J Forensic Sci, July 2004, Vol. 49, No. 4
Paper ID JFS2003155
Available online at: www.astm.org

TECHNICAL NOTE

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The Evaluation of the Extent of Transporting or "Tracking" an Identifiable Ignitable Liquid (Gasoline) Throughout Fire Scenes During the Investigative Process

ABSTRACT: Tests have determined that boots or shoes of individuals at a fire scene do not transport sufficient contaminants ("tracking") through the fire scene to produce a positive laboratory result for the presence of gasoline in a fire scene that was not present at the time of the fire. Questions about the validity of forensic laboratory results have been raised on the basis that low-level gasoline residues detected in the laboratory samples could have been the result of transporting the residue by footwear contaminated from the fire scene ("tracking"). The data collected in this study establish that "tracking" does not lead to false-positive laboratory results. Canines trained and experienced in the detection of trace ignitable liquid residues were also utilized in this study. The canine results confirmed that properly trained canines show a higher sensitivity than do standard ASTM laboratory techniques for fire debris analysis. In a few cases, canines responded to contamination, but laboratory testing (which is the definitive indicator) did not produce positive results.

KEYWORDS: forensic science, arson, contaminants, fire accelerants, footwear, gasoline, GC-MS analysis, ignitable liquids, tracking

In the investigation of fire scenes, it is often important to determine if ignitable liquids or liquid accelerants, e.g., gasoline, have been used (1, 2). The investigative procedure involves the collection of field debris samples and submitting those samples to a forensic laboratory experienced in the analysis of fire debris. When laboratory results are reported as positive, it may be necessary for the investigator to defend in court the location of the sample and the collection techniques and procedures utilized. It has been claimed by individuals charged with arson that the gasoline residues reported by the laboratory were not, in fact, present at the fire scene but comprise an artifact. Specifically, it has been claimed that fire investigation personnel have entered the fire scene having walked through some ground surface contaminated with gasoline before entering the fire scene. For example, the investigator may have crossed a driveway where a gasoline spill had taken place (3). This type of claim, nor its defense, has ever been subjected to scientific examination. Thus the purpose of this study was to create spills of gasoline, have fire investigation personnel walk through these spills, then attempt to track the spilled contaminant through "clean" areas. The resulting test areas were then collected as field samples to determine if sufficient residue could be isolated to produce a positive laboratory result. The test areas in this study corresponded to a series of footprints (steps) created by the investigator onto established test areas directly upon leaving the spill area.

Furthermore, claims have been made that canines used for ignitable liquid detection may respond to contaminants that were supposedly tracked by an investigator and not originally present at the scene. Thus, trained and experienced canines were incorporated in the same series of field tests and their responses were documented.

Methods and Materials

The ignitable liquid used in all cases for this study was unleaded, regular-grade, gasoline purchased from a local retail service station. The gasoline was stored in a closed container and was, in all cases, used within 24 h of purchase. Three types of footwear were used: (1) fire boots; (2) work boots; and (3) tennis shoes. The footwear items included in the study were not brand new. The footwear was cleaned and the trained canines were solicited to verify the absence of materials that would elicit a positive response from the canine, thus verifying a lack of contamination prior to the field experiment commencing.

The walking surfaces utilized for this study were (a) concrete and (b) standard carpet and padding. The concrete surface was an ordinary concrete slab. The carpet and pad were new materials made

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Received 11 May 2003; and in revised form 18 Dec. 2003 and 9 Feb. 2004; accepted 14 Feb. 2004; published 13 May 2004.

FIG. 1—*Fire investigator stepping on pour location.*

FIG. 2—*Fire investigator on the last step of the test area.*

of polyolefin and polyurethane, respectively. The carpet and pad pieces used to establish the pour and test areas were cut from a single roll for the entire test program. The carpet and pad pieces were cut into uniform squares measuring approximately 457 mm by 457 mm. A walk path was created using 6 sets of carpet and pad for each Test Series. The sample sets (comprised of carpet and pad) were placed approximately 300 mm apart. Each set was then sequentially numbered from 1 to X, beginning at the pour site (Figs. 1 and 2).

