



E15 and Infrastructure

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Strategic Partnership Project Report
NREL/TP-5400-64156
May 2015

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List of Acronyms

AHJ	authority having jurisdiction
CARB	California Air Resources Board
CFR	Code of Federal Regulations
E0	pure gasoline
E10	10% denatured ethanol; 90% gasoline blendstock
E100	pure ethanol fuel
E15	15% denatured ethanol, 85% gasoline blendstock
E25	25% denatured ethanol, 75% gasoline blendstock
E85	marketing term for high-blend ethanol 51%–83%
EPA	U.S. Environmental Protection Agency
FDEQ	Florida Department of Environmental Quality
NACS	National Association of Convenience Store Owners
NREL	National Renewable Energy Laboratory
OSHA	Occupational Safety and Health Administration
OUST	Office of Underground Storage Tanks
PEI	Petroleum Equipment Institute
psi	pounds per square inch
RFA	Renewable Fuels Association
STI	Steel Tank Institute
STP	submersible turbine pump
UL	Underwriters Laboratories
ULSD	ultra-low sulfur diesel
UST	underground storage tank
vol%	percent by volume

Executive Summary

This paper addresses the compatibility of E15 (15% denatured ethanol, 85% gasoline blendstock) with equipment at refueling stations. Over the last decade, a tremendous amount of work by refueling equipment manufacturers, industry groups, and federal agencies has resulted in a long list of equipment that can be used with E15. This report addresses compatibility through a literature review, a summary of applicable codes and standards, review of equipment manufacturer products, and verification with manufacturers regarding which ethanol blends work with their products. Over time, the refueling equipment manufacturers have improved their sealing materials for compatibility with a wide range of fuels. Upgrading materials in equipment improves consumer safety and reduces the risk of releases to the environment.

It is often stated that tanks cannot be used to store E15, but this assumption is incorrect as the majority of installed tanks can store blends above E10. For many decades, underground storage tank (UST) manufacturers approved their tanks for blends up to E100, for example, all steel tanks and double-walled fiberglass tanks since the year 1990. Manufacturers of pipe thread sealants (pipe dope) used in UST systems have stated that their products have been compatible with ethanol blends up to E20 for many years. For those tanks with low ethanol blend certifications, the U.S. Environmental Protection Agency's (EPA's) Office of Underground Storage Tanks (OUST) issued *Guidance – Compatibility of UST Systems with Biofuels Blends* in 2011 to enable alternative compliance with federal code as UST systems are in use for decades. This guidance allowed tank manufacturers to issue letters stating the compatibility of their tanks with specific ethanol blends. All existing tank manufacturers have issued such letters, and the majority of installed tanks are compatible with E15. Additionally, all existing pipe manufacturers have Underwriters Laboratories (UL) listing for E100.

All fuel and vapor handling equipment at a station was reviewed to determine if it was certified by a third-party (such as UL) and if it was listed for specific ethanol blends. The aggregated list confirms there are UL testing standards available now for all gasoline–ethanol blends from 0% to 85% ethanol. Stations comprise approximately 60 pieces of equipment designed to move and control fuel and vapors. The function of most equipment is to prevent, detect, and contain releases. The equipment includes tanks; pipes; dispensers and associated hanging hardware (breakaway, hose, nozzle, and swivel); fill equipment; leak detection; overfill prevention; and vapor equipment. Some of this equipment is specifically covered by codes and standards while other equipment relies on sound design and manufacturing. Certain equipment types are typically UL listed—these include tanks, pipes, dispenser, hanging hardware, submersible turbine pumps, and shear valves. UL listing is not a requirement; some manufacturers simply prefer to have UL listings for their products. Manufacturers will select, which, if any, models they will list for ethanol blends above E10. A review was conducted with each manufacturer to determine compatibility with ethanol blends. There is an extensive list of E15 and E15+ compatible equipment available in the appendices.

A literature review going back 15 years was conducted to determine if there were any negative impacts during the multi-year deployment of E10 nationwide. No incidents of E10 causing releases (also referred to as leaks) from UST systems were identified. None of the reviewed literature noted any association between E10 and any specific UST release. The EPA OUST's Performance Measures' data on UST releases were reviewed, and as E10 was deployed

nationwide, the trend was fewer UST releases. Anecdotal input solicited from infrastructure industry experts said that they knew of no published reports of releases caused by E10.

There are future opportunities for retailers to remove or replace their current equipment not necessarily related to continuous changes in motor fuel composition. Credit card companies are requiring retail fueling stations to update their dispensers to accept new chip and PIN secure credit cards by October 2017, at which time fraud liability would switch to station owners if they have not updated their equipment. This presents an opportunity to increase E25 UL-listed equipment through a retrofit kit if electronics are being upgraded to accommodate the new credit cards, or if a station owner must purchase a new dispenser, it could pay a minimal amount more for an E25 dispenser. If a new dispenser is purchased, this may also present an opportunity to upgrade to an E85 dispenser, but at significant additional cost.

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1 Background

1.1 E15 Background

In 2011, the U.S. Environmental Protection Agency (EPA) approved E15 for use in conventional light-duty cars and trucks model year 2001 and newer.¹ As of the end of 2014, 65% of the registered gasoline vehicles are 2001 and newer.² EPA approved the Clean Air Act waiver based on significant testing and research (McCormick et al. 2013). EPA defines E15 as ethanol blends greater than 10 volume percent (vol%) and up to 15 vol% ethanol. E15 is not widely available largely due to misinformation and retailer concerns. The primary concerns retailers have expressed include additional federal and state regulations to sell E15, misfueling liability, and the inability to meet the EPA's vapor pressure requirement for E15 in the summer.

Regulations to sell E15: There are several federal government requirements for selling E15 that do not apply to other fuel sold at stations. Federal regulations for a station to sell E15 include: an EPA E15 label on each dispenser selling E15, implementation of a misfueling mitigation plan,³ participation in a fuel quality survey (ensures dispenser is labeled and measures ethanol content and vapor pressure), product transfer documents for all deliveries of fuel for E15 use, and an approved dispenser/hose configuration.⁴ All requirements for E15 are available in the Renewable Fuels Association's (RFA's) *E15 Retailer Handbook*.⁵

Exposure to liability: Some stations owners have expressed concerns about misfueling of E15 into older vehicles. It is not uncommon for a consumer to be unaware of the model year of their vehicle. Under the Clean Air Act, any entity in the transportation fuel supply chain, including refueling stations, could be fined by the EPA up to \$37,500 per day for violations. The EPA has never fined a station this amount, and it has the authority under code to reduce the fine based on business size.

Vapor pressure: Blending of ethanol in to gasoline in the 10 to 15 vol% range typically causes the vapor pressure to increase by 1 pound per square inch (psi).⁶ The EPA regulates gasoline vapor pressure from June 1 to September 15 to reduce evaporative fuel emissions. In 1992, E10 received a 1-psi waiver, commonly known as the 1-pound waiver, from these requirements for non-reformulated gasoline areas. For purposes of the 1-pound waiver, E10 blends are defined as containing 9 to 10 vol% ethanol. The E10 1-pound waiver code is included in the Code of Federal Regulations which states that the waiver is for E10 only and not any other ethanol blend.

¹ E15 Notices & Regulations. EPA. <http://www.epa.gov/otaq/regs/fuels/additive/e15/e15-regs.htm>

² Polk data 2014. Based on a total U.S. gasoline light-duty vehicle registration of 228 million of which 149 million are model year 2001 and newer.

³ RFA developed *Renewable Fuels Association Model E15 Misfueling Mitigation Plan*, which was approved by EPA in March 2012 and is available free of cost to stations selling E15.

<http://www.epa.gov/otaq/regs/fuels/additive/e15/documents/rfa-model-e15-misfueling-mitigation-plan.pdf>

⁴ For hose configurations, please review the EPA-approved *Addendum: E15 Retail Advisory (updated 1/2013)*. Last accessed March 10, 2015: <http://www.epa.gov/otaq/regs/fuels/additive/e15/documents/rfa-e15-retail-advisory-addendum.pdf>

⁵ *E15 Retailer Handbook*. RFA. Accessed March 10, 2015:

http://ethanolrfa.3cdn.net/643f311e9180a7b1a8_wwm6iulj.pdf

⁶ Vapor pressure is a method to measure the volatility of gasoline. Formerly known as Reid vapor pressure or RVP, today it is technically dry vapor pressure equivalent (DVPE) and is measured using ASTM Method D5191.

E15 is not afforded the same 1-pound waiver and therefore cannot be sold in non-reformulated gasoline areas in summer months unless a lower vapor pressure hydrocarbon blendstock is used.⁷

1.2 Station Data

Overall, the total number of retail stations has declined over time, but approximately 1,600 new stations open annually (AFDC 2015, NACS 2014a). The following statistics from the National Association of Convenience Store Owners (NACS) *2015 Retail Fuels Report* show some of the challenges in reaching various types of station owner and their ability to afford equipment upgrades and installations (NACS 2015):

- There are approximately 153,000 fueling stations.
- Fifty-eight percent are single-store owners/operators.
- Major oil companies own 0.4% of stations.
- Approximately 50% of stations sell branded fuel.
- Convenience stores sell 80% of transportation fuels. Hypermarkets (large grocery chains or merchandise stores) sell 14%. The remainder of fuel is sold at low-volume locations like marinas.
- Sales per convenience store average 128,000 gallons per month (4,000 gallons/day).
- Transportation fuels are 71% of sales at a convenience store, but only 36% of profits.
- The average profit per convenience stores in 2013 was \$55,000 with most profit coming from selling products in the store.

One of the challenges in introducing E15 is reaching all the single-station owners. As evidenced in Figure 1, after single-store owners, the next highest percentage of ownership—17%—is ownership groups with more than 500 stations.

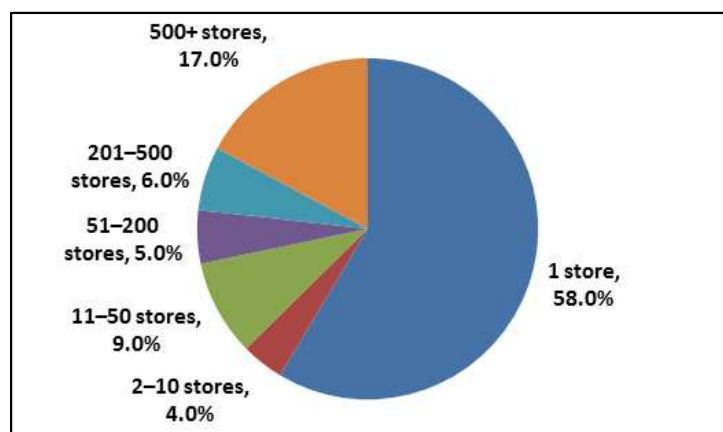


Figure 1. Breakout of station ownership

Source: *2015 Retail Fuels Report*. NACS, 2015

⁷ CFR 42 Chapter 85 Subchapter II Part A 7545 Regulation of Fuels (h) (4)

Approximately 50% of convenience stores are branded by either an oil company (31%) or refinery/distributor (19%) (NACS 2014b). This ensures a market for oil and refinery company products and provides station owners with brand recognition. A contract typically lasts 10 years, and the terms will include sales volume requirements for fuels supplied, including regular and premium, and diesel if the station sells it. Due to sales volume requirements, there will be more challenges for branded stations to sell E15 than independent stations or convenience store chains.

2 Regulations, Codes, and Certifications

In addition to the EPA requirements summarized in Section 1.1, E15 is subject to other regulations and codes that apply to other transportation fuels. There is no one entity that regulates all equipment at a station. Often times, the local authority having jurisdiction (AHJ) approves a station to sell a new fuel. “AHJ” refers to regulating organizations, offices, or individuals responsible for overseeing codes and standards and ensuring safety. Examples of AHJs include local fire marshals, state energy and environment offices, air and water boards, and similar organizations or offices. The most significant federal agencies overseeing some equipment at stations include EPA’s Office of Underground Storage Tanks (OUST) and the Occupational Safety and Health Administration (OSHA). The Underwriters Laboratories (UL) role is significant in developing testing protocols and certifying refueling equipment for specific fuels.

Two organizations, the National Fire Protection Association (in particular, Code 30A, which includes language on alternative compliance to address new fuels) and the International Code Council, provide standard codes for retail stations that are accepted or modified to meet local requirements. Other organizations developing best practices and codes include American Petroleum Institute, Fiberglass Tank and Pipe Institute, NACE International, National Conference on Weights and Measure, National Leak Prevention Association, Petroleum Equipment Institute (PEI), and Steel Tank Institute (STI).

2.1 EPA Office of Underground Storage Tanks

EPA’s OUST regulates tanks that store transportation fuels under Subtitle I of the Solid Waste Disposal Act states that a tank system must be compatible with the fuel stored. This code is currently under revision with a final rule expected in 2015. States administer the underground storage tank (UST) program, and compatibility is the responsibility of the tank owner.

The following critical components must be demonstrated as in compliance with federal code: tank (including tank lining); piping; line leak detector; flexible connectors; drop tube; spill/overflow equipment; submersible turbine pumps (STPs); sealants (pipe dope, thread sealant, fittings, gaskets, O-rings, bushings, couplings, boots); containment sumps; release detection floats/ sensors/probes; fill and riser caps; and shear valves.

Title 40 of the Code of Federal Regulations (CFR) Part 280–Technical Standards and Corrective Action for Owners and Operators of Underground Storage Tanks (UST), covers design, construction, and installation; operating requirements; release detection; release reporting; corrective action for releases; UST out-of-service and closures; financial responsibility (ability to cover the costs to clean up a release); and lender liability. It requires that tanks and piping be constructed, installed, and any portion that is underground and routinely contains product be protected from corrosion in accordance with a code of practice developed by a nationally recognized association or independent testing laboratory. It also requires that the UST be made of or lined with materials compatible with the regulated substance stored. There are requirements to have equipment installed to prevent releases, including the use of spill containment and overfill prevention equipment. There are also requirements to have equipment capable of detecting releases of regulated substances from the portions of the UST that routinely contain product. Since 1986, UST owners must submit documentation that a new tank has been installed

along with certification of installation and keep maintenance records. UST owners must report all suspected and confirmed releases, generally within seven days.

