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**Petroleum products — Fuels (class F) — Specifications of gas turbine fuels for industrial and marine applications**

*Produits pétroliers — Combustibles (classe F) — Spécifications des combustibles pour turbines à gaz en service dans l'industrie et la marine*

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## 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 should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. [www.iso.org/directives](http://www.iso.org/directives)

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. 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. [www.iso.org/patents](http://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.

The committee responsible for this document is ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 4, *Classifications and Specifications, WG 5, Gas turbine fuels*.

This second edition cancels and replaces the first edition (ISO 4261:1993), of which it constitutes a minor revision with the following changes:

- Reference to ISO 4260 has been removed; [ISO 4261:2013](https://standards.iteh.ai/catalog/standards/sist/9341a556-7afa-4186-bc0d-416a47889a/iso-4261-2013)
- Reference to ISO 4262 has been removed; <https://standards.iteh.ai/catalog/standards/sist/9341a556-7afa-4186-bc0d-416a47889a/iso-4261-2013>
- Reference is made to ISO 10370.

[Annex A](#) forms an integral part of this International Standard. [Annex B](#) and [C](#) are for information only.

# Petroleum products — Fuels (class F) — Specifications of gas turbine fuels for industrial and marine applications

**WARNING** — The use of this International Standard may involve hazardous materials, operations, and equipment. This International Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

## 1 Scope

This International Standard specifies the requirements for petroleum fuels for gas turbines (see ISO 3977) used in public utility, industrial, and marine applications. It does not cover requirements for gas turbine fuels for aviation use. This International Standard is intended for the guidance of users such as turbine manufacturers, suppliers, and purchasers of gas turbine fuels.

This International Standard sets out the properties of fuels at the time and place of transfer of custody to the user. Further information and recommendations for the quality of the fuel entering the turbine combustion chambers are provided in [Annex B](#).

The terminology used and the test methods referred to in these specifications are presented in [Annex C](#).

NOTE 1 Additional information on fuels for gas turbines is given in ISO 3977.

NOTE 2 The requirements for petroleum fuels for diesel engines and steam turbines for marine use are given in ISO 8217.

The fuel categories in this International Standard have been classified in accordance with ISO 8216-2:1986.

## 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.

ISO 2160, *Petroleum products — Corrosiveness to copper — Copper strip test*

ISO 2719, *Determination of flash point — Pensky-Martens closed cup method*

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3170, *Petroleum liquids — Manual sampling*

ISO 3171, *Petroleum liquids — Automatic pipeline sampling*

ISO 3405, *Petroleum products — Determination of distillation characteristics at atmospheric pressure*

ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*

ISO 3733, *Petroleum products and bituminous materials — Determination of water — Distillation method*

ISO 3735, *Crude petroleum and fuel oils — Determination of sediment — Extraction method*

ISO 4259, *Petroleum products — Determination and application of precision data in relation to methods of test*

ISO 6245, *Petroleum products — Determination of ash*

ISO 8217, *Petroleum products — Fuels (class F) — Specifications of marine fuels*

ISO 8754, *Petroleum products — Determination of sulfur content — Energy-dispersive X-ray fluorescence spectrometry*

ISO 10370, *Petroleum products — Determination of carbon residue — Micro method*

### 3 General requirements

**3.1** The fuel shall be a homogeneous mixture of hydrocarbons, free from inorganic acids and adventitious foreign matter.

NOTE Guidelines for limits for trace metals for fuels entering the turbine combustion chambers are contained in [Annex A](#).

**3.2** Fuels of all categories shall remain homogeneous during storage and handling in the countries or locality where the fuel is to be used, taking into account local storage conditions, handling, and duration of storage.

### 4 Detailed requirements

NOTE The properties listed in this specification are those which permit acceptable performance of the turbine. However, certain metals, even in trace quantities, are detrimental to gas turbine service life. Information on the significance and concentration of critical metallic elements in the fuel as it enters the turbine combustion chambers is provided in [Annex B](#).

**4.1** The various categories of gas turbine fuels shall conform to the limiting requirements shown in [Table 1](#) when the fuel is tested by the methods specified in [Table 1](#).

**4.2** Incorporation of additives by the fuel supplier for legal purposes or to improve certain aspects of performance is permitted, provided that the amount and type incorporated do not cause the additive-treated fuel properties to fall outside the general requirements and specification limits laid down in [Table 1](#).

NOTE Additives may also be introduced subsequent to delivery, as noted in [Annex C](#).

**4.3** A limit for low-temperature operability is a requirement of this International Standard, but limits cannot be included in [Table 1](#) because of the need to conform to local or national requirements. When this specification is called up, such limits, together with the test methods required, shall be stated.

