METHOD DEVELOPMENT TEST REPORT NO. 1

U.S. STEEL - CLAIRTON COKE WORKS
COKE OVEN BATTERIES 7, 8, AND 9
CLAIRTON, PENNSYLVANIA

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PEDCo ENVIRONMENTAL

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1.0 INTRODUCTION

On August 18-20, 1981, PEDCo Environmental, Inc., personnel participated in a series of method development tests at Clairton Coke Works, U.S. Steel Corporation, Clairton, Pennsylvania. The purpose of the test program was to document the performance of EPA Test Method 109, part C, in determining coke oven door area emissions when traverses were conducted along the yard and from the bench.

Results of an earlier test program, designed to determine the applicability of EPA Method 109, Part C at coke batteries with coke side sheds, revealed that there was a statistically significant difference in the number of door area leaks detected when traverses were conducted along the bench as opposed to, along the yard.

This test program was designed to quantify and document any difference in the number of door area leaks detected by traversing along the bench as opposed to along the yard. Batteries 7, 8, and 9 at Clairton Coke Works were selected for this test work. These batteries do not have sheds and are similar in construction, performance, and door leakage history.

This report presents results of the test series and describes the test procedures. The appendix contains a copy of the field

data sheets, list of project participants, and a copy of the regulation.

2.0 TEST PROCEDURE

EPA Test Method 109, Part C details procedures for determining emissions from coke oven doors. These procedures requires the observer to traverse each side of the battery from ground level. For safety reasons, the method recommends the traverse be conducted outside of the pusher machine and quench car tracks. Figure 1 presents a diagram of a coke oven battery showing observer positions for the traverses. Figure 2 presents a plan diagram of batteries 7, 8, and 9 and illustrates observer traverse positions during this test program.

This test program was designed to quantify and document any difference in the number of door area leaks detected by traversing along the bench as opposed to along the yard. In an effort to obtain accurate data and to minimize the bias created by process and observer variance, the following test procedures were used.

All leak observations made during this development test were conducted to include door area leaks as defined in the revised method. Company door leak inspectors count door area leaks similarly by noting all non-oven door or chuck door leaks in a miscellaneous category.

The test crew was comprised of four members which were divided into two teams. Each team traversed the same side of the battery simultaneously. One team traversed along the bench while the other team traversed along the yard.