40 CFR Part 281—Approval of State Underground Storage Tank Programs, and Part 282—Approved Underground Storage Tank Programs, explain the requirements to authorize states to administer UST federal code under Subtitle I of the Resource Conservation and Recovery Act. 40 CFR Part 302 Designation, Reportable Quantities, and Notification, defines hazardous subjects stored in USTs (includes gasoline, ethanol, and many other chemicals), releases, and penalties.

In 2011, OUST released the *Guidance – Compatibility of UST Systems with Biofuels Blends* document, which provides an alternative path for demonstrating compliance with the compatibility requirements in federal code when storing biofuels above E10 or B20 (20% biodiesel; 80% petroleum diesel) (EPA 2011). OUST believes that while most biofuel blends are compatible with tanks and pipes, there could be issues with associated UST equipment.⁸ Tanks and associated equipment are in use for decades, and the guidance allows manufacturers to state compatibility with specific biofuel blends. This guidance is expected to be published in the CFR in 2015 after the Office of Management and Budget approves it. Incorporating this guidance into the CFR gives refueling station owners an added layer of security as it ensures their tank insurance is uncompromised, which is also an important factor in their ability to maintain a line of credit with their financial institution.

2.2 Underwriters Laboratories

UL is the primary third-party certification laboratory servicing the refueling equipment industry globally. UL develops testing standards by consensus and allows manufacturers time to comply.⁹ These standards have been available for many decades in the marketplace. There are many standards covering individual products in the fueling system and many different approaches to evaluating safety. The more recent standards address higher levels of ethanol and the introduction of biodiesel. Some standards comprehensively evaluate structural integrity, material compatibility, operating performance, and electrical safety while others may limit evaluations to specific items. In the past, some standards that provided listings for specific fuels were limited to petroleum products, but were then revised to handle low levels of ethanol blends. Over time, many UL standards provided the option for equipment manufacturers to list their products for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85). While some UL standards allow manufacturers to select which fuel ratings to list for, there is trend towards revising standards to require equipment to be listed for all fuel types and blends that are commercially available. Testing is not conducted with commercial fuels. The trend is towards aggressive test fluids where gasoline is represented by Reference Fuel C (equal parts iso-octane and toluene) and it is mixed with ethanol, acid, and water. Table 1 summarizes the relevant refueling equipment UL standards. Information on applicable UL standards for each piece of refueling equipment at a station is described in Section 4. Table 1 confirms that there are UL testing standards available now for all gasoline–ethanol blends from 0% to 85% ethanol content.

⁸ Communicated by EPA OUST staff during a December 2013 call with National Renewable Energy Laboratory and Oak Ridge National Laboratory staff.

⁹ The terms “UL listed” and “UL certified” can be used interchangeably.

Table 1. Key UL Testing Standards for Refueling Equipment

UL Testing Standard	Equipment Covered	Listing for Ethanol Blends
UL 58	Underground steel tanks	Does not list for specific fuels
UL 1316	Underground fiberglass tanks	E100 (non-aggressive test fluids)
UL 971	Pipes and pipe fittings	E100 (non-aggressive test fluids)
UL 2447	<i>Sumps</i> : tank, dispenser, transition, fill/vent (spill buckets) <i>Sump fittings</i> : penetration, termination, internal, test and monitoring <i>Sump accessories</i> : cover, frame, brackets, chase pipe	E85 (non-aggressive test fluids for current listings). The new Standard 2447 requires testing with aggressive E25 and E85. Manufacturers must recertify by June 2016.
UL 2583	<i>Part I Vapor Control Products</i> : emergency vents, pressure vacuum vents, fill and vapor adaptors, and monitor well caps <i>Part II Liquid Control Products</i> : overfill protection (or prevention) valves, ball float vent valve (or flow restriction device), drop tubes, extractor tee, jack screw kit, face seal adaptor (or threaded riser adaptor), fill cap and adaptors	Part I and Part II require testing with aggressive E25, E85, B25, and Reference Fuel F.
UL 87	Power-operated dispensing devices for petroleum products	E10 (non-aggressive test fluid)
UL 87A	Power-operated dispensing devices for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 25	Meters for flammable and combustible liquids and LP-gas	E10 (non-aggressive test fluid)
UL 25A	Meters for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 79	Power-operated pumps for petroleum dispensing products	E10 (non-aggressive test fluid)
UL 79A	Power-operated pumps for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 330	Hose and hose assemblies for dispensing flammable liquids	E10 (non-aggressive test fluid)
UL 330A	Outline for hose and hose assemblies for use with dispensing devices dispensing gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 331	Strainers for flammable fluids and anhydrous ammonia	E10 (non-aggressive test fluid)

UL Testing Standard	Equipment Covered	Listing for Ethanol Blends
UL 331A	Strainers for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 428	Electrically operated valves	E10 (non-aggressive test fluid)
UL 428A	Outline for electrically operated valves for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 567	Emergency breakaway fittings, swivel connectors and pipe-connection fittings for petroleum products and LP-gas	E10 (non-aggressive test fluid)
UL 567A	Emergency breakaway fittings, swivel connectors and pipe-connection fittings for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 842	Valves for flammable fluids	E10 (non-aggressive test fluid)
UL 842A	Valves for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 - E85)	E25 and/or E85 (tests with aggressive test fluids)
UL 2586	Hose nozzle valves	E10 (non-aggressive test fluid)
UL 2586A	Hose nozzle valves for gasoline and gasoline–ethanol blends with nominal ethanol concentrations up to 85% (E0 – E85)	E25 and/or E85 (tests with aggressive test fluids)

Source: UL

2.2.1 UL Standards Summary

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

This standard covers underground fiberglass tanks and allows manufacturers to select in which of three fuel ratings to have their product listed. Essentially it is an “a la carte” menu. Both existing fiberglass tank manufacturers have UL listing for E100.

The test fluids used to evaluate compatibility for the three fuel ratings are:

1. Petroleum products: includes but is not limited to: regular and premium gasoline, diesel fuel, fuel oil, Reference Fuel C, kerosene, and fuel oil #6 (option at elevated temperature)
2. Alcohol and petroleum blends: includes fuel #1 plus E10 and E30. (This allows listing for E10 but not E30 despite testing with it.)
3. Alcohol and petroleum blends: includes #1 and #2 test fluids plus E15, E50, E100, and methanol blends at the same volumes.

UL 58, Standard for Steel Underground Tanks for Flammable and Combustible Liquids

This standard covers underground steel tanks. It does not test or certify equipment for specific fuels but instead for flammable and combustible liquids. All existing U.S. steel tank manufacturers have UL listing under this standard.

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

This standard provides certification for external corrosion protection systems applied to UL 58 steel tanks. There are four parts, and parts i (galvanic-type cathodic protection systems), ii (fiber-reinforced plastic composite systems), and iv (polyurethane-coated systems) do not test with specific fuels; listing is for flammable and combustible liquids. Part iii (polyurethane, polyurea, high density polyethylene, or fiber-reinforced plastic jacketed systems) provides ethanol listing only for jacket tanks with secondary containment because there is an interstitial space formed by the jacket. The test requires 30 days of exposure to test fluid and includes the same testing fluids as UL 1316.

UL 1856, Underground Fuel Tank Internal Retrofit Systems

This standard allows a station owner to retrofit the existing tank onsite in three ways, all of which require the tank's internal surface to be refurbished prior to applying nonmetallic coatings with new fuel ratings. In the past, this standard allowed manufacturers to select which class of fuels to list for, the same as UL 1316. However, UL 1856 has recently been revised to require compliance with all automotive fluids, including E25 and E85, by June 14, 2017.

UL 142, Aboveground Flammable Liquid Tanks

This standard covers aboveground tanks, which are not very common at commercial fueling stations. It does not test or certify equipment for specific fuels but instead for flammable and combustible liquids. UL Standards 2080 and 2085 also apply to aboveground tanks for fire protection, as they require use of a UL 142 core tank.

UL 971, Standard for Nonmetallic Underground Piping For Flammable Liquids, and UL 971A, Outline of Investigation for Metallic Underground Piping for Flammable Liquids

This standard covers flexible and rigid piping and pipe fittings for both fuel and vapor. This standard has similar fuel ratings and uses similar test fluids as UL 1316. All existing pipe manufacturers have UL listing for E100.

UL 2039, Outline of Investigation for Flexible Connector Piping for Fuels

This standard covers flexible connectors that typically connect underground piping to other equipment in sumps. In the past, this standard offered the same selection of test fluids as UL 1316. The standard was updated in December 2010 to require all automotive fluids, including E25 and E85.

UL 2447, Containment Sumps, Fittings and Accessories for Fuels

This standard covers containment sumps (dispenser, tank, transition, spill buckets) and all the fittings (termination, penetration, test/monitor, internal) and accessories (frames, brackets, chase, etc.). This standard previously and currently allows manufacturers to select test fluids from the same three classes as UL 1316. However, the standard has been updated, and manufacturers will need to demonstrate compliance with the standard and listing for all automotive fuels, including E25 and E85, by June 30 2016 (originally the date was June 30, 2015, but manufacturers asked for an extension). Some manufacturers list under this standard and others do not.

UL 2583, Outline for Investigation for Fuel Tank Accessories

This new standard covers equipment that may have been listed under other, older standards and also covers equipment that has never previously been listed by UL. Few manufacturers listed products under the old standards. This new standard requires manufacturers to list all automotive fuels, including E25 and E85. Part I was issued in June 2011 to cover all vapor control products—any functional device on tank top or directly fitting on or indirectly connected to a pipe to control vapors. Equipment covered includes emergency vents, pressure vacuum vents, fill and vapor adaptors, and monitor well caps. Part II was issued in June 2014 and covers liquid control products; specifically functional equipment designed to connect to tank top and to contain spills and prevent overfills. This covers overflow protection (or prevention) valves, ball float vent valves (or flow restriction devices), drop tubes (never previously listed by UL), extractor tees, jack screw kits, face seal adaptors (or threaded riser adaptors), fill caps, and adaptors.

UL 87, Power-Operated Dispensing Devices for Petroleum Products, and UL 87A, Standard for Power-Operated Dispensing Devices for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations up to 85 Percent (E0 – E85)

UL 87 allows listing for up to E10 with minimal exposure to test fluids. In 2007, UL introduced UL 87A, Outline of Investigation for Power-Operated Dispensing Devices for Gasoline/Ethanol Blends with Ethanol Content Greater than 15 Percent to address E85. At the time, UL 87A covered additional testing for multiple pieces of related equipment. These standards work somewhat differently than those for tanks, pipes, and associated tank equipment. A manufacturer can select UL 87 for listing a product up to E10 or UL 87A to list a product for up to just E25 or opt to test and list it for E85 also. Since development of UL 87A in November 2012, equipment has been split out into different standards specific to each equipment type. (The designation “A” after a listing denotes the option to list a product for up to just E25 and/or E85).

- Breakaways, swivels, pipe connection fittings: 567/567A
- Dispensers: 87/87A
- Filters: 331/331A
- Hoses: 330/300A
- Meters: 25/25A
- Nozzles: 2586/2586A

- Shear valve (emergency shut-off valve): 842/842A
- Submersible turbine pump: 428/428A

2.3 Occupational Safety and Health Administration

OSHA regulates some fuel-dispensing equipment. Its regulations applicable to service stations have not been updated in decades and therefore do not specifically address biofuels. OSHA is planning to update these standards to address new fuels in the marketplace.

OSHA 1910.106 (g)(3)(iv) and (g)(3)(vi)(a) require dispensers and nozzles to be listed by a third party for specific fuels.

OSHA 1910.106(b)(1)(i)(b) and (c)(2)(ii) require tanks, piping, valves, and fittings other than steel to use sound engineering design for materials used; however, there is no listing requirement. OSHA 1910.106(b)(1)(iii) covers steel tanks and requires sound engineering and compliance with UL 58 and American Petroleum Institute Standards 650 and 12B as applicable.

2.4 State Regulations

2.4.1 California Air Resources Board

The California Air Resources Board (CARB) is the division of the California Environmental Protection Agency tasked with reducing air pollutants. CARB developed test procedures for vapor recovery equipment and requires specialized enhanced vapor recovery equipment. The following equipment must be approved under this program: adaptors, drop tubes, hoses, nozzles, overfill protection devices, pressure vacuum vents, spill containers, and vapor return piping (CARB 2015). The requirements are not for equipment use with specific fuels.

2.4.2 Florida Department of Environmental Quality

The Florida Department of Environmental Quality (FDEQ) approves station storage tank equipment through state regulations (FDEQ 2015). The regulations require State of Florida approval of tank system equipment prior to installation or use, except for the following equipment: dispensers, islands, nozzles, hoses; monitoring well equipment; manhole and fillbox covers; valves; cathodic protection stations; metallic bulk product piping; small-diameter piping not in contact with soil unless the piping extends over or into surface waters; and vent lines. All other equipment must be approved through a third-party laboratory demonstration that provides a technical evaluation of the equipment, test results verifying equipment functions as designed, and a professional certification that the equipment meets Florida performance standards (FDEQ 2015). The performance standards are straightforward and are not fuel specific. The State of Florida has a long list of approved equipment (FDEQ 2015).

3 Literature Review

A literature review was performed to identify specific components or materials that have been associated with releases from USTs storing E10. The information is intended to be used to minimize the potential for future releases, particularly during the rollout of E15. The literature review was limited to releases identified during the years 2000 to the present. During the years covered by this literature review, the penetration of E10 into the U.S. gasoline pool went from minimal in many regions of the country to full saturation.

Scope of Review

The following sources were used:

- LUSTLine 2000 – present.
- *PEI Journal* 2009 – present (PEI Journal not available online before 2009).
- *TulsaLetter* (The *TulsaLetter* is the official e-newsletter of PEI.) 2000 – present.
- Experts in refueling infrastructure were contacted, including EPA, Fiberglass Tank and Pipe Institute, PEI, STI, and oil industry representatives.
- EPA OUST release data website.
- Web search for literature and data on UST E10 releases.

