Exposure to Regular Gasoline and Ethanol Oxyfuel during Refueling in Alaska

Lorraine C. Backer,[1] Grace M. Egeland,[2] David L. Ashley,[1] Nicholas J. Lawryk,[3] Clifford P. Weisel,[3] Mary C. White,[1] Tim Bundy,[4] Eric Shortt,[5] John P. Middaugh[2]

[1]National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA 30341-3724 USA; [2]Epidemiology Section, Alaska Department of Health and Social Services, Anchorage, AK 99524-0249 USA; [3]Environmental and Occupational Health Sciences Institute, Piscataway, NJ 08855-1179 USA; [4]Alaska Department of Labor, Kenai, AK 99611 USA; [5]State of Alaska Department of Labor, Anchorage, AK 99510-7022 USA

Although most people are thought to receive their highest acute exposures to gasoline while refueling, relatively little is actually known about personal, nonoccupational exposures to gasoline during refueling activities. This study was designed to measure exposures associated with the use of an oxygenated fuel under cold conditions in Fairbanks, Alaska. We compared concentrations of gasoline components in the blood and in the personal breathing zone (PBZ) of people who pumped regular unleaded gasoline (referred to as regular gasoline) with concentrations in the blood of those who pumped an oxygenated fuel that was 10% ethanol (E-10). A subset of participants in a wintertime engine performance study provided blood samples before and after pumping gasoline (30 using regular gasoline and 30 using E-10). The biological and environmental samples were analyzed for selected aromatic volatile organic compounds (VOCs) found in gasoline (benzene, ethylbenzene, toluene, *m-/p*-xylene, and *o*-xylene); the biological samples were also analyzed for three chemicals not found in gasoline (1,4-dichlorobenzene, chloroform, and styrene). People in our study had significantly higher levels of gasoline components in their blood after pumping gasoline than they had before pumping gasoline. The changes in VOC levels in blood were similar whether the individuals pumped regular gasoline or the E-10 blend. The analysis of PBZ samples indicated that there were also measurable levels of gasoline components in the air during refueling. The VOC levels in PBZ air were similar for the two groups. In this study, we demonstrate that people are briefly exposed to low (ppm and sub-ppm) levels of known carcinogens and other potentially toxic compounds while pumping gasoline, regardless of the type of gasoline used. *Key words*: benzene, blood VOCs, gasohol, gasoline, oxyfuels, toluene.
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Gasoline and other fuels contain toxic chemicals such as benzene that can cause a wide range of adverse health effects, including cancer (*1*). It has been estimated that more than 100 million people in the United States are briefly exposed to low levels of volatile organic compounds (VOCs) from gasoline during refueling activities (*2*). The major sources of exposure to gasoline during refueling are air that is displaced from the gasoline tank into the environment when the tank is filled and vapors from accidental gasoline spills. Despite widespread exposure, very few studies have examined either exposure to gasoline during refueling or the possible health effects associated with these exposures.

National ambient air quality standards (NAAQS) for outdoor air have been developed by the EPA for six important air pollutants including CO (*3*). For CO, EPA has set a time-weighted average level of 10.3 mg/m^3 (9 ppm) averaged over 8 hr as the national standard. The NAAQS level was exceeded in Fairbanks and Anchorage during 1991 and 1992; therefore, the state was required to introduce an oxygenated fuel program for the winter of 1992–1993.

In October of 1992, gasoline containing 15% (by volume) methyl tertiary butyl ether (MTBE) as the oxygenate was introduced in Alaska. Shortly thereafter, the Alaska Department of Health and Social Services received numerous health complaints, reportedly due to exposure to the new gasoline formulation (e.g., when pumping gasoline), and a study of occupational exposure to the oxyfuel was conducted by Moolenaar et al. (*4*). By December 1992, the governor of Alaska had suspended the oxyfuels program.

During the winter of 1994–1995, the Alaska Department of Environmental Conservation (ADEC) introduced a CO emissions reduction program in Anchorage that included the use of the oxyfuel E-10, a fuel made by mixing regular unleaded gasoline with ethanol to create a blend that is 10% ethanol by volume. Because E-10 had not been adequately tested under the environmental conditions typical of Alaskan winters, a wintertime engine performance study was initiated in Fairbanks.

