



TECHNICAL BULLETIN

SUBJECT	Interpretive Guidance for Ignitable Liquid Analysis Test Reports
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ISSUED BY	Alexander Visotin, Laboratory Manager

Introduction

Our laboratory analyses samples for the presence of ignitable liquid residues according to standardised methods. The current industry standard method for fire debris analysis is ASTM E1618, which includes a classification system for ignitable liquids. This classification system is designed to categorise all types of ignitable liquids that may be encountered in fire debris casework. The purpose of this Technical Bulletin is to explain this classification system and provide examples of various different types of ignitable liquids. This information is intended to assist the fire examiner in the interpretation of their laboratory results and may provide them with additional lines of enquiry regarding the significance of any ignitable liquids detected.

Flammable, combustible and ignitable liquids

There is confusion regarding the correct terminology to use when referring to volatile liquids that can be ignited. What is the difference between a flammable liquid, a combustible liquid, and an ignitable liquid? The difference between these terms is based on flash point. Definitions can vary depending on the authority issuing the definition. The below definitions are derived from AS 1940:2017 (Standard for the Storage and Handling of Flammable and Combustible Liquids). A similar series of definitions is incorporated into the Globally Harmonised System of Classification and Labelling of Chemicals (GHS).

Flammable liquids are those that have a flash point of 60°C or less. *Combustible liquids* are those liquids, other than flammable liquids, which have a flash point and fire point below their boiling point. Combustible liquids are generally divided into two subcategories, including combustible liquids with flash points between 60-93°C, and those with flash points higher than 93°C. Combustible liquids are generally considered more difficult to ignite than flammable liquids.

In fire debris analysis, slightly different terminology is used. This is because we analyse liquid residues with a variety of flash points, and often analyse liquid residues that are heavily weathered

or otherwise unrepresentative of the original liquid. We also have no way of estimating the flash points of the residues we detect. Therefore, the term *ignitable liquid* is used to describe both flammable and combustible liquid products, regardless of their flash point, and is regarded as a catch-all term for any liquid that can ignite.

It is important to note that typical laboratory extraction methods will generally only recover ignitable liquids with flash points below 100°C. Liquids with higher flash points may not be recoverable unless significant quantities of the liquid are present in the sample, or very specific extraction methods are used. This is generally not a problem for most fire scene examinations but is a significant consideration when heavier products such as oils and lubricants require analysis.

The ASTM E1618 ignitable liquid classification system

The ASTM system is made up of eight different classes, each composed of three subcategories based on the boiling point range of the components of the liquid. These subcategories are light, medium, and heavy. Light range liquids fall in the boiling range of butane (C₄) to nonane (C₉). Medium range liquids fall in the boiling range of octane (C₈) to tridecane (C₁₃). Heavy range liquids fall in the boiling range of nonane (C₉) to icosane (C₂₀) and beyond. Light range liquids are highly volatile, whereas heavy range liquids are not. Our laboratory generally classifies each liquid according to a single boiling point range.

Petrol is the only exception to the above rules. As petrol is one of the few ignitable liquids with a unique chemical composition, it has its own classification with no subcategories. For reference, fresh petrol typically occupies the light to medium carbon range.

A classification table based on the ignitable liquid classes specified in ASTM E1618 appears in Appendix 1. Through research and casework, our laboratory has identified a number of additional ignitable liquids that fit into the classification system. These liquids are shown in italics. Note that the classification table in Appendix 1 is not an exhaustive list. Ignitable liquid compositions are constantly changing, and new formulations are always being developed. If you wish to classify a specific ignitable liquid, a sample of it must be provided to the laboratory.

The difference between petrol and petroleum distillates

Petrol (automotive gasoline) and petroleum distillates are distinct ignitable liquids. Petrol is commonly used as automotive fuel but can also be used as a fuel for other types of internal combustion engines, as a degreaser, and as a solvent or thinning agent. It is a highly refined petroleum product which consists of multiple oil refinery streams blended into a single liquid. This is what gives petrol its unique composition.

Petroleum distillates are also refinery products but are less refined than petrol – they are products of the distillation of crude oil. Crude oil is vaporised in a furnace, and the resulting gases are cooled and siphoned off as condensates of varying boiling point ranges. A massive number of commercial ignitable liquid products are petroleum distillates. They are very common in industry and are used frequently as solvents for other compounds. When used as solvents, distillates appear in many common products. However, as they are rarely the active ingredient in a product and sometimes go unlabelled, their presence may go unnoticed. Distillates are often detected as background contaminants in fire debris.

The term “petroleum” in “petroleum distillate” simply refers to the crude oil origin of the product and is not a reference to automotive petrol. Apart from being derived from crude oil, petrol and petroleum distillates are similar in name only and have very different chemical properties.

Naphthenic-paraffinic? Branched alkane? What do all these classifications mean?

The ASTM classification system aims to encompass all ignitable liquids. There is an unfathomably large number of ignitable liquid products in use today, and the classification system is robust because it allows us to classify most of these liquids into a category. This includes liquids that are not commonly available, liquids used only in specific industries, or liquids that are otherwise esoteric.

