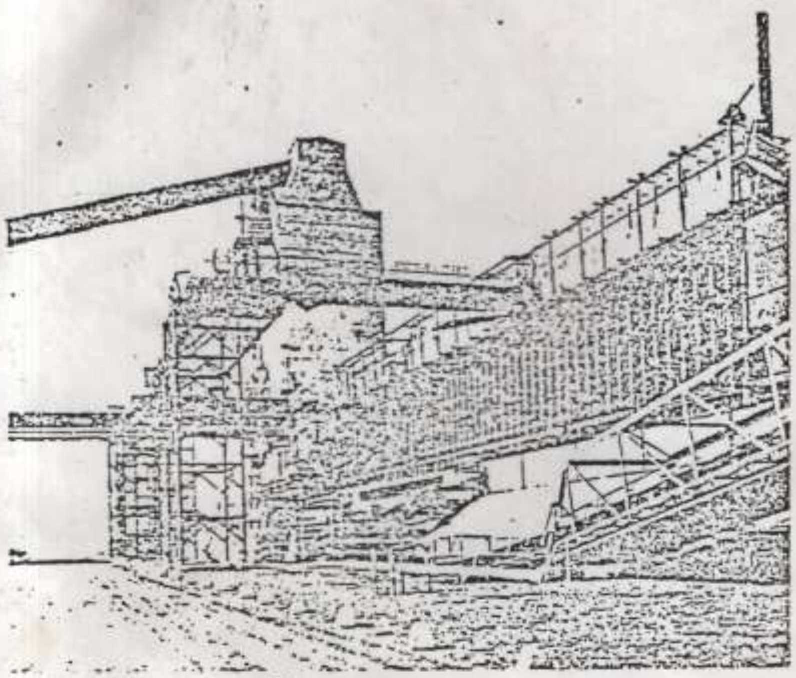
Wilputte



OPERATING INSTRUCTIONS

FOR

WILPUTTE COKE OVENS

BULLETIN NO. 7871

JULY 15, 1977

## FOREWORD

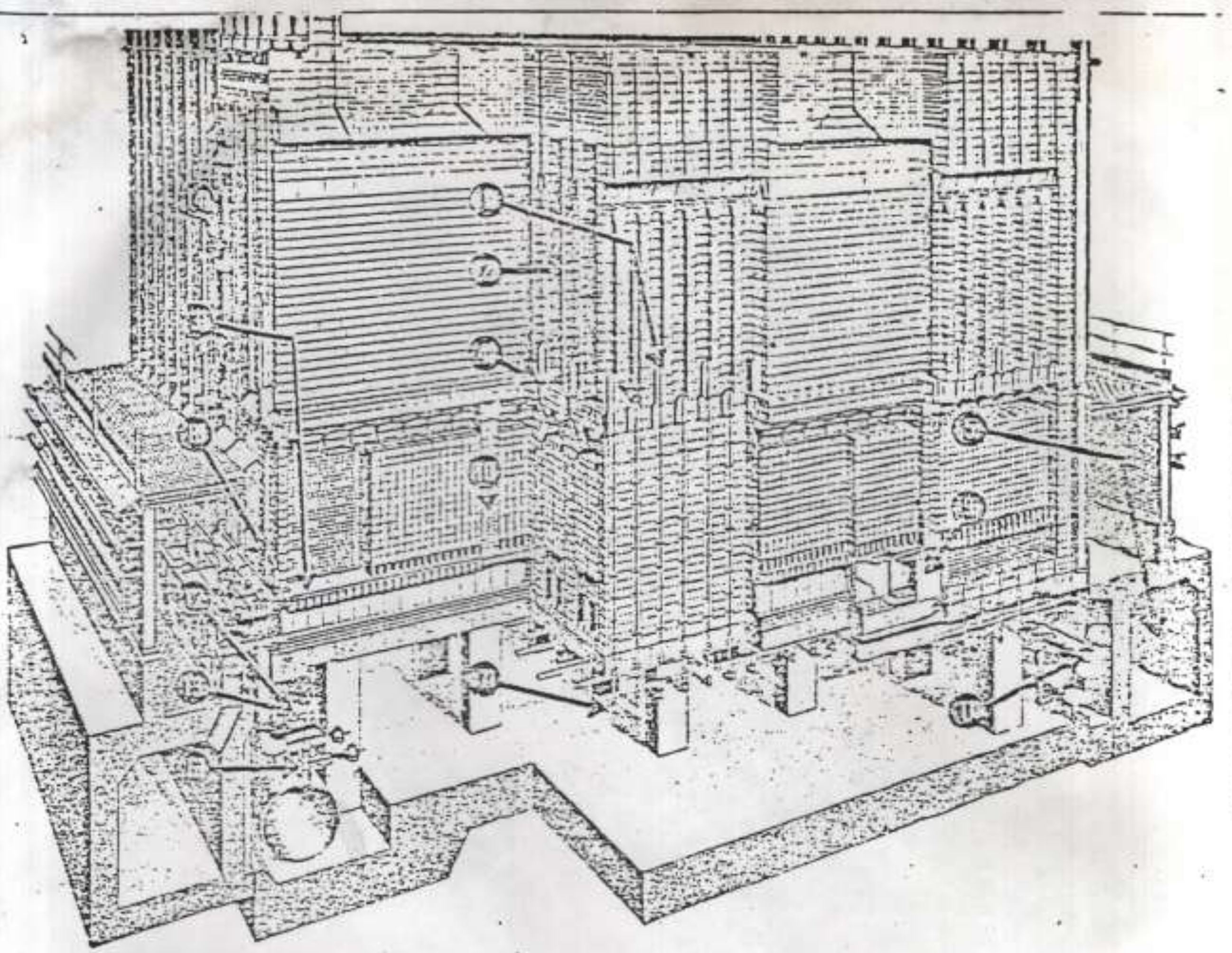
This Operation Manual lists the principles and procedures for good coke oven battery operation, which if followed will result in long battery life with a minimum of maintenance.

The contents of this manual are presented in such a way that a trained plant operator can follow the basic rules which are so important for safe and efficient operation of a coke oven battery. The fundamental principles of coal carbonization and detailed theoretical explanations have been purposely omitted. It is suggested that this manual be used together with the Operating Instructions for Control of Underfiring and Heating-Up Manuals so that other features of the battery are understood in more detail.

It is true that operating practices and maintenance programs vary from place to place, but the ultimate goal remains the same, i.e. safe, economic operation and utilization of design characteristics within practical limits. The manual is intended to adhere to basic guidelines of coke oven battery operation, and the instructions are applicable to Wilputte Coke Oven Batteries.

This manual has been prepared for Wilputte Coke Oven Batteries. The basic guidelines as outlined are applicable to all Wilputte batteries irrespective of size, capacity and heating system.

For operation and maintenance of the oven machinery, see the manuals furnished with the machinery.



*some of the reasons why*

# Wilputte Coke Ovens are SUPERIOR

1. ALTERNATING HIGH AND LOW BURNERS—*vertical uniformity in rich gas heating.*
2. WALLS OF UNSTEPPED THICKNESS—*vertical uniformity in heating with lean gas.*
3. VENTURI PORTS—*air, lean gas, and waste gases distributed uniformly through regenerators.*
4. GRADUATED AIR PORTS—*built-in regulation of air and lean gas.*
5. COMBUSTION AIR SYSTEM—*accurate control of combustion air, uniform ventilation of basement.*
6. ORIFICE AND BUTTERFLY—*for equalizing flow of lean gas to each regenerator.*
7. STAINLESS STEEL PINS—*precision distribution of rich gas to the burners, readily accessible for cleaning.*
8. INSULATED STEEL FACE PANELS—*air tight, reduce loss of heat from regenerators.*
9. CONTINUOUSLY WELDED-bus flue ducts eliminates leakage
10. SHORT DIVISION WALLS, TRIPLE-THICK—*for leakproof regenerators.*
11. FORCED DECARBONIZING AIR SYSTEM—*positive control of decarbonizing of burners.*
12. SIMPLE LATCH AT EACH LEAN GAS REVERSING VALVE—*change over entire battery from one gas to another within five minutes.*
13. POSITIVE INTERLOCK AT EACH GAS REVERSING VALVE—*air and lean gas cannot be admitted at the same time.*
14. SELF SEALING OVEN DOORS AND SELF SEALING LEVELING DOORS WITH RENEWABLE SEALING EDGES—*gas tight, easy maintenance.*
15. HYDRAULIC DOOR MACHINES—*smooth operation, low maintenance.*

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14. Clean the gas metering pins and orifices on a strict schedule.
15. Patch refractory promptly as soon as condition requiring repair occurs.
16. Maintain and lubricate the battery equipment.
17. Maintain the instrumentation in good working order.

## Basic Instructions For Battery Operation

18. Battery and heating supervisors to inspect battery and heating each shift to spot incipient problems before they develop.

19. Battery and heating supervisors should monitor the indicating instruments and recording charts to spot incipient problems before they develop.

20. Operate the battery and machinery safely. Operators to be alert at all times. Only properly trained operators are to operate battery machinery.

21. Maintain adequate flushing liquor at the battery at all times

22. Maintain proper collector main temperature and pressure at all times.

23. Make sure that gas off-take of each oven is clean before charging and no liquor is leaking into the standpipes.

24. Never leave aspirating or decarbonizing steam on after charging an oven or during the coking cycle.

25. Minimize the time doors are off the ovens prior to and after pushing.

# INTRODUCTION

Coke oven batteries have often operated 20 to 25 years before any major repairs became necessary. The secret to successful performance of coke ovens is strict adherence to proven, good operating practices; use of good coking coals, properly prepared; good carbon and leakage control on the inside; and good maintenance on the outside. Tons of hot, abrasive coke can be pushed from an oven each day, year after year, with little sign of wear, if the battery is operated and maintained properly.

In addition, the high capital costs of a battery of ovens and related by-product facilities demands proper care and maintenance. No battery or machine will maintain itself when operated continuously 24 hours per day, seven days per week.