Stage II vapor recovery systems, which collect gasoline vapors at the pump nozzle and recirculate them into the underground gasoline storage tanks, were not in use in Alaska at the time the E-10 oxyfuel was introduced. There was concern that the use of this fuel might increase the general population's exposure to gasoline constituents, e.g., due to increased volatility of the E-10 blend. In response to this concern, and because of previous community complaints associated with the introduction of an oxyfuel containing MTBE, we designed and implemented studies to characterize individual consumers' exposures to the aromatic components of regular gasoline while refueling and to examine whether the exposures changed when E-10 was introduced. We examined environmental (ambient air) exposure levels and internal levels (in blood) of several important constituents of gasoline in participants in Fairbanks, Alaska.

Methods

Recruitment of study participants. The protocol was approved by the Institutional Review Board of the Centers for Disease Control and Prevention, and informed consent was obtained from all study participants after the nature and possible consequences of the study were explained.

The ADEC recruited 264 participants for its wintertime engine performance study through advertisements in newspapers and at gasoline stations. Participants in the study were blinded to the type of gasoline (regular or E-10) they were using by being assigned to purchase gasoline from either pump A or pump B, from approximately January through March 1995. Each time they purchased gasoline, participants completed a brief questionnaire on how their car was functioning. When individuals volunteered to participate in the wintertime engine performance study, they were also asked if they would be willing to participate in the Fairbanks gasoline exposure assessment. The ADEC compiled a

Address correspondence to L.C. Backer, National Center for Environmental Health, Centers for Disease Control and Prevention, 4770 Buford Hwy NE, MS F46, Atlanta, GA 30341-3724 USA.

The current address for M.C. White is Agency for Toxic Substances and Disease Registry, Atlanta, GA 30333 USA.

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list of names and phone numbers of those interested in participating in our study. The staff from the Epidemiology Section of the Alaska Department of Health and Social Services contacted persons on this list until they had identified and recruited 30 people who had been using pump A and 30 who had been using pump B. To be eligible, people had to be nonsmokers who were not occupationally exposed to VOCs; 68 people were contacted before these target recruitment numbers were achieved. The people who declined to participate cited lack of time and concern about donating blood as reasons for not participating. On the scheduled date, each participant provided a 10-ml blood sample, pumped gasoline, and then provided a second 10-ml blood sample and answered the questionnaire. To compensate them for their time, we provided study participants with a voucher worth $25 toward future gasoline purchases at the gasoline station where the study was conducted.

Questionnaire. The questionnaire was designed to examine the frequency of self-reported symptoms (i.e., irritated eyes, headache, nausea, burning sensation in the nose or throat, cough, or dizziness) possibly associated with exposure to gasoline. Also included were questions regarding participants' demographic characteristics, smoking status, and exposure to environmental tobacco smoke and whether, during the previous week, they had other illnesses (e.g., the flu or a cold). Participants' exposure to gasoline was assessed by asking them how many times in the last week they had pumped gasoline and how much time they spend in a motor vehicle on a weekday. The number of gallons of gasoline they pumped just prior to providing a blood sample and the number of seconds they spent pumping gasoline were also recorded.

Biological measurements of internal dose for selected VOCs. VOCs have a very short half-life in blood. Because of the short half-life and because we wanted to avoid confounding exposures from environmental tobacco smoke in the gasoline station office, we arranged to have a recreational vehicle (RV) on site. We collected specimens from study participants in the RV immediately before and within 10 min after they finished pumping gasoline.

Venous blood samples were collected in Vacutainer (Becton Dickinson, Rutherford, NJ) tubes containing sodium oxalate and sodium fluoride according to the method of Ashley et al. (*5*). Blood samples were kept cold and shipped to the National Center for Environmental Health in Atlanta, Georgia, within 48 hr of collection.

