Ignitable Liquid Residue Distribution in Pour Patterns as Affected by Ignitable Liquid and Substrate Type

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ABSTRACT

For the best lab results, fire debris samples must be collected at the scene from an area of the pour pattern suspected to contain the highest concentration of ignitable liquid (IL) residue. The question is where in the pattern the evidence should be collected from and whether the IL used or the substrate it was poured onto has any effect on the situation. Higher percentages of gasoline residues were found compared to kerosene residues after a 70% burn of the same substrate and pour pattern. Higher concentrations of IL residues were found toward the center of both the linear and circular pour patterns than toward the outer edges for both absorbent and less absorbent substrates. This would suggest that the center of a pattern would be the best place to take the sample.

INTRODUCTION

- Where is the best place to collect evidence from a suspected ignitable liquid pour pattern?
  - Conventional teachings:
    - Suggest the outer edge of the burn pattern [1,2,3]
    - Take what you can get
  - Recent Preliminary studies suggest center of the pour pattern. [4]
- The goal was to look into the various factors that play a role in answering this question.
  - The substrate being consumed
    - Carpet, wood
  - The ignitable liquid being used
    - Kerosene, gasoline, diesel fuel
  - The pour pattern of the ignitable liquid
    - Circular pattern – representing a central dump of the IL [2,4]
- Scale of the fire:
  - Small scale timed and controlled tests burns
  - Full scale test burns with contents allowed to progress to flashover

MATERIALS AND METHODOLOGY

- Test a variety of substrates (24' x 24' squares)
- Use different IL sources pouring same amount each time.
  - Gasoline, Kerosene
  - 300ml each time for carpet
  - 50ml each time for wood
- Test 2 different pour patterns
  - Straight line across center of sample
  - Central dump
- Sample from specified points on each substrate (2" x 2")
  - See Figure 1
  - 1 control sample (X) taken before burn
  - Other samples taken post burn
    - 13 samples from circular pattern
    - 11 samples from linear pattern
- Allow ignitable liquid to soak in
  - 2 minutes for carpet samples
  - 5 minutes for wood samples
- Ignite in same fashion every time
  - Allow to burn to 70% of self-extinguishment
  - Extinguish with water
- Collect samples in clean paint cans
- Collect residues on activated carbon strips (ASTM E1412)
- Analysis by GC/MS
  - ASTM E1618
  - 0.2% 3-phenyltoluene internal standard (IS)
    - Percent tetradecane to IS to normalize kerosene
    - Percent 1,2,4-trimethylbenzene to IS for gasoline

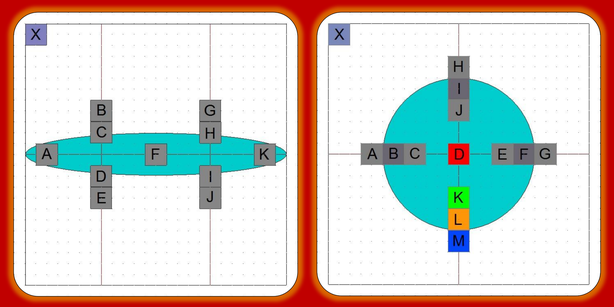

Figure 1: Designated circular and linear pour pattern templates for collection of samples. X is the location of the control sample collected prior to pouring the ignitable liquid. Samples are approximately 8 cm X 8 cm (2" X 2"). Overall size of the substrate is approx. 60 cm X 60 cm (24" X 24"). Color-coded tiles D, K, L, & M in the circular pattern correspond to the sampling locations of the color-coded chromatograms in Figure 3.

Figure 2: Carpet/kerosene circular pattern burn. (A) Some of the kerosene has wicked away from the center after soaking for 2 minutes. (B) The halo or ring pattern often seen in carpet burns. (C) Post burn, a protected area remains where the kerosene protected the carpet from the full effects of the flames. [5]

RESULTS

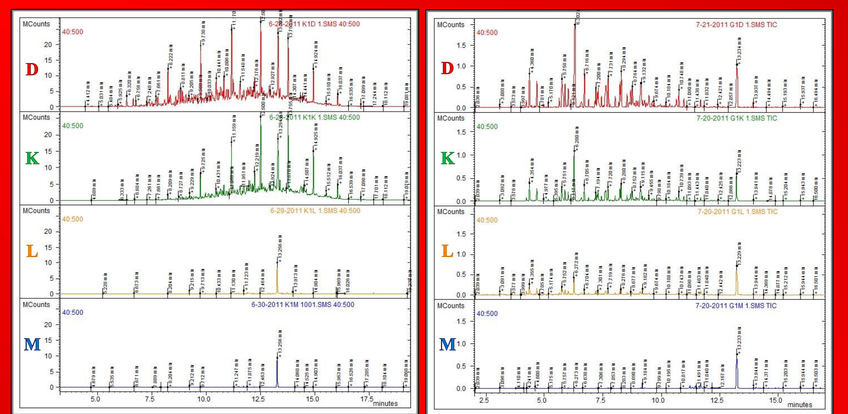

Figure 3: Chromatograms of the carpet/kerosene (left) and carpet/gasoline (right) samples D, K, L, and M as indicated in the color-coded diagram (found in Figure 1) showing the ignitable liquid residues diminishing as the samples move away from the center of the pour pattern

