DETAILED CONTROL TECHNOLOGY SURVEY OF A COKE OVEN PLANT

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ABSTRACT

This report describes the results of a coke oven control technology field survey at a fully integrated steel plant. The study's four major objectives were: 1) Evaluate coal shoveling practices by benchmen; 2) test a sampling approach for evaluating door emission controls; 3) evaluate filter air systems in the worker lunchroom and larry car cab; and 4) determine effect of meteorological conditions, such as wind speed and direction, on coke battery CTPV concentrations.

The detailed survey was performed by collecting area and personal samples for coal tar pitch volatiles (CTPV), and obtaining weather data from a nearby airport weather station. In the lunchroom the airflow of the filter and air conditioner units was measured.

The survey showed that coke oven benchmen throwing coal into the oven had higher exposure to CTPV than when throwing coal over the side of the bench; that area samples must be placed above at least every third coke oven door to effectively measure visible door emissions; and wind speed and direction have a major effect on top side CTPV levels. Much more sampling is needed to confirm the results of the coal shoveling practices study and to verify the effect of wind speed and direction on top side CTPV levels. In addition the larry car filtered air cab with the air filter and air conditioner working should be retested and the new results compared with the results from this report (when the air filter and air conditioner were not working).

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INTRODUCTION

"Coal tar" products present a significant health hazard to thousands of coke oven workers. Numerous studies have shown "coal tar" products increase the risk of skin and lung cancer. One study showed the lung mortality rate for top side coke oven workers was 10 times that of all steel workers. Another study showed that men who worked for more than five years showed a mortality rate 3.5 times the expected rate (1) (2). Because of the serious health hazard NIOSH undertook a study to assess coke oven control technology.

The study was performed in two parts. in the first phase coke oven control technology including engineering controls and work practices, developed in the United States and in other countries, was summarized in a report entitled "Control Technology for Worker Exposure to Coke Oven Emissions" (3). The first phase was performed through visits to United States coke plants with state-of-the-art control technology and through a review of the current control technology literature.

In the second phase a detailed survey of a coke oven at a fully integrated steel plant was performed to evaluate the following: 1) Benchmen's coal shoveling practices as mandated by the OSHA standard; 2) a sampling approach for monitoring door emissions; 3) filtered air systems for worker lunchrooms and larry car cab; and 4) effects of meteorological conditions, e.g., wind speed and direction, on coal tar pitch volatile (CTPV) concentrations in the general air of the coke oven battery. This report discusses and summarizes the results of the detailed sampling survey -- the second phase of the control technology assessment.

METHODOLOGY

The objectives of the detailed survey of coke oven control technology at a fully integrated steel mill were:

1. Evaluate the effect of coal shoveling practices.

2. Evaluate a sampling approach for door emission controls.

3. Evaluate the filtered air larry car and filtered air lunchroom.

4. Evaluate the effect of meteorological conditions on CTPV levels.

The detailed survey was performed by collecting personal and area samples and obtaining weather data from the nearby airport weather station.

Coal shoveling practices were evaluated by collecting personal samples for the benchmen on two batteries. Initially, samples were collected on two benchmen but this was increased to three benchmen on the third sampling day. The objective of this study was to determine whether throwing coal into the oven or over the side of the bench causes higher worker exposure. On three days coal was thrown over the side of the bench and on two days, coal was thrown into the oven.

The purpose of the door emissions aspect of the study was to 1) compare door emissions from a "clean" battery with a relatively older "dirty" battery and 2) determine if a correlation exists between visible door emissions and coal tar pitch volatiles as measured by area samplers. Two area samples were hung from the collector main catwalk above the doors on both the coke side and the push side of two batteries with identical orientation. Samples were located approximately at the 1/3 points along the length of the battery. The area samples were collected for five days. Visible emissions from all the doors on both sides of both batteries were recorded three times each day. In addition, a personal pump was worn by the lidmen on both batteries to try to determine to what extent door emissions affected their exposure. (NOTE: The lidmen may have received a greater amount of smoke from charging -- more than he would from door leaks.)

The filtered air lunchroom was evaluated by taking area samples in the intake and exit airstream of the lunchroom positive pressure filter, and at a location representative of the general air quality in the lunchroom. The airflow of the filter and the air conditioner units was also measured.

The larry car filtered air cab was evaluated by personal samples on the larry car operator and the samples inside and outside the larry car cab. (However, because the larry car cab air conditioner did not work and the weather was hot during the survey the larry car cab was sampled with the doors of the cab open).

To assess the effects of meteorological conditions, meteorological data was obtained from a nearby airport weather station and included temperature, wind speed and direction, relative humidity, dew point, visibility in distance and visibility conditon (e.g. haze). There was no precipitation during the survey. Coke battery CTPV levels were then evaluated in terms of average daily wind speed and wind direction.

All samples were collected on 37 mm diameter silver membrane filters preceded by a 37 mm diameter glass fiber filter using MSA and DuPont pumps. Sample airflow rates were 1.5 to 2.0 liters per minute for four to seven hours. Samples were sent to NIOSH for analysis. The NIOSH procesure P&CAM 217 using ultrasonic benzene extraction was followed. The limit of detection was 0.02 mg per sample.

