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Fuels and biofuels — Pure plant oil fuel for diesel engine concepts — Requirements and test methods

Kraftstoffe und Biokraftstoffe — Reines Pflanzenöl als Kraftstoff für Motoren mit Dieselkonzept — Anforderungen und Prüfverfahren

Carburants et bio-carburants — Huile végétale pure carburant pour moteurs de type diesel — Exigences et méthodes d'essais

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Foreword

This CEN Workshop Agreement has been drafted and approved by a Workshop of representatives of interested parties on 2011-10-11, the constitution of which was supported by CEN following the public call for participation made on 2011-01-27.

The Workshop 56, the Secretariat of which is held by the Netherlands Standardization Institute (NEN), consisted of the following organizations:

ACRO-KHLIM, Belgium
Bearth Energy Solutions, the Netherlands
EPPOA, France
FR Cuma Rhones-Alpes, France
IESPM, France
John Deere, Germany
MatureDevelopment., the Netherlands
VZW Zonnewindt / PPO.Be, Belgium
Solaroilsystems, the Netherlands
VWP, Germany
Waldland, Austria

The final internal review round for this CWA was started on 22 September 2010 (first phase) and on 18 January 2011 (second phase) and was successfully closed on 22 June 2011. The final draft was submitted to public enquiry using CEN/TC 19 expertise on 30 June 2011 and the overall endorsement of the text being finalised on 11 October 2011. The final text of this CWA was submitted to CEN for publication on …….

In this edition of CWA xxx all relevant characteristics, requirements and test methods are specified. These specifications are relevant for the driveability of the vehicles and are currently known to prevent harm to the vehicles and their powertrains. National adaptations of this document may choose differently based on local conditions and / or updated knowledge. Climate dependent requirements of this document may vary according to national situations.

The formal process followed by the Workshop in the development of this CEN Workshop Agreement has been endorsed by the National Members of CEN but neither the National Members of CEN nor the CEN Management Centre can be held accountable for the technical content of this CEN Workshop Agreement or possible conflict with standards or legislation. This CEN Workshop Agreement can in no way be held as being an official standard developed by CEN and its members.

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Introduction

This CEN Workshop Agreement has been laid down to define a specification for Pure Plant Oil (PPO) or Pure Vegetable Oil (PVO), a liquid fuel from vegetable origin that is optimized in terms of base product and pressing process. Virgin Oil Liquid Fuel (VOLF) is an example of a cold pressed PVO. The fuels are intended for (adapted) modern diesel type engines and can be produced, treated and used locally without large investments. Fuel classes are specified for at least two different emission requirements: a class that is directly processed and is aimed to fulfil at maximum Tier 3a requirements (PPO1) and a class that should fulfil all current emission requirements using advanced engine concepts (PPO2). The PPO2 class fuel has a lower metal elements' content than the PPO1 class, resulting in less ash forming elements and therefore less negative effects on eventual exhaust after-treatment system.

At its 2009 plenary meeting, the European fuel specification drafting committee, CEN/TC 19, agreed that there was no need for a European wide EN standard and that the industry can apply a CWA as a tool to develop a specification.

With the Renewable Energy Directive (RED - EC/2009/28 [1]) and the amended Fuels Quality Directive (FQD - EC/2009/30 [2], [3]) there is an increasing demand for bio-based fuels. PPO does not meet the current diesel fuel specification, EN 590 [4], or the current biodiesel (FAME) specification, EN 14214 [5]. From an environmental perspective, vegetable oil fuel is a high quality, clean burning fuel. When used in adapted diesel engines, vegetable oil fuel can substantially reduce regulated emissions. In order to have the greatest possible emission reduction, a specific design and/or calibration of engines may be necessary. PPO fuel will also offer a meaningful contribution to the target of increased renewable content in transportation fuel pool.

PPO is a pure, bio-based product and cannot be characterized according to diesel specifications. Therefore, EN 590, or the current biodiesel (FAME) specification EN 14214 do not suffice. This specification is based on DIN 51605 [6]. Additional qualities have been introduced and made feed-stock independent, as DIN 51605 was still rapeseed oil oriented[1)] The objectives of vegetable oil fuel specifications are achieving less emission, expanding the market that is local nowadays, decreasing dependence of energy supply, and improving social economic situation of rural communities. PPO used as engine fuel has potential for the most comprehensive ecologic, economic and social benefits of all biofuels.

