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Automotive fuels - Paraffinic diesel fuel and blends with FAME - Background to the parameters required and their respective limits and determination

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National foreword

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Automotive fuels - Paraffinic diesel fuel and blends with FAME - Background to the parameters required and their respective limits and determination

Carburants pour automobiles - Gazole paraffinique et consituent d'EMAG - Historique sur la définition des paramètres requis, de leurs limites et de leurs déterminations respectives

Kraftstoff für Kraftfahrzeuge - Paraffinischer Dieselkraftstoff und Kraftstoff-Mischungen - Hintergrund zu den erforderlichen Parametern, den entsprechenden Grenzwerten und deren Bestimmung

This Technical Report was approved by CEN on 28 May 2017. It has been drawn up by the Technical Committee CEN/TC 19.

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European foreword

This document (CEN/TR 16389:2017) 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.

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

This document supersedes CEN/TR 16389:2012.

This second version replaces the first edition, CEN/TR 16389:2012, which has been updated following the revision of CEN/TS 15940 into a full European Standard. Discussions within CEN/TC 19 and the results of two interlaboratory studies (ILS) initiated by NEN and the TF XTL/HVO and funded by the European Commission have been included.

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1 Scope

This Technical Report explains the requirements and test methods for marketed and delivered paraffinic diesel as such from synthesis (XTL) or hydrotreatment (HVO) and of blends thereof with up to 7%(*V/V*) of fatty acid methyl esters (FAME) according to European fuel specifications. It provides background information to judge the final text of the European Standard EN 15940 and gives guidance and explanations to the producers, blenders, marketers and users of paraffinic automotive diesel.

Paraffinic diesel is a high quality, clean burning fuel with virtually no sulfur and aromatics. Paraffinic diesel fuel can be used in diesel engines, also to reduce regulated emissions. In order to have the greatest possible emissions reduction, a specific calibration may be necessary. Paraffinic diesel fuel can also offer a meaningful contribution to the target of increased non-crude derived and/or renewable content in transportation fuel pool.

For general diesel engine warranty, paraffinic automotive diesel fuel may need a validation step to confirm the compatibility of the fuel with the vehicle, which for some existing engines may still need to be done. The vehicle manufacturer needs to be consulted before use.

NOTE 1 This document is directly related to the development of EN 15940 and will be updated once further publications take place.

NOTE 2 Paraffinic diesel is also used as a blending component in automotive diesel fuel. In that case, composition and properties of the final blends are defined by relevant fuel specification standards.

NOTE 3 For the purposes of this document, the term “% (*m/m*)” and “% (*V/V*)” are used to represent the mass fraction, μ, and the volume fraction, φ, respectively.

2 Normative references

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

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

EN 14214, *Liquid petroleum products — Fatty acid methyl esters (FAME) for use in diesel engines and heating applications — Requirements and test methods*

EN 15940, *Automotive fuels — Paraffinic diesel fuel from synthesis or hydrotreatment — Requirements and test methods*

3 Summary of the XTL-HVO taskforce work

Following the 68th CEN Technical Board meeting, CEN/TC 19 had been requested to check eventual and existing conflicts between the scope of work as proposed for Workshop 61 on "Automotive fuels - Blends of paraffinic diesel from synthesis (XTL) or hydrotreatment (HVO) and fatty acid methyl esters (FAME) - Requirements and test methods". At a CEN/TC 19/WG 24 meeting on 30 November 2010, the consensus was that there was a possible conflict between EN 590 and the Workshop 61. The advice to both the proposers and CEN/TC 19 was to take upon the work on XTL/HVO. A TF under WG 24 was established in order to address the matter and also to enable specific paraffinic diesel fuel and engine experts to exchange information.

