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# ENCLOSED COKE PUSHING AND QUENCHING SYSTEM DESIGN MANUAL

Office of Research and Development
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# ENCLOSED COKE PUSHING AND QUENCHING SYSTEM DESIGN MANUAL

by

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## ABSTRACT

The Weirton Steel Division of National Steel Corporation has contracted with Koppers Company to design and construct a new coke plant consisting of a single battery of 87 ovens and complete coal chemical plant and support facilities. The coke ovens are of the new tall oven configuration and the plant features the most advanced production techniques and air and water pollution control devices which set a new benchmark for modern coking operations.

A most significant feature of this new plant involves the development of a new concept in abating the air pollution normally associated with the pushing and quenching emissions. Koppers Company with the Weirton Steel Division and with the support and cooperation of the Environmental Protection Agency has designed and constructed an "Enclosed Coke Pushing and Quenching System."

The concept of this new system involves the containment of the hot coke from the face of the slot type oven during the pushing operation, through the successive handling and transport, and through a continuous and controlled quench. The hot coke emissions are confined and cleaned before discharge to the atmosphere and the quench emissions are controlled to stack discharge of low velocity steam vapor.

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| | |
|---|---|
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# SECTION I

## CONCLUSIONS

The overall goal in preparation of this report is to demonstrate a system designed for emission control capability, operability, reliability and maintainability. This report covers only Phase 1 relative to the Enclosed Coke Pushing and Quenching System and involves the design and construction of the system.

The final report in this program will be issued at the conclusion of Phase 2, Emission Testing and System Evaluation Program. Phase 2 will concern itself primarily with the degree to which the system goals were attained. As this report anticipates the operation of the system, it is not possible to draw conclusions at this time.

## SECTION II

## INTRODUCTION

The new 87 oven Koppers' twin-flue battery for the Browns Island plant of Weirton Steel will have a coke production rate of about 150 tons* per hour, while operating at a gross coking time of 15.4 hours. Modern pollution control equipment is being incorporated throughout this new plant and a totally new concept for the control of oven pushing and quenching emissions has been developed. This concept includes the total enclosure of the coke during the push and during the transfer period to the quenching system. Scrubbers are used to remove particulate matter throughout the operation and the intermittent large quenching vapor cloud, characteristic of all coke plants, has been reduced to a smaller continuously flowing plume of water vapor.

Full enclosure of the push has been made by the use of a hood which surrounds the coke guide and which makes a tight connection to a single position hot coke transfer car. Other coke plants rely upon the motion of the quench car during the push to spread the coke to a uniform depth for proper quenching, but with this system the car is sized so that the coke is pushing without moving the transfer car. Quenching of the coke is achieved by emptying the coke from the transfer car into one of three receiving hoppers, from which the coke

* A list of factors for converting from non-metric to metric units is provided on page 84.

is fed by vibrating feeders onto the vibrating quenching conveyors. Greater control of coke moistures is to be expected because of the thinner depth of coke at quenching and because of better control of quenching water volumes. Clean water is provided as makeup to the quenching and gas cleaning systems. The water system is closed and completely recirculating.

Figure 1, System General Arrangement (drawing #319-A600), illustrates the various components incorporated into this new system, their interaction with each other, and with the coke oven battery proper. (The components are identified in Figure 5.)

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## SECTION III

## PROCESS DESCRIPTION

Figures 2 and 3 (drawings #319-A616 and #319-A617) describe the conditions of transfer of hot coke from the oven through the quenching operation. The diagrams also provide information on design parameters used in the processing of the gas streams through the venturi scrubbers, quench steam to the stack, and the water spray services. Figure 4 (drawing #319-A618) is an instrumentation flow diagram with complete information on the monitoring and control of the process as conceived for this particular design.

The flow diagrams indicate the general application and use of water in the quench system. General service water is the source of makeup to the system and is used in a number of once through applications with subsequent discharge to recirculation sump. A direct service water makeup to the sump provides the makeup trim source necessary to maintain sump level control.

The venturi scrubbers, the stack mist suppressor, certain duct sprays, and the track hopper sprays all use service water as their primary source. The waters not vaporized in these services are ultimately returned to the quench sump.

The primary use of recirculated water is in direct spray application to the incandescent coke and for conveyor belt protection responding to temperature monitoring.

The gas flow definition as presented in Figure 2 represents the fume and steam flow quantities at the maximum levels. The quench steam discharge is based on the normal operating mode of two (2) quench units operating concurrently. The fume system discharge represents the condition when one (1) hopper is being charged and the maximum fan capacity is being utilized. The gas flows and particulate loadings are design values; they are not a result of measurements. Establishing the exact values will be one of the principal goals of Phase 2 of the demonstration.

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## SECTION IV

## PROCESS DESIGN

This section provides definition of the various major components contributing to the system as defined in Figure 5 (drawing #319-A600).

A. DOOR MACHINE

Each door machine is of the standard design with a door extractor, door and jamb cleaners, and the necessary electrical controls for all operations, including the coke guide. The traction drive for the door machine - coke guide unit is also a part of the door machine.

B. COKE GUIDE (Figure 6, drawing #319-A601)

The coke guide car consists of two connected sections. The first section is the coke guide rack which is similar to the standard design except that it has been totally enclosed and fits tightly againt the buckstays and against the top of the jamb casting. With this tight enclosure, no smoke will escape from the oven door opening or from the guide during a push.