Blending with other diesel type fuels, such as petroleum based diesel, FAME or paraffinic diesel is not covered in this document.

The production of PPO according to the requirements of this document takes place by mechanical cold or hot extraction or by mechanical extraction with aid of solvents. In any case control measures like refining or solid-liquid separation are aimed to minimize content of undesirable contaminants and solid particles in the PPO (see also Table 1).

The CWA will be usable on a voluntary basis for engine clearance, fuel acceptance and where necessary fuelling station allowance, supporting both local regulations and international trade. In the longer term, further work in this area, including moves towards a more formal standard, will depend on whether PPO and the adapted engines become available as a general automotive concept. The Workshop will in this respect maintain close contact with CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin”. In 2014 more severe emission restrictions will apply for non-road vehicles. Based on the knowledge gathered around that time, it is expected that further revision steps will be made.

1) During the drafting of this Workshop Agreement, the German Standardization Institute developed a revised plant oil specification [7]. This Workshop Agreement differs at some points with this DIN specification.

1 Scope

This CEN Workshop Agreement specifies those properties of pure plant oil (PPO) that are at least necessary to achieve smooth deployment of this fuel in diesel engines with/without exhaust gas after-treatment, compatible for PPO combustion. In this document two pure plant oil fuel classes are defined. These are effectively tailored towards use in diesel engines without and diesel engines with exhaust gas after treatment (catalyst, filter). Both classes are intended for, but not limited to, use in heavy duty vehicles[2)]. The specification is valid at the point of delivery.

EXAMPLE The delivery can be from an oil mill to a purchaser or from a fuelling station to a driver.

Since experience for long term and failure free use of PPO compatible combustion engines is limited, this document is not yet a comprehensive specification, but more limited to specific properties. Only those properties that are seen as necessary for minimum quality requirements in the current technical discussion have been included.

NOTE 1 The main differences between PPO and automotive diesel are in the areas of density, viscosity, contamination level and flash point.

Any oil seeds can equally be used for the production of PPO, when the produced plant oil fulfils all individual requirements of the properties and limits mentioned in this workshop agreement.

NOTE 2 This document has mainly been based on experience with seeds of the following oil plants: rape, canola, sunflower, Camelina sativa and Jatropha.

This document lays down properties and values for the use of PPO at present deemed necessary, along with the test methods for these properties to be applied. Application of the in this document defined PPO for vegetable oil compatible combustion engines is only allowed when warranties have been given accordingly from the engine or equipment manufacturer. Further properties can be included in later versions of this document as they become available form successful technical and analytical test results.

Blending with diesel fuel or FAME is not covered in this edition of the CEN Workshop Agreement. If the need arises for blends of PPO with diesel a revision process will be considered.

NOTE 2 For the purposes of this Workshop Agreement, the terms “% (*m/m*)” and “% (*V/V*)” are used to represent respectively the mass fraction, μ, and the volume fraction, φ.

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

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

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

2) Generally it is experienced that with a content of P or (Ca+Mg) lower than required in PPO1 also deposits in fuel filters and on injectors, piston, piston rings etc. can be reduced. Therefore any oil quality below the required parameters of P or (Ca+Mg) will have a positively impact on engine life span.

EN 15751:2009, *Automotive fuels — Fatty acid methyl ester (FAME) fuel and blends with diesel fuel — Determination of oxidation stability by accelerated oxidation method*

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 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 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)*

prEN ISO/DIS 13032, *Petroleum products — Determination of low sulfur content in automotive fuels — Energy dispersive X-ray fluorescence spectrometric method*

EN ISO 20846:2004, *Petroleum products — Determination of sulfur content of automotive fuels — Ultraviolet fluorescence method (ISO 20846:2004)* [2]

EN ISO 20884:2011, *Petroleum products — Determination of sulfur content of automotive fuels — Wavelength-dispersive X-ray fluorescence spectrometry (ISO 20884:2011)*

DIN 51627-6, *Automotive fuels - Testing - Part 6: Determination of Ca, K, Mg and Na content by optical emission spectral analysis with inductively coupled plasma (ICP OES)*

DIN 51750-1, *Testing of petroleum products — Sampling — General requirements*

DIN 51750-2, *Testing of petroleum products — Sampling — Liquids*

DIN 51900-1, *Testing of solid and liquid fuels - Determination of calorific value with the bomb-calorimeter and calculation of the heating value— Part 1: Basic indications, equipment and procedures*