Blinded blood samples were analyzed for a series of VOCs by purge and trap gas chromatography-mass spectrometry (GC-MS). The method is applicable to the determination of VOCs in whole blood at extremely low detection limits and is described by Ashley et al. (*5*). Measurements were completed within 10 weeks of collection in order to minimize any changes in blood VOC concentrations during refrigerated storage.

Detection limits for the analytes reported in this study are generally in the low parts per trillion (ppt) range. Gasoline constituents that were measured in blood, and their corresponding analytical limits of detection (LODs; in ppb), included benzene, 0.040; ethylbenzene, 0.024; *m-/p*-xylene, 0.055; *o*-xylene, 0.020; and toluene, 0.040. The concentrations of a series of VOCs not found in gasoline and thus not likely to change with a person's exposure to gasoline were determined and reported as part of quality assurance and quality control protocols. These additional VOCs and their corresponding LODs (in ppb) were 1,4-dichlorobenzene, 0.040; chloroform, 0.010; and styrene, 0.010.

In addition to measuring the levels of gasoline constituents and the other VOCs listed above, we verified that all study participants were nonsmokers by measuring the levels of 2,5-dimethylfuran in their blood samples (*6*). Levels of 2,5-dimethylfuran were below the detection limit of 0.024 ppb for all study participants, confirming that none were active smokers.

Some samples contained levels of one or more of the VOCs of interest that were below the analytical LOD. For values below the LOD, the values produced by the analytical method were used in the analyses (*7*).

Personal breathing zone samples. Personal breathing zone (PBZ) samples were collected according to the method described by Lioy et al. (*8*). SKC model 222-3 Low Flow Personal Air Samplers (SKC, Eighty Four, PA) equipped with sorbent tubes that contained a layered absorbant [0.1g Tenax GC (Alltech Corporation, Deerfield, IL), 0.1 g Carboxen 569, and 0.1 g carbosieve SIII (Supelco, Inc., Bellefonte, PA)] were used to collect the samples. The air-sampling pumps were placed in a pocket of a vest, which study participants put on over their clothing. The collection media were taped to the shoulder of the vest so that they would be in the participants' breathing zone. The sampling pumps were turned on when a participant began pumping gasoline and were turned off immediately after they finished.

Because PBZ VOC concentrations were assumed to be low, but were quantitatively unknown, two simultaneous samples with different air volumes were collected for each individual. The air flow rate for one of each pair of samplers was set at 1 l/min, and the rate for the other sampler was set at 0.1 l/min. The air samples were analyzed by GC-MS within 2 weeks of collection. The method's analytical detection limits were 2 ng for toluene and *m-/p*-xylene and 5 ng for benzene, ethylbenzene, and *o*-xylene.

Statistical analyses. Differences in baseline levels of each VOC in the blood of study participants when they arrived at the study site were accounted for by subtracting the level of each chemical in the participants' blood before pumping gasoline from the level of each chemical in their blood after pumping gasoline.

Neither the levels of VOCs in participants' blood before pumping gasoline, the levels in their blood after pumping gasoline, nor the differences between the two were normally distributed; therefore, nonparametric methods were used to analyze the data. The Wilcoxon signed rank test (*9*) was used to compare participants' paired blood levels of VOCs before and after pumping gasoline, and the Wilcoxon two-sample test (*9*) was used to compare the changes in blood VOC levels among people who pumped regular gasoline with the change among those who pumped E-10.

For the PBZ samples, analytical results from the two pumps running at different rates were averaged to produce a single value for each gasoline constituent for each participant. The data for the PBZ air samples were also not normally distributed; thus, we used the Wilcoxon two-sample test to compare the levels of VOCs in the PBZ air of those who pumped regular gasoline with the levels of VOCs in the PBZ air of those who pumped the E-10 blend. Spearman rank correlation coefficients were calculated using levels of gasoline constituents in blood and PBZ air for each person.

Regression analyses were used to examine confounders in the analysis of the association between levels of VOCs in blood and ambient air and the type of gasoline pumped. Because the blood VOC data were not normally distributed and because the difference (after pumping gasoline minus before pumping gasoline) variable was sometimes negative, the difference was expressed as a ratio (after pumping/before pumping). The $\log_{10}$ transformations of this ratio and the PBZ air data were used in regression analyses. We considered a variable to be a confounder if it changed the value for the parameter estimate for the type of gasoline pumped by 10% or more.