The second section of the coke guide is the hood. It is a double segmented, quandrant type shroud with a rectangular cross section. This shroud is mounted on the front steelwork of the coke guide frame to totally enclose the push and contain the smoke during the push. The stationary section of the hood is attached to the fixed frame of the coke guide; the movable segment pivots from this frame to contact the raised section of the hot coke

B. <u>COKE GUIDE</u> (Figure 6) - Continued

transfer car. Structural steel members of both segments are protected from the heat by stainless steel plates which also form the hood enclosure. These plates are loosely bolted to the structural frame. Seal plates are provided to cover the gaps between the fixed and movable sections of the hood.

After the door has been removed, the coke guide is positioned in front of the oven to be pushed by the door machine operator. The guide is then racked in to give support to the coke during the push. When the hot coke transfer car has been properly spotted, the movable hood is lowered onto the raised section of the coke transfer car. This lowering action prevents the car from traveling and prevents the coke receiving car's sealing curtain from closing. The cross-battery interlock circuit is then energized permitting the push to occur.

After the pusher ram has been retracted, the door machine operator raises the fume hood and the traction drive interlock for the hot coke transfer car is released.

C. <u>HOT COKE TRANSFER CAR</u> (Figure 7, drawing #319-A602)

The hot coke transfer car is a four-axle type car with a fabricated structural steel frame supporting one large hopper which is capable of handling one oven of coke in a single position. The hopper is totally enclosed including a sealable opening which is raised and

C. HOT COKE TRANSFER CAR (Figure 7) - Continued

canted toward the oven to meet the extendable hood segment of the coke guide. Also, there is a flexible stainless steel retractable sealing curtain which closes over the opening during the travel period. This curtain is driven by pushbutton from the cab of the gas cleaning car.

The enclosed hopper consists of structural steel and plate weldments with an internal lining of high duty refactory fire brick. Hinged hopper gates for the discharge opening in the bottom of the hopper are pneumatically operated from the locomotive cab. When the gates are opened, the car cannot travel. The gates open downward and out to provide a nearly total enclosure with the top of the individual track hopper.

To position the hot coke transfer car at the oven, the operator moves to an approximate location where lights will indicate whether the transfer car is either right or left of the receiving position. The operator then moves the transfer car as needed to complete this pushing interlock where a third light indicates that the car is centered. Once the car is spotted the sealing curtain is opened and the coke guide hood is lowered.

D. GAS CLEANING CAR (Figure 8, drawing #319-A603)

The gas cleaning car is composed of two sections: the operator's cab and locomotive and the gas cleaning system. From the operator's

D. GAS CLEANING CAR (Figure 8) - Continued

cab, the operator can move the gas cleaning car and the hot coke transfer car unit, and control the transfer car curtain dump gates, and the gas cleaning equipment.

The scrubbing system which is mounted on the gas cleaning car consists of spray nozzles for cooling the hot gases in the duct from the hot coke transfer car and a high energy variable throat venturi scrubber. The gas passes through the high energy venturi scrubber, the flooded elbow, the cyclonic separator, and finally through the fan and out the exhaust stack. Contaminated water from the scrubbing system is returned to the main recirculating water sump and is periodically replenished from a fixed source by the car operator.

The gas cleaning system has been sized conservatively by selection of the largest fan drive that can be reasonably supported by the collector rail system (400 HP). The prediction of actual particulate loading during the coke pushing operation contains many variables and involves the potential for abnormal operating conditions including partially carbonized coal in the push. It is anticipated that the system as furnished will provide some margin of capacity to effectively clean the gases evolving from abnormal operating conditions.

The suction fan is equipped with a two (2) position inlet louver control and the venturi throat is automatically operated to two (2)

D. GAS CLEANING CAR (Figure 8) - Continued

positions. Both of these operations are pneumatically controlled. This provides two (2) modes of gas cleaning operation. During startup and during the coke transport period the venturi is in a full open position and the fan inlet louvers are restricted. The drop across the venturi in this mode should be 10" w.c. or less. While in the coke receiving and discharge operations, the venturi is moved to its most restrictive position and the fan inlet is full open. A maximum drop across the venturi of approximately 35" w.c. is anticipated during this mode.

The referenced drawing indicates clearances between the gas cleaning car and the coke guide hood and door machine that are far more critical than any imposed by the use of the conventional quenching equipment. Track alignment becomes critical under these new conditions and of necessity tracks must be supported on firm and predictable foundations. Maintenance attention will be required to assure track and car conditions consistent with these clearances.

E. TRACK RECEIVING HOPPER (Figures 9 through 14)

Three coke receiving hoppers are located at the quenching station beneath the quenching track for receiving incandescent coke from the hot coke transfer car. Each of the three hoppers can hold one oven of coke although normally two hoppers will be used with the third available as a spare. Each hopper is formed of steel

E. TRACK RECEIVING HOPPER (Figures 9 through 14) - Continued

plate and lined with refractory brick and has a charging hole 3 ft - 6 in by 14 ft in the top. This rectangular opening is slightly larger than the opening in the hot coke transfer car to facilitate discharging. Hinged gates for the track hopper top openings are provided to prevent gas escape between the discharges of coke from the car. Each set of gates is operated by a shaft and lever system powered by a pneumatic cylinder. An interlock timer for each hopper's gates prevents the coke from being dumped into the same hopper until a preset time has elapsed permitting the hopper to empty. Also, a red light at the dump area for each hopper indicates to the operator that he should travel to the other available hopper if the full time has not elapsed. The top hinged gates of the hoppers open upon a signal from the gas cleaning car cab console, provided the hopper runout time has elapsed. When the gas cleaning car operator causes the hot coke transfer car gates to start to close after dumping the coke, the receiving hopper gates begin to close, and then the fume exhaust main suction bypass duct butterfly valve closes causing all fumes from the hopper to pass through the fume combustion system.

