Designation: E 1387 – 01

Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography[1]

1. Scope

1.1 This test method covers the identification of residues of ignitable liquids in extracts from fire debris samples. Extraction procedures are described in the referenced documents.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 6.3.

2. Referenced Documents

2.1 *ASTM Standards:*

E 1385 Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Steam Distillation[2]

E 1386 Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction[2]

E 1388 Practice for Sampling of Headspace Vapors from Fire Debris Samples[2]

E 1412 Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Passive Headspace Concentration[2]

E 1413 Practice for Separation and Concentration of Ignitable Liquid Residues from Fire Debris Samples by Dynamic Headspace Concentration[2]

E 1459 Guide for Physical Evidence Labeling and Related Documentation[2]

E 1492 Guide for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Laboratory[2]

E 1618 Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry[2]

3. Summary of Test Method

3.1 The sample extract or preparation is introduced into the gas chromatographic column containing a liquid phase suitable for the separation of common ignitable liquid components. The resulting chromatogram is interpreted by techniques of pattern recognition and pattern comparison described in this test method. Ignitable liquids may fall into one of eight major classifications, or into a "miscellaneous" category described in this test method.

4. Significance and Use

4.1 The identification of an ignitable liquid residue in samples from a fire scene can support a field investigator's opinion regarding the origin, fuel load, and incendiary nature of a fire.

4.1.1 The identification of an ignitable liquid residue in a fire scene does not necessarily lead to the conclusion that a fire was incendiary in nature. Further investigation may reveal a legitimate reason for the presence of ignitable liquid residues.

4.1.2 Due to the volatility of ignitable liquids and to variations in sampling techniques, the absence of detectable quantities of ignitable liquid residues does not necessarily lead to the conclusion that ignitable liquids were not present at the fire scene.

4.2 When the gas chromatographic pattern is not sufficiently complex, as described in 9.3, additional analytical techniques are required.

5. Apparatus

5.1 *Gas Chromatograph*—A chromatograph capable of using capillary columns and equipped with a flame ionization or mass spectral detector.

5.1.1 *Sensitivity*—The system shall be capable of detecting each component of the test mixture referenced in 6.5.

---

[1] This test method is under the jurisdiction of ASTM Committee E30 on Forensic Sciences and is the direct responsibility of Subcommittee E30.01 on Criminalistics.

Current edition approved Sept. 10, 2001. Published December, 2001. Originally published as E 1387 – 90. Last previous edition E 1387 – 95.

[2] *Annual Book of ASTM Standards*, Vol 14.02.

5.1.2 *Sample Inlet System*—A sample inlet system that allows a reproducible volume of liquid to be injected. The system may be operated in either split or splitless mode with capillary columns; the inlet system may use on–column technology.

5.1.3 *Column*—A capillary, bonded phase, methylsilicone or phenylmethylsilicone column or equivalent. Any column length or temperature program conditions may be used provided that each component of the test mixture is adequately separated.

5.1.4 *GC Oven*—A column oven capable of reproducible temperature and temperature program operation in the range of 50 to 300°C.

5.2 *Data Station*—A computerized data station, capable of storing chromatographic data from sample runs. A strip chart recorder is acceptable.

5.3 *Syringes*:

5.3.1 *For liquid samples*—a syringe, capable of reproducibly introducing sample sizes in the range of 0.1 to 10.0 µL.

5.3.2 *For gas samples*—a gas-tight syringe capable of reproducibly introducing sample sizes in the range of 0.5 to 5 mL.

6. Chemicals, Reagents and Reference Materials

6.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.[3] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *Solvent/Diluent*—Carbon disulfide, diethyl ether, pentane, or other solvent that will not interfere with the analysis. It is generally desirable to use a solvent whose volatility greatly exceeds that of the solute to facilitate sample concentration by evaporation if necessary.

6.2.1 Use of a heavier solvent, such a toluene or tetrachloroethylene, is sometimes necessary when the compounds of interest have low molecular weights..

6.3 *Carrier Gas*—Helium or hydrogen of purity 99.995% or higher.