Major Findings

- The number of reported UST releases has been steadily declining since 2000 from occurring in about 2% of all USTs in the United States to about 1% in 2014 (EPA 2015a).
- There is no evidence of different trends in the number of UST releases between states that were early adopters of E10 and states that only recently reached full saturation of E10.
- EPA has collected data on the source and cause of UST releases. Because of the high number of releases that were attributed to “unknown” or “other causes,” the data cannot be considered conclusive, but roughly 10% of all releases were attributed to corrosion in a 2004 review and 7% in 2009 (EPA 2004, Eigmey 2011).
- Anecdotal input solicited from infrastructure industry experts said that they knew of no published reports of releases caused by E10.
- None of the reviewed literature listed any association between E10 and any specific UST release.

Figure 2 shows the number of USTs declining over time which is a result of the declining number of retail stations. There were approximately 571,000 registered USTs in the United States as of September 2014 (EPA 2015a).¹⁰ OUST provides UST release data annually, and over the time that E10 spread across the country, the number of releases has tended to decline from 2% of registered tanks in 2000 to 1.2% of USTs experiencing a release in 2014. Figure 3

¹⁰ A year is measured by the federal government’s fiscal year from October 1 to September 30.

shows that as E10 was deployed over the last several years, the number of UST releases did not increase. Any problems associated with introducing a different fuel at an existing station usually happen soon after storing a different fuel. In interpreting these results, it should be noted that many releases are discovered and reported years after they first occurred when the tank is removed from service. Other releases are due to operator errors (such as overfilling or poor maintenance) and may be completely unrelated to the fuel stored.

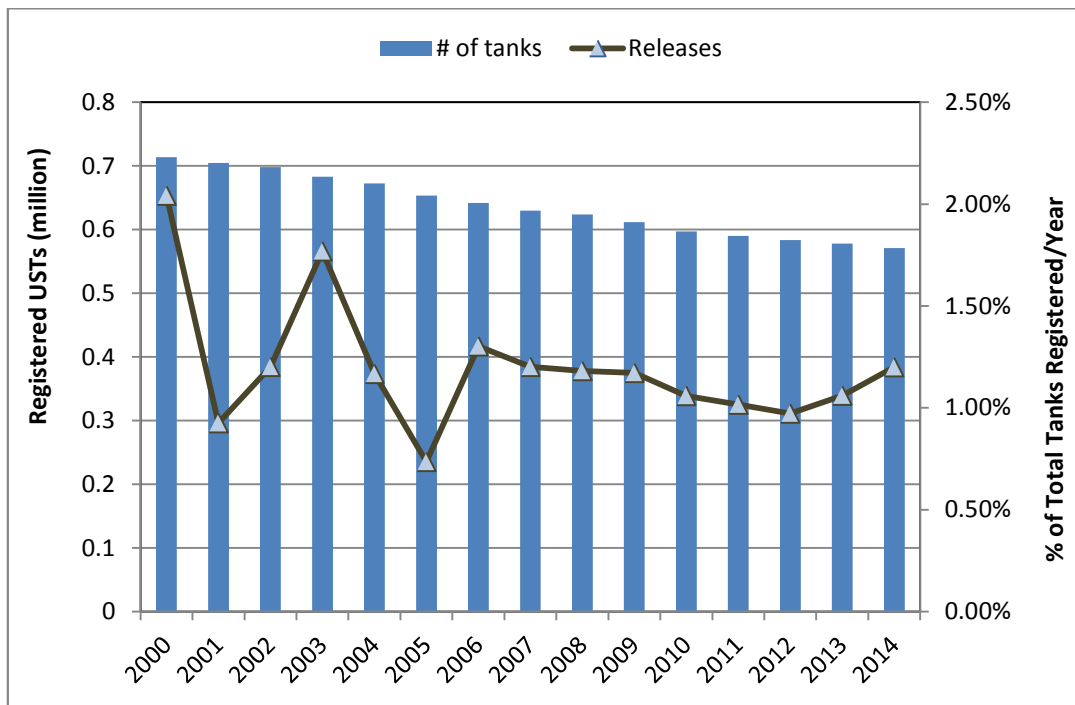


Figure 2. Registered USTs and releases

Source: UST Performance Measures. EPA OUST. Last accessed March 10, 2015:
<http://www.epa.gov/oust/cat/camarchv.htm>

The Energy Policy Act of 2005 included a requirement for UST release reports to include a source and cause. A LUSTLine report analyzed 2009 data reports from 47 states reviewing 5,168 UST releases (Eighmey 2011). While the data point to some areas where leaks are common and uncommon, approximately one-third of leaks were listed as other or unknown. Some releases occur no matter what fuel is being delivered or stored. These releases include physical/mechanical damage (14.9%), overfills (4.8%), spills (3.8%), and installation problems (1.0%). Transportation fuels can cause corrosion, and this study found corrosion caused 7.5% of releases. The topic of STP corrosion comes up as an issue, but a small scoping study performed for RFA found that STPs were not failing. This 2009 report shows the STP as the source of a release in just one of 5,168 incidents. The EPA reviewed 608 UST releases in 2004 and found causes of release were physical/mechanical (39.8%), other/unknown (27.0%), spill/overfill (26.6%), and installation (3.1%) (EPA 2004). Table 2 summarizes 2009 data for cause and source with detailed data available in Appendix A.

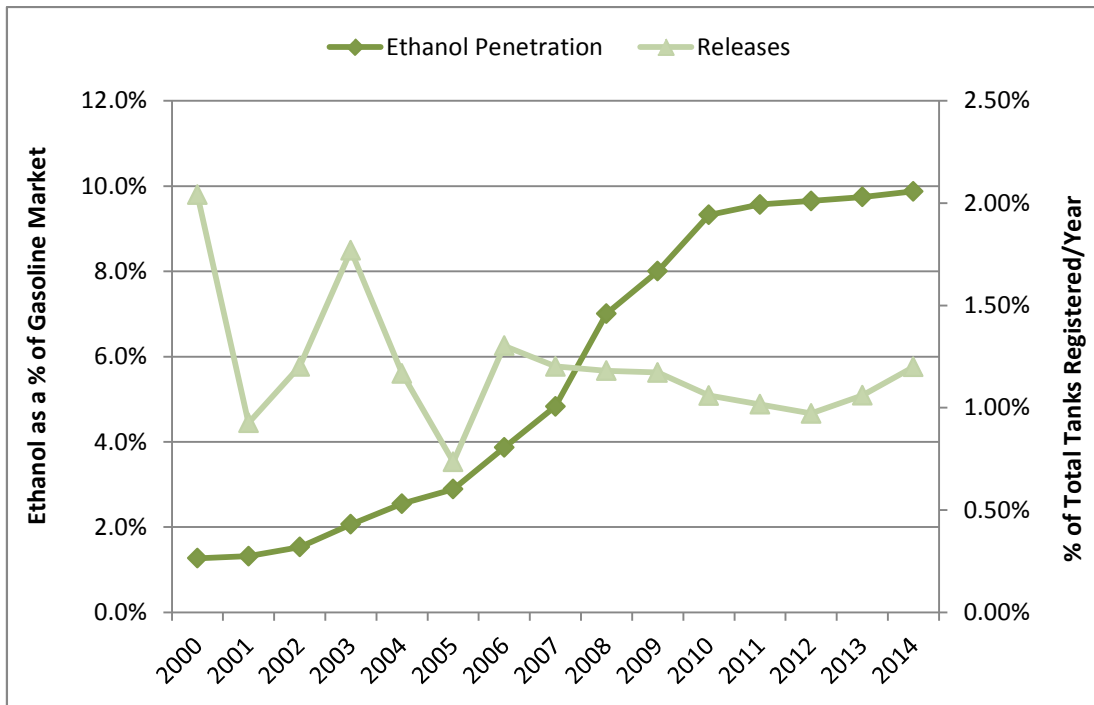


Figure 3. Ethanol penetration and UST releases

Source: Energy Information Agency U.S. Product Supplied of Finished Motor Gasoline: <http://www.eia.gov/tools/faqs/faq.cfm?id=23&t=10> and Monthly Energy Review Table 10.3 Fuel Ethanol Overview: <http://www.eia.gov/totalenergy/data/monthly/>

Table 2. Sources and Causes of UST Releases

UST Releases	2009 Data (5,168 releases)	
	#	%
Tank	1,616	31.3%
Piping	720	13.9%
Dispenser	655	12.7%
STP	76	1.5%
Delivery Problem	342	6.6%
Other	564	10.9%
Unknown	1,195	23.1%
Physical/Mechanical Damage	770	14.9%
Spill or Overfill	441	8.5%
Corrosion	385	7.4%
Installation	54	1.0%
Other	466	9.0%
Unknown	3,051	59.0%

Source: Eighmey, C., March 2011, LUSTLine Bulletin #67. Accessed March 10, 2015: http://www.neiwpc.org/lustline/lustline_pdf/lustline_67.pdf .

As of January 2003, FDEQ requires County Tanks Program inspectors to submit a leak autopsy form. A 2007 study reviewed Florida leak data and found the sources were spill buckets (48%), piping (14%), dispensers (12%), and tanks (10%) (Mott-Smith 2007). The causes were unknown (36%), overfill (25%), mechanical (16%), material (10%), and corrosion (7%). Spill buckets are designed to reduce leaks during fuel delivery. At the time of the report, Florida's E10 penetration was only 5%, so these results do not reflect E10 storage releases but do highlight the importance of maintenance and appropriate fill techniques.

The literature review was directed specifically at identifying ethanol sensitive equipment and included conversations with several leading infrastructure experts to determine if there was evidence and/or literature showing issues with E10 in USTs. Experts suggested that the long, slow introduction of E10 allowed time for refueling equipment manufacturers to adjust to it. None of the experts was aware of any reports and thought it would be unlikely to find any reports on E10 releases. There are examples of equipment failing such as Total Containment, Inc. flexible piping, but it was the opinion of experts that poorly made products would have failed with any fuel, and the failures of flexible piping occurred not long after their introduction and prior to the widespread use of E10. This is not to say that there were no issues during the deployment of E10, just that there were no known releases and no reports on this subject. An Oak Ridge National Laboratory study of E15 stated "UST stakeholders generally consider fueling infrastructure materials designed for use with E0 to be adequate for use with E10, and there are no known instances of major leaks or failures directly attributable to ethanol use. It is conceivable that many compatibility issues, including accelerated corrosion, do arise and are corrected onsite and, therefore do not lead to a release." (Kass et al. 2012).

Several experts cited EPA work on STP corrosion, and both EPA and Battelle work on ultra-low sulfur diesel (ULSD) corrosion. The National Renewable Energy Laboratory (NREL) previously reviewed the STP corrosion issue for RFA. STPs draw fuel from the UST and deliver it to pipes connected to an aboveground dispenser. The State of Tennessee and EPA OUST have investigated and presented on premature STP corrosion. The theory on the cause is that temperature differentials between sumps and UST systems in summer months (or in warm and humid climates) may enable vapors to enter the STP sumps. Vapors that may contain ethanol capable of dissolving in water may condense on metallic portions of an STP, which reacts with acetobacter and oxygen to form acetic acid, leading to corrosion. NREL spoke with numerous state UST offices and county-level experts and did not find any evidence that corrosion was leading to failures or early replacement of STPs. Accelerated corrosion of ULSD UST systems has been observed nationwide. These instances of corrosion started to be reported in 2007 when ULSD was first introduced. The cause of corrosion is currently under investigation, and an EPA OUST study on ULSD corrosion is expected in late 2015.

4 Equipment at Station

A service station consists of many interconnected pieces of refueling equipment necessary to deliver fuel to vehicles. There are approximately 60 pieces of equipment at a station designed to handle fuel and vapor. The equipment delivering fuel to a vehicle includes tanks, pipes, submersible turbine pump, dispenser, and hanging hardware. The remainder and majority of equipment are used to prevent, detect, and contain releases and there is equipment for fuel delivery. This category includes overfill protection, leak detection, shear valves, fill and vapor caps and adaptors, containment sumps and all associated fittings and accessories of these equipment types.

Figure 4 is a diagram of equipment at a station. Table 3 provides a list of the equipment shown in the diagram and includes the purpose of the equipment; common materials; if the equipment is listed by UL, and if it is UL listed, is it tested with fuel or not; if it was tested with fuel; and what the highest level of ethanol listing available under the standard is. Note that #1 in Figure 4 shows just the tank on the diagram, but the table includes information about steel, fiberglass, and aboveground storage tanks and their protections. This list is comprehensive, and not all stations will have equipment on this list. The table data were taken from the following sources: equipment list and diagram (Source North America); UL; equipment materials (manufacturer product websites and catalogs); and function (PEI Wiki and manufacturer product websites and catalogs).

All known manufacturer website product pages and catalogs were reviewed for every equipment type and model to determine if the products could be used with blends above E10. All known manufacturers were contacted to review compatibility lists. This resulted in an extensive list of equipment compatible with blends above E10. Appendix B provides an equipment list of UL-listed aboveground components for blends above E10. Appendix C provides a compatibility list of tanks. Appendix D is a list of compatible pipes. Appendix E provides information for other UST equipment with manufacturer, equipment type, model names/numbers, ethanol compatibility (%), if it is UL listed, and if it is listed for the ethanol fuel determined by the manufacturer. It is important to note that manufacturers typically keep product names over time but may change product model numbers. Also, manufacturers will introduce new product names, and there is a higher likelihood that these products will be compatible with E15.

Determination of compatibility of equipment with ethanol blends is determined by both regulations and manufacturer statements. Manufacturers have laboratories where they conduct fuels testing to determine if the materials they are using work with a range of fuels. Tanks are subject to EPA OUST regulations, and all existing tank manufacturers provided letters stating compatibility with ethanol blends (see Appendix A). Tanks, pipes, and most aboveground equipment are typically UL listed for specific fuels. This includes dispensers, breakaways, hoses, nozzles, swivels, shear valves, and STPs.