RESULTS AND DISCUSSION

COAL SHOVELING PRACTICES

To obtain information on the effect of coal shoveling practices on worker exposure to CTPV, the coke side and push side benchmen on two adjacent batteries were sampled. The benchmen were sampled throwing coal into the oven for two days, and throwing coal over the railing onto the track area for three days. The benchman worked on both batteries as needed.

The sampling results are presented in Table 1 and show that throwing coal into the oven caused higher CTPV exposures than throwing coal over the side. Of a total of 13 personal samples taken on the benchman, two were not analyzed (one sample was obviously tampered with and a second represented only 50 minutes exposure in the area of the bench); four were taken with the benchman throwing into the oven, and seven were obtained throwing coal over the side. The average CTPV exposure was 0.47 mg/m^3 when throwing into the oven and 0.12 mg/m^3 when throwing over. The average CTPV exposures on the two days throwing into the oven were 0.26 and 0.68 mg/m^3 and on the three days when throwing over were 0.05, 0.07 and 0.19 mg/m^3.

Because day-to-day variations in general air CTPV levels on the battery affect worker CTPV exposure, the benchmen's exposure data was analyzed in terms of the area CTPV data. Area samples were taken on one of the two batteries where the coal shoveling practices were being evaluated. These area samples were located above the doors on the collector main catwalk. A total of four area samples were collected each day. The average of the four area samples for each day is shown along with the benchmen's exposure data in Table 1. Both the area samples and the benchmen's personal samples were collected over the same time period each day.

The area sample data indicates general CTPV exposure levels changed significantly during the five sampling days and undoubtedly influenced the

Table 1. Benchman's Coal Tar Pitch Volatile Exposure (mg/m^3)

Date	10/11	10/12	10/13	10/14	10/16
Coal Shoveling Technique	A	B	B	A	B
Benchman #1	0.31	0.05			
Benchman #2	0.22		0.03		
Benchman #3				0.58	0.10
Benchman #4			0.12		
Benchman #5			0.07		
Benchman #6				0.78	0.31
Benchman #7					0.15
Avg. Concentrations (Benchman Personal Samples)	0.26	0.05	0.07	0.68	0.19
Avg. Concentrations (Battery F; Area Samples)	0.10	0.07	0.08	0.24	0.18
Ratio of Benchman's Concentrations to Area Sample Conc.	2.6	.7	.9	2.8	1.1

A = throw into oven

B = throw over side

benchman's CTPV exposure. General CTPV levels based on the area sampling data varied significantly on three days ranging from 0.07 to 0.10 mg/m^3 while on the other two days, levels were 0.24 and 0.18 mg/m^3. Analysis of the benchmen's personal sample data in terms of the area sample data supports the conclusion that the benchmen's exposure is significantly greater when throwing coal into the oven than when throwing coal over the side. On the three days coal was thrown over, the ratios of benchmen's CTPV exposure to area CTPV concentrations were relatively low -- 0.7, 0.9, and 1.1, whereas on the two days coal was thrown into the ovens, ratios were 2.6 and 2.8.

Analysis of several individual worker CTPV exposures also indicates higher exposure when throwing coal into the oven. Of the four workers who did both tasks, all showed higher exposure when throwing into the oven. The CTPV exposures (mg/m^3) for the four workers is as follows (the first number is when throwing into the oven and the second number when throwing over): 0.31/0.05; 0.22/0.03; 0.58/0.10; and 0.78/0.31.

DOOR EMISSIONS

DOOR EMISSIONS

Comparison of "Older" and "Newer" Batteries

Area samples were placed along the catwalk above the coke oven doors of both the "newer" and "older" batteries to measure coke oven door CTPV emissions. Results of the sampling along with the lidman's exposure data are shown in Table 2. It is clear from the data that CTPV levels were much lower on the "newer" battery than on the "older one. Average CTPV

Table 2. Area Sample CTPV Levels and Lidman's CTPV Exposure for two Coke Batteries (mg/m^3)

"Older" Battery	10/11	10/12	10/13	10/14	10/16	Average
Location						
NE	0.52	3.94	0.06	0.30	0.94	1.15
NW	0.10	0.41	0.19	0.36	5.18	1.25
SE	0.15	0.12	0.19	0.07	0.13	0.13
SW	0.45	0.32	0.44	0.17	0.10	0.30
Lidmen (personal)	0.26	0.07	0.17	1.5[1]	0.90	0.58
Average "Older" Battery						0.70
"Newer" Battery						
Location						
NE	0.11	0.07	<0.03	0.17	0.25	0.13
NW	0.07	0.03	0.03	0.41	0.40	0.19
SE	0.07	0.03	0.10	0.19	0.03	0.08
SW	0.13	0.14	0.16	0.18	<0.03	0.13
Lidmen (personal)	0.08	0.11	0.10	0.05	0.18	0.10
Average "Newer" Battery						0.13

[1] Sampled for only 86 minutes.

emissions, including the lidman's exposure, were more than five times higher on the "older" battery than on the "newer" battery.