6.4 *Combustion Gases*—Air and hydrogen (if a flame ionization detector is used).

6.5 *Test Mixture*—The test mixture shall consist of a minimum of the even–numbered normal alkanes (ranging n–octane through n–eicosane), methylbenzene (toluene), 1, 4–dimethylbenzene (p-xylene), 1–methyl–2–ethylbenzene (o–ethyltoluene), 1-methyl-3-ethylbenzene (m-ethyltoluene), and 1,2,4-trimethylbenzene (pseudocumene). Additional compounds may be included at the discretion of the analyst. The final test solution is prepared by diluting the above mixture such that the concentration of each component is 0.005% volume/volume (0.05 µL/mL) in the chosen solvent (see 6.2). A typical chromatogram of the test mixture is shown in Fig. 1.

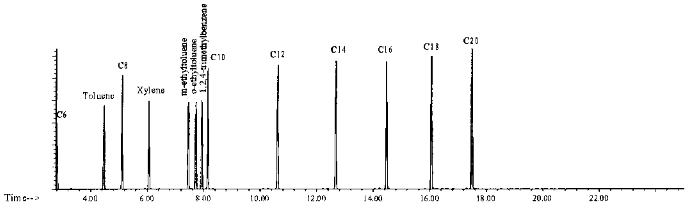
6.6 *Reference Ignitable Liquids*—Ignitable liquids must be available for the various ignitable liquids represented in Table 1.

6.6.1 Typically, reference ignitable liquids are diluted 1:100 in an appropriate solvent. Depending on the column capacity and injection technique, ignitable liquid solutions can be made somewhat more concentrated to ensure detection of minor compounds.

6.6.2 Certified ignitable liquid standards are not necessary. Most reference ignitable liquids can be obtained from commercial and retail sources.

7. Sample Handling

7.1 Methods for isolating ignitable liquid residues from fire debris for analysis are described in Practices E 1385, E 1386, E 1388, E 1412, and E 1413.



Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 1 Test Mixture containing C8-C20 normal hydrocarbons, toluene, p-xylene, o-ethyltoluene, m-ethyltoluene, and 1,2,4-trimethylbenzene

---

[3] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.

TABLE 1 Ignitable Liquid Classification Schemes[A]

Class	Light (C_{4}-$_{9}$)	Medium (C_8-C_{13})	Heavy (C_9- C_{20+})
Gasoline-all brands, including gasohol	Fresh gasoline is typically in the range C_4-C_{12}		
Petroleum Distillates	Petroleum Ether Some Cigarette Lighter Fluids[B] Some Camping Fuels	Some Charcoal Starters Some Paint Thinners Some Dry Cleaning Solvents	Kerosene Diesel Fuel Some Jet Fuels Some Charcoal Starters
Isoparaffinic Products	Aviation Gas Specialty Solvents	Some Charcoal Starters Some Paint Thinners Some Copier Toners	Commercial Specialty Solvents
Aromatic Products	Some Paint and Varnish Removers Some Automotive Parts Cleaners Xylenes, Toluene-based products.	Some Automotive Parts Cleaners Specialty Cleaning Solvents Some Insecticide Vehicles Fuel Additives	Some Insecticide Vehicles Industrial Cleaning Solvents
Naphthenic Paraffinic Products	Cyclohexane based solvents/products	Some Charcoal Starters Some Insecticide Vehicles Some Lamp Oils	Some Insecticide Vehicles Some Lamp Oils Industrial Solvents
Normal Alkanes Products	Solvents Pentane, Hexane, Heptane	Some Candle Oils Copier Toners	Some Candle Oils Carbonless Forms Copier Toners
De-Aromatized Distillates	Some Camping Fuels	Some Charcoal Starters Some Paint Thinners	Some Charcoal Starters Odorless Kerosenes
Oxygenated Solvents	Alcohols Ketones Some Lacquer Thinners Fuel Additives Surface Preparation Solvents	Some Lacquer Thinners Some Industrial Solvents Metal Cleaners/Gloss Removers	
Others-Miscellaneous	Single Component Products Some Blended Products Some Enamel Reducers	Turpentine Products Some Blended Products Various Specialty Products	Some Blended Products Various Specialty Products

[A] The products listed in Table 1, in the various classes are illustrations of known commercial uses of these ignitable liquids. These examples are not intended to be all-inclusive. Reference literature materials may be used to provide more specific examples of each classification.

