OFFICE OF ENFORCEMENT

EPA-330/2-77-007

Coke Plant Evaluation
Kaiser Steel Corporation
Fontana, California

(JANUARY 25-27, 1977)

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
DENVER, COLORADO
AND
DIVISION OF STATIONARY SOURCE ENFORCEMENT
WASHINGTON D.C.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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COKE PLANT EVALUATION
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National Enforcement Investigations Center - Denver, Colorado
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I. INTRODUCTION

BACKGROUND

Kaiser Steel Corporation operates an integrated steel manufacturing facility at Fontana, in San Bernardino County, California. It has for some time been the single largest stationary source of air pollution in the Southern California Air Pollution Control District (SCAPCD).

Since 1970, several operations at Kaiser have been operating under local variances with compliance schedules. In addition, since April 26, 1976, Kaiser has been under a Federal Consent Decree which requires the coke ovens and other operations at the facility to meet certain deadlines for controlling emissions. On July 19, 1976, executives of Kaiser Steel certified to the Environmental Protection Agency (EPA) that the combined emissions from the coke oven charging, oven doors and standpipes were in compliance with the Consent Decree.

The State of California Air Resources Board (ARB) visited Kaiser on August 30, 1976 to verify compliance with the Decree and observed substantial excessive emissions from the coke ovens and other operations. During the week of September 13-16, 1976, a team of 24 inspectors from the ARB, EPA, and SCAPCD conducted an intensive inspection of Kaiser to determine the magnitude of emission violations. Particular attention was given to coke oven charging, oven doors and standpipes which had been certified as being in compliance some months prior. The inspection of the coke ovens resulted in a total of 1,098 observations of excessive visible emissions.

As a result of the September, 1976 inspection, EPA Region IX is entering into litigation against Kaiser. The Region anticipates that Kaiser will claim that the terms of the April 26, 1976 Consent Decree are not technically feasible.

At the request of Region IX, personnel from the NEIC and EPA Division of Stationary Source Enforcement (DSSE) conducted an inspection of the Kaiser coke plant on January 25-27, 1977. The objective was to determine what specific steps the Company could take, but has not, to meet the terms of the Consent Decree or to minimize visible emissions. The results of the NEIC - DSSE inspection are contained in this report.

PARTICIPANTS

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APPLICABLE REQUIREMENTS

Section IV of the April 26, 1976 Consent Decree between the United States and Kaiser Steel Corporation is, in part, applicable to coke oven charging, oven doors and standpipes. Section IV reads as follows:

> "Defendant [Kaiser Steel] shall complete or have completed the following acts with respect to its COKE OVEN OPERATIONS on or before the dates specified:
>
> A. Defendant agrees that by the date of this Decree, combined visible emissions from the coke oven doors and standpipes at each coke oven in coke oven batteries "A", "B", "C", "D", "E", "F"

and "G" shall have achieved compliance with San Bernardino County Air Pollution Control District Regulation IV, Rule 50-A (hereinafter Rule 50-A).

B. Defendant shall install stage charging for coke oven batteries "A", "B", "C", "D", "E", "F" and "G" according to the following schedule:

1. By the date of this Decree - let contracts for the purchase of control equipment and/or issue work order for construction or installation of control equipment or process modification.
2. April 15, 1976 - initiate on-site construction or installation of control equipment or process modifications.
3. July 15, 1976 - complete on-site construction or installation of control equipment or process modifications.
4. July 31, 1976 - achieve compliance with Rule 50-A. Visible emissions from the charging operation, doors, and standpipes at each oven in coke oven batteries "A", "B", "C", "D", "E", "F" and "G" shall be combined in determining compliance."

San Bernardino County Air Pollution Control District Regulation IV, Rule 50-A reads as follows:

"Rule 50-A. Visible Emission.

A person shall not discharge into the atmosphere from any source of emission whatsoever, any air contaminant for a period or periods aggregating more than three (3) minutes in any one (1) hour which is:

(a) As dark or darker in shade as that designated as No. 1 on the Ringelmann Chart, as published by the United States Bureau of Mines, or

(b) Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in Section (a) of this Rule.

This rule is effective on June 1, 1972, for all sources which are not either in operation or under construction prior to that date, and Rule 50 shall not be applicable to such sources on or after that date. This Rule is to become effective for all other sources on January 1, 1975 and Rule 50 shall not be applicable on or after that date."

