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Petroleum

The Petroleum Program ensures consumer protection, safe storage and use of petroleum products and provides a swift environmental response to petroleum contamination.

COLORADO
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Overview of Proposed Revisions to the Storage Tank Regulations 7 C.C.R. 1101-14

Mahesh Albuquerque, Director
Division of Oil and Public Safety

Storage Tank Regulations

COLORADO DEPARTMENT OF LABOR AND EMPLOYMENT

DIVISION OF OIL AND PUBLIC SAFETY

STORAGE TANK REGULATIONS

7 C.C.R. 1101-14

Effective: October 15, 2014

Storage Tank Regulations

Table of Contents

Why revise regulations?

- EPA 2015 UST regulation revisions to 40 CFR part 280 and 281
  - changes establish federal requirements that are similar to key portions of the Energy Policy Act of 2005.
  - added new operation and maintenance requirements and addressed UST systems deferred in the 1988 UST regulation
  - adoption of federal requirements is necessary for continued state program approval status

- Updates to Motor Fuel Dispensing and Product Quality

- Minor updates to Articles 5, 7 and 8 – SCR, CAP, FR. PSTF

Underground Storage Tanks

EPA's 2015 UST Regulation

- Adds secondary containment requirements for new and replaced tanks and piping
- Adds operator training requirements
- Adds periodic operation and maintenance requirements for UST systems
- Adds requirements to ensure UST system compatibility before storing certain biofuel blends
- Removes past deferrals for emergency generator tanks, airport hydrant systems, and field-constructed tanks
- Updates codes of practice and makes editorial and technical corrections

EPA's New Secondary Containment Requirements

- **Secondary Containment** (after April 11, 2016)
  - Applies to new and replaced tanks and piping
  - Includes interstitial monitoring (and sumps if they are used for interstitial monitoring)
  - Includes under-dispenser containment for new dispenser systems

- ***OPS required this beginning January 1, 2009***

EPA's New Operator Training Requirements

- **Operator Training** (by October 13, 2018)
  - Owners must designate and ensure 3 classes of operators are trained
  - Recordkeeping is required for as long as the operator is designated at the facility
  - Retraining is required for Class A and B operators at facilities determined to be out of compliance

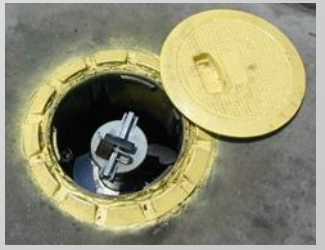
- ***OPS required this beginning January 1, 2010***

EPA's New Operation and Maintenance Requirements

- **Periodic walkthrough inspections** (beginning October 13, 2018*)*

  - Every 30 Days
    - Check spill prevention equipment
    - Check release detection equipment and records
  - Annually
    - Check containment sumps
    - Check hand held release detection equipment
  - Keep records of the walkthrough inspection for 1 year

OPS required most of this beginning January 1, 2010



EPA's New Operation and Maintenance Requirements

- **Three year spill prevention equipment testing**
  - To make sure the spill bucket will hold drips and small spills when the delivery hose is disconnected from the fill pipe.
    - Double-walled spill buckets with periodic interstitial monitoring between the spill bucket walls are not required to meet the testing requirement
    - Applies to new installations after October 13, 2015
    - Applies October 13, 2018 for UST systems installed on or before effective date of rule
    - Keep records for 3 years

- ***OPS required only some of this beginning January 1, 2009***
- ***New install Jan 1, 2017; all existing Jan 1, 2020***

EPA's New Operation and Maintenance Requirements

- **Three year overfill prevention equipment inspections**
  - Inspect to make sure overfill operates as intended
    - Applies to new installations after October 13, 2015
    - Applies October 13, 2018 for UST systems installed on or before effective date of rule
    - Keep records for 3 years

- ***New OPS requirement – new install Jan 1, 2017***
- ***Applies to all existing systems – Jan 1, 2020***

EPA's New Operation and Maintenance Requirements

- **Three year containment sump testing** for sumps used for piping interstitial monitoring
    - Applies to new installations after October 13, 2015
    - Applies October 13, 2018 for UST systems installed on or before effective date of rule
    - Double-walled sumps with periodic interstitial monitoring between the containment sump walls are not required to meet the testing requirement
    - Keep records for 3 years

