DZS 868: 2023
ICS: 75.160.20
Second Edition

DRAFT ZAMBIAN STANDARD

ANHYDROUS ETHANOL FUEL BLENDS QUALITY STANDARD FOR AUTOMOTIVE SPARK IGNITION ENGINES – Specification

ZAMBIA BUREAU OF STANDARDS

Amendments issued since publications

Amendment No.	Date	Text affected

DATE OF PUBLICATION

This Zambian Standard has been prepared and published under the authority of the Zambia Bureau of Standards on ……..

ZAMBIA BUREAU OF STANDARDS

The Zambia Bureau of Standards is the Statutory National Standards Body for Zambia established under an act of Parliament, the Standards Act, No. 4 of 2017 of the Laws of Zambia for the preparation and promulgation of Zambian Standards.

REVISION OF ZAMBIAN STANDARDS

Zambian Standards are revised, when necessary, by the issue of either amendments or of revised editions. It is important that users of Zambian standards should ascertain that they are in possession of the latest amendments or editions.

CONTRACT REQUIREMENTS

A Zambian standard does not purport to include all the necessary provisions of a contract. Users of Zambian standards are responsible for their correct application

TECHNICAL COMMITTEE RESPONSIBLE

This Draft Zambian Standard was prepared by the ……, (TC…), upon which the following organizations were represented:

Copperbelt Africa Investment
CFAO Motor Zambia Limited
Energy Regulation Board
INDENI Petroleum Refinery Company Limited
Ministry of Energy - Department of Energy
Puma Energy Zambia PLC
Surya Biofuels
Sunbird Bioenergy Zambia Limited
Zambia Bureau of Standards

Zambia Bureau of Standards
Lechwe House
Freedom Way South-end
P.O. Box 50259
Email: info@zabs.org.zm
Website: www.zabs.org.zm

TABLE OF CONTENTS

FOREWORD

This National Standard has been prepared by the ……, in accordance with the procedures of ZABS. All users should ensure that they have the latest edition of this publication as standards are revised from time to time.

No liability shall attach to ZABS or its Director, employees, servants or agents including individual experts and members of its Technical Committees for any personal injury, property damage or other damages of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon this ZABS publication or any other ZABS publication.

The preparation of this Standard has been undertaken by the …….. The absence of a Code of Practice Standards on Blending and Handling of Biofuel blends in Zambia necessitated the formulation of this standard.

The Absence of Standards on Bioethanol blends in Zambia necessitated the formulation of this standard. In the Preparation of the Standard assistance was drawn from:

- National Fuel Quality Standards (Australia)
- ASTM D 5798 Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines
- ZS 706 Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel
- ZS 395 Unleaded Petrol (Gasoline) For Motor Vehicles – Specification

ACKNOWLEDGEMENT

The Zambia Bureau of Standards would like to acknowledge the invaluable material and financial support of the Energy Regulation Board and all the institutions and stakeholders that contributed in the promulgation of this standard.

COMPLIANCE WITH A ZAMBIAN STANDARD DOES NOT OF ITSELF CONFER IMMUNITY FROM LEGAL OBLIGATIONS.

ZAMBIA BUREAU OF STANDARDS

Draft Zambian Standard

ANHYDROUS ETHANOL FUEL BLENDS QUALITY STANDARD FOR AUTOMOTIVE SPARK IGNITION ENGINES – Specification

1.0 SCOPE

1.1. This specification covers blends of anhydrous denatured fuel ethanol conforming to ZS 706 blended with unleaded gasoline conforming to ZS 395, at 10, 20, 50 and 85 volume percent (%) and suitable for use in spark-ignition internal combustion automotive engines other than aviation piston engines.

The specified properties are as given in tables 1, 2, 3 and 4.