II. PROCESS DESCRIPTION

Kaiser Steel Corporation operates a seven-battery coke plant at its Fontana, California facility. The batteries each have 45 Koppers-design ovens and are operated as three units: batteries A, B and half of C operate as one unit; the other half of C, D, and E operate as another; and F and G, which are physically separated from the rest, operate as a third unit. Each unit has its own coal bunker and quench tower. Batteries A through E have underjet ovens and F and G have gun-flue ovens. The batteries are equipped with double collector mains. Figure 1 is a schematic drawing of the plant layout.

Each oven has three charging ports (35.6 cm in diameter) numbered from push to coke side. Approximately 12.7 m. tons (14 tons) of coal are charged to the ovens with 35% (±1%) charged to the number 1 port, 25% (±1%) charged to the number 2 port, and 38% (±1.5%) charged to the number 3 port. The ovens are tapered in width from coke (38 cm) to push (33 cm) side, are 4.28 m (14 ft) high, and are 12.32 m (40 ft 5 in) long from door face to door face. All ovens are pushed and charged by the "Koppers" sequence (1's, 3's, 5's, 7's, 9's, 2's, 4's, 6's, 8's, 1's, 3's, etc.).

The ovens are equipped with self-sealing doors. The doors on batteries A through E are cam-latch and the doors on F and G are screw-latch. Three different sets of doors are used. Batteries A and B have one set; C, D and E another; and F and G a third.

The benches are about 1 meter below the level of the doors. The doors are removed and replaced by the pusher machine on the push side and a door machine on the coke side.