[B] As can be noted, there are products found in multiple classifications such as "charcoal starters". Therefore, many of the examples can be prefaced by the word" some", as in "some charcoal starters."

7.2 Due to the volatility of the solvents and the analytes, care must be taken to ensure that samples do not evaporate or otherwise change composition. Extracts in carbon disulfide may be covered with water prior to removing the extracts from the sample preparation hood. Alternatively, septum seal vials may be used for storing any solvents or extracts.

7.2.1 If water is used as a sealant, exercise care to avoid the introduction of water onto DMCS treated columns.

7.2.2 Avoid the use of water as a sealant if the presence of water soluble compounds is suspected.

7.3 Analyze solvent blanks at least every day that the instrument is used, and maintain documentation. A solvent blank will verify the purity of the solvent and potentially detect carryover or contamination.

7.4 Clean syringes thoroughly between injections to ensure no carryover.

7.4.1 Conduct carryover studies, and maintain documentation that demonstrates the adequacy of laboratory procedures to prevent carryover.

7.4.2 Running solvent blanks between each sample is not necessary if studies demonstrate that the cleaning procedure is adequate to prevent carryover.

7.4.3 Maintain reference files of known ignitable liquids that have been analyzed in the same manner as the questioned samples.

8. Calibration

8.1 Verify the consistent performance of the chromatographic instrument using known concentrations of known ignitable liquids or test mixtures as well as blanks. Optimize gas flows periodically.

8.1.1 Maintain quality control documentation.

8.1.1.1 Reference ignitable liquids must be run under the same chromatographic conditions as those used to produce the sample chromatogram.

8.1.1.2 Every case file that includes a positive identification of an ignitable liquid or residue must include the reference chromatogram used to confirm the identification.

8.2 *Chromatogram Evaluation*—A good chromatogram for comparison work is one in which the peaks of interest are 50 to 100 % of full scale. Rerun samples, or replot chromatogram, using different parameters (attenuation or sample size) to achieve a good chromatogram.

8.2.1 In addition to the chromatogram described above, it is sometimes necessary to produce other, off-scale plots, in order to bring some features into view for comparison. Such off-scale plots may be required when there are one or more components present at a significantly higher concentration than the other components in the sample.

8.3 *Cleaning of the equipment:*

8.3.1 Change septa and clean or replace injector liners on a periodic basis to avoid sample contamination by "carry-over" of residual material from previous sample injections.

8.3.2 Clean syringes thoroughly between injections to ensure no carryover.

8.3.3 System Solvent blanks should be run at least daily to ensure no carry-over between samples or contamination.

8.4 *Reference Files:*

8.4.1 Maintain files of reference ignitable liquids that have been analyzed in the same manner as the questioned samples.

9. Ignitable Liquid Classification Scheme

9.1 Eight major classes of ignitable liquids may be identified by gas chromatography when suitable peaks for comparison are present. These classes are outlined in 9.3 and Table 1. Typical chromatograms of many of these classes are shown in Figs. 2-10.

9.1.1 This test method is intended to allow identified ignitable liquids to be characterized as belonging to one of the classifications. Distinguishing between examples within any class may be possible, but such further characterization is not within the scope of this method.

9.1.2 A miscellaneous category is included for those ignitable liquids that do not fall into one of the first eight major ignitable liquid classifications.

9.1.3 Ignitable liquid classification of the questioned sample is determined by the classification of the reference ignitable liquid used for the comparison. Documented reference information or mass spectral analysis is required for the initial classification of the reference ignitable liquid.

