Storing and Handling Ethanol and Gasoline-ethanol Blends at Distribution Terminals and Filling Stations

API RECOMMENDED PRACTICE 1626
SECOND EDITION, AUGUST 2010

ERRATA, FEBRUARY 2011

ADDENDUM, AUGUST 2012

AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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Introduction

Ethanol is widely blended with gasoline in concentrations up to 10 % (E10). E85, a high-ethanol/gasoline blend is available in many parts of the US and will be required under current Federal rules in the near future. Also, there is interest in increasing the ethanol percentage in gasoline to 15 %.

This recommended practice (RP) provides guidance for designers and operators of terminals and filling stations in ethanol fuel blend service. This document will help interested parties understand the properties of ethanol fuel blends and how they differ from gasoline. It will assist in the design and selection of equipment that will promote safe storage, handing and dispensing of quality ethanol blends.

Storing and Handling Ethanol and Gasoline-ethanol Blends at Distribution Terminals and Filling Stations

1 Scope

This publication describes recommended practices for the storing, handling, and fire protection of ethanol and gasoline-ethanol blends from E1 to E15 and from E65 to E100 (used for E85) at distribution terminals and filling stations. Where information exists for gasoline-ethanol blends from E11 to E15, it is shared. Recommended practices for E16 through E69 are not covered because currently these blends are not legal gasolines blends or alternative fuels. There is a general lack of information on the properties of these blends and there are currently no filling station components certified by any nationally recognized testing laboratory for these blends.

This document is current at the time of publication, but changes to regulations and listings may affect the accuracy certain recommended practices. See the form in Annex D to provide suggestions for updating or revision.

While this publication does not address second or future generation biomass-based alcohols which use feedstocks and manufacturing processes that are different than those employed for current U.S. ethanol supplies, it is unlikely that sugar or cellulosic ethanols will alter the overall recommendations in this RP.

Future generation bioethanol fuels may have different properties and the practices described in this publication may not be applicable. When dealing with those fuels, good engineering practices should be employed until this document is updated.

This publication does not address ethanol diesel blends.

This publication does not address health effects or the remediation of ethanol or gasoline-ethanol blend spills or releases.

2 References

2.1 General

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

2.2 Normative References

API Publication 327, *Aboveground Storage Tank Standards: A Tutorial*

API Recommended Practice 562, *Lining of Aboveground Petroleum Storage Tank Bottoms*

API Standard 570, *Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems*

API Recommended Practice 574, *Inspection Practices for Piping System Components*

API Recommended Practice 579/ASME FFS-1, *Fitness-for-Service*

API Recommended Practice 580, *Risk-Based Inspection*

API Recommended Practice 582, *Recommended Practice and Supplementary Welding Guidelines for the Chemical, Oil, and Gas Industries*

API Standard 620, *Design and Construction of Large, Welded, Low-pressure Storage Tanks*

API Standard 650, *Welded Tanks for Oil Storage*

API Recommended Practice 651, *Cathodic Protection of Aboveground Storage Tanks*

API Recommended Practice 652, *Lining of Aboveground Petroleum Storage Tank Bottoms*

API Standard 653, *Tank Inspection, Repair, Alteration and Reconstruction*

API Technical Report 939-D, *Stress Corrosion Cracking of Carbon Steel in Fuel Grade Ethanol: Review, Experience Survey, Field Monitoring and Laboratory Testing*

API Bulletin 939-E, *Identification, Repair, and Mitigation of Cracking of Steel Equipment in Fuel Ethanol Service*

API Recommended Practice 1615, *Installation of Underground Petroleum Storage Systems*

API Recommended Practice 1621, *Bulk Liquid Stock Control at Retail Outlets*

API Recommended Practice 1631, *Interior Lining and Periodic Inspection of Underground Storage Tanks*

API Recommended Practice 1632, *Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems*

API Recommended Practice 1637, *Using the API Color-Symbol System to Mark Equipment and Vehicles for Product Identification at Service Stations and Distribution Terminals*

API Publication 1642, *Alcohol, Ethers, and Gasoline-Alcohol and Gasoline-Ether Blends*

API Standard 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

API Standard 2015, *Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks*

API Recommended Practice 2016, *Guidelines and Procedures for Entering and Cleaning Petroleum Storage Tanks*

API Publication 2021, *Management of Atmospheric Storage Tank Fires*

API Standard 2217A, *Guidelines for Safe Work in Inert Confined Spaces in the Petroleum and Petrochemical Industries*

API Publication 2219, *Safe Operation of Vacuum Trucks in Petroleum Service*

API Publication 2300, *Evaluation of Fire Fighting Foams As Fire Protection for Alcohol Containing Fuels*

API Standard 2610, *Design, Construction, Operation, Maintenance & Inspection of Terminal and Tank Facilities*

BOE-6000 [1], *Hazardous Materials Regulations of the Department of Transportation*

BOE Circular No.17, *Rules and Recommendations Relating to the Location of Loading Racks, Unloading Points, and Storage Facilities for any Flammable Liquid With Flash Point Below 20 °F (Including Gasoline, etc.)*

BOE Pamphlet 34, *Recommended Methods for the Safe Loading and Unloading of Non-Pressure (General Service) and Pressure Tank Cars*

[1] Bureau of Explosives, P.O. Box 1020, Sewickley, PA 15143, www.boepublications.com.

BOE, *United States Hazardous Materials Instructions for Rail*

ICC *International Fire Code* Chapter 22 [2], *Motor Fuel-Dispensing Facilities and Repair Garages*

ICC *International Fire Code* Chapter 27 *Hazardous Materials – General Provisions*

ICC *International Fire Code* Chapter 34 *Flammable and Combustible Liquids*

NFPA 11 [3], *Standard for Low-, Medium-, and High-Expansion Foam*

NFPA 30, *Flammable and Combustible Liquids Code*

NFPA 30A, *Code for Motor Fuel Dispensing and Repair Garages*

NFPA 70, *National Electrical Code*

NFPA 77, *Recommend Practice on Static Electricity*

NFPA *Uniform Fire Code* Article 52, *Motor Vehicle Fuel-Dispensing Stations*

NFPA *Uniform Fire Code* Article 79, *Flammable and Combustible Liquids*

NFPA *Uniform Fire Code* Article 80, *Hazardous Materials*

NWGLDE [4], *List of Leak Detection Evaluations for Storage Tank Systems*

STI [5], *Keeping Water Out of Your Storage System*

STI SP001, *A Standard for Inspection of In-Service Shop Fabricated Aboveground Tanks for Storage of Combustible and Flammable Liquids*

2.3 Informative References

APEA/IP [6], *Design, Construction, Modification, Maintenance and Decommissioning of Filling Stations,* "The Blue Book"

APEA/IP, *Guidance on Storage and Dispensing of High Blend Ethanol Fuels including E85 at Filling Stations*

ASTM D323-08 [7], *Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*

ASTM D4806-08a, *Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel*

ASTM D 4814, *Standard Specification for Automotive Spark-Ignition Engine Fuel*

ASTM D5798-07, *Standard Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines*

2 International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001-2070, www.iccsafe.org.
3 National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269-9990, www.nfpa.org.
4 National Work Group on Leak Detection Evaluations, www.nwglde.org.
5 Steel Tank Institute, 944 Donata Court, Lake Zurich, Illinois 60047, www.steeltank.com.
6 Association for Petroleum and Explosives Administration, P.O. Box 106 Saffron Walden Essex CB11 3XT, England, www.apea.org.uk.
7 ASME International, 345 E. 47th Street, New York, New York 10017, www.asme.org.

CONCAWE Report 3/08 [8], *Guidelines for Blending and Handling Motor Gasoline Containing up to 10 % v/v Ethanol*

UL 58 [9], *Steel Underground Tanks for Flammable and Combustible Liquids*

UL 79, *Power-Operated Pumps for Petroleum Dispensing Products*

UL 87, *Power-Operated Dispensing Devices for Petroleum Products*

UL 87A, *Outline of Investigation for Power-Operated Dispensing Devices for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations up to 85 Percent (E0-E85)*

UL 142, *Steel Aboveground Tanks for Flammable and Combustible Liquids*

UL 157, *Gaskets and Seals*

UL 330, *Hose and Hose Assemblies for Dispensing Flammable Liquids*

UL 331, *Strainers for Flammable Fluids and Anhydrous Ammonia*

UL 525, *Flame Arresters*

UL 536, *Flexible Metallic Hose*

UL 567, *Emergency Breakaway Fittings, Swivel Connectors and Pipe-Connection Fittings for Petroleum Products and LP-Gas*

UL 674, *Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations*

UL 842, *Valves for Flammable Fluids*

UL 971, *Metallic Underground Piping For Flammable Liquids*

UL 971A, *Outline of Investigation for Metallic Underground Fuel Pipe*

UL 1238, *Control Equipment for Use with Flammable Liquid Dispensing Devices*

UL 1316, *Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol-Gasoline Mixtures*

UL 1356, *Outline of Investigation for Pipe Joint Sealing Compounds*

UL 1604, *Electrical Equipment for Use in Class I and II, Division 2, and Class III Hazardous (Classified) Locations*

UL 1746, *External Corrosion Protection Systems for Steel Underground Storage Tanks*

UL 2080, *Fire Resistant Tanks for Flammable Liquids*

UL 2085, *Fire Protected Tanks for Flammable Liquids*

[8] Conservation of Clean Air and Water in Europe, www.concawe.be.
[9] Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, Illinois 60062, www.ul.com.

3 Definitions and Acronyms

3.1 Definitions

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

3.1.1
alcohol
An organic compound containing one or more hydroxyl groups (-OH) bound to a carbon atom.

3.1.2
alternative fuels
Ethanol, natural gas, propane, hydrogen, biodiesel, methanol, electricity, and P-Series fuels as defined by the Energy Policy Act of 1992 (EPAct). Synthetic fuels made by the Fischer-Tropsch (coal to liquid) process are also considered alternative fuels.

3.1.3
anhydrous ethanol
Neat ethanol that contains less than one percent water.

3.1.4
anhydrous denatured ethanol
Fuel ethanol. Neat ethanol with up to five volume percent hydrocarbons added as a denaturant.

3.1.5
API table
A liquid measurement table used to correct the metered volume of a blend component to the volume at a standard temperature of 60 °F. Each component or blend of components needs a separate table.

3.1.6
base gasoline
Gasoline without ethanol. Base gasoline is sometimes called clear gasoline.

3.1.7
blendstock for oxygenated blending
BOB
Gasoline refined especially for blending with an oxygenate such as fuel ethanol to produce a gasoline-ethanol blend for commerce.

3.1.8
blend growth
The 0.1 % to 0.4 % increase in volume that occurs when gasoline and ethanol are mixed.

3.1.9
clean agent
A fire extinguishant that relies on heat absorption and chemical interaction to extinguish fires and mitigate the effects of smoke and flames. It leaves no residue or collateral damage as a result of its use and newer types are safe for use where people are present.

3.1.10
denaturant
A hydrocarbon added to neat ethanol to make it unfit for consumption. Suitable denaturants are listed in ASTM D4806.

3.1.11
denatured ethanol
E97. See 3.1.18, **fuel ethanol**.

3.1.12
distribution terminal
A facility where base gasoline and fuel ethanol are received by tank truck, railroad tank car, pipeline, barge or tanker and stored in stationary tanks until they are blended and loaded into tank trucks for delivery to bulk plants, filling stations and end-use consumers.

3.1.13
ethanol
Ethyl alcohol. Neat ethanol. A straight-chain alcohol with the molecular formula C_2H_5OH.

3.1.14
ethanol blend
A motor fuel which is a blend of ethanol and gasoline.

3.1.15
EXX
The acronym used to describe a blend of XX percent ethanol by volume and gasoline. For example, E10 is 10 % ethanol and 90 % gasoline.

3.1.16
E85
E85 is blended according to ASTM D5798 which covers a fuel blend range which is nominally 75 to 85 volume percent fuel ethanol (Ed75 to Ed85) and 25 to 15 additional volume percent hydrocarbons. Like gasoline specifications, the E85 specification accommodates changes in ambient temperatures according to month and geographic location. During cold weather months in some areas, E85 may contain as low as 65 volume percent ethanol to increase volatility. E85 is also referred to as “nominal E85”. In this recommended practice, the term “E85” will be used to refer to the range of blends specified in ASTM D5798.

3.1.17
fill box
An engineered access cover or tank access point that may or may not have spill containment capability.

3.1.18
filling station
A public or private facility for the storage and dispensing of motor fuels to motor vehicles. Also called a service station or fuel dispensing facility.

3.1.19
flashpoint
The lowest temperature at which a flammable liquid can form an ignitable mixture in air when a spark or ignition source is passed over or near it.

3.1.20
fuel ethanol
Denatured ethanol often referred to as E97. Ethanol containing 1.96 % to 2.5 % denaturant that meets the specifications of ASTM D4806. Fuel ethanol is intended for blending with base gasoline for use as a motor fuel and can contain water up to 1 % by volume.

3.1.21
gasoline-ethanol blend
A motor fuel which is a blend of fuel ethanol and base gasoline.

3.1.22
high-blend ethanol
A gasoline-ethanol blend with an ethanol content of greater than 10 % by volume. A gasoline-ethanol blend above E10.

3.1.23
hydrophilic
Having an affinity for water; readily absorbing or dissolving in water.

3.1.24
hydrophobic
Tending to repel or fail to mix with water.

3.1.25
injection blending
See side-stream blending

3.1.26
in-line blending
See ratio blending.

3.1.27
in-line proportional blending
A type of ratio blending accomplished by controlling the ratio of all components at all times during the delivery. The ratio of the delivered blend is correct at all times. The delivery can be stopped at anytime during the blend and the delivered blend will be within specification.

3.1.28
in-line non-proportional blending
A type of ratio blending accomplished by delivering the low proportion component(s) of the blend only when the high proportion component is flowing at during a high flow rate. After the low proportion component(s) have been delivered, the high proportion component continues delivery until the final blend is achieved. The finished fuel blend is off specification until the total preset volume is loaded.

3.1.29
listed
A designation for products certified and published in a database by a nationally recognized testing laboratory (NRTL).

3.1.30
limiting oxygen concentration
LOC
The concentration of oxygen below which combustion is not possible, independent of the concentration of fuel. It is expressed in terms of volume percent oxygen.

3.1.31
low-blend ethanol
A gasoline-ethanol blend with an ethanol content of 10 % or less by volume. A gasoline-ethanol blend of E10 or below.

3.1.32
meter correction factor
The ratio between the measured volume and the actual volume flowing through a liquid flow meter. The factor for a meter can vary with flow rate.

3.1.33
Nationally Recognized Testing Laboratory
NRTL
A third-party public safety evaluation entity, such as Underwriters Laboratories (UL), which publishes equipment standards and conducts tests and product evaluations. NRTLs conduct periodic inspections of production to verify adherence to standards.

3.1.34
neat ethanol
Anhydrous ethanol that has not been made unfit for consumption by denaturing.

3.1.35
ratio blending
Ratio blending (in-line blending) consists of simultaneously loading two or more products components or blend stocks through separate dedicated meters and control valves to a common blend point on a single header. Ratio blending can be either proportional or non-proportional blending.

3.1.36
Reid vapor pressure
RVP
A measure of the volatility of gasoline as determined by test method ASTM 323.

3.1.37
sequential blending

a) A blend method in which each component flows through its own meter and control valve separately and then into the common line as with ratio blending. The two products flow sequentially one after the other, not simultaneously as they would with ratio blending.

b) A variation of this method that uses only a single meter and control valve located downstream of the blend point. A single meter however cannot be calibrated for more than one of the components that it meters. The blend fuel is correct only after all components of the blend have been loaded.

3.1.38
sidestream blending
A blending technique similar to variation b) of sequential blending. The smaller proportion blend stock component is metered and then delivered into the flow stream of the larger proportion blend stock component. The total flow stream is then metered after the components are mixed together. Sidestream blending can be either proportional or non-proportional.

3.1.39
splash blending
A type of blending accomplished by metering each blend component into a tank truck separately by using different loading arms. The loading arms are changed manually by the truck driver or operator. In some cases, the components may be loaded into compartments at different locations. There is no automatic checking of the validity of the finished product blend.

3.1.40
Stage I vapor recovery
Collection and routing of vapors generated from filling a stationary storage tank into a delivery truck tank.

3.1.41
Stage II vapor recovery
Collection and routing of vapors generated during vehicle refueling into a stationary storage tank.

3.1.42
striker plate
A flat piece of metal or material permanently placed on an underground storage tank bottom under the gauging point to prevent impact damage from measuring the liquid level with a gauge stick.

3.1.43
switch loading
The practice of loading a low vapor pressure product into a tank which previously contained a high or intermediate vapor pressure product, which can create a flammable atmosphere in the tank vapor space.

3.1.44
wild-stream blending
Wild-stream blending is normally off rack blending of two products that supplies a blended product to the loading rack, one product uses a meter and a control valve and the second flows by demand or wild. The finished blend flows through a custody transfer meter and control valve downstream at the loading rack.

3.2 Acronyms

For the purposes of this document, the following acronyms apply.

APEA/IP	Association for Petroleum and Explosives Administration/Institute of Petroleum
AFFF	aqueous film forming foam
AHJ	authority having jurisdiction
ASTM	American Society for Testing and Materials
BOB	blend stock for oxygenate blending
BOE	Bureau of Explosives
BTEX	benzene, toluene, ethylbenzene and xylene
CARB	California Air Resource Board
CFR	Code of Federal Regulations
DEQ	Department of Environmental Quality
DOT	Department of Transportation
FFV	flexible fuel vehicle
EPA	Environmental Protection Agency
EPAct	Energy Policy Act of 1992
EU	European Union
EVR	enhanced vapor recovery
ICC	International Code Council
kPa	kilopascals
LEL	lower explosive limit
MIC	microbial induced corrosion
MSDS	material safety data sheet
MTBE	methyl tertiary butyl ether
Neg	negligible

NFPA	National Fire Protection Association
NRTL	nationally recognized testing laboratory
NTEP	National Type Evaluation Program
NWGLDE	National Work Group on Leak Detection Evaluations
ORVR	onboard refueling vapor recovery
OSHA	Occupational Safety and Health Administration
POTW	publicly owned treatment works
psi	pounds per square inch
P/V	pressure/vacuum
PWHT	post weld heat treatment
RP	recommended practice
RVP	Reid vapor pressure
SCC	stress corrosion cracking
SPCC	Spill Prevention Control and Countermeasures
STI	Steel Tank Institute
UEL	upper explosive limit
UL	Underwriters Laboratories (a NRTL)
UST	underground storage tank

4 Ethanol and Ethanol Blend Characteristics

4.1 General

Blending fuel ethanol and base gasoline together can create a range of products with properties different than the original constituents. Before handling, storing and dispensing gasoline-ethanol blends, consideration should be given to the design and compatibilities of all components coming in contact with the blended liquid and vapors. Blend properties that should be taken into account include, stress corrosion cracking of steel structures, the flammability of vapors, vapor pressure, the hydrophilic nature of ethanol, the differential solvency of ethanol (i.e., the impact on polymeric materials, such as swelling, extraction, permeation, and embrittlement) and the water tolerance of ethanol blends. When a new blend is introduced, evaluate these properties for every step in the supply chain to assure product quality and safe handling and storage.

See Annex A for gasoline and gasoline-ethanol blend properties.