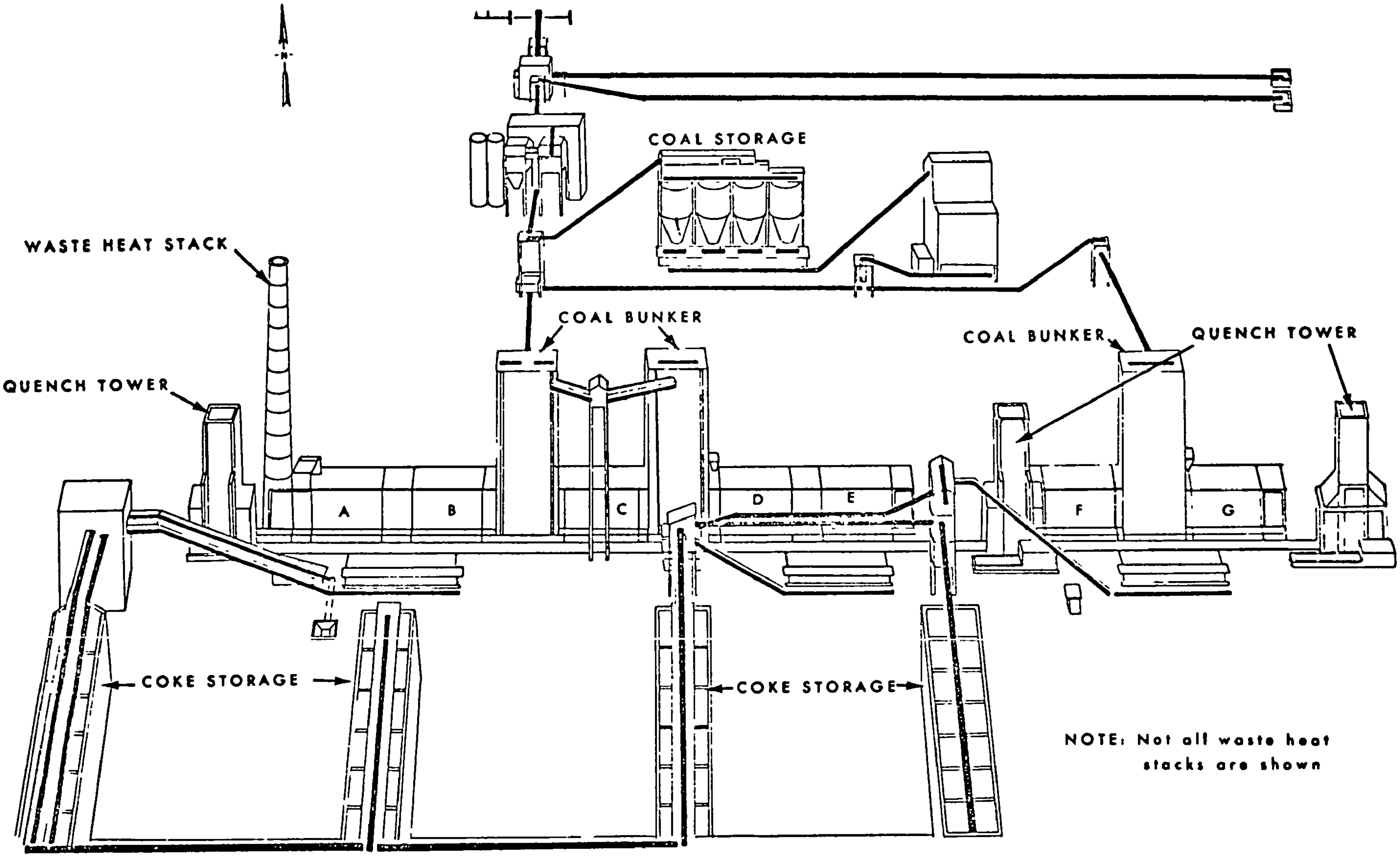

Figure 1. Kaiser Steel Coke Plant

On a 38-oven pushing schedule, each operating unit is staffed by one larry car operator, one pusher machine operator, one coke side door machine operator, two bench helpers (one on coke side and one on push side), and one lidman. The luterman and quench car operator may be shared with another operating unit. If the pushing schedule is 46 ovens or more, an additional bench helper is placed on the push side; if the pushing schedule is 32 ovens or less, the coke side bench helper position is eliminated.

The coal charged to the ovens during the January inspection ranged from 35% to 37% volatile matter, 6.3% to 9.8% moisture, 0.73% to 0.85% sulfur, 6.4% to 6.9% ash, and 68% to 83.5% less than 1/8-mesh. It was a mix of three types of coal plus 3% petroleum coke. Coking time was about 22 hours.

III. OPERATIONAL PRACTICES AND EQUIPMENT

During the inspection, operational practices and equipment having a bearing on emissions were observed and documented for charging, doors and topsides (lids and standpipes). The results are discussed below.

CHARGING

Larry Car Alignment

Proper alignment of the larry car drop sleeves with the charge ports is necessary to assure sufficient oven aspiration, and proper flow of coal into the oven. Misalignment can create an orifice through which oven aspiration can be lost, causing charging emissions. No significant misalignment of the larry car drop sleeves with the charging ports was observed.

Charge Port Blockage

Charge ports partially blocked with carbon buildup can interfere with the continuous flow of coal into the oven, a condition necessary for successful stage charging. No significant buildup of carbon in the charge ports was observed.

Charge Time Sequence

Stage charging requires controlled flow of coal into the oven to allow the gas evolved to be evacuated effectively. The Company operating procedure requires coal from hoppers 1 and 3 to be charged simultaneously into the oven, and coal from hopper 2 to be charged after hoppers 1 and 3 are empty. The time required to empty hoppers 1 and 3 was recorded to range from 50 seconds to 2 minutes and 22 seconds with an average of 1 minute and 17 seconds for 28 charges. The time required to empty hopper 2 was recorded to range from 1 minute 6 seconds to 2 minutes 46 seconds, with an average of 2 minutes 3 seconds also for 28 charges. The extra time required to empty hopper 2 is largely due to the leveling process which takes place while hopper 2 is emptying.

Proper charging sequence was not always followed by plant personnel. Instances were recorded when hopper 1 began charging ahead of hopper 3, and when hopper 2 began charging before hoppers 1 and 3 were empty.

Gas Passage

Proper volumetric distribution of coal introduced into the oven ensures that sufficient space will remain above the coal to expedite removal of evolved gases. Kaiser plant officials reported that coal distribution between hoppers was designed to provide a 30.5-cm (12-in) channel. Three sets (one per operating unit) of peak and channel height measurements* were made during the inspection. The results are listed in Table 1.

The channel heights for ovens A/9 and C/147 are about 10-15 cm less than the desired "normal" according to the Company's design criteria of 30.5 cm (12 in).

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* *Peak and channel heights are defined as the distance between the top of the coal and the roof of the oven before (for peak) and after (for channel) leveling. They are measured by placing a measuring rod into the charging ports.*

Table 1

PEAK AND CHANNEL HEIGHTS

Battery/Oven	Type	Clearance†					
		Port #1		Port #2 (cm)(in)		Port #3	
A/9	Peak	30.5	12			13	5
	Channel	23	9	18	7	23	9
C/147	Peak	18	7			23	9
	Channel	25.5	10	15	6	18	7
F/253	Peak	51	20			25.5	10
	Channel	25.5	10	28	11	33	13

† *Distance between coal in oven and roof of oven.*

Roof carbon buildup can effectively reduce the channel height if it is thick enough; however, no large roof carbon buildup was observed during the inspection.