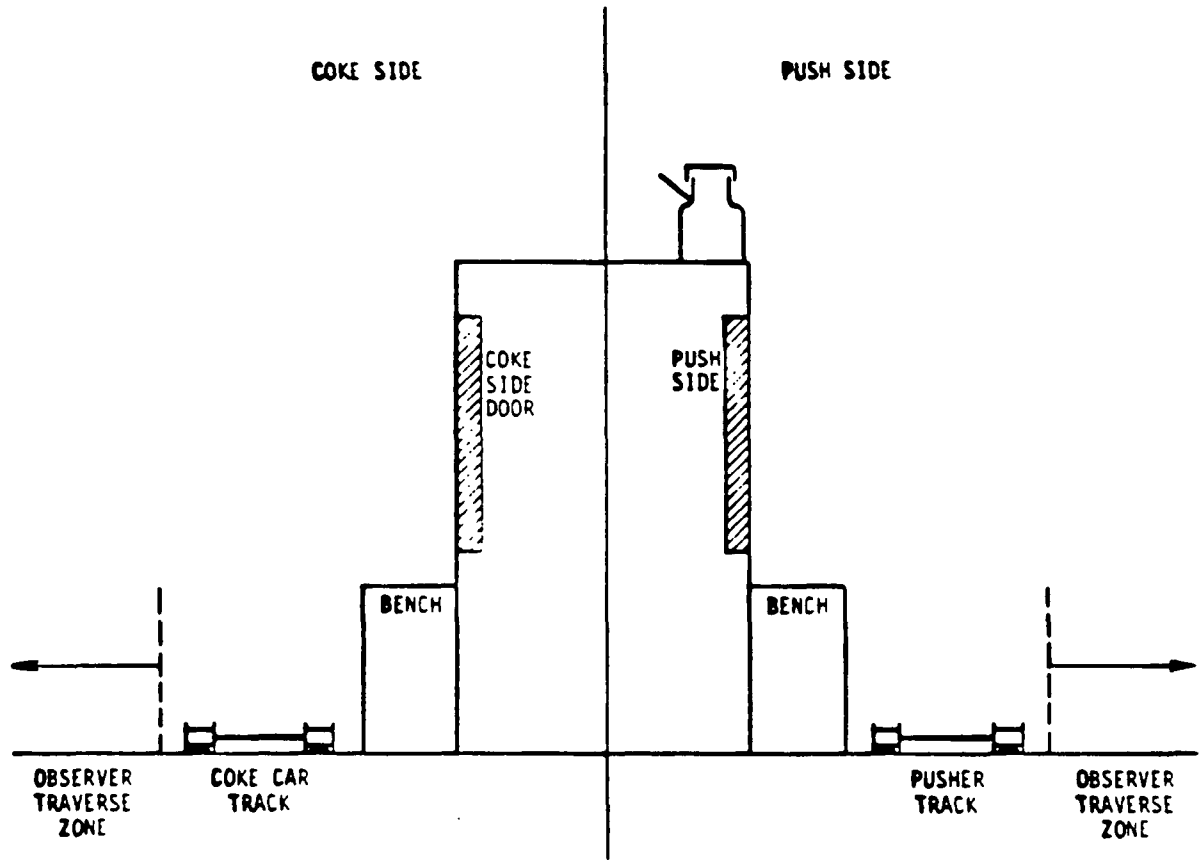

Figure 1. End view of coke oven battery showing recommended traverse zone.

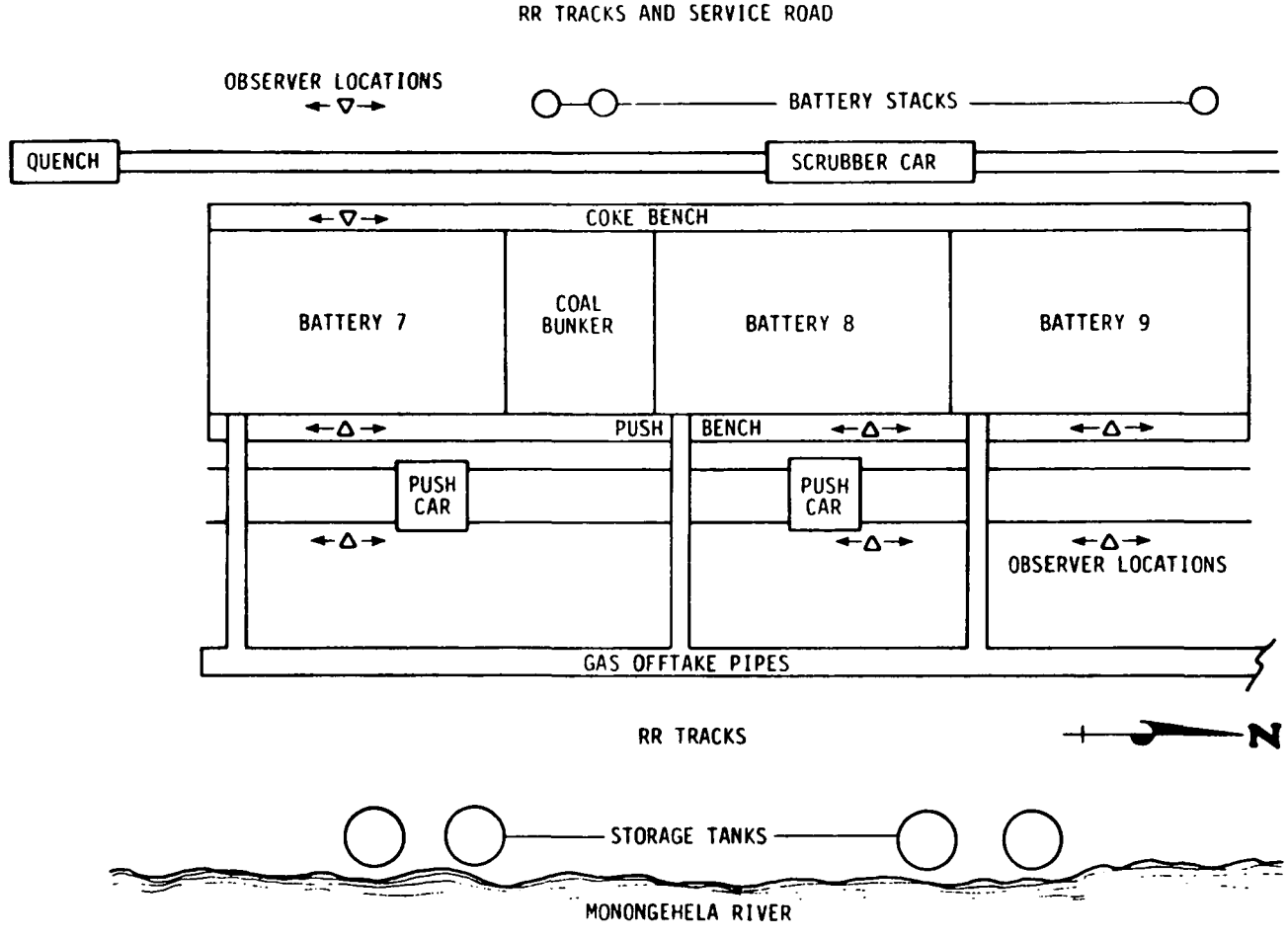

Figure 2. Plan view of Batteries 7, 8, and 9, U.S. Steel Corporation, Clairton, Pennsylvania.

