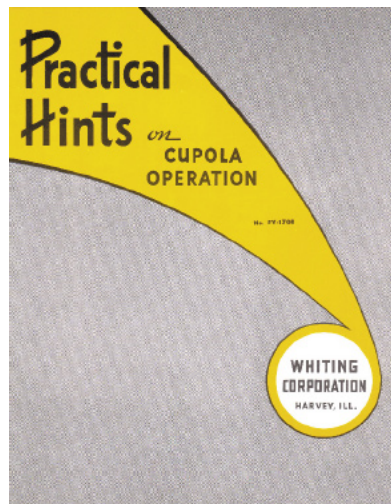




**Whiting Equipment Canada Inc.
Practical Hints on Cupola Operation**





Practical Hints on the Operation of

WHITING CUPOLAS

Although the cupola is the oldest and most generally used furnace for melting cast iron, it must be kept in mind that conditions vary widely from plant to plant. It is probable that no two foundries have exactly the same conditions or requirements. These individual conditions, however, do not greatly modify the basic principles of the cupola.

Cupolas are used today to produce malleable iron as well as gray cast iron. They are also used to melt bronze, ferro-manganese, steel scrap, etc., also to make mineral wool for insulating purposes. The main use, however, is for melting gray cast iron, and it is for this purpose that we give principal consideration.

We want to point out the several factors which govern cupola melting and guide the user in formulating the best practice for his particular needs. With this as the main objective, we present a general discussion of the factors involved, followed by an outline of recommended procedure for a typical example and a table of charges for various melting rates.

We believe this lays the groundwork for intelligent study of individual procedure. With over seventy-five years of experience in cupola manufacture and operation, we urge our customers to consult us on their specific problems. We have experienced operators to help in overcoming difficulties and establishing methods best suited for your purpose.

Directions for Erection

Foundation

A diagram giving the dimensions for the top of the foundation is sent to customers upon receipt of order for a cupola. The concrete footing should rest on hardpan with depth depending upon the soil.

Keep the top of foundation six inches below the level of the foundry floor, for sand fill to protect concrete footing.

It is not necessary to bolt the cupola legs to the foundation.

Erection

Erecting a cupola is a relatively simple job which some foundry men prefer to do with their own plant force. We can furnish a superintendent to supervise the erection and initial operation, if desired, on a per diem basis.

Erection may be accomplished by using two or three chain hoists suspended from the charging floor. A-frames, or gin poles (if erected outdoors). Stack sections are numbered for erected numbers joining. Match-mark numbers start at the top of the cupola. The top, or number one section of stack, is placed in position and raised high enough to slide the next section into place. Old automobile leaf type springs are very helpful in fitting one section of stack in another. THE SPARK ARRESTER IS PLACED ON THE ROOF AND SHOULD BE BOLTED ON THE CUPOLA AS IT IS BEING RAISED THROUGH THE ROOF OPENING.

Section two fits inside section one. Now section, one should be riveted or bolted to section



Fig. 2. Erecting a Whiting Cupola

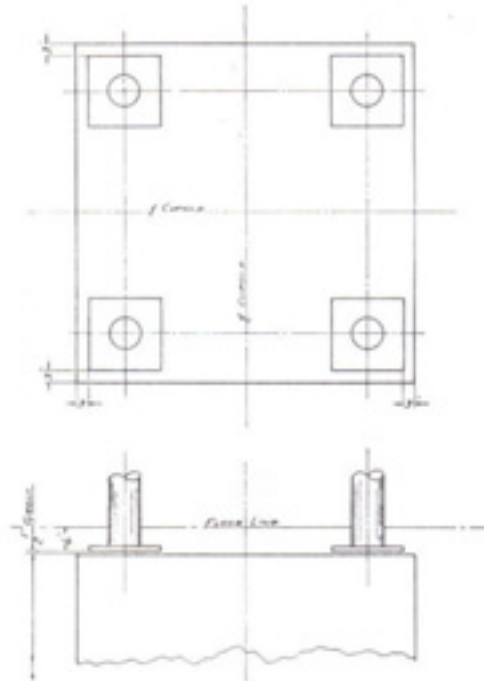


Fig. 1. Diagram of concrete foundation (depth of concrete to suit condition of soil).

two. Holes are all punched from uniform templates to facilitate assembly. The sections may be either bolted or riveted. Riveting makes a fine job and we furnish rivets with the cupola unless otherwise specified. If bolts are used, they should be turned up tight with heads on the inside. All remaining stack sections are connected in the same manner. The body section or wind boy fits outside the joining stack section. Note location of safety spout to be certain it is properly located for safety of personnel and accessory equipment.

The charging doors may be located at any desired point by turning the stack until proper position is obtained.

Now hoist cupola with body section high enough to admit columns, and loosely bolt to body section. Set columns, previously filled with concrete, on wedges in position desired, allowing one-half inch for grouting. Lower the cupola until it rests on foundation and tighten bolts after being certain that cupola columns are in proper position.

The slag and tap spouts, pressure gauge, and blast piping should now be connected to body section.

Directions for Lining

On pages 4 and 5 are shown various combinations of brick and block recommended for lining different sizes of cupolas. The table (page 5) shows the number of block and brick required to form any desired inside diameter. Refractory should not protrude more than $\frac{3}{4}$ " over hole in bottom plate.

Bricks should be dipped in a thin fire clay mortar and laid so as to provide for expansion beginning at the bed plate. We recommend leaving a space (about $\frac{1}{4}$ " to $\frac{3}{8}$ ") between the shell and the outer course of brick to take care of expansion. When silica or basic refractories are used, follow the recommendations of the refractory manufacturer on bonding materials, expansion and installation.

Standard Whiting tuyeres (shown in Fig. 3) are so designed as to minimize cutting and fitting of the lining. When the lining is even with the bottom of the tuyere openings, the segments forming the lower part of the tuyeres are laid in place, forming a continuous circle. The tuyere blocks or separators are then set in place, and the spaces between the webs in the tuyere blocks filled with ganister or ground fire brick as a protection against the heat. The top segments of the tuyeres are next laid in place, forming a continuous shelf all around for the next course of brick and block. TUYERES SHOULD FIT TIGHT AGAINST THE SHELL TO MINIMIZE

AIR LEAKAGE. THESE JOINTS SHOULD BE REGULARLY INSPECTED AND KEPT SEALED WITH SUITABLE REFRACTORY.

We recommend that the first seven courses of block above the lower tuyeres be extended by means of a split, or other, brick against the shell, so as to overhang 1" to 8" (depending on size of cupola), and then corbeled back to the original diameter (as illustrated in diagrams on page 4). This allows molten iron and slag to drip clear of the tuyeres and also keeps out the coke. If upper tuyeres are used, they should be placed within this boshed section.

If a fan type blower is used, it should be remembered that excessive reduction of diameter at tuyeres may seriously affect the performance of the fan blower.

