

English Version

Automotive fuels - Fatty acid methyl esters (FAME) for diesel engines - Requirements and test methods

Carburants pour automobiles - Esters méthyliques d'acides gras (EMAG) pour moteurs diesel - Exigences et méthodes d'essais

Kraftstoffe für Kraftfahrzeuge - Fettsäure-Methylester (FAME) für Dieselmotoren - Anforderungen und Prüfverfahren

This European Standard was approved by CEN on 25 October 2008.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Contents

Page

| | |
|---|-----------|
| Foreword | 3 |
| Introduction | 4 |
| 1 Scope | 5 |
| 2 Normative references | 5 |
| 3 Sampling | 6 |
| 4 Pump marking | 7 |
| 5 Requirements and test methods | 7 |
| 5.1 Dyes and markers | 7 |
| 5.2 Additives | 7 |
| 5.3 Stabilizing agents | 7 |
| 5.4 Generally applicable requirements and related test methods | 7 |
| 5.5 Climate dependent requirements and related test methods | 9 |
| 5.6 Precision and dispute | 9 |
| Annex A (normative) Details of interlaboratory test programme | 11 |
| Annex B (normative) Calculation of Iodine Value | 12 |
| Annex C (normative) Correction factor for calculation of density of FAME | 14 |
| Bibliography | 15 |

Foreword

This document (EN 14214:2008) has been prepared by Technical Committee CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2009, and conflicting national standards shall be withdrawn at the latest by May 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 14214:2003.

This European Standard exists in parallel with EN 590.

Significant technical changes between this European Standard and the previous edition are:

- suitable limits and test methods on the esters, glycerides and stability characteristics of FAME resulting from EU-funded research programmes ‘BIOSTAB’ and ‘BIOScopes’ have been incorporated, although a possible replacement for iodine value is still under discussion in CEN/TC 19;
- the phosphorus limit has been lowered from 10 ppm to 4 ppm, as a first reasonable step towards meeting the needs of the latest technology engines, being a measurable amount and achievable with not too large investments by the FAME producers;
- allowance of the automatic Pensky-Martens test method as an alternative for flash point determination and a corresponding change of the limit from 120 °C to 101 °C;
- addition of a workmanship subclause (5.4.5);
- inclusion of a note referring to good house keeping via CEN/TR 15367-1;
- a note to clarify that cold flow requirements of fatty acid methyl esters (FAME) when used as an extender for diesel according to EN 590 (as set out in Table 2) do not apply;
- a general update of the revised test methods, some of them already having been included in the Technical Corrigendum to the previous version.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard gives all relevant characteristics, requirements and test methods for fatty acid methyl esters (FAME), which are known at this time to be necessary to define the product to be used as automotive diesel fuel.

Many of the test methods included in this European Standard were the subject of interlaboratory testing to determine their applicability and their precision in relation to different sources of FAME. These FAME were produced from vegetable oils available in the market at that time, i.e. rapeseed, palm, soy and sunflower oil.

Concerning total contamination, an interlaboratory study with field samples, following a study with artificial samples, is pending and therefore the repeatability and reproducibility of EN 12662 have not yet been fully established. The precision for volume percentage levels of FAME of 7, 10 and 100 will be investigated.

1 Scope

This European Standard specifies requirements and test methods for marketed and delivered fatty acid methyl esters (hereafter known as FAME) to be used either as automotive fuel for diesel engines at 100 % concentration, or as an extender for automotive fuel for diesel engines in accordance with the requirements of EN 590. At 100 % concentration it is applicable to fuel for use in diesel engine vehicles designed or subsequently adapted to run on 100 % FAME.