At the end of the traverse, the teams switched positions and another traverse was conducted. Two traverses conducted in this manner constituted a set.

At the conclusion of each set, the two most inexperienced members of the test crew switched teams so that alternate sets were conducted with different pairs of observers.

The testing procedure for the coke side of the battery followed the above procedure except that the teams remained the same for all runs in order to comply with plant safety requirements. The hot coke car tracks extend the full length of batteries No. 7, 8, and 9 and there is no safe access across the tracks from the quench tower at the south end of battery No. 7 to the north end of battery No. 9. Safe access for observer switching from the bench to the yard position was available only by walking around the south end of the quench tower. Therefore, a set on the coke side consisted of two runs from the yard by the same team while simultaneous runs were being conducted from the bench by the other team. At the conclusion of a set, the teams switched positions in preparation for the next set.

Observation sets were designed to be made at fifteen minute intervals in order to avoid frequent repetitive recording of the same leaks. Actual run times were worked around door machine and pushing operations. Typically, there was an elapsed time of fifteen minutes in order for the pushing cycle to be completed. Whenver sections of the batteries were blocked from view by operational equipment no leaks were read by the observers from

either the bench or yard positions during the door area leak traverses.

3.0 SUMMARY OF RESULTS AND STATISTICAL ANALYSIS

Four observers divided into two teams, counted the number of door area leaks on coke ovens Batteries Nos. 7, 8, and 9. On Battery No. 7, 4 sets of observations were made from the Yard and the Bench on the Pusher Side and the Coke Side. For Battery No. 8, 13 sets of observations were made from the Yard and the Bench on the Pusher Side. Finally, for Battery No. 9, 4 sets of observations were made from the Yard and the Bench on the Pusher Side.

Tabulations of the number of door area leaks reported by each observer are presented in Tables 1, 2, and 3 for Batteries Nos. 7, 8, and 9, respectively. A summary of these results is presented in Table 4. In all instances, the number of leaks when observed from the Bench is greater than when observed from the Yard. The Bench to Yard ratio of total leaks for observations from the Pusher Side ranged from 1.9 for Battery 9 to 3.6 for Battery 7. While observations from the Coke Side were made for Battery No. 7 only, the Bench to Yard ratio was 1.4 compared to 3.6 for the Pusher Side.

In order to determine the statistical significance of the difference between the number of leaks observed from the Yard and the Bench the data presented in Tables 1, 2, and 3 were further investigated using Analysis of Variance. The model was of the form;

TABLE 1. NUMBER OF COKE OVEN DOOR AREA LEAKS

Pusher Side											Coke Side*										
Set No.	Yard Observer 1	2	3	4	Ave	Bench Observer 1	2	3	4	Ave	Set No.	Yard Observer 1	2	3	4	Ave	Bench Observer 1	2	3	4	Ave
1	5	5	3	5	4.5	14	16	8	17	13.8	5			6 5	5 5	5.2	8 8	10 11			9.2
2	2	3	2	2	2.2	5	12	7	7	7.8	6	6 8	7 8			7.2			7 10	11 10	9.5
3	1	3	3	3	2.5	10	10	3	8	7.8	7			10 8	10 10	9.5	11 11	14 16			13.0
4	0	0	0	0	0.0	4	7	2	1	3.5	8	9 8	9 11			9.2			14 12	14 12	13.0

*Because of concern over safety, the teams could not switch positions for the runs in a given set.

TABLE 2. NUMBER OF DOOR AREA LEAKS
Pusher Side Battery No. 8

Set No.	Yard					Bench				
	Observer				Ave	Observer				Ave
	1	2	3	4		1	2	3	4	
1	3	3	4	3	3.2	6	6	3	6	5.2
2	3	1	1	3	2.0	5	8	6	6	6.2
3	5	6	0	0	2.8	3	10	4	3	5.0
4	8	10	8	8	8.5	10	9	3	14	9.0
5	4	6	6	8	6.0	9	11	3	8	7.8
6	2	2	3	3	2.5	6	6	4	8	6.0
7	2	3	1	6	3.0	6	5	4	9	6.0
8	5	4	4	7	5.0	7	6	3	8	6.0
9	3	5	2	2	3.0	6	10	9	9	8.5
10	3	5	3	5	4.0	9	16	13	8	11.5
11	4	5	3	4	4.0	11	11	7	5	8.5
12	0	0	0	0	0	5	6	5	4	5.0
13	2	2	1	1	1.5	7	7	4	4	5.5

