2.

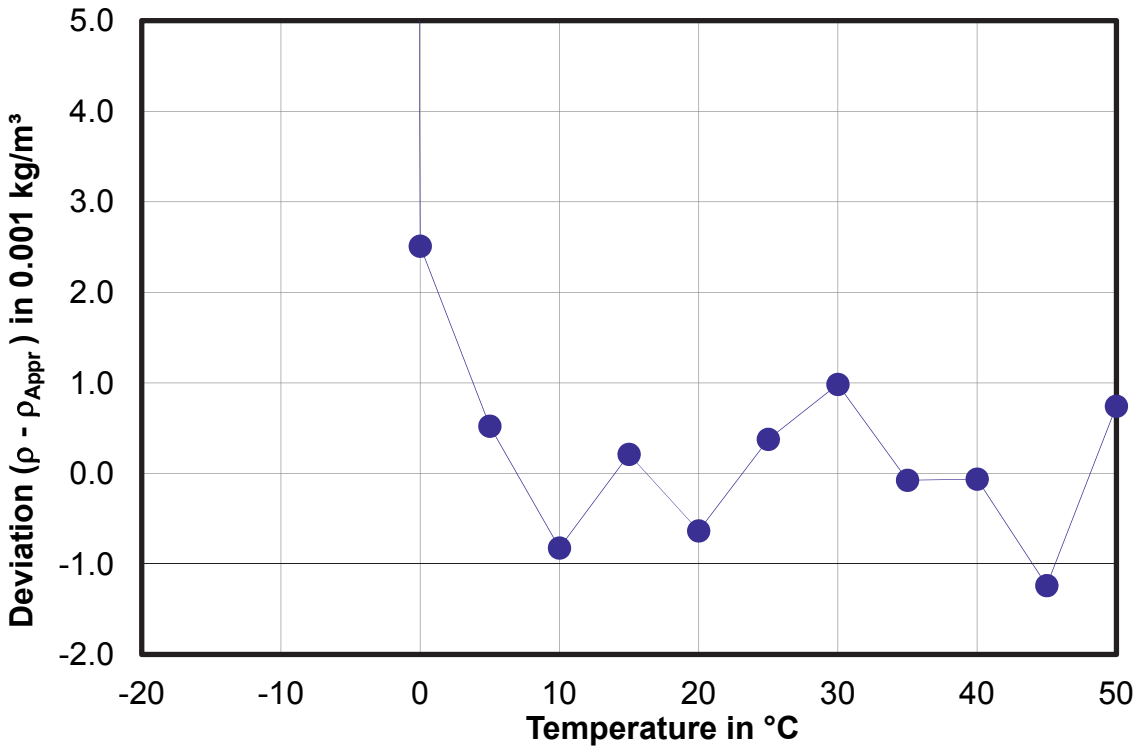


Fig. A1-2: Deviation of the measured density values from an approximation with a first-order polynomial, pure fossil diesel.

Annex 2: Functional description of the dependence of the density on the temperature by means of an exponential function

Another possibility of representing this is the (in petroleum standardization [2] and in legal metrology [3, 4]) widespread exponential representation which, besides the linear term, also contains a square term of the thermal expansion coefficient.

$$\rho(t) = \rho_0 e^{-\alpha \cdot \Delta t \cdot (1+\alpha \cdot 0{,}8 \cdot \Delta t)} \qquad \alpha = \frac{K_0}{\rho_0^2} + \frac{K_1}{\rho_0} \tag{A2.1}$$

ρ density

ρ_0 reference density, t_0 = 15 °C

t temperature in °C

Δt difference from the reference temperature, t_0 = 15 °C

α thermal expansion coefficient

K_1, K_2 product-specific constants

The deviation between the linear and the exponential representation (when using the same thermal expansion coefficient) is described in detail in Figure A2-1. The reference quantity represented here is the maximum permissible error amounting to 0.2 %.

This exponential representation accounts for the fact that, in an approximation to the critical point, the temperature dependence of the density goes from a linear behaviour to an exponential behaviour.

A simple Taylor series expansion, however, shows that the evolution of this exponential function in the temperature range between -10 °C and +50 °C, which is of interest for us in this context, is nearly linear.

$$\rho(t) \approx \rho_0 (1 - \alpha \cdot \Delta t - 0{,}3 \cdot \alpha^2 \cdot \Delta t^2) \approx \rho_0 (1 - \alpha \cdot \Delta t) \tag{A2.2}$$

Assuming that $\alpha = 1 \cdot 10^{-3}$ K^{-1} and that Δt is typically 10 K, then the value of the linear term is 0.01, that of the square correction term, however, is $3 \cdot 10^{-5}$, i.e. it amounts to only 0.3 % of the linear term.

Both representations are thus, within the limits of the maximum permissible error, equivalent. A slight "improvement" of the representation is possible in the case of petrols using the exponential form, since in this case, there is a slight bend in the density/temperature curve.

In the case of diesels and heating oils, the linear polynomial representation is better than the exponential representation.

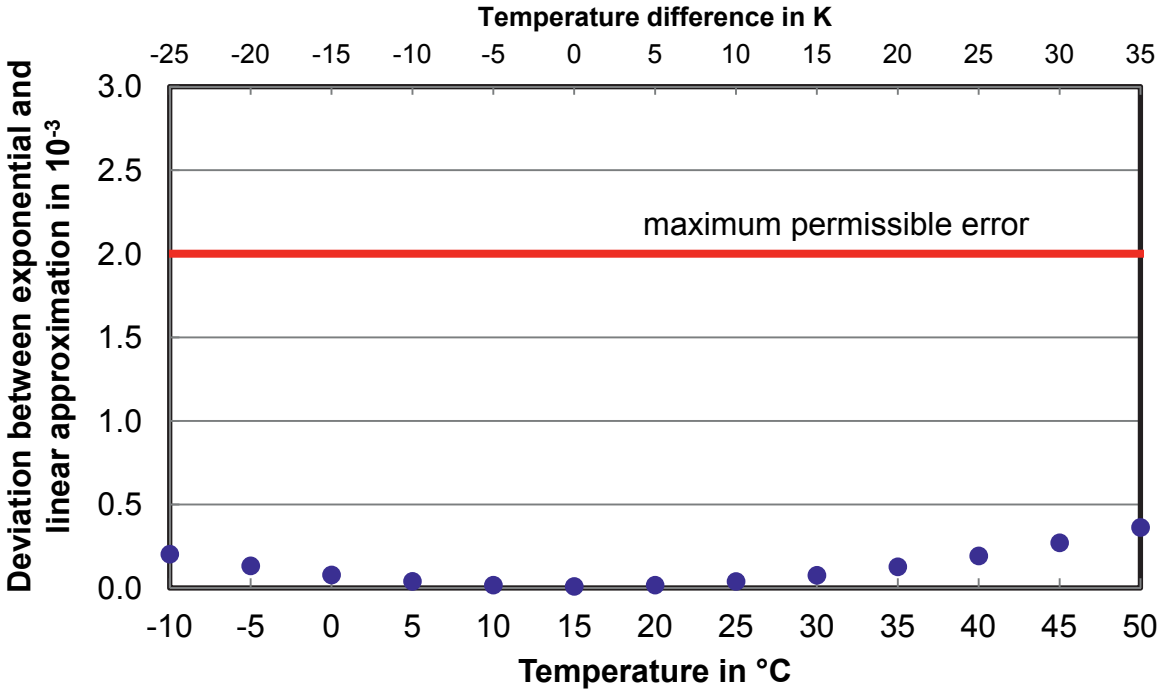


Fig. A2-1: Deviation between the linear and the exponential representation when using the same thermal expansion coefficient $\alpha = 0.001$. The temperature difference from 15 °C is plotted on the upper abscissa as it is relevant for the calculation.

A problem with the exponential representation is the associated provision which imposes a calculation of the thermal expansion coefficient (cf. Chapter A2.1). The thermal expansion coefficient is calculated by means of two prescribed constants, K_0 and K_1, and by means of the density at 15 °C. The addition of biofuels, however, causes the density of the mixtures to shift without shifting the expansion coefficient adequately. The calculation provision using the density therefore provides wrong values for the thermal expansion coefficient in the case of biofuel/fossil fuel blends. The only solution is to indicate the thermal expansion coefficient directly.

Annex 3: Diagrams

Diagrams: Density and thermal expansion coefficient of the regional samples

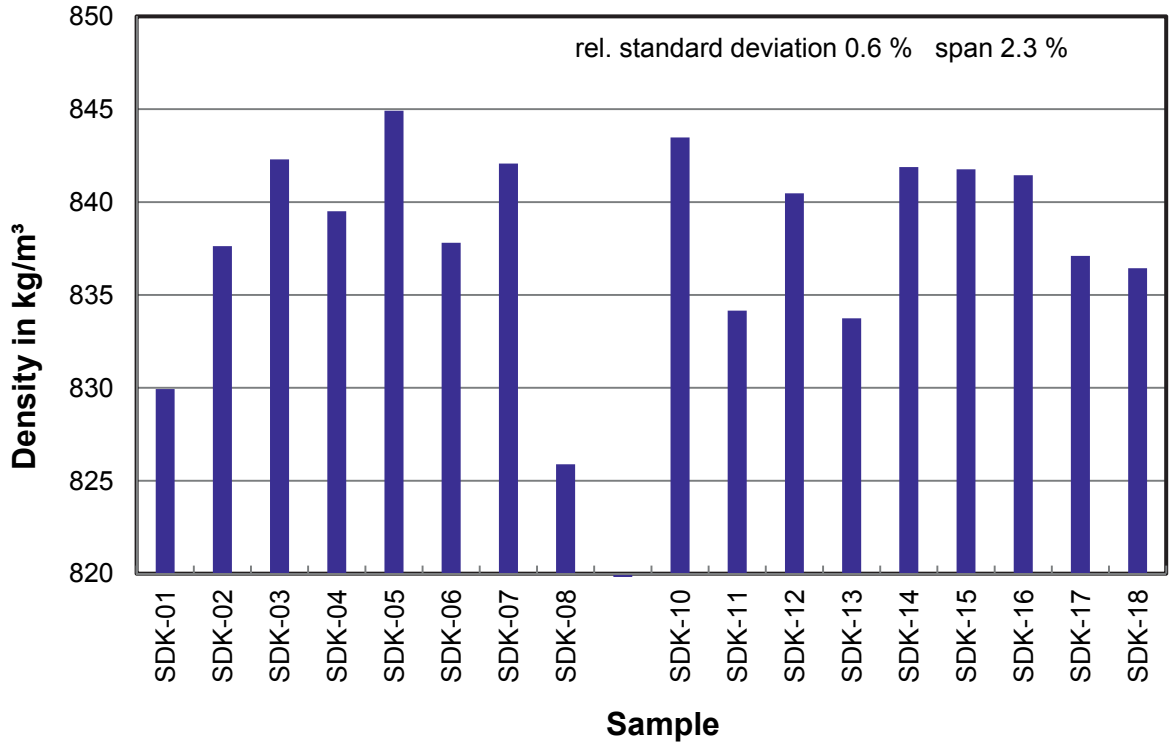


Fig. A3-1a: Densities of the regional samples: diesel B7, summer grade.

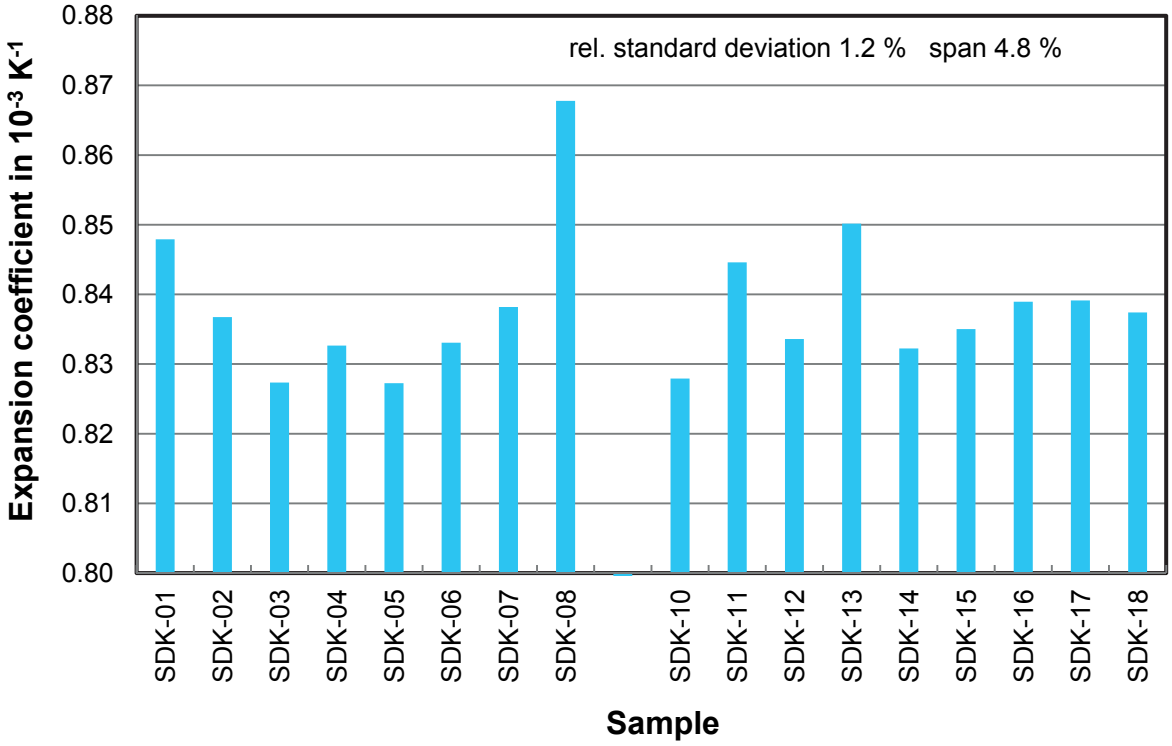


Fig. A3-1b: Thermal expansion coefficients of the regional samples: diesel B7, summer grade.

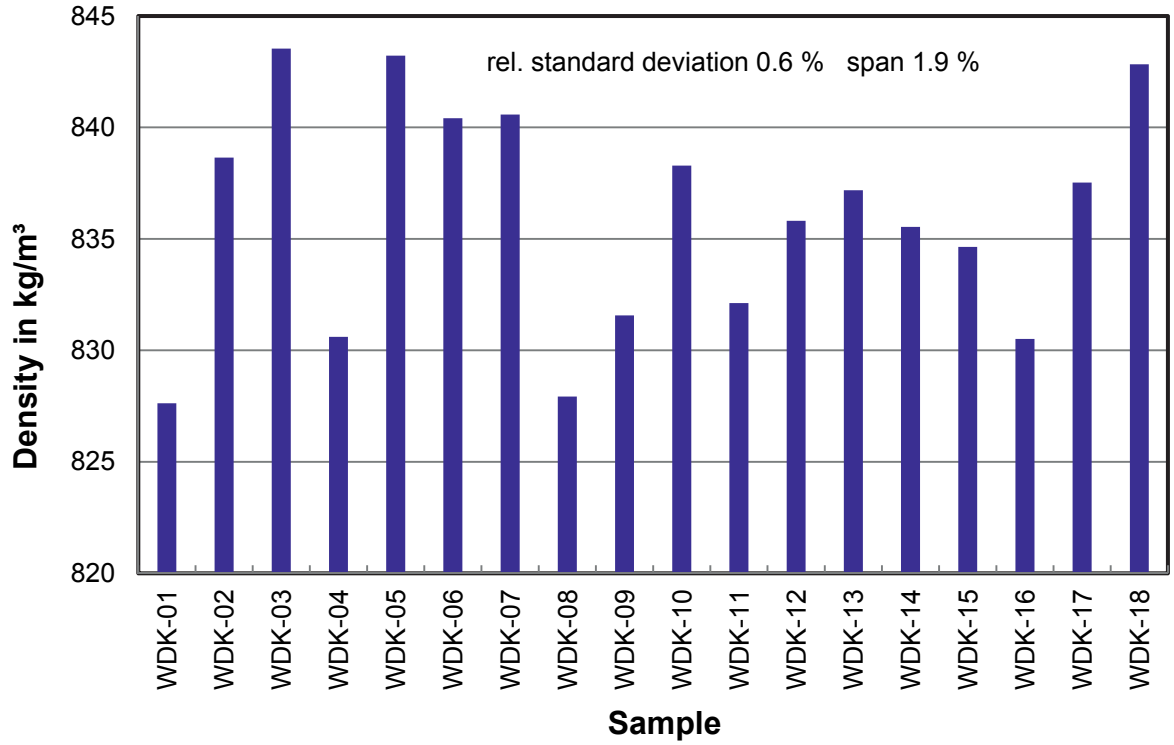


Fig. A3-2a: Densities of the regional samples: diesel B7, winter grade.

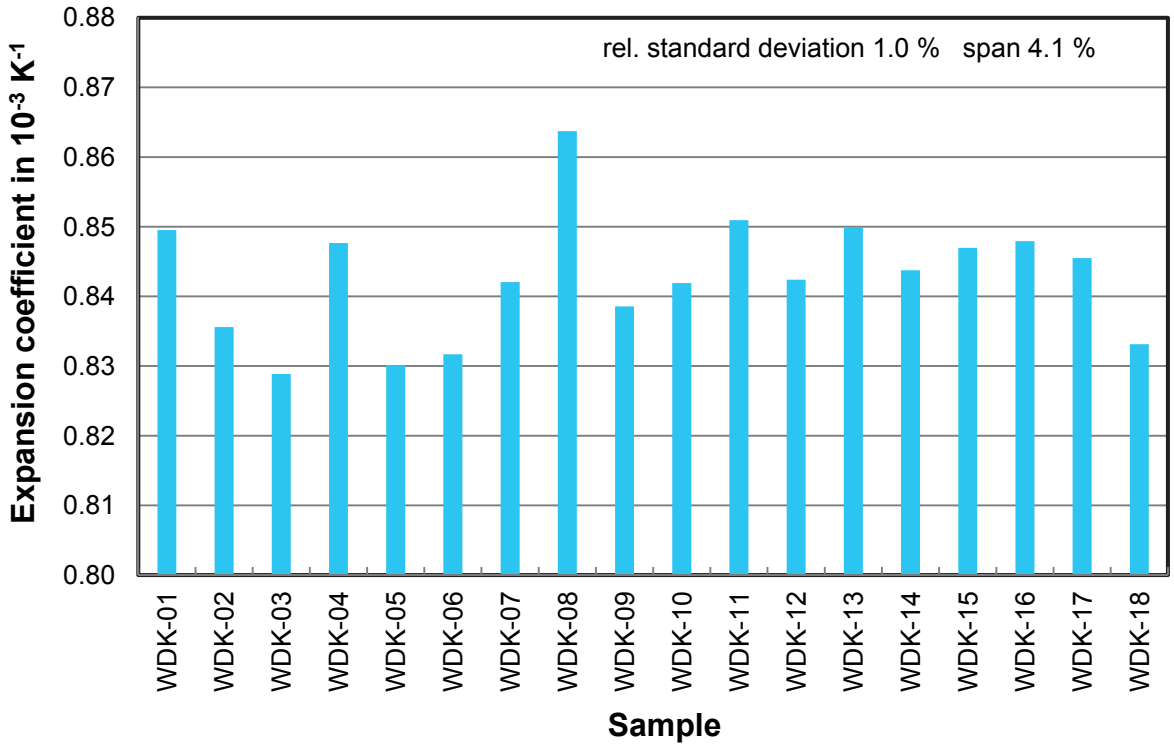


Fig. A3-2b: Thermal expansion coefficients of the regional samples: diesel B7, winter grade.

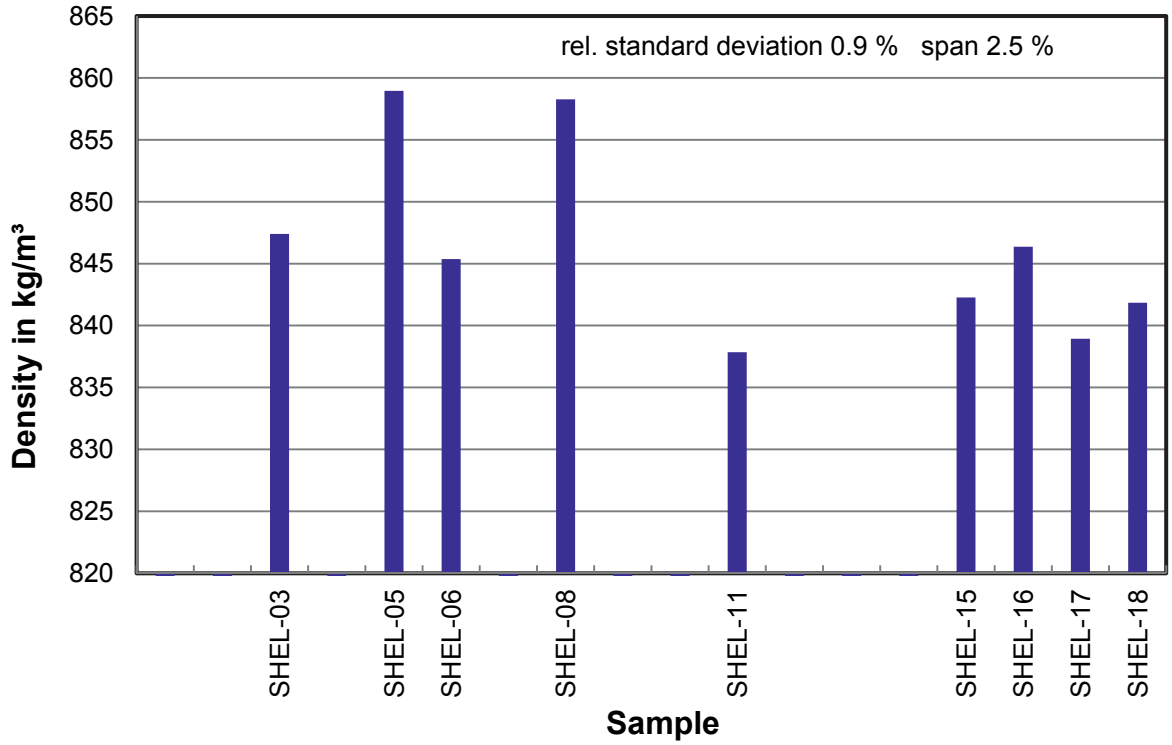


Fig. A3-3a: Densities of the regional samples: heating oil HEL, summer grade.

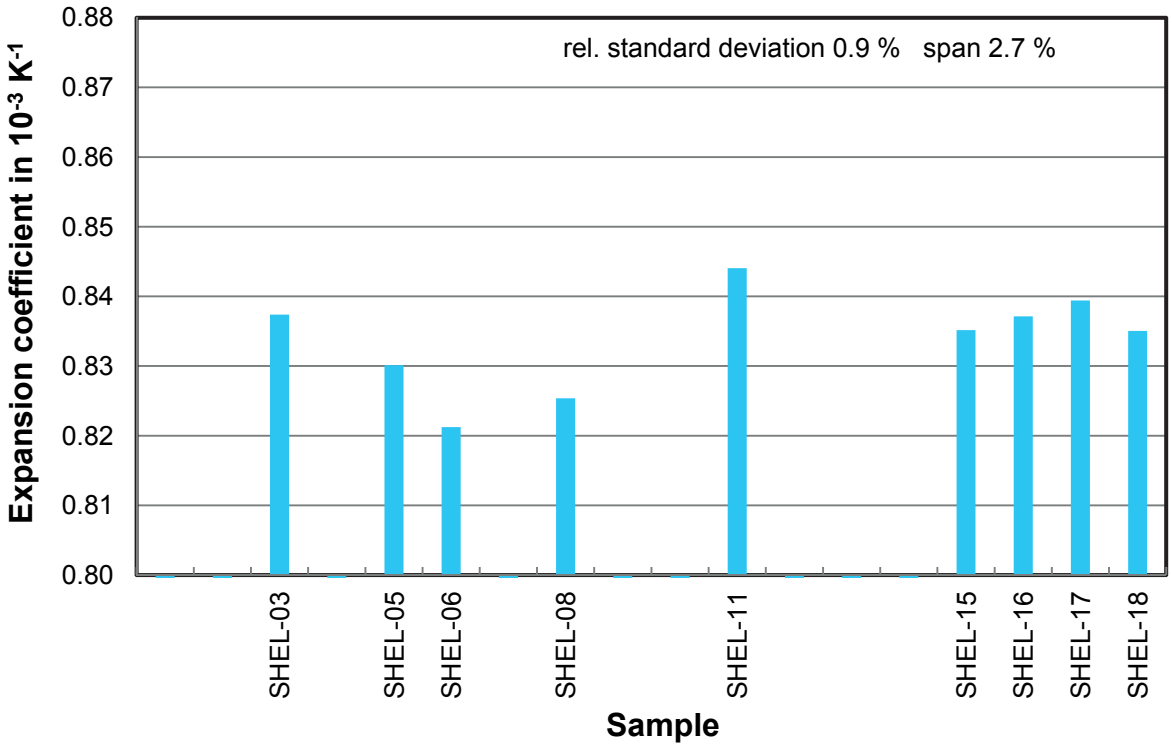


Fig. A3-3b: Thermal expansion coefficients of the regional samples: heating oil HEL, summer grade.

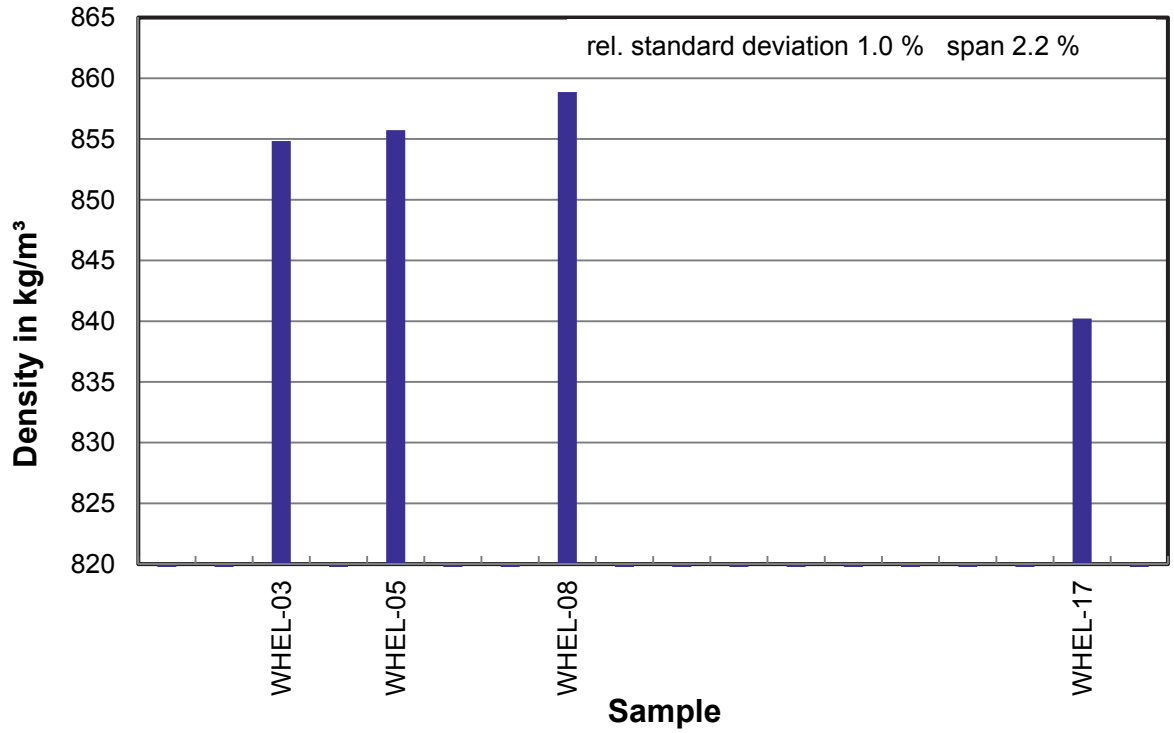


Fig. A3-4a: Densities of the regional samples: heating oil HEL, winter grade.

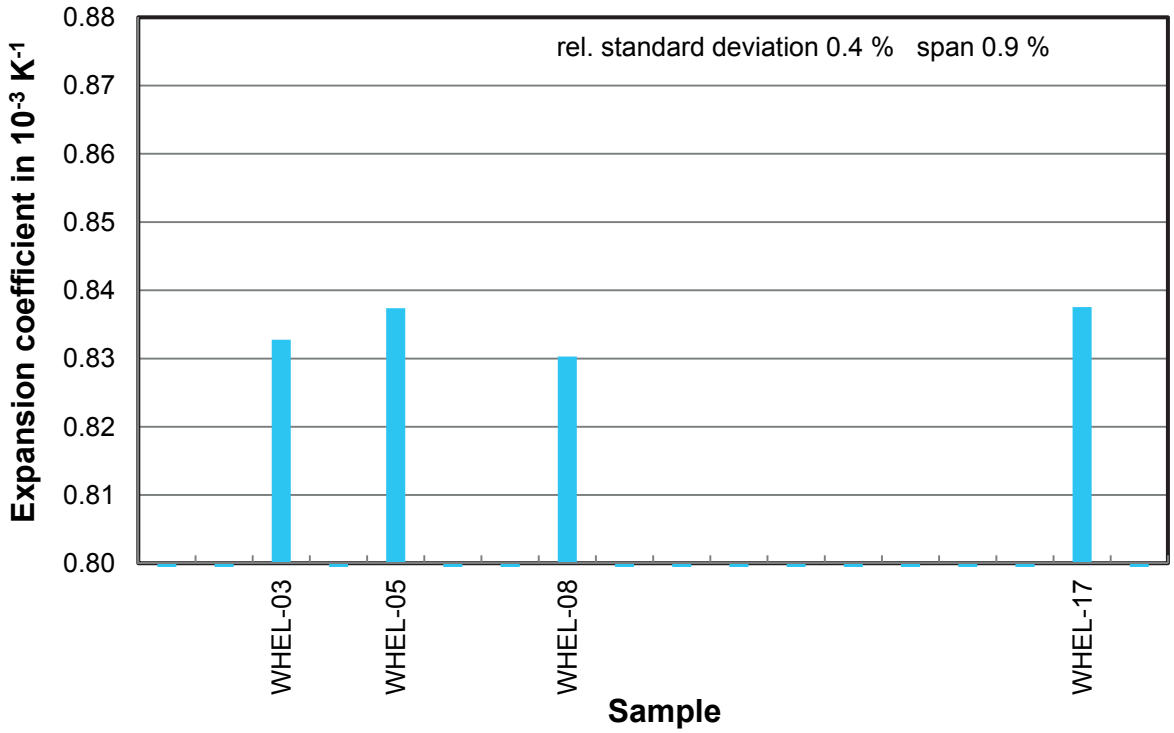


Fig. A3-4b: Thermal expansion coefficients of the regional samples: heating oil HEL, winter grade.

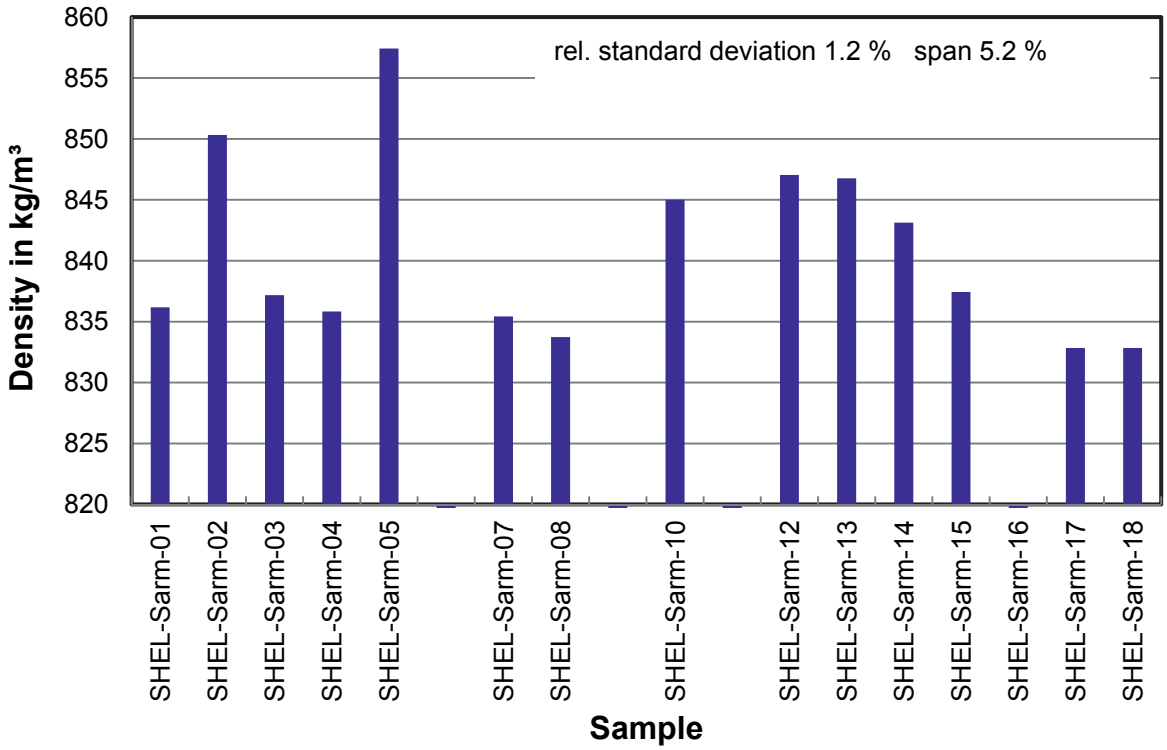


Fig. A3-5a: Densities of the regional samples: low-sulphur heating oil HEL, summer grade.

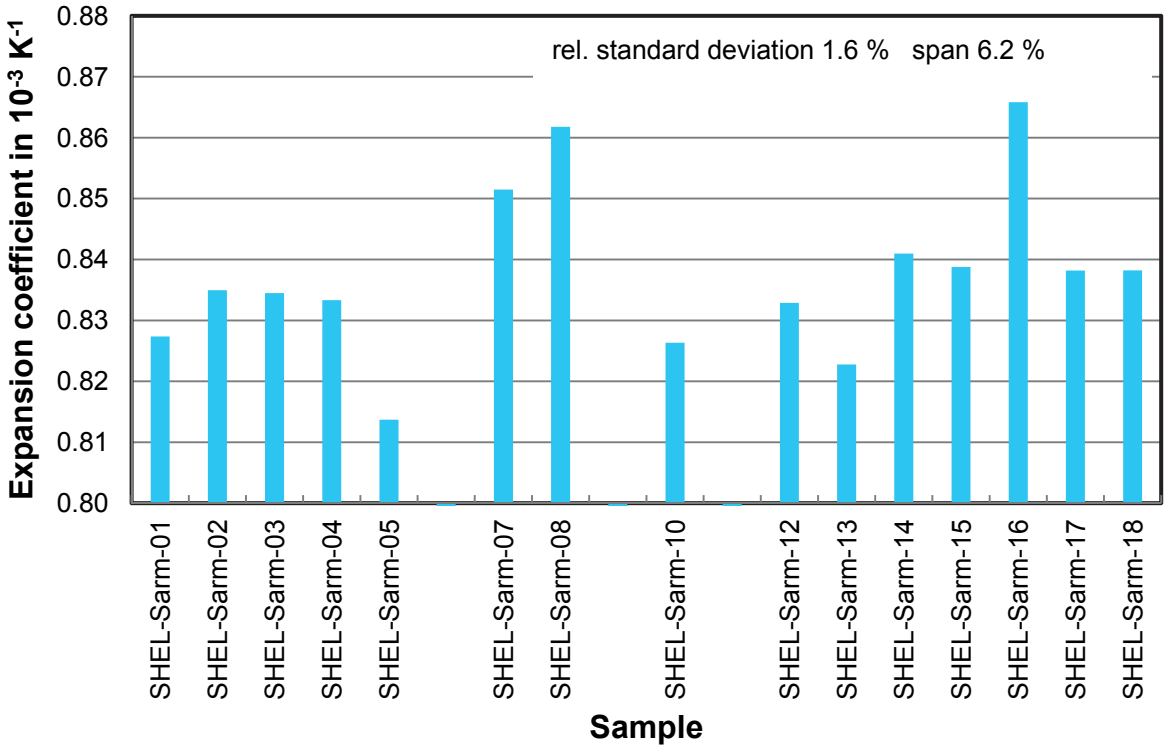


Fig. A3-5b: Thermal expansion coefficients of the regional samples: low-sulphur heating oil HEL, summer grade.