1.2. All values are stated in SI units, except for acidity and solvent-washed gum.

2.0 NORMATIVE REFERENCES

The following publications contains provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision and, since any reference to a standard is deemed to be reference to the latest edition of that standard, parties to agreements based on this standard are encouraged to take steps to ensure the use of the most recent editions of the standards indicated below. Information on currently valid National and International standards can be obtained from Zambia Bureau of Standards.

ZS ASTM D 323	Standard Test Method for Vapour Pressure of Petroleum Products (Reid Method)
ZS ASTM D 381	Test Method for Gum Content in Fuels by Jet Evaporation (ISO 6246)
ZS ASTM D 1298	Standard Test Method for Density, Relative Density (Specific Gravity) or API Gravity of crude petroleum and liquid petroleum products by hydrometer method
ZS ASTM D 1613	Test Method for Acidity in Volatile Solvents and Chemical Intermediates Used in Paint, Varnish, Lacquer, and Related Products (EN 15491)
ZS ASTM D 3231	Standard Test Method for Phosphorus in Gasoline
ZS ASTM D 4052	Standard Test Method for Density and Relative Density of Liquids by Digital Density meter
ZS ASTM D 4806	Standard Specification for Denatured Fuel Ethanol for Blending with Gasoline for Use as Automotive Spark-Ignition Engine Fuel
ZS ASTM D 4953	Standard Test Method for Vapour Pressure of Gasoline-oxygenate Blend (dry method)
ZS ASTM D 5453	Test Method for Determination of Total Sulphur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence (EN 15485)
ZS ASTM D 5501 (modified)	Test Method for Determination of Ethanol Content of Denatured Fuel Ethanol by Gas Chromatography
ZS ASTM D 5798-10a	Standard Specification for Fuel Ethanol (Ed70-Ed85) for Automotive Spark-Ignition Engines

ZS ASTM D 6423	Test Method for Determination of pHe of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75-Ed85) (EN 15490)
ZS ASTM D 7319	Standard Test Method for Determination of Existent and Potential Sulphate and Inorganic Chloride in Fuel Ethanol and Butanol by Direct Injection Suppressed Ion Chromatography
ZS ASTM D 7328	Standard Test Method for Determination of Existent and Potential Inorganic Sulphate and Total Inorganic Chloride in Fuel Ethanol by Ion Chromatography Using Aqueous Sample Injection
ZS ASTM E1064	Standard Test Method for Water in Organic Liquids by Coulometric Karl Fischer Titration
ZS EN 15837	Standard Specification for Ethanol as a blending component for petrol. Determination of phosphorus, copper and sulphur content. Direct method by inductively coupled plasma optical emission spectrometry (ICP OES)
ZS 395	Unleaded petrol (Gasoline) for Motor Vehicles - Specifications
ZS 396	Sampling Petroleum Products – Part 1: Manual Sampling of Liquid Hydrocarbons
ZS 706	Denatured Fuel Ethanol for Blending with Gasoline for use as Automotive Spark-Ignition Engine Fuel - Specification

3.0 DEFINITIONS

For purposes of this standard the following definitions shall apply:

3.1. **Anhydrous**: compound that does not contain water.

3.2. **Ethanol:** n-ethyl alcohol, the chemical compound C2H5OH.

3.3. **Gasoline**: a volatile mixture of liquid hydrocarbons, generally containing applicable amounts of additives, suitable for use as a fuel in spark-ignition internal combustion engines.

3.4. **Gasoline-ethanol blend:** A fuel consisting of gasoline along with amounts of denatured fuel ethanol.

3.5. **Oxygenate**: an oxygen-containing, ashes, organic compound, such as an alcohol or ether, which may be used as a fuel or fuel supplement.

3.6. **Denaturants**: Natural gasoline (unleaded), gasoline components, or toxic or noxious materials added to fuel ethanol to make it unsuitable for beverage use but suitable for automotive use.

3.7. **Denatured fuel ethanol:** fuel ethanol made unfit for beverage use by the addition of denaturants.

3.8. **Fuel ethanol**: ethanol with impurities common to its production (including water but excluding denaturants) conforming to ZS 706.

