

J.C. Broderick & Associates, Inc.

Environmental Consulting & Testing



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October 30, 2007

Mr. Montgomery Granger
Comsewogue Union Free School District
Buildings & Grounds
290 Norwood Avenue
Port Jefferson Station, New York 11776-2598

**Re: Ambient Air Sampling for PAH's
Comsewogue High School Football Field
565 Bicycle Path
Port Jeff Station, NY 11776
Sampling Date: October 16, 2007**

JCB#: 07-12062

Dear Mr. Granger:

J. C. Broderick & Associates, Inc. (JCB) was retained to perform air sampling at the above referenced athletic field due to concerns raised in the News 12 Long Island Focus 12 segment which aired on October 15, 2007 pertaining to artificial playing fields.

Specifically, News 12 reported that they collected samples of a "Port Washington field for lab studies" and reported the presence of three cancer-causing chemicals that were in excess of state safety levels. During the viewing of the News 12 segment, a New York State Department of Environmental Conservation (NYS DEC) logo was displayed suggesting that the turf sampling results were compared to NYS DEC published "safe levels". It should be noted that the NYS DEC does not establish "safe limits" for human exposure to chemicals and or hazardous substances, instead, they identify levels designed to protect the environment (e.g. soil clean up projects, water quality, etc.). Therefore it appears that News 12 may have erroneously compared their data to NYS DEC guidelines, which have been established to protect the environment and not as a means of determining the potential for human exposure or "safe limits." Since JCB does not have a copy of News 12's sampling methodology, laboratory analytical report, and or the state document referencing "safety levels", we can not comment on the accuracy and or reliability of their findings.

The News 12 Focus segment reported the following chemicals, classified as polycyclic aromatic hydrocarbons or PAHs, "in excess of state safety levels":

- Pyrene,
- BenzoPyrene, and
- Chrysene.

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It is not disputed that the chemicals identified in News 12's sample are typically present within the matrix of the rubber used to make synthetic fields; therefore this study focuses on the potential routes of exposure for users (athletes, coaches, etc.) to be exposed to these chemicals while using the athletic field.

Background Information on Polycyclic Aromatic Hydrocarbons

The Agency for Toxic Substances and Disease Registry (ATSDR) states that PAHs are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. Some PAHs are naturally occurring in the environment, while others are manufactured. PAHs are found in coal tar, crude oil, creosote, and roofing tar, asphalt and some are used in medicines or to make dyes, plastics, and pesticides.

Some types of PAH's have been identified as carcinogenic, or cancer causing, agents. The Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Health and Safety (NIOSH) and the American Congress of Governmental Industrial Hygienists (ACGIH) have all promulgated occupational exposure limits to airborne concentrations of PAH's.

Dermal Absorption

PAHs can be absorbed through the skin (dermal exposure). Typical exposures come from the handling of contaminated soil or bathing in contaminated water. Absorption exposure of low levels can also occur in people who use PAH-containing medicated skin creams or shampoos.

In the case of synthetic athletic fields, like the one at the above referenced facility, PAH's are found within the matrix of the rubber, therefore, exposure to PAH's through skin contact with the surface of the athletic field during normal use is unlikely. More significant potential exposure routes include ingestion and inhalation.

Ingestion Hazard

PAH exposure can occur through ingestion. It has been reported that eating foods grown in contaminated soils and by eating grilled foods can increase the amount of PAHs in the food. Other foods that may contain low levels of PAHs include roasted coffee, roasted peanuts, refined vegetable oil, grains, vegetables and fruits. It has been reported that the general population ingests 1-9 micrograms of PAHs per day through consumption of food, making food the primary route of exposure.

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It is anticipated that there will be some residue from the rubber material (e.g. rubber crumbs) of the athletic field at the above referenced facility, and when adhered to the children's hands or picked up could be ingested. However it is expected that the PAHs will leave the body through urine and feces in just a matter of days. The rubber matrix is not expected to be easily absorbed by the body during the digestive process and therefore would not be considered a significant threat. To minimize and or eliminate this potential exposure it is recommended that all users of the field be instructed to wash their hands and skin after playing on the field. In general, it is a good practice to always encourage and utilize good hygiene amongst athletes, regardless of whether the playing field is artificial or natural.

Inhalation

Most studies and literature on PAH exposure indicate that inhalation, or breathing of contaminated air, is a common route of exposure. Inhalation exposure can be attributed to breathing in fumes from vehicle exhaust, coal, coal tar, asphalt, wild fires, agricultural burning and cigarette/tobacco smoke. The operation of the athletic field does not typically include "burning it" and therefore this type of fume release is not an anticipated form of exposure.

