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Transportation and Storage of Containerized Flammable and Combustible Liquids:

The Disconnect Between U.S. Federal Regulations, and State and Local Fire Codes

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Executive Summary

The Occupational Safety and Health Administration (OSHA) Standard related to flammable and combustible liquids, 29 CFR 1910.106, is based upon an outdated 1969 edition of NFPA 30, *Flammable and Combustible Liquids Code,* and some interpretive letters.[1] This regulation is also silent on many important issues related to electrostatic ignition risks and fire performance of containers storing ignitable liquids.

The U.S. Department of Transportation (DOT) regulations govern the transport of various materials including containerized flammable and combustible liquids. The requirements included within these federal regulations are based in part upon a series of performance tests. These tests are intended to replicate potentially adverse conditions during transportation. None of these tests or associated transportation regulations addresses the fire and life safety risks associated with these commodities under fire conditions while being transported or in storage. In other words, fire testing of containers for shipping such liquids is not required for DOT approval. These DOT regulations also align with the United Nations (UN) Recommendations on the Transport of Dangerous Goods.

Many state and local jurisdictions adopt or recognize model fire codes, such as those promulgated by the National Fire Protection Association (NFPA). The NFPA's *Flammable and Combustible Liquid Code*, NFPA 30, does address fire risks associated with the storage of containerized flammable and combustible liquids. This code has prescriptive requirements for storage conditions including restrictions on container type and size which are intended to mitigate the associated fire risk. Once adopted by authorities having jurisdiction, the provisions within this code, and other building and fire codes that reference NFPA 30, becomes mandatory requirements.

The fire safety disconnect between federal transportation and the model building and fire safety codes can create conflict and misunderstanding among facility operators, code enforcers, and emergency responders. This can lead to a false sense of security among important stakeholders and presents serious life safety concerns.

Use of a container that has been tested and marked in accordance with DOT standards is often interpreted as being acceptable for indoor storage. This can manifest itself in an unacceptable high fire risk once shipments arrive at production and storage facilities. Conditions that are acceptable for transportation are not necessarily automatically acceptable per State and local codes applicable to production and storage facilities.

Additionally, the NFPA fire hazard classification system for flammable and combustible liquids includes rankings for all liquids, including those with ≥ 200 ^{o}F (93 ^{o}C) flash points. The U.S. DOT regulations do not include all such liquids in their scheme.

[1] NFPA 30, Flammable and Combustible Liquids Code, National Fire Protection Association, Quincy, MA, 2015.

Ignitable Liquid Properties and Fire Hazard Classifications

A thorough fire risk assessment of containerized liquids must consider many factors. These factors, including physical properties, ease of ignition, combustion behavior, and reactivity, define the inherent hazard of these liquids. Additionally, the ability to control or extinguish fires involving containerized liquids should also be part of a complete fire risk assessment. Failure to recognize all of these risk factors will result in an inadequate assessment.[2]

One of the ignition properties, closed cup flash point, is typically the basis for risk ranking classification systems applied to liquids. While the flash point method of hazard classification does not provide a complete assessment of a given liquid's fire risk, it does provide a repeatable measure of ease of ignition when a liquid is exposed to an open flame under prescribed test conditions.

NFPA 30 has such a classification system based upon this type of ignition as follows:

NFPA Classification	Flash Point	Boiling Point
Class IA Flammable Liquid	< 73 ^{o}F (22.8 ^{o}C)	< 100 ^{o}F (37.8 ^{o}C
Class IB Flammable Liquid	< 73 ^{o}F (22.8 ^{o}C)	≥ 100 ^{o}F (37.8 ^{o}C)
Class IC Flammable Liquid	≥ 73 ^{o}F (22.8 ^{o}C) & < 100 ^{o}F (37.8 ^{o}C)	-
Class II Combustible Liquid	≥ 100 ^{o}F (37.8 ^{o}C) & < 140 ^{o}F (60 ^{o}C)	-
Class IIIA Combustible Liquid	≥ 140 ^{o}F (60 ^{o}C) & < 200 ^{o}F (93 ^{o}C)	-
Class IIIB Combustible Liquid	≥ 200 ^{o}F (93 ^{o}C)	-

The U.S. DOT also employs flash point as a method of material classification for ignitable liquids, but with some significant differences.[3] The U.S. DOT system is derived from the UN model regulations for the transport of dangerous goods.[4] Ignitable liquids are categorized by the U.S. DOT as Class 3 materials with further sub-categorization as follows:

Class 3 Liquids	Flash Point
Flammable Liquid	< 140 ^{o}F (60 ^{o}C)
Combustible Liquid	≥ 140 ^{o}F (60 ^{o}C) & < 200 ^{o}F (93 ^{o}C)

Additionally, the U.S. DOT further defines the degree or level of danger as follows:

Class 3 Packing Groups	Flash Point	Initial Boiling Point
I – Great Danger	-	≤95 °F (35 °C)
II – Medium Danger	<73 °F (23 °C)	>95 °F (35 °C)
III – Minor Danger	≥73 °F, ≤140 °F (≥23 °C, ≤60 °C)	>95 °F (35 °C)

It should be noted that the U.S. DOT does not regulate liquids having a flash point ≥ 200 ^{o}F (93 ^{o}C), yet fires involving these high flashpoint liquids are capable of generating extremely high heat release rates once ignited.

[2] Nugent, David P., "Flammable and Combustible Liquids Hazards," Fire Protection Engineering, Society of Fire Protection Engineers, Bethesda, MD, October 1, 2013.
[3] Title 49, Code of Federal Regulations, Part 173.
[4] Recommendations on the Transport of Dangerous Goods, United Nations, New York and Geneva, Seventeenth Edition, 2011.

