AIR POLLUTION
ENGINEERING MANUAL

SECOND EDITION

Compiled and Edited

by

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COUNTY OF LOS ANGELES

ENVIRONMENTAL PROTECTION AGENCY

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Office of Air Quality Planning and Standards

Research Triangle Park, N.C. 27711

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use of hoods or of excess air is not necessary to capture the emissions.

Air Pollution Control Equipment

As emphasized previously, when operated below 400°F and when fired with natural gas, most core ovens do not require air pollution control equipment. There have been, however, several cases where excessive emissions have been discharged and control equipment has been necessary.

Excessive emissions from core ovens have been reduced to tolerable amounts by modifying the composition of the core binders and lowering the baking temperatures. For instance, smoke of excessive opacity was discharging from an oven baking cores containing 3 percent fuel oil and 1.5 percent core oil at 500°F. The core binder was modified so that the cores contained 1.5 percent kerosene and 1.5 percent core oil, and the baking temperature was reduced to 400°F. After these modifications, no visible emissions were discharged from the oven.

When it is not feasible or possible to reduce excessive emissions from an oven by modifying the core mix or the baking temperature, afterburners are the only control devices that have proved effective. Since the quantity and concentration of the contaminants in the oven effluent are small, no precleaners or flashback devices are needed.

Afterburners that have been used for controlling the emissions from core ovens are predominantly of the direct-flame type. The burners are normally designed to be capable of reaching a temperature of at least 1,200°F under maximum load conditions. For most operations, 1,200°F completely controls all visible emissions and practically all odors.

The afterburner should be designed to have a maximum possible flame contact with the gases to be controlled and it should be of sufficient size to have a gas retention time of at least 0.3 second. Most authorities agree that the length-to-diameter ratio should be in the range of 1-1/2 to 4

In some instances, particularly on larger core ovens, catalytic afterburners have been used to control the emissions. With inlet temperatures of from 600° to 650°F all visible emissions and most of the odors were controlled. When catalytic afterburners are used, however, care must be taken to keep the catalyst in good condition; otherwise, partial oxidation can result in the discharge of combustion contaminants more objectionable than the oven effluent.

FOUNDRY SAND-HANDLING EQUIPMENT

A foundry sand-handling system consists of a device for separating the casting from the mold, and equipment for reconditioning the sand. The separating device is usually a mechanically vibrated grate called a shakeout. For small castings a manual shakeout may be used.

TYPES OF EQUIPMENT

The minimum equipment required for reconditioning the sand is a screen for removing oversize particles, and a mixer-muller where clay and water are combined with the sand to render it ready for remolding. In addition, equipment may be used to perform the following functions: Sand cooling, oversize crushing, fines removal, adherent coating removal, and conveying. A typical sand-handling system is shown in Figure 214.

Both flat-deck screens and revolving, cylindrical screens are used for coarse-particle removal. Revolving screens can be ventilated at such a rate as to remove excess fines.

Sand cooling can be accomplished in a number of ways, depending upon the cooling requirements. The amount of cooling required depends mainly upon the ratio of metal to sand in the molds and on the rate of re-use of the sand. With low metal-to-sand and re-use ratios, no specific sand-cooling equipment is required. When considerable cooling is required, a rotary drum-type cooler is usually used. A stream of air drawn through the cascading sand both cools and removes fines.

Oversize particles are hard agglomerates not broken up by the handling operations from the shakeout grate to the screen. Most of these are portions of baked cores. Many foundries discard the oversize particles, while others crush the agglomerates to recover the sand. A hammer- or screen-type mill is usually used for crushing.

Since molding sand is continuously reused, the grains become coated with a hard, adherent layer of clay and carbonaceous matter from the bonding materials used. In time the sand becomes unusable unless the coating is removed or a certain percentage of new sand is continuously added. Pneumatic reclamation is the method most widely used for coating removal. The sand is conveyed in a high-velocity airstream from a turbine-type blower and impinged on the inner surface of a conical target. Abrasion removes a portion of the coating material in each pass. The fines thus created are carried away in the airstream while the sand grains settle in an expansion chamber, as shown in Figure 215.