On 13 December 2010, the Workshop 61 proposers had a teleconference with the TC Chairman and Secretary on the way forward for the agreed upon TF under WG 24. In the spirit of harmonization, they thought it advisable that the already existing CWA 15940 should also be revised. That document had been developed in 2007 – 2009 by a CEN Workshop 38 and was meant for dedicated fleet usage. In

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2010, XTL products were already reaching the EU and certain fleets had expressed interest in purchases on the basis of CWA 15940, therefore the CWA needed to stay in place until any revisions had been completed.

Hence, a proposal to accept the idea of Workshop 61 as an active work under CEN/TC 19, followed by a revision of CWA 15940 was balloted. At the plenary meeting of May 2011, CEN/TC 19 accepted the two proposals for new work. In view of the time pressure, the paraffinic diesel - FAME blends needed to be specified via a CEN/TS.

The work on the specifications was developed during a series of paraffinic diesel fuel and FAME blends Task Force (TF XTL-HVO) meetings between 2011 and 2016, and is presented by means of this Technical Report. The first deliverable from these discussions, CEN/TS 15940:2012 [1], comprised of a set of properties and limit values to define an adequate quality of the paraffinic diesel fuel and recommendations for precautions to be taken.

Discussion in the TF started with the task to handle only blends with FAME; CWA 15940 was to remain for the short term as an assurance for the industry for a non-FAME containing product. This allowed that the blending from 0 % to 7 % of FAME (as in EN 590) was copied. Because CWA 15940 allowed limited FAME blending for lubricity, the TF concluded that distinguishing (for instance via classes) between no FAME and up to 7 % FAME would be highly artificial. Therefore, a suggestion to CEN/TC 19 was made to draft the CEN/TS as a replacement of CWA 15940 and to use it for up to 7 % blending. This proposal was accepted and the task force started their work accordingly.

However, CEN/TS 15940 still contained some pending issues. The work towards the TS specification together with the first edition of CEN/TR 16389:2012 [2] provided the evidence that it was reasonable to use the cited test methods within CEN/TS 15940:2012. The pros and cons of further required test assessment work performed by the TF and CEN groups, plus the responses to the open comments after the last ballot were discussed in April 2013 and the TF agreed to request for revision of the TS into a full European Standard. The work towards EN 15940 has looked at the test methods in more detail to confirm the applicability of the scope to paraffinic diesel fuel and to determine if their precision is sufficient to support the limit values proposed.

Advice and support from both test method experts and other CEN Groups were sought where required. For all standard test methods referenced in EN 15940, the applicability for paraffinic diesel fuels was verified. For the methods to determine the cloud point, cold filter plugging point (CFPP), cetane number and total aromatics content inter laboratory test programmes were carried out. That work has been funded by the European Commission. The resulting precision limits for paraffinic diesel fuels for these methods are laid down in Annex A of EN 15940. The necessary alternative test procedure for the total aromatics content was laid down in a separate Annex to the standard. That procedure will be adopted by CEN/TC 19/WG 9 in an existing test method standard.

In May 2016, CEN approved EN 15940. Initiated by comments made in the enquiry ballot, the TF proposed to remove the limit on the application of the product to captive fleet usage. That led to some technical updates, a.o. an A-deviation for a country that only allows EN 590 automotive diesel fuel products on its public market, which could not be introduced in the formal vote. An amendment has thus been initiated after EN 15940 had been published by CEN.

4 Record of the work to date

4.1 Context

From an environmental perspective, paraffinic diesel is a high quality, clean burning fuel with virtually no sulfur and aromatics. Paraffinic diesel fuel can be used in existing diesel engines, substantially reducing regulated and unregulated emissions. In order to have the greatest possible emissions reduction, a specific calibration may be necessary. Paraffinic diesel fuel will also offer a meaningful contribution to the target of increased non-petroleum/renewable content in transportation fuel pool.

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As some production processes result in a fuel containing cyclo-paraffins, as well as to n-paraffins and iso paraffins, they show different cetane number compared to other paraffinic diesel fuels. Hence, two classes, one of them showing improved ignition quality compared to regular automotive diesel fuel, have been defined in EN 15940. Both classes are intended for use in dedicated diesel vehicles.