4.2 Vapor Pressure

The vapor pressure of neat ethanol is 59.3 mm Hg at 20 °C (68 °F). When ethanol is added to gasoline, the vapor pressure of the blend is higher than that of the gasoline alone for low ethanol concentrations. An addition of fuel ethanol to base gasoline to make an E10 blend will typically increase the vapor pressure of the blended fuel by approximately 6.89 kPa (1 psi) above that of the gasoline alone. With further addition of ethanol, the vapor pressure of the blend decreases until it reaches the vapor pressure of ethanol at 100 % concentration.

Base gasolines are refined to comply with Reid vapor pressure requirements that are based on regulatory requirements that reflect seasonal temperature variations. RVPs are typically just below the regulatory limit. If ethanol is added, the RVP of the blend will increase above regulatory limit. Gasoline-ethanol blends with ethanol contents of 10 % or less are blended using blend stock for oxygenate blending (BOB) which has a lower RVP than gasoline intended for sale. The use of a low RVP BOB allows the sale of the ethanol blend without exceeding the maximum RVP allowed. As part of the Clean Air Act Amendments, the federal EPA provides a waiver of 1.0 psi RVP for ethanol blends delivered to air quality attainment areas where it is not precluded by state implementation plan limitations. The higher vapor pressure blend can be sold as long as it contains base gasoline that meets the RVP standard and the blend contains between nine and ten percent ethanol by volume.

As with gasoline, the vapor pressure of E85 is regulated according to season and geographic region. The vapor pressure limits of E85 are established by the specifications of ASTM D5798. Vapor pressure is adjusted by varying the proportion and vapor pressure of the gasoline in the blend. During warmer months when gasoline RVP is lower, it may be necessary for blenders to use a higher RVP BOB as a blend stock to raise the vapor pressure to meet the ASTM specification. Some terminals may have operations that will allow for the addition of a pressurizing agent (such as butane or pentane) to increase volatility. However, this practice may require the terminal to register as a refiner and may trigger OSHA process safety management rules. These considerations are beyond the scope of this recommended practice.

In cold areas during winter, the amount of gasoline in gasoline-ethanol blends sold as E85 may increase from 15 % up to 35 % by volume to maintain vapor pressure.

4.3 Vapor Density

Ethanol vapor is denser than air, but not as dense as gasoline vapor. If released in air, vapors can collect in low places.

4.4 Liquid Density

Neat ethanol and gasoline-ethanol blends are slightly heavier than gasoline.

4.5 Flash Point

The flash point of neat ethanol is approximately 13 °C (55 °F). The flashpoints of gasoline-ethanol blends vary greatly depending on ethanol level, denaturant and water content.

4.6 Flammability

The lower explosive limit (LEL) of neat ethanol and fuel ethanol is 3.3 % and the upper explosive limit (UEL) is 19 %. The flammability range of neat ethanol and high-blend ethanols is wider than that of gasoline.

The flammability of ethanol blends up to 10 % by volume (E10 and below) is similar to that of base gasoline, and is normally too rich to burn in a tank headspace.

The headspace in tanks containing E70 to E100 is flammable for all ambient storage temperatures.

Flammability data is lacking for E11 through E69.

4.7 Flame Visibility

Neat ethanol does not produce visible smoke and burns with a slight blue flame. Denatured ethanol produces little to no smoke and a slight orange flame may be visible. The flame of a gasoline-ethanol blend is less bright than a gasoline flame, but it is visible in daylight.

The low luminosity of ethanol flames results in lower radiant heat transfer compared to gasoline flames which provides some fire-safety advantages relative to gasoline.

4.8 Electrical Conductivity

Ethanol and gasoline-ethanol blends are relatively electrically conductive compared to gasoline. This higher conductivity may contribute to or accelerate galvanic corrosion between dissimilar metals in wetted service. Gasoline, by contrast, has a low conductivity and is a relative electrical insulator.

4.9 Water and Gasoline Solubility

Neat ethanol is fully miscible or infinitely soluble in water and in gasoline. Neat ethanol will form a homogeneous mixture with either water or gasoline.

Phase separation occurs when the water content of a gasoline-ethanol blend exceeds the water saturation level causing the formation of a water/ethanol layer and a separate gasoline layer. The water-ethanol layer, which is also referred to as aqueous ethanol, is denser than gasoline and migrates to the tank bottom. For a blend that is already near the saturation level, separation can occur quite suddenly in response to a small increase in water content or decrease in temperature.

A typical water saturation level for an E10 blend is 0.5 volume percent at 60 °F.

A typical water saturation level for an E85 blend is 13 to 15 volume percent at 60 °F.

Phase separation is unlikely to occur in fuel ethanol during handling or storage.

See 5.5.2 and 7.8.3 for further information.

5 Distribution Terminals

5.1 General

The introduction of fuel ethanol storage and the blending of gasoline and fuel ethanol at distribution terminals will require the installation of new equipment and present new operating conditions. These changes necessitate a review of equipment and procedures to assure safe operations and on-specification blended products.

5.2 Product Receipts

Distribution terminals can receive neat ethanol and fuel ethanol by tank truck, tank car, ship and barge. Pipelines are not generally an option for transporting neat or fuel ethanol. With each mode of delivery, precautions need to be taken to ensure safe handling and maintain product quality.

5.2.1 Pipeline Receipts

Currently multi-product motor fuel pipelines do not allow the transport of neat or fuel ethanol or gasoline-ethanol blends. This prohibition is based on concerns about the deterioration of elastomers in critical equipment and the tendency for ethanol to pick up water while being transported. Ethanol can also affect the properties of other products transported in the pipeline. Ethanol can loosen rust and sediment throughout the pipeline and entrained particulate carried through the system can collect in storage tanks and clog filters. Water entrained in ethanol can contaminate blended products. Should ethanol come in contact with jet fuel in the pipeline, it can degrade filter coalescer performance and allow water to contaminate jet fuel. These impacts are key concerns limiting pipeline transport of ethanol and ethanol blends. At the time of publication, investigation is underway to determine the feasibility of transporting ethanol blends in pipelines.

5.2.2 Tank Truck Receipts

Tank trucks are a common mode of transporting ethanol from production plants and distribution hubs to terminals. Tank trucks used for neat ethanol and fuel ethanol transport should be dedicated to that service. If a dedicated truck is not available, a truck used for gasoline or gasoline-ethanol blend transport may be used. Do not use trucks that have carried other materials. Prior to loading ethanol, tank truck compartments should be clean and drained of water and any residual product retained from the previous load.

Before offloading an ethanol shipment, inspect the delivery truck for signs of damage during transit that could allow water ingress. Compartments showing evidence of product contamination should not be unloaded.

The ethanol delivery area in a terminal should be situated to allow the safe entry, unloading, and exit of tank trucks. High-blend ethanol fuels require more ethanol tank truck deliveries than E10 and can contribute to increased traffic congestion at terminals.

Before unloading, delivery tank trucks should be properly bonded and grounded. Bonding and grounding can be accomplished by using electrically continuous unloading hoses or a bonding connection made directly to the truck. See API 2003 for guidance on safe unloading procedures.

Pumps and hoses used to unload neat ethanol or fuel ethanol tank trucks should be compatible with ethanol and gasoline. Ethanol unloading pumps and lines at the terminal should be dedicated to ethanol service. If the unloading pump is located on the delivery tank truck, it should be compatible with ethanol and gasoline.

At a minimum, the ethanol transfer area should provide sufficient spill control capacity to contain the largest truck compartment. This requirement can be met in two ways. The unloading area can be designed to have a contained volume greater than the largest anticipated truck compartment so that any spilled liquid will be captured and retained in the transfer area. Alternatively, if the transfer area does not have sufficient impound capacity, install a high flow rate drainage system that can accommodate the flow and volume from the largest expected truck compartment and rapidly route it by gravity to a dedicated underground storage tank or other isolated remote impoundment. Design spill impoundment areas to comply with NFPA 30 requirements and include them in the Spill Prevention, Control, and Countermeasure (SPCC) plan for the site.

Paving materials in contained areas should be compatible with ethanol and gasoline and able to withstand heavy traffic loads. Concrete is the recommended paving option. Joints and cracks should be filled with sealing materials that are compatible with ethanol and gasoline. Containment areas should be inspected regularly and kept leak-tight.

See API 2610 for more information on truck unloading.

5.2.3 Railroad Tank Car Receipts

Railroad tank cars should be dedicated to ethanol service. If not, they should be cleaned and dried before loading. Visually inspect tank cars for damage prior to unloading. Tank cars showing evidence of product contamination should not be unloaded.

Before unloading, tank cars should be properly bonded and grounded. Bonding and grounding can be accomplished by using electrically continuous unloading hoses or a bonding connection made directly to the tank car.

Pumps and hoses used to unload neat ethanol or fuel ethanol should be compatible with ethanol and gasoline. Ethanol unloading pumps and lines at the terminal should be dedicated to ethanol service.

The tank car unloading area should have the capacity to contain the entire contents of a tank car at a minimum. This requirement can be met in two ways. The unloading area can be designed to have a contained volume greater than the largest anticipated tank car volume, so that any released liquid will be captured and retained. Alternatively, if the unloading area does not have sufficient capacity, a high flow rate drainage system that can accommodate the flow and volume from the largest expected tank car and rapidly route it by gravity to a dedicated underground storage tank or other isolated remote impoundment should be installed. Design spill impoundment areas to comply with NFPA 30 requirements and include them in the SPCC for the site.

The materials in the unloading area should be compatible with ethanol and gasoline (i.e. concrete). Joints and cracks should be filled with sealing materials that are compatible with ethanol and gasoline. Containment areas should be inspected regularly and kept leak-tight. If practical, locate tank cars that are being unloaded in contained areas. Loaded tank cars entering the terminal should be routed to the containment area and secured. If practical, loaded tank cars should not be parked or stored outside the containment area before unloading. SPCC plans should consider the risk of handling multiple tank cars and engineering controls should be adjusted as required.

Transloading fuel ethanol from tank cars directly to on-the-road tank trucks can introduce conditions that are not present when tank cars are unloaded into stationary storage tanks. Perform a risk assessment of equipment and procedures prior to initiating any new product transfer method.

Refer to the following publications for information on the design and safe operation of tank car loading and unloading facilities:

— API 2610

— BOE Tariff 6000

— BOE Circular No. 17

— BOE Pamphlet 34

— *United States Hazardous Materials Instructions for Rail*

For more information go to: http://boe.aar.com.

5.2.4 Receipts from Barges and Tankers

For marine terminals that receive neat ethanol, fuel ethanol, or gasoline-ethanol blends by tanker, ship or barge, a prime concern is the possible introduction of water during transport and transfer. Special precautions and procedures should be in place to assure and verify safety, cleanliness and product integrity during transport.

Establish whether the vessel is in dedicated ethanol service and, if not, confirm the previous product carried and its compatibility with ethanol. Compartments should be clean and drained before loading. Receipts from vessels with visual signs of damage, leaks, or water ingress should not be accepted. Single hull vessels or vessels that use product tanks to carry ballast water should generally not be used. Any possible exposure of ethanol to water during transport and transfer shall be avoided.

Some regulations require that flammable cargo compartments have the headspace filled with an inert gas to reduce the potential for fire or explosion. Flue gas from the exhaust of vessels should not be used as the source of the inert gas because it gives a misleading acidity test results and the water vapor in the exhaust gasses can condense and contaminate the load. In addition, the carbon dioxide in the flue gas can potentially be absorbed into the ethanol and increase its acidity. For further information, see ASTM guidelines.

During offloading of ethanol, follow standard gasoline unloading procedures for grounding and bonding. Segregated receipt piping systems should be used where possible. It is recommended that the receiving terminal be equipped with two ethanol storage tanks to ensure that deliveries are not received into a running tank which is simultaneously supplying product. Inbound filtration may be used to capture entrained scale and rust if sized to accommodate vessel off load flow rates. Redundant filter systems may be of benefit in accelerating offloading tidal areas where vessel draft is a concern.

Water purging of onshore transfer piping is not recommended.

See API 2610 for more information on marine unloading.

5.3 Blending

Gasoline blends up to E10 involve three main components, fuel ethanol, base gasoline and a deposit control additive. E85, which is an alternative fuel, involves three main components—fuel ethanol, base gasoline and a pressurizing agent to increase volatility. The recipes for blended products are regulated according to season and geographic region.

When choosing a blending system for a terminal, safety and product quality (adherence to the blend specification) should be the main considerations. Secondly, blenders should consider the initial cost of installation, recurring maintenance cost, flow rates, and range of blend ratios or recipes that can be delivered. In general, to minimize the risk of co-mingling, it is recommended that facilities have separate segregated systems for the storage and handling of base gasolines and fuel ethanol.

5.3.1 Terminal Blending

It is recommended that ethanol mixed fuels be blended at terminal loading racks using ratio (in-line) or sequential blending methods. These methods are safer than other blending techniques and produce the highest level of fuel quality.

Splash blending on trucks is acceptable as an interim solution until a fixed blending system can be installed. The use of splash blending should be limited due to the safety concerns of increased tank compartment flammability and the increased chance of blend errors from human involvement.

Wild-stream blending is not recommended. It provides less control over finished fuel quality because both blending streams are not metered.

Batch blending of fuel ethanol and gasoline directly in ASTs, while possible at some larger terminals, is not recommended. The difficulty of achieving a correct blend, the potential for insufficient receipt velocity to avoid component stratification in the tank, the increased opportunity for water contamination of the finished product, and the difficulty of correcting blend errors are significant risks with this method. Once an off-specification blend is in the tank, it is difficult to correct.

Batch blending of neat ethanol to create fuel ethanol in aboveground storage tanks is however the accepted method of denaturing ethanol. This is a common practice at water/marine supplier terminals.

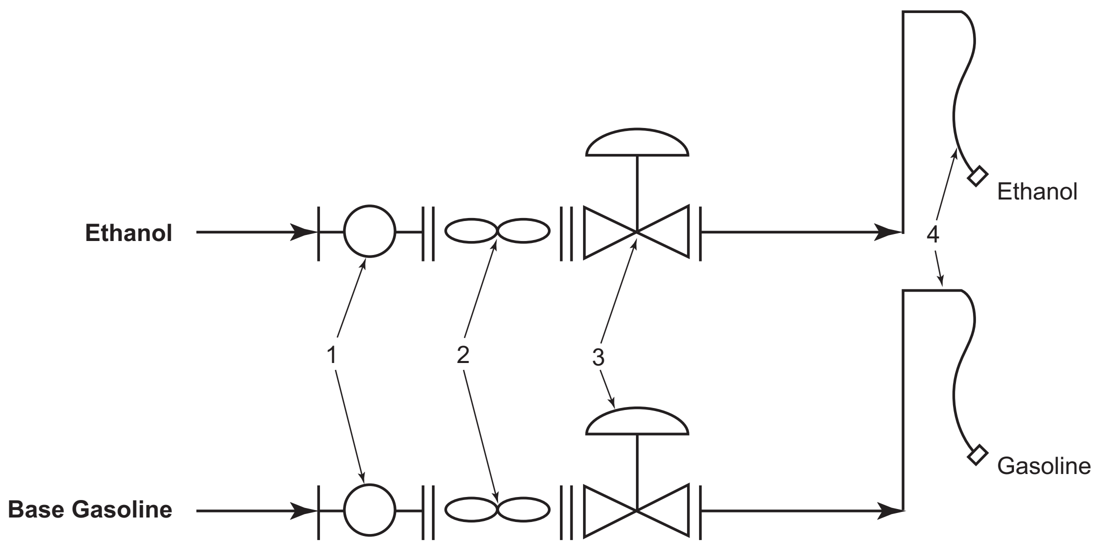
5.3.2 Rack Blending

Rack blending techniques are divided into three basic groups: splash, sequential, and ratio (in-line) blending.

5.3.3 Splash Blending

Splash blending consists of loading gasoline and fuel ethanol into a tank truck sequentially by using different loading arms. The truck driver or operator changes the loading arms manually. Each loading arm has its own meter and control valve. The quantity of each blend component is manually calculated, and there is no automatic checking of the validity of the finished product blend. In some cases, the components may be loaded into compartments at different locations. See Figure 1.

There are many disadvantages to splash blending. The blend recipe is determined directly by personnel at the loading rack. Splash blending requires the driver/operator to manually switch between blend stocks by disconnecting



Key
1 strainer
2 meter
3 control valve
4 loading hose

Figure 1—Splash Blending Schematic

the loading hose after loading the first blend component and then connecting another loading arm for the second component. It also requires setting two complementary blend stock volumes to meter the load into the truck. All of these operations increase the opportunity for a blending error, overfill, or an accident to occur because of the increased time and manpower required to complete the blend. At high volume terminals, reliance on splash blending may adversely impact the terminal's daily throughput.

In some cases, component loading may occur at two different facilities. Loading the second blending component into a truck compartment containing a partial load increases the chances for an incorrect blend or an overfill due to human error.

The blend ratio with splash loading is correct only after the all the components of the blend have been completely loaded. There is no automatic checking of the validity of the blend. Complete blending in the truck relies on the volume and the turbulence generated by the introduction of the second and, if required, third components.

Depending on the loading rate and the volume, initial mixing during loading may be incomplete. Incidental mixing may occur in the truck as the blend is driven to the delivery location and when it is loaded into the delivery tank, but the blend components may still not be mixed homogeneously. Because of these concerns, splash loading increases the chances of incomplete mixing and an off-specification blend.

The equipment costs for splash blending are relatively low compared to other blending methods. There is no need for automation and independent meters can be accurately calibrated, but it is not a preferred blending method because of concerns about safe and accurate blending.

Splash blending should be used only as a temporary measure until a permanent blending system can be installed, or at small terminals where only a few loads a day are blended.

5.3.3.1 Splash Blending E10

E10 can be blended by using the blend techniques described in 5.3.3, but in-truck splash blending is not recommended. However, if splash blending is necessary, gasoline should be loaded into the tank truck before the ethanol to ensure that the vapor concentration in the compartment headspace is above the upper flammable limit. The accepted industry practice, as described in API 2003, should be followed.

E10 blends should conform to the most recent version of ASTM D4814.

5.3.3.2 Splash Blending E85

E85 can be blended using the blend techniques described in 5.3.3, but in-truck splash blending is not recommended. However, if splash blending is necessary, gasoline should be loaded into the tank truck before the ethanol to ensure that the vapor in the compartment headspace is above the upper flammable limit. The accepted industry practice, as described in API 2003, should be followed.

E85 should be handled using the same procedures as those for distillates with regard to switch loading.

E85 blends should conform to the most recent version of ASTM D5798.

5.3.4 Sequential Blending

5.3.4.1 General

Sequential blending consists of loading each blend stock component, one at a time, using a single meter and control valve, delivering into a single load arm into the tank truck. The fuel blend is correct only after all components of the blend have been loaded. Mixing occurs in the truck compartment, during the delivery time to destination, and during the fuel offload.

Sequential blending may be done manually or electronically.

5.3.4.2 Sequential Blending Techniques

Under sequential blending, the blend components flow one at a time (sequentially). They are routed into a common load arm and then into the compartment being filled. There are two methods for accomplishing sequential blending.