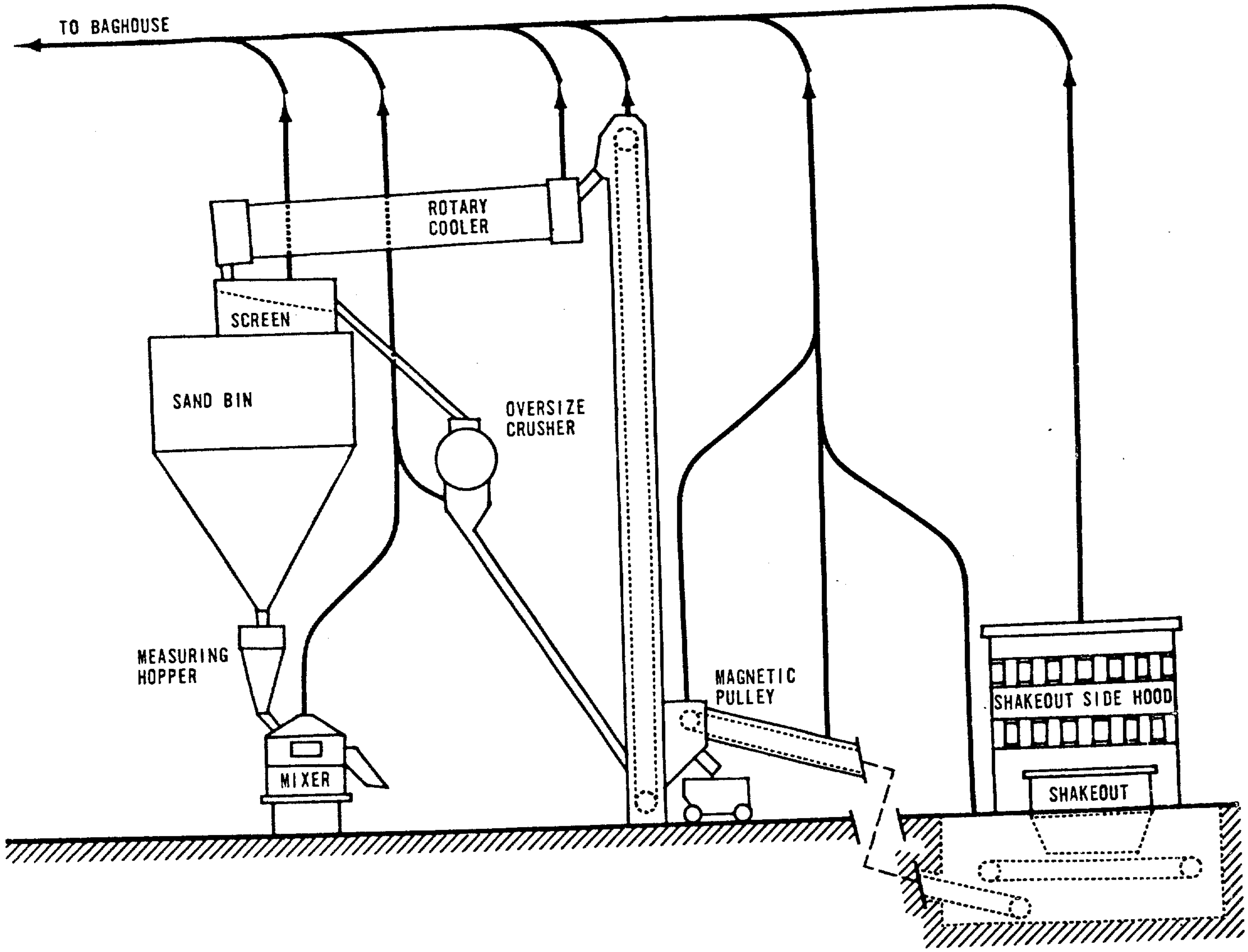


Figure 214. Typical foundry sand-handling system.

