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BLENDING AND HANDLING OF BIOFUELS – Code of Practice

ZAMBIA BUREAU OF STANDARDS

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

Copperbelt Africa Investment
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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.

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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.

During the preparation of this standard, the following publications were consulted:

- ASTM D5798 Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines
- Developing a B20 Fuel Quality Standard, Australian Government, Department of Sustainability, Environment, Water, Population and Communities.
- E 85 Fuel Ethanol Industry Guidelines, Specifications and Procedures
- Guidelines for handling and blending FAME
- Handbook for Handling, Storing, and Dispensing E85 and Other Ethanol-Gasoline Blends
- Technical Guidelines for Production, Storage, Handling, Transportation and Retailing of Biofuels – ERB
- ZS 395 Unleaded Petrol (Gasoline) For Motor Vehicles – Specification
- ZS 702: Automotive Biodiesel (B100) - Specification
- ZS 706: Specification for Anhydrous Denatured Fuel Ethanol for Blending with Gasolines for use as Automotive Spark-Ignition Engine Fuel
- ZS 718 Low Sulphur Gas Oil: Specification

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ZAMBIA BUREAU OF STANDARDS

Draft Zambian Standard

BLENDING AND HANDLING OF BIOFUELS – Code of Practice

0.0 INTRODUCTION

This Code of Practice is a guide for those who blend, store, distribute and use biofuels (ethanol and biodiesel) and biofuel blends. It provides basic information on the proper and safe use of biofuels and biofuels blends for use in spark ignition and compression ignition engines. It is intended to assist blenders, distributers and those involved in related activities, understand the procedures for blending and handling of biofuels.

1.0 SCOPE

This Code of Practice covers blending, handling, sampling, testing and storage of biofuels and biofuel blends covered by ZS 702, ZS 706, ZS 867 and ZS 868 for use as automotive engine fuels.

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 D4814	Standard Specification for Automotive Spark-Ignition Engine Fuel
ZS ASTM D4815	Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C1 to C4 Alcohols in Gasoline by Gas Chromatography
ZS ASTM D4824	Standard Test Method for Determination of Catalyst Acidity by Ammonia Chemisorption Standard Test Method for Determination of Catalyst Acidity by Ammonia Chemisorption
ZS ASTM D5191	Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method)
ZS ASTM D5501 (modified)	Test Method for Determination of Ethanol Content of Denatured Fuel Ethanol by Gas Chromatography
ZS ASTM D5599	Standard Test Method for Determination of Oxygenates in Gasoline by Gas Chromatography and Oxygen Selective Flame Ionization Detection
ZS ASTM D5798	Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines
ZS ASTM D5798-10a	Standard Specification for Fuel Ethanol (Ed70-Ed85) for Automotive Spark-Ignition Engines
UN 3475	A preprinted 4-four digit Flammable Liquid Placard used in the transportation of Ethanol Blended Fuel
ZS 371	Road tank vehicles for petroleum - based flammable liquids - Specification
ZS 372	Transportation of petroleum products: Operational requirements for road tank vehicles - Codes for practice

ZS 385	The petroleum industry - code of practice: Part 1: Storage and distribution of petroleum products in above - ground bulk installation
ZS 385	The petroleum industry - code of practice: The installation of underground storage tanks, pumps dispensers and pipeworks at service and customer's installation
ZS 392	The storage and handling of liquid fuel –Code of practice: Part 2: Large consumer Installations
ZS 392	The storage and handling of liquid fuel –Code of practice: Part 3: Bulk low flash – point fuel storage and allied facilities at large consumer installations
ZS 395	Unleaded petrol (Gasoline) for Motor Vehicles - Specifications
ZS 402	The Classification of Hazardous Locations and the selection of apparatus for use in such locations - Code of Practice
ZS 673	Rail Tank Wagons –Specification
ZS 702	Automotive (B100) - Specification
ZS 706	Specification for Anhydrous Denatured Fuel Ethanol for Blending with Gasoline for use as Automotive Spark-Ignition Engine Fuel
ZS 867	Biodiesel Fuel Blends Quality For Automotive Compression Ignition Engines – Specification
ZS 868	Ethanol Fuel Blends Quality Standard for Automotive Spark Ignition Engines

3.0 DEFINITIONS

In addition to the definitions covered in ZS 718, ZS 396, ZS 702, ZS 706, ZS 867, ZS 868 and ZS 395 the following definitions shall apply:

3.1. **In-line blending at the loading rack:** This is when biofuel is injected continuously into the fossil fuel stream under flow control during truck loading. Alternatively, the biofuel can be added in small slugs or in pulsed quantities spread evenly throughout the time that the truck is being loaded. This is similar to the way most additives are blended into fossil fuel at the loading rack.

3.2. **In-line blending into a tank:** This is when biofuel and other blend components are pumped simultaneously under flow control into a common product line to a product storage tank. The turbulent flow conditions at the injection points and in the line promote mixing but the use of a static mixer is also recommended. In this case, the receiving tank should not require mixing facilities.