After tapering back to the normal diameter, continue lining straight up to the top of the charging door. All joints should be broken. From the charging door, continue with reduced lining to the top of the stack.

If mechanical charging using cone-bottom buckets is employed, it is often advisable to use several courses of cast iron blocks at the charging door level to take care of abrasion.

WHEN THE CUPOLA IS TO BE USED FOR LONG HEATS. IT IS ADVISABLE TO USE A HEAVIER LINING.

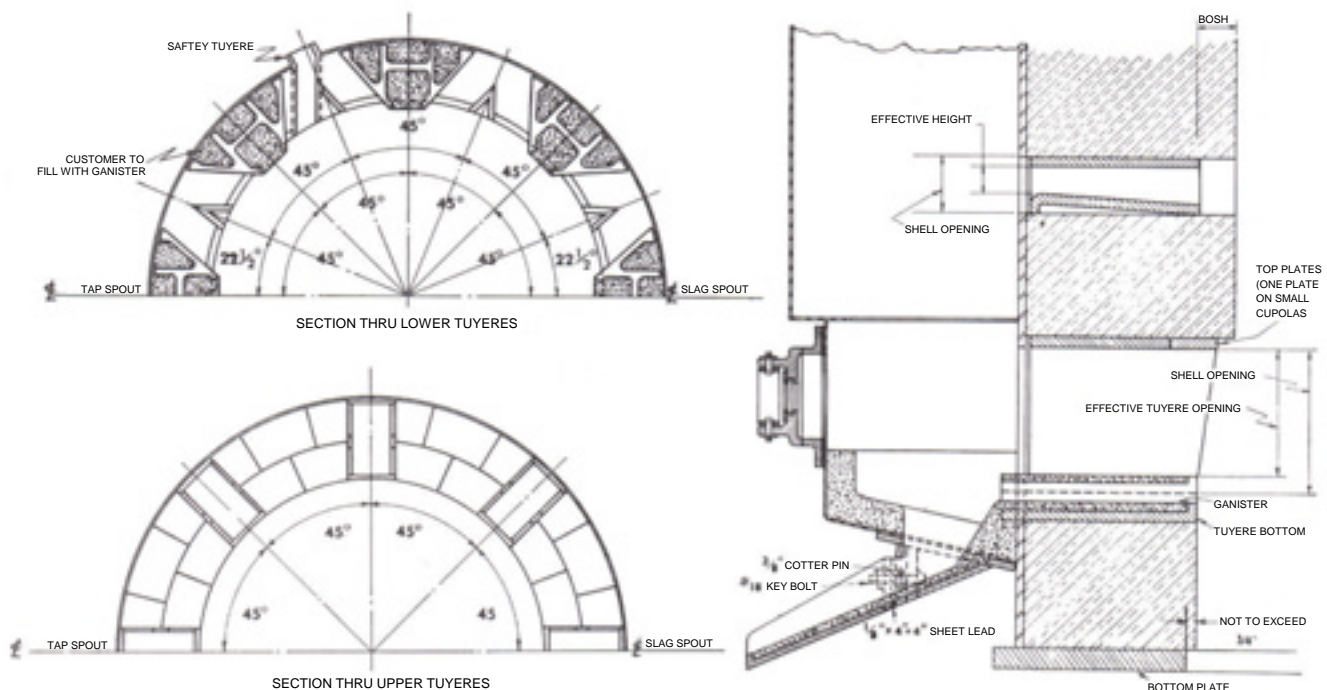
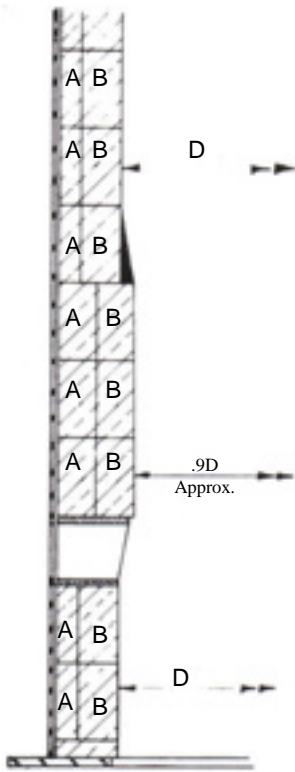
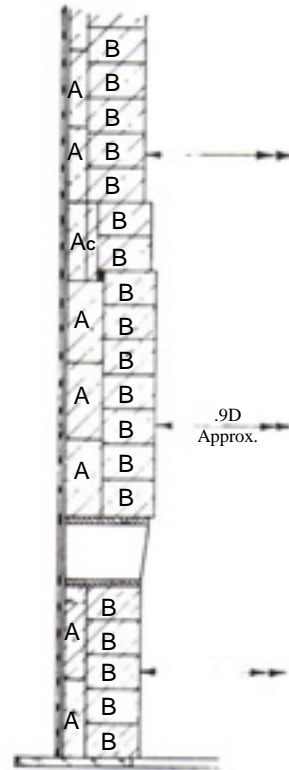


Fig. 3. Sectional views of Whiting type MR tuyeres (standard for Model "B" cupolas).
NOTE: Lower part of all tuyeres and tuyere elbows to be lined with ganister by customer.



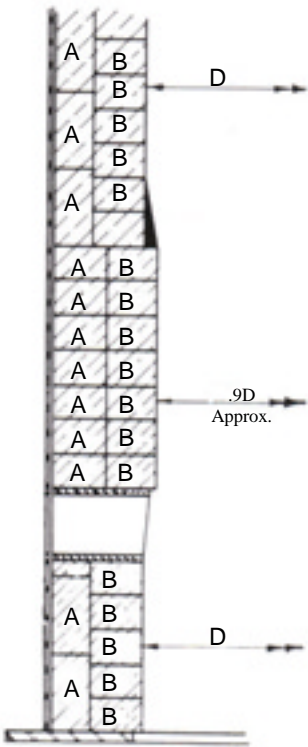
7" LINING

- Key
- A. 9" x 4 1/2" x 2 1/2" Straight
 - B. 9" x 4 1/2" x 9" Calliau Block
 - C. 9" x 4 1/2" x 2" Straight



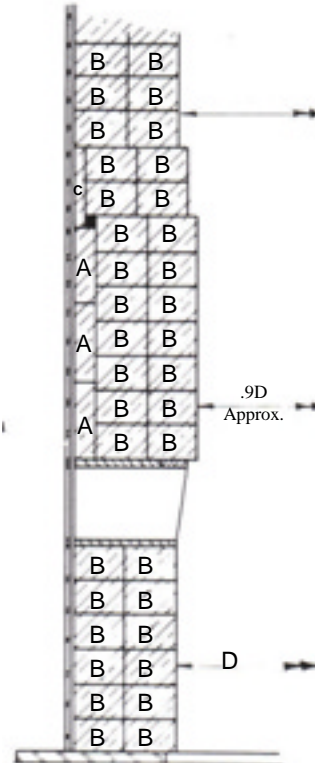
9" LINING

- Key
- A. 9" x 4 1/2" x 2 1/2" Straights and arches
 - B. 9" x 6" x 4" Cupola Block
 - C. 9" x 4 1/2" x 1 1/2" Split



10 1/2" LINING

- Key
- A. 9" x 4 1/2" x 2 1/2" Straights and arches
 - B. 9" x 6" x 4" Cupola Block



12" LINING

- KEY
- A. 9" x 4 1/2" x 2 1/2" Straight
 - B. 9" x 6" x 4" Cupola Block
 - C. 9" x 4 1/2" x 1 1/4" Split

Number of Brick and Block Required for Whiting Cupolas

Consult your refractory supplier for other available sizes.