Near the top of each hopper a refractory castable-line offtake duct withdraws fumes from the hot coke in the hopper. In each duct as well as at the top of each hopper are water sprays to reduce the temperature of these fumes. The withdrawn gases are sent by way of

E. TRACK RECEIVING HOPPER (Figures 9 through 14) - Continued

this duct to the fume combustion chamber which is described in Section H.

Each hopper has a working capacity for one load of coke from the hot coke transfer car. Since it requires approximately 18 minutes to discharge one hopper of coke to its quench system, it becomes necessary to drop the second load of incandescent coke into the other operating hopper (or the third hopper in an emergency).

On the bottom of each coke receiving hopper is a pneumatic vibrating feeder which controls the rate at which the hot coke is discharged onto the vibrating quench conveyor train. Maximum hot coke feed rate is 85 TPH; normal rate is 80 TPH based on a 15.4 hour gross coking time.

F. COKE HANDLING (Figures 9 through 14)

Vibrating quench conveyors receive the hot coke from the vibrating feeders. There is one fixed speed vibrating quench conveyor per coke receiving hopper, having a roughened surface which promotes coke conveying. Along the vibrating conveyor pans, from the receiving hopper to the M-1 conveyor belt, cooling sprays are directed upon the passing coke.

The M-1 conveyor belt transports the coke from the vibrating conveyors to a junction point just below yard level where it

F. <u>COKE HANDLING</u> (Figures 9 through 14) - Continued

discharges onto the M-2 conveyor belt. The M-2 conveyor belt carries the coke to the top of the loadout bin. These conveyor belts are also interlocked to prevent M-1 from running if M-2 is stopped and M-2 cannot be run if the loadout bin is full. M-4 conveyor belt from the emergency coke wharf also feeds onto M-2 at the junction point.

The 150 ton capacity quenched coke loadout bin has a double gated discharge at the bottom. High level probes at the top of the bin control the coke conveyor belt to prevent overloading of the bin. A coke bypass flop gate can be operated in case the bin becomes full, whereby the coke is discharged from M-2 conveyor across the flop gate into a discharge chute to the ground. Normally, the coke from the storage bin will be loaded into trucks. The truck operator will be able to observe and control the coke loading procedure from the cab of his truck through the use of a television monitor and a carrier type transmitter and receiver for operation of the hopper gate. In order to minimize the fugitive dust from the coke handling system, a dust collector as well as a vacuum cleaning system are provided.

G. SPRAY WATER AND STEAM EXHAUST SYSTEMS (Figures 9 through 14)

In order to cool the hot coke, water is sprayed on the coke at a controlled rate by five banks of sprays which are located along the sections of each vibrating conveyor. The tumbling action and movements of the coke in the water bed causes maximum water-coke contact, especially by the first four banks of sprays that are activated by the operation. These four are operating while hot coke is being conveyed and the fifth bank at the discharge end comes on only when a high coke temperature is sensed after the fourth spray bank.

The runoff water is collected in a floor channel and returned to a settling basin. In the settling basin the water and solids separate, with the clarified water flowing over a weir into the clear well where it is recirculated by one of two pumps to the sprays over the vibrating conveyors or to the M-1 conveyor belt in conjunction with another hot coke sensor. The solids which are collected in the settling basin fall to the bottom where they are pumped out by a sludge pump either onto the cool end of one of the vibrating conveyors or into a container at yard level. If the spray water pumps at the clear well fail, an emergency water tank located above ground contains sufficient water to quench any coke remaining in the track hoppers and on the vibrating conveyors. This emergency system is controlled by the quenching station operator who is warned of water failure by appropriate alarms.

G. SPRAY WATER AND STEAM EXHAUST SYSTEMS (Figures 9 through 14)-Continued

Makeup water to the spray water system is supplied from the general service source. Because this is a closed recirculating water system, only makeup water is added to compensate for steam losses and no water is discharged from the system.

Each coke quenching conveyor system has an exhaust hood enclosure constructed of removable stainless steel panels, with access doors for inspection of the vibrating conveyor pans and the sprays. At the top of each flared hood is an exhaust duct which contains an axial type fan for positive steam withdrawal. The steam is discharged into an exhaust duct which conducts it into the exhaust stack. A wooden louver mist suppressor is provided inside the stack to remove the entrained water and particulate matter. Water sprays are located above the suppressor to backwash the baffles.

After a short time delay, a spray in the duct near the exhaust fan comes on whenever the exhaust fan is operating to cool the gas and the fan drive system.

H. TRACK HOPPER FUME EXHAUST AND GAS CLEANING SYSTEM (Figures 9 through 14)

At the top of each receiving hopper is an exhaust duct which is independent of the steam withdrawal system. This duct consists of two sections, one for fumes and combustion gases from the incandescent coke in the hopper and the other for the initial coke dumping period when both ducts are used for handling the large volume of air and gas which is generated (Figures 10 and 14). This large volume comes from the quick displacement of air by the coke dropping into the hopper as well as from the burning of the incandescent coke while falling. It is therefore necessary to use the auxiliary suction duct to withdraw this large volume until the coke has been dumped and the receiving hopper top gates have been closed. This is, of course, a short interval (10 to 20 sec.) relative to the residence time of the coke within the hopper.

