Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.This updated publication was prepared under the direction of the API Safety and Fire Protection Subcommittee. The first edition was published in 1956 with subsequent editions in 1967, 1974, 1982, 1991, 1998, and 2008. This eighth edition builds on the technically sound work presented in prior editions. It emphasizes the need to maintain awareness and the continuing need to develop and use sound procedures for controlling hazards and minimizing the possible static ignition risks associated with handling hydrocarbons.

With environmental regulations requiring lower sulfur specification for diesel fuel throughout the world, revisions to the processing to remove sulfur with the need to supplement the new fuels with additives, such as those to improve lubricity, the resultant fuels are much lower in conductivity, often below 2 C.U. This in turn enhances the ability of the fuel to generate and accumulate static charges while flowing through pipes. While there is not a direct correlation between sulfur level and conductivity, current data shows that most low sulfur fuels have low conductivity. The precautionary advice regarding ULSD provided in this eighth edition of API 2003 has been updated to align with recently published guidance in other recommended practices.

Contents

Page

1 Scope . . . 1
1.1 General . . . 1
1.2 Concept of Hazard vs Risk . . . 1
1.3 Units of Measurement . . . 1

2 Normative References . . . 2

3 Terms, Definitions, Acronyms, and Abbreviations . . . 3
3.1 Terms and Definitions . . . 3
3.2 Acronyms and Abbreviations . . . 6

4 Static Electricity Hazards . . . 6
4.1 General . . . 6
4.2 Tank Truck Loading . . . 14
4.3 Tank Car Loading . . . 26
4.4 Marine Operations . . . 28
4.5 Storage Tanks . . . 31
4.6 Miscellaneous Electrostatic Hazards . . . 38

5 Lightning . . . 48
5.1 General . . . 48
5.2 Direct-stroke Lightning . . . 49
5.3 Indirect Lightning Currents . . . 49
5.4 Protection of Specific Equipment Against Lightning . . . 49
5.5 Protection Against Direct-stroke Lightning . . . 52

6 Stray Currents . . . 52
6.1 General . . . 52
6.2 Sources and Limitations . . . 52
6.3 Protection of Specific Operations Against Stray Currents . . . 53

Annex A (informative) Fundamentals of Static Electricity . . . 57

Annex B (informative) Measurement and Detection of Static Electricity . . . 69

Annex C (informative) Direct Strike Lightning Protection Systems . . . 72

Annex D (informative) Units of Measurement . . . 74

Bibliography . . . 75

Figures
1 Fixed Spark Promoter . . . 9
2 Floating Spark Promoter . . . 10
3 Approximate Relationship Between Temperature, Reid Vapor Pressure, and the Flammability Limits of Petroleum Products at Sea Level . . . 12
4 Tank Truck Bonding for Top Loading . . . 18
5 Loading and Unloading of Tank Trucks Through Closed Connections . . . 19
6 Conversion Chart for Flow Rates and Velocities for Selected Pipe Sizes . . . 22
7 Tank Car Bonding . . . 27

Contents

Page

8 Charge Separation in a Filter 40
9 Electrostatic Charge Generation During Tank Truck Loading Update Using Clear Copy 40
10 Bonding During Container Filling 42
11 Stray Current Bypass 53
12 Isolating Spur Tracks from Main-line Stray Current Sources. 54
13 Bonding, Grounding, and Insulating at Marine Wharves 56
A.1 Static Procedures 58
A.2 Charge Separation in a Pipe. 58
A.3 Charge Movement Through a Liquid. 59
A.4 Charged and Uncharged Bodies Insulated from Ground. 65
A.5 Both Insulated Bodies Share the Same Charge 65
A.6 Both Bodies are Grounded and Have No Charge 65

Tables

1 Summary of Precautions for Tank Truck Loading. 15
2 Charge Relaxation Precautions for Tank Truck Loading with Micropore Filtersh. 16
3 Velocities and Flow Rates for Schedule 40 Pipe 21
A.1 Conductivity and Relaxation Time Constant of Typical Liquids 62
B.1 Effect of Temperature on Hydrocarbon Conductivity 70
D.1 Conventional (English) to Metric (SI) Units of Measure 74

Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents

1 Scope

1.1 General

This recommended practice (RP) presents the current state of knowledge and technology in the fields of static electricity, lightning, and stray currents applicable to the prevention of hydrocarbon ignition in the petroleum industry and is based on both scientific research and practical experience. Furthermore, the principles discussed in this RP are applicable to other operations where ignitable liquids and gases are handled. Their use should lead to improved safety practices and evaluations of existing installations and procedures. When the narrow limits of static electricity ignition are properly understood, fire investigators should be encouraged to search more diligently for the true ignition sources in instances where static ignition is unlikely or impossible.