The number of gallons of gasoline pumped was a statistically significant predictor of exposure. Therefore, general linear models programs (*10*) were used to create least square mean values for exposure adjusted for the number of gallons pumped.

Statistical analyses were performed by using SAS 6.10 for Windows (SAS Institute, Cary, NC) unless specified otherwise.

Results

Questionnaire. The demographic characteristics of the group that pumped regular gasoline were similar to those of the group that pumped the 10% ethanol blend (E-10). The average age was 45 years for both groups. There were 11 (36.7%) females in the group that pumped regular gasoline and 14 (46.7%) in the group that pumped E-10.

One difference was in the amount of gasoline pumped the day of the study: people who used E-10 pumped somewhat more gasoline (mean 14.3 gallons) than those who pumped regular gasoline (mean 10.8 gallons; *t*-test, $p = 0.08$). One (3.3%) of the people who pumped regular gasoline and 3 (10%) of the people who pumped E-10 reported spilling some gasoline when refueling on the day of the study.

People in both groups reported very few of the symptoms likely to result from exposure to gasoline, and the prevalences of these symptoms were similar for both groups. For example, headache in the last week was the most commonly reported symptom, and it was reported by 7 (23.3%) of the people who pumped regular gasoline and 8 (26.7%) of the people who pumped E-10.

VOCs in blood. Although measured levels of VOCs in a few samples were below the analytical LOD, we used the values calculated by the method of Ashley et al. (*5*) in our analyses. This use of VOC measurements below the LOD was unlikely to affect our analyses or conclusions; benzene levels in blood were below the LOD in only one individual before pumping regular gasoline and in one individual before pumping E-10, and the levels of ethylbenzene were below the LOD for three individuals before pumping regular gasoline and for five individuals before pumping E-10. All reported values for *m-/p*-xylene, *o*-xylene, and toluene were measurable levels (≥LOD).

The results from the analysis of gasoline constituents in whole blood are presented in Tables 1 and 2 and Figures 1 and 2. The results from a few blood samples were not reported either because the sample volume collected was insufficient for analysis (the study was conducted in extremely cold weather, it was cold inside our RV, and we sometimes were unable to obtain enough blood for the post-pumping sample) or because quality assurance/quality control requirements were not met when the samples were analyzed. The levels of gasoline constituents in blood of participants before and after they pumped gasoline are presented in Table 1 and Figures 1 (benzene) and 2 (toluene). Participants had significantly higher blood levels of gasoline constituents ($p<0.05$) after pumping gasoline than before pumping gasoline whether they pumped regular gasoline or E-10. For example, participants' median benzene concentration in whole blood increased from 0.19 ppb to 0.54 ppb (Wilcoxon Signed Rank Statistic, $p<0.01$) after pumping regular gasoline. Study participants' levels of the other VOCs not found in gasoline either did not change as a result of exposure to gasoline during refueling (1,4-dichlorobenzene and styrene) or decreased during refueling activities (chloroform). Levels of 2,5-dimethylfuran were below the detection limit of 0.024 ppb for all study participants, confirming that none were active smokers.

Table 2 shows the differences in blood VOC concentrations (blood concentrations after pumping minus blood concentrations before pumping) for the group that pumped regular gasoline and for the group that pumped E-10. Blood benzene levels were somewhat higher for the group that pumped E-10, but the differences in the internal doses (as measured by levels of gasoline constituents in blood) received by the two groups were not statistically significant.

