NFPA 328
Manholes, Sewers, and Similar Underground Structures
1992 Edition

NFPA

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NFPA 328

Recommended Practice for the Control of

Flammable and Combustible Liquids and Gases in Manholes, Sewers, and Similar Underground Structures

1992 Edition

This edition of NFPA 328, *Recommended Practice for the Control of Flammable and Combustible Liquids and Gases in Manholes, Sewers, and Similar Underground Structures*, was prepared by the Technical Committee on Tank Leakage and Repair Safeguards, released by the Correlating Committee on Flammable Liquids, and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 18-21, 1992, in New Orleans, LA. It was issued by the Standards Council on July 17, 1992, with an effective date of August 14, 1992, and supersedes all previous editions.

The 1992 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 328

Sufficient case histories of fires and explosions in underground structures fully justify a careful review of the material contained within this recommended practice. The sources of flammable vapor-air mixtures in these locations, coupled with a study of unsafe practices and protective practices contained herein, certainly will indicate the desirability of utilizing the applicable corrective measures suggested in the summary of this report. This recommended practice was first adopted in 1956, and subsequent editions were published in 1964, 1970, 1975, 1982, 1987, and 1992.

Minor amendments were made to Sections 2-4, 2-4.4, and 2-6 in this 1992 edition.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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Contents

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Recommended Practice for the Control of

Flammable and Combustible Liquids and Gases in Manholes, Sewers, and Similar Underground Structures

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NOTICE: Information on referenced publications can be found in Chapter 4.

Foreword

Manholes, sewers, and similar underground conduits have long been recognized as constituting areas where fire and explosion hazards of some severity might exist. The probability of an explosion within an underground space depends on two factors: (1) that the atmosphere contains a mixture of flammable vapor and air within the flammable range, and (2) that there be a coincident source of ignition. The severity of an individual explosion and its consequences depends on various factors. The possibility that any one explosion might result in a major catastrophe is always present.

This publication is limited to the control of hazards presented by flammable and combustible liquids and gases found in manholes, sewers, vaults, and similar underground structures. The underground structures include: sanitary sewers, storm drains, water lines, fuel gas distribution systems, electric light and power conduits, telephone and telegraph communication lines, street-lighting conduits, police and fire signal systems, traffic signal lines, refrigeration service lines, steam lines, and petroleum pipelines.

The term "underground structures" is not intended to include subways, tunnels, and the substructural areas of buildings such as underground garages.

The purpose of this publication is to give to enforcement officials, fire authorities, contractors, and owners of underground structures guidance on problems involving flammable and combustible liquids and gases that might be found in underground structures.

Chapter 1 The Problem

1-1 General. With increasing congestion and for aesthetic considerations, the trend in civic planning is toward the installation of all types of utility services beneath the street surface. This results in a continuous program of excavation and construction, with frequent damage to existing structures.

1-2 Sources of Ignition.

1-2.1 The possibility of ignition of flammable gases or vapors that might collect in underground areas is limited by certain fundamental conditions. The vapor must be mixed with sufficient air to make a flammable mixture or it must be escaping into air at a point where a flammable mixture can be created. Heat of sufficient intensity to ignite the particular air-vapor mixture involved must be present at the place where a flammable mixture exists. Such heat might be caused by an open flame, an electric arc or spark, an incandescent heated particle, or a hot surface.

1-2.2 The flammable limits of the gases and vapors that have been found in underground structures are listed in Appendix A. Flammable mixtures are formed when the concentration of these gases in air is between the minimum and maximum shown.

1-2.3 Any open flame is a potential source of ignition. These can be encountered in everyday work operations. Little control can be exerted over the casual sources of ignition when flammable vapors are escaping from or into underground structures. Such casual sources of ignition include burners and warning lanterns used by street surface maintenance crews, automotive and other internal combustion engines, tar pots, and pedestrian smokers.

1-2.4 The heat of an electric arc occurring in electric underground structures can cause the distillation of insulating material, thus producing flammable gases that in turn can be ignited by the arc itself when the proper air-gas ratio is reached. This usually will occur when the arc reaches a manhole or vault after having started in a duct. Other gases or flammable vapors, if present, can also be ignited by such an arc.