Chuck Door and Lid Operations

The time the chuck door is open, prior to the entry of the leveling bar and after the leveling bar is withdrawn, should be kept to a minimum to prevent the introduction of air into the oven and the resultant loss of steam aspiration effectiveness.

Those times the chuck door was open, prior to the entry of the leveling bar, were documented while charging emissions were being observed as well as during the two days prior to observing charging. The times averaged 17.1 seconds with a high of 52 seconds and a low of 7 seconds.

Lids should not be removed from open ports during charging unless the port is being charged or is otherwise sealed to prevent the introduction of air with an escape of emissions from the oven. The sequence for removal and replacement of lids at Kaiser was as follows. Lids 1 and 3 were removed for charging and lid 2 was inverted. Then hoppers 1 and 3 were emptied simultaneously. The lid on the charge port for the hopper which emptied first was replaced, followed by the other lid. Inverted lid 2 was not replaced until the battery top around oven port 2 was swept.

Gooseneck and Standpipe Openings

The passageway through the goosenecks and standpipes must be kept clear to obtain maximum aspiration from the ovens. Figure 2 shows the effect of reducing the gooseneck area upon gas flow from the oven. As

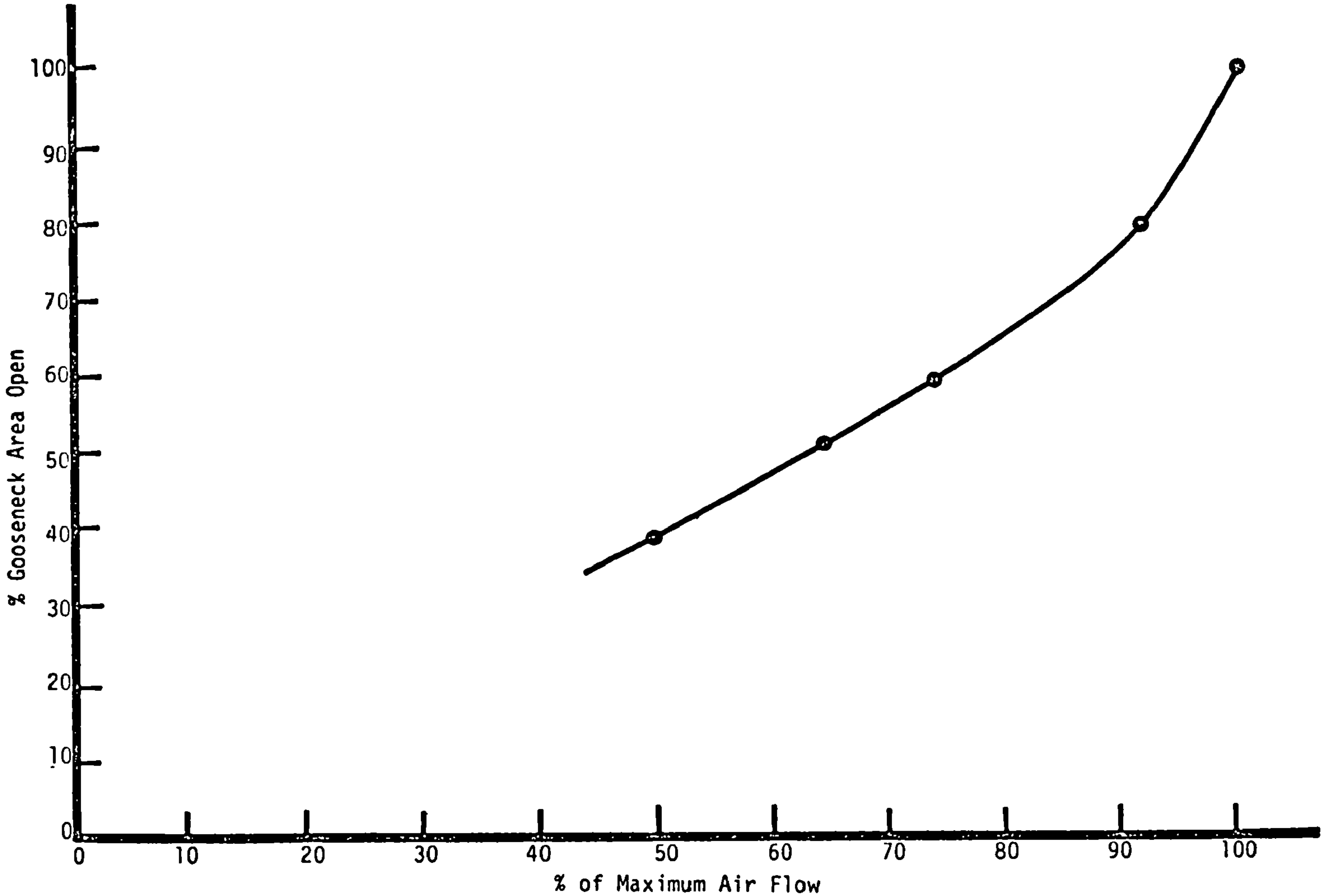

Figure 2. Percent Air Flow vs. Percent Gooseneck Area Open[1]

an example, a 3.8-cm buildup of carbon around the inside perimeter of a 33-cm diameter gooseneck reduces the area by 41%, and, according to Figure 2, reduces the aspiration by 25%.

During the inspection, four standpipes and twelve goosenecks were inspected with the aid of a mirror until the mirror broke. Three standpipes and seven goosenecks were free of significant carbon buildup. Five goosenecks had carbon buildup of 2.5 cm to 5 cm partially or completely around perimeter, and one standpipe was more than half blocked. This standpipe was replaced because of a leaking base.

The Company gooseneck cleaning procedure calls for cleaning approximately every fifth set of goosenecks, caps, and nozzles for all shifts. Cleaning is done manually with a chisel-headed steel bar.

Coal Bulk Density

If the bulk density of the charged coal is low (also indicated by a high percentage of less than 1/8-inch mesh), the amount of fines charged to the oven and the potential for emissions increases.