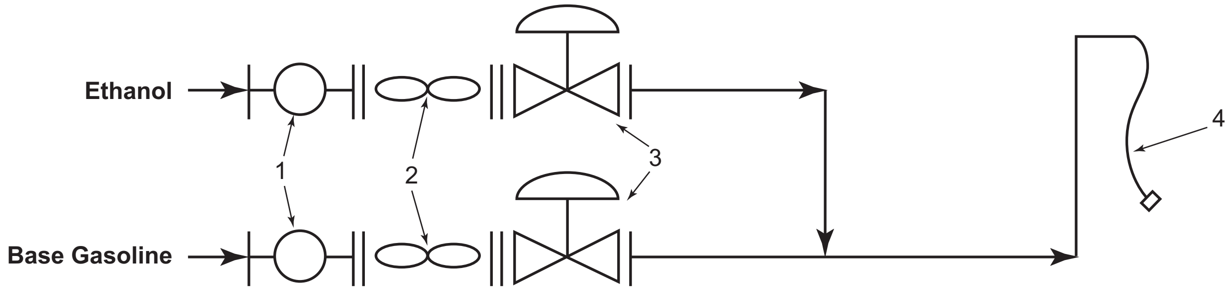
1) Dedicated Meters and Control Valves—The metered blend components are combined at a point downstream of the individual component meters and control valves, delivered into a single load arm and into the compartment. See Figure 2.

2) Single Meter and Control Valve—All components flow through a single meter and the flow rate is controlled by a single control valve in the line downstream of the point where the components are introduced into the common line. Each component flows individually through the same meter and control valve into a single load arm for delivery into the compartment. See Figure 3.

Under either of the sequential methods, the fuel blend is correct only after all components of the blend have been loaded. Mixing occurs in the truck compartment, on the road during the delivery to the destination, and in the storage tank during off loading.

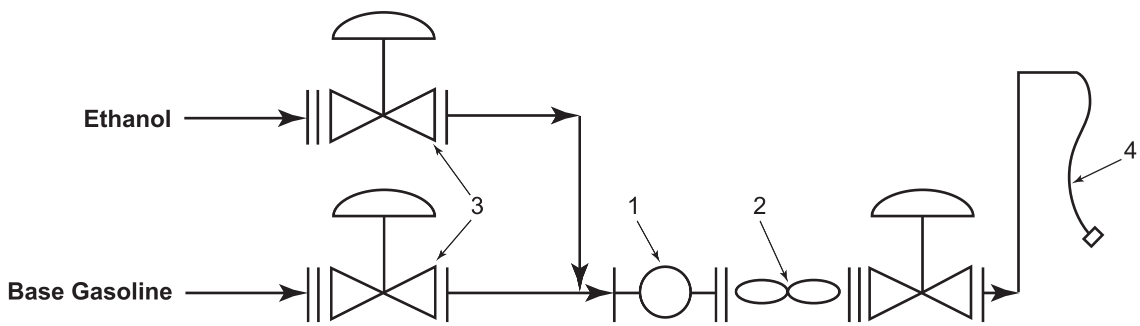
Sequential blending may be done manually or electronically.

With sequential blending, the blend is complete only after the total batch is finished. A load rack shutdown during the blending sequence will result in an out-of-specification product in the truck.



Key
1 strainer
2 meter
3 control valve
4 loading hose

Figure 2—Sequential Blending—Dedicated Meters and Control Valves



Key
1 strainer
2 meter
3 control valve
4 loading hose

Figure 3—Sequential Blending—Single Meter and Control Valves

Because blend components are loaded one at a time, sequential blending is slower when compared to ratio blending. The effect of increased loading times should be considered at high volume terminals.

Compared to ratio blending, sequential blending, using a single meter and control valve, has a lower initial capital investment and lower maintenance costs because there are fewer meters to calibrate and fewer valves to service. However, Sequential blending requires that a single meter be calibrated for two different blend stocks, which cannot be done without an electronic blender capable of utilizing specific meter correction factors, and API tables for each blend component. The requirements of weights and measures agencies may eliminate this method from consideration as a blending technique even if stock control issues related to meter accuracy are deemed acceptable.

A disadvantage of sequential blending is that mixing of the blend components may not be complete. Complete blending in the truck relies on the turbulence generated by the introduction of the second and, if required, third components to make a homogeneous mix. Depending on the loading rate and the volume, mixing may be incomplete. Incidental mixing may occur in the truck as the blend is driven to the delivery location and when it is loaded into the delivery tank, but the blend components may still remain stratified. Because of these concerns, sequential blending increases the chances of incomplete mixing and an off-specification blend.

Sequential blending can be controlled electronically allowing predetermined blending recipes to execute after a single-compartment pre-set volume is set. An alternative is to make blends manually by pre-setting each complementary blend stock volume to meter the load into the truck. Setting individual volumes manually introduces a chance for error and could contribute to an off-specification blend or compartment overfill.

Electronic sequential blending is recommended over manual sequential blending to improve safety, product quality and speed.

5.3.5 Ratio (In-line) Blending Techniques

5.3.5.1 Ratio Blending

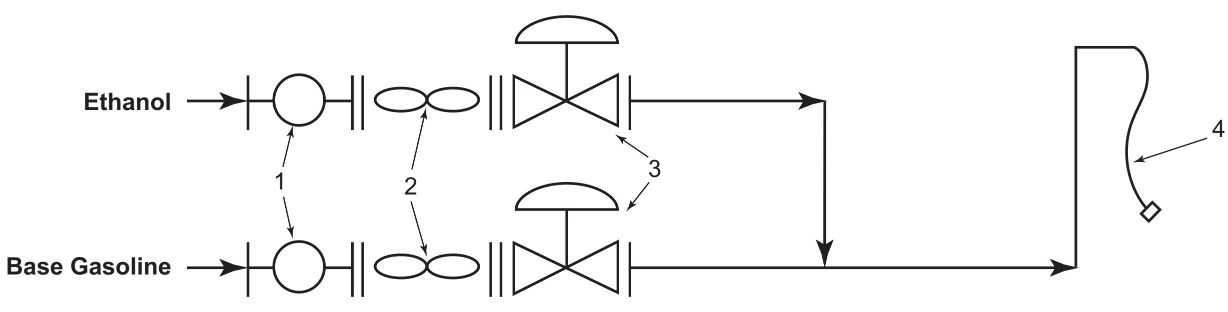
Ratio blending (in-line blending) is the simultaneous loading of two or more product components or blend stocks through separate dedicated meters and control valves to a common blend point. The blended product is transferred to the truck using a single loading arm.

The use of separate dedicated meters for each component allows for accurate calibration of each meter. Ratio blending involves fewer steps for the operator, takes less time than sequential blending, and provides a high level of accuracy from blend to blend.

Ratio blending can be either proportional or non-proportional.

5.3.5.2 Ratio (In-line) Proportional Blending

Ratio (in-line) proportional blending holds the blend ratio of all components constant throughout the blend. It provides a blend that is on-specification during the entire loading process and reduces the chance of an off-specification blend in case of a rack shutdown. See Figure 4.



Key
1 strainer
2 meter
3 control valve
4 loading hose

Figure 4—Ratio Blending Schematic

5.3.5.3 In-line Non-proportional Blending

In-line non-proportional blending is a type of ratio blending that is accomplished by delivering the low concentration component(s) of the blend during the portion of the delivery when the high concentration component is being loaded at its highest flow rate. With this approach, the flow rates during the middle of the blend are at the optimum design points for each meter and blending accuracy is improved. Blend accuracy is improved with this method because components are mixed when each meter is operating at its respective optimum design point. After the low concentration component(s) have been delivered, the high concentration component continues delivery until the final blend is achieved. If the blend is interrupted, the intermediate mixture will not be on-specification. The finished fuel blend is not correct until the total preset quantity is loaded.

The initial cost of ratio blending is higher than some other blending options and requires automation at the terminal for blend control.

5.3.6 Side-stream Blending

Side-stream blending is similar to ratio (in-line) blending except that one product is delivered upstream to another product component. Side-stream can be either proportional or non-proportional blending. Side-stream blending injects a smaller product stream into a larger stream thereby allowing the two products to mix together ahead of the delivery meter before being loaded into the truck. This method is also referred to as injection blending.

The method can provide some flexibility in limited applications, but is not generally recommended for widespread application because the system must be purged of off-specification fuels when a new product is blended. If there are different blend proportions, accurate calibration of the delivery meter can be difficult.

5.4 Terminal Material Compatibility

5.4.1 General

Numerous terminal components come in contact with blend stocks and blended product in the fuel and fuel vapor pathways. For safety, to meet fire codes, and to comply with regulatory requirements where specified, each of these components shall be compatible with the blend stocks or ethanol blends with which they come in contact.

Any new fuel blend that triggers a new MSDS should be judged as significantly different from previous products. Systems intended for use with these new fuels should be evaluated for material compatibility and conformity with fire safety and regulatory requirements before introduction. To use a new component, or continue using an existing one, it should have the manufacturer's confirmation of compatibility or a third-party certification and, if applicable, meet the requirements specified in fire codes or OSHA rules.

Incompatible materials should not be used because of the potential to degrade fuel quality and the possibility of component failure.

5.4.2 Terminal Compatibility Determination

Material compatibility for individual components or systems can be shown in several ways. First-party confirmation by the manufacturer is the most accepted method of proving compatibility in terminals. This ascertainment can be supplemented by an independent third-party determination, and when needed, by a Nationally Recognized Testing Laboratory (NRTL) should the equipment in question be listed.

Engineering judgment plays large role in the design and construction of terminals because of the individual characteristics and requirements of each facility. Consequently, most terminal equipment systems such as tanks, piping and loading racks are not required by code or regulation to be listed by a NRTL.

For components at terminals, equipment manufacturers have two choices to show compatibility:

1) hire a qualified third party or NRTL to determine compatibility, or

2) self-certify their equipment.

Third parties, acting as qualified testing laboratories hired by component manufacturers, can determine material compatibility. They can make determinations to confirm material compatibility for specified types of service based on component design, appropriate testing and previous experience.

Manufacturers can confirm the compatibility of components based on their own testing procedures and criteria. Test methods may vary between manufacturers, and may not be directly comparable. Manufacturers' determinations may not be accepted by all AHJs and cannot be used to replace a listing by a NRTL when that is required by law. However, manufacturers' determinations are important where there is no other indication of material compatibility.

Some components or systems that have been listed and shown acceptable material compatibility may need further testing to be approved for use by AHJs if the test fuel is different from the ethanol blend that will be used in service.

Owners and operators should maintain a complete record of compatibility findings for system components.

Finally, it is important to note that material compatibility does not guarantee operational compatibility. Terminal operators should verify that system and component accuracy in the fuel service with the equipment manufacturer.

5.4.3 Terminal Accelerated Corrosion and Conductivity

Compared to gasoline and hydrocarbon fuels in general, ethanol has a high electrical conductivity and oxygen content. The chemical properties of ethanol also contribute to its ability to readily absorb water. The suspension of water within gasoline-ethanol blends enhances galvanic corrosion and rusting by providing an oxygen-rich environment that is also a good conductor of electricity. These conditions present in ethanol blend service can lead to corrosion and ultimately metal loss of various components which are not normally adversely affected by gasoline.

Ethanol is not compatible with some grades of soft metals such as zinc, brass, copper, lead, and aluminum. These metals will degrade or corrode in contact with ethanol and possibly cause a component failure or affect fuel quality. Seals, gaskets, and other elastomers that are not specifically intended for use with ethanol blends can lose their integrity and cause a product leak. Before using any component in ethanol service, verify its compatibility with the manufacturer.

5.5 Terminal Fuel Quality

5.5.1 General

Ethanol is hydrophilic. It readily absorbs water and forms a homogenous solution with water over its entire dilution range. Water that gets into ethanol and gasoline-ethanol storage tanks is immediately absorbed and can contaminate fuel. In contrast, gasoline is hydrophobic and has a low solubility with water. Consequently, the presence of ethanol increases the overall solubility of water in ethanol-gasoline blends compared to base gasoline. Understanding how water affects gasoline-ethanol blends and how it can be detected can help assure better fuel quality.

5.5.2 Terminal Phase Separation

Phase separation is unlikely to occur in fuel ethanol or E85 because of the high ethanol concentration. Significant water accumulation in these tanks will most likely be discovered before phase separation occurs because of obvious tank defects or inventory control inconsistencies. Periodic testing of the tank for water content and the consistent performance of tank water draws are the best indicators of a water problem as the ethanol that is drawn off will have very high water saturation.

The quantity of water that can be absorbed or dissolved in a gasoline-ethanol blend is dependent on the amount of ethanol present. In low-ethanol blends, such as E10 or below, small amounts of water can be absorbed, but beyond a certain concentration, saturation will be achieved. Any additional water, even a small amount, or a drop in temperature, will cause the ethanol to separate from the gasoline and form a separate solution with the water. In ethanol blend storage tanks this phenomenon is known as phase separation. When phase separation occurs, the water/ethanol solution sinks and forms a layer on the bottom of the tank leaving off-spec gasoline in the upper layer with lower ethanol content and as a result, reduced octane level.

Discovery of phase separation in a storage tank may be an early indication of a tank or tank system defect. The tank should be immediately removed from service and the water phase should be treated as a hazardous flammable liquid and disposed of in accordance with federal, state and local requirements. The ethanol-depleted gasoline in the upper phase should be managed as off-specification product.

The water solubility of ethanol is temperature dependent and increases with higher temperatures. Water solubility also increases with increasing ethanol content in the blend. To minimize the chance of phase separation, fuel ethanol used for blending with gasoline should be free of any water contamination. If phase separation occurs, the process is irreversible.

The susceptibility of gasoline-ethanol blends to water requires that the tank and the entire piping system be clean and dry before ethanol blends are introduced. Good housekeeping practices shall be maintained during on-going operations to keep water from entering the system. To eliminate future contamination, determine and eliminate all sources of water.

5.5.3 Terminal Water Intrusion

Water can be introduced into a storage tank by rain or snow blowing or leaking in through unintended openings in the tank shell or roof. External floating roofs are particularly prone to water entering during inclement weather. Diurnal temperature changes and humid conditions can promote the formation of condensation on the inner surfaces of tanks above the internal floating roof. With sufficient accumulation, condensation can collect and drain past the floating roof seals into the liquid product.

Water can also enter the tank if it is entrained in the ethanol supplied by the manufacturer. Water can be present in the ethanol if it has not been kept dry during transit or it was not completely removed during the manufacturing process. Test periodically to ensure that ethanol receipts are on-specification for water content. If water in ethanol is detected, the source should be investigated and eliminated to prevent further fuel contamination.

5.5.4 Terminal Micro-organisms

Microbes may exist in tanks containing gasoline-ethanol blends and their presence can lead to microbial-induced corrosion (MIC). MIC can occur in aerobic and anaerobic tank environments. Aerobic micro-organisms survive by feeding on the hydrocarbons at the interface between the water layer and the gasoline layer. Other microbes can form colonies in tank bottom sludge that puts them in direct contact with steel tank surfaces.

The metabolic wastes secreted by microbes produce water, sludge and acidic byproducts that can cause material degradation. The acidic residues of sulfate reducing bacteria can cause metal corrosion, which if left unmanaged, may cause a tank failure. The odor of sulfur in fuel is a telltale sign of microbial presence. Microbes also attack and consume rubber gaskets and certain seal, hose and coating materials for their mineral content. There is recent evidence of MIC in un-phase-separated ethanol blends.

The primary cause of microbial growth is the presence of water. Minimizing the intrusion of water into tank systems and diligently checking for the first indications of phase separation can prevent most microbial growth. Biocides formulated for use in tanks can be added to fuel to control persistent microbial populations.

5.6 Terminal Spill/runoff Management at Terminals

Ethanol is miscible with gasoline and water and cannot be segregated from spills or wastewater using gravity separation. Unless cleaned up immediately, a spill of a gasoline-ethanol blend at a terminal will come in contact with water either at the location of the spill, such as the loading rack, or in the oil/water separator. When gasoline-ethanol blends come in contact with water, phase separation will occur and the ethanol will separate from the blend and partially dissolve into the water. Ethanol that is dissolved in water will pass through a gravity separator and will not be captured.

The following are techniques that can be used to manage ethanol-containing waste streams.

— Ethanol transfer areas should be kept separate from traditional gasoline transfer areas. The spill and runoff streams from the two sources should be kept segregated.

— Discharge to the Sewer—Some jurisdictions allow the discharge of ethanol-water mixtures into the sanitary sewer system. Check with the local AHJ regarding discharge requirements and limitations.

— Collection Tanks—Ethanol-containing mixtures can be collected and stored in segregated tanks for off-site treatment or disposal.

— Construct Wetlands—Waste streams containing only ethanol and water with trace amounts of hydrocarbons can be directed to segregated unpaved areas where percolation and natural biodegradation can occur. Consult a qualified environmental consultant and the AHJ to assess the feasibility of this option.

Other options employing advanced treatment technologies such as enhanced oxidation may provide alternative management techniques. Consult a qualified environmental consultant for further information.

5.7 Terminal Source Segregation

For E85 and fuel ethanol loading areas, keep ethanol-containing waste streams separate from clean storm water runoff. Ethanol unloading areas and each loading rack where ethanol blend fuels are loaded should have impoundment with dedicated drainage systems to capture and contain spilled ethanol and any incidental storm water runoff from the areas. Neat ethanol and fuel ethanol storage tanks should have diked areas separate from petroleum hydrocarbon storage tanks. The separated dike yards are necessary to minimize mingling of stormwater runoff from the two areas. Collected material should be managed in conformance with AHJ requirements.

5.8 Terminal Aboveground Storage Tanks

Neat ethanol, fuel ethanol, and gasoline-ethanol blends can be stored at terminals in either fixed roof tanks or tanks equipped with an internal floating roof. A major consideration when storing ethanol is to keep it from coming in contact with water.

External floating roof tanks are open to the elements and unable to prevent precipitation from running down the interior of the tank shell past the roof seals and thereby reaching the stored product. Rainwater may also be introduced into the stored product through a leaking roof drain. Therefore, tanks with external floating roofs are not recommended for ethanol or ethanol blend storage.

For tanks that are less than 12 ft to 15 ft in diameter, floating roofs are impractical because of the chance the roof may become stuck and possibly sink if the tank shell is out of round. Fixed roof tanks without an internal floating roof should control vapor venting with a pressure/vacuum (P/V) valve. The true vapor pressure of ethanol at ambient storage temperatures is near or above the vapor pressure that triggers control requirements for storage tanks in some jurisdictions. Check with the AHJ for specific tank emission control requirements for ethanol or gasoline-ethanol blends.

Because the vapors in an ethanol tank headspace are flammable under all storage conditions, a flame arrestor may be installed on the vent as a safety precaution. See 4.10 for a discussion of flame arrestors.

Tanks containing ethanol for blending should be clearly identified. Refer to API 1637 for specific color-symbol system information.

The design, construction, maintenance, inspection, testing and repair of aboveground storage tanks are covered in API 620, API 650, API 651, API 652, API 653, API 2610, API 12F, STI SP001, and UL-142. The applicable mandatory provisions stipulated in these standards shall be followed. Where applicable codes or regulations are more stringent, the provisions in those codes and standards shall apply.

5.8.1 Terminal Stress Corrosion Cracking in Tanks

Stress corrosion cracking is environmental cracking in a susceptible metal or tough thermoplastic material that is produced by the simultaneous application of a tensile stress and exposure to a corrosive environment.