The difference in door emissions between the two batteries were most likely due to: 1) Age of the battery; 2) types of door lock; and 3) experience of the operating personnel. The two batteries, from the pad up, are nearly identical in construction except the "older" one, built in 1942, has self-sealing doors with the old style cam-type locking mechanisms while the "newer" battery, built in 1958, has self-sealing doors with a screw locking mechanism. Furthermore, the "newer" battery employed the somewhat higher seniority workers; hence, the more skilled and experienced workers. The older battery employs the more recently hired workers. Worker skill and experience, no doubt, affect coke oven door emissions.

To sum-up, it appears that the lesser door emissions (CTPV) from the "newer" battery resulted from a combination of the following: 1) Better structural condition, fewer cracks, less warpage, and more even heating; 2) the better screw-type locking mechanism; and 3) the more highly skilled workers on the "newer" battery.

Correlation of Visible Door Emissions and Area Sampling Data

Area Sample CTPV data (samples located on the catwalk above the coke oven doors) and visible door emissions data were collected to determine if area CTPV levels correlate with visible door emissions. The average area CTPV concentrations and average visible door emission levels on 10/16/78 are compared in Figure 1. Each CTPV concentrationn shown is the average of two area samples for one side of a battery. Each visible emissions value is the summation of visible door emissions on one side of a battery. A typical visible emissions data sheet is shown in Figure 2. (The darkened squares represent a major visible leak and the empty squares represent light to medium leaks).

Figure 1 shows there is only a weak correlation between visible emissions and CTPV data. Both methods of measurement show that the older battery push side has the highest emissions and coke side of the newer battery has the least, however, the two methods greatly disagree as to where the second and third highest emissons occurred. This lack of correlation between the two measurement techniques were most likely due to: 1) Effect of pushing emissions on area samples; 2) top side leaks and gooseneck and standpipe leaks; and 3) the fact area samples pickup only emissions from oven doors directly below the sample.

This last factor is examined by looking at small bands of ovens directly below the area samples. Visible emissions from a band of three doors directly below the samples were computed and compared with the area sample CTPV data. The results for 10/16/78 are shown in Table 3, and indicate there is some correlation between the visible emissions data and the CTPV

