UL 340

STANDARD FOR SAFETY

Tests for Comparative Flammability of Liquids

UL Standard for Safety for Tests for Comparative Flammability of Liquids, UL 340

Sixth Edition, Dated July 24, 2017

Summary of Topics

This new edition of UL 340 was issued to incorporate the following changes in rerquirements:

> ***Addition of Requirements for Transformer Mineral Oil, Vegetable Oil, and Natural Ester Oil to Tables 3.1 and 13.1***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 14, 2017 and June 9, 2017.

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ANSI/UL 340-2017

UL 340

Standard for Tests for Comparative Flammability of Liquids

First Edition – March, 1972
Second Edition – July, 1979
Third Edition – June, 1993
Fourth Edition – September, 1997
Fifth Edition – March, 2009

Sixth Edition

July 24, 2017

This ANSI/UL Standard for Safety consists of the Sixth Edition.

The most recent designation of ANSI/UL 340 as an American National Standard (ANSI) occurred on July 24, 2017. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 This Standard provides a method, based on the results of specified flammability tests, for the classification of fluids or liquids as nonflammable, or as flammable with the degree of fire hazard rated both in general terms and on a numerical scale, in comparison with well-known products whose hazards have been established by field experience.

1.2 The classifications derived by this method are evaluations of the inherent flammability of liquids and their vapors. Increases in fire hazard due to partial evaporation of components of certain liquid mixtures during handling and use are taken into account in assigning the fire hazard classification. The assigned classifications do not apply when the liquid is dispersed in the atmosphere in the form of finely divided spray, mist, or fog.

1.3 The liquids may be pure chemical compounds, homogeneous mixtures or solutions, emulsions, or multilayer combinations of immiscible liquids. The liquid products may contain undissolved solid materials, either in suspension or as a separate layer.

1.4 This method of classification with respect to fire hazard is applicable to liquids which are essentially stable materials. Liquids susceptible to dangerous decomposition reactions during phase change or when exposed to heat or mechanical shock, and liquids subject to hazardous exothermic polymerization, are considered unstable materials within the intent of this Standard. It should be ascertained that the product is stable with respect to these features before applying the tests specified in this Standard. Evaluation of the more severe hazards presented by such unstable materials requires considerations which are beyond the scope of this Standard.

1.5 The classifications derived by this method are with respect to fire hazard only. The assigned ratings do not cover other potential hazards, including the physiological effects of the products, in any form, nor do they indicate the efficiency or effectiveness of the products in their intended uses.

2 General

2.1 Units of measurement

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Undated references

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Classification System

3.1 This System measures and correlates the most important flammability characteristics of a particular liquid in terms of corresponding characteristics of a number of well-known liquids such as gasoline, ethyl alcohol, kerosene, and paraffin oil, the fire hazards of which have been established by field experience. The System provides both a general classification and a numerical rating of the fire hazards, based on a numerical scale of hazard ranging from 0 to 100 assigned to the reference liquids as indicated in Table 3.1.

Table 3.1

General Classification	Numerical Classification
Diethyl ether	100
Gasoline	90 to 100
Ethyl alcohol	60 to 70
Kerosene	30 to 40[a]
Paraffin oil	10 to 20
Water or nonflammable	0 or nonflammable

[a] A standard kerosene of 100°F (37.8°C) flash point (closed cup) is rated 30 to 40.

3.2 The following descriptions set forth procedures for the basic tests used to develop information for the rating of a liquid with respect to its fire hazard under this Classification System. In the case of liquids intended for specific uses known to involve exposure to high temperatures or pressures, dissemination as spray or mist, or other special conditions related to the use, additional studies of flammability properties of the liquid under these pertinent conditions should be conducted, so as to provide supplementary information on fire hazards due to the special conditions of use.

4 Glossary

4.1 For the purpose of this Standard, the following definitions apply:

4.2 FLAMMABLE LIMITS –

a) The minimum and maximum concentrations of a vapor in air which, if ignited, propagate flame in the vapor-air mixture independently of continued application of the source of ignition; also known as the lower and upper explosive limits. No attempt is made to differentiate between the terms ″flammable″ and ″explosive″ as applied to limits as there is no practical difference in this context. These limits are usually expressed in terms of percentage by volume of vapor in mixture with air. The numerical difference between the upper and lower flammable or explosive limits is known as the flammable or explosive range.

b) Flammable or explosive limits are not physical constants for a given material, but depend upon the initial temperature and pressure, the shape and dimensions of the confining vessel, the direction of flame propagation, turbulence, and the nature of the source of ignition.

