

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

REAFFIRMED, MAY 2020



AMERICAN PETROLEUM INSTITUTE

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

Downstream Segment

API RECOMMENDED PRACTICE 1626
SECOND EDITION, AUGUST 2010

ERRATA, FEBRUARY 2011

ADDENDUM, AUGUST 2012

REAFFIRMED, MAY 2020



AMERICAN PETROLEUM INSTITUTE

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

Where applicable, authorities having jurisdiction should be consulted.

Work sites and equipment operations may differ. Users are solely responsible for assessing their specific equipment and premises in determining the appropriateness of applying the RP. At all times users should employ sound business, scientific, engineering, and judgment safety when using this RP.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 1220 L Street, NW, Washington, DC 20005.

Copyright © 2010 American Petroleum Institute

Foreword

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 1220 L Street, NW, Washington, DC 20005.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

	Page
1 Scope	1
2 References	1
2.1 General	1
2.2 Normative References	1
2.3 Informative References	3
3 Definitions and Acronyms	5
3.1 Definitions	5
3.2 Acronyms	9
4 Ethanol and Ethanol Blend Characteristics	10
4.1 General	10
4.2 Vapor Pressure	10
4.3 Vapor Density	11
4.4 Liquid Density	11
4.5 Flash Point	11
4.6 Flammability	11
4.7 Flame Visibility	11
4.8 Electrical Conductivity	12
4.9 Water and Gasoline Solubility	12
5 Distribution Terminals	12
5.1 General	12
5.2 Product Receipts	12
5.3 Blending	15
5.4 Terminal Material Compatibility	20
5.5 Terminal Fuel Quality	21
5.6 Terminal Spill/runoff Management at Terminals	22
5.7 Terminal Source Segregation	23
5.8 Terminal Aboveground Storage Tanks	23
5.9 Terminal Tank Vents and Air Dryers	25
5.10 Terminal Flame and Detonation Arrestors	25
5.11 Terminal Pipe, Valves, Pumps, and Piping Systems	26
5.12 Terminal Metering	26
5.13 Terminal Vapor Control Systems	27
5.14 Terminal Permits	28
6 Tank Truck and Railroad Tank Car Transportation	28
6.1 Compatibility	28
6.2 Truck Loading	28
6.3 Railroad Tank Car Loading	30
7 Filling Stations	30
7.1 General	30
7.2 Material Compatibility	32
7.3 New Facilities	33
7.4 New Filling Stations with Aboveground Tanks	39
7.5 Converting Existing Filling Stations to E10	39
7.6 Converting Existing USTs to High-Blend Ethanol Fuels or E85	42
7.7 Converting Existing Aboveground Storage Tanks to High-Blend Ethanol Fuels or E85	44
7.8 Water in Storage Tanks	44

Contents

	Page
7.9 Accelerated Corrosion and Conductivity	46
7.10 Tank Truck Unloading	46
7.11 Quality Assurance	48
7.12 Record Keeping	48
8 Releases	48
8.1 General	48
8.2 Spill Causes	48
8.3 Spill Response	49
8.4 Reporting Requirements.	50
8.5 Training.	50
8.6 Emergency Response and External Communication	50
8.7 Consumer Concerns	50
9 Fire Protection	51
9.1 General	51
9.2 Fire-fighting Agents for High-blend Ethanol	51
9.3 Fire-fighting at Facilities Handling Multiple Fuel Types	52
Annex A (informative) Generally Accepted Values for Gasoline and Gasoline-Ethanol Blend Properties.	55
Annex B (informative) Components that Require Listing as an Approved Device	56
Annex C (informative) Orderly Approach to Assure that Proper Equipment and Procedures are used in Preparation of Underground Storage Tanks, Piping, and Dispensing Equipment	57
Figures	
1 Splash Blending Schematic	16
2 Sequential Blending—Dedicated Meters and Control Valves	18
3 Sequential Blending—Single Meter and Control Valves.	18
4 Ratio Blending Schematic	19
5 Equipment Pyramid.	31
6 UST System Showing Location of Flame Arrestors for High-blend Ethanol Storage.	43
Tables	
1 Internal Tank Coating Comparisons	25
2 DOT Hazard Class Identification	30
3 Stage II Vapor Recovery Requirements	37
A.1 Ethanol and Gasoline-Ethanol Blend Properties.	55
B.1 Components that Require Listing as an Approved Device from a Nationally Recognized Testing Laboratory.	56

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, handling 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 gasoline 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 ethanol 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 ethanol 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.