Think about the last time you went to an industrial fire. Almost every industrial workshop or factory has a flammable liquids storage area. You would have looked in this area when you examined the scene. Did you notice how many different liquids were stored there? Any of those liquids could potentially be used to accelerate a fire, and our laboratory must be able to recognise and report on these liquids when we see them. The names of classes such as *naphthenic-paraffinic* and *branched alkane* simply refer to the chemical species that make up the liquid. As there are so many different liquids, most of which have multiple applications, few have common names such as “petrol”. Therefore, we rely on names that refer to their chemical makeup.

Some forensic laboratories only report on the presence of petrol in fire debris samples. These laboratories believe that, as liquids other than petrol are not commonly used as accelerants, their presence is meaningless. This approach is disingenuous as it withholds a great amount of potentially useful data from the fire examiner. Petrol is not the only accelerant. As any of the liquids in Appendix 1 can potentially be used as accelerants, our laboratory adopts the position that it is important to report on their presence. Even if their presence does not suggest a deliberately lit fire, they can help explain unusual burn patterns or fuel loads at the fire scene. The forensic examiner must be conversant with the different ignitable liquid classifications, and not be dismissive of results that indicate liquids other than petrol.

Manufacture and marketing of ignitable liquid products

It is important to note that some liquids appear in multiple classes. This raises an important point regarding the manufacture and sale of ignitable liquids. Very few hydrocarbon-based ignitable liquids have a unique chemical composition (petrol is the most notable exception). This means that many ignitable liquids in the same class are chemically indistinguishable from one another. In some cases, it is impossible to distinguish between different ignitable liquid products based solely on their GC-MS data. This is because many ignitable liquids are marketed based on their intended use, and not their chemical composition. Consider that there are no regulations or standards that specify precisely what liquids such as mineral turpentine, thinners, or degreasers must contain. These are simply marketing terms, and do not necessarily have any bearing on the chemical makeup of the liquid.

As a result, manufacturers will use the most readily available and the cheapest materials to produce a liquid that behaves as would be expected by the end-user of the product. It is common for manufacturers to put exactly the same liquid product into bottles with different labels. It is also possible for a manufacturer to use one set of chemical ingredients in one week, then switch to an entirely different set of ingredients the next week, based on the availability of materials or the practicality of their use. This will change the composition of the liquid (potentially putting it into a different liquid class) but the end user may not notice a difference. It is erroneous to assume the class or composition of an ignitable liquid before testing it, as there may be no indication on the label of the product regarding its formulation. The same liquid product may have a very different composition from manufacturer to manufacturer, depending on the ingredients and processes used by each company.

For this reason, our laboratory classifies liquids according to their class as prescribed by ASTM E1618 but generally does not identify specific ignitable liquids. Instead, examples are provided of ignitable liquids in the same chemical class with similar compositions. *To identify a sample as containing a specific ignitable liquid when the composition of liquids is unstandardized and subject to change is improper.* Exceptions are possible if a control sample is provided of a specific ignitable liquid, and a comparison between a debris sample and the control is requested. In most other cases, it is not possible to state that a specific ignitable liquid was present in a sample of debris to the exclusion of all other ignitable liquids.

Specific terminology

The term *weathering* is used in test reports to describe the effect of evaporation on ignitable liquid residues. Residues recovered from samples of debris are often weathered as no liquid can be exposed to fire and remain chemically intact. The terms *weathered* and *evaporated* are used interchangeably.

Appendix 1: ASTM E1618 Ignitable Liquid Classification System with Additional Examples