PAHs are semi-volatile compounds, which mean that they do not easily evaporate. It is expected that the rubber material will have to be heated to a temperature of approximately 250 °F for any significant amount of the PAHs to evaporate from the rubber material. It is not expected that the field material will reach this temperature during ambient conditions and uses.

If the rubber field material did reach this temperature and PAHs did evaporate, they would be out-gassing to an outdoor, open field environment. Which means that the concentrations or presence of these parameters would be diluted immediately with the ambient air and would not reasonably be expected to be present at any harmful concentration.

Inhalation of airborne PAH's while utilizing the above referenced athletic field for its intended purposes, does not appear to be a feasible means of exposure and is unlikely. However as a quality assurance measure, PAH air sampling on and around the above referenced playing field was conducted.

Air Sampling Protocol

The air sampling was performed utilizing laboratory supplied sorbent tubes in accordance with the NIOSH Manual of Analytical Methods (NMAM) Method 5515, Polynuclear Aromatic Hydrocarbons by GC (fourth edition 8/15/94). The samples were collected by an experienced JCB environmental sampling technician, assigned individual identification numbers, logged into a chain of custody document, and delivered via courier to an independent environmental laboratory approval program

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(ELAP) certified laboratory for analysis.

Air Sampling Results

The PAH air testing, performed on and around the athletic field of the above referenced facility, did not reveal the presence of any detectable concentrations of PAH's. All sixteen PAH's analyzed were found to be below the laboratory minimum detection limit (MDL) of 6 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). It should be noted that, the three types of PAH's identified in the News 12 investigation (Chrysene, Benzo(a)pyrene, and Pyrene), were observed below the laboratory MDL. A copy of the chain of custody form, laboratory analytical report, and laboratory analytical method can be referenced as an attachment to this letter.

Recommendations

Based upon the information reviewed on PAH exposure in humans and the results of the PAH air testing performed, the potential for exposure to PAH's during normal use of the athletic field, at the above referenced facility, appears to be minimal or insignificant.

However, to minimize any potential for exposure the following is recommended:

- Emphasize good hygiene practices (e.g. washing hands, showering, routine cleaning of uniforms, etc.) by athletes using the field,
- In the event that there is a school function during which younger children with the significant potential to put the synthetic turf, or pieces of rubber in their mouth exists, adult supervision should be present.

If you have any questions or are in need of additional information, please feel free to contact me.

Sincerely,



Brendan Broderick
J. C. Broderick & Associates, Inc.

Attch.

PROJECT NAME/LOCATION	PROJECT #	DATE	LABORATORY	OST-ABATE	TURNAROUND TIME							
Consenroque High School	07-12062	10/16/07	LIAL	HR	<input type="checkbox"/> 12 HR							
565 Bicycle Path Port Jervis Station, NY				4 HR	<input type="checkbox"/> OTHER							
CLIENT	Consenroque WSP											
	A=Air B=Bulk W=Wipe L=Liquid S=Sail											
SAMPLE ID	DATE	LAB #	TYPE	SAMPLE LOCATION/DESCRIPTION	FLOW BE (L)	FLOW AVG (L)	BEGIN TIME	END TIME	TOTAL MIN	TOTAL VOL (L)	ANALYSIS METHOD	RESULT
SV1-A	10/16		A	North Parking Lot		1146937			200	200	8270 VAH only	
SV1-B	10/16		A	North Parking Lot		1146938			200	200	8270 VAH only	
SV2-A	10/16		A	Synthetic Turf Field		1146939			200	200	8270 VAH only	
SV2-B	10/16		A	Synthetic Turf Field		1146940			200	200	8270 VAH only	
F8-1	10/16		A	Field Blank		1146941						
SAMPLERS NAME (PRINT)	Bryan Kzelus	SAMPLERS SIGNATURE	<i>Bryan Kzelus</i>	RECEIVED BY		SIGNATURE	<i>[Signature]</i>	DATE	10-18-07	TIME	9:18 AM	
REINQUISHED (PRINT)		SIGNATURE		ANALYST (PRINT)		SIGNATURE		DATE		TIME		
COMMENTS:	<input type="checkbox"/> ANALYZE EACH MATERIAL TO 1st POSITIVE <input checked="" type="checkbox"/> FAX RESULTS TO (631) 584-3395 <input type="checkbox"/> MANAGER <i>EL</i>											

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 White-Laboratory Yellow-Office Pink-Field



LONG ISLAND ANALYTICAL LABORATORIES INC.