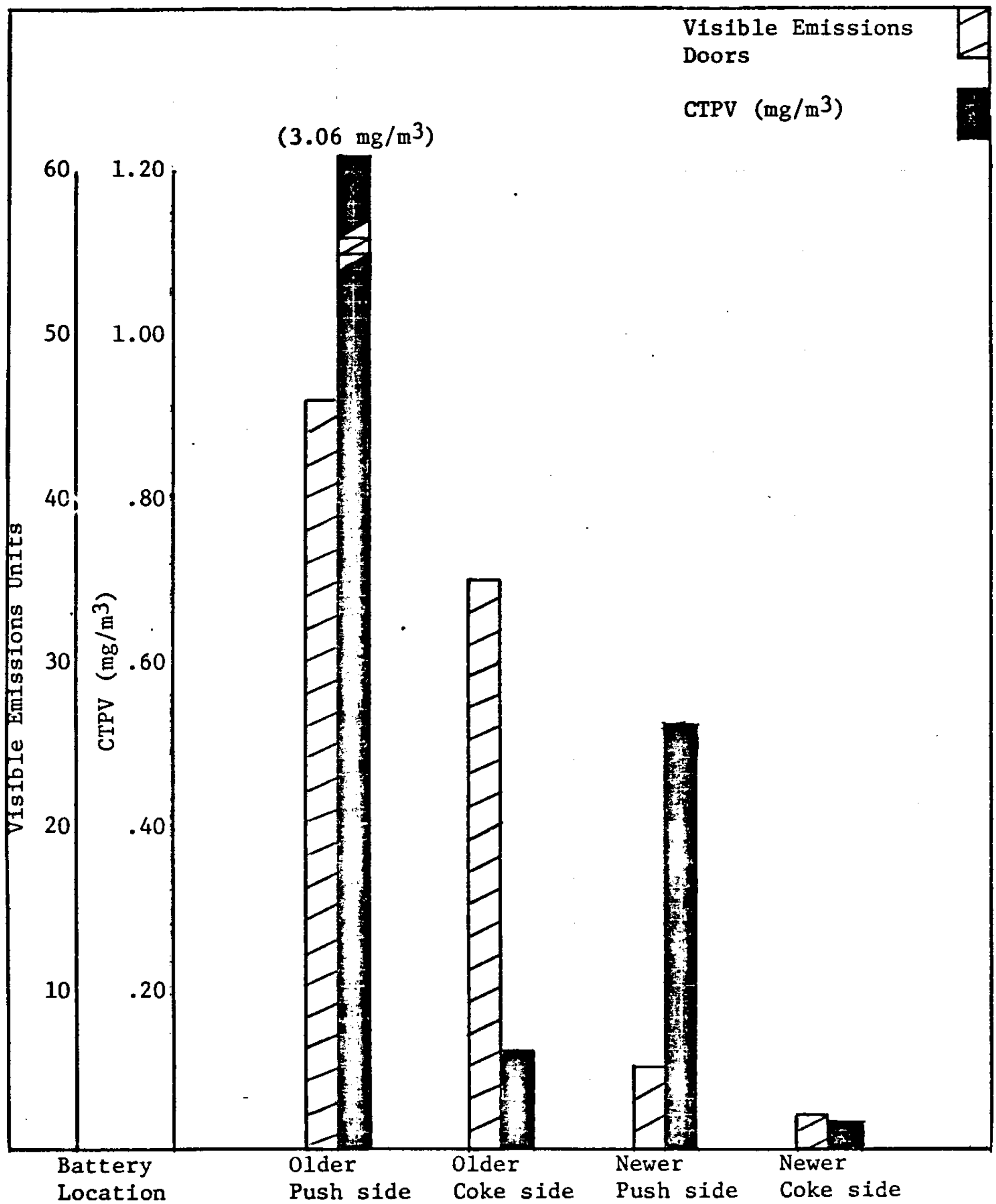

Figure 1. Comparison of Visible Door Emissions Data and Area Sample CTPV Data (10/16/78)

Figure 2. Visible Door Emissions

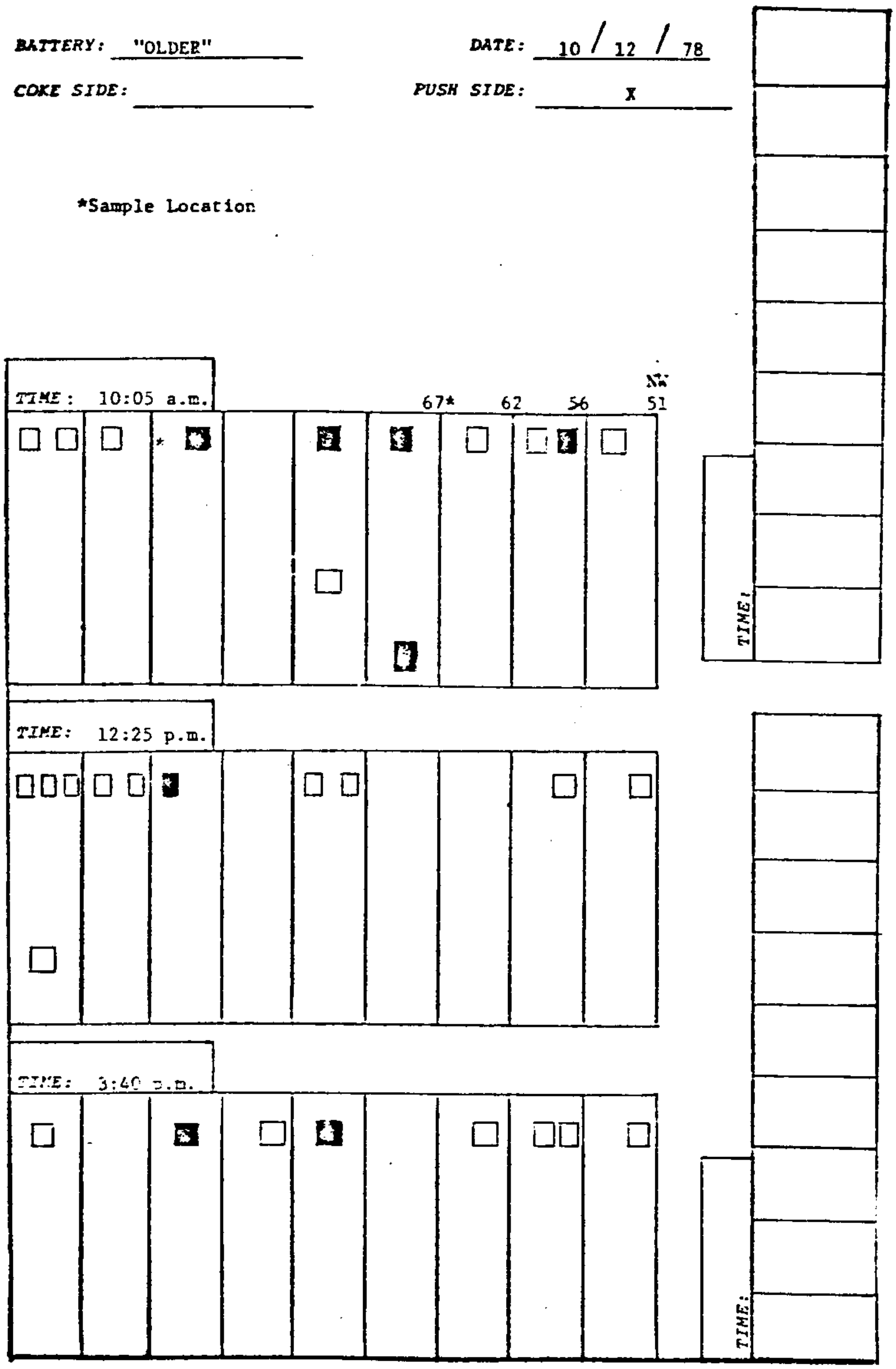

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Table 3. Comparison of visible emissions data from bands of three ovens area-sample CTPV data (10/16/79)