NOTE For the purposes of this European Standard, the terms “% (m/m)” and “% (V/V)” are used to represent respectively the mass fraction and the volume fraction.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 116:1997, *Diesel and domestic heating fuels — Determination of cold filter plugging point*

EN 590, *Automotive fuels — Diesel — Requirements and test methods*

EN 12662:2008, *Liquid petroleum products — Determination of contamination in middle distillates*

EN 14103:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of ester and linolenic acid methyl ester contents*

EN 14104:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of acid value*

EN 14105:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of free and total glycerol and mono-, di- and triglyceride content (Reference method)*

EN 14106:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of free glycerol content*

EN 14107:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of phosphorus content by inductively coupled plasma (ICP) emission spectrometry*

EN 14108:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of sodium content by atomic absorption spectrometry*

EN 14109:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of potassium content by atomic absorption spectrometry*

EN 14110:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of methanol content*

EN 14111:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of iodine value*

EN 14112:2003, *Fat and oil derivatives — Fatty Acid Methyl Esters (FAME) — Determination of oxidation stability (accelerated oxidation test)*

EN 14538:2006, *Fat and oil derivatives — Fatty acid methyl esters (FAME) — Determination of Ca, K, Mg and Na content by optical emission spectral analysis with inductively coupled plasma (ICP OES)*

prEN 15751:2008, *Automotive fuels — Fatty acid methyl ester (FAME) fuel and blends with diesel fuel — Determination of oxidation stability by accelerated oxidation method*

EN 14214:2008 (E)

EN ISO 2160:1998, *Petroleum products — Corrosiveness to copper — Copper strip test (ISO 2160:1998)*

EN ISO 2719:2002, *Determination of flash point — Pensky-Martens closed cup method (ISO 2719:2002)*

EN ISO 3104:1996, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity (ISO 3104:1994)*

EN ISO 3170:2004, *Petroleum liquids — Manual sampling (ISO 3170:2004)*

EN ISO 3171:1999, *Petroleum liquids — Automatic pipeline sampling (ISO 3171:1988)*

EN ISO 3675:1998, *Crude petroleum and liquid petroleum products — Laboratory determination of density or relative density — Hydrometer method (ISO 3675:1998)*

EN ISO 3679:2004, *Determination of flash point — Rapid equilibrium closed cup method (ISO 3679:2004)*

EN ISO 4259:2006, *Petroleum products — Determination and application of precision data in relation to methods of test (ISO 4259:2006)*

EN ISO 5165:1998, *Diesel fuels — Determination of ignition quality of diesel fuels — Cetane engine method (ISO 5165:1998)*

EN ISO 10370:1995, *Petroleum products — Determination of carbon residue (micro method) (ISO 10370:1993)*

EN ISO 12185:1996, *Crude petroleum and petroleum products — Determination of density — Oscillating U-tube method (ISO 12185:1996)*

EN ISO 12937:2000, *Petroleum products — Determination of water — Coulometric Karl Fisher titration method (ISO 12937:2000)*

EN ISO 13759:1996, *Petroleum products — Determination of alkyl nitrate in diesel fuels — Spectrometric method (ISO 13759:1996)*

EN ISO 20846:2004, *Petroleum products — Determination of sulfur content of automotive fuels — Ultraviolet fluorescence method (ISO 20846:2004)*

EN ISO 20884:2004, *Petroleum products — Determination of sulfur content of automotive fuels — Wavelength-dispersive X-ray fluorescence spectroscopy (ISO 20884:2004)*

ISO 3987:1994, *Petroleum products — Lubricating oils and additives — Determination of sulfated ash*

ASTM D 1160-06, *Standard Test Method for Distillation of Petroleum Products at Reduced Pressure*

3 Sampling

Samples shall be taken as described in EN ISO 3170 or EN ISO 3171 and/or in accordance with the requirements of national standards or regulations for the sampling of automotive diesel fuel. The national requirements shall be set out in a national annex to this European Standard, either in detail or by reference only.

In view of the sensitivity of some of the test methods referred to in this European Standard, particular attention shall be paid to compliance with any guidance on sampling containers, which is included in the test method standard.

4 Pump marking

Information to be marked on dispensing pumps used for delivering FAME diesel fuel, and the dimensions of the mark shall be in accordance with the requirements of national standards or regulations for the marking of pumps for automotive diesel fuel. Such requirements shall be set out in detail or shall be referred to by reference in a national annex to this European Standard.

5 Requirements and test methods

5.1 Dyes and markers

The use of dyes or markers is allowed.

5.2 Additives

In order to improve the performance quality, the use of additives is allowed. Suitable fuel additives without known harmful side effects are recommended in the appropriate amount, to help to avoid deterioration of driveability and emissions control durability. Other technical means with equivalent effect may also be used.

NOTE 1 Deposit forming tendency test methods suitable for routine control purposes have not yet been identified and developed.

