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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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Contents

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4261 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Sub-Committee SC 4, *Classifications and specifications*.

Annex A forms an integral part of this International Standard. Annexes B, C and D are for information only.

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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 standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this 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, and 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 recommendations of annex B as well as additional modifications by the gas turbine manufacturer may, however, be specified by mutual agreement between the interested parties.

The terminology used and the test methods referred to in these specifications are presented in annex C.

Nothing in these specifications shall preclude observance of legal or fiscal regulations that may be more restrictive.

NOTES

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

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, *Petroleum products — Fuels (class F) — Classification — Part 2: Categories of gas turbine fuels for industrial and marine applications.*

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2160:1985, *Petroleum products — Corrosiveness to copper — Copper strip test.*

ISO 2719:1988, *Petroleum products and lubricants — Determination of flash point — Pensky-Martens closed cup method.*

ISO 3104:—[1], *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity.*

ISO 3170:1988, *Petroleum liquids — Manual sampling.*

1) To be published. (Revision of ISO 3104:1976)

ISO 3171:1988, *Petroleum liquids — Automatic pipeline sampling.*

ISO 3405:1988, *Petroleum products — Determination of distillation characteristics.*

ISO 3675:1993, *Crude petroleum and liquid petroleum products — Laboratory determination of density or relative density — Hydrometer method.*

ISO 3733:—[2], *Petroleum products including bitumen — Determination of water — Distillation method.*

ISO 3735:1975, *Crude petroleum and fuel oils — Determination of sediment — Extraction method.*

ISO 4259:1992, *Petroleum products — Determination and application of precision data in relation to methods of test.*

ISO 4260:1987, *Petroleum products and hydrocarbons — Determination of sulfur content — Wickbold combustion method.*

ISO 4262:1993, *Petroleum products — Determination of carbon residue — Ramsbottom method.*

ISO 6245:1993, *Petroleum products — Determination of ash.*

ISO 8217:1987, *Petroleum products — Fuels (class F) — Specifications of marine fuels.*

ISO 8754:1992, *Petroleum products — Determination of sulfur content — Energy-dispersive X-ray fluorescence method.*

3 General requirements

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

NOTE 3 Guidelines for limits for trace metal 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.

2) To be published. (Revision of ISO 3733:1976)

4 Detailed requirements

NOTE 4 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 fuel shall conform to the limiting requirements shown in table 1 when the fuel is tested by the methods specified.

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 5 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 national standards.

NOTE 6 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[1]					
		DST.0	DST.1/DMT.1	DST.2/DMT.2	DST.3/DMT.3	RST.3/RMT.3	RST.4/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[2]		inland – 38 marine – 43[3]	inland – 56 marine – 60	inland – 56 marine – 60	60	60
Kinematic viscosity at 40 °C mm^2/s to 100 °C mm^2/s, max.	ISO 3104	1,3 min.[4]	1,3 – 2,4[4]	1,3 – 5,5	1,3 – 11,0	1,3 – 20,0	55 (see C.2.2)
Density at 15 °C in kg/m^2, max.[5]	ISO 3675	Value to be reported	Value to be reported	880	900 (see B.6)	920 (see B.6)	996 (see B.6)
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 4262	0,15 (on 10 % residue)	0,15 (on 10 % residue)	0,15 (on 10 % residue)	0,25	1,50	Value to be reported[6]
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
Sediment % (*m/m*), max.	ISO 3735	0,01	0,01	0,01	0,05	0,05	0,25
Sulfur % (*m/m*), max.[7]	ISO 4260 ISO 8754	0,5 0,5	0,5 0,5	— 1,3	— 2,0	— 2,0	— 4,5
Copper corrosion, 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

1) 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.

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

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

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

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

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

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

Annex A
(normative)

Method of calculation of specific energy

A.1 Specific energy (lower calorific valve) 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 incombustibles (ash) content that may be present (see C.2.11):

Specific energy (net), MJ/kg

$$= (46{,}704 - 8{,}802\rho^2 \times 10^{-6} + 3{,}167\rho \times 10^{-3})$$

$$[1 - 0{,}01\ (x + y + s)] + 0{,}01(9{,}420s - 2{,}449x)$$

where

ρ is the fuel density at 15 °C, in kilograms per cubic metre (see table 1, note 5);

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.

