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•Abstract

When an ignitable liquid is used as an accelerant in a fire, a pattern is created where the ignitable liquid is poured¹. Arson investigators differ in opinion as to whether chances are better to detect any ignitable liquid at the center of a burn pattern or at the edge of the burn pattern. An experiment was designed to sample from the center to past the edge of a pour pattern in carpet samples that varied from unburned to burned until self-extinguishment. Samples were taken in four directions and the results suggest that the best place to sample is in the center. It would be beneficial to test other ignitable liquids, pour patterns, and substrates in the future.

•Introduction

Which is the better place to sample a pour pattern, in the center or at the edge? Currently, the suggested place to sample is at the edge of the pour pattern, taking both burned and unburned material¹. An experiment was designed to sample from the center of a pour pattern to past the edge in carpet samples that varied in burn time. One quart of gasoline was poured onto five carpet squares, all of equal size. Burn times varied from unburned to burned until self-extinguishment (approximately 10 minutes). Samples were taken from the center of the pour pattern out to the edge of the carpet square in four directions. Samples were extracted by solvent extraction using n-pentane and analyzed by GC/MS. The hypothesis was that the edge of the pour pattern would be the most likely place to find any remaining gasoline because the gasoline would migrate during the fire to the edge where it could burn.

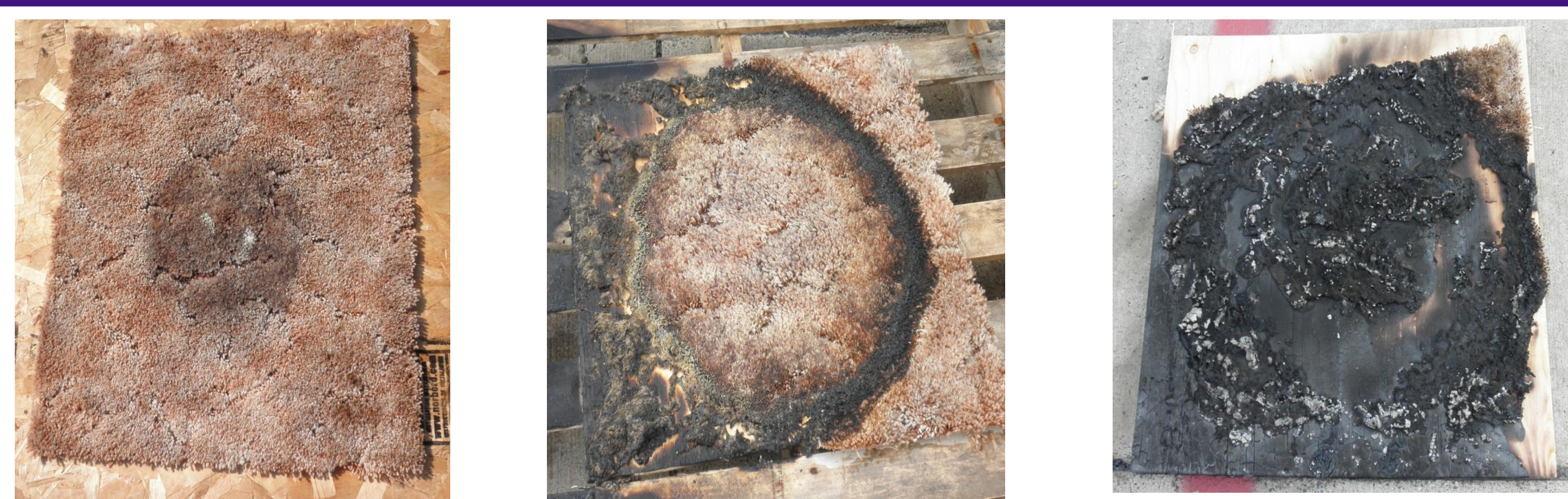


Figure 1. Left is the unburned carpet square. Center picture is the Time 2.5 Minute burned carpet square. Right is the Time End carpet square just after self-extinguishment.