9.1.3.1 Some ignitable liquids may require mass spectral techniques for proper identification/classification.

9.2 With the exception of the gasoline class, the major ignitable liquid classes may be divided into 3 subclasses based on n-alkane range. These subclasses are designated light, medium, and heavy products.

9.2.1 *Light product range*—C_4-C_9, the majority of the pattern occurs in the range C4-C9, no major peaks associated with the ignitable liquid exist above C11.

9.2.2 *Medium product range*—C_8-C_{13}, narrow range products, the majority of the pattern occurs in the range C8-C13, no major peaks associated with the ignitable liquid. Below C7 or above C14.

9.2.3 *Heavy product range*—C_9-C_{20+}, typically broad range products, the majority of the pattern occurs in the range C9–C23, with a continuous pattern spanning at least 5 n-alkanes. Also included in this subclass are narrow range (encompassing less than 5 n-alkanes) ignitable liquid products starting above C11.

9.2.4 It may be necessary to characterize a product as "light to medium" or "medium to heavy" when the carbon range does not fit neatly into one of the above categories. In such instances, the carbon number range should be reported.

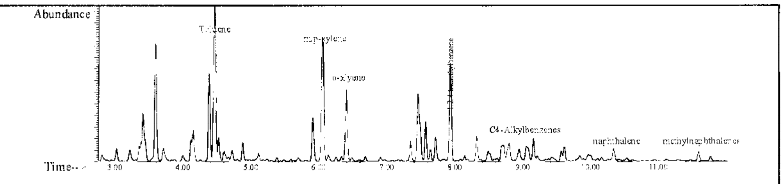
9.3 In order for an extract to be characterized as containing a particular class, the following minimum criteria must be met:

9.3.1 *Gasoline*—The C_3 alkylbenzene four-peak group, which represents *m*- ethyltoluene, *p*-ethyltoluene, 1,3,5-trimethylbenzene, *o*-ethyltoluene, and 1,2,4-trimethylbenzene (pseudocumene), must be present; this group occupies the range between C_9 and C_{10} and is still present in gasolines that have lost as much as 90 % of their initial ("fresh") weight by evaporation or combustion. Other peak groupings characteristic of gasoline including the C_4 alkylbenzenes and various aliphatic compounds must also be present.

CAUTIONS: The mere presence of these alkylbenzenes does not justify an identification of gasoline. These compounds must be present at approximately the same relative concentrations as are observed in samples of known gasoline. Many carpet samples that have been exposed to fire conditions contain these compounds in some concentration. Benzene, toluene, ethylbenzene, xylenes, C_3 alkylbenzenes, and naphthalenes, which are present in gasoline, are also sometimes found in fire debris samples containing no foreign ignitable liquid. The presence of high levels of other non-related compounds may indicate significant pyrolysis of the matrix and should make the recovery suspect.

Some aromatic products have patterns significantly similar to gasoline. The absence of significant but, less abundant aliphatic compounds is an indication that the product may be an aromatic solvent.

9.3.2 *Distillates*—Predominant peaks associated with a homologous series of normal alkanes in a Gaussian distribution of peak maxima with abundant but less significant isoparaffinic, cycloparaffinic, and aromatic compounds present. Light distillates may not exhibit a recognizable pattern, and may contain only one or two of the *n*-alkanes.



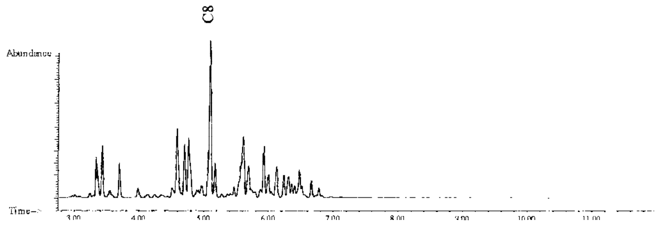
Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 2 Example of a Gasoline Pattern; 50 % Evaporated Gasoline