After the hopper gates have been closed, the butterfly valve in the secondary duct closes causing a reduction in volume of offtake gas, but the suction is sufficient to handle the gas generated. The suction from the fan pulls the gas from the hopper through the fume burner duct only. In the fume burner duct, an air admission port is provided along with a coke gas fired pilot burner to initiate combustion of any combustible gases that may be generated. There is also a cooling spray beyond the fume burner which is actuated by high gas temperature. After the gases pass through the burner section of the duct, they continue through a high energy type scrubber, across a flooded elbow which separates the heavier particulate matter from the gas stream, through the cyclonic moisture separator, and through a centrifugal type exhaust fan (which pulls the suction on the coke

H. TRACK HOPPER FUME EXHAUST AND GAS CLEANING SYSTEM
(Figures 9 through 14) - Continued

receiving hoppers) before being discharged as cleaned gas into the stack (Figure 9). The dirty water from the flooded elbow is returned to the settling basin described in Section G. The collected water from the cyclonic separator drains into a seal pot which overflows into a channel that also runs to the settling basin.

I. EMERGENCY COKE DUMP PIT (Figure 15, drawing #319-A610)

On the north side of the continuous quenching system is an emergency coke dump pit. This is used only when the continuous quenching system is inoperable and the hot coke transfer car contains a load of incandescent coke which must be dumped. When this condition is encountered the transfer car passes through the track hopper area to the emergency dump station. The car is manually positioned over the pit which has reinforced concrete sides with a firebrick lining and is capable of holding one load of coke. It is open on the east side with a concrete approach ramp so that the coke may be removed by a front-end loader. There is a spotting interlock which must be satisfied in order to open the coke car gates.

To cool the hot coke, three banks of sprays are located at the top of the pit, with five sprays per header. A manual shut off valve which regulates the mill water to the sprays is located

I. EMERGENCY COKE DUMP PIT (Figure 15) - Continued

adjacent to the pit. The car operator dumps the load of coke into the pit, leaves the car and goes to the valve station where the water valve for quenching the coke is opened for the required time and is then closed. Thereafter the standard coke quenching car must be employed until the continuous quench system is in operation again.

The run-off from the emergency quench is collected in a sump and is discharged into the quench track drainage trench which runs back to the sump in the continuous quench station pit.

J. EMERGENCY COKE QUENCHING SYSTEM AND WHARF (Figures 16 through 18)

In case of an extended downtime at the continuous coke quenching station an emergency quenching station is available at the south end of the battery. The regular enclosed coke transfer car is not adaptable to the conventional quenching system; therefore, a standard 40 foot quench car with a sloped bed (Figure 16, drawing #319-A612) is employed using a trackmobile as the method of moving the coke car. The trackmobile also serves for other emergency needs when not needed for quenching.

The quenching station is located at the south end of the battery and the emergency coke wharf is located midway between the station and the continuous quenching site. The quenching station (Figure 17, drawing #319-A611) is an open type with overhead sprays which are

J. EMERGENCY COKE QUENCHING SYSTEM AND WHARF
(Figures 16 through 18) - Continued

operated from a control room by the car operator. The dirty water is collected in a sump and pumped to a trench which drains to the main sump at the continuous quenching pit.

After the coke has been quenched, the trackmobile pulls the quenching car to the emergency coke wharf (Figure 18, drawing #319-A615) where the coke is dumped. The coke is fed onto a conveyor belt (M-3) by an operator using manual wharf gates. The coke is transferred from M-3 conveyor to M-4 conveyor and then to M-2 conveyor which leads to the loadout bin.

K. DESIGN COMMENTARY

The design and equipment scope for this particular project is being developed in very conservative terms. Since the reliability of performance of certain of the equipment and the system in general has not been established in actual operation, the owner has elected to provide operational spares for all critical components and has also provided complete, although limited, conventional quenching capability as backup protection. It is entirely possible that performance experience will permit reduction or elimination of certain of those facilities on subsequent installations.

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# SECTION V

## ENVIRONMENTAL POSTURE

The design concepts introduced with this new system were developed for the express purpose of eliminating the air pollution conditions inherent in the handling of incandescent coke from the ovens through the quenching operation.

The conventional system, currently in use throughout the industry, involves pushing hot coke from the ovens through a guide into an open, shallow-bed car for transport to a batch type quenching station. Substantial emissions of smoke and particulate are discharged into the atmosphere during the period when the coke passes through the guide, when the coke breaks up leaving the guide, and during the distribution of coke into the quench car. The quantity of the emissions encountered during this phase of the operation and in the subsequent transport is affected by the completeness or efficiency of the coking process within that particular oven. If the push contains coke that is not completely carbonized, the combustion of the volatile matter will cause smoke emission from the time of exposure until it is water quenched.

The conventional quenching station involves the introduction of large quantities of water distributed over the bed of hot coke. The formation of steam and vapor is almost explosive in nature during the initial phase of this quench procedure. This large volume of steam is discharged at relatively high velocity from an appropriate stack or tower. This condition creates a situation in which large quantities of steam and entrained moisture are discharged into the atmosphere.

This new system offers relief from all of the problem areas associated with the conventional process techniques.

The coke guide is totally enclosed within a segmental steel hood. Minimum clearance closure is provided at the interface of the hood and oven and between the hood and the coke transfer car. The transfer car is so configurated that it will accept the total coke push while in this single stationary position. During the coke push the guide hood and transfer car are under suction to a gas cleaning car. All emissions generated during this operation are drawn through a high energy venturi scrubber prior to release to the atmosphere. At the conclusion of the push, the guide hood is retracted from the transfer car and a wire mesh sealing curtain is drawn over the car opening. The car remains under suction to the scrubber during the entire residence time of the coke. The gas cleaning car also serves as the locomotive and is coupled to the transfer car.

The combination of facilities described above eliminates the emissions problems associated with the push as well as with the transport interval to the coke quench facility.