DIN 51900-2, *Testing of solid and liquid fuels - Determination of calorific value with the bomb-calorimeter and calculation of the heating value— Part 2: Test with iso-peribolem or static-jacket calorimeter*

DIN 51900-3, *Testing of solid and liquid fuels - Determination of calorific value with the bomb-calorimeter and calculation of the heating value— Part 3: Test with adiabatic cover*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply

3.1
chemically unmodified
not trans-esterified

3.2
Pure Plant Oil
PPO
Pure Vegetable Oil
PVO
vegetable oil produced through pressing, cold or hot extraction, solvent extraction or comparable procedures, crude or refined but chemically unmodified, compatible with the type of engines involved and the corresponding emission requirements

NOTE 1 Definition is based on EC/2009/28 [1]. PPO is chosen as the preferred designation for two reasons: it has no direct formal links to regulations (which mostly use "vegetable oil") and it is a designation used in the majority of the targeted markets. Both designations are however similar.

NOTE 2 Oil that is previously used (for cooking. lubrication, hydraulic fluid, etc.) is not intended to fall under this definition, see also 6.1.

3.3
virgin oil
oil obtained solely by mechanical pressing or other physical means under conditions which do not lead to the modification of the oil, and which have not undergone any treatment other than decantation, centrifugation or filtration

NOTE 1 Oils obtained using solvents, chemical or biochemical reagents, or re-esterification processes, as well as any mixtures with oils of other kinds, are excluded of this designation.

NOTE 2 By analogy with the definition of olive virgin oil as in EC/2006/1549 [8].

3.4
lower operation temperature
LOT
minimum temperature at which a certain kinematic viscosity is reached

NOTE LOT is a fuel classification related to startability of the engine

3.5
start point of operation
SPO
engine specific kinematic viscosity that is needed to guarantee starting of the engine

NOTE SPO is a fuel classification related to properties of the PPO

4 Sampling

Samples shall be taken as described in EN ISO 3170 and/or DIN 51750-1 and DIN 51750-2 in accordance with the requirements of national standards or regulations for the sampling of automotive diesel.

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

Samples shall be stored in a dark and cool place in a tightly closed container.

NOTE 1 The use of sample containers from HDPE has been proven as practical. Particularly for the determination of oxidation stability, it is recommended that the sample container is filled to the top to minimize contact with air. Storage at 8 °C has shown good results.

NOTE 2 One is reminded that the fulfilment of all limits of criteria should be particularly noted for long-term or unsuitable storage. Long-term storage periods usually result in negative changes of product characteristics.

5 Product marking

Information to be marked on containers and dispensing pumps used for delivering PPO, 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 fuel. Such requirements shall be set out in detail or shall be referred to by reference in a national annex to this CEN workshop agreement.

Pure plant oil for use as fuel in PPO compatible advanced diesel engines should be named: Pure plant oil according to CWA xxxxx, Class PPO1 or Class PPO2.

At the pump a standardised, clearly recognizable and non-interchangeable identification shall be given, which clearly distinguishes the product from other fuels.

EXAMPLE A suggested mark is "CWA xxxxx PPO2".

6 Requirements and test methods

6.1 Production

PPO according to the requirements of this document shall not have been used prior to its use as engine fuel (e.g. as baking oil, lubricant of hydraulic oil).

NOTE Oil that is "previously used" (for cooking. lubrication, hydraulic fluid, etc.) can affect fuel parameters that have a detrimental effect on the engine. In addition, combustion of not properly cleaned, used or recycled oils and fats bears a high risk for human health due to potentially dangerous emission elements. It is at this stage not sufficiently possible to analyse the affecting elements in the pure plant oil, so they cannot be limited yet.

It should be verified that PPO is not mixed with other types of fuels e.g. with diesel.

6.2 Dyes and markers

The use of dyes and markers is allowed provided they do not cause harmful side effects to the vehicle and the fuel distribution systems.

The use of dyes and markers should be such that the classification of PPO as non-hazardous for the environment should be maintained.

NOTE Pure vegetable oil and pure plant oil are classified as non-hazardous to water.

If a classification of 100% bio-based product is to be maintained, dyes and markers used shall only be of 100% bio-based origin.

6.3 Additives

The use of additives should be such that the classification of PPO as non-hazardous for the environment is maintained.

If a classification of 100% bio-based product origin is to be maintained, additives used shall only be of 100% bio-based origin.