•Materials and Methods

The gasoline (87 octane) was obtained from a local gasoline station. The carpet, provided by the intern, was from her parents' house and was 23 years old. The n-decylcyclohexane was purchased from TCI (98%). The 3-phenyltoluene was purchased from Alfa Aesar (95%, Lot # 10003533). The 2-methylnaphthalene was purchased from Aldrich Chemical Company (98%, Lot # 11626AF). The pentane extraction was performed according to the ASTM E 1386 method². The pentane for the first three carpet squares extracted was purchased from Mallinckrodt UltimAR (Lot # V557 X32E39) and for the last two carpet squares extracted was purchased from J.T. Baker (Lot # JO08599). Qorpak bottles (1oz FL A/C Grad., distributed by VWR International) were used to store carpet samples. The GC/MS vials (Target I-D Vials C4011-2W) and seals (11MM TEF/RR Red Seals) were by National Scientific Company and were purchased through VWR. Plywood was used as a base for the carpet squares during the burn.

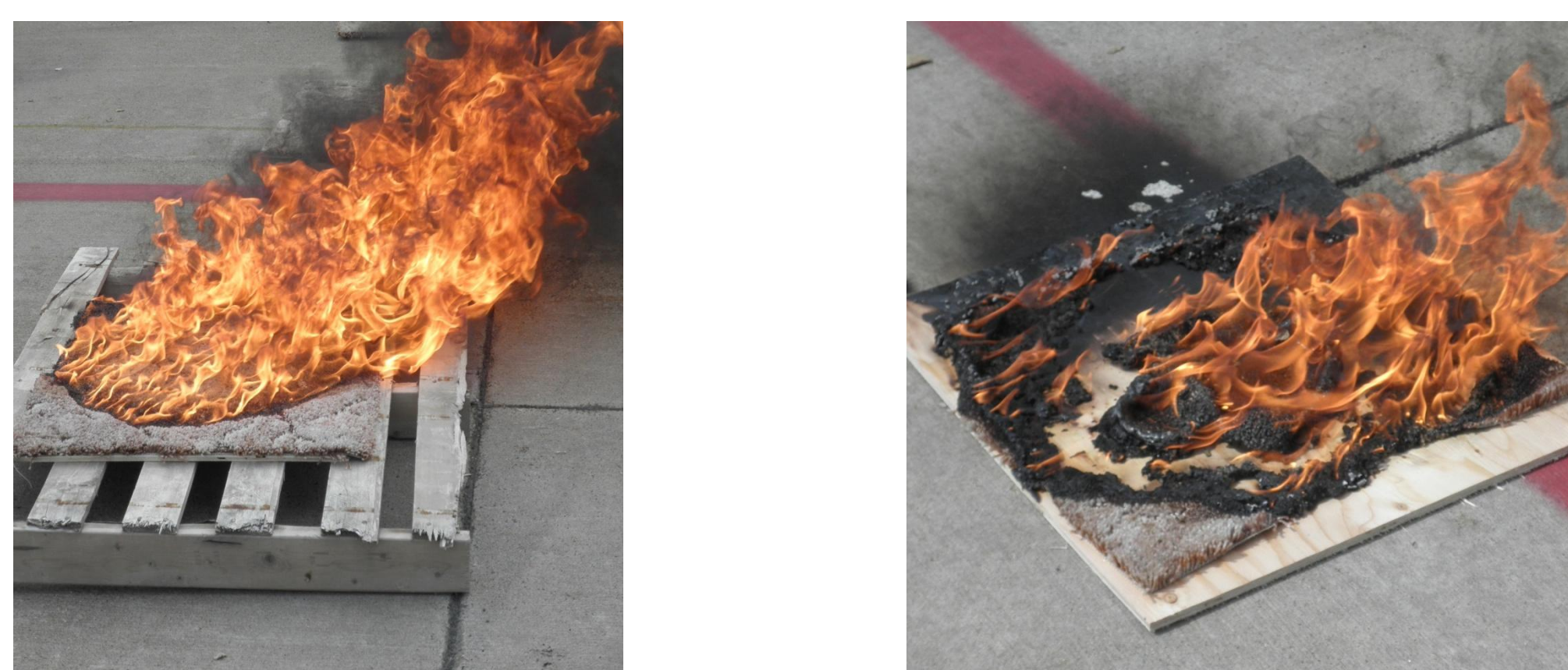


Figure 2. Left picture is the Time 2.5 Minute burned carpet. Right is the Time End carpet square, showing the exposed wood as the carpet was completely consumed in areas.