TABLE 3. NUMBER OF DOOR AREA LEAKS
Pusher Side Battery No. 9

Set No.	Yard					Bench				
	Observer				Ave	Observer				Ave
	1	2	3	4		1	2	3	4	
1	4	7	3	2	4.0	12	10	6	8	9.0
2	5	11	5	8	7.2	11	10	4	10	8.8
3	2	1	3	2	2.0	8	7	2	6	5.8
4	3	2	2	4	2.8	8	7	4	9	7.0

TABLE 4. AVERAGE NUMBER OF DOOR AREA LEAKS

Battery No.	No. of sets	Dates of tests	Pusher Side			Coke Side		
			Yard	Bench	Bench / Yard	Yard	Bench	Bench / Yard
7	4	8/20/81	2.3	8.2	3.6	7.8	11.2	1.4
8	8	8/18/81	4.1	6.4	1.6			
	5	8/19/81	2.5	7.8	3.1			
	13		3.5	6.9	2.0			
9	4	8/19/81	4.0	7.6	1.9			

$$Y_{ijk} = \mu + \lambda_i + \eta_{i(j)} + \varepsilon_{ijk}$$

where

μ = the overall mean number of leaks

λ_i = the effect due to the position on the side from which observations were made (i.e., Yard, Bench)

$\eta_{i(j)}$ = the effect due to the variation of the coking process

ε_{ijk} = the random error associated with an observation (this is the observer error)

The results of the analysis of variance of the data for Battery No. 7 are presented in Tables 5 and 6. Separate analyses were performed for observations made from the Pusher Side and the Coke Side, because of the difference in the test procedures. This difference in procedure was made necessary due to plant safety requirements. The average number of leaks observed from the Bench was higher than that observed from the Yard for the Pusher Side and the Coke Side. This difference between the number of leaks observed from the Yard and the Bench is statistically signficant ($p < 0.05$) for observation made from the Pusher Side and the Coke Side. The variance of an individual observation was determined to be 5.67 for observations made from the Pusher Side and 2.04 for observations made from the Coke Side. This difference in variance is statistically significant ($p < 0.05$).

The results of the analysis of variance of the data for Batteries Nos. 8 and 9 are presented in Tables 7 and 8, respectively. For both batteries the difference between the number of leaks observed from the Bench is significantly greater than that

TABLE 5. ANALYSIS OF VARIANCE OF DOOR AREA LEAKS
Pusher Side
Battery No. 7

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-ratio	p
Between position	1	276	276	6.52	<0.05
Between set within position	6	254	42.3	7.47	<0.01
Observer error	24	136	5.67		
Total	31	666			

TABLE 6. ANALYSIS OF VARIANCE OF DOOR AREA LEAKS
Coke Side
Battery No. 7

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-ratio	p
Between position	1	129	129	7.74	$p < 0.05$
Between set within position	6	100	16.7	8.17	$p < 0.01$
Observer error	24	49	2.04		
Total	31	278			

TABLE 7. ANALYSIS OF VARIANCE OF DOOR AREA LEAKS
Battery No. 8

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-ratio	p
Between positions	1	308	308	18.34	<0.01
Between sets within position	24	403	168	3.78	<0.01
Observer error	78	347	4.45		
Total	103	1058			

TABLE 8. ANALYSIS OF VARIANCE OF DOOR AREA LEAKS
Battery No. 9

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-ratio	p
Between positions	1	105	105	6.39	<0.05
Between sets within position	6	93	16.5	3.06	<0.05
Observer error	24	129	5.37		
Total	31	327			

observed from the Yard (i.e., $p < 0.01$ for No. 8 and < 0.05 for No. 9). Referring again to Table 4, the number of leaks observed from the Bench was approximately twice that from the Yard for both batteries.

The test results for each battery provide an estimate of the error of an individual observation.

Battery No.	Variance	Standard deviation
7		
Pusher side	5.67	2.38
Coke side	2.04	1.43
8	4.45	2.10
9	5.37	2.31

Based upon Bartlett's Test* the variation between these individual estimates of the error of an individual observation is statistically significant ($p < 0.10$). The observer variance of 2.04 for observations made from the Coke Side of Battery No. 7 is less than that for observations made from the Pusher Side for all three batteries (i.e., 5.67, 4.45, and 5.37 for Nos. 7, 8, and 9, respectively). This low variance and the low bench to yard ratio seen on the coke side of battery 7, as compared to the push side, should be investigated in more detail. One factor was noted during the testing of batteries 7, 8, and 9 which could have an affect on observer performance when traversing along each side of the battery. This factor consists of the following:

*Bartlett, M.S. Journal of the Royal Statistical Society Supplement, 4:137 (1937).

The observer traverse zone on the pusher side of the battery is approximately 3 times farther from the bench than the traverse zone on the coke side. This is due to the width of the pusher machine and the additional distance from the machine required to make a safe traverse.