To date, no cases of SCC have been reported at ethanol manufacturers' facilities, tanker trucks, tank cars, or barges. There have been no reported cases of SCC for equipment at blending or transportation facilities handling products containing fuel ethanol after it has been fully blended with gasoline. All occurrences of SCC have been at fuel ethanol distribution terminals or gasoline blending and distribution terminals. The reasons for this dichotomy are unclear. It may be related to the reduced susceptibility to SCC in specific supply chain facilities or simply a lack of reporting. Consequently, the causes of SCC remain under investigation.

API has issued two reports identifying probable root causes of SCC. See API 939-D and API 939-E for further information.

Until there is a more definitive understanding of how to mitigate significant risks from SCC for carbon steel components in fuel ethanol systems, the following recommendations should be considered.

5.8.1.1 Terminal Post Weld Heat Treatment (PWHT)

PWHT is an effective method for reducing the SCC susceptibility of welded steel components. It is a thermal treatment method that reduces residual tensile stresses and hardness in the heat stressed areas adjacent to welds. PWHT is not always a practical solution because it cannot be done on tank floor seams or floor to shell welds where much of the opportunity to reduce SCC exists.

5.8.1.2 Terminal Internal Tank Coating

Coatings can help reduce crack initiation and propagation on internal surfaces of ethanol tanks. As a minimum, phenolic epoxy coatings with demonstrated chemical resistance to ethanol under conditions of full immersion should be applied to tank bottoms and the first three to six feet of the tank shell.

When considering bottom coating for preventing SCC, it is reasonable to coat as much of the shell as feasible up to the floating roof seal area. This distance is usually about 5 ft to 7 ft above the bottom when the floating roof is landed on "high legs".

The highest degree of protection against SCC is to coat all wetted surfaces, including the panels on the underside of the floating roof. Typically the wetted underside of the floating roof is lap welded making it essentially impossible to keep ethanol from contacting the heat-affected areas on the bare steel surfaces between the laps. One solution is to seal weld the exposed edges of the lap welded panels. The heat-affected areas are then protected from ethanol contact by the seal weld. When the underside is coated, the seal welds and the heat affected areas from the original lap welds on the top side are protected. PWHT or stress relief is not recommended.

The cost to take extraordinary measures to prevent SCC in a floating roof should be weighed against the site and business risks associated with having an unexpected failure in service.

Table 1 provides a qualitative comparison among three levels of tank coating. It compares on a qualitative basis, the extents of internal coating and the associated benefits. Note that each successive case includes all provisions and benefits of the case(s) above it.

Table 1—Internal Tank Coating Comparisons

Coated Area	Level of Difficulty	Advantage/Disadvantage	Degree of Protection
Bottom and side (5 ft to 7 ft high)	Routine	Reduces risk of most common SCC	Minimum
Above plus: Complete shell	Above plus: Scaffolding installation	Protects entire shell against SCC Adds fall risk to personnel during coating application Increased cost	Medium
Above Plus: Underside of floating roof * (New Tanks Only)	Above Plus: Seal welding underside of roof	Extensive overhead welding Significantly increased cost	Maximum

See API 2610 and API 939-E for discussions on coating.

5.8.1.3 Terminal Inspection Intervals

Many steel tanks and pipes have been in fuel ethanol service for several years and have not experienced SCC. On the other hand, there have been several cases where SCC has occurred less than 12 months after equipment was first placed in fuel ethanol service. Experience to date is insufficient to establish a recommended SCC inspection interval. Consequently, when determining a tank, pipe and component inspection frequency, each user should consider individual factors such as the risk of leakage, the consequences of a leak or failure on the surrounding area, methods of release containment, operating conditions, criticality of equipment and the inspection and repair history of similar equipment at the facility.

The general methodology for a risk-based approach to inspection is explained in API 580 along with specific applications where SCC is a factor.

Regardless of approach used to determine the inspection frequency for tanks in ethanol service, inspection intervals should still be consistent with the inspection requirements in API 653 and STI SP001.

5.9 Terminal Tank Vents and Air Dryers

To minimize the risk of water vapor entering a fuel ethanol tank and condensing into the product, the vapor space can be vented through a desiccant drier system. The desiccant drier removes moisture in the air entering the tank and keeps the dew point in the vapor space well below the ambient temperature.

Review local conditions such as humidity and diurnal temperature variations to assess the need for a drier.

5.10 Terminal Flame and Detonation Arrestors

A flame arrestor is placed in the vapor return line between the loading rack and the vapor processing unit to prevent the propagation of a flame front when a flammable mixture exists in the line. With increased loading volumes of high-blend ethanols, the vapors in the line are more likely to be in the flammable range.

Flame arrestors can also be used on the outlet of vent lines of neat ethanol and fuel ethanol tanks that have flammable vapor/air mixtures in their headspace.

Where detonation/flame arrestors are already in place, check that they are approved for use in ethanol service. Materials and seals should be compatible with ethanol and ethanol vapor. Incompatible materials in the arrestor element can cause a flow restriction.

Loose scale and rust in the vapor return piping often collects on the detonation/flame arrestor elements. Ethanol vapors may contribute to this problem. Obstructing materials can become saturated with fuel vapor and become combustible and reduce the ability of the arrestor to prevent propagation of a deflagration. Flame arrestors should be monitored for the buildup of foreign materials that can reduce or block flow by checking the pressure drop across the matrix element.

Ethanol vapor will dissolve into the glycol-water solutions used in liquid-seal flame arrestors and diminish their effectiveness. The ethanol concentration should be monitored regularly by measuring the specific gravity of the liquid bath. If enough ethanol is pulled into solution, the overall solution may become flammable. When disposing of spent liquid seal solution, follow applicable waste handling and disposal regulations.

As an option, a detonation arrestor may be considered as an alternative to the liquid seal flame arrestor.

5.11 Terminal Pipe, Valves, Pumps, and Piping Systems

For pipes, valves, pumps, and piping systems, follow the recommendations of API 2610. All materials including seals, gaskets and other elastomers should be compatible with the ethanol concentration in service.

Avoid using cold-formed steel components such as the dished ends used for tanks and filters. Where this is impractical, fabrications should be shot-peened, checked for cracks and internally coated.

The key to reducing the incidence of SCC in piping is to reduce stress. Stresses on piping can be lessened by reducing the spacing between pipe supports and designing systems to minimize the stresses from thermal pipe movement. Avoid welding pipe supports to the parent pipe and use clamp-type pipe supports where possible. See API 939-E for recommendations to minimize SCC in piping.

5.12 Terminal Metering

Precise and accurate measurement of blend stock and gasoline-ethanol blend volumes is crucial for stock control and providing products that meet standard specifications and legal requirements. The accuracy for typical turbine meters used at terminals is 0.15 % and 0.10 % for positive displacement meters. Meters can be calibrated accurately for fuel ethanol and gasoline because they have uniform properties that remain consistent. Variation in volume caused by temperature variations can be compensated for by using readily available temperature coefficient of expansion tables. Each component has its own expansion table.

When fuel ethanol and gasoline are mixed, there is a small increase in volume and a slight cooling of the temperature of the blend. The volume growth factor, called blend growth, is between 0.1 % and 0.4 % depending on blend component characteristics. The volume increase is dependent on the ethanol/gasoline ratio, the base gasoline specific gravity, the temperatures of the components and the aromatic content of the gasoline. There are no temperature compensation tables available for mixed products nor would a single table suffice even if such table did exist.

Meter accuracy is also affected by the blend point location. If the smaller blend stock is introduced just upstream of the delivery meter, such as in sidestream blending, there may be insufficient distance for the two components to mix thoroughly before reaching the meter. Consequently, the amount of volume expansion is unknown, so the meter may be measuring a stream with varying characteristics and provide an inaccurate volume measurement. To promote more accurate volume measurement, the blend point location should be a minimum of six feet upstream of the delivery meter.

Delivery meters used for measuring gasoline-ethanol blend volumes should be calibrated using the blended fuel. The variables that affect the volume of a gasoline-ethanol blend make accurate meter calibration for blend streams difficult, if not impossible, because temperature correction tables are not available. Blending with a single meter is not recommended. If a delivery meter measures products with different ethanol concentrations, it should be calibrated for each blend.

Blend growth needs to be taken into account for sequential and splash blending and for ratio blending. If a meter is located downstream of the blend mixing location, blend growth will affect the meter reading. Meter calibrations should be checked ten days after any fuel change is commissioned.

5.13 Terminal Vapor Control Systems

Vapor control systems are designed to capture and process gasoline vapors displaced during tank truck or tank car loading. The vapors generated by loading gasoline-ethanol blends have different characteristics than gasoline and can affect the performance of some systems.

Prior to introducing a new ethanol blend, check with the vapor control system manufacturer to assure material compatibility and adequate emission control performance.

5.13.1 Terminal Truck Vapor Connections

Vapor connections during loading need to be leak-free. Vapor hoses, connectors, piping and sealing materials shall be compatible with all gasoline and gasoline-ethanol blends.

Vapor leaks can occur from the degradation of loading fittings and seals that are not compatible with ethanol-gasoline blends. These elements are subject to considerable wear during daily operation and should be checked frequently to assure components and seals are in good condition.

5.13.2 Terminal Vapor Processors

Vapor combustors and carbon adsorption vapor recovery units are able to process vapors containing ethanol efficiently. Ethanol in vapors does have the potential to reduce performance over time if materials are incompatible and routine maintenance activities are not performed. Vapor processors need to be checked frequently for vapor leaks from piping connections. Make sure that gasket and sealant materials are compatible with gasoline and ethanol vapors.

Vapor combustors should have a wide turn-down ratio to allow the complete oxidation of all vapors that are routed to the unit regardless of the incoming vapor concentration.

Because of the hydrophilic nature of ethanol, the effectiveness of carbon adsorption vapor recovery systems may be reduced. Ethanol in vapor tends to be absorbed into the glycol or glycol/water mixtures that are commonly used as the seal fluid for liquid ring vacuum pumps. This dilution reduces viscosity and therefore the ability of the liquid seal to pull a deep vacuum and operate efficiently. With a reduced vacuum during regeneration, carbon beds cannot purge fully and vapor recovery effectiveness is reduced. Carbon bed vacuum readings should be monitored for reduced vacuum levels. Liquid seal solutions in vacuum pumps should be checked frequently for dilution and replaced when the vacuum levels drop off. Dry vacuum pumps that do not use a liquid seal can help maintain specified vacuum levels when processing high-blend ethanol vapors.

Ethanol vapor will dissolve into the glycol-water solutions used in liquid-seal flame arrestors and diminish their effectiveness. The ethanol concentration should be monitored regularly by measuring the specific gravity of the liquid bath. If enough ethanol is pulled into solution, the overall solution may become flammable.

5.14 Terminal Permits

Some air quality operating permits specify which motor fuels can be loaded at a terminal. When adding a gasoline-ethanol blend, make sure that the air quality permit for the loading rack and the vapor processor is valid for handling the new product. Check operating permits and with the AHJ for information.

Some wastewater discharge permits specify the allowable components in the effluent stream. Check discharge permits when gasoline-ethanol blends are introduced to a terminal and, if necessary, revise permit conditions to reflect the potential presence of ethanol in discharges.

6 Tank Truck and Railroad Tank Car Transportation

6.1 Compatibility

6.1.1 Tank Truck Compatibility

Tank trucks and associated equipment carrying ethanol and ethanol blends should be constructed of compatible materials. Although aluminum is not recommended for continual contact with ethanol, it has proven to be suitable for intermittent contact in transport equipment. Look for signs of corrosion at any locations where dissimilar metals are wetted.

A common component that shall be upgraded is the acrylic sight glass in delivery hose sight flow indicators. It can frost and crack from contact with ethanol. The purchaser should specify alcohol-resistant or solvent-resistant acrylic material when ordering these glasses.

6.1.2 Railroad Tank Car Compatibility

Tank cars and associated equipment carrying ethanol and ethanol blends should be constructed of compatible materials.

6.2 Truck Loading

6.2.1 Loading Blends up to E10

Prior to loading any blend components or a finished blend, truck compartments should be clean and drained before loading. To prevent potential contamination, assure that the previous product loaded was fuel ethanol, gasoline or a gasoline-ethanol blend.

Gasoline-ethanol blends with up to 10 % ethanol (E10) have vapor generating characteristics similar to that of base gasoline. When loading E10 into a truck using ratio blending, a vapor/air mixture above the UEL can be achieved quickly because of the relatively high volatility of the blended fuel and its low lower flammability limit. Even at low temperatures, the volatile characteristics of E10 are such that the UEL is exceeded shortly after loading commences. Consequently, the same loading and unloading fire safety practices should be followed for blends up to E10 as for gasoline.

Although the loading procedures are not encouraged, when sequential blending or splash blending blends up to E10, it is safer to load the gasoline first because it will cause the vapor concentration in the truck headspace to rapidly exceed the upper flammability limit. An alternative loading technique that promotes better mixing is to load part of the gasoline volume first, then the entire volume of ethanol followed by the remaining volume of gasoline. For sequential blending, this procedure has the advantage of leaving the loading arm full of gasoline rather than ethanol.

6.2.2 Loading Blends Between E11 and E15

Although there is limited experience with loading blends between E11 and E15, the loading guidelines in 6.2.1 should be followed.

6.2.3 Loading E85

Prior to loading any blend components or finished blend, truck compartments should be clean and drained before loading. To prevent potential contamination, assure that the previous product loaded is compatible with gasoline or a gasoline-ethanol blend.

E85 blends have a wider flammability range than gasoline or E10. When loading E85 using ratio blending, the vapor concentration in the tank truck quickly exceeds the lower flammability limit and remains in the flammable range throughout the loading process. E85 vapors should be considered flammable at all ambient temperatures.

When loading E85, regardless of the previous load, switch loading safety procedures should be followed such as those described in API 2003.

It is not recommended to load E85 using sequential blending or splash blending until the terminal has conducted a risk assessment to determine and mitigate the risk of loading with potentially flammable head spaces in trucks.

The comments in this section apply to E85 with ethanol concentrations ranging from 70 % to 85 %. In certain areas, E85 may contain down to 65 % ethanol during cold weather months to maintain vapor pressure. The blend limits for the lower ethanol percentage may change, but the recommended practices in this section still apply. Refer to ASTM D5798 for the most current blend guidelines.

6.2.4 Neat Ethanol and Fuel Ethanol

To prevent potential contamination, tank trucks used for neat ethanol and fuel ethanol transport should be clean and drained prior to loading. If dedicated trucks are not available, trucks used for gasoline or gasoline-ethanol blend transport may be used. Do not use trucks that have carried other materials.

Neat ethanol and fuel ethanol have a wider flammability range than gasoline or E10. When loading these blend stocks, the vapor concentration in the tank truck quickly exceeds the LEL and remains in the flammable range throughout the loading process. Neat ethanol and fuel ethanol vapors should be considered flammable at all ambient temperatures.

When loading neat ethanol and fuel ethanol, regardless of the previous load, switch loading safety procedures should be followed such as those described in API 2003.

6.2.5 Truck Vapor Releases

Vapors are displaced from tank truck headspaces during loading. The flammability of these vapors varies depending on the previous product loaded and the current product being loaded. The vapors in the headspaces of trucks carrying gasoline-ethanol blends up to E10 are above the UEL as opposed to E85, fuel ethanol and neat ethanol vapors which should be considered to be flammable at all ambient temperatures.

Vapor releases from routine truck loading can be virtually eliminated at terminals equipped with vapor processors by hooking up vapor recovery hoses to trucks during loading. Vapor processors reduce emissions from truck loading by greater than 95 %. Hoses and fittings should be kept in good condition to minimize leakage and assure that vapors are routed to the vapor processing unit.

Spilled fuel constitutes a fire hazard because it can evaporate and form a flammable vapor-air mixture in open air. Neat ethanol has a higher autoignition temperature than gasoline; consequently, spilled neat ethanol is generally expected to have less potential for hot-surface ignition than gasoline. Spills of fuel ethanol and E85, with their high ethanol contents are also generally expected to have less potential for autoignition than gasoline vapor. Nonetheless, these differences are small and the vapors generated from spills of neat ethanol and high-blend ethanols should be treated as being flammable just as for low-blend ethanols and gasoline. The fire hazard for spilled E10 should be considered the same as for base gasoline.

The vapor density of E85 vapor is less than that of gasoline vapor, which suggests that E85 vapor might dissipate more quickly than gasoline vapor. However, the flammability range of E85 vapor is wider than that of gasoline, which causes mixtures in air to remain in the flammable range for a greater distance because it takes longer to dilute these vapors below the lower flammability limit. These offsetting fire safety impacts are not sufficient to change from using the current fire safety practices for handling vapor releases from gasoline.

The flammabilities of neat ethanol and fuel ethanol are similar to E85 and the same fire safety procedures as for E85 apply. Blends up to E10 generate vapors with concentrations and characteristics similar to gasoline. Although data is lacking for E11 through E15, flammability is expected to be the same as for gasoline.

6.2.6 Truck Switch Loading

Electrostatic charge accumulation is a concern during diesel and jet fuel loading because they are poor electrical conductors and prone to building up an electrostatic charge under common loading conditions. When switch loading diesel or jet fuel into a tank that previously contained gasoline, the vapor in the tank can be in the flammable range or above the UEL. If charge accumulation during loading is high enough inside the tank and a point exists to which an electrical discharge might arc, an electrostatic discharge could occur. If there is a flammable vapor/air mixture in the tank from a previous load, it could cause a fire or explosion.

Although high-blend ethanols have higher electrical conductivities than diesel and jet fuels and are less likely to promote charge accumulation, they do generate a flammable vapor concentration during loading. When loading neat ethanol, fuel ethanol and E85, follow switch loading precautions described in API 2003.

6.2.7 Transport Information

Transport trucks carrying ethanol and gasoline-ethanol blends should be properly identified in compliance with DOT requirements. Table 2 provides information on proper DOT hazard class identification.

In addition to displaying proper identification, trucks should be equipped to handle safely the gasoline-ethanol blend being transported.

Table 2—DOT Hazard Class Identification

Ethanol Concentration	Preferred Proper Shipping Name	UN/Identification Number
E1 to E10	Gasohol or Gasoline	UN 1203
E11 to E94	Ethanol and Gasoline Mixture	UN 3475
E95 to E99	Denatured Alcohol or Alcohols n.o.s	UN 1987
E100	Ethanol or Ethyl Alcohol	UN 1170

6.3 Railroad Tank Car Loading

For loading neat ethanol, fuel ethanol and gasoline-ethanol blends into tank cars, follow the guidance in 5.2.3.

7 Filling Stations

7.1 General

The widespread use of gasoline-ethanol blends containing up to 10 % ethanol and the availability of E85 in certain areas have emphasized the importance of the proper design and installation of fueling systems at filling stations.

At filling stations, fueling components are required to have proven material compatibility under UST rules. Under fire and OSHA rules, many key components are required to have listings by a NRTL, and in addition some devices require approvals from AHJs, state or federal agencies prior to being used (CARB, NTEP, and NWGLDE are examples).

At the time of the development of this recommended practice, the US generally has a retail infrastructure for base gasoline and E10. This equipment is not necessarily acceptable for service with blends containing ethanol concentrations greater than 10 %. High-ethanol blends have special material compatibility requirements. They have a wider flammability range than gasoline and the vapor spaces in storage tanks and lines are flammable under all conditions. Because of these characteristics, high-blend ethanols impose special storage and handling considerations.