•Instrumentation

The experiment was performed using a Varian CP-3800 gas chromatograph with a Saturn 2000 mass spectrometer and CP-8400 autosampler. Column was a Varian FactorFour VF-1MS capillary column, 20m x 0.15mm x 0.15 μm. Mass acquisition was from 0.96 to 21 minutes, ranging from low mass 25 to high mass 250 m/z. There was no low mass detection and no solvent detection. The autosampler had a 10μL syringe and was operated in the standard split/splitless injection mode. Sample depth was 98%. Injector temperature was 300 Celsius. Flow rate was constant at 1 mL/minute. Initial temperature of the column oven was 40 Celsius, held for three minutes. The temperature then increased from 40 Celsius to 300 Celsius at a rate of 14.5 Celsius/minute and held at 300 Celsius for 0.07 minutes.

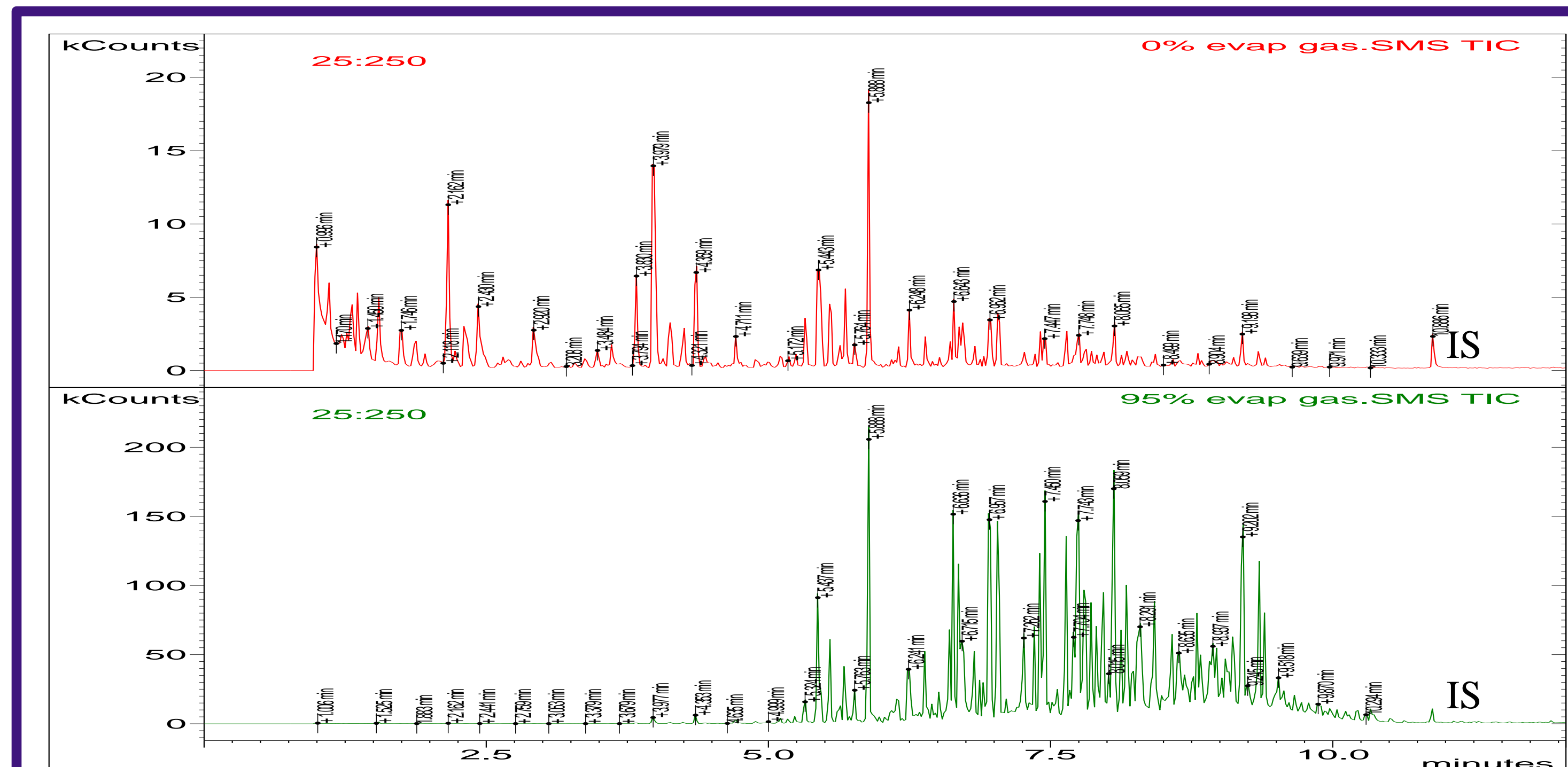


Figure 3. GC/MS chromatograms for 0% evaporated 87 octane gasoline (top) and 95% evaporated 87 octane gasoline. The internal standard (IS) was 3-phenyltoluene.

