~~ISO/CD 8217:2022(E)~~

**ISO/DTR 18588:2023(E)**

**ISO TC 28/SC 4/WG 6**

**Date: 2023-~~03-27~~05-11**

**Secretariat: AFNOR**

# Petroleum products — Characterisation of marine fuels by viscosity-gravity constant

*Produits pétroliers — Caractérisation des combustibles pour la marine par la constante viscosité-gravité*

~~DTR stage~~



**Formatted:** Font: 11 pt

**Formatted:** Left, Space After: 0 pt, Line spacing: single

**Style Definition** ...

**Formatted:** Bottom: 1 cm, Footer distance from edge: 0.5 cm, Different first page header

**Formatted:** Font: 13 pt

**Formatted:** zzCover, Left, Space After: 0 pt, Line spacing: single, Tab stops: Not at 0.71 cm

**Formatted:** zzCover, Space After: 0 pt, Line spacing: single, Tab stops: Not at 0.71 cm + 13.69 cm + 17.2 cm

**Formatted:** Font: 13 pt

**Formatted:** zzCover, Left, Space After: 0 pt, Line spacing: single, Tab stops: Not at 0.71 cm

**Formatted** ...

Formatted: Font: 11.5 pt
Formatted: Space After: 0 pt, Line spacing: single
Formatted: Font: 11.5 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Font: 11 pt
Formatted: Font: 11 pt
Formatted: Font: 11 pt
Formatted: Font: 11 pt
Formatted: Font: 11 pt
Formatted: zzCopyright, Left, Indent: First line: 0 cm, Right: 0 cm, Line spacing: single, Border: Left: (No border), Right: (No border), Tab stops: Not at 0.71 cm + 0.91 cm + 16.97 cm
Formatted: Font: 11 pt
Formatted: Font: 11 pt, English (United Kingdom)
Formatted: Font: 11 pt, English (United Kingdom)
Formatted: Font: 11 pt, English (United Kingdom)
Formatted: Font: 11 pt, English (United Kingdom)
Formatted: zzCopyright, Left, Indent: First line: 0 cm, Right: 0 cm, Space After: 0 pt, Line spacing: single, Border: Bottom: (No border), Left: (No border), Right: (No border), Tab stops: Not at 0.71 cm + 0.91 cm + 16.97 cm
Formatted: Font: 11 pt, English (United Kingdom)
Formatted: Font: 11 pt, English (United Kingdom)
Formatted: Font: 11 pt
Formatted: Space After: 0 pt, Line spacing: single

Formatted: Font: 11.5 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Space After: 0 pt, Line spacing: single
Formatted: Font: 11.5 pt
Formatted: Font: 15 pt
Formatted: Font: 15 pt

## Contents



Formatted: Font: 11 pt
Formatted: Normal, Right, Space After: 0 pt, Line spacing: single



© ISO 2023 – All rights reserved

Formatted: Font: 11.5 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Space After: 0 pt, Line spacing: single
Formatted: Font: 11.5 pt
Formatted: Default Paragraph Font, Font: Cambria, Bold
Formatted: Right: 0 cm, Line spacing: single, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted: Font: 11 pt
Formatted: Space After: 0 pt, Line spacing: single

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO ~~documents~~document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see ~~www.iso.org/directives~~www.iso.org/directives).

~~Attention is drawn~~ISO draws attention to the possibility that ~~some of~~ the ~~elements~~implementation of this document may ~~be~~involve the ~~subject~~use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights~~.~~ in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights. ~~Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).~~

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see ~~www.iso.org/iso/foreword.html~~www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 28, *Petroleum and related products, fuels and lubricants from natural or synthetic sources*, Subcommittee SC 4, *Classifications and specifications*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at ~~www.iso.org/members.html~~www.iso.org/members.html.