NOTE 2 For further information on preventing contamination by water or sediment that may occur in the supply chain it is advisable to check CEN/TR 15367-1 [1].

5.3 Stabilizing agents

In order to improve the long term stability of FAME, it is recommended that stabilizing agents should be added to the product immediately after its production, at least before its eventual blending into a mixture with petroleum based diesel fuel.

5.4 Generally applicable requirements and related test methods

5.4.1 When tested by the methods indicated in Table 1, FAME shall be in accordance with the limits specified in Table 1. The test methods listed in Table 1 have been shown to be applicable to FAME in an interlaboratory test programme. Precision data from this programme are given in normative Annex A, where these were found to be different from the precision data given in the test methods for petroleum products.

5.4.2 In case of a need for identification of FAME, a recommended method based on separation and characterisation of FAME by LC/GC is EN 14331 [2].

5.4.3 In case of a need for a check upon FAME quality, iodine value of FAME may be calculated by the method presented in Annex B, but this method does not constitute an alternative to the iodine value requirement of Table 1. See also the Foreword and Introduction.

5.4.4 The limiting value for the carbon residue given in Table 1 is based on product prior to addition of ignition improver, if used. If a value exceeding the limit is obtained on finished fuel in the market, EN ISO 13759 shall be used as an indicator of the presence of a nitrate-containing compound. If an ignition improver is thus proved present, the limit value for the carbon residue of the product under test cannot be applied. The use of additives does not exempt the manufacturer from meeting the requirement of maximum 0,30 % (*m/m*) of carbon residue prior to addition of additives.

5.4.5 FAME fuel shall be free from any adulterant or contaminant that may render the fuel unacceptable for use in diesel engine vehicles.

Table 1 — Generally applicable requirements and test methods

| Property | Unit | Limits | | Test method ^a (See Clause 2) |
|---|--------------------|-------------------|---------|--|
| | | minimum | maximum | |
| FAME content ^a | % (m/m) | 96,5 ^b | – | EN 14103 |
| Density at 15 °C ^c | kg/m ³ | 860 | 900 | EN ISO 3675 EN ISO 12185 |
| Viscosity at 40 °C ^d | mm ² /s | 3,50 | 5,00 | EN ISO 3104 |
| Flash point | °C | 101 | – | EN ISO 2719 ^e EN ISO 3679 ^f |
| Sulfur content | mg/kg | – | 10,0 | EN ISO 20846 EN ISO 20884 |
| Carbon residue (on 10 % distillation residue) ^g | % (m/m) | – | 0,30 | EN ISO 10370 |
| Cetane number ^h | – | 51,0 | – | EN ISO 5165 |
| Sulfated ash content | % (m/m) | – | 0,02 | ISO 3987 |
| Water content | mg/kg | – | 500 | EN ISO 12937 |
| Total contamination | mg/kg | – | 24 | EN 12662 |
| Copper strip corrosion (3 h at 50 °C) | rating | class 1 | | EN ISO 2160 |
| Oxidation stability, 110 °C | hours | 6,0 | – | prEN 15751 ⁱ EN 14112 |
| Acid value | mg KOH/g | – | 0,50 | EN 14104 |
| Iodine value | g iodine/100 g | – | 120 | EN 14111 |
| Linolenic acid methyl ester | % (m/m) | – | 12,0 | EN 14103 |
| Polyunsaturated (≥ 4 double bonds) methyl esters | % (m/m) | – | 1 | ^k |
| Methanol content | % (m/m) | – | 0,20 | EN 14110 |
| Monoglyceride content | % (m/m) | – | 0,80 | EN 14105 |
| Diglyceride content | % (m/m) | – | 0,20 | EN 14105 |
| Triglyceride content ^a | % (m/m) | – | 0,20 | EN 14105 |
| Free glycerol | % (m/m) | – | 0,02 | EN 14105 ^l EN 14106 |
| Total glycerol | % (m/m) | – | 0,25 | EN 14105 |
| Group I metals (Na+K) | mg/kg | – | 5,0 | EN 14108 ^l EN 14109 EN 14538 |
| Group II metals (Ca+Mg) | mg/kg | – | 5,0 | EN 14538 |
| Phosphorus content | mg/kg | – | 4,0 | EN 14107 |