NYSDOH ELAP# 11603
USEPA# NY01273
CTDOH# PH-0204
AIHA# 164456
NJDEP# NY012
PADEP# 06-2943

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1 of 6 pages

October 19, 2007

J.C. Broderick & Associates
Brendan Broderick
420 Lake Avenue
Saint James, NY 11780



Dear Mr. Broderick:

Enclosed please find the Laboratory Analysis Report(s) for sample(s) received on October 18, 2007. Long Island Analytical Laboratories analyzed the samples on October 18, 2007 for the following:

CLIENT ID	ANALYSIS
SV-1A North Parking Lot	EPA 8270PAH
SV1-B North Parking Lot	EPA 8270PAH
SV2-A Synthetic Turf Field	EPA 8270PAH
SV2-B Synthetic Turf Field	EPA 8270PAH
FB-1 Field Blank	EPA 8270PAH

If you have any questions or require further information, please call at your convenience. Long Island Analytical Laboratories Inc. is a NELAP accredited laboratory. All reported results meet the requirements of the NELAP standards unless noted above. Report shall not be reproduced except in full, without the written approval of the laboratory. Long Island Analytical Laboratories would like to thank you for the opportunity to be of service to you.

Best Regards,

Long Island Analytical Laboratories, Inc.

2 of 6 pages

Client: JC Broderick	Client ID: Comsewogue High School (SV-1A North Parking Lot)
Date received: 10/18/07	Laboratory ID: 1146937
Date extracted: 10/18/07	Matrix: Air
Date analyzed: 10/18/07	ELAP #: 11693

EPA METHOD 8270-PAH

PARAMETER	CAS No	MDL	RESULTS ug/m ³	Flag
ACENAPHTHENE	83-32-9	6 ug/m ³	<6	
ACENAPHTHYLENE	208-96-8	6 ug/m ³	<6	
ANTHRACENE	120-12-7	6 ug/m ³	<6	
BENZO(a)ANTHRACENE	56-55-3	6 ug/m ³	<6	
BENZO(a)PYRENE	50-32-8	6 ug/m ³	<6	
BENZO(b)FLUORANTHENE	205-99-2	6 ug/m ³	<6	
BENZO(ghi)PERYLENE	191-24-2	6 ug/m ³	<6	
BENZO(k)FLUORANTHENE	207-08-9	6 ug/m ³	<6	
CHRYSENE	218-01-9	6 ug/m ³	<6	
DIBENZO(a,h)ANTHRACENE	53-70-3	6 ug/m ³	<6	
FLUORANTHENE	206-44-0	6 ug/m ³	<6	
FLUORENE	86-73-7	6 ug/m ³	<6	
INDENO(1,2,3-cd)PYRENE	193-39-5	6 ug/m ³	<6	
NAPHTHALENE	91-20-3	6 ug/m ³	<6	
PHENANTHRENE	85-01-8	6 ug/m ³	<6	
PYRENE	129-00-0	6 ug/m ³	<6	

MDL = Minimum Detection Limit.

Calculated on a wet weight basis



Michael Veraldi-Laboratory Director



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Client: JC Broderick	Client ID: Comsewogue High School (SV-1B North Parking Lot)
Date received: 10/18/07	Laboratory ID: 1146938
Date extracted: 10/18/07	Matrix: Air
Date analyzed: 10/18/07	ELAP #: 11693

EPA METHOD 8270-PAH

PARAMETER	CAS No	MDL	RESULTS ug/m ³	Flag
ACENAPHTHENE	83-32-9	6 ug/m ³	<6	
ACENAPHTHYLENE	208-96-8	6 ug/m ³	<6	
ANTHRACENE	120-12-7	6 ug/m ³	<6	
BENZO(a)ANTHRACENE	56-55-3	6 ug/m ³	<6	
BENZO(a)PYRENE	50-32-8	6 ug/m ³	<6	
BENZO(b)FLUORANTHENE	205-99-2	6 ug/m ³	<6	
BENZO(ghi)PERYLENE	191-24-2	6 ug/m ³	<6	
BENZO(k)FLUORANTHENE	207-08-9	6 ug/m ³	<6	
CHRYSENE	218-01-9	6 ug/m ³	<6	
DIBENZO(a,h)ANTHRACENE	53-70-3	6 ug/m ³	<6	
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FLUORENE	86-73-7	6 ug/m ³	<6	
INDENO(1,2,3-cd)PYRENE	193-39-5	6 ug/m ³	<6	
NAPHTHALENE	91-20-3	6 ug/m ³	<6	
PHENANTHRENE	85-01-8	6 ug/m ³	<6	
PYRENE	129-00-0	6 ug/m ³	<6	

MDL = Minimum Detection Limit.