3.3. **In-tank blending:** This is where required volumes of fossil fuels and biofuels are pumped separately into a tank and proper mixing is achieved by in-tank agitators or by circulation of the tank contents.

3.4. **Microbial contamination:** This is when fuel contains deposits or suspended matter formed by microorganisms.

3.5. **Splash or sequential blending:** This is an operation where the biofuel and fossil fuel are sequentially loaded into a truck or other vessel.

3.6. **Stratification:** To separate into layers.

4.0 GUIDELINES FOR BLENDING GASOLINE WITH BIOETHANOL

4.1 General

It is important to maintain proper fuel handling and housekeeping practices to minimize contamination. Certain materials commonly used with gasoline may be incompatible with mid- and high-level alcohol blends. Some materials may degrade over time, potentially leading to equipment problems. They may also contaminate the fuel, which may adversely affect vehicle fuel system operation.

Only Ethanol-compatible materials should be used in storage and dispensing systems.

Ethanol acts like a cleaning agent and will initially mobilize sludge in storage tanks. Unplated steel, stainless steel, black iron, and bronze have shown acceptable resistance to Ethanol and higher Ethanol blends corrosion. Blends below E25 do not cause corrosion of metals.

4.2 Tank Cleaning before Handling E100 and Blends

Tanks previously used for storing other types of fuel may be used for Ethanol and ethanol blends if the tank is properly cleaned first. During storage, debris and moisture can build up over time to form sludge. Therefore, proper housekeeping guidelines should be instituted to limit debris and water contamination.

4.3 Ethanol and Ethanol Blends Handling

Handling of Petrol is covered under ZS 385 Part 1 and Part 3, ZS 392 Parts 2 and 3, and ZS 402**.** The same handling and product receipt safety and administrative procedures for gasoline are appropriate for Ethanol and ethanol blends.

E100 and Ethanol blends behave the same but must be differentiated from petrol because:

- Ethanol and higher ethanol blends such as E85's electrical conductivity is different than gasoline and is more prone to build a static charge.
- Ethanol and higher ethanol blends such as E85 vapors are more easily ignitable than gasoline vapors. Mixtures of air and vapors will only burn or explode within a certain range of concentrations. E85 vapors often fall between the lean and rich limits meaning that it is a combustible mixture.

Blending plans utilizing new equipment installation or conversion of existing equipment depend on thorough preparations and planning for the entire fuel system. The investigation and design of the wetted fuel system starts with a review of the flow of the fuel from receipt through retail delivery ensuring materials compatibility with the blending components and the blended mid-level ethanol fuel blends.

4.4 Determination of blending component properties

It is the responsibility of the suppliers of fuels that will be used for blending mid-level ethanol fuel blends to provide the blending parties with product transfer documents that contain, at a minimum, the information required by all applicable regulatory agencies. The fuel supplier is responsible for ensuring that the product transfer documents are a true and accurate representation of the materials being supplied. Because product transfer documents are not always required to contain all information necessary for the blending party to accurately determine compliance with the final blend, the blending party must be determined to obtain a Certificate of Analysis from the fuel supplier(s), arrange for specific purchase specifications with their supplier(s) or have a sample of each component tested periodically as specified in ZS 868.

The blending party should be aware that the spark-ignition engine fuel (ZS 395) used may contain ethanol up to the maximum concentrations permitted by fuel specifications and regulations, and that this content may change over time. Likewise, ethanol fuel blends (ZS 868) may change in ethanol content depending upon the month

and location of the intended sale of the ethanol fuel. These changes must be taken into account when preparing blending formulas for mid-level ethanol of ZS 868.

The blending party shall also be aware that denatured fuel ethanol for fuel blending (ZS 706) contains from 1.96 to 5.0 volume % hydrocarbons as denaturant (most often 2.0 to 2.5 volume % denaturant). This hydrocarbon content must be taken into account when preparing blending formulas for mid-level ethanol fuel blends.

4.4.1 Blending formula

The formula used for blending mid-level ethanol fuel blends is based on the lever arm rule for binary components used to make a blend. To make such a blend, gasoline or gasoline-ethanol blend (ZS 395 and 868) will be used to provide the hydrocarbon portion, and either ethanol fuel blend (ZS 868) or anhydrous denatured fuel ethanol (ZS 706) will provide the ethanol portion. Blending calculations shall be based on "gross" volume (litres); (not temperature compensated net volume).

The formula is:

$$FG = \frac{(FEE - FEML)}{(FEE - FEG)}$$

Where:

- FG = Fraction of gasoline to be used to make the mid-level ethanol fuel blend,
- FEE =fraction of ethanol in either the ethanol fuel blend (ZS 868) or anhydrous denatured fuel ethanol (ZS 706);
- FEML =the desired fraction of ethanol in the targeted mid-level ethanol fuel blend,
- FEG =the fraction of ethanol in the gasoline; and

The fraction of the ethanol fuel or denatured fuel ethanol to be used to make the mid-level ethanol fuel blend is calculated by 1-FG.