1-2.5 Static electricity can be a source of ignition and its accumulation is generally greatest in an atmosphere of low humidity. The hazard appears when static accumulates to the extent where a spark discharge occurs. Static electricity can be generated when a liquid under pressure escapes from a pipe at high velocity. Particles of dust, scale, or rust, or liquid droplets, inside the pipe can become heavily charged with static when blown out by gas or vapor and, if they impinge on an electrically isolated body, the body will accumulate the charge and a spark discharge can occur.

1-3 Sources of Flammable and Combustible Liquids and Gases.

1-3.1 The condition created by the existence of gases and vapors in underground structures can be grouped into two classes: (1) flammable and (2) injurious to life. The latter condition results from the toxic or suffocating properties of the gases or vapors. Some of these liquids and gases fall into both classes. While this publication deals primarily with the flammable limits associated with liquids and gases, some of which are listed in Appendix A, additional precautions may be required to protect against health hazards. An example is hydrogen sulfide; its dangerous breathing concentration is only a small fraction of the lower flammable limit (LFL).

1-3.2 Natural Gas. Natural gas is gas originating from naturally occurring gas- or oil-bearing strata. In oil- and natural gas-producing areas, cracks and faults in the underlying strata or abandoned wells may permit gas to permeate the soil and enter underground conduits and vaults. Within the boundaries of some cities, there are actively producing oil and gas fields and many of these underlie developed areas, residential and industrial, where underground structures are now installed.

1-3.3 Fuel Gas. Fuel gases include natural gas, liquefied petroleum gases, coke-oven gas, coal gas, oil gas, carbureted water gas, water gas, producer gas, and blast-furnace gas. These gases, except liquefied petroleum gases, have specific gravities lower than that of air so that, when released in an underground space, they will tend to rise and diffuse rather rapidly above the point of leakage. These gases, when mixed with air within certain limits, produce flammable mixtures. Since the oxygen content of each of these gases when not mixed with air is usually below 1.0 percent, they can be classed as suffocating gases. With the exceptions of natural gas and liquefied petroleum gases, they are also highly toxic because of the high carbon monoxide content. Natural gas and other fuel gases, as distributed by utility companies in underground pipes, are also a source of flammable gas. These pipes are subject to damage caused by corrosion, electrolysis, structural failures, and adjacent excavating. These causes are discussed in greater detail in later paragraphs of this section.

1-3.4 Refrigerant Gases. A number of the common refrigerants, such as ammonia, methyl chloride, ethyl chloride, methyl bromide, and ethyl bromide, have varying degrees of flammability. With the exception of ammonia, all of these refrigerants are heavier than air when in the vapor phase. Therefore, if they are released in large quantities in closed spaces, they will flow downward into the lowest areas. Of these, only ammonia has a sufficiently strong odor in dilute concentrations to indicate its presence. Exposure to ammonia vapors can cause severe burns even at concentrations below the flammable limits. Liquid ammonia is often distributed through underground street pipes for refrigeration service in the business districts of many large cities. This system of pipes is subject to the same exposure to physical damage as fuel gas pipes and petroleum pipelines.

1-3.5 Electric Cable and Other Insulating Material Gases. This source of flammable gas is practically limited to severely overloaded electric underground circuits. A breakdown of cable insulation will produce an electric arc. If the protective fuses do not operate promptly, this electric arc will continue. The heat of the arc can, by destructive distillation of cable insulation (varnished cambric, rubber, or paper), produce flammable gases containing hydrogen, carbon monoxide, and hydrocarbons.

1-3.6 Chemicals. Accidental spillage in chemical processing plants and disposal of waste chemical products through sewers by industrial plants are potential sources or contributing causes for explosive conditions. Examples of such products are carbon disulfide and ammonia. Calcium carbide will react with water to produce the flammable gas acetylene.

1-3.7 Sewage Gases. Sewage gas results from the fermentation or decomposition of organic matter. These gases can be produced when organic matter has settled as a solid in sewer lines as a result of flat grades, crevices, sumps, or obstructions where consistent flow of sewage is lacking, or as a result of bacterial action on wood or other organic material immersed in water. These flammable gases are principally methane, hydrogen sulfide, and hydrogen and, on the basis of present evidence, they seldom reach explosive concentrations in sewers and drains. However, when they are mixed with other flammable liquids and gases present in sewers, explosive conditions might exist.