	"OLDER" BATTERY		"NEWER" BATTERY	
AREA LOCATION	CTPV (mg/m^3)	Visible (Band of 3 Ovens)	CTPV (mg/m^3)	Visible (Band of 3 Ovens)
NE	0.94	7	0.25	0
NW	5.18	14	0.40	6
SE	0.13	1	0.03	0
SW	0.10	7	<0.03	0

data. On the older battery, the visible emissions increased with CTPV concentrations except for the SW sample. In the case of the newer battery, low visible emissions reflected low CTPV concentrations except for the NE sample which showed significant CTPV concentration but zero visible emissions.

A second factor, gooseneck leaks and standpipe leaks, were not observed within 15 to 20 feet of any area sample on the newer battery. On the older battery a significant standpipe leaks occurred near the NE sample but none occurred near the NW. Despite this, the NE sample CTPV concentration of 0.94 was much less than the NW sample with CTPV levels of 5.18 mg/m^3. Significant gooseneck and standpipe leaks occurred near the SE sample but not near the SW sample. Again, these leaks had little effect on the area samples. Based on this limited data it appears gooseneck and standpipe leaks did not influence the area samples on the catwalk.

The effect of the remaining factor -- pushing emissions -- on area sample CTPV levels was not examined because no pushing emissions data was obtained.

In conclusion, it appears that area samples located five feet above coke oven doors give a rough approximation of visible emissions for oven doors directly below the samples and that area samples located on the catwalk were not influenced by gooseneck and standpipe leaks.

FILTERED AIR SYSTEMS

FILTERED AIR LUNCHROOM

The lunchroom for two older batteries is located next to a coal bunker at an elevation approximately that of the bench. Entry into the lunchroom is through a vestibule. A supply air unit containing pleated fiberglass filters (Farr HP-2) and a fan is mounted on the lunchroom roof. Supply air outlets are located in the lunchroom and the foreman's office. A recirculating air conditioning unit is used in the lunchroom. The foreman's office which adjoins the lunchroom has a window air conditioner but it was not in use during the evaluation. Airflows of the air conditioner and supply air units were measured. Air samples were obtained at the supply air inlet, at the supply outlet in the lunchroom, and at a location in the lunchroom judged to be representative of the general air quality.

The results of the air sampling are shown in Table 4. The somewhat limited data show the supply air system did not effectively filter the outside air. The supply air filtration system improved the outside on two days --10/11 and 10/14 -- had little effect on two days -- 10/12 and 10/13, and appeared to worsen the air on one day, 10/16.

The supply air outlet (in the lunchroom) discharged increasing CTPV concentrations throughout the survey period, increasing from 0.01 to 0.10 mg/m^3. Since the supply air filter was not replaced during the survey, it is possible the filter became overloaded resulting in the breakthrough of

Table 4. Filtered Air Lunchroom CTPV Levels (mg/m^3)

DATE	OUTSIDE AIR INLET TO SUPPLY AIR UNIT	INSIDE LUNCH-ROOM SUPPLY AIR OUTLET	LUNCHROOM GENERAL AIR
10/11/78	.05	.01	<.01
10/12/78	.02	.01	<.01
10/13/78	.10	.07	.10
*10/14/78	.12	.07	.05
10/16/78	.02	.10	.12

*Door to the lunchroom open

CTPV. If this is the case, more frequent replacement of the filters may be necessary.

The data (Table 4) also shows that the general room air and the supply air CTPV concentrations each day were essentially the same. This suggests that the quality of the supply air greatly affects the quality of the lunchroom air.

The supply air unit supplied a significant airflow to the office and lunchroom as shown by airflow measurements. Supply air to the approximately 10,000 ft^3 lunchroom and office was 2900 cfm which equals an air change every three or four minutes. (The recirculating air conditioner (AC) in the lunchroom was operating; however, the AC was not evaluated in the survey).

The evaluation of the lunchroom air filtration system provided some limited information on the air filters effectiveness. The evaluation also showed that steps can be taken to improve the effectiveness of the filtration system and the quality of the lunchroom air: 1) Maintain the supply air and air conditioning units on a regular schedule; 2) install a manometer to indicate when filters need changing; 3) measure airflow direction and velocity through lunchroom doors periodically; and 4) consider a better location for the inlet to the sypply air unit.

FILTERED AIR LARRY CAR

Larry car #2, serving two older batteries, is equipped with an enclosed filtered air cab. A recirculating filter unit (Correct-Air) is located at one end of the cab. An air condition unit of unknown manufacture is located in the center of the cab. The inlet to the evaporator housing is equipped with a furnace type filter. Neither the filter nor the air conditioning unit has a provision for makeup air; consequently, the cab is not pressurized and is subject to smoke entry through cracks and open doors. The air conditioner condensor and compressor are located above the cab and are subject to loading from coal dust during larry car filling as well as coke oven emissions. The air conditioner was not working at the time of the evaluation. It had been hoped that repairs could have been completed on the first day of the survey but this was not the case. Sampling was performed during the evaluation with both doors normally open in the larry cab. Samples were taken both in and outside the cab and on the larry operator. The operator sampler was switched to the relief operator and thus is representative of a single larry operator's exposure only if he were to spend his entire shift top side.