^a See 5.6.1.
^b The addition of non-FAME components other than additives is not allowed, see 5.2. When C17-methyl esters naturally appear in FAME this can result in a lower measured fatty acid methyl ester content. In this situation reference should be made for verification to a modified determination procedure [4], until a modified method is established within CEN.
^c Density may be measured by EN ISO 3675 over a range of temperatures from 20 °C to 60 °C. Temperature correction shall be made according to the formula given in Annex C. See also 5.6.2.
^d If CFPP is -20 °C or lower, the viscosity shall be measured at -20 °C. The measured value shall not exceed 48 mm²/s. In this case, EN ISO 3104 is applicable without the precision data owing to non-Newtonian behaviour in a two-phase system.
^e Procedure A to be applied. Only a flash point test apparatus equipped with a suitable detection device (thermal or ionization detection) shall be used. See also 5.6.2.
^f A 2 ml sample and apparatus equipped with a thermal detection device shall be used.
^g ASTM D 1160 shall be used to obtain the 10 % distillation residue. See also 5.3.4.
^h See 5.6.3.
ⁱ See 5.6.2.
^k A suitable test method is under development by CEN [3].
^l See 5.6.2. See Annex A for precision data for sum of Na + K.

5.5 Climate dependent requirements and related test methods

5.5.1 For climate-dependent requirements options are given to allow for seasonal grades to be set nationally. The options are for temperate climates six CFPP (cold filter plugging point) grades and for arctic climates five different classes. Climate-dependent requirements are given in Table 2. Table 2 is divided into two sections, one for temperate climates (Table 2a) and one for arctic climates (Table 2b). When tested by the methods given in the Tables 2a and 2b, FAME "as fuel for diesel engines" shall be in accordance with the limits specified in these tables.

5.5.2 The climate-dependent requirements in Table 2 do not apply for FAME being used as a blend component in EN 590 diesel fuel.

NOTE A requirement for FAME to meet the climate-dependent requirements could result in incompatibility between the cold flow additives used in the FAME and the diesel fuel. This may compromise the performance of the finished diesel/FAME blend in respect of its low temperature operability and cause field failures as result of filter plugging in cold weather. Cold flow additives should be specifically matched to the base diesel fuel and FAME quality to ensure correct performance consistent with the requirements set out in EN 590. The choice of cold flow additive technology should be a contractual matter between the fuel blender and the biodiesel supplier taking into account the climatic-dependent requirements of the finished diesel fuel.

5.5.3 In a national annex to this European Standard each country shall detail requirements for a summer and a winter grade and may include (an) intermediate and/or regional grade(s) which shall be justified by national meteorological data.

Table 2 — Climate-related requirements and test methods

Table 2a — Temperate climates

| Property | Unit | Limits | | | | | | Test method ^a |
|------------------------------|----------|---------|---------|---------|---------|---------|---------|--------------------------|
| | | Grade A | Grade B | Grade C | Grade D | Grade E | Grade F | |
| CFPP | °C, max. | +5 | 0 | -5 | -10 | -15 | -20 | EN 116 |
| ^a See also 5.6.1. | | | | | | | | |

Table 2b — Arctic climates

| Property | Units | Limits | | | | | Test method ^a |
|------------------------------|----------|---------|---------|---------|---------|---------|--------------------------|
| | | class 0 | class 1 | class 2 | class 3 | class 4 | |
| CFPP | °C, max. | -20 | -26 | -32 | -38 | -44 | EN 116 |
| ^a See also 5.6.1. | | | | | | | |

5.6 Precision and dispute

5.6.1 All test methods referred to in this European Standard include a precision statement according to EN ISO 4259. In cases of dispute, the procedures described in EN ISO 4259 shall be used for resolving the dispute, and interpretation of the results based on the test method precision shall be used.

However, the methods currently available for FAME content and triglyceride content, do not meet the 2R requirement of EN ISO 4259 at the limit in Table 1. At the moment revised methods are under development in a joint effort by CEN/TC 19 and CEN/TC 307.

5.6.2 In cases of dispute concerning density, EN ISO 3675 shall be used with the determination carried out at 15 °C.

In cases of dispute concerning flash point, EN ISO 3679 shall be used.