NOTE: For long runs, heavier linings are required.

| Cupola No. | Shell Diam. | Thick-ness | Size of Cupola Block | LOWER LINING | | | | UPPER LINING | | | | |
|------------|-------------|------------|-----------------------|-----------------|---------------|---------------------------|---------------------------|--------------|-----------------|------------------|---------------------------|---------------------------|
| | | | | Number per foot | | Pounds Fire Clay per foot | Total Weight Per ft. lbs. | Thick-ness | Number per foot | | Pounds Fire Clay per foot | Total Weight Per ft. lbs. |
| | | | | Cupol a Block | 9" Str. Brick | | | | 9"Str. Brick | Arch Brick No. 1 | | |
| 0 | 27" | 4½" | *18-27 | 12 | ... | 15 | 303 | ... | ... | ... | ... | ... |
| 1 | 32" | 4½" | **23-32 | 16 | ... | 22 | 427 | 2½" | 31 | ... | 12 | 215 |
| 2 | 36" | 4½" | *27-36 | 28 | ... | 24 | 482 | 2½" | 35 | ... | 14 | 243 |
| 2½ | 41" | 7" | *27-36 | 28 | 39 | 40 | 790 | 2½" | 39 | ... | 16 | 271 |
| 3 | 46" | 7" | *32-42 | 20 | 43 | 44 | 869 | 2½" | 44 | ... | 18 | 308 |
| 3½ | 51" | 7" | **37-46 | 21 | 47 | 47 | 932 | 2½" | 48 | ... | 19 | 336 |
| 4 | 56" | 7" | *42-51 | 24 | 52 | 54 | 1059 | 2½" | 52 | ... | 21 | 364 |
| 5 | 63" | 9" | { †42-54 †48-60 } | { 30 30 } | 59 | 72 | 1422 | 4½" | 9 | 101 | 44 | 831 |
| 6 | 66" | 9" | †48-60 | 63 | 61 | 76 | 1500 | 4½" | 15 | 101 | 47 | 879 |
| 7 | 72" | 9" | †54-66 | 69 | 67 | 83 | 1643 | 4½" | 25 | 101 | 50 | 957 |
| 8 | 78" | 9" | †60-72 | 75 | 73 | 91 | 1791 | 4½" | 36 | 101 | 55 | 1045 |
| 9 | 84" | 9" | †66-78 | 81 | 78 | 98 | 1928 | 4½" | 45 | 101 | 58 | 1115 |
| 9½ | 90" | 9" | †72-84 | 87 | 84 | 105 | 2065 | 4½" | 56 | 101 | 63 | 1203 |
| 10 | 96" | 9" | †78-90 | 96 | 90 | 115 | 2265 | 4½" | 60 | 101 | 65 | 1235 |
| 11 | 102" | 12" | { †78-90 90-102 } | { 96 108 } | ... | 122 | 3400 | 4½" | 71 | 101 | 69 | 1322 |
| 12 | 108" | 12" | { †84-96 *96-108 } | { 102 114 } | ... | 130 | 3800 | 4½" | 82 | 101 | 75 | 1425 |

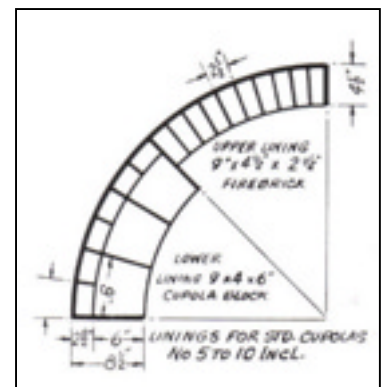
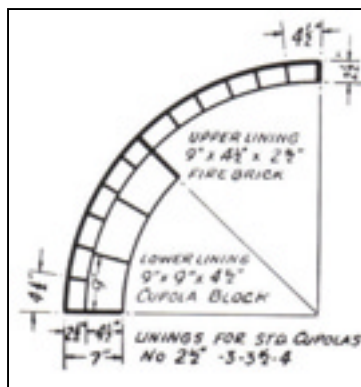
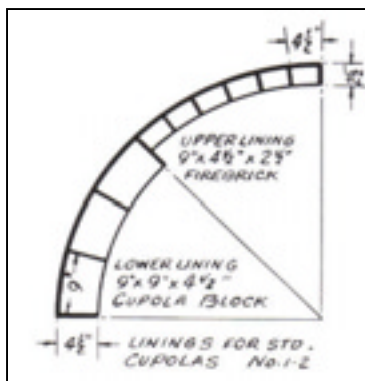
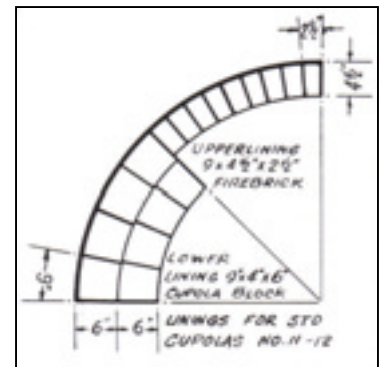
*Calliau Blocks; 9" across back, 9" high, 4 ½ radial.

†Cupola Blocks; 9" across back, 4" high, 6" radial.

**Special block 9" x 6" x 4½" – Name of a manufacturer on request.

Alternate arrangement for Lower Linings (Cupolas No. 0 to No. 4 using standard arch and straight brick.)

| Cupola No. | Shell Dia | Thick-ness | Shape – No. per ft. | 9" Straight Brick No. per ft. | Pounds Fire Clay per ft. | Total Weight Per ft. lbs. |
|------------|-----------|------------|--|-------------------------------|--------------------------|---------------------------|
| 0 | 27" | 4 ½" | 9" No. 3 Arch – 6 9" No. 2 Arch – 40 | ... | 18 | 317 |
| 1 | 32" | 4 ½" | 9" No. 2 Arch – 48 9" No. 1 Arch – 7 | ... | 22 | 383 |
| 2 | 36" | 4 ½" | 9" No. 2 Arch – 42 9" No. 1 Arch – 20 | ... | 25 | 430 |
| 2½ | 41" | 7" | 9" No. 2 Arch – 42 9" No. 1 Arch – 20 | 39 | 40 | 700 |
| 3 | 46" | 7" | 9" No. 2 Arch – 32 9" No. 1 Arch – 38 | 44 | 46 | 794 |
| 3½ | 51" | 7" | 9" No. 2 Arch – 24 9" No. 1 Arch – 54 | 48 | 50 | 878 |
| 4 | 56" | 7" | 9" No. 2 Arch – 15 9" No. 1 Arch – 71 | 52 | 55 | 962 |



Requirements for Good Cupola Operation

An old foundryman once remarked that the only thing needed to melt iron in a cupola was coke, wind, and common sense. These are three very important items, to be sure, but there are other things to consider as well. Let us discuss briefly the factors that have a bearing on good cupola operations.

