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Envirotech/ Chemico Pushing Emissions Control System Analysis

Final Report

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DISCLAIMER

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CONFIDENTIALITY STATUS

This report was reviewed by each steel company mentioned herein--Bethlehem Steel, U.S. Steel, Republic Steel, J&L Steel and Shenango. No confidential claims were asserted on any information contained in this report.

PEER REVIEW

This report was peer reviewed by several EPA personnel, and each individual's comments were addressed by GCA and/or the Assignment Manager during preparation of this Final Report.

ABSTRACT

This report summarizes a 3-month study of the 21 Envirotech/Chemico one-spot, mobile pushing emissions control systems currently installed at coke plants operated by five domestic steel companies. The study investigated; (1) design differences between cars; (2) startup, operational and maintenance problems reported by each steel company; (3) mass and visible emissions test data; (4) car availability; and (5) solutions to operating problems implemented and/or under consideration. Information in the report was developed through detailed discussions and field inspections at four steel companies; discussions with EPA engineers and review of EPA, state and local regulatory agency files; office discussions with the equipment vendor; and review of the technical literature. The objective of this report is to factually present information available through the above sources.

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ACKNOWLEDGMENT

A number of individuals within EPA and the steel industry contributed to this study. A high level of cooperation from staff members of each steel company visited is gratefully acknowledged. Messrs. T. Maslany, E. Wojciechowski, R. Ida, R. Craig, R. McCrillis and D. Hlustick, all with EPA, reviewed the report, and provided comments which have been incorporated into this Final Report.

SECTION 1

INTRODUCTION

PROJECT BACKGROUND AND APPROACH

At the request of EPA's Division of Stationary Source Enforcement in Washington, D.C. (DSSE), GCA/Technology Division conducted an engineering assessment of the 21 Envirotech/Chemico pushing emissions control cars operated by five domestic steel companies. The study objectives were defined by EPA as follows:

- Investigate design and construction parameters of the cars;
- Investigate startup, operational and maintenance problems encountered by each company;
- Document solutions to problems implemented by Envirotech/Chemico and each steel company;
- Review maintenance programs at each company;
- Summarize available mass and visible emissions test data;
- Assemble data to describe car availability; i.e., number of pushes caught and scrubbed divided by total number of pushes occurring during the same period.

The primary source of information in this report was office discussions and field inspections held between GCA and four of the five steel companies that operate Envirotech/Chemico cars. Office discussions were also held between GCA and Envirotech's Vice President and one of their Project Engineers. Bethlehem Steel Corporation declined to participate in the plant visits due to pending litigation. Some data for the Bethlehem plant were available from regulatory agencies.

Each EPA engineer responsible for steel mills in Regions II, III and V (all Envirotech/Chemico cars are in these three EPA regions) was contacted to obtain all available information relative to study objectives. Additionally, the technical literature including published and informal EPA reports were reviewed, especially for emissions test data.

The overall study objective was to provide a factual reporting of problem areas and solutions as described to GCA by each steel company. Two companies, Republic Steel and Shenango, reviewed GCA's trip reports describing discussions held at the plants, and their review comments were incorporated into this report. Trip report review comments were not received from U.S. Steel and J&L Steel.

REPORT ORGANIZATION

The background and development history of the Envirotech/Chemico push control cars are described in Section 2. A process description and status of each installed system as of Spring 1982 appears in Section 3. Mass and visible emissions data appear in Section 4.

A summary of problem areas described by the steel companies visited appears in Section 5, based on the detailed trip reports prepared for each plant visit. Section 6 provides available information on car availability and maintenance programs.

SECTION 2

ENVIROTECH/CHEMICO PUSH CONTROL CAR
DEVELOPMENT AND HISTORY

HALCON CAR DEVELOPMENT

Early History

The American Iron and Steel Institute (AISI) commissioned J.E. Allen Associates in the early 1970s to investigate pushing emissions control techniques. The so-called Allen hooded quench car/trailer control car concept was developed which eventually evolved into the current Envirotech/Chemico Halcon-II (H-II) and Halcon-III (H-III) designs.[1]

The original concept called for a three-car train consisting of: (1) a conventional electric locomotive, (2) an enclosed quench car, and (3) an equipment (scrubbing) car. The equipment car was envisioned to contain large rotating exhaust fans and conventional wet scrubbers. AISI did not readily accept this early design concept because gyrational and vibrating effects inherent to large rotating fans were not considered practical for continuous shuttle service.

Development of Halcon Car

The direct forerunner of the current design was developed in 1972 by John Allen and John Hanley (Hanley-Allen Pollution Control Services) in conjunction with Interlake Inc.'s technical center and the Aeronetics Division of Thermotics, Inc. Interlake suggested that the original concept be redesigned to use Aeronetic's Adtec static, jet-type exhauster/air cleaner device instead of conventional fans and scrubbers. The Aeronetics exhauster, developed during the NASA program, was operating at a ferroalloy electric furnace at Chromasco, Inc. in Memphis, TN with apparent success. Interlake agreed in April 1972 to finance development and testing of the new concept at Interlake's Chicago coke plant.

A prototype unit, termed the Halcon system, was designed and tested at Interlake during the summer and fall of 1973. Initial tests suggested the concept was viable but significant difficulties still existed. Modifications to the entrainment separator and quench car design during the winter of 1973-74 led to a demonstration of the system to EPA in November 1974. In December 1974, the system became the property of Chemico Air Pollution Control Corporation which became a division of Envirotech Corporation in 1978.

Design details of the Halcon prototype demonstrated at Interlake in 1974 appear in a technical paper by R.S. Patton of Interlake.[1] Major design differences between this prototype and the commercial Envirotech/Chemico H-II and H-III configurations are as follows:

- Flat water sprays were provided in the prototype to curtain the hood opening where coke first enters the system. The commercial version does not use water sprays.
- Equipment (scrubber) car was not enclosed at Interlake, while the commercial installations placed equipment inside an enclosed car.
- Interlake prototype was designed to quench coke in hooded quench car, eliminating the quench tower. This concept was eliminated in the commercial version, and a conventional quench tower with modified water sprays was used.
- An electric locomotive was used to propel the Interlake prototype, while the existing H-II and H-III cars are self propelled via on-board electric motors.
- Conventional quench car (not one-spot) on prototype was used with a plenum-type hood and exhaust duct. A one-spot quench car was developed by Chemico for the commercial installations.

Development of the Envirotech/Chemico H-II Car

After acquiring the Halcon design in 1974, Chemico further developed the system into the H-II configuration. The H-II is described in detail later in Section 3. Refinements to the Halcon prototype included the following:[2]

- Duplicates of key equipment were added, except for large and heavy components such as the diesel generator, water heater and separator.
- Equipment car was enclosed, pressurized and heated.
- Self-powering of control car eliminated need for locomotive and reduced overall system length from 165 to 100 feet.
- Onboard sump pumps were eliminated by providing gravity drain of dirty scrubber water.
- Number of wheel trucks were increased to reduce track loading.
- Diesel generator was isolated and soundproofed.
- Stainless steel ducts and rubber-lined pipe were added.
- Integral cab and control room were air conditioned with filtered air.
- One-spot quench car was developed.
- Coke guide hood configuration was improved.

Development of the H-III

The H-III car was developed in the late 1970s in response to concerns over fuel oil consumption of the H-II. The primary differences between the H-II and H-III cars are the elimination of the onboard diesel generator and fuel oil fired hot water heaters (H-II), relying instead on hot rail electric power and a land-based water heater designed to fire coke oven gas and water transfer system (H-III). Details are provided in Section 3, System Description. In discussions with GCA, Envirotech/Chemico emphasized that the H-III cars were sold and installed without the benefit of a prototype unit upon which to base final design.

CAR ORDERS

In November 1975, negotiations between EPA Region III and J&L Steel led to a commitment by J&L to select a push emissions control system by January 1976. On 1 February 1976, J&L became the first buyer of the Chemico H-II system when J&L announced selection of the H-II for battery P-4 at the Pittsburgh Works.

Also in 1976, the Pennsylvania DER was engaged in litigation with Bethlehem Steel relative to pushing emissions at the Johnstown and Bethlehem plants, among other issues. In February 1977, Bethlehem Steel ordered four Envirotech/Chemico H-II cars for the Bethlehem, Lackawanna and Sparrows Point plants. By 1978, 26 cars were sold; however, the last five car orders placed by Bethlehem Steel were cancelled before car delivery.

Table 1 summarizes H-II and H-III car orders as described by Envirotech/Chemico.

BACKGROUND AND CURRENT STATUS OF ENVIROTECH/CHEMICO

The Halcon system was acquired from John Hanley by Chemico Air Pollution Corporation in December 1974. At that time, 15 to 20 Chemico staff members were assigned to the task of commercializing the prototype system demonstrated at Interlake. In February 1975, John Hanley, the co-developer, became an independent representative of Chemico. Mr. Hanley was involved in development work, and later, marketing and car startup.

Chemico became a division of Envirotech Corporation in 1978. Mr. Anthony Fazio, the current (1982) Envirotech Vice President, became involved with the program in April 1978. By the summer of 1978, 200 Envirotech/Chemico employees were working on the project, of which about 75 were employed in Envirotech/Chemico's assembly shop. (Some construction was subcontracted to other organizations.)

In January 1980, Envirotech/Chemico announced they were withdrawing from the pushing emissions control market and no new orders would be accepted. The company announced they would continue to fulfill existing contract obligations.

TABLE 1. H-II AND H-III CAR ORDER SUMMARY

Company	No. of cars	Type	Order date	Delivery date	Chemico job No.	Assembly location	Frame builder
J&L/Pittsburgh (P4)[a,b]	1	H-II	2-76	10-77	3014-W	Buell	Atlas
Bethlehem/Bethlehem (No. 5)	1	H-II	2-77	9-77	3086-W	Atlas	Atlas
U.S. Steel/Clairton (Nos. 19,20)	1	H-II	3-77	5-79	3093-W	Buell	Easton
Bethlehem/Lackawanna (Nos. 7,8)	1	H-II	4-77	6-79	3100-W	Buell	Maxson
Bethlehem/Sparrows Pt. (Nos. 11,12)	1	H-II	4-77	6-79	3097-W	Buell	Maxson
Shenango/Neville Island	1	H-II	9-77	9-79	3121-W	Buell	Maxson
Republic/Warren (No. 4)	2	H-III	10-77	7-79	3124-W	Niles	Atlas
U.S. Steel/Clairton (Nos. 21,22)	1	H-III	1-78	9-79	3154-W	Niles	USS
Bethlehem/Bethlehem (Nos. 2,3)	1	H-II	2-78	12-79	3150-W	Atlas	Atlas
J&L/Ind. Harbor (Nos. 3,4)	1	H-III	2-78	12-79	3152-W	Niles	Maxson
Republic/Youngstown (Nos. B,C)	1	H-III	6-78	9-79	3124-Y	Niles	Atlas
U.S. Steel/Clairton (Nos. 1,2,3)	1	H-III	6-78	11-79	3154-W	Niles	USS

(continued)

TABLE 1 (continued)

Company	No. of cars	Type	Order date	Delivery date	Chemico job No.	Assembly location	Frame builder
U.S. Steel/Clairton (Nos. 13, 14,15)	2	H-III	11-78	1-80	3154-W	Niles	USS
Republic/Cleveland (Nos. 6,7)	2	H-III	11-78	3-80	3198-W	Niles	Morgan
J&L/Ind. Harbor (No. 9)	1	H-III	2-79	2-80	3152-W	Niles	Maxson
U.S. Steel/Clairton (Nos. 19,20)	1	H-III	2-79	3-80	3154-W	Niles	USS
Bethlehem/Lackawanna (No. 9)	1[c]	H-II	2-79	12-80	3219-W	-	-
U.S. Steel/Clairton (Nos. 1,2,3)	1	H-III	4-79	6-80	3154-W	Niles	USS
U.S. Steel/Clairton (Nos. 7,8,9)	1	H-III	5-79	6-80	3154-W	Niles	USS
Bethlehem/Bethlehem	1[c]	H-II	6-79	1-81	-	-	Maxson
Bethlehem/Sparrows Pt. (Nos. 1, 2,4,5)	3[c]	H-II	6-79	3-81	323-1	-	Maxson

[a]Batteries served shown in parenthesis.

[b]H-II on P-4 replaced with Minister Stein in 1981.

[c]Cancelled orders; cars never completed.

In 1981, General Electric Company purchased ongoing business of the Chemico and Buell Divisions of Envirotech Corporation in order to enter the pollution control equipment market. However, the new company, General Electric Environmental Services Inc. (GEESI) does not have responsibility for the push control project according to Mr. Fazio, Envirotech Vice President, and a Project Engineer, Mr. Sandor Kaldor who were the only two personnel assigned to the project in 1982. Messrs. Fazio and Kaldor continue to work out of GEESI's New York offices in order to complete Envirotech/Chemico's push control car contracts.

SECTION 3

SYSTEM DESCRIPTION

INTRODUCTION

Background data describing each battery served by an H-II or H-III system appears in Table 2. The basic operating principles of the scrubbing system are equivalent between the H-II and H-III cars since each design uses the Aeronetics hot water scrubber. The primary differences between the H-II and H-III systems are as follows:

- The H-II has an on-board hot water heater, while the H-III cars receive hot water from a land-based heating system.
- The H-II has an on-board diesel AC generator to power scrubber system equipment and the traction drive motors. The H-III is powered by DC current drawn from battery hot rails.
- The H-II is substantially heavier than the H-III due to the above differences.

All H-III systems were originally designed to use coke oven gas (COG) in the land-based heating building to heat hot water, except at Clairton. The Clairton system uses plant steam heating in lieu of COG heaters. Water treatment systems for land-based removal of solids were supplied to all steel companies as part of the Envirotech/Chemico package, except at Clairton where U.S. Steel provided their own water treatment facilities.

Coke guide hoods and one-spot quench cars are essentially identical between the H-II and H-III systems, except for minor design changes made prior or subsequent to startup.

Envirotech/Chemico indicated to GCA that design and construction details of each H-II and H-III system were essentially identical. Scrubber car frames, wheel truck assemblies, and the basic cab structure were purchased from suppliers by Envirotech/Chemico with the exception of the eight Clairton cars. U.S. Steel built their own frames and operator's cab structures for Clairton and Envirotech/Chemico installed the internal equipment. For all other H-II and H-III cars, Chemico or their subcontractor(s) built the system internals into the purchased car frames and wheel assemblies. All single-spot quench cars were built to Envirotech/Chemico's specifications by subcontractors except for the Clairton quench cars which were designed and built by U.S. Steel.

TABLE 2. DESCRIPTION OF BATTERIES SERVED BY ENVIROTECH/CHEMICO PUSH CONTROL SYSTEMS[a]

No. of cars	Facility/ location	Battery served	Battery startup date	Most recent battery rehabilitation date	Battery design	Battery heating system	Total number of ovens	Oven height	Number of pushes per day (all units listed)	Tons of coke per push
1	Bethlehem Steel Bethlehem, PA	Nos. 2,3	1941 1942	- -	Koppers-Becker Koppers-Becker	Gun-flue Gun-flue	102	3-meter	?	?
2	Bethlehem Steel Bethlehem, PA	No. 5	1953	1977 (rebuilt)	Koppers-Becker	Gun-flue	80	4-meter (12 ft.-6 in.)	96 (avg.)	11
1	Bethlehem Steel Lackawanna, NY	No. 7 No. 8	1952 1961	1979 (rebuilt) -	Wilputte Wilputte	Underjet Underjet	76 76	12 ft.-2 in.	210	11
1	Bethlehem Steel Sparrows Pt., MD	No. 11 No. 12	1955 1957	- -	Koppers-Becker Koppers-Becker	Underjet Underjet	65 65	4-meter	143	11
1	J&L Steel/ E. Chicago, IN	No. 4[a]	1956	1976[b]	Koppers-Becker	Underjet	75	13 ft-0 in.	105	12.1
1	J&L Steel E. Chicago, IN	No. 9[a]	1961	1979[b]	Koppers-Becker	Underjet	87	13 ft-0 in.	110 (116-max)	12.1
1	J&L Steel Pittsburgh, PA	P-4[c]	1953	1977[b]	Koppers-Becker	Underjet	79	13 ft-0 in.	111	?
2	Republic Steel Cleveland, OH	No. 6 No. 7	1952 1952	1979[d] 1981[d]	Koppers-Becker Koppers-Becker	Gun-flue Gun-flue	63 63	13 ft-2 in. (4-meter)	126 (174-max)	11.7
2	Republic Steel Warren, OH	No. 4	1979	-	Koppers	Gun-flue	85	13 ft-0 in. (4-meter)	110 (120-max)	12.7
1	Republic Steel Youngstown, OH	B C	1950 1960	1962 (rebuilt) -	Koppers Koppers	Gun-flue Gun-flue	65 59	13 ft-2 in. (4-meter)	120 (144-max)	11.5
1[g]	Shenango Inc. Neville Isl., PA	No. 3[f] No. 4	1948 1951	1971-1972[e] 1974-1975[e]	Koppers Koppers	Underjet Underjet	35 35	4-meter	80[g]	15

(continued)

TABLE 2 (continued)

No. of cars	Facility/ location	Battery served	Battery startup date	Most recent battery rehabilitation date	Battery manufacturer	Battery heating system	Total number of ovens	Oven height	Number of pushes per day (all units listed)	Tons of coke per push
2	U.S. Steel Clairton, PA	Nos. 1,2,3	1955	1979[h]	Wilputte	Gun-flue	192	13 ft-0 in.	240	11.3
1	U.S. Steel Clairton, PA	Nos. 7,8,9	1954	-	Koppers	?	192	4-meter	?	?
2	U.S. Steel Clairton, PA	No. 15	1953	1979 (rebuilt)	Koppers	?	61	4-meter	?	?
2	U.S. Steel Clairton, PA	No. 19 No. 20	1951 1951	1977 1978 (rebuilt)	Koppers-Becker Koppers-Becker	Underjet Underjet	87 87	5-meter 5-meter	171	14.5
1	U.S. Steel Clairton, PA	No. 21 No. 22	1947 1946	1972[b] 1973[i]	Koppers-Becker Koppers-Becker	Underjet Underjet	87 87	5-meter 5-meter	201	14.4

[a]Battery No. 4 pushed empty in October 1981, Battery No. 9 pushed empty in March 1982.

[b]End-flue rehabilitation.

[c]H-2 car was permanently removed from service July 3, 1981.

[d]End-flue, and some through-wall rehabilitation.

[e]End-flue, and some end-wall rehabilitation.

[f]Battery No. 3 scheduled for replacement with new 56 oven battery in June-July 1982. H-II car will then serve only Battery No. 4 (shed on new battery).

[g]System designed for three battery operation (Nos. 1, 3 and 4)--total of 105 ovens, 140 pushes/day.

[h]Partial rehabilitation (standpipes, doors, etc.)

[i]Complete rebuild from the bench up.

Although both Envirotech/Chemico and the steel companies visited reported all cars are identical, several minor differences were noted by GCA during plant inspections. The impact of the following differences on car reliability is further described later in Section 5.

- The U.S. Steel-supplied car frames at Clairton, and Republic's Warren car (all H-III) use wooden power pick-up arms. The cars supplied to J&L at Indiana Harbor use a steel pickup arm arrangement.

- The U.S. Steel-supplied scrubber car and quench car frames at Clairton, and the two cars at Republic/Cleveland were supplied with "stucki bearings". The other, Chemico-supplied car frames at plants visited by GCA used solid wear plates instead of stucki bearings.

- GCA was informed by Envirotech/Chemico that minor changes were made by Envirotech/Chemico during car production. Some changes were also made based on field experience with systems already on-line. Other minor differences may have resulted from the fact that cars were assembled at several different locations.

- All systems have been modified by each steel company, accounting for additional minor differences.

Design and operation details are discussed below, drawn primarily from a Chemico paper published in Iron and Steel Engineer magazine.[2] Differences between H-II and H-III systems are also described.

GENERAL SYSTEM DESCRIPTION

Both H-II and H-III systems consist of a control car that houses scrubbing equipment, a one-spot, enclosed quench car, a hooded coke guide and a land-based water treatment and transfer station. The heart of the scrubber car is the Aeronetics hot water scrubber which also provides the draft for gas movement. The H-II scrubber car contains an AC diesel generator to power on-board equipment, and an oil-fired hot water heater to supply the Aeronetics scrubber jets. The H-III cars are powered by DC current from bench-mounted hot rails, eliminating the onboard diesel generator. Additionally, the H-III draws hot water from a land-based heating and transfer system, eliminating the on-board heater used on the H-II.

For both H-II and H-III systems, a one-spot enclosed quench car travels with the scrubber car. The tilting stainless steel coke box (original Chemico-supplied coke boxes were stainless steel) is enclosed on three sides and the top to contain emissions. The side facing the oven is partially open to receive coke. After the push, quench water is introduced through this opening via modified quench tower nozzles.

Closure plates added to the plant's existing coke guide on both sides of the coke discharge opening align with the quench car opening to contain emissions. Other guide modifications in the H-II and H-III design close small openings on both sides, the top and the bottom of the guides.

A land-based water treatment system and gravity feed transfer system supply cold (or slightly heated) water to the H-II. The H-III receives heated, pressurized water from a land-based heating and transfer station. Quench tower portals (openings) and water spray nozzles usually required modifications to accomodate the one-spot quench cars. The water treatment system processes the raw water supply to a quality level required by the scrubber. Scrubber water is blown-down from the car at the quench tower and discharged to plant wastewater handling systems.

SCRUBBER CAR DESIGN AND OPERATION

Basic scrubbing functions are similar for the H-II and H-III cars. Two Aeronetics jet nozzles operating in parallel receive 400°F, 400 psi water from the onboard storage tank on the H-III, and either from an onboard storage tank or directly from the onboard heater on the H-II. The nozzles exhaust gas from the coke guide hood and quench car, through the scrubbing section, into an entrainment separator and out a short, rectangular, vertical stack at the same elevation as the battery top level.