1-3.8 Flammable and Combustible Liquids. Cleaning solvents and compounds washed down drains by industrial and domestic users can be the source of flammable vapors. Hydrocarbon liquids (for example, gasoline and kerosene at industrial plants, service stations, and garage wash racks) are occasionally sent to sewers and drains either accidentally or through negligence. Any leaking underground tank containing liquids, such as a service station's underground gasoline tanks, can also be a source of flammable vapors in underground structures (*see NFPA 329, Recommended Practice for Handling Underground Leakage of Flammable and Combustible Liquids*).

1-3.9 Petroleum Pipeline Liquids. Liquid petroleum and liquefied petroleum gases are conveyed by pipelines installed beneath public streets and rights-of-way. These pipelines are exposed to the same sources of physical damage as fuel gas pipes, as discussed in detail later. If any of these pipelines should fail, the escaping liquids and gases can penetrate substructure walls or rise to the street surface. Liquids can be washed into drains or enter the ventilating openings in the manhole covers of underground structures. Escaping liquid petroleum products can evaporate in the ground, penetrate the surrounding ground, or enter a confined space to produce a flammable mixture.

1-3.10 Penetration of Structures by Gases. Flammable gas present in the soil can enter conduits, sewers, drains, or basements because underground structures constructed of cement, concrete, brick, or vitreous tile generally are not built to be impervious to gas. If a flammable gas or liquid is present in the soil, as might be produced by decaying organic matter, there is some likelihood that it will penetrate an adjacent underground structure. Particular attention should be paid to landfill sites developed by the depositing of garbage and trash. Gas from this source, primarily methane, might not have an odor. Gas can enter the subsurface sections of buildings through cracks or around any underground conduits that penetrate the substructure walls.

1-3.11 Electric Circuit Oil Switches and Oil-Insulated Transformers. This equipment is frequently installed in a street vault, and electrical failures will occasionally result in an explosion. The action of protective devices in shutting off current is usually very fast, approximately two seconds or less. This has the effect of limiting the damage to the vault in which the failure occurs. However, when the vault is adjacent to or within a large structure, such an explosion can result in heavy damage.

1-4 Damage to Underground Lines.

1-4.1 Corrosion. One type of corrosion affecting gas lines and petroleum pipelines occurs when the soil composition and resistance are such that electric current from the development of local action cells can flow readily from anodic areas on the pipe surface through the soil to the cathodic areas on the same pipe. Such conditions may be due to the soil's acid or alkali content, organic matter, variations of water or oxygen content, soil type, or the presence of certain bacteria in the soil. Corrosion can also occur as a result of chemical reaction between the pipe and surrounding soil. Corrosion of this type can be controlled with cathodic protection.

1-4.2 Stray Currents. Another cause of corrosion in underground lines is stray electric currents originating from such sources as direct-current electric railways and trolley lines using rails to carry return currents; industrial plant direct-current machinery using the ground as a return conductor; stray currents from cross-connections with other structures carrying current; and leakage from foreign system cathodic protection rectifiers. These currents might not be destructive where they enter the piping system, but drainage of these stray currents to ground can cause corrosion at these points of discharge.

1-4.3 Structural Failures. The allocation of insufficient space for the installation of underground structures can, in some situations, result in the encasement of gas and flammable and combustible liquid pipes in the walls of ducts and subsequently constructed masonry vaults. Such pipes from vaults might be fractured under certain conditions. Flood washouts, earthquakes, and landslides can cause the dislocation and movement of ground and are often responsible for pipe fractures. Rupture of water mains due to corrosion, electrolysis, or structural failure can, in turn, cause washout of soil that supports gas and flammable liquid pipes. Lacking support, these pipes can fracture.

1-4.4 Excavating. Contractors doing excavation work often encounter gas mains and flammable and combustible liquid pipes. Even though aware of their presence, workers might unintentionally damage a pipe, resulting either immediately or ultimately in a leak. Damage such as this is not always reported and often inadequate repairs are attempted by the party responsible for the physical damage.

1-4.5 Fire Damage. Fires in underground structures can result in spalling of concrete, destruction of protective linings, and deterioration of other interior surfaces. Such damage, if extensive, can weaken the structure.