Following the field experiment, the samples were collected using new latex gloves for each set. Each sample consisted of the entire carpet square and its appurtenant pad. The containers utilized were new 3.8 L (1-gallon) friction-top metal cans furnished by the testing laboratory. The container lot had been tested for quality control prior to release to the research team. Samples were secured and transported utilizing the standards and guidelines of National Fire Protection Association (NFPA) (1) and ASTM International (ASTM) (4,5). The samples were transmitted to the testing laboratory, along with field blanks, trip blanks and blind control samples, in such a manner that the research samples were not distinguishable from standard fire scene samples typically submitted.

Recovery from the debris samples was by absorption on charcoal strips during controlled heating at a temperature of 90°C for 16 hours in accordance with ASTM E 1412-00 (1). The charcoal strips were extracted with laboratory grade diethyl ether. All of the samples were analyzed by (a) flame ionization, dual-capillary-column gas chromatography, according to ASTM E 1387-01 (2), and using cross-column confirmation; and (b) by capillary-column gas chromatography/mass spectrometry in accordance with ASTM E 1618-01 (3), utilizing ion profiling and compound identification by computer comparison to the EPA/NIST database. The gas chromatograph used was a Varian 3800 with a Varian 2200 ion trap mass spectrometer. Samples were injected using a Varian 8400 autosampler. Instrument conditions were the following. Column: 30 m DB-1, ID 0.25 mm, film 0.25 μm. Program: 35°C hold for 3.0 min; 6°C/min to 90°C; 12°C/min to 252°C; hold 4.33 min. Under the same conditions as described, the testing laboratory has determined that, under similar analytical conditons, 0.1 μL of gasoline contamination within collected fire-scene evidence is detectable from a 3.8 L sample container. Representative results of the GC/MS analyses are shown in Fig. 3 and Fig. 4.

Three trained and experienced fire-accelerant detection canines were included in the research project: *Maxmillian*, a Belgian Malinois; *Lady*, a Belgian Malinois; and *Deuce*, a Labrador retriever. The canines were trained by applying the principles of operant conditioning with an emphasis on positive reinforcement (8). The primary reinforcer selected was a toy. Extensive evaluations were done prior to animal selection in order to select only those that showed a motivation to pursue the chosen primary reinforcer. The animals were conditioned upon verbal command to search for the toy, and this behavior was reinforced by allowing the dog to locate, possess, and intermittently pursue the toy. The desired odors were then placed adjacent to the toy forming an association between the two. Once the canines exhibited significant odor recognition, which was visible in the animal's body movements, the toy was initially withheld and only given to the dog once it showed recognition of the odor. During this phase additional odors were paired with the initial odor until the canine was proficient at locating all of the desired odors. The next phase of conditioning involved again restricting the primary reinforcer but not initiating the chosen final response. The final response elicited was a passive response of sitting or laying down and placing the nose on the odor located. Once competent at giving the correct, unassisted final response to the desired odors and passing over undesired odors, all canines and their handlers went through an extensive third-party certification process. The canines were subsequently tested regularly as part of their routine maintenance training, and regular re-certification was conducted annually. The canines used in these tests were all veteran dogs with years of experience in fire scenes ranging from approximately three to eight years.

Procedures

The field experiment included: 1) establishing the testing area; 2) pouring a specified amount of gasoline at the designated "pour location"; 3) stepping into the "pour location" and walking the length of the testing area as shown in Figs. 1 and 2. Following the "tracking" process, the canines worked the scene with their handler/trainer. Canine response was documented and then samples were secured for transport to the testing laboratory.

The pour locations were either new carpet and pad, or bare, unpainted concrete as noted in Table 1. The amount of gasoline used at the pour location was intended to saturate the area. The test areas where the investigator stepped were, in all cases, new carpet and pad. The total length of the tracking course for Test Series 1, 2, 3 and 4, from the start of the pour location to end of the test area, was 14.25 m (46.8 ft). For Test Series 5 the length of the tracking course was 3.35 m (11 ft), which was preceded by a 30.5 m (100 ft) length of concrete surface over which the investigator walked prior to reaching the tracking course.