Information on internationally available test methods for low-temperature operability is given in [Annex C](#) (C.2.5).

### 5 Sampling

Sampling for the requirements in [Table 1](#) shall be carried out by the methods described in ISO 3170, ISO 3171, or equivalent International Standards.

NOTE If sampling for trace metals is agreed upon by the interested parties, the recommendations in [Annex B](#) should be followed.

### 6 Precision and interpretation of test results

The majority of test methods specified in [Table 1](#) contain a statement of the precision (repeatability and reproducibility) to be expected from it. Attention is drawn to ISO 4259, which covers the use of precision data in the interpretation of test results; this procedure shall be used in cases of dispute.

Table 1 — Detailed requirements for gas turbine fuels at time and place of custody transfer to user

| Property  | Test method           | ISO-F Category <sup>a</sup>                         |  |                                     |                              |  |  |
|---|-----------------------|---|--|-------------------------------------|------------------------------|--|--|
|   |                       | DST.0   | DST.1/<br>DMT.1  | DST.2/<br>DMT.2                     | DST.3/<br>DMT.3              | RST.3/<br>RMT.3  | RST.4/<br>RMT.4  |
|   |                       | Low flash point petroleum distillate (naphtha type) | Medium flash point petroleum distillate (jet fuel [kerosine] type) | Petroleum distillate (gas-oil type) | Low ash petroleum distillate | Low ash residual fuel or a distillate fuel containing heavy components from petroleum processing | Petroleum fuel containing heavy components from petroleum processing |
| Flash point, °C, min.   | ISO 2719 <sup>b</sup> |   | inland: 38<br>marine: 43 <sup>c</sup>                              | inland: 56<br>marine: 60            | inland: 56<br>marine: 60     | 60   | 60   |
| Kinematic viscosity at 40 °C to 100 °C, in mm <sup>2</sup> /s, max. | ISO 3104              | 1,3 min. <sup>d</sup>                               | 1,3 to 2,4 <sup>d</sup>  | 1,3 to 5,5                          | 1,3 to 11,0                  | 1,3 to 20,0  | 55<br>(see C.2.2)  |
| Density at 15 °C in kg/m <sup>3</sup> , max. <sup>e</sup>           | ISO 3675              | Value to be reported                                | Value to be reported   | 880                                 | 900<br>(see B.5)             | 920<br>(see B.5)   | 996<br>(see B.5)   |
| Distillation 90 % (V/V) recovered at °C, max.                       | ISO 3405              | 288   | 288  | 365                                 | —                            | —  | —  |
| Low-temperature operability, °C                                     | See 4.3               | Value to be reported                                | Value to be reported   | Value to be reported                | Value to be reported         | Value to be reported   | Value to be reported   |
| Carbon residue % (m/m), max.  | ISO 10370             | 0,15 (on 10 % residue)                              | 0,15 (on 10 % residue)   | 0,15 (on 10 % residue)              | 0,25                         | 1,50   | Value to be reported <sup>f</sup>                                    |
| Ash content % (m/m), max.   | ISO 6245              | 0,01  | 0,01   | 0,01                                | 0,01                         | 0,03   | 0,15   |
| Water % (V/V), max.   | ISO 3733              | 0,05  | 0,05   | 0,05                                | 0,30                         | 0,50   | 1,0  |

a Crude oils, because of their varied properties, do not necessarily fit any category designation. If crude oil is considered as a turbine fuel for industrial applications, the manner of its use should be agreed between the turbine manufacturer and user.

b Other methods may be required by law for the determination of minimum flash point.

c In marine applications, this category is for use in engines for emergency purposes and shall conform to the requirements of ISO 8217.

d Fuel with a viscosity below the minimum value of 1,3 mm<sup>2</sup>/s at 40 °C may be substituted by agreement with the turbine manufacturer.

e Density measured at 15 °C, in kilogram per litre or in units of similar magnitude, shall be multiplied by 1 000 before comparison with these values.

f An assessment of the significance of carbon residue for RST.4/RMT.4 is given in C.2.6.

g Gas turbines with waste heat recovery equipment may require additional sulfur control to prevent cold end corrosion (see C.2.9).

