THE PERSISTENCE OF IGNITABLE LIQUIDS ON UNBURNED SUBSTRATES

Research Study Completed By:

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CURRENT PRACTICE:

- Utilize accelerant detection devices, such as sniffers or canines, to detect possible presence of ignitable liquids.
- Collect fire debris samples from fire scene soon after fire.
- Submit evidence to forensic laboratory for analysis.
- Use one of a variety of extraction techniques and determine whether an ignitable liquid residue (ILR) is present.
REASONS WHY DELAY IN OR LACK OF EVIDENCE COLLECTION

- Laziness or lack of knowledge on proper evidence collection techniques or from where to collect samples
- Belief that any evidence of ignitable liquids is gone
  - Fire suppression efforts may dilute potential ignitable liquids
  - May take weeks or months for origin & cause investigators to arrive on scene and/or collect samples so ILRs evaporated
## HOW TO DETERMINE IF AN ILR PRESENT

### FIRE DEBRIS COLLECTION

1. Sniffers or canines
2. Lined cans for collection  
   - prevents rust & contamination
3. Fill up 2/3 volume of can
4. Comparison vs. Control Samples

### FIRE DEBRIS ANALYSIS

1. Passive Headspace
   Concentration Technique
   - Suspend activated charcoal strip in top 1/3 headspace of can
   - Usually heated to release volatile vapor molecules which stick to charcoal strip
   - Rinse charcoal strip with solvent (ex: carbon disulfide)
   - Inject liquid in GC-MS

### GC-MS Process

1. Gas Chromatograph – Separates mixture into individually identifiable compounds
2. Mass Spectrometer – Identifies those separated compounds
3. Product is a chromatogram – Chemist identifies and classifies compounds as a potential ignitable liquid class
PREVIOUS RESEARCH
PERSISTENCE OF IGNITABLE LIQUIDS ON SUBSTRATES

• 1990’s – Folkman – Lead gas only on some substrates
  • Result – Diesel fuel persists longer than gasoline due to boiling temperature and exposure to heat. Gasoline had evaporated after one day, while diesel fuel evaporated 10%. Only 20% evaporated after 50 days

• Later 1990’s – Cavanaugh-Steer – Carpeting & floor mats spiked with unleaded gasoline
  • Small quantity of gasoline used which evaporated quickly
  • Larger quantity of gasoline which had varying results as to evaporation levels
PREVIOUS RESEARCH
PERSISTENCE OF IGNITABLE LIQUIDS ON SUBSTRATES

• Lentini/Dolan – Floor Coating Solvents tested on wood boards
  • MPD’s became part of wood substrate and could be detected over 2 years later

• Mealy/Gottuk – Small scale testing of burned carpeting with foam underlay (Burned Substrates)
  • Results: Persistence dependent on the duration of fire exposure, quantity of ignitable liquid used, and the testing/sampling location
GAPS AND INCONSISTENCIES IN RESEARCH

- Passive Headspace Concentration Extraction Technique vs. Others
  - Neat (Liquid) Sample, Solvent Extraction, DFLEX
- Sampling Location of Fire Debris – Middle of the Pour Pattern or the Edge
- Quantity of Ignitable Liquid Used
- Substrate properties (density) and types (carpeting vs. wood vs. concrete)
- Outdoor weather conditions (Florida vs. Alaska) and Indoor Conditions (controlled?)
- Burned vs. Unburned Substrates – Difficult to control burned substrate testing
- Length of time left indoors/outdoors
- How many samples tested at each time period (tested in triplicate?) and how many sample testing periods used
QUESTIONS ASKED FOR THIS STUDY

• PRIMARY QUESTION: How long do ignitable liquid vapors persist in a variety of unburned substrates?

• ADDITIONAL HYPOTHESES BASED ON PRIOR STUDIES AND SCIENCE:
  • IL vapors will last longer in an indoor environment than in an outdoor environment?
  • IL vapors will last longer in higher density substrates such as concrete and OSB, than in less dense substrates such as carpeting?
  • HPD’s will persist longer than gasoline in each of these substrates in both the indoor and outdoor environments?
**Polyester Carpeting**
- Most economic and highly used carpeting in United States
- Shaw 4” x 4” square samples

**OSB Wood Board**
- Most commonly used flooring and subflooring in newly constructed residential and commercial structures
- ¾” Tongue & Groove OSB from Home Depot cut into 3” x 4” pieces

**Concrete**
- Found in basements and as slab below carpeting on many fire scenes
- Quikrete – Home Depot
  - Mixed and placed into Solo Cup molds
PERSISTENCE STUDY MATERIALS SETUP

• CARPETING, OSB WOOD, AND CONCRETE
  • 85 Samples of Each Used
  • 42 Spiked with 10 mL of Gasoline
  • 42 Spiked with 10 mL of HPD
  • 1 Control Sample
PERSISTENCE STUDY
MATERIAL SETUP