There were several potential confounders that may have affected the association between the type of gasoline pumped and levels of VOCs in participants' blood or in their PBZ air. In the regression analysis in which the ratio measure of after-pumping values to the before-pumping values (log-transformed) was the outcome measure, the initial model included as predictors the type of gasoline pumped, the day of the study, and whether the person spilled gasoline that day. The type of gasoline pumped had no statistically significant relationship with either benzene ($p = 0.13$) or toluene ($p = 0.34$) blood levels. A variable indicating whether the person had spilled gasoline was subsequently removed from all models because it was not statistically significant and its presence did not affect the parameter estimates for the other variables. The number of gallons of gasoline pumped

Table 1. Blood volatile organic compound concentrations among participants before and after pumping gasoline, by type of gasoline, in February 1995

	Regular gasoline ($n = 26$)[b]			Ethanol blend ($n = 22$)		
Chemical[a]	Before pumping median (range) in ppb	After pumping median (range) in ppb	Wilcoxon signed rank *p*	Before pumping median (range) in ppb	After pumping median (range) in ppb	Wilcoxon signed rank *p*
Constituents in gasoline						
Benzene	0.19	0.54	<0.01	0.18	0.70	<0.01
(0.040)	(0.08–0.65)	(0.13–1.70)		(0.06–0.55)	(0.14–4.20)	
Ethylbenzene	0.10	0.16	<0.01	0.11	0.16	<0.01
(0.024)	(0.02–0.73)	(0.06–1.40)		(0.04–0.55)	(0.06–0.64)	
m-/p-Xylene	0.44	0.58	<0.01	0.48	0.62	0.02
(0.055)	(0.18–2.60)	(0.31–4.90)		(0.23–2.10)	(0.25–2.50)	
o-Xylene	0.20	0.28	<0.01	0.26	0.30	<0.01
(0.020)	(0.10–0.59)	(0.15–1.50)		(0.09–0.62)	(0.15–0.72)	
Toluene	0.38	0.74	<0.01	0.38	0.85	<0.01
(0.040)	(0.11–0.78)	(0.22–3.30)		(0.13–1.20)	(0.26–3.10)	
Not in gasoline						
1,4 Dichlorobenzene	0.04	0.02	0.18	0.04	0.03	0.64
(0.040)	(<LOD–7.10)	(<LOD–6.40)		(<LOD–2.00)	(<LOD–2.00)	
Chloroform	0.012	0.008	<0.01	0.008	0.006	0.85
(0.010)	(<LOD–0.15)	(<LOD–0.12)		(<LOD–0.66)	(<LOD–0.10)	
Styrene	0.03	0.03	0.30	0.03	0.03	0.60
(0.010)	(0.01–0.06)	(<LOD–0.08)		(0.01–0.11)	(0.01–0.08)	

[a]Analytical limits of detection (LODs, ppb in whole blood) are shown in parentheses.
[b]Some blood samples were not included because of insufficient sample size or failure to meet quality assurance/quality control requirements.

was statistically significant in the regression models (which included type of gasoline pumped, day of study, and gallons pumped as predictors) for both the VOCs of interest, i.e., benzene (p = 0.04) and toluene (p = <0.01). When the number of gallons pumped was added to the model that included the day of the study and the type of gasoline pumped, the coefficients for the type of gasoline pumped decreased from 0.22 (p = 0.13) to 0.17 (p = 0.23) for benzene and from 0.10 (p = 0.34) to 0.05 (p = 0.61) for toluene; these still were not statistically significant for either VOC.

The adjusted means (adjusted for the number of gallons pumped) for the internal doses (after-pumping minus before-pumping levels) of benzene and toluene were similar for people exposed to regular gasoline and for those exposed to the E-10 blend. For benzene, the adjusted mean internal doses (95% confidence intervals; CI) were 0.53 ppb (0.20–0.85) in people who pumped regular gasoline and 0.84 ppb (0.50–1.18) in people who pumped E-10. For toluene, the adjusted mean internal doses (95% CI) were 0.64 ppb (0.34–0.93) in people who pumped regular gasoline and 0.58 ppb (0.22–0.93) in those who pumped E-10.

Environmental measurements of exposure to VOCs. The data for PBZ samples are presented in Figure 3. The results for a few samples of PBZ air are not reported because we were unable to collect air samples from both the high-volume sampler and the low-volume sampler for every participant. There were measurable levels of all five gasoline constituents in the PBZ air of all study participants. Although the median concentrations of the five gasoline constituents of interest in the PBZ air for people who pumped E-10 were somewhat lower than those for people who pumped regular gasoline, the differences in concentrations did not reach statistical significance. While there is overlap (three out of five for the regular-gasoline pumpers and two out of five for E-10 pumpers), the top five individuals in Figures 1 and 2 are not the same top five individuals in Figure 3.