Some manufacturers of other UST equipment make an effort to obtain UL listing for all their products, some obtain it for certain products, and others do not obtain UL listing for their products. Many products are approved by the manufacturer for blends above E10 but are not UL listed for blends above E10. This is largely due to the recent availability of ethanol test fluids under UL testing standards, and over time it is expected that more equipment will be UL listed

for blends above E10. In many instances, there is not a history of many manufacturers obtaining UL listing for certain product types such as fill equipment or containment sumps.

There is no regulation that requires station owners to keep records of their equipment, making determination of compatibility challenging for stations without equipment records. One potential source of tank information is the STI, which maintains a list of steel tanks if owners send in the warranty card. STI also provides a method to determine tank type and manufacturer (see Appendix F).

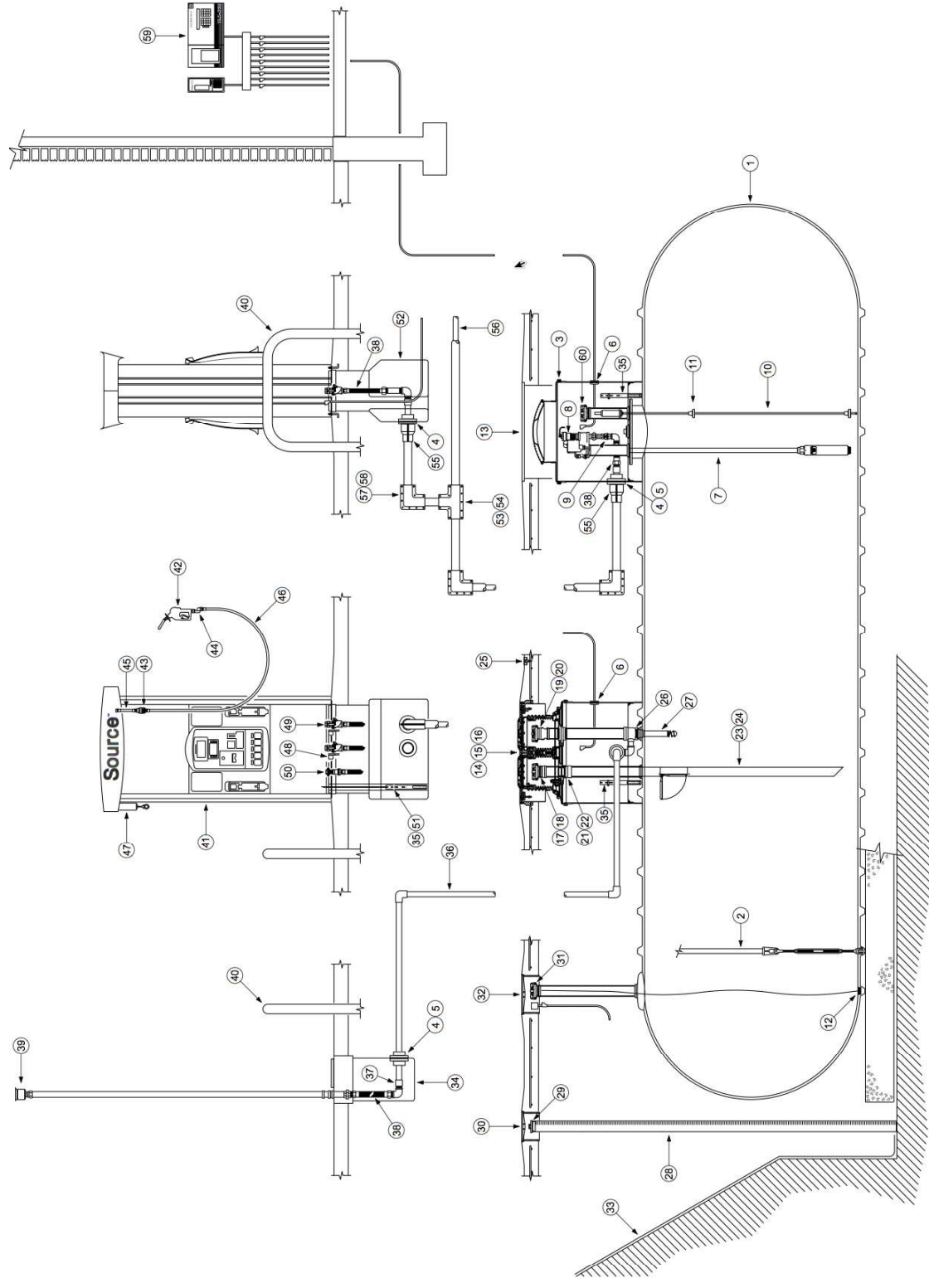


Figure 4. Station equipment diagram

Source: Diagram provided by Source North America, a fueling equipment distributor.

Table 2. Station Equipment List-Materials and Function

#	Equipment	UL	UL Std.	Test w/ fuel	Ethanol Test fluids	Materials	Function
1	Tank-steel	yes	58	no	none	steel	Stores fuel.
1	Tank-fiberglass	yes	1316	yes	E100	fiberglass	Stores fuel.
1	Tank-external corrosion protection Jacketed steel tank	yes	1746	yes ^a	E100 ^a		Protects tank from corrosion.
1	Tank-lining and upgrades	yes	1856	yes	E100		General tank protection.
1	Tank-above ground	yes	142/142A	no	none	fiberglass or steel	Stores fuel.
1	Tank-above ground fire protection	yes	2080/2085	no	none		Protects tank from fire.
2	Tank straps	no				metal, fiberglass, and other	Outside of tank and usually made of concrete. Devices installed in storage tank excavations to prevent tanks from floating out of the ground in event of a high level of groundwater in the excavation or a high groundwater level after the installation is complete.
3	Sump and cover (tank)	yes	2447	yes	E85	polyethylene, fiberglass	Contains spills from a tank.
4	Sump entry fitting (boot)	yes	2447	yes	E85	fiberglass, bronze, stainless steel, nitrile rubber	These seals provide a studed flange connection to create a positive and secure seal where the rubber contacts the sump wall and also around the pipe or conduit.
5	Sump penetration fittings	yes	2447	yes	E85	fiberglass or flexible plastic	A fitting that provides a liquid and vapor-tight seal around both the piping or conduit and the wall of a containment sump.
6	Flexible entry boots (conduit entry)	yes	no	no	none	glass filled nylon, nitrile	Pipe where electric wires are inserted.
7	Submersible turbine pump	yes	428 428A	yes	E10 E25 and/or E85	cast aluminum, steel, fluoroarbon	Delivers fuel from the tank to the dispenser.
8	Mechanical line leak detector	yes	1238	no	none	brass, stainless steel, copper, fluoroarbon	A device used to detect the presence of a leak in the piping. Usually connected to the STP.
9	Ball valve	yes	842 842A	yes	E10 E25 and/or E85	brass, plated steel, vinyl, fluoroarbon	A valve in a piping system that allows or stops flow of fuel.
10	Magnetostrictive probe	yes	1238	no	none	stainless steel, nitrile rubber	A form of measurement technology used in in-tank electronic monitoring systems. This is a leak detection method that relies on sound waves and a magnet.
11	Float kit	yes	1238	no	none	nitrile rubber, fluoropolymer	Works in conjunction with the magnetostrictive probe to determine inventory and identify leaks.
12	Interstitial sensor	yes	1238	no	none		An electronic device that can detect the presence of water, liquid product, product vapors or a loss of pressure or vacuum in the interstice of a tank, a tank top sump, fuel dispenser sump, or observation well.
13	Manhole-composite	yes	2447	yes	E85	fiberglass, steel, resin, nitrile	Manhole covering the STP sump.
a-only part III provides ethanol listing for jacket tanks with secondary containments; other methods covered in parts I, II, and IV list for flammable liquids rather than specific fuels							

#	Equipment	UL	UL Std.	Test w/ fuel	Ethanol Test fluids	Materials	Function
14	Manhole-multi-port spill containment	no				fiberglass, steel, aluminum, iron, polyethylene, resin, nitrile	Provides spill containment for UST fill pipes and vapor recovery risers. They are installed on top of the tank sump.
15	Spill bucket	yes	2447	yes	E85	cast aluminum, cast iron, polyethylene, stainless steel, nitrile	Prevents spilled product from entering the soil near the fill and vapor return riser connections on underground storage tanks during normal tank filling operation, or if the tank overfilled.
16	Fuel grade ID tag	yes	969	no	none		Identifies fuel being stored.
17	Fill adaptor (top or side)	yes	2583	yes	E85	Bronze, nylon, stainless steel, nitrile rubber, fluorocarbon	A permanent fitting at the top of the fill pipe of an underground storage tank that allows for a delivery hose to be quickly connected to the fill pipe in a liquid tight manner.
18	Fill cap (top or side)	yes	2583	yes	E85	brass, epoxy coated aluminum	A cap that fits over the open end of a fill pipe.
19	Vapor adaptor	yes	2583	yes	E85	bronze, conductive nylon, stainless steel, nitrile	A special fitting in a Stage I vapor recovery system that is installed at the top of the vapor recovery riser in two-point and manifolded Stage I vapor recovery systems. The vapor recovery adaptor mates to the vapor recovery elbow attached by the fuel delivery driver prior to a delivery.
20	Vapor cap	yes	2583	yes	E85	aluminum, glass filled nylon, iron, copper, stainless steel, nitrile	A dust cover for the vapor recovery system.
21	Face seal adaptor (threaded riser adaptor)	yes	2583	yes	E85	aluminum	Connects fill pipe to swivel fill adaptor and Provides a flat, true sealing surface on threaded fill pipe where a gasket seal exists. is installed on the fill pipe riser below the spill container to provide a true seating surface for the drop tube flange on the overfill prevention valves.
22	Jack screw kit	yes	2583	yes	E85	steel	The jack screw is designed to lock an overfill valve or a drop tube into an a spill container base below the outlet of the drain valve.
23	Overfill prevention valve	yes	2583	yes	E85	cast aluminum, nitrile rubber, fluoro based seals, acetal, stainless steel, acetal, closed cell foam	Prevents the overfill of underground storage tanks by providing a positive shut-off of product delivery.
24	Drop tube (often a part of #23)	yes	2583	yes	E85	stainless steel	Delivers fuel from fill cap to bottom of tank resulting in less vapors.
25	Fuel grade ID #	yes	969	no	none		Identifies fuel type.

#	Equipment	UL	UL Std.	Test w/ fuel	Ethanol Test fluids	Materials	Function
26	Extractor tee	yes	2583	yes	E85	cast iron, zinc	A fitting that allows access to ball valve be removed or repaired without the necessity of breaking concrete, digging down to the component, or cutting a hole in the tank.
28	Ball float vent valve (flow restriction device FRD)	yes	2583	yes	E85	Brass, chrome, fluoro based seals	During a product delivery, as the tank level rises, a counterweight stainless steel ball seats on the valve body and restricts flow of vapors back to the transport truck.
27	Monitoring well screen (pipe)	no	no	no	none	plastic, polypropylene (filter wrapping the pipe)	A slotted or screened tube or pipe, positioned vertically in an underground tank excavation, that permits an operator to check conditions in the excavation and, in particular, to determine whether there may be a leak in the tank system.
29	Well cap-monitoring	yes	2583	yes	E85	plastic, nitrile rubber	Provides access to well screen.
30	Manhole-monitoring	no				cast iron	Any tank opening, including those where delivery and vapor return hoses are connected.
31	Interstitial cap	yes	2583	yes	E85		Interstitial Caps are installed on tank riser pipes to help prevent vapors from escaping or water from entering the tank.
32	Manhole	no				fiberglass, steel, resin, nitrile	Access to UST system.
33	Roll filter fabric	no				polypropylene, or polyester	A porous synthetic fabric, used in underground storage tank excavations, to provide a barrier between different types of soil, or between backfill and adjacent soil.
34	Transition sump-vent	yes	2447	yes	E85	polyethylene, fiberglass	A liquid tight container typically installed at a point where product piping from an aboveground storage tank transitions to underground piping. Other forms of transition sumps may accommodate piping from an UST tank to AST generators, or for piping that resides only below grade. The transition sump exists to contain any contaminants that may leak from any piping or their connectors and to isolate and protect metallic components or equipment from the elements.
35	Sump sensor	yes	1238	no	none		An electronic device that can detect the presence of water, liquid product, product vapors or a loss of pressure or vacuum in the interstice of a tank, a tank top sump, fuel dispenser sump, or observation well.
36	Pipe	yes	971	yes	E100	fiberglass or flexible plastic	Delivers fuel between different pieces of equipment in the refueling system.
37	Pipe adaptor	yes	971	yes	E100	aluminum, stainless steel, nitrile rubber or fluoro based elastomers	connect fuel delivery transport truck hoses or nozzles to the fill pipe of an aboveground storage tank
38	Flexible connector	yes	2039	yes	E85	stainless steel, fluoro based elastomers or nitrile rubber	Flexible Connectors can be used as a convenient means of connecting piping to pumps and dispensers and throughout the piping systems where connections and changes of direction are necessary.