Ignitable liquid class	Examples
Petrol (gasoline) ¹⁰	Neat petrol is typically in the light to medium carbon range.
Light petroleum distillates	Petroleum ether, lighter fluids, camping fuels, naphtha, <i>cleaning solvents, dry cleaning naphtha, thinners¹, Shellite², stain removers, fuel additives, hand warmer fluids, rubber solvents, specialty solvents³</i>
Medium petroleum distillates	Charcoal starters ⁴ , paint thinners ¹ , dry cleaning solvents, mineral spirits, automotive parts cleaners ⁵ , spray lubricants ⁶ , lamp oils, deck sealers, varnishes, kerosene insecticides ⁶ , <i>white spirits, Stoddard solvent, cleaning solvents, degreasers, metal polishes, surface finishing products⁷, fuel additives, paint additives, sealants⁸, specialty solvents³</i>
Heavy petroleum distillates	Kerosene, diesel fuel ¹¹ , charcoal starters ⁴ , aviation fuels (i.e. Jet A), fuel additives, lamp oils, automotive parts cleaners ⁵ , <i>gasoil, heating oils, cleaning solvents, degreasers, fuel additives, insecticides⁶, spray lubricants⁶, paint additives, specialty solvents³</i>
Light isoparaffinic (branched alkane) products	Aviation gasoline, lighter fluids, charcoal starters ⁴ , <i>alkylate gasoline</i>
Medium isoparaffinic (branched alkane) products	Charcoal starters ⁴ , thinners ¹ , copier toners, mineral spirits, cleaning solvents, kerosene, lamp oils, gun oils, <i>'odourless' solvents, surface finishing products⁷, lighter fluids, automotive parts cleaners⁵, specialty solvents³</i>
Heavy isoparaffinic (branched alkane) products	Spot cleaners, penetrating oils, insecticides ⁶ , <i>specialty solvents³, lamp oils, paraffin oils and waxes</i>
Light aromatic products	Automotive parts cleaners ⁵ , cleaning solvents, xylenes, toluene-based products, thinners ¹ , <i>degreasers, racing fuels</i>
Medium aromatic products	Automotive parts cleaners ⁵ , cleaning solvents, insecticides ⁶ , <i>fuel additives, sticker removers, sealants⁸, specialty solvents³</i>
Heavy aromatic products	Insecticides ⁶ , adhesives, <i>specialty solvents³</i>
Light naphthenic-paraffinic (cycloalkane) products	Cyclohexane-based solvents ⁹ , <i>correction fluids, stain removers, adhesives</i>
Medium naphthenic-paraffinic (cycloalkane) products	Charcoal starters ⁴ , insecticides ⁶ , lamp oils, mineral spirits, automotive parts cleaners ⁵ , <i>'odourless' solvents, specialty solvents³</i>
Heavy naphthenic-paraffinic (cycloalkane) products	Insecticides ⁶ , lamp oils, <i>industrial solvents³, fuel additives, kerosene</i>
Light normal-alkane products ⁹	Pentane, hexane, heptane, octane, nonane
Medium normal-alkane products	Candle oils, copier toners, lamp oils, cleaning solvents, <i>charcoal starters⁴, specialty solvents³</i>
Heavy normal-alkane products	Candle oils, lamp oils, carbonless forms, copier toners, <i>specialty solvents³, paraffin oils and waxes</i>
Light oxygenated solvents	Alcohols, ketones, thinners ¹ , fuel additives, surface preparation solvents, automotive parts cleaners ⁵ , adhesives ⁶ , cleaning solvents, <i>paint strippers, nail polish removers, fire gels/pastes, charcoal starters⁴, denatured spirits, windshield washer additives, racing fuels, surface finishing products, specialty solvents³, sealants⁸, pharmaceutical liquids, sanitising products</i>
Medium oxygenated solvents	Metal cleaners, gloss removers, furniture strippers, cleaning solvents, insecticides ⁶ , <i>camping fuels, charcoal starters⁴, surface finishing products⁷, petrol¹⁰, lamp oils, scent diffusers⁶, spray lubricants⁶, thinners¹, industrial solvents³</i>

¹ Thinning and reducing solvents can be used with any solvent-based coating product including paints, lacquers, epoxies, etc.

² Shellite® is a trademarked naphtha product which is unique to Australia.

³ Esoteric liquids that are designed for specific uses in industrial and commercial processes.

⁴ Ignitable liquids, and solid material impregnated with ignitable liquids (i.e. briquettes), that assist in lighting stoves and barbeques.

⁵ Multipurpose cleaners, degreasers and tyre dressings specifically for automotive use.

⁶ Aerosol and diffusion-based products often use ignitable liquids as the vehicle/solvent to carry the active ingredient.

⁷ Designed for final application on a surface such as waxes, finishing oils, protectants, and similar coatings.

⁸ Waterproofing agents, rust inhibitors, and general surface sealing products.

⁹ These products are also common laboratory solvents and may interfere with ILR analysis.

¹⁰ Petrol can be classified as an oxygenated solvent if it is blended with a significant amount of ethanol. However, our laboratory generally classifies petrol as petrol.

Heavy oxygenated solvents	Biodiesel ¹¹ , fuel additives, surface finishing products ⁷ , insecticides ⁶ , <i>thinners</i> ¹ , <i>spray lubricants</i> ⁶ , <i>scent diffusers</i> ⁶
Light others – miscellaneous products	Single-component products, enamel reducers ¹ , thinners ¹ , aviation gasoline, racing fuels, <i>camping fuels</i> , <i>cleaning solvents</i> , <i>specialty solvents</i> ³ , <i>naphtha</i>
Medium others – miscellaneous products	<i>Natural</i> turpentine products, mineral spirits, fuel additives, spray lubricants ⁶ , cleaning solvents, thinners ¹ , citrus-based cleaners, charcoal starters ⁴ , <i>specialty products</i> ³ , <i>correction fluids</i> , <i>adhesives</i> , <i>lighter fluids</i> , <i>surface finishing products</i> ⁷ , <i>paint additives</i> , <i>sealants</i> ⁸
Heavy others – miscellaneous products	Lamp oils, insecticides ⁶ , citrus-based cleaners, automotive parts cleaners ⁵ , kerosene, fuel additives, specialty products ³ , <i>thinners</i> ¹ , <i>cleaning solvents</i> , <i>herbicides</i> , <i>spray lubricants</i> ⁶ , <i>mineral spirits</i> , <i>paint additives</i> , <i>sealants</i> ⁸

¹¹ Biodiesel can be classified as an oxygenated solvent if it is blended with a significant amount of fatty acid methyl esters. However, our laboratory generally classifies biodiesel as a heavy petroleum distillate.