Foundry sand is usually conveyed by belt conveyors and bucket elevators, though pneumatic conveyors are used to some extent. Pneumatic conveying aids in cooling and fines removal.

The Air Pollution Problem

The air contaminants that may be emitted are dust from sand breakdown, and smoke and organic vapors from the decomposition of the core binders by the hot metal.

Among the factors that influence emission rates are size of casting, ratio of metal to sand, metal-pouring temperature, temperature of casting and sand at the shakeout, and handling methods. These factors have a great influence on the magnitude of the air pollution problem. For instance, a steel foundry making large castings, with a high metal-to-sand ratio requires a very efficient control system to prevent excessive emissions. A nonferrous foundry making small castings with a low metal-to-sand ratio, on the other hand, may not require any controls, since the bulk of the sand remains damp and emissions are negligible.

Hooding and Ventilation Requirements

The need for ventilation is determined by the same factors that influence emission rates. Minimum volumes of ventilation air required to ensure the adequate collection of the air contaminants are indicated in the discussion that follows on the various emission sources.

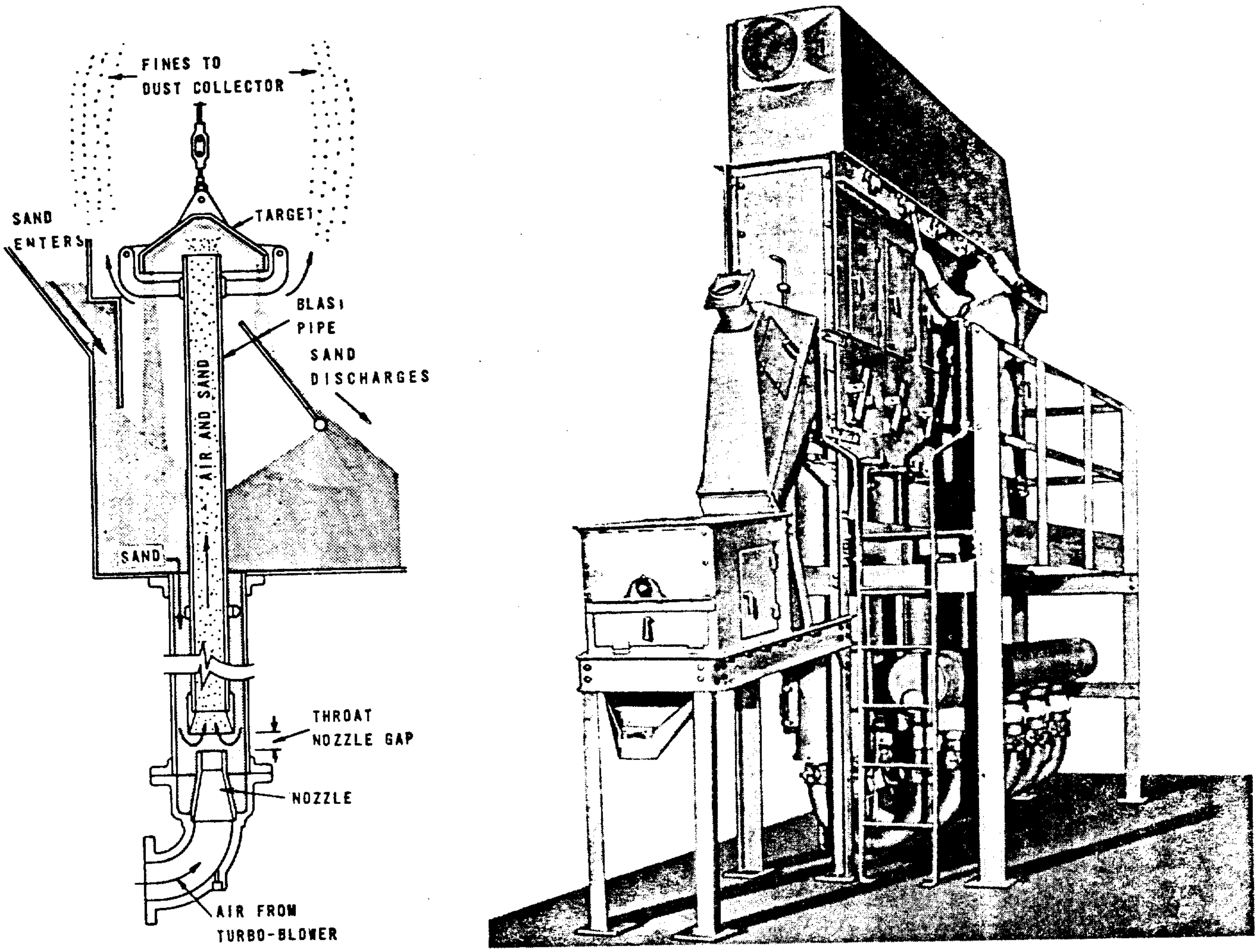


Figure 215. Pneumatic sand scrubber (National Engineering Co., Chicago, Ill.).

Shakeout grates