Example 1: Bulk Distribution Terminal Blending

The following example is used to make mid-level ethanol fuel blends at a terminal or bulk plant.

- Assume that an E30 mid-level ethanol fuel blend is desired to be made from straight gasoline and anhydrous denatured fuel ethanol at the terminal, thus FEML = 0.3.
- The gasoline in the terminal storage has no ethanol content, thus FEG in Eq 1 is 0.0.
- The ethanol content in the anhydrous denatured fuel ethanol at the terminal is determined to be 97.5 volume %, or FEE = 0.975.

For this example, we use Eq 1.

$$FG = \frac{(0.975 - 0.30)}{(0.975 - 0.0)} = 0.692$$

Thus the fraction of gasoline for this blend is 0.692 or 69.2 volume %. And the fraction of denatured fuel ethanol is 1-0.692 = 0.308 or 30.8 volume %.

Example 2, Retail Station Blending

The following example is used to make a mid-level ethanol fuel blends at retail stations using the fuel blending dispensers. Analysis of the ethanol content of the gasoline and the ethanol fuel blends is known from the supplier.

- Assume that an E30 mid-level ethanol fuel blend is desired to be made from gasoline with 10 volume % denatured fuel (E10) and ethanol fuel blend at retail site, thus FEML = 0.3
- The (E10) gasoline in the retail tank storage has 9.7 volume % ethanol content as reported by the fuel supplier, thus FEG in Eq 1 is 0.097.
- The ethanol fuel blend at the site is reported by the supplier to be 72.5 volume % ethanol, so the ethanol content in the anhydrous denatured ethanol FEE = 0.725

For this example, again we use Eq 1.

$$FG = \frac{(0.725 - 0.30)}{(0.725 - 0.097)} = 0.677$$

Thus the fraction of gasoline for this blend is 0.677 or 67.7 volume %. And the fraction of ethanol fuel is 1-0.677=0.323 or 32.3 volume %.

Example 3, Retail Station Blending

The following example is used to make mid-level ethanol fuel blends at retail stations using blending dispensers. In this case we have a bill of lading from the terminal listing the denatured fuel ethanol content in the ethanol fuel blend and the gasoline.

Assume that an E50 mid-level ethanol fuel blend is desired to be made from gasoline with 10 volume % de natured fuel ethanol (E10) and ethanol fuel blend at the retail site, thus FEML = 0.50

The E10 gasoline from the terminal has 9.5 volume % ethanol content assuming that the denatured ethanol and 30 volume % gasoline. Since denatured fuel ethanol contains hydrocarbon denaturant, we must account for this hydrocarbon to get the true ethanol content in the ethanol fuel. The denatured fuel ethanol contains about 95% pure ethanol. Thus the ethanol content in the ethanol fuel is 0.095 (70 volume %) = 66.5 volume, thus FEE = 0.665.

For this example, again we use Eq 1.

$$FG = \frac{(0.655 - 0.50)}{(0.665 - 0.095)} = 0.29$$

Thus the fraction of E10 gasoline for this blend is 0.290 or 29.0 volume % and the fraction of ethanol fuel blend is 1-0.290 = 0.710 or 71.0 volume %. If the ethanol and hydrocarbon components of the fuel inventory are unknown, retail fuel blending dispensers must be programmed to cease dispensing any mid-level ethanol blend.

It is recommended that Mid-Level Ethanol fuel blends be identified as "Mid-Level Ethanol Blend." It is also recommended that the product description name be followed by the term EXX, where XX represents the nominal percentage of denatured fuel ethanol and that each fuel dispenser offering Mid-Level Ethanol Fuel Blends provide a cautionary statement advising the purchaser that the fuel is "For Flexible Fuel Vehicles Only."

Volatility Requirements – In order to confirm compliance with applicable volatility requirement, it is necessary for blending parties of the mid-level ethanol blends to first confirm that the ethanol fuel blend used to prepare those blends is compliant with ZS ASTM D5798. This may be accomplished by receiving a certificate of analysis or other acceptable forms of product compliance assurance from the supplier of the ethanol fuel blends. If the blending party will be blending using ZS 706 denatured fuel ethanol, the blending party shall arrange for the preparation of a representative sample of the target ethanol/hydrocarbon ratio using the ZS 706 denatured fuel ethanol and ZS ASTM D4814 gasoline or gasoline-ethanol blend that will be used to make the blend and test the mixture for vapour pressure using ZS ASTM D5191.

The measured vapour pressure shall meet the minimum vapour pressure specified in ZS ASTM D5798 for the volatility class for the time and location where the mid-level ethanol fuel will be used.