A temperature sensor upstream of the Aeronetics jets controls hot water flow to the jets, thus regulating exhaust flowrates. The system was originally designed to operate at approximately 60,000 scfm during a "normal" push, with up to 90,000 scfm available for green pushes. Quench sprays in the duct between the quench car and the scrubber car were designed to prevent excessive temperatures during very green pushes. Exhaust flow is automatically reduced to 35,000 scfm during travel to the quench tower.

As designed, approximately 40 to 50 percent of the water supplied to the Aeronetics jets evaporates. The remaining water is removed in the multicyclone entrainment separator. Dirty water drains by gravity at the quench tower.

The scrubber car consists of two integrated sections on both the H-II and H-III, an operators cab and the equipment room. The entire scrubber car is air conditioned and pressurized to prevent dust entry. The H-II is propelled by two 150-hp, DC traction drive motors mounted on wheel trucks under the scrubber car. DC from hot rails can be used for emergency movement of the H-II in the event of generator failure. The H-III is propelled by four 75-hp DC traction drive motors, supplied with DC current from hot rails mounted along the battery bench. The H-III cannot propel itself if DC power is lost.

Onboard Equipment - H-II and H-III

The scrubber car houses all AC starters, DC contactors, switch gear, overload protection devices, relays, programmable control devices and a rectifier.

Two onboard rotary air compressors (one operating, one spare) rated at 125 cfm and 100 psig discharge pressure provide air for the brakes, instruments and in the case of the H-II only, fuel atomization in the water heater. Brake and instrument air is cooled; only instrument air is dried via a water separator and twin-tower, regenerative air dryer.

Two onboard hydraulic pumps (one operating, one spare) provide pressure for the twin hydraulic dump cylinders that tilt the coke box for dumping to the wharf. The prime hydraulic pumps and air compressors are AC powered. On some H-II and H-III cars, the spares are DC powered so if one power source fails, the other maintains braking and coke box dump capability. (The U.S. Steel quench cars use air cylinders to empty the coke box; all Envirotech/Chemico-supplied quench cars use hydraulic cylinders).

Programmable controllers consisting of banks of removable, printed circuit boards control car sequence operations, i.e., the scrubbing cycle and safety interlocks. For example, the car was designed so the car won't move when the coke box is in the dump position, hot water transfer won't occur unless the car is properly aligned at the charge station, etc.

The onboard AC diesel generator on the H-II cars is rated at 400 kw prime, and provides 460V, 3-phase, 60 Hz power at 1200 rpm for scrubbing system equipment. The standard 400 kw generator can move the scrubber car with gas cleaning equipment turned off if DC hot rail power is lost. Envirotech/Chemico also offered a 600 kw generator capable of scrubbing and moving the car simultaneously, eliminating the need for hot rail power.

The water heaters in the H-II cars are fired with No. 2 fuel oil and sized at 8, 10 or 12 mm Btu/hr depending on length of duty cycle (i.e., elapsed time between pushes). The larger heater sizes fill much of the available space inside the H-II car.

After the scrubbing section, scrubbing liquor and particulate are removed from the exhaust gas in a two-chamber entrainment separator. Exhaust gas first enters an open chamber in the separator where the gas decelerates and water droplets and particulate drop out by contact with internal surfaces. The gas then enters a bank of small cyclones in the second section of the separator for final gas/liquid separation. Design pressure drop across the entire separator at maximum exhaust gas flow is 8 in. WC.

Exhaust Flow Rate Selection

The 6 to 9 inch gap between the coke guide closure plates and the quench car was selected to handle elevation differences between the track and ovens. No sealing material was originally envisioned for this 6 to 9 inch gap, although some steel companies have attempted to find a suitable sealing material. A seal was provided by Envirotech/Chemico for at least one system (Shenango).

Exhaust flow rate selection was based on achieving adequate fume capture and maintaining combustion of volatiles and fixed carbon contained in the exhaust stream. Design intake velocity at the 6 to 9 inch gap between the coke guide closure plates and the quench car opening is 20,000 fpm at the maximum design flowrate of 90,000 scfm. Chemico selected this indraft velocity to contain emissions based on the Interlake prototype and fume capture design principles.

Maintaining combustion of volatiles and fixed carbon provided another basis for design flowrates. Envirotech/Chemico reports that discussions with coke oven experts indicated that 10 lb of fixed carbon and 5 lb of volatile matter per ton of coke are typically evolved. The total amount of air necessary for complete combustion was determined stoichiometrically at 60,000 scfm for a 30-second push duration. A maximum design flowrate of 90,000 scfm was selected to handle green pushes.

Aeronetics Scrubber Details

The jet ejector effect of expanding water through the Aeronetics nozzles transfers momentum from the water to the gas, thereby increasing gas pressure. This provides a particulate removal capability that Chemico reported to be equivalent to a venturi scrubber operating at over 100 inches WC pressure drop. Because of the momentum transfer, the Aeronetics scrubber only has to overcome duct and separator pressure drops of approximately 12 in WC.

Scrubbing efficiency is proportional to water velocity and droplet size. The greater the velocity difference between the water and particulate, and the more droplets available, the higher the scrubbing efficiency. The water velocity is dependent on hot water temperature (and pressure), i.e., higher velocities (and better scrubbing) are achieved with hotter water and pressure. Also, finer droplets are formed with higher water velocity, enhancing scrubbing efficiency. The H-III system has interlocks to prevent hot water transfer to the car if temperature and pressure are too low, thus maximizing control device efficiency.

DESCRIPTION OF H-III LAND-BASED HOT WATER SYSTEM

The Envirotech/Chemico-supplied land-based equipment for the H-III system consists of a water treatment system, hot water heaters and storage tanks, and the transfer mechanism which feeds hot water to the control car. (The only exception is Clairton Works where U.S. Steel provided water treatment.)

Incoming river or lake water is filtered to remove suspended solids, softened to remove hardness, and chemically treated. Chemical treatment consists of: (a) oxygen scavenging; (b) dispersant addition to prevent scaling in the heat exchanger; and (c) corrosion inhibitor addition to protect all steel components. Treated water, stored in a service water tank, is pumped into the heater system via one of two high pressure pumps that maintains system pressure. A portion of the water passes through the heater; a by-pass picks up heat from the charge tank cooling loop. Both streams are mixed and discharged to a 4400 gallon hot water charge tank located in the transfer building. When the charge tank is full, flow through the heater stops and the heater goes into a low fire, "soak" mode.

When full, charge tank water is at 460°F and the equilibrium vapor pressure is 467 psig. The pressure differential between the land-based charge tank and the H-III car tank provides the driving force for water transfer to the car. Prior to entering the H-III, water from the charge tank is cooled to approximately 430°F in a second tank containing a shell and tube heat exchanger. This is necessary to prevent flashing in the transfer line since water in the charge tank is at its equilibrium vapor pressure. The system was designed to transfer water to the car every other quench (push) cycle.

Hot water transfer is accomplished during quenching when the H-III car is aligned with the transfer station located at the side of the transfer building. The charge arm on the car extends outward and mates with a nozzle on the transfer building. A number of limit switches must be satisfied by precise charge and alignment before transfer can occur. The transfer line is pressurized with water from the land-base cooler tank, and isolation valves on either side of the coupling open to allow water transfer. After transfer, the isolation valves vent and drain the coupling prior to disengagement.

Vapor pressure in the car tank provides the driving force for water flow through the jets when the jet isolation valves are opened. When full, car tank water is at approximately 430°F and 366 psia. To prevent flashing in the line between the jets and the car tank, water flows through a heat exchanger for subcooling prior to entering the jets.

DESCRIPTION OF THE H-II LAND-BASED SYSTEM

The H-II land-based system is simple relative to the H-III land-base because the water is unheated and unpressurized when transferred to the car. The H-II water treatment system discharges to an overhead storage tank near the quench tower. Cold or slightly preheated scrubber water fills the H-II during the quench via a simple gravity flow arrangement.

SECTION 4

EMISSIONS DATA SUMMARY

This section summarizes mass and visible emissions (VE) data available through regulatory agencies. When available, information useful for interpreting test results is included herein; i.e., coking time, VE observer position and observation techniques, deviations from test procedures and problems. However, it is important to note that background information was often not available in the test reports.

MASS EMISSIONS DATA

Mass emissions data available for H-II cars appears in Tables 3 and 4. Mass data for the H-III cars appears in Table 5. Generally, pushing and travel emissions were measured together. Front-half and back-half catches were reported for most H-II tests, while only front-half data were reported for the H-III cars. Additionally, it should be noted that all front-half results for both H-II and H-III cars were performed in accordance with EPA Reference Method 5. Back-half analysis must be performed in accordance with the requirements of the Pennsylvania Department of Environmental Resources (PADER) for all H-II and H-III cars located in the State of Pennsylvania. All mass data were drawn from stack test reports unless otherwise noted. Information contained in test reports pertinent to interpreting test results appear in the comments section of each table, if available.

VISIBLE EMISSIONS DATA SUMMARY

Available VE data for emissions escaping capture by the hot car - coke guide hood assembly appears in Tables 6 and 7 for the H-II and H-III, respectively. Most data were collected by recording the number of seconds of VE $\geq$20 percent opacity escaping the hood during the push using a cumulative stopwatch. A typical methodology appears in Appendix F. Unless otherwise noted, all data represent emissions during the push itself, defined as the time period between start of ram movement and the time all coke is in hot car.

The background used for observing VE is listed in the comments section if this information was available. Most of the VE data were compiled from test reports or letters and reports to regulatory agencies from steel companies. Often, data describing the observation background (i.e., sky, collector main, battery) were not available. The table headings vary somewhat between pages, reflecting the different types of VE data summaries available from EPA.

TABLE 3. SUMMARY OF PARTICULATE MASS EMISSIONS DATA FOR THE ENVIROTECH/CHEMICO H-II PUSH CONTROL CARS

Facility/ location	Test date(s)	Exhaust flow rate measured during push[a] ACFM	Exhaust flow rate measured during push[a] °F	Push and travel emissions, combined Front-half (gr/dscf)	Push and travel emissions, combined Back-half (gr/dscf)	Comments
Bethlehem Steel/ Bethlehem, PA Battery No. 5	7/27/78	-	-	0.043	0.038	• Tests by Bethlehem Steel • Particulate exiting the cyclonic separator noted by test crew.
	8/15/78	-	-	0.034	0.036	
	8/16/78	-	-	0.017	0.015	
	8/30/78	-	152	0.0327	0.0305	• Tests by Buell • Modifications by Buell (before these tests) included false bottom to prevent creeping of separated water.
		-	153	0.0226	0.0445	
	10/11/78	120,700	151	0.051	-	• Tests by Buell during the following modifications: stabilizing system pressure cycling and modifying heater controls to allow higher water temperature and prevent local pipeline flashing.
	10/12/78	120,700	150	0.031	-	
	10/26/78	100,000	147	0.021	0.058	
	10/27/78	105,000	150	0.026	0.083	

(continued)

TABLE 3 (continued)

Facility/ location	Test date(s)	Exhaust flow rate measured during push[a] ACFM	°F	Push and travel emissions, combined Front-half (gr/dscf)	Back-half (gr/dscf)	Comments
Bethlehem Steel Bethlehem, PA Battery No. 5	11/1/78	105,700	148	0.0318	0.037	• All following tests after above mentioned changes made. • Tests by Buell with unheated probe (11/1/78). • Tests by Buell with two high pressure pumps to scrubber nozzles operating simultaneously (11/2-3/78). • Each test consisted of ~15 push-travel cycles per run.
	11/2/78	116,900	150	0.017	0.057	
	11/3/78	123,500	150	0.013	0.041	
	11/14/78	107,000	151	0.0206	0.104	• Tests by Buell • Each test consisted of ~15 push-travel cycles per run. • Stopcock grease noted in back-half samples (first time checked).
	11/15/78	99,500	149	0.0144	0.103	
	1/16/79	122,000	139	0.0424	0.0514	• Tests by Betz-Converse-Murdoch • Results questionable according to test report.
	1/17/79	132,000	127	0.0316	0.0597	
	1/18/79	122,000	107	0.0274	0.0141	

(continued)

TABLE 3 (continued)

Facility/ location	Test date(s)	Exhaust flow rate measured during push[a] ACFM	°F	Push and travel emissions, combined Front-half (gr/dscf)	Back-half (gr/dscf)	Comments
Bethlehem Steel, Bethlehem, PA Battery No. 5	3/7/79	126,000	150	0.0423	-	• Compliance tests by Betz-Converse-Murdoch. • Each test consisted of 16 push-travel cycles per run. Average coking time = 20 hours. Approximately 11.3 tons coke pushed per oven. • No detectable stopcock grease in back-half.
	3/8/79	122,000	150	0.0295	0.079	
	3/9/79	122,000	150	0.0319	0.100	

[a]Test data at saturated conditions.

TABLE 4. ADDITIONAL MASS EMISSIONS DATA FOR THE ENVIROTECH/CHEMICO H-II CARS

Facility/ location	Test date(s)	Push emissions: Front-half (gr/dscf)	Push emissions: Exhaust flow rate, acfm	Push emissions: Temp. °F	Travel emissions: Front-half (gr/dscf)	Travel emissions: Exhaust flow rate acfm	Travel emissions: Temp. °F	Push and travel combined: Front-half (gr/dscf)	Push and travel combined: Back-half (gr/dscf)	Push and travel combined: Full-train (gr/dscf)	Comments
Bethlehem Steel/ Sparrows Pt., MD (Batteries 11 and 12)	10/13-17/ 1980	0.016	-	-	0.025	-	-	(0.0154 lb/ ton coke)	-	-	• Compliance tests by Betz-Converse-Murdoch. • First run conducted over 2 days.
		0.008*	134,029	150	0.013	43,660	143	(0.0140 lb/ ton coke)	-	-	• 48 pushes per run, 532.8 tons coke pushed/test run (based on 11.1 tons coke/oven).
		0.011	128,275	148	0.018**	44,754	143	(0.0179 lb/ ton coke)	-	-	• *Percent isokinetics = 111.04. • **Percent isokinetics = 110.92.
		0.010	133,145	153	0.016	58,362	143	(0.0179 lb/ ton coke)			• Allowable concentration (push) = 0.015 gr/dscf. • Allowable concentration (travel) = 0.010 gr/dscf. • Allowable emission rate (push and travel combined) = 0.015 lb/ ton coke pushed.
J&L Steel/ Pittsburgh, PA Battery P-4	8 - 9/ 1979	-	166,646	149	-	85,385	145	0.0855	0.0158*	-	• Compliance tests by Betz-Converse-Murdoch.
			159,993	149	-	100,827	146	0.0373	0.0110		• Each test consisted of 16 push-travel cycles per run.
		-	164,868	151	-	98,344	147	0.0210	0.0059	-	
		-	163,517	154	-	98,466	150	0.0187	0.0063	-	• *Back-half results represent back-half catch minus back-half sulfates. Back-half sulfates ranged from 0.0000-0.0290 gr/dscf.
		-	173,580	142	-	100,666	139	0.0253	0.0425	-	
		-	178,792	125	-	88,619	122	0.0234	0.0354	-	
		-	190,963	140	-	92,856	138	0.0209**	0.0405**	-	• **Percent isokinetics = 89.65.

(continued)

TABLE 4 (continued)

Facility/ location	Test date(s)	Push emissions: Front-half (gr/dscf)	Push emissions: Exhaust flow rate acfm	Push emissions: Temp. °F	Travel emissions: Front-half (gr/dscf)	Travel emissions: Exhaust flow rate, acfm	Travel emissions: Temp. °F	Push and travel combined: Front-half (gr/dscf)	Push and travel combined: Back-half (gr/dscf)	Push and travel combined: Full-train (gr/dscf)	Comments
Shenango, Inc./ Neville Is., PA Batteries 3 and 4)	2/10-13/ 1981	-	-	-	-	-	-	-	-	0.0194*	• Compliance tests by Betz-Converse-Murdoch.
		-	-	-	-	-	-	-	-	0.0234	• First run consisted of 48 push-travel cycles, remaining two runs consisted of 24 push-travel cycles per test.
		-	-	-	-	-	-	-	-	0.0098	• First run isokinetics = 115.4% • *Full-train results consist of front-half, and filterable back-half catch. • Allowable concentration (push-travel combined) = 0.020 gr/dscf.
U.S. Steel/ Clairton, PA (Batteries 19[a] and 20)	08/30/79	-	82,844 (dscfm)		-	50,148 (dscfm)		0.061	3.144	3.205	• Compliance tests by U.S. Steel.
	09/05/79	-	81,276 (dscfm)		-	50,892 (dscfm)		0.015	0.593	0.608	• 1st and 3rd run consisted of 24 push-travel cycles per test run, 2nd run consisted of 48 push-travel cycles.
	09/06/79	-	80,043 (dscfm)		-	49,371 (dscfm)		0.091	1.078	1.169	• Allowable full-train = 0.020 gr/dscf (July 10, 1979 Consent Decree).
	08/23/79	-	-	-	-	-	-	0.024	0.286	0.310	• Additional tests conducted by U.S. Steel. • 1st run isokinetics = 75.5%. • 2nd run isokinetics = 124.5%.
	08/29/79 08/31/79	-	77,630 (dscfm)		-	51,092 (dscfm)		0.032	0.955	0.987	• 1st and 2nd runs consists of 24 push-travel cycles per test run, 3rd run consisted of 16 push-travel cycles.
		-	-	-	-	-	-	0.056	2.200	2.256	

[a]Car also tested in April 1980; results were not available.

TABLE 5. PARTICULATE MASS EMISSIONS TEST DATA FOR H-III CARS (PUSH AND TRAVEL COMBINED)

Facility/Location	Test date(s)	Front-half (gr/dscf)	Front-half lb/ton coke	Comments
J&L Steel/ E. Chicago, IN (Battery 4)	04/30/81	0.025	0.040	• Compliance tests run by Betz-Converse-Murdoch.
	05/01/81	0.066	0.099	• Each run consisted of 24 push-travel cycles per test run, 12 tons coke per push, and 288 tons coke per test run.
	05/05/81	0.105	0.158	• Allowable front-half emission rate (push and travel combined) = 0.040 lb/ton coke.
J&L Steel/ E. Chicago, IN (Battery 9)	11/06/80	NA	0.080	
	01/20/81	NA	0.093	• No additional data available
	03/17/81	NA	0.052	
	03/25/81	0.012	0.024	• Complaince tests run by Betz-Converse-Murdoch.
	03/26/81	0.024	0.040	• Each run consisted of 24 push-travel cycles per test run, 12 tons coke per push, 288 tons coke per test run.
	3/27/81	0.032	0.068	• Allowable front-half emission rate (push and travel combined) = 0.040 lb/ton coke.
Republic Steel/ Cleveland, OH (Batteries 6&7)	04/07/81	0.014	0.026	• Compliance tests run by Betz-Converse-Murdoch on car No. 21.
	04/08/81	0.019	0.032	• Each run consisted of 24 push-travel cycles per test run, 11.7 tons coke per push, 280.8 tons coke pushed per test run.
	04/09/81	0.017	0.028	• Allowable front-half emission rate (push and travel combined) = 0.03 lb/ton coke.
Republic Steel/ Cleveland, OH (Batteries 6&7)	04/14/81	0.012	0.020	• Compliance tests run by Betz-Converse-Murdoch on car No. 22.
	04/15/81	0.011	0.021	• Each run consisted of 24 push-travel cycles per test run, 11.7 tons coke per push, 280.8 tons coke pushed per test run.
	04/16/81	0.015	0.027	• Allowable front-half emission rate (push and travel combined) = 0.03 lb/ton coke.

(continued)

TABLE 5 (continued)

Facility/Location	Test date(s)	Front-half (gr/dscf)	Front-half lb/ton coke	Comments
Republic Steel/ Warren, OH (Battery 4)	10/13/81	0.0302	0.0586	• Compliance tests run by Betz-Converse-Murdoch on car No. 1.
	10/14/81	0.0106	0.0206	• Each run consisted of 24 push-travel cycles per test run, 12.65 tons coke per push, 303.6 tons coke per test run.
	10/15/81	0.0122	0.0254	• Allowable front-half emission rate (push and travel combined) = 0.03 lb/ton coke.
Republic Steel/ Warren, OH (Battery 4)	10/20/81	0.0147	0.0258	• Compliance tests run by Betz-Converse-Murdoch on car No. 2.
	10/21/81	0.0152	0.0271	• Each run consisted of 24 push-travel cycles per test run, 12.65 tons coke per push, 303.6 tons coke per test run.
	10/22/81	0.0141	0.0248	• Allowable front-half emission rate (push and travel combined) = 0.03 lb/ton coke.
Republic Steel/ Youngstown, OH (Batteries B&C)	10/27/81	0.0149	0.0370	• Compliance tests run by Betz-Converse-Murdoch.
	10/28/81	0.0117	0.0309	• Each run consisted of 24 push-travel cycles per test run, 11.5 tons coke per push, 275.5 tons coke per test run.
	10/29/81	0.0107	0.0293	• Allowable front-half emission rate (push and travel combined) = 0.03 lb/ton coke.