Sampling results for the larry car cab are shown on Table 5. Comparing the CTPV concentrations inside and outside the cab shows that for three of the seven sampling periods, concentrations inside and outside were the same; however, for four of the seven sampling periods CTPV were reduced from outside to inside by 26 to 70 percent. The average reduction for all seven samples was about 28 percent. Thus, it appears the larry car cab, even with the doors open, provided some reduction in CTPV levels. (No attempt was made to evaluate the larry car air filter because the filter was

Table 5. Larry Car CTPV Levels (mg/m^3)

	AREA SAMPLES		PERSONAL SAMPLES		
Date	Outside Larry Car Cab	Inside Larry Car Cab	Larry Car Operator*	Lidman*	COMMENTS
10/12/78 a.m.	0.56	0.45	0.91	0.07	Doors closed part of time.
10/12/78 p.m.	0.40	0.46	0.05	-	Filter ON A/C OFF
10/13/78 a.m.	0.46	0.23	0.26	0.17	Doors Open. Filter OFF
10/13/78 p.m.	0.89	0.27	0.37		A/C OFF
10/14/78 a.m.	0.86	0.43	0.53	-	Doors open.
10/14/78 p.m.	0.61	0.45	0.64		A/C OFF
10/16/78 (all day)	0.79	0.82	0.51	0.90	Doors Open. Filter OFF A/C OFF
Average	0.65	0.44	0.47	0.38	

*Wore respirator (date does not include reduction factor for respirators) operated only one day, and the doors of the cab were open part of that day).

Larry car operator personal sampling data is also shown in Table 5. In each specific sampling period, e.g. 10/12 a.m., the larry car operator CTPV exposure usually differed greatly from the CTPV levels inside or outside the larry car cab. However, when the data is averaged over the four day sampling period the larry car operator exposure and the area sample data for inside the cab agree closely; the former averaging 0.47 and the latter 0.44 mg/m3. In any case these results indicate the difficulty of using short term samples -- one half and one day -- to evaluate worker exposure. The results also point out that differences among individual operators and variations in their daily routine, for example, amount of relief time spent in the lunchroom can significantly affect their exposure.

Additionally, the lidman was sampled to see how the lidman, who is without the protection of the larry car cab, compared to the larry car operator. Overall, the lidman's exposure was lower than the larry car operator's exposure as shown in Table 5.

EFFECT OF METEOROLOGICAL DATA ON CTPV LEVELS

Meteorological data for the period of the coke oven survey is shown in Table 6. Data includes wind speed (mph), wind direction, temperature (°F),

Table 6. Meteorological Data - from airport near coke plant

DATE	TIME	WIND SPEED (mph)	WIND DIRECTION	TEMPERATURE °F	RELATIVE HUMIDITY	CONDITIONS
10/11/78	8:00 a.m. - 4:00 p.m.	11.7	E	88	32	Haze - 50%
10/12/78	8:00 a.m. - 3:00 p.m.	10.4	ESE	89	25	Haze - 100% Smoke - 100%
10/13/78	8:00 a.m. - 4:00 p.m.	13.7	ENE	92	31	Haze - 100% Smoke - 100%
10/14/78	8:00 a.m. - 3:00 p.m.	11.5	ESE	87	31	Haze - 100% Smoke - 100%
10/16/78	8:00 a.m. - 3:00 p.m.	10.0	ESE	77	47	Haze - 100% Smoke - 70%

relative humidity (percent) and visible conditions. The data is the average of the hourly readings during the sampling periods (which were either 8:00 a.m. - 3:00 p.m. or 8:00 a.m. - 4:00 p.m. The airport is located about seven miles from the coke oven site. There is no interfering topography and both the airport and the coke oven plant are at about the same elevation.