We also conducted regression analyses for individual chemicals analyzed in the PBZ samples. The outcome was $\log_{10}$ (ppb benzene in PBZ air), and the initial model included as predictors the type of gasoline pumped, the day of the study, and whether or not the person spilled gasoline that day. When gallons pumped was added to the model, the parameter estimate for type of gasoline pumped decreased from -0.004 (p = 0.96) to -0.0001 (p = 0.99); the addition of gallons pumped to the model for $\log_{10}$ (ppb toluene in PBZ air) increased the parameter estimate for type of gasoline pumped from 0.006 (p = 0.92) to 0.02 (p = 0.72), but the type of gasoline pumped was still not statistically significant (p = 0.72). In the regression models including day of study, gasoline type, and gallons pumped, the variable day of study was a statistically significant predictor of the levels of benzene (p<0.01) and toluene (p<0.001) in the blood, i.e., exposures were slightly lower on the second day of the study than they were on the first.

Table 3 shows the Spearman rank correlations between levels of VOCs in PBZ air and blood. All of the correlations for gasoline constituents were statistically significant.

Table 4 shows the results of the analyses of samples of gasoline from storage tanks in Fairbanks, Alaska. The gasoline samples were analyzed using standard EPA

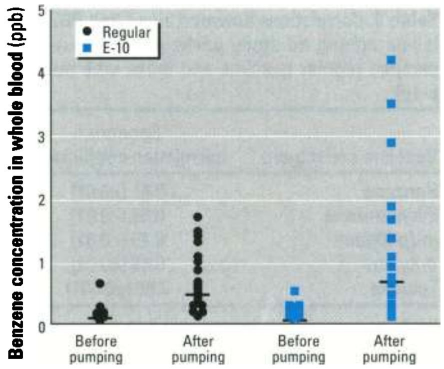

Figure 1. The median concentrations of volatile organic compounds (in ppb) in the blood of people who provided samples before and after pumping either regular gasoline or the 10% ethanol blend (E-10).

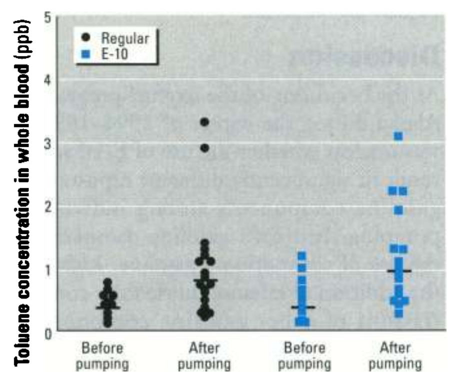

Figure 2. The median difference (after pumping minus before pumping) in the concentrations of volatile organic compounds (in ppb) in the blood of people who pumped regular gasoline compared with the median difference in blood concentrations of those who pumped the 10% ethanol blend (E-10).

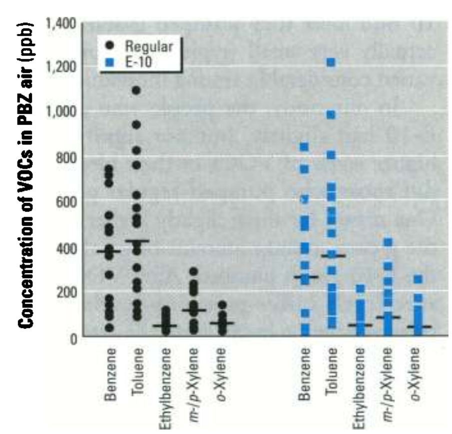

Figure 3. Median volatile organic compound (VOC) concentrations in personal breathing zone air (PBZ) sampled during refueling. The values are the averages of the high- and low-volume sampling pumps for each individual; the horizontal line represents the median value for the group. E-10, 10% ethanol blend.