The equipment pyramid describes three independent requirements for assessing whether a component or system can be used in a particular type of fuel service (see Figure 5). Material compatibility shall be shown by scientific research that equipment components are compatible with the fuel. Requirements for making this determination are found in pollution prevention rules. The next step is to secure a listing. A listing is a certification by an NRTL that the equipment is safe for use with the fuel. Equipment requiring a listing is identified in public and worker safety requirements such as fire codes and OSHA regulations. Approvals are based on functionality or performance tests of assembled equipment to assess whether it works as designed with the particular type of fuel in service. Approvals are provided by organizations such as CARB, NTEP and NWGLDE. The three requirements—compatibility, listing, and approval—while sometimes mutually independent, assure that equipment placed in service will perform properly and safely during its lifetime.

Critical safety devices for use with high-blend ethanols, which are cited in OSHA regulations and national fire codes, have not been proven by an NRTL to comply with recognized standards to protect public safely. In addition, many components do not have proven material compatibility with these fuels. Until these approvals are issued, AHJs will be unable to evaluate equipment performance and systems for dispensing high-ethanol fuels will not be available.

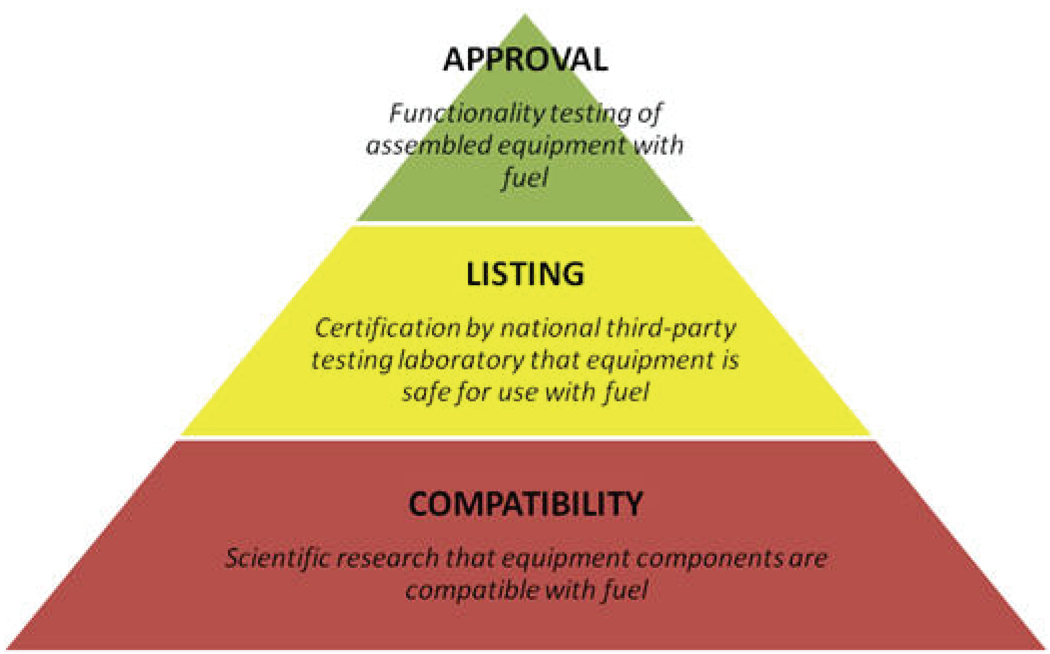


Figure 5—Equipment Pyramid

7.2 Material Compatibility

7.2.1 General

At filling stations, numerous fuel system components come in contact with the stored product in the fuel, vapor and spill/release pathways. For safe use and to meet fire code and regulatory requirements, each of these components shall be able to demonstrate compatibility with the ethanol blends that they contact.

Any new fuel blend that triggers a new MSDS should be judged as significantly different from previous products. Any system or component, new or existing, intended for use with a new fuel shall be evaluated for material compatibility and conformity with fire safety regulatory requirements before the introduction of the new fuel.

Material compatibility does not necessarily guarantee operational compatibility. For example, certain sensors, probes, gauges, and other components that are not designed specifically for ethanol blends may be unreliable or inaccurate when used with such fuels, even if the materials are compatible. Verify system and component accuracy and reliability with the manufacturer.

7.2.2 Filling Station Compatibility Determination

To assure safe use and regulatory compliance, filling station fuel system components that are in the fuel, vapor or spill/release pathways shall be compatible with the ethanol blends that they come in contact with. Material compatibility for individual components or systems can be shown three ways: by third-party determination, by listing, or confirmation by the manufacturer. However it is important to note that some AHJs will not accept a manufacturer's self-certification of its own equipment.

Certain components are listed by a Nationally Recognized Testing Laboratory (NRTL) for use with the specific gasoline-ethanol blend in service. Underwriters Laboratories is the most recognized NRTL that tests and lists components for filling stations. Most listings are accepted by users and AHJs as confirmation of compatibility to applicable standards. Filling station operators should confirm that the UL standard for each listed component in use at their facility addresses the material compatibility with the ethanol blend in question. Some UL standards are silent in this regard and may not provide proof of compatibility with high-blend ethanols.

For components not required to be listed, equipment manufacturers have two choices to show compatibility as follows:

a) hire a qualified third party or a NRTL to determine compatibility; or

b) self-certify their equipment.

Third parties, acting as qualified test laboratories hired by component manufacturers, can determine material compatibility. They make determinations to confirm material compatibility for specified types of service based on component design, appropriate testing and previous experience. Not all AHJs accept third party testing and they may require testing to be done by the listing NRTL to conditions specified in the listing standard.

Manufacturers can confirm the compatibility of components based on their own testing procedures and criteria. Test methods may vary between manufacturers, and may not be directly comparable. Manufacturers' determinations may not be accepted by all AHJs and cannot be used to replace a listing by a NRTL that is required by law. However, manufacturers' determinations are important where there is no other indication of material compatibility.

Finally, some components or systems that have been listed and have shown acceptable material compatibility may need further testing to be approved for use by AHJs. These approvals may be based on performance tests using the agency's own test procedures to prove component accuracy and reliability. This is most common in the area of leak detection and vapor recovery equipment. Owners and operators should maintain a complete record of compatibility findings for systems and system components.

7.3 New Facilities

7.3.1 General

This section provides information on requirements for underground and aboveground storage tank systems, piping, dispensers, dispensing components, and leak detection equipment for new and rebuilt filling stations.

In addition to the recommended practices presented in this publication, underground storage tanks and piping systems should be installed according to applicable requirements and recommendations in API 1615.

A table listing the filling station components that require NRTL listings can be found in Annex B.

7.3.2 Underground Fuel Storage Systems

It is recommended that tanks be listed by an NRTL based on the intended fuel service. Listing by a NRTL is required by some pollution prevention rules and fire codes as enforced by state and local regulatory agencies and Fire Marshals.

All tank components that come in contact with gasoline-ethanol blend liquids or vapors shall have third-party or manufacturer confirmation of compatibility for use with the gasoline-ethanol blend as required by code or AHJ. Where required by law, these devices shall be listed by an NRTL.

Underground storage tanks are recommended to be constructed of double-wall fiberglass reinforced plastic or double-wall steel and have proven material compatibility. They shall be approved, when required by local AHJ, for the gasoline-ethanol blend in service.

Tanks equipped with a P/V valve can be under pressure or vacuum during routine operation. Tanks should be equipped with drop tubes to prevent the flow of vapor/air mixtures out of the tank or flow of air into the tank ullage when the fill cap is removed on the fill connection. Tanks required to have Stage I vapor recovery should be equipped with a vapor-tight poppeted dry break on the vapor connection. When the fill cap is removed, the dry break prevents release of vapors or the flow of air into the tank.

All tank fill and vapor return locations should be labeled according to the API color code system. See API 1637.

7.3.2.1 Underground Fuel Storage Systems for up to E10

Most, if not all, currently listed tanks and listed tank components are suitable for service with ethanol concentrations up to E10. Tank operators should confirm listing and material compatibility information with the manufacturer, as some older tanks and equipment are not intended for ethanol service.

Careful consideration should be given to older single wall tanks, because of material compatibility questions and the prospect of existing corrosion. Filling station operators should conduct an engineering evaluation of older tanks to determine their suitability for continued service in E10.

7.3.2.2 Underground Fuel Storage Systems from E11 to E15

In general, all new listed tanks are suitable for service with ethanol concentrations between 11 % and 15 %, but some individual tank components are listed only to E10. Newer components may be listed to standards that allow a higher concentration. Operators should carefully examine the listing, the UL standard, and material compatibility information for their tanks and each tank component to determine if they are appropriate for service with ethanol concentrations between 11 % and 15 %. Given that some listings may be silent on material compatibility, it is recommend that only tanks and components with proven compatibility and listed for use with ethanol concentrations between E11 and E15 be installed and operated.

Careful consideration should be given before putting older single wall tanks into E11 to E15 service because of potential material compatibility issues with fiberglass and the effects of corrosion in steel tanks. Filling station operators should conduct an engineering evaluation of older tanks to determine their suitability for conversion to service in E11 to E15.

7.3.2.3 Underground Fuel Storage Systems for E85 and other High-Blend Ethanols from E16 to E100

Many new listed tanks are suitable for service with ethanol concentrations between 16 % and 100 %. But, most individual tank and tank components are not listed for use with fuels in this concentration range. Tank operators should carefully examine the listing, the UL standard, and compatibility information for their tanks and tank components to determine if they are appropriate for service with ethanol concentrations between 16 % and 100 %. Given that some listings may be silent on material compatibility, it is recommend that only tanks and components with proven compatibility and listed for use with the expected ethanol fuel concentration be installed and operated.

Careful consideration should be given to older single wall tanks, because of material compatibility questions and the prospect of existing corrosion. Filling station operators should conduct an engineering evaluation of older tanks to determine their suitability for conversion to service for E16 to E100.

7.3.3 Underground Piping Systems

7.3.3.1 General

Piping systems include the following components:

— double-walled fuel piping;

— flexible connections at pumps, tanks and dispensers as required by local codes to meet seismic, fire or secondary containment requirement;

— safety (shear/fire) break valves for liquid and vapor at connections to dispensers;

— provision for safe drain-down of piping for maintenance;

— vapor recovery piping if required, meeting CARB certification and AHJ requirements;

— vapor vent piping and P/V valves;

— submersible pump sumps, under dispenser containment sumps and their entry and termination fittings.

— fill boxes for product delivery and vapor recovery fittings.

All piping system components that come in contact with gasoline-ethanol blend liquids or vapors shall have third-party or manufacturer confirmation of compatibility for the gasoline-ethanol blend in use as required by code or AHJ. Many of these components are required by law be listed by a NRLT.

A table of equipment which commonly requires listings can be found in Annex B.

Pressure or suction fuel distribution piping should be designed to provide the required flow rates to dispensers. Double wall product piping is recommended. Single wall tank vapor vent line and Stage II vapor piping is recommended. In some jurisdictions, double wall vent and vapor piping are required by the AHJ.

Tank systems equipped with P/V valves should be periodically checked for vapor tightness. Fugitive leaks in tank systems that generate positive pressure can present a potential safety hazard if vapors escape and migrate into nearby structures.

Stage I vapor piping for high-blend ethanol should be kept separate for each product and separate from gasoline and diesel storage. The vapor spaces of high-blend ethanols, and E85, tanks should not be connected with gasoline tanks. Existing vent and vapor piping will most likely have to be modified to meet these piping requirements.

The vapors in any piping for E85 or high-blend storage should be assumed flammable at all ambient temperatures. Consider installing a flame arrestor on the outlet of the vent line and at the Stage I connection to prevent the propagation of a flame front throughout the system. If Stage II vapor recovery is required, consider installing a flame arrestor on the vapor return line at each dispenser.

A local risk assessment should be conducted to determine the value of flame arrestors. This is a safety requirement in EU member countries, but the risk is not fully understood in the US. Consideration should be given to the requirements in the APEA/IP *Guidance on Storage and Dispensing of High Blend Ethanol Fuels including E85 at Filling Stations*.

Tank vapor spaces, tank vents or vapor piping should not be manifolded or shared between diesel fuel, base gasoline, E10, E15, or E85 tanks. Facilities should develop and implement procedures to prevent the cross-contamination of these liquids and vapors during delivery and storage.

7.3.3.2 Underground Piping Systems for up to E10

Most, if not all, currently listed pipe systems are suitable for service with ethanol concentrations up to E10. Operators should confirm listing and material compatibility information with the manufacturer.

7.3.3.3 Underground Piping Systems for Fuel from E11 to E15

Most new listed underground piping systems are suitable for service with ethanol concentrations between 11 % and 15 %, but some pipe and other individual components are listed only to E10. Newer components may be listed to standards that allow a higher concentration. Filling station operators should carefully examine the listing, the standard and compatibility information for their piping and pipe components to determine if they are appropriate for service with ethanol concentrations between 11 % and 15 %. Only piping systems and system components with proven compatibility, listed for use with ethanol concentrations between E11 and E15 shall be installed and operated.

Most older pipe and pipe components have unknown material compatibility and are not listed for E11 to E15 service.

7.3.3.4 Underground Piping Systems for E85 and other High-Ethanol Blends from E16 to E100

Some new listed piping systems are suitable for service with ethanol concentrations between 16 % and 100 %, but some pipe systems and most individual components are not listed for use with fuels in this concentration range. Newer components may be listed to standards that allow a higher concentration. Tank operators should carefully examine the listing, the standard and compatibility information for their piping and piping components to determine if they are appropriate for service with ethanol concentrations between 16 % and 100 %. Only piping systems and individual components with proven compatibility, listed for use with ethanol concentrations between E16 and E100 shall be installed and operated.

Most older pipe and pipe components have unknown material compatibilities and are not listed for E16 to E100 service.

7.3.3.5 Remote Fill Piping

If remote fill piping is used, it should meet the recommendations of 7.3.3.2 through 7.3.3.4 for the ethanol concentration in service.

7.3.4 Dispensers and Dispensing Equipment

All dispensers and dispensing equipment (hoses, nozzles, breakaways, etc.) that come in contact with gasoline-ethanol blend liquids or vapors shall have proven material compatibility. They shall be listed by the NRTL and have all the necessary equipment approvals (NTEP, CARB, etc) as required by law or AHJ for use with the gasoline-ethanol blend in use. UL87 is for E0 to E10 ratings and UL87A covers E0-E85 and E0-E25 ratings.

7.3.4.1 Dispensers and Dispensing Equipment for up to E10

All new listed dispensers and dispenser equipment are suitable for E10 service. Tank operators should confirm listing and material compatibility information.

7.3.4.2 Dispensers and Dispensing Equipment from E11 to E15

Most new, and some legacy, low-blend ethanol dispenser systems and components are only listed for ethanol concentrations up to E10. UL has stated that, “In situations where E15 is to be dispensed, UL recommends the use of new, listed equipment designed and identified for use with mid-level blends.” [10] New dispensers will need to be listed by UL 87A for use with E11 to E15.

Operators need to examine carefully the listing and compatibility information from the manufacturer to determine if equipment is appropriate for service from E11 up to E15.

It should be noted that older dispensers and components have unknown material compatibilities and are not listed for E11 to E15 service.

7.3.4.3 Dispensers and Dispensing Equipment for E85 and other High-Blend Ethanols from E16 to E85

Carefully examine the dispenser listing and compatibility information provided by manufacturers to determine if equipment is appropriate for service with ethanol concentrations between 16 % and 85 %. Only dispensers and components with proven material compatibility, specifically listed for use with the ethanol blends between E16 and E85, and with all appropriate approvals shall be installed and operated.

It is anticipated that E85 dispensers will not need Stage II vapor recovery because flex fuel vehicles (FFVs) have been equipped with onboard refueling vapor recovery (ORVR) systems beginning in 1998.

However, where Stage II vapor recovery is required, dispensers and dispensing equipment for E85 should meet AHJ certification requirements. For most states, this is the most current pre-EVR CARB certification. Because it is not expected that Stage II vacuum assist systems will be listed, consideration should be given to balance vapor recovery systems. At the time of this RP publication, there are no efforts to list any form of filling station vapor recovery equipment including balance systems.

E85 dispensers should have a warning message stating that E85 fuel is not gasoline and is only for use in FFVs, and have all warnings as required by law.

To prevent possible misfueling, consideration should be given to differentiating E85 dispensing nozzles by using different color scuff guards and splash shields than are used for low-blend ethanols and gasoline.

It should be noted that older dispensers and components have unknown material compatibility and are not listed for E16 to E85 service.

[10] “Update—December 2010.” Underwriters Laboratories. http://www.ul.com/global/eng/pages/offerings/industries/energy/alternative/flammableandcombustiblefluids/updates/.

7.3.4.4 Blending Dispensers

Equipment suppliers are developing ethanol-compatible dispensers that can dispense multiple ethanol blend concentrations by combining or directly delivering blend stock components from two storage tanks (i.e. one storage tank will hold motor gasoline or BOB and the other tank will hold “ethanol fuel” [11]). Blending dispensers are required to meet all listing, material compatibility, and approval requirements as described in previous sections for single-product dispensers.

Denatured ethanol (E98) should not be stored at fuel dispensing facilities at this time unless headspace flammability concerns with storing high-ethanol fuels are addressed and dispensers listed for denatured ethanol service are available [12].

The vapors in the headspace above denatured ethanol are flammable at temperatures that are typical to those in many storage tanks and present a more significant ignition hazard than “ethanol fuel”. As the ethanol content of fuel decreases, the flammability risks decrease. The existing U.S. standards governing the storage of gasoline do not fully address the risk of storing high ethanol content fuels at fuel dispensing facilities. The storage of denatured ethanol will require fuel dispensing facility operators to take special precautions regarding the choice of tanks, piping, fittings and blending dispensers. All components will need to be compatible with denatured ethanol and special attention should be paid to sealing materials for connections and pipe thread sealants.

At the time of publication, no Nationally Recognized Testing Laboratory has developed a standard to test and prove the safety and suitability of critical dispensing equipment using denatured ethanol as an inlet stream to blend fuels. As such, there are no blending dispensers, pumps, or impact valves listed to accept denatured ethanol. Additionally, there are currently no listed flame arrestors for the vapor pathways of tanks containing high ethanol content fuels.

In addition, fuels blended at fuel dispensing facilities raise fuel quality and equipment compatibility concerns.

— Regarding compatibility, the EPA states: “[M]ost UST systems currently in use are likely to contain components not designed to store ethanol blends greater than 10 percent” [13].

— As discussed in 4.2, both gasoline and “ethanol fuel” have vapor pressures that are regulated according to season and geographic region. “Ethanol fuel” produced by blending dispensers at fuel dispensing facilities may require the addition of a pressurizing agent in some markets in order to provide fuel with the correct RVP. It is unlikely that this activity will occur at fuel dispensing facilities. Therefore, unless additional infrastructure and higher RVP BOBs become available in certain areas, fuel dispensing facilities will be unable to provide on-specification “ethanol fuel” blends.

— The percentage of ethanol in “ethanol fuel” can legally vary from 51 % to 83 % ethanol which affects the ethanol percentage of the blended product. It is impossible to determine, without testing the amount of ethanol in the “ethanol fuel” entering the dispenser, the amount of ethanol in the blended product regardless of the blend percentage the dispenser is set to deliver.