1-5 Unsafe Practices.

1-5.1 Before washing spilled petroleum products from street surfaces into drains or sewers (a potentially dangerous action and often an unlawful practice), other disposal means, such as soaking up the substance with sand, rags, or mops, should be considered. If, in an emergency, no alternative is available, disposal into a drain or sewer should be done only on the decision of a qualified person, after appropriate public authorities have been notified.

1-5.2 Disastrous consequences can result from the thoughtless or deliberate dumping into drains of waste products that are either flammable or that, by reaction with organic matter in sewers, can produce a flammable mixture. Though the presence of a flammable material might be detected, its source can be difficult to determine.

Chapter 2 Protective Practices

2-1 The adoption of protective measures that will detect the presence of flammable materials in manholes and vaults and provide the means to prevent the accumulations of gas or vapor within the explosive range should reduce the incidence of explosions in underground structures. Such a defensive procedure is necessary because of the difficulty of eliminating the flammable material at its source.

2-2 Numerous sources of ignition can be found in underground structures. The operators of underground structures can materially reduce the number of ignitions by eliminating the use of flames in suspected areas. Experience has shown, though, that fire and explosion incidence can best be reduced by the elimination of flammable vapors from the atmosphere of the underground structure. It is all but impossible to remove all ignition sources.

2-3 Considering the diversity of contributing causes for flammable products in underground structures, protective practices should be designed to reduce to a minimum the quantity of flammable vapors. Where such vapors are found to be present, a complete purge of the manhole or vault atmosphere should be made and the source of the flammable vapors eliminated. Manholes and vaults should be ventilated by forced draft when necessary to prevent concentrations of these vapors within the explosive range. After complete ventilation of the underground structure, the atmosphere should be tested with a combustible gas indicator before entering and before any hot work is performed. A low reading on the combustible gas indicator does not necessarily mean that the toxicity hazard has been eliminated. Adequate ventilation should be maintained and periodic gas analysis of the atmosphere during any such work should be made.

2-4 Detection Instruments. There are a number of instruments that can be used to detect unsafe atmospheres found in underground structures. They should be used to determine the characteristics of any questionable situation. Ensure that instruments are properly calibrated before use.

2-4.1 Oxygen. There are indicators that give a direct reading of oxygen concentration. Under no conditions should an area be entered without self-contained breathing apparatus unless it contains at least 19.5 percent oxygen.

2-4.2 Carbon Monoxide. This gas in concentrations greater than 0.10 percent by volume results in unconsciousness in little more than an hour and death in four hours. Further increases in concentration reduce this time element. Its effect is to displace oxygen in the blood stream. Several instruments have been developed for the quick detection of carbon monoxide. Those capable of detecting the smallest concentrations considered hazardous are the carbon monoxide tester (palladium-molybdate complex) and the carbon monoxide indicator.

2-4.3 Hydrogen Sulfide. This flammable and toxic gas is colorless and has an odor resembling rotten eggs. It is toxic in concentrations above 0.002 percent by volume. Continued exposure will paralyze the olfactory nerves. The hydrogen sulfide detector will detect the low toxic concentrations of this gas.

2-4.4 Fuel Gases and Vapors from Flammable and Combustible Liquids. Combustible gas indicators are available in a number of different types to meet the requirements of the specific use to which they may be applied. The most common type is an "all-purpose" instrument suitable for the detection of flammable gases such as natural gas, manufactured gas, hydrogen, and acetylene and all vapor-air mixtures associated with fuel oils, gasoline (including leaded gasoline), alcohols, and acetone. This instrument indicates the presence of gases and vapors in percent of the lower flammable limit (LFL). It must be calibrated, used, and maintained in accordance with the manufacturer's instructions. This instrument must be calibrated on the specific gas being sampled, i.e., natural or manufactured gas, and has a scale range of zero to 100 percent. A portable combustible gas indicator is also available for operation in explosive atmospheres.

2-4.5 Periodic checks for the presence of flammable vapors using appropriate instruments should be made in all water, gas, and electric underground structures. The frequency of such surveys will depend on the previous experience and the potential hazard.