Table 2. The differences in blood volatile organic compound levels (blood concentration after pumping minus blood concentration before pumping) among people who pumped regular gasoline (n = 26) and among those who pumped the 10% ethanol blend (n = 22)

Chemical	Differences in ppb after pumping regular gasoline, median (range)	Differences in ppb after pumping 10% ethanol blend, median (range)	Wilcoxon Z p
In gasoline			
Benzene	0.335 (0–1.46)	0.500 (-0.05–4.07)	0.26
Ethylbenzene	0.050 (-0.01–0.67)	0.054 (-0.08–0.31)	0.77
m-/p-Xylene	0.160 (-0.03–2.30)	0.155 (-0.42–1.01)	0.92
o-Xylene	0.055 (-0.01–0.91)	0.030 (-0.07–0.28)	0.34
Toluene	0.300 (-0.03–2.73)	0.340 (-0.09–2.70)	0.88
Not in gasoline			
1,4 Dichlorobenzene	-0.001 (-0.70–0.11)	-0.001 (-0.03–0.13)	0.52
Chloroform	-0.002 (-0.03–0.00)	-0.001 (-0.66–0.02)	0.31
Styrene	0.003 (-0.03–0.02)	-0.001 (-0.06–0.04)	0.40

Table 3. Correlations between blood and PBZ VOC levels among all study participants (those who pumped regular gasoline and those who pumped E-10).

Gasoline constituent	Spearman correlation coefficient (*p*)
Benzene	0.47 (<0.01)
Ethylbenzene	0.45 (<0.01)
m-/*p*-Xylene	0.45 (<0.01)
o-Xylene	0.48 (<0.01)
Toluene	0.59 (<0.001)

PBZ, personal breathing zone; VOC, volatile organic compound. PBZ levels were calculated as the average of the low-volume and high-volume sampling pumps.

Table 4. Selected components of regular and 10% ethanol blend (E-10) gasolines that were used in Fairbanks, Alaska, during the winter of 1994–1995

	Percent carbon by weight	
Component	Regular gasoline	E-10
Benzene	5.2	4.4
Ethylbenzene	2.1	1.9
Toluene	9.9	8.0
Ethanol	ND	9.0

ND, not detected.

gas chromatographic analyses (K. Knapp, personal communication). These analyses confirmed that the E-10 had lower levels of benzene, ethylbenzene, and toluene than regular gasoline did.

Discussion

At the beginning of the oxyfuel program in Alaska during the winter of 1994–1995, it was unclear whether the use of E-10 would result in significantly different exposures to gasoline components among individuals pumping their own gasoline compared to the use of conventional gasoline. Although the addition of ethanol diluted the concentrations of other gasoline components, under the environmental conditions of our study, the levels of gasoline components in blood and PBZ air were similar, regardless of which type of gasoline was used.

The VOCs associated with exposure to gasoline have short half-lives in blood and would not be expected to stay elevated in the blood of people who were only acutely exposed (*11*). The levels of VOCs found in the blood of our study participants within 10 min after they pumped gasoline were actually very small (typically <5 ppb) and varied considerably among individuals.

In our study, the people who pumped E-10 had slightly, but not significantly, higher levels of VOCs in their blood than did those who pumped regular gasoline. One reason for these slightly higher levels is the greater average amount of gasoline that the E-10 group pumped. After VOC exposure levels (after-pumping levels minus before-pumping levels) were adjusted for the amount of gasoline pumped, the exposure levels in people who pumped E-10 were still not significantly different from those in people who pumped regular gasoline.

In the regression models of VOC levels measured in PBZ air, day of study was the only variable that was a significant predictor ($p<0.01$ for both benzene and toluene) of VOC levels, i.e., VOC levels were slightly lower on the second day. Meteorologic conditions that would affect the movement of air around the gasoline pump were similar for both days (i.e., the winds were calm and the temperatures ranged from -12°C to -3°C during the study periods) and would not likely account for the observed difference in VOC levels. The difference in VOCs may have been due to localized wind gusts or to differences in activity at the gasoline station on the 2 days of the study.