1—AIR SUPPLY

The total weight of air required for melting a given tonnage of iron is about as much as the combined weight of all the solid materials that make up the charge. The proper amount of air is important for good melting practice. Insufficient air slows down the melting rate. Excess air may increase loss of silicon, manganese, and iron. Adjusting melting rate by radically changing the air volume to meet fluctuating production line demands for molten iron should be avoided if possible.

Blower:

It is important that the blower for supplying the air have sufficient capacity to take care of maximum melting rate. This can be computed on the basis of 2½ c.f.m. per sq. in. of cupola area inside the lining. It is also important that the blower have adequate pressure capacity.

BLOWER CAPACITY RATINGS ARE BASED ON CONDITIONS AT THE BLOWER DISCHARGE AND NOT ON CONDITIONS AT THE WINDBOX. The blower should be so located that the intake will draw clean air.

the area of the main pipe should be at least equal to the combined area of the two small pipes. We also recommend that the air pipe have as few bends as possible and these should be large radius bends. The blower should not be too close to the cupola, and the portion of the pipe leading into the windbox should be straight for a distance of at least 12 times the diameter of the pipe. It is essential that all joints be air-tight. It is desirable to have a blast gate (or bleeder if a positive pressure blower is used) to regulate the volume of air delivered to the cupola. A strong blast near the end of the heat may do more damage to the lining than in all the previous melting period.

Blast Control:

More and more foundry men are adopting automatic air weight or volume control apparatus for controlling the air supply. Dependable equipment is available for measuring and controlling the amount of air actually passing through the blast line. With such equipment the cupola supervisor can set the melting rate at the desired amount. In our opinion, it is important to measure the quantity of air delivered. It is important also to know the pressure and each Whiting cupola is equipped with a suitable pressure gauge.

Control of Moisture Content:

Water in the air blast affects the melting operation. The amount of water in the air varies widely from time to time. On a very humid day it is possible for a ton of water to pass through the cupola for every 50 tons of iron melted, while on a day when the air is very dry there would be a ton of water for every 300 tons of iron melted.

Apparatus for controlling the moisture content in the blast to a uniform and small amount is available and is being used with good results in a number of foundries. Silicon and manganese losses increase with increasing moisture content. Metal temperature decreases: fuel consumption increases. The metallurgical quality of the metal is affected. Moisture is another among many variables whose removal will improve the operation.

Hot Blast:

Apparatus for heating the air represents a sizeable investment and its use has been almost entirely confined to production shops using large cupolas and running long heats. The benefits of preheating the air before it enters the wind chamber have been proved very definitely in numerous installations. The savings are sufficient in many cases to earn a handsome return on the added investment and improve overall operation. Whiting Corporation is in position to furnish hot blast equipment and will be glad to quote on request.

2—REFRACTORIES

For best results and long cupola life it is essential that great care be used in placing and maintaining the lining, it pays to use high grade materials. A variety of standard blocks are available and carried in stock by the refractory manufacturers. The diagrams, page 4, show the combination of block and bricks for different thicknesses of linings. The table on page 5 shows the number of blocks and brick required to form any desired inside diameter.

3—COKE

In selecting coke we recommend the use of U.S. Navy, Spec. 7C2b, Grade A, for cupola coke. We would stress uniformity of size and structure.

Generally speaking, the coke size should be 1/10 to 1/12 of the cupola diameter. Hard dense, slow-burning coke gives the best results in most cases, but some special irons may require softer cokes that tend to give a higher carbon pickup. It is especially important for successful operation of small cupolas that the coke be carefully sized and uniform.

4—PIG IRON

The grade of pig iron to be used depends entirely on the chemistry of the castings to be made. We recommend using the American Iron & Steel Institute manual as a guide in pig iron selection (published by American Iron & Steel Institute, New York City). In the purchase of pig iron, like all materials, it should be remembered that selecting the right grade is important.

THE SIZE HAS AN IMPORTANT EFFECT ON COST OF OPERATION, PIG IRON, AS WELL AS SCRAP, SHOULD NOT BE LARGER THAN 1/3 THE INSIDE DIAMETER OF THE CUPOLA LINING.

5—SCRAP

The amount and kind of scrap used is determined by the character of the castings to be made, the materials available and the skill of the operator. All scrap should be graded and a record kept of the weight charged.

Many foundries use turnings and borings in briquetting form with very good results. In plants large quantities of this material are available from the machine shop, it may be economical to install a briquetting press for this purpose,

6—FLUX

A good grade of limestone or dolomite is the common material used for producing slag in the cupola. Fluorspar also may be used in small quantities. For small cupolas the limestone

should be in small pieces just as the scrap and coke are of smaller size. All fluxing materials should be spread uniformly over the charge. The quantity used depends on the kind of coke, the grade of scrap used, the method of slagging, and the length of the heat. Sufficient flux should be used to make a free-flowing slag. An excess of flux, however, may injure the lining. See table on page 15.

7—CORRECT PROCEDURE

Correct procedure is the most important factor of all. Careless operation, even with a good cupola and good materials will lead only to indifferent results, increased costs, and a low

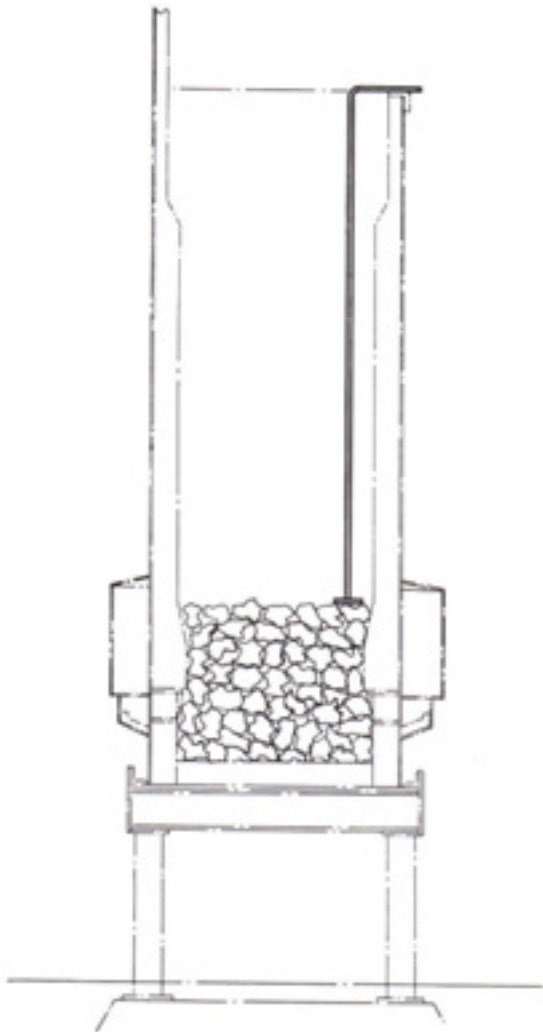


Fig. 4. Bar gauge for measuring height of coke bed.

quality product. Because conditions vary so widely from plant to plant, this outline of procedure is necessarily general, intended as a guide rather than an explicit rule.