The continuous quenching facility as conceived for this particular design involves the use of several underground refractory lined hoppers. The transfer car is positioned over one of these hoppers. Pneumatically operated doors on the hopper and on the transfer car are opened and the hot coke is discharged into the underground hopper. The doors provide limited exposure of the coke to the atmosphere during this transfer and during this period the hopper is under suction to another high energy venturi scrubber. The hopper remains under the influence of this suction and scrubber during the entire residence time of the hot coke.

A vibrating feeder at the base of each hopper distributes hot coke onto a vibrating conveyor at controlled rates. The coke is quenched by water sprays as it passes the length of the vibrating conveyor. The quench conveyor is completely hooded and steam generated is drawn off through a combination of induced and natural draft to a stack.

The stack provides a common discharge for both the quenching steam and the scrubber serving the underground hopper. It is anticipated that the discharge from the stack will be a low velocity, low volume plume at an almost continuous rate. The stack also contains a vapor suppressor to further reduce any tendency for carryover.

Experimental testing confirmed that 120 gallons of water per ton of coke is required to quench coke in the manner projected by this new system. It is anticipated that the system will operate at 10 to 20% in excess of this requirement.

Conventional quench stations utilize approximately 500 gallons of water per ton of coke with considerable variation in this quantity reported by various plant practices.

Table 1 indicates the maximum design ratings of the various service water commitments to the continuous quench system and to a comparably sized conventional system. It does not reflect the actual rate of water consumption.

TABLE 1

COMPARISON OF QUENCH SYSTEM SERVICE WATER

| | Closed Quench System | Conventional |
|---|---|---|
| Quench Sump Make-Up | 500 gpm | 1,250 gpm |
| Quench Stack Mist Suppressor (Intermittent Use) | 400 gpm | 650 gpm |
| Underground Coke Hoppers Venturi Scrubber | 350 gpm | |
| Gas Cleaning Car Venturi Scrubber System | 300 gpm | |

The water system is described schematically in Figure 2. The system is completely closed and the source of makeup water is uncontaminated service water. Although a direct source of service water capable of delivering 500 gpm is available at the recirculating water sump and responsive to level control, a major portion of the makeup requirements will actually be provided by the gas cleaning systems and other service water users. The once through waters used continuously at the stationary gas cleaning system and the intermittent return from the gas cleaning car venturi scrubber and mist suppressor will provide the major source of quench water makeup. The coke fines settled from the recirculating water are periodically pumped to one of the quench conveyors for removal with the coke. The water flows as indicated represent capability and do not represent a water balance.

The commitment of gas cleaning and miscellaneous water to quench system makeup, the capability for close control of coke moisture, and the substantial reduction in vapor carryover in quench steam are anticipated to result in a water consumption reduction of approximately one-third.

Table 2 summarizes the relative position of the new closed coke quench system to the conventional quench system in terms of resolution of air and water pollution problems.

As can be seen, the new system offers a solution to all of the current pollution abatement problems associated with the coke side of the battery.

TABLE 2

COMPARISON OF ENVIRONMENTAL POSTURE

| | | Closed Coke System | Conventional System |
|---|---|---|---|
| 1. | Coke pushing at the ovens | All particulate and fume contained and scrubbed prior to discharge | All particulate and fume discharged directly to the atmosphere |
| 2. | Coke transport to quench | Coke totally enclosed with all fumes scrubbed prior to discharge | All fumes discharged directly to the atmosphere. When green coke is present, fume discharge is substantial during transport |
| 3. | Coke quenching | All fume is contained and scrubbed in period from transport to quench. Steam generated by quench is at controlled rate and at relatively low velocity when discharged to atmosphere | Batch quenching results in explosive evolution and discharge of steam, particulate, and entrained moisture direct to atmosphere |
| 4. | Water use | No water pollution, completely recirculating system | No water pollution implication. This system, too, can be completely recirculating |

## SECTION VI

## CAPITAL COST ESTIMATES

The following cost estimates represent the installed cost of facilities including engineering, material and labor. They are considered representative of project costs prevailing to January, 1973:

1. Enclosed Coke Guide and Telescoping Quadrant Hood

   Estimated cost each - $80,600.00

   Three (3) units are included in this project.....$241,800.00

2. Hot Coke Transfer Car

   Estimated cost each - $230,700.00

   Two (2) units are included in this project.......$461,400.00

3. Gas Cleaning - Traction Drive Car

   Estimated cost each - $404,000.00

   Two (2) units are included in this project.......$808,000.00

4. Track Foundations and Trackage.......................$138,700.00

5. Collector Rail System ...............................$ 52,250.00

6. Emergency Drive Car (Trackmobile)....................$ 35,600.00

7. Emergency Quench Car (Modification)

   Estimate includes costs to modify configuration and increase size of an existing open type quench car of acceptable condition.....................$ 19,450.00

8. Coke Quenching and Distribution System including:

   A. Underground track hoppers

   B. Vibrating coke feeders

   C. Vibrating conveyors

   D. Quenching and track hopper emission collection and control systems including hoods, fume mains, induced draft fans, scrubbers, mist eliminator and stack.

   E. Concrete foundations

   F. Quench water recirculation system including equipment to handle contaminated water from and supply clean water to the gas cleaning car.