— Uni-hose blending dispensers may cross contaminate storage tanks through Stage II vapor recovery systems. Additionally, E10+ vapors would come into contact with Stage II equipment listed for use only with E10 or lesser ethanol blends.

— Should a fuel dispensing facility choose to blend E10 from gasoline and “ethanol fuel”, the resulting E10 may not contain adequate levels of detergent additives.

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[11] “Ethanol Fuel” refers to gasoline-ethanol blends between 51 vol% ethanol and 83 vol% ethanol. "Ethanol fuel" has previously been referred to as "E85".

[12] Gardiner, D.P., Bardon M.F., and Clark, W., “Experimental and Modeling Study of the Flammability of Fuel Tank Headspace Vapors from Ethanol/Gasoline Fuels: Phase 3: Effects of Winter Gasoline Volatility and Ethanol Content on Blend Flammability; Flammability Limits of Denatured Ethanol”, Contract Report NREL/TP-5400-52043 produced for the DOE National Renewable Energy Laboratory under Contract No. DE-AC36-08GO28308, July, 2011.

[13] “Compatibility of Underground Storage Tank Systems With Biofuel Blends; Notice of final guidance,” 76 Federal Register 128 (5 July 2011), p. 39096.

Consequently, the installation and use of blending dispenser systems at fuel dispensing facilities is not recommended for blending gasoline-ethanol fuels until these concerns are adequately addressed.

7.3.4.5 Stage II Vapor Recovery

Stage II vapor recovery systems capture and control gasoline vapors that are displaced during vehicle refueling. Stage II is required in areas of the United States where ambient air quality is non-attainment for ozone. Most states with Stage II regulations require systems to be certified by the California Air Resources Board. At the time of writing, no Stage II vapor recovery systems for gasoline-ethanol blends greater than 15% have been certified by CARB. Vehicles equipped with onboard refueling vapor recovery (ORVR) systems can replace Stage II systems when ORVR is considered to be in widespread use by the AHJ.

Table 3 shows what Stage II controls may be required for different gasoline-ethanol blends and the approvals based on the requirements of the equipment triangle in Figure 6.

Table 3—Stage II Vapor Recovery Requirements

Fuel Ethanol Content, %	Stage II Required?	Is a System Available with Compatible Materials?	Are System Components NRTL-Approved?	Is a CARB-Certified System Stage II Available?
0 to 10	Yes	Yes	Yes	Yes
11 to 15	Probably yes	No	No	Yes
16 to 64	Undetermined	No	No	No
65 to 85	Stage II may be replaced by ORVR if deemed in widespread use.	No	No	No

7.3.5 Leak Detection Equipment

Leak detection equipment consists of the following:

— fuel line integrity testing systems such as electronic line leak detectors;

— tank leak containment and detection system;

— submersible pump containment sump leak detectors;

— under-dispenser containment leak detectors.

All leak detection systems that come in contact with gasoline-ethanol blend liquids or vapors shall have third-party material compatibility, be listed by a NRTL, and be approved as for use with the gasoline-ethanol blend in use as required by code or AHJ.

Material compatibility does not necessarily guarantee operational compatibility. For example, certain sensors, probes, gauges, and other components that are not designed specifically for ethanol blends may be unreliable or inaccurate when used with such fuels, even if the materials are compatible. In general, equipment that is noted on the National Work Group on Leak Detection Evaluations (NWGLDE) List of Leak Detection Evaluations for Underground Storage Tank Systems will be approved by AHJs.

7.3.5.1 Leak Detection Equipment for up to E10

Most, if not all currently listed leak detection equipment systems have proven over time that they are suitable for E10 service. Operators need to carefully examine the NRTL listing, material compatibility and approval information provided by the manufacturer to determine if a leak detection system or component is appropriate for service from E1 to E10. Filling station operators should confirm listing and material compatibility information with the manufacturer.

Validate the equipment performance by confirming that it is on the NWGLDE List of Leak Detection Evaluations for Underground Storage Tank Systems. In general, equipment on the NWGLDE List will be approved by AHJs.

7.3.5.2 Leak Detection Equipment from E11 to E15

Operators need to examine carefully the NRTL listing, material compatibility and approval information provided by the manufacturer to determine if a leak detection system or component is appropriate for service between E11 to E15. Validate the equipment performance by confirming that it is on the NWGLDE List of Leak Detection Evaluations for Underground Storage Tank Systems. In general, equipment on the NWGLDE List will be approved by AHJs.

Only leak detectors and leak detection components specifically listed by a NRTL, that have material shown to be compatible by the manufacturer and approved by the AHJ for use with the ethanol concentration in service shall be installed and operated.

It should be noted that at the time of this writing, most leak detection equipment has unknown material compatibility with E11 to E15, is not listed for this service, and is not on the NWGLDE List for these fuels.

7.3.5.3 Leak Detection Equipment for E85 and other High-Blend Ethanols from E16 to E97

Operators need to examine carefully the NRTL listing, material compatibility and approval information provided by the manufacturer to determine if a leak detection system or component is appropriate for service between E16 to E97. Newer components may be listed to standards that allow a higher concentration. Validate the equipment performance by confirming that it is on the NWGLDE List of Leak Detection Evaluations for Underground Storage Tank Systems. In general, equipment on the NWGLDE List will be approved by AHJ.

Only leak detectors and leak detection components specifically listed by a NRTL, that have material shown to be compatible by the manufacturer and approved by the AHJ for use with the ethanol concentration in service shall be installed and operated.

It should be noted that most leak detection equipment has unknown material compatibility with E16 to E97, is not listed for this service, and is not on the NWGLDE List.

7.4 New Filling Stations with Aboveground Tanks

For new filling stations with aboveground tanks, follow the recommendations of this Recommended Practice where they apply and ensure that the requirements of local fire codes, NFPA 30, NFPA 30A, IFC and SPCC requirements are met as applicable.

7.5 Converting Existing Filling Stations to E10

Existing gasoline fuel system equipment and components in most cases are suitable for use with E10. Before storing or dispensing gasoline blended with up to 10 % ethanol, the storage tank, piping system and dispensing equipment shall be confirmed to be compatible with the new fuel. See 7.3 for details.

Incompatible components shall be removed and replaced with listed components that are approved for use with the new fuel formulation. Incompatible components can deteriorate or fail and put public health, safety and the environment at risk should a leak or release occur. Failed components may also cause product contamination that can affect vehicle drivability.

If converting a diesel storage tank, the tank shall be cleaned prior to the introduction of the ethanol blend to prevent the formation of sludge that can block strainers and filters. Diesel tank piping will need to be revised to accommodate Stage I vapor recovery. Check with the AHJ for vapor recovery requirements.

Careful consideration should be given to older single wall tanks, because of material compatibility questions and the prospect of existing corrosion. Filling station operators should conduct an engineering evaluation of older tanks to determine their suitability for continued service in E10.

7.5.1 Conversion Checklist

Preparing underground storage tanks, piping and dispensing equipment for gasoline-ethanol blends containing up to 10 % ethanol requires an orderly approach to assure that the proper equipment and procedures are used. The following components and any others that come in contact with stored product should be included in any analysis:

— underground storage tanks;

— product fill pipes connections and drop tubes;

— vapor recovery connectors;

— caps and cap gaskets on fill and vapor fittings;

— fill boxes, drain fittings and sump housings;

— UST automatic shutoff or overfill prevention valves;

— lining materials on new and relined tanks;

— submersible pumps, interface gaskets and pump impellers;

— all gaskets, bushings and couplings;

— piping materials;

— pipe adhesives and glues;

— thread sealant;

— piping flex connectors;

— shear valves under dispensers for product and vapor lines;

— line leak detectors;

— automatic tank gauging probes, floats and sump sensors;

— dispensers;

— dispenser filters;

— dispenser hoses and hose fittings;

— hose breakaway couplings;

— hose and nozzle swivel fittings;

— dispensing nozzles.

The following comprises a checklist that should be used when converting storage and dispensing equipment for ethanol concentrations up to E10.

Prepare for transition by taking the following steps:

— Check that all components listed in this section are suitable for use with the proposed ethanol blend by verifying material compatibility with a third party certification, or with proof from their respective manufacturers.

— Check the NRTL listing for each component, and examine the standard to which the equipment was listed, being mindful that not all standards address material compatibility.

— Confirm that all required approvals for the equipment are in place.

— Review the water infiltration history of the site using tank inventory records. Investigate any instances that indicate that groundwater or runoff from heavy rainfall may have entered the tank, and correct any defects.

— Inspect fill pipe and vapor return fitting caps and gaskets for wear and cracking. Replace if necessary.

— Inspect the submersible pump sump, fill box and spill containment covers to assure that they are in good condition and will prevent water entry.

— Check the submersible pump suction height. The recommended level is between 4 in. and 8 in. from the bottom.

— Check that the product and vapor fill boxes are clean and dry.

— Inspect the drain valve in each fill box to assure that it is liquid and vapor tight. A leaking drain valve can allow water in the fill box to drain into the tank and contaminate stored product. All fittings and connections at the top of the tank shall be tight to prevent vapor escape or entry of water into the storage tank. Take corrective action if necessary.

— Verify that the steel vent line riser is not corroded at the base where water could intrude.

— Confirm with the manufacturer that automatic tank gauging probes, floats, and sump sensors will perform properly with the designated ethanol blend.

— Draw down the product level in the tank as low as possible. This may be accomplished by vehicle refuelings through filling station dispensers. If the tank previously contained diesel fuel or regulations require that the exact ethanol blend percentage be posted, remove all product from the tank.

Careful consideration should be given to older single wall tanks, because of material compatibility questions and the prospect of existing corrosion. Filling station operators should conduct an engineering evaluation of older tanks to determine their suitability for continued service in E10.

— Remove all water and sludge from the bottom of the tank. If the tank is tilted away from the fill end, it may be necessary to remove the submersible pump to remove all contaminants. If water is present, determine the means of entry and rectify. Clean the tank if all contamination cannot be removed or if internal inspection or repair is needed.

— If the tank is tilted, confirm whether the stick readings are taken on the high or low end. Consideration should be given to moving the stick gauging location to the low point of the tank to detect and measure the water level accurately. When making measurements, confirm that the stick readings are to the tank bottom and not to an elevated striker plate.

— Adjust the water float on the automatic tank gauge to detect water at the lowest level.

— Obtain ethanol-compatible water detecting paste for use with gauge sticks. Dispose of any incompatible pastes in a safe manner.

— Identify and properly label the fill and vapor recovery connections, access covers and dispensers with the new product description. See API 1637 for specific information. Do not allow sales until delivery of the new product.

— Change the dispenser filters and/or clean the dispenser strainers prior to switching fuels. Filters should have at least a 10 micron nominal rating. Consider the installation of filters that can detect the presence of water to alert for phase separation.

— Perform liquid and vapor tightness tests on the tank system following the recommendations of API 1615 and AHJ permit requirements.

— Ethanol blends act as a solvent and will loosen sediment and sludge from tanks and product lines. Tanks should be clean and free from water.

After receiving the first load of ethanol blended gasoline take the following steps.

— Immediately after the delivery of the new product, check for phase separation. Before allowing sale of product, manually gauge the tank using ethanol-compatible water detecting paste. If water is detected, do not allow any sales. Determine the cause of the water and resolve it.

— Ethanol blends act as a solvent and will loosen sediment and sludge from tanks and product lines. Tanks should be clean and free from water and sediment before the introduction of the first load of a new blend. Fill the tank with the conversion load of new product to 80 % capacity. If the desired tank level is not accomplished with the initial load, a second load should be brought in immediately after. The high product level allows the ethanol to loosen sediment and varnish deposits from the sides and upper portions of the tank. Keep the tanks as full as possible during the first seven to ten days after conversion to accelerate the deposit removal process. Tank operators should be alert that the tank cleansing effects of ethanol may reveal tank defects which may lead to product releases.

— After beginning ethanol blend service, inspect delivery fittings, dispenser interiors, hoses and nozzles daily for any evidence of leakage from the shrinkage of gaskets and sealants or other causes. Take corrective action if necessary.

— Monitor the dispensing rate of each nozzle daily for 10 days to 14 days after conversion. A reduced flow rate of less than 5 gpm most likely indicates that the dispenser filter has become plugged and should be replaced. If the flow rate does not return to a normal value of 6 gpm to 10 gpm, check the dispensing system for contamination.

— During the initial phase of operation after the introduction of a new blend, higher than normal dirt loads in the stored product can be anticipated. The increased level of contamination may cause filter clogging and reduced dispensing rates. Therefore, the frequency of filter cleaning and strainer basket replacement should be increased. Assure that applicable safety procedures are followed when changing filters and strainer baskets.

— Check the calibration of dispensing meters 10 days to 14 days after conversion to ensure that the product change has not affected meter accuracy. Confirm meter accuracy again two to three months after conversion to check for accelerated wear.

— For the first two weeks after the conversion to the new blend, test for phase separation daily using the gauge stick and then test before each subsequent delivery. If water is detected, stop all sales immediately. Determine the cause of the water in the fuel and resolve it. The remaining product in the tank is off specification and cannot be sold. Pump out and dispose or recycle off-specification product according to applicable hazardous waste regulations.

7.6 Converting Existing USTs to High-Blend Ethanol Fuels or E85

As noted earlier in this recommended practice, most older equipment and components are not suitable for conversion. The exceptions are newer tanks and pipe manufactured for use with high-blend ethanol and E85 and a limited number of newer dispensers for blends up to E15. Station owners need to assess their individual site equipment and confirm if older components are suitable for use with the proposed ethanol blend.

The suitability of older components for use with high-blend ethanols can be determined in three steps:

— verify material compatibility;

— confirm that the equipment is listed for the ethanol blend in question;

— assure that the equipment has the appropriate equipment approvals from local, state or federal agencies for site operations.

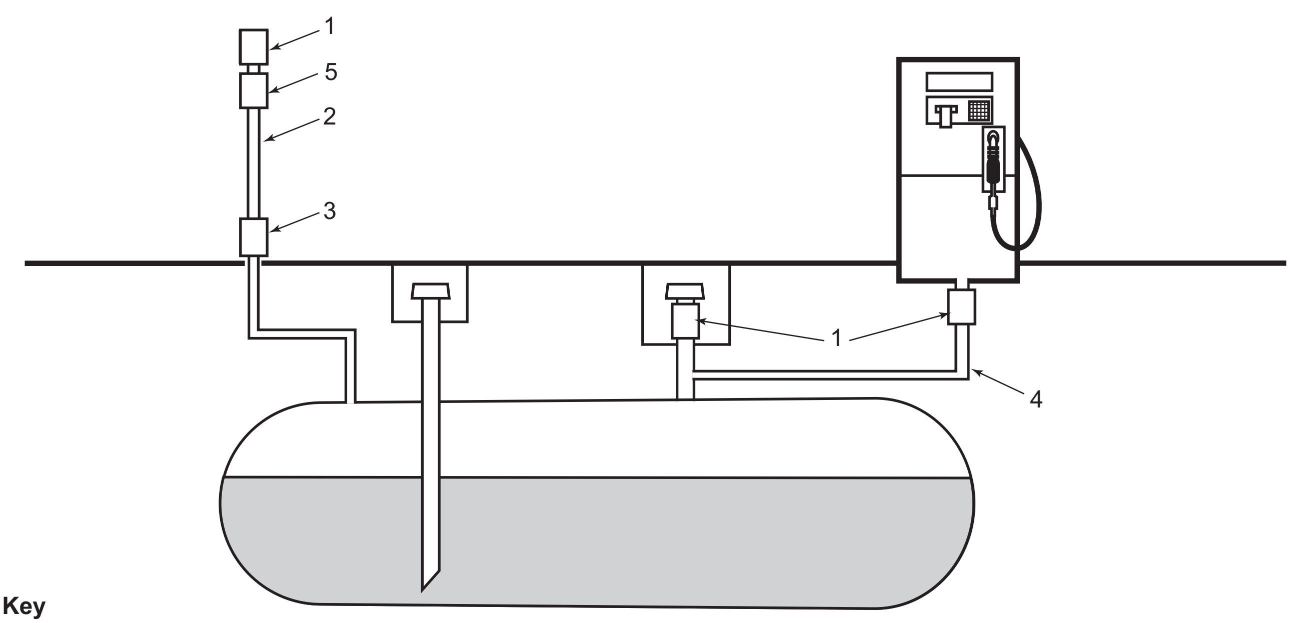
Components that do not meet all three criteria cannot be used with high-blend ethanols.

In addition, incompatible components can deteriorate or fail and put public health, safety and the environment at risk. Failed components may also cause product contamination that can affect vehicle drivability.

New high-blend ethanol and E85 equipment is currently in development and testing at the time of publication of this recommended practice. These components are being developed under UL Subject 87A. When these components are listed and assembled with the appropriate listed tanks and piping, a station operator will be able operate a site with proven material compatibility and NRTL listed equipment. The only remaining issue will be confirming with AHJs that all necessary approvals are in place.

Once material compatibilities and listings have been confirmed, follow the procedures indicated in 7.5 for a tank conversion.

For E85 and high-blend ethanol storage, the vapors in the UST headspace and any piping should be considered flammable at all ambient temperatures. Consider installing a flame arrestor on the vent line and the Stage I vapor recovery fitting to prevent the propagation of a flame front through the system. If Stage II vapor recovery is required, consider installing flame arrestors on the inlet and outlet of each vapor return line or in the dispenser. See Figure 6.



Key
1 flame arrestor
2 vent line
3 flame arrestor (alternate location)
4 vapor return line
5 pressure/vacuum valve

Figure 6—UST System Showing Location of Flame Arrestors for High-blend Ethanol Storage

Low throughput sites may have trouble with fuel becoming off-specification as it ages. At these facilities, fuel quality should be checked periodically to assure that it remains on-specification and is salable. If fuel is out of specification, sales shall be stopped immediately.

Currently there are no electronic probes capable of measuring the water content of E85 until phase separation occurs. The product specification allows for a maximum of 1 % dissolved water. E85 phase separates when the water content reaches 13 % to 15 %. When separation does occur, which is a rare occurrence, probe readings are unreliable, and the product is out of specification.

7.7 Converting Existing Aboveground Storage Tanks to High-Blend Ethanols or E85

To convert existing aboveground storage tanks to high-blend ethanol service at filling stations, use the procedures referenced in 7.5 that are appropriate to aboveground storage tank installations.

Pumps used to transfer ethanol into storage tanks from tank trucks should be dedicated to ethanol service, listed for use in the hazardous environment and compatible with gasoline-ethanol blends.

Careful consideration should be given to older single wall tanks, because of material compatibility questions and the prospect of existing corrosion. Filling station operators should conduct an engineering evaluation of older tanks to determine their suitability for continued service in high-blend ethanol service.

7.8 Water in Storage Tanks

Ethanol is hydrophilic, so water that enters storage tanks is immediately absorbed and contaminates fuel. Understanding how water can enter fuel systems and how it can be detected will help assure better fuel quality.

7.8.1 Sources of Water Contamination

Water can enter a storage tank with delivered fuel, by intrusion thorough loose tank fittings, directly through a fill or vapor recovery connection if the cap is left off, or through a leak in the tank itself. A high water table or stormwater runoff can cause water to accumulate in spill containment boxes and seep into the tank through loose fittings or leaking drain valves. Tank fittings should be kept tight and drain valves should be kept leak-tight and closed to prevent water entry.