The cupola breast and slag hole may be lined with either fire brick or a sand and clay mixture. A good mixture for this purpose is made of two-thirds silica sand and one-third fire clay.

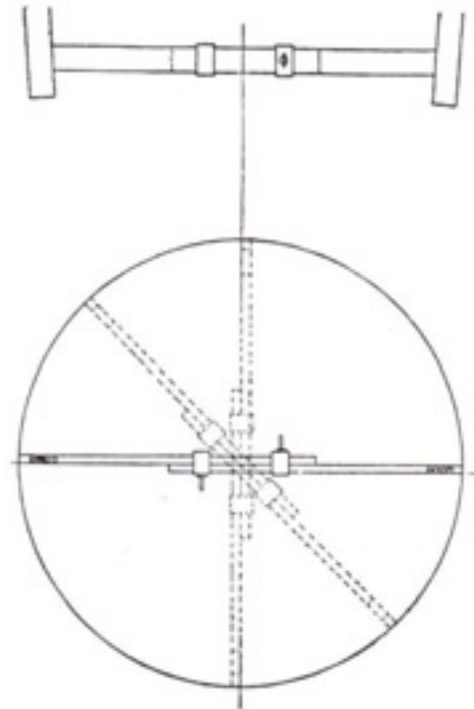


Fig. 5. Adjustable measuring stick.

The cupola lining at the melting zone should be repaired after each heat, bringing the lining back to the original dimensions. If lining is cut back more than $1\frac{1}{4}$ " , it is advisable to use split brick, set up in a good refractory daubing material. An adjustable measuring stick, as shown in Fig. 5, will aid considerably in getting the cupola repaired to the proper diameter.

A good practical daubing mixture consists of $\frac{1}{4}$ fire clay, $\frac{1}{4}$ ground fire brick, and $\frac{1}{2}$ sharp sand. It is important that the above daubing be properly mixed and tempered and also be made up the day before it is used.

The extent of melting zone repairs will depend on the number of hours of operation and operating conditions. If cupola bridges, the refractories are damaged. Careful attention to daily repairs on melting zone will preserve the lining and will give better cupola operation, and lower operating costs.

Preparation for Heat:

The bottom doors are raised and securely propped. Joints should be mudded. Props should be placed on heavy steel plate or equally solid foundation, otherwise the weight of the charge might cause bottom doors to settle, cracking bottom sand, which would cause a runout.

On large cupolas we recommend raising the door by means of a bottom door hoist. (See page 14, Fig. 8).

Lay in bottom sand from six to nine inches thick, depending on duration of melt, and tamp down securely. A good bottom may be made with one-half old heavy molding sand and one-half new molding sand and tempered as for molding. Care should be taken to see that the bottom sand does not contain any nails or pieces of iron which might cause iron to run out through the bottom doors. The bottom should slope toward the tap hole from all directions. It is good practice to check this daily with a gauge or template. The top of the slag hole should be six inches below the bottom of the lower tuyeres. A wood form may be used to form the slag hole and lining material rammed around this form.

Makeup of Charges:

Making up the charges and getting them into the cupola is an important phase of cupola operation. Proper supervision should be provided to make sure that the amounts of iron and coke are ACCURATELY weighed according to the requirements of the job (See table on page 15). However, local conditions vary considerably and the best operating technique will be developed

after careful study and experimentation have been applied to each operating problem. It is advisable to make alterations gradually, observing the effect of each change before making another.

All charges should be weighed and an accurate record kept of the charges. The tendency today is toward smaller charges and more intimate mixture of the metal and the coke. Where mechanical charging equipment is employed, it is common practice to put the pig, scrap, coke, and flux all in one bucket so that it will be uniformly distributed in the cupola. Coke, Preferably, should be kept in covered storage and in this case should be measured by weight and not by volume.

If no mechanical charging equipment is available, enough charging cars should be provided and loaded in advance so that sufficient material will be on the charging floor to keep the cupola going. Where mechanical charging is employed, equal care should be exercised to accurately proportion the charges, but due to more rapid movement of materials the charges need not be made up in advance. In a properly planned charging system, the mechanical equipment is so synchronized as to keep material moving to the cupola in a definite cycle.

Taking a Heat:

We now have the cupola lined and ready for operation.

We assume that the cupola has been properly lined and the sand bottom rammed in place. The next step is a very important one—namely, starting the fire.

Various Methods Are Used:

(a) Kindling wood:

An old but common method is the use of small kindling wood so that it will burn through readily and make a uniform fire for the coke bed. Avoid large chunks and green wood. A good

way is to cover the sand bottom with flat boards before adding the kindling to keep it from puncturing the sand bottom. About one-third the bed coke is placed on top of the wood and then the fire is started. It is a good idea to light the wood at several points and get a uniform fire.

(b) Oil or Gas Torch:

Some foundries prefer a blow torch for lighting up the coke bed. The torch should enter the cupola very close to the sand bottom. If the breast opening cannot be used, special openings usually are made in the shell, and these openings are closed afterward with brick. Channels of large coke should be made in the bed to permit the oil or gas flame to ignite the coke evenly. It is also desirable to have a piece of wood on the sand bottom so that the oil flame will not blow the sand away while the coke is being ignited.

(c) Electric Coke Igniter:

A newer and very satisfactory method is the Electric Coke Igniter. This device is inserted into the coke bed through the cupola breast or through a special opening in the side or back. An electric arc lights the coke bed in less than a minute; a booster blast pipe is then inserted to support rapid combustion and the entire coke bed is perfectly fused in about thirty minutes. One important advantage of this method is the complete absence of smoke.

But whatever method is used, the bed should be properly burned in before putting on the blast.