   G. Substation control facility including all quench station instrumentation and controls

   H. Quenched coke distribution system

   I. Any additional items not specifically listed, but necessary to this system..................$3,652,400.00

9. Emergency Dump Pit Including Water Quench System and Controls ....................................$ 112,700.00

10. Emergency Quench Station and Emergency Conventional Coke Wharf .......................................$ 384,700.00

Total ..............$5,907,000.00

The distribution of the total cost is estimated as follows:

| | |
|---|---|
| Engineering and Administrative Expense.... | $ 977,000.00 |
| Material .................................. | 2,619,000.00 |
| Labor ..................................... | 2,311,000.00 |
| Total ........... | $5,907,000.00 |

Cost of expanding the initial installation to serve an additional coke oven battery of similar size. This includes an additional transfer car, gas cleaning car, enclosed coke guide, and extension of the underground facilities to serve two (2) additional coke hoppers and continuous quenchers...$1,810,000.00

As stated elsewhere in this text, the project estimated cost reflects a very conservative approach in providing backup protection facilities and 100% sparing of all critical operating units. As operating experience is established, it is possible that reductions in overall costs can be justified as the reliability of the system components is confirmed.

## SECTION VII

## OPERATING COST ESTIMATES

An evaluation of the projected operating and maintenance expense of the new closed coke quench system as compared to the conventional quenching system in use at the existing Weirton coke plant is presented in tabular form.

The tabulation provides a comparison on the basis of operating, service and maintenance manpower on a facility basis and also on a tonnage basis. The evaluation involved all facilities from the coke guide at the oven face through the quenching operation. Distribution of coke after quenching has been excluded, since no technical differences are imposed by the system.

The cost of installing and operating the closed coke quench system is significantly higher in both cases. The prevailing means of handling and quenching coke provides a simple and economical method. It does not, however, provide a satisfactory solution to the elimination of serious pollution problems inherent in this batch process. This new closed coke quenching system does offer solution to abating pollution in processing coke from slot type ovens. The cost of this solution is reflected in higher operating and maintenance charges.

From the ovens through the quench, more equipment and complexity is involved. Although the equipment utilized represents technology utilized individually in other applications and as such should perform reliably in this case, the fact that more apparatus is involved creates an additional maintenance problem.

The use of high quality refractories in the wear areas of the transfer car and the underground hoppers is expected to support a reasonable maintenance position in these areas. The use of vibrating feeders and conveyors in the mainstream of coke processing will most certainly inflate maintenance considerations.

The skills required to operate and maintain this new system are no more demanding than those currently employed in coke plant operation. The complexity of the gas cleaning car-coke transfer car does not approach that of the modern larry car or pusher machine. It is anticipated that the current level of skill of the quench car operator will be sufficient for the coke transfer position. The quench station operator will be a new position with appropriate training required. The operation is displayed by graphic means (see Figures 19 and 20) and the operator's responsibility will be primarily observation and monitoring with actual operation taking place in a semi-automatic mode. The equipment controls and instrumentation, while adding a substantial maintenance load, do not add new technology to the current skills of coke plant maintenance personnel.

Tables 3 and 4 present a comparison of operating labor and maintenance labor and materials between a new tall oven battery and an existing coke plant complex of six (6) 13 foot high oven batteries arranged in two (2) units of three (3) batteries. It is presented on a manhour basis (Table 3) and on a cost per ton of coke basis (Table 4). While this comparison is meaningful in this particular situation, a comparison of two (2) modern high production batteries of similar size would present a significantly different cost prediction. These costs are average, over the life of the battery. Therefore, it is expected costs will be lower at the start and somewhat higher as the battery approaches the end of its useful life.

Table 5 indicates the application of significantly higher connected horsepower requirements to serve this new system. The most significant contributors to the increased power requirements are the fans necessary to the gas cleaning systems. The actual energy requirements reflecting in operating costs will be specifically determined in the Phase 2 continuing evaluation program.

TABLE 3

ESTIMATED OPERATING COST COMPARISON ON A

MAN-HOUR PER WEEK BASIS

Comparison: Mainland - 6 Batteries, 2 Quenching Stations

Island - 1 Battery, 1 Quenching Station

| Operating Sequence | Expense Item | Basis | 87 Ovens New Closed System | | 294 Ovens Conventional System |
|---|---|---|---|---|---|
| Coke Handling from Oven to Transport Vehicle | Operating Labor | M.H./Week | 168 | | 672 |
| | Assigned Mechanical | " " | 83 | | 111 |
| | Assigned Electrical | " " | 61 | | 82 |
| | Car & Track Repair | " " | 8 | | 11 |
| | SW Mech. Shops | " " | 35 | | 47 |
| | SW Elect. Shops | " " | 8 | | 11 |
| | Funded Repairs | Ratio | 0.75 | to | 1.00 |
| | R & M Materials | " | 0.75 | to | 1.00 |
| | Tools & Oper. Supplies | " | 0.75 | to | 1.00 |
| Coke Transport | Operating Labor | M.H./Week | 168 | | 336 |
| | Assigned Mechanical | " " | 134 | | 84 |
| | Assigned Electrical | " " | 101 | | 7 |
| | Car & Track Repair | " " | 34 | | 22 |
| | SW Mech. Shops | " " | 57 | | 3 |
| | SW Elect. Shops | " " | 14 | | - |
| | Funded Repairs | Ratio | 2.00 | to | 1.00 |
| | R & M Materials | " | 1.50 | to | 1.00 |
| | Tools & Oper. Supplies | " | 2.00 | to | 1.00 |

## TABLE 3 (cont'd)

| Operating Sequence | Expense Item | Basis | 87 Ovens New Closed System | 294 Ovens Conventional System |
|---|---|---|---|---|
| Coke Quenching | Operating Labor | M.H./Week | 336 | 336 |
| | Assigned Mechanical | " " | 312 | 70 |
| | Assigned Electrical | " " | 235 | 17 |
| | Car & Track Repair | " " | 51 | 34 |
| | SW Mech. Shops | " " | 132 | 62 |
| | SW Elect. Shops | " " | 32 | 3 |
| | Funded Repairs | Ratio | 5.00 to | 1.00 |
| | R & M Materials | " | 3.50 to | 1.00 |
| | Tools & Oper. Supplies | " | 4.00 to | 1.00 |

NOTE: Funded repair costs were estimated over the life of the battery.