This booklet lists many causes of conditions that will damage ovens and machines and many of the principles and procedures that must be followed to prevent their premature wear and failure. There are a few standards that must be kept to prevent rapid deterioration:

1. Excess carbon or pitch must not be allowed to build up in the oven roof, offtake, standpipe, gooseneck, pullman valve, or collector main. The large volume of gas generated in the oven after charging must flow from the oven easily. With heavy doors clamped in place, and heavy lids on the charging holes, the gas produced will flow into the collector main easily or force its way under pressure through joints in the oven enclosure to the outside, and/or into the heating flues. Without question, plugged or restricted flow of gas from the oven has been the greatest single cause of battery failure. Repairing and rehabilitating a damaged battery is far more expensive than any maintenance costs required for good carbon control.

2. Doors and frames must be kept clean. Mechanical cleaners are designed to clean the soft tar and char deposited during one coking cycle only. Accumulated hard carbon must be cleaned to the metal before mechanical cleaners can keep the surfaces in a clean condition. Door fires that are allowed to continue will start a chain of

conditions that result in failure of the ends of the ovens. Over heating from the fires causes door frames to loosen causing more leakage and fires, and finally the only solution is to remove the frame and reset it with new packing, and replace the bowed or twisted buckstay.

3. The brick jambs must be maintained uniformly and sealed by periodic spraying with patching compound. Due to thermal shock and friction of coke, the jamb brick are subject to greater wear than other parts of the oven. Jambs must be kept smooth to minimize coke friction, and must be kept sealed to prevent gas leakage developing behind the door frame. Again, maintenance costs are far less than replacement costs in both dollars and tonnage.

## COAL PREPARATION

In the early development of the by-product coking industry in this country, it was learned that by mixing properly chosen coals the resultant coke could be given physical characteristics that permitted marked improvement in metallurgical practice.

However, the coals chosen for the mixture are decidedly different in physical and chemical characteristics. To blend differing coals properly so that the coke will be the expected resultant of the coal mixture, it is fundamentally essential that the mixture be very intimate even down to the small particles obtainable only by pulverization through a hammermill crusher or impactor. Therefore, to mix coals it is necessary first to pulverize them. The industry in general recognizes this requirement, but it is not generally realized that only fine pulverization and pulverization equally fine for the different coals is of paramount importance. Without fine pulverization and of the same degree of fineness for the different coals, you cannot make coke with the inherent uniformity so desirable for the blast furnace operation.

The sieve tests of the pulverized mixture should be at least 80% through 1/8" mesh with maximum of 10-12% through 100 mesh. Coke stability increases with degree of pulverization. However, to pulverize above 80% through 1/8" mesh without a prohibitive amount of minus 100 mesh, the minus 1/8" coal must be screened out before pulverizing.

It is well known that the hammermill product varies in fineness, other things being equal, with the setting of the screen bars, screen plates, or breaker plates. It is known that the setting for a soft, friable coal such as Pocahontas (low volatile) will not be suitable for a harder (high volatile) coal, to pulverize the two coals to the same degree of fineness.

Therefore, it is self-evident that each kind of coal should be pulverized separately, each with its proper setting of the screen bars or plates. In other words, the coals should be pulverized before mixing.

Most coal preparation plants are not equipped to pulverize before mixing, because some coke plant operators place emphasis on mixing, and they want to take advantage of

COAL PREPARATION (CONTINUED)

the thorough mixing of the different coals passing through the hammermill together. In other words, they use the hammermill as a mixer, believing that at the same time it will pulverize the mixture well enough for the purpose.

They overlook the fact that a thoroughly intimate mixture is nullified by subsequent segregation unless there is uniformly fine pulverization of all of the constituents of a mixture.

This brings us to the subject of segregation. Inasmuch as the harder coal has been more resistant to pulverization, it predominates in the coarse particles of the mixture and therefore separates out by segregation. This takes place throughout the coal preparation plant. It occurs in the travel on conveyor belts and where the mixture is poured into a bin, into the hoppers of the charging car, and into the oven chamber. It can be minimized only by fineness and uniformity of pulverization.

In modern coking practice, the coal mixture usually includes one kind which by itself is unsuitable because of its dangerous swelling during carbonization, but which, when intimately mixed with shrinking coal, can be used without damage to oven brickwork and when so used decidedly improves the metallurgical value of the coke.

A non-homogeneous blend of coking coals of varying swelling characteristics will result in segregation in irregular, concentration streaks in the oven charges. This causes stickers, with danger of damage to oven brickwork.

So segregation not only prevents uniformity in the coke, but also it may shorten the life of the ovens.

A uniform mixture of coal in the ovens is the whole aim and object of coal preparation. But this does not mean that an efficient mixing machine alone will fill the bill; because, mixing however thorough, cannot prevent subsequent segregation if the coals have not been individually pulverized to a specified degree of fineness.

If the coal handling equipment is such that pulverization is made after the mixing, pay careful attention to the maintenance of the hammers and the screens of the pulverizer. By such vigilant maintenance, it is possible to partly overcome the handicap imposed by the plant arrangement.

## COAL PROPORTIONING

The blast furnace demands uniform coke. Therefore the proportions of the different coals in the mixture must be maintained without variation.

Further, one of the coals may expand when coking and it may have been found that you can operate safely only by keeping below a definite maximum percentage of this particular constituent. Therefore, for the protection of the oven brickwork the proportioning of the coals is important. In this connection, bear in mind that coal in storage changes its composition. When using coal from storage, allowance must be made for such changes, by changing the proportions in the mixture.

DO NOT ALLOW ONE OF THE MIXING BINS TO RUN LOW OR EMPTY WITHOUT STOPPING THE FLOW FROM ALL OF THE BINS. See that the proportioning conveyors are equipped with an automatic safety device to guard against this, and also see that this device is in first-class working order at all times.

## COAL TEST OVEN

The blend of coal used in the coke ovens is a mixture of high volatile, low volatile and medium volatile coals selected to make the type of coke being produced by the particular coke oven battery. In existing plants the blend has already been selected so as not to produce a pressure on the oven walls greater than 2 PSI as measured in a test oven. It is suggested that before changing to a different blend of coals or if one of the coals in the mix is changed, or if there is any other change in the coals, that the new blend be tested in the Coal Test Oven so as to insure that the coke oven walls will not be damaged.

It is good practice to sample and test in the test oven the coal blend at periodic intervals so as to be alerted to any possible change in coal characteristics that may affect the coke ovens.

## COAL MIXING

Thorough mixing of the properly pulverized and proportioned coals is important. However, as stated above, thorough mixing is largely wasted unless the coals have been properly pulverized.

MAKE REGULAR ROUTINE SIEVE TESTS TO CHECK PULVERIZATION AND ROUTINE COAL ANALYSES FOR CHECKING PROPORTIONING.

Also make regular determinations of volatile matter in the coarser particles from sieve tests if coal is mixed before pulverizing.

If it is not a fairly uniform mixture of properly pulverized coals, see that the coal preparation procedure is corrected. Until it can be determined that the coal handling plant can deliver and continue to deliver to the larry bin a correctly prepared, uniform mixture of coal, it is not recommended to speed up the oven operation.

## COAL BULK DENSITY

Producing uniform, high stability coke and maintaining uniform oven heating also depends on uniform control of coal bulk density. Same plants add a light petroleum oil to their pulverized coal before mixing to increase bulk density. A higher bulk density increases the coke tonnage per oven pushed and improves the physical properties of the coke.

However, a very high bulk density would have a damaging effect on oven walls during coking due to high stresses on the oven walls. If coal bulk density is being controlled, regular sampling of the coal is required to insure the maximum allowable bulk density is not exceeded. Control within plus or minus 0.5 lb. per cubic foot is realistic.

## OVEN CHARGING

One major step in smooth oven operation is to get level, full ovens at each charge. The Wilputte charging car is designed to give this when the volumetric controls for each hopper have been adjusted properly. Short charges can cause (1) excess carbon, (2) uneven heats, (3) over heated doors, frames and walls, (4) lost tonnage.

The hoppers on the charging car are provided with adjustable measuring sleeves at the top of each hopper. The charging car is loaded volumetrically at the oven coal bin. At the coal bin, the coal bin gates are opened and coal flows into the hoppers until no more coal can enter the car. At that point the coal bin gates may be closed, and the car operated to charge an oven.

The charging car operator and pusher operator must coordinate their movements to minimize fire and smoke to atmosphere, prevent fire around charging car. When the hoppers run empty, hot gases and fire can damage the charging car if lids are not replaced promptly and in the proper sequence. Operators must always remember to take the steam out of standpipe immediately after charging is completed.

Stage charging is used on the Wilputte dual collector main battery to further reduce fire and smoke to atmosphere. This technique involves dropping the coal from outer hoppers first and then dropping the coal from inner hopper after the lids are replaced on outer charging holes. The oven is charged on both mains and by means of steam injectors in the standpipes, the oven chamber is placed under a negative pressure, thereby drawing the gas evolved during charging into the collector mains.

The "stage charging" procedure is as follows:

1. Make sure pusher machine is ready to level.

2. Close the standpipe lids, turn on the aspirating steam at the standpipe elbows and open the pullman valves. This valve should not be opened until immediately before charging in order to minimize the interval during which air is drawn into the oven and delivered into the collecting mains by the steam injectors.

## OVEN CHARGING (CONTINUED)

3. Rotate charging hole lids. Remove outer charging hole lids and drop telescopic sleeves.

4. Charge coke side outer first, a few seconds later start pusher side outer hopper. After charging lift outer sleeves, rotate and replace outer lids.

5. Rotate and lift inner lid, drop inner sleeve and start charging. After a lapse of approximately 10 seconds start leveling.

6. After charging, lift inner sleeve, rotate and replace inner lid.

7. Shut off aspirating steam and move car to next oven to be charged.

On Wilputte turntable charging cars not equipped for stage charging, the hoppers on the car and the charging holes in the oven top are so located, sized and designed so that the full load of coal in the charging car may be emptied into the oven before the leveler bar is used. Because of the varying amounts of coal in each hopper which had been calculated to agree with the oven volume, there is space above each coal pile in the oven to permit gas passage between the top of the coal pile and the oven roof prior to leveling. It should be noted that to obtain this condition, there should be a minimum of carbon on the oven roof.

The Wilputte charging car is designed and built to give fast, efficient service with little work left to the operator. He must be thoroughly instructed in the proper use of the components of the car. There will be times when he will neglect to use the elbow cleaner, or spin the lids, or take steam out of oven promptly, or clean the smoke sleeves. The foreman must make regular checks on the operation and prevent any of these bad habits forming. New or replacement operators must be instructed in the correct procedures before "soloing". Operators must report any abnormal behavior or malfunction of equipment so that corrections can be made. Failure to do this can result in breakdown and serious damage to equipment.