Worldwide, policy makers are increasingly keen to move away from petroleum-based fuels to more diverse or renewable sources of energy for reasons of environmental protection, energy security and continued economic development. Amongst the available solutions are the paraffinic diesel fuels (as discussed in a CEN workshop WS 38, which led to the workshop specification CWA 15940). Typical production processes, covered by that workshop, are:

1) Fischer Tropsch synthesis (XTL),

2) Hydrotreatment of vegetable oils (HVO), and

3) Conversion of olefins to distillates (COD).

The WS 38 activity in 2007 to 2009 covered the requirements and test methods for the B0 variants of paraffinic diesel fuels (where B0 indicates no addition of FAME). However, against the background of the EU Renewable Energy Directive (RED, 2009/28/EC) [3] and also the EN 590 regular diesel specification which allows B7 FAME blends, there is now a pressing requirement to allow for Bx variations of those paraffinic diesel fuels, which are not already classified as being from renewable resources.

Allowing a Bx variant of paraffinic diesel up to B7, in the same way that the EN 590 specification allows for regular diesel up to B7, would have the following advantages:

a) it gives flexibility of supply within EU against the backdrop of both the Renewable Energy Directive and the Fuels Quality Directive (2009/30/EC) [4], which demand total fuel supply contains certain percentages of bio-components, to decrease fossil energy usage;

b) it brings a synthetic diesel CWA specification more in line with the EU regular diesel specification EN 590.

The original intention of CEN/TC 19 was to redraft the CWA into a CEN Technical Specification for the FAME blend up to 7 %, in alignment with EN 590. The aim of the TF was to keep the specification simple and straightforward, allowing blends to be introduced in the market for dedicated vehicles or fleets. The original idea was to ensure basic car functionality, for which the existing CWA succeeded. From the beginning it was felt advantageous for the market to first draft a FAME blend specification and thus not immediately replace the CWA. However, because technically one could not sufficiently distinguish the two and any "no-FAME" guarantee could only be given in a purchase contract, it was decided to continue on the path of replacing the CWA by a specification for paraffinic diesel fuel in general, assuming it could be blended up to 7 % (*V/V*) of FAME.

The revision of the Technical Specification (TS) into a European Specification (EN) was again intended for paraffinic diesel fuels where their main use is a diesel fuel in dedicated diesel vehicle fleets, e.g. captive fleets. Such a scope guides the user to consult the vehicle manufacturer or manual on the appropriateness of the fuel for the vehicle. However, in early 2015, WG 24 introduced a proscriptive definition of the term “captive fleets” in order to cope with fuels which do not meet the FQD (EU Fuels Quality Directive) requirements. As paraffinic diesel fuels meet the FQD and have had trouble-free operation for a number of years, the TF thought this new definition of “captive fleets” – with the link to the FQD and the requirement that continuous maintenance needed to be regarded - was inappropriate as it would place too many restrictions on the use of a paraffinic diesel and/or FQD compliant fuel.

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Before deciding to remove the term “captive fleet” from EN 15940, the TF decided that a substitute phrase was required to cover the original intentions, i.e. to ensure checks are made that the use of fuel in a given application is valid. An appropriate phrase was adapted from the B10 specification. The scope now contains the phrase “It is applicable to fuel for use in diesel engines and vehicles compatible with paraffinic diesel fuel” together with the following note “The vehicle manufacturer needs to be consulted before use”.

This document is the report on the work to date carried out by the TF XTL-HVO towards establishing a European Fuel Specification (EN) for paraffinic diesel fuel – FAME blends.