In cases of dispute concerning oxidation stability, prEN 15751 shall be used.

In cases of dispute concerning free glycerol, EN 14105 shall be used.

In cases of dispute concerning metal content, EN 14538 shall be used, as EN 14108 and EN 14109 do not meet the 2R requirements of EN ISO 4259 at the limit in Table 1.

5.6.3 For the determination of cetane number alternative methods may also be used in cases of dispute, provided that these methods originate from a recognized method series, and have a valid precision statement, derived in accordance with EN ISO 4259, which demonstrates precision at least equal to that of the referenced method. The test result, when using an alternative method, shall also have a demonstrable relationship to the result obtained when using the reference method.

Annex A (normative)

Details of interlaboratory test programme

The precision data given in Table A.1 apply in the case of FAME, as far as not already indicated in the standard. In Table A.1 only those data for requirements from standardized test methods that differ from ISO/TC 28 or ASTM precision data are given. More details are available in the interlaboratory test report [5].

Table A.1 — Precision data from interlaboratory test programme

| Property | Test method | Unit | CEN/TC 19 data for pure FAME |
|---------------------------------------|--------------|--------------------|---|
| Viscosity at 40 °C | EN ISO 3104 | mm ² /s | r = 0,001 1 X R = 0,018 X |
| Flash point | EN ISO 2719 | °C | r = 2,4 R = 11,4 |
| | EN ISO 3679 | | r = 2,1 R = 11,1 |
| Sulfur content | EN ISO 20846 | mg/kg | r = 0,028 5 X + 2 R = 0,108 8 X + 2 |
| | EN ISO 20884 | | r = 0,026 X + 1,356 R = 0,056 7 X + 1,616 |
| Distillation | ASTM D 1160 | °C | r = 2,0 R = 3,0 (90 % distilled) |
| Cetane number | EN ISO 5165 | | r = 2,4 R = 5,0 |
| Sulfated ash content | ISO 3987 | %(m/m) | r = 0,06 X ^{0,85} R = 0,142 X ^{0,85} |
| CFPP | EN 116 | °C | not available |
| Sum of Na + K | EN 14108 | mg/kg | r = -0,017 X + 0,512 |
| | EN 14109 | | R = 0,305 X + 1,980 |
| where | | | |
| r repeatability (EN ISO 4259); | | | |
| R reproducibility (EN ISO 4259); | | | |
| X mean of two results being compared. | | | |

Annex B (normative)

Calculation of Iodine Value

B.1 General

NOTE This method is adapted for biodiesel from the AOCS recommended practice Cd 1c – 85 for the determination of the iodine value of edible oil from its fatty acid composition [5].

B.2 Scope

This method describes a procedure for calculating the iodine value of neat biodiesel or biodiesel extracted from blends with diesel fuel. In case of dispute on the iodine value this method shall not be used as a substitute for EN 14111.

B.3 Principle

This method is used to calculate the iodine value expressed in g I₂/100 g sample from the percentage by mass of methyl esters as determined by either EN 14103 (neat biodiesel) or EN 14331 [2] (biodiesel extracted from blends with diesel fuel).

B.4 Procedure

The methyl ester composition of the sample is checked using the appropriate method as described in 5.4.

NOTE The total methyl esters thus revealed should equal 100 after the deduction of the methyl ester C17 used for internal standard in EN 14103.

The percentage by mass thus obtained is then used to calculate the sample's iodine value, being the sum of the individual contributions of each methyl ester, obtained by multiplying the methyl ester percentage by its respective factor (Table B.1), as indicated in the example in Table B.2.

The factor for each constituent of biodiesel is given in Table B.1.

Table B.1 — Methyl ester factors

| Methyl ester | Factor |
|---|--------|
| Methyl ester of saturated fatty acids | 0 |
| Methyl hexadecenoate (Methyl palmitoleate) C16:1 | 0,950 |
| Methyl octadecenoate (Methyl oleate) C18:1 | 0,860 |
| Methyl octadecadienoate (Methyl linoleate) C18:2 | 1,732 |
| Methyl octadecatrienoate (Methyl linoleate) C18:3 | 2,616 |
| Methyl eicosenoate C20:1 | 0,785 |
| Methyl docasenoate (Methyl erucate) C22:1 | 0,723 |

An example of the calculation of iodine value from the percentage by mass of methyl esters is given in Table B.2.