The bulk densities reported by the Company during the inspection were within the normal range (480 to 800 kg/m^3)[2] Therefore, bulk density was probably not a contributing factor to the charging emissions observed.

Aspiration Steam Pressure

Sufficient aspiration steam pressure at the oven is necessary to evacuate air and evolved gas from the oven during charging. Insufficient aspiration steam pressure can be due to low header pressure, excessive pressure drop in the lines, blocked or partially blocked nozzles, and improperly sized nozzles or header pipes.

At Kaiser, the header pressure was recorded from a gauge about 10 meters north of midbattery for all units; the accuracy of the gauges was not requested. Header steam pipes were reported to be 5.1 cm (2 in) inside diameter and the nozzle size was reported to be 1.4 cm (9/16 in) inside diameter. The static (between charges) and dynamic (during charging) pressures were recorded during charging observations.

Table 2 compares average steam pressures with average duration of emissions for each battery (each battery has its own steam line). The Table shows a general trend toward shorter emissions as steam pressure increases, although the data base is small; exceptions include batteries C and F which do not show good correlation. On an oven-to-oven basis, there are instances of no correlation between steam pressure and duration of emissions. For example, ovens 303 and 333 had the highest (65 sec) and lowest (5.5 sec) emission times for battery E, and both had the same dynamic pressure of 6 kg/cm^2 (85 psi).

Available aspiration steam pressure was lower than that for other coke batteries observed by the NEIC for 5 of the 7 batteries (batteries D and F being the exceptions). Studies show that a 4.28 m (14 ft) oven requires about 62 std m^3/min (2,200 scfm) aspiration[1]. Figure 3, which is a plot of aspiration capacity and steam pressure at the nozzle, indicates that approximately 7.7 kg/cm^2 (110 psig) is needed at the nozzle for a double collector main to provide 62 std m^3/min aspiration. At 5.27 to 6.33 kg/cm^2 (75 to 90 psig), which is the steam pressure for most of Kaiser's batteries, aspiration ranges from 47 to 52 std m^3/min (1,650 to 1,850 scfm) for a double collector main battery.