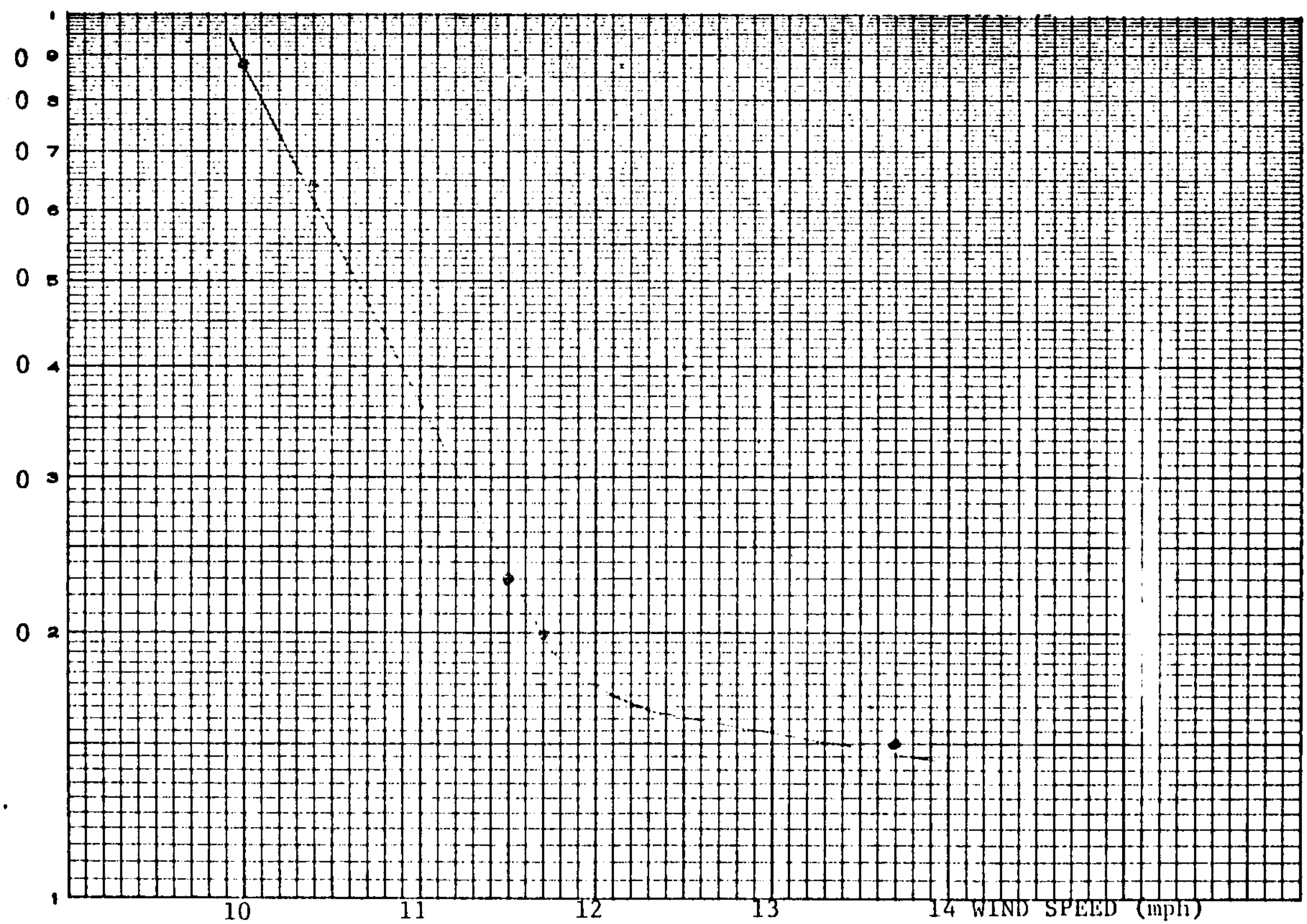
The data show that temperature and humidity varied little from day-to-day except for October 16, when the temperature was slightly cooler. Therefore, temperature and humidity were assumed to be insignificant factors in the study.

Wind speed varied sufficiently from day-to-day to allow an analysis of its effect on the coke oven CTPV levels. Wind speed and CTPV concentrations are compared in Table 7. Daily CTPV values represent the average of eight area samples taken on the catwalk above the doors of two coke oven batteries. The data shows that increased wind speed resulted in much lower CTPV levels. At an average wind velocity of 14 mph CTPV concentration averaged 0.15 mg/m^3, while at 10 mph average CTPV concentrations were 0.64 and 0.88 mg/m^3. The effect of wind speed is also illustrated in Figure 3, which shows lower CTPV levels at higher wind speeds. Table 7 also compares wind speed to the daily geometric mean CTPV concentration for the eight area samples. This data supports the contention that increased wind speed results in lower CTPV levels.

Table 7. Area Sample Data and Wind Speed

DATE	WIND SPEED (mph)	CTPV (mg/m^3) Average of 8 Area Samples Arith Mean	Geo Mean
10/11/78	11.7	.20	.15
10/12/78	10.4	.64	.16
10/13/78	13.7	.15	.10
10/14/78	11.5	.23	.20
10/16/78	10.0	.88	.22