(continued)

TABLE 5 (continued)

Facility/Locations	Test date(s)	Front-half (gr/dscf)	Back-half insoluble (gr/dscf)	Back-half soluble (gr/dscf)	Front-half plus back-half insoluble (gr/dscf)	Comments
United States Steel/ Clairton, PA (Batteries 19 and 20)	03/24/81	0.0248	0.0022	0.0957	0.0270	• Compliance tests by Betz-Converse-Murdoch. • Runs No. 1 and 3 each consisted of 16 push-travel cycles per test run, 14.25 tons coke per push, 228 tons coke per test run. • Run No. 2 consisted of 24 push-travel cycles per test run, 14.25 tons coke per push, 342 tons coke per test run.
	03/26/81	0.0416	0.0077	0.0846	0.0493	
	04/04/81	0.0380	0.0016	0.0877	0.0396	

TABLE 5 (continued)

Facility/Location	Test date(s)	Full-train (gr/dscf)	Full-train (lb/ton coke)	Comments
United States Steel/ Clairton, PA (Battery 15)	08/17-19/81	0.026	0.070	• Compliance tests by U.S. Steel on H3-6 car. • 24 pushes per test run, one traverse point per push • Isokinetic range: 90.9 - 95.3% • Average composite gas flowrate - 84,445 dscfm.
	08/20-21/81	0.025	0.066	
	08/24-27/81	0.042	0.114	

TABLE 6. SUMMARY OF VISIBLE EMISSIONS DATA FOR THE ENVIROTECH/CHEMICO H-II CARS

Facility/Location	Date	No. of pushes observed	Range of seconds VE ≥20%	Avg. seconds per push VE ≥20%	Maximum opacity (%)	Avg. max. opacity (%)	Comments
Bethlehem Steel Bethlehem, PA Battery 5	01/16/79	2	14-26	20.0	50	40.0	- Observations by EPA inspectors during stack tests. - Push data only.
	01/17/79	8	0-7	2.5	30	13.1	
	01/30/79	4	0-2	0.75	30	15.0	- Observations by EPA inspectors during nonstack test periods. - Push data only.
	01/31/79	2	0-12	6.0	-	-	
	03/08/79	11*	0-11	1.9	75	26.8	- *Observations during BCM stack tests (7 out of 11 pushes showed VEs ≥20%).
	03/08/79	4+	0-5	1.7	70	33.7	- +Observations during nonstack test periods (2 out of 4 pushes showed VEs ≥20%). - Sun visible (40% cloud cover). - Observations by PADER;[a] background unknown. - Push data only (20-hr coke) - Company reported scrubber valve problems during tests.
	03/09/79	13*	0-6	1.1	70	19.2	- *Observations during BCM stack tests (5 out of 13 pushes showed VEs ≥20%).
	03/09/79	3+	0-2	1.0	30	18.3	- +Observations during nonstack test periods (2 out of 3 pushes showed VEs ≥20%). - Sun visible - clear sky. - Observations by PADER; background unknown. - Push data only (20-hr coke). - Scrubber valves adjusted before tests.
	04/02/79	14(13)	0-6(0-19)	0.71(2.0)	-	-	- JACA observations during nonstack test periods. (Data in parentheses represent VEs ≥0% opacity).
	04/03/79	3(3)	0(0-5)	0.(2.67)	-	-	
	04/06/79	17(17)	0-3(0-13)	0.41(2.18)	-	-	
	04/09/79	1(1)	0(0)	0(0)	-	-	
	05/21/79	22	0-37	7.73	-	-	- Sky used for background. - Push data only.
	05/29/79	24	0-50	12.0	-	-	
	05/30/79	19	0-36	6.53	-	-	

[a]Pennsylvania Department of Environmental Resources.

(continued)

TABLE 6 (continued)

Facility/Location	Date	No. of pushes observed	Range of seconds VE ≥20%	Avg. seconds per push VE ≥20%	Maximum opacity (%)	Avg. max. opacity (%)	Comments
Bethlehem Steel/ Bethlehem, PA (Battery 5) (continued)	05/21/79	22	0-32	3.32	-	-	- JACA observations during nonstack test periods. - Coke guide hood for background. - Push data only.
	05/29/79	25	0-42	5.6	-	-	
	05/30/79	19	0-19	3.32	-	-	
Bethlehem Steel/ Sparrows Pt., MD (Batteries 11 and 12)	10/14/80	18*	0-45	13.2	-	-	- BCM observations during stack tests. -*Push and travel VE data combined. - Blue sky for background. - Sun in front of observer during all observations.
	10/15/80	11*	0-90	36.5	-	-	
	10/16/80	21*	0-106	23.1	-	-	
	10/17/80	7*	3-12	6.0	-	-	

(continued)

TABLE 6 (continued)

Facility/Location	Date[b]	Average of 24 consecutive opacity readings[a] (%)	Comments[b,c]
Bethlehem Steel/ Lackawanna, N.Y. (Battery 7)	02/20-21/80	32.1	
	08/12/80	12.6	
	12/02/80	9.6	
	03/16/81	14.2	
	09/15/81	15.6	
	02/09/82	57.1	- H-car inoperative
	05/11/82	7.9	
Bethlehem Steel/ Lackawanna, N.Y. (Battery 8)	02/20-21/80	31.9	
	09/15/81	12.7	
	02/09/82	42.7	- H-car inoperative
	05/11/82	17.5	

[a]Observations were recorded at 15-second intervals, for a minimum of 24 consecutive opacity observations, at the point of greatest opacity and only during the coke pushing and transport periods.

[b]Visible emissions recorded in February and August 1980 were observed and documented in accordance with 6NYCRR, Part 214, By-Product Coke Oven Batteries, effective August 23, 1979. Visible emissions recorded in December 1980 and in 1981-1982 were observed and documented in accordance with the Delayed Compliance Orders signed May 28, 1979 and proposed policies submitted to the U.S. EPA, as required by the conditional approval of the New York State Implementation Plan.

[c]Both the 6NYCRR, Part 214.2(b) regulation and the Delayed Compliance Order requires that visible emissions from coke pushing and transport of coke to the quench tower shall be less than 20 percent opacity; determined by averaging the results of a minimum of 24 consecutive opacity observations made at 15-second intervals.

(continued)

TABLE 6 (continued)

Facility/Location	Date	No. of pushes observed	Range of seconds VE >0%	Avg. seconds per push VE >0%	Range of maximum opacity (%)	Comments
J&L Steel Pittsburgh, PA (Battery P-4)	8/16/79	16 (5)	0-30 (0-24)	13.2 (8.4)	0-90 (0-100)	• Data taken by Weston Environmental during BCM stack testing. • Data in ( ) taken by County for VEs >20%.
	8/18/79	16	0-17	3.2	0-65	• Data by Weston only during BCM stack tests.
	8/20/79	16 (10)	0-20 (0-6)	5.5 (1.1)	0-20 (0-40)	• Data taken by Weston during BCM stack tests. • Data in ( ) taken by County for VE >20%.
	8/22/79	16 (12)	0-45 (0-22)	12.3 (7.8)	0-80 (0-100)	• Data taken by Weston during BCM stack tests. • Data in ( ) taken by County for VE >20%.

Note: VEs observed by Weston emanated from between quench car and the capture hood. Background - <u>coke oven battery</u>. Travel emissions also observed during stack tests (not summarized above). VEs observed by Allegheny County.

(continued)

TABLE 6 (continued)

Facility/ Location	Date	No. of pushes observed	Range of seconds VE ≥20%	Avg. seconds per push VE ≥20%	Range of maximum opacity (%)	Comments
J&L Steel/ Pittsburgh, PA (Battery P-4)	09/19/79	9 (9)	0-3 (0-7)	0.56 (1.1)	0-35 (80)	• Data taken by BCM during stack tests. • Data in ( ) taken by County simultaneously with BCM observations.
	09/20/79	12 (12)	0-9 (0-14)	1.4 (1.8)	0-30 (30)	• Data taken by BCM during stack tests. • Data in ( ) taken by County simultaneously with BCM observations.
	11/05/79	11	0	0	0-10	• BCM observations, not during stack tests. (applies to 11/05/79–11/07/79)
	11/06/79	11	0-3*	0.27*	0-30*	• *Only one push had VEs ≥20%, scrubber turned on late.
	11/07/79	32	0-1**	0.03**	0-20**	• **Only one push had VEs ≥20%.

Note: Travel emissions also observed during above dates (not summarized above). Background and conditions during observations not included with data.

(continued)

TABLE 6 (continued)

Facility/ Location	Date(s)	No. of pushes observed	No. of pushes $\geq$20%	Total sec. $\geq$20% per test	Avg. sec. $\geq$20% per push	Comments
Shenango Inc., Neville Isl. (Batteries 3&4)	2/10-11/81	31	19(61.3%)	229	7.4	• Data taken by BCM during stack tests (Method 9 VE copies difficult to read).
	2/12	23	10(43.5%)	455	19.8	
	2/13	24	14(58.3%)	243	10.1	

Note: From February 9 to July 1, 1981 a total of 130 pushes were observed at Shenango by EPA and Allegheny county inspectors; average seconds VEs $\geq$20% opacity = 12.9.

(continued)

TABLE 6 (continued)

Facility/ Location	Date(s)	Test No./ Battery	Avg. secs per push, fugitive VEs $\geq$20%[a]	Avg. secs per push, scrubber stack VEs $\geq$20%[b]	Comments
USS/Clairton, PA (Batteries #19 and 20)	08/30/79	3/19	20.5	3.1	(No details available)
		3/20	18.1	8.8	
	09/05/79	5/19	3.7	0.4	
		5/20	3.5	0.1	
	09/06/79	6/19	3.8	0.5	
		6/20	15.2	6.5	
	08/23/79	1/19	2.3	2.6	
		1/20	10.8	4.5	
	08/29/79	2/19	12.0	6.3	
		2/20	10.2	22.4	
	08/31/79	4/19	11.9	2.8	
		4/20	13.0	6.1	

[a]Fugitive emissions observed from quench car and/or door machine during push only.

[b]Scrubber stack emissions averaged for push and travel combined.

(continued)

TABLE 6 (continued)

Facility/ Location	Date	No. of pushes observed	Range of seconds VEs ≥20%	Avg. secs per push VEs ≥20%	Maximum opacity (%)	Avg. maximum opacity per push (%)	Comments
USS/Clairton, PA (Battery 19)	4/02/80	2	7-19	13	25	22.5	• Observations by County during testing of car. • Travel data also available, but not summarized in this table.
	4/07/80	4	0-30	19	65	31.25	
	4/08/80	6	12-37	26.8	85	56.7	
	4/28/80	12	20-36	28.2	100	81.7	
	4/29/80	11	22-39	31.6	100	93.2	

TABLE 7. SUMMARY OF VISIBLE EMISSIONS DATA FOR THE ENVIROTECH/CHEMICO H-III CARS

Facility/ Location	Date(s)	No. of pushes observed	Total No. of Method 9 readings	No. of readings <20%	No. of readings ≥20%, but <40%	No. of readings ≥40%, but <60%	No. of readings ≥60%	Comments
J&L Steel/ E. Chicago, IN (Battery 9)	11/05/80	18	105	61(58.1%)[a]	23(21.9%)	13(12.4%)	8(7.6%)	• BCM observations. • Clear sky (background unknown). • 15 of 18 pushes observed during stack tests.
	01/20/81	16	80	48(60.0%)	10(12.5%)	6(7.5%)	16(20.0%)	• BCM observations. • Clear sky (7 obs.); 100% clouds (9 obs.) • 15 of 16 pushes observed during stack test. • Unknown background.
	01/20/81	15	53	36(67.9%)	8(15.1%)	2(3.8%)	7(13.2%)	• BCM observations during stack tests. • Generally clear (some clouds). • All observations - background unknown.
	03/17/81	24	212	182(85.9%)	19(9.0%)	3(1.4%)	8(3.8%)	• BCM observations during stack tests. • Overcast sky. • All observations - background unknown.
	03/26/81	2	11	8(72.7%)	3(27.3%)	0(0.0%)	0(0.0%)	• BCM observations during stack tests. • Conditions/background unknown. • Emissions from top of hot car.

[a]Data in parentheses represents the percentage of readings (of the total number of Method 9 readings) that were in the category shown.

(continued)

TABLE 7 (continued)

Facility/ Location	Date(s)	No. of pushes observed	Range of seconds ≥20%	Avg. seconds per push ≥20%	Maximum opacity (%)	Avg. max. opacity (%)	Comments
J&L Steel/ E. Chicago, IN (Battery 9)	3/26/81	23*	0-35	13.1	-	-	• BCM observations during stack tests. • VEs observed from top of hot car. • *Includes VE data from three (3) pushes noted as "green" coke on each day.
	3/27/81	24*	4-60	19.9	100	76.0	

TABLE 7 (continued)

Facility/ Location	Date	No. of pushes observed	Range of seconds ≥20%	Avg. seconds per push ≥20%	Comments
J&L Steel/ E. Chicago, IN (Battery 4)	4/30/81	15	8-80	29.0	• EPA observer. • Background: overcast sky on 4/30; battery on 5/1. • Observations taken during stack tests.
	5/1/81	14	4-108	37.0	
J&L Steel/ E. Chicago, IN (Battery 9)	3/25/81	22	0-29	17.4	• EPA observer. • During stack tests. • Excludes one sticker on 3/26. • Overcast sky background. • *Observer noted two (2) pushes were "green" coke on each day.
	3/26/81	25*	0-38	16.9	
	3/27/81	21*	9-62	26.0	

(continued)

TABLE 7 (continued)

Facility/ Location	Date(s)	No of pushes observed	Range of seconds ≥20%	Avg. seconds per push ≥20%	Maximum opacity (%)	Avg. max. opacity (%)	Comments
J&L Steel/ E. Chicago, IN (Battery 4)	4/30/81	24	1-59	27.0	-	-	• BCM observations during stack tests. • Observer on top of ovens. • Overcast skies. • Background unknown. • 15 of 24 pushes used a conventional open coke guide.
	5/01/81	14	3-108	37.0	-	-	• BCM observations during stack tests. • Partly cloudy skies. • Background - position unknown. • 9 of 14 pushes used a conventional open coke guide.
	5/05/81	24	5-64	32.8	-	-	• BCM observations during stack tests. • Overcast skies, background unknown. • Observer positioned on ovens. • 15 of 24 pushes used a conventional open coke guide.

(continued)

TABLE 7 (continued)

Facility/ Location	Date(s)	No. of pushes observed	Total No. of Method-9 readings	No. of readings <20%	No. of readings ≥20%	Comments
Republic Steel/ Cleveland, OH (Car No. 21)	04/07/81	24*	12	12	0	• BCM observations during stack tests. • *Only 3 out of 24 pushes observed with sun obscured or in correct Method-9 position. • **Only 9 out of 25 pushes observed with sun obscured or in correct Method-9 position. • +Only 17 out of 25 pushes observed with sun obscured or in correct Method-9 position. • Skies generally clear; observation background unknown.
	04/08/81	25**	64	64	0	
	04/09/81	25+	81	81	0	
Republic Steel/ Cleveland, OH (Car No. 22)	04/15/81	24	144	144	0	• BCM observations during stack tests. • Observations recorded from above coke ovens using blue sky for background. • Clear skies prevailed throughout observations.
	04/16/81	23	142	142	0	

(continued)

TABLE 7 (continued)

Facility/ Location	Date(s)	No. of pushes observed	Range of seconds ≥20%	Avg. seconds per push ≥20%	Maximum opacity (%)	Average maximum opacity (%)	Comments
Republic Steel/ Warren, OH (Car No. 1)	10/13/81	22	0-29.1	9.5	45	20.5	• BCM observations during stack tests. • Skies relatively clear (0-10% cloud cover). • Sun in observer eyes during all observations. • Observation background unknown.
	10/14/81	19	0-34.8	7.1	35	20.3	
	10/15/81	20	0-14.1	3.0	25	16.0	• Same as above, except 90% cloud cover with drizzle. • Observations taken from top of collector main.
Republic Steel/ Warren, OH (Car No. 2)	10/20/81[a]	21	0-8	3.0	25	25.7	• BCM observations during stack tests. • Background unknown, 50% cloud cover. • Sun in observers' eyes when out.
	10/21/81[a]	21	0-16	1.9	90	17.1	• Same as above, except 10% cloud cover.
	10/22/81[a]	22	0-13	2.0	25	13.9	• Same as above, except 100% cloud cover. (white/gray clouds).

[a]Note: VE data labeled in test report indicates seconds of VEs ≥30% opacity, however, maximum opacities do not reflect these data.

(continued).

TABLE 7 (continued)

Facility/ Location	Date(s)	No. of pushes observed	Total No. of Method-9 readings	No. of readings <20%	No. of readings ≥20%	Comments
Republic Steel/ Youngstown, OH	10/27/81	23	110	110	0	• BCM observations during stack tests. • Sky conditions generally cloudy in morning with clearing, blue skies in afternoon. • Sun in observers' eyes when out. • Background unknown.
	10/28/81	22	105	105	0	
	10/29/81	22	112	109	3	

SECTION 5

SUMMARY OF H-III PROBLEMS AND SOLUTIONS REPORTED BY STEEL COMPANIES

INTRODUCTION

Frequently-reported problems affecting H-III system availability are summarized in this section. Problems that were reported by only one plant are not generally included herein, but are described in the Trip Reports. Tables listing each problem described in the Trip Reports appear in Appendices A-E. Trip reports are on file at EPA.

Available data describing H-II problems appears later in Section 6 and in the Shenango Trip Report. Detailed analysis of H-II problems was not conducted primarily because GCA was able to discuss H-II problems with only one plant (Shenango). However, company-supplied malfunction data are available from Bethlehem/Bethlehem and J&L/Pittsburgh.

The data shows that many problems affecting H-III car availability are either solved, or being brought under control as plants gain operating experience. However, several major problems affecting car reliability were reported as only partly solved. Several companies noted that as existing problems are solved and the cars operate longer, new problems are expected as equipment ages and wears.

Overall, the steel companies visited indicated that the Envirotech/ Chemico cars are inherently difficult to maintain. Envirotech/Chemico responded (to GCA) by stating that the cars are not complicated compared to other steel mill equipment, but are complicated compared to the relatively unsophisticated process equipment in a coke plant. Envirotech/Chemico felt strongly that the primary problem was the reluctance of the steel companies to assign experienced technical personnel to assist car maintenance crews.

Several important points to consider when reviewing the data in this section became evident during this study, i.e.:

- Steel companies were responsible for supplying Envirotech/Chemico with up-to-date plant drawings (for clearance and design work), raw water samples for water treatment system design (except for U.S. Steel who supplied their own water treatment). Steel companies were also responsible for modifications to quench car tracks and hot rails prior to car installation.

- Envirotech/Chemico designed and installed the H-car (scrubber and control car), the one-spot quench car and modified the coke guide (installed hooding).

- Subcontractors to Envirotech/Chemico built all one-spot quench cars, based on Envirotech/Chemico's design specifications, except at Clairton where U.S. Steel designed and constructed the quench cars.

- Envirotech/Chemico purchased H-car frames, wheel truck and basic cab assemblies from vendors except the Clairton frames and cabs which were supplied by U.S. Steel. Envirotech/Chemico or their subcontractors constructed the internal components of each car.

Several additional observations should also be considered when reviewing these data, i.e.:

- USS/Clairton attempted to debug seven H-III cars almost simultaneously; the company reported in September 1981 that the overwhelming number of cars and problems led them to conclude that debugging efforts should be confined to one car at a time. During an April 1982 status meeting held at Clairton, U.S. Steel reported that solutions to all but two problems (drive motor bore elongation and ductwork erosion) were developed and would be implemented on all cars when currently idle batteries returned to service.

- Republic Steel had previous experience with H-III cars at the Warren and Youngstown plant prior to starting-up and debugging the Cleveland cars, where less problems were reported for Cleveland.

- Availability data submitted to EPA by J&L, Indiana Harbor Works shows very low availability of their two H-III systems, and thus, these systems have not been operated as long as others.

H-III LAND-BASE PROBLEM SUMMARY

Table 8 summarizes problems reported by each company for the H-III land-based hot water heater system and transfer station. Frequently-reported land-base problems that reduced car availability may be summarized as:

- Coke oven gas combustion problems in the land-based heater;

- Heater system malfunctions (generally, heater controls);

- Scrubber water treatment system malfunctions;

- Hot water transfer (to car) failures.

TABLE 8. H-III LAND-BASED HOT WATER SYSTEM PROBLEMS AND CORRECTIVE ACTION TAKEN, AS REPORTED BY COMPANIES VISITED

Problem	Effect	U.S. Steel Clairton	Republic Steel, Warren, Youngstown	Republic Steel, Cleveland	J&L Steel, Indiana Harbor
Poor COG combustion	Low heat, burner flame-outs	NA[a]	Switched to natural gas, improved controls	Switched to natural gas, improved controls	Switched to natural gas, improved controls
Heater controls malfcn.	Back-up heater failure	NA[a]	NR[b]	Redesigned controls	Redesigned controls
Undersized combustion air fans	Low heater output	NA[a]	Installed larger fans	Installed larger fans	Installed larger fans
No water flow through tubes during low-fire	Poor temperature control, tube damage	NA[a]	Installed recirculation line	Installed recirculation line	Installed recirculation line
Water treatment malfunction	Filter and piping plugging	Adding deaerator	Switched to city water	New system controls installed	Planning system improvements
Water line corrosion	Pitting, corrosion of lines, valves	Adding deaerator	Added nitrogen	NR	NR
Transfer arm failure	Water transfer failure	Varied problems (see text)	Varied problems (see text)	Limit switch failures corrected by moisture control	Varied problems (see text)
Transfer line valve failure	Accidental discharge, leakage	NR	NR	Valves upgraded	Additional limit switches installed
Charge arm support bolt failure	Alignment problems	Stainless bolts and keepers modified	Air motor modified	NR	NR
Steam hammer in lines	Damaged valves	NR	NR	Installed bypass line	NR
FEMCO radio communication difficulty	Water transfer failure	Many problems	Some problems	Some problems	Minor problems, typical of other plant machinery
Pressure sensor failure	Water transfer failure	Testing new sensor	NR	NR	NR

[a]NA = Not Applicable - i.e., U.S. Steel uses different system (plant steam) for hot water treatment and heating.

[b]NR = Plant did not report this problem area.

Note: Problems not listed in any order.

Note that U.S. Steel uses plant steam to provide hot water heating, and not the gas burners and heaters used at all other plants. Also, U.S. Steel supplied their own water treatment capability whereas all other plants purchased a system supplied by Envirotech/Chemico.

Many land-base problems have been either completely or partially solved during start-up and debugging. However, several minor problems, and the general problem of hot water heating and transfer still affect car availability at several plants as discussed below. More details are available in the Trip Report for each company.