Table 2

AVERAGE STEAM PRESSURES AND DURATION OF EMISSIONS

Battery	Static Pressure Readings			Dynamic Pressure Readings			Emissions
	No.	kg/cm^2	psig	No.	kg/cm^2	psig	seconds $\geq$ 20% opacity
A	2	5.03	71.5	2	5.24	74.5	43.6
B	2	5.83	83	3	5.74	81.7	47.4
C	4	6.70	95.3	2	6.19	88	5.5
D	2	8.15	116	2	7.38	105	6.9
E	1	7.24	103	3	6.44	91.6	13.2
F	4	8.95	127.2	6	8.32	118.3	19
G	1	6.33	90	5	6.05	86	29.1

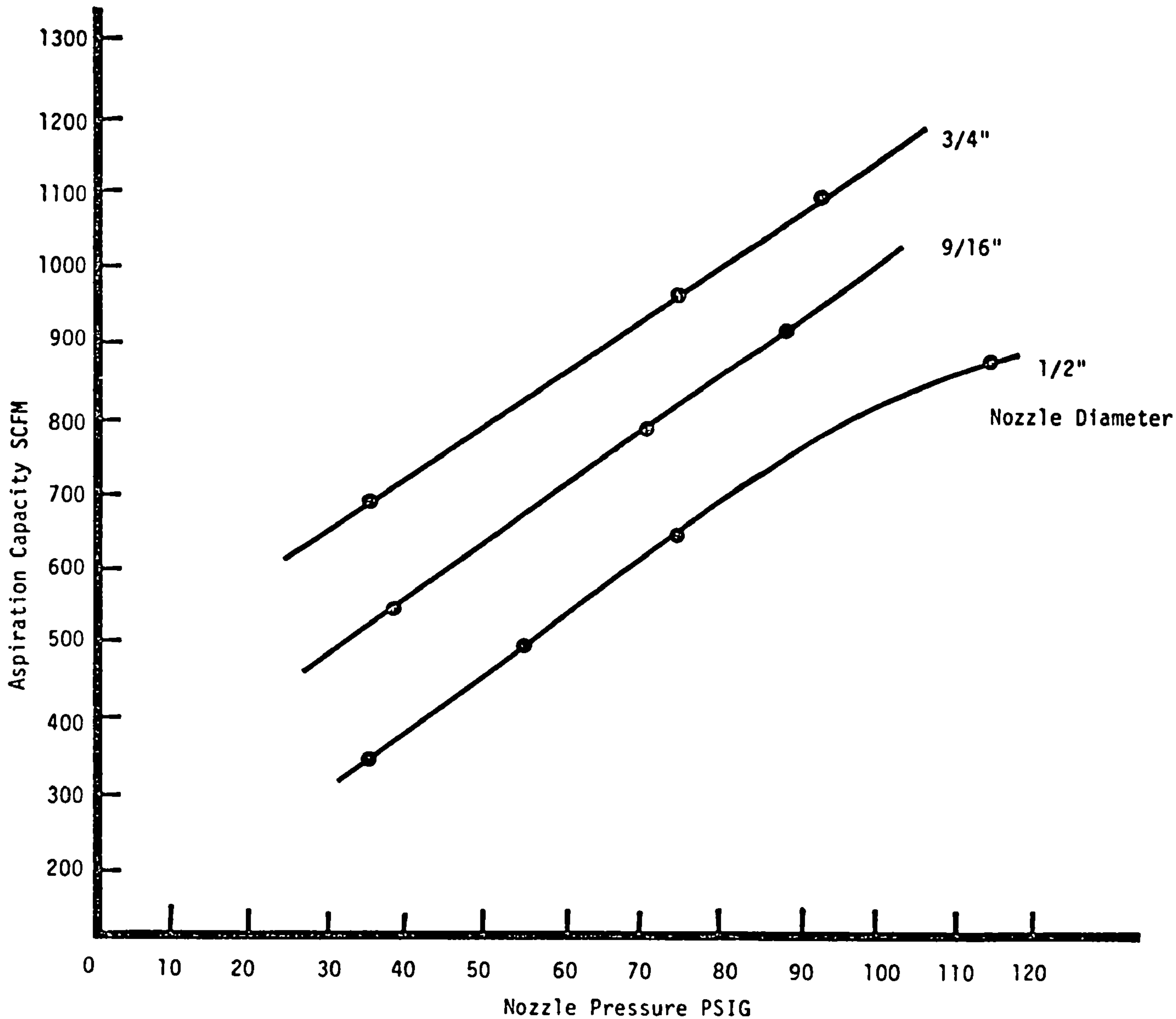

Figure 3. Nozzle Pressure vs. Aspiration Capacity for Single Standpipe[1]

The above estimates were made with the following variables taken into consideration. Although Kaiser's ovens are 4.28 m (14 ft) high, they are not as wide as the ovens that the study is based on and therefore would not require as much aspiration. On the other hand, the steam pressures evaluated were measured at the header. Actual nozzle pressure, hence aspiration, would be less due to pressure drop in the lines. Also, the volume of air in the oven which would be displaced by coal during charging was not taken into consideration and would require slightly more aspiration.