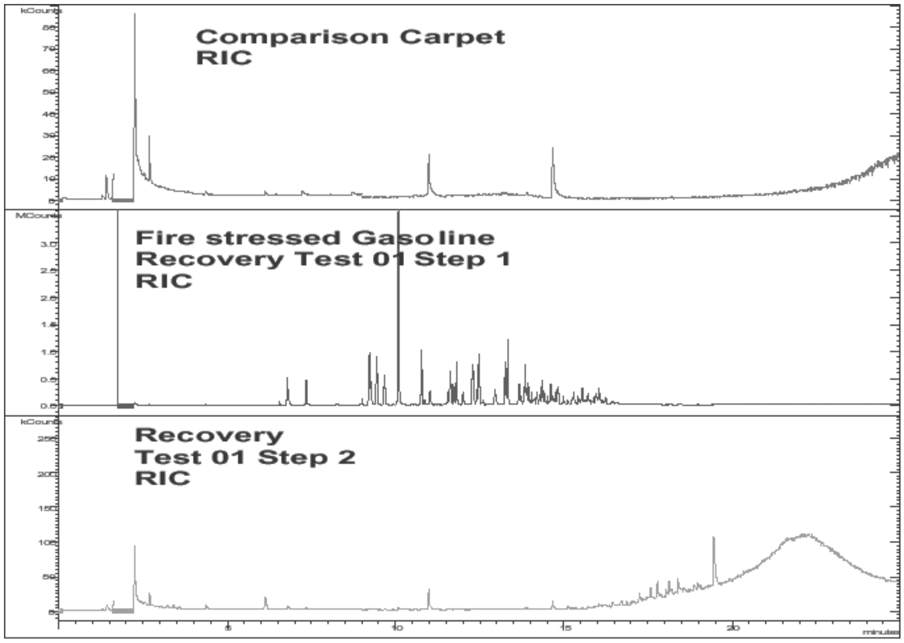
The fire investigator first stepped into the pour area (Fig. 1) wearing the footwear noted for each Test Number in Table 1. In the case of Test Series 3, the investigator stood for 20 s at the pour location before continuing to walk through the test area. This was done in order to examine any effect of footwear/liquid contact time on the results. In all other Test Series, the investigator walked continuously through the pour location and directly onto the test area. Both feet were exposed to the pour area and both feet "tracked" through each test area. The time delay between the application of the gasoline and the start of the test was less than 1 min. Test Series 5 consisted of fresh gasoline poured on the concrete slab and the investigator, after walking through the pour area, walk across 30.5 m of "clean" concrete slab, then onto the test area that had carpet and pad.

To establish canine response, each canine worked the Test Series with their personal handler/trainer. At no time was more than

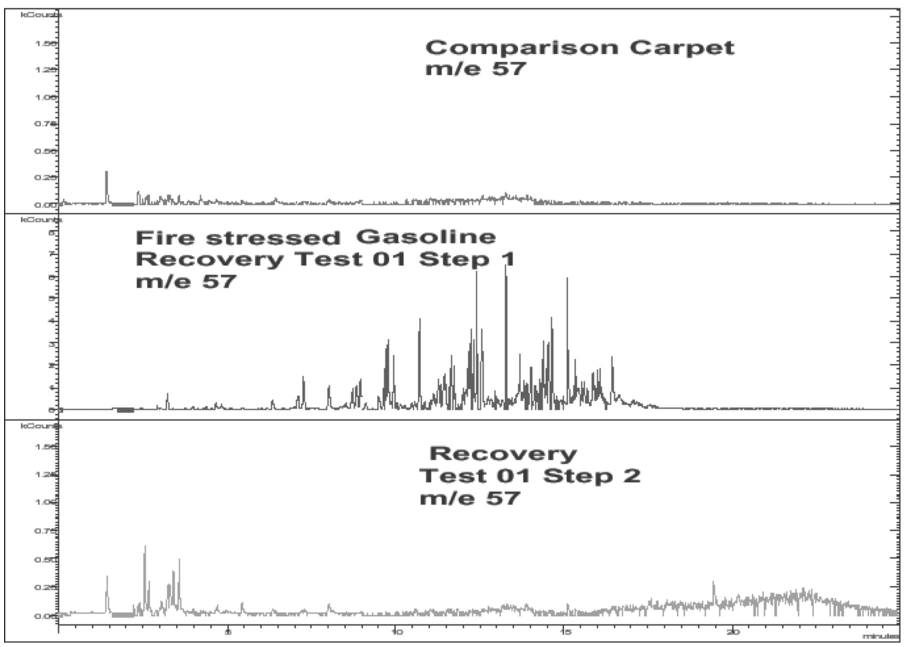
TABLE 1—*Experimental details and test series results.*