Calculated on a wet weight basis



 Michael Veraldi-Laboratory Director

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Client: JC Broderick	Client ID: Comsewogue High School (SV2-A Synthetic Turf Field)
Date received: 10/18/07	Laboratory ID: 1146939
Date extracted: 10/18/07	Matrix: Air
Date analyzed: 10/18/07	ELAP #: 11693

EPA METHOD 8270-PAH

PARAMETER	CAS No	MDL	RESULTS ug/m ³	Flag
ACENAPHTHENE	83-32-9	6 ug/m ³	<6	
ACENAPHTHYLENE	208-96-8	6 ug/m ³	<6	
ANTHRACENE	120-12-7	6 ug/m ³	<6	
BENZO(a)ANTHRACENE	56-55-3	6 ug/m ³	<6	
BENZO(a)PYRENE	50-32-8	6 ug/m ³	<6	
BENZO(b)FLUORANTHENE	205-99-2	6 ug/m ³	<6	
BENZO(ghi)PERYLENE	191-24-2	6 ug/m ³	<6	
BENZO(k)FLUORANTHENE	207-08-9	6 ug/m ³	<6	
CHRYSENE	218-01-9	6 ug/m ³	<6	
DIBENZO(a,h)ANTHRACENE	53-70-3	6 ug/m ³	<6	
FLUORANTHENE	206-44-0	6 ug/m ³	<6	
FLUORENE	86-73-7	6 ug/m ³	<6	
INDENO(1,2,3-cd)PYRENE	193-39-5	6 ug/m ³	<6	
NAPHTHALENE	91-20-3	6 ug/m ³	<6	
PHENANTHRENE	85-01-8	6 ug/m ³	<6	
PYRENE	129-00-0	6 ug/m ³	<6	

MDL = Minimum Detection Limit.

Calculated on a wet weight basis



Michael Veraldi-Laboratory Director



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Client: JC Broderick	Client ID: Comsewogue High School (SV2-B Synthetic Turf Field)
Date received: 10/18/07	Laboratory ID: 1146940
Date extracted: 10/18/07	Matrix: Air
Date analyzed: 10/18/07	ELAP #: 11693

EPA METHOD 8270-PAH

PARAMETER	CAS No	MDL	RESULTS ug/m ³	Flag
ACENAPHTHENE	83-32-9	6 ug/m ³	<6	
ACENAPHTHYLENE	208-96-8	6 ug/m ³	<6	
ANTHRACENE	120-12-7	6 ug/m ³	<6	
BENZO(a)ANTHRACENE	56-55-3	6 ug/m ³	<6	
BENZO(a)PYRENE	50-32-8	6 ug/m ³	<6	
BENZO(b)FLUORANTHENE	205-99-2	6 ug/m ³	<6	
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FLUORENE	86-73-7	6 ug/m ³	<6	
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NAPHTHALENE	91-20-3	6 ug/m ³	<6	
PHENANTHRENE	85-01-8	6 ug/m ³	<6	
PYRENE	129-00-0	6 ug/m ³	<6	

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Table 1 MW: Table 1 CAS: Table 2 RTECS: Table 2