DOORS

Door Cleaning Practices

Adequate door cleaning before each coking cycle is necessary to reduce door leaks.[3] The door knife edge, refractory and jamb need to be reasonably clean to allow the door to fit well for sealing. The knife edges and jambs are especially prone to permitting door leaks if they are not clean. The door gas channel needs to be reasonably clean to allow coke gas formed near the door bottom to flow to the top of the oven. Gas pressures as high as 710 mm of H_2O can be present in the gas channel at the bottom of an oven shortly after charging[4]. Any restrictions in the channel to the flow of these gases can contribute to door leaks.

Kaiser's operating procedure requires regular door cleaning. Every door is given a routine cleaning each time it is removed. Worker instructions for a routine cleaning are as follows:

1. Using a short bar, all carbon must be removed from around the bottom of the jamb.
2. All carbon and loose tar must be removed from the jamb, using the long bar if necessary.

3. Gas passage on all doors must be kept open.

4. All loose carbon must be removed from each door.

5. Chuck door sealing edges and chuck door jamb surfaces must be clean of all carbon and heavy tar.

6. The sill plate must be cleared of all loose material.

7. Loose coke and tar must be pulled off the apron plate using a hoe.

8. The bench must be kept clean at all times to eliminate tripping hazards.

9. Everyone must understand the difference between: carbon, which is hard; heavy tar, which is very thick and will ultimately become carbon; and the light tar film which forms on the jamb surfaces. The light tar film is beneficial for sealing the ovens and should not be removed until it has accumulated beyond the regular film thickness and has started to form heavy tar and carbon.

Approximately every fifth door removed is given a special cleaning. Worker instructions for a special cleaning are:

1. Clean all loose carbon and tar from the door.

2. Using both the long and short bar, clean all carbon and heavy tar from the jamb face, shaving the carbon buildup on the inside of the jamb flush with the jamb surface.

3. Chip carbon from the door sill and the underside of the door butt plate.

4. Clean all tar from the apron plate, particularly in the area next to the jamb.

5. Clean the chuck door and chuck door jamb of all carbon and heavy tar.

6. Spillage must be thrown clear of the sill plate.

7. The pusherman (or benchman on 52 oven schedules) will scrape tar from top of jamb face immediately after removing the door and before the push.

Approximately once per month each door is given a chipping, which means stripping all hard tar and carbon from the door and knife edge. Worker instructions for chipping are:

1. Strip all carbon down to the brick and metal on the door and behind the sealing ring.
2. In all other ways, chipping is the same as special cleaning mentioned above.

Actual observation of the door cleaning practices revealed some significant deviations from the required procedures discussed above.

On routine cleaning, the door jambs were seldom cleaned, often deposits remained. The gas channels on the upper part of the door were sometimes nearly blocked and were not cleaned, and chuck doors were seldom cleaned.

On special cleaning, the upper part of the door jamb and the inside of the jamb were seldom cleaned. Observations also indicated that cleaning practices were sometimes not thorough. Instances were recorded where carbon deposits remained in gas channels and jambs after cleaning. Knife edges, however, were normally free of excessive deposits.

Door and Jamb Conditions

The condition of the door, especially the knife edge and gas channel, and the jamb are important to controlling door leaks. Warpage or other damage to these areas can result in significant leaks. An adequate supply of spare doors is necessary to replace warped or damaged doors so that they can be repaired.

Of approximately one hundred doors that were observed during the inspection, five had knife-edge damage, fifteen had refractory damage, none had gas channel damage, and no jamb damage was noted. The effect of recorded door damage was not evident from readings made on door leaks.

Spare Door Availability

Spare door checks indicated 0 to 2 readily available spare doors per side per operating unit. The need for spare doors is determined from operating experience, but in any case should be greater than zero.