COG Combustion Problems

All three plants using gas-fired hot water heaters reported that maintaining steady COG combustion in the hot water heaters was nearly impossible. Poor gas flow and burner/pilot flameouts restricted hot water availability. A pressure sensor prevents hot water transfer to the car at temperatures below about 450°F. (Water pressure and temperature are directly proportional). Each company reported that heater systems were designed to burn COG, and noted that few problems were encountered with other COG-burning equipment at their plants. (Recall that Clairton uses steam heating and reported no problems).

After 6 months of attempting to solve COG combustion problems, RSC/Warren and Youngstown converted to natural gas (NG). RSC/Cleveland also converted to NG, and J&L is planning NG conversion. Although NG was originally intended as a backup fuel at all three plants, the conversion to a primary fuel reportedly requires changing gas lines and process controls and instrumentation to accomodate the higher Btu content and lower feed pressures associated with NG.

Heater System Malfunctions

The hot water heater switches to a low-fire mode ("soak") once the charge tank in the transfer building is full. The Envirotech/Chemico-supplied system did not provide for water circulation in heater tube bundles during soak periods, according to steel companies, and overheating problems were reported by all three plants using this system. RSC/Cleveland reported that two tube bundles were destroyed due to this problem. (The Clairton steam heat system does not have these hot water heaters).

Recirculation lines installed at Republic's three plants reportedly solved most overheating problems. However, hot spots from flame impingement on heater tubes remains a major concern relative to tube life. J&L also installed a recirculation line to control overheating and also increase the low water temperature encountered during normal fire periods. The newly-installed line was untested in actual operation as of January 1982 since the push control systems were out of service.

All three companies using the COG heater system reported that undersized combustion air fans prevented attaining adequate water temperature. Larger, new fans were installed which partially corrected the problem.

Backup heater control system failures were reported for three of four plants using this system. The control system either failed to start the backup unit upon failure of the primary heater, or else both heaters were fired simultaneously. Each company reporting these problems redesigned controls to correct the situation.

Water Quality Problems

All three companies using the Envirotech/Chemico-supplied water treatment system reported serious operational problems. Filter plugging with influent solids, carbonate plugging of water lines, and pipe/valve corrosion were reported. Treatment system design was based on water samples supplied by each steel company.

After attempts by Envirotech/Chemico and Republic to improve system performance failed, Republic switched to city water at Warren and Youngstown. New process controls were installed at Cleveland, which reportedly solved water quality problems. J&L was planning to improve their existing system sometime in 1982.

U.S. Steel reported plugging and corrosion of the water system in the transfer building and onboard the H-III car. Solutions to sparger tube plugging were reportedly developed by April 1982, and a deaerator was to be installed to eliminate storage tank corrosion onboard the H-III car. U.S. Steel supplied their own water treatment for the push control system

Republic/Cleveland has what appears to be a unique hot water supply problem because their hot water charge system was supplied without a building, and the heat tracing on water lines didn't prevent freezing. RSC/Cleveland installed a lean-to and applied "torches" to points prone to freezing.

Hot Water Transfer Problems

Maintaining charging arm alignment and poor limit switch performance were commonly reported problems. Between 9 and 17 limit switches (depending on plant) must be satisfied by proper positioning of the charge arm relative to the land base transfer hub. Frequent switch malfunction was commonly reported, causing inability to transfer hot water.

RSC/Cleveland reported limit switch problems consisting of winter freeze-ups were solved by enclosing (the unenclosed) charge station and adding a vent stack to divert steam discharges away from switches. RSC/Cleveland was the only plant with an unenclosed charge station. No major limit switch problems were reported by RSC/Warren and Youngstown. J&L reported limit switch failures usually occurred once per shift, requiring about 30 minutes to correct. USS/Clairton reported frequent limit switch failures often caused downtime on the order of an hour or two. In April 1982, Clairton also reported failures of the water pressure sensor that caused inability of water transfer. A new sensor design was undergoing tests.

Charge Arm Alignment Problems

Charge arm alignment problems occur between the horizontal faces of the land-based hub and the car-based charge arm. These two faces must be aligned to within 0.010 to 0.030 inches. Several inches of "misalignment" in the vertical direction can be handled by the land-based guide rollers. Misalignment is caused by track wear/deterioration, stucki bearing wear, weak car springs, and wheel wear. Generally, the problem is differential wear causing an elevation difference between the two sides of a car.

U.S. Steel reported major problems with charge arm alignment when the cars were new. U.S. Steel developed an optical alignment technique that reduced alignment time to less than 8 hours compared to a day or more for the Envirotech/Chemico procedure. USS noted that total realignments are infrequently required; i.e., only in cases such as total failure and major repairs on a land-base system. Before a new car is placed in service at Clairton, it is prealigned on the set-up tracks using reference points, and checked at the land-base station. USS is planning to build a "dummy" land-base station for standardizing car alignments between batteries and to facilitate prealignment.

RSC/Cleveland installed a "dummy" charge station in their maintenance shed to allow alignment (of the spare car) prior to returning to service. RSC/Warren and Youngstown reported alignment problems of a minor nature have largely been solved. J&L indicated that their charging arms required realignment about once every three months.

Charge arm alignment is aggravated by serious track deterioration which was reported by all plants. The heavy H-III combined with poor drainage of quench water from battery tracks due to coke spillage from the coke box were cited by several steel companies as the cause. Track improvements made by each plant prior to H-III installation ranged from simple ballast cleaning (Battery 4 at J&L) to installing an 18 inch thick concrete pad along the entire battery length (RSC/Cleveland). Regardless of track modifications already made, all companies report frequent track maintenance has been required and they anticipate replacement in the near future.

Status of Land-Base Problem Resolution

Transfer arm failures, FEMCO problems and water treatment problems are still affecting availability at some plants. Table 9 summarizes the status of land-base problems as described by each company interviewed.

H-III QUENCH CAR AND COKE GUIDE PROBLEMS

Commonly reported quench car and coke guide problems are summarized in Table 10. A few additional, apparently isolated problem areas at certain plants are listed in the Appendix. Three continuing problems are apparently only partially solved, i.e.:

TABLE 9. STATUS OF H-III LAND-BASE PROBLEM RESOLUTION

Problem	Status of resolution[b]	Solved by[c]	Comments
Poor COG combustion (3)[a]	Mostly solved	Steel mills; some Chemico assistance	Poor performance of burners and controls used in system.
Soak period overheating (3)	Mostly solved	Steel mills and Chemico	Equipment or design problem.
Undersized combustion air fans (3)	Mostly solved	Steel mills	Equipment or design problem.
Backup heater failures (2)	Solved	Steel mills	Equipment or design problem.
Water treatment problems (4)	Partly solved	Steel mills	Mills supplied raw water samples for system design. Chemico implied that some companies ignored recommended O&M procedures.
Transfer arm failures (4)	Partly solved	Steel mills, some Chemico assistance	Aggravated by track deterioration, moisture. Chemico suggests more experienced maintenance personnel needed; companies claim system is inherently difficult to maintain.
FEMCO radio communication difficulty (3)	Partly solved	Steel mills, some Chemico assistance	Some companies report FEMCO malfunctions, others report problems no greater than with other FEMCO equipment. Chemico reports all companies specified that FEMCO equipment be used.
Charge arm support bolt failure (2)	Solved	Steel mills	Original design; operational problems likely aggravate problems.
Water line freeze-up, steam hammer (1)	Solved	Steel mill (occurred at one plant only)	Company reports Chemico advised enclosure was not needed, winter operations no problem.

[a]Number of plants experiencing problems shown in parentheses; counting RSC/Warren and Cleveland as one, four plants total.

[b]Terms "mostly, partly and solved" assigned by GCA based on comments made by steel companies during plant visits.

[c]Based on discussions between GCA and each steel company visited. Specific solutions were presented previously in this section, and details appear in the Trip Reports.

TABLE 10. H-III QUENCH CAR AND COKE GUIDE PROBLEMS AND CORRECTIVE ACTION TAKEN, AS REPORTED BY COMPANIES VISITED

Problem	Effect	U.S. Steel Clairton	Republic Steel, Warren, Youngstown	Republic Steel, Cleveland	J&L Steel, Indiana Harbor
Car rocking - track deterioration, weak springs	Derailment, collisions	Installed stabilizers, track improvements, new stuckis	Track improvements and maintenance	Track improvements and maintenance	Installed shock absorbers, track maintenance
Coke spillage	Poor track drainage, increased car maintenance, damage	Enlarged box, for better distribution	Modified guide, hot box, ram	Modified guide and ram	Coke distribution improvements, extended push ram
Coke box warpage	Repairs, possible clearance problems	Convert channel-floor to solid plate	Reinforced frame	NR	Unspecified design change
Tilt limit switch failure	Clearance, dump problems	New switch design	Installed timer mechanism	Added backup switches, third-rail control	Reworked switches
Dump cylinder failure	Frequent malfunctions, maintenance	Several problems	NR	Replace seals	Continued maintenance
TV camera failure	Poor operator vision	Improved protection, purge air, wire relocation	NR	NR	Improved weatherproofing
Running light failure	Poor operator vision	Installed steel shields	NR	Installed plexiglass enclosures	NR
Brake shoe wear	Frequent replacement	Converted to conventional design	NR	Installed pressure sensor	New shoe design

[a]NR = Plant did not report this problem area.

Note: Problems not listed in any order.

- Coke spillage (also affects H-II) (all four plants);
- Track deterioration, car rocking, potential derailment (also affects H-II) (all four plants);
- Coke box warpage (two of four plants).

Other quench car and coke guide problems reported by the mills substantially affected car reliability during start-up periods but appear to be largely solved or under control. Each problem area is discussed below, and additional details are available in the Trip Reports.

Quench Car Rocking, Track Deterioration

All companies reported excessive quench car and H-car rocking due to weak car springs and/or track deterioration. USS and J&L added stabilizers and springs respectively to better support the car. USS is replacing the "stucki bearings" that support cars on wheel trucks with a solid design. The stucki bearings are a cylindrical roller-type bearing which lies between the wheel trucks and the railroad car body with its primary axis in a horizontal plane. The bearing supports the car on either side of the wheel truck vertical axis while allowing for wheel truck movement on curves relative to the car body.

Quench car rocking and track deterioration problems cause potential for car derailment and collisions with the coke guide, quench tower or combustion stack due to close clearances. Track deflections exceeding one inch have been observed (by GCA). The companies identified the cause as car weight and soggy track beds due to poor water drainage from spilled coke. Track deterioration problems have apparently not been solved by any steel company and remain a problem. Details of track modifications already made at each plant appear in the Trip Reports.

Coke Spillage

Coke spillage during the push was reported by all companies as a severe problem when cars were first placed in operation. Substantial spillage during the push resulted in daily track cleanup to prevent derailments and control soggy track ballast. Coke spillage also damages the cars with burning coke (i.e. hydraulic and electrical cable deterioration). Only USS reported spillage problems were solved, although all other companies visited indicated spillage had been reduced and brought under control. Spillage rates and track cleaning frequency during conventional quench car operation were not provided to GCA.

J&L reported the spillage problem was solved by extending the push ram head, removing deflector plates inside the quench car, and other unspecified improvements. Some improvements were reportedly made by Envirotech/Chemico while others were made by J&L.

RSC/Warren reported that coke guide and quench car deflector plate modifications by Envirotech/Chemico were ineffective. RSC extended the push ram face by 8 inches, affixed a shovel-type wedge to the ram bottom, and added a tilting lip to the coke box. Some improvements were achieved, but daily track cleaning is still required.

RSC/Cleveland's experience was similar to RSC/Warren, except Envirotech/Chemico's modifications (similar to those at RSC/Warren) reduced, but didn't eliminate spillage. Track cleaning for 3 days per week is still required.

RSC/Youngstown's spillage problems occur primarily at the wharf, since the quench car discharge is slightly misaligned with the wharf.

USS/Clairton reported severe spillage problems were not solved by adding deflector beams and baffles to the quench car. A portion of the horizontal plate covering the car opening was removed as an interim measure. Spillage required track cleaning once every one or two days compared to weekly with a conventional car. Spillage problems were reported to be solved at the April 1982 status meeting by enlarging the coke box by 50 cubic feet to achieve better coke distribution during the push.

Coke Box Warpage

Three plants reported coke box warpage was eliminated by design changes and reconstruction. One plant did not report warpage problems. Warpage was due to thermal stresses from the pushing-quench cycle, sometimes aggravated by a malfunction causing coke to be held in the quench car for a longer than normal time.

Coke Box Tilt Limit Switches

The Envirotech/Chemico-supplied quench car contained two mechanical switches to prevent car movement with a tilted box. This was important to avoid hitting a tilted box on an adjacent stack or other structure.

All companies reported frequent limit switch failures contributing to car immobility and/or concern over inadvertent dump problems and collisions. Various modifications to limit switch design reported by each company solved these problems.

Other Quench Car Problems Reported

Failure of the coke box dump cylinder, TV camera, and running lights, and rapid brake shoe wear were commonly reported. Dump cylinders are replaced and/or given increased maintenance. TV cameras and running lights necessary for operator's vision suffer damage from water and coke spillage. Physical protection, shielding and weatherproofing reportedly solves these problems. Other minor problems that contribute to downtime appear in the Trip Reports.

Status of Quench Car and Coke Guide Problem Resolution

Table 11 summarizes the status of quench car and coke guide problems. With the exception of the Clairton quench cars supplied by U.S. Steel, all

TABLE 11. STATUS OF H-III QUENCH CAR AND COKE GUIDE PROBLEM RESOLUTION

Problem	Status of resolution	Solved by[c]	Comments[c]
Car rocking due to springs, stuckis (all 4)[a]	Mostly solved[b]	Steel mills	USS designed, built Clairton boxes. Other mills - Chemico subcontractor supplied cars. Problem aggravated by track deterioration.
Track deterioration (all 4)	Partially solved; high maintenance	Steel mills responsibility	Companies responsible for track modifications. One company (RSC) stated Chemico advised conventional track ballast adequate.
Coke spillage (all 4)	Partially solved	Chemico, partly; Mills, primarily	Related to guide and box design/ construction.
Coke box warpage (3)	Partially solved	Steel mills	Increased by equipment malfunctions causing coke to be held for extended periods. Original boxes of stainless steel
Limit switch-box tilt (all 4)	Mostly solved	Steel mills	USS supplied Clairton quench cars. Chemico subcontractor supplied others. Problems aggravated by quench and land base moisture, coke spillage.
Dump cylinder failure (2)	Mostly solved; high maintenance	Steel mills	Supplied by Chemico except for USS/Clairton.
TV camera, running light (2) failure	Mostly solved	Steel mills	Supplied by Chemico except for USS/Clairton.
Brake shoe wear (3)	Mostly solved	Steel mills	Supplied by Chemico except for USS/Clairton.

[a]Number of plants reporting problems shown in parentheses; counting RSC/Warren and Youngstown as one, four plants total.

[b]Terms "mostly, partly and solved" assigned by GCA based on comments made by steel companies during plant visits.

[c]Based on discussions between GCA and each steel company visited. Specific solutions were presented previously in this section, and details appear in the Trip Reports.

quench cars were built to Envirotech/Chemico's specifications by subcontractors, according to Envirotech's Vice President.

H-III SCRUBBER CAR PROBLEM SUMMARY

Table 12 summarizes commonly-reported problems with the H-III scrubber car.

The only two remaining problems for which no solution has yet been developed at USS/Clairton involve the H-III car. Elongation of the bores in the electric traction drive motors is accelerating. The supplier (General Electric) is working on the problem but is reportedly unable to identify the cause. Erosion and development of holes in the scrubber ductwork is the other unresolved problem at Clairton.

At other plants, a multitude of problems seriously affecting car reliability during startup and debugging were reported, as shown in Table 12 and in the Trip Reports. Most of these problems appear to be solved or under control as discussed below.

Charge Arm Alignment/Track Deterioration

These problems affect the H-III scrubber car and were discussed previously in the land base section and Table 8.

Jet Valve Leakage

Jet valve leakage and substantial water loss was reported by USS/Clairton and RSC/Cleveland. Leakage developed at Clairton when Envirotech/Chemico changed the 1.4 inch diameter jet valve needles to 2.0 inches to provide more scrubbing water to the jets and improve gas cleaning. U.S. Steel was working with Envirotech/Chemico in September 1981 to solve the problems, and reported in April 1982 that their jet valve problem appears solved. The nature of the solution was not disclosed by USS at the April 1982 meeting.

RSC/Cleveland reported in March 1982 that valve leakage is becoming serious, approaching a quarter million gallons per week. No solution had yet been developed at that time.

FEMCO Radio Communication System

FEMCO units are commonly used in coke plants to provide process-related signals for coordinating machinery. Clairton reported serious problems with all FEMCO units due to an inadequate number of transformer couplings in the original units. New couplings were on order in September 1981 and planned for installation.

RSC/Cleveland reported unreliable FEMCO operation relative to coordinating quench car alignment with the coke guide. RSC solved the problem by installing an infrared spotting device and a radio interlock mechanism.

TABLE 12. H-III SCRUBBER CAR PROBLEMS AND CORRECTIVE ACTION TAKEN, AS REPORTED BY COMPANIES VISITED

Problem	Effect	U.S. Steel Clairton	Republic Steel, Warren, Youngstown	Republic Steel, Cleveland	J&L Steel, Indiana Harbor
Charge arm alignment	(described in Table 11)	-	-	-	-
Track deterioration	(described in Table 11)				
Jet valve leakage	Water loss	Appears solved as of 4/82	NR[a]	Rewelded flanges	NR
FEMCO communications	Occasional poor communications	Increased number of transformer couplings	Increased signal strength	Only affects quench car spotting; infrared spotting and radio interlock added	No changes; problems same as other in-plant FEMCO
Traction drive motors	Car immobility	Several serious problems; most resolved	Unspecified serious problems at Youngstown	Coil failure; unspecified changes	NR
Power pickup arm damage	Arm, shoe failure, car immobility	Redesigned arms, added second set	NR	Covered exposed wires	Hot rail redesign to reduce shoe wear
Electrical inverter failure	Trip-out, car shutdown	Added additional units to allow repair while online	NR	Delay installed to reduce power surges	One failure; unit replaced
Air compressor overheat	Car shutdown	Manually open car vents	Installed exhaust fans	NR	Installed cooling fans
Air dryers	Weak air supply to instruments	Converted pneumatic controls to electrical	NR	Installed larger dryers	Installed larger air dryer
	Excessive moisture, freeze-up	Adding new separator	NR	NR	NR
Stucki bearing/wear plate	Failure, car instability	Converting stuckis to solid supports	NR	Converting stuckis to solid supports	Teflon pads replaced
Exposed, mixed wiring	Damaged by coke, troubleshooting difficult, shutdowns	Isolated, insulated wiring	Isolated and insulated	NR	NR

(continued)

TABLE 12 (continued)

Problem	Effect	U.S. Steel Clairton	Republic Steel, Warren, Youngstown	Republic Steel, Cleveland	J&L Steel, Indiana Harbor
Hot rail icing	Car shutdown	Automatic car restart equipment added; steam tracing of rails successful	NR	NR	Heat tape; restart button moved to operators cab.
Oxygen release from hot water	Corrosion, pitting	Adding deaerator	Observed in lines, valves. Added N_2	NR	NR
TV camera reliability	Poor/lack of vision	Protected, sealed cameras. Cannot operate without cameras	NR	NR	Improved weatherproofing. Can operate without cameras.
Water leakage into cab	Control panel, wiring malfunction	NR	Attempting to seal cab	Attempting to seal cab	NR

[a]NR = Plant did not report this problem area.

Note: Problems not listed in any order.

RSC/Warren and Youngstown reported weak FEMCO contact between the land base and H-car sometimes prevented water transfer. Hot rail power was used to increase FEMCO signal strength, with some improvement, but problems are still experienced.

J&L reported some FEMCO problems but noted that the problems experienced were no greater than problems encountered with other coke plant FEMCO units already in use.

Envirotech/Chemico noted that FEMCO systems were requested by the mills for the push control cars since mill personnel are familiar with the FEMCO system.

Air Compressor Overheating

Overheating air compressors and car shutdown due to high cabin temperatures were commonly reported. Installation of cooling fans and opening car sides/louvers were reportedly partially effective, but problems occasionally still develop in warm months.

Traction Drive Motors

Several serious, debilitating problems experienced at Clairton were traced to defective motor manufacture. Minor problems with an electrical coil were reported by RSC/Cleveland. Serious, unspecified problems with drive motors were reported for RSC/Youngstown. The other companies reported no traction motor problems.

According to Envirotech/Chemico, the GE motors used at Clairton are somewhat different than at other plants because U.S. Steel designed and built the H-III frames and wheel assemblies.

An update of the Clairton motor problems was provided at the April 1982 status meeting. Remachining of motor housings by GE to eliminate field coil shorting was complete on 60 percent of the 28 drive motors (four motors per H-III car). USS reported 3 days are required to remove four defective motors and replace four new (repaired) units.

Motor power lead shorting from rubbing on wheels was eliminated on all Clairton cars by fixing leads to the car frame and reducing wire length. USS indicated that their Johnstown shop designed the leads and Envirotech/Chemico was responsible for the motors.

USS reported (April 1982) working with GE for 2 months attempting to solve a serious motor "load problem". Motor bores which hold the motor main shafts are elongating (wearing) much more quickly than normal due to high mechanical strain from unknown causes. GE reportedly claims the motors are well suited to the application, and has not yet discovered the cause or solution. USS does not know when this problem will be solved.

Electrical Inverter Failures

Three plants reported failure of the inverters which convert hot rail DC power to AC for onboard equipment. J&L and RSC/Warren, and Youngstown each reported one inverter failure. J&L replaced the inverter unit: RSC reported long delivery time from the New Jersey-based supplier was experienced.

RSC/Cleveland reported that power surges frequently caused inverter failure and car shutdown. A delay mechanism in the electrical line reportedly solved the problem.

USS/Clairton reported electrical congestion in inverters frequently caused failure of onboard AC equipment. Also, loss of hot rail power from ice buildup caused inverters to trip-out and shut down the car. U.S. Steel noted difficulty in working on inverters due to restricted access. In April 1982, U.S. Steel reported that a third inverter unit was being added to each car to allow repairs to a malfunctioning unit while the car remains in service. U.S. Steel stated that the back-up unit supplied with the car could not be operated while repairs were underway on the primary unit due to the wiring setup.