A.2 This method is technically equivalent to that given in annex A of ISO 8217, which also includes figures that may be used for the rapid estimation of gross and net specific energies.

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, 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.

B.2 Definition

For the purpose of this annex, the following definition applies.

B.2.1 fuel entering the combustion chambers: Fuel that is actually burned in the gas turbine.

B.3 Analytical methods

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 are under development for the determination of concentrations of sodium, potassium, calcium and lead. For vanadium, the recommended method is ISO 8691; for sodium, potassium, lead and calcium a suitable method is ASTM D 3605[3], or equivalent methods pending the publication of relevant International Standards.

B.4 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.5 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.

B.6 Fuel purification procedures

The turbine user and manufacturer should agree on the most appropriate method for the removal of solid contaminants and water-soluble compounds so as to ensure the required final quality of the oil at the entrance to the turbine combustion chambers. Fuels of categories 3 and 4 near the density limit specified in table B.1 may require special consideration, or the limits modified to relate to existing fuel purification systems available.

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3) ASTM D 3605:1977, *Trace metals in gas turbine fuels by atomic absorption and flame emission spectroscopy.*

Table B.1 — Guideline limits, in milligrams per kilogram, for maximum trace metals in fuel entering turbine combustion chambers

Category	Vanadium (V)	Sodium plus potassium (Na + K)	Calcium (Ca)	Lead (Pb)
DST.0 DST/DMT.1 DST/DMT.2 DST/DMT.3	0,5	0,5	0,5	0,5
RST/RMT.3 RST/RMT.4	Consult turbine manufacturer			

B.7 Sampling for trace metal determinations

B.7.1 General

For the purposes of control of trace metals, fuel may be sampled at a point upstream from the point of entry to the combustion chambers, provided that the sample is representative of fuel entering the combustion chambers. Because of the extremely low levels of elements being analysed in distillate fuels, great care has to be taken to ensure that the sample taken for analysis is representative.

B.7.2 Fuel sampling points

Sampling of the fuel at the critical points in the fuel system is recommended to assess the quality of the delivered fuel, to monitor the performance of the fuel clean-up or treatment system and to ensure that the fuel at the gas turbine combustion chambers meets specifications. The sampling points will depend upon the specific fuel system in question. These will include:

a) a sample taken on delivery during transfer into the fuel storage tank;

b) fuel storage tank samples, including both tank bottom samples and samples at various levels in the tank. These should be taken at a frequency determined by the user based on the rate of accumulation of water and other dispersed contaminants. Where the system consists of multiple tankage, it is suggested that such samples be taken preparatory to drawing fuel from a given tank. Where the gas turbine is used for standby or emergency service, the sample should be taken according to a closely observed schedule;

c) in installations which include fuel clean-up and/or treatment, samples should be taken at the fuel input and output to monitor the performance of the equipment;

d) the effectiveness of fuel filters may also be monitored by input and output samples;

e) a sample taken as close as practicable to the gas turbine combustion chambers is essential to ensure that the fuel meets specifications, especially for critical thresholds of trace metal contaminants.

B.7.3 Sample containers

Samples destined specifically for analysis of trace metals should be taken in containers manufactured from plastics materials which are hydrocarbon-resistant and low in trace metal content. These materials include polyethylene, polypropylene and polytetrafluorethylene. Metal and glass containers with unperforated liners of hydrocarbon-resistant plastic film materials are also suitable. Unlined metal and glass containers, while suitable for sampling for some analyses, can both add and remove significant amounts of trace metal contaminants.

The sample container should be filled only three-quarters full to allow shaking of the contents before the sample aliquot is taken for analysis.

B.7.4 Inspection and analysis of samples

Inspection and analysis of fuel to determine fuel quality at various sampling locations and at different times in the fuel storage tanks and the feed system are very important to ensure that only fuel of acceptable quality will reach the turbine combustion chambers. Brief visual inspections may serve to suggest

the presence of some contaminants, but established methods of fuel analysis, including chemical analysis for trace elements, are needed for more complete evaluation of fuel quality.

The effectiveness of a fuel separation system can best be judged by the use of specialized analytical methods, as recommended by the suppliers of the equipment or the fuel. These might include measurement of conductivity, dielectric properties, colour, content and quality of particulate matter, turbidity, spectral properties or filterability. From such data, useful deductions may be made to supplement more detailed chemical analysis.