- ***New OPS requirement – new install Jan 1, 2017***
- ***Systems installed after Aug 2008 – Jan 1, 2020***

EPA's New Operation and Maintenance Requirements

- **Annual release detection equipment testing** to make sure release detection equipment is operating properly
  - Applies beginning October 13, 2018
  - Keep records for 3 years

- ***New OPS requirement – Jan 1, 2020***

Addressing Deferrals – Emergency Generator USTs

- Removes the deferral and requires release detection for Emergency Generator Tanks
  - Required October 13, 2018 for systems installed on or before October 13, 2015
  - Required immediately for UST systems installed after October 13, 2015

- ***New OPS requirement – new install Jan 1, 2017***
- ***Applies to all existing systems – Jan 1, 2020***

Addressing Deferrals – FCTs and AHF Distribution Systems

- 1988 UST regulation deferred AHS and FCT from meeting release prevention and detection requirements
- 2015 UST regulation removes the deferral, however given the unique nature of these systems EPA created more specific and appropriate requirements for these systems
  - Exceptions to meeting secondary containment requirement for some FCT & AHS piping
  - Provides unique options for meeting release detection requirements
  - One-time notification by October 13, 2018 for these systems
  - Implementation depends on requirement
    - October 13, 2015: release reporting, response, and investigation; financial responsibility; closure, notification (except one-time)
    - October 13, 2018: Spill and overfill prevention, corrosion protection, general operating requirements (including compatibility and repairs), release detection, and operator training
  - Partially excludes aboveground tanks associated with these systems

- ***New OPS requirement – applies fully to new install Jan 1, 2017***
- ***Applies fully to all existing systems – Jan 1, 2020***

Addressing Deferrals

- Wastewater Treatment Tank Systems
- USTs Containing Radioactive Materials, and
- Emergency Generator USTs at NRC facilities

  - These previously deferred systems are reclassified as partially excluded from the 2015 UST rule. As with 1988 rule, we will continue to regulate installation under subpart A and cleanup under subpart F.

- ***New OPS requirement – applies to existing systems – Jan 1, 2017***

Compatibility

- **Notification** - Owners and operators must notify the implementing agency at least 30 days before switching to a regulated substance containing greater than 10 percent ethanol, 20 percent biodiesel, or any other regulated substance identified by the implementing agency

- **Demonstration of compatibility** – Owners and operators must demonstrate compatibility of the UST system through a nationally recognized testing lab listing or manufacturer approval of UST equipment or components, of use an alternative option identified by the implementing agency that is no less protective than demonstrating compatibility of the UST system

- **Recordkeeping** - Owners and operators must maintain records for as long as the biofuel blend is stored to demonstrate compliance

- ***Partially new OPS requirement – new and existing Jan 1, 2017***

Groundwater and Vapor Monitoring

Requires owner or operator to have a record of site assessment for as long as using **groundwater or vapor monitoring for release detection**

Record of site assessments needed by October 13, 2018

- ***New OPS requirement – new and existing Jan 1, 2020***

Additional Requirements

Repairs

- 1988 regulation linked a repair to a release to the environment
- 2015 UST regulation removes this link so that fixes not associated with releases are also repairs
- Added testing after repairs to spill, overfill, and secondary containment equipment

Interstitial monitoring results

- 2015 regulation considers an interstitial alarm being an unusual operating condition and added interstitial integrity testing as part of release investigation and confirmation

- ***Partially new OPS requirement – new and existing Jan 1, 2017***

Additional Requirements

- **Flow restrictors** - flow restrictors in vent lines (ball floats) are no longer an option for overfill protection in new UST systems and when these devices need to be replaced

- I**nternally lined USTs** - if the periodic internal lining inspection shows that the lining fails and cannot be repaired according to a code of practice, then that UST system must be permanently closed

- **Notification** – new owners must notify implementing agency within 30 days of becoming an UST owner

- ***Partially new OPS requirement – new and existing Jan 1, 2017***

Switching Gears- Release Response

Overview of Article 5 Revisions

- More flexibility given to collect the amount of data needed based on the complexity of the release
- Proposed revisions do a better job of selecting the right technology based on the objectives and site knowledge
- Pilot testing is introduced at the right time
- Remove ‘start/stop’ process associated with regulatory review and approval