Table 1 (continued)

| Property  | Test method | ISO-F Category <sup>a</sup>                         |  |                                     |                              |  |  |
|---|-------------|---|--|-------------------------------------|------------------------------|--|--|
|   |             | DST.0   | DST.1/<br>DMT.1  | DST.2/<br>DMT.2                     | DST.3/<br>DMT.3              | RST.3/<br>RMT.3  | RST.4/<br>RMT.4  |
|   |             | Low flash point petroleum distillate (naphtha type) | Medium flash point petroleum distillate (jet fuel [kerosine] type) | Petroleum distillate (gas-oil type) | Low ash petroleum distillate | Low ash residual fuel or a distillate fuel containing heavy components from petroleum processing | Petroleum fuel containing heavy components from petroleum processing |
| Sediment % (m/m), max.  | ISO 3735    | 0,01  | 0,01   | 0,01                                | 0,05                         | 0,05   | 0,25   |
| Sulfur % (m/m), max. <sup>g</sup>   | ISO 8754    | 0,5   | 0,5  | 1,3                                 | 2,0                          | 2,0  | 4,5  |
| Copper corrosion classification, max.   | ISO 2160    | 1   | 1  | 1                                   | —                            | —  | —  |
| Calculated net specific energy in MJ/kg, min. (lower calorific value)   | See Annex A | Value to be reported                                | 42,8   | 41,6                                | 40,0                         | 40,0   | 39,4   |
| <p>a Crude oils, because of their varied properties, do not necessarily fit any category designation. If crude oil is considered as a turbine fuel for industrial applications, the manner of its use should be agreed between the turbine manufacturer and user.</p> <p>b Other methods may be required by law for the determination of minimum flash point.</p> <p>c In marine applications, this category is for use in engines for emergency purposes and shall conform to the requirements of ISO 8217.</p> <p>d Fuel with a viscosity below the minimum value of 1,3 mm<sup>2</sup>/s at 40 °C may be substituted by agreement with the turbine manufacturer.</p> <p>e Density measured at 15 °C, in kilogram per litre or in units of similar magnitude, shall be multiplied by 1 000 before comparison with these values.</p> <p>f An assessment of the significance of carbon residue for RST.4/RMT.4 is given in C.2.6.</p> <p>g Gas turbines with waste heat recovery equipment may require additional sulfur control to prevent cold end corrosion (see C.2.9).</p> |             |   |  |                                     |                              |  |  |



## Annex A (normative)

### Method of calculation of specific energy

**A.1** Specific energy (lower calorific value) is controlled indirectly by the specification of other properties. Specific energy shall be calculated with a degree of accuracy acceptable for normal purposes from the density of the fuel, applying corrections as follows for any sulfur, water, and incombustible (ash) content that may be present (see C.2.11):