When the coke is white throughout the remaining two-thirds of coke is added, a third at a time. Generally, it is desirable to have the bed coke extend 30 to 60 inches above the tuyeres, although this may vary for different blast pressures. We recommend that the coke bed be set by height, rather than by weight, and checked with a gauge as in Fig. 4. The following empirical formula is a practical guide for determining the height of the coke bed:

Multiply the square root of the blast pressure by 10.5 and add 6. For example, suppose the blast pressure is 18 oz. The square root of 16 is 4; $4 \times 10.5 + 6 = 48$ ". So the bed coke (for 16 oz. blast) should measure 48" above the tuyeres.

After the bed has been set properly, the function of succeeding coke charges is to keep bed at proper height.

A good way to determine the proper amount of coke on the bed is to check the length of time from turning on blast until iron starts to melt. If bed is near the right height, iron should pass the tuyeres in four to five minutes, and show at the tap hole in six to eight minutes, providing proper volume of air is being supplied.

If it takes longer for iron to show at the tap hole, then coke bed is too high and fuel is being wasted. If iron shows at the tap hole in less than six minutes, coke bed is too low.

Coke that has been reclaimed from the cupola should not be used on the bed charge.

The peephole covers on the tuyere boxes should be kept open until the cupola is charged. If the cupola is not to be operated immediately on completion of charging, close all the peepholes except one or two.

ANY TIME THAT THE BLAST IS CUT OFF DURING OPERATION, THE PEEPHOLE COVERS SHOULD BE OPEN TO PREVENT ACCUMULATION OF EXPLOSIVE GASES IN THE WINDBOX AND PIPING.

After the bed has been burned in properly, the cupola is ready to receive the first iron charge. For many years it was considered important to charge iron and coke separately in alternate layers. The advent of mechanical charging showed that equally good results were obtainable by putting the iron, coke, and flux all in one bucket and dumping it at one operation. If the cupola is charged by hand, it is, of course, simpler to charge alternate layers of coke and iron.

The table on page 15 gives sizes of charges recommended for different sizes of upolas for a given melting rate. The succeeding charges of coke vary from 1/6 to 1/12 of the iron charge by weight, depending upon the temperature of iron desired, size of scrap, quality of coke, and other conditions. It is good practice to fill the cupola to the charging door and keep it full for the duration of the heat. In this way a good portion of the heat in the ascending gases is imparted to the cold material as it travels down to the melting zone.

If the cupola is to be operated longer than one hour, an amount of flux equal in weight to 20% to 30% of the coke charge should be added to the coke bed and to each succeeding charge. If the slag is too fluid, the amount of flux may be decreased.

In starting a new cupola it is best to add an extra amount of coke, which may be diminished gradually as familiarity with its operation is acquired. Long heats will produce economy of fuel, as the effect of the coke bed on the total fuel ratio decreases as the daily melt increases. A cupola using 1500 pounds of coke on the bed might have a daily run of 15 tons, or a run of 60 tons. When melting 15 tons, the coke bed represents 100 pounds per ton, but only 25 pounds when melting 60 tons. In figuring fuel economy, total coke should be used (including the bed), but in comparing coke ratios for two cupolas the bed coke should be disregarded.

Slagging and Tapping

There are several methods of slagging, depending on how the cupola is tapped. Standard cupolas are provided with a separate spout for slagging usually placed at the rear, and a tapping spout on the front. The most common method is to tap intermittently. In this case the tap hole should be not less than 1" in diameter to permit the metal to flow rapidly into the ladle with the least chilling action. The tap spout should be lined so that the through will permit a narrow, deep stream of metal.

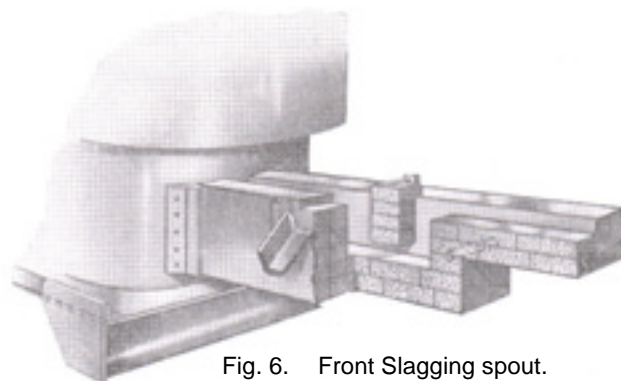


Fig. 6. Front Slagging spout.

As iron accumulates in the well, the slag rises and flows out through the slag hole, and down the slag spout.

If the cupola is operated continuously, as in production foundries, the tap hole may be somewhat smaller so as to keep constant depth of metal in the well. In this case the slag hole should be about 1½" diameter and placed 6"

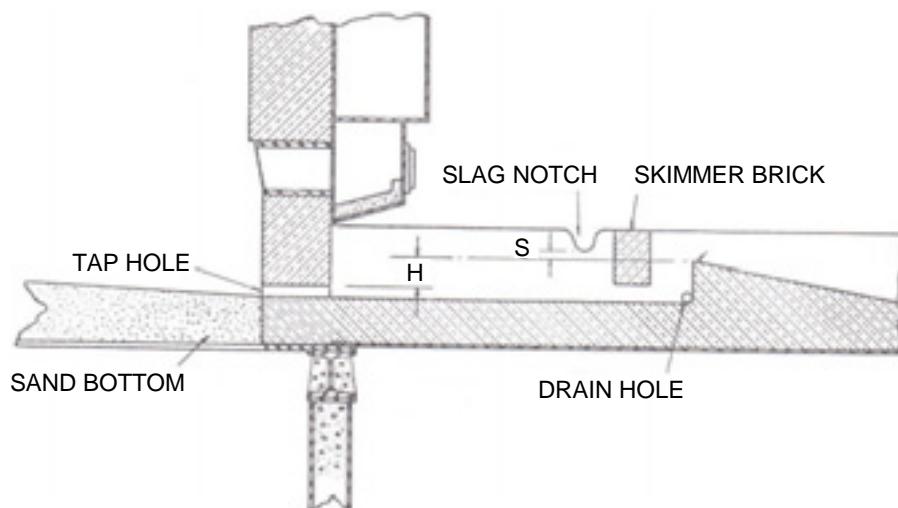


Fig. 7. Cross section of front slagging spout.

| Cupola pressure in oz. | "H" in inches | "S" in inches |
|------------------------|---------------|---------------|
| 4 | 1 | 1¼ |
| 8 | 2 | 1¼ |
| 12 | 3 | 1¼ |
| 16 | 4 | 1¼ |
| 20 | 5 | 1¼ |
| 24 | 6 | 1¼ |

below the tuyeres. It should be far enough below the tuyeres to prevent the blast from chilling the slag. The slag hole should be kept open throughout the heat so slag can flow freely.

Another method, used extensively in plants running continuously, employs a front slagging spout, similar to Fig. 8. and shown in cross section in Fig. 7. In this case, iron flows under the skimmer brick and over the dam while the slag is drained off through a slag notch and down a side spout. This method permits continuous tapping and slagging. It is being used successfully in many foundries and is particularly effective in plants using a duplex melting system.

