INTERNATIONAL STANDARD

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Petroleum products — Determination of knock characteristics of motor and aviation fuels — Motor method

Produits pétroliers — Détermination des caractéristiques antidétonantes des carburants pour moteurs automobiles et aviation — Méthode moteur

Reference number
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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

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 28, Petroleum products and lubricants.

This fourth edition cancels and replaces the third edition (ISO 5163:2005). It also incorporates the Technical Corrigendum ISO 5163:2005/Cor.1:2008. Besides improving the understanding of some of the procedures, the main revision lays in the introduction of the so-called digital detonation meter. The revision includes allowances both measurement systems:

a) the knock measurement system based on analogue technology, and

b) the XCP digital technology used in the digital detonation meter.

Introduction

The purpose of this International Standard is to accord ISO status to a test procedure that is already used in a standardized form all over the world. The procedure in question is published by ASTM International as Standard Test Method D 2700-12. This International Standard is based on combining two former test methods for motor spark-ignition[1] and aviation piston[2] engine concepts

By publishing this International Standard, ISO recognizes that this method is used in its original text in many member countries and that the standard equipment and many of the accessories and materials required for the method are obtainable only from specific manufacturers or suppliers. To carry out the procedure requires reference to annexes and appendices of ASTM D 2700-12. The annexes detail the specific equipment and instrumentation required, the critical component settings and adjustments, and include the working tables of referenced settings. The appendices provide background and additional insight about auxiliary equipment, operational techniques and the concepts relative to proper maintenance of the engine and instrumentation items.

The accumulated motor and aviation-type fuel data relating to knock characteristics determined in many countries has, for many years, been based on the use of the CFR engine and the ASTM octane test methods. Accepted worldwide, petroleum industry octane number requirements for motor and aviation-type fuels are defined by the motor method and associated CFR F-2 Octane Rating Unit[1)], which emphasizes the need for this method and test equipment to be standardized. The initiation of studies to use a different engine for ISO purposes has therefore been considered an unnecessary duplication of effort.

It is further recognized that this method for rating motor and aviation-type fuels, which does include metric operating conditions, is nevertheless an exceptional case in that the CFR engine is manufactured to inch dimensions and requires numerous settings and adjustments to inch dimensions. Application of metrication to these dimensions and tolerances can only be accomplished by strict numerical conversion which would not reflect proper metric engineering practice. Attempts to utilize metric measurement instruments for checking component dimensions to the numerically converted metric values would only introduce an additional source of test variability.

For these reasons, it has been considered desirable by ISO Technical Committee 28, *Petroleum products and lubricants,* to adopt the ASTM D 2700 standard rewritten to comply with the ISO Directives, Part 2, *Rules for the structure and drafting of International Standards*. However, this International Standard refers to annexes and appendices of ASTM D 2700 without change because of their extensive detail. These annexes and appendices are not included in this International Standard because they are published in the Annual Book of ASTM Standards, Section 5.

Due to identified component obsolescence issues, the original, analogue control panel has been replaced by the manufacturer by the new digital panel. Service parts availability for the analogue system will be phased out in the future. Research work was executed by ASTM International[8] to check whether there was statistically observable systemic bias between the 501C and the new digital knock measurement system.

With respect to precision ISO and ASTM technical committees concluded that there was numerically comparable precision for repeatability between the 501C and new panel knock measurement systems, and no statistically observable difference for reproducibility between the 501C and new panel knock measurement systems. For Motor octane number results, the evaluation detected neither a statistically observable bias between the two systems nor sample-specific bias, so the results obtained by the two knock measurement systems are practically equivalent (as obtained, no bias correction required). This means that the new CFR octane panel could be included in the test method.

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1) The sole manufacturer of the Model CFR F-2 Octane Rating Unit is Waukesha Engine, Dresser, Inc., 1000 West St. Paul Avenue, Waukesha, WI 53188, USA.

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WARNING — The use of this International Standard may involve hazardous materials, operations and equipment. This International Standard does not purport to address 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 establishes the rating of liquid spark-ignition engine fuel in terms of an arbitrary scale of octane numbers using a standard single-cylinder, four-stroke cycle, variable-compression ratio, carburetted, CFR engine operated at constant speed. Motor octane number (MON) provides a measure of the knock characteristics of motor fuels in automotive engines under severe conditions of operation. The motor octane number provides a measure of the knock characteristics of aviation fuels in aviation piston engines, by using an equation to correlate to aviation-method octane number or performance number (lean-mixture aviation rating).

This International Standard is applicable for the entire scale range from 0 MON to 120 MON, but the working range is 40 MON to 120 MON. Typical motor fuel testing is in the range of 80 MON to 90 MON. Typical aviation fuel testing is in the range of 98 MON to 102 MON.