3.9. **Impurities:** in commercially produced fuel ethanol, compounds other than ethanol or denaturants present, such as methanol and fusel oil (for example, amyl and isoamyl alcohols).

3.10. **pHe**: a measure of the acid strength of alcohol fuels.

3.11. **ASTM**: American Society for Testing and Materials.

4.0 BLENDING PROCEDURES

4.1. Refer to the Blending, Handling and Usage of Biofuels - Code of Practice ZS 869.

5.0 ETHANOL FUEL BLENDS PERFORMANCE REQUIREMENTS

5.1 E10 PERFORMANCE REQUIREMENTS

Table 1: Requirements for 10% Ethanol Blend with Petroleum Gasoline (E10)

Characteristic	Requirement	Test Method
Ethanol Content, % v/v	9.5 – 10.5	ASTM D5501 (Modified) ASTM 5798-10a
Reid Vapour Pressure (RVP) at 37.8 °C, kPa	45 - 75	ASTM D 4953 ASTM D 323 ASTM 5798-10a
Total Acid Number, mg KOH/g, max	0.03	ASTM D 664 ASTM 5798-10a
Colour	Yellow	Visual
Appearance	Bright and Clear	ASTM D 4806 ASTM 5798-10a
Copper Strip Corrosion Number, 3h at 50°C, max	1	EN 15837 ASTM D 130 ASTM 5798-10a
Density at 20°C, g/cm^3	0.710 – 0.785	ASTM D 1298 ASTM D 4052 ASTM 5798-10a
Ethers (5 or more C atoms)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Higher Alcohols (C_3-C_8)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Inorganic Chloride. mg/kg, max	1.2	ASTM D7319 ASTM D 7328 ASTM D 5798-10a
Methanol, % (v/v), max	0.5	ASTM D5501 (Modified) ASTM 5798-10a
Oxidation Stability, minutes, min	360	ASTM D 5798 - 10a ASTM D525
pHe	6.5 – 9	ASTM 6423 ASTM 5798-10a
Phosphorous, g/L, max	0.0013	ASTM D 3231 ASTM 5798-10a
Solvent Washed gum, mg/100 ml, max	4	ASTM D 381 ASTM 5798-10a
Sulphate, mg/kg, max	4	ASTM D7319 ASTM 5798-10a
Sulphur, % mass, max	0.015	ASTM D5453 ASTM 5798-10a
Water Content, % volume, max	0.1	ASTM E1064 ASTM D 6304 ASTM 5798-10a
Research Octane Number (RON), min	91	ASTM D 2699 ASTM 5798-10a

Distillation		
Initial Boiling Point (IBP), °C	Report	
10% (v/v) evaporated, °C, max	65	
50% (v/v) evaporated, °C, max	77 - 115	
90% (v/v) evaporated, °C, max	185	ASTM D 86
% evaporated to 70°C, %(v/v)	Report	
Final Boiling Point (FBP), °C, max	215	
Residue, %(v/v),max	2	

5.2 E20 PERFORMANCE REQUIREMENTS

Table 2: Requirements for 20% Ethanol Blend with Petroleum Gasoline (E20)