Section 5-2 Site Characterization

- Provide flexibility on frequency of monitoring following well installation (monthly, quarterly, semi annual, etc.)
- New requirement to develop a Conceptual Site Model (CSM)
- Evaluate the need for active remediation
- Pilot testing not required during site chartecterization

Section 5-3 Corrective Action

- CAP is due one year from the release discovery date (as opposed to 60 days upon request)
- Incorporate a technology selection framework based on defining remedial objectives, identifying targeted treatment areas, and performing a remedial technology evaluation
- Pilot testing and collection of other critical data needs to be completed after technology selection process

Article 7 and 8 – FR and PSTF

Article 7 and 8 – FR and PSTF

- Adds airport hydrant systems, field constructed USTs and emergency power generator USTs to those requiring FR.
- Deletes 8-4(b)(6) unallowed cost related to “prosecuting” an application. The definition of “prosecuting” in this case is “to pursue or persist in so as to complete”. 8-3(b)(17) allows costs associated with preparing and filing an application.
- Clarifies 8-4(b)(8) so that if a release is reported and concentrations do not exceed the RBSLs, the costs of making that determination would be reimbursable.
- Minor wording changes to match EPA.

Fuel Dispensing and Product Quality

RMFD Inspection and Testing

- New section 1.5-2(c) - Notification using placed in service report whenever a new or remanufactured RMFD is placed in service at a new or existing installation

- New section 1.5-2(g) - All RMFD's shall be labeled in accordance with the minimum standards as prescribed by the applicable sections of NFPA 30A and NIST Handbook 130, EPA regulations, and Colorado Statutes.

- Minor cleanup of language

Product Quality

- Three grades of gasoline available in Colorado: 85, 87 and 91
- Allows vehicle owner to purchase fuel recommended by vehicle manufacturer
- New section 1.5-3(d) – recognizes octane number reduction for altitude as included in current ASTM D4814-16a
- The allowable reductions in vehicle antiknock requirements for altitude are 4.5 for less than 89 Antiknock Index (AKI), and 3.0 for greater than 89 AKI. Fuel may be marketed using these reductions, but actual AKI minimum must be posted.

ASTM D4814-16a

Designation: D4814 – 16a

Standard Specification for Automotive Spark-Ignition Engine Fuel[1]

This standard is issued under the fixed designation D4814; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers the establishment of requirements of liquid automotive fuels for ground vehicles equipped with spark-ignition engines.

1.2 This specification describes various characteristics of automotive fuels for use over a wide range of operating conditions. It provides for a variation of the volatility and water tolerance of automotive fuel in accordance with seasonal climatic changes at the locality where the fuel is used. For the period May 1 through Sept. 15, the maximum vapor pressure limits issued by the United States (U.S.) Environmental Protection Agency (EPA) are specified for each geographical area except Alaska and Hawaii. Variation of the antiknock index with seasonal climatic changes and altitude is discussed in Appendix X1. This specification neither necessarily includes all types of fuels that are satisfactory for automotive vehicles, nor necessarily excludes fuels that can perform unsatisfactorily under certain operating conditions or in certain equipment. The significance of each of the properties of this specification is shown in Appendix X1.

1.3 The spark-ignition engine fuels covered in this specification are gasoline and its blends with oxygenates, such as alcohols and ethers. This specification does not apply to fuels that contain an oxygenate as the primary component, such as Fuel Methanol (M85). The concentrations and types of oxygenates are not specifically limited in this specification. However, depending on oxygenate type, as oxygenate content increases above some threshold level, the likelihood for vehicle problems also increases. The composition of both unleaded and leaded fuel is limited by economic, legal, and technical consideration, but their properties, including volatility, are defined by this specification. In addition, the composition of unleaded fuel is subject to the rules, regulations, and Clean Air Act waivers of the U.S. Environmental Protection Agency (EPA). With regard to fuel properties, including volatility, this specification can be more or less restrictive than the EPA rules, regulations, and waivers. Refer to Appendix X3 for discussions of EPA rules relating to fuel volatility, lead and phosphorous contents, deposit control additive certification, and use of oxygenates in blends with unleaded gasoline. Contact the EPA for the latest versions of the rules and additional requirements.

1.4 This specification does not address the emission characteristics of reformulated spark-ignition engine fuel. Reformulated spark-ignition engine fuel is required in some areas to lower emissions from automotive vehicles, and its characteristics are described in the research report on reformulated spark-ignition engine fuel.[2] However, in addition to the legal requirements found in this research report, reformulated spark-ignition engine fuel should meet the performance requirements found in this specification.