6.4 Generally applicable requirements and related test methods

6.4.1 When tested by the methods indicated in Table 1, PPO shall be in accordance with the limits specified in Table 1.

6.4.2 In case of a need for identification of PPO, a recommended method based on separation and characterisation of oils by LC/GC is EN ISO 5508 [9].

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

NOTE 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 [10].

Table 1 — Generally applicable requirements and test methods

Property	Unit	Limits				Test method [a]
		Direct processed		Improved quality		
		PPO1 minimum	PPO1 maximum	PPO2 minimum	PPO2 maximum	(See Clause 2)
Visual aspect	--	Free from visible contamination, sediment and free water				
Density at 15 °C	kg/m ^{3}	910,0	940,0	910,0	940,0	EN ISO 3675 EN ISO 12185
Flash point	°C	101	–	101	–	EN ISO 2719 [c] EN ISO 3679 [d]
Lower heating value	kJ/kg	36 000		36 000		DIN 51900-1 and -2, or DIN 51900-1 and -3
Sulfur content	mg/kg	–	10,0	–	10,0	EN ISO 20846 EN ISO 20884 prEN ISO/DIS 13032
Ignition quality [e]						
Water content	mg/kg	–	750	–	750	EN ISO 12937
Total contamination	mg/kg	–	24	–	24	EN 12662 [f]
Oxidation stability	h. at, 110 °C	6,0	–	6,0	–	EN 14112 EN 15751
Acid value	mg KOH/g	–	2,0 [g]	–	2,0 [g]	EN 14104
Phosphorus content [h]	mg/kg	–	12,0 [i]	–	1,0	DIN 51627-6
Ca + Mg [h]	mg/kg	–	20,0 [i]	–	1,0	DIN 51627-6

[a] See 7
[b] See 6.5.
[c] Procedure A to be applied. Only a flash point test apparatus equipped with a suitable detection device (thermal or ionization detection) shall be used.
[d] A 2 ml sample and apparatus equipped with a thermal detection device shall be used.
[e] See 6.6
[f] The test method developed for diesel may show analytical problems when applied to PPO. Lower levels are advisable for long term correct functioning of the engine.
[g] This limit may increase if future engine tests present positive results
[h] See 6.7.1.
[i] Lower limits may apply for specific countries or regions

6.5 Climate dependent requirements and related test methods; winter suitability

For winter suitability of an engine operated with PPO a smooth cold start shall be guaranteed. Regular test methods, like the cloud point or the cold filter plugging point (CFPP), have been assessed for PPO and been found not applicable. The filter blocking tendency test (FBT, IP 387 [11]) was assessed as an alternative. Due to a viscosity limit of 6 mm^2/s at 40°C in the test method, the FBT test is found not applicable for PPO. Until a suitable test method can be found, this document follows the line of classification according to the Low Operational Temperature (LOT), which is a new method explained here in more detail

Below about 10 °C for storage, distribution and cold start important flow properties of PPO become limiting, dependent on type of PPO feedstock and production method. A low operation temperature (LOT) viscosity

limit that guarantees cold startability has been developed. This LOT is basically the temperature at which viscosity measured via EN ISO 3104 is ≤ 150 mm^2/s. It allows the fuel producer by using Table 2 to classify his product towards a certain operation temperature. At lower temperatures further control measures such as preheating of the fuel or use of flow improvers are recommended.

Table 2 — Low operation classification

Table 2a — LOT classification

LOT_C Classification index a	**LOT** ℃		**T_{KV}** ℃
	minimum	maximum	
-10	≥ -20	≤ -10	40
0	> -10	≤ 0	40
10	> 0	≤ 10	40
20	> 10	≤ 20	40
30	> 20	≤ 30	40
40	> 30	≤ 40	50

Table 2b — Normal operation classification

KV_{PO} Classification index b	**Kinematic viscosity measured at T_{KV} via EN ISO 3104** *mm^2/s*
	maximum
10	≤ 10
20	≤ 20
30	≤ 30
40	≤ 40
50	≤ 50

The classification of the PPO is based on determining the LOT of the pure plant oil and check its class according to Table 2a (index a). Next one shall determine the kinematic viscosity at 40 ℃ and check the connected class according to Table 2b (index b). Identification shall be designated as <index a> P <index b>, or <LOT_c> P <KV_{PO}>.

EXAMPLE 20P40 means a pure plant oil with an LOT between 10 ℃ and 20 ℃ and a kinematic viscosity at 40 ℃ below 40 mm²/s.