Power Pick-Up Arms

Broken power pick-up arms, excessive pick-up shoe wear and damaged wiring from spilled coke caused downtime at three plants. These problems were reportedly solved by various modifications.

According to Envirotech/Chemico, U.S. Steel built the power pick-up system for the Clairton cars. GCA's September 1981 inspection at Clairton noted that the U.S. Steel design being retrofit to all cars at that time appeared less complicated, less prone to damage, and easier to repair than the original design.

J&L encountered excessive shoe wear with their Envirotech/Chemico-supplied pick-ups. J&L redesigned the hot rails, and shoes are frequently replaced. The pick-up arms were supplied with a steel housing for protection against spilled coke.

RSC/Cleveland reported their system was supplied without a protective shield, and unprotected wiring was exposed to spilled coke. The wiring and pick-up arms were enclosed and shielded to solve the problem.

Stucki Bearing/Wear Plate Failure

Stucki bearings on the USS-supplied H-III car frames and quench cars at Clairton wore rapidly, causing car instability, charge arm alignment problems and potential for derailment. The company was replacing the roller-type stucki bearings with a solid design in September 1981. The Envirotech/-Chemico-supplied cars at RSC/Cleveland also had stucki bearings that wore quickly and were replaced by RSC with solid supports.

No problems were reported at RSC/Warren and Youngstown. J&L reported that the Envirotech/Chemico-supplied Teflon wear plates used on their cars wore quickly and required replacement. These systems were originally supplied with solid-type wear plates instead of stucki bearings.

<u>Summary of H-III Scrubber Car Problem Resolution</u>

Table 13 summarizes the status of H-III car problems reported by the steel companies. In assessing responsibility for problem areas, several thoughts should be kept in mind when reviewing this table.

- U.S. Steel designed and built the H-III frames, wheel assemblies, drive motor supports, power pick-up assemblies and cab structures while Envirotech/Chemico added the internal components, according to Envirotech/Chemico.

- H-III frames and wheel truck assemblies for all other plants were purchased by Envirotech/Chemico from a supplier, based on Chemico's general specifications. The car internal components were added at Envirotech/Chemico's or a subcontractor's shop. This arrangement partially accounts for minor differences observed in car construction.

TABLE 13. STATUS OF H-III SCRUBBER CAR PROBLEM RESOLUTION

Problem	Status of resolution	Solved by[c]	Comments[c]
FEMCO communications (4)[a]	Partly solved	Steel mills	Chemico reports FEMCO systems specified by mills. Mills state units supplied were inadequate.
Jet valve leakage (2)	Mostly solved	Chemico, mills investigating	Possible machining problems with valves.
Traction drive motors (3)	Partly solved	Motor manufacturer at Clairton; Republic at Cleveland	Motor vendor (Clairton). Unspecified at RSC.
Air compressor overheating (3)	Continuing problem	Steel mills	
Inverter failure (3)	Mostly solved	Steel mills	Original units inadequate
Stucki/wear plate failure (3)	Solved	Steel mills	USS supplied Clairton car frames. Chemico's vendor supplied others.
Air dryers inadequate (3)	Solved	Steel mills	
Exposed, mixed wiring (2)	Solved	Steel mills	
Hot rail icing (2)	Partly solved	Steel mills	Mills responsible for hot rails
Piping, tank corrosion (2)	Partly solved	Steel mills	
TV camera reliability (2)	Under solution	Steel mills	
Water leakage into cab (2)	Unsolved	-	

[a]Number of plants experiencing problems shown in parentheses (4 plants total, counting RSC/Warren, Youngstown as one.

[b]Terms "mostly, partly and solved" assigned by GCA based on comments made by steel companies during plant visits.

[c]Based on discussions between GCA and each steel company visited. Specific solutions were presented previously in this section, and details appear in the Trip Reports.

SECTION 6

MAINTENANCE PROGRAMS AND AVAILABILITY DATA

MAINTENANCE PROGRAMS

Table 14 summarizes car maintenance program information obtained during the plant visits. Each program is described below. Additional details appear in the Trip Report for each plant visit.

All information presented below was obtained through discussions with representatives of each company during the GCA plant visits. Representatives of Envirotech/Chemico Corporation attended one meeting, the April 1982 status meeting at USS/Clairton. All other discussions were held between GCA and steel company representatives.

U.S. Steel/Clairton - Maintenance Program Described to GCA During September 1981 Inspection

Checklists used for routine maintenance inspections at Clairton appear in the Trip Report. The company was beginning to record malfunction and repair data by computer in September 1981. An example computer printout also appears in the Trip Report.

One maintenance foreman is assigned full time to manage the 20-member maintenance crew that handles the cars. This foreman also has responsibility for Clairton's door program, but he stated that virtually all his time was spent on the cars since experienced foremen in the door shop handled door repair duties.

Four locations are used for maintenance of the Clairton cars. Sidings near each battery are used for routine efforts; little permanent repair equipment is available. A car set-up area near the maintenance office is used for in-plant repairs. A concrete jacking pad/pit arrangement was under construction at another location in September 1981. Finally, major repairs are made off-site at a U.S. Steel car shop.

In September 1981, maintenance was reportedly conducted on an "as needed" basis since the cars frequently broke down. GCA spoke with a number of people involved with the cars at Clairton in September 1981, including maintenance workers, operations foremen, the maintenance general foreman, environmental control personnel and the plant general superintendent. All levels of U.S. Steel personnel, including the general superintendent, impressed on GCA that the company had made an honest commitment to debugging the cars and improving car availability.

TABLE 14. MAINTENANCE PROGRAM DETAILS OBTAINED FROM PLANT VISITS

Plant (No. of cars)[a]	Maintenance frequency	Maintenance workers assigned to cars	Work area description	Spare parts	Comments
Clairton (7 H-III, 1 H-2 cars, several spares)	As needed, day turns, 7 days/week	20, total full-time assigned to car maintenance	Battery area, set up area. Concrete jacking pads under construction (outdoors). Offsite car shop. Proposed building.	Inventory and orders tracked on computer. Parts spread around plant.	Computer listing of repairs planned. Management appears fully supportive of maintaining cars.
J&L/Indiana Harbor (2 H-3 cars) (no spare)	One 8-hr turn/week	Maintenance supervisor, 1 mechanical foreman, 1 electrical foreman, Millwrights, motor inspectors on rotating basis.	Outdoor siding. Designing "pit" with utilities, storage.	Company reported extensive inventory. "Everything recommended by Chemico."	Experienced maintenance personnel assigned only to day turns.
Republic/Cleveland (2 H-3 cars) (one spare)	Revolving, 10-day schedule	Day turn--4 mechanical, 2-4 electrical, 4 millwrights, 2 pipefitters. Backturns--2-3 workers available.	Enclosed building with jacking pad and mock transfer station for alignment. Additional jacking pad on battery siding.	Extensive, reportedly much greater than recommended by Chemico.	
Republic/Warren (2 H-3 cars) (one spare)	Revolving, 14-day schedule	6 maintenance workers assigned to entire coke plant. Additional workers available as needed.	Outdoor siding with utilities.	Not reported	
Republic/Youngstown (1 H-3 car, no spare)	One 8-hr turn/week	Not specified by company.	Outdoor siding with utilities available.	Not reported	
Shenango (1 H-2 car, no spare)	One 8-hr turn/week	18-worker crew, many involved in startup.	Outdoor siding with utilities, some storage.	All parts recommended by Chemico.	

[a]Number of spare cars a function of number of batteries on-line.

U.S. Steel/Clairton - Maintenance Program Described to GCA During April 1982 Status Meeting

USS described the recently-implemented Maintenance Information Management (MIM) system for tracking car maintenance and repair. USS felt the programmable controls were especially troublesome, but their ability to keep the controllers operating was improving as the plant gained more experience. USS commented that they (at Clairton) had no previous experience with programmable control equipment which hindered troubleshooting during the first year or so of operation.

Tony Fazio, Envirotech Vice President, noted that the Chemico system components are interrelated and somewhat complicated relative to other coke battery equipment. Envirotech/Chemico had always recommended that USS assign one individual to be responsible for overall car maintenance and training of operators and maintenance workers. Mr. Fazio also indicated they have always recommended that problems be addressed immediately to insure spare car availability.

The USS Maintenance Superintendent described the maintenance organization as consisting of two departments, both reporting to himself. The water treatment system and heating plant are maintained by the boiler house maintenance department while the land base transfer unit and the cars are maintained by another department. The two Department Heads reportedly meet daily to plan work and coordinate outages.

The Envirotech/Chemico onsite coordinator left the plant in November 1981. The monthly car review meetings between Envirotech/Chemico and USS reportedly stopped in August 1981.

J&L/Indiana Harbor

Each car (no spares) is scheduled for one 8-hour preventative maintenance turn per week. Major problems that sideline the car are addressed on an as needed basis during the week.

One maintenance supervisor was reportedly responsible for the two cars. One mechanical foreman and one electrical foreman assigned to the cars on a semi-permanent basis are assisted by several millwrights and motor inspectors assigned on a rotating basis. J&L reported that the most experienced maintenance workers are assigned to the day turn, and they usually work on major problems that occur during second or third shifts. Minor problems occurring during the second and third shift are usually addressed quickly, if the cause of the problem can be found according to J&L. However, major problems that develop during second and third shifts usually sideline the car until the more experienced day turn workers are on duty.

Car maintenance is performed on a siding adjacent to the batteries. J&L reported their engineering department was designing an unenclosed "pit" to facilitate work underneath the car.

Republic/Cleveland

The maintenance area is enclosed with a building ("the barn") housing utilities and repair equipment. A jacking pad system enables lifting the cars for access underneath. Another jacking pad system is installed in the turnout near the battery. A "dummy" transfer station in the barn allows prealignment of the charging arm prior to set-out on the battery.

Routine maintenance to each car in the barn occurs on a revolving 10-day schedule. Normal preventive maintenance is performed according to an established checklist. Corrective maintenance of problems experienced during recent car operation is also conducted.

Daylight turn maintenance personnel consist of four mechanical, two to four electrical, four millwrights, and two pipefitters. Generally, at least two to three maintenance personnel are available during back turns. Republic noted that approximately 5 to 7 days (three people) are required to pre-stage charging arm alignment with the "dummy" transfer station in the barn. Minor maintenance is performed at the turnout area near the battery which has a second jacking system.

Republic indicated that their spare part inventory is quite extensive, containing far more spare parts than recommended by Envirotech/Chemico.

Republic/Warren, Youngstown

Limited maintenance information was available from RSC/Youngstown for their single car. Generally, the car is run until a disabling breakdown occurs according to plant representatives. The frequency of such breakdowns was not reported by the company.

At Warren, Republic stated that six maintenance workers per turn inspect and lubricate all coke plant machinery including the cars. After performing these routine duties, all six are assigned to problem areas around the plant, including the cars. The following additional maintenance workers are available for the day turn as needed (for the cars or other plant equipment): maintenance general foreman, electrical and mechanical foreman, millwrights and pipe fitters.

Republic stated that during the two week period the spare car is off-line at Warren, 2 to 4 coke plant maintenance workers generally spend approximately 2 to 4 hours per turn exclusively on the car.

Shenango

Routine maintenance on Shenango's single H-II car is performed during one 8-hour turn per week (Wednesday) and involves examining each car system using a check-list. Shenango indicated that if routine maintenance is not performed weekly, disabling problems develop. The routine program consists of the following:

- Brakes and hydraulic system inspection;
- Cleaning jets of foreign matter, inspecting jet isolation valves;
- Debris removal from traction drives;
- Tamping track ballast, removing spilled coke from rails;
- Examining all electrical, mechanical, and instrumentation systems;
- Check engine oil, filters, belts, etc.

The 18-worker maintenance crew available for car work consists of three instrumentation personnel (two for the cars, one for water treatment system), four millwirghts, two pipe fitters, two garage mechanics, two electricians, and two to five laborers. Shenango indicated that many of the same people involved in car startup currently perform car maintenance. The company noted that maintenance worker turn-over was very low.

Car maintenance is performed in an open area to the northwest of battery No. 4. The area contains a pit for access underneath the car. Utilities (water, air, and electricity), and some storage are available at the site. Shenango reported that their spare part inventory includes all parts recommended by Chemico, excluding expensive items such as the heater coils and diesel generator.

During the plant visit, Shenango emphasized that their maintenance program was designed to maximize car availability in order to demonstrate that a spare car was unnecessary.

AVAILABILITY DATA

Data describing car availability were requested from each company, and EPA, state and local regulatory agencies. The data summarized herein are based on the number of pushes caught and scrubbed divided by the number of pushes during that time period.

H-III Availability Data

Availability data for each Clairton H-III system appears in Figures 1 through 5. Monthly averages of all operating Clairton batteries combined appears in Figure 6. Figure 7 shows production of the Clairton plant.

Availability data for H-III cars at J&L/Indiana Harbor and Republic/Warren appear in Figures 8 and 9, respectively. All H-III availability data were supplied by the respective steel company.

H-II Availability Data

Availability data for H-II cars for Bethlehem/Bethlehem Battery 5, Shenango and J&L/Pittsburgh Battery P-4 appear in Figures 10, 11 and 12, respectively. Consistent with the H-III data, the H-II data are based on the number of pushes caught and scrubbed divided by the total number of pushes.

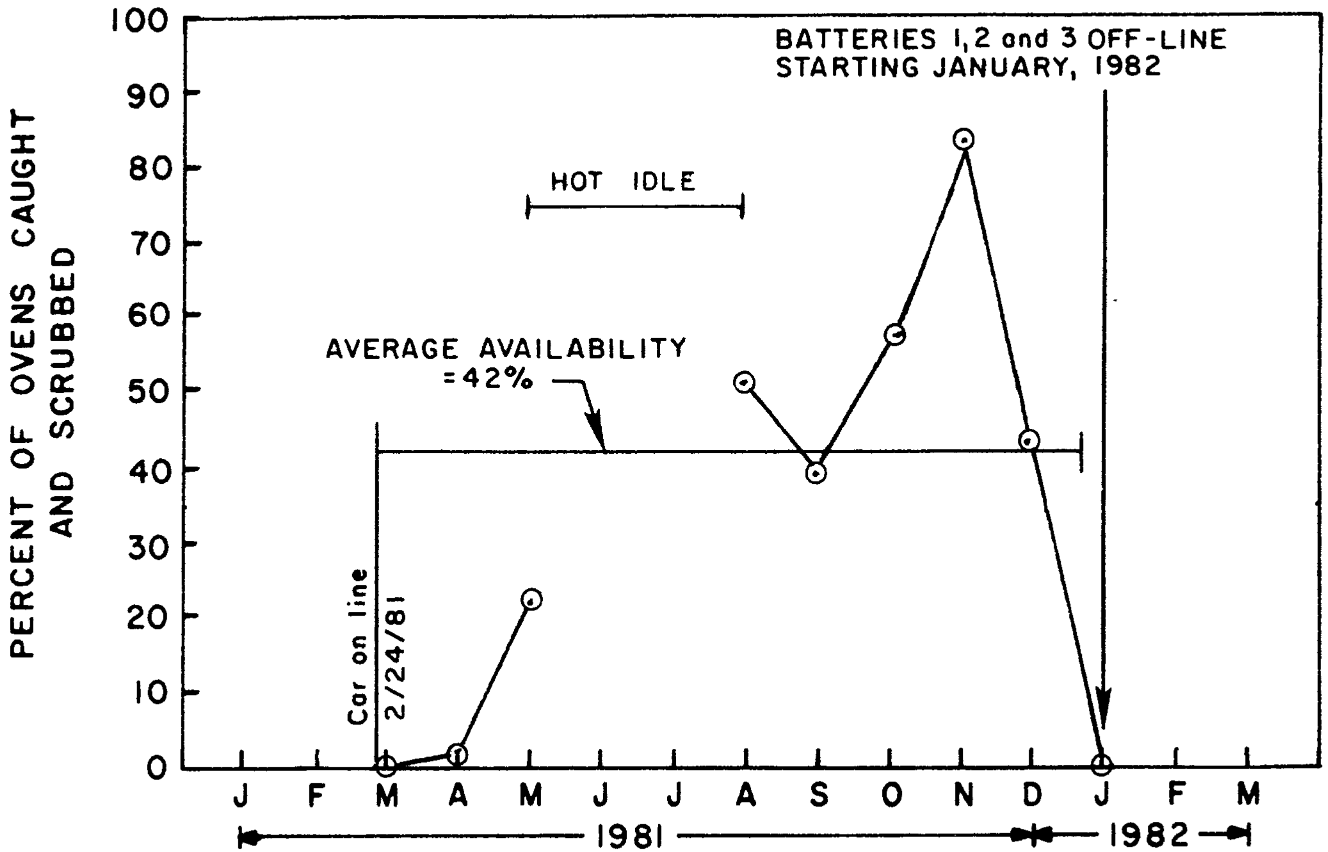

Figure 1. Availability data for H-III serving Batteries 1, 2 and 3 at U.S. Steel/Clairton. Average shown for 7 months operation, March 1981 through December 1981, excluding hot idle downtime.

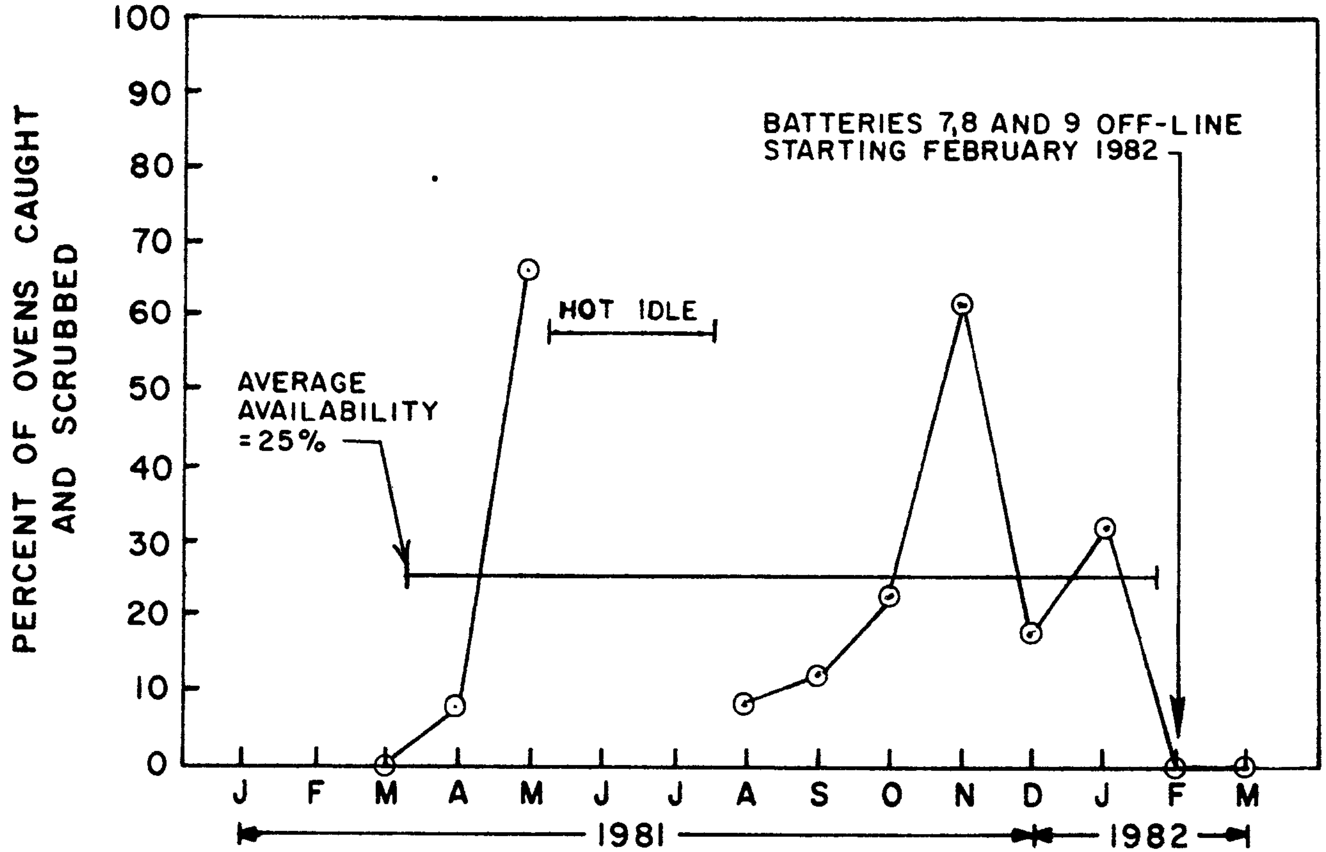

Figure 2. Availability data for H-III serving Batteries 7, 8 and 9 at U.S. Steel/Clairton.