If the minimum vapour pressure limit is not met, a more volatile gasoline or gasoline-ethanol blend shall be used and the vapour pressure confirmed once again using test method ZS ASTM D5191.

4.5 Transportation

Truck compartment(s) should be clean and dry before loading. Avoid contamination from water, diesel, etc. Always ground the truck during loading and unloading operations. Hoses must be purged. It is best to have pumped ethanol or unleaded gasoline prior to pumping anhydrous denatured Ethanol or E85 to avoid contamination. Ethanol and ethanol blends are Class 3 flammable liquids. Handle with the same safety precautions as gasoline. Avoid sparks and flames. It is advisable to wear safety goggles when handling Ethanol and E85. If E85 contacts the body or face, flush with water. Use good ventilation. Avoid breathing vapours, because they can cause headaches, dizziness, and nausea. If delivering to an outlet not within your own control, you should contact the manager to verify their unloading hours and procedures. All transport drivers should be issued with a Material Safety Data Sheet (MSDS) on Ethanol and higher ethanol blends. Transport drivers should also be advised of all safety and firefighting guidelines.

If product is blended in the truck compartments the gasoline should be loaded first to reduce buildup of static charge. This also results in a more homogenous blend. Also the blends should be blended by compartment to ensure proper mixing. The truck should always be grounded during loading and unloading.

Prior Commodities Hauled: Prior commodities hauled that are acceptable in trucks include E85, ethanol, fuel grade denatured ethanol, unleaded gasoline, unleaded racing gasoline, unleaded RBOB, unleaded CaRBOB, and

natural gasoline. Equipment used to haul other commodities should not be used unless the equipment has been properly cleaned. Residual amounts of other products may contaminate the Ethanol and ethanol blends.

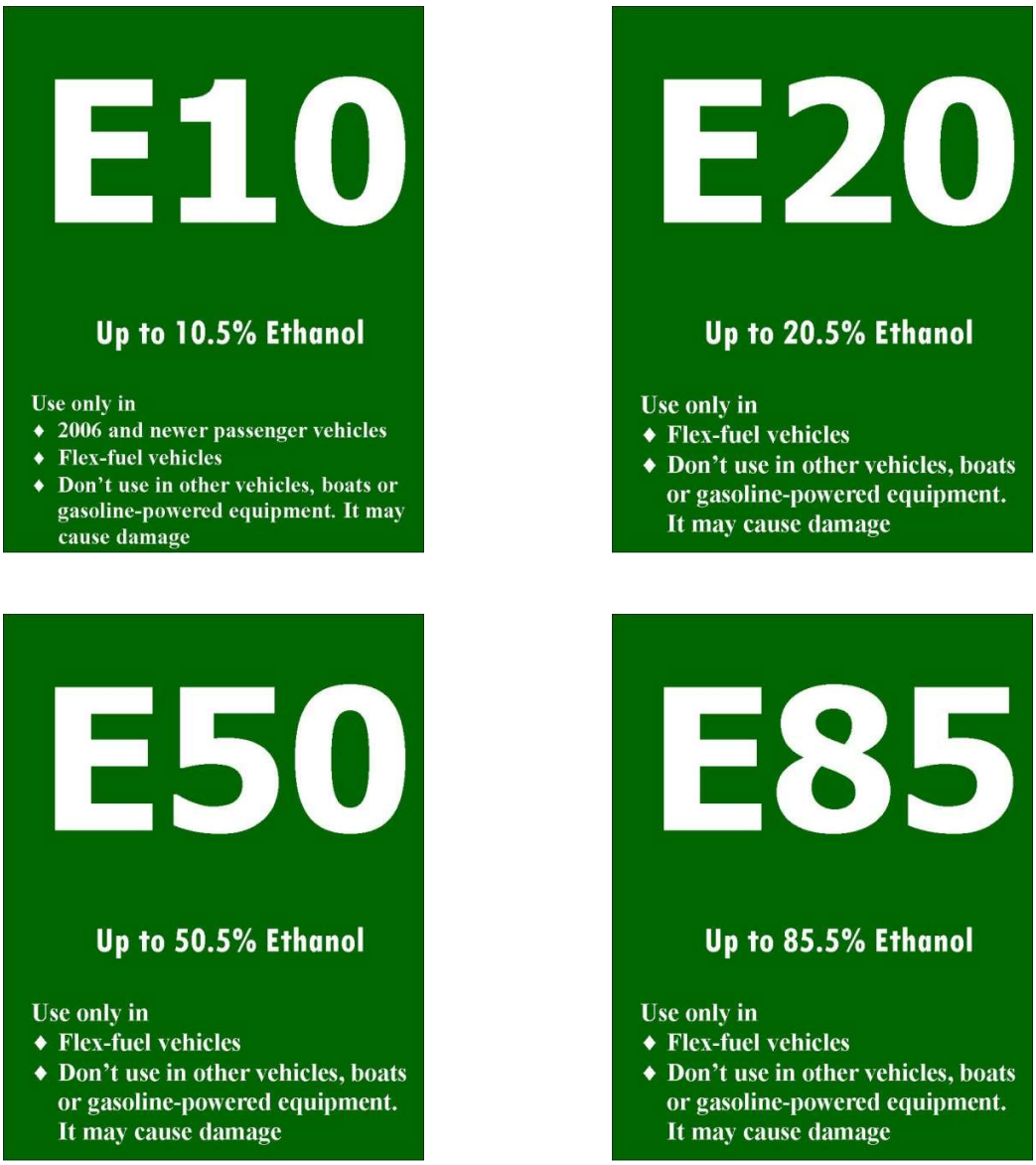
4.6 Storage of Ethanol Blends in Refineries and Terminals

