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FIRE SAFETY

Flash Point

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INTRODUCTION

The flash point of a liquid is an indication of the temperature at which a liquid may present a fire or explosion hazard. Flash points are referenced in Federal standards and governmental regulations, and in the codes and regulations of states and municipalities. The flash point defines whether a liquid is classified as a flammable or a combustible liquid under codes and regulations which determine how it can be packaged, stored and shipped and what warnings are required. It also establishes whether it must be considered "highly flammable" under Consumer Product Safety Commission rules.

Flash Point can be defined as the lowest temperature at which a liquid produces sufficient vapors to ignite momentarily upon application of a pilot flame under specific test conditions. The flash point is measured as a temperature-based liquid property, using standardized apparatus and at standard temperature and atmospheric temperature. The liquid does not self ignite at the flash point temperature; a pilot flame is necessary. In addition, at the flash point the ignition is transient; the vapor just flashes and the fire goes out. Flame is not sustained until the liquid is at or above the fire point temperature; fire point is defined as the lowest temperature at which a specimen will sustain burning for at least five seconds under specified conditions of test. More vapors must be given off by the liquid to sustain combustion than to flash so the fire point temperature is normally higher than the flash point.

When the vapors are ignited at the flash point temperature there is no significant explosive pressure developed in a closed container. A richer mixture is needed to produce a destructive force. As concentration of the fuel vapor in air is increased from its value at flash point, the explosive pressure and the rate of pressure rise both increase to a maximum value. The maximum value will be slightly above the stoichiometric fuel air mixture†.

The flash point of a liquid corresponds roughly to the lowest temperature at which the vapor pressure of a liquid is just sufficient to produce a flammable mixture at the lower limit of flammability. The Lower Limit of Flammability is the minimum vapor or gas concentration in air which can undergo combustion. Below this limit, the mixture is too "lean" to burn.

CLOSED CUP/OPEN CUP

Flash point tests are subdivided into closed cup and open cup tests. In a CLOSED CUP test, the test apparatus "cup" which contains the liquid being heated is covered so that the vapors produced are contained within the cup as shown in Figure 1. In an OPEN CUP test the test "cup" is not covered so that some of the vapors being produced are dissipated into the open air. The flash point of a liquid determined by a CLOSED CUP test will be lower than the flash point of the same liquid determined by an OPEN CUP test because more of the vapors produced are contained within the cup in a CLOSED CUP test.

† *Stoichiometric Mixture - The gas or vapor concentration in air or other oxidant in which the weight oxidant available to participate in the combustion reaction is that required for complete combustion of the gas or vapor. This value within the flammable limits is important in explosion analysis because the strength of a vapor air explosion depends on the vapor air mixture. The maximum explosion pressure and peak pressure rise occurs when the mixture is slightly above stoichiometric.*

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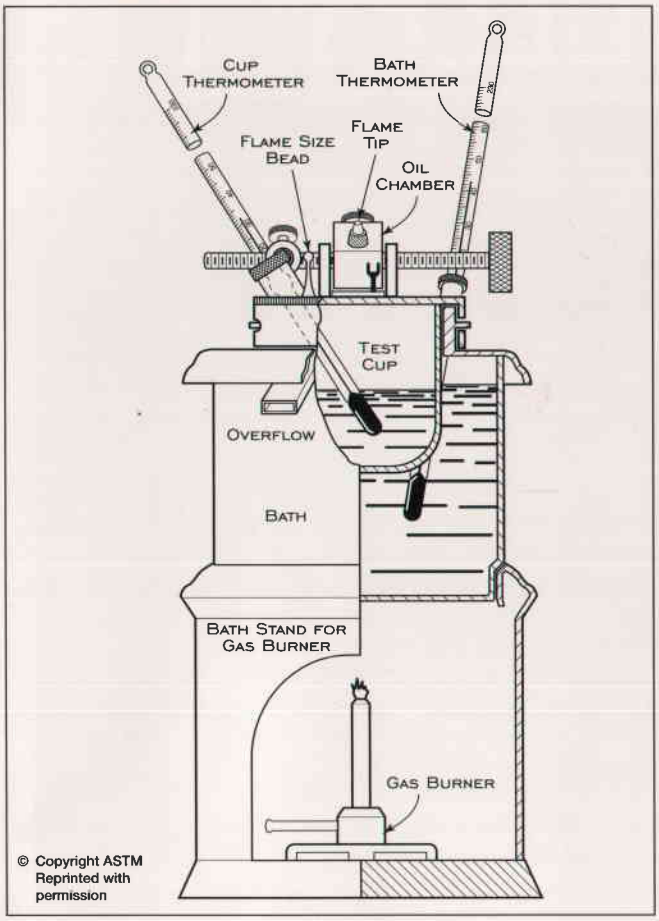