2-4.6 Liquefied petroleum gases and utility gases are odorized to facilitate detection unless the odorant would serve no useful purpose as a warning agent, but such cases are relatively rare and practically all such gases distributed by underground pipelines are odorized. Experience has shown that odorants can be absorbed when traveling through the soil.

2-5 Volatile flammable liquids can enter a drainage system because of a spill or other emergency. Steps should be taken to minimize the hazard by exhausting the vapors with blowers or exhaust fans driven by explosionproof motors and by pumping out the liquid with pumps equipped with explosionproof motors. Floor drain openings into buildings in the area of the spill and for some distance downstream should be checked for escape of vapors. Water should be placed in any dry traps to seal them. Copious quantities of water should be used to flush any flammable or combustible liquid through the system quickly and to dilute it, if miscible with water.

2-6 Underground tanks of flammable liquids can be a source of leakage. When a tank is found to be leaking, its contents should be removed immediately. When such a tank is taken out of service, abandoned, or removed, the procedures described in Appendix C of NFPA 30, *Flammable and Combustible Liquids Code*, entitled Abandonment or Removal of Underground Tanks, should be followed.

2-7 Sewers and drains should be periodically flushed and cleaned to prevent deposits of organic material and slime growth. Periodic inspections should be made of industrial plants to prevent the discharge into sewers of waste that might produce explosive gases due to physical or chemical impurities, high temperatures, alkalies, or acids, unless the system is specifically designed for such materials.

2-8 Periodic checks of protective equipment in underground electric systems should be made. Efforts should be made to prevent the overloading of cables and to avoid arcing conditions that might form flammable gas by the breakdown of insulation.

Chapter 3 Summary

3-1 A review of all the factors relating to the problem of explosive hazards in underground structures, together with an analysis of causes of explosions, indicates that flammable material might at some time be present in an underground structure.

Control procedures and education are the proper approaches to the problem. Effective control cannot be maintained unless the various utilities involved, the administrative bodies of cities, and others cooperate in an adequate safety program.

3-2 Utility companies should maintain an adequate inspection program for the detection of leaks at street openings. This can best be accomplished by the use of combustible gas indicators, vegetation surveys, and other methods. Periodic inspection and testing of key equipment should be conducted with reasonable frequency as a part of regular maintenance operations. Such a distribution piping maintenance program could be carried out in accordance with the requirements of federal and state pipeline regulations.

3-3 Inactive gas services and mains should be abandoned in accordance with federal and state regulations.

3-4 Automatic or manually operated drains in industrial piping should be designed so as not to discharge their product into underground structures.

3-5 Owners and operators of underground pipelines carrying flammable and combustible liquids should maintain an adequate inspection program for the detection of escaping liquids.

3-6 RP 1621, *Recommended Practice for Bulk Liquid Stock Control at Retail Outlets*, published by the American Petroleum Institute, will be of value to operators of service stations.

3-7 An in-service training program for all employees whose occupation is associated with underground structures will teach them to recognize the presence of fire and toxic hazards and oxygen deficiencies and teach them how to take proper precautions against such possibilities.

3-8 Some public authorities have established a program to control or prevent the discharge into sewers and drains of all products likely to result in flammable atmospheres in vaults and manholes.

3-9 Sewers and drains should be designed to ensure that proper cleansing velocities and proper ventilation are maintained so as to prevent infiltration and to avoid the settling of heavy solids. Sewers and drains should be designed to minimize the danger of settlement and failure that in turn might break other adjacent underground structures.

3-10 Where ventilation of a vault or manhole is necessary and mechanical ventilation cannot be provided, the manhole or vault should be designed (depending on local conditions) so that effective natural ventilation for vapors or gases lighter than air can be obtained. Manholes for sewers should be regularly spaced to provide effective ventilation and explosion relief.

3-11 Every effort should be made to establish standard practice for the design, construction, and maintenance of all underground structures with respect to the elimination of explosive hazards and the contributory causes.

3-12 Close liaison should be established between the fire chief and industrial safety officials. Mutually approved procedures should be developed to cope with emergencies so that fire fighters can act effectively in their line of duty.

3-13 All agencies having underground structures should be prepared to furnish contractors with the record of the locations of such adjacent structures or furnish a person who knows the location of these pipes. In the event the exact location of any underground structure is not known, the contractor should make a physical inspection of the entire right-of-way of the proposed excavation by employing underground detecting devices and visual inspection of adjacent structures.