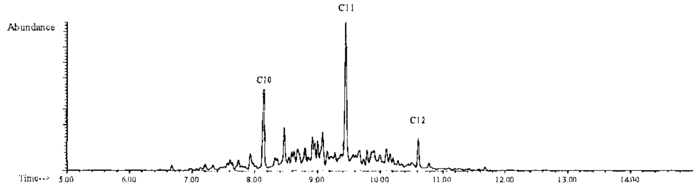
Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 3 Example of a Light Petroleum Distillate; Cigarette Lighter Fluid



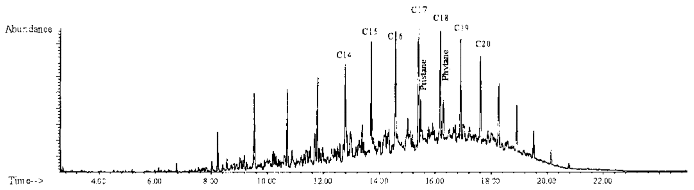
Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 4 Example of a Medium Petroleum Distillate Pattern; 50 % Evaporated Mineral Spirits



Chromatographic Conditions

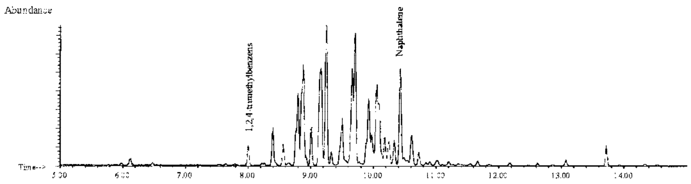
Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 5 Example of Heavy Petroleum Distillate; Diesel Fuel

CAUTION: The absence of specific less abundant compounds or disproportionate representation of the lesser abundant compounds may indicate the presence of a de-aromatized distillate or a naphthenic paraffinic product. The sole presence of normal alkanes may indicate a normal alkane product. It may not be possible to distinguish between distillates and de-aromatized distillates without the use of mass spectrometry.



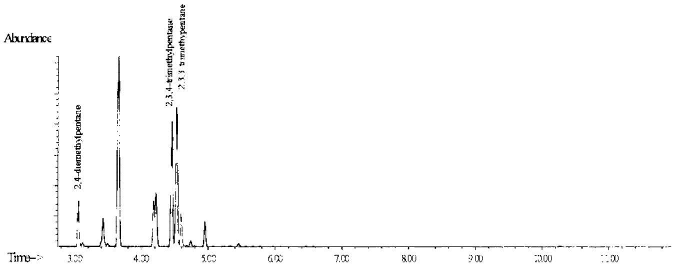
Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 6 Example of a Medium Aromatic Solvent; Fuel Additive



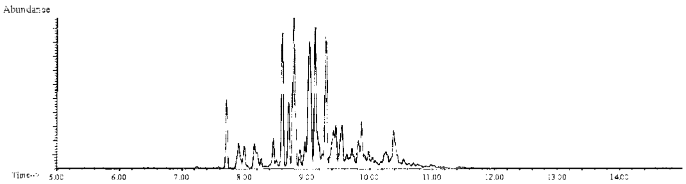
Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 7 Example of Light Isoparaffinic Product; Aviation Gas



Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

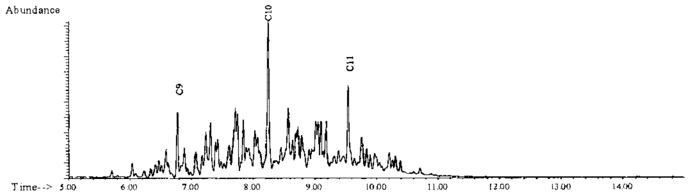
FIG. 8 Example of Medium Isoparaffinic Product; Charcoal Starter

9.3.3 *Isoparaffinic Products*—Products comprised almost exclusively of isoparaffinic compounds. The boiling range and pattern are dependent on formulation. The normal alkanes are not present or are significantly diminished.

9.3.4 *Aromatic Products*—Products comprised almost exclusively of aromatic compounds. The boiling range and pattern are dependent on formulation.

9.3.4.1 Light aromatic products may consist of single or few components. It may be necessary to identify these components by mass spectrometry.