The amount of ventilation air required for a shakeout grate is determined largely by the type of hood or enclosure. The more nearly complete the enclosure, the less the required volume. When large flasks are handled by an overhead crane, an enclosing hood cannot be used, and a side or lateral hood is used instead. Recommended types of hood are shown in Figure 216 and Figure 217 (upper). Downdraft hoods are not recommended except for floor-dump type of operations where sand and castings are dropped from a roller conveyor to a gathering conveyor below the floor level (Manual of Exhaust Hood Designs, 1950). An excessive exhaust volume is required to achieve adequate control in a downdraft hood because the indraft velocity is working against the thermal bouyancy caused by the hot sand and casting. The indraft velocity is lowest where it is needed most--at the center of the grate. The exhaust volume requirements for the different types of hood are shown in Table 90. Shakeout hoppers should be exhausted with quantities of about 10 percent of the total exhaust volume listed in this table.

Other sand-handling equipment

Recommended ventilation volumes and hooding procedure for bucket elevators and belt conveyors are given in Figure 218; for sand screens, in Figure 219; and for mixer-mullers, in Figure 220. The ventilation requirement for rotary coolers is 400 cfm per square foot of open area. For crushers the requirement varies from 500 to 1,000 cfm per square foot of enclosure opening.

Air Pollution Control Equipment

The most important contaminant to be collected is dust, though smoke is sometimes intense enough to constitute a problem. Organic vapors and gases are usually not emitted in sufficient quantities to be bothersome. The collectors usually used are baghouses and scrubbers.

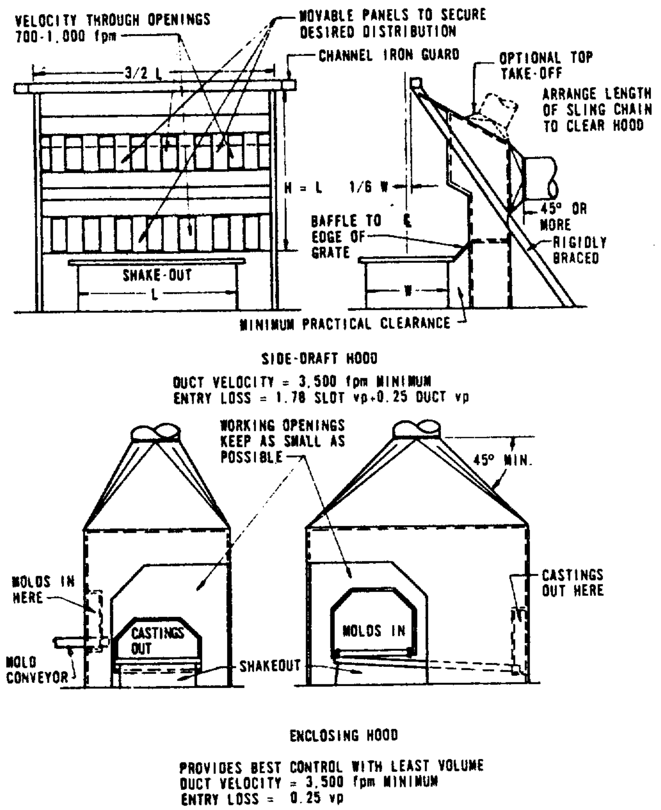


Figure 216. Foundry shakeout (Committee on Industrial Ventilation, 1960).