## GAS JUMPER PIPES

On batteries equipped with a single collecting main system, stage charging can be effected by the modification of the charging car by changing the hopper volumes, providing individual drives to the turntables under each hopper and adding a jumper pipe on the charging car to vent the charging hole located on the side of the battery opposite to the collecting main into the charging hole of a coked out oven usually two ovens away from the oven being charged. The procedure for stage charging listed in this booklet could then be used on the battery.

## PUSHING AMPERAGE AND HARD PUSHING

The amperage required for pushing is an important indication of the proper coking of the charge. Therefore see that this is carefully recorded on the pusher machine log sheets.

Unusually hard pushing with high amperage readings means under-coking or over-coking locally or throughout the charge. Or, it may be caused by improper coal preparation.

Whatever the cause, high pushing amperage calls for immediate investigation with prompt and positive remedial measures.

Do not overlook so-called incipient "stickers"; that is, coke charges which push with difficulty, requiring more than one try with the pusher ram. The ram head should be applied slowly and with gradually increasing power. Oven walls may be ruined by punching with the ram, even though the circuit breaker is set at what is considered a safe limit.

The ram head must be stopped completely at the point where the head barely touches the coke. Then the power should be applied and increased slowly to maximum. If the coke does not move out, the ram should be retracted and the foreman summoned. If the ram is started from the cabin and hits the coke with full force, wall damage may be the result, even if the oven of coke is normal and would push easily by the correct method. The foreman must supervise the pushing of any oven which stuck on the first try.

Many coke ovens have been ruined or at least have had their normal useful life decidely shortened by hard pushing. If coke ovens are not ruined by careless or ignorant operation, they should function efficiently for 20 to 25 years. Considering the large capital investment involved, the importance of the careful attention to pushing amperage cannot be overstressed.

Have the circuit breaker on the pusher ram motor circuit set at not more than 15% above the normal amperage required for the kind of coal and taper of oven. If more current is required for any charge, the battery foreman should supervise the pushing and decide whether to leave the charge in longer for further coking, or to dig out the charge, or part of it, with hand rakes, tools which should be kept ready for such an emergency.

## PUSHING AMPERAGE AND HARD PUSHING (CONTINUED)

Each oven will push easily time after time when all oven and coal conditions are normal. The pushing ampere record is very important. The pusher operator must keep an accurate record of pushing amperes and the time each oven is pushed and charged. Any condition that causes a hard push must be corrected - serious damage can result from "hunching" an oven out, and at least, hard pushing greatly reduces the life of a battery.

Some of the basic causes for hard pushes are listed below:

1. Short coking time - coke too "green".
2. Improper coal blend or coal quality.
3. Coal not leveled properly.
4. Insufficient shrinkage.
5. Excess wall or roof carbon.
6. Short oven ½ pusher side - insufficient face on coke for ram head - coke crushing.
7. Spalls in liner bricks.
8. Irregular oven walls - older battery, wall-liners moved due to repeated hard pushing.
9. Coke too hot.

## CLOSE ADHERENCE TO PUSHING SCHEDULE

SEE THAT THE CHARGING AND PUSHING SCHEDULE ONCE ESTABLISHED IS MAINTAINED WITH REGULARITY. THIS IS VERY IMPORTANT. If the plant conditions are such that there are recurring irregularities due to inadequate coal supply, delayed coke disposal, shortage of operators or from any other causes, everything possible should be done to remedy such abnormal conditions before speeding up the battery to normal rating. IT IS DANGEROUS TO THE LIFE OF OVEN BRICKWORK TO OPERATE AT THE TEMPERATURE NECESSARY FOR FAST COKING IF HEAT CONTROL IS HANDICAPPED BY RECURRING DELAYS IN CHARGING AND PUSHING. Without adherence to regularly scheduled pushing and charging, uniform heating is impossible. BESIDES, THE TEMPERATURE REQUIRED FOR FAST COKING IS TOO CLOSE TO THE MELTING TEMPERATURE OF THE BRICKWORK TO ALLOW MUCH VARIATION IN HEATS WITHOUT OVERSTEPPING THE MARGIN OF SAFETY.

The practice of pushing ahead 30 minutes or more at each change of shifts is not in accord with good operation.

Ovens must be pushed in sequence to prevent abnormal temperature variations in the oven walls and in the coke.

## OPERATION OF PUSHER RAM

Before the pusher ram can be operated, a cross battery interlock system must be energized. This is accomplished automatically as signals sent from sensing units on both the pusher machine and hydraulic door machine are received on a control panel near each of the operators' consoles.

When the pusher machine is correctly spotted in front of an oven to be pushed and the hydraulic door machine is spotted opposite the pusher (on the same oven) a contact closes thereby energizing the cross battery interlock circuit in the pusher ram panel and an indicator light on the console. The sequence of operations to complete the interlock and push the oven is outlined below.

1. The oven doors on both the coke side and pusher side shall have been previously removed.

2. The coke guide shall be spotted in front of the oven to be pushed.

3. The traveling frame of the coke guide is extended to the oven by the Door Machine Operator. A limit switch in the traction drive circuit opens preventing the door machine from moving under its own power.

## OPERATION OF PUSHER RAM (CONTINUED)

4. The door machine operator will visually verify that the quenching car is in position to receive the coke. Upon verification, the door machine operator presses an ON button on the Control Console and a GREEN indicator lamp will illuminate on the console indicating that the interlock circuit has been energized.

5. The operator at the master control console in the pusher machine will receive a green "OK to push" light simultaneous with the Green light on the door machine console. The green light indicates all preliminary operations have been completed and the oven is clear to be pushed.

6. Verify receipt of "OK to PUSH" signal.

7. Advance pusher ram control lever forward. The ram will advance pushing the coke through the oven as long as the control lever is held in the forward position.

8. When the ram has been fully extended it will stop automatically. The ram is then withdrawn by placing the control lever in the reverse position.

9. When the oven has been pushed, the traveling frame of the coke guide is withdrawn breaking the cross battery interlock.

10. The oven doors on the coke side and pusher side are replaced. The pushing sequence is completed.

## PUSHER RAM AND DAKE ENGINE

If the current goes off while the pusher ram is in an oven, it is necessary to withdraw the ram as soon as possible to prevent its being overheated and warped. Such warping may prevent its further use without damage to oven wall brick, in which case it would be necessary to remove the ram from the pusher machine for straightening.

## PUSHER RAM AND DAKE ENGINE (CONTINUED)

To avoid such overheating of the ram, an air-operated Dake engine, with air hose and reel, is installed on the pusher machine. To operate, the hose is connected to the air piping system along the oven bench, and a clutch engages the Dake Engine to withdraw the ram.

To assure yourself of the reliability of this auxiliary drive and to become familiar with its application, try out the Dake engine itself once each shift and try out the Dake engine with the ram engaged once a week with supervision present.

## CROSS BATTERY INTERLOCK

A system of sensors, panels and interconnecting wiring located on the door machine, pusher machine and battery, insures that the coke guide is aligned at the proper oven.

## ALARMS

Audio alarms are provided to warn of the movement of the door machine, door extractor, coke guide, and reversing mechanism. These must be kept in good working order at all times for safety.

## DOORS AND JAMBS

As coking progresses, tar condenses onto the cooler end surfaces and collects on the bottom areas of doors and jambs. Char and tar deposited on doors and jambs should be cleaned at each push. If allowed to accumulate, this must be chipped off with a power tool. When doors and frames are neglected, the heavier deposits near the bottom hold the door out causing excessive smoke and fire, and can finally prevent doors from latching. Buildups on the door and jamb also make door removal difficult. Fires on the doors will cause serious damage to the battery if not eliminated. When doors, frames, or buckstays are overheated, uneven thermal expansion causes bending, which in turn can further increase the leakage causing fires.

Sometimes when doors are very tight due to carbon build-up on the door-brick and jamb-brick, operators have tried to "rock" the doors by moving the machine traction while the door is on the arms of the machine. This is one of the surest ways to loosen jamb castings and jamb bricks, and will eventually result in complete failure, requiring door jamb and jamb brick replacements. Such operation should never be condoned.

Door cleaners and jamb cleaners must be maintained in good operating condition, and used each time an oven is pushed. If for any reason these are out of operation, cleaning must be done by hand until mechanical cleaners are returned to service.

The ends of the oven are subjected to thermal shock and mechanical pressures at each push and charge. Jamb brick, door frame, door and door lining cool rapidly while door is off for pushing. After the door is replaced, and before oven is charged, these same areas are subject to high radiant heat. Frame clips must be checked regularily and any loose ones tightened properly. The packing around the frame must be checked regularly, and repaired or renewed before leakage begins. The joints between the door frame and jamb brick must be maintained tight using a suitable refractory spray at regular intervals.

Obviously,.all char and carbon must be cleaned from the joints before the spray can bond and seal the area. Gas leakage must not be allowed to increase to the extent that smoke or fires occur after each charge.

## DOORS AND JAMBS (CONTINUED)

To keep the doors at their initial high standard of efficiency, attention is directed to the following essential operating details:

1. The clearance between the oven brickwork and the door lining is about 5/8 inch. Therefore the brickwork and lining must be kept free from carbon.

2. CAREFULLY AVOID DAMAGING THE SEALING EDGE.

3. Clean out the tar and pitch from the space between the sealing edge and the door lining retainer. This is especially important at the bottom of the door.

   At the bottom of the door jamb, in the center, is a cast iron lug that must engage a cast iron bottom fork on the door frame. This lug and this fork must be carefully scraped off at each door removal to ensure exact seating of the door without interference of carbon or pitch.

4. The carbon and pitch removed from the doors MUST NOT BE SHOVELED INTO THE OVEN. On the coke side, throw it into the empty quenching car; on the pusher side, into a hopper on the pusher machine.

5. When replacing the door it is important to line up the door machine within ½ inch of the corrrect position, to avoid damaging the sealing edge.

6. Adjustment of the backing-up screws is an operation requiring skill and experience. ASSIGN THIS DUTY TO ONLY ONE MAN who must be both capable and reliable.