Characteristic	Requirement	Test Method
Ethanol Content, % v/v	19.5-20.5	ASTM D5501 (Modified) ASTM 5798-10a
Reid Vapour Pressure (RVP) at 37.8 °C, kPa	45 - 75	ASTM D 4953 ASTM D 323 ASTM 5798-10a
Total Acid Number, mg KOH/g, max	0.03	ASTM D 664 ASTM 5798-10a
Colour	Yellow	Visual
Appearance	Bright and Clear	ASTM D 4806 ASTM 5798-10a
Copper Strip Corrosion Number, 3h at 50ºC. max	1	EN 15837 ASTM D 130 ASTM 5798-10a
Density at 20°C, g/cm^3	0.710 - 0.785	ASTM D 1298 ASTM D 4052 ASTM 5798-10a
Ethers (5 or more C atoms)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Higher Alcohols (C_3-C_8)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Inorganic Chloride. mg/kg, max	1.2	ASTM D7319 ASTM D 7328 ASTM D 5798-10a
Methanol, % (v/v), max	0.5	ASTM D5501 (Modified) ASTM 5798-10a
Oxidation Stability, minutes, min	360	ASTM D 5798 - 10a ASTM D525
pHe	6.5 – 9	ASTM 6423 ASTM 5798-10a
Phosphorous, g/L, max	0.0013	ASTM D 3231 ASTM 5798-10a
Solvent Washed gum, mg/100 ml, max	4	ASTM D 381 ASTM 5798-10a
Sulphate, mg/kg, max	4	ASTM D7319 ASTM 5798-10a
Sulphur, % mass, max	0.015	ASTM D5453 ASTM 5798-10a
Water Content, % volume, max	0.1	ASTM E1064 ASTM D 6304 ASTM 5798-10a
Research Octane Number (RON), min	93	ASTM D 2699 ASTM 5798-10a
Distillation Initial Boiling Point (IBP), °C 10% (v/v) evaporated, °C, max 50% (v/v) evaporated, °C, max	 Report 65 60 - 115	 ASTM D 86

90% (v/v) evaporated, °C, max	185	
% evaporated to 70°C, %(v/v)	Report	
Final Boiling Point (FBP), °C, max	215	
Residue, %(v/v),max	2	

5.3 E50 PERFORMANCE REQUIREMENTS

Table 3: Requirements for 50% Ethanol Blend with Petroleum Gasoline (E50)

Characteristic	Requirement	Test Method
Ethanol Content, % v/v	48.5 - 50.5	ASTM D5501 (Modified) ASTM 5798-10a
Reid Vapour Pressure (RVP) at 37.8 °C, kPa	45- 75	ASTM D 4953 ASTM D 323 ASTM 5798-10a
Total Acid Number, mg KOH/g, max	0.03	ASTM D 664 ASTM 5798-10a
Colour	Yellow	Visual
Appearance	Bright and Clear	ASTM D 4806 ASTM 5798-10a
Copper Strip Corrosion Number, 3h at 50°C. max	1	EN 15837 ASTM D 130 ASTM 5798-10a
Density at 20°C, g/cm^3	0.710 - 0.785	ASTM D 1298 ASTM D 4052 ASTM 5798-10a
Ethers (5 or more C atoms)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Higher Alcohols (C_3-C_8)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Inorganic Chloride. mg/kg, max	1.2	ASTM D7319 ASTM 7328 ASTM 5798-10a
Methanol, % (v/v), max	0.5	ASTM D5501 (Modified) ASTM 5798-10a
Oxidation Stability, minutes, min	360	ASTM D 5798 - 10a ASTM D525
pHe	6.5 - 9	ASTM 6423 ASTM 5798-10a
Phosphorous, g/L, max	0.0013	ASTM D 3231 ASTM 5798-10a
Solvent Washed gum, mg/100 ml, max	5	ASTM D 381 ASTM 5798-10a
Sulphate, mg/kg, max	4	ASTM D7319 ASTM 5798-10a
Sulphur, % mass, max	0.008	ASTM D5453 ASTM 5798-10a
Water Content, % volume, max	1	ASTM E1064 ASTM D 6304 ASTM 5798-10a

Research Octane Number (RON), min	95	ASTM D 2699 ASTM 5798-10a
Distillation Initial Boiling Point (IBP), °C 10% (v/v) evaporated, °C, max 50% (v/v) evaporated, °C, max 90% (v/v) evaporated, °C, max % evaporated to 70°C, %(v/v) Final Boiling Point (FBP), °C, max Residue, %(v/v),max	 Report 65 60-115 185 Report 215 2	ASTM D 86