We are confident that active smoking did not contribute to the levels of VOCs we observed in the blood samples. Smoking contributes substantially to an individual's internal dose of many VOCs, including benzene, ethylbenzene, *m*-/*p*-xylene, and *o*-xylene (*12*). Smoking also greatly increases levels of 2,5-dimethylfuran in the blood, and levels of this compound are highly correlated with levels of other VOCs among people who smoke (*6*). In our study, the levels of 2,5-dimethylfuran in blood were not elevated, indicating that participants were not active smokers.

During our study, we did not collect gasoline samples for analysis. However, the analyses of gasoline samples from storage tanks in Fairbanks suggested that, compared to people who pumped regular gasoline, people who pumped the E-10 blend should be exposed to lower levels of gasoline constituents (except ethanol). However, our results indicate that people who pump their own gasoline received similar internal doses (as measured by levels of VOCs in blood) whether they pump regular gasoline or E-10.

In our study, the correlations between the levels of VOCs in PBZ air and blood were statistically significant; however, the correlation coefficients were modest. These modest correlations are probably due to the exponential change in the levels of VOCs in blood that occur after exposure combined with the fact that the interval between exposure and blood sampling was not precisely controlled. It would be useful in future studies that compare exposure to gasoline of varying formulations or under different conditions of exposure to include both PBZ and biological monitoring, as well as a precisely timed interval between exposure and biological sample collection.

Our study population consisted of a fairly small sample of nonsmokers who did not report being occupationally exposed to gasoline evaporative fumes or emissions. Although there had been a considerable amount of concern in the community about oxygenated fuels in the past, E-10 was introduced 2 years after the problems that arose with the use of gasoline oxygenated with MTBE, and community awareness of the oxygenated fuels programs may have ebbed. It is possible that the people who volunteered to participate in our study were those unlikely to report adverse symptoms. However, the absence of an elevation in symptom prevalence associated with refueling with E-10 is consistent with the results of a phone survey conducted in Anchorage throughout the same winter (*13*).

The results from our study indicate that people are exposed to measurable doses of volatile gasoline components while refueling their vehicles and that exposures to gasoline components are similar for those who pumped regular gasoline and for those who pumped the ethanol blend, E-10. In our study, very few people reported symptoms likely to result from exposure to gasoline, and the prevalences of these symptoms were similar for both groups.

We have demonstrated that people are briefly exposed to low (typically sub-ppm) levels of known carcinogens and other potentially toxic compounds while refueling, regardless of the type of gasoline used. Consumers living in very cold climates should be encouraged to limit their own exposures to gasoline fumes and emissions by moving away from their vehicle while the gasoline pump is running and limiting cold starts by using engine heating devices during extremely cold weather.

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VI International Symposium of the International Section of the ISSA for the Prevention of Occupational Risks in the Iron and Metal Industry

- **Safety**
- **Health at the Workplace**
- **Competitiveness**

Barcelona, Spain October 20-22, 1997

The main themes of the symposium are:
- Management, organization, and control in the field of safety and health in the workplace (programs, risk analysis, assessment, normalization, quality...)
- Specific problems of occupational safety and health in small- and medium-sized enterprises as well as possibilities for counseling and support
- Current problems of occupational hygiene (dust, mineral fibers, surface treatments)

Furthermore, the symposium will discuss other current problems and solutions, such as the transposition of European Directives or outsourcing.

Target groups

The symposium is aimed at safety engineers, occupational physicians, and hygenists, human resources managers, management representatives, experts in various fields from the industry, representatives of the social partners, social insurance institutions, and the authorities.

The symposium is organized by the International Section of the International Social Security Association (ISSA) for the Prevention of Occupational Risks in the Iron and Metal Industry, whose Secretariat is represented by the Allgemeine Unfallversicherungsanstalt (AUVA) in Vienna, together with the Asociación para la Prevención de Accidentes (APA) in Spain.

For more information, contact:
Secretariat of the ISSA Section "Metal"
c/o Kongressbüro, Allgemeine Unfallversicherungsanstalt
Adalbert-Stifter-Strasse 65, A-1200 Vienna, Austria
Telephone: +43-1-33111-537 Fax: +43-1-33111-469

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