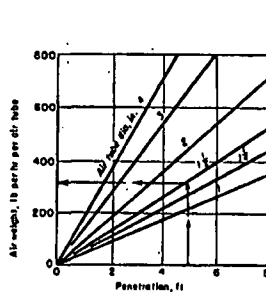
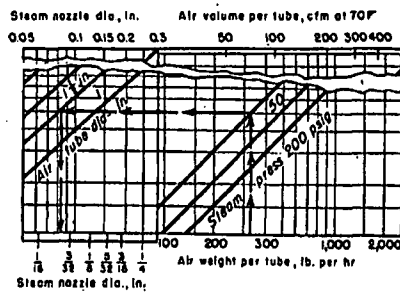


STEAM JETS: Simplified, Step-by-Step Procedure for Selection



6 Air injected per tube per hr with steam jets can be found from above



7 Proper size of steam nozzle required comes from applying known air weight per tube, steam pressure and tube size

III: Pounds of Overfire Air Needed per Pound Coal Burned for Different Smoke Densities

Heating value of coal, Btu per lb.	Light	Density of smoke	Heavy
10,000	.15	1.5	2.25
11,000	.12	1.65	2.47
12,000	.10	1.80	2.70
13,000	.08	1.95	2.92
14,000	.05	2.10	3.15

IV: Performance of Steam-Air Jet Consisting of 1-in. Air Tube Equipped With 1/4-in. Dia. Steam Nozzle

Pressure of steam supplied to steam nozzle, psi	Length of penetration of jet stream, ft.	Pounds of air injected into furnace per hr
15	3	125
25	4	160
40	5	210
55	6	250
70	7	290
85	8	325

between fan discharge and air tubes to hold velocity down to about 2000 fpm under a pressure of 13 in. water. The formula is maximum output of fan in cfm at 70 F (746) $\times .072$ and it equals 53.7 sq in.; the required cross-sectional area.

An 8-in. dia duct has a cross-sectional area of 50.3 sq in. and a 9-in. duct has 63.6-sq-in. area. The first results in a top air velocity of 2137 fpm, and the second 1695 fpm. Either is satisfactory.

Air tube and header duct may be constructed of standard pipe and fittings with no sharp bends or abrupt changes in cross-sectional area. Fig. 5 shows a suggested assembly.

Steam-Air Jets. So much for the blower type; now for the steam-air jets. Here we'll use a furnace 5 ft long with a grate 5 ft wide. We'll have coal of 13,500 Btu per lb, maximum coal burned per hr, 875 lb; smoke density, heavy; jets in the sidewall, and available steam pressure 50 psig.

Our first four factors, Table V, are (1) maximum burning rate per sq ft per hr—875 lb coal per hr $\div$ 25 sq ft grate area, 35 lb (2) overfire air re-

quired—from guide, p. 79,—30% (3) length of penetration—5 ft (4) heating value of coal—13,500 Btu per lb.

Air-tube diameter comes from Fig. 2, dotted line, and is 1.5 in. Tube spacing shows on Table I, but this table applies only to the nearest inch. If air-tube dia from Fig. 2 shows less than one in., use the alternate procedure to be discussed later. Our example with a 5-ft penetration length and 1.5-in. tube dia falls between 6 and 8 in., or 7 in.

Number of air tubes is arrived at just the same as above and it proves to be 8:

$$5 \text{ ft} \times 12 \text{ in. per ft} \div 7 \text{ in. tube spacing} = 7.57$$

With sidewall location, put end jets in about one-jet spacing, 7 in. from the inside faces of front and bridgewalls; then space remaining six at equal distances between them. An alternate possibility if both sidewalls are accessible is to locate 4 jets in each wall and stagger them with the opposite side.

Fig. 6 employs penetration length

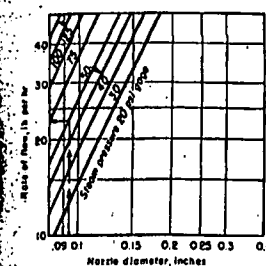
and air-tube size to determine weight injected in the furnace per tube per hr—approximately 325 lb.

Fig. 7 provides the guide for proper steam-nozzle size. Using the various figures for the example at hand, the chart calls for a steam nozzle slightly less than 1/4 in. dia. Recommended choice is a 1/4-in. dia nozzle to avoid plugging, which may occur with smaller-sized nozzles.

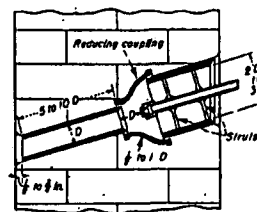
Steam consumption can be estimated with the aid of Fig. 8. As an example, consider the 1/4-in. (.094 in.) nozzle above. They use 50-psi steam and assume 25 lb per hr per nozzle. Eight jets amounts to 184 lb per hr of steam if jets operate continuously. With a coal-burning rate of 875 lb per hr, the example given generates a total of 7500 lb per hr of steam. This means jets consume 2.5% of total output; they operate all the time. If the work only 30% of the time they are only 0.75% of boiler output.