7. Also give this man sole authority to adjust door jamb clips on oven provided with door jamb clips. DO NOT HAVE THESE TOO TIGHT BUT MERELY SNUG ENOUGH TO HOLD THEM IN PLACE. IF TOO TIGHT, THERE IS DANGER OF BENDING THE BUCKSTAYS.

8. If the sealing edge is damaged, it should be built up carefully with welding metal, then truing the edge with a flat file.

9. For further instructions on the care and maintenance of the oven doors and door machine, see Wilputte Corporation's "Manual for Hydraulic Door Machine".

## PRINCIPLES OF CARBON CONTROL

Carbon formation is necessary to the operation of coke ovens. Without carbon, walls and floors would erode away from the friction of abrasive coke, leakage would be out of control, and the battery would have a very short life.

Since gases are in continuous contact with the hot walls, carbon is formed on the interior surfaces during each coking period. Retaining the correct amount, and eliminating the excess, is the secret to good oven operation.

At lower coking rates (lower temperatures and foundry coke), the problem is usually to retain enough carbon for sealing joints and fissures. At faster coking rates (higher temperatures and furnace coke), the problem is to prevent or eliminate excess carbon formation during coking.

An understanding of the causes of carbon deposits will aid the operator in preventing excessive carbon formation. Several techniques of carbon control are listed below, which are commonly used to attain good oven operation:

1. The temperature of the free gas space across the top of the oven must be maintained between 1450-1650°F.
2. Exessive wall temperatures for average coking time causes carbon build-ups. High wall temperatures should not be used to take care of major variations from the standard coking time.
3. At faster coking rates, a predetermined vertical temperature differential on the oven chamber walls must be maintained to retard roof carbon deposition.
4. Ovens must be charged level-full each time to prevent overheating. Any excess wall carbon must be burned out during the decarbonizing period following each push.
5. A carbon cutter may be mounted on top of the pusher ram, and maintained to the proper dimensions, to assist in removing excess carbon but caution must be exercised to prevent damage to brick.
6. An adequate decarbonizing procedure must be established and followed. This may involve carrying one-two-or three ovens empty before charging, proper use of the decarbonizing steam in the standpipe, and keeping the gooseneck wide open for easy passage of gas.

PRINCIPLES OF CARBON CONTROL (CONTINUED)

7. The charging steam piping must be kept in good operating condition so that gases will pull in at all charging holes while charging. This will protect the charging car from fire damage and relieve excessive gas pressure on the oven chamber when charging. Likewise, the decarbonizing steam piping must be kept in good operating condition so aspiration for decarbonizing air will be provided when needed.

8. Steam should never be left in an oven to control smoke or fire. Putting the oven on a suction can pull air in causing localized heating and serious damage. Never point decarbonizing steam downward in the standpipe since this will cause overheating of the lintel brick. Door frames, charging hole frames, standpipes, goosenecks, and brick jambs can be damaged from the localized heating.

9. Carbon in the flue gas ports is controlled by the decarbonizing air system through the reversing cocks. The decarbonizing air is on for the full gas off period. This air flow should be adjusted to be adequate to burn out all carbon during the "off" period. Avoid excess air, which cools the flue bottom unnecessarily. The optimum setting for the blower damper can be determined by trial only.

10. The gooseneck cleaner on the charging car must be kept in good operating condition and used each time before an oven is charged. If the unit is out of operation for any reason, cleaning must be done by hand. If the tarry deposits are not cleaned regularly, they will harden, blocking gas flow from the oven, and must then be chipped out. Tarry deposits may deflect the liquor spray into the standpipe. This must be avoided.

## STEAM LEFT IN OVENS

Charging steam and decarbonizing steam are to be used for that purpose only. Leaving steam turned on to prevent fires merely changes a fire on the outside to a torch on the inside, which does damage such as melting off the bottom half of charging-hole frames. Neglecting to take steam out after charging is completed puts the oven chamber on a suction, which can open leakage throughout the oven by burning out the carbon seal in joints and cracks.

Some specific damages caused by improper use of steam are listed below:

1. Air pulled in around leaks at the standpipe meets hot gases inside causing a torch which warps or melts standpipe base ring expansion joint, gooseneck etc.

2. Air pulled in around a loose fitting charging-hole lid causes a rolling torch which can melt the bottom of the frame, or cause the frame to warp and crack.

3. Air pulled in around the door frame causes a rolling torch which overheats the frame resulting in unequal expansion and it may become hourglassed or burned away in spots.

4. Air pulled into the hot gases in the door sealing area causes overheating of the door and uneven expansion of sealing strip and frame.

5. All burning in the top area of the oven chamber adds to the heat in the top which promotes excess carbon formation.

6. Keeping an oven on suction tends to pull air from the flue system through fissures and joints, and burn out the carbon seal which is necessary to protect the oven wall liners.

7. Steam used on one side only of a dual collector main battery will cause a flow of gas from one collector main, across the oven chamber into the opposite collector main. This may draw liquor from the gooseneck spray into the oven chamber, causing spalling on oven walls under the standpipe. This cross flow condition must not be tolerated.

## GAS OFFTAKE SYSTEM

The collector mains, standpipes, and goosenecks are designed to allow the hot gases to flow easily from the oven while holding a steady positive pressure inside the oven chamber. The positive pressure is to prevent air infiltration into the oven chamber. Pressure carried on the modern Wilputte 5 meter battery is 8 MM $H_2O$ approximately, and should be adequate to hold a slight positive pressure at all points in the oven chamber at the end of coking cycle when gas evolution is at lowest level. Butterfly regulators in the foul gas offtakes and crossovers leaving the battery are used to control the desired pressure.

Carbonaceous material from the gas will collect in the standpipes during the coking period. The procedure for burning out all excess carbon here must be established by experiment. Excessive use of decarbonizing steam or improper use can cause serious damage to the uptakes.

Carbonaceous deposits in the gooseneck must be cleaned so that hard buildups are prevented from blocking gas flow or distorting or deflecting any part of the spray pattern. Inspections must be made each time the oven is pushed for any condition that would cause liquor from the spray to splash or leak back into the oven, which will result in brick spalls and/or brick disintegration. If an abnormal condition is noted, the problem must be corrected before the oven is charged.

The steam aspirators must be maintained in good condition to prevent fire damage to the charging car and reduce air pollution. Valves must be kept leak-proof to prevent condensate leaking onto brickwork.

The high volumes of gas generated during and following a charge requires that the gas offtakes and steam aspirators be kept in good condition. High pressures with fires caused by inadequate aspiration can seriously damage the charging car. High pressures in the oven following a charge can open leaks around door frames, charging hole frames, and standpipes. An oven must never be charged that has serious blockage in the gas space above coal line, standpipes or goosenecks.

## GAS OFFTAKE SYSTEM (CONTINUED)

To further reduce environmental pollution during charging, the battery is equipped with dual collector mains. Although smokeless stage charging is easily attained on dual collector main batteries, serious damage to oven brickwork can occur if a flow of cool gas from one collector main, across the oven roof, to the opposite side collector main is allowed. A flow of gas in this manner carries with it flushing liquor from the gooseneck spray into the oven chamber. This liquor attack on the oven brick together with the cooling effect on the oven roof and gas offtake will lead to rapid deterioration of oven brickwork.

Cycling of raw, cool gas can be prevented by properly balancing the pusher side and coke side collector main pressures and dampering off one side of an oven at nearly half coking cycle. This procedure will eliminate cross flow of gas through ovens.

Thermocouples may be installed in standpipes and standpipe temperatures may be used to check on whether the proper standpipe has been dampered off to eliminate cycling of raw coke oven gas across the top of an individual oven.

Ovens must be dampered off on one side at half coking cycle to prevent standpipe temperatures from falling below 1000°F. The dampering off procedure on coke and pusher sides must be followed so that an equal flow of gas passes through each collector main.

The dampering off procedure selected by the plant should be simple and practicable for the operators to follow and yet make sure that there is no cross flow of cool gases across the top of the oven chamber. Care must be taken that there is sufficient gas in each collecting main for proper gas flow control at the battery. The battery foreman should make frequent checks at the oven top to assure that the procedures are being carried out.

It is suggested that when the heater foreman makes out the pushing schedule for each shift that another column be added listing the next standpipe on the coke or pusher side that should be dampered off.

The Wilputte suggested dampering off schedule listed on page 29 would provide an easily executed plan in which the ovens are dampered off after approximately half the coking cycle has been completed.

GAS OFFTAKE SYSTEM (CONTINUED)

The dampering off schedule adopted by the plant should make sure that the dampering off is done in the first half of the coking cycle while there is no danger of cross flow.

## OVEN DAMPERING OFF SEQUENCE

Following is a recommended procedure for dampering of ovens, one side only at nearly half coking cycle to minimize circulation of cool, raw coke oven gas through free gas space of oven during carbonization period. This procedure must be followed to maintain desired top temperature at all times. For example, oven No. 4 is ready to be pushed.

1. Push oven No. 4 and damper off oven No. 5 coke side only.
2. Continue pushing No. 4 series and dampering off No. 5 series coke side only.
3. Push ovens of No. 6 series and damper off No. 7 series pusher side only.
4. Push ovens of No. 8 series and damper off No. 9 series coke side only.
5. Push ovens of No. 1 series and damper off No. 2 series pusher side only.
6. Push ovens of No. 3 series and damper off No. 4 series coke side only.
7. Push ovens of No. 5 series and damper off No. 6 series pusher side only.
8. Push ovens of No. 7 series and damper off No. 8 series coke side only.
9. Push ovens of No. 9 series and damper off No. 1 series pusher side only.
10. Push ovens of No. 2 series and damper off No. 3 series coke side only.
11. During next round of pushing cycle the dampering of ovens will reverse from pusher to coke side and vice versa.

## CONTROL OF DOUBLE COLLECTING MAIN SYSTEM

Each half of the battery is provided with collecting mains on both the coke and pusher sides. The crossover main and gas offtake main are provided with hand operated worm gear controlled butterfly valves.

The hand operated butterfly valves shall be adjusted during start-up so that there is equal pressure in both collecting mains. Since these valves are compensating for pressure drop in the crossover and offtake piping, they should not require any additional adjustment once they are set. However, if there is a drastic change in coking time, they should be checked. The pressure should also be checked approximately once a month or if there is reason to suspect a malfunction.