•Procedure

1. Rolls of carpet cut into 2 foot by 2 foot squares
2. One quart of gasoline poured into center of one carpet square, unburned
3. One quart of gasoline poured into center of one carpet square, burned until self-extinguishment (approximately 10 minutes)
4. One quart of gasoline poured into center of each of three carpet squares, burned for 2.5 minutes, 5 minutes, and 7.5 minutes respectively
5. A sample approximately 2 inches by 2 inches taken from center of each square
6. Strips cut out from the center to the edge of each carpet square in four directions: north (N), south (S), east (E), and west (W); each strip cut into 5 pieces roughly 2 inches in length, except for the east and west directions of the unburned carpet square where the strips were cut into 6 pieces
7. Each sample extracted with n-pentane for one hour, agitating every 10 minutes
8. Each sample filtered using glass wool; brought up to 25 mL with n-pentane
9. From each sample, 1 mL transferred to a GC/MS vial and 0.5 μL of 3-phenyltoluene added
10. Samples run on the GC/MS and the data analyzed

•Results

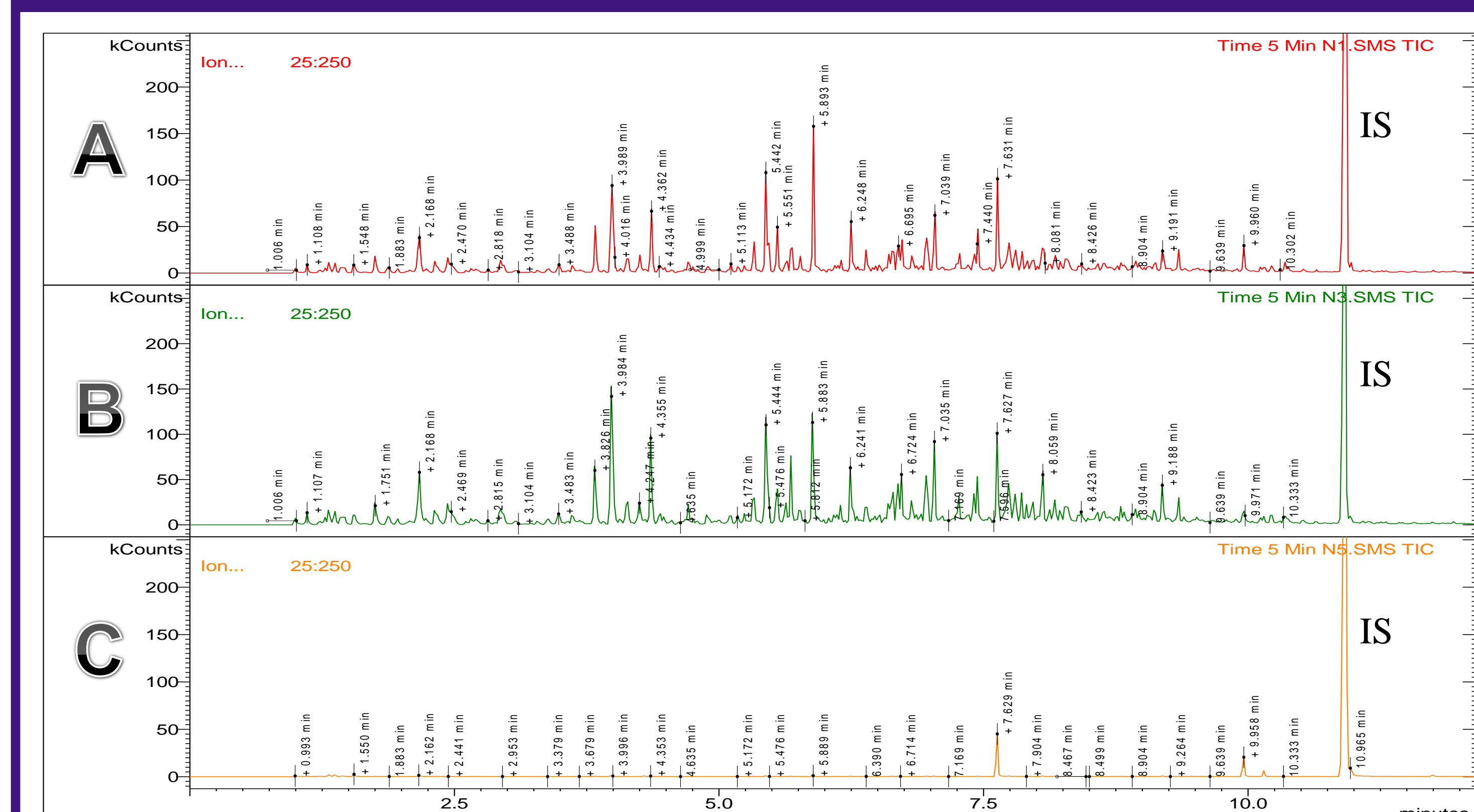


Figure 4. Time 5 Minute burn samples N1 (A), N3 (B), and N5 (C). The abundance scale is the same for each chromatogram. The internal standard (IS) was 3-phenyltoluene.