4.2 Paraffinic diesel fuel and FAME blending Task Force

CEN, requested CEN/TC 19/WG 24 to convene a task force and begin work on a draft paraffinic diesel fuel and FAME blend standard. A call was made to the industries concerned for experts to participate in the TF XTL-HVO. The experts that have contributed to the work during the years are listed in Table 1. The task force has met on the following occasions:

1) 24 October 2010, Brussels, kick-off meeting WS 61

2) 6 May 2011, Brussels, Belgium

3) 7 June 2011, Brussels, Belgium

4) 21 July 2011, Paris, France

5) 7 September 2011, Brussels, Belgium

6) 7 November 2011, Brussels, Belgium

7) 12 July 2012, Espoo, Finland

8) 12 October 2012, Brussels Belgium

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Table 1 — Membership of the taskforce in 2011-2012

Name	Organization	Country
Andras Hollo	MOL	Hungary
Andreas Eklund	EcoPar	Sweden
Benoit Engelen	Total	Belgium
Gérald Crépeau	PSA	France
Jörg Ullmann	Robert Bosch	Germany
Jose Gomez-Martinech	Cepsa	Spain
Ludivine Pidol	IFP	France
Markku Kuronen	Neste Oil	Finland
Pascal Manuelli	Total	France
Piet Roets	Sasol	South-Africa
Richard Clark	Shell	United Kingdom
Róbert Auer	MOL	Hungary
Sören Eriksson	Preem	Sweden
Thierry Chapus	IFP	France
Thomas Wilharm	ASG Analytik-Service	Germany
Ulrich Nowak	MB Holding	UPEI
Wolfgang Dörmer	BP Europe SE Global Fuels Technology	Germany
Wolfgang Lueke	Shell	Germany

At the end of 2012, CEN/TC 19/WG 24 agreed to revise CEN/TS 15940 on the basis of a test plan developed by the TF. By that time, Jörg Spanke took over from Wolfgang Lueke as TF leader. A call was made to the industries concerned for possible new experts to participate in the TF XTL-HVO. The experts that have contributed to the work during the last couple of years are listed in Table 2.

The renewed task force has met on the following occasions, apart from several intermediate web-conferences:

9) 11 December 2012, Brussels, Belgium

10) 20 March 2013, Paris, France

11) 18 June 2013, London, UK

12) 13 May 2014, Brussels, Belgium

13) 25 March 2015, Hamburg, Germany

14) 21 April 2016, Brussels, Belgium

15) 6 October 2016, Hamburg, Germany

16) 21 February 2017, Oslo, Norway

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Table 2 — Participants in the taskforce in 2013-2016

Name	Company	Country
Andreas Eklund	EcoPar	Sweden
Arthur Bell	Sasol	South-Africa
Charlotte Kehoe	BP Europa SE	Germany
Fabien Chainet	IFPEN	France
Gaëlle Jousset	Total	France
Gérald Crépeau	PSA	France
Jörg Spanke	Shell Global Solutions	Germany
Jörg Ullmann	Robert Bosch	Germany
Jose Gomez-Martinech	Cepsa	Spain
Jürgen Fischer	DIN FAM	Germany
Luca Baldini	ENI	Italy
Ludivine Pidol	IFPEN	France
Markku Kuronen	Neste	Finland
Ville Vauhkonen	UPM Biorefining	Finland
Pascal Manuelli	Total	France
Piet Koppen	PAC	Netherlands
Richard Clark	Shell UK	United Kingdom
Thierry Chapus	IFPEN	France
Thomas Wilharm	ASG Analytik-Service	Germany
Tom Feuerhelm	DIN-FAM	Germany
Ulrich Nowak	MB Holding	UPEI

4.3 Planning

The initial planning of the paraffinic diesel fuel specification was: CEN/TS enquiry text to be provided to WG 24 in November 2011, enquiry ballot to start in February 2012, comments to be handled in July 2012 and the final text to be delivered to CEN/CMC in October 2012. For the full revision, a Round Robin programme needed to be defined and results thereof were to be discussed with the relevant WGs and even with ISO and ASTM groups. The following planning was made:

a) review of the actual draft specification by each of the two TFs within three months;

b) defining test methods' assessment plan by the TFs and subcontracting the work (month 6);

c) preparation of samples by a subcontracted party;

d) executing an analytical applicability check on the identified test methods by the TFs;

e) executing a full RR study on the identified test methods initiated by the subcontractor (month 12);

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f) incorporating the conclusions in and finalizing the draft standards by the TFs (month 18).