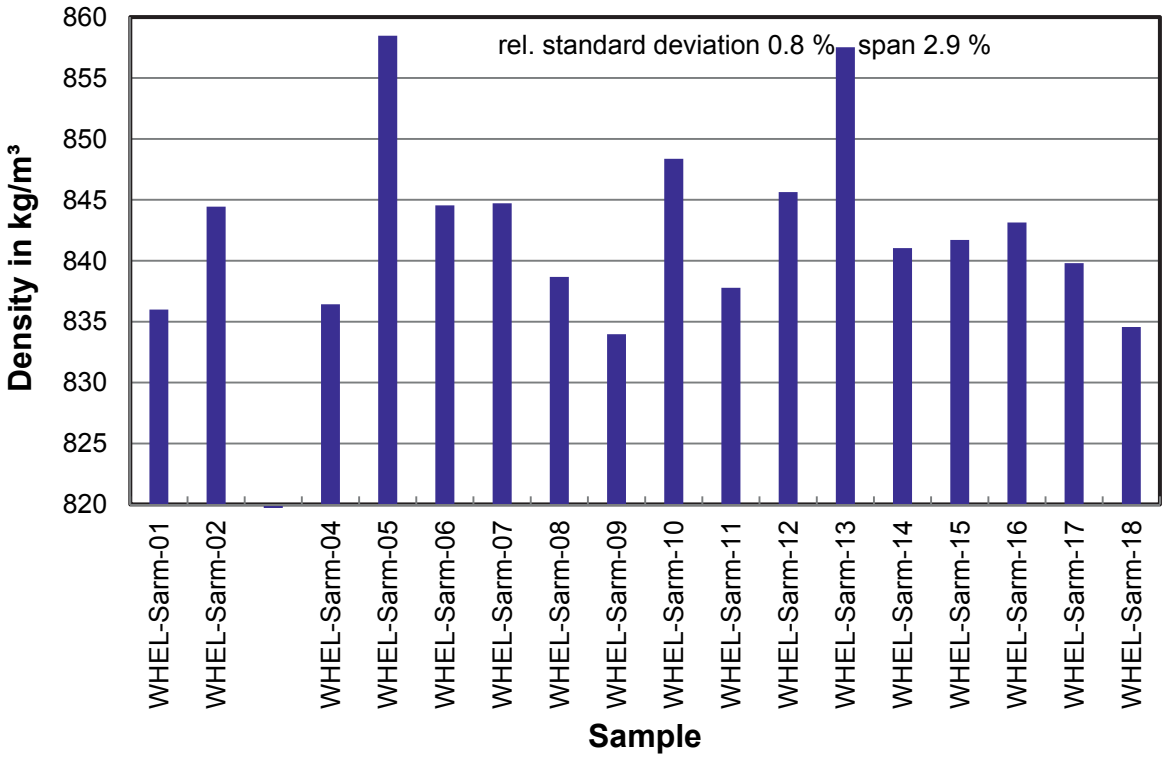


Fig. A3-6a: Densities of the regional samples: low-sulphur heating oil HEL, winter grade.

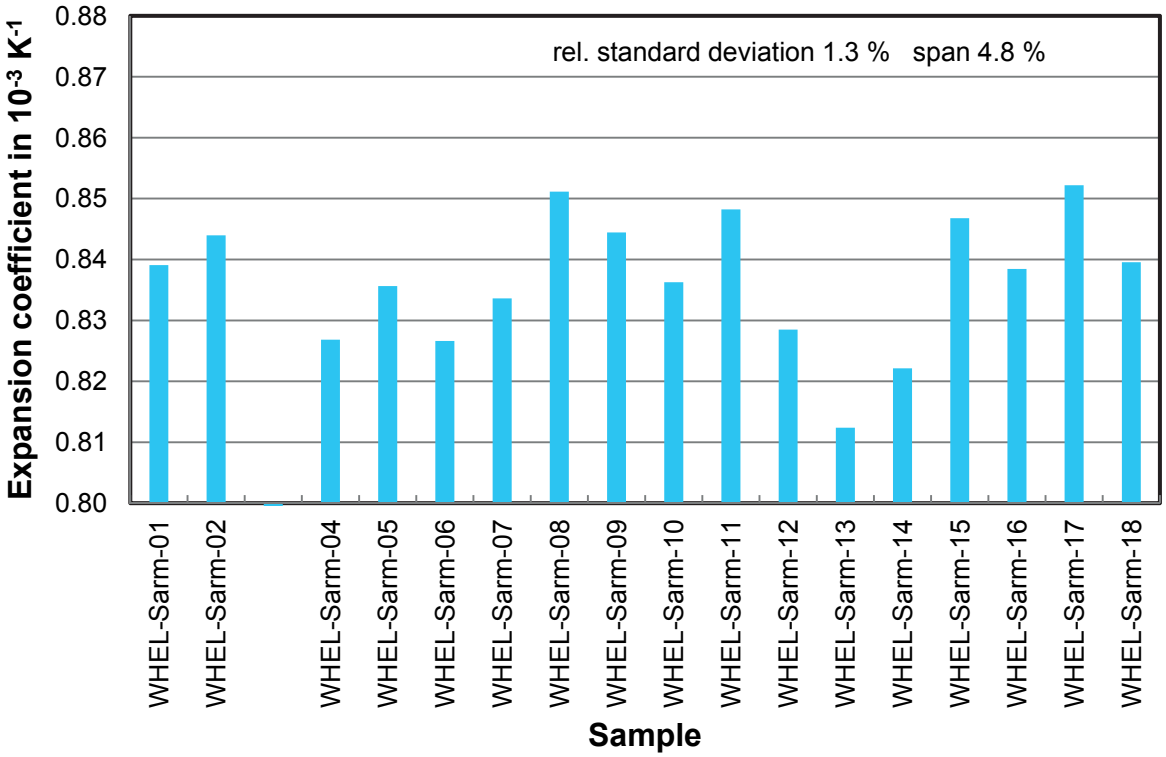


Fig. A3-6b: Thermal expansion coefficients of the regional samples: low-sulphur heating oil HEL, winter grade.

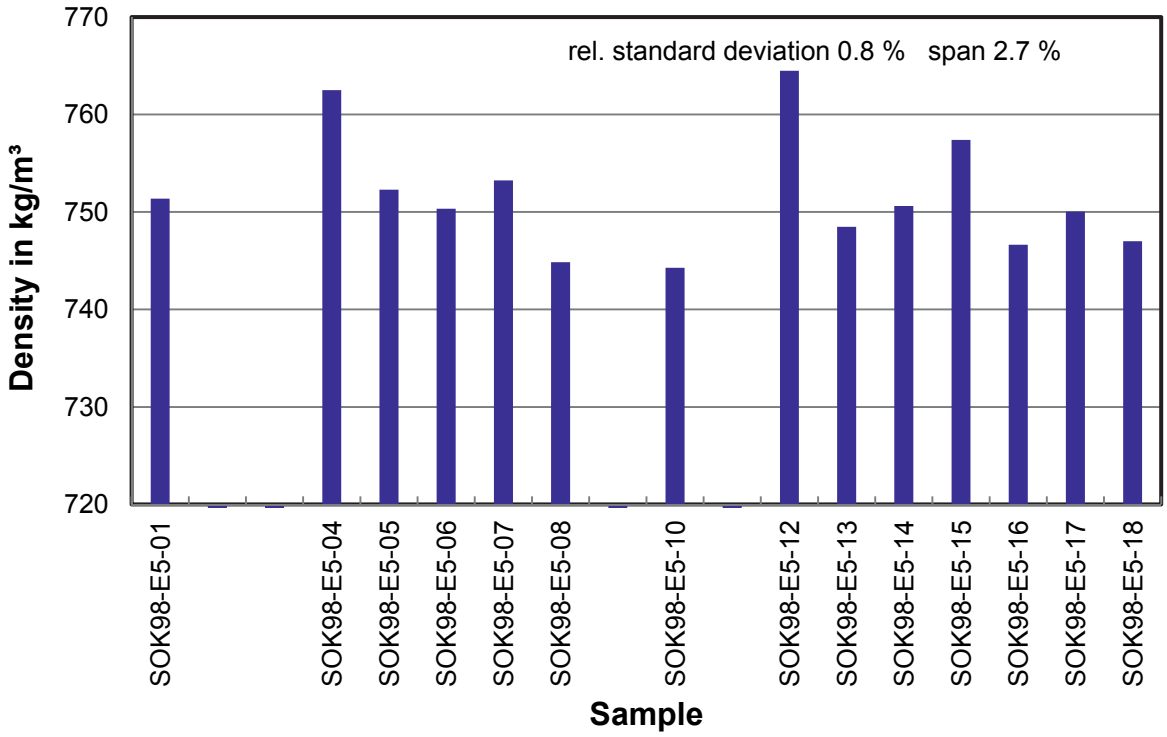


Fig. A3-7a: Densities of the regional samples: petrol OK98 E5, summer grade.

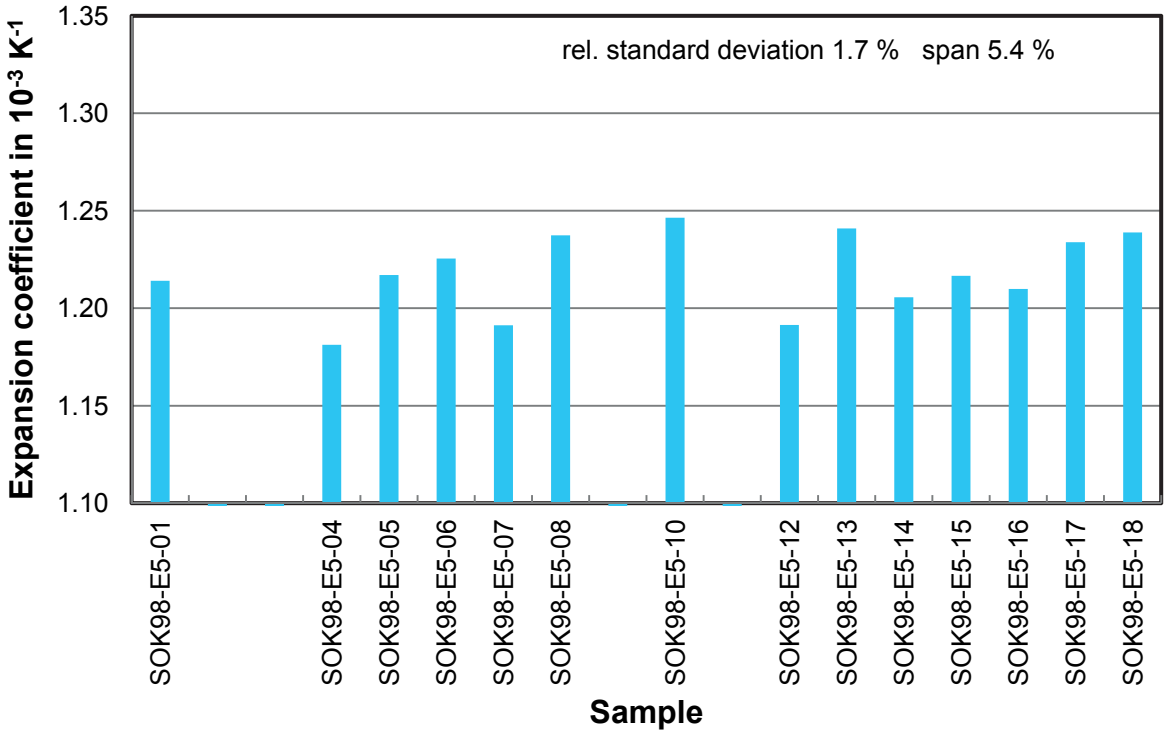


Fig. A3-7b: Thermal expansion coefficients of the regional samples: petrol OK98 E5, summer grade.

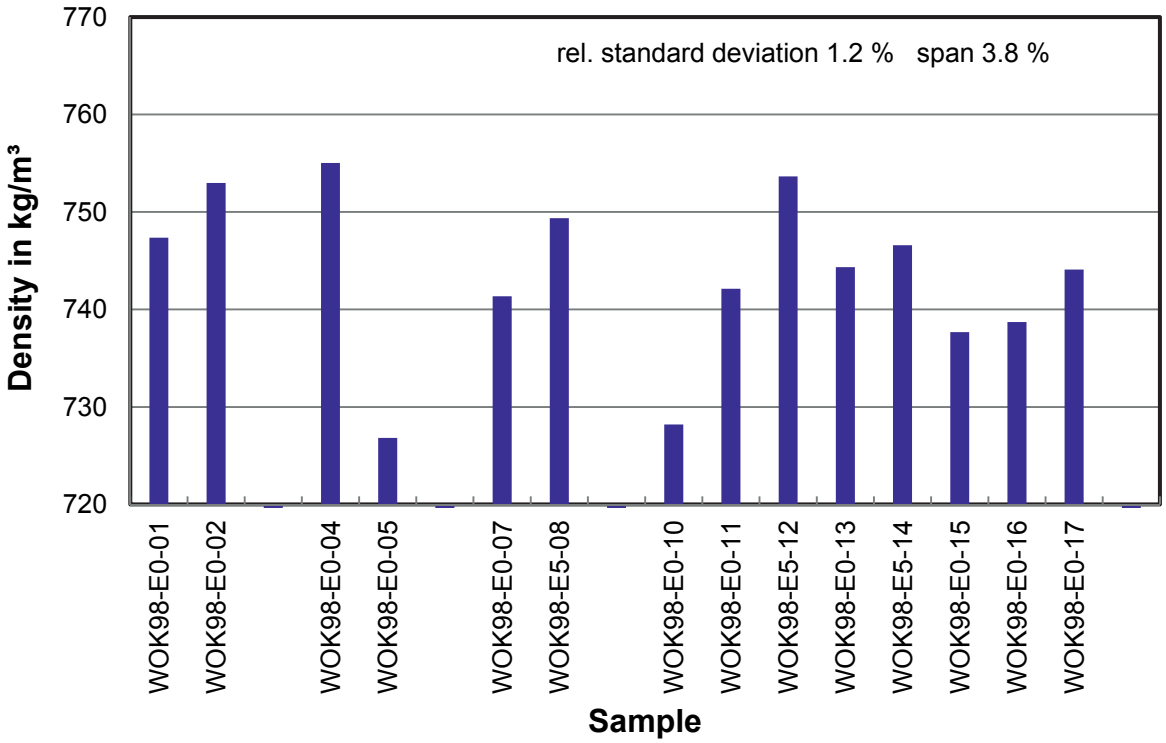


Fig. A3-8a: Densities of the regional samples: petrol OK98, winter grade; this figure shows E0 and E5 samples.

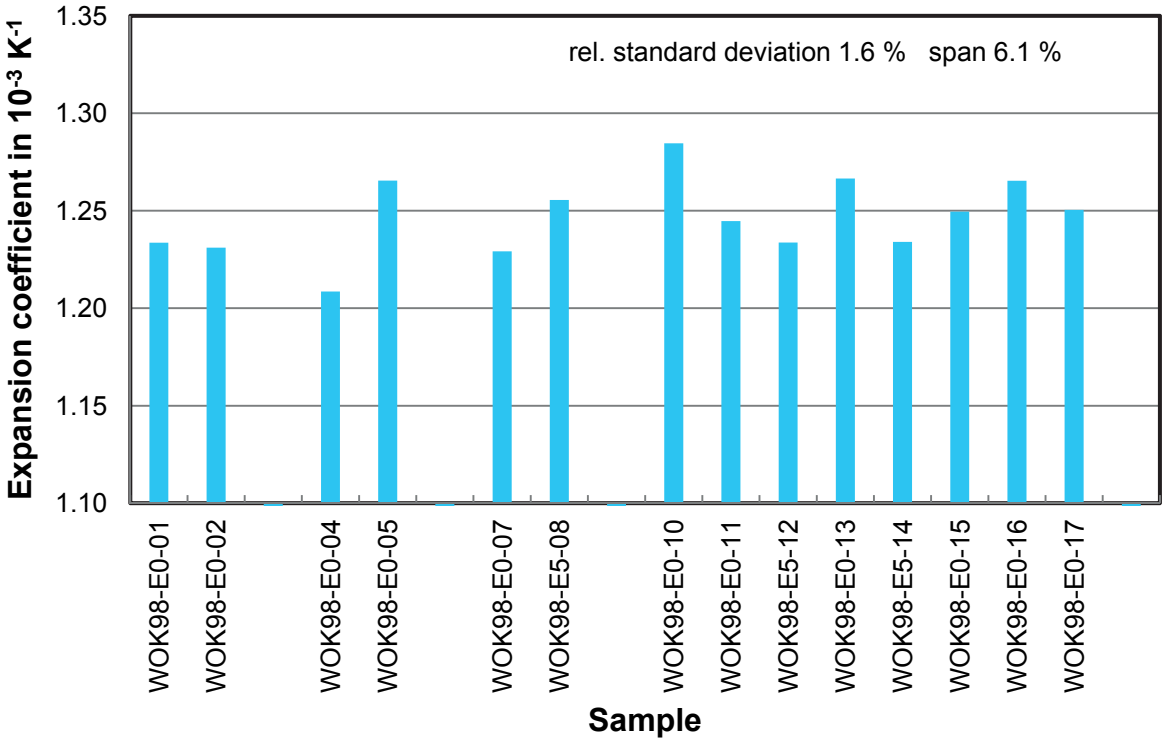


Fig. A3-8b: Thermal expansion coefficients of the regional samples at 15 °C: petrol OK98, winter grade; this figure shows E0 and E5 samples.

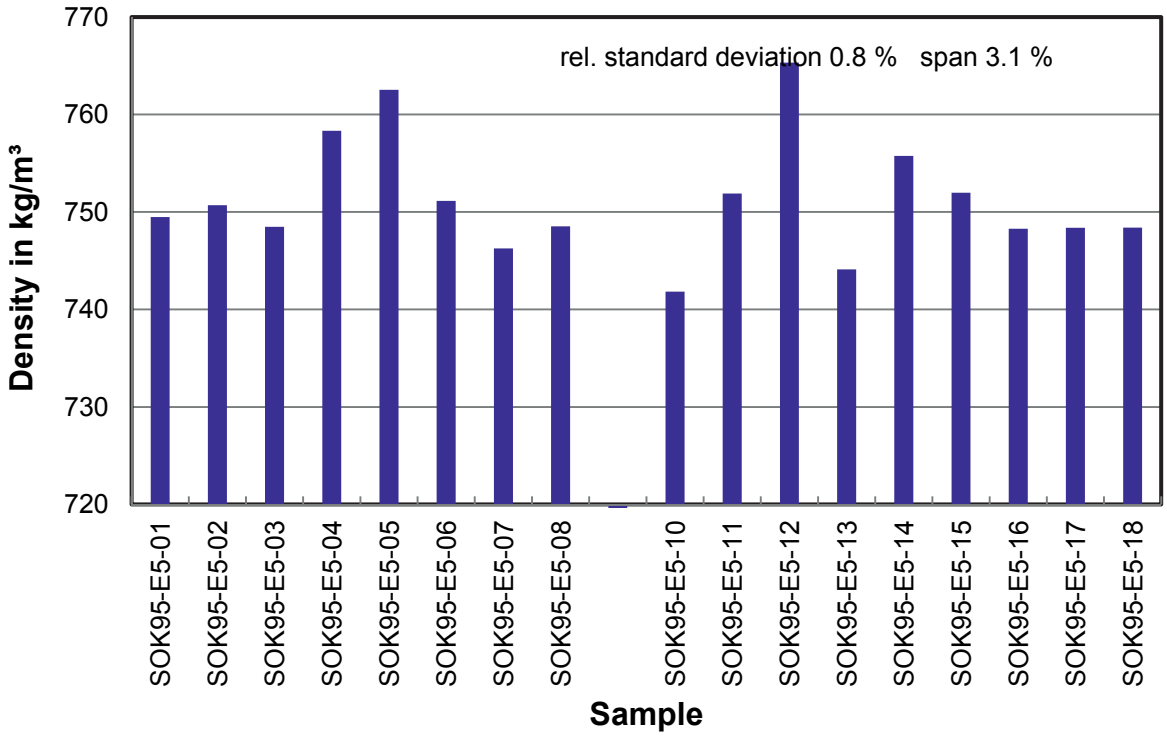


Fig. A3-9a: Densities of the regional samples: petrol OK95 E5, summer grade.

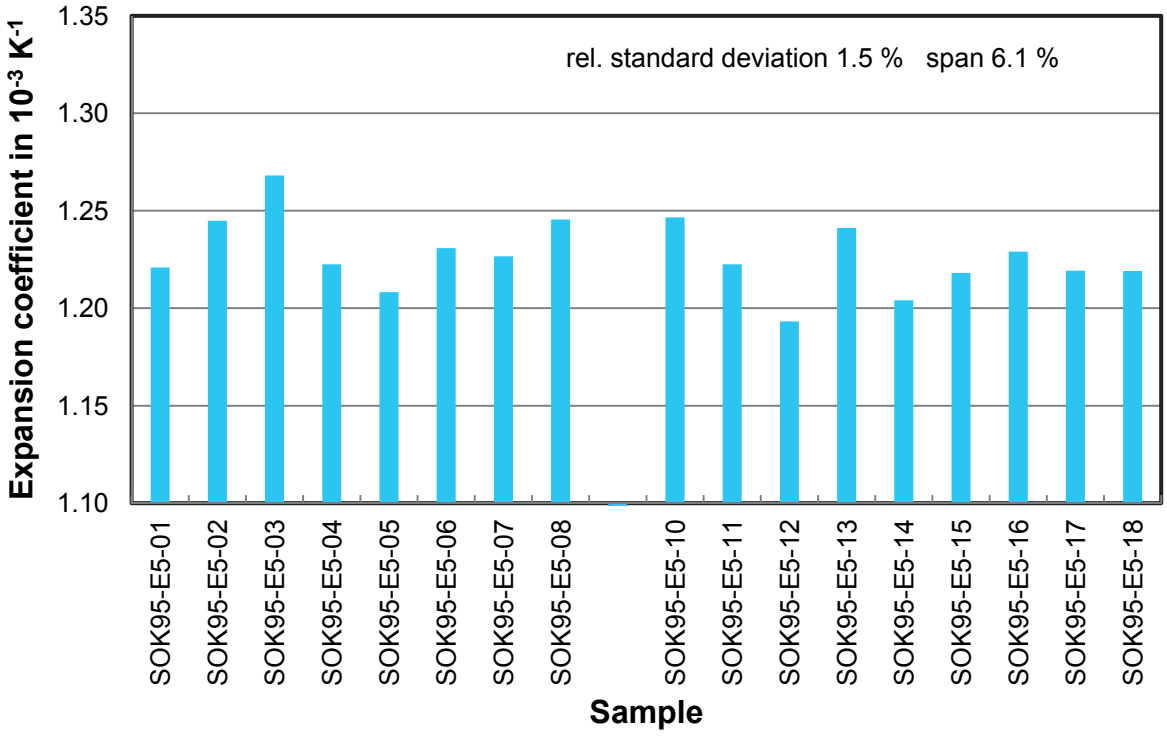


Fig. A3-9b: Thermal expansion coefficients of the regional samples: petrol OK95 E5, summer grade.

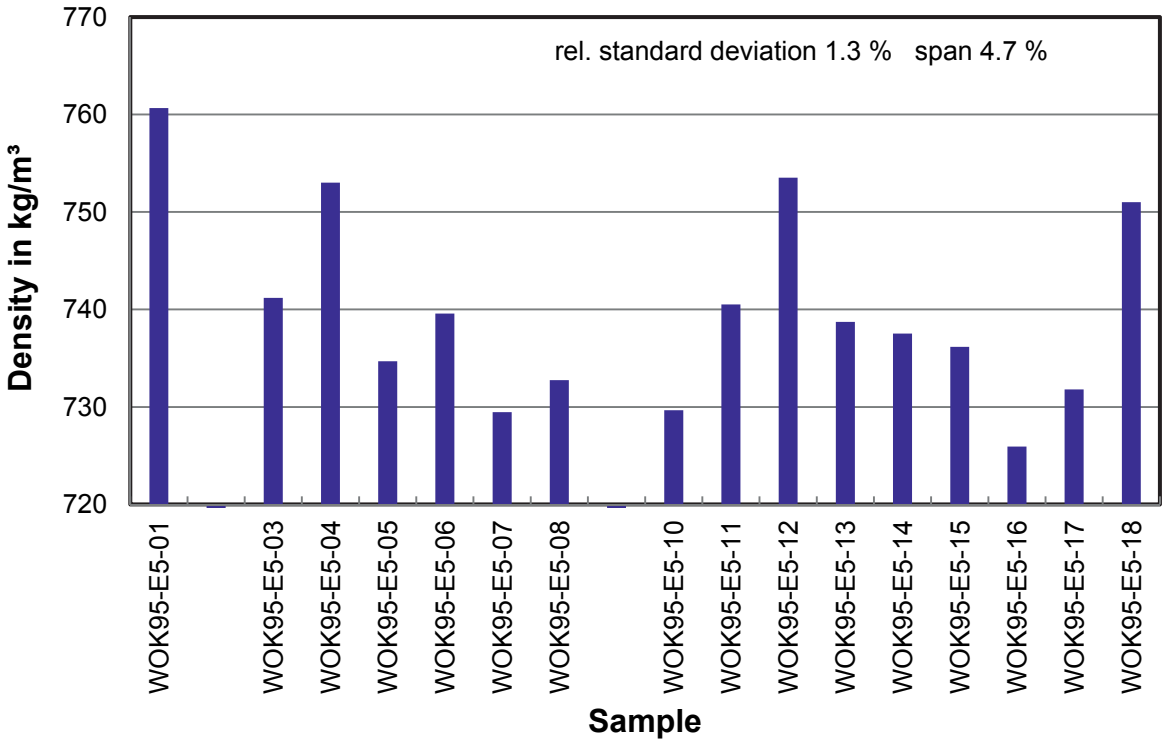


Fig. A3-10a: Densities of the regional samples: petrol OK95 E5, winter grade.

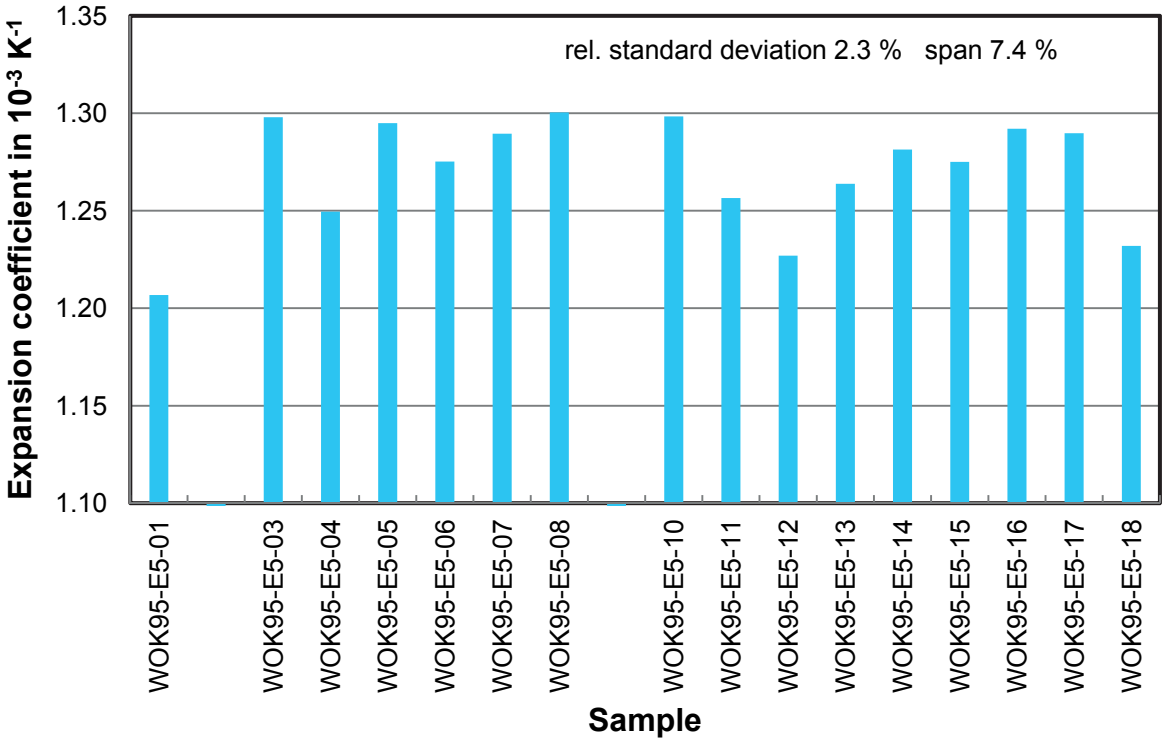


Fig. A3-10b: Thermal expansion coefficients of the regional samples: petrol OK95 E5, winter grade.

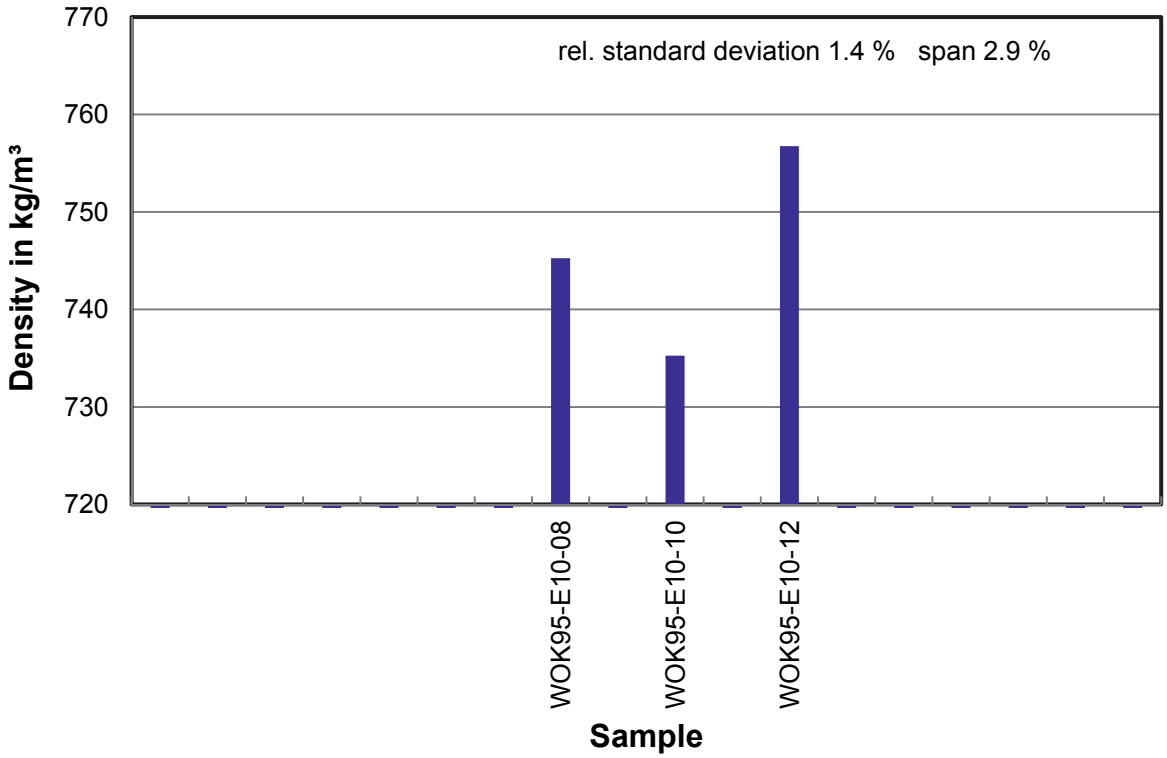


Fig. A3-11a: Densities of the regional samples: petrol OK95 E10, winter grade.

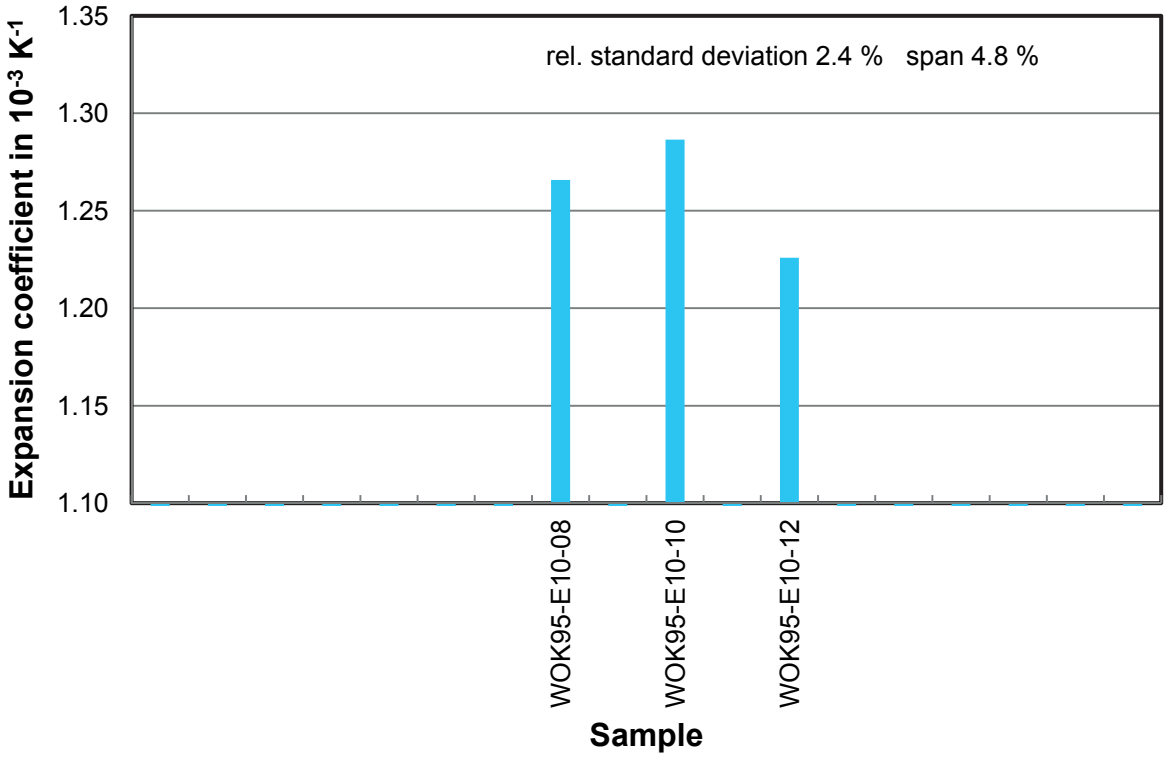


Fig. A3-11b: Thermal expansion coefficients of the regional samples: petrol OK95 E10, winter grade.

Diagrams: Viscosity of the regional samples

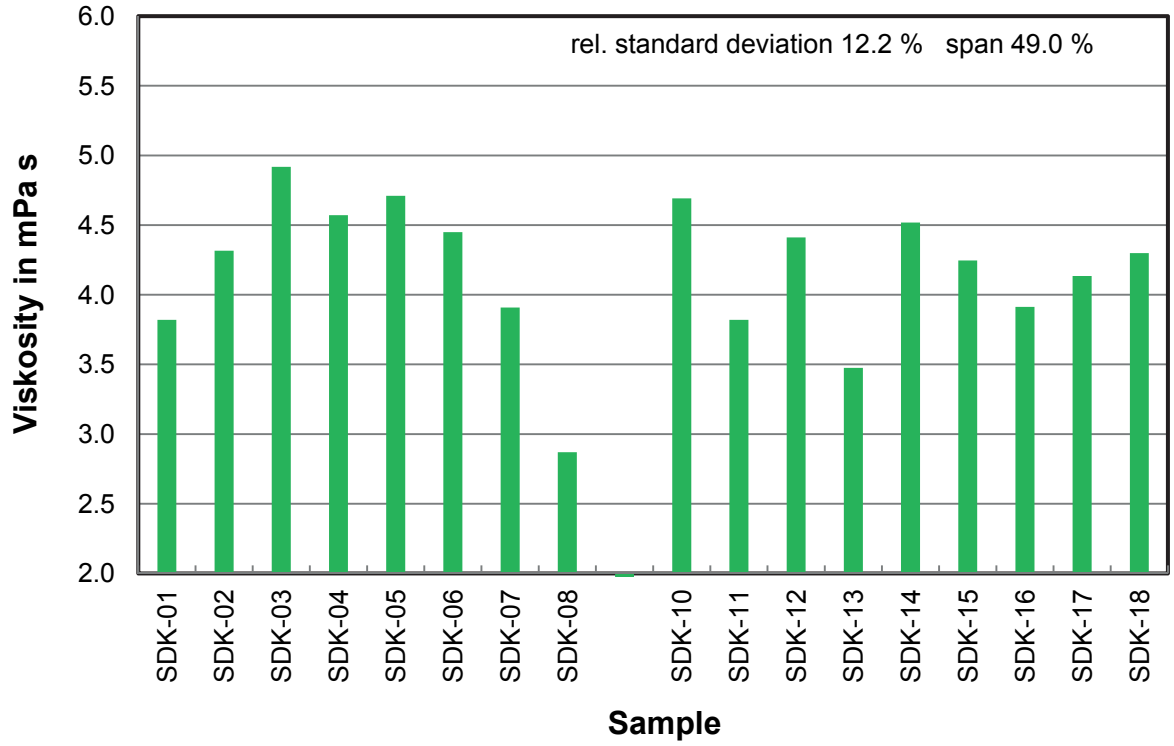


Fig. A3-12: Viscosities of the regional samples: diesel B7, summer grade.