Each combined gas offtake is provided with one Askania controlled butterfly valve designed to maintain the pressure on the battery at +8 MM WG.

An additional Askania operated butterfly valve has been installed in some coke oven batteries to minimize variation of suction main pressure by other batteries of the coke plant. This kind of installation assures constant positive pressure on the battery side and steady suction in the suction-main. The suction pressure should be determined in the field and preferably be in the range of 100 mm WG negative.

A gas shut off valve is provided at each connection to the suction main for use during start-up and emergency conditions.

## FLUSHING LIQUOR

A continuous, adequate, supply of clean flushing liquor is mandatory for oven operation. Hot gases evolving from each oven into the collector main are sprayed with flushing liquor and cooled to about 180°F before entering the cross-over mains. IT MUST BE REMEMBERED THAT ONLY A FEW MINUTES STOPPAGE OF FLUSHING LIQUOR TO THE BATTERY CAN WARP COLLECTOR MAIN, BREAK STANDPIPE ELBOW CASTINGS, BREAK SEALS AT BOTTOM OF STANDPIPE.

All by-product operators, oven fluemen, and foremen, must be thoroughly instructed in what to do if flushing liquor fails. Some causes are:

1. Power failure.

2. Liquor strainer plugged with solids.

3. Decanter imbalance letting tar into liquor system, etc.

A bypass is provided around the liquor strainer. There is mill water connected to the ends of the collector main for emergency use.

Each flushing liquor header is fitted with a 2" tar drain from the end of the liquor header to the gas collecting main. The valve on this line should be about one-third open at all times to drain off small quantities of tar which may settle to the bottom of the flushing liquor header. In case of known larger quantities of tar which are sent to the battery because of trouble at the flushing liquor decanter area, these drain valves should be opened wide to minimize the amount of tar getting to the flushing liquor sprays. These drains must be checked frequently to be sure they are not plugged.

When the flushing liquor supply to the battery is interrupted for any reason, the control room operator must notify the battery topman to take emergency steps immediately.

Should tar get into the flushing liquor piping at the battery and cold emergency water be used to protect collector main, some of the small piping to individual sprays may plug and not resume flow after flushing liquor pressure is restored to normal. Following the emergency, each spray must be checked to assure normal flow. Bends in this small piping are fitted with pipe plugs for use in cleaning blocked lines. Flow in small piping is easily checked-open lines will be hot, plugged lines will be cooler.

## FLUSHING LIQUOR (CONTINUED)

The continuous spraying of the standpipe pullman valves and of the collecting mains, using an adequate volume of clear ammonia liquor free from tar, is an essential requirement for battery operation.

The spray onto the pullman valves not only keeps them flushed clear of pitch deposits, but it also forms the sealing liquid for the valves when they are closed for oven pushing. In addition, some of this sprayed liquor is vaporized by the hot oven gas, thereby materially cooling the gas.

The gas is further cooled by the sprays in the collecting mains. Here the sprays also flush the walls and floor of the mains and keep tar and pitch moving out to and through the collector mains to the flushing liquor decanter. The collector mains must be checked periodically to insure that tar and pitch are not accumulating in the bottom of the main.

The decanter, if maintained properly, delivers clear flushing liquor. As an added precaution, a self-cleaning pitch strainer is provided.

Frequent periodic inspections during each shift must be made checking collecting mains, foul gas temperature, foul gas pressure and flushing liquor header pressure.

By visualizing the important part played by the flushing liquor system in coke oven operation, you realize the necessity of keeping all the spray nozzles clean and the flushing liquor running continuously.

The steam-driven flushing liquor pump provided as spare equipment for use in case of power failure must be maintained ready to run. When needed, put it into service with the least possible delay to minimize the clogging of the spray nozzles, and to avoid overheating and warping the collecting mains.

Emergency connections also are provided on the collecting main for turning plant water into the flushing system in the event of total failure of liquor supply.

All spray nozzles at standpipes, collecting mains and bleeders must be checked daily and cleaned at frequent intervals during normal operation and where required after an interruption of flushing liquor system irrespective of time duration.

## FLUSHING LIQUOR LEAKS

A cardinal rule every coke oven builder or operator must know is that nothing can be more destructive to hot silica brick, in particular, and also clay to a lesser degree, than for it to be permeated by ammoniacal flushing liquor. The brick will most certainly crack, spall, and finally disintegrate completely. Sometimes this will happen with one such exposure and most certainly will if saturated repeatedly.

Every standpipe and gooseneck must be inspected before charging. This is generally the duty of the charging car operator, but the responsibility must lie with supervision.

Any kind of leakage noted by any operator or supervisor must be brought to the attention of the battery supervisor for immediate action. THE OVEN-TOP OPERATOR MUST SHUT OFF THE FLUSHING LIQUOR SPRAY to stop the leak with proper precaution and must take proper steps to rectify the problem immediately. THE OVEN SHOULD NOT BE CHARGED WITHOUT CORRECTING THE FLUSHING LIQUOR SPRAY PROBLEM.

## STANDPIPE ELBOWS AND PULLMAN VALVES

Before charging an oven, the accumulated pitch in the standpipe elbow must be removed. This cleaning operation is very important. If neglected, the deposit may deflect spray liquor back into the standpipe and down onto the oven wall bricks, causing brick spalling and disintegration.

The standpipe valves (pullman valves) are liquor-sealed, a continuous supply of sealing liquor being supplied through the standpipe elbow spray nozzles. Therefore the spray nozzles must be kept clear of any tarry matter.

Before taking an oven off the gas collecting main for pushing, the pullman valve must be closed, shown by the position of the valve operating lever.

With the pullman valve in its closed position, the spray liquor maintains a gas-tight seal, overflowing surplus liquor into the collecting main.

If you fail to close the valve before opening up an oven to push, you lose gas from the collecting main to the atmosphere through the oven standpipe, and have a damaging fire if the gas ignites.

Before charging an oven, while the standpipe lid is open, the flushing liquor spray should be inspected and the spray nozzle cleaned if necessary, for proper spray pattern. A partially plugged spray nozzle may deflect spray liquor down the standpipe onto the oven wall bricks.

If the flushing liquor spray nozzles frequently clog with pitch, improper functioning of the flushing liquor decanter or of the flushing liquor strainer is indicated. Also, the tar drains at the ends of the flushing liquor headers may not be functioning properly. These should be checked daily.

## INSTRUMENTS AND CONTROLLERS

NO COKE OVEN BATTERY CAN BE INTELLIGENTLY OPERATED WITHOUT INDICATING AND RECORDING INSTRUMENTS AND CONTROLLERS TO MAINTAIN CONTINUOUSLY THE MOST FAVORABLE TEMPERATURE AND PRESSURE CONDITIONS.

These instruments are the "SENTINEL MESSENGERS" that convey the exact conditions under which the battery is operating. It is absolutely impossible to obtain good operation without them. Unhappily, some coke plant operators do not seem to realize their real necessity; and in many plants these instruments are allowed to get out of order and are finally abandoned. WE WARN YOU THAT WHEN THIS HAPPENS YOU ARE DEFINITELY ON THE ROAD TO TROUBLE.

After a new battery of ovens have been operating a few months and conditions have reached somewhat "steady state", there is often the tendency to neglect keeping complete and accurate daily records, and later to neglect the repairs of maintenance of some instruments and controllers. A controller fails, you go on hand control, get by, and somehow the controller is forgotten. A gauge gets broken, operator continues to record an "estimated temperature" or the column is left blank, and that piece of information is forgotten. If you allow your operation to start down this road of neglect, you are headed for trouble.

With a complete and accurate set of daily operating conditions, you are usually able to determine what caused any irregular production occurrence. Recording charts give continuous records without effort, and are necessary to establish exact times of irregular behavior. Operators must keep complete and accurate logs of each shift showing any changes made, any abnormal events, and basic operating conditions. Operators must be encouraged to report any condition that calls for repairs or correction that is not in his work assignments.

YOU SHOULD APPOINT AND HOLD RESPONSIBLE ONE CAPABLE INDIVIDUAL FOR THE PROPER MAINTENANCE OF THESE INSTRUMENTS. Train him for this work and see that he studies the detailed maintenance instructions furnished by the instrument manufacturers. Have him inspect all instruments and controllers at least once a week. In addition, all operators should be instructed to report immediately on their daily operating report any instruments which they find out of order.

## OVEN HEATING - UNDERJET BATTERY

The modern Wilputte oven is designed to give easy control of heating within the coking-time range desired by the customer. The fixed metering ports for fuel gas and combustion air have been calibrated to give uniform distribution of heat producing a uniform coke both end-to-end and top-to-bottom.

In the Wilputte Underjet Coke Oven the control of heating has been simplified to adjustment of total fuel gas and total air to the battery, viz: adjustment of fuel gas rate, stack draft, basement draft and air boxes. The distribution of gas and air to individual flues is accomplished by the following "built-in" elements of the oven:

1. Metal orifices and calibrated pins which provide precise distribution of fuel gas to the individual heating flues.

2. Pre-set slide brick which provide precise distribution of air to the individual heating flues. By means of improved design it has been possible to set the slide brick during construction more accurately than has ever been possible by the old trial and error method.

3. "Built-in" zone air distribution. In a single waste heat flue oven, each bus flue under the regenerators serves two heating zones; one bus flue serving the two outer zones, and one bus flue serving the two inner zones. The distribution of the correct proportion of air to the two zones of each pair is incorporated in the design of the bus flue ports.

Heaters accustomed to the gas gun clay nozzle ovens are often inclined to change gas pins and re-set slide brick on an underjet oven. THIS SHOULD NOT BE DONE UNDER ANY CIRCUMSTANCES. A real necessity for changes in gas pins and slide brick represents an abnormal condition which should be referred to Wilputte Corporation for advice.

NO CHANGES SHOULD BE MADE WITH REFERENCE TO GAS METERING PINS AND SLIDE BRICK SETTING.

Slide brick have been known to move from charging car vibration, minor flue explosions on gas reversal, and by heater helpers punching out carbon in the air and gas ports. A systematic check of slide brick setting with a gauge rod should be made by the heater foreman if movement is suspected.