1.5 This specification represents a description of automotive fuel as of the date of publication. The specification is under continuous review, which can result in revisions based on changes in fuel, automotive requirements, or test methods, or a combination thereof. All users of this specification, therefore, should refer to the latest edition.

NOTE 1—If there is any doubt as to the latest edition of Specification D4814, contact ASTM International Headquarters.

1.6 Tests applicable to gasoline are not necessarily applicable to its blends with oxygenates. Consequently, the type of fuel under consideration must first be identified in order to select applicable tests. Test Method D4815 provides a procedure for determining oxygenate concentration in mass percent. Test Method D4815 also includes procedures for calculating mass oxygen content and oxygenate concentration in volume percent. Appendix X4 provides a procedure for calculating the mass oxygen content of a fuel using measured oxygenate type, oxygenate concentration in volume percent, and measured density or relative density of the fuel.

1.7 The following applies to all specified limits in this standard: For purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded "to the nearest unit" in the right-most significant digit

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.A0.01 on Gasoline and Gasoline-Oxygenate Blends.

Current edition approved Feb. 1, 2016. Published February 2016. Originally approved in 1988. Last previous edition approved in 2016 as D4814 – 16. DOI: 10.1520/D4814-16A.

[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1347.

*A Summary of Changes section appears at the end of this standard

ASTM D4814-16a

each method, with the exception of Driveability Index. In many cases, the precision applicable to gasoline-oxygenate blends has not been established yet.

9.2 *Precision and Bias of Driveability Index (DI):*

9.2.1 The following statements apply to the precision and bias of DI, which is a derived quantity not addressed in any other standard.[9]

9.2.2 The precision of DI is a function of the individual precisions of the 10 %, 50 %, and 90 % evaporated temperatures from Test Method D86. The precisions of these percent evaporated temperatures vary for different apparatuses (manual or automatic), for fuels of different volatilities (for example, above and below 65.5 kPa (9.5 psi) vapor pressure) and with different distillation curve slopes.

9.2.3 *Repeatability*—The difference between two successive DI determinations using Test Method D86 results, where the two test results were obtained by one operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in normal and correct operation of the test method, exceed 9 °C (17 °F) derived units in only one case in twenty.

9.2.4 The repeatability value was calculated using the precision data from Test Method D86 and average distillation characteristics from the 1994 through 1998 ASTM Committee D02 Interlaboratory Crosscheck Program for Motor Gasoline and from the 1997 and 1998 ASTM Committee D02 Interlaboratory Crosscheck Program for Reformulated Gasoline.

9.2.5 *Reproducibility*—The difference between two single and independent DI determinations using Test Method D86 results, where the two test results were obtained by different operators in different laboratories on identical test material, would in the long run, in normal and correct operation of the test method, exceed 27 °C (48 °F) derived units in only one case in twenty.

9.2.6 The reproducibility values were determined directly using the distillation data from each laboratory participating in cooperative programs to calculate DI. The data used to calculate DI were available from the 1994 through 1998 ASTM Committee D02 Interlaboratory Crosscheck Program for Motor Gasoline, the 1997 and 1998 ASTM Committee D02 Interlaboratory Crosscheck Program for Reformulated Gasoline, the Auto/Oil Air Quality Improvement Research Program, the Auto/Oil AAMA Gasoline Inspections Program, and the 1995 to 1996 CRC volatility program.

9.2.7 *Bias*—Since there is no acceptable reference material suitable for determining bias for DI, bias has not been determined.

10. Keywords

10.1 alcohol; antiknock index; automotive fuel; automotive gasoline; automotive spark-ignition engine fuel; copper strip corrosion; corrosion; distillation; driveability; Driveability Index; EPA regulations; ethanol; ether; fuel; gasoline; gasoline-alcohol blend; gasoline-ethanol blend; gasoline-ether blend; gasoline-oxygenate blend; induction period; lead; leaded fuel; methanol; MTBE; octane number; octane requirement; oxidation stability; oxygenate; oxygenate detection; phase separation; phosphorous; solvent-washed gum; sulfur; $T_{V/L=20}$; unleaded fuel; vapor-liquid ratio; vapor lock; vapor pressure; volatility; water tolerance

APPENDIXES

(Nonmandatory Information)

X1. SIGNIFICANCE OF ASTM SPECIFICATION FOR AUTOMOTIVE SPARK-IGNITION ENGINE FUEL

X1.1 General

X1.1.1 Antiknock rating and volatility define the general characteristics of automotive spark-ignition engine fuel. Other characteristics relate to the following: limiting the concentration of undesirable components so that they will not adversely affect engine performance and ensuring the stability of fuel as well as its compatibility with materials used in engines and their fuel systems.