4.3 FLAMMABILITY TEMPERATURE LIMIT –

a) The minimum temperature at which vapor is evolved by a liquid in sufficient quantity to form a flammable mixture with the surrounding air. It is a function of the vapor pressure of the liquid and the lower flammable limit of the vapor at the prevailing temperature and pressure. While evaporation of a liquid occurs at temperatures below the flammability temperature limit, the vapor pressure of the liquid at those temperatures will not produce a vapor concentration sufficient to form a flammable mixture with air. This temperature limit will vary with atmospheric pressure and to some extent with humidity. However, from the standpoint of this Standard, the flammability temperature limit depends principally on the test procedure and apparatus used (rate of temperature rise in the liquid, exposed surface area of the liquid, conditions of exposure to air, and the ignition means and location).

b) The flammability temperature limit of liquids which are pure chemical compounds does not change during evaporation of the liquid, provided the ambient atmospheric pressure remains constant. In the case of liquids which are mixtures of compounds of different volatility and flammability characteristics, however, the flammability temperature limit of the residual liquid may increase or decrease on partial evaporation of the liquid. Thus a mixture of a nonflammable highly volatile component and a flammable component of lower volatility may not form flammable vapor-air mixtures initially, but the residual liquid after partial evaporation may produce flammable mixtures due to the decrease in the proportional amount of the volatile nonflammable component.

4.4 FLASH POINT -

a) The minimum temperature of a liquid at which vapor is evolved in sufficient quantity to form a flammable mixture with air, as determined using a specified flash point testing apparatus and test procedure.

b) For many flammable liquids, the flash point, as determined with a conventional closed cup flash point tester, provides an indication of the flammability temperature limit. Some liquids, notably certain halogenated hydrocarbons or mixtures containing these compounds, produce vapor-air mixtures which do not yield a flash point when tested in a conventional flash point tester. In such cases, it is then necessary to conduct additional tests to determine the flammability temperature limit, or to determine that the liquid is nonflammable.

4.5 IGNITION TEMPERATURE –

a) The minimum temperature to which a vapor-air mixture must be raised by application of heat to produce autogenous combustion, as indicated by the appearance of flame or glow.

b) The ignition temperature of a liquid is not a physical constant, and may be affected by variables such as the size, shape, and degree of confinement of the space in which the ignition occurs, catalytic and other actions of the heated surface, surface combustion, initial pressure, and the concentration of the vapor-air mixture.

4.6 SPONTANEOUS HEATING –

a) A rise in temperature above ambient due to chemical reaction of a combustible material itself (exothermic decomposition or polymerization), or between a combustible material and a supporter of combustion, in the absence of external sources of heat such as flames, sparks, thermal radiation, or other heat sources above 100°C.

b) When the increase in temperature resulting from the chemical reaction is sufficient to cause ignition of the combustible, the process is known as ″spontaneous ignition.″

c) In the case of chemically unsaturated liquids liable to spontaneous heating by reaction with the oxygen in air, the process may be accelerated by factors such as the ratio of surface area to volume of liquid (liquid distributed on fibrous material), the degree of ventilation, and the ambient temperature.

PERFORMANCE

5 General

5.1 Test information

5.1.1 The tests used to obtain data for the classification of liquids with respect to fire hazard are to be conducted as described in Sections 6 through 12.

5.1.2 Burning Characterization (Section 9), Flash Point (Section 6), Ignition Temperature (Section 7) and Spontaneous Heating (Section 8) tests of the original liquid are typically performed for all products. Based on the results of these tests and available data on the composition of the liquid, some of the remaining tests are to be performed to obtain sufficient information to establish its fire hazard rating in accordance with the classification criteria given in Figure 13.1. The flow chart in Figure 13.1 provides guidelines for determining when these additional tests are necessary.