5.4 E85 PERFORMANCE REQUIREMENTS

Table 4: Requirements for 85% Ethanol Blend with Petroleum Gasoline (E85)

Characteristic	Requirement	Test Method
Ethanol Content, % v/v	70.5 - 85.5	ASTM D5501 (Modified) ASTM 5798-10a
Reid Vapour Pressure (RVP) at 37.8 °C, kPa	38 - 59	ASTM D 4953 ASTM D 323 ASTM 5798-10a
Total Acid Number, mg KOH/g, max	0.03	ASTM D 664 ASTM 5798-10a
Colour	Yellow	Visual
Appearance	Bright and Clear	ASTM D 4806 ASTM 5798-10a
Copper Strip Corrosion Number, 3h at 50°C. max	1	EN 15837 ASTM D 130 ASTM 5798-10a
Density at 20°C, g/cm^3	0.710 - 0.785	ASTM D 1298 ASTM D 4052 ASTM 5798-10a
Ethers (5 or more C atoms)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Higher Alcohols (C_3-C_8)	Report	ASTM D5501 (Modified) ASTM 5798-10a
Inorganic Chloride. mg/kg, max	1.2	ASTM D7319 ASTM 7328 ASTM 5798-10a
Methanol, % (v/v), max	0.5	ASTM D5501 (Modified) ASTM 5798-10a
Oxidation Stability, minutes, min	360	ASTM D 5798 - 10a ASTM D525
pHe	6.5 - 9	ASTM 6423 ASTM 5798-10a
Phosphorous, g/L, max	0.0013	ASTM D 3231 ASTM 5798-10a
Solvent Washed gum, mg/100 ml, max	5	ASTM D 381 ASTM 5798-10a
Sulphate, mg/kg, max	5	ASTM D7319 ASTM 5798-10a

Sulphur, % mass, max	0.008	ASTM D5453 ASTM 5798-10a
Water Content, % volume, max	1	ASTM E1064 ASTM D 6304 ASTM 5798-10a
Research Octane Number (RON), min	95	ASTM D 2699 ASTM 5798-10a
Distillation Initial Boiling Point (IBP), °C	Report	ASTM D 86
10% (v/v) evaporated, °C, max	Report	
50% (v/v) evaporated, °C, max	Report	
90% (v/v) evaporated, °C, max	Report	
% evaporated to 70ºC, %(v/v)	Report	
Final Boiling Point (FBP), °C, max	Report	
Residue, %(v/v),max	Report	

6.0 SAMPLING, CONTAINERS AND SAMPLE HANDLING

6.1. For the purpose of this Zambian Standard all sampling shall be carried out in accordance with the relevant procedures of ZS 396 Part 1 and, additionally, as detailed in 6.2.

6.2. SAMPLING FROM GASOLINE-ETHANOL BLENDS DISPENSERS

6.2.1. Sampling cans of 5 Litres and 1 Litre Capacity: The construction of the cans shall comply with the appropriate safety requirements for cans that are to hold highly flammable material. They shall be provided with screw caps incorporating a petroleum resistant washer in good condition. A stock of cans shall be kept solely for the purpose of taking gasoline-ethanol blended fuel.

6.2.2. Preparation of Cans: New cans shall be rinsed with petrol (gasoline) before being used, to remove any residual traces of oil left during manufacturing operations, and then allowed to dry. Before use, all cans shall be checked to ensure that they are sound and free from leaks.

6.2.3. Sampling Procedure: From the dispenser nozzle, 5 litres of gasoline-ethanol blend shall be drawn carefully into a cool 5-litre can using a clean dry funnel. Immediately afterwards, this sample shall be decanted carefully into the requisite number of 1 litre cans, using a funnel, filling the cans within 15 mm of the brim.

If more than 5 litres are needed, the operation shall be repeated immediately and before the pump has been used for any other purpose. The screw cap shall be tightened fully and the cans checked to ensure that there are no leaks.

The sampling procedure shall not be carried out in direct sunlight.