Collector Main Pressure

During coking, the oven is kept under a slight positive pressure to prevent outside air from entering. If the oven pressure is higher than normal (up to 12 mm of H_2O) the additional pressure will tend to increase door, lid, standpipe cap, and other leaks. Table 3 lists approximate average collector main pressures obtained from chart recordings during the inspection period. These pressures are considered to be within the normal range.

Door Design

The knife-edge sealing mechanism and the depth and width of the gas channels are design parameters that could affect door leaks. Based on limited data from other coke plants, the depth of the gas channel (1.9 cm) on Kaiser's doors is shallow compared to other gas channel depths.

Table 3

COLLECTOR MAIN PRESSURE

Battery	Coke Side Chart mm/H_2O 8:00-16:00	Push Side Chart mm/H_2O 8:00-16:00
A	9	10
B	8	8
C	9	9
D	9	8
E	8	8
F	11	10
G	10	9

Chuck Door Sealing

Chuck doors are usually small metal doors that are especially susceptible to warping and leaks because they have no refractory lining. When a chuck door leak becomes significant at Kaiser, a gasket is inserted between the chuck door and its jamb. The gasket is replaced each time the door is opened. Inspection observations indicated that most gaskets were able to seal chuck door leaks.

LIDS AND STANDPIPES

Luting Practices

Luting lids and standpipe caps can greatly reduce the amount of leaks from these sources. Kaiser's luting procedure requires the following:

1. The standpipe lids are luted prior to dropping the charge.
2. The charging hole lids are luted immediately after the charge has been completed.
3. All charging steam must be left on until the luting operation has been completed.
4. All charging hole lids and standpipe lids must be luted to the point that there are *no visible smoke emissions*.
5. All smoke emissions that are visible within assigned working areas must be luted and/or reluted immediately. There are no exceptions to this rule.

Actual observation of lid and standpipe luting practice revealed that steps 4 and 5 listed above were not adhered to. The percentage of standpipe caps leaking per operating unit ranged from 3.3% to 21.1% and averaged 10.6%; the percentage of lids leaking per operating unit ranged from 0% to 5.2% and averaged 2.9%.

Physical Condition

Battery topsides (lids, standpipes, and collector mains) in poor condition due to warping, cracking, holes, etc. contribute to topside leaks. Inspection of the battery topsides at Kaiser did not indicate that the equipment condition was a major problem. Some standpipes with leaking flanges or bases were noted, along with several collector main leaks. However, the problem appeared to be one of maintenance, not of design, construction, or materials.

Collector Main Pressure

The effect of collector main pressure on lid and standpipes leaks was discussed in the section on Doors.

IV. RECOMMENDATIONS

Because of the limited amount of data with which to establish correlation between operating parameters and emissions, most of the following recommendations to reduce visible emissions are based on general observations and commonly accepted practices throughout the industry.

CHARGING

Aspiration steam pressure should be maintained at 7.7 to 8.4 kg/cm^2 (110 to 120 psi) for each battery.

Goosenecks, caps and nozzles should be cleaned for every oven charged rather than every fifth oven. Gooseneck cleaning should be improved; nearly half of the goosenecks observed following cleaning had carbon buildup of 2.5 to 5 cm. Machine cleaning should be considered.

Channel heights should be at least 30.5 cm (12 in). The installation of aprons in the larry car coal hoppers should be considered so that the volumetric settings and, hence, the channel height can be more closely controlled. In addition, if peak and channel heights cannot be taken, the angle of repose of the coal should be closely monitored and adjustments to volumetric settings made to ensure a 30.5-cm-high channel.

Chuck doors should be kept open for the minimum amount of time (less than 30 seconds) before and after the leveling bar is in the oven to minimize aspiration loss.

A proper charging sequence should be maintained. The number 2 hopper should be charged only after hoppers 1 and 3 are empty. In addition, number 2 lid should be replaced before seating to minimize leaks during the time while cleanup is taking place and before the lids are finally reseated and luted.

DOORS

Every door and jamb should be cleaned to the specifications of a "special cleaning" as defined in Kaiser's standard operating procedures. The oven schedules obtained each morning from the Company allowed no additional time for special cleaning. Therefore, special cleaning each door, rather than "routine cleaning", should not slow production.

More spare doors should be made available for both coke and push sides on all batteries. Doors observed in need of repair when removed should be replaced by a spare door.

LIDS AND STANDPIPES

The standard operating procedure for luting and reluting lids and caps should be strictly adhered to.

Collector main and standpipe flange leaks should receive greater attention. They should be luted or otherwise repaired.

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