Formatted: Font: 11.5 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Space After: 0 pt, Line spacing: single
Formatted: Font: 11.5 pt
Formatted: Foreword Title, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted: Foreword Text, Left, Space After: 0 pt, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted: Font: 11 pt
Formatted: Normal, Right, Space After: 0 pt, Line spacing: single

## Introduction

On 1 January 2020, MARPOL Annex VI Regulation 14.1 reduced the maximum sulfur (S) content of marine fuels when operating outside an emission control area (ECA) from 3,50 % by mass to 0,50 % by mass. This resulted in a more diverse range of fuel blend formulations being offered to the marine market and an increasing interest by the marine industry in the characterisationcharacterization of petroleum-derived fuels not including fatty acid methyl ester (FAME), in terms of their aromatic or paraffinic nature.

This document was prepared in cooperation with ship owners, ship operators, shipping associations, national standards bodies, classification societies, fuel testing services, engine designers, fuel treatment equipment manufacturers, marine fuel suppliers, fuel additive suppliers and the petroleum industry. This document provides an indicator tofor defining whether a petroleum-derived residual fuel which does not includinginclude FAME, as supplied to a ship, is more aromatic or paraffinic in nature, thus therefore providing additional onboard handling information of marine fuels irrespective of sulfur content.





Formatted: Font: 11.5 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Space After: 0 pt, Line spacing: single
Formatted: Font: 11.5 pt
Formatted: Intro Title, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted: Body Text, Left, Space After: 0 pt, Tab stops: Not at 0.71 cm
Formatted: Font: 11 pt
Formatted: Space After: 0 pt, Line spacing: single

# ~~Characterisation~~Petroleum products — Characterization of marine fuels by viscosity gravity constant

## 1 Scope

This document provides ~~general guidance~~best practices on the calculation and use of an informative indicator for the ~~characterisation~~characterization of fossil residual marine fuels not containing FAME as defined in ISO 8217. ~~It~~This document is based on established guidance used by the petroleum industry to characterize petroleum fractions in terms of their paraffinic ~~to~~, naphthenic or aromatic nature, by their viscosity-gravity constant.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp

— IEC Electropedia: available at ~~https://www.electropedia.org~~https://www.electropedia.org/



**3.1**
**fatty acid methyl ester**
**FAME**
~~fatty acid methyl~~ ester~~(s)~~ derived by (trans-)esterification of fats and vegetable oils

**3.2**
**very low sulfur fuel oil**
**VLSFO**
marine fuel with a maximum sulfur content of 0,50 % by mass

**3.3**
**high sulfur fuel oil**
**HSFO**
marine fuel with a sulfur content exceeding 0,50 % by mass

## 4 ~~Characterisation~~Characterization of petroleum fuels

### 4.1 General

~~The ASTM publication "Characterisation and properties of petroleum fractions" by M.R.~~ Riazi-[1] ~~refers to~~cites two methods for the ~~characterisation~~characterization of petroleum fractions:

— — the Bureau of Mines correlation index (BMCI);




**Formatted:** Header, Space After: 6 pt, Line spacing: single
**Formatted Table**
**Formatted:** Font: Bold, English (United Kingdom)
**Formatted:** Font: Bold, English (United Kingdom)
**Formatted:** Different first page header
**Formatted** ...
**Formatted:** Font color: Blue
**Formatted** ...
**Formatted** ...
**Formatted:** English (United Kingdom)
**Formatted:** English (United Kingdom)
**Formatted** ...
**Formatted:** English (United Kingdom)
**Formatted** ...
**Formatted:** English (United Kingdom)
**Formatted:** English (United Kingdom)
**Formatted:** English (United Kingdom)
**Formatted:** English (United Kingdom)
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted** ...
**Formatted:** cite_bib
**Formatted:** Superscript
**Formatted** ...
**Formatted** ...
**Formatted:** English (United Kingdom)

— the viscosity-gravity constant (VGC).

## 4.2 BMCI (or CI)

### 4.2.1 General

BMCI, often also referred to as correlation index (CI) is used to characterize petroleum fractions/crude oils. Riazi[1] reports that values of BMCI between 0 and 15 indicate a predominantly paraffinic oil. A value of BMCI greater than 50 indicates a predominance of aromatic compounds[2]. According to the CI scale[3], all n-paraffins have a CI value of 0, while cyclohexane (the simplest naphthene), has a CI value of 50, and benzene has a CI value of 100. Using the CI scale, petroleum fractions can be classified as described in Table 1.