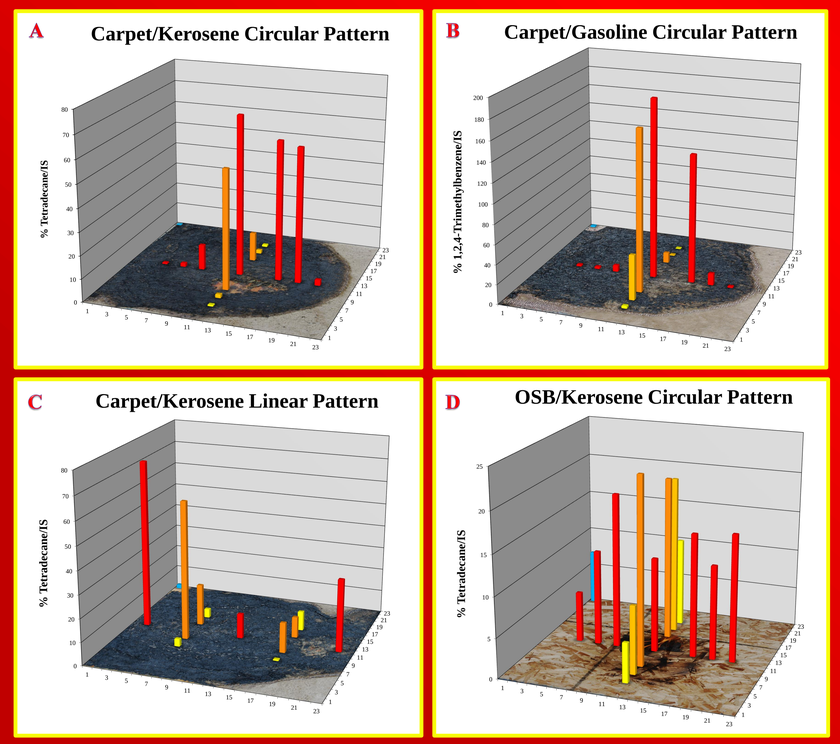

Figure 4: Graphs A, C, & D (Kerosene Graphs): Represent the percent ratios of the peak areas of tetradecane (C14) to 3-phenyltoluene (IS) for each sample in relation to the place each was sampled from on the substrate square. Graph B (Gasoline): Represents the percent ratios of the peak areas of 1,2,4-trimethylbenzene to 3-phenyltoluene (IS) for each sample in relation to the place each was sampled from on the substrate square. Photo overlay on bottom shows extent of the burn.

FULL SCALE TEST BURN

On November 10th, 2011, the opportunity presented itself to do a full scale test burn on two bedrooms on the second floor of a house in WV to aid this research. New carpet was laid down in each room and contents from the property were added to the rooms to increase the fuel load. Diesel fuel was poured in a large "S" shaped pattern on the floor of each room, and the diesel fuel was ignited. The fires were allowed to progress to flashover before being put out by the fire departments. Samples were taken around the ends of the "S" pattern in Room 1, the larger room, and straight across the entire pattern in Room 2, the smaller room.

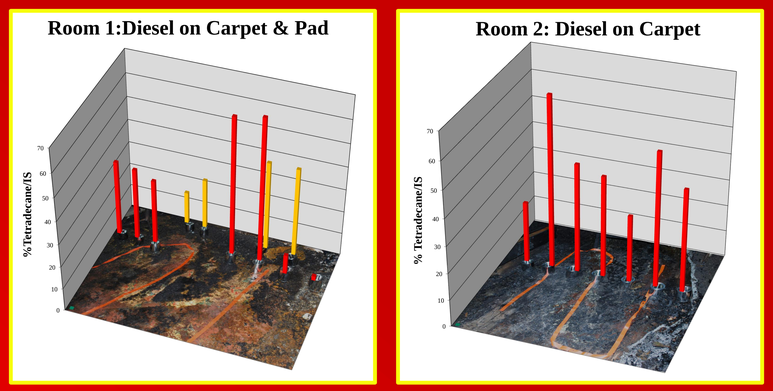

Figure 5: 3-D graph representing the percent ratios of the peak areas of tetradecane (C14) to 3-phenyltoluene (IS) for each sample in relation to the place each was sampled from across the floor of Rooms 1 and 2. Photo overlay on bottom shows extent of the burn, the pour pattern (orange tape), and the location of the evidence cans.

DISCUSSION AND CONCLUSIONS

- Sampling closer to the center gives best results for porous and nonporous substrates
  - More ignitable liquid found here
  - Chromatographically more similar to ignitable liquid used
- Further research should be performed:
  - Variety of different combinations with more materials
    - Substrate types – carpets, hardwood floors, atypical flooring, cushions
    - Pour patterns – circular, linear, splash, S-pattern
    - Ignitable liquids – diesel, charcoal lighter fluid, mineral spirits
  - Test a larger pattern of sample areas for each substrate and pour pattern combination
    - More sample areas near the center of the pour pattern
  - Tests closer to 100% or self-extinguishment
  - Perform at a much larger and more realistic scale.

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