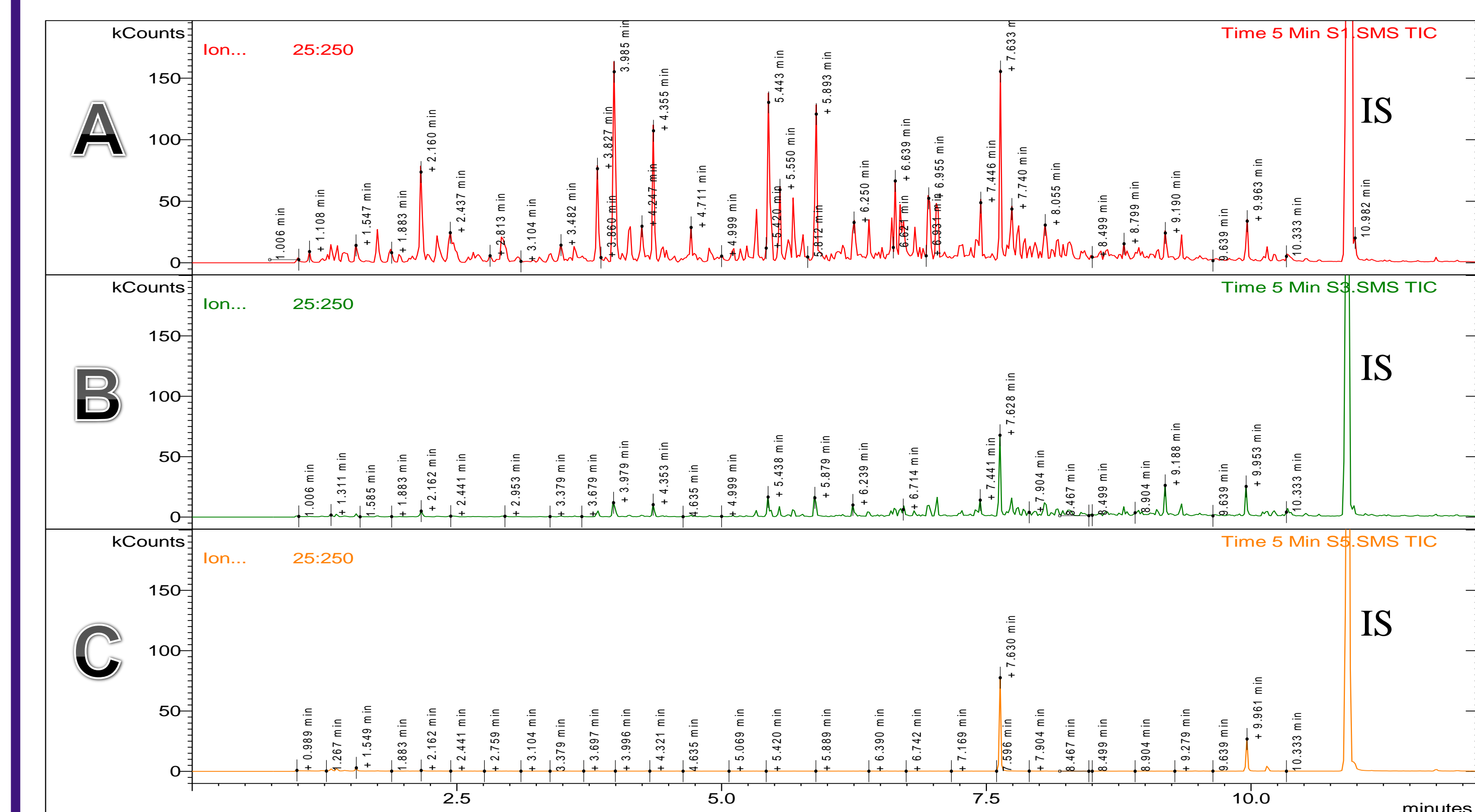


Figure 5. Time 5 Minute burn samples S1 (A), S3 (B), and S5 (C). The abundance scale is the same for each chromatogram. The internal standard (IS) was 3-phenyltoluene.

•Discussion

The chromatogram for each of the carpet samples was integrated and the ratio of peak areas for 2-methylnaphthalene over 3-phenyltoluene was calculated. Using the peak area ratios, an approximate amount of gasoline extracted from each carpet sample was calculated using the trendline from the graph of the known gasoline concentrations vs. the peak area ratio of 2-methylnaphthalene over 3-phenyltoluene for the known concentrations. Graphs of gasoline concentrations