X1.1.2 Fuel for spark-ignition engines is a complex mixture composed of relatively volatile hydrocarbons that vary widely in their physical and chemical properties and may contain oxygenates. Fuel is exposed to a wide variety of mechanical, physical, and chemical environments. Thus, the properties of fuel must be balanced to give satisfactory engine performance over an extremely wide range of operating conditions. The prevailing standards for fuel represent compromises among the numerous quality and performance requirements. This ASTM specification is established on the basis of the broad experience and close cooperation of producers of fuel, manufacturers of automotive equipment, and users of both.

X1.2 Engine Knock

X1.2.1 The fuel-air mixture in the cylinder of a spark-ignition engine will, under certain conditions, autoignite in localized areas ahead of the flame front that is progressing from the spark. This is engine spark knock which can cause a ping that may be audible to the customer.

X1.2.2 The antiknock rating of a fuel is a measure of its resistance to knock. The antiknock requirement of an engine depends on engine design and operation, as well as atmospheric conditions. Fuel with an antiknock rating higher than that required for knock-free operation does not improve performance.

X1.2.3 A decrease in antiknock rating may cause vehicle performance loss. However, vehicles equipped with knock limiters can show a performance improvement as the antiknock quality of the fuel is increased in the range between customer-audible knock and knock-free operation. The loss of power and the damage to an automotive engine due to knocking are generally not significant until the knock intensity becomes very severe. Heavy and prolonged knocking may cause power loss and damage to the engine.

X1.3 Laboratory Octane Number

X1.3.1 The two recognized laboratory engine test methods for determining the antiknock rating of fuels are the Research method (Test Methods D2699 or D2885) and the Motor method (Test Methods D2700 or D2885). The following paragraphs define the two methods and describe their significance as applied to various equipment and operating conditions.

X1.3.2 Research octane number is determined by a method that measures fuel antiknock level in a single-cylinder engine under mild operating conditions; namely, at a moderate inlet mixture temperature and a low engine speed. Research octane number tends to indicate fuel antiknock performance in engines at wide-open throttle and low-to-medium engine speeds.

X1.3.3 Motor octane number is determined by a method that measures fuel antiknock level in a single-cylinder engine under more severe operating conditions than those employed in the Research method; namely, at a higher inlet mixture temperature and at a higher engine speed. It indicates fuel antiknock performance in engines operating at wide-open throttle and high engine speeds. Also, Motor octane number tends to indicate fuel antiknock performance under part-throttle, road-load conditions.

X1.4 Road Octane Number

X1.4.1 The road octane of a fuel is the measure of its ability to resist knock in customers' vehicles, and is ultimately of more importance than laboratory octane numbers. Since road octanes are difficult to measure and interpret, the industry has agreed to use ASTM laboratory engine tests to estimate the road octane performance of spark-ignition engine fuel in vehicles.

X1.4.2 The antiknock index (AKI) is the arithmetic average of the Research octane number (RON) and Motor octane number (MON):

$$AKI = (RON + MON)/2 \quad (X1.1)$$

This value is called by a variety of names, in addition to antiknock index, including:

Octane rating
Posted octane
(R + M)/2 octane

X1.4.3 The AKI is posted on retail gasoline dispensing pumps in the United States and is referred to in car owners' manuals. The AKI is also required for certification at each wholesale fuel transfer and is referred to in United States federal law as "Octane Rating."[10] Areas outside the United States may or may not use AKI as the standard means for reporting octane rating; for example, minimums for RON and MON may be required rather than the AKI.

X1.4.4 The most extensive data base that relates the laboratory engine test methods for Research and Motor octane to actual field performance of fuel in vehicles is the annual Coordinating Research Council (CRC)[11] Octane Number Requirement Survey conducted for new light-duty vehicles. Analysis of these data shows that the antiknock performance of a fuel in some vehicles may correlate best with Research octane number, while in others, it may correlate best with Motor octane number. These correlations also differ from model year to model year or from vehicle population to vehicle population, reflecting changes in engine designs over the years.