NOTE 1: If carried out in direct sunlight, changes in fuel quality, especially octane level, may occur.

NOTE 2: A quantity of 1 litre is sufficient for the determination of octane number and certain other tests but it is advisable to provide each laboratory with 2 litres of sample in case further work is needed; it is essential that these 2 litres be of identical material.

6.2.4. Storage, Labelling and Transportation: Samples shall be kept in a cool place although it is not necessary to keep them refrigerated.

NOTE 1:.If left in direct sunlight there is a danger that the cans will balloon.

Full and legible information relating to the source of the sample shall be attached to the can in such a manner that it will not easily become detached subsequently.

NOTE 2:.If required, the sample may be sealed and labelled to maintain its legal integrity.

NOTE 3:.If the sample has to be sent to a laboratory by public transport, it will be necessary to comply with the general regulations covering transportation of flammable materials and with the requirements of the transport authority concerned. Information on the appropriate procedures and the type of packaging required should be obtained from the transport authority involved.

All intended test methods should be reviewed prior to sampling to better understand the importance and effects of sampling technique, proper containers, and special handling required for each test method.

A minimum sample size of 1L is recommended.

6.3. TEST METHODS

For all characteristics, use the applicable methods listed in Tables 1 - 4

ANNEX A
(Informative)

SIGNIFICANCE OF SPECIFICATIONS FOR GASOLINE-ETHANOL FUEL BLENDS FOR SPARK-IGNITION ENGINES

A.1. Ethanol

A.1.1 The ethanol content of ethanol fuel blends is a critical parameter as it affects the capability of the fuel metering system of the flexible-fuel vehicle to establish the proper air/fuel ration for optimum vehicle operation. Ethanol content can also affect the lubricating properties of the fuel, the water tolerance of the fuel, and the ability to meet cold and cool area volatility requirements.

A.1.2 The inclusion of impurities, some denaturants, and contaminants, except for the deliberately added hydrocarbons or additives, or both, can impact adversely on the properties and performance of ethanol fuel blends as an automotive spark-ignition engine fuel. The quantities of some of these materials are controlled by specified property limits. The limits on water, methanol, and types of denaturants, as well as minimums on the amounts of ethanol and hydrocarbons, limit but do not prevent the presence of trace materials.

A.2. Vapour Pressure

A.2.1 The addition of volatile hydrocarbons is required for adequate cold startability. The addition of hydrocarbon blendstocks that are too volatile can contribute to hot fuel handling problems. Higher vapour pressures are required in colder ambient temperatures while lower volatility fuels are less prone to problems at higher (summertime) ambient temperatures.

A.3. Acidity

A.3.1 Very dilute aqueous solutions of organic acids, such as acetic acid, are highly corrosive to a wide range of metals and alloys. It is therefore necessary to keep such acids at a very low level.

A.3.2 The acidity method is intended to determine the concentration of organic acids in ethanol. However, carbon dioxide is very soluble in ethanol, and in the presence of water it converts to carbonic acid. Test method ZS ASTM D1613 has an option to use either water or alcohol as solvent. Since ethanol is completely soluble in water, water is added to the sample and the mixture is titrated with aqueous sodium hydroxide solution. Dissolved CO_2, converted into carbonic acid will be titrated as an acid'. The presence of dissolved CO_2 will thus create a high bias in the acidity results. If there is sufficient dissolved CO_2, Test method ZS ASTM D1613 can incorrectly indicate that the sample is above the maximum allowable acidity in the specification. In the absence of any dissolved CO_2, Test Method D1613 is an acceptable method. If a sample is known to have dissolved CO_2 or if dissolved CO_2 is expected to be present, Test Method ZS ASTM D7795 is the preferred test method. In cases of differing results between the two test methods, Test Method ZS ASTM D7795 shall be the referee test method.