These are estimates; these data will be updated with the actual cost figures developed during Phase 2.

## TABLE 4

### ESTIMATED OPERATING COST COMPARISON

### ON A MAN-HOUR PER TON OF COKE BASIS

Comparison: Mainland - Labor & Material per Ton

Island - Labor & Material per Ton

| Operating Sequence | Expense Item | Basis | 3,325 Tons BF Coke/Day New Closed System | | 4,400 Tons BF Coke/Day Conventional System |
|---|---|---|---|---|---|
| Coke Handling from Oven to Transport Vehicle | Operating Labor | M.H./Ton | 0.00721 | | 0.02181 |
| | Assigned Mechanical | " " | 0.00356 | | 0.00360 |
| | Assigned Electrical | " " | 0.00262 | | 0.00266 |
| | Car & Track Repair | " " | 0.00034 | | 0.00035 |
| | SW Mech. Shops | " " | 0.00150 | | 0.00152 |
| | SW Elect. Shops | " " | 0.00034 | | 0.00035 |
| | Funded Repairs | Ratio | 1.00 | to | 1.00 |
| | R & M Material | " | 1.00 | to | 1.00 |
| | Tools & Oper. Supplies | " | 1.00 | to | 1.00 |
| Coke Transport | Operating Labor | M.H./Ton | 0.00721 | | 0.01090 |
| | Assigned Mechanical | " " | 0.00575 | | 0.00272 |
| | Assigned Electrical | " " | 0.00433 | | 0.00022 |
| | Car & Track Repair | " " | 0.00146 | | 0.00071 |
| | SW Mech. Shops | " " | 0.00244 | | 0.00009 |
| | SW Elect. Shops | " " | 0.00060 | | - |
| | Funded Repairs | Ratio | 2.75 | to | 1.00 |
| | R & M Material | " | 2.00 | to | 1.00 |
| | Tools & Oper. Supplies | " | 2.25 | to | 1.00 |

## TABLE 4 (cont'd)

| Operating Sequence | Expense Item | Basis | 3,325 Tons BF Coke/Day New Closed System | | 4,400 Tons BF Coke/Day Conventional System |
|---|---|---|---|---|---|
| Coke Quenching | Operating Labor | M.H./Ton | 0.01443 | | 0.01090 |
| | Assigned Mechanical | " " | 0.01340 | | 0.00227 |
| | Assigned Electrical | " " | 0.01009 | | 0.00055 |
| | Car & Track Repair | " " | 0.00219 | | 0.00110 |
| | SW Mech. Shops | " " | 0.00567 | | 0.00201 |
| | SW Elect. Shops | " " | 0.00137 | | 0.00009 |
| | Funded Repairs | Ratio | 6.50 | to | 1.00 |
| | R & M Material | " | 4.75 | to | 1.00 |
| | Tools & Oper. Supplies | " | 5.00 | to | 1.00 |

NOTE: These are estimates; these data will be updated with the actual cost figures developed during Phase 2.

## TABLE 5

## ELECTRICAL COMPARISON CONNECTED HORSEPOWER OF MAJOR FACILITIES

| Operating Sequence | New Closed Quench System | | Conventional System | |
|---|---|---|---|---|
| A. Coke Handling from Oven to Transport Vehicle | 1. Door Machine, Coke Guide and Hood | | 1. Door Machine and Coke Guide | |
| | a. Traction Drive | 60 | a. Traction Drive | 40 |
| | b. Hydraulic Pump | 25 | b. Hydraulic Pump | 20 |
| | c. Door and Jamb Cleaning Devices | 12 | c. Door and Jamb Cleaning Devices | 12 |
| | Sub Total | 97 | Sub Total | 72 |
| B. Coke Transport | 1. Transfer Car | | 1. Quench Car | - |
| | a. Sealing Curtain | 7½ | | |
| | 2. Gas Cleaning Car | | 2. Locomotive | |
| | a. Venturi Scrubber Fan | 400 | a. Traction Drive | 180 |
| | b. Water Recirculating Pumps | 20 | b. Air Compressor & Misc. | 30 |
| | c. Air Compressor | 10 | | |
| | d. Locomotive Traction Drive | 172 | | |
| | Sub Total | 609½ HP | Sub Total | 210 HP |

TABLE 5 (cont'd)

| Operating Sequence | | New Closed Quench System | | | Conventional System | |
|---|---|---|---|---|---|---|
| C. Coke Quenching | 1. | Venturi Scrubber Induced Draft Fan | 400 | 1. | Quench Water Pump | 150 |
| | *2. | Quench Steam Induced Draft Fan | 100 | 2. | Breeze Pump | 7½ |
| | *3. | Hopper Vibrating Feeder | 5 | 3. | Mist Eliminator Backwash | 7½ |
| | *4. | Quench Conveyor | 50 | | | |
| | 5. | Quench Water Pump | 75 | | | |
| | 6. | Breeze Pump | 50 | | | |
| | 7. | Control House Air Conditioning and Ventilation | 25 | | | |
| | | Sub Total | 705 | | Sub Total | 165 |
| | | Total | 1,411½ HP | | Total | 447 HP |

*NOTE - Two (2) of the units as indicated would operate concurrently to serve the normal operating requirements.