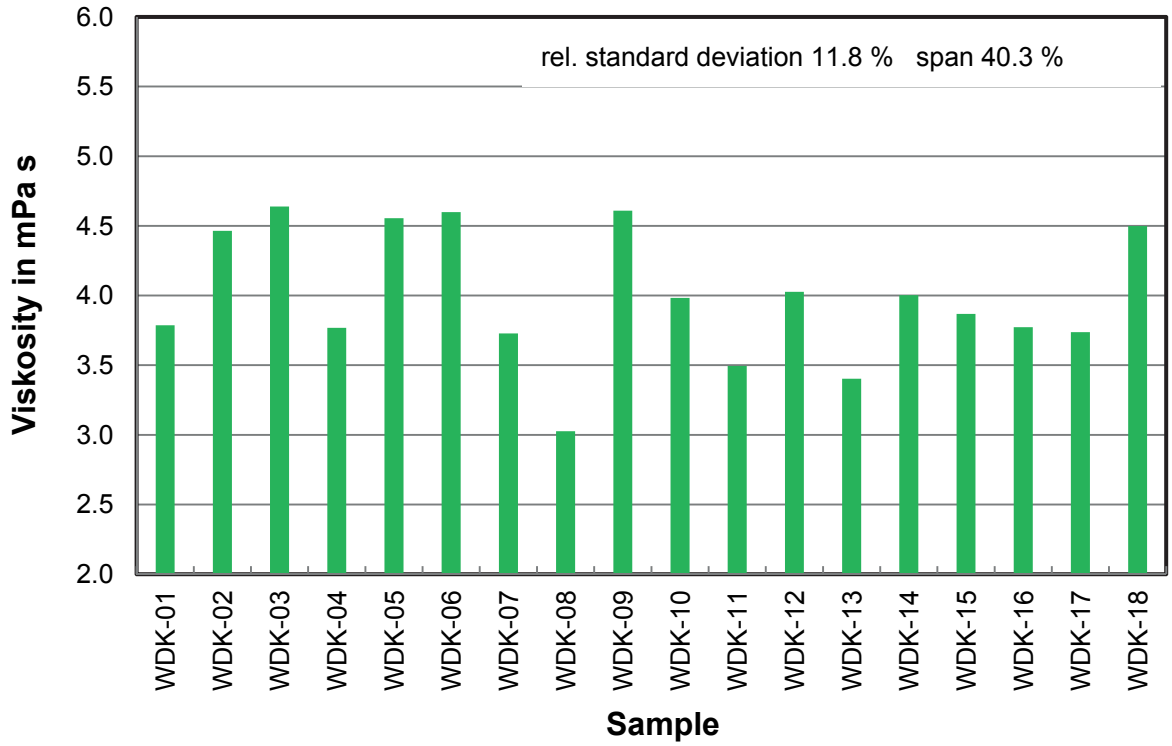


Fig. A3-13: Viscosities of the regional samples: diesel B7, winter grade.

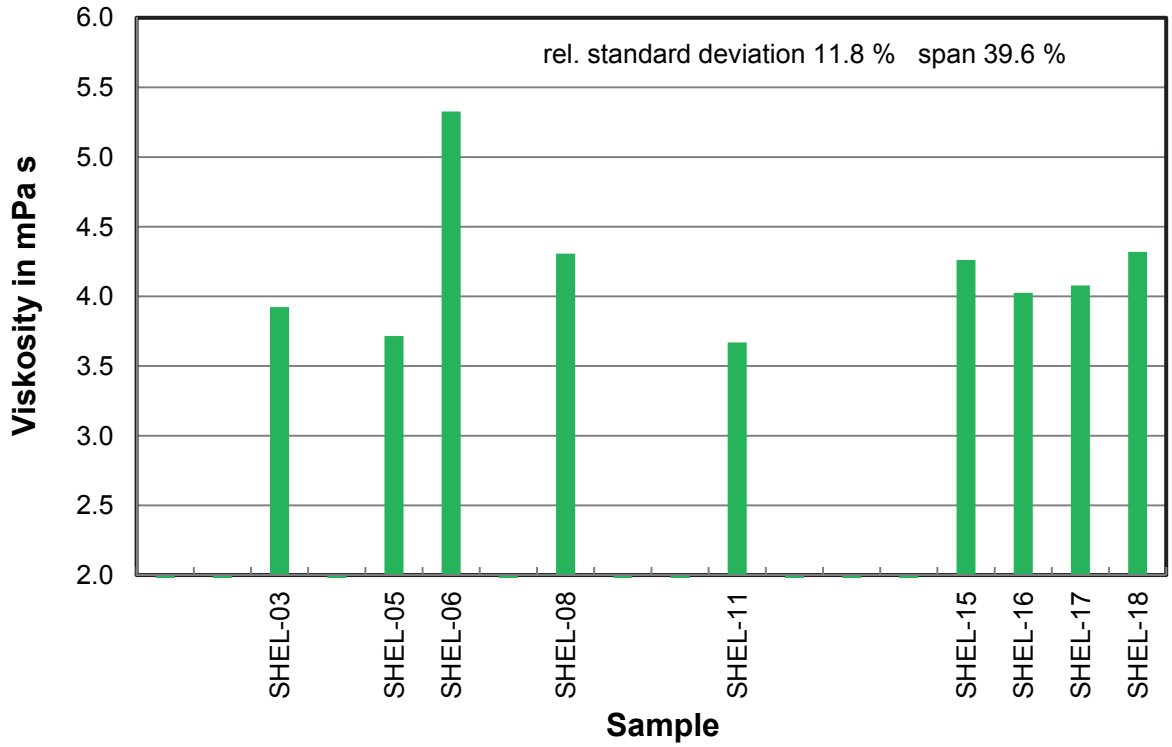


Fig. A3-14: Viscosities of the regional samples: heating oil HEL, summer grade.

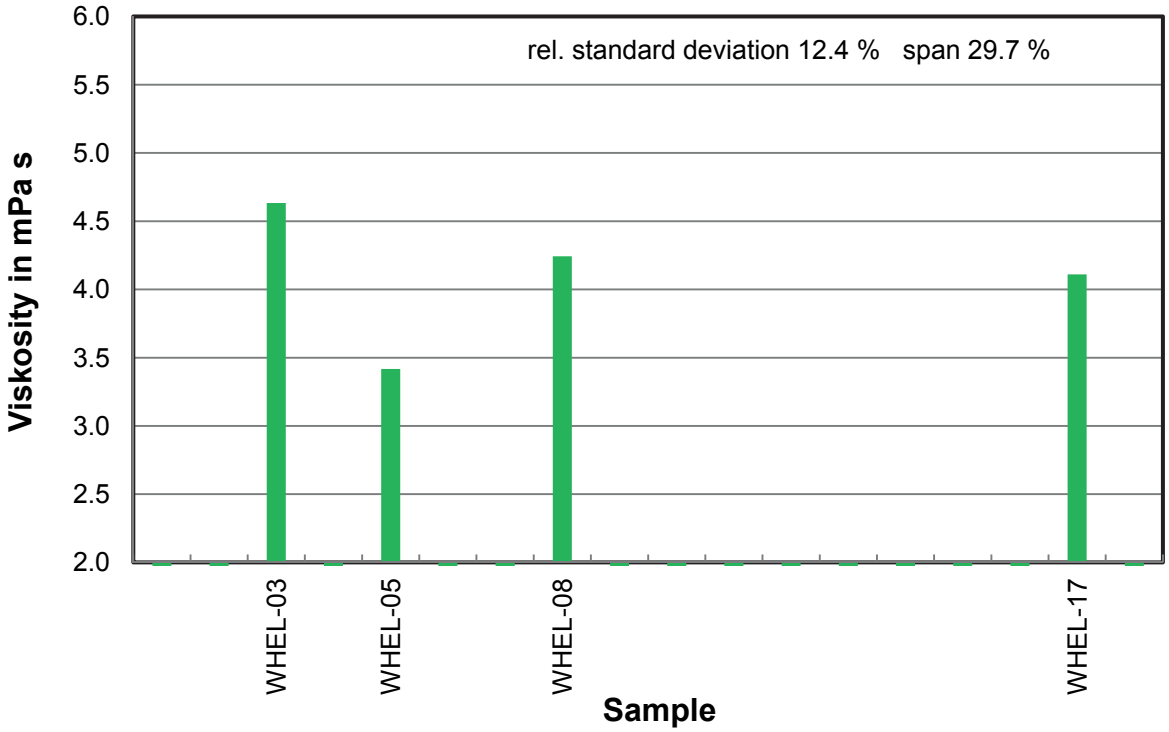


Fig. A3-15: Viscosities of the regional samples: heating oil HEL, winter grade.

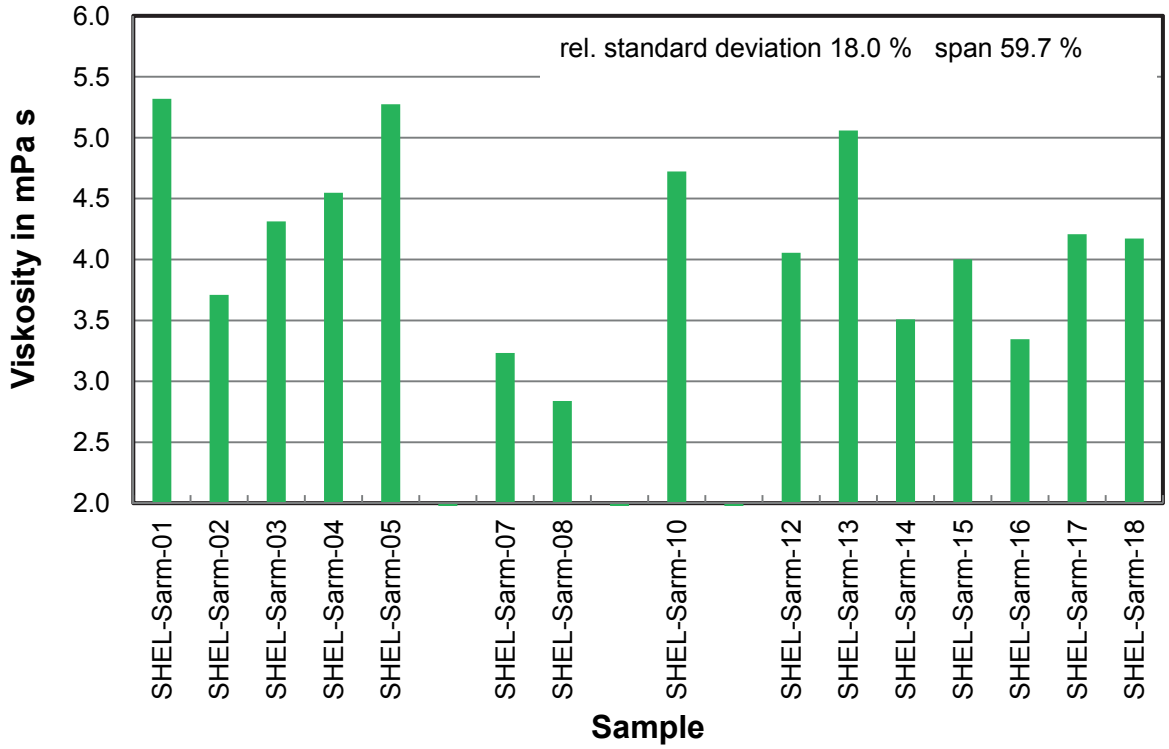


Fig. A3-16: Viscosities of the regional samples: low-sulphur heating oil HEL, summer grade.

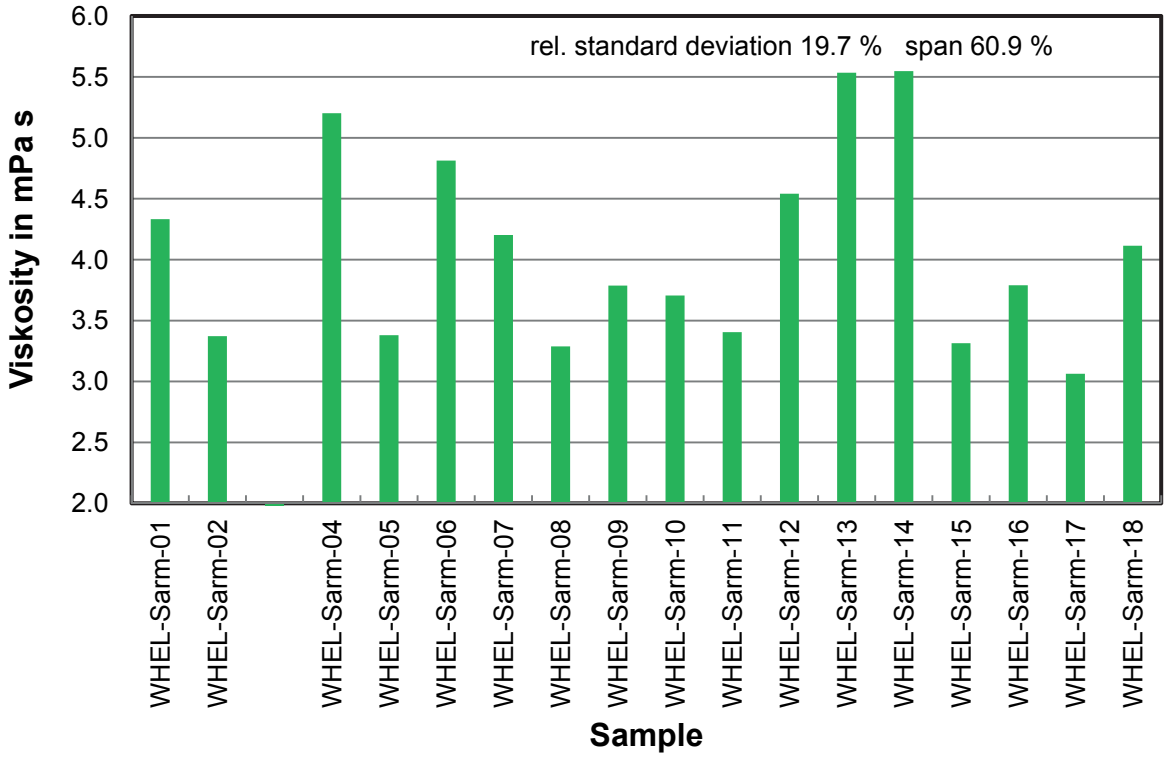


Fig. A3-17: Viscosities of the regional samples: low-sulphur heating oil HEL, winter grade.

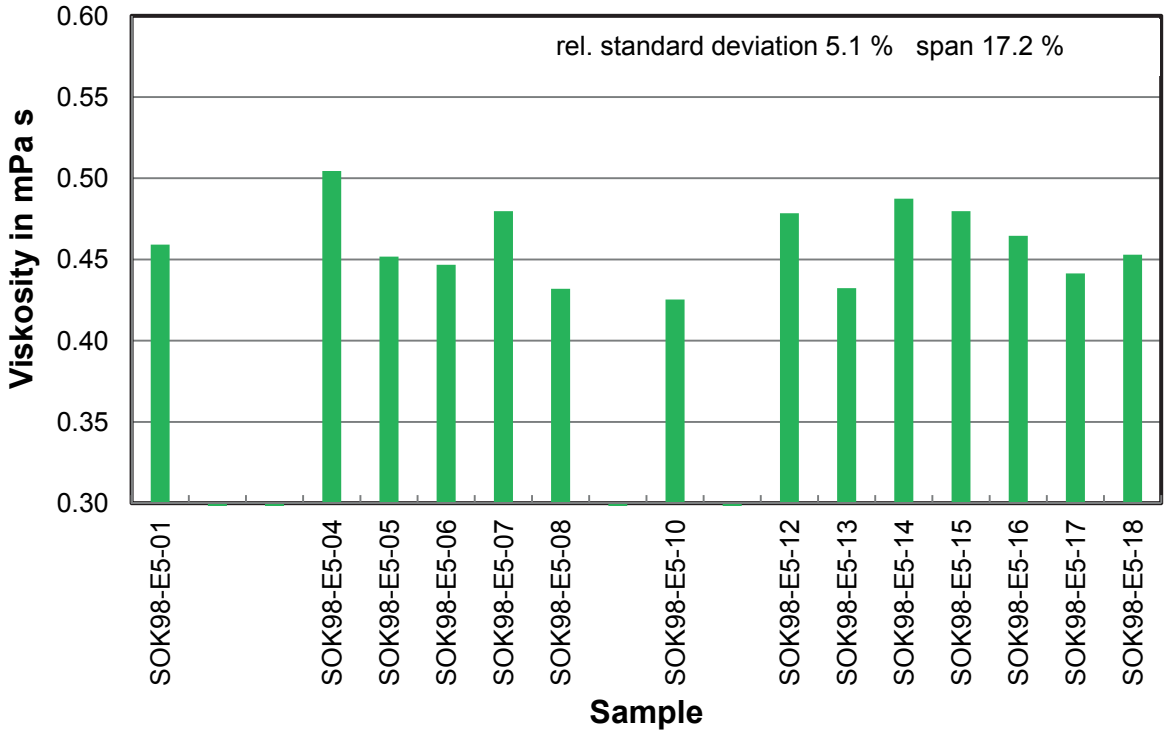


Fig. A3-18: Viscosities of the regional samples: petrol OK98 E5, summer grade.

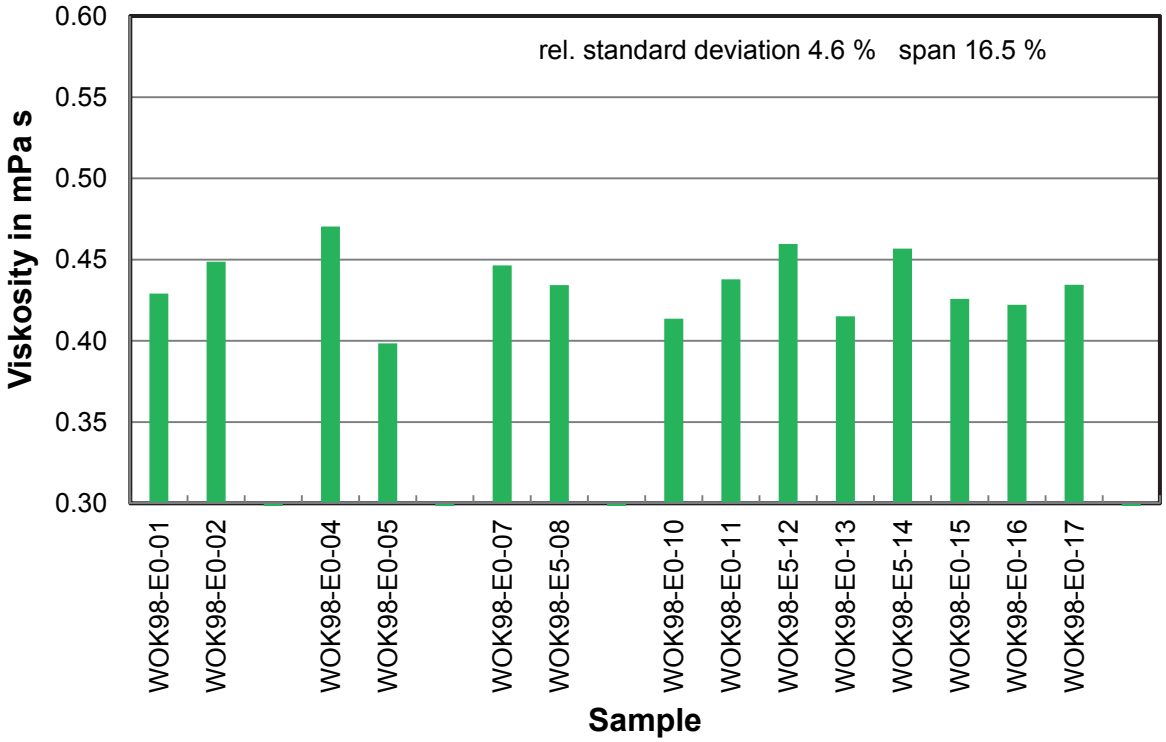


Fig. A3-19: Viscosities of the regional samples: petrol OK98 E0 and E5, winter grade.

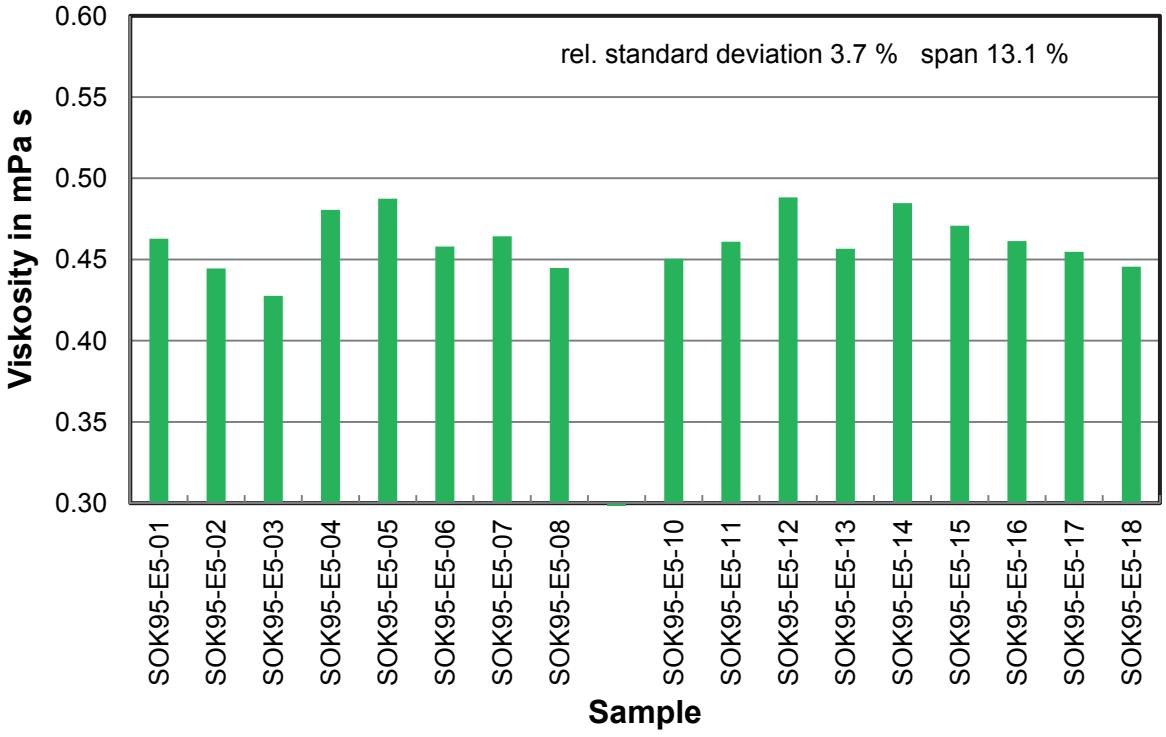


Fig. A3-20: Viscosities of the regional samples: petrol OK95 E5, summer grade.

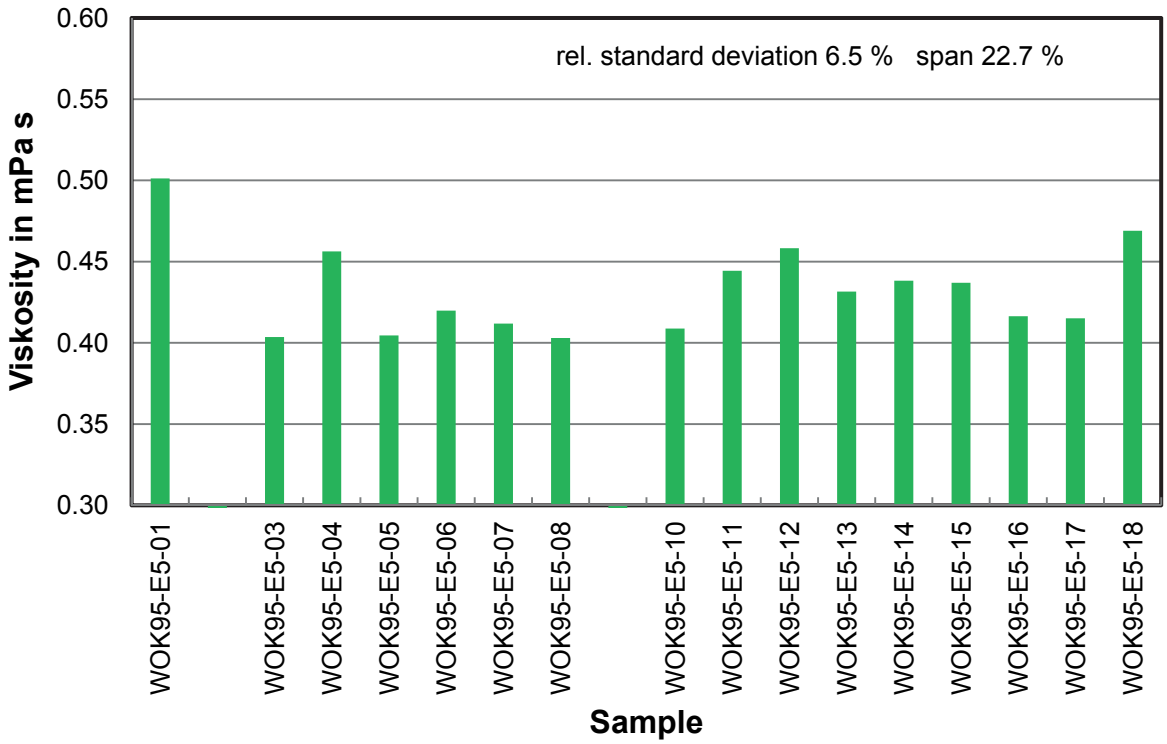


Fig. A3-21: Viscosities of the regional samples: petrol OK95 E5, winter grade.

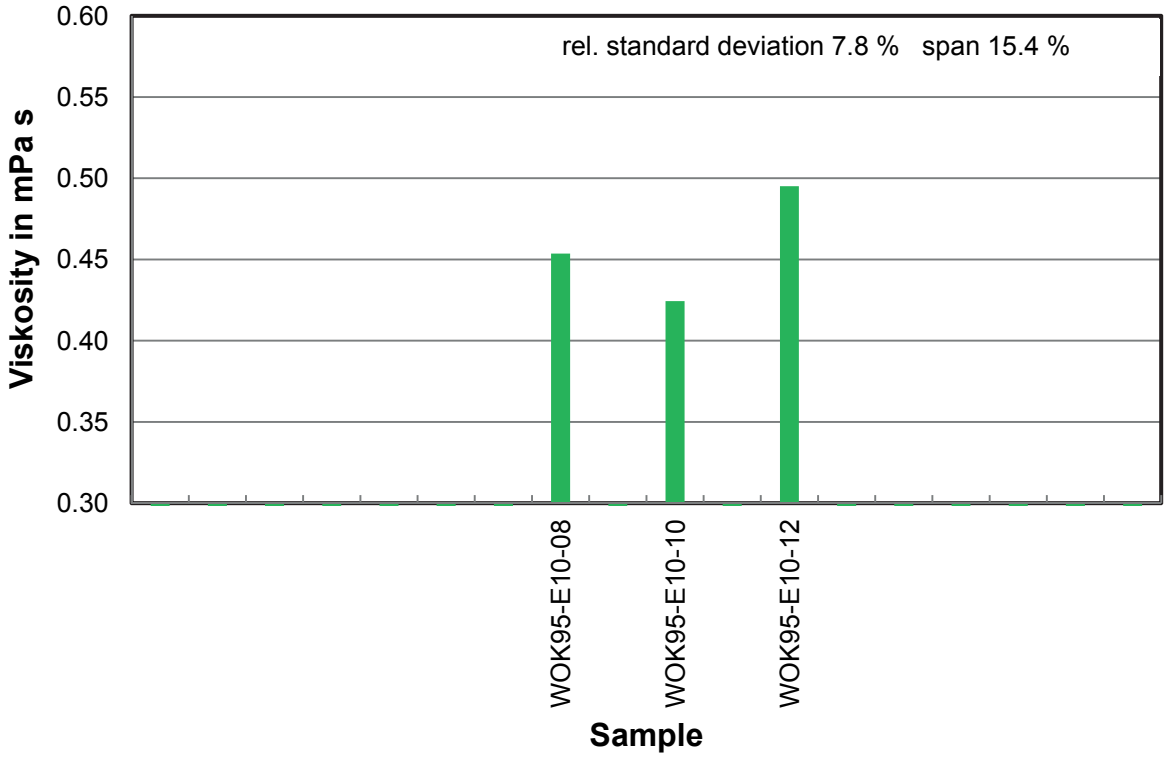


Fig. A3-22: Viscosities of the regional samples: petrol OK95 E10, winter grade.

Annex 4: Original measurement data

Density of the regional samples

Petrol, super E5, ROZ 95, summer grade

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-01	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-02	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-03
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	789.194	-30.00	791.228	-30.00	789.527
-25.00	784.858	-25.00	786.815	-25.00	785.063
-20.00	780.508	-20.00	782.386	-20.00	780.584
-15.00	776.143	-15.00	777.942	-15.00	776.087
-10.00	771.763	-10.00	773.48	-10.00	771.571
-5.00	767.365	-5.00	768.997	-5.00	767.035
0.00	762.947	0.00	764.493	0.00	762.475
5.00	758.507	5.00	759.964	5.00	757.890
10.00	754.043	10.00	755.412	10.00	753.277
15.00	749.553	15.00	750.828	15.00	748.632
20.00	745.033	20.00	746.213	20.00	743.952
25.00	740.481	25.00	741.566	25.00	739.236
30.00	735.895	30.00	736.883	30.00	734.478
35.00	731.274	35.00	732.160	35.00	729.679
40.00	726.612	40.00	727.396	40.00	724.830
45.00	721.909	45.00	722.590	45.00	719.932
50.00	717.164	50.00	717.736	50.00	714.981

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-04	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-05	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-06
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	798.485	-30.00	802.498	-30.00	791.159
-25.00	794.106	-25.00	798.136	-25.00	786.796
-20.00	789.708	-20.00	793.760	-20.00	782.418
-15.00	785.298	-15.00	789.369	-15.00	778.025
-10.00	780.871	-10.00	784.963	-10.00	773.615
-5.00	776.425	-5.00	780.539	-5.00	769.186
0.00	771.957	0.00	776.095	0.00	764.736
5.00	767.468	5.00	771.628	5.00	760.263
10.00	762.952	10.00	767.136	10.00	755.764
15.00	758.408	15.00	762.618	15.00	751.233
20.00	753.833	20.00	758.069	20.00	746.673
25.00	749.222	25.00	753.486	25.00	742.074
30.00	744.578	30.00	748.870	30.00	737.443
35.00	739.893	35.00	744.215	35.00	732.769
40.00	735.164	40.00	739.519	40.00	728.052
45.00	730.387	45.00	734.778	45.00	723.289
50.00	725.566	50.00	729.993	50.00	718.477

Petrol, super E5, ROZ 95, summer grade

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-07	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-08	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-10
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	785.907	-30.00	788.847	-30.00	781.837
-25.00	781.584	-25.00	784.455	-25.00	777.479
-20.00	777.246	-20.00	780.046	-20.00	773.104
-15.00	772.894	-15.00	775.621	-15.00	768.714
-10.00	768.524	-10.00	771.179	-10.00	764.304
-5.00	764.137	-5.00	766.717	-5.00	759.878
0.00	759.730	0.00	762.234	0.00	755.429
5.00	755.299	5.00	757.727	5.00	750.957
10.00	750.842	10.00	753.192	10.00	746.456
15.00	746.356	15.00	748.627	15.00	741.927
20.00	741.839	20.00	744.029	20.00	737.368
25.00	737.288	25.00	739.396	25.00	732.770
30.00	732.703	30.00	734.724	30.00	728.135
35.00	728.075	35.00	730.010	35.00	723.461
40.00	723.404	40.00	725.249	40.00	718.741
45.00	718.688	45.00	720.443	45.00	713.974
50.00	713.924	50.00	715.585	50.00	709.160

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-11	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-12	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-13
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	791.733	-30.00	804.964	-30.00	784.055
-25.00	787.385	-25.00	800.631	-25.00	779.701
-20.00	783.024	-20.00	796.286	-20.00	775.331
-15.00	778.649	-15.00	791.925	-15.00	770.946
-10.00	774.257	-10.00	787.551	-10.00	766.544
-5.00	769.847	-5.00	783.160	-5.00	762.122
0.00	765.416	0.00	778.750	0.00	757.679
5.00	760.963	5.00	774.320	5.00	753.213
10.00	756.486	10.00	769.864	10.00	748.718
15.00	751.979	15.00	765.384	15.00	744.196
20.00	747.443	20.00	760.872	20.00	739.640
25.00	742.872	25.00	756.331	25.00	735.048
30.00	738.268	30.00	751.754	30.00	730.421
35.00	733.623	35.00	747.142	35.00	725.751
40.00	728.933	40.00	742.488	40.00	721.036
45.00	724.201	45.00	737.791	45.00	716.274
50.00	719.420	50.00	733.051	50.00	711.463

Petrol, super E5, ROZ 95, summer grade

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-14	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-15	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-16
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	795.230	-30.00	791.677	-30.00	788.118
-25.00	790.919	-25.00	787.346	-25.00	783.776
-20.00	786.593	-20.00	783.000	-20.00	779.417
-15.00	782.253	-15.00	778.640	-15.00	775.045
-10.00	777.899	-10.00	774.264	-10.00	770.657
-5.00	773.528	-5.00	769.871	-5.00	766.249
0.00	769.137	0.00	765.455	0.00	761.821
5.00	764.725	5.00	761.021	5.00	757.369
10.00	760.290	10.00	756.559	10.00	752.892
15.00	755.827	15.00	752.069	15.00	748.386
20.00	751.333	20.00	747.546	20.00	743.848
25.00	746.807	25.00	742.993	25.00	739.275
30.00	742.249	30.00	738.404	30.00	734.670
35.00	737.651	35.00	733.776	35.00	730.021
40.00	733.013	40.00	729.104	40.00	725.329
45.00	728.332	45.00	724.387	45.00	720.590
50.00	723.603	50.00	719.622	50.00	715.805

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-17	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-18
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	788.160	-30.00	788.163
-25.00	783.816	-25.00	783.820
-20.00	779.457	-20.00	779.460
-15.00	775.084	-15.00	775.088
-10.00	770.696	-10.00	770.701
-5.00	766.291	-5.00	766.297
0.00	761.867	0.00	761.872
5.00	757.424	5.00	757.427
10.00	752.957	10.00	752.960
15.00	748.468	15.00	748.470
20.00	743.952	20.00	743.955
25.00	739.408	25.00	739.410
30.00	734.838	30.00	734.838
35.00	730.235	35.00	730.236
40.00	725.598	40.00	725.599
45.00	720.929	45.00	720.930
50.00	716.223	50.00	716.226

Petrol, super E5, ROZ 95, winter grade

Class	Regional samples	Class	Regional samples	Class	Regional samples
Batch	Super petrol OK95	Batch	Super petrol OK95	Batch	Super petrol OK95
Mixture	WOK95-E5-01	Mixture	WOK95-E5-03	Mixture	WOK95-E5-04
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
-25.00	796.128	-25.00	778.146	-25.00	789.272
-20.00	791.758	-20.00	773.611	-20.00	784.812
-15.00	787.374	-15.00	769.061	-15.00	780.337
-10.00	782.978	-10.00	764.492	-10.00	775.844
-5.00	778.564	-5.00	759.901	-5.00	771.328
0.00	774.134	0.00	755.286	0.00	766.796
5.00	769.682	5.00	750.642	5.00	762.245
10.00	765.204	10.00	745.972	10.00	757.665
15.00	760.699	15.00	741.267	15.00	753.055
20.00	756.167	20.00	736.526	20.00	748.414
25.00	751.602	25.00	731.747	25.00	743.738
30.00	747.004	30.00	726.925	30.00	739.025
35.00	742.367	35.00	722.055	35.00	734.269
40.00	737.689	40.00	717.140	40.00	729.468
45.00	732.967	45.00	712.168	45.00	724.619
50.00	728.202	50.00	707.144	50.00	719.720