The equipment used to store gasoline fuels is the same equipment used for alcohol-based fuels, with modifications in some materials. Above-ground dispensing equipment must be designed specifically for ethanol blends.

4.7 Signs, Labels, and Stickers for Ethanol Blends

Placarding: Transport vessels hauling Ethanol or ethanol blends should be placarded as UN 3475 (ethanol and gasoline mixture).

Dispenser Labels: Labels must be placed on the upper two-thirds of a dispenser. For a multi-hose dispenser, the label must be placed where it is immediately visible to the consumer.



4.8 Ethanol Blends Safety, Health, and Environmental Issues

4.8.1 Health and Environmental Considerations

Fuel ethanol should be handled in the same manner as gasoline. Personal exposure should be minimized. Fuel ethanol is flammable and may contain additives that can be harmful even with casual contact. Fuel ethanol is toxic and should not be ingested. Exposure to fuel ethanol can occur by inhalation (breathing in its vapors), absorption (contact with the skin or the eyes), or ingestion (swallowing).

4.8.2 Fire Safety Considerations

Fuel ethanol fires require specific equipment, materials, and training. Conventional gasoline fire-fighting methods and chemicals are insufficient for fighting fires fueled by ethanol blends higher than E10. Ethanol blended fuels with greater than 10% ethanol require the use of a Polar Solvent or Alcohol Resistant (AR) type of Foam commonly known as an AR-AFFF. Traditional AFFF foams have limited to no ability to extinguish fire emergencies when the ethanol content is above 10% by volume. AR type foams work on all alcohol variations of ethanol and gasoline blended fuels and would be the best use of fire response equipment. Dry Chemical fire extinguishing agents may also work on ethanol blended fuels, however, the dry chemical manufacturer must be consulted for appropriateness

These recommendations should be applied to all ethanol blends, including low-level blends such as E6 and E10, E15, and high-level blends such as E85.

Before constructing any fueling installations, the local fire brigade should be consulted to determine local regulations governing safe fuel ethanol handling procedures.

5.0 BIODIESEL AND BIODIESEL BLENDS HANDLING

5.1 Tank cleaning before handling B100 and Blends

For automotive fuels, long-term storage requires stability. If the Oxidation Stability, Acid Number, Viscosity, or sediment measurements exceed the limits, the B100 is degraded out of specification and cannot be used. Therefore, biodiesel shall have a high Oxidation Stability (longer induction time) i.e four to five hour induction time for it to be within the required specification. To increase its storage life, usually for a period of about six (6) to twelve (12) months, antioxidants shall be incorporated or nitrogen blankets used on storage tanks. Alternatively biodiesel shall be stored in sealed drums to eliminate contact of biodiesel with oxygen. Monitoring the Acid Number and Viscosity of B100 over time can indicate whether it is oxidizing.

B100 is a good solvent. It may loosen or dissolve varnish and sediments in fuel tanks and fuelling systems left by conventional diesel over time. Should the system contain sediments, care shall be taken to clean tanks and the fuel system before handling or using B100.

B100 freezes at higher temperatures than conventional diesel fuel. Most B100 starts to cloud between 2ºC and 15ºC, so heated fuel lines and tanks are needed, even in moderate climates, during winter, to ensure that its viscosity is maintained and not allowed to rise to much higher levels which could in turn, increase stress on pumps and make the use of B100 more challenging.

B100 is not compatible with some materials from which hoses and gaskets are made. It may soften and degrade certain types of rubber compounds used for hoses and gaskets (buna-N, nitrile, natural rubber) and may cause them to leak and degrade to the point where they crumble and become useless. Therefore, for bulk handling of B100, seals, gaskets and hoses must be compatible with it.

B100 is not compatible with some metals and plastics. It will degrade and form high sediment levels if in contact for long periods with copper or copper containing metals (brass, bronze) or with lead, tin, or zinc (galvanized

surfaces). These high sediments may clog filters. B100 may also permeate some common plastics (polyethylene, polypropylene) over time, so these shall not be used for storing B100.