~~Table 1 — Classification of petroleum fractions according to CI values~~

Table 1 — Classification of petroleum fractions according to CI values

| Nature of petroleum fraction | CI value |
|---|---|
| Paraffinic (P) | <29,8 |
| Naphthenic (N) | <57,0 |
| Aromatic (A) | >75,0 |

### 4.2.2 Calculation of BMCI (or CI)

BMCI (or CI) relies on terms that are not available from the routine testing of marine fuels. It can be determined from Formula (1).

~~$$BMCI = \frac{48\,640}{T_b} + 473{,}7 \times SG - 456{,}8$$~~

$$I_{BMC} = \frac{48\,640}{T_b} + 473{,}7 \times G_s - 456{,}8 \quad (1)$$

where

~~SG is the liquid specific gravity at 60 °F (see Formula (2));~~

~~$T_b$ is the volume average boiling point, expressed in degree kelvin (K) (see Formula (3)).~~

~~SG~~

$I_{BMC}$ is the Bureau of Mines correlation index;

$G_s$ is the liquid specific gravity at 15,6 °C (60 °F) [see Formula (2)];

$T_b$ is the volume average boiling point, expressed in degree kelvin (K) [see Formula (3)].

$G_s$ can be calculated from the fuel's density as follows:

~~$$SG = \frac{\left(\frac{\rho_{15}}{1\,000} - K\right)}{H}$$~~

$$G_s = \frac{\left(\frac{\rho_{15}}{1\,000} - K\right)}{H} \quad (2)$$

where

~~$\rho_{15}$ is the density at 15 °C, expressed in kilogram per cubic metre (kg/m³);~~

~~$H$ and $K$ are variables the values of which are to be selected from Table 2.~~






Formatted ... (repeated)
Formatted Table ...

Formatted: Font: 11.5 pt

Formatted: Font: 11.5 pt

Formatted: Font: 11 pt, Not Bold

Formatted: Space After: 0 pt, Line spacing: single



Formatted: Font: 11 pt

Formatted: Footer, Space Before: 18 pt, Line spacing: Exactly 12 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

~~Table 2 — Values of H and K versus SG~~

~~SG value~~ ~~H value~~ is the density at 15 °C, expressed in kilogram per cubic metre (kg/m³); ~~K value~~ ~~ρ15~~

~~min.~~ ~~max.~~ *H* and *K* are variables the values of which are to be selected from Table 2

**Table 2 — Values of *H* and *K* versus $G_s$**

| $G_s$ value | | *H* value | *K* value |
|---|---|---|---|
| min. | max. | | |
| ≥0,79 | <0,81 | 0,998 342 | 0,000 964 |
| ≥0,81 | <0,83 | 0,998 492 | 0,000 842 |
| ≥0,83 | <0,849 999 9 | 0,998 641 | 0,000 718 |
| ≥0,849 999 9 | <0,875 000 1 | 0,998 761 | 0,000 616 |
| ≥0,875 000 1 | <0,900 000 1 | 0,998 881 | 0,000 511 |
| ≥0,900 000 1 | <1 | 0,999 011 | 0,000 394 |
| ≥1 | ~~<1~~ 1 | 0,998 861 | 0,000 544 |

The volume average boiling point $T_b$ can be calculated from ~~Formulae~~Formula (3) ~~and (4)~~:

~~$T_b = 9{,}336\,9 \times e^{\left(1{,}651\,4\times10^{-4}\times M+1{,}410\,3\times SG-7{,}515\,2\times10^{-4}\times M\times SG\right)} \times M^{0{,}536\,9} \times SG^{-0{,}727\,6}$~~

$$T_b = 9{,}336\,9 \times e^{\left(1{,}651\,4\times10^{-4}\times M+1{,}410\,3\times G_s-7{,}515\,2\times10^{-4}\times M\times G_s\right)} \times M^{0{,}536\,9} \times G_s^{-0{,}727\,6} \quad (3)$$