CAUTION: Some aromatic products have patterns significantly similar to gasoline; the presence of significant but, less abundant aliphatic compounds is an indication that the product may be gasoline.



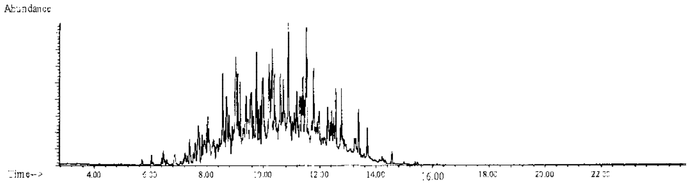
Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 9 Example of Medium De-aromatized Distillate; Odorless Paint Thinner



Chromatographic Conditions

Instrument: HP 5890 Gas Chromatograph
Detector: HP 5970 Mass Selective Detector
Column: 30 meter, Rtx-1 (polymethylsiloxane)
0.25mm ID, 0.25 micron film thickness
Sample: 1.0 microliter of 1% solution in pentane

Initial Temperature: 50C, 2.5 minutes
Rate: 15C/min
Final Temperature: 300C, 5.83 minutes
Total Run Time: 25.00 minutes
Split 20:1

NOTE: This is a typical chromatogram, provided for illustration only. Each laboratory is likely to obtain slightly different retention times and relative abundance of individual components, depending on sample history, separation procedure, and chromatographic conditions.

FIG. 10 Example of a Heavy Naphthenic Paraffinic Product; Lamp Oil

9.3.5 *Naphthenic-Paraffinic Products*—Products comprised almost exclusively of branched chain (isoparaffinic) and cyclic (naphthenic) alkanes. The boiling range and pattern are dependent on specific formulation but are characterized by a Gaussian distribution of numerous peaks. Normal alkanes are absent or significantly diminished.

9.3.6 *Normal Alkane Products*—Products comprised solely of n-alkanes. The boiling range and pattern are dependent on the specific formulation. Normal alkane products are typically comprised of 5 components or less. These compounds must be identified by GC retention time and/or mass spectral characteristics.

9.3.7 *De-aromatized Distillates*—Predominant peaks associated with a homologous series of normal alkanes in a Gaussian distribution of peak maxima with abundant but less significant isoparaffinic and cycloparaffinic compounds present. Products are characterized by traditional distillate distribution with the notable absence of aromatic compounds.

9.3.7.1 De-aromatized distillates are a special class that cannot be distinguished from straight distillates using this method. The distinction may be made using gas chromatography-mass spectrometry as described in Test Method E 1618.

CAUTION: The absence of *n*-alkanes or disproportionate abundance of cycloparaffins may indicate the presence of a naphthenic paraffinic product. The sole presence of *n*-alkanes may indicate a normal alkane product.

9.3.8 *Oxygenated Solvents*—Products containing major oxygenated components. This may include mixtures of oxygenated compounds and other compounds or products. Oxygenated products may contain alcohols, esters, or ketones. Other major compounds including toluene, xylene and distillate formulations may also be present.

9.3.8.1 Depending on the formulation it may be necessary to identify individual compounds by GC retention time or mass spectral characteristics, or both.

CAUTION: Oxygenated compounds are produced in combustion. The mere presence of oxygenated compounds such as methanol, ethanol, or acetone does not necessarily indicate that a foreign ignitable liquid is present in the sample. There should be a large excess of the compound (at least one order of magnitude above the other peaks in the chromatogram) before the analyst should consider the finding of an oxygenated compound significant.

9.4 No classification system is likely to describe all possible ignitable liquids. There are numerous commercial and industrial products which are ignitable but which fall into more than one category or do not fall into any of the above categories, other than “miscellaneous.” Many of these are synthetic mixtures consisting of only a few compounds, rather than distillation fractions, and require multiple column analysis in order to achieve identification. Other techniques such as GC/MS or GC-Infrared Spectroscopy may be indicated when the gas chromatographic pattern is not sufficiently complex to identify a mixture of components.