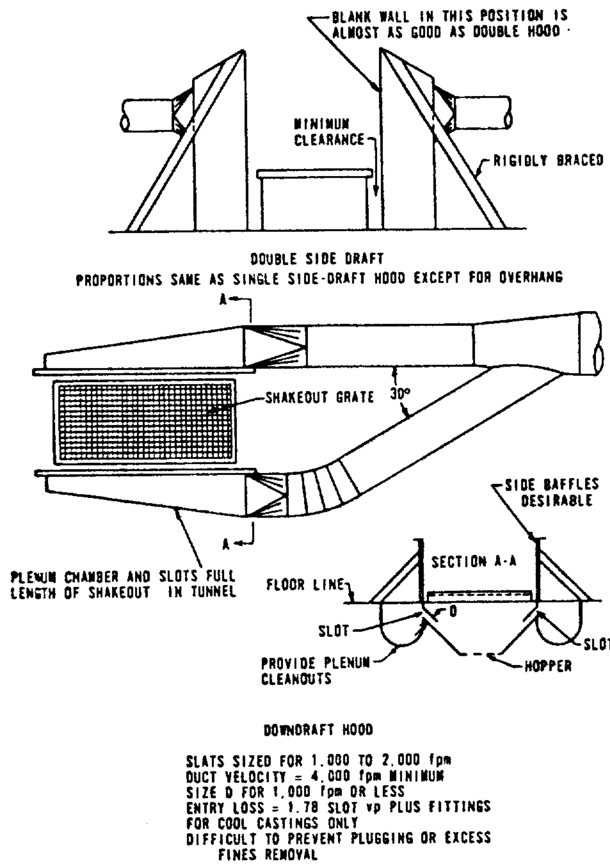
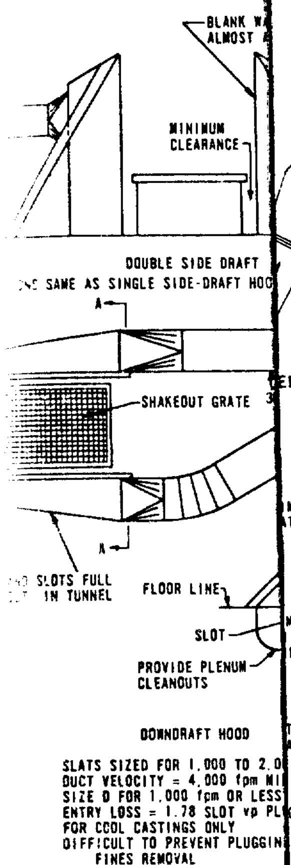


Figure 217. Foundry shakeout (Committee on Industrial Ventilation, 1960).

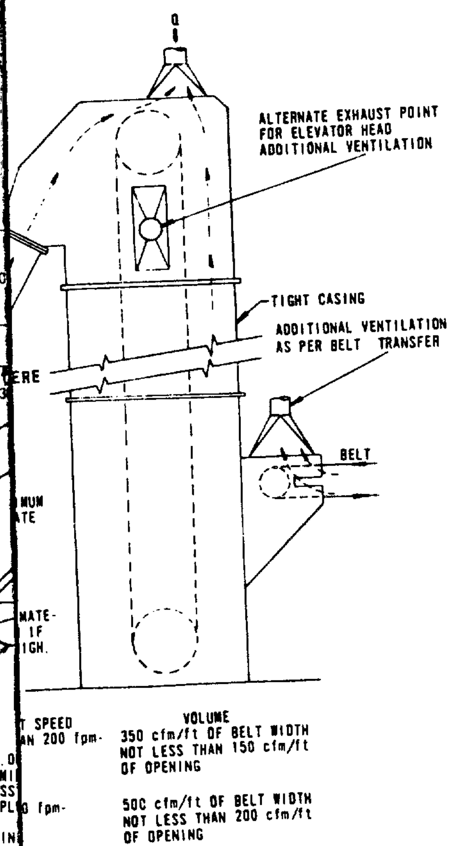
Table 90. EXHAUST VOLUME REQUIREMENTS FOR DIFFERENT TYPES OF HOOD VENTILATING SHAKEOUT GRATES