METHOD: 5515, Issue 2		EVALUATION: PARTIAL	Issue 1: 15 May 1985 Issue 2: 15 August 1994
NIOSH: Table 3 OSHA :	PROPERTIES: Table 1		
COMPOUNDS:	acenaphthene acenaphthylene anthracene benz[a]anthracene benzo[b]fluoranthene benzo[k]fluoranthene	benzo[ghi]perylene benzo[a]pyrene benzo[e]pyrene chrysene dibenz[a,h]anthracene fluoranthene	fluorene indeno[1,2,3-cd]pyrene naphthalene phenanthrene pyrene
SYNONYMS: PAH; PNA; also see Table 2.			
SAMPLING		MEASUREMENT	
SAMPLER: FILTER + SORBENT (2- μ m, 37-mm PTFE + washed XAD-2, 100 mg/50 mg)	FLOW RATE: 2 L/min	METHOD: GAS CHROMATOGRAPHY, CAPILLARY COLUMN, FID	ANALYTE: compounds above
VOL-MIN: 200 L -MAX: 1000 L	SHIPMENT: transfer filters to culture tubes; wrap sorbent and culture tubes in Al foil; ship @ 0 °C	EXTRACTION: 5 mL organic solvent appropriate to sample matrix (step 7)	INJECTION VOLUME: 4 μ L; 10:1 split
SAMPLE STABILITY: unknown; protect from heat and UV radiation	FIELD BLANKS: 2 to 10 field blanks per set	COLUMN: 30 m x 0.32-mm ID, fused silica capillary, 1- μ m DB-5	TEMPERATURE-INJECTOR: 200 °C -DETECTOR: 250 °C -PROGRAM: 130 to 290 °C @ 4 °C/min
MEDIA BLANKS: 6 to 10	AREA SAMPLES: 8 replicates on preweighed filters for solvent selection	GASES-CARRIER: He @ 1 mL/min -MAKEUP: He @ 20 mL/min	LOD: ca. 0.3 to 0.5 μ g per sample [1]
ACCURACY	RANGE STUDIED, ACCURACY, BIAS, and OVERALL PRECISION (\hat{S}_{rt}): not measured	CALIBRATION: external standards in toluene	RANGE, LOD, and PRECISION (\hat{S}): EVALUATION OF METHOD
APPLICABILITY: The working range for B[a]P is 3 to 150 μ g/m ³ for a 400-L air sample. Specific sample sets may require modification in filter extraction solvent, choice of measurement method, and measurement conditions.			
INTERFERENCES: Any compound which elutes at the same GC retention time may interfere. Heat, ozone, NO ₂ , or UV light may cause sample degradation.			
OTHER METHODS: This revises P&CAM 183 [2]. The spectrophotometric methods, P&CAM 184 and 186 [2], have not been revised. Method 5506 (HPLC) uses the same sampling technique and is more sensitive.			

REAGENTS:

1. Filter extraction solvent: acetonitrile, benzene,* cyclohexane, methylene chloride,* or other appropriate solvents, pesticide grade (step 7).
2. Toluene, pesticide grade.
3. Water, distilled, deionized.
4. PAH reference standards,* appropriate to the PAH-containing matrix sampled.
5. Calibration stock solution, 0.25 mg/mL.* Check purity of each PAH reference standard by GC/FID, HPLC/fluorescence and/or melting point. Purify, if necessary, by recrystallization. Weigh 25 mg of each PAH into a 100-mL volumetric flask; dilute to volume with toluene. Stable six months if refrigerated and protected from light.
6. Helium, prepurified.
7. Hydrogen, dry.
8. Air, filtered.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler:
 - a. Filter. PTFE-laminated membrane filter, 2- μ m pore size, 37-mm diameter (Gelman Zefluor, Membrana, Pleasantown, CA, or equivalent), backed by a spacer (37-mm OD, 32-mm ID) cut from a cellulose support pad or SKC #225-23, in cassette filter holder.
NOTE 1: If sampling is to be done in bright sunlight, use opaque or foil-wrapped cassettes to prevent sample degradation.
NOTE 2: Take filters to be preweighed from the filter package and allow to equilibrate 24 h with laboratory atmosphere before taring.
 - b. Sorbent tube, connected to filter with minimum length PVC tubing. Plastic caps are required after sampling. Washed XAD-2 resin (front = 100 mg; back = 50 mg) (Supelco ORBO 43 or equivalent). Pressure drop at 2 L/min airflow 1.6 to 2 kPa (15 to 20 cm H₂O).
2. Personal sampling pump capable of operating for 8 h at 2 L/min, with flexible connecting tubing.
3. Aluminum foil.
4. Vial, scintillation, 20-mL, glass, PTFE-lined cap.
5. Refrigerant, bagged.
6. Culture tubes, PTFE-lined screw cap, 13-mm x 100-mm.
7. Forceps.
8. Filters, 0.45- μ m, PTFE (for filtering sample solutions).
9. Pipet, 5-mL.
10. Syringes or micropipets, 1- to 100- μ L.
11. Ultrasonic bath.
12. Gas chromatograph with FID, electronic integrator, and capillary column (page 5515-1).
13. Volumetric flasks, 10- and 100-mL.
14. Lighting in laboratory: incandescent or UV-shielded fluorescent.

