Cold Properties of Biodiesel

The cold properties of fuels have always been an important quality criterion. For fuels with insufficient cold properties, partial or complete crystallization may occur at low temperatures. As a result, lines and filters in the vehicle can be blocked and lead to break down. The requirements for the cold properties of fuels vary according to the country, depending on the prevailing climatic conditions and the season. This leaflet is intended to give an overview of the national requirements and the cold properties of biodiesel (fatty acid methyl ester - FAME).

Regulatory Base - Parameters

Both the diesel fuel standard EN 590[1] and the biodiesel standard EN 14214[1] define requirements for the fuel depending on the climate. The climatic requirements are defined in the national annex on the basis of meteorological data and provide the requirements for a summer and a winter class as well as two intermediate classes.

The Cold Filter Plugging Point (CFPP, EN 116[1]) is defined as a requirement for diesel fuel as well as for biodiesel as pure fuel (B100) and as blend component for diesel fuel. The CFPP is considered a measure of cold filterability. A sample is cooled in 1 °C steps and sucked through a filter. If the sample is no longer filterable within 60 seconds, the limit of filterability is reached.

In addition, for biodiesel as a blend component for diesel fuel, the Cloud Point (CP, EN 23015[1]) is defined. The Cloud Point indicates the temperature at which the first precipitates ("clouds") form in a clear, liquid product when cooled under specified test conditions. (Detailed information on the two parameters can also be found in the leaflet *Biodiesel Analytics*.)

The following table lists the limit values for CFPP and CP for B100 and biodiesel as blend component, which apply in Germany depending on the period:

Period	**B100 (CFPP)**	**FAME as blend component (CFPP/CP)**
15.04.-30.09.	0 °C	0 °C / 5 °C
01.10.-15.11. and 01.03.-14.04.	-10 °C	-5°C / 0 °C
16.11.-28./29.02.	-20 °C	-10 °C / -3 °C

The FAME used from April to September is also referred to as FAME zero.

Influence of different FAME Types/Fatty Acid Patterns

Biodiesel consists of fatty acid methyl esters, which differ in chain length and degree of saturation. Their composition varies depending on the raw material used. Methyl esters of saturated fatty acids have significantly higher melting points than those of unsaturated fatty acids.

The melting points of the fatty acids and their share allow conclusions about the cold properties of the corresponding biodiesel. In palm oil or animal fats, the share of saturated fatty acids is very high. Biodiesel from these raw materials has correspondingly lower cold properties than biodiesel from e.g. rapeseed oil with a high content of unsaturated fatty acids (see table below).[2]

From the table it can be seen that the use of a pure palm methyl ester is not possible in the summer months, since the climatic requirements cannot be met. A blend of different FAME types is therefore common. Due to the high requirements on the CFPP, predominantly FAME blends with rapeseed methyl ester as main component are used in winter.

[1] www.beuth.de

[2] Biodiesel the comprehensive handbook, Martin Mittelbach, Claudia Remschmidt

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Fatty Acid Methyl Ester	Melting Point [°C]	Share Palm Methyl Ester (PME)	Share Rapeseed Methyl Ester (RME)	Share Soja Methyl Ester (SME)
C12:0	+5	0,5 %	-	-
C14:0	+19	1-2 %	-	-
C16:0	+31	40-48 %	3-5 %	11-12 %
C18:0	+39	4-5 %	1-2 %	3-5 %
C18:1	-20	37-46 %	55-65 %	23-25 %
C18:2	-35	9-11 %	20-26 %	52-56 %
C18:3	-46	0,3 %	8-10 %	6-8 %

Resulting CFPP	PME appx. +13 °C	RME appx. -14 °C	SME appx. -2 °C

Additives

Through the use of additives, the cold properties of fuels can be improved. In fossil diesel fuel, typically Middle Distillate Flow Improvers (MDFI) and Wax Anti-Settling Agents (WASA) are used. In biodiesel flow improvers (Biodiesel Flow Improver, BDFI) are used as well.

All flow improvers (MDFI and BDFI) work in the same way. When middle distillates are cooled to temperatures below the Cloud Point, flaky crystals are typically formed in rhombic form. Due to their size and shape, these can block filters or assemble into a larger wax structure. Flow improvers modify the crystals into smaller sized needles so that the formed crystals cannot block filters or coalesce. Flow improvers only have an influence on the CFPP, the Cloud Point of the fuel remains untouched. There are known additives that can lower Cloud Point and Pourpoint (see Additional Parameters). However, these are suspected to adversely affect other properties of the fuel.

AGQM together with the mineral oil industry is currently developing a no-harm test for BDFI, which will test the additives for trouble-free use and possible negative interactions.

Additional Parameters

The **Pourpoint** (PP, EN ISO 3016[3]) is not required in EN 590[3] and EN 14214[3], but it provides additional information about the cold properties of the fuel. It indicates the temperature to which the sample can be cooled without losing its fluidity.

Sterylglycosides (SG, EN 16934[3]) can be a major cause of poor filterability of FAME. At the end of 2017, EN 16934[3] was published to determine the content of SG. Complete refining of the crude oil usually results in no significant levels of sterylglycosides in the resulting FAME. Therefore, currently there are few reported problems associated with sterylglycosides.

Saturated monoglycerides (SMG, EN 17057[3]) are difficult to dissolve in fossil diesel because of their physicochemical properties. They accumulate in the cold and can lead to precipitation. Since 2018, there is a method to directly determine the content of saturated monoglycerides. An implementation in EN 14214[3] is planned, but so far no limit value for the content of saturated monoglycerides has been established.

The AGQM recommends not to exceed a level of 1,200 mg/kg for saturated

[3] www.beuth.de

monoglycerides based on independently performed FAME tests.

The **Filter Blocking Tendency** (FBT, IP 387[4]) was developed as a performance test on the filterability of fuels in the cold. AGQM does not recommend the designation of a limit value for FBT because the method does not have sufficient precision. So far no correlation between FBT and field events (e.g. filter blocking) has been established. Moreover, no correlation could be found between FBT and other parameters such as sterylglycosides or saturated mono-glycerides, although the latter have a significant influence on the cloud point of FAME. In conclusion, there are a variety of factors (e.g. storage, transport) that affect the FBT value.

Different committees are currently working on methods derived from the FBT, Cold FBT and Cold Soak FBT. The problems of the original FBT remain however.

[4] https://publishing.energyinst.org/topics/fuel-quality-and-control/ip-test-methods/ip-387-determination-of-filter-blocking-tendency

Note

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