Class	Regional samples	Class	Regional samples	Class	Regional samples
Batch	Super petrol OK95	Batch	Super petrol OK95	Batch	Super petrol OK95
Mixture	WOK95-E5-05	Mixture	WOK95-E5-06	Mixture	WOK95-E5-07
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
-25.00	771.260	-25.00	775.853	-25.00	765.606
-20.00	766.772	-20.00	771.398	-20.00	761.170
-15.00	762.269	-15.00	766.929	-15.00	756.719
-10.00	757.749	-10.00	762.442	-10.00	752.249
-5.00	753.207	-5.00	757.932	-5.00	747.759
0.00	748.639	0.00	753.401	0.00	743.246
5.00	744.049	5.00	748.849	5.00	738.709
10.00	739.427	10.00	744.267	10.00	734.142
15.00	734.774	15.00	739.651	15.00	729.542
20.00	730.083	20.00	735.002	20.00	724.906
25.00	725.357	25.00	730.315	25.00	720.233
30.00	720.588	30.00	725.589	30.00	715.517
35.00	715.773	35.00	720.819	35.00	710.759
40.00	710.911	40.00	716.000	40.00	705.949
45.00	705.996	45.00	711.131	45.00	701.088
50.00	701.026	50.00	706.211	50.00	696.172

Petrol, super E5, ROZ 95, winter grade

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-08	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-10	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-11
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	769.362	-25.00	766.058	-25.00	776.354
-20.00	764.874	-20.00	761.591	-20.00	771.950
-15.00	760.368	-15.00	757.109	-15.00	767.532
-10.00	755.844	-10.00	752.608	-10.00	763.097
-5.00	751.297	-5.00	748.085	-5.00	758.642
0.00	746.728	0.00	743.537	0.00	754.167
5.00	742.132	5.00	738.969	5.00	749.670
10.00	737.509	10.00	734.368	10.00	745.145
15.00	732.850	15.00	729.734	15.00	740.588
20.00	728.155	20.00	725.064	20.00	735.998
25.00	723.422	25.00	720.356	25.00	731.374
30.00	718.647	30.00	715.608	30.00	726.712
35.00	713.823	35.00	710.815	35.00	722.007
40.00	708.951	40.00	705.974	40.00	717.256
45.00	704.025	45.00	701.079	45.00	712.455
50.00	699.044	50.00	696.132	50.00	707.605

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-12	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-13	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-14
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	789.222	-25.00	774.664	-25.00	773.905
-20.00	784.829	-20.00	770.245	-20.00	769.439
-15.00	780.422	-15.00	765.811	-15.00	764.960
-10.00	776.003	-10.00	761.363	-10.00	760.463
-5.00	771.563	-5.00	756.893	-5.00	755.945
0.00	767.105	0.00	752.403	0.00	751.407
5.00	762.625	5.00	747.889	5.00	746.844
10.00	758.120	10.00	743.348	10.00	742.250
15.00	753.589	15.00	738.778	15.00	737.625
20.00	749.025	20.00	734.174	20.00	732.964
25.00	744.428	25.00	729.534	25.00	728.269
30.00	739.795	30.00	724.855	30.00	723.533
35.00	735.123	35.00	720.133	35.00	718.753
40.00	730.409	40.00	715.364	40.00	713.924
45.00	725.648	45.00	710.548	45.00	709.045
50.00	720.842	50.00	705.682	50.00	704.115

Petrol, super E5, ROZ 95, winter grade

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-15	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-16	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-17
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	772.267	-25.00	761.947	-25.00	768.077
-20.00	767.836	-20.00	757.530	-20.00	763.624
-15.00	763.390	-15.00	753.098	-15.00	759.157
-10.00	758.926	-10.00	748.646	-10.00	754.671
-5.00	754.443	-5.00	744.174	-5.00	750.162
0.00	749.935	0.00	739.677	0.00	745.631
5.00	745.404	5.00	735.154	5.00	741.074
10.00	740.843	10.00	730.599	10.00	736.487
15.00	736.252	15.00	726.015	15.00	731.867
20.00	731.625	20.00	721.395	20.00	727.214
25.00	726.962	25.00	716.736	25.00	722.524
30.00	722.258	30.00	712.035	30.00	717.794
35.00	717.510	35.00	707.290	35.00	713.017
40.00	712.712	40.00	702.493	40.00	708.194
45.00	707.865	45.00	697.643	45.00	703.320
50.00	702.963	50.00	692.739	50.00	698.392

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-18
Temperature °C	Density kg/m³
-25.00	786.710
-20.00	782.321
-15.00	777.914
-10.00	773.495
-5.00	769.054
0.00	764.599
5.00	760.115
10.00	755.607
15.00	751.072
20.00	746.505
25.00	741.905
30.00	737.269
35.00	732.594
40.00	727.876
45.00	723.110
50.00	718.301

Petrol, super E10, ROZ 95, winter grade

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E10-08	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E10-10	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E10-12
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	781.503	-25.00	771.611	-25.00	792.444
-20.00	777.057	-20.00	767.152	-20.00	788.053
-15.00	772.596	-15.00	762.676	-15.00	783.647
-10.00	768.115	-10.00	758.182	-10.00	779.228
-5.00	763.614	-5.00	753.667	-5.00	774.788
0.00	759.091	0.00	749.128	0.00	770.327
5.00	754.545	5.00	744.563	5.00	765.843
10.00	749.970	10.00	739.969	10.00	761.336
15.00	745.360	15.00	735.345	15.00	756.798
20.00	740.714	20.00	730.687	20.00	752.225
25.00	736.029	25.00	725.989	25.00	747.619
30.00	731.301	30.00	721.250	30.00	742.970
35.00	726.527	35.00	716.465	35.00	738.278
40.00	721.701	40.00	711.628	40.00	733.537
45.00	716.817	45.00	706.739	45.00	728.745
50.00	711.879	50.00	701.796	50.00	723.898

Petrol, super E5, ROZ 98, summer grade

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-01	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-04	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-05
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	791.209	-30.00	801.948	-30.00	792.316
-25.00	786.839	-25.00	797.623	-25.00	787.933
-20.00	782.455	-20.00	793.284	-20.00	783.535
-15.00	778.064	-15.00	788.935	-15.00	779.126
-10.00	773.661	-10.00	784.578	-10.00	774.702
-5.00	769.240	-5.00	780.206	-5.00	770.265
0.00	764.803	0.00	775.817	0.00	765.810
5.00	760.349	5.00	771.412	5.00	761.338
10.00	755.875	10.00	766.989	10.00	756.847
15.00	751.380	15.00	762.547	15.00	752.335
20.00	746.862	20.00	758.082	20.00	747.801
25.00	742.319	25.00	753.597	25.00	743.241
30.00	737.751	30.00	749.088	30.00	738.657
35.00	733.153	35.00	744.552	35.00	734.043
40.00	728.521	40.00	739.986	40.00	729.397
45.00	723.855	45.00	735.389	45.00	724.719
50.00	719.156	50.00	730.760	50.00	720.004

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-06	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-07	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-08
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	790.440	-30.00	792.506	-30.00	785.060
-25.00	786.055	-25.00	788.200	-25.00	780.663
-20.00	781.656	-20.00	783.884	-20.00	776.254
-15.00	777.241	-15.00	779.556	-15.00	771.830
-10.00	772.813	-10.00	775.214	-10.00	767.392
-5.00	768.368	-5.00	770.860	-5.00	762.937
0.00	763.905	0.00	766.489	0.00	758.462
5.00	759.424	5.00	762.102	5.00	753.970
10.00	754.924	10.00	757.697	10.00	749.456
15.00	750.400	15.00	753.274	15.00	744.919
20.00	745.850	20.00	748.829	20.00	740.357
25.00	741.273	25.00	744.361	25.00	735.769
30.00	736.671	30.00	739.866	30.00	731.153
35.00	732.036	35.00	735.348	35.00	726.507
40.00	727.367	40.00	730.796	40.00	721.825
45.00	722.665	45.00	726.213	45.00	717.107
50.00	717.825	50.00	721.598	50.00	712.352

Petrol, super E5, ROZ 98, summer grade

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-10	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-12	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-13
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	784.712	-30.00	804.446	-30.00	789.020
-25.00	780.297	-25.00	800.070	-25.00	784.591
-20.00	775.867	-20.00	795.680	-20.00	780.145
-15.00	771.423	-15.00	791.281	-15.00	775.686
-10.00	766.961	-10.00	786.869	-10.00	771.212
-5.00	762.482	-5.00	782.441	-5.00	766.721
0.00	757.984	0.00	778.000	0.00	762.214
5.00	753.464	5.00	773.542	5.00	757.686
10.00	748.922	10.00	769.068	10.00	753.138
15.00	744.356	15.00	764.574	15.00	748.567
20.00	739.764	20.00	760.059	20.00	743.971
25.00	735.145	25.00	755.522	25.00	739.346
30.00	730.500	30.00	750.962	30.00	734.696
35.00	725.822	35.00	746.374	35.00	730.012
40.00	721.109	40.00	741.757	40.00	725.295
45.00	716.360	45.00	737.111	45.00	720.539
50.00	711.574	50.00	732.433	50.00	715.746

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-14	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-15	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-16
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	789.888	-30.00	797.336	-30.00	786.130
-25.00	785.601	-25.00	792.979	-25.00	781.808
-20.00	781.300	-20.00	788.605	-20.00	777.474
-15.00	776.985	-15.00	784.219	-15.00	773.125
-10.00	772.655	-10.00	779.815	-10.00	768.765
-5.00	768.309	-5.00	775.395	-5.00	764.389
0.00	763.943	0.00	770.952	0.00	759.997
5.00	759.555	5.00	766.488	5.00	755.586
10.00	755.144	10.00	761.998	10.00	751.157
15.00	750.705	15.00	757.479	15.00	746.707
20.00	746.238	20.00	752.932	20.00	742.236
25.00	741.738	25.00	748.351	25.00	737.737
30.00	737.206	30.00	743.735	30.00	733.212
35.00	732.633	35.00	739.077	35.00	728.660
40.00	728.018	40.00	734.379	40.00	724.075
45.00	723.361	45.00	729.635	45.00	719.457
50.00	718.66	50.00	724.846	50.00	714.802

Petrol, super E5, ROZ 98, summer grade

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-17	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-18
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-30.00	790.469	-30.00	787.382
-25.00	786.047	-25.00	782.972
-20.00	781.609	-20.00	778.545
-15.00	777.156	-15.00	774.103
-10.00	772.691	-10.00	769.646
-5.00	768.210	-5.00	765.171
0.00	763.710	0.00	760.678
5.00	759.193	5.00	756.165
10.00	754.655	10.00	751.632
15.00	750.098	15.00	747.073
20.00	745.514	20.00	742.491
25.00	740.906	25.00	737.884
30.00	736.272	30.00	733.248
35.00	731.607	35.00	728.582
40.00	726.908	40.00	723.882
45.00	722.178	45.00	719.148
50.00	717.411	50.00	714.377

Petrol, super E0, ROZ 98, winter grade

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-01	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-02	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-04
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	783.218	-25.00	788.973	-25.00	790.580
-20.00	778.791	-20.00	784.531	-20.00	786.188
-15.00	774.353	-15.00	780.076	-15.00	781.786
-10.00	769.903	-10.00	775.608	-10.00	777.371
-5.00	765.438	-5.00	771.123	-5.00	772.945
0.00	760.955	0.00	766.621	0.00	768.501
5.00	756.457	5.00	762.099	5.00	764.042
10.00	751.937	10.00	757.559	10.00	759.564
15.00	747.396	15.00	752.993	15.00	755.065
20.00	742.831	20.00	748.406	20.00	750.547
25.00	738.242	25.00	743.792	25.00	746.004
30.00	733.625	30.00	739.149	30.00	741.435
35.00	728.979	35.00	734.475	35.00	736.838
40.00	724.299	40.00	729.767	40.00	732.209
45.00	719.584	45.00	725.023	45.00	727.547
50.00	714.833	50.00	720.243	50.00	722.851

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-05	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-07	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E5-08
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	762.515	-25.00	776.807	-25.00	785.624
-20.00	758.115	-20.00	772.431	-20.00	781.166
-15.00	753.702	-15.00	768.044	-15.00	776.692
-10.00	749.277	-10.00	763.644	-10.00	772.205
-5.00	744.833	-5.00	759.231	-5.00	767.696
0.00	740.373	0.00	754.803	0.00	763.166
5.00	735.893	5.00	750.357	5.00	758.616
10.00	731.394	10.00	745.889	10.00	754.039
15.00	726.869	15.00	741.401	15.00	749.429
20.00	722.320	20.00	736.889	20.00	744.788
25.00	717.745	25.00	732.353	25.00	740.114
30.00	713.138	30.00	727.789	30.00	735.399
35.00	708.499	35.00	723.195	35.00	730.642
40.00	703.823	40.00	718.569	40.00	725.840
45.00	699.109	45.00	713.910	45.00	720.989
50.00	694.356	50.00	709.213	50.00	716.087

Petrol, super E0, ROZ 98, winter grade

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-10	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-11	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E5-12
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	764.492	-25.00	778.034	-25.00	789.530
-20.00	760.022	-20.00	773.606	-20.00	785.115
-15.00	755.540	-15.00	769.165	-15.00	780.687
-10.00	751.041	-10.00	764.709	-10.00	776.244
-5.00	746.524	-5.00	760.236	-5.00	771.781
0.00	741.988	0.00	755.746	0.00	767.299
5.00	737.435	5.00	751.237	5.00	762.797
10.00	732.860	10.00	746.708	10.00	758.271
15.00	728.259	15.00	742.163	15.00	753.713
20.00	723.631	20.00	737.590	20.00	749.124
25.00	718.975	25.00	732.991	25.00	744.502
30.00	714.290	30.00	728.365	30.00	739.842
35.00	709.571	35.00	723.708	35.00	735.143
40.00	704.815	40.00	719.019	40.00	730.399
45.00	700.020	45.00	714.294	45.00	725.609
50.00	695.186	50.00	709.534	50.00	720.772

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-13	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E5-14	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-15
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	780.873	-25.00	782.137	-25.00	773.481
-20.00	776.362	-20.00	777.764	-20.00	769.069
-15.00	771.837	-15.00	773.377	-15.00	764.643
-10.00	767.300	-10.00	768.977	-10.00	760.203
-5.00	762.744	-5.00	764.555	-5.00	755.744
0.00	758.172	0.00	760.115	0.00	751.274
5.00	753.580	5.00	755.653	5.00	746.783
10.00	748.967	10.00	751.168	10.00	742.269
15.00	744.329	15.00	746.653	15.00	737.733
20.00	739.665	20.00	742.107	20.00	733.171
25.00	734.973	25.00	737.528	25.00	728.584
30.00	730.251	30.00	732.912	30.00	723.967
35.00	725.496	35.00	728.255	35.00	719.318
40.00	720.704	40.00	723.555	40.00	714.635
45.00	715.874	45.00	718.808	45.00	709.915
50.00	711.004	50.00	714.015	50.00	705.158

Petrol, super E0, ROZ 98, winter grade

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-16	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-17	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-08
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-25.00	774.962	-25.00	780.262	-25.00	783.222
-20.00	770.495	-20.00	775.803	-20.00	778.726
-15.00	766.012	-15.00	771.330	-15.00	774.215
-10.00	761.515	-10.00	766.842	-10.00	769.692
-5.00	756.998	-5.00	762.339	-5.00	765.150
0.00	752.465	0.00	757.817	-0.00	760.590
5.00	747.914	5.00	753.276	5.00	756.013
10.00	743.341	10.00	748.716	10.00	751.414
15.00	738.744	15.00	744.133	15.00	746.792
20.00	734.121	20.00	739.526	20.00	742.145
25.00	729.469	25.00	734.894	25.00	737.470
30.00	724.787	30.00	730.237	30.00	732.767
35.00	720.071	35.00	725.547	35.00	728.028
40.00	715.320	40.00	720.821	40.00	723.256
45.00	710.530	45.00	716.061	45.00	718.445
50.00	705.700	50.00	711.263	50.00	713.595

Summer-grade diesel

Class Batch Mixture	Regional samples Diesel SDK-01	Class Batch Mixture	Regional samples Diesel SDK-02	Class Batch Mixture	Regional samples Diesel SDK-03
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	805.295	50.00	813.086	50.00	817.904
45.00	808.820	45.00	816.595	45.00	821.388
40.00	812.344	40.00	820.102	40.00	824.874
35.00	815.864	35.00	823.609	35.00	828.357
30.00	819.379	30.00	827.114	30.00	831.840
25.00	822.897	25.00	830.615	25.00	835.320
20.00	826.413	20.00	834.117	20.00	838.802
15.00	829.931	15.00	837.620	15.00	842.287
10.00	833.449	10.00	841.124	10.00	845.772
5.00	836.969	5.00	844.633	5.00	849.262
0.00	840.491	0.00	848.144	0.00	852.757
-5.00	844.363	-5.00	851.661	-5.00	856.258
-10.00	848.412	-10.00	856.127	-10.00	861.404
-15.00	852.918	-15.00	860.588	-15.00	866.469
-20.00	857.449	-20.00	865.452	-20.00	870.846
-25.00	861.906	-25.00	869.847	-25.00	874.509

Class Batch Mixture	Regional samples Diesel SDK-04	Class Batch Mixture	Regional samples Diesel SDK-05	Class Batch Mixture	Regional samples Diesel SDK-06
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	815.038	50.00	820.447	50.00	813.373
45.00	818.536	45.00	823.943	45.00	816.865
40.00	822.032	40.00	827.440	40.00	820.359
35.00	825.529	35.00	830.935	35.00	823.856
30.00	829.006	30.00	834.415	30.00	827.343
25.00	832.513	25.00	837.916	25.00	830.830
20.00	836.003	20.00	841.411	20.00	834.317
15.00	839.499	15.00	844.906	15.00	837.806
10.00	842.995	10.00	848.401	10.00	841.296
5.00	846.493	5.00	851.899	5.00	844.789
0.00	849.996	0.00	855.401	0.00	848.285
-5.00	853.505	-5.00	858.910	-5.00	852.550
-10.00	857.753	-10.00	862.774	-10.00	856.906
-15.00	862.051	-15.00	867.232	-15.00	861.696
-20.00	866.851	-20.00	871.961	-20.00	866.085
-25.00	871.165	-25.00	876.121	-25.00	870.297

Summer-grade diesel

Class Batch Mixture	Regional samples Diesel SDK-07	Class Batch Mixture	Regional samples Diesel SDK-08	Class Batch Mixture	Regional samples Diesel SDK-10
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	817.362	50.00	800.782	50.00	819.037
45.00	820.894	45.00	804.377	45.00	822.529
40.00	824.429	40.00	807.968	40.00	826.023
35.00	827.959	35.00	811.551	35.00	829.513
30.00	831.475	30.00	815.141	30.00	832.995
25.00	835.014	25.00	818.724	25.00	836.492
20.00	838.541	20.00	822.303	20.00	839.983
15.00	842.065	15.00	825.884	15.00	843.472
10.00	845.595	10.00	829.464	10.00	846.965
5.00	849.127	5.00	833.044	5.00	850.459
0.00	852.660	0.00	836.625	0.00	853.960
-5.00	856.200	-5.00	840.211	-5.00	858.131
-10.00	860.222	-10.00	843.800	-10.00	862.866
-15.00	864.377	-15.00	847.444	-15.00	867.170
-20.00	869.019	-20.00	852.436	-20.00	871.419
-25.00	873.271	-25.00	857.570	-25.00	875.396

Class Batch Mixture	Regional samples Diesel SDK-11	Class Batch Mixture	Regional samples Diesel SDK-12	Class Batch Mixture	Regional samples Diesel SDK-13
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	809.494	50.00	815.943	50.00	808.917
45.00	813.019	45.00	819.449	45.00	812.471
40.00	816.550	40.00	822.954	40.00	816.022
35.00	820.073	35.00	826.465	35.00	819.567
30.00	823.595	30.00	829.964	30.00	823.115
25.00	827.115	25.00	833.464	25.00	826.657
20.00	830.634	20.00	836.964	20.00	830.197
15.00	834.154	15.00	840.467	15.00	833.741
10.00	837.678	10.00	843.971	10.00	837.283
5.00	841.202	5.00	847.477	5.00	840.826
0.00	844.729	0.00	850.986	0.00	844.372
-5.00	848.736	-5.00	855.019	-5.00	848.119
-10.00	853.591	-10.00	860.000	-10.00	852.248
-15.00	857.945	-15.00	864.483	-15.00	856.260
-20.00	862.389	-20.00	868.760	-20.00	860.423
-25.00	866.662	-25.00	872.564	-25.00	864.957

Summer-grade diesel

Class Batch Mixture	Regional samples Diesel SDK-14	Class Batch Mixture	Regional samples Diesel SDK-15	Class Batch Mixture	Regional samples Diesel SDK-16
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	817.361	50.00	817.155	50.00	816.732
45.00	820.866	45.00	820.672	45.00	820.267
40.00	824.373	40.00	824.190	40.00	823.800
35.00	827.872	35.00	827.705	35.00	827.332
30.00	831.376	30.00	831.211	30.00	830.852
25.00	834.877	25.00	834.730	25.00	834.387
20.00	838.377	20.00	838.249	20.00	837.914
15.00	841.880	15.00	841.759	15.00	841.443
10.00	845.385	10.00	845.273	10.00	844.969
5.00	848.891	5.00	848.790	5.00	848.501
0.00	852.402	0.00	852.310	0.00	852.036
-5.00	855.920	-5.00	855.836	-5.00	855.575
-10.00	860.091	-10.00	860.034	-10.00	859.646
-15.00	864.553	-15.00	864.379	-15.00	863.920
-20.00	869.481	-20.00	869.255	-20.00	868.783
-25.00	873.953	-25.00	873.844	-25.00	873.148

Class Batch Mixture	Regional samples Diesel SDK-17	Class Batch Mixture	Regional samples Diesel SDK-18
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	812.513	50.00	811.920
45.00	816.030	45.00	815.424
40.00	819.546	40.00	818.930
35.00	823.057	35.00	822.433
30.00	826.569	30.00	825.935
25.00	830.078	25.00	829.433
20.00	833.586	20.00	832.933
15.00	837.100	15.00	836.434
10.00	840.611	10.00	839.937
5.00	844.126	5.00	843.442
0.00	847.644	0.00	846.953
-5.00	851.572	-5.00	851.030
-10.00	855.889	-10.00	855.391
-15.00	860.464	-15.00	860.104
-20.00	865.498	-20.00	865.149
-25.00	870.068	-25.00	869.714

Winter-grade diesel

Class Batch Mixture	Regional samples Diesel WDK-01	Class Batch Mixture	Regional samples Diesel WDK-02	Class Batch Mixture	Regional samples Diesel WDK-03
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	803.008	50.00	814.113	50.00	819.061
45.00	806.530	45.00	817.621	45.00	822.559
40.00	810.051	40.00	821.129	40.00	826.057
35.00	813.568	35.00	824.634	35.00	829.553
30.00	817.081	30.00	828.136	30.00	833.031
25.00	820.596	25.00	831.638	25.00	836.540
20.00	824.109	20.00	835.138	20.00	840.028
15.00	827.622	15.00	838.640	15.00	843.528
10.00	831.135	10.00	842.144	10.00	847.025
5.00	834.650	5.00	845.650	5.00	850.523
0.00	838.169	0.00	849.160	0.00	854.027
-5.00	841.698	-5.00	852.677	-5.00	857.539
-10.00	845.723	-10.00	856.203	-10.00	861.166
-15.00	849.862	-15.00	860.461	-15.00	865.280
-20.00	854.093	-20.00	864.599	-20.00	869.651
-25.00	858.545	-25.00	868.910	-25.00	874.327

Class Batch Mixture	Regional samples Diesel WDK-04	Class Batch Mixture	Regional samples Diesel WDK-05	Class Batch Mixture	Regional samples Diesel WDK-06
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	805.958	50.00	818.714	50.00	815.945
45.00	809.483	45.00	822.217	45.00	819.443
40.00	813.008	40.00	825.720	40.00	822.941
35.00	816.532	35.00	829.221	35.00	826.438
30.00	820.048	30.00	832.717	30.00	829.932
25.00	823.571	25.00	836.217	25.00	833.424
20.00	827.084	20.00	839.709	20.00	836.916
15.00	830.605	15.00	843.211	15.00	840.407
10.00	834.124	10.00	846.711	10.00	843.903
5.00	837.643	5.00	850.214	5.00	847.399
0.00	841.166	0.00	853.720	0.00	850.900
-5.00	844.695	-5.00	857.233	-5.00	854.406
-10.00	848.248	-10.00	860.753	-10.00	858.547
-15.00	852.553	-15.00	865.187	-15.00	862.867
-20.00	856.687	-20.00	870.316	-20.00	867.222
-25.00	861.022	-25.00	874.899	-25.00	871.729

Winter-grade diesel

Class Batch Mixture	Regional samples Diesel WDK-07	Class Batch Mixture	Regional samples Diesel WDK-08	Class Batch Mixture	Regional samples Diesel WDK-09
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	815.796	50.00	802.882	50.00	807.157
45.00	819.341	45.00	806.466	45.00	810.645
40.00	822.884	40.00	810.053	40.00	814.134
35.00	826.426	35.00	813.632	35.00	817.623
30.00	829.960	30.00	817.205	30.00	821.109
25.00	833.500	25.00	820.779	25.00	824.592
20.00	837.037	20.00	824.353	20.00	828.070
15.00	840.574	15.00	827.927	15.00	831.560
10.00	844.112	10.00	831.498	10.00	835.048
5.00	847.651	5.00	835.070	5.00	838.536
0.00	851.192	0.00	838.646	0.00	842.031
-5.00	854.741	-5.00	842.224	-5.00	845.531
-10.00	858.543	-10.00	845.808	-10.00	849.053
-15.00	862.688	-15.00	850.129	-15.00	853.971
-20.00	866.914	-20.00	854.677	-20.00	859.072
-25.00	871.304	-25.00	859.672	-25.00	864.320

Class Batch Mixture	Regional samples Diesel WDK-10	Class Batch Mixture	Regional samples Diesel WDK-11	Class Batch Mixture	Regional samples Diesel WDK-12
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	813.576	50.00	807.327	50.00	811.160
45.00	817.111	45.00	810.875	45.00	814.684
40.00	820.645	40.00	814.422	40.00	818.207
35.00	824.178	35.00	817.966	35.00	821.728
30.00	827.687	30.00	821.493	30.00	825.248
25.00	831.232	25.00	825.045	25.00	828.763
20.00	834.753	20.00	828.578	20.00	832.281
15.00	838.284	15.00	832.119	15.00	835.802
10.00	841.812	10.00	835.658	10.00	839.323
5.00	845.340	5.00	839.196	5.00	842.847
0.00	848.873	0.00	842.739	0.00	846.376
-5.00	852.412	-5.00	846.286	-5.00	849.912
-10.00	856.519	-10.00	850.362	-10.00	854.147
-15.00	860.825	-15.00	854.877	-15.00	858.787
-20.00	865.297	-20.00	859.550	-20.00	863.591
-25.00	869.951	-25.00	864.499	-25.00	868.472

Winter-grade diesel

Class Batch Mixture	Regional samples Diesel WDK-13	Class Batch Mixture	Regional samples Diesel WDK-14	Class Batch Mixture	Regional samples Diesel WDK-15
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	812.268	50.00	810.860	50.00	809.885
45.00	815.833	45.00	814.389	45.00	813.433
40.00	819.395	40.00	817.917	40.00	816.972
35.00	822.956	35.00	821.442	35.00	820.506
30.00	826.514	30.00	824.965	30.00	824.038
25.00	830.068	25.00	828.487	25.00	827.569
20.00	833.621	20.00	832.009	20.00	831.102
15.00	837.178	15.00	835.533	15.00	834.635
10.00	840.735	10.00	839.060	10.00	838.169
5.00	844.291	5.00	842.587	5.00	841.705
0.00	847.854	0.00	846.118	0.00	845.247
-5.00	851.421	-5.00	849.655	-5.00	848.793
-10.00	855.442	-10.00	853.203	-10.00	852.782
-15.00	859.573	-15.00	857.756	-15.00	856.969
-20.00	863.724	-20.00	862.327	-20.00	861.612
-25.00	867.992	-25.00	867.067	-25.00	866.749

Class Batch Mixture	Regional samples Diesel WDK-16	Class Batch Mixture	Regional samples Diesel WDK-17	Class Batch Mixture	Regional samples Diesel WDK-18
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	805.858	50.00	812.732	50.00	818.255
45.00	809.385	45.00	816.282	45.00	821.768
40.00	812.909	40.00	819.825	40.00	825.281
35.00	816.432	35.00	823.368	35.00	828.791
30.00	819.953	30.00	826.905	30.00	832.296
25.00	823.469	25.00	830.444	25.00	835.804
20.00	826.986	20.00	833.982	20.00	839.313
15.00	830.508	15.00	837.521	15.00	842.824
10.00	834.031	10.00	841.062	10.00	846.337
5.00	837.554	5.00	844.605	5.00	849.854
0.00	841.079	0.00	848.154	0.00	853.375
-5.00	844.610	-5.00	851.704	-5.00	856.902
-10.00	848.712	-10.00	855.265	-10.00	860.848
-15.00	853.082	-15.00	859.480	-15.00	865.037
-20.00	857.542	-20.00	863.708	-20.00	869.372
-25.00	862.111	-25.00	868.184	-25.00	873.914

Summer-grade heating oil EL

Class Batch Mixture	Regional samples Heating oil SHEL-03	Class Batch Mixture	Regional samples Heating oil SHEL-05	Class Batch Mixture	Regional samples Heating oil SHEL-06
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	822.554	50.00	833.960	50.00	821.065
45.00	826.106	45.00	837.529	45.00	824.537
40.00	829.659	40.00	841.099	40.00	828.009
35.00	833.208	35.00	844.666	35.00	831.479
30.00	836.756	30.00	848.231	30.00	834.949
25.00	840.300	25.00	851.792	25.00	838.416
20.00	843.845	20.00	855.355	20.00	841.885
15.00	847.391	15.00	858.919	15.00	845.357
10.00	850.939	10.00	862.483	10.00	848.828
5.00	854.489	5.00	866.050	5.00	852.304
0.00	858.044	0.00	869.622	0.00	855.785
-5.00	862.245	-5.00	873.196	-5.00	860.209
-10.00	866.634	-10.00	876.776	-10.00	864.586
-15.00	871.042	-15.00	881.012	-15.00	869.055
-20.00	874.203	-20.00	885.037	-20.00	873.682
-25.00	878.683	-25.00	889.114	-25.00	878.398

Class Batch Mixture	Regional samples Heating oil SHEL-08	Class Batch Mixture	Regional samples Heating oil SHEL-11	Class Batch Mixture	Regional samples Heating oil SHEL-15
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	833.467	50.00	813.097	50.00	817.645
45.00	837.009	45.00	816.639	45.00	821.166
40.00	840.551	40.00	820.180	40.00	824.685
35.00	844.091	35.00	823.717	35.00	828.204
30.00	847.630	30.00	827.254	30.00	831.714
25.00	851.167	25.00	830.786	25.00	835.231
20.00	854.705	20.00	834.319	20.00	838.745
15.00	858.248	15.00	837.851	15.00	842.263
10.00	861.793	10.00	841.385	10.00	845.780
5.00	865.342	5.00	844.922	5.00	849.299
0.00	868.899	0.00	848.464	0.00	852.822
-5.00	874.283	-5.00	852.861	-5.00	857.000
-10.00	879.060	-10.00	857.278	-10.00	861.461
-15.00	883.686	-15.00	861.951	-15.00	865.922
-20.00	888.265	-20.00	866.787	-20.00	870.458
-25.00	892.986	-25.00	871.224	-25.00	875.077

Summer-grade heating oil EL

Class Batch Mixture	Regional samples Heating oil SHEL-16	Class Batch Mixture	Regional samples Heating oil SHEL-17	Class Batch Mixture	Regional samples Heating oil SHEL-18
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	821.558	50.00	814.278	50.00	817.226
45.00	825.105	45.00	817.803	45.00	820.745
40.00	828.651	40.00	821.327	40.00	824.264
35.00	832.196	35.00	824.850	35.00	827.779
30.00	835.736	30.00	828.353	30.00	831.296
25.00	839.277	25.00	831.895	25.00	834.805
20.00	842.817	20.00	835.410	20.00	838.312
15.00	846.355	15.00	838.930	15.00	841.831
10.00	849.900	10.00	842.450	10.00	845.347
5.00	853.444	5.00	845.973	5.00	848.864
0.00	856.994	0.00	849.501	0.00	852.389
-5.00	861.787	-5.00	853.914	-5.00	856.854
-10.00	866.360	-10.00	858.333	-10.00	861.388
-15.00	870.897	-15.00	862.869	-15.00	865.992
-20.00	875.434	-20.00	867.446	-20.00	870.667
-25.00	879.974	-25.00	872.121	-25.00	875.581

Winter-grade heating oil EL

Class Batch Mixture	Regional samples Heating oil WHEL-03	Class Batch Mixture	Regional samples Heating oil WHEL-05	Class Batch Mixture	Regional samples Heating oil WHEL-08
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	829.972	50.00	830.639	50.00	833.956
45.00	833.514	45.00	834.228	45.00	837.505
40.00	837.056	40.00	837.816	40.00	841.053
35.00	840.591	35.00	841.399	35.00	844.600
30.00	844.132	30.00	844.978	30.00	848.149
25.00	847.669	25.00	848.558	25.00	851.691
20.00	851.206	20.00	852.140	20.00	855.236
15.00	854.747	15.00	855.722	15.00	858.785
10.00	858.291	10.00	859.305	10.00	862.338
5.00	861.839	5.00	862.890	5.00	865.895
0.00	865.808	0.00	866.480	0.00	869.886
-5.00	870.396	-5.00	870.073	-5.00	874.919
-10.00	875.008	-10.00	873.673	-10.00	879.665
-15.00	879.595	-15.00	877.808	-15.00	884.315
-20.00	884.150	-20.00	881.866	-20.00	888.897
-25.00	888.696	-25.00	885.932	-25.00	893.500

Class Batch Mixture	Regional samples Heating oil WHEL-17
Temperature °C	Density kg/m³
50.00	815.588
45.00	819.109
40.00	822.631
35.00	826.149
30.00	829.662
25.00	833.179
20.00	836.695
15.00	840.214
10.00	843.735
5.00	847.259
0.00	850.785
-5.00	854.345
-10.00	858.590
-15.00	863.378
-20.00	867.761
-25.00	872.120

Summer-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil
Batch		Batch		Batch	
Mixture	SHEL-Sarm-01	Mixture	SHEL-Sarm-02	Mixture	SHEL-Sarm-03
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	811.972	50.00	825.470	50.00	812.715
45.00	815.430	45.00	829.026	45.00	816.212
40.00	818.890	40.00	832.581	40.00	819.708
35.00	822.347	35.00	836.133	35.00	823.203
30.00	825.785	30.00	839.683	30.00	826.696
25.00	829.258	25.00	843.230	25.00	830.184
20.00	832.713	20.00	846.776	20.00	833.681
15.00	836.171	15.00	850.324	15.00	837.170
10.00	839.629	10.00	853.870	10.00	840.663
5.00	843.093	5.00	857.422	5.00	844.160
0.00	846.572	0.00	860.977	0.00	847.658
-5.00	851.751	-5.00	864.916	-5.00	851.163
-10.00	856.580	-10.00	868.877	-10.00	854.694
-15.00	861.303	-15.00	872.796	-15.00	859.097
-20.00	865.863	-20.00	876.730	-20.00	864.174
-25.00	870.311	-25.00	880.627	-25.00	869.287

Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil
Batch		Batch		Batch	
Mixture	SHEL-Sarm-04	Mixture	SHEL-Sarm-05	Mixture	SHEL-Sarm-07
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	811.450	50.00	833.004	50.00	810.521
45.00	814.935	45.00	836.491	45.00	814.087
40.00	818.420	40.00	839.978	40.00	817.653
35.00	821.904	35.00	843.465	35.00	821.216
30.00	825.385	30.00	846.936	30.00	824.768
25.00	828.864	25.00	850.435	25.00	828.328
20.00	832.343	20.00	853.915	20.00	831.882
15.00	835.826	15.00	857.410	15.00	835.432
10.00	839.316	10.00	860.901	10.00	838.988
5.00	842.799	5.00	864.396	5.00	842.543
0.00	846.285	0.00	867.897	0.00	846.100
-5.00	850.135	-5.00	871.404	-5.00	849.660
-10.00	854.262	-10.00	875.443	-10.00	853.669
-15.00	858.685	-15.00	879.596	-15.00	857.852
-20.00	863.412	-20.00	883.898	-20.00	862.066
-25.00	867.669	-25.00	888.680	-25.00	866.705

Summer-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	SHEL-Sarm-08	Mixture	SHEL-Sarm-10	Mixture	SHEL-Sarm-12
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
50.00	808.571	50.00	820.560	50.00	822.343
45.00	812.174	45.00	824.055	45.00	825.874
40.00	815.775	40.00	827.547	40.00	829.405
35.00	819.370	35.00	831.038	35.00	832.934
30.00	822.946	30.00	834.507	30.00	836.461
25.00	826.562	25.00	838.014	25.00	839.986
20.00	830.147	20.00	841.501	20.00	843.510
15.00	833.735	15.00	844.992	15.00	847.036
10.00	837.324	10.00	848.485	10.00	850.564
5.00	840.914	5.00	851.982	5.00	854.094
0.00	844.506	0.00	855.480	0.00	857.630
-5.00	848.100	-5.00	859.919	-5.00	862.347
-10.00	852.558	-10.00	864.198	-10.00	866.707
-15.00	857.119	-15.00	868.510	-15.00	870.982
-20.00	861.631	-20.00	873.018	-20.00	875.238
-25.00	866.123	-25.00	877.560	-25.00	879.529

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	SHEL-Sarm-13	Mixture	SHEL-Sarm-14	Mixture	SHEL-Sarm-15
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
50.00	822.394	50.00	818.299	50.00	812.843
45.00	825.874	45.00	821.853	45.00	816.360
40.00	829.355	40.00	825.405	40.00	819.877
35.00	832.835	35.00	828.954	35.00	823.392
30.00	836.303	30.00	832.500	30.00	826.896
25.00	839.795	25.00	836.039	25.00	830.411
20.00	843.270	20.00	839.583	20.00	833.921
15.00	846.750	15.00	843.127	15.00	837.432
10.00	850.229	10.00	846.670	10.00	840.943
5.00	853.716	5.00	850.214	5.00	844.457
0.00	857.342	0.00	853.763	0.00	847.973
-5.00	861.764	-5.00	857.314	-5.00	851.494
-10.00	865.952	-10.00	860.870	-10.00	855.538
-15.00	870.457	-15.00	864.815	-15.00	859.721
-20.00	875.098	-20.00	868.955	-20.00	864.079
-25.00	879.439	-25.00	873.268	-25.00	868.808

Summer-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	SHEL-Sarm-16	Mixture	SHEL-Sarm-17	Mixture	SHEL-Sarm-18
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
50.00	789.176	50.00	808.397	50.00	808.404
45.00	792.709	45.00	811.893	45.00	811.898
40.00	796.241	40.00	815.387	40.00	815.393
35.00	799.768	35.00	818.879	35.00	818.884
30.00	803.281	30.00	822.360	30.00	822.375
25.00	806.820	25.00	825.857	25.00	825.862
20.00	810.337	20.00	829.343	20.00	829.350
15.00	813.857	15.00	832.828	15.00	832.839
10.00	817.377	10.00	836.321	10.00	836.328
5.00	820.897	5.00	839.813	5.00	839.821
0.00	824.418	0.00	843.308	0.00	843.318
-5.00	827.943	-5.00	847.493	-5.00	847.532
-10.00	832.054	-10.00	851.961	-10.00	851.979
-15.00	836.629	-15.00	856.740	-15.00	856.822
-20.00	841.615	-20.00	861.519	-20.00	861.524
-25.00	846.220	-25.00	865.970	-25.00	865.982

Winter-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	WHEL-Sarm-01	Mixture	WHEL-Sarm-02	Mixture	WHEL-Sarm-04
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
50.00	811.441	50.00	819.484	50.00	812.226
45.00	814.952	45.00	823.056	45.00	815.686
40.00	818.458	40.00	826.622	40.00	819.144
35.00	821.967	35.00	830.190	35.00	822.600
30.00	825.473	30.00	833.754	30.00	826.055
25.00	828.976	25.00	837.314	25.00	829.507
20.00	832.482	20.00	840.875	20.00	832.964
15.00	835.989	15.00	844.435	15.00	836.422
10.00	839.496	10.00	847.998	10.00	839.884
5.00	843.009	5.00	851.562	5.00	843.347
0.00	846.525	0.00	855.129	0.00	846.817
-5.00	851.449	-5.00	858.979	-5.00	850.657
-10.00	856.402	-10.00	862.924	-10.00	855.215
-15.00	861.206	-15.00	866.844	-15.00	859.706
-20.00	865.829	-20.00	870.798	-20.00	864.317
-25.00	870.283	-25.00	874.712	-25.00	869.178

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	WHEL-Sarm-05	Mixture	WHEL-Sarm-06	Mixture	WHEL-Sarm-07
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
50.00	833.348	50.00	820.113	50.00	820.065
45.00	836.937	45.00	823.605	45.00	823.591
40.00	840.530	40.00	827.092	40.00	827.115
35.00	844.117	35.00	830.583	35.00	830.636
30.00	847.703	30.00	834.072	30.00	834.157
25.00	851.286	25.00	837.559	25.00	837.671
20.00	854.871	20.00	841.048	20.00	841.191
15.00	858.456	15.00	844.539	15.00	844.711
10.00	862.044	10.00	848.032	10.00	848.234
5.00	865.635	5.00	851.527	5.00	851.758
0.00	869.230	0.00	855.029	0.00	855.287
-5.00	872.830	-5.00	858.755	-5.00	859.343
-10.00	876.436	-10.00	863.495	-10.00	863.577
-15.00	880.574	-15.00	868.093	-15.00	867.936
-20.00	884.651	-20.00	872.829	-20.00	872.406
-25.00	888.826	-25.00	877.799	-25.00	876.874

Winter-grade low-sulphur heating oil EL

Class Batch Mixture	Regional samples Low-sulphur heating oil WHEL-Sarm-08	Class Batch Mixture	Regional samples Low-sulphur heating oil WHEL-Sarm-09	Class Batch Mixture	Regional samples Low-sulphur heating oil WHEL-Sarm-10
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	813.670	50.00	809.313	50.00	823.532
45.00	817.246	45.00	812.840	45.00	827.085
40.00	820.821	40.00	816.365	40.00	830.637
35.00	824.392	35.00	819.886	35.00	834.186
30.00	827.958	30.00	823.406	30.00	837.732
25.00	831.527	25.00	826.924	25.00	841.274
20.00	835.092	20.00	830.439	20.00	844.821
15.00	838.660	15.00	833.961	15.00	848.367
10.00	842.229	10.00	837.484	10.00	851.914
5.00	845.800	5.00	841.010	5.00	855.465
0.00	849.376	0.00	844.538	0.00	859.021
-5.00	853.317	-5.00	848.953	-5.00	862.739
-10.00	858.174	-10.00	854.061	-10.00	867.077
-15.00	862.686	-15.00	859.775	-15.00	871.378
-20.00	867.214	-20.00	864.804	-20.00	875.689
-25.00	871.750	-25.00	869.699	-25.00	880.295

Class Batch Mixture	Regional samples Low-sulphur heating oil WHEL-Sarm-11	Class Batch Mixture	Regional samples Low-sulphur heating oil WHEL-Sarm-12	Class Batch Mixture	Regional samples Low-sulphur heating oil WHEL-Sarm-13
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
50.00	812.899	50.00	821.112	50.00	833.136
45.00	816.460	45.00	824.615	45.00	836.620
40.00	820.018	40.00	828.118	40.00	840.103
35.00	823.574	35.00	831.622	35.00	843.585
30.00	827.126	30.00	835.116	30.00	847.061
25.00	830.674	25.00	838.615	25.00	850.541
20.00	834.225	20.00	842.116	20.00	854.024
15.00	837.777	15.00	845.616	15.00	857.509
10.00	841.329	10.00	849.119	10.00	860.996
5.00	844.884	5.00	852.628	5.00	864.487
0.00	848.443	0.00	856.170	0.00	867.984
-5.00	852.007	-5.00	861.675	-5.00	872.600
-10.00	856.322	-10.00	866.646	-10.00	876.997
-15.00	860.758	-15.00	871.475	-15.00	881.394
-20.00	865.287	-20.00	876.224	-20.00	885.805
-25.00	870.011	-25.00	880.905	-25.00	890.222

Winter-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	WHEL-Sarm-14	Mixture	WHEL-Sarm-15	Mixture	WHEL-Sarm-16
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
50.00	816.835	50.00	816.754	50.00	818.392
45.00	820.291	45.00	820.323	45.00	821.929
40.00	823.747	40.00	823.894	40.00	825.468
35.00	827.201	35.00	827.460	35.00	829.005
30.00	830.654	30.00	831.024	30.00	832.537
25.00	834.103	25.00	834.583	25.00	836.068
20.00	837.560	20.00	838.145	20.00	839.599
15.00	841.021	15.00	841.707	15.00	843.133
10.00	844.483	10.00	845.270	10.00	846.669
5.00	847.948	5.00	848.834	5.00	850.207
0.00	851.418	0.00	852.402	0.00	853.748
-5.00	854.899	-5.00	855.974	-5.00	857.292
-10.00	859.885	-10.00	859.549	-10.00	860.843
-15.00	864.460	-15.00	863.131	-15.00	864.927
-20.00	868.896	-20.00	867.546	-20.00	869.131
-25.00	873.239	-25.00	871.927	-25.00	873.567

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil
Mixture	WHEL-Sarm-17	Mixture	WHEL-Sarm-18
Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³
50.00	814.745	50.00	810.027
45.00	818.334	45.00	813.535
40.00	821.921	40.00	817.041
35.00	825.503	35.00	820.545
30.00	829.079	30.00	824.049
25.00	832.657	25.00	827.548
20.00	836.232	20.00	831.048
15.00	839.807	15.00	834.552
10.00	843.384	10.00	838.055
5.00	846.962	5.00	841.562
0.00	850.543	0.00	845.071
-5.00	854.125	-5.00	848.589
-10.00	857.713	-10.00	853.115
-15.00	861.307	-15.00	857.636
-20.00	865.543	-20.00	862.456
-25.00	870.339	-25.00	867.088

Density of the mixtures containing biofuel

Ethanol – n-hexane

Class	Ethanol - hexane	Class	Ethanol - hexane	Class	Ethanol - hexane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 05-95	Mixture	Mixture 10-90
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-15.00	690.372	-15.00	696.010	-15.00	702.066
-10.00	686.062	-10.00	691.659	-10.00	697.701
-5.00	681.727	-5.00	687.276	-5.00	693.304
0.00	677.365	0.00	682.861	0.00	688.877
5.00	672.976	5.00	678.413	5.00	684.413
10.00	668.559	10.00	673.928	10.00	679.909
15.00	664.106	15.00	669.398	15.00	675.364
20.00	659.622	20.00	664.826	20.00	670.772
25.00	655.098	25.00	660.205	25.00	666.128
30.00	650.538	30.00	655.533	30.00	661.432
35.00	645.935	35.00	650.804	35.00	656.672
40.00	641.286	40.00	646.013	40.00	651.847
45.00	636.590	45.00	641.159	45.00	646.953
50.00	631.843	50.00	636.235	50.00	641.985

Class	Ethanol - hexane	Class	Ethanol - hexane	Class	Ethanol - hexane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 40-60
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-15.00	708.249	-15.00	714.453	-15.00	739.723
-10.00	703.879	-10.00	710.086	-10.00	735.383
-5.00	699.479	-5.00	705.688	-5.00	731.023
0.00	695.047	0.00	701.259	0.00	726.636
5.00	690.580	5.00	696.795	5.00	722.220
10.00	686.074	10.00	692.291	10.00	717.771
15.00	681.523	15.00	687.746	15.00	713.283
20.00	676.924	20.00	683.153	20.00	708.753
25.00	672.275	25.00	678.507	25.00	704.175
30.00	667.570	30.00	673.804	30.00	699.544
35.00	662.801	35.00	669.038	35.00	694.851
40.00	657.965	40.00	664.203	40.00	690.090
45.00	653.057	45.00	659.293	45.00	685.256
50.00	648.069	50.00	654.304	50.00	680.343

Class	Ethanol - hexane	Class	Ethanol - hexane	Class	Ethanol - hexane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 50-50	Mixture	Mixture 60-40	Mixture	Mixture 80-20
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-15.00	752.528	-15.00	765.494	-15.00	792.079
-10.00	748.210	-10.00	761.198	-10.00	787.825
-5.00	743.874	-5.00	756.886	-5.00	783.566
0.00	739.514	0.00	752.560	0.00	779.297
5.00	735.131	5.00	748.210	5.00	775.015
10.00	730.717	10.00	743.838	10.00	770.716
15.00	726.271	15.00	739.432	15.00	766.397
20.00	721.785	20.00	734.989	20.00	762.052
25.00	717.253	25.00	730.498	25.00	757.675
30.00	712.673	30.00	725.963	30.00	753.262
35.00	708.034	35.00	721.382	35.00	748.805
40.00	703.333	40.00	716.747	40.00	744.296
45.00	698.561	45.00	712.046	45.00	739.735
50.00	693.711	50.00	707.273	50.00	735.110

Ethanol – hexane

Class	Ethanol - hexane	Class	Ethanol - hexane	Class	Ethanol - hexane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 85-15	Mixture	Mixture 90-10	Mixture	Mixture 95-05
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-15.00	798.951	-15.00	805.728	-15.00	812.677
-10.00	794.708	-10.00	801.493	-10.00	808.450
-5.00	790.462	-5.00	797.255	-5.00	804.222
0.00	786.198	0.00	793.012	0.00	799.990
5.00	781.932	5.00	788.761	5.00	795.752
10.00	777.650	10.00	784.497	10.00	791.504
15.00	773.349	15.00	780.213	15.00	787.240
20.00	769.025	20.00	775.909	20.00	782.956
25.00	764.673	25.00	771.578	25.00	778.647
30.00	760.288	30.00	767.216	30.00	774.310
35.00	755.859	35.00	762.815	35.00	769.935
40.00	751.384	40.00	758.369	40.00	765.518
45.00	746.855	45.00	753.872	45.00	761.053
50.00	742.264	50.00	749.318	50.00	756.532

Class	Ethanol - hexane	Class	Ethanol - hexane	Class	Ethanol - hexane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 100-0	Mixture	Mixture 2.5-97.5	Mixture	Mixture 7.5-92.5
Temperature °C	Density kg/m³	Temperature °C	Density kg/m³	Temperature °C	Density kg/m³
-15.00	819.697	-15.00	693.091	-15.00	699.005
-10.00	815.475	-10.00	688.751	-10.00	694.645
-5.00	811.254	-5.00	684.380	-5.00	690.255
0.00	807.033	0.00	679.979	0.00	685.830
5.00	802.808	5.00	675.544	5.00	681.374
10.00	798.570	10.00	671.074	10.00	676.877
15.00	794.324	15.00	666.563	15.00	672.340
20.00	790.059	20.00	662.009	20.00	667.753
25.00	785.770	25.00	657.410	25.00	663.117
30.00	781.454	30.00	652.763	30.00	658.431
35.00	777.105	35.00	648.062	35.00	653.686
40.00	772.714	40.00	643.305	40.00	648.875
45.00	768.278	45.00	638.489	45.00	643.997
50.00	763.789	50.00	633.610	50.00	639.047

Class	Ethanol - hexane
Batch	Batch 01
Mixture	Mixture 12.5-87.5
Temperature °C	Density kg/m³
-15.00	705.149
-10.00	700.780
-5.00	696.381
0.00	691.948
5.00	687.480
10.00	682.969
15.00	678.413
20.00	673.813
25.00	669.163
30.00	664.459
35.00	659.696
40.00	654.864
45.00	649.963
50.00	644.983

Ethanol – n-nonane

Class	Ethanol - nonane	Class	Ethanol - nonane	Class	Ethanol - nonane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 05-95	Mixture	Mixture 10-90
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
-15.00	744.993	-15.00	747.856	-15.00	751.092
-10.00	741.171	-10.00	743.977	-10.00	747.178
-5.00	737.348	-5.00	740.087	-5.00	743.252
0.00	733.515	0.00	736.184	0.00	739.311
5.00	729.673	5.00	732.263	5.00	735.353
10.00	725.822	10.00	728.328	10.00	731.377
15.00	721.960	15.00	724.371	15.00	727.377
20.00	718.085	20.00	720.392	20.00	723.352
25.00	714.200	25.00	716.390	25.00	719.299
30.00	710.302	30.00	712.361	30.00	715.217
35.00	706.386	35.00	708.300	35.00	711.100
40.00	702.452	40.00	704.208	40.00	706.943
45.00	698.500	45.00	700.082	45.00	702.749
50.00	694.527	50.00	695.919	50.00	698.510

Class	Ethanol - nonane	Class	Ethanol - nonane	Class	Ethanol - nonane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 40-60
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
-15.00	754.446	-15.00	757.884	-15.00	771.948
-10.00	750.501	-10.00	753.914	-10.00	767.899
-5.00	746.547	-5.00	749.933	-5.00	763.844
0.00	742.577	0.00	745.939	0.00	759.775
5.00	738.591	5.00	741.926	5.00	755.693
10.00	734.582	10.00	737.892	10.00	751.589
15.00	730.549	15.00	733.835	15.00	747.461
20.00	726.490	20.00	729.749	20.00	743.306
25.00	722.403	25.00	725.632	25.00	739.118
30.00	718.281	30.00	721.480	30.00	734.893
35.00	714.121	35.00	717.289	35.00	730.625
40.00	709.920	40.00	713.052	40.00	726.306
45.00	705.675	45.00	708.768	45.00	721.937
50.00	701.380	50.00	704.435	50.00	717.510

Class	Ethanol - nonane	Class	Ethanol - nonane	Class	Ethanol - nonane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 50-50	Mixture	Mixture 60-40	Mixture	Mixture 80-20
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
-15.00	779.181	-15.00	786.637	-15.00	802.375
-10.00	775.106	-10.00	782.534	-10.00	798.220
-5.00	771.023	-5.00	778.427	-5.00	794.062
0.00	766.927	0.00	774.309	0.00	789.898
5.00	762.819	5.00	770.178	5.00	785.724
10.00	758.692	10.00	766.028	10.00	781.536
15.00	754.541	15.00	761.857	15.00	777.329
20.00	750.362	20.00	757.659	20.00	773.099
25.00	746.151	25.00	753.432	25.00	768.844
30.00	741.907	30.00	749.169	30.00	764.556
35.00	737.616	35.00	744.863	35.00	760.229
40.00	733.277	40.00	740.510	40.00	755.855
45.00	728.884	45.00	736.103	45.00	751.430
50.00	724.432	50.00	731.636	50.00	746.949

Ethanol – nonane

Class	Ethanol - nonane	Class	Ethanol - nonane	Class	Ethanol - nonane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 85-15	Mixture	Mixture 90-10	Mixture	Mixture 95-05
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
-15.00	806.515	-15.00	810.803	-15.00	815.218
-10.00	802.346	-10.00	806.617	-10.00	811.015
-5.00	798.174	-5.00	802.431	-5.00	806.812
0.00	793.996	0.00	798.239	0.00	802.607
5.00	789.811	5.00	794.043	5.00	798.396
10.00	785.613	10.00	789.832	10.00	794.174
15.00	781.395	15.00	785.607	15.00	789.938
20.00	777.158	20.00	781.363	20.00	785.682
25.00	772.895	25.00	777.090	25.00	781.403
30.00	768.602	30.00	772.791	30.00	777.095
35.00	764.268	35.00	768.453	35.00	772.752
40.00	759.889	40.00	764.071	40.00	768.365
45.00	755.464	45.00	759.642	45.00	763.933
50.00	750.981	50.00	755.157	50.00	759.447

Class	Ethanol - nonane	Class	Ethanol - nonane	Class	Ethanol - nonane
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 100-0	Mixture	Mixture 2.5-97.5	Mixture	Mixture 7.5-92.5
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg/m³	°C	kg/m³	°C	kg/m³
-15.00	819.685	-15.00	746.328	-15.00	749.443
-10.00	815.463	-10.00	742.471	-10.00	745.545
-5.00	811.242	-5.00	738.600	-5.00	741.636
0.00	807.020	0.00	734.719	0.00	737.711
5.00	802.795	5.00	730.828	5.00	733.772
10.00	798.564	10.00	726.919	10.00	729.814
15.00	794.321	15.00	722.992	15.00	725.837
20.00	790.059	20.00	719.045	20.00	721.833
25.00	785.772	25.00	715.077	25.00	717.801
30.00	781.458	30.00	711.086	30.00	713.745
35.00	777.108	35.00	707.068	35.00	709.654
40.00	772.716	40.00	703.021	40.00	705.527
45.00	768.279	45.00	698.946	45.00	701.364
50.00	763.788	50.00	694.844	50.00	697.161

Class	Ethanol - nonane
Batch	Batch 01
Mixture	Mixture 12.5-87.5
Temperature	Density
°C	kg/m³
-15.00	752.766
-10.00	748.834
-5.00	744.895
0.00	740.938
5.00	736.964
10.00	732.972
15.00	728.955
20.00	724.911
25.00	720.839
30.00	716.736
35.00	712.596
40.00	708.415
45.00	704.193
50.00	699.925

Ethanol – summer-grade super petrol

Class:	Ethanol - super petrol	Class:	Ethanol - super petrol	Class:	Ethanol - super petrol
Batch:	Batch 14	Batch:	Batch 14	Batch:	Batch 14
Sample liquid:	Mixture 0-100	Sample liquid:	Mixture 5-95	Sample liquid:	Mixture 10-90
Temperature °C	Density kg - m³	Temperature °C	Density kg - m³	Temperature °C	Density kg - m³
-15.00	768.965	-15.00	771.843	-15.00	775.391
-10.00	764.567	-10.00	767.419	-10.00	770.964
-5.00	760.150	-5.00	762.977	-5.00	766.517
0.00	755.720	0.00	758.511	0.00	762.047
5.00	751.273	5.00	754.019	5.00	757.554
10.00	746.805	10.00	749.503	10.00	753.031
15.00	742.317	15.00	744.957	15.00	748.477
20.00	737.806	20.00	740.379	20.00	743.889
25.00	733.268	25.00	735.763	25.00	739.259
30.00	728.705	30.00	731.111	30.00	734.591
35.00	724.114	35.00	726.416	35.00	729.877
40.00	719.490	40.00	721.678	40.00	725.115
45.00	714.829	45.00	716.891	45.00	720.296
50.00	710.136	50.00	712.053	50.00	715.419

Class:	Ethanol - super petrol	Class:	Ethanol - super petrol	Class:	Ethanol - super petrol
Batch:	Batch 14	Batch:	Batch 14	Batch:	Batch 14
Sample liquid:	Mixture 15-85	Sample liquid:	Mixture 20-80	Sample liquid:	Mixture 40-60
Temperature °C	Density kg - m³	Temperature °C	Density kg - m³	Temperature °C	Density kg - m³
-15.00	776.790	-15.00	779.286	-15.00	789.754
-10.00	772.360	-10.00	774.861	-10.00	785.378
-5.00	767.911	-5.00	770.419	-5.00	780.984
0.00	763.440	0.00	765.953	0.00	776.571
5.00	758.940	5.00	761.459	5.00	772.133
10.00	754.413	10.00	756.937	10.00	767.671
15.00	749.852	15.00	752.382	15.00	763.174
20.00	745.253	20.00	747.789	20.00	758.644
25.00	740.616	25.00	743.155	25.00	754.075
30.00	735.933	30.00	738.477	30.00	749.459
35.00	731.203	35.00	733.744	35.00	744.792
40.00	726.419	40.00	728.961	40.00	740.068
45.00	721.577	45.00	724.116	45.00	735.281
50.00	716.675	50.00	719.204	50.00	730.423

Class:	Ethanol - super petrol	Class:	Ethanol - super petrol	Class:	Ethanol - super petrol
Batch:	Batch 14	Batch:	Batch 14	Batch:	Batch 14
Sample liquid:	Mixture 50-50	Sample liquid:	Mixture 60-40	Sample liquid:	Mixture 80-20
Temperature °C	Density kg - m³	Temperature °C	Density kg - m³	Temperature °C	Density kg - m³
-15.00	794.404	-15.00	799.683	-15.00	809.243
-10.00	790.050	-10.00	795.357	-10.00	804.969
-5.00	785.682	-5.00	791.022	-5.00	800.692
0.00	781.300	0.00	786.674	0.00	796.408
5.00	776.896	5.00	782.307	5.00	792.114
10.00	772.467	10.00	777.920	10.00	787.803
15.00	768.010	15.00	773.504	15.00	783.474
20.00	763.520	20.00	769.060	20.00	779.117
25.00	758.989	25.00	764.582	25.00	774.733
30.00	754.418	30.00	760.059	30.00	770.315
35.00	749.796	35.00	755.493	35.00	765.855
40.00	745.118	40.00	750.870	40.00	761.350
45.00	740.378	45.00	746.188	45.00	756.791
50.00	735.569	50.00	741.443	50.00	752.171

Ethanol – summer-grade super petrol

Class:	Ethanol - super petrol	Class:	Ethanol - super petrol	Class:	Ethanol - super petrol
Batch:	Batch 14	Batch:	Batch 14	Batch:	Batch 14
Sample liquid:	Mixture 85-15	Sample liquid:	Mixture 100-0	Sample liquid:	Mixture 2.5-97.5
Temperature °C	Density kg - m³	Temperature °C	Density kg - m³	Temperature °C	Density kg - m³
-15.00	811.677	-15.00	819.519	-15.00	770.732
-10.00	807.418	-10.00	815.298	-10.00	766.292
-5.00	803.153	-5.00	811.076	-5.00	761.823
0.00	798.884	0.00	806.853	0.00	757.320
5.00	794.607	5.00	802.626	5.00	752.840
10.00	790.316	10.00	798.389	10.00	748.351
15.00	786.005	15.00	794.144	15.00	743.805
20.00	781.673	20.00	789.878	20.00	739.236
25.00	777.310	25.00	785.591	25.00	734.651
30.00	772.919	30.00	781.274	30.00	730.036
35.00	768.488	35.00	776.927	35.00	725.399
40.00	764.012	40.00	772.539	40.00	720.715
45.00	759.485	45.00	768.108	45.00	715.984
50.00	754.898	50.00	763.622	50.00	711.207

Class:	Ethanol - super petrol	Class:	Ethanol - super petrol
Batch:	Batch 14	Batch:	Batch 14
Sample liquid:	Mixture 7.5-92.5	Sample liquid:	Mixture 12.5-87.5
Temperature °C	Density kg - m³	Temperature °C	Density kg - m³
-15.00	773.534	-15.00	776.121
-10.00	769.106	-10.00	771.696
-5.00	764.661	-5.00	767.246
0.00	760.192	0.00	762.774
5.00	755.696	5.00	758.278
10.00	751.176	10.00	753.752
15.00	746.623	15.00	749.194
20.00	742.035	20.00	744.601
25.00	737.413	25.00	739.967
30.00	732.750	30.00	735.291
35.00	728.043	35.00	730.571
40.00	723.285	40.00	725.794
45.00	718.479	45.00	720.964
50.00	713.619	50.00	716.074

Ethanol – Winter-grade super petrol

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 0-100
Temperature °C	Density kg - m³
-15.00	760.728
-10.00	756.303
-5.00	751.861
0.00	747.399
5.00	742.919
10.00	738.418
15.00	733.896
20.00	729.348
25.00	724.771
30.00	720.168
35.00	715.533
40.00	710.865
45.00	706.160
50.00	701.413

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 5-95
Temperature °C	Density kg - m³
-15.00	765.828
-10.00	761.386
-5.00	756.920
0.00	752.432
5.00	747.921
10.00	743.381
15.00	738.809
20.00	734.204
25.00	729.561
30.00	724.879
35.00	720.153
40.00	715.379
45.00	710.558
50.00	705.682

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 10-90
Temperature °C	Density kg - m³
-15.00	768.472
-10.00	764.020
-5.00	759.550
0.00	755.053
5.00	750.530
10.00	745.978
15.00	741.394
20.00	736.772
25.00	732.113
30.00	727.406
35.00	722.656
40.00	717.850
45.00	712.992
50.00	708.071

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 15-85
Temperature °C	Density kg - m³
-15.00	771.446
-10.00	766.998
-5.00	762.530
0.00	758.037
5.00	753.517
10.00	748.966
15.00	744.382
20.00	739.760
25.00	735.095
30.00	730.385
35.00	725.627
40.00	720.811
45.00	715.936
50.00	710.997

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 20-80
Temperature °C	Density kg - m³
-15.00	774.378
-10.00	769.938
-5.00	765.476
0.00	760.992
5.00	756.478
10.00	751.933
15.00	747.357
20.00	742.740
25.00	738.082
30.00	733.376
35.00	728.621
40.00	723.806
45.00	718.930
50.00	713.986

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 40-60
Temperature °C	Density kg - m³
-15.00	784.237
-10.00	779.840
-5.00	775.424
0.00	770.990
5.00	766.531
10.00	762.044
15.00	757.524
20.00	752.968
25.00	748.370
30.00	743.727
35.00	739.027
40.00	734.271
45.00	729.451
50.00	724.557

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 60-40
Temperature °C	Density kg - m³
-15.00	795.756
-10.00	791.418
-5.00	787.069
0.00	782.707
5.00	778.326
10.00	773.922
15.00	769.493
20.00	765.031
25.00	760.534
30.00	755.993
35.00	751.407
40.00	746.763
45.00	742.062
50.00	737.291

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 80-20a
Temperature °C	Density kg - m³
-15.00	807.195
-10.00	802.917
-5.00	798.636
0.00	794.345
5.00	790.046
10.00	785.728
15.00	781.392
20.00	777.029
25.00	772.640
30.00	768.216
35.00	763.750
40.00	759.235
45.00	754.668
50.00	750.038

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 85-15a
Temperature °C	Density kg - m³
-15.00	810.230
-10.00	805.966
-5.00	801.700
0.00	797.427
5.00	793.146
10.00	788.852
15.00	784.539
20.00	780.203
25.00	775.841
30.00	771.444
35.00	767.010
40.00	762.527
45.00	757.994
50.00	753.402

Ethanol – Winter-grade super petrol

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 100-0
Temperature °C	Density kg - m³
-15.00	819.323
-10.00	815.100
-5.00	810.878
0.00	806.656
5.00	802.430
10.00	798.196
15.00	793.948
20.00	789.682
25.00	785.396
30.00	781.083
35.00	776.737
40.00	772.352
45.00	767.920
50.00	763.437

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 2.5-97.5
Temperature °C	Density kg - m³
-15.00	763.888
-10.00	759.423
-5.00	754.930
0.00	750.431
5.00	745.918
10.00	741.386
15.00	736.832
20.00	732.245
25.00	727.626
30.00	722.969
35.00	718.241
40.00	713.486
45.00	708.711
50.00	703.896

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 7.5-92.5
Temperature °C	Density kg - m³
-15.00	766.535
-10.00	762.082
-5.00	757.611
0.00	753.115
5.00	748.594
10.00	744.043
15.00	739.460
20.00	734.840
25.00	730.181
30.00	725.482
35.00	720.736
40.00	715.939
45.00	711.091
50.00	706.181

Class:	Ethanol - super petrol
Batch:	Batch 13
Sample liquid:	Mixture 12.5-87.5
Temperature °C	Density kg - m³
-15.00	769.535
-10.00	765.085
-5.00	760.614
0.00	756.115
5.00	751.591
10.00	747.037
15.00	742.449
20.00	737.824
25.00	733.155
30.00	728.444
35.00	723.683
40.00	718.868
45.00	713.994
50.00	709.060

Rapeseed methyl ester RME – summer-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 5-95	Mixture	Mixture 10-90
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	820.308	50.00	822.080	50.00	823.837
45.00	823.781	45.00	825.560	45.00	827.325
40.00	827.256	40.00	829.043	40.00	830.814
35.00	830.728	35.00	832.522	35.00	834.302
30.00	834.200	30.00	836.002	30.00	837.787
25.00	837.670	25.00	839.479	25.00	841.274
20.00	841.140	20.00	842.958	20.00	844.761
15.00	844.613	15.00	846.438	15.00	848.250
10.00	848.086	10.00	849.920	10.00	851.740
5.00	851.564	5.00	853.407	5.00	855.235
0.00	855.046	0.00	856.898	0.00	858.734
-5.00	858.722	-5.00	860.596	-5.00	862.433
-10.00	862.783	-10.00	864.749	-10.00	866.603
-15.00	867.300	-15.00	869.311	-15.00	871.184

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	825.631	50.00	827.462	50.00	831.126
45.00	829.128	45.00	830.965	45.00	834.644
40.00	832.625	40.00	834.470	40.00	838.164
35.00	836.120	35.00	837.972	35.00	841.682
30.00	839.615	30.00	841.476	30.00	845.201
25.00	843.108	25.00	844.977	25.00	848.717
20.00	846.604	20.00	848.480	20.00	852.237
15.00	850.102	15.00	851.986	15.00	855.760
10.00	853.601	10.00	855.493	10.00	859.284
5.00	857.104	5.00	859.005	5.00	862.814
0.00	860.612	0.00	862.523	0.00	866.348
-5.00	864.318	-5.00	866.230	-5.00	870.062
-10.00	868.508	-10.00	870.442	-10.00	874.331
-15.00	873.095	-15.00	875.020	-15.00	878.914

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	834.841	50.00	838.590	50.00	842.386
45.00	838.372	45.00	842.137	45.00	845.946
40.00	841.905	40.00	845.685	40.00	849.509
35.00	845.438	35.00	849.233	35.00	853.071
30.00	848.971	30.00	852.782	30.00	856.634
25.00	852.504	25.00	856.329	25.00	860.198
20.00	856.039	20.00	859.879	20.00	863.764
15.00	859.577	15.00	863.433	15.00	867.333
10.00	863.118	10.00	866.992	10.00	870.908
5.00	866.664	5.00	870.555	5.00	874.488
0.00	870.216	0.00	874.124	0.00	878.075
-5.00	873.938	-5.00	877.851	-5.00	881.804
-10.00	878.242	-10.00	882.166	-10.00	886.112
-15.00	882.830	-15.00	886.787	-15.00	890.766

Rapeseed methyl ester RME – summer-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	846.221	50.00	850.072	50.00	853.971
45.00	849.795	45.00	853.660	45.00	857.571
40.00	853.372	40.00	857.249	40.00	861.175
35.00	856.949	35.00	860.840	35.00	864.780
30.00	860.526	30.00	864.432	30.00	868.388
25.00	864.103	25.00	868.026	25.00	871.994
20.00	867.685	20.00	871.622	20.00	875.608
15.00	871.273	15.00	875.224	15.00	879.225
10.00	874.861	10.00	878.831	10.00	882.847
5.00	878.459	5.00	882.444	5.00	886.478
0.00	882.063	0.00	886.065	0.00	890.115
-5.00	885.791	-5.00	889.795	-5.00	893.864
-10.00	890.090	-10.00	894.098	-10.00	898.203
-15.00	894.930	-15.00	899.138	-15.00	903.286

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 95-5	Mixture	Mixture 100-0	Mixture	Mixture 7-93
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	855.945	50.00	857.959	50.00	822.786
45.00	859.552	45.00	861.572	45.00	826.272
40.00	863.161	40.00	865.190	40.00	829.758
35.00	866.773	35.00	868.807	35.00	833.241
30.00	870.388	30.00	872.429	30.00	836.724
25.00	874.002	25.00	876.052	25.00	840.204
20.00	877.623	20.00	879.680	20.00	843.686
15.00	881.248	15.00	883.312	15.00	847.170
10.00	884.879	10.00	886.952	10.00	850.655
5.00	888.516	5.00	890.597	5.00	854.144
0.00	892.164	0.00	894.256	0.00	857.638
-5.00	895.945	-5.00	898.062	-5.00	861.332
-10.00	900.222	-10.00	902.406	-10.00	865.478
-15.00	906.188	-15.00	909.317	-15.00	870.054