Figure 3. CTPV (mg/m^3) Arithmetic Mean



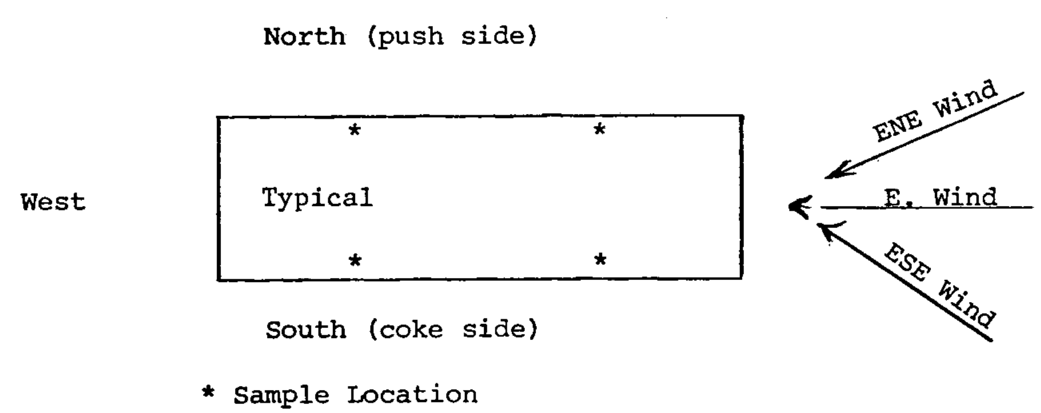
Although the above data strongly indicates wind speed effects exposure levels on the battery much more data is needed to verify this effect. With additional data it may also be possible to show a mathematical relationship between wind speed and CTPV levels.

Although limited data was available it appears that wind direction affected the CTPV concentrations observed on top of the two batteries sampled. The data in Table 8 shows that with the wind direction partly from the South (3-day), the CTPV concentration of the South sample were well below emissions on the North. On the one day wind was partly North, CTPV levels on the South samples were almost three times the North and finally with a wind directly from the East, North and South samples CTPV levels were the same.

Although this data is based on only 40 area samples over five days, it does indicate that wind direction as well as wind speed are two of the most important factors in determining exposure levels on the coke oven batteries. More data is needed to verify the effect of wind direction on worker exposure to CTPV.

Table 8. Effect of Wind Direction on Area Sample CTPV Levels

DATE	AVERAGE CTPV (mg/m^3) North (Pushside)	AVERAGE CTPV (mg/m^3) South (Cokeside)	RELATIVE EMISSION LEVELS	WIND DIRECTION
10/11/78	0.20	0.20	Same	E
10/12/78	1.11	0.15	South-much lower	ESE
10/13/78	0.08	0.22	North-lower	ENE
10/14/78	0.31	0.15	South-lower	ESE
10/16/78	1.69	0.07	South-much lower	ESE



CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Coke oven benchmen had significantly higher exposure to coal tar pitch volatiles when throwing coal into the oven than when throwing coal over the side of the bench.

2. It appears that lesser door emissions on the "newer" battery were the result of fewer cracks and more even heating; a better screw type locking mechanism instead of the cam-type locking mechanism; and higher skilled workers than on the "older" battery.

3. CTPV concentrations for area samples -- located about five feet directly above the doors -- appears to give a rough approximation of visible emissions from those doors. However, to effectively measure visible door emissions, area samples would need to be placed above at least every third oven. Thus, 30 samples would be needed to cover both sides of a 45-foot oven battery.

4. Chuck door leaks were a major emission source for the "older" battery.

5. Based on limited data (only five sampling days), the lunchroom makeup air unit did not effectively filter the outside air.

6. The effectiveness of the larry car filtered air system was compromised by open doors, louvered doors, and propped-open windows. "Please close door" placards and automatic door closers could alleviate this situation. The filters on the makeup air unit showed a heavy dust buildup. A washable prefilter or a filter with an automatic cleaning cycle would provide a longer life for the pleated fiberglass after filters. A manometer should be installed in a prominent location to indicate when the filter needs changing or cleaning.

7. The fact that the larry car cab air conditioner was not functioning is indicative that long unprotected condensor coils cannot be expected to work in a coke oven environment. The condensor (and compressor) needs to be protected from the heavy dust loading by an industrial air filter with possibly an automatic cleaning cycle. Such a system could also protect larry car electrical and hydraulic components and supply precleaned air to a larry cab filtered makeup unit. The need for makeup air was obvious during this evaluation. With the filter unit running, smoke rapidly filled the cab, even with the doors closed, and was not rapidly cleared until the doors were opened.

8. Wind speed and direction appears to have a major effect on CTPV levels on the top side of the coke oven battery.

RECOMMENDATIONS

1. The evaluation of coal shoveling practices should be repeated. However, in doing so, a much larger number of personal samples of the benchman throwing into the oven and throwing over the side should be obtained.

2. Door emissions can be reduced by frequently checking the speed of the door machine. Proper machine speed will ensure the doors will fit tightly and seal properly.

3. Filters in the air conditioned lunchroom should be replaced on a scheduled basis. Responsibility for replacing the filters should be someone who regularly works on the coke oven rather than the plant air conditioning maintenance staff. A coarse filter ahead of the high efficiency filter in the makeup air unit is recommended also.

4. The larry car cab with the air conditioner and air filter working and the windows and doors closed, should be retested. The results should then be compared with results from the survey reported here to obtain a reduction factor in CTPV levels between the "uncontrolled" and "controlled" larry car cab environment.

5. Standby pulpits which have been installed since the subject field survey, should be evaluated. A reduction factor in CTPV levels from on the battery to inside pulpit should be determined.

6. Much more field testing is needed to allow firm valid conclusions on the effect of wind speed and direction on coke battery CTPV leaks.

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