## OVEN HEATING - UNDERJET BATTERY (CONTINUED)

An exception to this rule applies when the battery is operating on very slow coking time, say in excess of 30 hours. Under such conditions it might be desirable to install smaller pins in the outside flues to compensate for the heat lost through proportionately greater oven face radiation.

There are many causes for uneven heating. Among them are incorrect gas rate, incorrect stack draft, variations in the heating value of the fuel gas, uneven adjustment of the waste gas valve dampers, poor suction main pressure regulation, dirty fuel gas meter pins and orifices, uneven pushing schedule, pushing delays, charging delays, poor coal preparation, irregularities in charging or leveling, insufficient decarbonizing air rate, etc.

Most of the unsuccessful attempts to correct heating conditions are the result of hasty decisions based on the "hunch" system. Unbalanced heating can be corrected most quickly by adjustments based on careful consideration of all possible, variable factors. The battery will respond to change in the fuel gas rate within a few hours. However, responses to some other adjustments or changes are slow. For example, when the cross-wall temperature gradient has been upset by a series of pushing delays, it may be several days before the battery settles back to normal. If, at such time, it is believed that heating adjustments are correct, the proper procedure is to wait a few days before making additional adjustments.

Some of the causes and corrections for uneven heating are covered in detail later in this manual. (page 48)

## OVEN HEATING GAS-GUN BATTERY

The modern Wilputte oven is designed to give easy control of heating within the coking time range desired by the customer. The fixed metering ports for fuel gas and combustion air have been calibrated to give uniform distribution of heat producing a uniform coke both end to end and top to bottom.

In the Wilputte Gas Gun Coke Oven, the control of heating has been simplified to adjustments of total fuel gas and total air to the battery, viz.: adjustment of fuel gas rate, stack draft and air boxes. The distributions of gas and air to individual flues is accomplished by the following "built-in" elements of the oven heating system:

1. Metal orifices provide precise gas flow rate to individual gas gun. Calibrated nozzles provide precise distribution of fuel gas to the individual heating flues.

2. Pre-set slide brick which provide precise distribution of air to the individual heating flues. By means of improved design, it has been possible to set the slide brick during construction more accurately than has ever been possible by the old trial and error method.

3. Built-in zone air distribution. In a single waste heat flue oven, each bus flue under the regenerators serves two heating zones; one bus flue serving the two inner zones and one bus flue serving the two outer zones. The distribution of the correct proportion of air to the two zones of each pair is incorporated in the design of the bus flue ports.

NO CHANGES SHOULD BE MADE WITH REFERENCE TO GAS NOZZLE SIZE AND SLIDE BRICK SETTING.

A real necessity for changes in gas nozzles and slide brick represents an abnormal condition which should be referred to Wilputte Corporation for advice.

Slide brick have been known to move from charging car vibration, minor flue explosions on gas reversal and by heater helpers punching out carbon from the gas nozzles. A systematic check of slide brick setting with a gauge rod should be made by the heater foreman if movement is suspected.

OVEN HEATING GAS-GUN BATTERY (CONTINUED)

An exception to this rule applies when the battery is operating on very slow coking time, say in excess of 30 hours. Under such conditions, it might be desirable to install smaller gun orifices serving outer flues to compensate for the pressure drop caused by reduced gas flow rate.

There are many causes for uneven heating. Among them are incorrect gas flow rate, incorrect stack draft, variations in the heating value of the fuel gas, uneven adjustment of the waste gas valve dampers, poor suction main pressure regulation, plugged gas nozzles and orifices, irregular pushing schedule, pushing delays, charging delays, poor coal preparation, irregularities in charging or leveling, incorrect decarbonizing air rate, etc.

Most of the unsuccessful attempts to correct heating conditions are the result of hasty decisions based on the "hunch" system. Unbalanced heating can be corrected most quickly by adjustments based on careful consideration of all possible, variable factors. The battery will respond to change in the fuel gas rate within a few hours. However, responses to some other adjustments or changes are slow. For example, when the cross-wall temperature gradient has been upset by a series of pushing delays, it may be several days before the battery settles back to normal. If, at such time, it is believed that heating adjustments are correct, the proper procedure is to wait a few days before making additional adjustments.

Some of the causes and corrections for uneven heating are covered in detail later in this manual. (page 48)

## BLAST FURNACE GAS OR COMBINATION UNDERFIRING

There are some Wilputte Coke Oven Batteries designed for underfiring with coke oven gas, blast furnace gas or a combination of coke oven and blast furnace gas. The switchover of modes of underfiring is done entirely from the control room. For the adjustment of heating for blast furnace gas operation and for the method of switchover of the modes of underfiring, see the "Control of Underfiring" manual.

## ADJUSTMENT OF DAMPERS IN WASTE GAS REVERSING VALVES

As soon as gas is on into the flues, the dampers in the waste gas reversing valves are adjusted so that each heating wall is on the same draft.

There are several methods available to make this kind of adjustment. However, from practical standpoint, the end result is the same irrespective of the method used. The method as described below is simple and straightforward.

1. Adjust stack draft to a fixed setting and make sure that it does not vary more than ± 0.25 mm WG during adjustment period.

2. Adjust all dampers approximately two-third open position.

3. Read draft as a spot check in several waste gas boxes to determine an approximate value. Exclude regenerator of the end wall.

4. Start adjusting dampers to a set figure as described in No. 3, moving from centerline of the stack canal and away from the stack.

5. Repeat step No. 4 at least once.

6. Readjust stack draft if necessary.

7. Spot check to make sure that all draft readings are nearly same. Minor variation of 0.25 mm WG between waste gas boxes is normal.

These adjustments, once made, are not affected by changes in coking schedule or any other normal operating condition.

## FINGER BARS IN AIR INLET PIPES

On a battery equipped for underfiring with coke oven gas only, the air inlets from the basement to the air and waste gas reversing valves are all alike, and no finger bars are required.

However, some batteries are equipped with reversing valves and air inlet pipes for either coke oven gas or blast furnace gas underfiring, but the batteries are operated with coke oven gas as fuel. In this case, pairs of small air inlet pipes alternate with pairs of large pipes, and finger bars are inserted in the large pipes to reduce their inlet areas to those of the small pipes.

This usually requires some finger bars of width varying from 2" to ½" in each air box.

## FLUE TEMPERATURE READINGS

The heater assigned to the new Battery should be thoroughly trained in the methods of accurately taking flue temperatures, correcting readings, and reporting accurate data. All heaters must use the same procedures in reading, correcting, and calculating the averages for the shift. A good cooling curve should be determined from the average of several sets of readings taken at one minute intervals from reverse time through the complete gas-off period, and used to correct readings to 0-minutes from reverse time.

Since the shift heater is primarily responsible for heating performance on his shift, he must be trained to check all controls and heating conditions, and report any abnormal condition that he cannot correct. The flue temperatures are affected by changes in:

1. BTU content of gas.
2. Stack draft.
3. Gas preheat.
4. Air-intake settings in air boxes.
5. Coal mix density and moisture, etc.
6. Variation of coking time.
7. Non-uniformity in pushing and charging schedule.

Following a pushing delay read frequently (every 30 minutes if necessary) the hottest coke side flues of the walls affected by the delay. If any flue is found that exceed 2700°F (corrected 0-minutes after reversal), immediately cut the gas off that wall for ½ hour or more at the emergency cock on the manifold. Leave off as necessary to prevent overheating. BE SURE GAS IS TURNED ON AFTER NORMAL TEMPERATURES ARE ATTAINED, AND AFTER OVEN IS PUSHED AND CHARGED.

It is not necessary to close any emergency gas cocks during a pushing delay of a duration of 30-45 minutes. However, the emergency gas cocks of heating walls of a ready oven and accompanying wall should be closed halfway for a delay extending one hour or more. Total gas flow reduction must be made if the delay or shut down period exceeds four hours.

Adjustment of gross coking time must be made at least ten hours ahead of next coking cycle after a planned shutdown or delay not exceeding four hours. It will be necessary to drop a few ovens during next coking cycle if the delay period has exceeded a total of four hours during the 24 hour period.

Early in the operation of the battery a definite procedure, and a regular schedule for reading flue temperatures should be established. The following is suggested:

Procedure

1. For all readings, sight the optical pyrometer on the tops of the burner nozzle brick.

2. Note the time in minutes after reversal at which each reading is taken.

3. Correct all readings back to reversal time, based on an established cooling curve. Since the cooling curve varies with the operating schedule, and particularly with the amount of excess air used for combustion, a new cooling curve should be determined whenever an appreciable change has been made in the oven operating schedule.

TYPICAL COOLING OF VERTICAL FLUES

AFTER REVERSAL

| Minutes After Reversal | Cooling °F. | Minutes After Reversal | Cooling °F. |
|---|---|---|---|
| 1 | 18 | 16 | 172 |
| 2 | 63 | 17 | 175 |
| 3 | 83 | 18 | 177 |
| 4 | 95 | 19 | 179 |
| 5 | 107 | 20 | 181 |
| 6 | 117 | | |
| 7 | 125 | | |
| 8 | 133 | | |
| 9 | 139 | | |
| 10 | 145 | | |
| 11 | 151 | | |
| 12 | 156 | | |
| 13 | 160 | | |
| 14 | 164 | | |
| 15 | 168 | | |

## FLUE TEMPERATURE READINGS (CONTINUED)

### Schedule of Readings

1. Read at least two, cross-walls every morning and afternoon shift. The choice of walls read should follow a uniform pattern, so that the day to day readings will be comparable. For example, each shift read one wall adjacent to an oven ready to be pushed, and one wall adjacent to an oven at half coking time.

2. Each day plot the averages of the cross-walls on cross-section paper. DO NOT DRAW ANY CONCLUSIONS regarding heating conditions until these readings have been plotted. The complete cross-wall data thus assembled almost invariably show heating tendencies not disclosed by casual and haphazard spot readings.

3. Each shift read all numbers 4 and 11 coke and pusher side flues. Frequently inspect every flue in the battery, reading temperatures on all which do not appear normal.

4. FOLLOWING A PUSHING DELAY read frequently (every 30 minutes if necessary) the numbers 6 and 7 coke side flues affected by the delay. If any flue is found to exceed 2700°F corrected to zero minutes after reverse, read at the hottest part of the flue, IMMEDIATELY cut the gas off the wall by closing the 2-½" gas cock at the fuel gas manifold. The gas should be left off fifteen minutes or more; and should be cut off again on subsequent "ON" periods if necessary to prevent excessive flue temperatures. But be sure to turn the gas back on after normal temperatures have been restored.