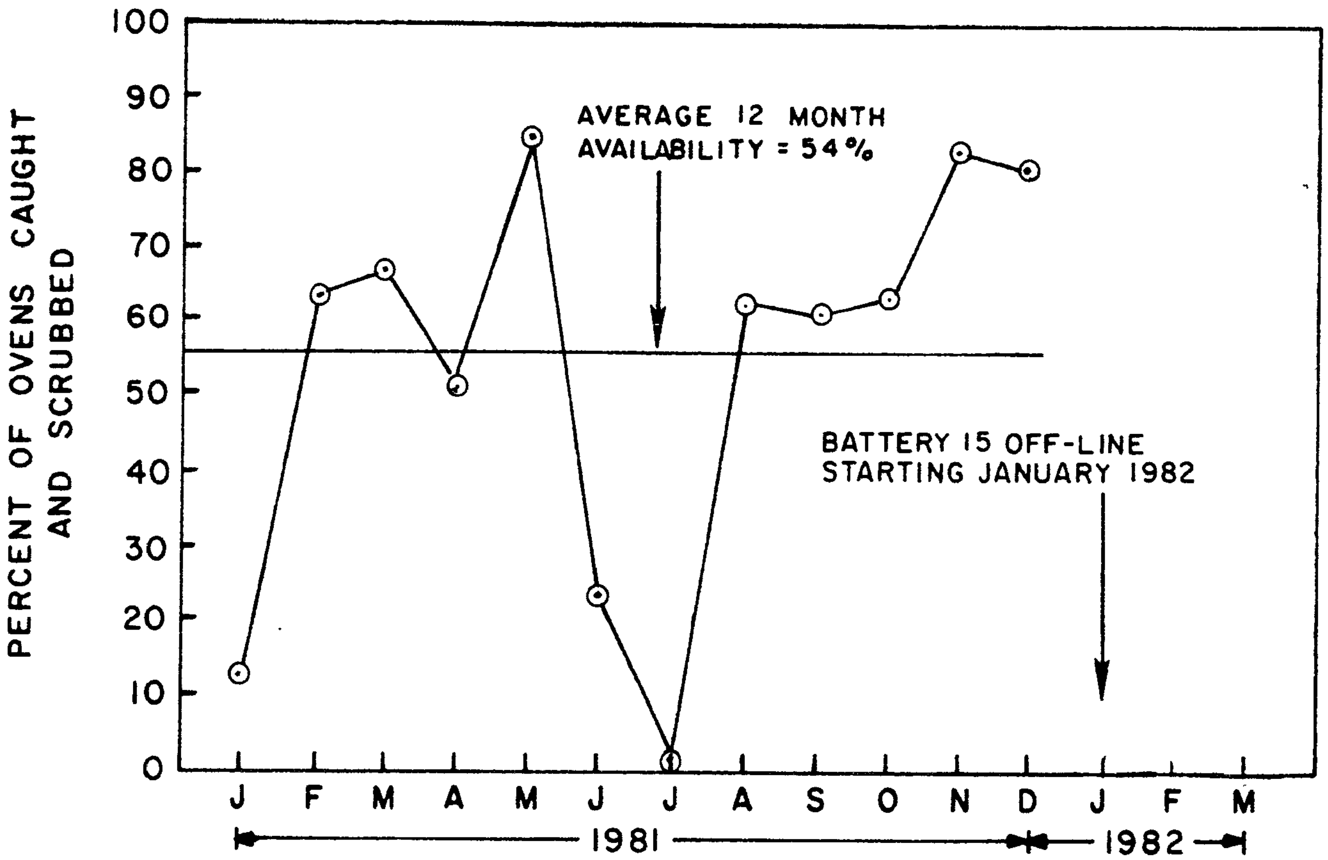

Figure 3. Availability data for H-III serving Battery 15 at U.S. Steel/Clairton.

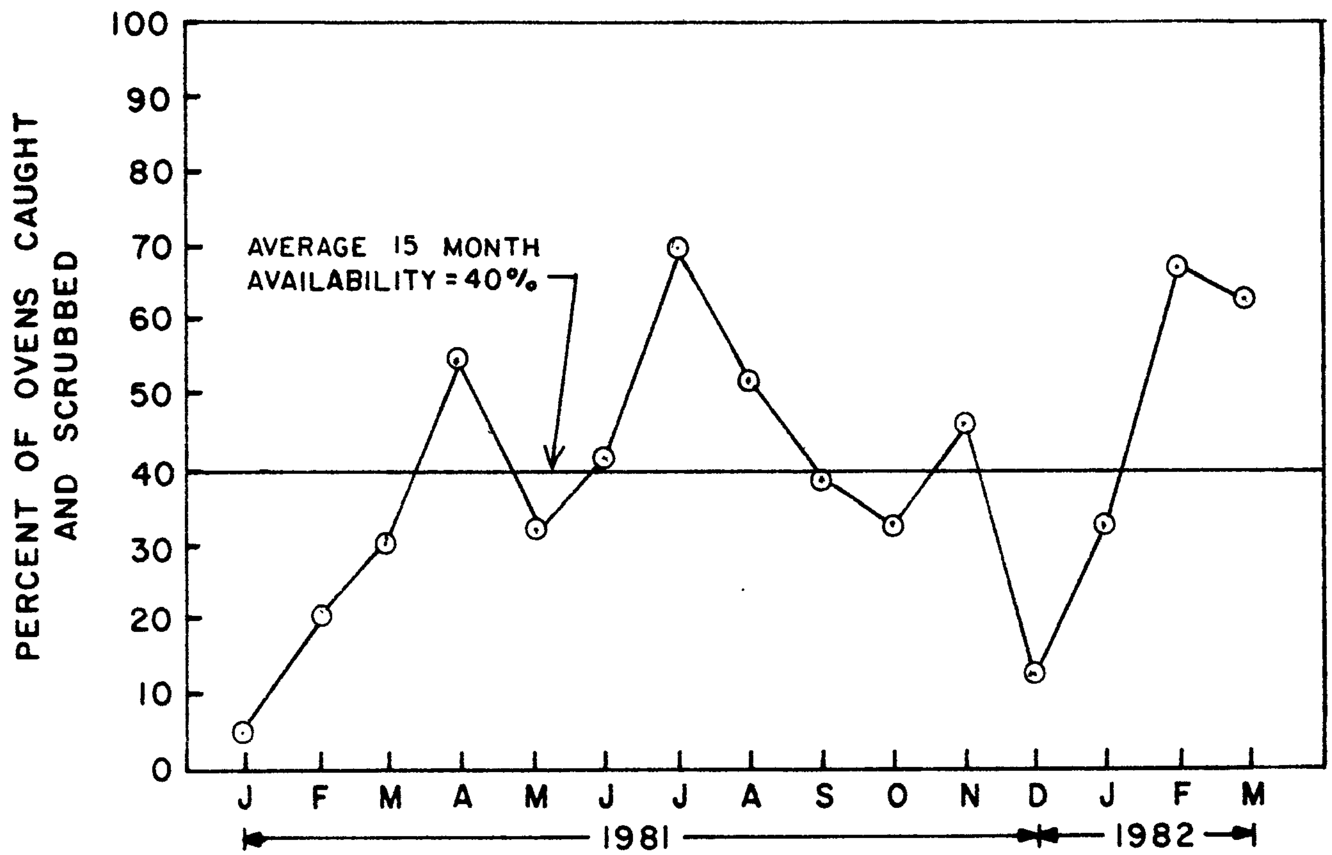

Figure 4. Availability data for H-III serving Batteries 19 and 20 at U.S. Steel/Clairton.

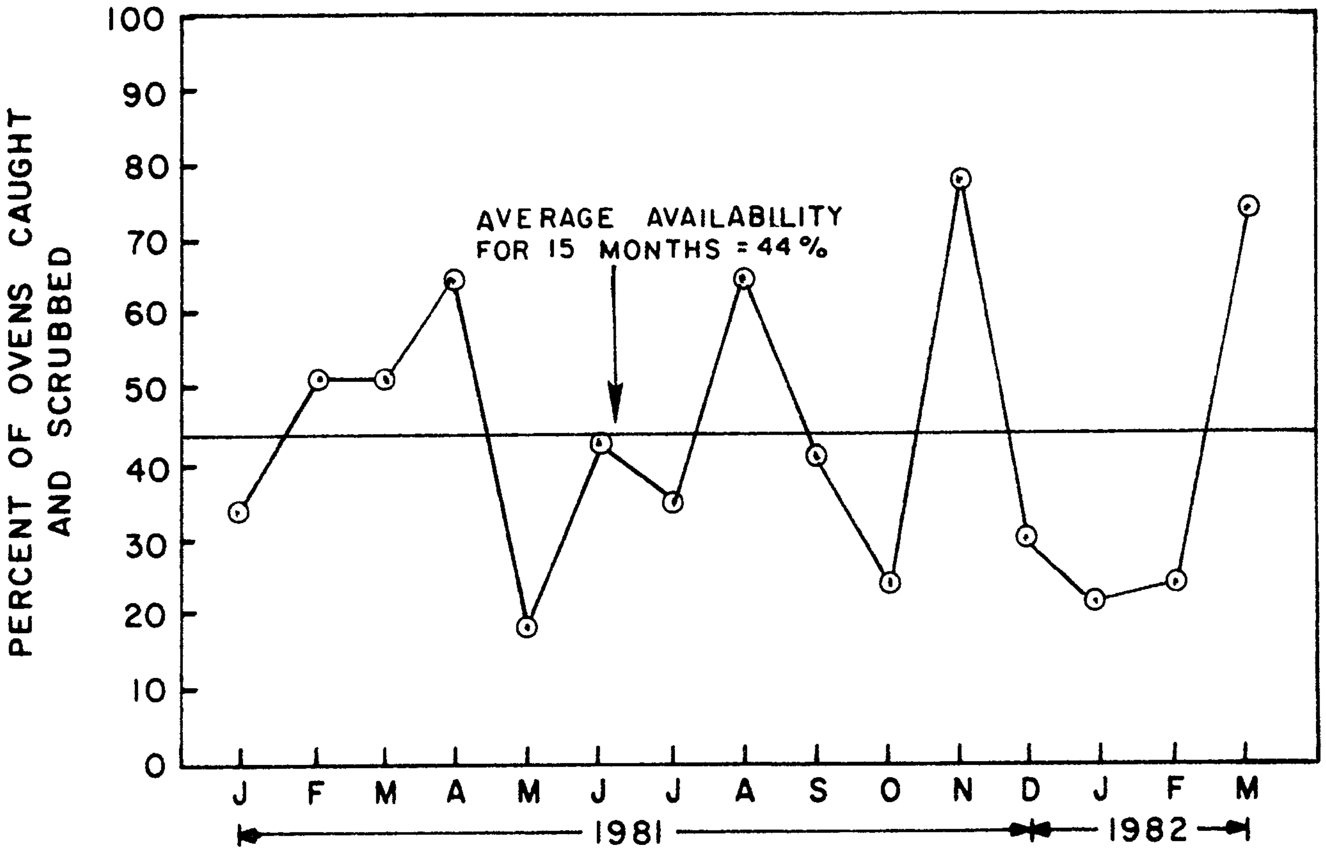

Figure 5. Availability data for H-III serving Batteries 21 and 22 at U.S. Steel/Clairton.

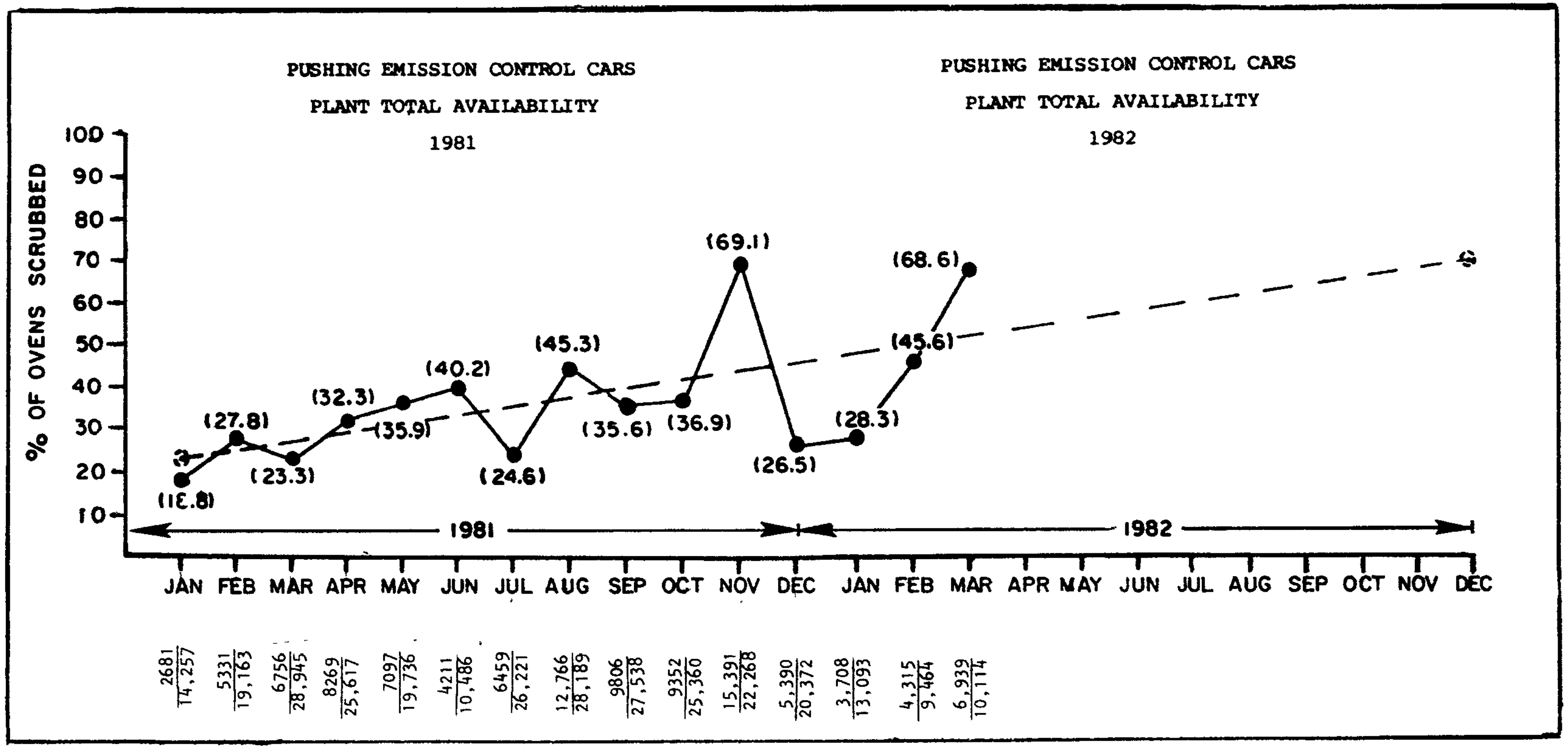

Figure 6. Availability of all operating H-III systems (combined) at U.S. Steel/Clairton (supplied by U.S. Steel).

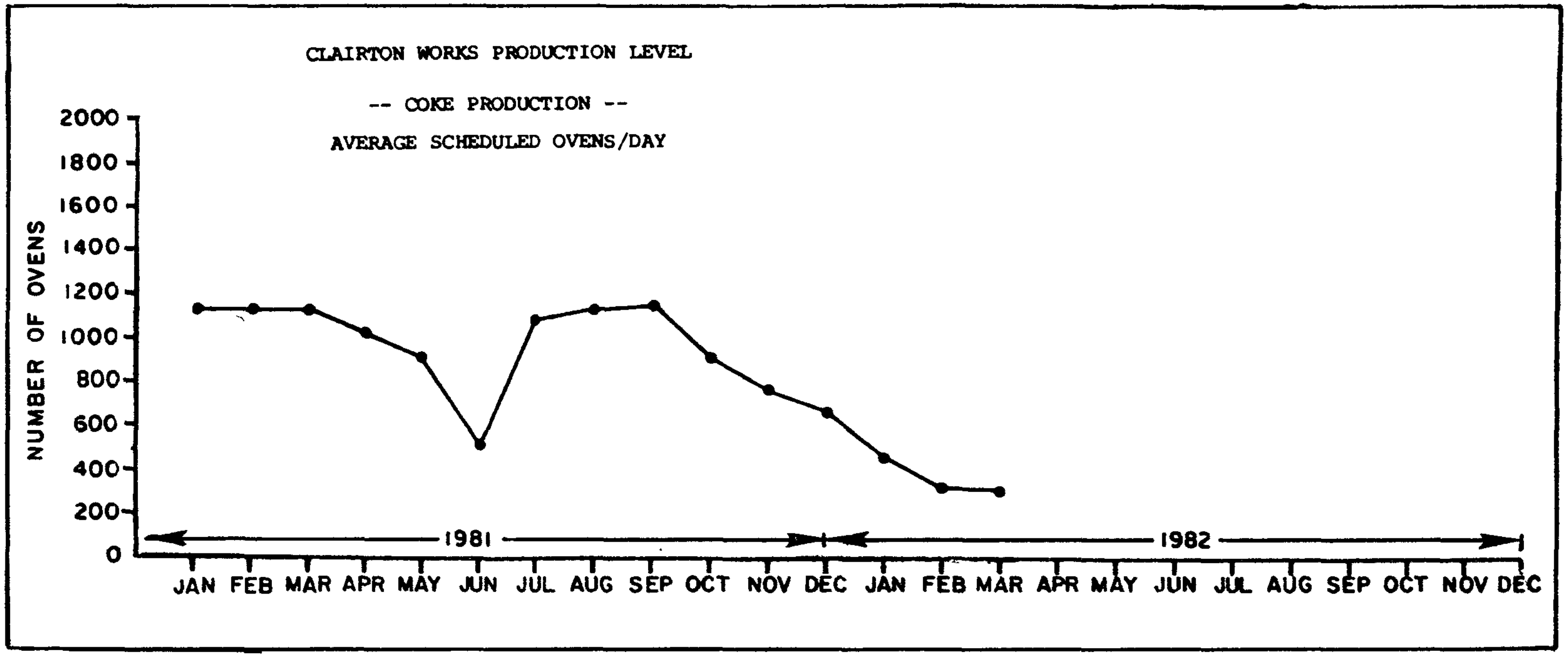

Figure 7. Plant production at Clairton Works (supplied by U. S. Steel).

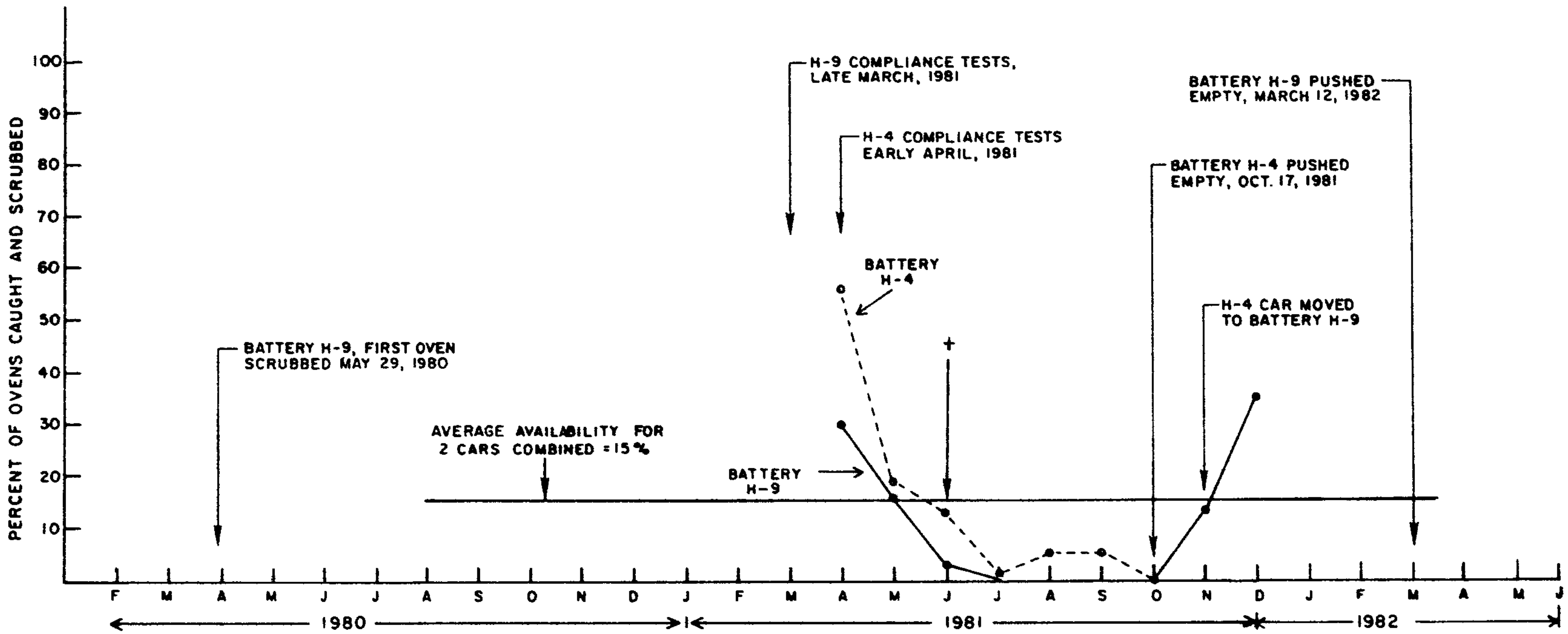

Figure 8. Availability data for H-III at J&L/Indiana Harbor Works (two cars, two batteries). Additional data not available from EPA or J&L.

+Accidents at both batteries occurred in June 1981 due to operator error, according to J&L, placing both cars out of service.