Test Series	Amount of gasoline (mL)	Gasoline burned?	Footwear	Pour Location Material	Results Source	Step Number							
						1	2	3	4	5	6	7	8
1	118	no	fire boots	carpet and pad	test lab	pos	neg	neg	neg	neg			
					canine	pos	pos	pos	neg	neg			
2	79	yes	work boots	carpet and pad	test lab	pos	neg	neg	neg	neg	neg		
					canine	pos	pos	neg	neg	neg	neg		
3	473	no	tennis shoes	concrete	test lab	a	a	neg	neg	neg	neg	neg	neg
					canine	a	a	pos	pos	pos	pos	pos	pos
4	473	yes	tennis shoes	concrete	test lab	b	neg	neg	neg	neg	neg	neg	
					canine	b	neg	neg	neg	neg	neg	neg	
5	473	no	fire boots	concrete	test lab	c	neg						
					canine								

Step No. 1 = Pour Location; "pos" = positive result/response; "neg" = negative result/response.
[a] First two steps were taken on concrete, not on carpet; investigator stood 20 s at location of first two steps.
[b] First step taken on concrete, not on carpet
[c] Walked 30.5 m on concrete prior to stepping on carpet



(a)

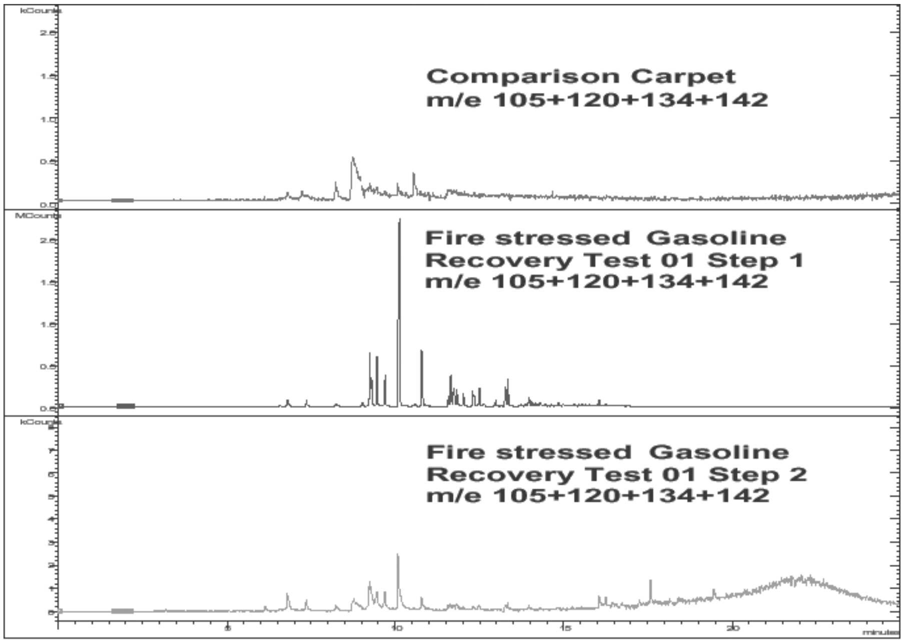


(b)

