I. Scope: This policy and procedure guideline establishes a standard Ignitable Liquid Classification System.

Ignitable liquids recovered in fire debris analysis will generally fall into the following classifications:

- Distillates (Light, Medium, Heavy)
- Aromatic Products
- Isoparaffinic Products
- Normal Alkane Products
- Naphthenic/Paraffinic Products
- Oxygenated Products

The **Distillate** category must be further classified based on boiling point range as Light, Medium or Heavy. The remaining categories may be sub-classified as Light, Medium or Heavy at the discretion of the analyst.

Gasoline is a unique product and shall be identified and reported as such.

The fact that some petroleum products do not fall clearly into any of these categories, will not necessarily preclude their identification.

II. References

ASTM E-1618, Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography Mass Spectrometry.

Mann DC, Gresham WR. Microbial degradation of gasoline in soil. J Forensic Sci. 35:913–21, 1990.

Kirkbride K, et al., Microbial degradation of petroleum hydrocarbons: implications for arson residue analysis, J Forensic Sci. 37:1585–1599, 1992.

Turner DA, Goodpaster JV. The effects of microbial degradation on ignitable liquids. Anal Bioanal Chem. 394(1):363–72, 2009.

Turner DA, Goodpaster JV. Comparing the Effects of Weathering and Microbial Degradation on Gasoline Using Principal Components Analysis. J Forensic Sci. 57(1):64-9 , 2012.

III. Descriptions of Classifications

When the descriptor Light, Medium or Heavy is used, the following general guidelines for peak spread shall be used:

- Light $C_4 – C_9$
- Medium $C_8 – C_{13}$
- Heavy $C_8 – C_{23+}$
- When the carbon range does not fit into one of the above categories, it may be necessary to characterize a product as “light to medium” or “medium to heavy”.

Gasoline: The predominant feature of gasoline is its aromatic content. Gasoline will also have a significant aliphatic content. Naphthalene and substituted naphthalenes are typically present but are not necessary for identification. The peak spread for gasoline will typically be from $C_4 – C_{13}$. Microbial degradation of gasoline in soil has been well documented in scientific literature. Degraded gasoline may be identified as gasoline, if the substrate is soil and data agrees with published references or with activity observed in a comparison sample.

Distillates: The predominant feature of distillates is a Gaussian distribution of straight-chain alkanes. Distillates will also contain branched-chain alkanes, cycloalkanes and aromatic compounds at abundance less than that of the predominant normal alkane structure. Some of these compounds present at lower levels may not be readily visible in a total ion chromatogram, however a recognizable pattern should be present in the appropriate extracted ion profiles.

- Light Petroleum Distillates are an exception to the above criteria in that they typically will not contain significant amounts of aromatic compounds, yet will still be classified as a distillate. Based on the boiling point range of LPDs and the instrumental technique used, it is recognized that the entire Gaussian distribution of the alkane pattern will not be visible. Additionally, due to the nature of these products, branched-chain and cyclic alkanes may be higher in abundance in light petroleum distillates (possibly similar or greater abundance than the n-alkanes) than those seen in medium or heavy petroleum distillates.
- Medium Petroleum Distillates typically have four n-alkanes and therefore appear as a narrow Gaussian distribution, with a fairly sharp beginning and end.
- Heavy Petroleum Distillates are typically broad fractions and must have at least five consecutive n-alkanes. When C_{17} and C_{18} are present, pristane and phytane must also be present in appropriate ratios. Also included in this classification are narrow range (encompassing fewer than five consecutive n-alkanes) ignitable liquid products starting above C11.
- It is recognized that certain distillates will have greatly reduced or non-existent aromatic content. These products will not be separately classified.

Aromatic Products: Aromatic products consist essentially of aromatic compounds with virtually no aliphatic content. Typically aromatic products will have a narrow peak spread. Depending on boiling point range, polynuclear aromatics may be present.

Isoparaffinic Products: Isoparaffinic products consist essentially of branched-chain alkanes. There will be no significant presence of straight-chain alkanes, aromatic compounds, or cycloalkanes. Typically isoparaffinic products will have a narrow peak spread.

Normal Alkane Products: Normal alkane products consist essentially of straight-chain alkanes. There will be no significant presence of branched-chain alkanes, aromatic compounds, or cycloalkanes. Typically these products will consist of 3 to 5 normal alkanes.

Naphthenic/Paraffinic Products: Naphthenic/Paraffinic products consist essentially of branched-chain alkanes and cycloalkanes. There will be no significant presence of straight-chain alkanes or aromatic compounds. The total ion chromatogram of this type of product will typically appear similar to that of a distillate without the n-alkanes. Typically naphthenic/paraffinic products will have a broad peak spread.

Oxygenated Products: The defining characteristic of an oxygenated product is the significant presence of one or more oxygen-containing compounds, such as an alcohol, ester, or ketone. These commonly appear in blends with petroleum products. At examiner discretion the oxygenated compounds and the petroleum product may be reported separately. If only distinct oxygenated compounds are present, they should be identified and reported as such.

If a pattern is observed which meets some, but not all of the criteria for classification within the previously defined categories, it may be classified as a petroleum product. Differences from existing categories must be minor, such as a difference in peak spread or slight differences in ratios of components. These minor differences could be explained by evaporation sample preparation technique or bacterial degradation associated with soil samples. It should be emphasized that a petroleum product shall not be identified without the presence of a suitable reference ignitable liquid for comparison.

Ignitable Liquid Classification System

CLASSIFICATION	PEAK SPREAD BASED n-ALKANE CARBON RANGE (UNEVAPORATED LIQUID)	EXAMPLES
Gasoline	C_4 - C_{13}	All brands & grades of automotive gasoline, including gasohol
	Light C_4 – C_9	Petroleum ethers, pocket "cigarette" lighter fuels, some rubber cement products, VM &

Distillates	**Medium** C_8 - C_{13}	P Naphtha, Skelly solvent, some camping fuels
	Heavy C_8 - C_{16}	Mineral spirits, some paint thinners, some charcoal starters, some dry-cleaning solvents, some torch fuels, and some lamp oils, some insecticide vehicles, some polishes
	C_{10} - C_{23+}	Kerosene, No. 1 fuel oil, Jet-A fuel, some insecticide vehicles, some polishes, some paint thinners, some lamp oils
		Diesel fuel, No. 2 fuel oil (home heating oil), highly evaporated gasoline
Aromatic products	*Variable*	Some paint/varnish removers, some automotive parts cleaners, Xylenes, Toluene based products. Some automotive parts cleaners, specialty cleaning solvents, some insecticide vehicles, some fuel additives Some insecticide vehicles, some cleaning solvents, some adhesive solvents

Isoparaffinic products	*Variable*	Specialty solvents, some aviation gases Some charcoal starters, some paint thinners, some camping fuels, some copier toners, some lamp oils Some commercial specialty solvents, some insecticide vehicles, some polishes, some adhesive solvents
Normal Alkane products	*Variable*	Solvents (pentane, hexane) Some candle oils, some copier toners, some insecticide vehicles, some polishes Some candle oils, some copier toners, NCR papers, some insecticide vehicles, some polishes
Naphthenic/Paraffinic products	*Variable*	Cyclohexane based solvents/products Some charcoal starters, some insecticide vehicles, some lamp oils Some insecticide vehicles, some lamp oils, some industrial solvents
Oxygenated products	*Variable*	Some lacquer thinners, some fuel additives, some surface preparation solvents, some industrial solvents, some metal cleaners & gloss removers

Notes: Peak spread may vary based on commercial products