• 28 Milk Crates Used
• 14 Outdoor and 14 Indoor
  • 7 each spiked with Gasoline Samples
  • 7 each spiked with HPD Samples
  • Covered with 18” galvanized steel mesh wire (outdoor)
  • Non-temperature controlled warehouse (indoor)
• Location – Beltsville, MD in rear of ATF FRL
  • 7 Test Dates – 1 week, 2 weeks, 1 month, 3 months, 6 months, 9 months, and 12 months
• Each set of 14 indoor and outdoor crates separated by space from one another to prevent cross-contamination

Testing began on November 14, 2014
PERSISTENCE STUDY
MATERIAL SETUP

EACH MILK CRATE CONSISTED OF:

• 9 Substrates Each
• 3 Carpet Samples spiked with gasoline or HPD
• 3 OSB Wood Samples spiked with gasoline or HPD
• 3 Concrete Samples spiked with gasoline or HPD
  • Reason for 3 samples each due to triplicate testing *
WEATHER CONDITIONS

- Temperature – Ranged from 5° F to 95° Fahrenheit
- Humidity – Ranged from near 0% to 100% humidity
- Wind – Maximum wind gusts over the 12 month period was approximately 46 mph
- Precipitation – Over 40 inches of total precipitation fell on samples including rain, snow, and sleet

Weather conditions listed above indicate that high evaporation rates could occur to all outdoor samples, with potentially less dilution of indoor samples due to the lack of precipitation.

** Personal weather station used for calculating weather conditions was located two (2) physical miles from the ATF Forensic Science Laboratory **
SAMPLE COLLECTION

• 7 Time Intervals – Milk Crates Collected and each substrate put in can and labeled

• 4 Milk Crates collected each testing period
  • Outdoor/Indoor Gas/HPD – 36 Total Samples
ORGANIZE CANS ON LAB TABLES

- Substrate
- Gas/HPD
- Indoor/Outdoor
- Collection Date
- Sample Number
PASSIVE HEADSPACE CONCENTRATION

• Suspend activated charcoal strip in each can using paperclips and magnets
HEAT IN OVEN TO RELEASE VAPORS

• Cans heated to approximately 149° F (65° C) for approximately 16 hours

• Compounds released into vapor phase adsorb onto charcoal strip
RINSE CHARCOAL STRIP

• Allow cans to cool – Remove charcoal strips and place in small glass vials
• Rinse with solvent (400 µL Carbon Disulfide) and transfer using pipettes
TRANSFER SOLVENT TO GC-MS
CHROMATOGRAMS

Outdoor Carpet HPD Samples

Outdoor Concrete Gas Samples
RESULTS

- ALL HPD (Diesel) samples from BOTH indoor and outdoor locations tested POSITIVE for the presence of HPD at every testing period for the full year.

- All Gasoline samples on OSB and concrete tested positive for the presence of gasoline at every testing period for the full year.

- At the 6-month mark, the indoor/outdoor gas carpet samples tested positive for ILR, but likely as a medium-heavy petroleum distillate. Negative at 9- and 12- months.

- Almost all samples weathered/evaporated significantly, but still detectable as ILRs.

<table>
<thead>
<tr>
<th>Date</th>
<th>Gasoline Inside</th>
<th>Gasoline Outside</th>
<th>HPD Inside</th>
<th>HPD Outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/24/2014 (11 d)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>12/1/2014 (18 d)</td>
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<td>+</td>
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<td>12/15/14 (1 mo)</td>
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</tr>
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<td>2/11/15 (3 mo)</td>
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<td>+</td>
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<tr>
<td>5/4/15 (6 mo)</td>
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<tr>
<td>8/12/15 (9 mo)</td>
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<tr>
<td>11/16/15 (12 mo)</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

(+) = all 3 replicates were positive for an ignitable liquid
(-) = all 3 replicates are negative for an ignitable liquid
(A) = pattern would be classified as an ignitable liquid, but likely medium-heavy petroleum distillate or product, not gasoline
CONCLUSIONS

• HPD, and especially Gasoline, last a LOT longer than anticipated by researchers and the fire investigation community

• There was not much difference between the weathering and evaporation of the indoor and outdoor substrate samples, even with the heavy precipitation outdoors

• There was higher than expected weathering of the indoor concrete samples, which could be the result of chance (Solo cup issues) or high humidity indoors due to the lack of temperature control and air movement
LESSONS LEARNED

• ALWAYS take and submit comparison samples. OSB had weird inherent properties that should always be tested and considered during fire debris analysis

• Collect substrate (concrete, OSB) UNDERNEATH the burned debris because it may still contain ILR

• Collect substrate even if there were negative results from a sniffer or accelerant detection canine with an irregular burn pattern

• END RESULT: Fire investigators SHOULD collect samples if it is suspected that an ILR may have been present, even many months after a fire. Could alter fire debris collection practices in the fire investigation community!
FUTURE STUDIES BASED ON THE RESULTS OF THIS RESEARCH

• Conduct a similar study for a longer duration to determine how long the gasoline and HPD samples persist

• Include additional substrates in a similar study, such as nylon carpeting, other woods, etc.

• Increase the amount of ignitable liquid on the substrates to a quantity greater than 10 mL

• Use Light or Medium Petroleum Distillate products, or other fuels in the HPD class, on similar substrates

• Conduct more persistence studies on burned substrates (though more difficult to control)
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QUESTIONS?

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