FIG. 3—*Results from GC/MS analysis for Test 1. (a) Reconstructed ion chromatograms for comparison sample, sample from Step 1, and sample from Step 2. (b) Chromatograms for selected ion m/e 57, which corresponds to aliphatic hydrocarbons. (c) Chromatograms for selected ions m/e 105 + 120 + 134 + 142, which corresponds to aromatic hydrocarbons.*

one canine admitted to the testing area. For Test Series 1, all three canines were used. For Test Series 2, 3, and 4, only *Maxmillian* and *Deuce* were available. Each canine was led to the individual step area (test area) by the canine's handler/trainer and the canine's response was noted. A positive canine response is illustrated in Fig. 5. If the canine responded to a particular sample set, that sample set (carpet and pad) was removed and the canine continued to work the remainder of the Test Series. After the canine had been led through the entire Test Series sequentially, the sample sets were randomly placed at a location removed from the original experiment site and each canine worked the sample sets again. For Test Series 1 and 2, the random sampling procedure was conducted as a separate set of tests (i.e., independent of each other). For Test Series 3 and 4 the sample sets were randomly arranged as a consolidated group; in other words, the canines were led through 12 carpet/pad sample sets.

As noted in Table 1, some of the Test Series involved "burned" conditions (Test Series 2 and 4). For these experiments, the gasoline was poured at the pour location, ignited and allowed to burn out. The fire investigator only commenced to walk through the pour location once the fire had self-extinguished.



(c)

FIG. 3—*Continued.*

For each Test Series, the sample sets of the carpet and pad were secured from each location (pour and test areas). In those Test Series where the pour location was carpet and pad (Test Series 1, 2, and 3) all test areas were submitted for laboratory analysis. This corresponds to Step Numbers 1 through 6 (refer to Table 1). For those Test Series where the gasoline pour site was concrete, only those test areas where visible liquid material was not noted were submitted to the testing laboratory. In other words, Step Number 1 (the concrete pour site) was not submitted for analysis. Step 2 from Test Series 3 was not submitted due to visible liquid present following the step.

A blind control sample that consisted of new, unused carpet and pad from the same rolls of material as used for the field tests was submitted to the laboratory. The debris samples[6] were sealed in 3.8 L containers and submitted to the testing laboratory for analysis. This was established as the most effective method for obtaining maximum sensitivity during laboratory analysis.

Results

Table 1 details the experiment parameters, canine responses, and analytical results for each Test Series and sample set submitted. Laboratory analyses establish the positive presence of gasoline only at the pour locations (Step 1). Canine responses, as noted in the table, proved to be more sensitive and were sometimes documented for several steps following the pour location. In the Test Series where a relatively large amount of gasoline (473 mL) was poured but not burned, a positive canine response was noted through the last step studied.

It is understood that canines trained in the detection of ignitable liquids respond to the strongest scent first. This understanding was confirmed through this Test Series. When responding, the canines always alerted first at the step closest to the start, since that had the highest residue concentration.

The names of the individual canines' are not included in Table 1, because there was 100% of agreement in the canine responses. In no case was there a sample set where mixed canine responses were recorded. The canines were allowed to walk on the test areas as would occur during a typical fire scene investigation, but the results indicate that the canines did not transport any gasoline residue that would be responded to by the other canines.

Discussion

The results obtained in this study disprove the claim that positive results are likely to be reported by a testing laboratory from fire scene samples as a result of "tracking" contamination from the footwear of investigation personnel. In the present study, large quantities of fuel (and in some cases, exceedingly large) were poured onto common surfaces found at a fire scene and the investigator intentionally walked through this area onto pre-established test areas. In two of the four Test Series the gasoline was "fresh," that is, it was neither burned nor allowed to evaporate. Yet laboratory results were uniformly negative, apart from samples taken from the pour location itself. Consequently, it is concluded that even significant carelessness by a fire scene investigator (such as entering the fire scene with contaminated shoes) would not result in tracking sufficient gasoline to potential sample sites that would result in positive results reported from the testing laboratory.

In addition, the study showed that the sensitivity of properly trained and experienced canines is higher than the sensitivity of standard laboratory procedures for fire-debris analysis. This conclusion confirms the findings of Kurz (9) and NFPA (1). The fact that canines responded to "tracking" in some cases does not create a forensic error since the laboratory results—which were negative—are the definitive forensic indicator.