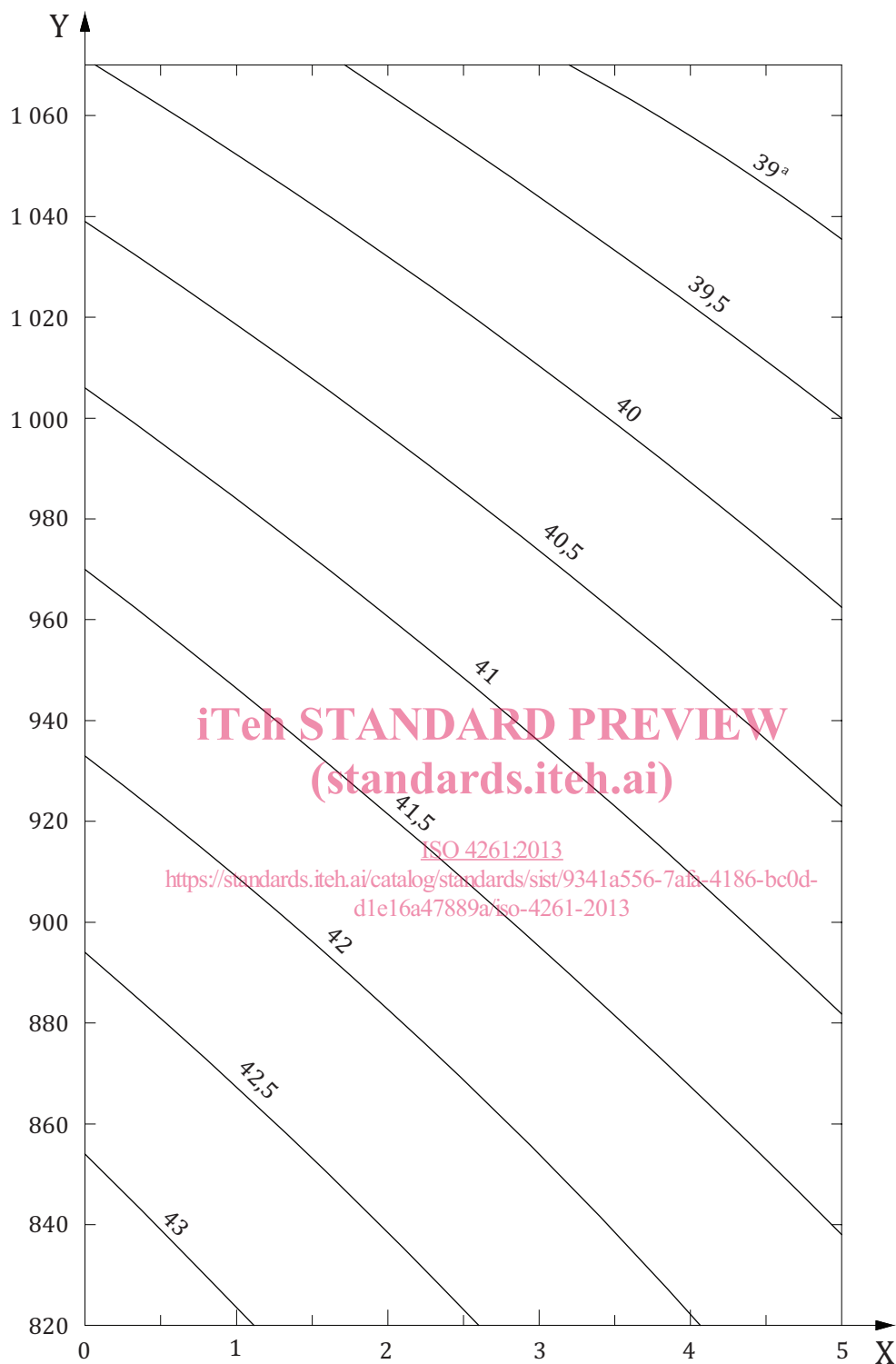
Specific energy (net), MJ/kg

$$= (46\,704 - 8\,802 \rho^2 \times 10^{-6} + 3\,167 \rho \times 10^{-3}) [1 - 0,01 (x + y + s)] + 0,01 (9\,420 s - 2\,449 x)$$

where

- $\rho$  is the fuel density at 15 °C, in kilogram per cubic metre (see [Table 1](#));
- $x$  is the water content, expressed as a percentage by mass;
- $y$  is the ash content, expressed as a percentage by mass;
- $s$  is the sulfur content, expressed as a percentage by mass.

NOTE [Figure A.1](#) may be used for a rapid estimation of the specific energy.



**Key**

- X sulfur content, expressed as a percentage by mass
- Y density at 15 °C, expressed in kilogram per cubic metre
- a Specific energy.

**Figure A.1 — Specific energy expressed in megajoules per kilogram**

## Annex B (informative)

### Trace metal limits of fuel entering turbine combustion chambers

#### B.1 Introduction

The turbine user should confirm that arrangements are made to ensure that the fuel entering the combustion chambers meets the manufacturer's requirements. This might include transportation arrangements with the fuel supplier, particular care in fuel storage, quality control at the point of use, and fuel purification procedures. Distillate fuels are usually of satisfactory purity as refined fuels, but suppliers rarely have control over possible trace contamination by metals during distribution and storage. The limits in the present Annex, although recommended for the fuel entering combustion chambers, do not apply to the fuel as delivered unless mutually agreed upon by the interested parties. Fuels may, therefore, require further treatment, quality control procedures, special handling, or other arrangements. The significance of trace metals in respect to hot corrosion of turbine components is discussed in C.4. In the absence of specific guidance from the turbine manufacturer, the present Annex gives guideline limits for trace metals in the fuel entering the combustion chambers. These limits are shown in [Table B.1](#).

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#### B.2 Analytical methods [\(standards.iteh.ai\)](http://standards.iteh.ai)

Appropriate reference methods for the determination of trace metals are under development. Other methods may be agreed between the user, fuel supplier, and turbine manufacturer for quality control purposes. Adapted methods for the determination of concentrations of sodium, potassium, calcium, and lead are under development. For vanadium, the recommended method is ISO 8691; for sodium, potassium, lead, and calcium, a suitable method is ASTM D 3605<sup>[2]</sup> or equivalent methods pending the publication of relevant International Standards.

#### B.3 Exceptions to [Table B.1](#)

There is a relationship between operating conditions, materials, material life, and the corrosive trace metal content of the fuel. However, although maintenance may be reduced and the life of turbine parts prolonged by exceptionally low levels of metals in fuels, the availability of such fuels may be restricted. The user may choose to adopt levels different from those of [Table B.1](#) if, after discussion with the turbine manufacturer and the fuel supplier, he determines that his overall operation can thereby be optimized.

#### B.4 Alternative to trace metals determination

In order to minimize high-temperature corrosion, it is important that the melting point of the ash be well above the maximum temperature of materials in the gas passage. Therefore, by agreement between the manufacturer of the turbine and the user, either the melting point or the sticking point can be determined and may be used as an alternative to the limits given in [Table B.1](#). This point is discussed further in C.4.