Biodiesel is generally susceptible to microbial degradation. Microbial contamination of fuel storage tanks can plug dispensers and vehicle fuel filters and cause vehicles to stall. The best way to deal with this issue is adequate fuel storage tank housekeeping and monitoring, especially minimizing water in contact with the fuel. Therefore, water bottoms must be removed from tanks, and standing tanks shall be sampled and tested for microbial contamination. Biocides (reagents that kill microbes) may also be used, if and when necessary, for prevention of microbial attack on the biodiesel in fuel tanks.

5.2 Blending Biodiesel at Refineries and at Terminals

Blending fossil diesel with biodiesel shall take place at refineries or at fuel depots. Because refineries are usually better equipped to perform fuel product quality testing and optimise blend composition, they are also the preferred place to carry out blending operations. Terminal blending is also acceptable, however, from a quality assurance point of view as long as proper procedures are followed.

The following are some of the significant characteristics of biodiesel that can impact blending.

- Biodiesel has a higher density (~0.88 vs. 0.84 g/ml) and viscosity (max ~5 vs. 4 mm^2/s at 40°C) compared to fossil diesel fuel. If blend components are added sequentially into a blending tank, biodiesel should not be the first or the last component to be added in order to avoid the formation of an unmixed bottom layer. Precautions should be taken to ensure a homogeneous blend.
- Biodiesel has a higher cloud point than fossil diesel. If different components are added into the blending tank, the temperature of all of the components should be well above the biodiesel cloud point to ensure easy flow and prevent formation of precipitates that may be difficult to re-dissolve.

Several blending strategies can be used to achieve proper mixing: **in-tank blending**, **in-line blending to a tank**, **in-line blending at the loading rack**, and **splash or sequential blending**.

- **In-tank blending:** The tank shall be sampled and tested prior to releasing the diesel blend.
- **In-line blending into a tank:** The turbulent flow conditions at the injection points and in the line promote mixing but the use of a static mixer is also recommended. In this case, the receiving tank should not require mixing facilities.
- **In-line blending at the loading rack:** This is similar to the way most additives are blended into diesel fuel at the loading rack.
- **Splash or sequential blending:** In this case, relatively little mixing occurs as the fuels are loaded into the vessel. After the fuels are in the truck, driving down the road is sometimes considered to be sufficient agitation to allow the biodiesel and diesel fuel to be mixed in transit. This blending strategy is not recommended, however, because there is some risk that the product may not be homogeneous when it arrives at the delivery point, particularly when the ambient temperature is low.

Diesel performance additives such as cold flow improvers or cetane boosters should be injected into the diesel fuel stream during blending. The additive dosage in diesel blends will probably be different from fossil diesel fuels in order to achieve the same level of performance; some dosages may be higher and some may be lower.

Additive dosages that should be rechecked include cold flow, cetane improvers, lubricity enhancers, conductivity improvers, performance packages, and antifoam additives.

The B20 and B100 should have different/distinct procedures as these products behave differently.

Fossil diesel handling is covered by ZS 385 Part 1 and Part 2 and 3, ZS 392 Parts 2 and 3, ZS 402

5.3 Transport and Delivery of Diesel Blends to Terminals and Filling Stations

Existing supply and distribution facilities designed for use with fossil diesel fuels will in general be adequate for handling diesel fuels containing biodiesel. It is recommended to review the need for hardware modifications throughout the supply chain with consideration of potential material incompatibilities and the increased risk of deposit formation. The following points should be specifically considered:

- Dedicated lines may be needed for imports and exports (at terminals) in order to avoid water contamination.
- Gaskets should be compatible with B100 including those fitted in flanges and swivel joints.
- Lagged or heat traced pipelines may be appropriate depending on the ambient temperatures and the cold flow properties of the diesel blend.
- The design of product filters should be considered as well as the frequency of change out.

Throughout the supply chain, good housekeeping practices that apply to diesel fuel handling should also be used for diesel blends. These practices are even more important for diesel blends in view of the more hygroscopic nature of biodiesel.

The presence of biodiesel requires that adequate measures are taken to prevent cross-contamination in the supply chain between diesel and other fuels that may not be permitted to contain more than trace amounts of biodiesel. Contamination of Jet A-1 with diesel containing biodiesel should be avoided. Other fuels, such as heating oil and marine gasoil, may be similarly restricted and should also be protected from potential biodiesel contamination.

5.4 Transport Via Multi-Product Pipelines

There exists a concern on the potential cross-contamination of Jet A-1 with diesel fuel containing biodiesel transported through a multi-product pipeline. This may be caused by the adsorption of biodiesel on the pipeline wall during transport of a diesel blend batch and the later desorption of biodiesel into trailing products. Contamination may also be caused by inadequate operation of pipeline feeder and take-off systems, resulting in the entrainment of small amounts of biodiesel left behind in manifolds, pump stations, dead legs or meter bays during the changeover to other products. Insufficient buffer volumes and small batch sizes are another potential source of contamination. These issues should be reviewed before considering pipeline shipment of diesel blends and acceptability should be confirmed by large scale trials.