Finally, it should be noted that the chemical composition of "fresh" gasoline is different from that of gasoline where the lighter

[6] The test samples themselves—carpet and pad—were not burned in any of the tests.

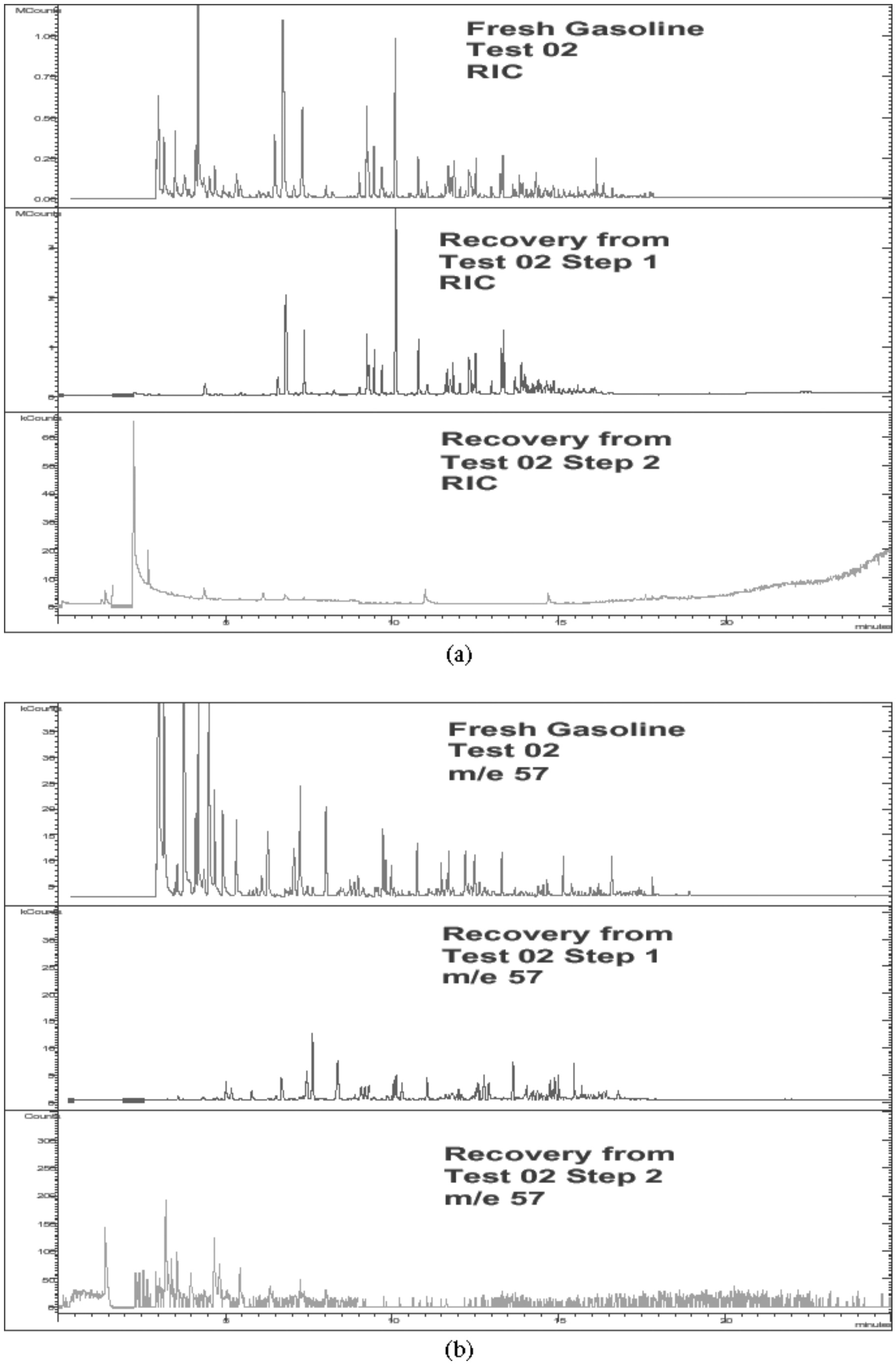
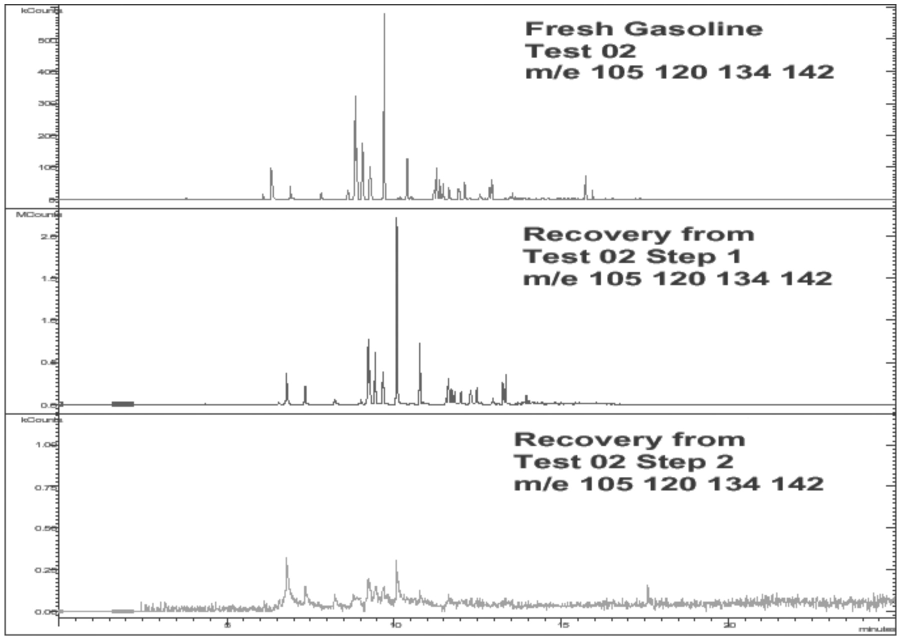