By applying certain basic principles, this spout can be successfully applied to a variety of cupola conditions. The size of the taphole should be established according to the melting rate of the cupola. The height of the dam above the top of the taphole should be set on the basis of $\frac{1}{4}$ " height per ounce of cupola pressure. Some operators add a fixed $\frac{1}{4}$ " safety factor to the height calculated by this rule. The level of the slag notch should be a minimum of $1\frac{1}{4}$ " above the height of the dam, but not so high as to cause slag to back up into the tuyeres or flow out of the safety tuyere. The skimmer brick should be set low enough below the height of the dam to hold the slag but high enough to permit free flow of the metal under the skimmer. Usual practice is to set the skimmer so that clearance underneath is approximately $\frac{1}{4}$ the height of the dam. A drain hole at the dam permits draining the residual metal in the spout before dropping the cupola bottom.

All Whiting cupolas are equipped with a safety tuyere to prevent iron and slag from accumulating in the tuyeres and tuyere elbows. This safety tuyere should be checked daily (See sketches, page 3).

End of the Heat:

As the heat nears the end, the blast should be reduced and stopped altogether as soon as the cupola is dry. Otherwise the lining will be burned out much more than necessary. The drop in

pressure as shown on the pressure gauge will indicate when the cupola is running dry.

For protection against accidents and fires, the cupola should be drained free of iron before dropping the bottom. The sand floor under the cupola should be dry. with sand banked up around the legs. to protect them from the drop. Sometimes the lower part of the cupola legs is encased in brick as additional protection against the drop. Bottom doors are opened by pulling out the props. In quenching the drop the water stream should be kept away from the doors to prevent cracking.

A drag, as illustrated in Fig. 9, page 14, is a convenient means for removing the drop. The drag is placed under the cupola and covered with dry sand. By hooking on a chain or cable, the drag is hauled away right after dropping the bottom to any convenient point in the yard.

Daily Repairs:

The cupola lining at the melting zone should be chipped free of slag and coke after each run and the lining repaired to its original diameter. Any accumulation of slag, coke, or iron in the tuyere elbows must be removed daily. The slag hole, tap hole, slag spout, and safety tuyere must have daily attention.

Particular attention should be used when putting in a sand bottom on a rainy day. If water gets in the cupola the bottom will get wet, causing the iron to boil, which may damage the sand bottom.

The use of a safety screen at the charging door to protect workmen inside the cupola from falling material which becomes loosened in the stack is strongly recommended.

The sand bottom for long heats should be deeper than for regular operation. A good grade of daubing should be used in patching the lining. Failure to chip out the slag thoroughly after a heat and before applying daubing will result in slag becoming soft when iron begins to melt. carrying the daubing away with it and exposing the lining to further cutting by the iron and slag.

Supervision

Obviously best results may be expected only if strict attention is paid to every detail of operation. For the benefit of supervisors we list below some of the things they should check from time to time.

1. Air Supply

Make sure that the blower or fan is in good operating condition, particularly the bearings. Check the air line from blower to windbox for possible leaks. See that blast gates are in good order. Check air losses with the air circuit under pressure.

2. Lining

Check daily for proper repair. See that all slag adhering after the heat is removed and worn spots patched up. Lining should be repaired to a true circle at all times.

3. Base Plate

Inspect frequently for possible cracks. Also, inspect the bottom doors.

4. Blast Pressure

See that the pressure gauge is working right and that it registers zero when the pressure is actually zero.

5. Safety Spout

Make sure that the lead disc is in place and clear from sand and clay.

6. Tap Hole and Slag Hole

These should be maintained at the desired size and position.

7. Tuyeres

Peepholes are provided in the tuyere doors to observe operation. See that tuyeres are free from slag or iron.

8. Scales

Scales for weighing up charges should be checked frequently. A scale that does not weigh accurately is of little use. It is good practice to use a separate scale for the coke.

9. Charges

Keep close tab on the makeup gang. See that proper amounts of pig. scrap, coke, and flux are delivered to the cupola as called for by the metallurgist. Check the tares for buckets and barrows used in making up charges.

10. Temperature

Check metal temperatures with an accurate pyrometer. Know what you are getting.

11. Analysis

Analyze all materials going into the cupola, also the test bars from every heat.

12. Log

Insist on an accurate record of every heat.

Melting Log

On page 18 of this booklet is a sample form that we recommend to all users of Whiting cupolas. The information called for on this form will give a very complete record of each day's operation. Comparing results over a period of

time is most helpful in determining what is the best procedure under given conditions. Such reports also give the service man a very good picture of what has been attempted and enable him to be of more help in overcoming difficulties.

Whiting Accessories Increase Economy

Bottom Door Hoist and Props

For reasons of safety, and to lighten an otherwise hard task, some mechanical means for raising the bottom doors on the larger sizes of cupo-

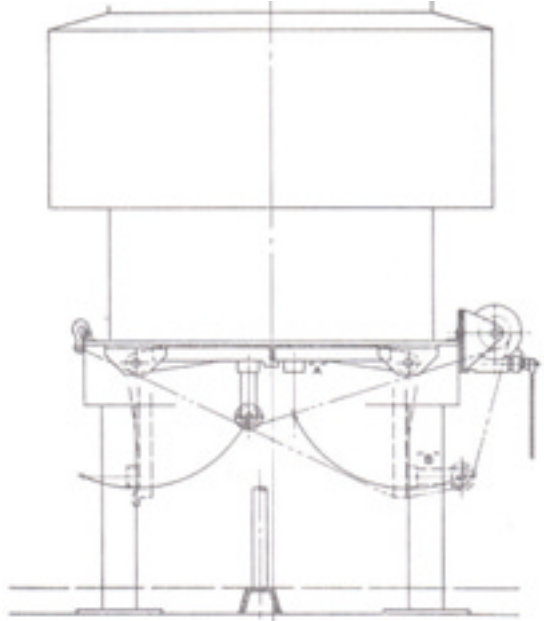


Fig. 8. Safety hoisting device for pulling up and tightly closing cupola bottom doors.

las is very desirable. For this purpose, Whiting has developed a simple hoisting rig. This device raises the doors mechanically without danger of slipping and can be operated with the attendant standing in the clear. Also, the job is speeded up, giving the attendant more time for other work. Substantial props can be furnished with the hoist, which permit screwing up the doors absolutely tight and with complete safety.

Air Weight Control

The advances made in cupola practice in the past decade have been accompanied by much closer attention to control of all factors involved. It is just as desirable to control the air supplied as to weigh the coke, iron, and flux. For this purpose we recommend automatic air weight control apparatus mentioned on page 6. On small jobs, a volume meter is desirable.

Blast Gate

Blast gates of any style and for any size of blast pipe are available.

Tilting Spouts

Cupolas can be provided with tilting spouts, to enable the operator to fill working ladles without wasting metal or stopping off the cupola.