Figure 1 – Tag Closed Flash Tester

STANDARD TESTS: A major promulgator of flash point standards is the American Society for Testing and Materials (ASTM). Founded in 1898, ASTM approved its first flash point standard in 1918. Since that time, the various ASTM committees have approved and reaffirmed or revised a wide variety of standards related to flash point. Eight of these are considered "basic flash point standards." Thirty six standards address specific product types. An additional thirty-six ASTM product specifications include flash point requirements. ASTM flash point standards are referenced in Federal standards and governmental regulations, and in the regulations of states and municipalities.

MISTING AND WICKING

Flash points as listed in the literature are apparatus-dependent. For most situations, flash points are conservative. Flammable/combustible liquid spills usually occur under conditions having more ventilation than the typical "cup" apparatus. There are several circumstances, however, when flash point data may not represent the absolute minimum temperatures at which a material may evolve flammable vapors. When a liquid is sprayed or agitated into a mist it may be ignitable by a pilot flame even though it is well below its flash point. In addition, wicking situations, such as when a suspended rag soaks up a combustible liquid, may actually have a scenario-dependent flash point less than tabulated for a given ignition source. This is because the very large surface area, three dimensional boundaries, and low thermal inertia available with some wicking materials will result in higher local vapor concentrations than that above a pool of liquid at a given temperature[1].

CONTAMINATION

Flash points of liquids consisting of mixtures of different compounds will be greatly influenced by the properties of the more volatile components [2,3,4]. This becomes very significant when the mixture is composed primarily of low volatility, high flash point liquids such as found in kerosenes and jet engine fuels. The flash points of these is reported to be dependent on relatively small amounts of more volatile fuels. Contamination of mixtures by a small amount of more volatile fuel can cause a significant lowering of the flash point. For example, experiments indicated that contamination of kerosene with about five percent gasoline lowered the flash point approximately 75°F [5]. The reduction in flash point is more gradual when there is a smaller difference in the initial flash points of components [6].

AGING

It is very important in fire and explosion investigations to recognize that liquid mixtures age; the flash point increases as volatile constituents evaporate. The evaporation of the more volatile constituents is hastened by heating, agitation and exposure to reduced atmospheric pressures, e.g. high altitude. To determine if a blended liquid such as kerosene or jet fuel could have been above its flash point may require both an analysis of its history and of the possibility of contamination with a volatile liquid [3]. For example, when a small amount of blended liquid is stored in a large tank which is almost empty, there may not be enough of the most volatile constituents present in the blend to form a combustible mixture at the nominal flash point.

ATMOSPHERIC PRESSURE

Just as the boiling point varies with atmospheric pressure so does the flash point. The ASTM flash point standards contain a formula for correcting a flash point measurement for local atmospheric pressure. The National Fire Protection Association (NFPA) Fire Protection Handbook [7] contains a graph of the lower flammable limits of selected liquids as a function of pressure which relates to closed cup flash point. The ASTM correction is linear and is intended to provide a common basis for tests conducted in laboratories at different altitudes or in varying weather conditions [8]. The NFPA correction, intended for a much broader application, is exponential and based on analysis reported in 1938 in which the authors assumed the lower flammable limit of liquids was a constant percent by volume at each pressure [9].

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