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Petroleum products — Determination of knock characteristics of motor fuels — Research method

Produits pétroliers — Détermination des caractéristiques antidétonantes des carburants pour moteurs automobile — Méthode recherche

Reference number
ISO 5164:2005(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 5164 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*.

This third edition cancels and replaces the second edition (ISO 5164:1990), which has been technically revised.

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 2699-01a.

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 six annexes and three appendices of ASTM D 2699-01a, contained in the Annual Book of ASTM Standards, Section 5[1]. 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 fuel data relating to knock characteristics determined in many countries has, for many years, been based on the use of the CFR engine[2] and the ASTM octane test methods. Accepted worldwide, petroleum industry octane number requirements for motor fuels are defined by the research method and associated CFR F-1 Octane Rating Unit, 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 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 2699 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 2699 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.

1) Copies may be purchased directly from the publisher, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA, telephone: +1 610-832-9585, fax: +1 610-832-9555, e-mail: service@astm.org, website: www.astm.org.

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

Petroleum products — Determination of knock characteristics of motor fuels — Research method

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. Research octane number (RON) provides a measure of the knock characteristics of motor fuels in automotive engines under mild conditions of operation.

This International Standard is applicable for the entire scale range from 0 RON to 120 RON, but the working range is 40 RON to 120 RON. Typical motor fuel testing is in the range of 88 RON to 101 RON.

This International Standard can be used for oxygenate-containing fuels containing up to 4,0 % (*m*/*m*) oxygen.

Certain gases and fumes, such as halogenated refrigerants used in air-conditioning equipment, that can be present in the area where the CFR engine is located, may have a measurable effect on the RON rating. Electrical power transient voltage or frequency surges or distortion can affect RON ratings.

NOTE 1 This International Standard specifies operating conditions in SI units but engine measurements are specified in inch-pound units because these are the units used in the manufacture of the equipment, and thus some references in this International Standard include these units in parenthesis.

NOTE 2 For the purposes of this International Standard, the expressions "% (*m*/*m*)" and "% (*V*/*V*)" are used to represent the mass and volume fractions of a material, respectively.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3170:2004, *Petroleum liquids — Manual sampling*

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

ISO 3696:1987, *Water for analytical laboratory use — Specification and test methods*

ISO 4787:1984, *Laboratory glassware — Volumetric glassware — Methods for use and testing of capacity*

ASTM D 2699-01a, *Standard Test Method for Research 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
check fuel
fuel of selected characteristics that has a RON accepted reference value determined by round-robin testing by multiple engines in different locations

3.2
cylinder height
relative vertical position of the CFR engine cylinder with respect to the piston at top dead center (t.d.c.) or the top machined surface of the crankcase

3.3
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 The dial indicator reading is expressed in thousandths of an inch.

3.4
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

3.5
detonation meter
knock signal conditioning instrumentation that accepts the electrical signal from the detonation pickup and produces an output signal for display

3.6
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

3.7
firing
engine operation with fuel and ignition

3.8
fuel-air ratio for maximum knock intensity
proportion of fuel to air that produces the highest knock intensity for each fuel

3.9
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

3.10
knock
abnormal combustion, often producing an audible sound, caused by auto-ignition of the air-fuel mixture

3.11
knock intensity
measure of engine knock

3.12
knockmeter
indicating meter with a 0-to-100 division scale that displays the knock intensity signal from the detonation meter

3.13
motoring
engine operation without fuel and with the ignition off

3.14
research octane number
RON
numerical rating of knock resistance for a fuel obtained by comparing its knock intensity with that of primary reference fuels of known research octane number when tested in a standardized CFR engine operating under conditions specified in this International Standard

3.15
oxygenate
oxygen-containing organic compound, such as various alcohols or ethers, used as a fuel or fuel supplement

3.16
primary reference fuel
PRF
2,2,4-trimethylpentane (isooctane), heptane, volumetrically proportioned mixtures of isooctane with heptane, or blends of tetraethyl lead in isooctane, which define the octane number scale

3.17
spread
sensitivity of the detonation meter expressed in knockmeter divisions per octane number

3.18
toluene standardization fuel blend
TSF blend
volumetrically proportioned blend of two or more of the following; reference fuel grade toluene, heptane, and isooctane, that have RON accepted reference values 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.

5 Reagents and reference materials

5.1 Cylinder-jacket coolant, consisting of water conforming to grade 3 of ISO 3696:1987. Water shall be used in the cylinder jacket for laboratory locations where the resultant boiling temperature is 100 °C ± 2 °C. Water with commercial glycol-based antifreeze added in sufficient quantity to meet the boiling temperature requirement shall be used when laboratory altitude dictates.

A commercial multi-functional water treatment material should be used in the coolant to minimize corrosion and mineral scale that can alter heat transfer and rating results.

5.2 Carburettor coolant, if required (see 8.29), consisting of water or a water-antifreeze mixture, chilled sufficiently to prevent fuel bubbling, but neither colder than 0,6 °C nor warmer than 10 °C.

5.3 Engine crankcase-lubricating oil, comprising an SAE 30 viscosity grade oil meeting service classification SF/CD or SG/CE.

It shall contain a detergent additive and have a kinematic viscosity of 9,3 mm^2/s to 12,5 mm^2/s at 100 °C and a viscosity index of not less than 85. Oils containing viscosity index improvers shall not be used. Multi-grade lubricating oils shall not be used.

5.4 2,2,4-trimethylpentane (isooctane) primary reference fuel, of minimum purity 99,75 % (V/V), containing no more than 0,10 % (V/V) heptane and no more than 0,5 mg/l lead. This material shall be designated as 100 RON.