Operator's Platform

For large cupolas and those with legs of unusual height, a platform is recommended from which the operator can open and close the tap-hole. Platforms are made of steel plate and structural shapes with handrail and steel stairway or ladder.

Cupola Drag

A cupola drag, as illustrated in Fig. 9, provides a very convenient means for removing the cupola drop. The drop should be removed from the cupola just after the bottom is dropped.

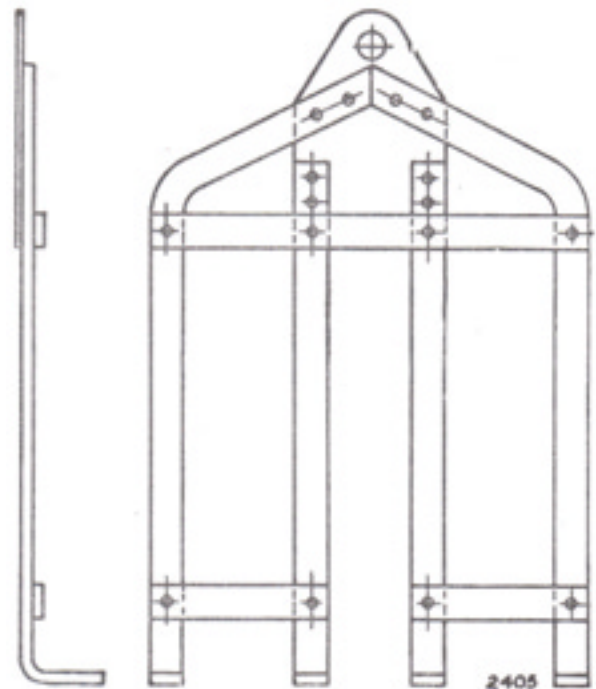


Fig. 9. Cupola drag for removing drop.

A set of cupola tender's tools can be furnished, if desired, at an additional price. Tools consist of one bott stick, to chisel bars, one brick hammer, one bottom door prop remover, and one tap out bar.

General Recommendations for Operating Whiting Cupolas

| Cupola Size | Shell Dia. | Minimum Thickness of Lower Lining* | Dia. Inside Lining | Area Inside Lining. Square Inches | Melting Rate † Tons per Hour With Iron/ Coke (After Bed) Ratios of | | | Bed Coke Height Above Tuyeres** Inches** | Coke & Iron Charges Lbs. | | | | Lime-stone Lbs. | CFM Air Thru Tuyeres | Suggested Blower Selection*** | |
|-------------|------------|------------------------------------|--------------------|-----------------------------------|--|-----|-----|--|--------------------------|------|------|------|-----------------|----------------------|-------------------------------|------|
| | | | | | 6 | 8 | 10 | | 12 | Coke | 6/1 | 8/1 | | | 10/1 | 12/1 |
| 0 | 27" | 4½" | 18" | 254 | ¾ | 1 | | 28-44 | 20 | 120 | 160 | | 4 | 570 | 640 | 8 |
| 1 | 32" | 4½" | 23" | 415 | 1 | 1½ | | 36-42 | 35 | 210 | 280 | | 7 | 940 | 1040 | 16 |
| 2 | 36" | 4½" | 27" | 572 | 1¾ | 2¼ | | 36-42 | 45 | 270 | 360 | | 9 | 1290 | 1430 | 20 |
| 2½ | 41" | 7" | 27" | 572 | 1¾ | 2¼ | 4 | 36-42 | 45 | 270 | 360 | | 9 | 1290 | 1430 | 20 |
| 3 | 46" | 7" | 32" | 804 | 2½ | 3¼ | | 40-46 | 65 | 390 | 520 | 650 | 13 | 1810 | 2000 | 24 |
| 3½ | 51" | 7" | 37" | 1075 | 3¼ | 4½ | 5¼ | 40-46 | 85 | 510 | 680 | 850 | 17 | 2420 | 2700 | 24 |
| 4 | 56" | 7" | 42" | 1385 | 4 | 5½ | 7 | 42-48 | 110 | 660 | 880 | 1110 | 22 | 3100 | 3450 | 24 |
| 5 | 63" | 9" | 45" | 1590 | 4¼ | 6¼ | 8 | 42-48 | 130 | 780 | 1040 | 1300 | 23 | 3600 | 4000 | 28 |
| 6 | 66" | 9" | 48" | 1809 | 5½ | 7¼ | 9 | 45-51 | 145 | 870 | 1160 | 1450 | 29 | 4100 | 4500 | 32 |
| 7 | 72" | 9" | 54" | 2290 | 7 | 9¼ | 11½ | 45-51 | 185 | 1100 | 1480 | 1850 | 37 | 5200 | 5750 | 32 |
| 8 | 78" | 9" | 60" | 2827 | 9 | 11¼ | 14 | 45-51 | 225 | 1350 | 1800 | 2250 | 45 | 6400 | 7100 | 32 |
| 9 | 84" | 9" | 66" | 3421 | 10½ | 13¾ | 17 | 45-51 | 275 | 1650 | 2200 | 2750 | 55 | 7700 | 8600 | 36 |
| 9½ | 90" | 9" | 72" | 4071 | 12¼ | 16¼ | 20½ | 47-53 | 325 | 1950 | 2600 | 3250 | 65 | 9200 | 10200 | 36 |
| 10 | 96" | 9" | 78" | 4778 | 15 | 19 | 23¾ | 47-53 | 385 | 2300 | 3080 | 3850 | 77 | 10700 | 11900 | 36 |
| 11 | 102" | 12" | 78" | 4778 | 15 | 19 | 23¾ | 47-53 | 385 | 2300 | 3850 | 3850 | 77 | 10700 | 11900 | 36 |
| 12 | 108" | 12" | 84" | 5542 | 17 | 22¼ | 27¾ | 47-53 | 445 | 2670 | 4450 | 4450 | 89 | 12500 | 13900 | 36 |

Notes:

* For long heats, use heavier linings.

** Height of bed coke varies as square root of blast pressure, see formula on page 10.

*** Additional pressure capacity may be required when auxiliary equipment is added to the blast system, or when piping is long or complicated.

† Under normal conditions metal temperature will decrease as iron to coke ratio increase. Select coke ratio on basis of your operational characteristics, i.e.: charging bucket, size and quality of coke and scrap, charging door height, etc.

- **Rail/Rapid Transit Maintenance Equipment** car progression and repair systems, turntables, washers, jacks
- **Chemical Process Equipment** including Swenson evaporators, crystallizers, dryers
- **Metallurgical Equipment** complete melt shop equipment from Electric arc furnaces to ladles
- **Material Handling** light to heavy duty cranes, roller, Belt and telescopic conveyors
- **Trackmobile®** bi-modal transport system providing an efficient and economical means of switching railcars within industrial plants and railroad terminals.

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