Type of hood	Exhaust requirement[a]	
	Hot castings	Cool castings
Enclosing	200 cfm/ft^2 of opening. At least 200 cfm/ft^2 of grate area	200 cfm/ft^2 of opening. At least 150 cfm/ft^2 of grate area
Enclosed two sides and 1/3 of top area	300 cfm/ft^2 of grate area	275 cfm/ft^2 of grate area
Side hood (as shown or equivalent)	400 to 500 cfm/ft^2 of grate area	350 to 400 cfm/ft^2 of grate area
Double side hood	400 cfm/ft^2 of grate area	300 cfm/ft^2 of grate area
Downdraft	600 cfm/ft^2 of grate area Not recommended	200 to 250 cfm/ft^2 of grate area

[a]Choose higher values when (1) castings are very hot, (2) sand-to-metal ratio is low, (3) crossdrafts are high.



. Foundry shakeout (C
ntilation, 1960).



ket elevator ventilation (Com-
strial Ventilation, 1960).

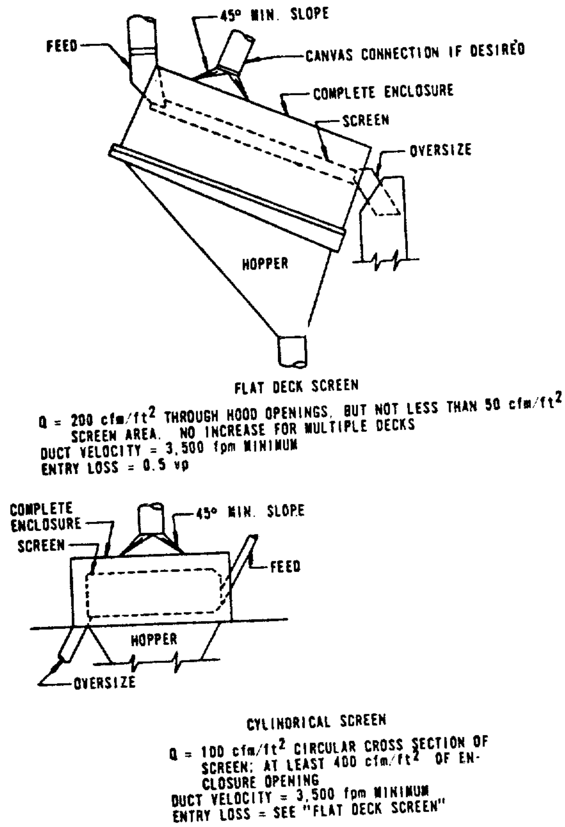
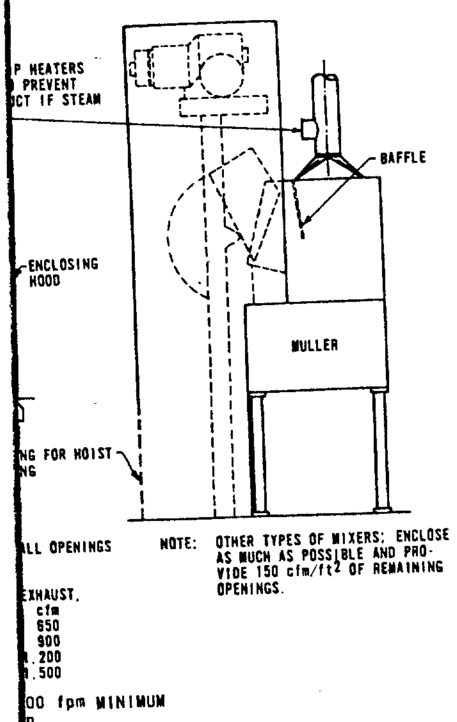