This International Standard is applicable for oxygenate-containing fuels containing up to 4,0 % (*m*/*m*) oxygen and for gasoline containing up to 25 % (*V*/*V*) ethanol.

NOTE 1 Although 25 % (*V*/*V*) of ethanol corresponds to approximately 9 % (*m*/*m*) oxygen, full applicability of this test method for that oxygen range has only been checked for gasoline type of fuels.

NOTE 2 Work is under way to check the possibility to use the method for gasoline containing up to 85 % (*V*/*V*) ethanol.

NOTE 3 This International Standard specifies operating conditions in SI units but engine measurements may be specified in inch-pound units because these were the units used in the manufacture of the equipment, and thus some references in this International Standard include these units in parenthesis.

NOTE 4 For the purposes of this standard, the terms "% (*m*/*m*)" and "% (*V*/*V*)" are used to represent the mass fraction, μ, and the volume fraction, φ, of a material respectively.

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 3170, *Petroleum liquids — Manual sampling*

ISO 3171, *Petroleum liquids — Automatic pipeline sampling*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

ISO 4787, *Laboratory glassware — Volumetric instruments — Methods for testing of capacity and for use*

ASTM D2700-12, *Standard Test Method for Motor Octane Number of Spark-Ignition Engine Fuel*

3 Terms and definitions

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

3.1
accepted reference value
ARV
value that serves as an agreed-upon reference for comparison, and which is derived as: a theoretical or established value, based on scientific principles, an assigned or certified value, based on experimental work of some national or international organization, or a consensus or certified value, based on collaborative experimental work under the auspices of a scientific or engineering group

3.2
check fuel
fuel of selected characteristics that has a MON assigned reference value determined by round-robin testing by multiple engines in different locations

3.3
cylinder height
relative vertical position of the CFR engine cylinder with respect to the piston at top dead centre (t.d.c.) or the top machined surface of the crankcase

3.4
dial indicator reading
numerical indication of cylinder height, indexed to a basic setting when the engine is motored with the compression ratio set to produce a specified compression pressure

Note 1 to entry: The dial indicator reading is expressed in thousandths of an inch.

3.5
digital counter reading
numerical indication of cylinder height, indexed to a basic setting when the engine is motored with the compression ratio set to produce a specified compression pressure

3.6
detonation meter
knock signal conditioning instrumentation that accepts the electrical signal from the detonation pickup and produces an output signal for display

Note 1 to entry: The meter is either analogue or digital.

3.7
detonation pickup
magnetostrictive-type transducer that threads into the engine cylinder to sense combustion-chamber pressure and provide an electrical signal proportional to the rate-of-change of that cylinder pressure

3.8
firing
engine operation with fuel and ignition

3.9
fuel-air ratio for maximum knock intensity
proportion of fuel to air that produces the highest knock intensity for each fuel

3.10
guide table
tabulation of the specific relationship between cylinder height and octane number for the CFR engine operated at standard knock intensity and a specified barometric pressure

3.11
knock
abnormal combustion, often producing an audible sound, caused by auto-ignition of the air-fuel mixture

3.12
knock intensity
measure of engine knock

3.13
knockmeter
indicating meter with a division scale that displays the knock intensity signal from the detonation meter

Note 1 to entry: The meter is either analogue or digital.

3.14
lean mixture aviation rating
indication of the knock resistance for a fuel operating in an aviation piston engine under lean fuel-air ratio conditions

3.15
motoring
engine operation without fuel and with the ignition shut off

3.16
motor octane number
MON
numerical rating of knock resistance for a fuel obtained by comparing its knock intensity with that of primary reference fuels of known motor octane number when tested in a standardized CFR engine operating under conditions specified in this International Standard

3.17
oxygenate
oxygen-containing organic compound, such as various alcohols or ethers, used as a fuel or fuel supplement

3.18
primary reference fuel
PRF
2,2,4-trimethylpentane (iso-octane), *n*-heptane, volumetrically proportioned mixtures of iso-octane with *n*-heptane, or blends of tetraethyl lead in iso-octane, which define the octane number scale

3.19
spread
sensitivity of the detonation meter expressed in knockmeter divisions per octane number

3.20
toluene standardization fuel blend
TSF blend
volumetrically proportioned blend that has MON accepted reference value and specified rating tolerances

4 Principle

A sample fuel, operating in a CFR engine at the fuel-air ratio that maximizes its knock, is compared to primary reference fuel blends to determine that blend which, when operated at the fuel-air ratio that maximizes its knock, would result in both fuels producing the same standard knock intensity when tested at the same engine compression ratio. The volumetric composition of the primary reference fuel blend defines both its octane number and that of the sample fuel.