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 2.5-97.5	Mixture	Mixture 7.5-92.5	Mixture	Mixture 12.5-87.5
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	821.190	50.00	822.962	50.00	824.734
45.00	824.669	45.00	826.448	45.00	828.226
40.00	828.147	40.00	829.934	40.00	831.719
35.00	831.624	35.00	833.418	35.00	835.211
30.00	835.098	30.00	836.901	30.00	838.703
25.00	838.571	25.00	840.382	25.00	842.191
20.00	842.046	20.00	843.865	20.00	845.683
15.00	845.523	15.00	847.350	15.00	849.175
10.00	849.001	10.00	850.836	10.00	852.671
5.00	852.483	5.00	854.327	5.00	856.169
0.00	855.971	0.00	857.822	0.00	859.673
-5.00	859.663	-5.00	861.523	-5.00	863.376
-10.00	863.788	-10.00	865.688	-10.00	867.558
-15.00	868.327	-15.00	870.272	-15.00	872.145

Rapeseed methyl ester RME – winter-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 0-100	Mixture	Mixture 5-95	Mixture	Mixture 10-90
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	798.047	50.00	800.956	50.00	803.863
45.00	801.574	45.00	804.487	45.00	807.399
40.00	805.099	40.00	808.016	40.00	810.935
35.00	808.620	35.00	811.543	35.00	814.465
30.00	812.139	30.00	815.067	30.00	817.995
25.00	815.654	25.00	818.586	25.00	821.520
20.00	819.168	20.00	822.106	20.00	825.044
15.00	822.681	15.00	825.625	15.00	828.570
10.00	826.194	10.00	829.144	10.00	832.094
5.00	829.709	5.00	832.664	5.00	835.621
0.00	833.226	0.00	836.187	0.00	839.151
-5.00	836.750	-5.00	839.719	-5.00	842.689
-10.00	840.962	-10.00	843.943	-10.00	846.923
-15.00	845.403	-15.00	848.375	-15.00	851.345

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	806.790	50.00	809.732	50.00	815.688
45.00	810.330	45.00	813.275	45.00	819.241
40.00	813.870	40.00	816.818	40.00	822.794
35.00	817.405	35.00	820.360	35.00	826.346
30.00	820.940	30.00	823.900	30.00	829.896
25.00	824.470	25.00	827.436	25.00	833.444
20.00	828.001	20.00	830.974	20.00	836.992
15.00	831.533	15.00	834.511	15.00	840.542
10.00	835.064	10.00	838.049	10.00	844.092
5.00	838.598	5.00	841.588	5.00	847.645
0.00	842.135	0.00	845.133	0.00	851.202
-5.00	845.680	-5.00	848.683	-5.00	854.769
-10.00	849.927	-10.00	852.941	-10.00	859.032
-15.00	854.337	-15.00	857.342	-15.00	863.434

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	821.643	50.00	827.670	50.00	833.744
45.00	825.205	45.00	831.241	45.00	837.323
40.00	828.767	40.00	834.813	40.00	840.904
35.00	832.329	35.00	838.385	35.00	844.486
30.00	835.889	30.00	841.956	30.00	848.067
25.00	839.448	25.00	845.526	25.00	851.647
20.00	843.007	20.00	849.096	20.00	855.230
15.00	846.570	15.00	852.670	15.00	858.817
10.00	850.133	10.00	856.247	10.00	862.405
5.00	853.700	5.00	859.827	5.00	865.998
0.00	857.271	0.00	863.413	0.00	869.599
-5.00	860.852	-5.00	867.010	-5.00	873.211
-10.00	865.113	-10.00	871.260	-10.00	877.454
-15.00	869.546	-15.00	875.772	-15.00	882.040

Rapeseed methyl ester RME – winter-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	839.867	50.00	845.976	50.00	852.142
45.00	843.455	45.00	849.574	45.00	855.748
40.00	847.047	40.00	853.174	40.00	859.358
35.00	850.637	35.00	856.775	35.00	862.967
30.00	854.229	30.00	860.377	30.00	866.578
25.00	857.820	25.00	863.979	25.00	870.190
20.00	861.415	20.00	867.584	20.00	873.808
15.00	865.012	15.00	871.196	15.00	877.430
10.00	868.616	10.00	874.809	10.00	881.059
5.00	872.222	5.00	878.429	5.00	884.697
0.00	875.836	0.00	882.057	0.00	888.342
-5.00	879.464	-5.00	885.699	-5.00	892.004
-10.00	883.711	-10.00	889.986	-10.00	896.392
-15.00	888.371	-15.00	894.704	-15.00	901.596

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 95-05	Mixture	Mixture 100-0	Mixture	Mixture 7-93
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	855.266	50.00	858.210	50.00	802.117
45.00	858.877	45.00	861.825	45.00	805.651
40.00	862.492	40.00	865.443	40.00	809.182
35.00	866.106	35.00	869.062	35.00	812.710
30.00	869.725	30.00	872.683	30.00	816.237
25.00	873.343	25.00	876.308	25.00	819.759
20.00	876.967	20.00	879.936	20.00	823.280
15.00	880.595	15.00	883.570	15.00	826.801
10.00	884.229	10.00	887.208	10.00	830.323
5.00	887.869	5.00	890.854	5.00	833.845
0.00	891.519	0.00	894.512	0.00	837.371
-5.00	895.196	-5.00	898.314	-5.00	840.905
-10.00	899.595	-10.00	902.660	-10.00	845.133
-15.00	905.711	-15.00	909.574	-15.00	849.560

Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 2.5-97.5	Mixture	Mixture 12.5-87.5
Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³
50.00	799.499	50.00	805.322
45.00	803.029	45.00	808.859
40.00	806.556	40.00	812.396
35.00	810.079	35.00	815.931
30.00	813.601	30.00	819.462
25.00	817.117	25.00	822.989
20.00	820.635	20.00	826.517
15.00	824.150	15.00	830.046
10.00	827.666	10.00	833.574
5.00	831.183	5.00	837.104
0.00	834.703	0.00	840.637
-5.00	838.230	-5.00	844.179
-10.00	842.453	-10.00	848.419
-15.00	846.883	-15.00	852.837

Soy methyl ester SME – summer-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 5-95	Mixture	Mixture 10-90
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	820.308	50.00	822.148	50.00	824.019
45.00	823.781	45.00	825.631	45.00	827.510
40.00	827.256	40.00	829.114	40.00	831.001
35.00	830.728	35.00	832.595	35.00	834.490
30.00	834.200	30.00	836.074	30.00	837.979
25.00	837.670	25.00	839.552	25.00	841.466
20.00	841.140	20.00	843.033	20.00	844.955
15.00	844.613	15.00	846.515	15.00	848.445
10.00	848.086	10.00	849.998	10.00	851.937
5.00	851.564	5.00	853.484	5.00	855.434
0.00	855.046	0.00	856.975	0.00	858.934
-5.00	858.722	-5.00	860.661	-5.00	862.625
-10.00	862.783	-10.00	864.815	-10.00	866.864
-15.00	867.300	-15.00	869.471	-15.00	871.647

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	825.900	50.00	827.801	50.00	831.651
45.00	829.400	45.00	831.309	45.00	835.174
40.00	832.899	40.00	834.818	40.00	838.700
35.00	836.397	35.00	838.324	35.00	842.222
30.00	839.894	30.00	841.830	30.00	845.747
25.00	843.391	25.00	845.335	25.00	849.269
20.00	846.888	20.00	848.841	20.00	852.793
15.00	850.387	15.00	852.349	15.00	856.320
10.00	853.889	10.00	855.861	10.00	859.848
5.00	857.394	5.00	859.376	5.00	863.383
0.00	860.904	0.00	862.894	0.00	866.920
-5.00	864.601	-5.00	866.592	-5.00	870.635
-10.00	868.926	-10.00	871.013	-10.00	875.232
-15.00	873.818	-15.00	875.990	-15.00	880.877

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	835.559	50.00	839.510	50.00	843.503
45.00	839.097	45.00	843.064	45.00	847.071
40.00	842.638	40.00	846.620	40.00	850.644
35.00	846.177	35.00	850.175	35.00	854.216
30.00	849.717	30.00	853.733	30.00	857.790
25.00	853.257	25.00	857.289	25.00	861.362
20.00	856.799	20.00	860.848	20.00	864.938
15.00	860.343	15.00	864.408	15.00	868.515
10.00	863.889	10.00	867.974	10.00	872.099
5.00	867.441	5.00	871.543	5.00	875.686
0.00	870.998	0.00	875.119	0.00	879.279
-5.00	874.725	-5.00	878.868	-5.00	883.080
-10.00	879.578	-10.00	884.424	-10.00	889.205
-15.00	885.462	-15.00	890.018	-15.00	896.309

Soy methyl ester SME – summer-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	847.543	50.00	851.620	50.00	855.746
45.00	851.129	45.00	855.219	45.00	859.360
40.00	854.716	40.00	858.822	40.00	862.977
35.00	858.305	35.00	862.427	35.00	866.597
30.00	861.894	30.00	866.031	30.00	870.218
25.00	865.484	25.00	869.638	25.00	873.840
20.00	869.077	20.00	873.246	20.00	877.465
15.00	872.673	15.00	876.859	15.00	881.095
10.00	876.271	10.00	880.476	10.00	884.729
5.00	879.876	5.00	884.100	5.00	888.371
0.00	883.489	0.00	887.730	0.00	892.019
-5.00	887.406	-5.00	892.352	-5.00	897.930
-10.00	894.141	-10.00	901.997	-10.00	908.482
-15.00	902.057	-15.00	908.195	-15.00	914.245

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 95-5	Mixture	Mixture 100-0	Mixture	Mixture 7-93
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	857.821	50.00	859.832	50.00	822.891
45.00	861.444	45.00	863.461	45.00	826.378
40.00	865.070	40.00	867.094	40.00	829.863
35.00	868.697	35.00	870.728	35.00	833.348
30.00	872.326	30.00	874.364	30.00	836.831
25.00	875.955	25.00	878.002	25.00	840.313
20.00	879.589	20.00	881.645	20.00	843.796
15.00	883.226	15.00	885.292	15.00	847.281
10.00	886.869	10.00	888.945	10.00	850.766
5.00	890.519	5.00	892.603	5.00	854.258
0.00	894.177	0.00	896.270	0.00	857.751
-5.00	902.523	-5.00	907.446	-5.00	861.440
-10.00	911.439	-10.00	910.464	-10.00	865.624
-15.00	917.155	-15.00	909.742	-15.00	870.325

Soy methyl ester SME – winter-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 0-100	Mixture	Mixture 05-95	Mixture	Mixture 10-90
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	798.078	50.00	801.049	50.00	804.043
45.00	801.603	45.00	804.581	45.00	807.580
40.00	805.128	40.00	808.112	40.00	811.117
35.00	808.649	35.00	811.639	35.00	814.649
30.00	812.168	30.00	815.163	30.00	818.180
25.00	815.682	25.00	818.683	25.00	821.707
20.00	819.196	20.00	822.204	20.00	825.233
15.00	822.708	15.00	825.725	15.00	828.761
10.00	826.221	10.00	829.244	10.00	832.288
5.00	829.736	5.00	832.766	5.00	835.816
0.00	833.253	0.00	836.290	0.00	839.349
-5.00	836.776	-5.00	839.822	-5.00	842.891
-10.00	840.991	-10.00	844.070	-10.00	847.177
-15.00	845.429	-15.00	848.548	-15.00	851.710

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	807.056	50.00	810.089	50.00	816.201
45.00	810.598	45.00	813.636	45.00	819.760
40.00	814.140	40.00	817.184	40.00	823.319
35.00	817.678	35.00	820.729	35.00	826.875
30.00	821.215	30.00	824.272	30.00	830.429
25.00	824.749	25.00	827.810	25.00	833.983
20.00	828.284	20.00	831.351	20.00	837.536
15.00	831.816	15.00	834.892	15.00	841.090
10.00	835.350	10.00	838.433	10.00	844.646
5.00	838.885	5.00	841.977	5.00	848.204
0.00	842.426	0.00	845.524	0.00	851.767
-5.00	845.978	-5.00	849.088	-5.00	855.346
-10.00	850.302	-10.00	853.451	-10.00	859.805
-15.00	854.921	-15.00	858.199	-15.00	865.065

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	822.374	50.00	828.623	50.00	834.886
45.00	825.943	45.00	832.203	45.00	838.477
40.00	829.513	40.00	835.785	40.00	842.070
35.00	833.080	35.00	839.366	35.00	845.661
30.00	836.648	30.00	842.947	30.00	849.253
25.00	840.213	25.00	846.527	25.00	852.844
20.00	843.780	20.00	850.108	20.00	856.439
15.00	847.348	15.00	853.691	15.00	860.035
10.00	850.918	10.00	857.276	10.00	863.633
5.00	854.491	5.00	860.864	5.00	867.236
0.00	858.068	0.00	864.460	0.00	870.845
-5.00	861.666	-5.00	868.070	-5.00	874.472
-10.00	866.318	-10.00	873.186	-10.00	880.666
-15.00	872.540	-15.00	880.056	-15.00	888.274

Soy methyl ester SME – winter-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	841.202	50.00	847.561	50.00	853.946
45.00	844.804	45.00	851.171	45.00	857.567
40.00	848.406	40.00	854.783	40.00	861.190
35.00	852.008	35.00	858.398	35.00	864.815
30.00	855.612	30.00	862.012	30.00	868.441
25.00	859.215	25.00	865.627	25.00	872.069
20.00	862.820	20.00	869.245	20.00	875.699
15.00	866.430	15.00	872.867	15.00	879.335
10.00	870.040	10.00	876.494	10.00	882.973
5.00	873.659	5.00	880.126	5.00	886.619
0.00	877.283	0.00	883.765	0.00	890.271
-5.00	881.177	-5.00	888.040	-5.00	896.011
-10.00	888.539	-10.00	897.925	-10.00	906.540
-15.00	896.273	-15.00	903.796	-15.00	908.565

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 95-05	Mixture	Mixture 100-0	Mixture	Mixture 07-93
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	857.153	50.00	860.206	50.00	802.241
45.00	860.778	45.00	863.836	45.00	805.775
40.00	864.407	40.00	867.471	40.00	809.306
35.00	868.037	35.00	871.105	35.00	812.837
30.00	871.670	30.00	874.743	30.00	816.364
25.00	875.302	25.00	878.381	25.00	819.887
20.00	878.939	20.00	882.023	20.00	823.410
15.00	882.582	15.00	885.671	15.00	826.932
10.00	886.228	10.00	889.323	10.00	830.455
5.00	889.881	5.00	892.984	5.00	833.980
0.00	893.543	0.00	896.653	0.00	837.508
-5.00	901.959	-5.00	907.777	-5.00	841.044
-10.00	910.755	-10.00	915.056	-10.00	845.306
-15.00	916.436	-15.00	920.334	-15.00	849.805

Palm oil methyl ester PME – summer-grade diesel

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 0-100	Mixture	Mixture 10-90	Mixture	Mixture 20-80
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	820.321	50.00	823.150	50.00	826.036
45.00	823.796	45.00	826.640	45.00	829.546
40.00	827.270	40.00	830.132	40.00	833.054
35.00	830.743	35.00	833.622	35.00	836.563
30.00	834.214	30.00	837.108	30.00	840.070
25.00	837.684	25.00	840.600	25.00	843.577
20.00	841.155	20.00	844.089	20.00	847.086
15.00	844.626	15.00	847.583	15.00	850.596
10.00	848.100	10.00	851.078	10.00	854.119
5.00	851.578	5.00	854.590	5.00	857.672
0.00	855.060	0.00	858.108	0.00	861.221
-5.00	858.707	-5.00	861.706	-5.00	864.827
-10.00	862.767	-10.00	866.325	-10.00	873.266
-15.00	867.286	-15.00	872.229	-15.00	873.943

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	831.953	50.00	834.969	50.00	838.027
45.00	835.496	45.00	838.529	45.00	841.606
40.00	839.042	40.00	842.092	40.00	845.186
35.00	842.586	35.00	845.654	35.00	848.765
30.00	846.130	30.00	849.217	30.00	852.347
25.00	849.674	25.00	852.779	25.00	855.928
20.00	853.222	20.00	856.346	20.00	859.514
15.00	856.771	15.00	859.917	15.00	863.105
10.00	860.349	10.00	863.523	10.00	866.755
5.00	864.000	5.00	867.228	5.00	883.026
0.00	867.611	0.00	884.762	0.00	895.094
-5.00	877.030	-5.00	884.189	-5.00	902.500
-10.00	875.425	-10.00	881.063	-10.00	908.357
-15.00	874.636	-15.00	879.590	-15.00	912.917

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 80-20	Mixture	Mixture 90-10	Mixture	Mixture 100-0
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	844.230	50.00	847.376	50.00	850.522
45.00	847.843	45.00	851.006	45.00	854.171
40.00	851.458	40.00	854.641	40.00	857.823
35.00	855.075	35.00	858.277	35.00	861.478
30.00	858.695	30.00	861.916	30.00	865.138
25.00	862.316	25.00	865.557	25.00	868.799
20.00	865.942	20.00	869.204	20.00	872.470
15.00	869.575	15.00	872.859	15.00	876.148
10.00	888.819	10.00	898.862	10.00	892.887
5.00	902.019	5.00	890.699	5.00	887.337
0.00	902.100	0.00	886.781	0.00	884.504
-5.00	899.473	-5.00	884.619	-5.00	883.188
-10.00	897.429	-10.00	883.372	-10.00	882.967
-15.00	896.419	-15.00	883.468	-15.00	882.939

Palm oil methyl ester PME – winter-grade diesel

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 10-90	Mixture	Mixture 20-80
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	798.132	50.00	803.288	50.00	808.357
45.00	801.669	45.00	806.835	45.00	811.913
40.00	805.205	40.00	810.380	40.00	815.470
35.00	808.739	35.00	813.922	35.00	819.024
30.00	812.271	30.00	817.463	30.00	822.577
25.00	815.801	25.00	821.000	25.00	826.126
20.00	819.332	20.00	824.536	20.00	829.674
15.00	822.862	15.00	828.074	15.00	833.223
10.00	826.393	10.00	831.611	10.00	836.774
5.00	829.924	5.00	835.150	5.00	840.341
0.00	833.456	0.00	838.698	0.00	843.931
-5.00	836.996	-5.00	842.260	-5.00	847.512
-10.00	841.259	-10.00	846.652	-10.00	853.197
-15.00	845.731	-15.00	852.187	-15.00	862.764

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	818.702	50.00	823.927	50.00	828.982
45.00	822.280	45.00	827.515	45.00	832.596
40.00	825.858	40.00	831.104	40.00	836.090
35.00	829.434	35.00	834.693	35.00	839.958
30.00	833.010	30.00	838.280	30.00	843.559
25.00	836.584	25.00	841.867	25.00	847.159
20.00	840.159	20.00	845.456	20.00	850.762
15.00	843.734	15.00	849.046	15.00	854.370
10.00	847.313	10.00	852.640	10.00	857.983
5.00	850.981	5.00	856.361	5.00	861.773
0.00	854.618	0.00	873.827	0.00	882.856
-5.00	870.564	-5.00	882.605	-5.00	884.269
-10.00	876.160	-10.00	888.976	-10.00	882.546
-15.00	875.550	-15.00	894.226	-15.00	880.899

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 80-20	Mixture	Mixture 90-10	Mixture	Mixture 100-0
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	839.777	50.00	845.140	50.00	850.449
45.00	843.401	45.00	848.775	45.00	854.096
40.00	847.026	40.00	852.415	40.00	857.749
35.00	850.654	35.00	856.056	35.00	861.405
30.00	854.282	30.00	859.700	30.00	865.062
25.00	857.912	25.00	863.344	25.00	868.723
20.00	861.545	20.00	866.996	20.00	872.392
15.00	865.186	15.00	870.654	15.00	876.070
10.00	868.954	10.00	896.601	10.00	888.747
5.00	887.519	5.00	899.193	5.00	883.444
0.00	883.835	0.00	894.228	0.00	880.946
-5.00	881.822	-5.00	891.630	-5.00	880.085
-10.00	880.545	-10.00	890.210	-10.00	879.972
-15.00	880.158	-15.00	889.528	-15.00	879.725

Coconut oil methyl ester CME – summer-grade diesel

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 0-100	Mixture	Mixture 05-95	Mixture	Mixture 10-90
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	820.304	50.00	821.383	50.00	822.540
45.00	823.779	45.00	824.879	45.00	826.057
40.00	827.253	40.00	828.375	40.00	829.573
35.00	830.725	35.00	831.869	35.00	833.087
30.00	834.198	30.00	835.363	30.00	836.601
25.00	837.667	25.00	838.854	25.00	840.114
20.00	841.137	20.00	842.347	20.00	843.625
15.00	844.610	15.00	845.839	15.00	847.141
10.00	848.085	10.00	849.336	10.00	850.658
5.00	851.564	5.00	852.834	5.00	854.178
0.00	855.047	0.00	856.336	0.00	857.701
-5.00	858.708	-5.00	859.975	-5.00	861.306
-10.00	862.760	-10.00	864.009	-10.00	865.322
-15.00	867.275	-15.00	868.458	-15.00	869.690

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 40-60
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	823.688	50.00	824.867	50.00	829.735
45.00	827.226	45.00	828.428	45.00	833.378
40.00	830.763	40.00	831.987	40.00	837.022
35.00	834.301	35.00	835.546	35.00	840.663
30.00	837.835	30.00	839.102	30.00	844.305
25.00	841.369	25.00	842.655	25.00	847.943
20.00	844.904	20.00	846.211	20.00	851.583
15.00	848.437	15.00	849.767	15.00	855.224
10.00	851.975	10.00	853.324	10.00	858.868
5.00	855.514	5.00	856.886	5.00	862.514
0.00	859.059	0.00	860.451	0.00	866.165
-5.00	862.623	-5.00	864.025	-5.00	869.825
-10.00	866.669	-10.00	868.108	-10.00	873.780
-15.00	871.040	-15.00	872.414	-15.00	877.937

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 60-40	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	834.838	50.00	840.122	50.00	842.850
45.00	838.566	45.00	843.932	45.00	846.703
40.00	842.294	40.00	847.743	40.00	850.557
35.00	846.019	35.00	851.553	35.00	854.410
30.00	849.745	30.00	855.366	30.00	858.262
25.00	853.468	25.00	859.181	25.00	862.114
20.00	857.194	20.00	862.999	20.00	865.971
15.00	860.921	15.00	866.819	15.00	869.833
10.00	864.652	10.00	870.640	10.00	873.700
5.00	868.389	5.00	874.469	5.00	877.577
0.00	872.130	0.00	878.306	0.00	881.466
-5.00	875.880	-5.00	882.156	-5.00	885.368
-10.00	879.723	-10.00	896.399	-10.00	906.281
-15.00	915.872	-15.00	895.455	-15.00	896.743

Coconut oil methyl ester CME – summer-grade diesel

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 95-05	Mixture	Mixture 100-0	Mixture	Mixture 07-93
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	844.223	50.00	845.595	50.00	821.865
45.00	848.097	45.00	849.489	45.00	825.369
40.00	851.972	40.00	853.385	40.00	828.874
35.00	855.847	35.00	857.281	35.00	832.377
30.00	859.721	30.00	861.177	30.00	835.877
25.00	863.596	25.00	865.074	25.00	839.378
20.00	867.475	20.00	868.975	20.00	842.877
15.00	871.361	15.00	872.882	15.00	846.379
10.00	875.250	10.00	876.796	10.00	849.883
5.00	879.153	5.00	880.724	5.00	853.390
0.00	883.067	0.00	884.666	0.00	856.901
-5.00	886.998	-5.00	888.628	-5.00	860.526
-10.00	891.338	-10.00	874.291	-10.00	864.554
-15.00	886.341	-15.00	872.940	-15.00	868.974

Coconut oil methyl ester CME – winter-grade diesel

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 05-95	Mixture	Mixture 10-90
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	797.936	50.00	800.234	50.00	802.484
45.00	801.476	45.00	803.786	45.00	806.058
40.00	805.016	40.00	807.337	40.00	809.627
35.00	808.552	35.00	810.885	35.00	813.195
30.00	812.089	30.00	814.431	30.00	816.760
25.00	815.624	25.00	817.973	25.00	820.321
20.00	819.159	20.00	821.514	20.00	823.880
15.00	822.694	15.00	825.055	15.00	827.439
10.00	826.228	10.00	828.596	10.00	830.998
5.00	829.763	5.00	832.139	5.00	834.559
0.00	833.299	0.00	835.683	0.00	838.121
-5.00	836.843	-5.00	839.234	-5.00	841.690
-10.00	841.102	-10.00	843.405	-10.00	845.794
-15.00	845.570	-15.00	847.785	-15.00	850.123

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 40-60
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	804.742	50.00	807.015	50.00	816.328
45.00	808.334	45.00	810.623	45.00	820.009
40.00	811.924	40.00	814.234	40.00	823.689
35.00	815.508	35.00	817.838	35.00	827.365
30.00	819.091	30.00	821.440	30.00	831.039
25.00	822.668	25.00	825.040	25.00	834.710
20.00	826.247	20.00	828.638	20.00	838.380
15.00	829.824	15.00	832.234	15.00	842.050
10.00	833.400	10.00	835.830	10.00	845.722
5.00	836.978	5.00	839.428	5.00	849.394
0.00	840.558	0.00	843.028	0.00	853.070
-5.00	844.145	-5.00	846.635	-5.00	856.753
-10.00	848.171	-10.00	850.588	-10.00	860.448
-15.00	852.505	-15.00	854.956	-15.00	864.821

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 60-40	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	825.883	50.00	835.651	50.00	840.604
45.00	829.635	45.00	839.475	45.00	844.464
40.00	833.388	40.00	843.298	40.00	848.324
35.00	837.137	35.00	847.119	35.00	852.182
30.00	840.885	30.00	850.940	30.00	856.040
25.00	844.629	25.00	854.758	25.00	859.898
20.00	848.374	20.00	858.581	20.00	863.759
15.00	852.122	15.00	862.405	15.00	867.625
10.00	855.870	10.00	866.235	10.00	871.496
5.00	859.622	5.00	870.072	5.00	875.376
0.00	863.380	0.00	873.916	0.00	879.268
-5.00	867.146	-5.00	877.773	-5.00	883.176
-10.00	870.922	-10.00	881.646	-10.00	906.050
-15.00	909.764	-15.00	898.545	-15.00	893.233

Coconut oil methyl ester CME – winter-grade diesel

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 95-05	Mixture	Mixture 100-0	Mixture	Mixture 07-93
Temperature	Density	Temperature	Density	Temperature	Density
°C	kg - m³	°C	kg - m³	°C	kg - m³
50.00	843.102	50.00	845.605	50.00	801.126
45.00	846.979	45.00	849.500	45.00	804.686
40.00	850.857	40.00	853.395	40.00	808.248
35.00	854.734	35.00	857.291	35.00	811.803
30.00	858.611	30.00	861.188	30.00	815.358
25.00	862.489	25.00	865.083	25.00	818.907
20.00	866.371	20.00	868.984	20.00	822.458
15.00	870.256	15.00	872.892	15.00	826.008
10.00	874.150	10.00	876.806	10.00	829.557
5.00	878.055	5.00	880.733	5.00	833.109
0.00	881.970	0.00	884.674	0.00	836.661
-5.00	885.904	-5.00	888.635	-5.00	840.221
-10.00	886.633	-10.00	875.903	-10.00	844.367
-15.00	880.993	-15.00	871.939	-15.00	848.723

Rapeseed oil methyl ester RME – heating oil EL

Class Batch Mixture	RME - heating oil Batch 03 Mixture 0-100	Class Batch Mixture	RME - heating oil Batch 03 Mixture 05-95	Class Batch Mixture	RME - heating oil Batch 03 Mixture 10-90
Temperature °C	Density kg - m³	Temperature °C	Density kg - m³	Temperature °C	Density kg - m³
50.00	810.566	50.00	812.857	50.00	815.190
45.00	814.055	45.00	816.354	45.00	818.693
40.00	817.544	40.00	819.850	40.00	822.195
35.00	821.031	35.00	823.344	35.00	825.697
30.00	824.515	30.00	826.836	30.00	829.197
25.00	827.997	25.00	830.326	25.00	832.694
20.00	831.481	20.00	833.816	20.00	836.192
15.00	834.965	15.00	837.308	15.00	839.691
10.00	838.450	10.00	840.802	10.00	843.193
5.00	841.938	5.00	844.296	5.00	846.698
0.00	845.429	0.00	847.796	0.00	850.206
-5.00	848.928	-5.00	851.304	-5.00	853.723
-10.00	853.376	-10.00	855.756	-10.00	858.175
-15.00	857.805	-15.00	860.237	-15.00	862.719

Class Batch Mixture	RME - heating oil Batch 03 Mixture 20-80	Class Batch Mixture	RME - heating oil Batch 03 Mixture 50-50	Class Batch Mixture	RME - heating oil Batch 03 Mixture 100-0
Temperature °C	Density kg - m³	Temperature °C	Density kg - m³	Temperature °C	Density kg - m³
50.00	819.891	50.00	834.404	50.00	859.165
45.00	823.407	45.00	837.959	45.00	862.783
40.00	826.925	40.00	841.518	40.00	866.403
35.00	830.440	35.00	845.074	35.00	870.026
30.00	833.954	30.00	848.632	30.00	873.651
25.00	837.468	25.00	852.186	25.00	877.278
20.00	840.981	20.00	855.744	20.00	880.908
15.00	844.498	15.00	859.306	15.00	884.545
10.00	848.014	10.00	862.873	10.00	888.188
5.00	851.535	5.00	866.443	5.00	891.839
0.00	855.061	0.00	870.018	0.00	895.499
-5.00	858.597	-5.00	873.609	-5.00	899.247
-10.00	863.046	-10.00	878.094	-10.00	903.618
-15.00	867.609	-15.00	882.700	-15.00	910.376

Viscosity of the regional samples

Petrol, super E5, ROZ 95, summer grade

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-01	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-02	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-03
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.99	-25.00	0.934	-25.00	0.892
-20.00	0.981	-20.00	0.928	-20.00	0.890
-15.00	0.875	-15.00	0.830	-15.00	0.796
-10.00	0.825	-10.00	0.784	-10.00	0.753
-5.00	0.779	-5.00	0.743	-5.00	0.714
0.00	0.736	0.00	0.704	0.00	0.677
5.00	0.698	5.00	0.670	5.00	0.644
10.00	0.662	10.00	0.637	10.00	0.612
15.00	0.629	15.00	0.606	15.00	0.583
20.00	0.548	20.00	0.525	20.00	0.502
25.00	0.571	25.00	0.550	25.00	0.531
30.00	0.543	30.00	0.524	30.00	0.494
35.00	0.503	35.00	0.501	35.00	0.467
40.00	0.484	40.00	0.466	40.00	0.411
45.00	0.436	45.00	0.446	45.00	0.421
50.00	0.406	50.00	0.380	50.00	0.403

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-04	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-05	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-06
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	1.015	-25.00	1.029	-25.00	0.973
-20.00	1.005	-20.00	1.018	-20.00	0.966
-15.00	0.896	-15.00	0.907	-15.00	0.862
-10.00	0.844	-10.00	0.855	-10.00	0.813
-5.00	0.796	-5.00	0.807	-5.00	0.769
0.00	0.754	0.00	0.763	0.00	0.728
5.00	0.714	5.00	0.722	5.00	0.690
10.00	0.677	10.00	0.685	10.00	0.654
15.00	0.643	15.00	0.650	15.00	0.622
20.00	0.562	20.00	0.571	20.00	0.541
25.00	0.581	25.00	0.589	25.00	0.564
30.00	0.554	30.00	0.561	30.00	0.538
35.00	0.528	35.00	0.520	35.00	0.514
40.00	0.493	40.00	0.497	40.00	0.491
45.00	0.469	45.00	0.439	45.00	0.408
50.00	0.530				

Petrol, super E5, ROZ 95, summer grade

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-07	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-08	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-10
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.992	-25.00	0.942	-25.00	0.966
-20.00	0.984	-20.00	0.936	-20.00	0.959
-15.00	0.878	-15.00	0.836	-15.00	0.856
-10.00	0.833	-10.00	0.790	-10.00	0.808
-5.00	0.783	-5.00	0.747	-5.00	0.764
0.00	0.742	0.00	0.707	0.00	0.723
5.00	0.704	5.00	0.672	5.00	0.686
10.00	0.668	10.00	0.638	10.00	0.651
15.00	0.635	15.00	0.607	15.00	0.620
20.00	0.553	20.00	0.525	20.00	0.537
25.00	0.575	25.00	0.551	25.00	0.562
30.00	0.548	30.00	0.525	30.00	0.536
35.00	0.523	35.00	0.501	35.00	0.512
40.00	0.489	40.00	0.479	40.00	0.477
45.00	0.423	45.00	0.409	45.00	0.438

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-11	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-12	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-13
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.980	-25.00	1.037	-25.00	0.986
-20.00	0.972	-20.00	1.024	-20.00	0.977
-15.00	0.867	-15.00	0.912	-15.00	0.871
-10.00	0.818	-10.00	0.858	-10.00	0.822
-5.00	0.773	-5.00	0.809	-5.00	0.776
0.00	0.731	0.00	0.764	0.00	0.733
5.00	0.693	5.00	0.723	5.00	0.695
10.00	0.658	10.00	0.685	10.00	0.659
15.00	0.625	15.00	0.650	15.00	0.626
20.00	0.544	20.00	0.570	20.00	0.544
25.00	0.566	25.00	0.588	25.00	0.567
30.00	0.540	30.00	0.560	30.00	0.541
35.00	0.516	35.00	0.534	35.00	0.500
40.00	0.481	40.00	0.500	40.00	0.481
45.00	0.404	45.00	0.470	45.00	0.507

Petrol, super E5, ROZ 95, summer grade

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-14	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-15	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-16
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	1.035	-25.00	1.006	-25.00	0.985
-20.00	1.024	-20.00	0.996	-20.00	0.976
-15.00	0.913	-15.00	0.888	-15.00	0.871
-10.00	0.860	-10.00	0.837	-10.00	0.822
-5.00	0.811	-5.00	0.790	-5.00	0.777
0.00	0.766	0.00	0.748	0.00	0.735
5.00	0.726	5.00	0.708	5.00	0.697
10.00	0.688	10.00	0.672	10.00	0.662
15.00	0.653	15.00	0.638	15.00	0.629
20.00	0.572	20.00	0.557	20.00	0.547
25.00	0.591	25.00	0.578	25.00	0.569
30.00	0.563	30.00	0.551	30.00	0.543
35.00	0.522	35.00	0.523	35.00	0.501
40.00	0.490	40.00	0.491	40.00	0.477
45.00	0.435	45.00	0.453		

Class Batch Mixture	Regional samples Super petrol OK95 SOK95-17	Class Batch Mixture	Regional samples Super petrol OK95 SOK95-18
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.975	-25.00	0.979
-20.00	0.969	-20.00	0.971
-15.00	0.865	-15.00	0.867
-10.00	0.817	-10.00	0.817
-5.00	0.772	-5.00	0.756
0.00	0.731	0.00	0.715
5.00	0.693	5.00	0.676
10.00	0.659	10.00	0.647
15.00	0.620	15.00	0.604
20.00	0.529	20.00	0.529
25.00	0.552	25.00	0.557
30.00	0.523	30.00	0.522
35.00	0.502	35.00	0.499
40.00	0.438	40.00	0.470

Petrol, super E5, ROZ 95, winter grade

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-01	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-03	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-04
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	1.082	-25.00	0.840	-25.00	0.963
-20.00	1.065	-20.00	0.842	-20.00	0.956
-15.00	0.947	-15.00	0.754	-15.00	0.854
-10.00	0.890	-10.00	0.715	-10.00	0.806
-5.00	0.839	-5.00	0.679	-5.00	0.763
0.00	0.792	0.00	0.646	0.00	0.722
5.00	0.749	5.00	0.615	5.00	0.685
10.00	0.709	10.00	0.586	10.00	0.650
15.00	0.672	15.00	0.559	15.00	0.618
20.00	0.591	20.00	0.477	20.00	0.537
25.00	0.597	25.00	0.510	25.00	0.560
30.00	0.557	30.00	0.471	30.00	0.514

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-05	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-06	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-07
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.856	-25.00	0.892	-25.00	0.878
-20.00	0.857	-20.00	0.892	-20.00	0.877
-15.00	0.767	-15.00	0.796	-15.00	0.785
-10.00	0.727	-10.00	0.753	-10.00	0.744
-5.00	0.691	-5.00	0.714	-5.00	0.706
0.00	0.656	0.00	0.679	0.00	0.671
5.00	0.625	5.00	0.644	5.00	0.638
10.00	0.595	10.00	0.612	10.00	0.608
15.00	0.567	15.00	0.583	15.00	0.579
20.00	0.484	20.00	0.501	20.00	0.496
25.00	0.516	25.00	0.531	25.00	0.528
30.00	0.495	30.00	0.507	30.00	0.487