X1.4.5 The antiknock index of a fuel approximates the CRC road octane ratings for many vehicles. However, the user must also be guided by experience as to which fuel is most appropriate for an individual vehicle. The antiknock index formula is reviewed periodically and may have to be adjusted in the future as engines and fuels continue to evolve. The present (RON + MON)/2 formula is an estimate and is not an absolute measure of fuel antiknock performance in general or in any specific vehicle.

X1.4.6 Car antiknock requirements vary, even within a single model, so the statistical distribution of the octane needs of any car population are usually shown in graphical form, as shown in Fig. X1.1. As antiknock index increases, larger and larger fractions of the car population in question will be free of knock, that is, be "satisfied" with the octane quality of fuels at or above that level of antiknock index. The data in Fig. X1.1 are for new model cars and trucks sold in the United States in the model year 1988 and are included as an example of the antiknock requirement distribution, not as a data reference.

X1.4.7 According to the winter 1988–1989 motor gasoline survey published by the National Institute for Petroleum and Energy Research, unleaded fuel antiknock indexes in current practice range from a low near 84 in the mountain areas to a high of near 94. Companies typically market two or three unleaded grades of fuel, one of which usually has a minimum antiknock index of 87, for which most post-1971 vehicles are designed. Most companies also market a higher octane fuel with an antiknock index of 91 or above. This fuel is intended to satisfy those vehicles with a higher octane requirement. Some companies offer three grades of unleaded fuel. The third grade usually has an antiknock index of 89. Leaded fuel is still available in some markets and usually has an antiknock index of 88 or 89.

[10] Details of this regulation can be found in Code of Federal Regulations Title 16, Chapter I, Subchapter C, part 306 (16 CFR306), U.S. Government Printing Office, Superintendent of Documents, Washington DC 20402.

[11] Coordinating Research Council, Inc., 3650 Mansell Rd., Ste. 140, Alpharetta, GA 30022–8246.

ASTM D4814-16a

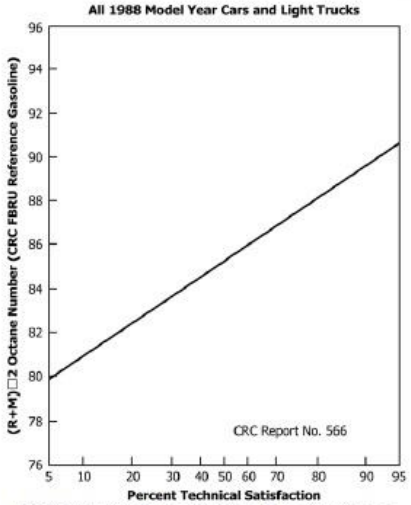


FIG. X1.1 An Example of the Statistical Distribution of Vehicle Antiknock Requirements

X1.4.8 Marketers set the grades and octane based on their perception of the technical and competitive needs in the market.

X1.4.9 Antiknock indexes of fuel sold in current practice in the United States are shown in Table X1.1 for both unleaded and leaded fuels.

X1.5 Precision and Bias of Antiknock Index

X1.5.1 The following statements apply to the precision and bias of antiknock index of fuel, which is a composite quantity not addressed in any other standard.

X1.5.2 The precision of the antiknock index, (RON + MON)/2, is a function of the individual precisions of Research (Test Method D2699) and Motor (Test Method D2700) octane numbers. The repeatability and reproducibility variances for these test methods are summed and divided by four to obtain the variance of the antiknock index.

X1.5.2.1 *Repeatability*—The difference between two sets of antiknock index determinations, where two test results by each octane number method were obtained by one operator, with the same apparatus under constant operating conditions on identical test material would, in the long run, and in the normal and correct operation of the test methods, exceed the values in the following table in only one case in twenty.

X1.5.2.2 *Reproducibility*—The difference between two independent sets of antiknock index determinations, obtained by different operators working in different laboratories on identical test material would, in the long run, and in the normal and correct operation of the test methods, exceed the values in the following table in only one case in twenty.