NOTE Certified reference materials, such as CRM IRMM-442 and NIST SRM 1816a, are commercially available.

5.5 Heptane primary reference fuel, of minimum purity 99,75 % (V/V), containing no more than 0,10 % (V/V) isooctane and no more than 0,5 mg/l lead. This material shall be designated as 0 RON.

NOTE Certified reference materials, such as CRM IRMM-441 and NIST SRM 1815a, are commercially available.

5.6 80-octane primary reference fuel blend, prepared using reference fuel grade isooctane (5.4) and heptane (5.5); this blend shall contain 80 % (V/V) ± 0,1 % (V/V) isooctane.

NOTE ASTM D 2699-01a, Annex A5 (Reference Fuel Blending Tables), provides information for preparation of primary reference fuel blends to specific RON values.

5.7 Tetraethyl lead, dilute, (TEL dilute volume basis), consisting of a solution of aviation mix tetraethyl lead antiknock compound in a hydrocarbon diluent of 70 % (V/V) xylene and 30 % (V/V) heptane.

The anti-knock compound shall contain 18,23 % (m/m) ± 0,05 % (m/m) tetraethyl lead and have a relative density at 15,6 °C/15,6 °C of 0,957 to 0,967.

NOTE The typical composition of the compound, excluding the tetraethyl lead, is as follows:

Ethylene dibromide (scavenger):	10,6 % (m/m)
Diluent:	
xylene	52,5 % (m/m)
heptane	17,8 % (m/m)
dye, antioxidant and inerts	0,87 % (m/m)

5.8 Primary reference fuel blends for ratings over 100 RON, prepared by adding dilute tetraethyl lead (5.7), in millilitre quantities, to a 400 ml volume of isooctane (5.4). These blends define the RON scale above 100.

NOTE ASTM D 2699-01a, Annex A5 (Reference Fuel Blending Tables), provides the RON values for blends of tetraethyl lead in isooctane.

5.9 Methylbenzene (toluene), reference fuel grade, with a minimum purity of 99,5 % (V/V) as determined by chromatographic analysis, a peroxide number not exceeding 5 mg/kg and a water content not exceeding 200 mg/kg.

Antioxidant treatment should be added by the supplier at a rate suitable for long term stability as empirically determined with the assistance of the antioxidant supplier.

5.10 Check fuels, consisting of in-house typical spark-ignition engine fuels having RON accepted reference values, low volatility and good long-term stability.

6 Apparatus

6.1 Test engine assembly, a CFR F-1 octane rating unit consisting of a single-cylinder engine consisting of a standard crankcase, a variable compression ratio cylinder — clamping sleeve assembly, thermal-siphon recirculating jacket cooling system, a fuel bowl to deliver fuel through a single-jet passage (a multiple-fuel-bowl system with selector valving is commonly used) and carburettor venturi, an intake air system with controlled temperature and humidity equipment, electrical controls, and a suitable exhaust pipe.

The engine shall be connected by a belt to a special electric power-absorption motor that acts as a motor driver to start the engine and as a means to absorb power at constant speed when combustion is occurring (engine firing). See ASTM D 2699-01a, Annex A2 (Engine Equipment Description and Specifications), for all critical, non-critical and equivalent engine equipment, which shall apply for this International Standard.

6.2 Instrumentation, consisting of electronic detonation metering instrumentation, including a detonation pickup and knockmeter to measure and display the intensity of combustion knock, as well as conventional thermometry, gauges and general-purpose meters. See ASTM D 2699-01a, Annex A3 (Instrumentation Description and Specifications), for all critical, non-critical and equivalent instrumentation, which shall apply for this International Standard.

NOTE Engine equipment and instrumentation are available from the single source manufacturer, Waukesha Engine, Dresser, Inc., 1000 West St. Paul Avenue, Waukesha, WI 53188, USA. Waukesha Engine also has authorized sales and service organizations in selected geographic areas. This information is given for the convenience of users of this International Standard but does not constitute an endorsement by ISO of this product.

6.3 Reference and standardization fuel dispensing equipment, consisting of calibrated burettes or volumetric ware having a capacity of 200 ml to 500 ml and a maximum volumetric tolerance of ± 0,2 %.

Calibration shall be verified in accordance with ISO 4787. Burettes shall be outfitted with a delivery valve and delivery tip to accurately control dispensed volumes. The delivery tip shall be of such size and design that shut-off tip discharge does not exceed 0,5 ml. The rate of delivery from the dispensing system shall not exceed 400 ml/min.

6.4 Tetraethyl lead (TEL) dispensing equipment, consisting of a calibrated burette, pipette assembly, or other liquid-dispensing apparatus, having a capacity not exceeding 4,0 ml, and a critically controlled tolerance for dispensing dilute TEL into 400 ml batches of isooctane.

Calibration shall be verified in accordance with ISO 4787.

NOTE ASTM D 2699-01a, Appendix X1 (Reference Fuel Blending Apparatus and Procedures), provides additional information for application of this International Standard.

6.5 Special maintenance tools, consisting of a number of specialty tools and measuring instruments available for easy, convenient and effective maintenance of the engine and testing equipment.

NOTE Lists and descriptions of these tools and instruments are available from the manufacturers of the engine equipment and those organizations offering engineering and service support for this International Standard.

7 Sampling and sample preparation

7.1 Obtain samples in accordance with ISO 3170, ISO 3171 or an equivalent national standard.

7.2 Cool samples to 2 °C to 10 °C, in the container in which they are received and before the container is opened.

7.3 Minimize the sample's exposure to light before pouring it into the engine carburettor fuel bowl, because of possible sensitivity to light that can affect fuel characteristics.