#	Equipment	UL	UL Std.	Test w/ fuel	Ethanol Test fluids	Materials	Function
39	Vent	yes	2853	yes	E85	aluminum, brass	A pipe, usually 2 inches in diameter, that extends from a gasoline storage tank at a service station to a point 12 feet or more above grade level. The vent allows vapors that build up in the tank to escape and outside air to enter, thus keeping the tank at atmospheric pressure when liquids are added or removed. Not fuel wetted. Designed to protect dispenser from vehicle impact.
40	Steel bumper	no				steel	
41	Dispenser	yes	87 87A	yes	E10 E25 and/or E85	multiple parts/materials (metal, plastic, elastomers) in a dispenser-treated as a whole piece of equipment	The dispenser delivers fuel from the piping connected to the STP through the hanging hardware into a vehicle. It has numerous parts including meters, valves, seals, and electronics.
42	Nozzle	yes	2586 2586A	yes	E10 E25 and/or E85	aluminum, plastic, fluorocarbon	A device consisting of a spout, handle and operating lever, attached to the end of a hose and used for controlling the flow of a liquid motor fuel.
43	Breakaway	yes	567 567A	yes	E10 E25 and/or E85	steel, zinc, nylon, acetal, fluorocarbon	A device that disconnects dispenser from hanging hardware if a vehicle pulls away with the nozzle still in the vehicle gas tank.
44	Swivel	yes	567 567A	yes	E10 E25 and/or E85	aluminum, zinc, nitrile rubber	The swivel permits the nozzle to be rotated without rotating the hose at the same time.
45	Whip hose	yes	330 330A	yes	E10 E25 and/or E85	nitrile rubber	A short length of hose with threaded fittings at both ends that is usually installed adjacent to a breakaway valve. The whip hose ensures that forces exerted during a drive off are aligned with the axis of a breakaway valve.
46	Hose	yes	330 330A	yes	E10 E25 and/or E85	nitrile rubber	Delivers fuel to the nozzle.
47	Hose retractor	no				aluminum, polyester	A cable device, fixed to a gasoline station hose and dispenser, to pull the hose back to its storage position after it has been used. Usually used for longer hoses that allow refueling on either side of a vehicle.
48	Stabilizer bar kit	yes	2447	yes	E85	steel	Provides support in a dispenser sump to attach the shear valve.
49	Shear valve	yes	842 842A	yes	E10 E25 and/or E85	cast iron, stainless steel, fluorocarbon	Cuts off the flow of fuel from the UST system in the event of vehicle impact, fire, or other catastrophe.
50	Shear valve-vapor (stage II only)	yes	842 842A	yes	E10 E25 and/or E85	cast iron, stainless steel, fluorocarbon	A fitting installed in the vapor piping at the base of a dispenser that is designed to "shear" or break off if the dispenser cabinet is dislodged from its base.

#	Equipment	UL	UL Std.	Test w/ fuel	Ethanol Test fluids	Materials	Function
51	Sensor tube	yes	1238	no	none		Contains the sump sensor.
52	Dispenser sump	yes	2447	yes	E85	fiberglass, flexible plastic	A container designed to contain leaks from dispensers
53	Pipe-secondary containment tee	yes	971	yes	E100	flexible plastic, fiberglass	A pipe fitting connector
54	Pipe-product tee	yes	971	yes	E100	flexible plastic, fiberglass	A pipe fitting connector
55	Concentric reducer	yes	2447	yes	E85		A seal that connects the sump entry/termination fitting to secondary containment pipe.
56	Pipe-product	yes	971	yes	E100	flexible plastic, fiberglass	Delivers fuel between tank and dispenser.
57	Pipe-secondary containment elbow	yes	971	yes	E100	flexible plastic, fiberglass	A pipe fitting that makes a right-angle turn
58	Pipe-product elbow	yes	971	yes	E100	flexible plastic, fiberglass	A pipe fitting that makes a right-angle turn
40	Steel bumper	no				steel	Protects equipment from vehicle impact.
59	Console	yes	1238	no	none		A control unit, containing switches, keys, or similar elements, used to control the operation of a dispenser or other device at a gasoline dispensing facility.
60	Probe cap adaptor	yes	2583	yes	E85	cast aluminum, nitrile rubber	Monitoring Probe Caps are installed on tank riser pipes to help prevent vapors from escaping or water from entering the tank. Monitoring Probe Caps include a wire grommet fitting to accommodate the electronic tank gauge probe.

4.1 Dispensers, Hanging Hardware, Shear Valves, and STPs

There are multiple dispenser options to sell E15: retrofit an existing dispenser with a UL-listed kit, purchase a UL-listed E25 dispenser (minimal cost over conventional E10 dispenser), or purchase a UL-listed E85 blender pump dispenser (higher cost but more options for fuel offerings). Both Gilbarco and Wayne provide UL-listed dispensers for blends above E10. Credit card companies are requiring retail fueling stations to update their dispensers to accept new chip and PIN secure credit cards by October 2017, at which time fraud liability would switch to station owners if they have not updated their equipment. This presents an opportunity to increase E25 UL-listed equipment through either a retrofit kit if electronics are being upgraded to accommodate the new credit cards, or if a station must purchase a new dispenser, they could pay a minimal amount more for an E25 dispenser.

Hanging hardware includes hoses, nozzles, breakaways, and swivels (Figure 5). OPW obtained E25 listing for a conventional swivel and breakaway, for which there is no price premium. Husky offers UL-listed E25 and E85 nozzles while OPW offers a UL-listed E85 nozzle. EMCO Wheaton, IRPCO, and Veyance have hoses warrantied for E15, and Veyance has a UL-listed E85 hose product. A best practice is to replace all hanging hardware with E15-compatible equipment.

Shear valves are an important piece of safety equipment that cut off the flow of fuel from the UST to the dispenser to prevent a release in the event of an accident dislodging the dispenser or fire. UL-listed E85 shear valves are available from Franklin Fueling and OPW.

STPs draw fuel from the tank and into piping that delivers the fuel to the dispenser. Both Veeder-Root and Franklin Fueling offer UL-listed E85 pumps.

Appendix B lists specific manufacturers and models for use with blends above E10.



Figure 5. Aboveground equipment

(NREL 13531)

4.2 Tanks, Pipes, and Other UST Equipment

4.2.1 Compatibility of Tanks

Most tanks are compatible with ethanol blends above E10. Appendix B lists tank manufacturers and their compatibility with ethanol blends. If a station owner does not have equipment lists, the information in Appendix F describes methods to determine tank type.

All existing steel tank companies manufacturing tanks to store transportation fuels have issued signed letters stating compatibility with up to E100 per EPA OUST biofuels guidance. Tanks are listed under UL 58, which does not expose tanks to test fluids. All STI members who fabricate regulated fuel USTs in the United States have UL 58 listings. STI conducted independent testing and determined that steel tanks are compatible with all ethanol blends.

Xerxes and Containment Solutions manufacture fiberglass tanks, and both have E100 listing for their products under UL 1316.¹¹ Per EPA OUST's biofuels guidance, Containment Solutions issued a letter stating that all tanks it has manufactured are compatible all ethanol blends. Xerxes and Owens Corning (which no longer manufactures tank) have stated that compatibility depends on tank type and the year manufactured. Appendix C includes specific information on fiberglass tank compatibility.

The following is from a Fiberglass Tank and Pipe Institute paper on ethanol compatibility (Curran 2015):

“By 1990, Institute member fiberglass tank manufacturers had modified their tanks constructions to handle gasoline with any level of ethanol or methanol up to 100% for all double-wall fiberglass tanks and in some cases single-wall fiberglass tanks. In 1992, Owens Corning, the manufacturer of the oldest UL Listed fiberglass tanks for petroleum service, advised certain major oil companies that some tanks were approaching 30 years in age and their 30-year warranties would expire. As a result, the affected companies conducted surveys of these older tanks, including tanks in E-10 ethanol service (e.g., in the Midwest) and confirmed that the tanks were performing satisfactorily for continued service. In summary, technical evaluations and historical experience demonstrated that there is no material or technical reason why properly installed pre-1988 piping and tanks in conventional gasoline or MTBE service should not perform equally as well when handling 10 percent ethanol blends.”

4.2.2 Compatibility of Pipes

Installed pipes are evenly split between fiberglass and flexible plastic pipes. Piping is listed under UL 971. E100 became an eligible test fluid in 1988, and all existing pipe companies have E100 listing (Appendix D). Fiberglass was the primary pipe type for decades. NOV is the only existing company providing fiberglass piping in this market, and its products received E100 listing in 1990. NOV provides a 30-year warranty.

Flexible pipes entered the marketplace in the 1990s after EPA OUST recommended development of jointless pipes. There were some issues with initial deployment and failures of Total Containment piping. Total Containment is no longer in business, and its piping is largely

¹¹ Decades-old fiberglass tanks may only be approved for use with E10; please refer to Appendix C.

believed to have been replaced. This occurred before E10 was widely available. Over time, more robust products were developed, and all existing flexible plastic pipe manufacturers have UL listing for E100. These manufacturers include Advantage Earth Products, Brugg Pipesystems,¹² Franklin Fueling, NUPI, Omega Flex, and OPW. Both Franklin Fueling and Omega Flex require the use of stainless steel pipe fittings for blends above E10. A typical warranty for flexible pipes is 10 years.

It is likely that there are stations using piping from companies no longer in business, and the compatibility with ethanol blends for these products is unknown.

4.2.3 Other UST Equipment

Other associated UST equipment includes sumps and accessories, manholes, flexible connectors, fill caps and adaptors, entry fittings, overflow prevention, leak detection, sensors, drop tubes, vents, and similar. Per EPA OUST's biofuels guidance, several manufacturers have issued letters for specific products and model numbers stating compatibility with various ethanol blends above E10. Some major manufacturers have not issued letters but have provided statements on their website product pages that the products are compatible with various ethanol blends, including E15, E85, and E100. Most manufacturers have their own laboratories where they test their products with fuels. Some smaller manufacturers likely rely on materials analysis to determine compatibility. Appendix D provides a list by manufacturer of compatible equipment.

While UL now has listing standards for most of this equipment, few products have UL listing for E10 and even fewer for blends above E10. This does not mean that the products are not compatible, just that manufacturers have yet to obtain listings.

Retailers should specifically investigate if their leak detection equipment is compatible with E15 (refer to Appendix E). Leak detection equipment is required by federal regulations developed by EPA OUST (EPA 2015b). All federally regulated UST systems (tanks and piping) storing motor fuel must have leak detection equipment to detect any potential releases so the spread of contamination can be stopped before significant environmental impact occurs. Regulations allow for several types of leak detection methods. The National Work Group on Leak Detection Evaluations has developed test protocols for various technologies with blends above E10 (NWGLDE 2011). It is expected that some will function with ethanol blends while others may require testing to determine functionality.

In 2011, Battelle conducted a test of ethanol-blended fuels and an automatic tank gauging system to determine water detection functionality (Carvitti and Gregg 2010). E0 was used as a baseline, and E15 and E85 were tested. Fuel was tested at two tank levels—25% and 65% full. Two methods of water ingress were used: a continuous stream of water into a tank, and a quick water dump followed by a fuel dump. An automatic tank gauging system has a float that performs two functions: product level monitoring that leads directly to leak detection; and water detection. The water detection function detected the water stream with E0 and E15 but was not conclusive for E85.

¹² Brugg Pipesystems manufacturers stainless steel pipes, which are rarely used at United States stations.

As a result of the E15 waiver request, the American Petroleum Institute funded a study to determine compatibility of some associated UST equipment, specifically tank vapor recovery equipment and overfill protection devices with E15 (Ken Wilcox Associates 2011). The testing protocol was to expose equipment to test fluids E10 (control) and aggressive E17 (test fluid formula from UL) for four weeks at 140°F followed by performance testing. The following equipment was tested: ball float vent valve, monitoring probe cap, overfill prevention valve, replacement drain valve kit (used to drain spill container after an overfill during delivery), swivel product adaptor, and swivel vapor adaptor. The report states that most of the equipment performed well during testing. All ball float vent valves, monitoring probe caps, and replacement drain valve kits passed. Two of three overfill prevention valves passed; the failing product was stuck in the OFF position during performance testing. Swivel product adaptor results were mixed, with one product failing on E10 and passing on aggressive E17 while the other product failed on both fuels. Swivel vapor adaptors did not perform well either with one failing on both test fluids and a second product failing on the E17 test fluid. The adaptor failures happened during performance testing due to leaks in sealing materials. Most manufacturers have upgraded sealing materials in the past few years after this test was performed to address the introduction of more ethanol and ULSD into the market.

The subject of older pipe dopes/sealants and their compatibility with ethanol fuels came up in the course of the original E15 infrastructure work performed by U.S. Department of Energy national laboratories. Pipe dope, also referred to as pipe thread sealant, is a sealing product used to make pipe thread joints leak proof and pressure tight. Refueling equipment with threaded ends is designed to achieve a tight fit during proper assembly but it is a regular practice to use pipe dope in some instances. Appendix G is a diagram of where pipe dope might be used in a refueling system. Jobbers who install, fix, and replace equipment at stations always have a jar of pipe dope available for use and the two main brands are RectorSeal and Gasoila. Gasoila's pipe thread sealants have used the same formula for decades and are compatible with ethanol blends up to 20%.¹³ RectorSeal No.5 is their best selling product for use at refueling station and the manufacturer said it has long been compatible with ethanol blends including E15.¹⁴

¹³ Gasoila pipe thread sealants are compatible with up to 20% ethanol. Blends above E20 need to use their Gasoila E-Seal product. <http://www.gasoila.com/products/pipe-thread-sealants.html>

¹⁴ RectorSeal's Pipe Thread Sealant Chart shows No.5 as compatible with gasohol (10%), however, NREL spoke with their technical staff who said it is compatible with E15.

5 Conclusions

This study found that significant changes to safety testing standards have incorporated fuel blends with more than 10% volume ethanol. This has led to many refueling equipment products compatible with E15. A station owner can compare its equipment records against the compatibility list in the appendices of this report to determine if there is a need to update or upgrade any equipment to sell E15. The majority of tanks are compatible as existing pipe manufacturers have had listing for E100 for many years, UL-listed E25 dispensers and retrofit kits are available, as is hanging hardware (a combination of E25 and E85 UL-listed equipment). Many manufacturers' models, as well as other UST equipment including fill equipment, leak detection, overfill prevention, and containment, are compatible with E15.

A literature review was conducted to determine if there were any negative impacts during the multi-year deployment of E10 nationwide. No incidents of E10 causing releases were identified, and no infrastructure industry experts suggested that there were widespread issues with E10.