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DIGITALLY

## SECTION VIII

## START UP EXPERIENCE TO JUNE 30, 1973

The Weirton coke plant was made operational on May 30, 1973. The Enclosed Coke Pushing and Quenching System was complete and accepted the first coke push on the following day. This section summarizes the experience demonstrated during the first month of operation.

The quenching system operated on a sporadic basis during this start up period. There was an anticipated incidence of debugging of apparatus and controls under operating conditions, since little time was permitted for pre-operational debugging due to the start up schedule requirements.

A problem of serious magnitude became evident almost immediately after start up. The facilities and design provided to handle and segregate the fines developed through gas cleaning and coke fines (breeze) generated through the handling and quenching process have proven to be inadequate. The preponderance of delay time encountered at the continuous quencher during this initial operating period can be attributed to this factor. As this inadequacy became evident, a two (2) phase program was initiated immediately to support continued operation of the system. Additional pumping apparatus, immediately available from in-plant sources, was installed with necessary piping to bring breeze laden water from the collecting sump in the underground pit to the surface where a temporary decanting sump was constructed. The decanted water is returned to the recirculating water pump clear well within the pit. The breeze in the temporary decanting sump is periodically removed by clamshell bucket operated from a mobile crane.

Engineering was initiated to develop permanent facilities suitable for long term solution to the breeze segregation and handling problem. Although these plans are in the formative stage of engineering, it is probable that the ultimate solution will involve appropriate decanting facilities with mechanical means for removal of breeze and transport to the coke delivery conveyor system.

The gas cleaning car also encountered difficulty due to particulate and breeze clogging of the gas cleaning recirculating water system. It was apparent during this initial operation that the gas cleaning system was doing a very good job in withdrawing and cleaning all of the emissions generated during the coke pushing operation. The volume of particulate collected in the recirculated water was large and required dumping and replenishment (in part) after each push. Physical changes to certain piping, the configuration of the water separator reservoir, and the mechanism for dumping contaminated water were initiated to overcome these plugging problems.

The basic equipment related to the whole system has operated well during the first month of operation. While it is certain that minor modification to certain of the facilities will be necessary and appropriate as operating experience increases, it is equally apparent at this early stage that the performance of the individual system components and the system as a whole does provide the emission abatement capability as predicted.

Definition of any specific changes or additions made to the Enclosed Coke System will be included in the Phase 2 program, Emission Testing and System Evaluation to be carried out under EPA Contract 68-02-1347 which was signed June 29, 1973.

## SECTION IX

## UNITS OF MEASURE - CONVERSIONS

Environmental Protection Agency policy is to express all measurements in agency documents in metric units. When implementing this practice will result in undue cost or lack of clarity, conversion factors are provided for the non-metric units used in a report. Generally, this report uses British units of measure. For conversion to the metric system, use the following conversions:

| To convert from | To | Multiply by |
|---|---|---|
| cfm | $m^3$/sec | .0004719 |
| $^oF$ | $^oC$ | 5/9($^oF$-32) |
| ft | m | .3048 |
| gal. | 1 | 3.785 |
| gpm | 1/sec | 0.0631 |
| gr/scf | mg/$Nm^3$ | 2288.136 |
| hp | W | 745.7 |
| in. | m | .0254 |
| in.wc | N/$m^2$ | 248.84 |
| lb | kg | 0.454 |
| tons (short)/hr | kg/hr | 907.185 |

| BIBLIOGRAPHIC DATA SHEET | 1. Report No. EPA-650/2-73-028 | 2. | 3. Recipient's Accession No. |
|---|---|---|---|
| 4. Title and Subtitle<br>Enclosed Coke Pushing and Quenching System Design Manual | | | 5. Report Date<br>September 1973<br>6. |
| 7. Author(s)<br>D.A. Pengidore | | | 8. Performing Organization Rept. No. |
| 9. Performing Organization Name and Address<br>National Steel Corporation<br>Weirton Steel Division<br>P.O. Box 431<br>Weirton, West Virginia 26062 | | | 10. Project/Task/Work Unit No.<br>1AB013<br>11. Contract/Grant No.<br>68-02-0622 |
| 12. Sponsoring Organization Name and Address<br>EPA, Office of Research and Development<br>NERC-RTP, Control Systems Laboratory<br>Research Triangle Park, North Carolina 27711 | | | 13. Type of Report & Period Covered<br>Final<br>14. |

15. Supplementary Notes

16. Abstracts The manual describes a new concept in abating air pollution normally associated with coke pushing and quenching emissions in the iron and steel industry. The "enclosed coke pushing and quenching system" involves containment of the hot coke from the face of the slot-type oven during the pushing operation, through the successive handling and transport, and through a continuous and controlled quench. The hot coke emissions are confined and cleaned before discharge to the atmosphere and the quench emissions are controlled to stack discharge of low velocity steam vapor. The coke plant itself consists of a single battery of 87 "tall" ovens and complete coal chemical plant and support facilities.

17. Key Words and Document Analysis. 17a. Descriptors

Air Pollution
Metallurgical Fuels
Coke
Coking
Iron and Steel Industry
Capitalized Costs
Operating Costs
Scrubbers

17b. Identifiers/Open-Ended Terms

Air Pollution Control
Stationary Sources
Coke Pushing
Coke Quenching
Particulates
Mist Suppressors

17c. COSATI Field/Group 13B, 14D

| 18. Availability Statement | 19. Security Class (This Report) | 21. No. of Pages |
|---|---|---|
| Unlimited | UNCLASSIFIED | 95 |
| | 20. Security Class (This Page) UNCLASSIFIED | 22. Price |

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