were made for each carpet square. The general shape of the quadratic trendlines for each graph is an upside down bowl shape, with the highest point generally being between the center and four inches from the center (**Figures 6 and 7**). With the east and west samples, there is a skewing to either the east or the west noticed, which is a result of a slight breeze on the day of the burn.

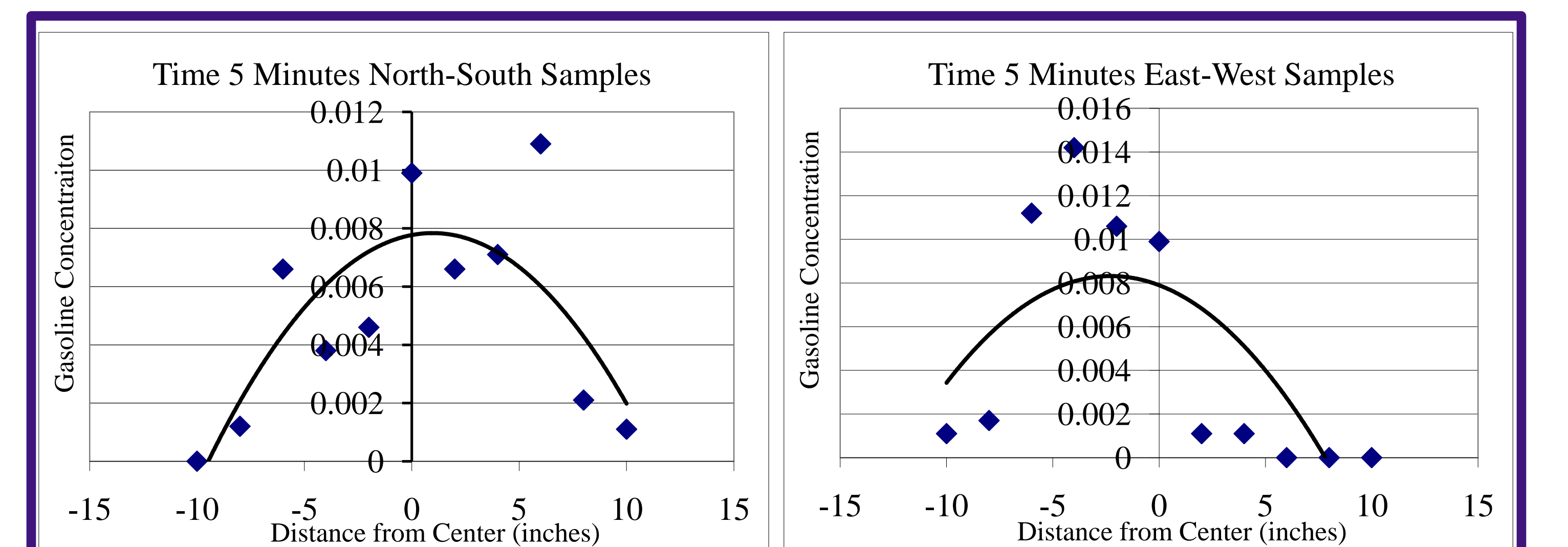


Figure 6. The graph on the left is gasoline concentrations for north and south samples taken from the Time 5 Minute carpet square. The graph on the right is gasoline concentrations for east and west samples taken from the Time 5 Minute carpet square.