5.2 Preparation of partially evaporated samples

5.2.1 Partially evaporated samples for a liquid mixture having a boiling point below 200°F (93.3°C) containing nonflammable, highly volatile component(s) and flammable component(s) are to be prepared by placing measured volumes of the liquid in open vessels (beakers) and allowing evaporation to proceed at ordinary room temperature and atmospheric pressure until predetermined volumes (usually in 10 percent increments) remain.

6 Flash Point Test

6.1 The flash point of the liquid is to be determined using the apparatus and test method as described in 6.2 and 6.3.

6.2 The Tag Closed Tester and method described in Standard Test Method for Flash Point by Tag Closed Cup Tester, ANSI/ASTM D56 is to be used for liquids having a viscosity below 5.5 mm^2/s (cSt) at 104°F (40°C), or below 9.5 mm^2/s (cSt) at 77°F (25°C), and a flash point below 200°F (93°C), except for suspensions of solids, liquids which tend to form a surface film under the test conditions, cut-back asphalts, and liquids of low thermal conductivity (see 6.3).

6.3 The Pensky-Martens Closed Cup Tester and Method described in Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester, ANSI/ASTM D93 is to be used for fuel oils, lube oils, liquids with suspensions of solids, liquids which tend to form a surface film under test conditions, and other liquids with viscosities of 5.5 mm^2/s (5.5 cSt) or more at 104°F (40°C).

7 Ignition Temperature (Autogenous) Test

7.1 The ignition temperature of the liquid is to be determined using the apparatus and test method as described in 7.2 and 7.3.

7.2 The apparatus employed is to consist essentially of a combustion chamber surrounded by a heat transfer medium such as a molten alloy or fluidized silica bath heated by an electric furnace and a thermostatic control capable of maintaining a temperature up to 1382°F (750°C). The combustion chamber is to consist of a quartz flask of conical form with flat bottom, 4.49 inches (114 mm) in height, 2.36 inches (60 mm) in diameter at the bottom, and 1.10 inches (28 mm) in diameter at the top. It is to be of about 160 mL (9.76 in^3) capacity, having a ratio of surface area to volume of about 1:1. The temperature of the bath is to be measured by means of thermocouples.

7.3 In conducting the tests, measured test samples of the liquid are to be introduced into the heated combustion chamber. When ignition is obtained in this test, different amounts of the liquid are to be introduced in successive trials at progressively lower temperatures in order to determine the minimum temperature at which the vapor, in any proportion with air, will ignite without application of flame. After each trial, the combustion chamber is to be purged of vapors and solid residuals by passage of a stream of air.

8 Spontaneous Heating Test

8.1 The liquid is to be tested for spontaneous heating using the apparatus and test method as described in 8.2 and 8.3. A rise in the temperature of the sample above the temperature of the water bath under the conditions of the test is to be considered an indication of spontaneous heating of the material.

8.2 The apparatus used for the spontaneous heating test is to consist of a vertical cylindrical test chamber, 7 inches (178 mm) in height and 4 inches (102 mm) in diameter, surrounded at the side and bottom by an electrically heated water bath. The cover is to have two vertical tubes of unequal height, one terminating near the top of the interior of the test chamber, and the other extending to near the bottom of the interior of the test chamber, to provide for a thermally induced circulation of air through the chamber. The cover is also to have an opening for a thermocouple. The sample is to be contained within the test chamber by a cylinder of wire gauze, 6 inches (152 mm) in height and 1-1/2 inches (38 mm) in diameter. This cylinder is to be placed in a position concentric with the axis of the chamber, leaving an annular space through air of 1-1/4 inches (32 mm) between the cylinder and the wall of the chamber.

8.3 In conducting the test, typically 14 grams of the product are to be uniformly distributed over 7 grams of cotton fiber (commercial absorbent cotton) and placed in the upper 5 inches (127 mm) of the containing cylinder within the test chamber. A thermocouple, connected to an automatic recording potentiometer, is to be inserted into the cotton bearing the test sample so as to measure the temperature at the approximate center of the mass. The cover is then to be placed on the test chamber and the water bath surrounding the chamber maintained at boiling for at least 24 hours.