SPECIAL PRECAUTIONS: Treat benzene, methylene chloride, and all polynuclear aromatic hydrocarbons as carcinogens. Neat compounds should be weighed in a glove box. Spent samples and unused standards are toxic waste. Regularly check counter tops and equipment with "black light" for fluorescence as an indicator of contamination by PAH.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Take personal samples at 2 L/min for a total sample size of 200 to 1000 L. Take a concurrent set of eight replicate area samples at 2 to 4 L/min on preweighed, 2- μ m PTFE filters in an area of highest expected PAH concentration.
NOTE: The area samples are needed for solvent selection (step 7).
3. Immediately after sampling, transfer the filter carefully with forceps to a scintillation vial. Hold filter at edge to avoid disturbing the deposit. Cap the scintillation vial and wrap it in aluminum foil.
NOTE: This step is necessary to avoid loss of analytes due to sublimation and degradation by light.
4. Cap the sorbent tube and wrap it in aluminum foil.
5. Ship to laboratory in insulated container with bagged refrigerant.

SAMPLE PREPARATION:

NOTE: UV light may degrade PAH. Use yellow, UV-absorbing shields for fluorescent lights or use incandescent lighting.

6. Refrigerate samples upon receipt at laboratory.
7. Determine optimum extraction solvent.
 - a. Allow the preweighed area filter samples to equilibrate 24 h with the laboratory atmosphere.
 - b. Weigh the area filters. Determine total weight collected on each.
 - c. Extract the first pair of area filters with acetonitrile, the second with benzene, the third with cyclohexane, and the fourth with methylene chloride, according to step 8.
NOTE: Use alternate solvents, if appropriate. PAH of interest may be entrained within, and adsorbed by, particulate matter collected on the filter. It is necessary to determine the solvent which maximizes recovery of the PAH from each sample matrix. For example, methylene chloride [3,4] and benzene:ethanol (4:1 v/v) [5] have been recommended for extraction of PAH from diesel exhaust particulate.
 - d. Analyze the extracts for the PAH of interest (steps 10 through 18). Normalize the total mass of PAH found to the mass of sample collected.
 - e. Choose the solvent which gives the highest recovery of PAH of interest. Use the solvent chosen to extract the personal filter samples.
8. Extract filters.
 - a. Add 5.0 mL of the solvent chosen in step 7 to each scintillation vial containing a filter. Start media and reagent blanks at this step.
 - b. Cap and let stand 15 to 20 min in an ultrasonic bath.
NOTE: Soxhlet extraction may be required when large amounts of highly adsorptive particulate matter (e.g., fly ash or diesel soot) are present.
9. Desorb PAH from sorbent.
 - a. Score each sorbent tube with a file in front of the primary (larger) sorbent section. Break tube at score line.
 - b. Transfer front glass wool plug and front sorbent section to a culture tube. Transfer back

- sorbent section and the middle glass wool plug to a second culture tube.
- c. Add 5.0 mL toluene to each culture tube. Cap the culture tubes.
 - d. Allow samples to stand for 30 min. Swirl occasionally.
10. Filter all sample extracts through an 0.45- μ m membrane filter.

CALIBRATION AND QUALITY CONTROL:

11. Calibrate daily with at least six working standards.
 - a. Dilute aliquots of calibration stock solution with toluene in 10-mL volumetric flasks (e.g., to 5, 1, 0.2, 0.05, and 0.005 μ g/mL).
 - b. Intersperse working standards and samples in the measurements.
 - c. Prepare calibration graphs (peak area vs. μ g of each PAH per sample).
12. Recovery and desorption efficiency.
 - a. Determine recovery (R) from filters and desorption efficiency (DE) from sorbent tubes at least once for each lot of filters and sorbent tubes used in the range of interest.
 - (1) Filters. Using a microliter syringe or micropipette, spike four filters at each of five concentration levels with calibration stock solution. Allow the filters to dry in the dark overnight. Analyze the filters (steps 8, 10, and 14 through 16). Prepare graphs of R vs. amounts found.

NOTE: This step may not be used for some highly adsorptive particulate matrices for which calibration by the method of standard additions may be more accurate.
 - (2) Sorbent tubes. Transfer an unused front sorbent section to a culture tube. prepare a total of 24 culture tubes in order to measure DE at five concentration levels plus blanks in quadruplicate. Using a microliter syringe or micropipette, add calibration stock solution directly to sorbent. Cap culture tubes and allow to stand overnight in the dark. Analyze (steps 9, 10, and 14 through 16). Prepare graphs of DE vs. amounts found.
 - b. Check R and DE at two levels for each sample set, in duplicate. Repeat determination of R and DE graphs if checks do not agree to within $\pm 5\%$ of DE graph.
13. Analyze at least three field blanks for each sample medium.