In the end, the RR work was done in two parts. First to check method applicability and precision for all test method standards in the CEN/TS and another programme in order to establish a precise enough test method to determine the 100 % paraffinic nature of the fuel. This resulted in a fairly longer development process. The first RR had been concluded by May 2014. Its objective being to measure total aromatics at a very low level. The enquiry ballot was initiated 25 September of that same year. Details of the second RR were developed in parallel and that work was concluded in Fall 2015. All input was written into the enquiry, respectively the formal vote ballot text and EN 15940 adopted in April 2016.

5 The paraffinic diesel fuel specification

5.1 Parameters included

The original CWA had been established for dedicated vehicle use, although it was at that time felt that there would be no need to exclude other uses as long as guarantee for the engine compatibility could be given. The first scope of work given to the task force was to present a specification for captive fleets. At the third meeting that limitation was accepted and it was suggested copying the captive fleet description of the B30 TF. As it presented some further understanding difficulties towards the original CWA scope, that was reformulated into: "This document specifies requirements and test methods for marketed and delivered paraffinic diesel fuel blended with fatty acid methyl ester (FAME) up to a level 7 % (*V/V*), for use in diesel engine vehicles. Paraffinic diesel fuel originates from synthesis or hydrotreatment processes."

All parameters discussed in this document are either based on the paraffinic nature of the XTL and HVO and on the introduction of FAME complying with EN 14214 as a blending component (thus specific to the Bx-blend specification).

The parameters chosen by the TF are those presented in Table 1 (general requirements) and in 5.7 (seasonal requirements) of CEN/TS 15940:2012. After the 4th meeting, all-but-two of the parameters were agreed upon in full consensus, where the seizure and cavitation prevention needed further clarification from outside the taskforce. All the test methods applicability had been checked within CEN/TC 19 or are under improvement process (like EN 116) [5].

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Table 3 — Test methods' assessment

Property	Unit	Test method	Applicability	Precision not available	Assessment executed
Cetane number		EN ISO 5165 [6]	X		X
		EN 15195 [7]	X		X
		prEN 16906:2015 [8]	X		X
Density at 15 °C	kg/m³	EN ISO 3675 [9]	X		
		EN ISO 12185 [10]	X		X
Flash point	°C	EN ISO 2719 [11]	X		
Viscosity at 40 °C	mm²/s	EN ISO 3104 [12]	X	X	
Distillation	°C or % recovered	EN ISO 3405 [13]	X		
Lubricity, corrected wear scar diameter (WSD 1,4) at 60 °C	µm	EN ISO 12156-1 [14]	X	X	
FAME content	% (*V/V*)	EN 14078 [15]	X	X	X
Total aromatics content	% (*m/m*)	EN 12916 [16]	X		X
		SS 155116 [17]	X		X
Sulfur content	mg/kg	EN ISO 20846 [18]	X	X	
		EN ISO 20884 [19]	X	X	
Carbon residue (on 10 % distillation residue)	% (*m/m*)	EN ISO 10370 [20]	X	X	
Ash content	% (*m/m*)	EN ISO 6245 [21]	X		
Water content	mg/kg	EN ISO 12937 [22]	X		
Total contamination	mg/kg	EN 12662 [23]	X	X	
Copper strip corrosion (3 h at 50 °C)	rating	EN ISO 2160 [24]	X		
Oxidation stability	g/m³	EN ISO 12205 [25]	X		
	h	EN 15751 [26]	X		
CFPP	°C	EN 116 [5]	X	X	X
Cloud point	°C	EN 23015 [27]	X		X
Cetane index		EN ISO 4264 [28]		X	X
Manganese content	mg/kg	EN 16576 [29]	X		

NOTE 1 Exact references to the test methods are given in EN 15940.