9 Burning Characterization Test

9.1 The burning characteristics of the liquid are to be determined as described below.

9.2 A small sample (approximately 5 mL) of the liquid at room temperature is to be placed in a nominal 80 mL porcelain evaporating dish in a draft-free location. A small test flame approximately 1/4 inches in length produced by passing natural gas through a 1/16 inch orifice shall be applied to the vapors evolved. Observations shall be made to determine whether the vapors ignite and continue to burn after removal of the test flame. If the vapors do not ignite, the sample is to be gently heated and the test flame applied at intervals until ignition occurs, the liquid reaches the boiling point, or polymerization occurs.

10 Tests for Flammability (Explosiveness) of Vapor-Air Mixtures

10.1 General

10.1.1 The apparatus and method of test for liquids which are volatile [boiling point below about 200°F (93.3°C)], and liquids containing volatile ingredients, are to be as described in 10.2. For liquids that are less volatile [boiling point above 200°F (93.3°C)], the apparatus and method referred to in 10.3 are to be employed. If no ignition is obtained using the apparatus and procedure in 10.2, additional tests are to be conducted using the apparatus and procedure described in 10.3.

10.2 Test in Spherical Glass Flask

10.2.1 The explosion vessel is to be a spherical flask of heat resistant glass having a nominal capacity of two liters. The spherical diameter of the vessel is to be 6-3/8 inches (162 mm). It is to be provided with a vertical neck, 1-7/8 inches (48 mm) in diameter and 2-7/8 inches (73 mm) in length, the outlet of this neck being closed by a stopper having an inlet for introduction of samples of the product in the liquid phase. A paddle type stirrer, 1-5/8 inches by 2-1/4 inches (41 by 57 mm), for mixing vapors from the product with air within the vessel, is to be located about 2-1/2 inches (64 mm) above bottom, this stirrer being driven by an external motor with shaft passing through a tightly fitted sleeve in the stopper for the vessel. The stirrer should not contact the unevaporated sample of the product.

10.2.2 The explosion vessel, except for the upper part of the neck, is to be immersed in a liquid bath maintained at a predetermined constant temperature.

10.2.3 The electric discharge from a transformer rated 110 volts, alternating current for the primary and 23 milliamperes, 10,000 volts for the secondary is to be used as a source of ignition for the vapor-air mixtures. A 0.01-microfarad capacitor is to be connected across the secondary of the transformer. Electrodes, connected to the secondary, are to terminate within the explosion vessel at its vertical axis, 1 inch (25.4 mm) above bottom. The gap between these electrodes is to be about 1/4 inch (6.4 mm).

10.2.4 In conducting tests of the explosiveness of the vapors of the product, a measured sample of the product in the liquid phase is to be introduced into the explosion vessel maintained at a predetermined temperature and the inlet to the vessel closed thereafter. The stirrer is to be operated to obtain rapid mixing of the vapor evolved by the sample with the air in the test vessel. At intervals (1/4, 1/2, 3/4, 1, 1-1/2, 2, 3, 5, 10, 15, 20, 25, and 30 minutes) after introduction of the sample or upon evaporation of the sample, stirring is to be discontinued and the electrical discharge from the transformer is to be passed across the gap between the electrodes for 0.4 seconds. Observations are to be made for flame propagation.

10.2.5 Any unevaporated sample is to be removed from the explosion vessel and the vessel is to be purged of residual gases and vapors in preparation for the introduction of the next sample.

10.2.6 When flame propagation occurs in this test, different amounts of liquid are to be admitted to the explosion vessel at progressively lower temperatures in order to determine the minimum temperature at which the vapor, in any proportion with air, will form a flammable mixture.

10.3 Test in Cylindrical Steel Vessel

10.3.1 The explosion vessel is to be a cylindrical steel vessel, 6 inches (152 mm) inside diameter, and 26 inches (660 mm) long. The vessel is to be provided with a small mica window, a sample inlet, and an outlet to atmosphere. The vessel is to be heated externally by gas burners. Electrodes, with a gap of 1/4 inch (6.4 mm), are to be located inside the vessel at its center. The external terminals of these electrodes are to be connected to the secondary of a transformer identical in characteristics to that described for the apparatus in 10.2.3. A thermocouple, connected to a potentiometer, and with hot junction in a well extending into the interior of the vessel, is to be used for measurements of the temperature of the vapor-air mixture inside the vessel.