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Appendix A. EPA OUST Release Data

2009 release data from 47 states:

Source	Total		Spill		Overfill		Phys/Mech Damag		Corrosion		Install Problem		Other		Unknown	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Tank	1616	31.3%	37	19.0%	59	24.0%	179	23.3%	321	83.2%	9	16.7%	157	33.7%	854	28.0%
Piping	720	13.9%	9	4.6%	6	2.4%	190	24.7%	48	12.4%	25	46.3%	43	9.2%	399	13.1%
Dispenser	655	12.7%	38	19.5%	31	12.6%	160	20.8%	8	2.1%	9	16.7%	49	10.5%	360	11.8%
STP	76	1.5%	4	2.1%	2	0.8%	36	4.7%	1	0.3%	5	9.3%	9	1.9%	19	0.6%
Delivery Problem	342	6.6%	92	47.2%	121	49.2%	100	13.0%	0	0.0%	1	1.9%	14	3.0%	14	0.5%
Other	564	10.9%	14	7.2%	6	2.4%	97	12.6%	6	1.6%	4	7.4%	171	36.7%	266	8.7%
Unknown	1195	23.1%	1	0.5%	21	8.5%	8	1.0%	2	0.5%	1	1.9%	23	4.9%	1139	37.3%
Totals	5168		195		246		770		386		54		466		3051	

Source: Eighmey, C. LUSTLine Bulletin #67. March 2011

Appendix B. Aboveground Compatibility

Manufacturer	Product	Model	E%	UL listed	UL listed for this fuel?
Franklin Fueling	Shear valve	662 models (UL listing for #662502902)	E85	yes	yes
Franklin Fueling	Submersible turbine pump	FE Petro STPAG, IST	E85	yes	yes
Gilbarco	Dispenser, Retrofit Kit	E25 option on any dispenser; E25 retrofit kit	E25	yes	yes
Gilbarco	Dispenser	Encore Flex Fuel	E85	yes	yes
EMCO Wheaton	Breakaway	A2119, A2219, A3019, A3219, A4119EVR	E15	yes	no
EMCO Wheaton	Breakaway	A4119-020E	E85	no	
EMCO Wheaton	Hose	all	E15	yes	no
EMCO Wheaton	Nozzle	A4005-002, A4005-004, A4015-002, A4015-004	E15	yes	no
EMCO Wheaton	Nozzle-balance vapor recovery	A4005-002E, A4015-002E	E85	yes	no
EMCO Wheaton	Swivel	A0360 (not listed), A4110EVR (UL listing)	E15	yes	no
Husky	Nozzle	X E25, X E25, XSE25	E25	yes	yes
Husky	Nozzle	X E85, X E85 Cold Weather, XS E85, XS E85 Cold Weather	E85	yes	yes
IRPCO	Hose-dispenser	Steelflex Ultra Hardwall, Softwall (2 Braid, 4SP), Marina	E15	yes	no
OPW	Breakaway	66V-0300	E25	yes	yes
OPW	Breakaway	66V-0492	E85	yes	yes
OPW	Nozzle	21GE, 21GE-A	E85	yes	yes
OPW	Swivel	241TPS-0492	E85		
OPW	Swivel	241TPS-0241, 241TPS-1000, 241TPW-0492	E25	yes	yes
OPW	Shear valve	10P-0142E85, 10-P-4152E85	E85	yes	yes
Veeder-Root	Submersible turbine pump	Redjacket, Redjacket AG,	E100	yes	no
Veyance	Hose	Flexsteel Futura Ethan-all	E85	yes	yes
Veyance	Hose	Flexsteel Futura	E15	yes	no
Wayne	Dispenser	E25 option on any dispenser; E25 retrofit kit	E25	yes	yes
Wayne	Dispenser	Ovation E85, Helix E85	E85	yes	yes

For compatibility of older dispensers with E85, please refer to: DOE Clean Cities. *Handbook for Handling, Storing, and Dispensing E85 and Other Ethanol-Gasoline Blends*. September 2013.

http://www.afdc.energy.gov/uploads/publication/ethanol_handbook.pdf

Appendix C. Tank Compatibility

Tank Manufacturer Compatibility with Ethanol Blends	
Manufacturer	Compatibility Statement with Ethanol Blends
FIBERGLASS¹	
Containment Solutions	Tanks manufactured after January 1, 1995 are all compatible with ethanol blends up to 100% (E100) (UL Listed)
Owens Corning	
Single Wall Tanks	Tanks manufactured between 1965 and 1994 are approved to store up to 10% ethanol (E10)
Double Wall Tanks	Tanks manufactured between 1965 and July 1, 1990 are approved to store up to 10% ethanol (E10).
	Tanks manufactured between July 2, 1990 and December 31, 1994 were warranted to store any ethanol blend.
Xerox	
Single Wall Tanks	Tanks manufactured prior to 1981 are not compatible with ethanol blends
	Tanks manufactured from February 1981 through June 2005 are designed for the storage of ethanol fuel up to a 10% blend (E10)
	Tanks manufactured from July 2005 to date are designed for the storage of ethanol fuel blends up to 100% (E100) (UL Listed)
Double Wall Tanks	Tanks manufactured prior to April 1990 were designed for the storage of ethanol fuel up to a 10% blend (E10)
	Tanks manufactured from April 1990 to date are designed for the storage of ethanol fuel blends up to 100% (E100) (UL Listed)
STEEL²	
Acterra Group Inc.	Compatible with all blends up to 100% (E100)
Caribbean Tank Technologies Inc.	Compatible with all blends up to 100% (E100)
Eaton Sales & Service LLC	Compatible with all blends up to 100% (E100)
General Industries	Compatible with all blends up to 100% (E100)
Greer Steel, Inc.	Compatible with all blends up to 100% (E100)
Hall Tank Co.	Compatible with all blends up to 100% (E100)
Hamilton Tanks	Compatible with all blends up to 100% (E100)
Highland Tank	Compatible with all blends up to 100% (E100)
J.L. Houston Co.	Compatible with all blends up to 100% (E100)
Kennedy Tank and Manufacturing Co.	Compatible with all blends up to 100% (E100)
Lancaster Tanks and Steel Products	Compatible with all blends up to 100% (E100)
Lannon Tank Corporation	Compatible with all blends up to 100% (E100)
Mass Tank Sales Corp.	Compatible with all blends up to 100% (E100)
Metal Products Company	Compatible with all blends up to 100% (E100)
Mid-South Steel Products, Inc	Compatible with all blends up to 100% (E100)
Modern Welding Company	Compatible with all blends up to 100% (E100)
Newberry Tanks & Equipment, LLC	Compatible with all blends up to 100% (E100)
Plasteel ¹	Compatible with all blends up to 100% (E100)
Service Welding & Machine Company	Compatible with all blends up to 100% (E100)
Southern Tank & Manufacturing Co., Inc.	Compatible with all blends up to 100% (E100)
Stanwade Metal Products	Compatible with all blends up to 100% (E100)
Talleres Industriales Potosinos	Compatible with all blends up to 100% (E100)
Tanques Antillanos C. xA.	Compatible with all blends up to 100% (E100)
Watco Tanks, Inc.	Compatible with all blends up to 100% (E100)
We-Mac Manufacturing Company	Compatible with all blends up to 100% (E100)
Letters stating compatibility 1 PEI http://www.pei.org/PublicationsResources/ComplianceFunding/USTComponentCompatibilityLibrary/tabid/882/Default.aspx 2 STI http://www.steeltank.com/Publications/E85BioDieselandAlternativeFuels/ManufacturerStatementsofCompatibility/tabid/468/Default.aspx	

Appendix D. Pipe Compatibility

Manufacturer	Product	Model	E%	UL listed	UL listed for this fuel?
Advantage Earth Products	Pipe	1.5", 2", 3", 4"	E100	yes	yes
Brugg Pipesystems	Pipe	FLEXWELL-HL, SECON-X, NIROFLEX, LPG	E100	yes	yes
Franklin Fueling	Pipe	XP, UPP	E100	yes	yes
Franklin Fueling	Pipe ducting	APT, UPP	E100	yes	yes
Franklin Fueling	Pipe fittings	XP stainless steel (ELB-XP-150, ELB-XP-175, ELB-XP-200, GSHP-150, GSHP-200, MS-XP-150-150SS, MS-XP-175-200SS, MS-XP-200-200SS, MS-100-100SS, MS-XP-150-150, MS-XP-SW-175-200, MS-XP-SW-200-200, QRS-XP-150-200, QRS-XP-175-200, QRS-XP-200-200, SSC-150, SSC-200, SSE90-150, SSE90-200, SSE90-150, SST-150, SST-200, SSU-150, SSSH-150, TEE-XP-150, TEE-XP-175, TEE-XP-200) UPP stainless fittings	E85	yes	yes
NOV Fiberglass	Red Thread IIA	fiberglass	E100	yes	yes
NUPI	Smartflex	flexible plastic	E100	yes	yes
OMEGAFLEX	DoubleTrac	flexible plastic (must use stainless steel fittings)	E100	yes	yes
OPW	Pipe	FlexWorks, Pisces (discontinued)	E100	yes	yes
OPW	Pipe adaptors, couplers, fittings	FlexWorks	E100	yes	yes

Appendix E. Other UST Equipment Compatibility

Note: "UN" in the E% column indicates the manufacturer does not know if it is compatible with ethanol blends. ? = waiting on information from OEM

Manufacturer	Product	Model	E%	UL Listed	UL listed for this fuel	Other Approval
Clay and Bailey	AST anti-siphon valve	405	E10	no		
Clay and Bailey	AST manhole	API-650	E85	no		
Clay and Bailey	AST alarm	1400	E10	no		
Clay and Bailey	AST overflow prevention valve	1228	E85	yes	no	
Clay and Bailey	AST pressure vacuum vent	88	E10	no		
Clay and Bailey	AST spill containment	all	E85	no		
Clay and Bailey	AST emergency vent	354, 365, 366, 367, 368, 369, 370	E85	yes	no	
Clay and Bailey	Manholes	all	E10	no		
Clay and Bailey	Ball valve	736	E10	no		
Clay and Bailey	Fill cap	94, 232, 233, 234, 235, 254	E85	no		
Clay and Bailey	Vent-upflow	395	E10	no		
Cimtek	Filter	300, 400, 450, 475	E15	yes	no	
Cimtek	Filter	800	E85	yes	no	
EMCO Wheaton	Nozzle-balance vapor recovery	A4005-002E, A4015-002E	E85	yes	no	CARB EVR
EMCO Wheaton	Nozzle-balance vapor recovery	A4005-002, A4005-004, A4015-002, A4015-004	E15	yes	no	CARB EVR
EMCO Wheaton	Breakaway	A4119-020E	E85	no		
EMCO Wheaton	Breakaway	A2119, A2219, A3019, A3219, A4119EVR	E15	yes	no	CARB EVR (A4119 only)
EMCO Wheaton	Swivel	A0360, A4110EVR	E15	yes (EVR only)	no	CARB EVR (A4110 only)
EMCO Wheaton	Hose	all	E15	yes	no	
EMCO Wheaton	Adaptors	A0030, A0030-142, A0076, A0076-142S, A0089, A0096,	E15	no		CARB EVR (both A0030 and A0076)
EMCO Wheaton	Ball float	A0075E, A0078E	E85	no		CARB EVR (A0078)
EMCO Wheaton	Ball float	A0075, A0078	E15	no		CARB EVR (A0078)
EMCO Wheaton	Caps	A0097-005, A0097-004LP, A0097-010, A0099-002, A0099-004LP	E15	no		CARB EVR (A0097-005, A0099-02)
EMCO Wheaton	Drop tube	A0020-004E, A0020-005E, A0020-007E	E15	no		CARB EVR (A0020, A0088)
EMCO Wheaton	Drop tube	A0020-004, A0020-005, A0020-007, A0020-008, A0020-021, A0020-133, A0020-144, A0070, A0088	E15	no		CARB EVR (A0020, A0088)
EMCO Wheaton	Extractor fittings	A0079	E85	yes	no	CARB EVR
EMCO Wheaton	Overflow prevention valve	A1100-010E, A1100-056SE, A1100-055SERF, A1100-056SERF, A1100EVR-057E, A1100-067E, A1100-087E	E85	no		CARB EVR
EMCO Wheaton	Overflow prevention valve	A1100-010, A1100-011, A1100-054S, A1100-054SC, A1100-054SCN, A1100-055SRF, A1100-056SRF, A1100-053S, A1100-055S, A1100EVR-055, A1100-056S, A1100EVR-056, A1100-057S, A1100EVR-057, A1100-058S, A1100EVR-058, A1100-065S, A1100-066S, A1100-067S, A1100-085S, A1100-087S, A1100-087S	E15	no		CARB EVR (only models with EVR in model no.)
EMCO Wheaton	Ball valve	A0750	E15	no		
EMCO Wheaton	Check valve	A0066, A0732	E15	no		
EMCO Wheaton	Shear valve	A0060 with stainless steel body	E85	yes	no	
EMCO Wheaton	Shear valve	A0060 with cast iron body, A0063	E15	yes	no	
EMCO Wheaton	Vent	A0084, A0085, A4103, A0785	E15	yes (A4103 only)	no	
Husky	Pressure vacuum vents	4620, 4885, 5885, 8060	E85	yes	yes	