Vacuum assist Stage II vapor recovery systems can draw ambient air into storage tanks through the dispensing nozzles during vehicle refuelings. If the ingested air is humid, water vapor can condense inside the tank and end up in the fuel. Assuring that the vapor recovery system components are in good condition and they are operating properly can minimize this problem.

Tanks that experience temperature fluctuations in the headspace are more likely to have condensation occur inside the tank. Aboveground tanks are more susceptible to temperature swings than underground tanks.

The presence of water in fuel can be an indication of the ability of the storage tank to store fuel safely. A leak in the tank shell can allow water intrusion from a high water table. After removing the water and off-specification fuel, check the tank for tightness and integrity.

If external sources of water intrusion have been ruled out, check with your fuel supplier regarding water entrained in fuel delivered from the terminal.

7.8.1.1 Fill Boxes

Water can enter the tank when product deliveries are made during heavy rainstorms. Take extra care during product deliveries under weather conditions that could allow water to get into fuel. Fill boxes and submersible pump access covers should be slightly above grade and make a tight seal to prevent water from entering. O-rings on the covers and the mating surfaces on the boxes should be in good condition to make a tight seal. Fill caps on tank fittings should be kept securely in place except during deliveries.

Check for water accumulation in fill boxes before each product delivery and more frequently during periods of rain or snow. Remove any accumulated water from containment boxes promptly and dispose of it in accordance with AHJ requirements. If the fill box is equipped with a drain valve, do not use it to dispose of accumulated water into the fuel. The water will contaminate the product.

7.8.2 Water Detection

Water in storage tanks can have many sources, but it is not always apparent when contamination has occurred. Be especially vigilant during wet or humid conditions which can promote water accumulation. Routine fuel testing and listening to fuel complaints from customers can provide an indication of the presence of water in fuel.

When looking for water in fuel, the gauging point should be at the low end of the tank to assure that any water, which sinks to the bottom of the tank, is detected. Confirm that the stick readings are to the tank bottom and not to an elevated striker plate. Retrofitted striker plates, which have been inserted into the drop tube, may also prevent accurate sampling for the presence of water.

7.8.2.1 Water Finding Paste

A tank with a gasoline-ethanol blend where phase separation has occurred will have a layer of water and ethanol on the bottom. Water finding paste that is compatible with ethanol placed on the end of the tank gauge stick can detect the presence of water. Follow the directions for using water finding paste furnished by the manufacturer.

To detect water, put at least 4 in. to 8 in. of water finding paste on the sides of the gauge stick at the tip and insert it all the way to the bottom of the tank. Hold the stick at the bottom for the time specified in the manufacturer's directions. Remove the stick and inspect the paste. If the paste shows a color change, water is present and phase separation has occurred. Water finding paste has the ability to detect the presence of water just before total phase separation occurs.

Tanks with gasoline-ethanol blends should not have any water bottoms. If water is detected, shut down fueling and remove the tank from service.

Filling station personnel should become familiar with how to use water finding paste prior to the introduction of gasoline-ethanol blends.

7.8.3 Phase Separation

Small quantities of water can be dissolved in low-ethanol blends such as E10 or below, but beyond a certain concentration, saturation will be achieved. Any additional water, even a small amount, will cause the ethanol to separate from the gasoline and form a separate solution with the water. This phenomenon in gasoline-ethanol storage tanks is known as phase separation. When phase separation occurs, the water/ethanol solution sinks and forms a layer on the bottom of the tank leaving gasoline in the upper layer with a lower ethanol content and a reduced octane level.

The solubility of water in gasoline-ethanol blends is temperature dependent and increases with higher temperatures. The ability of gasoline-ethanol blends to absorb water also increases with the amount of ethanol in the fuel. It should be noted that if phase separation occurs, the process is essentially irreversible.

Phase separation is unlikely to occur in fuel ethanol or E85 because of the high ethanol concentration. Significant water accumulation in these tanks will most likely be discovered before phase separation occurs because of obvious tank defects or inventory control inconsistencies.

In tanks where phase separation has occurred, the remaining gasoline-ethanol blend in the upper layer is out of compliance for ethanol content and the posted octane rating on the dispenser. Off-specification motor fuels caused by phase separation are illegal to sell, may cause vehicle drivability problems and can potentially harm vehicle fuel systems. If phase separation has occurred, stop all fuel sales immediately and take the tank out of service. The water phase should be treated as a flammable liquid and disposed of in accordance with federal, state, and local requirements. The ethanol-depleted gasoline in the upper phase should be managed as off-specification product.

The susceptibility of gasoline-ethanol blends to water contamination requires that the tank and the entire piping system be clean and dry before an ethanol blend is introduced. Good housekeeping practices should be maintained during on-going operations to keep water from entering the system.

Discovery of phase separation in a storage tank may be an early indication of a tank or tank system defect. The source of water should be determined and eliminated.

7.8.4 Micro-organisms

Microbes may exist in tanks containing gasoline-ethanol blends and cause corrosion of internal tank surfaces. Microbial-induced corrosion (MIC) can occur under aerobic and anaerobic conditions. Micro-organisms survive by feeding on the hydrocarbons at the interface between the water layer and the gasoline layer. Wastes and fermentation products secreted by the microbes produce water, sludge and acidic byproducts that can cause material degradation. The acidic residues of sulfate-reducing bacteria can cause metal corrosion and may, if left unmanaged, cause a tank failure. Microbes can also form colonies in tank bottom sludge and be in direct contact with steel. Micro-organisms also attack rubber gaskets and certain seal, hose, and coating materials for their mineral content. There is also recent evidence of MIC in un-phase separated product.

Indications of microbial presence include slow dispensing rates that are caused by microbes clogging filters and product having the smell of sulfur. Biocides formulated for use in fuel tanks can be added to control persistent microbial populations.

The primary cause of microbial growth is the presence of water. Minimizing water intrusion into the tank system from all sources and diligently checking for the first indications of phase separation are effective measures to discourage the growth of microbial colonies.

7.8.5 Customer Feedback

Comments from customers about slow dispensing rates can indicate that fuel filters are clogged because of phase separation, micro-organisms or particulates in the fuel. Likewise, complaints about vehicle drivability shortly after refueling may also indicate the presence of water or particulates in fuel. In either case, take the product out of service. Change fuel filters and use water finding paste to check for phase separation. If fuel contamination is suspected, take corrective action before returning the tank to service.

7.9 Accelerated Corrosion and Conductivity

Compared to gasoline and hydrocarbon fuels in general, ethanol has a high electrical conductivity and oxygen content. The chemical properties of ethanol also contribute to its ability to readily absorb water. The suspension of water within gasoline-ethanol blends enhances galvanic corrosion and rusting by providing an oxygen-rich environment that is also a good conductor of electricity. These conditions present in ethanol blend service can lead to corrosion and ultimately metal loss in various components that are not normally adversely affected by gasoline.

Ethanol is not compatible with some grades of soft metals such as zinc, brass, copper, lead, and aluminum. These metals will degrade or corrode in contact with ethanol and possibly cause a component failure or affect fuel quality. Before using any component in ethanol service, verify its compatibility with the manufacturer.

7.10 Tank Truck Unloading

7.10.1 Tank Truck Unloading into Underground Storage Tanks

Drivers of tank trucks transporting gasoline-ethanol blends should be provided training in the proper delivery procedures.

At filling stations, on-site personnel should be given appropriate training for product deliveries.

All tank connections should be labeled according to the API color code system. See API 1637.

7.10.1.1 Unloading Ethanol Blends up to E10

The vapor spaces of underground storage tanks containing ethanol blends up to 10 % ethanol concentration are in most cases almost completely saturated prior to the start of a delivery even if essentially empty. The turbulence created during the filling process circulates rich fuel vapor generated at the liquid surface throughout the ullage space and promotes the saturation of any lean vapor/air pockets that might exist. Consequently, vapors displaced while the tank is being filled are above the UEL. Rich vapors emitted from the tank should be considered flammable until they are diluted below the LEL.

Unloading gasoline-ethanol blends with ethanol concentrations up to 10 % presents the same fire-safety hazards as gasoline. Follow unloading procedures as specified for gasoline in NFPA 30A and API 2003.

7.10.1.2 Unloading Ethanol Blends from E11 to E15

Unloading gasoline-ethanol blends with ethanol concentrations between 11 % and 15 % should present the same fire-safety hazards as gasoline. Follow unloading procedures as specified for gasoline in NFPA 30A and API 2003.

7.10.1.3 Unloading E85

The vapor spaces of underground storage tanks storing E85 are almost completely saturated prior to the start of a delivery. For all ambient temperatures, the vapors in the ullage should be considered flammable even when tanks are essentially empty. The wide flammability range of E85 makes it likely that all parts of the vapor space in an UST system will contain flammable mixtures.

Stage I vapor recovery systems recover vapors generated during fuel deliveries to underground storage tanks and routes them back to the tank truck. It provides excellent capture and control of vapors that would otherwise be emitted to the atmosphere without controls in place.

When unloading E85 into underground storage tanks vapors should be considered to be flammable at all temperatures. Follow unloading procedures as specified for gasoline in NFPA 30A and API 2003. Rich vapors emitted from the tank should be considered flammable until they are diluted below the lower flammability limit.

As discussed in 7.3.3.1, a risk assessment should be conducted to consider the need for flame arrestors on UST connections and the vent line.

7.10.2 Tank Truck Unloading into Aboveground Storage Tanks

Unloading gasoline-ethanol blends into an aboveground storage tank requires the use of a pump to transfer liquid from the delivery truck into the tank. The pump can be located either on the delivery tank truck or mounted permanently near the storage tank with piping between the unloading area and the tank. The pump and piping should be compatible with gasoline and ethanol.

Collision protection and spill prevention and control structures should be provided as required by code and the AHJ.

Tank truck drivers transporting gasoline-ethanol blends to aboveground tanks should be provided training in the proper delivery procedures.

Filling station personnel should be given appropriate training for product deliveries.

Unloading gasoline-ethanol blends into aboveground tankage presents the same fire-safety hazards as loading gasoline into underground tanks. See 7.10.1.1 to 7.10.1.3 for more information. Follow unloading procedures as specified for gasoline in NFPA 30A and API 2003.

All tanks should be placarded to identify the product stored in compliance with AHJ conditions. All tank connections should be labeled according to the API color code system. See API 1637.

As discussed in 7.3.3.1, a risk assessment should be conducted to consider the need for flame arrestors on tanks containing E85 blends.

7.11 Quality Assurance

A robust quality assurance and quality control program can prevent fuel quality incidents when handling and storing gasoline-ethanol blends.

The presence of water in a gasoline-ethanol blend storage tank indicates a serious problem. If water is detected, stop dispensing product immediately. The presence of water indicates that phase separation has occurred and the product in the tank is no longer legal for sale.

Aside from routine checks for the presence of water in tanks using water-finding paste on a gauge stick, sampling and testing of fuel should be carried out by a reputable laboratory.

7.12 Record Keeping

Daily records should be maintained in the same manner as for any other motor fuel. These procedures are set forth in API 1621.

Tank inventories should be monitored to guarantee that there is sufficient turnover to assure that products for sale are on-specification.

Documentation verifying the material compatibility of each fuel system component should be kept on file permanently.

8 Releases

8.1 General

Product releases from terminals and filling stations have the potential to cause property damage, environmental impairment and affect public health and safety. Identification of the causes of leaks and spills and taking proper steps to manage releases can minimize their effects.

Storage tanks, piping, dispensers and other system components should be maintained and operated in proper working order. Periodically inspect equipment for damage, leakage or other hazards. The frequency of inspection may be specified by the AHJ. If damage, leakage or hazards are found, repair or replace equipment as required. To limit the risk of spills and releases from equipment failure, use only components that have proven material compatibility and approvals for the material being stored.

8.2 Spill Causes

8.2.1 Terminals

Storage tanks and tank trucks can be overfilled if proper loading procedures are not followed. Releases can also occur because of a failure of product transfer lines or storage tanks. Loading and storage activities should follow the accepted product handling practices shown in API 1615 and API 2610.

Response to fires caused by a product release are covered in Section 9.

8.2.2 Filling Stations

In general, releases at filling stations are caused by the overfilling of storage tanks during deliveries, failures of tanks and tank piping systems, and spills occurring during vehicle refueling. Releases can also occur from vehicles accidentally hitting and dislodging dispensers.

8.3 Spill Response

8.3.1 Terminals

If a product release occurs, eliminate all hot surfaces and sources of ignition in the vicinity of the spill or released vapor. Cease all hot work. If liquid or vapors are released into a work area, evacuate it immediately and keep unnecessary personnel away. Contact emergency responders. Stop the source of the release if it can be done without risk.

Working with responders, take measures to contain the release and halt its spread. Clean up spilled product as soon as possible, observing precautions to control exposure and assure personal protection.

Isolate diked or bermed areas used to capture spilled liquids. Containment for the fuel ethanol unloading area and the tank truck loading areas should provide sufficient spill control capacity to contain the largest truck compartment that will be accommodated. Drainage from the fuel ethanol unloading area should be kept separate from drainage accumulated from other plant areas. Fuel ethanol spills should be routed by gravity to a segregated containment area such as a collection tank. Keep spills containing ethanol separate from storm water, base gasoline and diesel contact water.

Employ appropriate clean-up techniques such as using non-combustible absorbent materials to collect spilled product from paved areas. Used sorbent materials should be placed into containers for disposal. Pump free product and standing liquid into proper containers. Assure that electrical equipment used for cleanup is designed and rated for use in flammable atmospheres and is properly grounded. Use vapor suppressing foam that is compatible with the spilled fuel to reduce vapor generation.

Where feasible and appropriate, remove contaminated soil. Use clean, non-sparking tools when handling spilled or contaminated material and to collect used sorbents. Place contaminated materials in sealed disposable containers, and dispose of in a manner consistent with applicable AHJ regulations.

Ethanol can cause cracking of clay dikes, therefore, containment areas should be constructed using alcohol-resistant liners that will retain their integrity when in contact with spilled materials. After a spill has been cleaned up, inspect dikes and containment areas for damage and deterioration. Repair any deficiencies promptly.

8.3.2 Filling Stations

If a product release occurs, disconnect power to all dispensers by activating the emergency shutoff. Contact emergency responders. Stop the source of the release if it can be done without risk. Keep customers away from the spill area. Eliminate hot surfaces and all sources of ignition in the vicinity of the spill or released vapor.

Working with responders, take measures to contain the release and halt its spread. Clean up spilled product as soon as possible, observing precautions to control exposure and assure personal protection. Keep gasoline-ethanol mixtures from reaching storm sewers by covering drains to block flow. Keep drain cover materials readily available to provide a quick response in case of spill.

Use appropriate clean-up techniques such as non-combustible absorbent materials to collect spilled product from paved areas. Used sorbents should be placed into proper containers for disposal. Use clean, non-sparking tools to collect absorbed material. Assure that any electrical equipment used for cleanup is designed and rated for use in flammable atmospheres and is properly grounded.

8.3.3 Off-site Migration

Most terminals and some filling stations are equipped with oil/water separators. Gasoline-ethanol blends that reach a gravity oil/water separator will separate into two phases—a gasoline phase and a water-ethanol phase. The water-ethanol phase will pass through the separator. The gasoline-phase will be retained. Ethanol that passes through the separator can generate vapors in areas with enclosed headspaces that under certain conditions may be flammable.

If the facility sends its separator wastewater to a publicly owned treatment works (POTW), check to determine if the plant can handle the volume and concentration of ethanol created by a spill. If the POTW cannot accept ethanol, then the waste stream shall be collected and handled onsite or sent off site for disposal. Examples of on-site management options for separator effluent at terminals include diversion to wetlands for biodegradation and enhanced oxidation. In any case, the management of separator wastewater shall be done in accordance with AHJ discharge regulations and permit requirements.

Ethanol in gasoline-ethanol mixtures reaching soil can dissolve readily into groundwater. It also poses a threat to surface water (lakes, wetlands and streams), underground structures (basements and garages) and potable water supplies. Preferential biodegradation of ethanol in soil creates a significant demand on oxygen and extends MTBE and BTEX dissolved plumes. The ethanol in E85 is easily degraded through natural attenuation, which increases the potential for anaerobic subsurface conditions to promote the generation of methane. Methane in soil can be a safety concern if vapors become concentrated and reach the flammability limit—especially in enclosed spaces.

8.4 Reporting Requirements

Report spills and releases to the appropriate AHJ.

8.5 Training

Terminal and filling station personnel should be trained to respond to spills and releases of ethanol and ethanol blends. E85 training should include information about on-site equipment, handling and storage guidelines, fire prevention procedures, fire fighting, and first aid for eye or skin contact, inhalation, or ingestion.

Make Material Safety Data Sheets (MSDS) available to all facility personnel for each product stored and handled.

In addition to employee training to discuss a new ethanol blend, terminal and filling station operators should consider offering a special orientation session for third parties such as maintenance personnel and fire fighters. This session should identify specifics about the site, material and compatibility issues for equipment maintenance and fire fighting measures.

8.6 Emergency Response and External Communication

Review and update facility emergency response plans prior to the introduction of any ethanol blend requiring a new MSDS.

Notify emergency responders, such as the local fire department when product changes occur, and advise them of the special fire-fighting requirements for high-blend ethanols.

8.7 Consumer Concerns

Misfueling is the introduction of high-blend ethanol into a vehicle that is not designed to operate with fuel greater than 10 % ethanol content. Only flexible fuel vehicles (FFV) are allowed by federal law to operate on high-blend ethanol. Accidental or intentional misfueling of vehicles designed to operate on conventional gasoline can damage or degrade vehicle fuel system components that come in contact with fuel. Misfueling can also affect vehicle drivability causing difficulty starting, stalling and poor fuel economy. Misfueling can also increase exhaust emissions and void the manufacturer’s warranty.

Customers may be unaware that high-ethanol blends cannot be used to refuel conventional gasoline powered vehicles. E85 dispensers should have an advisory stating that E85 is not gasoline and is only for use in FFVs.

To prevent possible misfueling, consideration should be given to differentiating E85 dispensing nozzles by using different color scuff guards and splash shields than are used for low-blend ethanols and gasoline.

9 Fire Protection

9.1 General

This section discusses fire fighting agents and techniques used with high-blend ethanol products and neat ethanol. Low-blend ethanol products can be controlled using the same techniques as used with standard hydrocarbon fires. High-blend ethanol products fires should be treated as polar solvent fires which require a different approach to fire fighting.

Personnel should approach ethanol fires with caution. Neat ethanol fires may burn with a nearly invisible flame and can be effectively detected with an infrared camera or fusible cable. Denatured or high-blend ethanol fires, however, are visible with a less intensive flame than gasoline or other conventional fuels and will burn with very little smoke. If other fuels are involved in an ethanol fire, additional smoke and a more intense flame is likely to be evident.

The existence and boundaries of high-blend ethanol fires may be less clearly defined than fires of gasoline and low-blend ethanols. All affected individuals, including fire fighters, should be appropriately advised.

Practices for controlling and extinguishing fires involving flammable liquid stored in atmospheric storage tanks fires are provided in documents such as API 2021 and applicable NFPA standards. [14]

9.2 Fire-fighting Agents for High-blend Ethanol

9.2.1 Dry Chemical

Dry chemicals are an acceptable agent for fighting all types ethanol blend fires (spill, pressure, three-dimensional, and fuel in-depth) because ethanol does not affect dry chemical extinguishing properties. These powder-based agents work by preventing the chemical reaction between heat, fuel, and oxygen which halts the production of fire sustaining free radicals. [15]

Dry chemical hand hose line systems are effective for fighting ethanol blend fuel fires. They can deliver large amounts of extinguishing agent for quick knockdown and extinguish relatively large fires such as those that may occur at truck loading racks.