10. Procedure

10.1 Obtain a chromatogram of the fire debris sample extract.

10.2 Obtain a chromatogram of a matching, or nearly matching, reference ignitable liquids, and compare the pattern of peaks visually.

10.2.1 The essential requirement for making a classification using this procedure is the matching of the sample chromatogram with a known reference ignitable liquid chromatogram obtained under similar conditions, noting sufficient significant points of correlation or similarities. Make all comparisons using only good chromatograms, as described in 8.2.

10.2.1.1 The use of externally generated libraries of chromatograms is not sufficient for identification of an ignitable liquid. Such libraries are intended to give guidance for selection of reference ignitable liquids.

10.2.2 Pattern matching requires that the entire pattern used for comparison be displayed at the same sensitivity.

10.2.2.1 To provide sufficient detail for some comparisons, different amplitudes or presentations of the data may be necessary.

10.2.2.2 The carbon number range is determined by comparing the chromatogram to a reference ignitable liquid or test mixture containing known normal alkanes.

10.2.3 Store the reference chromatogram(s) in the case file, along with the sample chromatogram(s).

11. Interpretation of Results

11.1 Pattern matching of chromatograms rarely gives perfect correlation with reference ignitable liquids. In general, the unknown pattern (if positive) will be skewed towards less volatile compounds for weathered samples or skewed toward more volatile compounds for incompletely recovered samples. Compounds may be missing from either the light end, the heavy end, or both. Under certain conditions, selective loss of classes of compounds may result from microbiological degradation. Compounds may also be added to the pattern when the pyrolysis of materials at the fire scene yields target compounds or compounds of the same type as those being compared. The analyst must take all of these circumstances into account during visual pattern evaluation. It is therefore imperative that the analyst have a sufficient library of reference ignitable liquids, in successive stages of evaporation. A library of extracts from common substrate materials containing no foreign ignitable liquids should also be maintained.

11.2 *Interferences*:

11.2.1 *Extraneous Components*— from which the sample is extracted usually contributes extraneous components to an extract. The amount and type of pyrolysis and combustion products formed during a fire depend on the substrate material and its fire history. They can consist of paraffinic, cycloparaffinic, aromatic, or condensed ring aromatic hydrocarbons, all of which appear in the extracted ion profiles. The presence of these extraneous product components is acceptable when sufficient ignitable liquid product compounds remain to allow proper classification of the sample. When the pattern becomes overwhelmed by extraneous components, identification is not possible by this method.

11.2.2 Extracts that meet the criteria for heavy petroleum distillates should be reviewed carefully for “extraneous components” that elute near *n*-alkanes and are the result of polyolefin or high molecular weight hydrocarbon (asphalt) decomposition. Peaks representing the corresponding 1-alkene or 1, (*n*-1) diene, and having an abundance near the concentration (within ½ an order of magnitude) of the alkane, should be considered as indicating the presence of polyolefin or asphalt decomposition products rather than fuel oil products. Polyolefin decomposition products typically do not exhibit the same pattern of branched alkanes as fuel oils.

11.3 *Missing Components*—Exposure of the ignitable liquid to heat usually results in the preferential loss of lighter components, thereby enhancing the chromatographic pattern at the heavy end. Some sample preparation techniques may result in the preferential recovery of either the lighter or heavier components, resulting in the “loss” in the opposite end. Neither of these factors will cause the selective loss of intermediate components. The unexplainable absence of components from the middle of a pattern is generally sufficient grounds for a negative finding. Possible explanations for missing intermediate compounds include low sample concentration (compound below detection limit), and in rare cases, selective losses due to digestion by microbes. Any such explanation for loss of compounds in the middle of a pattern must be scientifically supportable, and efforts should be made, if possible, to retrieve evidence of their existence from the data file or by reanalyzing the sample.

11.4 The presence of small quantities of some components common to a particular class of ignitable liquid products does not necessarily indicate the presence of that liquid in the debris at the time of the fire.

11.4.1 For example, the pyrolyzates of aromatic-containing polymers may include toluene and xylenes. The pyrolyzates of asphalt and polyolefin plastic may include a homologous series of alkanes.