Whilst revising the CEN/TS document the decision was made to not limit the usage to captive fleet anymore (see also 4.1). Hence the limitation for MMT had to be adopted from the legal requirements coming forward from the Fuels Quality Directive [4]. An overview of the assessment is presented in Table 3, the last three columns. These describe the applicability of the test method as is, where a test

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method revision is needed to incorporate paraffinic diesel fuel in the scope or where an assessment by a full Round Robin study is required.

NOTE 2 Parameters not included are presented in 5.3.

5.2 Considerations on the parameters

5.2.1 Cetane number

Cetane number is a measure of the compression ignition behaviour of a fuel. It influences cold startability, exhaust emissions and combustion noise. The cetane number is measured on a test engine or a Derived Cetane Number (DCN) is determined from a correlation with ignition delay as measured in a constant volume combustion chamber. The cetane number reflects the combination of the natural self-ignition properties and the effects of cetane improver additives.

The choice of two different classes originates from the differences between the processes which results in different chemical composition. The processes are the low-temperature and high-temperature Fischer-Tropsch (LTFT and HTFT) and Hydrogenated Vegetable Oils (HVO). Because a higher cetane number is an advantage for some applications, the specific distinction between regular automotive diesel (minimum cetane of 51) and a high-cetane fuel (minimum 70) has been incorporated in the CEN/TS.

As the composition of LTFT GTL and HVO is highly paraffinic, and comprised nearly exclusively of linear paraffins, these diesel fuels have very high cetane numbers, in excess of 70. Generally, a high cetane number leads to a reduction in white smoke, noise, engine misfire, emissions and improved cold starting in some engines, especially in engines without pilot injection. HTFT GTL will in general be produced with a cetane between 52 and 65, as this paraffinic diesel fuel also contains significant quantities of cyclo-paraffins. A clear cut for the LTFT and HVO processes was 70, it being a clear identification of the products advantage. The number has been based on good experience, also looking at the test method's precision. In earlier discussions in the CWA a maximum cetane had been considered by the OEMs, but such would at this stage be difficult to correctly measure.

In the CWA 15940 the goal was to clarify that the product had an improved cetane. Therefore originally a minimum of 55 had been included. The OEMs wished to have a certain band in order to tune the engine where possible. The original band was 55 to 70. Because 55 was really borderline for the HTFT producers, the minimum was lowered to 51 and the maximum to 66 in order to preserve the band width.

At the fourth meeting, of the new TF, the classes were reviewed. Based on the test method precision the two classes cannot correctly be distinguished. With the four points gap, it might happen that a producer has a correct product for the high cetane class, but cannot consistently measure 68 due to the test method imprecision. At such moment the producer would not be allowed to sell a compliant product. The taskforce agreed to remove the middle ground and to delete the maximum on class B (regular cetane).

As a requirement to attain a full EN standard status, all referenced test methods must be applicable to the product and have valid precision statements. As this was not the case for all of the cetane methods referenced in the Technical Specification (TS), there was a need to undertake a round robin exercise. This was undertaken alongside certain cold flow test methods as well as the determination of a density correction for temperature [30].

CEN/TS 15940 referenced two cetane test methods, EN ISO 5165:1998 [6] and EN 15195 [7]. EN ISO 5165 is the method using the CFR cetane engine and EN 15195 is derived cetane by combustion in a constant volume chamber and specifically using the Ignition Quality Tester or IQT apparatus. EN 15195 directly measures the ignition delay under prescribed conditions from which a derived cetane number (DCN) is calculated from a correlation to cetane number.

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