~~$M = 223{,}56 \times \upsilon_{38}^{(-1{,}243\,5+1{,}122\,8\times SG)} \times \upsilon_{99}^{(3{,}475\,8-3{,}038\times SG)} \times SG^{-0{,}666\,5}$~~ ~~(4)~~

where

~~$T_b$ is the volume average boiling point, expressed in degree kelvin (K);~~

~~$M$ is a variable;~~

~~$\upsilon_{38}$ is the viscosity at 38 °C, expressed in square millimeter per second (mm²/s);~~

~~$\upsilon_{99}$ is the viscosity at 99 °C, expressed in square millimeter per second (mm²/s).~~

$T_b$ is the volume average boiling point, expressed in degree kelvin (K);

$G_s$ is the liquid specific gravity at 15,6 °C (60 °F) [see Formula (2)];

$e$ is the Euler number;

$M$ is a variable, the value of which can be calculated from Formula (4).

$$M = 223{,}56 \times \upsilon_{38}^{(-1{,}243\,5+1{,}122\,8\times G_s)} \times \upsilon_{99}^{(3{,}475\,8-3{,}038\times G_s)} \times G_s^{-0{,}666\,5} \quad (4)$$

where

$\upsilon_{38}$ is the viscosity at 38 °C, expressed in square millimetre per second (mm²/s);

$\upsilon_{99}$ is the viscosity at 99 °C, expressed in square millimetre per second (mm²/s).

Hence, the conversion of viscosity at 50 °C, ~~$\upsilon_{50}$~~$\upsilon_{50}$, to viscosity at 38 °C and 99 °C is ~~required~~essential.

Formulae (5) and (6) can be used to convert viscosity at 50 °C to viscosity at 38 °C and 99 °C as follows:

$$\upsilon_{38} = e^{e^{\left\{\ln[\ln(\upsilon_{50}+0,7)]+3,55\times\ln\left(\frac{273,15+50}{273,15+38}\right)\right\}}} - 0,7$$

$$\upsilon_{38} = e^{e^{\left\{\ln[\ln(\upsilon_{50}+0,7)]+3,55\times\ln\left(\frac{273,15+50}{273,15+38}\right)\right\}}} - 0,7 \quad (5)$$

$$\upsilon_{99} = e^{e^{\left\{\ln[\ln(\upsilon_{50}+0,7)]+3,55\times\ln\left(\frac{273,15+50}{273,15+99}\right)\right\}}} - 0,7$$

$$\upsilon_{99} = e^{e^{\left\{\ln[\ln(\upsilon_{50}+0,7)]+3,55\times\ln\left(\frac{273,15+50}{273,15+99}\right)\right\}}} - 0,7 \quad (6)$$

where

~~$\upsilon_{50}$~~ $\upsilon_{50}$ is the viscosity at 50 °C, expressed in square ~~millimeter~~millimetre per second (mm²/s).






Formatted: Font: 11.5 pt
Formatted: Font: 11.5 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Space After: 0 pt, Line spacing: single
Formatted: English (United Kingdom)
Formatted: English (United Kingdom)
Formatted: Body Text, Space After: 0 pt, Line spacing: single, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted: English (United Kingdom)
Formatted: English (United Kingdom)
Formatted: cite_eq, English (United Kingdom)
Formatted: English (United Kingdom)
Formatted: Formula, Left, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers, Tab stops: 0.7 cm, Left + 1.4 cm, Left + 2.1 cm, Left + 2.8 cm, Left + 3.5 cm, Left + 4.2 cm, Left + 4.9 cm, Left + 5.6 cm, Left + 6.3 cm, Left + 7 cm, Left + Not at 1.27 cm
Formatted: English (United Kingdom)
Formatted: Body Text, Space After: 0 pt, Line spacing: single, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted: English (United Kingdom)
Formatted: English (United Kingdom)
Formatted: Font: 11 pt
Formatted: Footer, Space Before: 18 pt, Line spacing: Exactly 12 pt
Formatted: Font: 11 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Font: Not Bold