Figure 219. Screens (Committee on Industrial Ventilation, 1960).



xer and muller hood (Committee on
tilation, 1960)

ENTS FOR

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ement[a]
Cool castings
00 cfm/ft² of opening. At least 150 cfm/ft² of grate area
75 cfm/ft² of grate area
50 to 400 cfm/ft² of grate area
00 cfm/ft² of grate area
00 to 250 cfm/ft² of grate area

hot, (2) sand-to-

A baghouse in good condition collects all the dust and most of the smoke. A scrubber of moderately good efficiency collects the bulk of the dust, but the very fine dust and the smoke are not collected and in many cases leave a distinctly visible plume, sufficient to violate some control regulations. A baghouse, therefore, is the preferred collector when the maximum control measures are desired.

When only the shakeout is vented to a separate collector, there may be sufficient moisture in the gases in some cases to cause condensation and consequent blinding of the bags in a baghouse. When, however, all the equipment in a sand-handling system is served by a single exhaust system, ample ambient air is drawn into the sys-tem to preclude any moisture problem in the baghouse. The filtering velocity for this type of service should not exceed 3 fpm. Cotton sateen cloth is adequate for this service. A noncompartmented-type baghouse is adequate for most job shop foundries. For continuous-production foundries, a compartmented baghouse with automatic bag-shaking mechanisms gives the most trouble-free performance.

HEAT TREATING SYSTEMS

Heat treating involves the carefully controlled heating and cooling of solid metals and alloys for effecting certain desired changes in their physical properties. At elevated temperatures, various phase changes such as grain growth, recrystallization, and diffusion or migration of atoms take place in solid metals and alloys. If sufficient time is allowed at the elevated temperature, the process goes on until equilibrium is reached and some stable form of the metal or alloy is obtained. If, however, because of sudden and abrupt cooling, time is not sufficient to achieve equilibrium at the elevated temperature, then some intermediate or metastable form of the metal or alloys is obtained. The tendency to assume a stable form is always present and metals and alloys in a metastable form can be made to approach their stable form as closely as desired simply by reheating. The widely differing properties that can be imparted to solid metals and alloys in their stable and metastable forms give purpose to the whole process of heat treating.

In general, the methods used to heat treat both ferrous and nonferrous metals are fundamentally similar. These methods include hardening, quenching, annealing, tempering, normalizing ferrous metals, and refining grain of nonferrous metals. Also included in the category of heat treating are the various methods of case hardening steels by carburizing, cyaniding, nitriding, flame hardening, induction hardening, carbonitriding, siliconizing, and so forth.

HEAT TREATING EQUIPMENT

Furnaces or ovens, atmosphere generators, and quench tanks or spray tanks are representative of the equipment used for heat treating.

Furnaces for heat treating are of all sizes and shapes depending upon the temperature needed and upon the dimensions and the number of pieces to be treated. A furnace may be designed to operate continuously or batchwise. The controls may be either automatic or manual. These furnaces are known by descriptive names such as box, oven, pit, pot, rotary, tunnel, muffle, and others. Regardless of the name, they all have the following features in common: A steel outer shell, a refractory lining, a combustion or heating system, and a heavy door (either cast iron or reinforced steel with refractory lining) that may be opened from the top, the front, or from both the front and the back.

Atmosphere generators are used to supply a controlled environment inside the heat treating chamber of the furnace. The atmosphere needed may be either oxidizing, reducing, or neutral depending upon the particular metal or alloy undergoing heat treatment and upon the final physical properties desired in the metal or alloy after treatment. An atmosphere can be provided that will protect the surface of the metal during heat treatment so that subsequent cleaning and buffing of the part is minimized, or one can be provided that will cause the surface of the metal to be alloyed by diffusion with certain selected elements in order to alter the physical properties of the metal.