There are two ways of using the LOT classification. The first option is to calculate a temperature at which operation is guaranteed using equation (1), if the required information on maximum of the kinematic viscosity of the fuel for the engine to start is known. When assuming linearity of the viscosity, the user can for his PPO fuel calculate the temperature at which the start point of operation is guaranteed, T_{SPO} for a specific engine, using:

$$T_{SPO} = LOTc + (KV_{SPO} - 150)\frac{T_{KV} - LOTc}{KV_{PO} - 150} \quad (1)$$

where:

LOTc is the classification indication from Table 2a

KV_{SPO} is the vehicle specific required kinematic viscosity for starting the engine in mm^2/s

KV_{PO} is the classification indication from Table 2b for kinematic viscosity at permanent operation measured at T_{KV} using EN ISO 3140 in mm^2/s

T_{KV} is the temperature, in °C, at which kinematic visc osity shall be measured as indicated in Table 2aThe other option is for the vehicle manufacturer to present a certain lower operation temperature class needed for operating the engine correctly, LOT_n, according to the following equation:

$$LOTn = ROUND\left[T_{SPOD} - \left(T_{SPOD} - T_{KV}\,\frac{KV_{SPO} - 150}{KV_{SPO} - KV_{PO}}\right)\right] \quad (2)$$

where:

T_{SPOD} is the desired vehicle temperature for the start point of operation in °C

Only flow improvers shall be used that do not influence the classification of PPO as non-hazardous for the aquatic environment (see 6.3).The viscosity of PPO is influenced by temperature and time factors.

6.6 Requirements for ignitability

On the one hand the relevance of this property is recognized, whilst on the other hand the standard for the determination of cetane number in a test engine only has limited relevance for the measurement of ignitability of PPO.

More modern but experimental methods in which the derived cetane number (DCN) is identified without the use of a test engine for measurement of the ignition time, from constant volume measurement equipment [12], are being developed for the determination of the ignitability of plant oils. The experimental test equipment is however not yet sufficiently available nor is a test method with necessary precision available for sufficient quality proof.

Whilst the necessity for an ignitability criterion holds, the requirement is delayed due to the absence of a reliable test method and equipment.

6.7 Other requirements

6.7.1 Content of ash (deposit) forming elements

Limit values especially for Potassium (K), Sodium (Na), Phosphorous (P), Calcium (Ca) and also Magnesium (Mg) are very important for failure free use of PPO in diesel engines. These ash forming elements are on the one hand naturally present in plant oil and can therefore only be removed or reduced by refining, or by applying treatment systems with filter aids especially developed for decentralized oil mills. On the other hand high values of these elements raise deposits and wear effects in PPO enabled engines. With the background of increasing technical requirements from advanced or future engine concepts a further alignment of the level of these deposit building elements will be even more important.

A study by the workshop participants was executed to check whether a linear correlation exists between the content of phosphorus in the PPO and the content of K, Na, Ca and Mg. The study was inconclusive, which is the reason that the (Ca+Mg) requirement is maintained in this document.

At low engine load, deposits can be formed by unsaturated oils with long chains (C18 or higher). At the moment, the actual problems caused and their correlation towards results from regular carbon residue tests, do not allow to set a limit. It is however advised to blend these unsaturated oils with other, more favourable oils.

6.7.2 Distillation characteristics

Specifications for distillation characteristics as are otherwise normally given for fuels, are omitted from this standard, as the distillation analysis from PPO e.g. according to EN ISO 3405 introduces the risk of thermal degradation, which therefore can influence the results to such an extent that the result of measurement should no longer be used.

7 Precision and dispute

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.

NOTE All test methods and limits presented in Table 1 are based on actual knowledge and are found acceptable for a pre-standard as specified by the this CWA.

Annex A
(informative)

Explanation on cold startability requirements

For a single specific vegetable oil of any source it is reasonable to define a maximum viscosity which at the same time mainly complies with inherent properties of the specific vegetable oil and on the other side complies with assumed engine requirements. With this intention DIN 51605 [6] and DIN 51623 [7] define the maximum of rapeseed oil as 36,0 mm²/s at 40 °C. That value specifies a quality criterion of the oil which engines have to comply with, too.

Unlike DIN 51605, this CWA defines a quality specification for a larger set of oils. Out of this set, different vegetable oils with different characteristic values might be suitable for variable applications with multiple requirements. This situation requires variable quality definitions. A multiple fuel standard like specified in this CWA allows for blending different pure plant oils. The blending allows for achieving certain characteristics.