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-08	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-10	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-11
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.855	-25.00	0.876	-25.00	0.951
-20.00	0.856	-20.00	0.875	-20.00	0.947
-15.00	0.766	-15.00	0.783	-15.00	0.846
-10.00	0.726	-10.00	0.742	-10.00	0.799
-5.00	0.689	-5.00	0.704	-5.00	0.756
0.00	0.654	0.00	0.669	0.00	0.716
5.00	0.622	5.00	0.636	5.00	0.679
10.00	0.592	10.00	0.605	10.00	0.644
15.00	0.564	15.00	0.576	15.00	0.613
20.00	0.481	20.00	0.493	20.00	0.530
25.00	0.515	25.00	0.525	25.00	0.557
30.00	0.474	30.00	0.502	30.00	0.512

Petrol, super E5, ROZ 95, winter grade

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-12	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-13	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-14
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.986	-25.00	0.939	-25.00	0.909
-20.00	0.978	-20.00	0.934	-20.00	0.912
-15.00	0.872	-15.00	0.834	-15.00	0.814
-10.00	0.822	-10.00	0.788	-10.00	0.787
-5.00	0.777	-5.00	0.746	-5.00	0.729
0.00	0.735	0.00	0.707	0.00	0.684
5.00	0.696	5.00	0.671	5.00	0.658
10.00	0.661	10.00	0.637	10.00	0.637
15.00	0.627	15.00	0.606	15.00	0.601
20.00	0.530	20.00	0.507	20.00	0.539
25.00	0.549	25.00	0.531	25.00	0.560
30.00	0.508	30.00	0.506	30.00	0.516

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-15	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-16	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-17
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.934	-25.00	0.898	-25.00	0.886
-20.00	0.928	-20.00	0.897	-20.00	0.885
-15.00	0.830	-15.00	0.802	-15.00	0.791
-10.00	0.785	-10.00	0.760	-10.00	0.749
-5.00	0.744	-5.00	0.721	-5.00	0.711
0.00	0.707	0.00	0.684	0.00	0.675
5.00	0.672	5.00	0.650	5.00	0.641
10.00	0.638	10.00	0.619	10.00	0.610
15.00	0.608	15.00	0.589	15.00	0.581
20.00	0.526	20.00	0.506	20.00	0.490
25.00	0.536	25.00	0.521	25.00	0.510
30.00	0.494	30.00	0.484	30.00	0.431

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E5-18
Temperature °C	Dynamic viscosity mPa s
-25.00	1.009
-20.00	0.998
-15.00	0.891
-10.00	0.839
-5.00	0.792
0.00	0.749
5.00	0.709
10.00	0.672
15.00	0.638
20.00	0.557
25.00	0.578
30.00	0.551

Petrol, super E10, ROZ 95, winter grade

Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E10-08	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E10-10	Class Batch Mixture	Regional samples Super petrol OK95 WOK95-E10-12
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.993	-25.00	0.915	-25.00	1.084
-20.00	0.983	-20.00	0.911	-20.00	1.065
-15.00	0.875	-15.00	0.815	-15.00	0.946
-10.00	0.823	-10.00	0.770	-10.00	0.888
-5.00	0.776	-5.00	0.729	-5.00	0.835
0.00	0.732	0.00	0.691	0.00	0.789
5.00	0.693	5.00	0.656	5.00	0.744
10.00	0.656	10.00	0.623	10.00	0.703
15.00	0.622	15.00	0.593	15.00	0.665
20.00	0.539	20.00	0.510	20.00	0.583
25.00	0.561	25.00	0.538	25.00	0.598
30.00	0.517	30.00	0.514	30.00	0.549

Petrol, super E10, ROZ 98, summer grade

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-01	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-04	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-05
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.985	-25.00	1.077	-25.00	0.946
-20.00	0.976	-20.00	1.063	-20.00	0.939
-15.00	0.867	-15.00	0.944	-15.00	0.840
-10.00	0.816	-10.00	0.886	-10.00	0.793
-5.00	0.771	-5.00	0.835	-5.00	0.752
0.00	0.730	0.00	0.789	0.00	0.712
5.00	0.692	5.00	0.747	5.00	0.676
10.00	0.657	10.00	0.708	10.00	0.643
15.00	0.625	15.00	0.673	15.00	0.612
20.00	0.545	20.00	0.593	20.00	0.532
25.00	0.557	25.00	0.609	25.00	0.557
30.00	0.524	30.00	0.580	30.00	0.533
35.00	0.503	35.00	0.554	35.00	0.509
40.00	0.463	40.00	0.513	40.00	0.470

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-06	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-07	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-08
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.944	-25.00	1.018	-25.00	0.909
-20.00	0.937	-20.00	1.007	-20.00	0.907
-15.00	0.837	-15.00	0.899	-15.00	0.815
-10.00	0.791	-10.00	0.848	-10.00	0.766
-5.00	0.749	-5.00	0.801	-5.00	0.725
0.00	0.710	0.00	0.758	0.00	0.688
5.00	0.674	5.00	0.719	5.00	0.654
10.00	0.641	10.00	0.682	10.00	0.622
15.00	0.610	15.00	0.649	15.00	0.593
20.00	0.529	20.00	0.568	20.00	0.512
25.00	0.544	25.00	0.588	25.00	0.540
30.00	0.514	30.00	0.561	30.00	0.516
35.00	0.491	35.00	0.517	35.00	0.494
40.00	0.467	40.00	0.494	40.00	0.458

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-10	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-12	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-13
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.947	-25.00	1.016	-25.00	0.912
-20.00	0.943	-20.00	1.010	-20.00	0.905
-15.00	0.841	-15.00	0.894	-15.00	0.807
-10.00	0.794	-10.00	0.842	-10.00	0.763
-5.00	0.751	-5.00	0.794	-5.00	0.722
0.00	0.686	0.00	0.751	0.00	0.685
5.00	0.650	5.00	0.712	5.00	0.651
10.00	0.614	10.00	0.675	10.00	0.620
15.00	0.588	15.00	0.641	15.00	0.591
20.00	0.498	20.00	0.556	20.00	0.510
25.00	0.534	25.00	0.568	25.00	0.538
30.00	0.509	30.00	0.543	30.00	0.499
35.00	0.487	35.00	0.512	35.00	0.475
40.00	0.413	40.00	0.488	40.00	0.453

Petrol, super E10, ROZ 98, summer grade

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-14	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-15	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-16
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	1.057	-25.00	1.020	-25.00	0.990
-20.00	1.046	-20.00	1.008	-20.00	0.982
-15.00	0.932	-15.00	0.900	-15.00	0.877
-10.00	0.877	-10.00	0.848	-10.00	0.827
-5.00	0.826	-5.00	0.800	-5.00	0.782
0.00	0.780	0.00	0.756	0.00	0.741
5.00	0.738	5.00	0.716	5.00	0.703
10.00	0.699	10.00	0.679	10.00	0.668
15.00	0.663	15.00	0.644	15.00	0.635
20.00	0.582	20.00	0.564	20.00	0.555
25.00	0.590	25.00	0.583	25.00	0.577
30.00	0.549	30.00	0.556	30.00	0.531
35.00	0.522	35.00	0.510	35.00	0.507
40.00	0.499	40.00	0.487	40.00	0.485

Class Batch Mixture	Regional samples Super petrol OK98 SOK98-17	Class Batch Mixture	Regional samples Super petrol OK98 SOK98-18
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.933	-25.00	0.961
-20.00	0.927	-20.00	0.953
-15.00	0.827	-15.00	0.851
-10.00	0.781	-10.00	0.803
-5.00	0.739	-5.00	0.759
0.00	0.701	0.00	0.719
5.00	0.666	5.00	0.682
10.00	0.633	10.00	0.647
15.00	0.603	15.00	0.616
20.00	0.522	20.00	0.534
25.00	0.534	25.00	0.559
30.00	0.507	30.00	0.534
35.00	0.483	35.00	0.462
40.00	0.439		

Petrol, super E5, ROZ 98, winter grade

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-01	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-02	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-04
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.938	-25.00	0.940	-25.00	0.991
-20.00	0.932	-20.00	0.935	-20.00	0.983
-15.00	0.831	-15.00	0.835	-15.00	0.878
-10.00	0.784	-10.00	0.789	-10.00	0.829
-5.00	0.741	-5.00	0.747	-5.00	0.784
0.00	0.701	0.00	0.709	0.00	0.743
5.00	0.661	5.00	0.673	5.00	0.705
10.00	0.624	10.00	0.640	10.00	0.670
15.00	0.586	15.00	0.610	15.00	0.637
20.00	0.507	20.00	0.529	20.00	0.558
25.00	0.532	25.00	0.555	25.00	0.580
30.00	0.507	30.00	0.521	30.00	0.554

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-05	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-07	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E5-08
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.841	-25.00	0.943	-25.00	0.917
-20.00	0.843	-20.00	0.939	-20.00	0.913
-15.00	0.756	-15.00	0.839	-15.00	0.816
-10.00	0.718	-10.00	0.794	-10.00	0.771
-5.00	0.683	-5.00	0.752	-5.00	0.730
0.00	0.650	0.00	0.714	0.00	0.692
5.00	0.620	5.00	0.679	5.00	0.656
10.00	0.591	10.00	0.645	10.00	0.624
15.00	0.565	15.00	0.615	15.00	0.594
20.00	0.482	20.00	0.534	20.00	0.513
25.00	0.517	25.00	0.561	25.00	0.539
30.00	0.496	30.00	0.514	30.00	0.505

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-10	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-11	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E5-12
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.883	-25.00	0.926	-25.00	0.989
-20.00	0.882	-20.00	0.922	-20.00	0.982
-15.00	0.790	-15.00	0.824	-15.00	0.871
-10.00	0.748	-10.00	0.780	-10.00	0.820
-5.00	0.710	-5.00	0.739	-5.00	0.775
0.00	0.674	0.00	0.701	0.00	0.733
5.00	0.641	5.00	0.666	5.00	0.694
10.00	0.611	10.00	0.633	10.00	0.659
15.00	0.582	15.00	0.603	15.00	0.626
20.00	0.499	20.00	0.522	20.00	0.533
25.00	0.531	25.00	0.550	25.00	0.550
30.00	0.489	30.00	0.505	30.00	0.492

Petrol, super E5, ROZ 98, winter grade

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-13	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E5-14	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-15
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.875	-25.00	0.982	-25.00	0.906
-20.00	0.871	-20.00	0.975	-20.00	0.903
-15.00	0.779	-15.00	0.870	-15.00	0.809
-10.00	0.735	-10.00	0.821	-10.00	0.766
-5.00	0.696	-5.00	0.776	-5.00	0.727
0.00	0.661	0.00	0.734	0.00	0.689
5.00	0.629	5.00	0.696	5.00	0.655
10.00	0.599	10.00	0.661	10.00	0.624
15.00	0.572	15.00	0.628	15.00	0.595
20.00	0.491	20.00	0.547	20.00	0.513
25.00	0.522	25.00	0.548	25.00	0.522
30.00	0.483	30.00	0.525	30.00	0.501

Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-16	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-17	Class Batch Mixture	Regional samples Super petrol OK98 WOK98-E0-08
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-25.00	0.880	-25.00	0.918	-25.00	0.877
-20.00	0.879	-20.00	0.914	-20.00	0.882
-15.00	0.786	-15.00	0.817	-15.00	0.779
-10.00	0.745	-10.00	0.773	-10.00	0.732
-5.00	0.707	-5.00	0.732	-5.00	0.693
0.00	0.672	0.00	0.694	0.00	0.659
5.00	0.639	5.00	0.659	5.00	0.629
10.00	0.608	10.00	0.627	10.00	0.600
15.00	0.580	15.00	0.597	15.00	0.572
20.00	0.498	20.00	0.516	20.00	0.492
25.00	0.530	25.00	0.544	25.00	0.522
30.00	0.439	30.00	0.504	30.00	0.500

Summer-grade diesel

Class Batch Mixture	Regional samples Diesel SDK-01	Class Batch Mixture	Regional samples Diesel SDK-02	Class Batch Mixture	Regional samples Diesel SDK-03
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.226	50.00	2.396	50.00	2.634
45.00	2.460	45.00	2.658	45.00	2.934
40.00	2.697	40.00	2.927	40.00	3.245
35.00	2.973	35.00	3.241	35.00	3.610
30.00	3.296	30.00	3.612	30.00	4.044
25.00	3.678	25.00	4.053	25.00	4.565
20.00	4.130	20.00	4.578	20.00	5.187
15.00	4.682	15.00	5.229	15.00	5.970
10.00	5.352	10.00	6.025	10.00	6.932
5.00	6.180	5.00	7.017	5.00	8.144
0.00	7.216	0.00	8.274	0.00	9.696
-5.00	9.461	-5.00	9.892	-5.00	11.716
-10.00	12.672	-10.00	15.677	-10.00	20.933

Class Batch Mixture	Regional samples Diesel SDK-04	Class Batch Mixture	Regional samples Diesel SDK-05	Class Batch Mixture	Regional samples Diesel SDK-06
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.501	50.00	2.520	50.00	2.491
45.00	2.780	45.00	2.796	45.00	2.769
40.00	3.066	40.00	3.088	40.00	3.055
35.00	3.401	35.00	3.431	35.00	3.390
30.00	3.797	30.00	3.838	30.00	3.786
25.00	4.270	25.00	4.323	25.00	4.259
20.00	4.834	20.00	4.903	20.00	4.823
15.00	5.536	15.00	5.629	15.00	5.526
10.00	6.395	10.00	6.523	10.00	6.386
5.00	7.471	5.00	7.641	5.00	7.464
0.00	8.838	0.00	9.073	0.00	8.834
-5.00	10.604	-5.00	10.934	-5.00	13.058
-10.00	17.343	-10.00	15.663	-10.00	20.303

Class Batch Mixture	Regional samples Diesel SDK-07	Class Batch Mixture	Regional samples Diesel SDK-08	Class Batch Mixture	Regional samples Diesel SDK-10
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.212	50.00	1.776	50.00	2.600
45.00	2.446	45.00	1.945	45.00	2.895
40.00	2.684	40.00	2.115	40.00	3.199
35.00	2.962	35.00	2.310	35.00	3.556
30.00	3.288	30.00	2.537	30.00	3.980
25.00	3.673	25.00	2.801	25.00	4.488
20.00	4.131	20.00	3.113	20.00	5.096
15.00	4.693	15.00	3.480	15.00	5.857
10.00	5.376	10.00	3.922	10.00	6.793
5.00	6.224	5.00	4.457	5.00	7.970
0.00	7.289	0.00	5.115	0.00	9.475
-5.00	8.650	-5.00	5.935	-5.00	14.783
-10.00	12.813	-10.00	6.973	-10.00	24.311

Summer-grade diesel

Class Batch Mixture	Regional samples Diesel SDK-11	Class Batch Mixture	Regional samples Diesel SDK-12	Class Batch Mixture	Regional samples Diesel SDK-13
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.220	50.00	2.443	50.00	2.050
45.00	2.455	45.00	2.713	45.00	2.258
40.00	2.693	40.00	2.988	40.00	2.470
35.00	2.971	35.00	3.313	35.00	2.714
30.00	3.298	30.00	3.698	30.00	2.999
25.00	3.683	25.00	4.150	25.00	3.334
20.00	4.141	20.00	4.694	20.00	3.732
15.00	4.703	15.00	5.367	15.00	4.211
10.00	5.385	10.00	6.193	10.00	4.792
5.00	6.228	5.00	7.224	5.00	5.503
0.00	7.287	0.00	8.533	0.00	6.388
-5.00	9.841	-5.00	11.447	-5.00	7.951
-10.00	14.858	-10.00	16.383	-10.00	10.217

Class Batch Mixture	Regional samples Diesel SDK-14	Class Batch Mixture	Regional samples Diesel SDK-15	Class Batch Mixture	Regional samples Diesel SDK-16
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.455	50.00	2.345	50.00	2.216
45.00	2.727	45.00	2.600	45.00	2.451
40.00	3.007	40.00	2.861	40.00	2.690
35.00	3.334	35.00	3.166	35.00	2.969
30.00	3.721	30.00	3.525	30.00	3.296
25.00	4.184	25.00	3.953	25.00	3.684
20.00	4.734	20.00	4.461	20.00	4.144
15.00	5.420	15.00	5.090	15.00	4.709
10.00	6.259	10.00	5.858	10.00	5.397
5.00	7.310	5.00	6.816	5.00	6.249
0.00	8.647	0.00	8.026	0.00	7.322
-5.00	10.370	-5.00	9.591	-5.00	8.692
-10.00	14.849	-10.00	13.519	-10.00	13.308

Class Batch Mixture	Regional samples Diesel SDK-17	Class Batch Mixture	Regional samples Diesel SDK-18
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.330	50.00	2.415
45.00	2.581	45.00	2.679
40.00	2.838	40.00	2.949
35.00	3.137	35.00	3.265
30.00	3.489	30.00	3.638
25.00	3.908	25.00	4.083
20.00	4.402	20.00	4.610
15.00	5.016	15.00	5.264
10.00	5.761	10.00	6.062
5.00	6.689	5.00	7.060
0.00	7.859	0.00	8.315
-5.00	10.122	-5.00	11.095
-10.00	13.657	-10.00	16.465

Winter-grade diesel

Class Batch Mixture	Regional samples Diesel WDK-01	Class Batch Mixture	Regional samples Diesel WDK-02	Class Batch Mixture	Regional samples Diesel WDK-03
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.208	50.00	2.429	50.00	2.469
45.00	2.438	45.00	2.695	45.00	2.743
40.00	2.672	40.00	2.969	40.00	3.024
35.00	2.944	35.00	3.289	35.00	3.354
30.00	3.262	30.00	3.667	30.00	3.744
25.00	3.637	25.00	4.117	25.00	4.210
20.00	4.081	20.00	4.653	20.00	4.766
15.00	4.623	15.00	5.319	15.00	5.458
10.00	5.279	10.00	6.133	10.00	6.306
5.00	6.089	5.00	7.148	5.00	7.368
0.00	7.100	0.00	8.437	0.00	8.718
-5.00	8.411	-5.00	10.099	-5.00	10.470
-10.00	10.937	-10.00	12.373	-10.00	12.951
-15.00	13.353	-15.00	16.324	-15.00	16.488
-20.00	16.647	-20.00	20.627	-20.00	21.703

Class Batch Mixture	Regional samples Diesel WDK-04	Class Batch Mixture	Regional samples Diesel WDK-05	Class Batch Mixture	Regional samples Diesel WDK-06
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.177	50.00	2.417	50.00	2.455
45.00	2.404	45.00	2.684	45.00	2.727
40.00	2.634	40.00	2.958	40.00	3.006
35.00	2.901	35.00	3.279	35.00	3.332
30.00	3.213	30.00	3.660	30.00	3.718
25.00	3.582	25.00	4.113	25.00	4.179
20.00	4.019	20.00	4.655	20.00	4.728
15.00	4.551	15.00	5.328	15.00	5.411
10.00	5.196	10.00	6.153	10.00	6.247
5.00	5.991	5.00	7.186	5.00	7.291
0.00	6.985	0.00	8.500	0.00	8.619
-5.00	8.254	-5.00	10.204	-5.00	10.336
-10.00	10.237	-10.00	12.485	-10.00	13.363
-15.00	12.724	-15.00	19.346	-15.00	16.722
-20.00	15.852	0.00	0.000	-20.00	23.225

Winter-grade diesel

Class Batch Mixture	Regional samples Diesel WDK-07	Class Batch Mixture	Regional samples Diesel WDK-08	Class Batch Mixture	Regional samples Diesel WDK-09
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.139	50.00	1.843	50.00	2.506
45.00	2.361	45.00	2.020	45.00	2.784
40.00	2.587	40.00	2.199	40.00	3.069
35.00	2.848	35.00	2.405	35.00	3.403
30.00	3.155	30.00	2.644	30.00	3.797
25.00	3.518	25.00	2.923	25.00	4.267
20.00	3.948	20.00	3.253	20.00	4.828
15.00	4.472	15.00	3.644	15.00	5.525
10.00	5.107	10.00	4.115	10.00	6.377
5.00	5.892	5.00	4.687	5.00	7.442
0.00	6.875	0.00	5.393	0.00	8.793
-5.00	8.127	-5.00	6.275	-5.00	10.535
-10.00	10.433	-10.00	7.395	-10.00	13.409
-15.00	12.816	-15.00	9.466	-15.00	18.114
-20.00	15.961	-20.00	11.656	-20.00	23.837

Class Batch Mixture	Regional samples Diesel WDK-10	Class Batch Mixture	Regional samples Diesel WDK-11	Class Batch Mixture	Regional samples Diesel WDK-12
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.208	50.00	2.053	50.00	2.275
45.00	2.440	45.00	2.262	45.00	2.518
40.00	2.676	40.00	2.477	40.00	2.764
35.00	2.951	35.00	2.717	35.00	3.052
30.00	3.274	30.00	3.002	30.00	3.390
25.00	3.656	25.00	3.338	25.00	3.791
20.00	4.109	20.00	3.736	20.00	4.266
15.00	4.664	15.00	4.222	15.00	4.851
10.00	5.339	10.00	4.797	10.00	5.562
5.00	6.174	5.00	5.512	5.00	6.444
0.00	7.222	0.00	6.398	0.00	7.554
-5.00	8.560	-5.00	7.524	-5.00	8.984
-10.00	10.868	-10.00	9.591	-10.00	11.964
-15.00	13.431	-15.00	11.596	-15.00	15.045
-20.00	19.177	-20.00	14.644	-20.00	19.547

Winter-grade diesel

Class Batch Mixture	Regional samples Diesel WDK-13	Class Batch Mixture	Regional samples Diesel WDK-14	Class Batch Mixture	Regional samples Diesel WDK-15
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.006	50.00	2.244	50.00	2.167
45.00	2.208	45.00	2.482	45.00	2.393
40.00	2.412	40.00	2.724	40.00	2.623
35.00	2.648	35.00	3.007	35.00	2.890
30.00	2.923	30.00	3.339	30.00	3.202
25.00	3.246	25.00	3.732	25.00	3.572
20.00	3.628	20.00	4.199	20.00	4.010
15.00	4.088	15.00	4.772	15.00	4.545
10.00	4.644	10.00	5.469	10.00	5.194
5.00	5.326	5.00	6.333	5.00	5.995
0.00	6.173	0.00	7.420	0.00	6.999
-5.00	7.250	-5.00	8.810	-5.00	8.277
-10.00	9.167	-10.00	10.703	-10.00	11.086
-15.00	11.022	-15.00	14.531	-15.00	14.109
-20.00	13.712	-20.00	18.514	-20.00	20.885

Class Batch Mixture	Regional samples Diesel WDK-16	Class Batch Mixture	Regional samples Diesel WDK-17	Class Batch Mixture	Regional samples Diesel WDK-18
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.135	50.00	2.131	50.00	2.439
45.00	2.359	45.00	2.353	45.00	2.708
40.00	2.586	40.00	2.577	40.00	2.984
35.00	2.851	35.00	2.838	35.00	3.308
30.00	3.161	30.00	3.145	30.00	3.690
25.00	3.527	25.00	3.506	25.00	4.145
20.00	3.963	20.00	3.934	20.00	4.689
15.00	4.494	15.00	4.456	15.00	5.365
10.00	5.139	10.00	5.089	10.00	6.191
5.00	5.935	5.00	5.871	5.00	7.225
0.00	6.934	0.00	6.849	0.00	8.538
-5.00	8.207	-5.00	8.092	-5.00	10.236
-10.00	10.417	-10.00	9.713	-10.00	13.803
-15.00	13.011	-15.00	13.231	-15.00	17.259
-20.00	17.814	-20.00	16.463	-20.00	22.891

Summer-grade heating oil EL

Class Batch Mixture	Regional samples Heating oil SHEL-03	Class Batch Mixture	Regional samples Heating oil SHEL-05	Class Batch Mixture	Regional samples Heating oil SHEL-06
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.200	50.00	2.047	50.00	2.738
45.00	2.433	45.00	2.262	45.00	3.059
40.00	2.670	40.00	2.480	40.00	3.394
35.00	2.948	35.00	2.735	35.00	3.790
30.00	3.273	30.00	3.035	30.00	4.262
25.00	3.658	25.00	3.391	25.00	4.831
20.00	4.115	20.00	3.813	20.00	5.516
15.00	4.677	15.00	4.329	15.00	6.382
10.00	5.360	10.00	4.970	10.00	7.455
5.00	6.208	5.00	5.762	5.00	8.819
0.00	7.274	0.00	6.740	0.00	10.579
-5.00	9.312	-5.00	7.997	-5.00	13.910
-10.00	11.347	-10.00	9.649	-10.00	17.679

Class Batch Mixture	Regional samples Heating oil-01 SHEL-08	Class Batch Mixture	Regional samples Heating oil-01 SHEL-11	Class Batch Mixture	Regional samples Heating oil-01 SHEL-15
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.315	50.00	2.112	50.00	2.340
45.00	2.569	45.00	2.332	45.00	2.594
40.00	2.831	40.00	2.556	40.00	2.856
35.00	3.137	35.00	2.817	35.00	3.163
30.00	3.499	30.00	3.122	30.00	3.523
25.00	3.931	25.00	3.483	25.00	3.955
20.00	4.448	20.00	3.911	20.00	4.466
15.00	5.091	15.00	4.433	15.00	5.102
10.00	5.880	10.00	5.068	10.00	5.881
5.00	6.872	5.00	5.851	5.00	6.847
0.00	8.262	0.00	6.862	0.00	8.076
-5.00	10.690	-5.00	8.665	-5.00	10.218
-10.00	14.040	-10.00	11.313	-10.00	12.549

Class Batch Mixture	Regional samples Heating oil-01 SHEL-16	Class Batch Mixture	Regional samples Heating oil-01 SHEL-17	Class Batch Mixture	Regional samples Heating oil-01 SHEL-18
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.246	50.00	2.275	50.00	2.370
45.00	2.485	45.00	2.521	45.00	2.630
40.00	2.730	40.00	2.772	40.00	2.898
35.00	3.016	35.00	3.066	35.00	3.210
30.00	3.353	30.00	3.411	30.00	3.579
25.00	3.751	25.00	3.822	25.00	4.018
20.00	4.224	20.00	4.311	20.00	4.541
15.00	4.806	15.00	4.913	15.00	5.189
10.00	5.515	10.00	5.650	10.00	5.983
5.00	6.396	5.00	6.568	5.00	6.975
0.00	7.560	0.00	7.763	0.00	8.269
-5.00	9.636	-5.00	9.923	-5.00	10.590
-10.00	11.929	-10.00	12.354	-10.00	13.392

Winter-grade heating oil EL

Class Batch Mixture	Regional samples Heating oil-02 WSHEL-03	Class Batch Mixture	Regional samples Heating oil-02 WSHEL-05	Class Batch Mixture	Regional samples Heating oil-02 WSHEL-08
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.470	50.00	1.939	50.00	2.293
45.00	2.745	45.00	2.136	45.00	2.543
40.00	3.027	40.00	2.336	40.00	2.799
35.00	3.358	35.00	2.568	35.00	3.099
30.00	3.749	30.00	2.839	30.00	3.453
25.00	4.217	25.00	3.159	25.00	3.875
20.00	4.775	20.00	3.539	20.00	4.379
15.00	5.471	15.00	3.999	15.00	5.004
10.00	6.322	10.00	4.559	10.00	5.771
5.00	7.389	5.00	5.250	5.00	6.730
0.00	9.438	0.00	6.115	0.00	8.640
-5.00	11.589	-5.00	7.214	-5.00	10.876
-10.00	14.561	-10.00	8.637	-10.00	13.783

Class Batch Mixture	Regional samples Heating oil-02 WSHEL-17
Temperature °C	Dynamic viscosity mPa s
50.00	2.284
45.00	2.533
40.00	2.787
35.00	3.085
30.00	3.436
25.00	3.854
20.00	4.352
15.00	4.969
10.00	5.727
5.00	6.672
0.00	7.871
-5.00	9.959
-10.00	14.404

Summer-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	SHEL-Sarm-01	Mixture	SHEL-Sarm-02	Mixture	SHEL-Sarm-03
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.787	50.00	2.079	50.00	2.357
45.00	3.111	45.00	2.297	45.00	2.615
40.00	3.449	40.00	2.519	40.00	2.881
35.00	3.848	35.00	2.778	35.00	3.192
30.00	4.324	30.00	3.082	30.00	3.559
25.00	4.897	25.00	3.442	25.00	3.997
20.00	5.584	20.00	3.868	20.00	4.518
15.00	6.452	15.00	4.390	15.00	5.166
10.00	7.527	10.00	5.026	10.00	5.958
5.00	8.885	5.00	5.814	5.00	6.949
0.00	11.058	0.00	6.806	0.00	8.206
-5.00	14.309	-5.00	8.440	-5.00	9.829
-10.00	18.567	-10.00	10.169	-10.00	12.041

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	SHEL-Sarm-04	Mixture	SHEL-Sarm-05	Mixture	SHEL-Sarm-07
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.487	50.00	2.658	50.00	1.917
45.00	2.765	45.00	2.970	45.00	2.108
40.00	3.052	40.00	3.296	40.00	2.301
35.00	3.388	35.00	3.681	35.00	2.525
30.00	3.785	30.00	4.141	30.00	2.785
25.00	4.260	25.00	4.697	25.00	3.091
20.00	4.828	20.00	5.367	20.00	3.453
15.00	5.535	15.00	6.215	15.00	3.886
10.00	6.403	10.00	7.270	10.00	4.410
5.00	7.491	5.00	8.614	5.00	5.053
0.00	8.875	0.00	10.355	0.00	5.850
-5.00	11.778	-5.00	12.661	-5.00	6.853
-10.00	15.743	-10.00	18.219	-10.00	8.618

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	SHEL-Sarm-08	Mixture	SHEL-Sarm-10	Mixture	SHEL-Sarm-12
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	1.743	50.00	2.530	50.00	2.251
45.00	1.907	45.00	2.816	45.00	2.492
40.00	2.074	40.00	3.112	40.00	2.739
35.00	2.266	35.00	3.460	35.00	3.028
30.00	2.489	30.00	3.873	30.00	3.367
25.00	2.748	25.00	4.368	25.00	3.770
20.00	3.056	20.00	4.960	20.00	4.249
15.00	3.417	15.00	5.702	15.00	4.840
10.00	3.854	10.00	6.615	10.00	5.560
5.00	4.386	5.00	7.764	5.00	6.457
0.00	5.041	0.00	9.245	0.00	7.600
-5.00	5.857	-5.00	12.867	-5.00	9.726
-10.00	7.339	-10.00	16.297	-10.00	12.116

Summer-grade low-sulphur heating oil EL

Class	Regional samples	Class	Regional samples	Class	Regional samples
Batch	Low-sulphur heating oil	Batch	Low-sulphur heating oil	Batch	Low-sulphur heating oil
Mixture	SHEL-Sarm-13	Mixture	SHEL-Sarm-14	Mixture	SHEL-Sarm-15
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.645	50.00	2.005	50.00	2.237
45.00	2.952	45.00	2.211	45.00	2.476
40.00	3.270	40.00	2.420	40.00	2.722
35.00	3.646	35.00	2.664	35.00	3.008
30.00	4.094	30.00	2.949	30.00	3.345
25.00	4.634	25.00	3.285	25.00	3.746
20.00	5.282	20.00	3.685	20.00	4.221
15.00	6.100	15.00	4.169	15.00	4.807
10.00	7.111	10.00	4.757	10.00	5.522
5.00	8.393	5.00	5.485	5.00	6.411
0.00	10.268	0.00	6.396	0.00	7.533
-5.00	13.578	-5.00	7.554	-5.00	8.972
-10.00	19.366	-10.00	9.054	-10.00	11.874

Class	Regional samples	Class	Regional samples	Class	Regional samples
Batch	Low-sulphur heating oil	Batch	Low-sulphur heating oil	Batch	Low-sulphur heating oil
Mixture	SHEL-Sarm-16	Mixture	SHEL-Sarm-17	Mixture	SHEL-Sarm-18
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.022	50.00	2.358	50.00	2.358
45.00	2.226	45.00	2.616	45.00	2.616
40.00	2.434	40.00	2.880	40.00	2.880
35.00	2.674	35.00	3.188	35.00	3.189
30.00	2.954	30.00	3.552	30.00	3.553
25.00	3.284	25.00	3.986	25.00	3.986
20.00	3.673	20.00	4.502	20.00	4.501
15.00	4.142	15.00	5.140	15.00	5.140
10.00	4.709	10.00	5.921	10.00	5.919
5.00	5.405	5.00	6.894	5.00	6.893
0.00	6.269	0.00	8.128	0.00	8.124
-5.00	7.365	-5.00	10.791	-5.00	11.115
-10.00	10.154	-10.00	14.234	-10.00	16.104

Winter-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	WHEL-Sarm-01	Mixture	WHEL-Sarm-02	Mixture	WHEL-Sarm-04
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.400	50.00	1.958	50.00	2.728
45.00	2.664	45.00	2.155	45.00	3.045
40.00	2.933	40.00	2.356	40.00	3.375
35.00	3.249	35.00	2.588	35.00	3.760
30.00	3.622	30.00	2.860	30.00	4.222
25.00	4.066	25.00	3.179	25.00	4.777
20.00	4.595	20.00	3.557	20.00	5.443
15.00	5.251	15.00	4.013	15.00	6.282
10.00	6.053	10.00	4.567	10.00	7.317
5.00	7.054	5.00	5.247	5.00	8.626
0.00	8.326	0.00	6.096	0.00	10.319
-5.00	10.942	-5.00	7.431	-5.00	13.172
-10.00	13.655	-10.00	8.894	-10.00	16.786

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	WHEL-Sarm-05	Mixture	WHEL-Sarm-06	Mixture	WHEL-Sarm-07
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	1.921	50.00	2.549	50.00	2.343
45.00	2.115	45.00	2.838	45.00	2.572
40.00	2.312	40.00	3.138	40.00	2.818
35.00	2.541	35.00	3.490	35.00	3.119
30.00	2.807	30.00	3.907	30.00	3.473
25.00	3.121	25.00	4.408	25.00	3.896
20.00	3.494	20.00	5.007	20.00	4.398
15.00	3.943	15.00	5.758	15.00	5.021
10.00	4.489	10.00	6.682	10.00	5.781
5.00	5.161	5.00	7.846	5.00	6.731
0.00	5.999	0.00	9.336	0.00	7.939
-5.00	7.062	-5.00	11.918	-5.00	9.939
-10.00	8.434	-10.00	15.315	-10.00	12.805

Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur	Class	Regional samples Low-sulphur
Batch	heating oil	Batch	heating oil	Batch	heating oil
Mixture	WHEL-Sarm-08	Mixture	WHEL-Sarm-09	Mixture	WHEL-Sarm-10
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	1.938	50.00	2.210	50.00	2.099
45.00	2.132	45.00	2.443	45.00	2.318
40.00	2.328	40.00	2.679	40.00	2.541
35.00	2.555	35.00	2.954	35.00	2.800
30.00	2.820	30.00	3.277	30.00	3.104
25.00	3.131	25.00	3.658	25.00	3.463
20.00	3.500	20.00	4.110	20.00	3.890
15.00	3.943	15.00	4.662	15.00	4.411
10.00	4.481	10.00	5.332	10.00	5.046
5.00	5.142	5.00	6.162	5.00	5.834
0.00	5.964	0.00	7.201	0.00	6.825
-5.00	7.368	-5.00	9.705	-5.00	8.658
-10.00	8.722	-10.00	14.793	-10.00	10.852

Winter-grade low-sulphur heating oil EL

Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil
Batch		Batch		Batch	
Mixture	WHEL-Sarm-11	Mixture	WHEL-Sarm-12	Mixture	WHEL-Sarm-13
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	1.984	50.00	2.449	50.00	2.760
45.00	2.184	45.00	2.732	45.00	3.087
40.00	2.388	40.00	2.999	40.00	3.429
35.00	2.624	35.00	3.328	35.00	3.835
30.00	2.900	30.00	3.721	30.00	4.321
25.00	3.224	25.00	4.179	25.00	4.908
20.00	3.609	20.00	4.733	20.00	5.618
15.00	4.073	15.00	5.426	15.00	6.520
10.00	4.636	10.00	6.276	10.00	7.645
5.00	5.331	5.00	7.341	5.00	9.081
0.00	6.198	0.00	9.506	0.00	10.952
-5.00	7.294	-5.00	11.674	-5.00	14.145
-10.00	8.962	-10.00	14.884	-10.00	18.133

Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil
Batch		Batch		Batch	
Mixture	WHEL-Sarm-14	Mixture	WHEL-Sarm-15	Mixture	WHEL-Sarm-16
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.826	50.00	1.929	50.00	2.125
45.00	3.160	45.00	2.123	45.00	2.349
40.00	3.508	40.00	2.319	40.00	2.577
35.00	3.921	35.00	2.547	35.00	2.843
30.00	4.415	30.00	2.813	30.00	3.156
25.00	5.011	25.00	3.126	25.00	3.526
20.00	5.729	20.00	3.497	20.00	3.966
15.00	6.638	15.00	3.943	15.00	4.505
10.00	7.764	10.00	4.483	10.00	5.161
5.00	9.198	5.00	5.149	5.00	5.975
0.00	11.067	0.00	5.979	0.00	7.001
-5.00	13.595	-5.00	7.030	-5.00	8.315
-10.00	17.864	-10.00	8.381	-10.00	10.025

Class	Regional samples Low-sulphur heating oil	Class	Regional samples Low-sulphur heating oil
Batch		Batch	
Mixture	WHEL-Sarm-17	Mixture	WHEL-Sarm-18
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s
50.00	1.827	50.00	2.300
45.00	2.004	45.00	2.548
40.00	2.185	40.00	2.801
35.00	2.393	35.00	3.097
30.00	2.635	30.00	3.446
25.00	2.918	25.00	3.860
20.00	3.254	20.00	4.354
15.00	3.652	15.00	4.963
10.00	4.135	10.00	5.705
5.00	4.726	5.00	6.629
0.00	5.457	0.00	7.797
-5.00	6.374	-5.00	9.366
-10.00	7.545	-10.00	12.390

Viscosity of the mixtures containing biofuel

Ethanol – n-hexane

Class Batch Mixture	Ethanol - hexane Batch 01 Mixture 05-95	Class Batch Mixture	Ethanol - hexane Batch 01 Mixture 10-90
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-15.00	0.712	-15.00	0.761
-10.00	0.678	-10.00	0.722
-5.00	0.645	-5.00	0.685
0.00	0.616	0.00	0.650
5.00	0.587	5.00	0.617
10.00	0.560	10.00	0.587
15.00	0.533	15.00	0.559

Ethanol – n-nonane

Class Batch Mixture	Ethanol - nonane Batch 01 Mixture 05-95	Class Batch Mixture	Ethanol - nonane Batch 01 Mixture 50-50	Class Batch Mixture	Ethanol - nonane Batch 01 Mixture 80-20
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-15.00	1.675	-15.00	2.388	-15.00	2.734
-10.00	1.537	-10.00	2.161	-10.00	2.471
-5.00	1.418	-5.00	1.963	-5.00	2.239
0.00	1.312	0.00	1.788	0.00	2.033
5.00	1.218	5.00	1.634	5.00	1.851
10.00	1.135	10.00	1.496	10.00	1.689
15.00	1.060	15.00	1.374	15.00	1.544
20.00	0.964	20.00	1.252	20.00	1.411
25.00	0.931	25.00	1.166	25.00	1.299
30.00	0.878	30.00	1.077	30.00	1.195
35.00	0.826	35.00	0.991	35.00	1.099
40.00	0.767	40.00	0.919	40.00	1.007
45.00	0.716	45.00	0.846	45.00	0.930
50.00	0.665	50.00	0.763	50.00	0.840

Ethanol – summer-grade super petrol

Class	Ethanol - super petrol	Class	Ethanol - super petrol	Class	Ethanol - super petrol
Batch	Batch 14	Batch	Batch 14	Batch	Batch 14
Sample liquid	Mixture 0-100	Sample liquid	Mixture 5-95	Sample liquid	Mixture 10-90
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-15.00	0.680	-15.00	0.716	-15.00	0.784
-10.00	0.642	-10.00	0.674	-10.00	0.735
-5.00	0.608	-5.00	0.636	-5.00	0.691
0.00	0.578	0.00	0.602	0.00	0.651
5.00	0.550	5.00	0.571	5.00	0.615
10.00	0.524	10.00	0.542	10.00	0.582
15.00	0.500	15.00	0.516	15.00	0.552
25.00	0.459	25.00	0.469	25.00	0.499
30.00	0.439			30.00	0.476
				35.00	0.454
				40.00	0.434

Class	Ethanol - super petrol	Class	Ethanol - super petrol	Class	Ethanol - super petrol
Batch	Batch 14	Batch	Batch 14	Batch	14
Sample liquid	Mixture 15-85	Sample liquid	Mixture 20-80	Sample liquid	Mixture 40-60
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-15.00	0.862	-15.00	0.952	-15.00	1.420
-10.00	0.802	-10.00	0.883	-10.00	1.296
-5.00	0.750	-5.00	0.821	-5.00	1.188
0.00	0.703	0.00	0.765	0.00	1.091
5.00	0.661	5.00	0.716	5.00	1.005
10.00	0.623	10.00	0.670	10.00	0.929
15.00	0.588	15.00	0.629	15.00	0.861
		25.00	0.558	25.00	0.743
		30.00	0.527		
		35.00	0.500		
		40.00	0.474		
		45.00	0.451		

Class	Ethanol - super petrol	Class	Ethanol - super petrol	Class	Ethanol - super petrol
Batch	14	Batch	14	Batch	14
Sample liquid	Mixture 50-50	Sample liquid	Mixture 60-40	Sample liquid	Mixture 80-20
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
-15.00	1.665	-15.00	1.920	-15.00	2.446
-10.00	1.514	-10.00	1.741	-10.00	2.206
-5.00	1.381	-5.00	1.583	-5.00	1.995
0.00	1.263	0.00	1.443	0.00	1.810
5.00	1.159	5.00	1.319	5.00	1.646
10.00	1.066	10.00	1.208	10.00	1.501
15.00	0.982	15.00	1.110	15.00	1.372
		25.00	0.942	25.00	1.154
		30.00	0.871	30.00	1.061
		35.00	0.807		

Ethanol – summer-grade super petrol

Class	Ethanol - super petrol
Batch	Batch 14
Sample liquid	Mixture 85-15
Temperature °C	Dynamic viscosity mPa s
-15.00	2.580
-10.00	2.324
-5.00	2.100
0.00	1.903
5.00	1.728
10.00	1.572
15.00	1.434

Class	Ethanol - super petrol
Batch	Batch 14
Sample liquid	Mixture 100-0
Temperature °C	Dynamic viscosity mPa s
-15.00	3.042
-10.00	2.729
-5.00	2.458
0.00	2.218
5.00	2.007
10.00	1.821
15.00	1.657
25.00	1.380
30.00	1.263
35.00	1.160
40.00	1.065

Class	Ethanol - super petrol
Batch	Batch 14
Sample liquid	Mixture 2.5-97.5
Temperature °C	Dynamic viscosity mPa s
-15.00	0.695
-10.00	0.655
-5.00	0.620
0.00	0.588
5.00	0.558
10.00	0.531
15.00	0.507
25.00	0.463
30.00	0.444
35.00	0.426
40.00	0.409

Class	Ethanol - super petrol
Batch	Batch 14
Sample liquid	Mixture 7.5-92.5
Temperature °C	Dynamic viscosity mPa s
-15.00	0.745
-10.00	0.700
-5.00	0.660
0.00	0.623
5.00	0.589
10.00	0.559
15.00	0.532

Class	Ethanol - super petrol
Batch	14
Sample liquid	Mixture 12.5-87.5
Temperature °C	Dynamic viscosity mPa s
-15.00	0.819
-10.00	0.765
-5.00	0.717
0.00	0.674
5.00	0.634
10.00	0.599
15.00	0.567
25.00	0.510

Ethanol – Winter-grade super petrol

Class	Ethanol - super petrol	Class	Ethanol - super petrol	Class	Ethanol - super petrol
Batch	Batch 13	Batch	Batch 13	Batch	Batch 13
Sample liquid	Mixture 0-100	Sample liquid	Mixture 5-95	Sample liquid	Mixture 10-90
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
-15.00	0.631	-15.00	0.692	-15.00	0.733
-10.00	0.599	-10.00	0.650	-10.00	0.686
-5.00	0.569	-5.00	0.613	-5.00	0.647
0.00	0.542	0.00	0.580	0.00	0.610
5.00	0.517	5.00	0.551	5.00	0.577
10.00	0.493	10.00	0.526	10.00	0.547
				15.00	0.520
				25.00	0.468

Class	Ethanol - super petrol	Class	Ethanol - super petrol	Class	Ethanol - super petrol
Batch	Batch 13	Batch	Batch 13	Batch	Batch 13
Sample liquid	Mixture 15-85	Sample liquid	Mixture 20-80	Sample liquid	Mixture 40-60
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
-15.00	0.816	-15.00	0.920	-15.00	1.374
-10.00	0.762	-10.00	0.854	-10.00	1.256
-5.00	0.712	-5.00	0.794	-5.00	1.150
0.00	0.668	0.00	0.741	0.00	1.057
5.00	0.628	5.00	0.693	5.00	0.974
10.00	0.591	10.00	0.650	10.00	0.899
25.00	0.501	15.00	0.611	15.00	0.833

Class	Ethanol - super petrol	Class	Ethanol - super petrol	Class	Ethanol - super petrol
Batch	Batch 13	Batch	Batch 13	Batch	Batch 13
Sample liquid	Mixture 60-40	Sample liquid	Mixture 80-20a	Sample liquid	Mixture 85-15a
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
-15.00	1.878	-15.00	2.413	-15.00	2.560
-10.00	1.704	-10.00	2.179	-10.00	2.309
-5.00	1.551	-5.00	1.973	-5.00	2.088
0.00	1.414	0.00	1.790	0.00	1.892
5.00	1.292	5.00	1.628	5.00	1.719
10.00	1.184	10.00	1.484	10.00	1.565
15.00	1.088	15.00	1.356	15.00	1.428
		25.00	1.140	25.00	1.198
		30.00	1.048		

Ethanol – Winter-grade super petrol

Class	Ethanol - super petrol
Batch	Batch 13
Sample liquid	Mixture 100-0
Temperature °C	Dynamic viscosity mPa s
-15.00	3.032
-10.00	2.723
-5.00	2.453
0.00	2.214
5.00	2.004
10.00	1.820
15.00	1.655
25.00	1.379
30.00	1.262
35.00	1.159
40.00	1.067

Class	Ethanol - super petrol
Batch	Batch 13
Sample liquid	Mixture 2.5-97.5
Temperature °C	Dynamic viscosity mPa s
-15.00	0.653
-10.00	0.618
-5.00	0.586
0.00	0.557
5.00	0.530
10.00	0.505

Class	Ethanol - super petrol
Batch	Batch 13
Sample liquid	Mixture 7.5-92.5
Temperature °C	Dynamic viscosity mPa s
-15.00	0.700
-10.00	0.659
-5.00	0.623
0.00	0.589
5.00	0.559
10.00	0.531
15.00	0.506

Class	Ethanol - super petrol
Batch	Batch 13
Sample liquid	Mixture 12.5-87.5
Temperature °C	Dynamic viscosity mPa s
-15.00	0.772
-10.00	0.723
-5.00	0.679
0.00	0.640
5.00	0.603
10.00	0.571
15.00	0.541
25.00	0.487
30.00	0.465

Rapeseed methyl ester – summer-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 5-95	Mixture	Mixture 10-90
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.640	50.00	2.676	50.00	2.710
45.00	2.944	45.00	2.983	45.00	3.021
40.00	3.259	40.00	3.301	40.00	3.342
35.00	3.630	35.00	3.675	35.00	3.721
30.00	4.071	30.00	4.121	30.00	4.171
25.00	4.602	25.00	4.657	25.00	4.712
20.00	5.238	20.00	5.299	20.00	5.359
15.00	6.040	15.00	6.108	15.00	6.174
10.00	7.027	10.00	7.103	10.00	7.175
5.00	8.276	5.00	8.361	5.00	8.440
0.00	9.880	0.00	9.975	0.00	10.061

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.748	50.00	2.788	50.00	2.874
45.00	3.061	45.00	3.106	45.00	3.202
40.00	3.387	40.00	3.436	40.00	3.540
35.00	3.770	35.00	3.823	35.00	3.940
30.00	4.225	30.00	4.284	30.00	4.414
25.00	4.771	25.00	4.837	25.00	4.981
20.00	5.424	20.00	5.498	20.00	5.660
15.00	6.246	15.00	6.330	15.00	6.513
10.00	7.256	10.00	7.350	10.00	7.558
5.00	8.530	5.00	8.636	5.00	8.874
0.00	10.160	0.00	10.281	0.00	10.556

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.968	50.00	3.068	50.00	3.175
45.00	3.305	45.00	3.417	45.00	3.536
40.00	3.655	40.00	3.779	40.00	3.910
35.00	4.067	35.00	4.204	35.00	4.351
30.00	4.556	30.00	4.709	30.00	4.875
25.00	5.141	25.00	5.314	25.00	5.501
20.00	5.839	20.00	6.036	20.00	6.247
15.00	6.717	15.00	6.942	15.00	7.185
10.00	7.793	10.00	8.052	10.00	8.332
5.00	9.145	5.00	9.445	5.00	9.772
0.00	10.871	0.00	11.223	0.00	11.609

Rapeseed methyl ester RME – summer-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.288	50.00	3.408	50.00	3.534
45.00	3.661	45.00	3.795	45.00	3.936
40.00	4.050	40.00	4.199	40.00	4.355
35.00	4.507	35.00	4.674	35.00	4.849
30.00	5.050	30.00	5.237	30.00	5.434
25.00	5.699	25.00	5.911	25.00	6.135
20.00	6.471	20.00	6.713	20.00	6.968
15.00	7.444	15.00	7.723	15.00	8.017
10.00	8.633	10.00	8.956	10.00	9.299
5.00	10.124	5.00	10.504	5.00	10.906
0.00	12.025	0.00	12.475	0.00	12.952

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 95-5	Mixture	Mixture 100-0	Mixture	Mixture 7-93
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.600	50.00	3.669	50.00	2.689
45.00	4.008	45.00	4.085	45.00	2.997
40.00	4.437	40.00	4.522	40.00	3.316
35.00	4.940	35.00	5.036	35.00	3.693
30.00	5.538	30.00	5.645	30.00	4.140
25.00	6.251	25.00	6.374	25.00	4.677
20.00	7.102	20.00	7.241	20.00	5.321
15.00	8.173	15.00	8.334	15.00	6.131
10.00	9.479	10.00	9.667	10.00	7.127
5.00	11.119	5.00	11.342	5.00	8.386
0.00	13.211	0.00	13.508	0.00	10.000

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 2.5-97.5	Mixture	Mixture 7.5-92.5	Mixture	Mixture 12.5-87.5
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.663	50.00	2.691	50.00	2.729
45.00	2.971	45.00	2.999	45.00	3.041
40.00	3.290	40.00	3.319	40.00	3.364
35.00	3.667	35.00	3.695	35.00	3.744
30.00	4.115	30.00	4.143	30.00	4.197
25.00	4.653	25.00	4.681	25.00	4.740
20.00	5.300	20.00	5.325	20.00	5.389
15.00	6.113	15.00	6.136	15.00	6.208
10.00	7.117	10.00	7.133	10.00	7.213
5.00	8.386	5.00	8.394	5.00	8.481
0.00	10.017	0.00	10.009	0.00	10.105

Rapeseed methyl ester RME – winter-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 0-100	Mixture	Mixture 5-95	Mixture	Mixture 10-90
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.061	50.00	2.107	50.00	2.165
45.00	2.273	45.00	2.322	45.00	2.388
40.00	2.486	40.00	2.541	40.00	2.613
35.00	2.735	35.00	2.793	35.00	2.874
30.00	3.024	30.00	3.089	30.00	3.179
25.00	3.366	25.00	3.437	25.00	3.539
20.00	3.770	20.00	3.848	20.00	3.964
15.00	4.260	15.00	4.347	15.00	4.481
10.00	4.856	10.00	4.950	10.00	5.106
5.00	5.588	5.00	5.690	5.00	5.875
0.00	6.498	0.00	6.610	0.00	6.831

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.224	50.00	2.285	50.00	2.428
45.00	2.454	45.00	2.522	45.00	2.684
40.00	2.686	40.00	2.763	40.00	2.943
35.00	2.957	35.00	3.043	35.00	3.241
30.00	3.273	30.00	3.370	30.00	3.595
25.00	3.645	25.00	3.755	25.00	4.013
20.00	4.085	20.00	4.211	20.00	4.502
15.00	4.621	15.00	4.768	15.00	5.107
10.00	5.269	10.00	5.442	10.00	5.841
5.00	6.067	5.00	6.271	5.00	6.743
0.00	7.060	0.00	7.307	0.00	7.871

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.566	50.00	2.716	50.00	2.897
45.00	2.833	45.00	3.010	45.00	3.215
40.00	3.112	40.00	3.309	40.00	3.535
35.00	3.435	35.00	3.658	35.00	3.935
30.00	3.815	30.00	4.069	30.00	4.359
25.00	4.264	25.00	4.556	25.00	4.889
20.00	4.796	20.00	5.133	20.00	5.516
15.00	5.452	15.00	5.848	15.00	6.298
10.00	6.248	10.00	6.716	10.00	7.244
5.00	7.231	5.00	7.790	5.00	8.421
0.00	8.464	0.00	9.139	0.00	9.908

Rapeseed methyl ester RME – winter-grade diesel

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.077	50.00	3.268	50.00	3.479
45.00	3.416	45.00	3.632	45.00	3.871
40.00	3.766	40.00	4.010	40.00	4.280
35.00	4.176	35.00	4.451	35.00	4.760
30.00	4.660	30.00	4.974	30.00	5.329
25.00	5.236	25.00	5.601	25.00	6.009
20.00	5.919	20.00	6.342	20.00	6.817
15.00	6.773	15.00	7.271	15.00	7.832
10.00	7.809	10.00	8.402	10.00	9.071
5.00	9.099	5.00	9.814	5.00	10.621
0.00	10.731	0.00	11.605	0.00	12.597

Class	RME - mineral diesel	Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 95-05	Mixture	Mixture 100-0	Mixture	Mixture 7-93
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.586	50.00	3.690	50.00	2.130
45.00	3.991	45.00	4.110	45.00	2.348
40.00	4.415	40.00	4.551	40.00	2.569
35.00	4.915	35.00	5.070	35.00	2.825
30.00	5.508	30.00	5.685	30.00	3.124
25.00	6.221	25.00	6.422	25.00	3.476
20.00	7.060	20.00	7.299	20.00	3.892
15.00	8.122	15.00	8.404	15.00	4.399
10.00	9.419	10.00	9.755	10.00	5.029
5.00	11.044	5.00	11.452	5.00	5.764
0.00	13.126	0.00	13.645	0.00	6.699

Class	RME - mineral diesel	Class	RME - mineral diesel
Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 2.5-97.5	Mixture	Mixture 12.5-87.5
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s
50.00	2.079	50.00	2.194
45.00	2.290	45.00	2.419
40.00	2.506	40.00	2.648
35.00	2.755	35.00	2.913
30.00	3.046	30.00	3.223
25.00	3.389	25.00	3.589
20.00	3.794	20.00	4.021
15.00	4.283	15.00	4.549
10.00	4.875	10.00	5.186
5.00	5.602	5.00	5.968
0.00	6.507	0.00	6.943

Soy methyl ester SME – summer-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 5-95	Mixture	Mixture 10-90
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.640	50.00	2.663	50.00	2.685
45.00	2.944	45.00	2.967	45.00	2.991
40.00	3.259	40.00	3.283	40.00	3.307
35.00	3.630	35.00	3.654	35.00	3.679
30.00	4.071	30.00	4.096	30.00	4.122
25.00	4.602	25.00	4.627	25.00	4.652
20.00	5.238	20.00	5.262	20.00	5.287
15.00	6.040	15.00	6.062	15.00	6.085
10.00	7.027	10.00	7.045	10.00	7.066
5.00	8.276	5.00	8.286	5.00	8.302
0.00	9.880	0.00	9.878	0.00	9.884

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.711	50.00	2.740	50.00	2.802
45.00	3.019	45.00	3.050	45.00	3.118
40.00	3.337	40.00	3.371	40.00	3.443
35.00	3.712	35.00	3.747	35.00	3.825
30.00	4.156	30.00	4.194	30.00	4.278
25.00	4.688	25.00	4.729	25.00	4.820
20.00	5.325	20.00	5.368	20.00	5.465
15.00	6.124	15.00	6.169	15.00	6.274
10.00	7.104	10.00	7.151	10.00	7.264
5.00	8.339	5.00	8.387	5.00	8.505
0.00	9.916	0.00	9.963	0.00	10.084

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.872	50.00	2.947	50.00	3.029
45.00	3.193	45.00	3.276	45.00	3.365
40.00	3.525	40.00	3.615	40.00	3.713
35.00	3.915	35.00	4.012	35.00	4.120
30.00	4.375	30.00	4.483	30.00	4.601
25.00	4.926	25.00	5.044	25.00	5.175
20.00	5.581	20.00	5.710	20.00	5.856
15.00	6.401	15.00	6.547	15.00	6.708
10.00	7.402	10.00	7.563	10.00	7.745
5.00	8.656	5.00	8.835	5.00	9.040
0.00	10.249	0.00	10.448	0.00	10.680

Soy methyl ester SME – summer-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.116	50.00	3.208	50.00	3.305
45.00	3.461	45.00	3.563	45.00	3.669
40.00	3.818	40.00	3.929	40.00	4.047
35.00	4.235	35.00	4.358	35.00	4.488
30.00	4.729	30.00	4.865	30.00	5.009
25.00	5.317	25.00	5.468	25.00	5.629
20.00	6.013	20.00	6.182	20.00	6.361
15.00	6.885	15.00	7.075	15.00	7.280
10.00	7.945	10.00	8.160	10.00	8.392
5.00	9.266	5.00	9.512	5.00	9.778
0.00	10.937	0.00	11.219	0.00	11.526

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 95-5	Mixture	Mixture 100-0	Mixture	Mixture 7-93
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.356	50.00	3.403	50.00	2.671
45.00	3.725	45.00	3.777	45.00	2.976
40.00	4.108	40.00	4.165	40.00	3.292
35.00	4.556	35.00	4.619	35.00	3.664
30.00	5.085	30.00	5.153	30.00	4.106
25.00	5.713	25.00	5.790	25.00	4.637
20.00	6.456	20.00	6.542	20.00	5.272
15.00	7.387	15.00	7.483	15.00	6.071
10.00	8.515	10.00	8.623	10.00	7.052
5.00	9.918	5.00	10.041	5.00	8.291
0.00	11.690	0.00	11.831	0.00	9.879

Soy methyl ester SME – winter-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 0-100	Mixture	Mixture 05-95	Mixture	Mixture 10-90
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.062	50.00	2.101	50.00	2.151
45.00	2.271	45.00	2.314	45.00	2.370
40.00	2.482	40.00	2.530	40.00	2.592
35.00	2.737	35.00	2.780	35.00	2.850
30.00	3.013	30.00	3.073	30.00	3.150
25.00	3.350	25.00	3.418	25.00	3.503
20.00	3.749	20.00	3.826	20.00	3.920
15.00	4.231	15.00	4.320	15.00	4.428
10.00	4.815	10.00	4.917	10.00	5.040
5.00	5.532	5.00	5.651	5.00	5.794
0.00	6.424	0.00	6.564	0.00	6.732

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 15-85	Mixture	Mixture 20-80	Mixture	Mixture 30-70
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.215	50.00	2.251	50.00	2.365
45.00	2.445	45.00	2.482	45.00	2.608
40.00	2.674	40.00	2.716	40.00	2.855
35.00	2.941	35.00	2.989	35.00	3.143
30.00	3.250	30.00	3.307	30.00	3.480
25.00	3.622	25.00	3.682	25.00	3.877
20.00	4.053	20.00	4.125	20.00	4.347
15.00	4.580	15.00	4.667	15.00	4.921
10.00	5.239	10.00	5.319	10.00	5.615
5.00	5.952	5.00	6.116	5.00	6.469
0.00	6.910	0.00	7.110	0.00	7.534

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.486	50.00	2.620	50.00	2.761
45.00	2.746	45.00	2.898	45.00	3.056
40.00	3.011	40.00	3.180	40.00	3.357
35.00	3.319	35.00	3.508	35.00	3.708
30.00	3.678	30.00	3.893	30.00	4.121
25.00	4.103	25.00	4.349	25.00	4.608
20.00	4.604	20.00	4.885	20.00	5.183
15.00	5.220	15.00	5.548	15.00	5.896
10.00	5.962	10.00	6.349	10.00	6.754
5.00	6.876	5.00	7.335	5.00	7.820
0.00	8.018	0.00	8.571	0.00	9.154

Soy methyl ester SME – winter-grade diesel

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 70-30	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.917	50.00	3.082	50.00	3.256
45.00	3.231	45.00	3.416	45.00	3.613
40.00	3.552	40.00	3.761	40.00	3.985
35.00	3.928	35.00	4.163	35.00	4.412
30.00	4.370	30.00	4.637	30.00	4.920
25.00	4.893	25.00	5.200	25.00	5.523
20.00	5.510	20.00	5.863	20.00	6.237
15.00	6.278	15.00	6.691	15.00	7.129
10.00	7.205	10.00	7.693	10.00	8.210
5.00	8.352	5.00	8.935	5.00	9.552
0.00	9.795	0.00	10.498	0.00	11.245

Class	SME - mineral diesel	Class	SME - mineral diesel	Class	SME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 95-05	Mixture	Mixture 100-0	Mixture	Mixture 07-93
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.347	50.00	3.434	50.00	2.122
45.00	3.714	45.00	3.809	45.00	2.337
40.00	4.095	40.00	4.200	40.00	2.556
35.00	4.541	35.00	4.658	35.00	2.809
30.00	5.066	30.00	5.198	30.00	3.104
25.00	5.692	25.00	5.841	25.00	3.452
20.00	6.432	20.00	6.601	20.00	3.865
15.00	7.357	15.00	7.554	15.00	4.365
10.00	8.480	10.00	8.709	10.00	4.969
5.00	9.876	5.00	10.147	5.00	5.708
0.00	11.638	0.00	11.962	0.00	6.632

Palm oil methyl ester PME – summer-grade diesel

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 0-100	Mixture	Mixture 10-90	Mixture	Mixture 20-80
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.641	50.00	2.716	50.00	2.800
45.00	2.944	45.00	3.026	45.00	3.122
40.00	3.259	40.00	3.351	40.00	3.457
35.00	3.631	35.00	3.734	35.00	3.852
30.00	4.072	30.00	4.186	30.00	4.321
25.00	4.603	25.00	4.732	25.00	4.885
20.00	5.240	20.00	5.386	20.00	5.559
15.00	6.041	15.00	6.207	15.00	6.409
10.00	7.030	10.00	7.222	10.00	7.505
5.00	8.279	5.00	8.621	5.00	9.007
0.00	9.884	0.00	10.313	0.00	10.799

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.990	50.00	3.096	50.00	3.210
45.00	3.336	45.00	3.455	45.00	3.583
40.00	3.697	40.00	3.829	40.00	3.973
35.00	4.121	35.00	4.272	35.00	4.434
30.00	4.626	30.00	4.798	30.00	4.982
25.00	5.235	25.00	5.430	25.00	5.641
20.00	5.958	20.00	6.185	20.00	6.428
15.00	6.874	15.00	7.138	15.00	7.423
10.00	8.133	10.00	8.485	10.00	8.840
5.00	9.857	5.00	10.330		
0.00	12.096				

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 02	Batch	Batch 02	Batch	Batch 02
Mixture	Mixture 80-20	Mixture	Mixture 90-10	Mixture	Mixture 100-0
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	3.452	50.00	3.583	50.00	3.717
45.00	3.855	45.00	4.004	45.00	4.154
40.00	4.280	40.00	4.446	40.00	4.616
35.00	4.782	35.00	4.970	35.00	5.163
30.00	5.379	30.00	5.594	30.00	5.814
25.00	6.096	25.00	6.345	25.00	6.598
20.00	6.955	20.00	7.241	20.00	7.535
15.00	8.041	15.00	8.378	15.00	8.724

Palm oil methyl ester – winter-grade diesel

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 0-100	Mixture	Mixture 10-90	Mixture	Mixture 20-80
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.052	50.00	2.171	50.00	2.295
45.00	2.261	45.00	2.395	45.00	2.537
40.00	2.475	40.00	2.624	40.00	2.784
35.00	2.721	35.00	2.889	35.00	3.070
30.00	3.008	30.00	3.200	30.00	3.405
25.00	3.349	25.00	3.567	25.00	3.802
20.00	3.751	20.00	4.002	20.00	4.272
15.00	4.237	15.00	4.532	15.00	4.848
10.00	4.829	10.00	5.174	10.00	5.546
5.00	5.556	5.00	5.965	5.00	6.451
0.00	6.460	0.00	6.954	0.00	7.625

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 40-60	Mixture	Mixture 50-50	Mixture	Mixture 60-40
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.577	50.00	2.758	50.00	2.900
45.00	2.857	45.00	3.061	45.00	3.225
40.00	3.143	40.00	3.371	40.00	3.559
35.00	3.478	35.00	3.735	35.00	3.952
30.00	3.871	30.00	4.164	30.00	4.415
25.00	4.339	25.00	4.674	25.00	4.968
20.00	4.892	20.00	5.278	20.00	5.623
15.00	5.578	15.00	6.032	15.00	6.443
10.00	6.412	10.00	6.953	10.00	7.442
5.00	7.738				
0.00	9.323				

Class	PME - mineral diesel	Class	PME - mineral diesel	Class	PME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 80-20	Mixture	Mixture 90-10	Mixture	Mixture 100-0
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
45.00	3.658	50.00	3.492	50.00	3.714
40.00	4.051	45.00	3.897	45.00	4.150
35.00	4.514	40.00	4.324	40.00	4.611
30.00	5.063	35.00	4.827	35.00	5.155
25.00	5.721	30.00	5.425	30.00	5.804
20.00	6.504	25.00	6.143	25.00	6.584
15.00	7.491	20.00	7.000	20.00	7.519
0.00	0.000	15.00	8.084	15.00	8.701

Coconut oil methyl ester CME – summer-grade diesel

Class	CME - mineral diesel
Batch	Batch 02
Mixture	Mixture 40-60
Temperature °C	Dynamic viscosity mPa s
50.00	2.369
45.00	2.627
40.00	2.889
35.00	3.196
30.00	3.556
25.00	3.986
20.00	4.495
15.00	5.129
10.00	5.893
5.00	6.847
0.00	8.049

Class	CME - mineral diesel
Batch	Batch 02
Mixture	Mixture 60-40
Temperature °C	Dynamic viscosity mPa s
50.00	2.289
45.00	2.532
40.00	2.780
35.00	3.068
30.00	3.406
25.00	3.807
20.00	4.282
15.00	4.867
10.00	5.576
5.00	6.453
0.00	7.553

Class	CME - mineral diesel
Batch	Batch 02
Mixture	Mixture 80-20
Temperature °C	Dynamic viscosity mPa s
50.00	2.235
45.00	2.470
40.00	2.707
35.00	2.983
30.00	3.306
25.00	3.688
20.00	4.139
15.00	4.692
10.00	5.360
5.00	6.184
0.00	7.212

Class	CME - mineral diesel
Batch	Batch 02
Mixture	Mixture 90-10
Temperature °C	Dynamic viscosity mPa s
50.00	2.216
45.00	2.446
40.00	2.678
35.00	2.948
30.00	3.265
25.00	3.639
20.00	4.080
15.00	4.620
10.00	5.272
5.00	6.075
0.00	7.079

Class	CME - mineral diesel
Batch	Batch 02
Mixture	Mixture 95-05
Temperature °C	Dynamic viscosity mPa s
50.00	2.204
45.00	2.433
40.00	2.664
35.00	2.933
30.00	3.247
25.00	3.617
20.00	4.055
15.00	4.589
10.00	5.235
5.00	6.029
0.00	7.018

Class	CME - mineral diesel
Batch	Batch 02
Mixture	Mixture 100-0
Temperature °C	Dynamic viscosity mPa s
50.00	2.195
45.00	2.422
40.00	2.652
35.00	2.919
30.00	3.230
25.00	3.598
20.00	4.031
15.00	4.560
10.00	5.199
5.00	5.985
0.00	6.964

Class	CME - mineral diesel
Batch	Batch 02
Mixture	Mixture 07-93
Temperature °C	Dynamic viscosity mPa s
50.00	2.577
45.00	2.870
40.00	3.172
35.00	3.528
30.00	3.950
25.00	4.456
20.00	5.062
15.00	5.822
10.00	6.756
5.00	7.933
0.00	9.439

Coconut oil methyl ester CME – winter-grade diesel

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 60-40	Mixture	Mixture 80-20	Mixture	Mixture 90-10
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.087	50.00	2.135	50.00	2.164
45.00	2.298	45.00	2.354	45.00	2.387
40.00	2.514	40.00	2.575	40.00	2.613
35.00	2.762	35.00	2.832	35.00	2.874
30.00	3.052	30.00	3.132	30.00	3.180
25.00	3.392	25.00	3.484	25.00	3.539
20.00	3.795	20.00	3.901	20.00	3.964
15.00	4.284	15.00	4.407	15.00	4.481
10.00	4.872	10.00	5.018	10.00	5.105
5.00	5.597	5.00	5.767	5.00	5.872
0.00	6.491	0.00	6.699	0.00	6.825

Class	CME - mineral diesel	Class	CME - mineral diesel	Class	CME - mineral diesel
Batch	Batch 01	Batch	Batch 01	Batch	Batch 01
Mixture	Mixture 95-05	Mixture	Mixture 100-0	Mixture	Mixture 07-93
Temperature	Dynamic viscosity	Temperature	Dynamic viscosity	Temperature	Dynamic viscosity
°C	mPa s	°C	mPa s	°C	mPa s
50.00	2.179	50.00	2.205	50.00	2.043
45.00	2.404	45.00	2.433	45.00	2.251
40.00	2.632	40.00	2.663	40.00	2.461
35.00	2.895	35.00	2.929	35.00	2.703
30.00	3.204	30.00	3.242	30.00	2.986
25.00	3.567	25.00	3.610	25.00	3.320
20.00	3.996	20.00	4.044	20.00	3.723
15.00	4.519	15.00	4.575	15.00	4.199
10.00	5.151	10.00	5.215	10.00	4.773
5.00	5.926	5.00	6.001	5.00	5.482
0.00	6.893	0.00	6.979	0.00	6.364

Rapeseed oil methyl ester – heating oil EL

Class Batch Mixture	RME - heating oil Batch 03 Mixture 0-100	Class Batch Mixture	RME - heating oil Batch 03 Mixture 05-95	Class Batch Mixture	RME - heating oil Batch 03 Mixture 10-90
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.422	50.00	2.465	50.00	2.510
45.00	2.690	45.00	2.738	45.00	2.788
40.00	2.966	40.00	3.018	40.00	3.074
35.00	3.288	35.00	3.347	35.00	3.408
30.00	3.670	30.00	3.734	30.00	3.803
25.00	4.124	25.00	4.197	25.00	4.275
20.00	4.667	20.00	4.749	20.00	4.837
15.00	5.342	15.00	5.435	15.00	5.538
10.00	6.168	10.00	6.275	10.00	6.394
5.00	7.202	5.00	7.326	5.00	7.465
0.00	8.516	0.00	8.660	0.00	8.825

Class Batch Mixture	RME - heating oil Batch 03 Mixture 20-80	Class Batch Mixture	RME - heating oil Batch 03 Mixture 50-50	Class Batch Mixture	RME - heating oil Batch 03 Mixture 100-0
Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s	Temperature °C	Dynamic viscosity mPa s
50.00	2.612	50.00	2.977	50.00	3.748
45.00	2.902	45.00	3.312	45.00	4.179
40.00	3.201	40.00	3.659	40.00	4.632
35.00	3.550	35.00	4.066	35.00	5.167
30.00	3.964	30.00	4.548	30.00	5.827
25.00	4.456	25.00	5.123	25.00	6.559
20.00	5.043	20.00	5.808	20.00	7.462
15.00	5.776	15.00	6.667	15.00	8.604
10.00	6.671	10.00	7.716	10.00	10.007
5.00	7.790	5.00	9.030	5.00	11.761
0.00	9.211	0.00	10.699	0.00	14.008

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