10.3.2 In conducting the test, the cylinder is to be heated to a predetermined temperature, the outlet of the cylinder is to be closed loosely with a heat resistant plug, and a measured amount of the liquid is to be introduced into the cylinder. The electrical discharge from the transformer is then to be passed across the gap between the electrodes. Observations are to be made through the mica window for flame propagation.

10.3.3 When flame propagation occurs in this test, different amounts of liquid are to be admitted to the explosion vessel at progressively lower temperatures in order to determine the minimum temperature at which the vapor, in any proportion with air, will form a flammable mixture.

11 Test for Behavior on Heating

11.1 A weighed sample of the liquid is to be heated slowly (at a temperature below the boiling point), in an open tared beaker on an electric hot plate, with magnetic stirring. The vapors evolved during the heating are to be tested for flammability at frequent intervals, by application of small test flame approximately 1/4 inch in length produced by passing natural gas through a 1/16 inch orifice.

11.2 If ignition of the vapors occurs during evaporation of the liquid, the liquid remaining in the beaker is to be immediately cooled and weighed, and the flash point of this residue determined in accordance with Section 6.

11.3 If no ignition of vapors occurs before the liquid evaporates to dryness or becomes too viscous to stir, the residue (if any) is to be weighed. A portion of the residue is to be tested to determine its ignition temperature if any.

12 Test for Lower Flammable Limit

12.1 The lower flammable limit is to be determined in accordance with the Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases), ASTM E681. Tests are to be conducted at 212 ±4°F (100 ±2°C) and at one percent by volume (sample/air) increments. The relative humidity of the air used for mixing is to be 50 ±5 percent at 73.4 ±5°F (23 ±3°C).

CLASSIFICATION

13 General

13.1 The fire hazard of liquids is to be classified in accordance with the numerical and general scale shown in Table 13.1.

Table 13.1
Fire hazard classification scale

Numerical fire hazard rating	General classification	Flammability temperature limit °F (°C)[a, b]
100	With diethyl ether	-49 (-45) or lower
90 to 100	With gasoline	13 (-10.6) to -48 (-44.4)
80 to 90	Between gasoline and ethyl alcohol	38 (3.3) to 14 (-10)
70 to 80	Between ethyl alcohol and gasoline	51 (10.6) to 39 (3.9)
60 to 70	With ethyl alcohol	67 (19.4) to 52 (11.1)
50 to 60	Between ethyl alcohol and kerosene	83 (28.3) to 68 (20.0)
40 to 50	Between kerosene and ethyl alcohol	99 (37.2) to 84 (28.9)
30 to 40	With kerosene	129 (53.9) to 100 (37.8)
20 to 30	Between kerosene and paraffin oil	256 (124.4) to 130 (54.4)
10 to 20	With paraffin oil	440 (226.7) to 257 (125)
0 to 10	Less hazardous than paraffin oil	441 (227) or greater
0 or nonflammable	With water or nonflammable	Noncombustible[c]

NOTE: Dielectric Media/Transformer Fluids including mineral oil, natural and synthetic esters, silicone oil and refined petroleum oil exhibiting flammability temperature limits > 464°F (240°C) may be assigned a Numerical Fire Hazard Rating of “4-5 Less Hazardous than paraffin oil”.

[a] Flammability temperature limits are just one measure of liquid flammability, and do not indicate the propensity for ignition when the liquid is dispersed as a spray or mist. A more fundamental consideration for a burning pool of liquid is the heat release rate per unit surface area at a given imposed heat flux, as measured in a cone calorimeter.

[b] Liquids can be ignited at temperatures below the indicated temperature limits when they are dispersed as a mist or are decomposed by an arc. Furthermore, the temperature of an arc can be well above the flammability point of the liquid, on the order of 700 °C.

[c] In this classification scale, materials which do not burn under any conditions are rated nonflammable.

13.2 The fire hazard classification assigned to a liquid shall be determined on the basis of results of tests in the manner indicated in Figure 13.1.

Figure 13.1
Classification Criteria