Following this recommended practice is not required where:

a) static discharges may occur, but flammable vapors are verified to be excluded by gas freeing or inerting the atmosphere in the area of discharge;

b) product handling occurs in a closed system, and oxygen in that system is verified to be below the minimum concentration required to support combustion, such as in the handling of liquefied petroleum gas (LPG);

c) the flammable concentration is verified to be above the upper flammable limit (UFL).

This document does not address electrostatic hazards relating to solids handling. (See [4], [5], and [15] in the Bibliography.) Vehicle fueling (truck or passenger car) is also outside the scope of this document.

1.2 Concept of Hazard vs Risk

Hazards are situations or properties of materials with the inherent ability to cause harm. Flammability, toxicity, corrosivity, stored electrical, chemical, or mechanical energy all are hazards associated with various industrial materials or situations. Charge separation and the accumulation of a static charge are inherent properties of low conductivity hydrocarbon fluids.

Risk includes a consequence such as a hot surface or material that can cause thermal skin burns or a corrosive acid can cause chemical skin burns, but these can occur only if there is contact to the skin. An accumulated static charge can be a source of ignition only if exposed to a flammable fuel-air mixture under conditions where a discharge is possible. There is no risk when all the required elements do not exist; charge accumulation, flammable mixture, and spark discharge.

Determining the level of risk involves estimating the probability and severity of exposure of an event that could lead to harm. While the preceding examples relate hazards to the risk to people, the same principles are valid for evaluating risks to property and the environment. For instance, hydrocarbon vapors in a flammable mixture with air can ignite if exposed to a source of ignition (such as a static discharge) resulting in a fire which could injure people or damage property.

1.3 Units of Measurement

Values for measurements used in this document are generally provided in both U.S. customary and SI (metric) units. To avoid implying a level of precision greater than intended, the second cited value may be rounded to a more appropriate number. Where specific code or test criteria are involved, an exact mathematical conversion is used. Some conversions are included in Annex D.

2 Normative References

No single publication covers all the material needed to understand electrostatic ignition of hydrocarbons and the appropriate protection against such ignition. The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API/EI Standard 1529 [1], *Aviation fueling hose* and hose assemblies

API Recommended Practice 2027, *Ignition Hazards and Safe Work Practices for Abrasive Blasting of Atmospheric Storage Tanks in Hydrocarbon Service*

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

API Standard 650, *Welded Steel Tanks for Oil Storage*—Annex H

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

API/ANSI Recommended Practice 2016, *Guidelines and Procedures For Entering and Cleaning Petroleum Storage Tanks*

API Recommended Practice 545, *Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids*

AIChE/CCPS [2], *Electrostatic Ignitions of Fires and Explosions*, Thomas H. Pratt ISBN 0-8169-9948-1 (with errata)

AIChE/CCPS, *Avoiding Static Ignition Hazards in Chemical Operations*, L. G. Britton, ISBN 0-8169-0800-1

ASTM D323 [3], *Standard Test Method for Vapor Pressure of Petroleum Products* (Reid Method)

ASTM D2624, *Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels*

ASTM D4308, *Standard Test Method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter*

ISO 1813 [4], *Belt Drives—V-ribbed belts, Joined V-belts and V-belts including wide section belts and hexagonal belts—Electrical conductivity of antistatic belts: Characteristics and methods of test*

ISO 9563, *Belt Drives—Electrical conductivity of antistatic endless synchronous belts—Characteristics and test method*

NFPA [5], *Fire Protection Guide to Hazardous Materials*, 14th Edition

NFPA 30, *Flammable and Combustible Liquids Code*, 2015 Edition

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2015 Edition

NFPA 69, *Standard on Explosion Prevention Systems, 2014 Edition*

1 Energy Institute, formerly the Institute of Petroleum, 61 New Cavendish Street, London W1G 7AR, UK, www.energyinst.org.
2 American Institute of Chemical Engineers, Center for Chemical Process Safety, 3 Park Avenue, 19th Floor, New York, New York 10016, www.aiche.org/ccps.
3 ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.
4 International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.
5 National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

NFPA 70, *National Electrical Code®*, 2014 Edition

NFPA 77, *Recommended Practice on Static Electricity*, 2014 Edition

NFPA 407, *Standard for Aircraft Fuel Servicing*, 2012 Edition

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2014 Edition

OCIMF [6], *International Safety Guide for Oil Tankers and Terminals* (*ISGOTT)*, 5th Edition 2006

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

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

3.1.1
arc
An electrical discharge that occurs at the instant two points, through which a large current is flowing, are separated. Technically, electrostatic discharges are always sparks, not arcs.