Manufacturer	Product	Model	E%	UL listed	UL listed for this fuel?	Other Approval
STP Equipment						
Franklin Fueling	Mechanical line leak detector	MLD+AG	E85	yes	?	
Franklin Fueling	Mechanical line leak detector	STP-MLD	E10	yes	yes	
Franklin Fueling	Shear valve (emergency shear)	662 models	E85	yes (66250 2902)	yes	
Franklin Fueling	Shear valve-vapor	362 models	UN	no		
Franklin Fueling	Submersible pump controller	MagVFC IST,	E85	yes		
Franklin Fueling	Submersible turbine pump	STP	E10	yes	yes	
Franklin Fueling	Submersible turbine pump	FE Petro STPAG, IST	E85	yes	yes	
Fill Equipment						
Franklin Fueling	Ball float vent valve	308 models	E85	no		EVR CARB
Franklin Fueling	Drop tube	306 and 708 models, 782-204-30-2, 782-204-32-2, 782-202-12, 782-203-12, 782-204-10-2, 782-204-12-2, 782-204-15-2	E85	no		
Franklin Fueling	Extractor vent valve (tee)	300 series models	E85	no		
Franklin Fueling	Fill adaptor-side	776-300-01, 776-300-31	E85	no		
Franklin Fueling	Fill adaptor-swivel	SWFV-100-SS, SWFV-PKGSS	E85	no		EVR CARB
Franklin Fueling	Fill adaptor-swivel	SWFV-PKG, 705-412-01, 705-412-02	E85	no		
Franklin Fueling	Fill adaptor-top	778-301-05	E85	no		EVR CARB
Franklin Fueling	Fill adaptor-top	776-300-01, 776-300-31, 778-301-01, 778-301-02, 778-301-06, 778-301-32, 778-301-01, 778-302-31, 778-303-02, 778-303-32, 780-200-01	E85	no		
Franklin Fueling	Fill cap-side	775 series	E85	no		
Franklin Fueling	Fill cap-top	777-201-02	E85	no		EVR CARB
Franklin Fueling	Fill cap-top	777-202-01, 777-202-02, 779-200-01, 774-202-03	E85	no		
Franklin Fueling	Vapor cap	304-301-03	E85	no		EVR CARB
Franklin Fueling	Vapor cap	304-200-01, 304-200-02, 304-301-01, 304-301-02	E10	no		EVR CARB (301-01 only)
Franklin Fueling	Vapor pipe adaptor	SWV-101-SS, SWFV-PKGSS	E85	no		EVR CARB
Franklin Fueling	Vapor pipe adaptor	SWV-101-B, SWFV-PKG, 705-413-01, 705-413-02	E10	no		
Franklin Fueling	Vapor recovery adaptor	306 and 708 models	E85	no		
Franklin Fueling	Overfill prevention valve	708-491-31, 708-491-32, 708-492-21, 708-492-22, 708-492-31, 708-492-32, 708-498-11	E85	yes	?	EVR CARB (ending in 11 or 12)
Franklin Fueling	Overfill prevention valve	708-491-01, 708-491-02, 708-491-11, 708-491-12, 708, 491-21, 708-492-01, 708-492-02, 708-498-11, 708-493-03, 708-493-04, 708-493-23, 708-493-24, 708-340-901, 708-494-02, 708-494-03, 708-494-04, 708-498-01, 708-498-02, 708-498-03	E10	yes	?	EVR CARB
Franklin Fueling	Probe cap and adaptor kit	90037-E	E85	no		EVR CARB
Franklin Fueling	Spill container (bucket)	702, 703, 705, 715	E10	yes (705 and 715 models only)		yes (705 and 715 models only)
Franklin Fueling	Spill container (bucket)	Phil-Tite series, Defender Series	E85	yes	?	EVR CARB
Franklin Fueling	Tank bottom protector	TBP-3516-E	E85	no		
Franklin Fueling	Tank bottom protector	785-200-02	E10	no		
Franklin Fueling	Vent valve (pressure/vacuum)	PV-ZERO models	E85	yes	?	EVR CARB

Manufacturer	Product	Model	E%	UL listed	UL listed for this fuel?	Other Approval
UST Equipment						
Franklin Fueling	API adaptor	880-500-04	E85	no		
Franklin Fueling	Automatic tank gauge	TSP	E10	yes	yes	
Franklin Fueling	Ball valve (for pipe)	FLEX-ING	E85	yes	no	CSA
Franklin Fueling	Check valve	622-300-01, 65, 515, 516, 615, 635, 650	E10	no		
Franklin Fueling	Dispensing cutoff system	DC400	E10	no		
Franklin Fueling	Flexible connectors	FLEX-ING	E10			
Franklin Fueling	Flexible connectors	FIREFLEX	E85	yes	no	
Franklin Fueling	Float kit	TSP-IGF4P	E15	no		
Franklin Fueling	Float kit	TSP-IGF4D3, TSP-IGF4D	E85	no		
Franklin Fueling	Foot valve	50-201, 320	E10	no		
Franklin Fueling	Interstitial sensor	TSP-HIS, TSP-DIS, TSP-EIS, TSP-HFS	E85	no		
Franklin Fueling	Level sensor	TSP-HLS	E85	no		
Franklin Fueling	Magnostriuctive probe	Moorman	E85	no		
Franklin Fueling	Manhole	14U, 20UR, 780, 781, 789, 808, 810, 814, 987, Defender, SSQ, SR series	E10	no		
Franklin Fueling	Monitoring test well	772, 773, 808, 810	E10	no		
Franklin Fueling	Monitoring well cap	TSP-KW4	E10	no		
Franklin Fueling	Monitoring well sensor	TSP-MWS	E0	no		
Franklin Fueling	Probe installation kit	FFS	E10	no		
Franklin Fueling	Pipe fittings	GC-150, GC-200, GE90-150, GE90-200, GE90-215, GE90-252, GHB-200-150, GT-150, GT-200, GT-215, GT-252, GU-150, GU-200, GHB-200-150, GSHP-150, GSHP-200, XP brass (MS-XP-150-150, MS-XP-175-200, MS-XP-200-200)	E10	yes	yes	
Franklin Fueling	Sumps	2400, 4542 (UL), 4736, APT, AST, LM, TS, UPP (UL) models	E85	yes	no	
Franklin Fueling	Sump accessories, fittings, boots	APT	E85	yes	no	
Above-ground Equipment						
Franklin Fueling	Nozzle	400, 600, 708, 709, 800, 900 series (all vapor recovery II)	E10	no		EVR CARB (400, 600, 900)
Franklin Fueling	Breakaway	697, 698, ACCUBREAK, SAFETY-SEVER	E10	yes	yes	
Franklin Fueling	Hoses	FLEX-ING	E10	no		
Franklin Fueling	Hoses	FLEX-ON	E15	yes	no	
Franklin Fueling	Swivel	465	E10	no		
Franklin Fueling	Swivel	FLEX-ING multi-plane	E10	no		
AST Equipment						
Franklin Fueling	Anti-siphon valve	636-300-11, 636-300-12	E85	no		
Franklin Fueling	Anti-siphon valve	605-300-01, 606-300-01, 616-300-01, 616-300-02, 616-300-03	E10	no		API/RP 2000
Franklin Fueling	AST emergency vent	803	E10	yes		
Franklin Fueling	AST fill cap	751, 770	E10	no		
Franklin Fueling	AST overflow prevention valve	709	E10	no		
Franklin Fueling	AST Pressure regulator valve	620, 621, 622, 644	E10	yes		API/RP 2000
Franklin Fueling	AST pressure vacuum vent	802	E10	no		
Franklin Fueling	AST spill container (bucket)	706	E10	no		
Franklin Fueling	AST tank vent	800	E10	no		

Company	Product	Model	E%	UL Listed	UL listed for this fuel	Other Approval
Morrison Bros	Adaptor-coaxial	605	UN	no		
Morrison Bros	Anodized Farm Nozzle	200S	E85	no		
Morrison Bros	Anti-Syphon Valve	912	E85	no		
Morrison Bros	AST adaptor	927	E85	no		EVR CARBa (some)
Morrison Bros	AST adaptor	926, 927B	UN	no		
Morrison Bros	AST clock gauge	818, 818C, 818F, 818MET, 818MEF, 918F, 918FT, 918MEF, 918MET, 918T, 1018GM, 8181	UN	no		EVR CARBa (some)
Morrison Bros	Ball Valves	691BSS	E85	no		
Morrison Bros	Cap relief	779	UN	no		
Morrison Bros	Caps	305C	E85	no		EVR CARBa (some)
Morrison Bros	Caps-monitoring well	305XP, 305XPU	UN	yes (XPU)		EVR CARBa (some)
Morrison Bros	Cap-test well	178XAT, 178XB, 178XA, 305XA, 678XA	UN	no		
Morrison Bros	Clock Gauge with Alarm	918	E85	no		
Morrison Bros	Clock Gauges	818	E85	no		
Morrison Bros	Combination Vent/Overfill Alarm	922	E85	no		
Morrison Bros	Diffuser	539TO, 539TC	E85	no		EVR CARBa (some)
Morrison Bros	Diffuser	539, 539EXT, 539TC, 539TO	UN	no		EVR CARBa (some)
Morrison Bros	Double Tap Bushing	184	E85	no		
Morrison Bros	Drop Tubes	419A	E85	no		
Morrison Bros	Drop tubes	275, 419, 419SOS	UN	no		EVR CARBa (some)
Morrison Bros	Emergency Vents	244	E85	yes	yes	EVR CARBa (some)
Morrison Bros	Expansion Relief Valve	076DI, 078DI	E85	no		
Morrison Bros	External Emergency Valves	346DI, 346FDI, 346SS, 346FSS	E85	no		
Morrison Bros	Extractor pipe cap	578, 578P	UN	no		
Morrison Bros	Extractors	560/561/562/563	E85	no		
Morrison Bros	Fill cap	178, 178DT, 179, 179CI, 179M, 179MCI, 180M, 305CU, 379, 405C	UN	no		EVR CARBa (some)
Morrison Bros	Fill cap and adaptor	307	UN	no		
Morrison Bros	Fill swivel adaptor	305SA	UN	no		
Morrison Bros	Flame Arrester	351S	E85	no		
Morrison Bros	Float Vent Valves	317	E85	no		
Morrison Bros	Frost Proof Drain Valve	128DIS	E85	no		
Morrison Bros	Indicator paste	490G, 490W, SAR-GEL	UN	no		
Morrison Bros	In-Line Check Valve	958	E85	no		
Morrison Bros	Internal Emergency Valves	272DI, 72HDI	E85	no		
Morrison Bros	Interstitial sensor	918TCPS, 924LS	UN	no		
Morrison Bros	Manholes	318, 318L, 318TM, 318VR, 318XA, 418, 418L, 418TM, 418XA, 418XAP, 418XAH, 418XAW, 418LC, 424, 519, 524, 524H	UN	no		

Company	Product	Model	E%	UL Listed	UL listed for this fuel	Other Approval
Morrison Bros	Mechanical gauge	1018GM	UN	no		
Morrison Bros	Overfill Alarm	918TCP	E85	no		
Morrison Bros	Overfill Prevention Valve	9095A-AV, 9095SS	E85	no		
Morrison Bros	Overfill Prevention Valve	9095AA, 9095GBT	E85	no		
Morrison Bros	Pressure Vacuum Vent	948A	E85	yes	yes	
Morrison Bros	Probe cap and adaptor	307P	UN	no		
Morrison Bros	Solenoid Valves (3" Must be all Teflon version)	710SS	E85	no		
Morrison Bros	Spill Containers	515/516/517/518	E85	no		EVR CARBa (516)
Morrison Bros	Strainer	285	E85	no		
Morrison Bros	Strainer	284B, 284S, 285AL, 285DI, 285FDI, 286, 286FDI, 286U	UN	no		
Morrison Bros	Swing Check Valves	246ADI, 246DRF	E85	no		
Morrison Bros	Tank gauge	618	UN	no		
Morrison Bros	Tank Monitor Adaptor and Cap	305XPA	E85	no		
Morrison Bros	Vapor Recovery Adaptor	323	E85	no		EVR CARBa
Morrison Bros	Vapor Recovery Caps	323C	E85	no		
Morrison Bros	Vent-double outlet (small UST)	155	E85	no		
Morrison Bros	Vent-double outlet (small UST)	155S, 155FA	UN	no		
Morrison Bros	Vent-pressure vacuum	548, 748, 749	E85	no		
Morrison Bros	Vent-updraft	354	E85	no		
Morrison Bros	Vent-updraft	354T	UN	no		
Morrison Bros		571, 571P	UN	no		
National Environmental Fiberglass	Sumps-tank	All	E85	yes	no	EVR CARB
National Environmental Fiberglass	Sumps-transition	All	E85	yes	no	EVR CARB
National Environmental Fiberglass	Sumps-dispenser	All	E85	yes	no	EVR CARB

Company	Product	Model	E%	UL Listed	UL listed for this fuel	Other Approval
Above Ground Equipment						
OPW	Balance Adaptor	28CS	E25	no		
OPW	Breakaway	66V-0492	E85	yes	yes	
OPW	Breakaway	66V-030RF	E25	yes	yes	
OPW	Breakaway	66V-0300, 66RB-2000, 68EZR-7575, 66REC-1000, 66SB-7575, 66SB-1010, 66CAS-0300, 66ISU-5100, 66ISB-5100, MFVA, 66CLP-5100, 66CSU-5200	E10	yes	yes	
OPW	nozzle	21GE-0992	E85	yes	yes	
OPW	Nozzle	11AP-0100-E25, 11AP-0300-E25, 11AP-0400-E25, 11AP-0900-E25, 11BP-0100-E25, 11BP-0300-E25, 11BP-0400-E25, 11BP-0900-E25	E25	yes	yes	
OPW	Nozzle	11AP / 11BP Series	E10	yes	yes	
OPW	Swivel	241TPS-75RF	E25	yes	yes	
OPW	Swivel	36S series, 241TPS series, 20S series, 45 series	E10	yes	yes	
OPW	Swivel	241TPS-0492	E85	yes	yes	
OPW	Emergency shear valve	10 series	E100	yes	no	
OPW	Vapor shear valve	60VS	E100	yes	no	EVR CARBa
AST Equipment						
OPW	AST anti-siphon valve	199ASV	E85	yes	no	
OPW	AST ball valve	21BV SS	E85	yes	no	
OPW	AST check valve	175, 1175	E85	no	no	
OPW	Drop tube	61FT	E25	no	no	EVR CARBa
OPW	AST emergency shut off valve	178S	E85	no	no	
OPW	AST emergency vent	201, 202	E85	yes	no	
OPW	AST emergency vent	301	E86	yes	no	EVR CARBa
OPW	AST mechanical gauge	200TG	E85	yes	no	EVR CARBa
OPW	AST overfill prevention valve	61fSTOP A or M versions	E85	yes	no	EVR CARBa
OPW	AST overfill prevention valve	61fSTOP	E25	yes	no	
OPW	AST pressure vacuum vent	523V, 623V	E100	yes	no	
OPW	AST solenoid valve	821	E25	yes	no	
OPW	AST spill container	211-RMOT, 331, 332	E85	yes (ulc	no	EVR CARBa
OPW	AST swing check valve	all	E85	no	no	
OPW	AST tank alarm	444TA	E85	no (ETL	no	
OPW	AST vapor adaptor	1611AVB-1625	E85	no		
OPW	AST vapor cap	1711T-7085-EVR, 1711LPC-0300	E85	no		