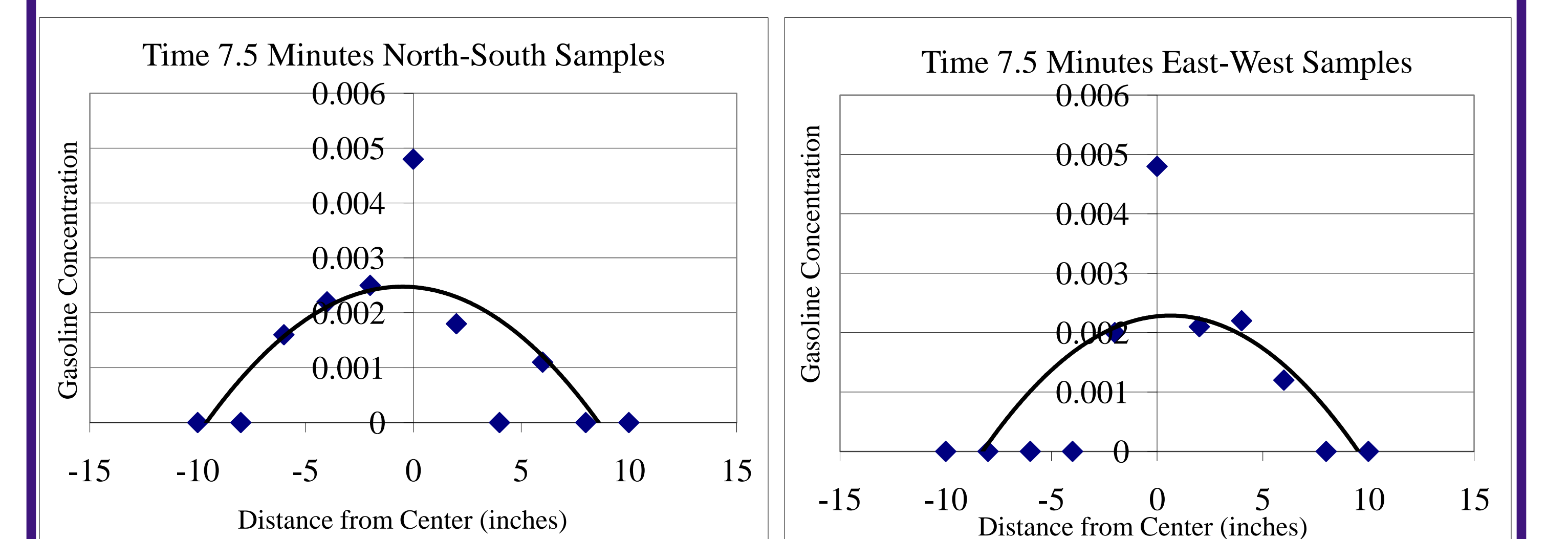


Figure 7. The graph on the left is gasoline concentrations for north and south samples taken from the Time 7.5 Minute carpet square. The graph on the right is gasoline concentrations for east and west samples taken from the Time 7.5 Minute carpet square.

•Conclusion

The results suggest that the best place to sample a pour pattern is the center. This is opposite of a previous experiment, which concluded that the edge of a pour pattern on carpet had a higher relative accelerant concentration³. In this experiment, however, the best area to sample was from the center out to about four inches (10 cm). This conclusion is believed to have been reached due to using too much gasoline for this experiment. The high amount of gasoline may have resulted in the carpet material burning faster than the gasoline.

•Future

In the future, different ignitable liquids should be tested, such as kerosene, diesel, paint thinner, and other ignitable liquids. Varying the amount of ignitable liquid used may affect results. Dispersing the liquids in different manners may also affect the results, such as splashing or trailing. More substrates should also be tested, such as wood, tile, linoleum, etc., and in varying sizes. Lastly, controlling the ventilation, temperature, and humidity during the burn will also affect results.

•References

1. Stauffer, E.; Dolan, J.A.; Newman, R. Fire Debris Analysis. Boston: Academic Press, 2008.
2. American Society for Testing and Materials. E 1386-00 Standard Practice for Separation and Concentration of Ignitable Liquid Resides from Fire Debris Samples by Solvent Extraction. June 2005.
3. O'Donnell, J.F. The sampling of burned areas for accelerant residue analysis. The Fire and Arson Investigator 1985 June; 35(4):18-20.

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