If diesel blends are transported through a pipeline system, more frequent cleaning and inspection may be required due to the potential for diesel blends to pick up dirt throughout the system. It is also important to note that biocides cannot be used to treat Jet A-1.

5.5 Transport by Road, Rail and other Conveyance Media

As with fossil diesel, biodiesel must be transported in a way that does not lead to contamination. Transport vessels should be clean and should not contain residuals from a previous load that may not be compatible. Precautions should be taken to avoid contamination with water, dirt and rust. Transport vessels shall be equipped with necessary features that take account of safety and the environment. Therefore, road tank vehicles and rail tank wagons carrying biodiesel shall be in compliance with the technical requirements of ZS 371, ZS 372 and ZS 673 respectively. The following procedures shall be used in transporting biodiesel;

- Only tankers that are constructed of aluminum, carbon steel or stainless steel shall be used.
- Ensure proper inspection or washout before loading.
- Always check for residue of previously transported product. Generally only diesel or biodiesel is acceptable as a residue.
- Ensure that there is no residual water in the tanker.
- Always check that the hoses and seals are clean and made from materials that are compatible with B100
- Determine the need for insulation or a method to heat the road and rail tanker contents if shipping during the cold weather (Guiding temperature - between 2°C to 15°C).

5.6 Storage of Biodiesel in Refineries and Terminals

5.6.1 Storage temperature

Biodiesel (B100) should be stored at temperatures at least 6°C higher than the cloud point. Therefore, most underground storage facilities are adequate, but above ground storage, depending on the climate, should be protected with insulation, agitation, heating systems or other methods. This precaution includes piping, tanks, pumping equipment, and trucks used to transport biodiesel. Heating can be achieved by any of the common heating methods, but should be designed to minimize hotspots and prolonged exposure of the biodiesel to high temperatures.

If the temperature does drop and crystals begin to form, the crystals should re-dissolve if the fuel is warmed up although residual mono-glycerides and Sterol Glucocides (SGs) may be difficult to re-dissolve. This re-dissolving process can be slow, however, especially if the fuel only warms marginally or very slowly. Crystals formed in biodiesel or in diesel blends can also settle to the bottom of the tank and begin to form a gel layer.

Slow agitation can prevent crystals from building up on the tank bottom and agitation can also help to re-dissolve crystals once they are present in the fuel. If the biodiesel product has gelled completely, it is advisable to raise the temperature up to 40-60°C in order to melt the most saturated biodiesel components, especially if the biodiesel needs to be used right away. Lower warming temperatures can be used for the biodiesel to reach its equilibrium cloud point if enough time is available.

During colder seasons, B100 can be pre-blended with low cloud point diesel fuel in order to prevent crystallisation. This pre-blend is prepared before it is blended into the diesel fuel.

5.6.2 Storage duration

It is recommended to limit biodiesel storage to no more than six months. It appears that diesel blends have a longer storage life than B100, depending on the biodiesel type and additive treatment. Even so, it is also recommended to limit the storage of diesel blends to no more than 6 months.

In practice, operators should turnover their biodiesel stock faster than this.

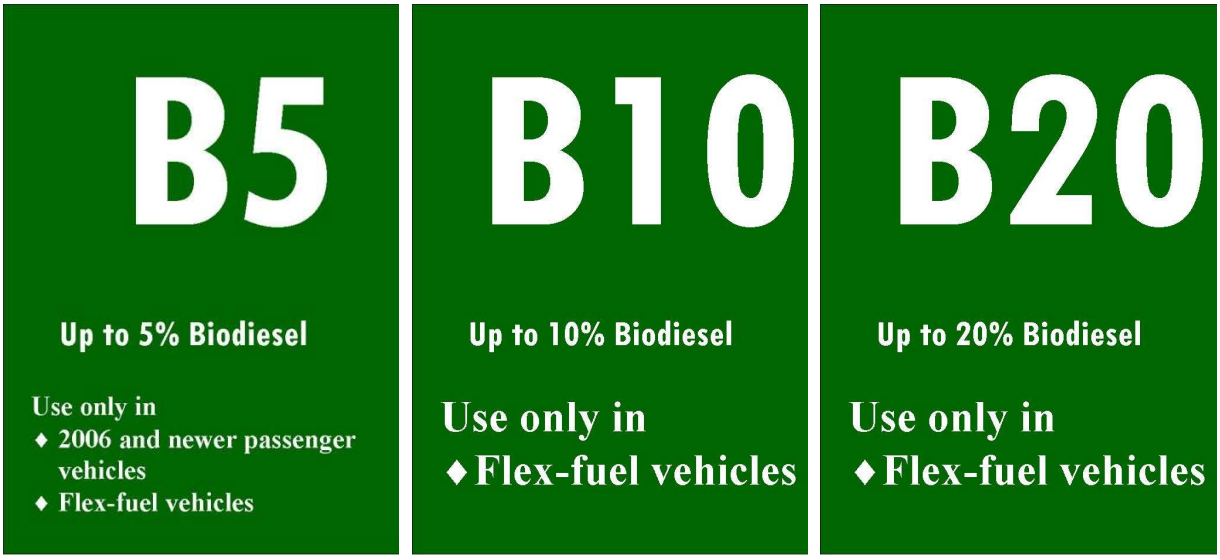
Biodiesel ages in storage, therefore, the acid number tends to increase, the viscosity can increase, and gums and varnish can form. To monitor biodiesel quality during storage, oxidation stability, acid number, viscosity, water, and sediment can all be used as indicators to ensure that the biodiesel complies with ZS 702.