5. Check your pyrometer for accuracy at least once per week.

## FUEL GAS METERING PINS

The fuel gas metering pins are graduated in size to conform with the heating requirement of the tapered charge. The pins must be removed and cleaned as often as is necessary to insure constant flow of gas. The required frequency of cleaning will vary from once every two weeks to once in seven days, depending on the cleanliness of the fuel gas. In some plants it is most convenient to do all the cleaning on the day shift; in other plants each shift is assigned a certain number of rows to clean. The cleaning should be done in a cross wise sequence along the battery.

Keep on hand a complete supply of surplus cleaning brushes for the different sizes of fuel gas connections and for the nozzle orifices. Do not use any material which can score or reduce the diameter of the pins. Orifice brushes should be small enough to swab freely without sticking.

## BATTERY AIR ADJUSTMENT

### CROSS-WALL COMBUSTION

The combustion, usually represents a 15-20% excess air in all flues. The variations in the appearance of combustion across the wall are due to the following two causes:

1. With a given percentage of excess air the combustion appears heavier in the high burner flues hence terminates at a higher point than in the low burner flues.

2. Combustion appears to become progressively heavier toward the coke side because of the progressively greater quantity of gas burned per flue.

The best flues to observe when making air adjustment are numbers 2 and 4 on the coke side which may show some, but not excessive spill-over.

The combustion, as described above, will provide the most uniform possible vertical distribution of temperature in the coke. When cooler tops are desired the air should be increased until the combustion is slightly lighter in color than described. Orsat readings will then show about 5% excess air.

BATTERY AIR ADJUSTMENT (CONTINUED)

CROSS-WALL COMBUSTION

The combustion air to the battery is regulated by adjustment of the stack and basement drafts. The two drafts are adjusted together so that:

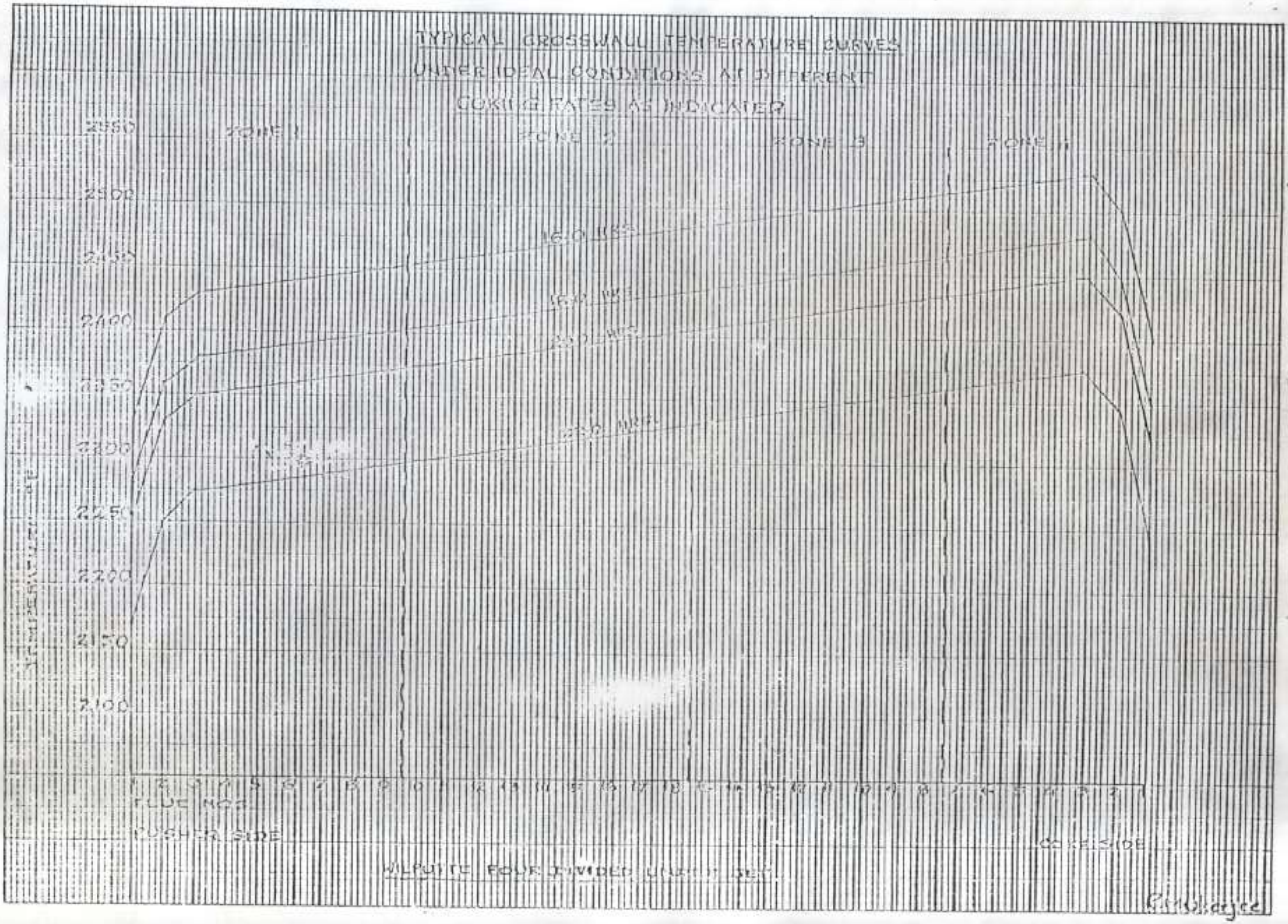
1. The quantity of air for combustion is correct.

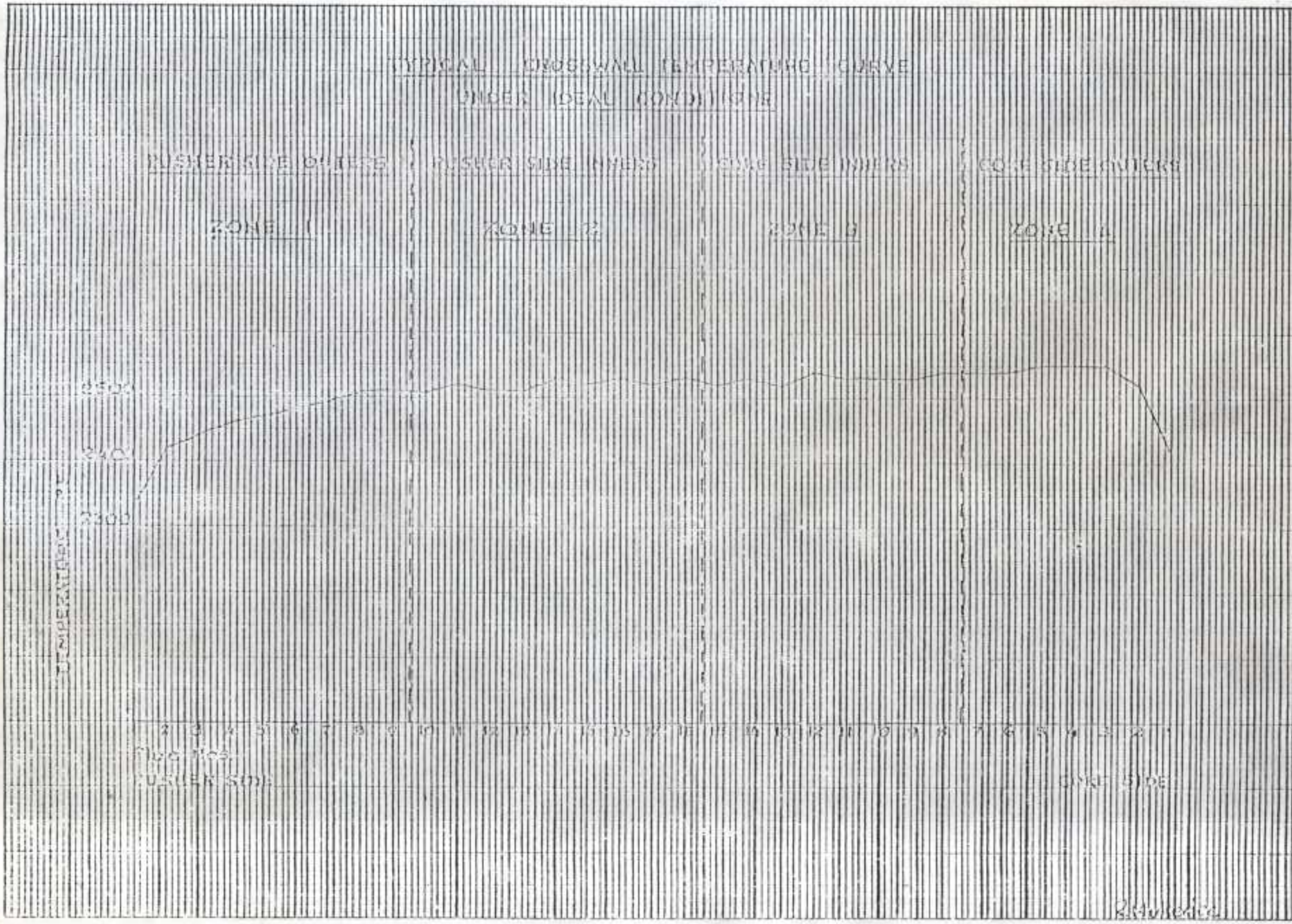
2. The pressure in the horizontal flues, as measured at the inspection caps, is nearly balanced (preferably from 1.5 m.m. to ± 0.5 m.m. W.G.).

The measure of combustion air to the battery is the difference between stack draft and basement draft. Hence, the stack and basement drafts are adjusted to suit the combustion requirement; then both are raised or lowered together until the horizontal flue pressure is balanced.

CROSS-WALL TEMPERATURES

The average flue temperature will, of course, vary with the operating schedule, and with the desired coke temperature. The cross-wall temperature gradient (increase in flue temperature from the pusher side toward the coke side) will vary with the oven taper.