MEASUREMENT:

14. Set GC according to manufacturer's recommendations and to the conditions on page 5515-1.
15. Inject sample aliquot. Start temperature program.
16. Measure peak areas.

NOTE 1: Approximate retention times appear in Table 4.

NOTE 2: If peak area is above the calibration range, dilute with appropriate solvent, reanalyze, and apply dilution factor in calculations.

NOTE 3: If sample has many interferences, additional sample cleanup may be necessary. Many cleanup procedures have been published. Liquid-liquid partitioning between cyclohexane and nitromethane [6,7] is widely used, but other techniques may be more appropriate for specific samples.

CALCULATIONS:

17. Read the mass, μ g (corrected for R or DE) of each analyte found on the filter (W_f) and front sorbent (W_{f_s}) and back sorbent (W_{b_s}) sections, and on the average media blank filter (B) and front sorbent (B_f) and back sorbent (B_{b_s}) sections from the calibration graphs.
18. Calculate concentration, C (mg/m^3), in air as the sum of the particulate concentration and the vapor concentration using the actual air volume sampled, V (L).

$$C = \frac{(W - B + W_f + W_b - B_f - B_b)}{V}, \text{ mg/m}^3.$$

EVALUATION OF METHOD:

Owing to large interferences that occurred while utilizing NIOSH Method P&CAM 206 for samples collected during asphalt roofing operations, the gas chromatographic capillary column method was developed. The GC method has been evaluated using several hundred field filter and sorbent tube sampling trains. To date, no statistical studies have been initiated. Overall, standard spiked filters and sorbent tubes have yielded reproducible measurement calibration graphs. The method has been applied to the following sources with semi-quantitative results using three separate particulate extraction solvents (benzene, cyclohexane, acetonitrile): aluminum reduction facilities, asphalt fume, coal gasification plants, coal liquefaction plants, coal tar pitch, coke oven emissions, creosote treatment facilities, diesel exhaust, graphite electrode manufacturing, petroleum pitch, and roofing tearoff operations.

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METHOD REVISED BY:

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Table 1. Formulae and physical properties.

COMPOUND (by M.W.)	EMPIRICAL FORMULA	MOLECULAR WEIGHT	MELTING POINT (°C)*	BOILING POINT (°C)*	REF.
1. NAPHTHALENE	C ₁₀ H ₈	128.17	80.2	218	[10]
2. ACENAPHTHYLENE	C ₁₂ H ₈	152.20	92-93	265-275	[11]
3. ACENAPHTHENE	C ₁₂ H ₁₀	154.21	96.2	279	[11]
4. FLUORENE	C ₁₃ H ₁₀	166.22	116	293-295	[10]
5. ANTHRACENE	C ₁₄ H ₁₀	178.23	218	340	[10]
6. PHENANTHRENE	C ₁₄ H ₁₀	178.23	100	340	[10]
7. FLUORANTHENE	C ₁₆ H ₁₀	202.26	110	384*	[10], [12]
8. PYRENE	C ₁₆ H ₁₀	202.26	156	393	[10]
9. BENZ[a]ANTHRACENE	C ₁₈ H ₁₂	228.29	162-167	435	[10]
10. CHRYSENE	C ₁₈ H ₁₂	228.29	255-256	448	[10]
11. BENZO[b]FLUORANTHENE	C ₂₀ H ₁₂	252.32	168	--	[10]
12. BENZO[k]FLUORANTHENE	C ₂₀ H ₁₂	252.32	217	480	[11]
13. BENZO[a]PYRENE	C ₂₀ H ₁₂	252.32	179	495	[10]
14. BENZO[e]PYRENE	C ₂₀ H ₁₂	252.32	178-179	--	[10]
15. BENZO[ghi]PERYLENE	C ₂₂ H ₁₂	276.34	273	--	[10]
16. INDENO[1,2,3-cd]PYRENE	C ₂₂ H ₁₂	276.34	161.5-163	530	[9]
17. DIBENZ[a,h]ANTHRACENE	C ₂₂ H ₁₄	278.35	267	524	[10]

*Many of these compounds will sublime.

Table 2. Synonyms.