When oxidised or aged biodiesel is blended with diesel, some of the sediments and gums that are soluble in the B100 become insoluble in the diesel blend and form sediments. For this reason, biodiesel that does not comply with ZS 702 should never be used for blending.

5.7 Signs, Labels, and Stickers for Biodiesel Blends

Biodiesel blends with diesel and kerosene are required to be transported in placarded trucks and wagons. If the flash point is lower than 60°C, the liquid is considered flammable and the Hazard Class 3 flammable placard is required. Between 60° to 93°C, the liquid is generally considered to be Hazard Class 3 combustible, and the combustible placard shown below is required for transport. Local fire regulations determine the requirements for signage on storage containers, but typically, tanks containing fuels (including B100) must be labeled with National Fire Protection Association (NFPA) diamonds. The NFPA diamonds will indicate whether the fuel is flammable or combustible.

Dispenser Labels Labels must be placed on the upper two-thirds of a dispenser. For a multi-hose dispenser, the label must be placed where it is immediately visible to the consumer.



5.8 Biodiesel Safety, Health, and Environmental Issues

5.8.1 Safe Handling

Biodiesel contains no hazardous materials and is generally regarded as safe when used as directed. Inhalation effects are negligible unless heated to produce vapours. Vapours or finely misted materials may irritate the mucous membranes and cause irritation, dizziness, and nausea and may also cause eye irritation. Prolonged or repeated contact is not likely to cause significant skin irritation and no hazards are anticipated from incidental ingestion through industrial exposure.

Safety precautions and equipment for storing and handling biodiesel and diesel blends are similar to those used for fossil diesel fuels. Protective equipment including gloves should always be worn and skin that is inadvertently exposed to fuel should be washed with soapy water. The relevant Safety Data Sheet (SDS or MSDS) should also be reviewed for recommendations on safe handling, type of gloves, and related procedures before beginning work with biodiesel and biodiesel blends.

5.8.2 Surface Spills and Leaks, Auto-Ignition

If biodiesel is released to the environment, the following can occur:

- **Release in soil:** Biodegradation of the biodiesel product will occur, with faster rates under aerobic conditions than under anaerobic conditions.
- **Release in water:** Although biodiesel is only slightly soluble in water, it will degrade rapidly and fairly extensively in aquatic environments at a rate that is approximately four times faster than that of fossil diesel fuel. Spills and underground leaks of biodiesel or diesel blends should be treated in the same manner as conventional diesel fuel spills and leaks, including notification of the proper authorities. The biodiesel supplier's SDS should also be reviewed for recommendations on clean-up procedures for spills.

Biodiesel having high iodine values can oxidise rapidly when exposed to air. Cloths and rags that have been used to clean up neat biodiesel may exhibit spontaneous combustion due to oxidation of the biodiesel. This

oxidation reaction can generate a significant amount of heat and, if conditions are favourable, temperatures can rise above the auto-ignition temperature of the fuel soaked rags, resulting in spontaneous combustion.

It is recommended that rags and cloths saturated with biodiesel are put into a dedicated storage and disposal drum or a can filled with enough water to completely immerse the contents. Facility operators should know where neat biodiesel is handled and where storage/disposal containers are located. Appropriate warning signs should also be placed in the areas where biodiesel is handled.

5.8.3 Fire Protection and Fire-Fighting Agents

Personnel should approach a biodiesel or diesel blend fire with the same caution as they would use in approaching a fossil diesel fire and similar fire-fighting techniques should be used. Suitable extinguishing media include dry chemical powder, foam, halon, carbon dioxide, and water spray (fog).

5.8.4 Static Electricity Hazards

While neat biodiesel has a higher electrical conductivity than fossil diesel fuel, introducing up to 7% v/v biodiesel into diesel fuel has only a small impact on the conductivity of the blended fuel. In some cases, however, large reductions in conductivity have been observed upon blending 7% v/v biodiesel into diesel fuel that already contains conductivity additive. Hence, when conductivity additives are used, the conductivity should be verified on a case-by-case basis.