TABLE X1.1 Automotive Spark-Ignition Engine Fuel Antiknock Indexes in Current Practice

Unleaded Fuel[A] (for vehicles that can or must use unleaded fuel)	
Antiknock Index[B,C,D,E] (RON + MON)/2	Application
87	Designed to meet antiknock requirements of most 1971 and later model vehicles
89	Satisfies vehicles with somewhat higher antiknock requirements
91 and above	Satisfies vehicles with high antiknock requirements
Leaded Fuel (for vehicles that can or must use leaded fuel)	
Antiknock Index[B,C,D,E] (RON + MON)/2	Application
88	For most vehicles that were designed to operate on leaded fuel

[A] Unleaded fuel having an antiknock index of at least 87 should also have a minimum Motor octane number of 82 in order to adequately protect those vehicles that are sensitive to Motor octane quality.
[B] Reductions in vehicle antiknock requirements for altitude are shown in Fig. X1.2.
[C] Reductions in vehicle antiknock requirements for seasonal variations are shown in Fig. X1.3.
[D] Not all antiknock index levels listed in this table are available at all locations.
[E] The Federal Trade Commission requires octane posting and certification in accordance with 16 CFR Part 306.

Antiknock Index	Repeatability, Antiknock Index Units	Reproducibility, Antiknock Index Units
83	0.2	0.7
85	0.2	0.7
87	0.2	0.6
89	0.2	0.6
91	0.2	0.6
93	0.2	0.6
95	—	0.6
97	—	0.7

NOTE X1.1—These precision values were calculated from Research and Motor octane number results utilizing exchange sample test data obtained by the ASTM National Exchange Group (NEG), the Institute of Petroleum, or the Institut Français du Petrole, or combination thereof, participating in cooperative testing programs. The precision values for 83, 85, 95, and 97 AKI were obtained from NEG data during the period 1980 through 1982 and have been analyzed in accordance with RR:D02-1007, "Manual on Determining Precision Data for ASTM Methods on Petroleum Products and Lubricants," Spring 1973.[12] The precision values for 87 though 93 AKI were calculated using the data from RR:D02-1383, "Research and Motor Octane Number Precision Study Report, 1988 through 1994," December 1995.[13]

X1.5.2.3 *Bias*—Since knock ratings are determined by the conditions of the empirical test methods involved, bias cannot be determined.

X1.6 Effects of Altitude and Weather on Vehicle Antiknock Requirement

X1.6.1 A vehicle's antiknock requirement can vary with changes in altitude, ambient temperature, and humidity, depending on the control system of the vehicle. New vehicles have sensors to measure and engine management computers, which take into account such conditions as air charge temperature and barometric pressure. These vehicles are designed to have the same antiknock requirement at all altitudes and a reduced sensitivity to changes in ambient temperature. This more sophisticated control technology began to be used extensively in 1984. This technology, while constantly evolving and improving, is used on almost all new vehicles. This means that many vehicles in today's fleet require fuel having the same antiknock index regardless of changes in altitude or ambient temperatures. Older vehicles, which do not have sophisticated control systems, will likely experience changes in antiknock requirement due to changes in altitude and weather conditions. However, the changes in antiknock requirement indicated in the following sections apply to a continually smaller part of the vehicle fleet.

X1.6.2 The antiknock requirement of an older vehicle decreases as altitude increases, primarily due to reduction in mixture density caused by reduced atmospheric pressure. The change in antiknock requirement for altitude for older vehicles is given in Fig. X1.2. Boundaries of the areas defined and the corresponding antiknock index reductions were established to protect vehicles driven from a higher altitude to a lower altitude (and, hence higher antiknock requirement) area while using a fuel obtained in the high altitude area.

[12] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1007.
[13] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1383.

D4814 – 16a

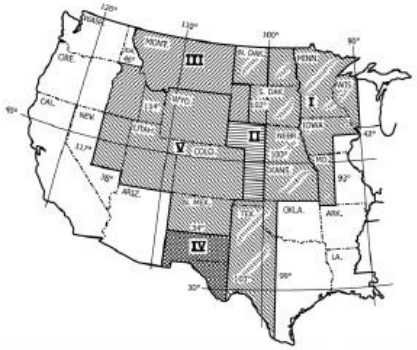


FIG. X1.2 Reduction in U.S. Vehicle Antiknock Requirements for Altitude[A,B]

Area	Less than 89 AKI	89 AKI or Greater[A,B]
I	0.7	0.5
II	1.5	1.5
III	2.2	1.5
IV	3.0	2.0
V	4.5	3.0

[A] Fuel may be marketed using these reductions, but actual antiknock index minimums must be posted.
[B] While the reductions in this table apply to most pre-1984 vehicles, the control technology on almost all new vehicles will cause them to have no reduction in antiknock requirement at higher altitudes.