TYPICAL CROSSWALL TEMPERATURE CURVES
UNDER IDEAL CONDITIONS AT DIFFERENT
COKING RATES AS INDICATED
ZONE 1
ZONE 2
ZONE 3
ZONE 4
2550
2500
2450
2400
2350
2300
2250
2200
2150
2100
16.0 HRS.
FLUE NOS.
PUSHER SIDE
COKE SIDE


TYPICAL CROSSWALL TEMPERATURE CURVE
UNDER IDEAL CONDITIONS
PUSHER SIDE OUTERS
PUSHER SIDE INNERS
COKE SIDE INNERS
COKE SIDE OUTERS
ZONE 1
ZONE 2
ZONE 3
ZONE 4
2500
2400
2300
TEMPERATURE °F
Flue Nos.
PUSHER SIDE
COKE SIDE

## UNEVEN COKE HEATS

Gas and air distribution has been pre-set for a given coking range, and this will give uniform coking from end to end when stack draft and gas flow are properly adjusted. However, the gas and air distribution systems must be maintained properly. Several causes for uneven heating are listed below:

1. Carbon in gas burners - inadequate decarbonizing air.

2. Pushing delays - overheated areas, spotty.

3. Uneven pushing schedule.

4. Dirty metering pins or orifices - tar deposits blocking gas flow, precipitators at B.P. not efficient, inadequate maintenance.

5. Dirt, sludge, in small gas piping - piping from manifold to risers must be swabbed regularly.

6. Poor combustion - air adjustment - finger bars, waste gas dampers, slide brick, or stack control, need adjustment.

7. Incorrect pin sizes - pins switched after cleaning, improper distribution following a new setting.

8. Coal segregation - poor mixing, faulty preparation, slugs of old coal from empty bin walls or corner.

9. Erroneous fuel gas flow indication - due to changes in temperature, BTU, gravity, etc.

10. Uneven charging - coal too wet, charging car operation faulty, leveler bar out too soon, low volume in charging hoppers.

11. Cool top or hot bottoms - too much air to flues, poor adjustment of finger bars or stack draft.

12. Charging delays - oven pushed empty too far ahead of charging will overheat, loose some necessary carbon sealing. Condition should normalize in one to two days.

## CAUSES FOR UNEVEN HEATING

1. Cross-wall temperatures uneven, coke spotty:

   a. Gas metering pins dirty.

   b. Incorrect sizes of pins in place.

   c. Battery air adjustment not correct.

   d. Oven delays.

   e. Segregation in coal charges.

   f. Insufficient decarbonizing air. This can be checked by referring to the fuel gas pressure chart.

   g. Slide brick out of adjustment; check openings, and adjust any found out of place.

   h. Gas nozzles plugged, obstruction in gas gun.

2. Cross-wall temperatures even, coke spotty:

   a. Insufficient fuel gas.

   b. Oven delays. When due to this cause, usually the coke will be spotty on one whole series, and may be good, or fair on the other series.

   c. Uneven pushing schedule.

   d. Coal segregation, due to poor pulverization resulting in poor mixing; or bad charging procedure.

3. Flue temperatures low on pusher side:

   a. Too much combustion air on the battery.

   b. Pushing delays. A series of prolonged pushing delays will tend to overheat the coke side. Since at such time the gas to the battery will be cut, the net result will be a cold pusher side. The effect will persist for several days after normal pushing schedule has been restored. The heater is warned not to upset his combustion in a hurried effort to correct this condition; the best procedure is to make sure that combustion conditions are correct, then wait.

## CAUSES FOR UNEVEN HEATING

4. Flue temperatures too low on the coke side:

   a. Charging delays. Charging delays have the opposite effect of pushing delays. The effect is less persistent, however, and the temperature gradient across the wall should be back to normal within 24-48 hours after pushing is back on schedule.

5. Hot bottoms and cool tops.

6. Too much combustion air on battery.

7. Gas recycling across top of coal in oven.

## REGULATING SUPPLY OF DECARBONIZING AIR

Starting with the decarbonizing fan damper wide open, gradually close the damper until any carbon, deposited on the burner nozzles in the vertical flues, just fails to burn off within the first 15 minutes of the "OFF" gas period. Then open the damper slightly.

In other words, use only enough air to burn off any carbon deposits within 15 minutes.

## REVERSING MACHINE AND REVERSING MECHANISM

This system automatically reverses the flow of fuel gas, air and waste gas through the flues and regenerators at some preset interval, usually 20 to 30 minutes. The regenerative principle of preheating the combustion air is thus used for maximum utilization of heat from the waste gas.

Cold air is drawn into and up through the regenerators and into the vertical heating flues where it meets the fuel gas for combustion. The hot products of combustion pass over through the horizontal flue into and down through the "OFF" vertical flues and thence down through the opposite regenerators into the bus flues, and from there to the stack.

At regular 20 minute intervals by means of the reversing machine and a system of valves, all operated automatically, the direction of flow is reversed so that cold air passes up through the regenerators previously heated by products of combustion and meets the fuel gas for combustion now taking place in the previously "OFF" vertical flues.

If the mechanism is lubricated and adjusted properly, you will get years of trouble-free service from this equipment. An indicating ammeter on the controller cabinet shows the load during the reversing movement; any significant change should be investigated and causes corrected immediately. Some responsible person should inspect the various units regularly for wear, such as lid chains, or slippage, such as reversing cock lever brackets, or any abnormal movement. If a reversing cock sticks, something will break at reverse time. Adequate lubrication is vitally important.

If for any reason the reversing machine fails to operate at the regular time interval, the fuel gas will continue to burn in the same flues, and flues can overheat causing brick damage. Batteries have been ruined in this way. If the reverse fails to go on time for some mechanical reason, the "reverse-failure" alarm will signal failure. A "power failure" alarm operated from storage batteries will also sound if electricity fails. All operators and supervisors must be thoroughly instructed in use of emergency equipment. The reversing machine has a Dake engine which can operate on compressed air or steam. The reversing machine can also be operated manually.

REVERSING MACHINE AND REVERSING MECHANISM (CONTINUED)

To ensure the reliability of this stand-by drive and to become familiar with its application, try it out a few times each shift and then regularly once per week.

Also see that the signal horn and its storage battery are maintained in good working condition. Try it out each day.

In addition, it is necessary for the head heater on each shift to read at each reversal time all instruments in the Control Room.

The reversing machine is equipped with a D.C. motor and a set of storage batteries with a battery charger. In case of power failure, if the battery is on blast furnace gas firing, the reversing machine MUST be sent to the neutral position immediately to prevent damage to the battery. On resumption of power the battery shall be placed on blast furnace gas firing in accordance with the instructions in the "Control of Underfiring Manual."

NEUTRAL POSITION

In case of an extended delay in the pushing of coke or loss of fuel gas pressure, the battery may be sent to the Neutral Position. In this condition, all the gas to the battery is shut off and the air reversing valves and the waste gas reversing valves are slightly open. In this way the battery is prevented from rapid cooling.

For more extended delays, other corrective standby procedures must be invoked.

## REVERSING COCK LUBRICATION

If a gas reversing cock sticks, something will break when the reversing machine turns over. Therefore be sure that the reversing cocks are properly lubricated at all times.

This lubrication is very important and the job should be assigned to a capable and reliable mechanic.

## PRESSURE RELIEF HEAD ON COKE OVEN & BLAST FURNACE GAS MANIFOLDS

A pressure relieving device is provided at one end of the coke oven gas manifold comprising a manually operated valve and beyond that a rupture diaphragm and flame arrestor relieving to above the larry level. Be sure to have on hand a spare diaphragm for replacement of the one that may be ruptured in the event of a "pop".

A pressure relieving device is provided at one end of the blast furnace gas manifold comprising a counterweighted cap relieving above the larry level.

## CLEANING VALVE DISCS AND SEATS IN AIR AND WASTE GAS BOXES

The valve discs and seats become coated with dust deposits interfering with proper closure. Clean these regularly every week by rotating the discs on their seats. If any of these valves leak, the air supply for combustion will be inadequate and the heat regulation upset.

## COKE OVEN GAS PREHEATER - TEMPERATURE CONTROL

The gas distribution system to the flues regulates the gas volume to each heating wall and to each flue. Accurate metering requires a constant temperature gas, free of any condensates.

A fuel gas preheater is provided which automatically raises temperature of incoming gas to well above the dew point, usually 115-135°F, such that no condensation occurs in the metering devices and small piping downstream. This unit delivers a constant - temperature flow of gas to the heating flues for uniform and accurate metering. Condensates in preheater drain are drained through a seal pot.

A recorder in control room gives a continuous record of the gas temperature to battery. Any abnormal behavior should be explored and corrected promptly. A bypass at the control valve permits manual heating if repairs are necessary.

Operators should open the drain once per shift to assure no build-up of condensates in the preheater due to blocked line to seal pot.

## WASTE GAS ANALYSES

By analysis for oxygen content in the waste gases, you determine the combustion efficiency of the battery. The excess air is equal to approximately five times the oxygen content in the waste gases.

The samples should be taken through a nickel or nickel chrome tube inserted down into the waste gas box.

The oxygen content of the waste gas should be maintained 3-5% oxygen under normal circumstances. Oxygen content of the waste gas can be varied by changing stackdraft and finger bars in the air boxes.

Waste gas analysis from individual bus flues should be made periodically as a spot check.

## TIE ROD SPRINGS

Keep the buckstay tie rod springs tightened up to the specific gauge dimensions as shown on the drawings by using the gauges provided for this purpose at regular intervals. Neglect of these adjustments may cause brick damage under varying temperature conditions or may cause breaking of the tie rods with the consequent brick damage.

## UPKEEP AND MAINTENANCE

### SPARE MACHINERY AND SPARE PARTS

Spare machines should be checked over and put back into first-class operating condition as soon as possible after being taken out of service.

Spare parts are a very important part of the operating equipment. The stock of spares should be carefully maintained in order to minimize delays from breakdowns.

### SWEEPING THE BATTERY TOP

The battery top must be maintained clean by daily sweeping. Do not allow coal spillage to pile up between standpipes, charging holes and flue caps. If coal is allowed to accumulate, it may result in overheating and undue expansion of the tie rods. Also it is vitally important to keep the coal from dropping into the heating flues when inspection caps are removed, as it will slag and clog the air ports at the bottom of the flues. Such slag is exceedingly hard to remove and can throttle combustion air to the vertical flues, thereby seriously interfering with heat distribution.