To improve fire fighting performance, replace all traditional sodium bicarbonate-based fire extinguishers with potassium bicarbonate (Purple K) or urea-potassium bicarbonate (Monnex® [16]) dry powder units. Refer to manufacturers' recommendations for application rates.

A concern with using dry chemical extinguishers, with ethanol blends as well as hydrocarbon fires, is their inability to prevent re-flashing of the fire. Once the powder "cloud" dissipates after application, vapors remain in the area that are in the flammable range and they come in contact with hot surfaces from the fire or other ignition sources, re-ignition is possible. The combination of dry chemical and foam solution is typically more effective for fighting ethanol fires than dry chemical alone. This is because dry chemical will quickly knock down and extinguish the fire and the foam solution will cover any remaining ethanol and cool-off the hot surfaces to prevent re-ignition.

9.2.2 Foam

Use foam prepared from an alcohol-resistant foam concentrate to fight high-blend ethanol fires Extinguish ethanol blend spill fires and in-depth fires with foam prepared from alcohol-resistant aqueous film forming foam (AR-AFFF)

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[14] Information on fighting ethanol blend fires can be found at http://www.ethanolresponse.com/resources.html.
[15] Methods for extinguishing fires formerly involved removing one of the legs of the fire triangle—heat, fuel or oxygen. Current methods are based on the fire tetrahedron which consists of the same components as the fire triangle and adds the chemical chain reactions supporting the fire. Removing any one of these components will extinguish the fire.
[16] This term is used as an example only, and does not constitute an endorsement of this product by API.

concentrate or alcohol-resistant film forming fluoroprotein (AR-FFFP) concentrate. Use with the application rates recommended by the manufacturer and/or as required in the "Listing" for the product. NFPA 11 also recommends application rates, but they are strictly for hydrocarbon fires. Fires involving ethanol blend fuels may require higher application rates than hydrocarbon only fires. Fire fighters should consult the "Listing" application rates for the brand of foam being used.

For fuel in depth fires, foam solution should be applied using Type II applicators to avoid splashing as encountered in dike hazard areas, tanks farms and storage tank applications. For foam sprinkler applications, such as truck loading racks, the sprinkler heads of the appropriate type should be used at the "Listed" application rate for ethanol using the manufacturer's alcohol-resistant foam concentrate.

Existing systems should be evaluated prior to any foam agent change. When performing a system evaluation, particular attention should be paid to reviewing existing sprinkler head specifications, foam density and application rates, water flow demand, foam tank size, foam proportioner specifications, orifice plate dimensions and the specifications of other key components to determine if suitable for use with the new foam concentrate.

9.2.3 Clean Agents

Carbon dioxide and other clean agents may not be as effective as dry chemical and foam agents for fighting neat ethanol or high-blend ethanol blend fuel fires. This is because they use oxygen displacement as the extinguishing mechanism and the agent may be disbursed before it can reach an extinguishing concentration. Unless the burning fuel is in an enclosed space and the gaseous agent can reduce the oxygen concentration below the limiting oxygen concentration (LOC), clean agents will be ineffective. The LOC for hydrocarbons is 10 % to 11 %. For high-blend ethanols the LOC is even lower because ethanol contains oxygen, which aids the combustion reaction.

If the fuel fire is located within an enclosure, clean agents or carbon dioxide may be used. They provide the advantage of not leaving a residue after discharge which can reduce clean-up and recovery time after an incident. Carbon dioxide systems cannot be used to fight fires in normally occupied enclosures because the potentially high CO_2 concentrations that may be generated will not support life. For occupied spaces, newer types of clean agents provide a safe alternative to carbon dioxide.

Before installation, clean agents should be approved by a recognized testing organization to verify their ability to extinguish fires.

9.2.4 Dilution

Dilution of ethanol blend spill fires (fuel depth less than 1 in.) and in-depth fires (fuel depth 1 in. or greater) with water is not an effective fire fighting technique. Ethanol remains combustible when diluted with up to 80 % water. To effectively extinguish a high-blend ethanol fire by dilution, a large volume of water is required.

9.3 Fire-fighting at Facilities Handling Multiple Fuel Types

9.3.1 General

At terminals where neat ethanol, fuel ethanol, high-blend ethanol, and gasoline are stored, fire fighting systems shall be provided with foam prepared from an alcohol-resistant foam concentrate. In case of a fire, local authorities may be uncertain what fuels are involved. Signage should clearly inform fire responders of the flammable materials and hazards involved with fighting high-ethanol blend fires. Foam prepared from an alcohol-resistant foam concentrate will be suitable for all fire situations and eliminate uncertainty as to agent selection.

The foam concentration and application rate may be far higher for fire-fighting situations involving high-ethanol blends than for normal hydrocarbons. Therefore, legacy fire systems for handling gasoline and ethanol fires need to be reviewed and properly sized as compared to those used with fuels containing only hydrocarbons.

Foam application on fires involving alcohol should be directed onto tank and dike walls and allowed to flow gently onto the ethanol to avoid splashing. Minimize the surface area of dike yards containing ethanol blend tanks because of the possibility that larger foam quantities may be required—up to three times as much for some older foams than for normal hydrocarbon fires—to suppress any fire.

Existing stockpiles of foams should be tested annually as required by NFPA 11. These stockpiles should be inventoried, evaluated, and consideration should be given to limiting the number and types of foam. It should be noted that newer technology is available which proportions foam at a 3 % rate for any fuel thus limiting confusion during an emergency.

9.3.2 Suggested Fire Protection

9.3.2.1 Ethanol Unloading Area

Tank trucks should unload fuel ethanol on a concrete spill control pad designed to prevent pooling of spills under trucks and piping. Spills should drain by gravity to a closed containment system. Efficient drainage on the pad reduces the amount of fuel available to burn in case of a spill.

The following equipment should be available for fire fighting:

— suitable extinguishers (at least 2 × 75 kg dry powder trolleys);

— a water monitor to cool trucks and adjacent equipment. A foam system is preferred;

— a safety shower is suggested.

9.3.2.2 Ethanol Storage Tanks

Each neat ethanol and high-blend ethanol tank should be equipped with an in-line balanced pressure proportioning system, which utilizes a positive displacement foam pump and an atmospheric foam tank if required by the AHJ. This type of system is also called a fixed foam pourer.

If the system is supplied by a fixed foam tank, it should be able to be re-supplied easily during emergency conditions. The foam system should provide means for testing by discharging foam from the tank without contaminating the foam stock. The foam level should be easy to check and a sample point should be provided. For smaller diked areas, or small bulk tanks, a bladder tank proportioning system may be considered. Although this system cannot be re-supplied during an emergency, it may be suitable for small or remote locations where a reliable electrical power supply is not available to operate the foam pump.

Low expansion Type II foam makers should be used as “listed”.

9.3.2.3 Truck Loading Rack

Loading high-blend ethanol requires different fire detection and protection equipment from that used at loading racks where only low-blend ethanol products are loaded.

The preferred fire protection technique for truck loading racks is a fixed foam deluge/sprinkler system using only an AR-AFFF alcohol-resistant foam, as “listed” when required by the AHJ. For truck loading racks without a canopy, fixed spray nozzles or monitors (cannons) are an option in place of overhead foam/water sprinkler system. As an alternative, a fixed dry chemical system may be used if properly designed and evaluated by a fire safety professional.

Review fire suppression methods intended for use with high-ethanol fuels and evaluate their effectiveness by taking into account the loading rack configuration, loading equipment in use, fire suppressant application rates and escape routes.

Fire suppression system design changes should be reviewed by a fire safety professional and approved by the AHJ to assure that they are effective, applicable for the types of risks involved, and compatible with the loading rack equipment and facility configuration.

Safety showers and eye wash stations should be located 10 ft to 50 ft from the loading rack with an unobstructed path.

9.3.2.4 Ethanol and Denaturant Pumps

Install fusible cable detection or infrared detection where ethanol and denaturant pumps are located to detect ethanol fires.

9.3.2.5 Filling Stations

A fixed dry chemical system using “Listed” agents is the preferred option when required by the AHJ.

Potassium bicarbonate (Purple K) and urea/potassium bicarbonate (Monnex®) are effective in extinguishing fires of ethanol blends. Refer to manufacturers’ recommendations for application rates.

Fire suppression system designs should be reviewed and approved by a fire safety professional to assure that they are effective, applicable for the types of risks involved, and compatible with dispensers and canopy configurations.

9.3.2.6 Railroad Tank Car Unloading

Railroad tank cars should unload neat ethanol and high-blend ethanol products inside a spill control area designed to prevent pooling of spills under tank cars and piping. Spills should be controlled and drain by gravity to a closed containment system. Efficient drainage on the pad reduces the amount of fuel available to burn in case of a spill.

The unloading area around tank cars presents the greatest fire hazard potential during product transfers. The preferred fire suppression method is a fixed foam deluge/sprinkler system. At facilities that are not covered by a canopy, an alternative approach is to use manual or oscillating foam monitors.

A fixed dry chemical system may not be feasible unless it is a supplement to the fixed foam system. Portable dry chemical fire extinguishers are of value in fighting potential running fuel and pressure type fuel fires in conjunction with foam application.

9.3.2.7 Marine Terminals

Marine terminals receive neat ethanol and high-blend ethanol from tankers or barges that are towed by tug vessels. Larger tankers docking at piers typically have fixed deck foam systems equipped with the appropriate type of foam agent for the products they transport. Tug vessels may also have smaller foam systems on board, but may not necessarily have the proper type of foam agent for high-blend ethanol products. Check with vessel operators to confirm that they are equipped with the proper type of alcohol-resistant foam before allowing unloading to begin.

Land-based fire suppression systems typically involve a fixed monitor foam system to protect the dock and jetty facility. Monitors may be the manual type, but tower-mounted versions operating remotely from a safe location are preferred. In addition, a foam water deluge sprinkler system and/or a foam pourer system located under the dock can be used to protect the structure. Under-dock systems connected to the jetty provide protection immediately below the structure and guard it from a fire burning on the surface of the water.

The primary design intent of these systems is to protect the dock and jetty facility. If necessary, land-based equipment may be used to fight a fire on a tanker or barge.

Annex A
(informative)

Generally Accepted Values for Gasoline and Gasoline-Ethanol Blend Properties

Table A.1 provides generally accepted values for gasoline and gasoline-ethanol blend properties based on published data.

Table A.1—Ethanol and Gasoline-Ethanol Blend Properties

Property	Gasoline	Neat Ethanol	Denatured Ethanol	E85
Boiling Point, °F	80 to 437	173	165 to 175	80 to 435
Flash Point, °F	–40	55	<10	–30
RVP, psi	7 to 15	2.3	4.5	6 to 12
Vapor Density with air	3.4:1 to 5.0:1	1.1:1	1.6:1	2.0 to 4.0
Flammability Limits in air, %	1.4 to 7.6	6 to 36	3 to 19	1.4 to 19
Electrical Conductivity, picoSiemens/ meter	1	1.4×10^5	1.4×10^5	1.4×10^5
Auto Ignition Temperature, °F	495	793	689	[a]
Latent Heat of Vaporization, Btu/lb	150	396	396	355
Flame Visibility [b]	1	2	3	1
Solubility in Water, %	Neg <0.1 %	100	95	70 to 90
Stoichiometric Ratio	14.7	9	NA	10

[a] Depends on the characteristics of the hydrocarbon fraction.

[b] Visibility key: 1 = visible under all conditions; 2 = invisible in daylight; 3 = difficult to see in daylight.

NOTE NA = Not available in literature at the time of publication of this document.

Annex B
(informative)

Components that Require Listing as an Approved Device

The items in Table B.1 are required to be listed by a NRTL according to 29 *CFR* Part 1910.106(g), 29 *CFR* Part 1910.303, 29 *CFR* 1910.307, NFPA or the IFC.

Thoroughly investigate which equipment is required to be listed in individual states and jurisdictions prior to changing any components or stored fuel.

Table B.1—Components that Require Listing as an Approved Device from a Nationally Recognized Testing Laboratory

Equipment Area	Item
Fuel-Dispensing Systems	Dispensers
	Nozzles
	Hose assemblies (hose, swivels, fittings)
	Breakaways (at hose)
	Impact/fire (valve under dispenser)
	Electrical equipment
	Pumps
	Leak detection
Tank and Pipe Systems	Fuel and vapor piping
	Flexible piping joints
	Tanks
	Flame arresters
Vapor Recovery Systems	Vapor recovery devices
	Vapor recovery nozzles
	Shear valve (dispenser)
	Vapor-processors
	Vapor valves
	Vapor meters

Annex C
(informative)

Orderly Approach to Assure that Proper Equipment and Procedures are used in Preparation of Underground Storage Tanks, Piping, and Dispensing Equipment

The following checklists are reproduced from 7.5.1.

Preparing underground storage tanks, piping and dispensing equipment for gasoline-ethanol blends containing up to 10 % ethanol requires an orderly approach to assure that the proper equipment and procedures are used. The following components and any others that come in contact with stored product should be included in any analysis:

- underground storage tanks;
- product fill pipes connections and drop tubes;
- vapor recovery connectors;
- caps and cap gaskets on fill and vapor fittings;
- fill boxes, drain fittings and sump housings;
- UST automatic shutoff or overfill prevention valves;
- lining materials on new and relined tanks;
- submersible pumps, interface gaskets and pump impellers;
- all gaskets, bushings and couplings;
- piping materials;
- pipe adhesives and glues;
- thread sealant;
- piping flex connectors;
- shear valves under dispensers for product and vapor lines;
- line leak detectors;
- automatic tank gauging probes, floats and sump sensors;
- dispensers;
- dispenser filters;
- dispenser hoses and hose fittings;
- hose breakaway couplings;
- hose and nozzle swivel fittings;

— dispensing nozzles.

The following comprises a checklist that should be used when converting storage and dispensing equipment for ethanol concentrations up to E10.

Prepare for transition by taking the following steps.

— Check that all components listed in this section are suitable for use with the proposed ethanol blend by verifying material compatibility with third party certification, or with proof from their respective manufacturers.

— Check the NRTL listing for each component, and examine the standard to which the equipment was listed, being mindful that not all standards address material compatibility.

— Confirm that all required approvals for the equipment are in place.

— Review the water infiltration history of the site using tank inventory records. Investigate any instances that indicate that groundwater or runoff from heavy rainfall may have entered the tank, and correct any defects.

— Inspect fill pipe and vapor return fitting caps and gaskets for wear and cracking. Replace if necessary.

— Inspect the submersible pump sump, fill box and spill containment covers to assure that they are in good condition and will prevent water entry.

— Check the submersible pump suction height. The recommended level is between 4 in. to 8 in. from the bottom.

— Check that the product and vapor fill boxes are clean and dry.

— Inspect the drain valve in each fill box to assure that it is liquid and vapor tight. A leaking drain valve can allow water in the fill box to drain into the tank and contaminate stored product. All fittings and connections at the top of the tank shall be tight to prevent vapor escape or entry of water into the storage tank. Take corrective action if necessary.

— Verify that the steel vent line riser is not corroded at the base where water could intrude.

— Confirm with the manufacturer that automatic tank gauging probes, floats, and sump sensors will perform properly with the designated ethanol blend.

— Draw down the product level in the tank as low as possible. This may be accomplished by vehicle refuelings through filling station dispensers. If the tank previously contained diesel fuel or regulations require that the exact ethanol blend percentage be posted, remove all product from the tank.

  Careful consideration should be given to older single wall tanks, because of material compatibility questions and the prospect of existing corrosion. Filling station operators should conduct an engineering evaluation of older tanks to determine their suitability for continued service in E10.

— Remove all water and sludge from the bottom of the tank. If the tank is tilted away from the fill end, it may be necessary to remove the submersible pump to remove all contaminants. If water is present, determine the means of entry and rectify. Clean the tank if all contamination cannot be removed or if internal inspection or repair is needed.

— If the tank is tilted, confirm whether the stick readings are taken on the high or low end. Consideration should be given to moving the stick gauging location to the low point of the tank to detect and measure the water level accurately. When making measurements, confirm that the stick readings are to the tank bottom and not to an elevated striker plate.

— Adjust the water float on the automatic tank gauge to detect water at the lowest level.

— Obtain ethanol-compatible water detecting paste for detecting product levels with gauge sticks. Dispose of any incompatible pastes in a safe manner.

— Identify and properly label the fill and vapor recovery connections, access covers and dispensers with the new product description. See API 1637 for specific information. Do not allow sales until delivery of the new product.

— Change the dispenser filters and/or clean the dispenser strainers prior to switching fuels. Filters should have at least a 10 micron nominal rating. Consider the installation of filters that can detect the presence of water to alert for phase separation.

— Perform liquid and vapor tightness tests on the tank system following the recommendations of API 1615 and AHJ permit requirements.

— Ethanol blends act as a solvent and will loosen sediment and sludge from tanks and product lines. Tanks should be clean and free from water.

— After receiving the first load of ethanol blended gasoline take the following steps:

— Immediately after the delivery of the new product, check for phase separation. Before allowing sale of product, manually gauge the tank using ethanol-compatible water detecting paste. If water is detected, do not allow any sales. Determine the cause of the water and resolve it.

— Ethanol blends act as a solvent and will loosen sediment and sludge from tanks and product lines. Tanks should be clean and free from water and sediment before the introduction of the first load of new blend. Fill the tank with the conversion load of new product to 80 % capacity. If the desired tank level is not accomplished with the initial load, a second load should be brought in immediately after. The high product level allows the ethanol to loosen sediment and varnish deposits from the sides and upper portions of the tank. Keep the tanks as full as possible during the first seven to ten days after conversion to accelerate the deposit removal process. Tank operators should be alert that the tank cleansing effects of ethanol may reveal tank defects which may lead to product releases.

— After beginning ethanol blend service, inspect delivery fittings, dispenser interiors, hoses and nozzles daily for any evidence of leakage from the shrinkage of gaskets and sealants or other causes. Take corrective action if necessary.

— Monitor the dispensing rate of each nozzle daily for 10 to 14 days after conversion. A reduced flow rate of less than 5 gpm most likely indicates that the dispenser filter has become plugged and should be replaced. If the flow rate does not return to a normal value of 6 gpm to 10 gpm, check the dispensing system for contamination.

— During the initial phase of operation after the introduction of a new blend, higher than normal dirt loads in the stored product can be anticipated. The increased level of contamination may cause filter clogging and reduced dispensing rates. Therefore, the frequency of filter cleaning and strainer basket replacement should be increased. Assure that applicable safety procedures are followed when changing filters and strainer baskets.

— Check the calibration of dispensing meters 10 days to 14 days after conversion to ensure that the product change has not affected meter accuracy. Confirm meter accuracy again two to three months after conversion to check for accelerated wear.

— For the first two weeks after the conversion to the new blend, test for phase separation daily using the gauge stick and then test before each subsequent delivery. If water is detected, stop all sales immediately. Determine the cause of the water in the fuel and resolve it. The remaining product in the tank is off specification and cannot be sold. Pump out and dispose or recycle off-specification product according to applicable hazardous waste regulations.

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