11.5 Certain ignitable liquid residues may be found in many some substrates common to fire scenes.

11.5.1 Examples include: normal alkane products found in linoleum and in components of carbonless paper forms; distillates found in some printed materials; solvents used in some adhesives and coatings.

11.5.2 If there is suspicion that an ignitable liquid found might be indigenous to the substrate, the testing of an appropriate comparison sample, if available, may aid in determining whether or not an ignitable liquid is foreign to the substrate.

11.6 *Difficult Patterns*—Patterns will occasionally be encountered that make a distinction between an ignitable liquid and a background material such as carpet very difficult. In those cases, the use of GC/MS as described in Test Method E 1618 is recommended.

12. Report

12.1 Forensic laboratory reports must contain the following information: Identifying case reference numbers, the submitting agency's name and address, the date(s) of sample delivery, the name of the person(s) making the requested analysis, an itemized list describing the submitted samples, and the result of the laboratory examination.

12.1.1 The description of the evidence would seem to be merely a clerical matter, but it is important that the analyst be sure that the evidence is described accurately, not simply as it was identified by the submitting agent. Fire debris samples, especially, tend to appear similar from the outside. It is possible for samples coming from different locations within a fire scene, or even from different fire scenes, to be confused with each other.

12.1.1.1 While it may not be possible for the analyst to distinguish by visual inspection the difference between carpeting from the living room and carpeting from the hallway, it is possible to determine by visual inspection the difference between bedding from the master bedroom and carpeting from the hallway or concrete from the basement. The information that the analyst puts into the report should be verified by the analyst to the extent possible. An analyst's first hand observations, and information supplied by a submitter when a sample is delivered, should be easily distinguishable.

12.2 The results section should state which preparation techniques were used and which analytical techniques were used.

12.2.1 The results section should list examples of commercial products and or substrates that might contain the ignitable liquid identified.

12.3 The conclusion should give the scientist's opinion as to whether an ignitable liquid was identified in the sample. If a negative result was obtained, a disclaimer to the effect that negative results do not preclude the possibility that ignitable liquids were present at the fire scene may help to avoid misunderstanding by readers of the report.

12.3.1 In the case of a positive report, it may be appropriate to add a disclaimer to the effect that the identification of an ignitable liquid residue in a fire scene does not necessarily lead to the conclusion that a fire was incendiary in nature. Further investigation may reveal a legitimate reason for the presence of ignitable liquid residues.

12.3.2 A conclusion, summarizing the results in terms understandable to a lay person, may be added to the report.

12.4 Certain words should not appear without explanation within the report. All extracts from organic materials are likely to contain" hydrocarbons." The word "hydrocarbon" should not appear in a report unless those hydrocarbons can be specifically identified and classified. The phrase "hydrocarbons from an unknown source" is expressly prohibited. Similarly, words such as "consistent with," " in the boiling range of," "similar to," or "characteristic of" a particular ignitable liquid should not be used unless that liquid has been positively identified using the methods described in Section 10.

12.4.1 The analyst cannot determine the source or intended use of an ignitable liquid residue. For this reason, residues should not be characterized as "accelerants" by the analyst.

13. Precision and Bias

13.1 Since this is a qualitative test method, the terms precision and bias do not apply.

14. Keywords

14.1 fire debris samples; forensic sciences; gas chromatography; ignitable liquid residues; mass spectrometry

ANNEX

(Mandatory Information)

A1. SAMPLE STORAGE

A1.1 Store the original sample after extraction using appropriate procedures for handling and documentation.

A1.1.1 *Extract Storage-Short Term*—Extracts may be stored in a refrigerator in a stoppered tube to prevent evaporation.

A1.1.2 *Extract Storage-Long Term*—Long term stability can be obtained by adding activated charcoal to the solvent containing the extract and allowing the solvent to slowly evaporate. The sample can later be reconstituted by addition of the solvent. A charcoal adsorption package, such as a C-strip, may serve the same purpose as added charcoal.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).