3.1.2
bonding
The practice of providing electrical connections between isolated conductive parts of a system to preclude voltage differences between the parts (see Figure A.5). The low current associated with static charges can be satisfactorily bled off using small wires over long distances. In field use, a strong wire resistant to physical damage may be needed, in which case a bond wire may be sized for physical or mechanical strength. These larger wires typically have low resistance. The process of connecting two or more conductive objects together by means of a conductor so that they are at the same electrical potential does not necessarily mean they are at the same potential as the earth.

NOTE A bond resistance as high as 1 megohm (10^6 ohms) can be adequate for static dissipation. However, for stray current protection, lightning protection, and other electrical systems, the bonding resistance needs to be significantly lower, no more than a few ohms.

3.1.3
closed connection
A connection in which contact is made before flow starts and is broken after flow is completed (e.g. bottom loading of tank trucks).

3.1.4
combustible liquid
A liquid with a flash point at or above 100 °F (38 °C) as defined by NFPA 30.

3.1.5
conductivity
σ
The capability of a substance to transmit electrostatic charges, normally expressed in picoSiemens per meter (pS/m) or conductivity units. For petroleum products, the following conductivities are defined for the liquid temperature during transfer operations. Conductivity measurements at laboratory temperature shall be adjusted to represent transfer temperature using rationale such as explained in Annex B.6.

High Conductivity—measured conductivity above 50 conductivity units (C.U.)
Low Conductivity—measured conductivity less than 50 C.U. but no less than 2 C.U.
Ultra-low Conductivity—measured conductivity 2 C.U.

[6] Oil Companies International Marine Forum, 27 Queen Anne's Gate, London, SW1H9BU, England, www.ocimf.com.

3.1.6
conductivity unit
C.U.
A unit of electrical conductivity equal to 1 pS/m where 1 pS/m = 1×10^{-12} siemens per meter = 1×10^{-12} ohm^{-1} m^{-1}. (The pS/m unit represents the same conductivity value as the now obsolete picomho/m.)

3.1.7
flammable liquid
A liquid as defined by NFPA 30 having a flash point below 100 °F (38 °C) and having a Reid vapor pressure (RVP) not exceeding 40 psia (276 kPa).

3.1.8
grounding
NFPA 77 defines grounding as the process of bonding one or more conductive objects to the ground, so that all objects are at zero (0) electrical potential (also referred to as "earthing"). For hydrocarbon transfers this is accomplished by providing electrical continuity between a fuel handling system and ground or earth to ensure that the fuel handling system is at zero potential (see Figure A.6). A resistance as high as 1 megohm is adequate for static dissipation. For other purposes, such as electrical systems, lightning protection, etc., very much lower resistances are needed.

3.1.9
hazard
A situation or inherent chemical or physical property with the potential to do harm (flammability; oxygen deficiency; toxicity; corrosivity; stored electrical, chemical, or mechanical energy).

3.1.10
high vapor pressure products
Liquids with a Reid vapor pressure 100 °F (38 °C) above 4.5 psia (31 kPa). These products include aviation and motor gasoline and high vapor pressure naphtha.

3.1.11
intermediate vapor pressure products
Flammable liquids with a Reid vapor pressure 100 °F (38 °C) below 4.5 psia (31 kPa) and a closed-cup flash point of less than 100 °F (38 °C). These can form flammable vapors at ambient operating temperatures. Examples of these products are commercial aviation fuel (Jet B), military aviation turbine fuel (JP-4, TF-4), and solvents such as xylene, benzene, and toluene.

3.1.12
low vapor pressure products
Liquids with closed cup flash points above 100 °F (38 °C). Examples of these products include heating oil, kerosene, diesel fuel, commercial aviation turbine fuel (Jet A), and "safety solvents."

3.1.13
Reid vapor pressure
RVP
The vapor pressure of a petroleum product in a closed vessel at 100 °F (38 °C) (ASTM D323).

3.1.14
relaxation time constant
The time for a charge to dissipate to e^{-1} (approximately 37 %) of the original value. In general, for hydrocarbon liquids, relaxation time constant is approximated by the relationship:

$$\tau = 18/\sigma$$

where

τ is relaxation time in seconds;