3-14 Apart from direct damage to piping, contractors should take extra precautions to avoid damage to corrosion protecting coatings, anodes, electrodes, bonding facilities, and related devices. If these are disturbed or damaged, the owner of the structures should be notified before backfilling the excavation. Care should be taken in all excavations in which wire or metal is found, even though these are not immediately adjacent to a pipeline. They may be part of the protective system.

3-15 Public authorities should:

(a) Adopt an ordinance that would require a contractor before starting construction or excavation work (1) to obtain a permit, (2) to notify the owner of adjacent underground structures in writing of his intention to start work, and (3) to obtain from the owner the exact information on the location of the underground structures and pipes containing flammable materials. All agencies having underground structures should be prepared to furnish contractors with exact information on the location of such underground structures. This permit should prohibit the contractor from interference with the above-mentioned pipes without giving prior notice to the owner or operator.

(b) Require anyone conducting blasting operations to obtain a permit. The permit should not be granted until the owners of adjacent underground structures have been consulted. NFPA 495, *Explosive Materials Code*, contains additional information on this subject.

(c) Require anyone razing buildings to obtain a permit. The permit should not be granted until the owners of underground structures in the area have been consulted.

(d) Prohibit the encasement of pipes containing flammable materials within the constructed walls of new structures. This recommendation does not apply to piping entering buildings.

(e) Establish a procedure for connecting direct-current electrical equipment to ground on the premises of the user. This is to prevent the inclusion, directly or indirectly, of underground pipes carrying flammable materials in the return electric circuit.

(f) Promote cooperative efforts on the part of all organizations having underground facilities to reduce corrosion.

Chapter 4 Referenced Publications

4-1 The following documents or portions thereof are referenced within this recommended practice and should be considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

4-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 30, *Flammable and Combustible Liquids Code*, 1990 edition

NFPA 325M, *Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*, 1991 edition

NFPA 329, *Recommended Practice for Handling Underground Leakage of Flammable and Combustible Liquids*, 1992 edition

NFPA 495, *Explosive Materials Code*, 1992 edition.

4-1.2 API Publications. American Petroleum Institute, 1220 L St., NW, Washington, DC 20005.

API Recommended Practice 1621, *Bulk Liquid Stock Control at Retail Outlets*, Fourth Edition, 1987.

Appendix A

This Appendix is a not part of the recommendations of this NFPA document, but is included for information purposes only.

Properties of Some Flammable and Combustible Liquids and Gases That Have Been Found in Underground Structures[1]

	Flash Point Closed Cup Deg. F	Flammable Limits in Air % by Vol Lower	Upper	Specific Gravity of Liquid (Water = 1)	Vapor Density (Air = 1)
Acetone	-4	2.15	13.0	0.8	2.00
Acetylene	Gas	2.5	100.0	—	0.90
Ammonia	Gas	16.0	25.0	—	0.6
Benzene	12	1.3	7.1	0.9	2.8
Butadiene	Gas	2.0	12.0	—	1.9
Butane	Gas	1.6	8.5	—	2.00
Carbon Disulfide	-22	1.3	50.0	1.30	2.60
Carbon Monoxide	Gas	12.5	74.0	—	1.0
Ethane	Gas	3.0	12.5	—	1.0
Ethyl Chloride	-58	3.8	15.4	0.9	2.2
Gas Oil*	150*	0.5	5.0	< 1	—
Gasoline (Values vary for different grades of gasoline)	-45	1.4	7.6	0.8	3.-4.0
Hydrogen	Gas	4.0	75.0	—	0.1
Hydrogen Sulfide	Gas	4.0	44.0	—	1.2
Kerosene	100-162	0.7	5.0	< 1	—
Methane	Gas	5.0	15.0	—	0.6
Methyl Bromide (Practically nonflammable)	Gas	10.0	15.0	—	3.3
Methyl Chloride	Gas	8.1	17.4	—	1.8
Natural Gas*	Gas	3.8	13.0	—	—
Petroleum Naphtha* (Petroleum Ether)	< 0	1.1	5.9	0.6	2.5
Propane	Gas	2.1	9.5	—	1.6
Toluene	40	1.2	7.1	0.9	3.1

*These liquids and gases are mixtures, and their properties may vary depending on the composition.
[1]Properties of other flammable materials can be found in NFPA 325M, *Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids.*

Index

The NFPA Codes and Standards Development Process

Since 1896, one of the primary purposes of the NFPA has been to develop and update the standards covering all areas of fire safety.