Quench tanks may be as simple as a tub of water or as elaborate as a well-engineered vessel equipped with properly designed means to circulate the quenching fluid and maintain the fluid at the correct temperature. The part to be quenched is either immersed into the fluid or is subjected to a spray that is dashed against the part so that no air or steam bubbles can remain attached to the hot metal and thereby cause soft spots. The fluid used for quenching may be water, oil, molten salt, liquid air, brine solution, and so forth. The purpose of quenching is to retain some metastable form of an alloy (pure metals are not affected by quenching) by rapidly cooling the alloy to some temperature below the transformation temperature.

The Air Pollution Problem

The heat treating process is currently regarded as only a minor source of air pollution. Nonetheless, air pollutants that may be emitted from heat treating operations, and their origin, are as follows:

1. Smoke and products of incomplete combustion arising from the improper operation of a gas- or oil-fired combustion system;

2. vapors and fumes emanating from the volatilization of organic material on the metal parts being heat treated;

3. oil mists and fumes issuing from oil quenching baths (if water-soluble oils are used, the fumes will be a combination of steam and oil mist);

4. salt fumes emitted from molten salt pot furnaces;

5. gases, produced by atmosphere generators, used in the heat treating chamber of muffle furnaces. (Insignificant amounts occasionally leak out from some furnace openings that cannot be sealed, but somewhat larger amounts get into the surrounding air during purging and also during loading and unloading operations.)

Hooding and Ventilation Requirements

Hooding and ventilation systems designed for heat treating processes should be based on the rate at which the hot, contaminated air is delivered to the receiving face of the exhaust hood. To prevent the hot, contaminated air from spilling out around the edges of the exhaust hood, the rate at which the exhaust system draws in air must in all cases exceed the rate at which the hot, contaminated air is delivered to the exhaust system.

In the general case, a canopy hood mounted about 3 or 4 feet above a hot body has an excellent chance of capturing all the hot, contaminated air rising by convection from the hot body. The face area of a canopy hood such as this should be slightly larger than the maximum cross-sectional area of the hot body. In order to avoid the need for excessive exhaust capacity, it is advisable not to oversize the canopy hood face area.

If a canopy hood is mounted too high above the hot body, the column of hot, contaminated air is influenced by turbulence, and the column becomes more and more dilute by mixing with the surrounding air. Consequently the exhaust capacity must be sufficient to handle this entire volume of diluted, contaminated air. This is an inefficient way to collect hot, contaminated air.

Many variations of canopy hoods are used because of the many types of heat treating furnaces employed. Lateral-type hoods are also used. General features of design of hoods for these hot processes are discussed in Chapter 3.

Air Pollution Control Equipment

The following methods effectively prevent and control emissions resulting from heat treating operations.

1. Proper selection of furnace burners and fuels along with observance of correct operating procedures will eliminate smoke and products of incomplete combustion as a source of air pollution. (See Chapter 9.)

2. Removal of organic material adhering to metal parts to be heat treated by either steam cleaning or solvent degreasing before heat treating will eliminate this source of air pollution.

3. Mists and fumes issuing from oil quenching baths can be greatly reduced by selecting appropriate oils and by adequate cooling of the oil.

4. Baghouses are a satisfactory method of controlling salt fumes from molten salt pots. Particle sizes of fumes are usually between 0.2 and 2 microns but may vary from this range depending upon local factors such as temperature, humidity, turbulence, and agglomeration tendencies of the effluent. The fumes are slightly hygroscopic and corrosive; therefore, operation of the baghouse must be continuous to prevent blinding and deterioration of the bag cloth and corrosion of the metal structure. Acrylic-treated orlon is a satisfactory bag cloth because of its chemical and thermal resistance and its general physical stability. Filtering velocities should not be greater than 3 fpm. With these design features, collection efficiencies exceeding 95 percent are normally achieved.

5. Flame curtains placed at the open ends of continuous heat treating furnaces are effective in the control of any escaping, combustible gases used for controlling the atmosphere inside the furnace.