A differentiation of applications can be found especially with regard to the cold start behaviour of diesel engines utilizing pure plant oils. So for example, it is obvious that engines in tropical regions can be started in a comparatively easy way with pure plant oils. Stationary (indoor) applications have different requirements compared with mobile (outdoor) machines. In such mobile applications, one-tank-systems can be assumed to have stronger requirements than two-tank-systems using diesel for engine start.

Results from the EU project 2ndVegOil (EU-FP7-219004) have shown that engines in mobile (one-tank) machines can be started on pure plant oils already at a maximal kinematic viscosity of 150 mm²/s and even higher. After engine start these oils are heated almost “naturally” in the vehicle’s fuel recirculation system and thus achieve temperatures and viscosities in the same dimension as required by for instance EN 590 [4] or DIN 51623 for permanent operation. The afore mentioned project 2ndVegOil also showed that neither the cloud point (CP) nor the cold filter plugging point (CFFP) nor the pour point (PP) can give an indication for the real lowest ambient temperature for proper start of operation of an engine or an application. Only a maximum viscosity gives a reasonable indication for startability of the engine.

Based on this background this CWA herewith recommends not to define a single, fixed maximum viscosity level, but to set a specification according to engine's and applications specific needs which can be fulfilled by multiple types of pure plant oil. This is achieved by two ideas represented by two indexes:

The first sub-idea of this CWA is to give a maximum kinematic viscosity for permanent operation (KV_{PO}) such as in regular diesel fuel. This is done by an ‘index 2’, which specifies a temperature and viscosity tuple. Generally, the temperature value is assumed to be T_{KV}=40°C. At this and higher temperatures index 2 specifies the maximum kinematic viscosity in mm²/s. In one case (see Table 2a), T_{KV} is set to 50°C (which refers especially to palm oil for which the viscosity cannot be determined at 40°C).

The data pair defined by index 2 is additionally supporting the specification of oil characteristics below T_{KV}. For this, an index 1 defines a second data pair - namely [*LOT*, 150 mm²/s]. LOT represents the lowest operational temperature. The pre-assumption for choosing this value simply is arbitrary and fictive: an application could be started at viscosities up to 150 mm²/s. Generally index 1 has the physical unit °C and with this *LOT* is defined as:

$$index\ 1 - 10°C < LOT \leq index\ 1 \qquad \text{(A.1)}$$

The data pairs according to index 1 and index 2 should be used as a specification for the maximum viscosity below T_{KV} by interpolation down to the temperature according index 1 and below this temperature 150 mm²/s is the cut off threshold for specifying viscosity. Alternatively, if the application or vehicle is able to run at higher viscosities than 150 mm²/s extrapolation may be used for product specification.

Linear interpolation is recommended for calculation of index 1 and index 2 by interpolation for specific applications. Alternatively, non-linear interpolation can be applied. For extrapolation beyond 150 mm²/s non-linear methods are preferred.

Engine, machine or vehicle manufactures shall specify as a fuel that their equipment run on:

Pure Plant Oil according to CWA xxxxxx, <index 1> P <index 2>

It is clear that pure plant oils with lower index-values fulfil equipment specifications with higher index values.

EXAMPLE PPO classified as 0P40 is complying with the 10P40 engine requirement, but not vice versa.

Bibliography

[1] *Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC*.

[2] *Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC*

[3] *Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC*

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

[5] EN 14214, *Automotive fuels — Fatty acid methyl esters (FAME) for diesel engines — Requirements and test methods*

[6] DIN 51605:2010, *Fuels for vegetable compatible combustion engines — Fuel from rapeseed — Requirements and test methods*

[7] DIN SPEC 51623, *Fuels for vegetable oil compatible combustion engines – Fuel from vegetable oil – Requirements and test method*

[8] *Commission Regulation No 1549/2006 of 17 October 2006 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff*

[9] EN ISO 5508, *Animal and vegetable fats and oils -- Analysis by gas chromatography of methyl esters of fatty acids (ISO 5508:1990)*

[10] CEN/TR 15367-1, *Petroleum products — Guide for good housekeeping — Part 1: Automotive diesel fuels*

[11] IP 387, *Determination of filter blocking tendency*

[12] EN 15195, *Liquid petroleum products - Determination of ignition delay and derived cetane number (DCN) of middle distillate fuels by combustion in a constant volume chamber*