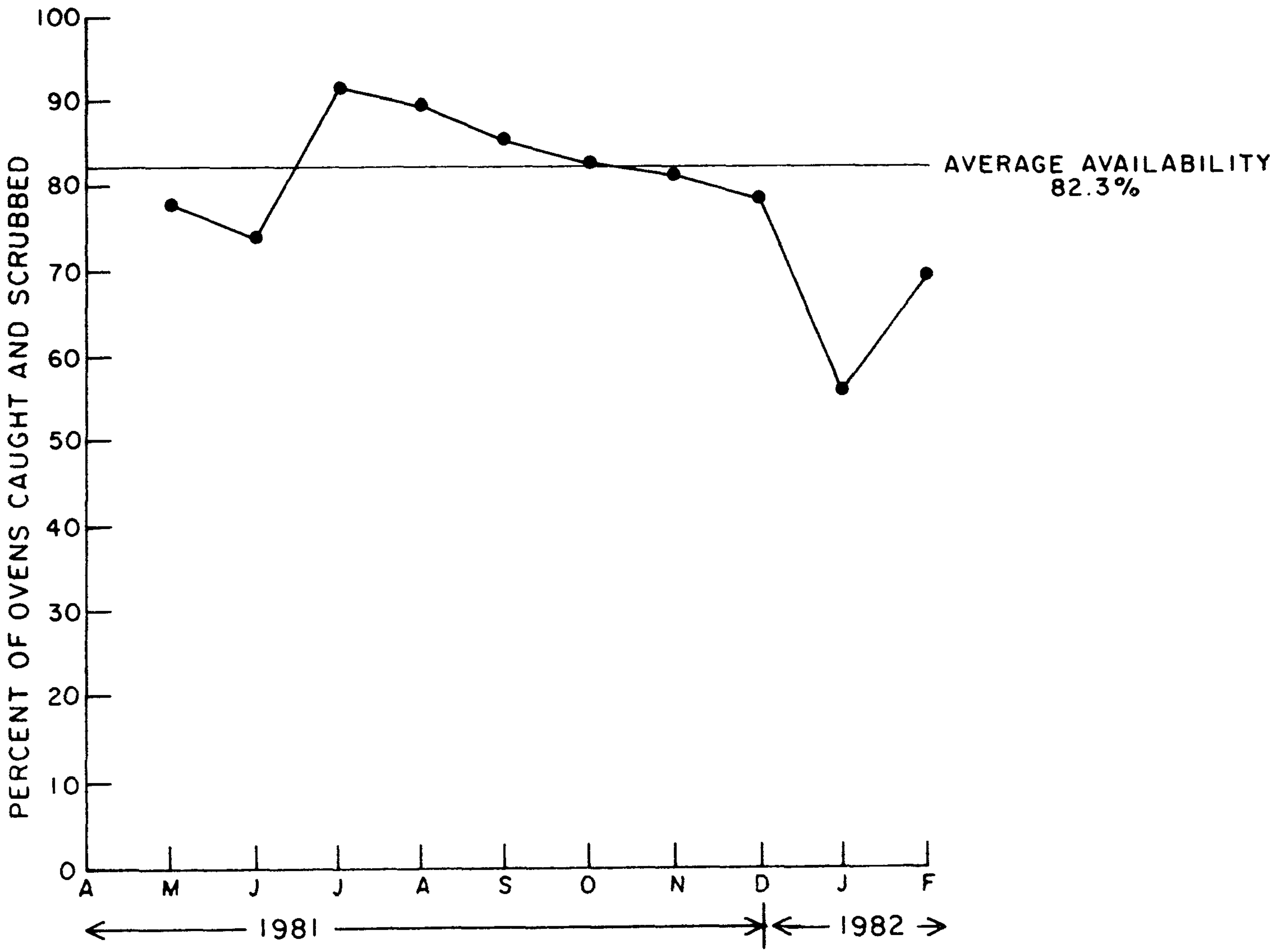

Figure 9. Availability data for H-III at Republic/Warren (two cars serve one battery).

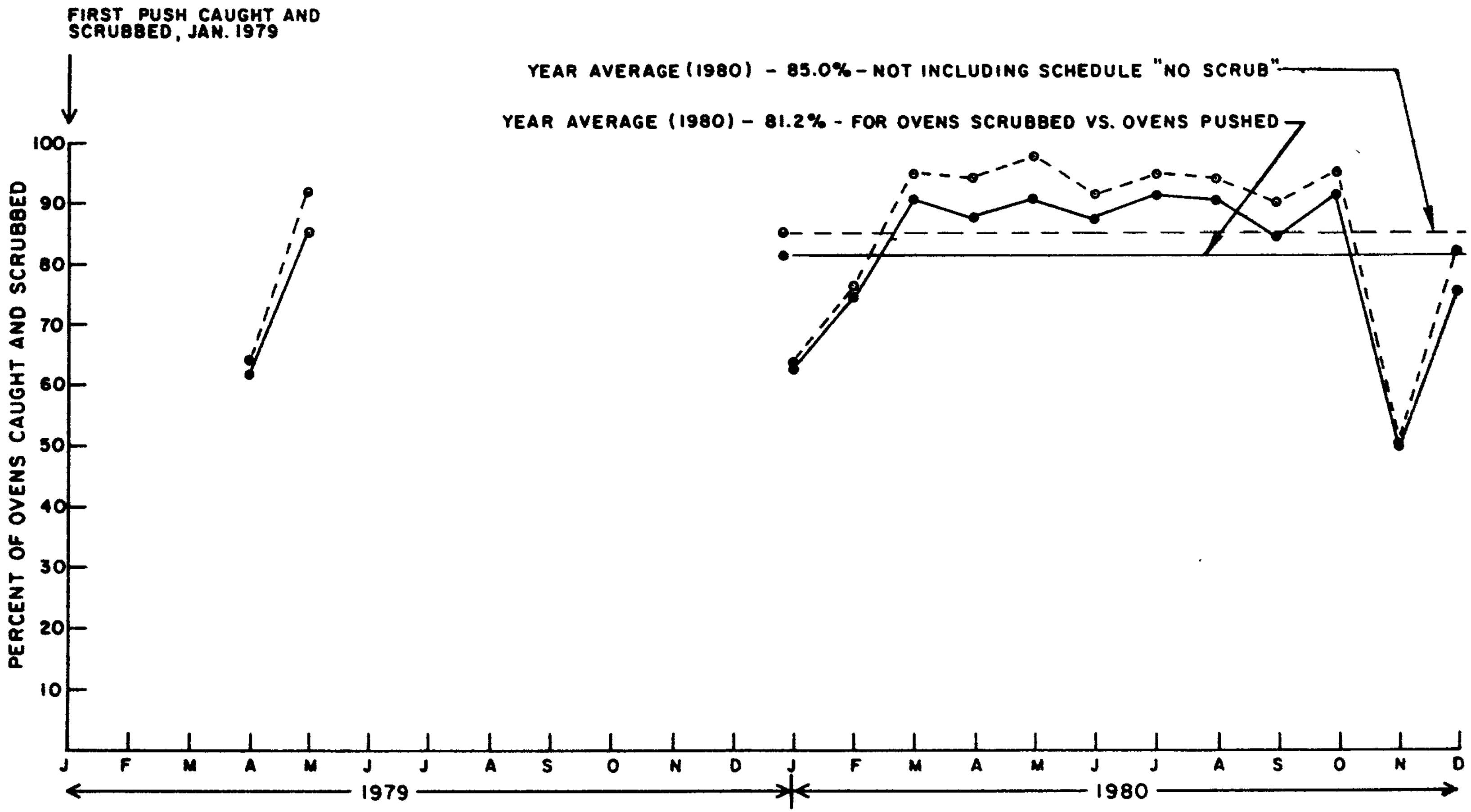

Figure 10. Availability data for H-II at Bethlehem Battery No. 5 at Bethlehem (one car, one battery).

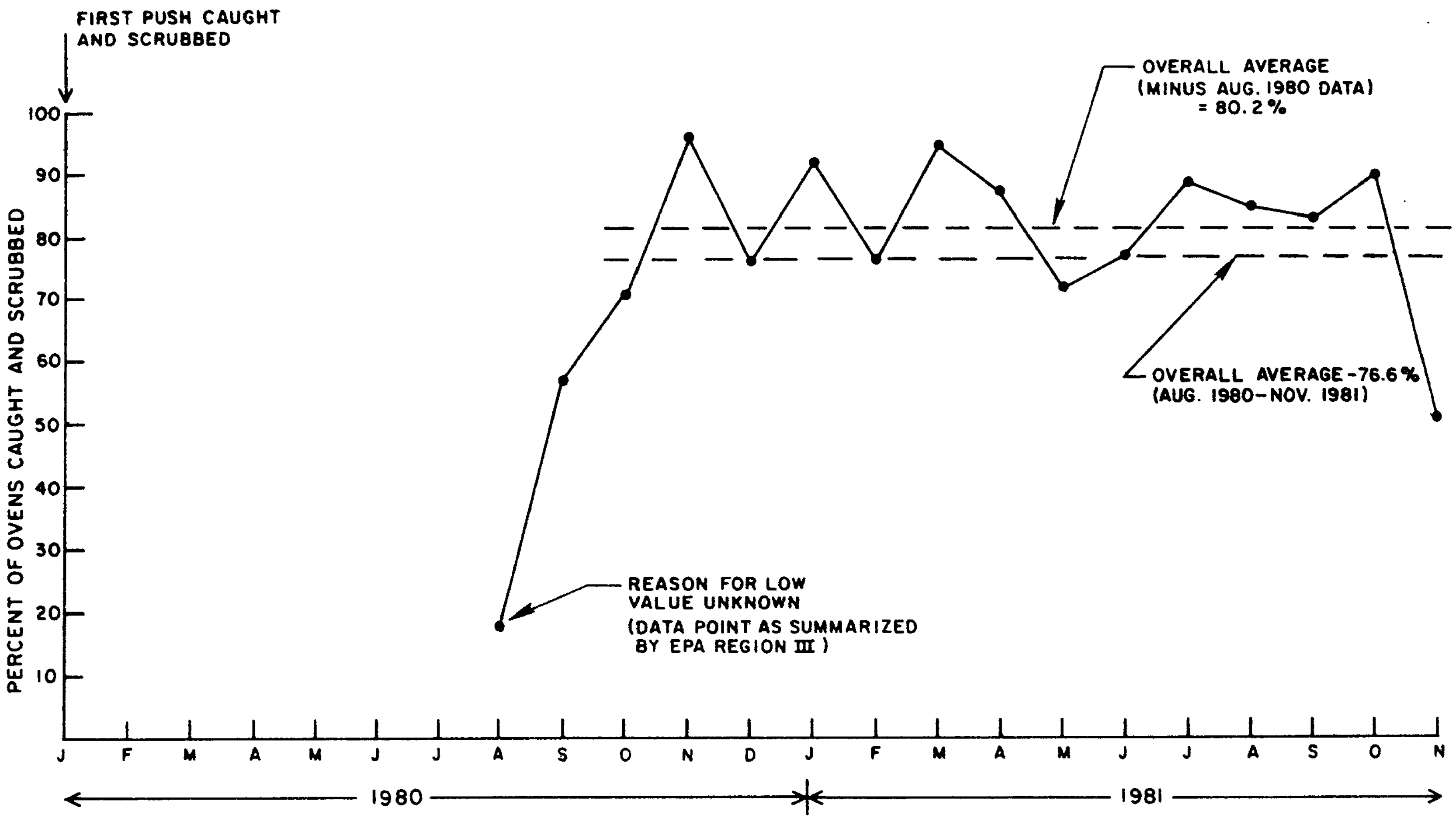

Figure 11. Availability data for H-II at Shenango (one car, two batteries).

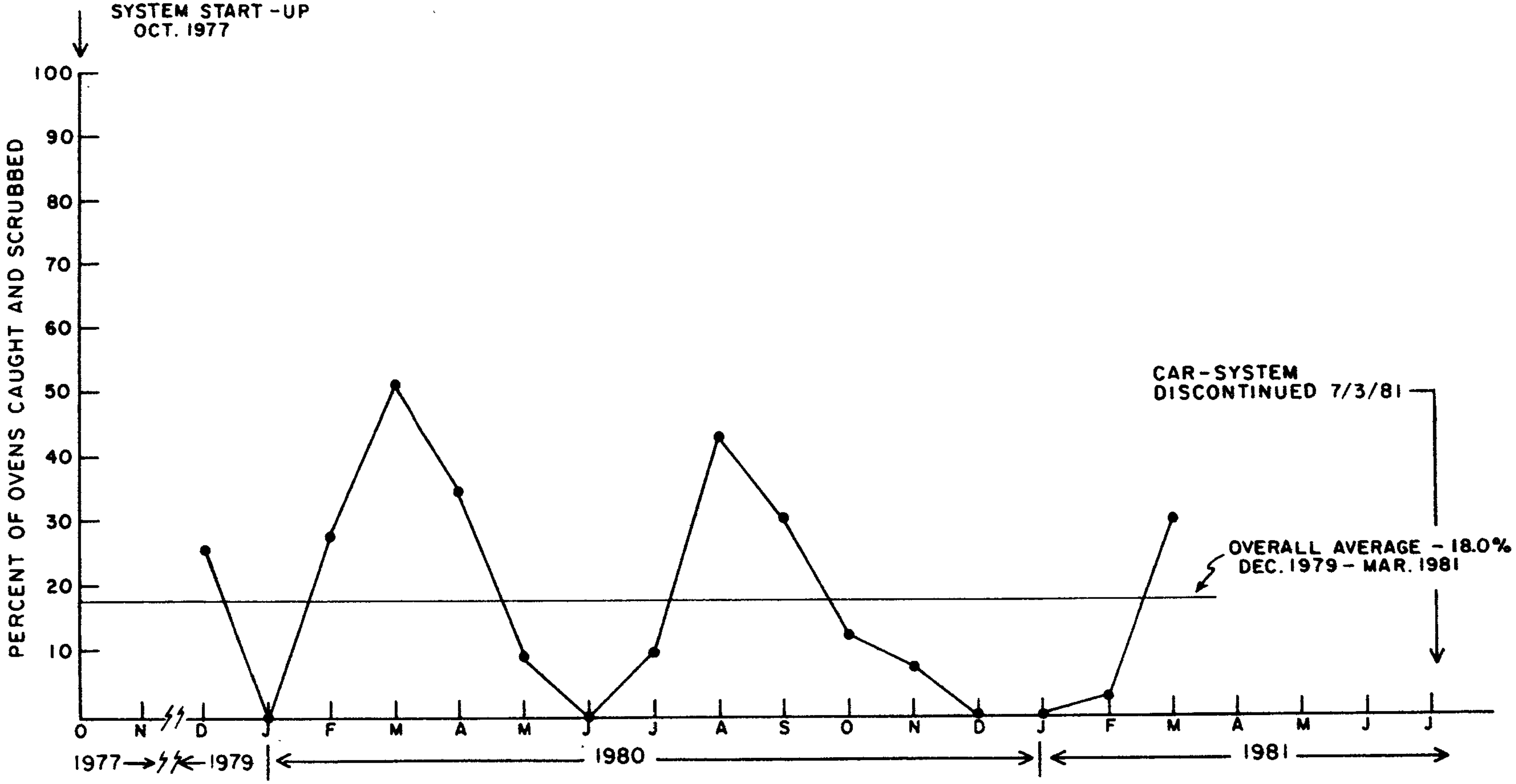

Figure 12. Availability data for H-II at J&L/Pittsburgh Battery P-4
(one car, one battery).

The Bethlehem data were compiled from daily plant records supplied to EPA by the company. Some entries in the Bethlehem data package were illegible. However, it was possible to fairly accurately compile a list of ovens not caught and scrubbed, and the causes as shown in Tables 15 and 16 for 1979 and 1980, respectively. In addition, Table 17, supplied by Bethlehem Steel, provides more car availability details for 1980.

Car breakdown data compiled from J&L reports to EPA regarding the H-II on Battery P-4 in Pittsburgh appear in Table 18. Note that substantial downtime was incurred from construction of the new Minister Stein system and unspecified work on the door machine. For the 1-year period from 2/14/80 through 2/23/81, J&L reported an average availability of 22 percent based on total operating hours.

Problem areas at Shenango are described in the Trip Report, and summarized in tables shown in this report Appendix.

TABLE 15. H-II DOWNTIME REPORTED FOR BETHLEHEM/BETHLEHEM BATTERY NO. 5 IN APRIL AND MAY 1979.

Reason	Total pushes not scrubbed[a]
Accumulator leaks Isolation valve problems Diesel fuel pump change	947
Seal pump and A/C problems	173
Leak in temperature well	22
Junction box ground	15
Heater flame failure	12
Air regulator line break	8
Low water levels	4
High storage tank level	3
Low water temperature	2
TOTAL DOWNTIME, April-May 1979	1186 pushes

[a]Total number of ovens pushed during the 2-month period not supplied by company.

TABLE 16. H-II DOWNTIME REPORTED BY BETHLEHEM/ BETHLEHEM BATTERY NO. 5 IN 1980 (entire year)

Cause of downtime	Number of occurrences	Total pushes not scrubbed
High pressure pump failure	16	1,110
Diesel overheating (radiator problem)	9	769
Brake failure, problems	8	643
Jet and high pressure pump leaks	2	393
Isolation valve problems	7	312
Wheel bearing problems	2	236
Drive motor problem	4	194
Heater flame failure	12	163
Limit switch problem	84	2
TV camera problem	3	80
OVERALL 1980 DOWNTIME =		4,081 pushes[a]
Total pushes, 1980 =		28,296 pushes

Note: 85% availability, subtracting out ovens not scheduled to be scrubbed.

[a]Does not agree with Table 17; data are reported herein as supplied by company.

TABLE 17. MONTHLY AVAILABILITY DATA FOR H-II ON BATTERY NO. 5 AT BETHLEHEM/BETHLEHEM

Month	# ovens pushed	# ovens scrubbed	% ovens scrubbed	# ovens planned "No Scrub"
1980				
January	2,848	1,770	62.1	64
February	2,749	2,038	74.1	74
March	2,916	2,650	90.9	124
April	2,690	2,357	87.6	185
May	2,711	2,463	90.9	195
June	2,098	1,827	87.1	95
July	2,039	1,858	91.1	77
August	2,046	1,846	90.2	79
September	1,953	1,640	84.0	120
October	2,046	1,865	91.2	80
November	1,980	976	49.3	22
December	2,220	1,682	75.8	167
TOTALS	28,296	22,972	81.2	1,282

\# Ovens Not Scrubbed = # ovens pushed − # ovens scrubbed
= 28,296 − 22,972
= 5,324

\# Unscheduled "No Scrub" = # ovens not scrubbed − # planned "no scrub"
= 5,324 − 1,282
= 4,042

(Planned "no scrub" represents ovens for which use of the system was not planned for a variety of reasons).

TABLE 18. J&L/PITTSBURGH CHEMICO H-II BREAKDOWN REPORT SUMMARY FOR 2/14/80 - 2/23/81 ON BATTERY P-4

Date	Reason	Total outage time, hrs[a]
2/15/80	Broken wire	0.5
2/16	Broken hydraulic line	120
2/21	Broken hose	4.5
2/22	Flame failure	13
3/6	[#5 door machine-broken shaft]	6.75
3/7	[#5 door machine-motor limit short]	0.75
3/9	Replace hydraulic fluid	1
3/11	Hydraulic problems	2
3/14	Maintenance	11
3/15	[#5 door machine-straighten coke guide]	6
3/16	[#5 door machine-repairs]	2
3/17	Heater coil problem	6.25
3/18	Hydraulic & electrical short problem	11
3/19-20	[#5 door machine]	18.25
3/21-22	High pressure pump seal	25
3/22-23	[#5 door machine-burnt wiring]	26.5
3/22-23	Bad dump plungers	26
3/24-28	High pressure pump breakdown	86
3/30	Hydraulic pump problem	14
3/31-4/4	[#5 door machine-OSHA mods]	56
4/5-7	Diesel engine overheating	46
4/8	[#5 door machine]	17
4/8-12	Recirculatory pump failure	88
4/13-15	[#5 door machine]	46.25
4/16-17	Flame problem in heater	37.5
4/18	[#5 door machine]	8.75
4/20	[#5 door machine-OSHA]	11.75
4/20	[#5 door machine-door jack]	2
4/21-5/1	[#5 door machine-OSHA]	134.5
5/2	[#5 door machine-coke guide]	12
5/2-3	Water supply problem	11
5/3-4	Lost motor on diesel	6.25
5/4	[#5 door machine-coke guide]	5.5
5/5-6	Broken hydraulic line	17
5/6-7	Electrical failure	39.5
5/7-7/18	A.C. generator failure	1781 (1.5 months)
7/18-19	Car travel problem	23.5
7/20-26	Tilt box trouble	155
7/28-29	Problem with quench	32
7/30-8/2	Work on P-4 Wharf	71.25
8/2-6	Broken air line	82
8/6	Broken hydraulic pipe	4.75
8/8-9	Work on P-4 Wharf	32
8/9-10	Clean-up coke spillage P-4 Wharf	19
8/11	Broken hydraulic pipe	15.5

(continued)

TABLE 18 (continued)

Date	Reason	Total outage time, hrs.
8/12	Work on P-4 Wharf for Min. Stein system	9.5
8/12-14	Trouble with haul cable & R.R. switch P-4 Screening Station	46.75
8/15	Broken hydraulic pipe	4.25
8/16	Trouble with dump box	22.25
8/16	[#5 door machine-air compressor]	17.5
8/21	Work on P-4 Wharf for M. S.	8
8/22-23	Work on P-4 Screen Station	24
8/24-28	[Battery problem-repair door on diesel room struck by coke guide & repair #5 door machine]	96
8/29-30	Bad coil on dump box	5.5
8/30	[#5 door machine breakdown]	6.5
8/31	Flame failure	14.25
9/1	Clean-up P-4 Screen Station	8.5
9/3	Would not dump	1.5
9/4	Work on #5 door machine	10
9/5	Work on P-4 Screen Station	9.5
9/6	Pusher off tracks	6.5
9/7-8	High pressure pump failure	23
9/9	Work on P-4 Wharf Screen Station	8
9/10	Broken hydraulic pipe	11.5
9/11	Work on M.S. Push Control Station	8
9/11-27	Hole in heater tube & bad combustion fan	382.5
9/29	Work on #5 door machine	10
9/29-30	Problem w/ temperature control on heater	9.5
10/3-5	Track work	63
10/10-14	Hydraulic cylinder bearing	96
10/14-11/14	M.S. System work	744 (1 month)
11/15-19	Clearance problem with pillar at P-4 Wharf of M.S. System	99.5
11/19-22	[#5 door machine]	57
11/22-23	Broken hydraulic line	19
11/24-27	Flame failure	64
11/27-2/18	Flame failure, recirculatory pump problem, broken hydraulic cylinder	2010
2/18-20/81	Water sprays, AC recirculating pump & track problem	36.75
2/20-21/81	Hydraulic leak	26
TOTAL OUTAGE REPORTED		7084 hrs
TOTAL OPERATING TIME		9072 hrs
AVAILABILITY		22 percent

[a]Actual ovens not caught and scrubbed is not available; battery P-4 is normally operated at approximate 111 push/day, i.e., 4.6 pushes/hr, average.