Calls for Proposals
The code adoption process takes place twice each year and begins with a call for proposals from the public to amend existing codes and standards or to develop the content of new fire safety documents.

Report on Proposals
Upon receipt of public proposals, the technical committee members meet to review, consider, and act on the proposals. The public proposals – together with the committee action on each proposal and committee-generated proposals – are published in the NFPA's Report on Proposals (ROP). The ROP is then subject to public review and comment.

Report on Comments
These public comments are considered and acted upon by the appropriate technical committees. All public comments – together with the committee action on each comment – are published as the Committee's supplementary report in the NFPA's Report on Comments (ROC).

The committee's report and supplementary report are then presented for adoption and open debate at either of NFPA's semi-annual meetings held throughout the United States and Canada.

Association Action
The Association meeting may, subject to review and issuance by the NFPA Standards Council, (a) adopt a report as published, (b) adopt a report as amended, contingent upon subsequent approval by the committee, (c) return a report to committee for further study, and (d) return a portion of a report to committee.

Standards Council Action
The Standards Council will make a judgement on whether or not to issue an NFPA document based upon the entire record before the Council, including the vote taken at the Association meeting on the technical committee's report.

Voting Procedures
Voting at an NFPA Annual or Fall Meeting is restricted to members of record for 180 days prior to the opening of the first general session of the meeting, except that individuals who join the Association at an Annual or Fall Meeting are entitled to vote at the next Fall or Annual Meeting.

"Members" are defined by Article 3.2 of the Bylaws as individuals, firms, corporations, trade or professional associations, institutes, fire departments, fire brigades, and other public or private agencies desiring to advance the purposes of the Association. Each member shall have one vote in the affairs of the Association. Under Article 4.5 of the Bylaws, the vote of such a member shall be cast by that member individually or by an employee designated in writing by the member of record who has registered for the meeting. Such a designated person shall not be eligible to represent more than one voting privilege on each issue, nor cast more than one vote on each issue.

Any member who wishes to designate an employee to cast that member's vote at an Association meeting in place of that member must provide that employee with written authorization to represent the member at the meeting. The authorization must be on company letterhead signed by the member of record, with the membership number indicated, and the authorization must be recorded with the President of NFPA or his designee before the start of the opening general session of the Meeting. That employee, irrespective of his or her own personal membership status, shall be privileged to cast only one vote on each issue before the Association.

Sequence of Events Leading to Publication of an NFPA Committee Document

Call goes out for proposals to amend existing document or for recommendations on new document.

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Committee meets to act on proposals, to develop its own proposals, and to prepare its report.

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Committee votes on proposals by letter ballot. If two-thirds approve, report goes forward. Lacking two-thirds approval, report returns to committee.

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Report — *Report on Proposals* (ROP) — is published for public review and comment.

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Committee meets to act on each public comment received.

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Committee votes on comments by letter ballot. If two-thirds approve, supplementary report goes forward. Lacking two-thirds approval, supplementary report returns to committee.

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Supplementary report — *Report on Comments* (ROC) — is published for public review.

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NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP or ROC).

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Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

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Appeals to Standards Council on Association action must be filed within 20 days of the NFPA Annual or Fall Meeting.

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Standards Council decides, based on all evidence, whether or not to issue standard or to take other action, including upholding any appeals.

Committee Membership Classifications

The following classifications apply to Technical Committee members and represent their principal interest in the activity of a committee.

M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.

U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.

I/M *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.

L *Labor:* A labor representative or employee concerned with safety in the workplace.

R/T *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.

E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.

I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.

C *Consumer:* A person who is, or represents, the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in the *User* classification.

SE *Special Expert:* A person not representing any of the previous classifications, but who has special expertise in the scope of the standard or portion thereof.

NOTE 1: "Standard" connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of members or unique interests need representation in order to foster the best possible committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of "Utilities" in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.