FIG. 4—*Results from GC/MS analysis for Test 2. (a) Reconsructed ion chromatograms for comparison sample, sample from Step 1, and sample from Step 2. (b) Chromatograms for selected ion m/e 57, which corresponds to aliphatic hydrocarbons. (c) Chromatograms for selected ions m/e 105 + 120 + 134 + 142, which corresponds to aromatic hydrocarbons.*

component fractions have evaporated ("weathered") due to an ongoing fire. This difference can readily be detected by standard GC or GC/MS techniques (10). In the present study, laboratory testing correctly identified the Test Series 1, 3, and 5 samples from Step 1 as being "fresh" and Test Series 2 and 4 samples from Step 1 as "weathered" (burned or evaporated) gasoline. Typically, debris samples collected from a fire accelerated with gasoline show the presence of weathered, not fresh, gasoline. If the laboratory analysis shows fresh gasoline from samples that were collected from a burned area, then the implication would be that either: (1) the gasoline was tracked in by investigating/fire scene personnel; or (2) the gasoline remained "fresh" because very large quantities were used to accelerate the fire. The present study, however, has shown that even walking through major quantities of spilled gasoline and onto the fire scene will not cause laboratory analysis to indicate a false positive result when the fire debris are tested. Thus, detected presence of fresh gasoline should be taken to indicate that gasoline may have been poured or spilled in that location, and not tracked in from another area. If there is a presence of a sizable amount of unburned gasoline, this will also commonly be visibly observable.



(c)

FIG. 4—*Continued.*

FIG. 5—*Positive alert of canine Maxmillian indicated at step No. 1 (pour location) of test 1.*

Acknowledgments

The assistance of the following personnel in conducting the tests is gratefully acknowledged: Robert Calderon, Terry Dees, Dustin Deutsch, Holly Hera, Bryan D. Holmes, J. J. Jack, Shawn Keesler, Bo Montague, and Salvadore Russo.

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