COMPOUND (alphabetically)	SYNONYMS
1. ACENAPHTHENE	CAS# 83-32-9; RTECS# AB1000000
2. ACENAPHTHYLENE	CAS# 208-96-8; RTECS# AB1254000
3. ANTHRACENE	CAS# 120-12-7; RTECS# CA9350000
4. BENZ[a]ANTHRACENE	1,2-benzanthracene; benzo[b]phenanthrene; 2,3-benzophenanthrene; tetraphene; CAS# 56-55-3; RTECS# CV9275000
5. BENZO[b]FLUORANTHENE	3,4-benzofluoranthene; 2,3-benzofluoranthene; benz[e]acephenanthrylene; B[b]F; CAS # 205-99-2; RTECS# CU1400000
6. BENZO[k]FLUORANTHENE	11,12-benzofluoranthene; CAS# 207-08-9; RTECS# DF6350000
7. BENZO[ghi]PERYLENE	1,12-benzoperylene; CAS# 191-24-2; RTECS# DI6200500
8. BENZO[a]PYRENE	3,4-benzopyrene; 6,7-benzopyrene; B[a]P; BP; CAS# 50-32-8; RTECS# DJ3675000
9. BENZO[e]PYRENE	1,2-benzopyrene; 4,5-benzopyrene; B[e]P; CAS# 192-97-2; RTECS# DJ4200000
10. CHRYSENE	1,2-benzophenanthrene; benzo[a]phenanthrene; CAS# 218-01-9; RTECS# GC0700000
11. DIBENZ[a,h]ANTHRACENE	1,2,5,6-dibenzanthracene; CAS# 53-70-3; RTECS# HN2625000
12. FLUORANTHENE	benzo[jk]fluorene; Idryl; CAS# 206-44-0; RTECS# LL4025000
13. FLUORENE	o-biphenylenemethane; CAS# 86-73-7; RTECS# LL5670000
14. INDENO[1,2,3-cd]PYRENE	2,3-phenylenepyrene; CAS# 193-39-5; RTECS# NK9300000
15. NAPHTHALENE	naphthene; CAS# 91-20-3; RTECS# QJ0525000
16. PHENANTHRENE	CAS# 85-01-8; RTECS# SF7175000
17. PYRENE	benzo[def]phenanthrene; CAS# 129-00-0; RTECS# UR2450000

Table 3. Exposure Limits.

<u>COMPOUND</u> (alphabetically)	<u>OSHA</u>	<u>NIOSH</u>	<u>ACGIH</u>
1. ACENAPHTHENE	--	--	--
2. ACENAPHTHYLENE	--	--	--
3. ANTHRACENE	0.2 mg/m ³	--	--
4. BENZ[A]ANTHRACENE	--	--	--
5. BENZO[B]FLUORANTHENE	--	--	--
6. BENZO[K]FLUORANTHENE	--	--	suspect carcinogen
7. BENZO[GHI]PERYLENE	--	--	--
8. BENZO[A]PYRENE	0.2 mg/m ³ (benzene sol.)	0.1 mg/m ³ (cyclohexane sol.)	suspect carcinogen
9. BENZO[E]PYRENE	--	--	--
10. CHRYSENE	0.2 mg/m ³ (benzene sol.)	lowest feasible, carcinogen	suspect carcinogen
11. DIBENZ[A,H]ANTHRACENE	--	--	--
12. FLUORANTHENE	--	--	--
13. FLUORENE	--	--	--
14. INDENO[1,2,3-CD]PYRENE	--	--	--
15. NAPHTHALENE	10 ppm	10 ppm; STEL 15 ppm	10 ppm; STEL 15 ppm
16. PHENANTHRENE	0.2 mg/m ³	--	--
17. PYRENE	--	--	--

Table 4. Approximate PAH retention times.

<u>COMPOUND</u>	<u>RETENTION TIME (min)*</u>
1. NAPHTHALENE	not available
2. ACENAPHTHALENE	7.66
3. ACENAPHTHENE	8.37
4. FLUORENE	10.5
5. PHENANTHRENE	15.0
6. ANTHRACENE	15.3
7. FLUORANTHENE	21.4
8. PYRENE	22.6
9. BENZ[a]ANTHRACENE	29.4
10. CHRYSENE	29.6
11. BENZO[e]PYRENE	36.4
12. BENZO[b]FLUORANTHENE	35.1
13. BENZO[k]FLUORANTHENE	35.2
14. BENZO[a]PYRENE	36.2
15. DIBENZ[a,h]ANTHRACENE	43.9
16. BENZO[ghi]PERYLENE	45.6
17. INDENO[1,2,3-cd]PYRENE	43.6

*NOTE: Actual retention times will vary with individual columns and column age.