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2. Rudolph, H. and S. Sawyer. Engineering Criteria for a Hooded Quench Car System. Iron and Steel Engineer. 54(3):27. March 1977.

3. Hooded Quench Car System Controls Coke Pushing Emissions. Iron and Steel Engineer. 55(3):83. March 1978.

4. Car order summary sheet provided by Envirotech/Chemico.

APPENDICES A-E

TABLES FROM TRIP REPORTS LISTING H-II and H-III SYSTEM PROBLEMS REPORTED BY STEEL COMPANIES

TABLE A-1. HOT CAR PROBLEM SUMMARY DESCRIBED BY U.S. STEEL IN SEPTEMBER 1981

Problem	Result	Solution
Coke spillage	Frequent track cleaning, potential derailment	Increase SS volume (tests underway)
SS clearance	Lack of combustion stack clearance limits interchangeability	Remove portion of protruding beam on SS
TV camera reliability	Lack of vision, downtime	Increased physical protection, purge air lens cleaning, wire relocation.
Stucki bearing failure	Excessive car rocking	New design
Box tilt limit switch	Switch failure-operator can't determine box position	New switch design
Weak springs	Excessive rocking	Install stabilizers
Ross valve modification	Poor performance of box dump cylinders	Modify cylinder controls to improve reliability
Standardize wiring	DC circuit wiring plugs not all interchangeable	Standardized plugs
Dump cylinder line	Poor hose design, failure of box dump cylinders	Redesigned hose and connections.
Straight brake shoe	Excessive brake wear	Convert to conventional design; i.e., wrap-around brake shoe
Separate 110 supply	TV and light wires in exposed position, shorted	Moved wires inside chassis for protection
Cover air receivers	Falling coke damage	Partial solution
Air receiver gauge	SS box dump cylinders	Air pressure gauge in operator's cab

Note: Items above double line were described to GCA/EPA by coke plant management at 15 September meeting. Items below double line were discussed on 16 and 17 September during plant inspection.

TABLE A-2. H CAR PROBLEM SUMMARY DESCRIBED BY U.S. STEEL IN SEPTEMBER 1981

Problem	Result	Solution
Quench tower limit switch positions vary	Different positions, poor interchangeability	Standardize switch location
Jet valve leakage	New valve to increase scrubber flow are malfunctioning	Ongoing discussion with Chemico
Electric inverter malfunctions	Electric congestion causes failure of AC-powered equipment. Quick troubleshooting and repairs difficult.	New inverters on order
Femco signal malfunction	Pusher can't communicate with hot car	Increased number of transformer couplings
Power rail icing	Dead spots cause power loss and inverter malfunction	Add second power pick-up, steam trace rails automatic inverter reactivation equipment
Power pick-up problems	Broken arms, long replacement time, shoe wear	Add pick-up arm, new design
Traction drive motors	Several problems with motor design-see text	Motor supplier accepted responsibility for repairs
Stucki bearing failure	Bearing failure causes car rocking-charging arm misalignment	New design being tested
Charging station alignment	Multitude of charging station problems	See text
Track deterioration	Due to car weight, derailment possible, difficult to align charging arm	New track on 13, 14, and 15 - temporary repairs on rest of plant
Onboard hot water tank corrosion	Ultimate tank failure	Investigating anti-corrosion additive
Air compressor belt covers	Poor access to onboard compressor belts	Simplified cover removal
Set screw spring cannisters	Spring cannisters on hot water transfer arm would loose setting	Teflon insert with set screw added

(continued)

TABLE A-2 (continued)

Problem	Result	Solution
Standardize hydraulic hoses	Different lengths on charging arm caused breakage, difficult replacement	Convert to uniform length for easier maintenance, less wear
Insulate air lines	Freezing-plugging	Temporary insulation to be replaced with permanent
Revise spotting lights	Damaged by coke, difficult location for replacement	Lowered lights for better access, steel shields
Malfunctioning air dryer controls	Current pneumatic controls unreliable	Converting to electric controls
Electric timers-air tanks	Pneumatic tank drains not reliable	Converting to electric controls
Duct expansion joint	Problems in maintaining neoprene joint	Working with Chemico-no immediate solution
Controls to avoid stacks	Cars programmed to stop if SS box tilted, but need final hardware	Install hardware
Pivot bearing bolts	Bolts holding charging arm loosen, loose alignment	Stronger bolts plus keepers

Note: Items above double line were described to GCA/EPA by coke plant management at 15 September meeting. Items below double line were discussed on 16 and 17 September plant inspection.

TABLE A-3. STATUS OF H-III CAR PROBLEMS AS REPORTED BY U.S. STEEL[a] IN APRIL 1982 STATUS MEETING

Problem	Effect	Solution	Status as of 4/20/82
Traction drive motors	Lead wire shorting	Shorten wires, fix to frame	Complete
	Field coil shorting	Repairs by supplier	60 percent complete
	Bore elongation	Unknown	Working with GE
Power pickup problems	Excessive shoe wear, 2-hr arm replacement time	Simplified 6-wire design to 2-wire	Complete
Inverter failure	Car must be removed from service to repair	Added 3rd inverter to allow repairs while car in service	Complete on one car - Inverters back-ordered
	Damage from reversed set-out cables	Added diode to prevent failure	Complete
Charge Arm Hoses/Cables	Too long, wore, non-standard lengths, custom fabricating	Standardized hose lengths to reduce replacement time	Complete
Hydraulic system solenoid	Solenoid failure prevented fluid return to reservoir	Rewired circuitry	Complete - two cars
Hydraulic system	Difficult due to lack of schematic, isolation valves	New system schematics drawn, valves installed	Complete
Moisture in air lines	Brake line and coke box dump cylinder freeze-up	New filters, coalescers only partially effective; will add mechanical separator	Mechanical separator tested, not yet installed
Hot rail freeze-up	Car shutdown due to power loss	Steam tracing proven effective	Complete
Expansion duct deterioration	Safety problem, car off-line for replacement	Working with Chemico	Several ideas, untested, still a problem

(continued)

TABLE A-3 (continued)

Problem	Effect	Solution	Status as of 4/20/82
Separator support failure	Fatigue due to vibrations	Adding stiffners, repairing supports	Complete - one car working on two cars, will repair rest
Brake shoe wear	Excessive wear, frequent replacement	Converted to larger, wraparound shoe	Complete
Charge arm alignment	Excessive downtime for realignment	Developed quicker realignment procedure	Complete
Valve leakage	Split body valves - poor sealing	New gasket material, improved torquing procedure	?
Land base pressure sensor failure	Cannot transfer water, downtime to repair	Plan to test new pressure sensor on LB No. 7	Future improvement
Water quality problems	Sparger tube plugging, onboard tank corrosion, valve problem	Will add deaerator for corrosion control. Other problem solutions not discussed	Future improvement (dearator onsite)
Jet valve leakage	Water loss	Problem appears solved, although early to tell	(Complete)

[a]Problems appear in order of discussion at meeting.

TABLE B-1. LAND BASE PROBLEM SUMMARY

H-III PROBLEMS DESCRIBED BY J&L/INDIANA HARBOR IN JANUARY 1982

Problem	Result	Solution
Maintaining COG combustion in central heating plant	Poor control of water temperature, burner flameout and overfiring	Switching to natural gas
Low water temperature	Controls prevent transfer to H car if temperature and pressure are too low	Installed recirculation line
Intermittent water overheating	System shuts down	Recirulation line (see above)
Poor control of treated water hardness	Occasional carbonate plugging of sparger tubes in land base mixing tank	Planning to improve coagulation system controls, install hardness monitor and increase sparger tube openings
Ruptured boiler tubes	North boiler damaged by freezing; south boiler tube failure under investigation	Recent problem, under study

TABLE B-2. HOT CAR AND COKE GUIDE HOOD PROBLEM SUMMARY

H-III PROBLEMS DESCRIBED BY J&L/INDIANA HARBOR
IN JANUARY 1982

Problem	Result	Solution
Excessive car rocking	Hot car hit coke guide	Installed shock absorbers
Coke guide hood warpage	Occasional repairs	Designing water cooling sprays
Coke spillage	Frequent track cleanup, damage to cables, wires, hoses	Extended push ram head, coke distribution improvement
Hot box dump cylinder	High maintenance of valves and solenoid	Continued maintenance
High moisture coke - poor hot car drainage	Coke quality affected	None reported
Hot car warpage	Distortion of box	Unspecified design changes
Hot car limit switch tilt malfunctions	Box does not return to proper position	Reworked limit switches

TABLE B-3. H-CAR PROBLEM SUMMARY

H-III PROBLEMS DESCRIBED BY J&L/INDIANA HARBOR IN JANUARY 1982

Problem	Effect	Solution
Charging arm alignment and limit switch	Realignment approximately 3 months. Short-duration malfunction approximately every turn	Realign as necessary. Improve limit switch operation. Operator and maintenance personnel improving troubleshooting ability
Track deterioration	Charge arm alignment problems, potential car derailment	Frequent rail shimming and ballast tamping. Investigating rail welding and ballast impregnation to stabilize
Brake shoe wear	Original shoes lasted 2 to 4 weeks	New shoes, last approximately 1-1/2 months
Pickup arm shoe wear	Rapid shoe wear	Hot rail redesign, frequent shoe replacement
Air dryer controls malfunction	Moisture in system	Installed larger capacity dryer
Air compressor overheat	Car shutdown	Installed cooling fans, some problems remain
FEMCO communication	Occasinal poor communication	None - problem no more severe than with other FEMCO units in coke plant
Power rail icing	Power interruption shuts car down	Heat tape installed on rails near quench tower. Still a problem during severe weather. Car restart buttons moved into operator's cab
TV camera electrical problems due to poor sealing of protective boxes	Poor camera operation	Improve weatherproofing. Can operate car without cameras (according to plant representatives)

TABLE C-1. LAND BASE PROBLEM SUMMARY AS REPORTED BY RSC/CLEVELAND

Problem	Result	Solution
No water circulation in heater tubes during low fire	Destroyed two sets of heater bundles, flame impingement	Partial solution, blowdown system with recirculation installed
Unreliable heater system controls	Simultaneous heater firing; poor flame-out detection, constant monitoring	Interlock system installed, new process controls
Poor COG firing	Btu content of COG low; poor heating control	Converted to natural gas, instrumentation changes
Undersized combustion air fans	Low heater output	New fans with increased hp (partial solution)
Heater system control panel melting	Heater inoperative	Partial solution, insulation added
Standby air compressor malfunction	Failure to automatically actuate; heater inoperative	Redesign, rewiring interlock system
Water treatment system	Constant maintenance, intermittent water hardness problem	Micro-processor controls installed
Temperature loss in water lines	Difficulty in maintaining design water temperature	Discontinued use of thermo-siphon
Steam hammer problems	Piping shifted, damaged block valve flange and seals	Installed bypass valve
Charging arm limit switches	Limit switch freeze-up from moisture fallout	Vent stack and lean-to installed--still problems.
FEMCO communication system, noise and heat	Water transfer problems, constant maintenance	Cooling and shield protection installed

TABLE C-2. HOT CAR AND COKE GUIDE HOOD PROBLEM SUMMARY AS REPORTED BY RSC/CLEVELAND

Problem	Result	Solution
Coke spillage	Frequent track cleaning, damage to hydraulic and electrical cables	Partial solutions (see text)
Track deterioration	Potential car rocking, increased charging arm alignment	Partial solution, tie plates redesigned and splice joints constantly shimmed
Hot box dump limit switch failure	Inaccurate dump box position, recurring maintenance	Installed additional hot rail, added back-up limit switches
Brake shoe wear	Numerous brake shoe replacements	Pressure sensor installed
Hot car TV camera reliability	Difficult to maintain in constant operation	None, considering new housing
Running lights poorly sealed	Bulb life reduced, frequent burn-outs	Plexiglass enclosures installed
Hot box dump cylinders	Seals worn	Replacement

TABLE C-3. H-CAR PROBLEM SUMMARY AS REPORTED BY RSC/CLEVELAND

Problem	Result	Solution
Power pick-up arm and shoe damage	Power losses (coke production), exposed wire destroyed	Protective cover added, conduit installed
Inverter failure	Power surge caused malfunctions	Delay mechanism installed
Resistor bank panel failure	Resistor shortcircuiting from water and coke breeze infiltration	Redesigned seal and ventilation added
FEMCO communication	Verbal communication inadequate for hot box spotting	Infrared spotting device and radio interlock mechanism added
Operator cab water leakage	Damage to control panels and cables/wiring	Continual problem
Stucki bearing failure	Inability to roll, flat spots developed	Partial solution; upper set replaced with steel pads, lower set to be replaced
Traction drive motors failure	Numerous holdout coil replacement	Unspecified changes
Air compressor and hydraulic motors	Maintenance access to brushes difficult	None reported, continual problem
Jet isolation valves	Intermittent, considerable water leakage	Rewelded flanges
Air dryers undersized	Fluidic control of air valves difficult	New, larger dryers to be installed

TABLE D-1. H-III LAND BASE SYSTEM PROBLEM SUMMARY FOR REPUBLIC STEEL/ WARREN AND YOUNGSTOWN

Problem	Result	Solution
Insufficient gas flow and heat output with COG combustion	Heater failures, burner flameouts.	Converted to natural gas, changed all gas lines and instrumentation.
No water flow through tubes during low fire ("soak")	Hot spots and tube warpage.	Installed recirculation line.
Oxygen release with high temperature water	Water lines and valves became pitted and corroded.	Currently use nitrogen purge.
Plugged filters; poor control of water hardness with river water	Heater tube bundles "blew-up", piping deteriorated.	Partial solution using city water; scaling still problem.
Transfer mechanism failure	Bent hydraulic cylinders, mechanism drift.	Installed additional limit switches.
Isolation valve leakage	Accidental turn-on.	Installed check valves; replaced seat, stems, and air operated valve.
By-pass valve leakage	Water loss.	Replaced valve seals.

TABLE D-2. H-III HOT CAR AND COKE GUIDE HOOD PROBLEM SUMMARY FOR REPUBLIC STEEL/WARREN AND YOUNGSTOWN

Problem	Result	Solution
Coke spillage	Daily track cleaning, equipment damage, track deteriorating.	Partial solution; modifications to coke guide, hot box, and pusher ram. (See text for plant differences.)
Coke box warpage	Excessive distortion to box lines.	Partial solution; reinforce frame. Experiments with various liners-little success.
Excessive car rocking	Potential for collision and charge arm alignment problems.	Redesigned rail splicings (Warren). Replaced steel pads on trucks (Youngstown).
Long hydraulic hoses	Rubbed on car; coke abrasion damage.	Reduced hose lengths.
Hot box limit switch tilt modifications	False indication to operator, premature tripping of switch.	Changed limit switch to override timer mechanism.

TABLE D-3. H-CAR PROBLEM SUMMARY FOR WARREN AND YOUNGSTOWN

Problem	Result	Solution
Oxygen release from water	Water lines and valves became pitted and eroded.	Added nitrogen purge.
Track deterioration	Charge arm alignment problems.	Replaced tracks twice; reduced coke spillage (see text).
Charging arm alignment	Clamping mechnism failure; storage tank water shifting.	Provided balance thrust to feed air motor base; shimmed battery side of car.
Exposed wiring-junction boxes	Moisture and coke abrasion, failure.	Placed junction boxes inside car; replaced wiring with covering material.
Mixed wiring at junction boxes	Troubleshooting was time consuming; difficult to interpret wiring diagrams.	Isolated wiring; installed fuses at key locations.
FEMCO communications	Weak signal from H-car to land-based station.	Increased signal strength. FEMCO units still problem.
Cyclone separator replacement	Deterioration and cracks developed.	Converted unit into multi-piece construction for quicker maintenance.
Water leakage into cab	Control panel, electrical cable malfunction.	None reported.
Air compressors overheating	Continuous maintenance.	Installed exhaust fans.

TABLE E-1. H CAR PROBLEM SUMMARY[a]

SHENANGO H-II PROBLEM SUMMARY BASED ON GCA INSPECTION OF FEBRUARY 1982

Problem	Result	Solution
High-pressure pump cavitation	Erosion of pump housings and seals.	None apparent. Using stainless steel housing.
Jet isolation valve wear	Jet wear, and continued leakage.	Partial solution, higher maintenance (see text).
Jet plugging	Poor scrubbing, can't shut off water.	Remove bugles, blow out jets.
Brake shoe holder/hanger assembly failure	Broken assemblies, derailment occurred.	New design installed.
Spatial confinement	Maintenance access difficult.	Careful scheduling of maintenance crews.
Heater failure	Frequent flame-outs, other malfunction causes car shutdown.	Increased pilot tube length, added third scanner for increased detection.
High oxygen content of water	Pipe and high-pressure pump corrosion.	Stainless steel pipe now used, caustic added to water, O_2 scavengers.
Teflon pad wear	Car rocking.	Modified pads.
Radiator clogging	Diesel overheating.	Steam clean radiator.
Poor location of traction drives	Clogging from coke breeze.	Routine cleaning.
FEMCO signal malfunction	Slight communication problems. Occasionally prevents quench water transfer.	None reported.
Electric hot water transfer valve	Valve failure, numerous rebuilds.	Replaced with an air valve system.
Ductwork abrasion	Buildup of coke breeze.	Frequent cleaning and patching, complete rebuild anticipated in future.

(continued)

TABLE E-1 (continued)

Problem	Result	Solution
Camera and wire exposure to heat	Weather proofing deterioration.	Replaced, and added wrapping material.
High influent solids content to treatment system	Increased filter plugging.	Additional maintenance above normal. Changed filters, added activated carbon before main filter.
Duct expansion joint	Deteriorated seal.	Replaced neoprene seal.

[a]Items above single line were described by Shenango as major, and those below as minor areas of concern.

TABLE E-2. HOT CAR PROBLEM SUMMARY[a]

SHENANGO PUSHING PROBLEM SUMMARY BASED ON GCA INSPECTION OF FEBRUARY 1982

Problem	Result	Solution
Brake shoe holder/hanger assembly failure	Broken assemblies, derailment occurred.	New design installed.
Coke guide hood/hot box seal material	Destruction of original material, escape of emissions.	New material installed, problem not solved.
Teflon pad design	Wear of original pads.	Modified pads.
Moisture on box limit switch	Freeze-up in winter.	Considering new switch
Dump cylinder hoses	Broken hydraulic hoses from coke and vibration.	Frequent hose replacement.
Brake cylinders	Pin wear, freezing.	Replacement, maintenance.

[a]Items above single line were described by Shenango as major, and those below as minor areas of concern.

APPENDIX F

METHOD D: PROCEDURE FOR OBSERVING VISIBLE EMISSIONS EQUAL TO OR GREATER THAN 20% OPACITY DURING PUSHING

PRINCIPLE

The visible emissions equal to or greater than 20 percent opacity emitted during the push cycle are timed by an observer located on the cokeside of the battery. In addition, the maximum opacity observed during the coke fall period is recorded.

DEFINITIONS

Push Cycle

The period of time commencing when the cokeside oven door is removed and ending when the coke is quenched. Further, the push cycle is divided into three periods, as follows:

A ⟶ B ⟶ C ⟶ D

A to B = 1: Period from time door comes off to time start of ram movement.

B to C = 2: Period from time start of ram movement to time all coke is in hot car.

C to D = 3: Period from time all coke is in hot car to time of quench.

Coke Fall Period

The period of time B to C or 2, above.

Quench

Cooling the red hot coke to a temperature below its ignition temperature at the quench tower.

Quench Tower

The structure where the quench is carried out, normally made of wood or brick and designed to conduct the steam plume generated during the quench into the atmosphere.

Hot Car

The railroad car into which the coke is pushed; sometimes called the quench car.

Opacity

The degree to which emissions reduce the transmission of light and obscure the view of an object in the background.

PROCEDURE

Position

The observer makes the observation from the cokeside of the battery, where a clear view of the push can be obtained. In general, a location on the ground, in the cokeside yard, outside the hot car tracks approximately perpendicular to the observed oven is acceptable. However, the observer is not restricted to being on the ground level, but may make the observation from some elevated level. If multiple observers are recording the same emissions, the observers should be positioned as closely to each other as feasible. Observer position is recorded on the data sheet.

Observations

During the push cycle, the observer watches all the potential emission sources. These include the oven and the hot car. Upon observing any visible emission with an opacity equal to or greater than 20 percent opacity, as determined against any contrasting background, an accumulative stopwatch is started. The watch is stopped when the visible emission goes below 20 percent and is restarted when a visible emission equal to or greater than 20 percent reappears. The observer continues this procedure for the entire push cycle; using either separate stopwatches for each of the three periods of the cycle or noting the time of each period and recording on the data sheet while employing one or two stopwatches. The time recorded on the data sheet at the end of each period is the total time on the stopwatch for that period. In addition to the above, the observer also mentally notes the densest opacity occuring during the coke fall period and at the end of the push cycle records on the data sheet the maximum opacity observed.

The following visible emissions are not timed:

- Steam vapor;

- Visible emissions generated from jamb cleaning;

- Visible emissions from the removed door; or
- Visible emissions from the pushside of the oven.

In some cases, coke battery operators will keep the standpipe cap open during the push cycle. These emissions should be regarded as pushing emissions. However, on some inspections emissions from the standpipe caps will not be observed. In this situation, a note should be placed on the data sheet indicating that the standpipe cap was open and not read.

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

This report summarizes a 3-month study of the 21 Envirotech/Chemico one-spot, mobile pushing emissions control systems currently installed at coke plants operated by five domestic steel companies. The study investigated; (1) design differences between cars; (2) startup, operational and maintenance problems reported by each steel company; (3) mass and visible emissions test data; (4) car availability; and (5) solutions to operating problems implemented and/or under consideration. Information in the report was developed through detailed discussions and field inspections at four steel companies; discussions with EPA engineers and review of EPA, state and local regulatory agency files; office discussions with the equipment vendor; and review of the technical literature. The objective of this report is to factually present information available through the above sources.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Iron and Steel Industry Air Pollution Coking Performance Tests Availability Maintenance	Pollution Control Envirotech/Chemico	

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