FIG. X1.3 Reduction in U.S. Vehicle Antiknock Requirements for Weather[A]

	J	F	M	A	M	J	J	A	S	O	N	D
Northeast	1.0	0.5	0.5	0	0	0	0	0	0	0.5	0.5	1.0
Southeast	0.5	0	0	0	0	0.5	0.5	0.5	0.5	0	0	0.5
Midwest	1.0	0.5	0.5	0	0	0	0	0	0	0	0.5	1.0
Northwest	1.0	1.0	0.5	0.5	0	0	0	0	0	0.5	1.0	1.0
Southwest	1.0	0.5	0	0	0	0	0	0	0	0	0.5	1.0
California[A,B]												
No Coast	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0.5	0.5
So Coast	0	0	0.5	0.5	1.0	1.0	1.0	0.5	0.5	0	0	0
Alaska	1.0	1.0	0.5	0.5	0	0	0	0	0	0.5	1.0	1.0
Hawaii	0	0	0	0	0	0	0	0	0	0	0	0

[A] Fuel may be marketed using these reductions, but actual antiknock index minimums must be posted.
[B] Details of California coastal areas are shown in Footnote G of Table 4.

X1.6.3 Tests by CRC and other organizations have shown that the decrease in antiknock requirements with altitude is larger for most models between 1971 and 1984, designed to use a fuel with an antiknock index of 87, than for pre-1971 vehicles. Generally the pre-1971 vehicles have high compression ratios and were designed for fuels with an antiknock index of 88 or higher. Fuels with antiknock indexes below 89 are adjusted by a larger factor than those with an antiknock index of 89 or greater.

X1.6.4 The antiknock requirements of older vehicles rise with increasing ambient temperature on the average by 0.097 MON per degree Celsius (0.054 MON per degree Fahrenheit).

X1.6.5 The antiknock requirements of both older and new vehicles decrease with increasing specific humidity by 0.245 MON per gram of water per kilogram of dry air (0.035 MON per grain of water per pound of dry air).

X1.6.6 Because temperature and humidity of geographical areas are predictable throughout the year from past weather records, antiknock index levels can be adjusted to match seasonal changes in vehicle antiknock requirements. Fig. X1.3 defines the boundaries of areas and the typical reduction in vehicle antiknock requirements for weather for older vehicles. This figure may not apply to newer vehicles.

X1.7 Leaded Versus Unleaded Fuel Needs

X1.7.1 In addition to selecting the appropriate antiknock index to meet vehicle antiknock needs, a choice must be made between leaded and unleaded fuel. Vehicles manufactured for sale in the U.S. that must use unleaded fuel are required by

Product Quality

Section 1.5-3 Product Quality

(a) All liquid fuel products in Classes I, II, and III shall comply with the applicable specifications of ASTM, which are found in section 5 of that organization's publication "Petroleum Products, Lubricants, and Fossil Fuels" (ASTM 4814).

[Note 1: Class I flammable liquids include all grades of gasoline, and most motor fuels blended using alcohol and MTBE (methyl-tertiary-butyl-ether).]

[Note 2: Class II combustible liquids include #1 and #2 diesel fuels, #1 and #2 heating oil, kerosene, and Jet-A grade jet fuel.]

[Note 3: Class III combustible liquids include most lubricating oils and heavy fuel oils.]

(b) If gasoline is blended with ethanol, the ASTM D 4814 specifications shall apply to the base gasoline prior to blending. Blends of gasoline and ethanol shall not exceed the ASTM D 4814 vapor pressure standard, except that, if the ethanol is blended at nine percent or higher but not exceeding ten percent, the blend may exceed the ASTM D 4814 vapor pressure standard by no more than 1.0 PSI.

(c) In addition to the above, all liquid fuel products shall comply with the requirements published in the NIST Handbook 130 "Uniform Laws and Regulations in the area of legal metrology and engine fuel quality" except as modified or rejected by this regulation.

(d) The allowable reductions in vehicle antiknock requirements for altitude are 4.5 for less than 89 Antiknock Index (AKI), and 3.0 for greater than 89 AKI. Fuel may be marketed using these reductions, but actual AKI minimum must be posted.