Alternate Procedure. Where Fig. 7 calls for an air-tube diameter of less than one inch a different procedure applies. Use only 1-in. dia tubes

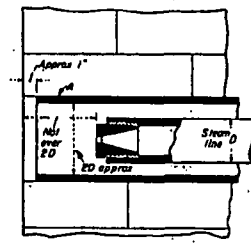
and Sizing to Get Effective Overfire Action in Stoker Furnaces



8 Effect of different steam pressures on flow through nozzles shows here



9 Where air-tube length runs less than wall thickness, follow this method



10 For turbulence alone steam-jet arrangement shown is recommended

V: To Choose Steam-Air Jets Properly

- Estimate maximum burning rate per sq ft of grate area per hr.
- Estimate the percentage of overfire air required.
- Estimate length of penetration needed.
- Determine heating value of coal burned.
- Determine air-tube diameter required.
- Determine air-tube spacing required.
- Calculate number of air tubes required.
- Calculate weight of air per tube.

- Determine the steam-nozzle diameter.
- Make air-tube length between 5 and 10 times its diameter.
- Keep nozzle centered and aligned with axis of air-tube dia back of throat.
- Arrange for air to flow into air tube as smoothly and gradually as possible.
- Design silencers.
- Don't allow any jet to impinge on the furnace walls or burning coal.

with 1/4-in. dia steam nozzles, Table IV. Let's set up an example: Take a stoker-fired hrt boiler with a grate 5 ft long by 3 ft, 6 in. wide and a furnace height of 3 ft burning 350 lb of 13,000 Btu coal per hr at maximum rating and giving off a moderate smoke. Available steam pressure is 50 psig.

Calculate total weight of overfire air required per hr by multiplying (1) maximum coal burned per hr (350) by (2) lb of overfire air required per lb of coal burned, from Table III (1.95) and we find 683 lb of overfire air required per hr.

Next, determine weight of air injected in the furnace per tube per hr if tubes are placed in the sidewall to give a 3-ft, 6-in. length of penetration, and steam supplied to the nozzle is at 20 psig. For a one-in. tube, air injected in the furnace from Table IV by interpolation will be 143 lb per hr per tube. It may be well to say at this point that available steam pressure is higher than the nozzle requires, a reducing valve must be used to supply the lower pressure.

Here, total number of air tubes required is determined by dividing total weight of overfire air (above) by weight of air injected per tube per hr, or 683 $\div$ 143 gives 5 tubes. If all five tubes go in on one side they should be equally spaced with end tubes at least 6 in. from the adjacent end walls. The five tubes could be put in both walls, 3 on one side, two on the other, end staggered with the opposite side tubes.

Construction Details. Fig. 9 shows the important features of construction of a steam-air jet. Air tube can be made of standard pipe. The smooth, rounded or funnel-shaped approach to the air tube can be formed of plastic refractory or a pipe coupling, reducing from at least two sizes larger than the air tube down to air-tube size.

The steam nozzle may be made from a standard pipe cap or plug. A drilled hole forms the nozzle bore and should be countersunk to provide smooth flow into the nozzle. Alloy cast iron or heat-treated high-chromium, medium- or high-carbon steel makes a nozzle material that resists erosion and gives long life under this service.

Proper control and operation depends upon building into the system valves and steam gages. They provide a ready means of holding steam pressure to the desired point and shutting off jets when not needed. Hand-controlled purging valves or traps remove moisture from the lines.

Unmuffed steam jets give off a disturbing noise. There are several designs of mufflers both concentric and suspended that have been worked up to reduce this nuisance. In our next article, in an early issue, on the application of overfire jets to particular designs of furnaces and stokers we will illustrate some of these muffler arrangements.

Where only turbulence fits the bill, steam nozzles may discharge directly into the firebox instead of into the throat of the air tube. And here's how that is accomplished.

Ordinarily the steam nozzle discharges directly into the firebox instead of the throat of an air tube. It gives nearly as much penetration without an air tube as with it.

But it is not practicable to install jets with air tubes and then stop the air inlet if it is found later that air is unnecessary. A vacuum forms in the air tube and penetration becomes almost nil. In a case like this extend the steam line through the air tube so the nozzle discharges near the air-tube outlet. Whatever small amounts of air flow through the air tube, under natural draft, keep the steam nozzle cool when not in use. Fig. 10 shows just such a nozzle assembly.

Our next article discusses the recommended application points for various stoker arrangements.