Table B.2 — Calculation example

| Methyl ester of the following acids | Percentage % m/m | Factor | Contribution |
|-------------------------------------|------------------|--------|--------------|
| Myristic C14:0 | 0,3 | 0 | 0 |
| Palmitic C16:0 | 4,0 | 0 | 0 |
| Palmitoleic C16:1 | 1,1 | 0,950 | 1,0 |
| Stearic C18:0 | 2,0 | 0 | 0 |
| Oleic C18:1 | 60,5 | 0,860 | 52,0 |
| Linoleic C18:2 | 19,8 | 1,732 | 34,3 |
| Linolenic C18:3 | 9,4 | 2,616 | 24,6 |
| Eicosanoic C20:0 | 0,4 | 0 | 0 |
| Eicosenoic C20:1 | 0,7 | 0,785 | 0,6 |
| Docosanoic C22:0 | 0,7 | 0 | 0 |
| Docosenoic C22:1 | 1,1 | 0,723 | 0,8 |
| Calculated iodine Value | | | 113,3 |

B.5 Expression of the result

The iodine value, as calculated from the methyl ester composition, shall be expressed in g iodine/100 g. The result shall be reported to one decimal place.

NOTE 1 In 1994 the AOCS Uniform Methods Committee reviewed the coefficients used and concluded that no changes were necessary at that time. The present procedure uses the coefficients selected in the past for use in calculating the iodine value in triglyceride blends. The reasoning behind that choice is that triple the molecular weight of a methyl ester is almost identical to the molecular weight of the corresponding triglyceride.

NOTE 2 For samples with unsaponifiable content greater than 0,5 % (*m/m*) or those containing a significant additive content, the calculated value tends to be higher than the true value.

NOTE 3 The calculated result tends to be lower than the true value in samples with a lower iodine value.

Annex C (normative)

Correction factor for calculation of density of FAME

The conversion factor for the correction of density, determined by EN ISO 3675 over a range of temperatures from 20 °C to 60 °C, to density at 15 °C is based on data published at the International Conference on Standardization and Analysis of Biodiesel, Vienna, November 1995 [6].

NOTE At the moment a DIN investigation is generating additional data.

The density of seven samples of FAME was measured by pycnometer at 6 temperatures over the range 20 °C to 60 °C. The mean correction factor over the range was calculated as 0,723 kg/(m³ °C), with a standard deviation of 1,2 %. The average density of the FAME samples at 15 °C was calculated as 886,5 kg/m³.

The following equation shall be used for the calculation of density of FAME at 15 °C ($\rho_{(15)}$, given in kg/m³), using the density ($\rho_{(T)}$) at a certain temperature (T), determined by EN ISO 3675 over the range of temperatures from 20 °C to 60 °C:

$$\rho_{(15)} = \rho_{(T)} + 0,723(T - 15) \quad (\text{C.1})$$

Bibliography

- [1] CEN/TR 15367-1, *Petroleum products — Guide for good housekeeping — Part 1: Automotive diesel fuels*
- [2] EN 14331, *Liquid petroleum products — Separation and characterisation of fatty acid methyl esters (FAME) from middle distillates — Liquid chromatography (LC)/gas chromatography (GC) method*
- [3] prEN 15779, *Fats and oil derivatives — Fatty acid methyl esters (FAME) for use in diesel engines — Determination of poly-unsaturated fatty acid methyl esters by gas chromatography*
- [4] S. Schober, I. Seidl and M. Mittelbach, *Ester content evaluation in biodiesel from animal fats and lauric oils*, Eur. J. Lipid Sci. Technol. 108 (2006) 309–314
- [5] CEN/TR 15160:2005, *Petroleum and related products — Applicability of diesel fuel test methods for Fatty Acid Methyl Esters (FAME) — Information and results on round robin tests*
- [6] *The Official Methods and Recommended Practices of the AOCS*, 5th edition, 1998, Champaign, IL, USA.
- [7] J. Rathbauer & A. Bachler, *Physical Properties of Vegetable Oil Methyl Esters*, International Conference on Standardization and Analysis of Biodiesel, November 6th – 7th, 1995, Vienna.