A.4. pHe

A.4.1 When the pH_e of gasoline-ethanol fuel blends used in automotive spark-ignition engines is below 6.5, fuel Dispensers can malfunction as a result of a film forming between the brushes and commutator, fuel injectors can fail from corrosive wear, and excessive engine cylinder wear can occur. When the pH_e is above 9.0, fuel pump plastic parts can fail.

A.5. Gum Content, Solvent Washed and Unwashed

A.5.1 The test for solvent washed gum content measures the amount of residue after the evaporation of the final and following a heptane wash. The heptane wash removes the heptane-soluble, non-volatile material, such as additives, carrier oils used with the additives, and diesel fuel. Unwashed gum content consists of fuel-insoluble and fuel soluble gum. The fuel-insoluble portion can clog fuel filters. Both can be deposited on surfaces when the fuel evaporates.

A.5.2 Solvent washed gum can contribute to deposits on the surface of carburettors, fuel injectors, and intake manifolds, ports, valves, and valve guides. The impact of solvent washed gum on malfunctions of modern engines that can operate on ethanol fuel blends has not been fully established but is based on limited experience gained with high alcohol fuels in field tests and from historic gasoline limits. Performance effects depend on where the deposits form; the presence of other deposit precursors, such as airborne debris, blow-by and exhaust gas recirculation gases, oxidized engine oil; and the amount of deposit.

A.5.3 The difference between the solvent washed and unwashed gum content values can be used to assess the presence and amount of non-volatile material in the fuel. Additional analytical testing is required to determine if the material is additive, carrier oil, diesel fuel, and so forth.

A.5.4 The unwashed gum content limit is intended to limit high-boiling contaminants, like diesel fuel, that can affect engine performance, yet allow the use of appropriate levels of deposit control additives with carrier oils in ethanol fuel blends.

A.5.5 The precision statements for Test Method ZS ASTM D381 were developed using only data on hydrocarbons, they may not be applicable to ethanol fuel blends.

A.6. Inorganic Chloride

A.6.1 Inorganic (ionic) chloride is corrosive to many metals, and it is desirable to minimize inorganic chloride compounds in ethanol fuel blends.

A.6.2 An inorganic chloride limit of 1mg/kg, maximum, has been found to be adequate in protecting fuel system components.

A.7. Lead

A.7.1 Most vehicles equipped to operate on ethanol fuel blends are equipped with exhaust catalyst that control emissions of aldehydes (formaldehyde and acetaldehyde) as well as regulated emissions. Lead components deactivate the catalyst and are therefore limited to trace amounts.

A.8. Phosphorous

A.8.1 Like lead, phosphorous deactivates exhaust catalysts and is limited to trace amounts.

A.9. Appearance

A.9.1 Turbidity, phase separation, or evidence of precipitation normally indicates contamination.

A.10. Water

A.10.1 The solubility of hydrocarbons in gasoline-ethanol fuel blends decreases with lowering temperature and increasing water content. Separation of the hydrocarbon from the fuel will adversely affect cold starting and driveability and denaturing. Phase separation of this type indicates that the gasoline-ethanol fuel blend is contaminated with water or other materials far in excess of what is allowed by this specification. Water may affect the calibration of some types of composition sensors of multifuel-capable vehicles. Water also reduces the energy content of the fuel and thus adversely affects fuel economy and power. Because some degree of water contamination is practically unavoidable in transport and handling, and because the ethanol fuel blends are miscible with water, the water content of ethanol fuel blends are limited to reduce the potential for problems.

A.11. Copper

A.11.1 Copper is a very active catalyst for low-temperature oxidation of hydrocarbons. Experimental work has shown that copper concentrations higher than 0.012 mg/kg in commercial gasoline can significantly increase the rate of gum formation.

A.12. Sulphur

A.12.1 The limit on sulphur content is included to protect against engine wear, deterioration of engine oil, corrosion of exhaust system parts, and exhaust catalyst deactivation.

A.13. Methanol

A.13.1 The limit on methanol content is included to protect against engine and fuel system wear, corrosion, and deterioration.