Company	Product	Model	E%	UL Listed	UL listed for this fuel	Other Approval
UST Equipment						
Caps and adaptors						
OPW	Fill adaptor-top	633T, 633TC	?	yes	no	
OPW	Fill-swivel adaptor	61SALP-MA, 61SALP-1020-EVR	E85	yes	no	CARB EVR
OPW	Vapor swivel adaptor	61VSA	?	yes	no	CARB EVRa
OPW	Fill-swivel adaptor (vapor)	61VSA-MA, 61VSA-1020-EVR	E85	yes	no	CARB EVR
OPW	Fill cap-side	62TT	?	yes	no	
OPW	Fill adaptor-side	61AS	?	yes	no	
OPW	Vapor adaptor	1611AV, 1611AVB	E100	yes	no	CARB EVR
OPW	Vapor Cap	1711T	E85	yes	no	CARB EVR
OPW	Monitoring well probe cap	62M, 116M	E100	yes	no	
OPW	Monitoring well probe cap	62M-MA	E85	yes	no	CARB EVR
OPW	Monitoring well cap kit	634TTM, 62PMC	?	yes	no	
OPW	Monitoring test well	61SPVC	?	no		
Extractors, Manholes, Multi-ports						
OPW	Extractor fittings and plug	233, 233VP	E85	no		CARB EVR
OPW	Multi-port spill containment	411, 511, 521, Fiberlite,	E100	no		CARB EVR
OPW	Jack screw	71JSK	E85	no		
OPW	Jack screw	61JSK	?	no		
OPW	Face seal adaptor (threaded riser adaptor)	FSA-400	?	no		CARB EVR
OPW	Manhole	Conquistador, Fiberlite, 104AOW-1200, 104C,	?	no		
Overfill Prevention						
OPW	Overfill prevention valve	61SOM-412C-EVR, 61SOCM-4000, 71SO, 71SO-T, 71SOM	E85	no		CARB EVR
OPW	Overfill prevention valve	61SOC-4001, 61SOC-4011, 61SOP-4002, 61SOP-4012	E10	no		
OPW	Float kit	61SOK-0001	E10	no		
OPW	Ball float vent valve	21BV, 53VML, 30MV	E85	no		
OPW	Drop tube	61T, 61TC, 61TCP	E10	no		
OPW	Drop tube	61TSS	E85	no		CARB EVR
OPW	Spill container (bucket)	1-2100, 1SC-2100, EDGE	E100	yes	no	CARB EVRa
OPW	Spill container (bucket)	1-2105, 1-2200, 101-BG2100	E100	yes	no	
OPW	Tank bottom protectors	6111, 61TP	E10	no		
Check Valve, Flexible Connectors, Vents						
OPW	Flexible connectors	All	E100	yes	no	SA
OPW	Check valve	70, 70S	E85	yes	no	
OPW	Pressure vacuum vent	523V, 623V	E85	yes	no	
OPW	Pressure vacuum vent	23	?	yes		
OPW	Vent	514, 515	?	?		
Sumps						
OPW	Dispenser sumps	FlexWorks	E85	yes	no	
OPW	Tank sumps	Fiberlite, FlexWorks	E85	yes	no	
OPW	Transition sumps	FlexWorks	E85	yes	no	
OPW	Sump accessories	FlexWorks	E85	yes	no	

Manufacturer	Product	Model	E%	UL Listed	UL listed for this fuel	Other Approval
Petroleum Containment	Sump-dispenser	CLE, DCL, EZ-PLUMB, MVR	?	no		
Petroleum Containment	Sump-tank	4200	E100	no		
Petroleum Containment	Sump-transition	all	?	no		
Pneumercator	Magnetostrictive probe	MP450S, MP451S, MP452S, MP461S, MP462S, MP463S, MP464S □ MP550S, MP551S, MP552S, MP561S, MP562S, MP563S, MP564S	E100	yes	no	
Pneumercator	Leak sensors	ES825-100F, ES825-100XF, ES825-100CF, ES825-200F, ES825-200XF □ ES825-300F, ES825-300XF, ES825-300CF, ES825-400F, ES825-400XF □ HS100D, HS100ND □ LS600LD, LS600S, LS610 □ RSU800-2, RSU801F, RSU810	E100	yes	no	
Pneumercator	Single/Multi-Point Level □ Sensors	LS600, LS600F4, LS600M, LS600W, LS600X	E100	yes	no	
Pneumercator	Mechanical Gauges	DR-1-10, P5, P14	E100	no	no	
S. Bravo Systems	Fiberglass Fittings	Series F, FF, FPE, FR, Retrofit-S, D-BLR-S, D-INR-S, FLX, FLX-INR, FPS, TBF	E100	yes	no	
S. Bravo Systems	Spill Buckets	B3XX	E100	yes	no	
S. Bravo Systems	Tank Sumps & Covers	B4XX	E100	yes	no	
S. Bravo Systems	Transition Sumps	B5XX, B6XX, B7XX, B8XX	E100	yes	no	
S. Bravo Systems	Under Dispenser Containment Sumps	B1XXX, 7XXX, B8XXX, B9XXX	E100	yes	no	
Vaporless Manufacturing	Leak detector	99LD-2000/2200/3000 without stainless steel tubing/fittings	E20	yes	no	
Vaporless Manufacturing	Leak detector	99LD-2000/2200/3000 with stainless steel tubing/fittings	E100	yes	no	
Vaporless Manufacturing	Overfill prevention valve	OPF-2/3 without stainless steel tubing/fittings	E20	yes	no	
Vaporless Manufacturing	Overfill prevention valve	OPF-2/3 with stainless steel tubing/fittings	E100	yes	no	

Manufacturer	Product	Model	E%	UL Listed	UL listed for this fuel	Other Approval
Veeder-Root	AST probe	Mag-FLEX	E15	yes	no	
Veeder-Root	Float kit	846400	E15	yes	no	
Veeder-Root	Magnostriuctive probes	Mag Plus Probe for Alternative Fluids with Water Detection P/N 846391-1xx or -2xx, Inventory Only Mag Plus Probe for Alternative Fluids with Water Detection P/N 846391-3xx	E20	yes	no	
Veeder-Root	Magnostriuctive probes	Mag Plus Probe for Alternative Fluids without Water Detection P/N 846391-4xx or -5xx, Mag Plus Probe for Alternative Fluids without Water Detection P/N 846391-6xx	E100	yes	no	
Veeder-Root	Magnostriuctive probes	Mag-D Density Probe, MagPlus Leak Detection Probe, MagPlus Inventory Measuremeant Probe	E15	yes	no	
Veeder-Root	Mechanical line leak detect	Red Jacket FXV	E100	yes	no	
Veeder-Root	Phase separation float	Phase-2	E15	yes	no	
Veeder-Root	Sensor-dispenser and sump	Discriminating and Non Discriminating Dispenser Pans and Containment Sensors, Sump sensor (piping), Mag Sump Sensor, Stand-alone Dispenser Pan Sensor	E15	yes	no	
Veeder-Root	Sensor-dispenser and sump	Position Sensitive Interstitial Sensor	E85	yes	no	
Veeder-Root	Sensor-groundwater	Groundwater Sensor	E15	yes	no	
Veeder-Root	Sensor-tank	Discriminating Interstitial Sensor Double Wall Fiberglass, Interstitial Sensors for Fiberglass Tanks, Intersitial Sensors for Steel Tanks	E15	yes	no	
Veeder-Root	Sensor-tank	Discriminating Interstitial Sensor Double Wall Fiberglass, Interstitial Sensors for Fiberglass Tanks-High Alcohol, Interstisial Sensors for Steel Tanks-High Alcohol, MicroSensor (steel tanks, fill riser)	E85	yes	no	
Veeder-Root	Sensor-vapor	Vapor Sensor	E15	yes	no	
Western Fiberglass	Co-Flex piping	all	E100	yes	no	
Western Fiberglass	Cuff fittings	all	E100	no		
Western Fiberglass	Sumps (tank, dispenser, transition, vapor, vent)	all	E100	yes	no	
Western Fiberglass	Co-flow hydrostatic Monitoring systems	all	E100	no		

Appendix F. Methods to Identify Underground Storage Tanks

http://www.steeltank.com/Portals/0/TTNewsletter/September2012/TankTalk_September2012.pdf



Tank Talk, September 2012

Identifying Buried Fuel Storage Tanks

by Bert Schutz, Tanknology, with contributions from Danny Brevard, ACCENT

How to identify the construction of your buried fuel storage tank when original purchase documents are missing – a guidance tool offering some simple suggestions.

More than one method is often required to make conclusions specific to tank type:

1. Stick your tank to determine the tank diameter. Certain diameters of tanks between 6,000-gallon to 15,000-gallon capacity are indicative of steel tanks and some of the fiberglass reinforced plastic (FRP) tanks. 92" diameter tanks, for example, are almost always FRP, while 96" diameter tanks are normally steel.
 - a. Tank Diameter Measurement: Measure from bottom of tank to top of riser and then subtract the length of the riser.
2. Knowing the date of installation is a great tool for figuring out what type of steel tank you might have. This chart gives you important dates in the history of steel tank technology development:



Finding a label is very helpful!

Date	Event	Tank Type
1969	Sti-P3 technology created	Cathodically Protected
1984	STI Dual Wall Tank Standard published	
1987	Original Association for Composite Tanks was formed	Composite
1990	First STI standard for ACT-100 developed	Composite
1992	STI adopted the Permatank technology	Jacketed
1996	ACT-100-U created	Coated

3. Is your tank single wall or double wall? Double wall tanks will have an interstitial monitoring opening, which is often a 2" fitting. Double wall steel tanks have an access port directly down to the bottom of the steel tank, usually at the end of the tank. Some steel tanks, most often jacketed tanks, have a 2" interstitial riser pipe down through the inside of the tank, with tanks constructed since 1998 with the pipe in the longitudinal center of the tank. FRP tanks will usually have an access riser that goes down the tank top, and then circles the annular space around the tank. Some double wall FRP tanks have a liquid reservoir at the tank top, and the interstice is full of brine solution.



Liquid reservoir

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Appendix G. Pipe Dope Diagram

This diagram shows areas at a refueling station where pipe dope/pipe thread sealant might be used.

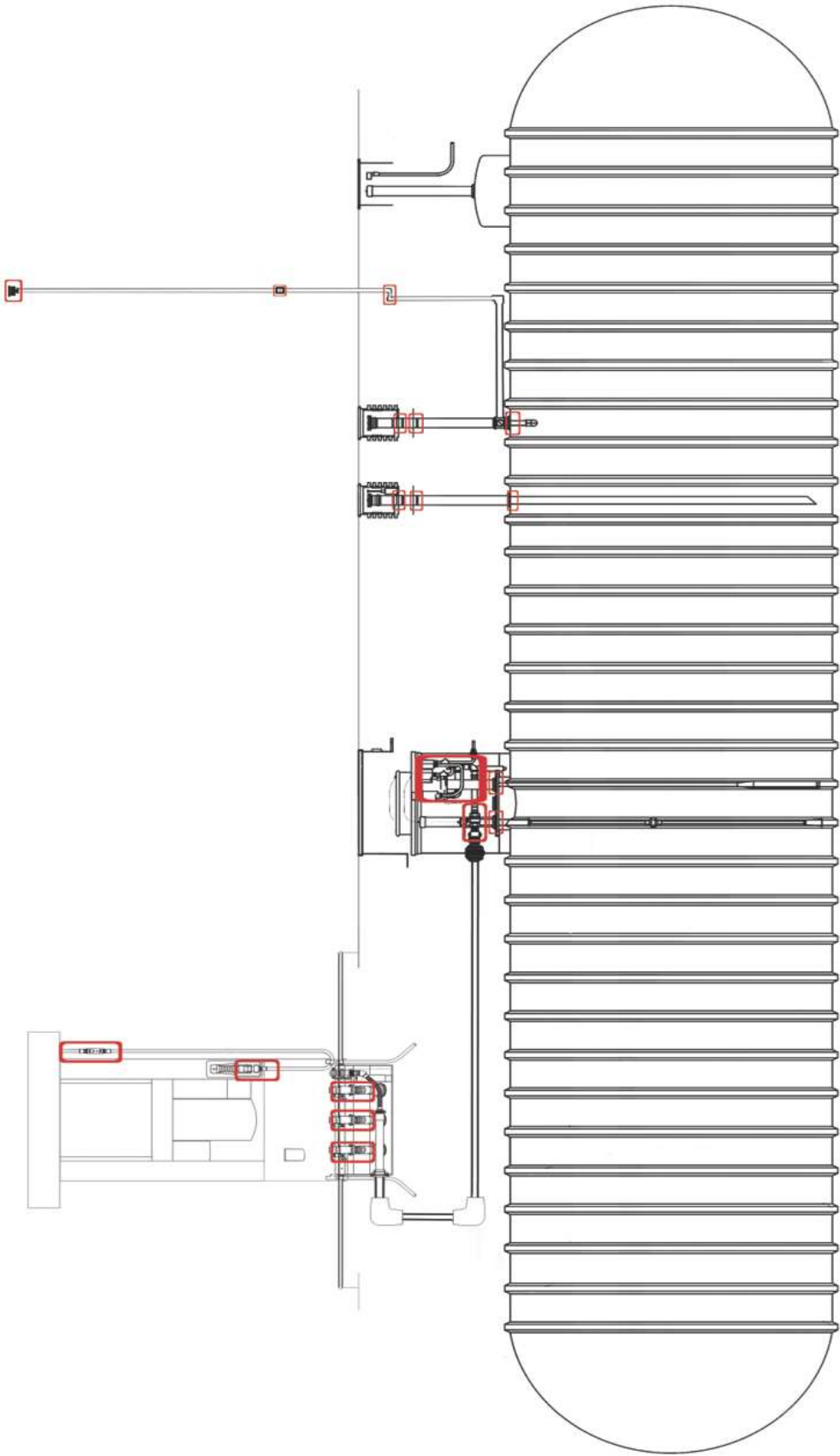


Diagram provided by Source North America, a fueling equipment distributor