The implication for the U.S. DOT ranking system is that liquids with flashpoints ≥ 200 °F (93 °C) pose no fire danger. Moreover, the term "minor danger" used to describe Packing Group III liquids is quite misleading from a fire risk perspective.

Role of Containers in Prevention and Mitigation of Fires

Liquids are typically packaged in containers manufactured from a number of materials such as glass, steel, plastic, fiber, or various combinations of these materials. When filling containers with flammable liquids there is a risk of electrostatic ignition. If this flammable liquid is non-conductive, such as a hydrocarbon, and it is being filled into a non-conductive container, such as plastic, the risk is much higher.[5]

For this reason, NFPA 30 does not permit flammable liquids to be stored in the larger sizes of plastic or composite intermediate bulk containers (IBCs). However, the U.S. DOT and the corresponding UN model code allows for the shipment of combustible liquids and some flammable liquids in certain of these larger container types, such as plastic and composite IBCs.

Also, when fire exposed, liquid-filled containers exhibit various failure modes and resultant fire types. Container failure can result in fire types such as static pool fires, flowing two and three-dimensional fires, and pressurized releases resulting in jet-flames and violent ruptures. These possibilities are based upon the properties of the liquids and the design of the containers. The containers allowed by NFPA 30 for storage and handling of flammable and combustible liquids do consider the fire performance of containers. This code also has requirements for a wide variety of occupancy types, such as mercantile venues and liquid warehouses. Within these occupancies, NFPA 30 has provisions for what is categorized as "protected storage" and "unprotected storage."

"Protected storage" refers to a storage arrangement protected by a fire sprinkler system capable of significantly controlling a fire. The design criteria for such systems, which are specific to certain storage conditions, are listed within tables contained in NFPA 30. These tables contain limits on ceiling and storage height, storage aisle width, and sprinkler system design criteria. Additionally, and most importantly, each table is specific to a certain container type and certain liquid classification. Deviations from these prescriptive requirements could render a facility classification as "unprotected."

Each table in NFPA 30 is based upon a series of full-scale fire tests, which intend to replicate actual storage and protection conditions.[6] Details regarding the supporting full-scale fire tests can be found in Annex D.2, NFPA 30.

"Unprotected storage" has certain limitations on storage quantity and height. Adopting an unprotected storage strategy assumes large uncontrolled fires are possible. Therefore, property insurance carriers and authorities having jurisdiction may not allow for "unprotected storage."

Containers manufactured from plastic, in whole or in part, tend to be the more challenging container types in fire situations. When subjected to direct flame impingement, or radiant heat, plastic can melt resulting in release and ignition of the liquid contents. This can produce uncontrollable fires typical

[5] Bennett, D, "Plastic Containers for Flammable Liquids/Hazardous Areas, Electrostatic Risks, RR804 Research Report," Health and Safety Laboratory, Harpur Hill, Buxton, Derbyshire, SK17 9JN, Health and Safety Executive, June 2010.

[6] Nugent, David P., "Full-Scale Sprinklered Fire Tests," Fire Protection Engineering, Society of Fire Protection Engineers, Bethesda, MD, Summer, 2002, pp. 40-44.

sprinkler systems cannot control. This assessment is particularly relevant to lower flash point hydrocarbons in larger containers, 55-gallon (208-liter) plastic drums, and intermediate bulk plastic or composite containers.

While containers made from steel can produce pressurized releases resulting in uncontrollable fires, this behavior can be more readily controlled when using relieving-style containers and are protected with properly engineered sprinkler systems.[7]

The U.S. DOT does not differentiate between container types on the basis of fire performance. Containers are required to pass a battery of performance tests to be considered approved and include the following:

- Drop Test
- Leakproofness Test
- Hydrostatic Pressure Test
- Stacking Test
- Vibration Test

None of these DOT tests involves a container's ability to dissipate electrostatic charges, or fire resistance and failure mode, when exposed to flames. This situation has resulted in a significant disconnect between transportation regulations and building and fire codes, such as NFPA 30.

Finally, the OSHA standard related to ignitable liquids is 29 CFR 1910.106, "Flammable Liquids."[8] This federal regulation is based upon on the 1969 edition of NFPA 30 and subsequent interpretive letters. This dated regulation is silent on electrostatic ignition risks that are addressed in the Recognized and Generally Accepted Good Engineering Practices contained in NFPA 77, *Recommended Practice on Static Electricity*.[9] 29 CFR 1910.106 also does not address the fire performance of containers storing ignitable liquids.

Recommendations

The following recommendations are suggested to begin to address the aforementioned issues:

1. A task group, to include representatives of the stakeholder Federal agencies (DOT, OSHA, and perhaps others), relevant voluntary consensus standards developers (NFPA and others), and industry groups (the American Petroleum Institute, the American Chemistry Council, the Industrial Packaging Alliance of North America, and the American Coatings Association), should be formed to identify areas of conflict or lack of correlation among the agency rules and the voluntary consensus standards. It is possible that this work could be coordinated with the extensive review of chemical facility safety that is contained in Executive Order 13650, *Improving Chemical Facility Safety and Security*.

2. OSHA should promptly initiate rulemaking proceedings to revise the existing, dated regulations in 29 CFR 1910.106 to assure, at a minimum, that they are consistent with current NFPA 30 requirements, and adequately reflect the fire risks presented by the new containers that have entered the marketplace since the 1969 version of NFPA 30, the basis for the current regulation.

[7] Nugent, David P., "Double the Height Not Double the Risk", *NFPA Journal*, National Fire Protection Association, Quincy, MA, January/February, 2000.
[8] 29 CFR 1910.106, "Flammable Liquids." Occupational Safety and Health Standards, United States Department of Labor.
[9] NFPA 77, Recommended Practice on Static Electricity, National Fire Protection Association, Quincy, MA, 2014.