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Notes From The Editor

Thanks to the contribution authored by Bob Hunt, many of us will benefit from the following article, entitled "Gas Burner Design".

GAS BURNER DESIGN By Bob Hunt

Burner Size

A box style burner that covers most of the grate area and is $\frac{1}{2}$ to $\frac{3}{4}$ inch deep works well in a locomotive boiler. A reasonably deep burner head helps to maintain an even static pressure which keeps individual flames the same height. The secondary air tubes are $\frac{1}{4}$ to $\frac{3}{8}$ inch o.d. tubing and are surrounded by a circular pattern of holes (ports) to anchor the flame. These tubes are swaged, silver soldered or welded to the upper and lower burner plates. The thickness of the metal in the upper burner plate is usually about the same as the port hole diameter, but thinner metal is often used with only minor loss in burner performance. It's best to drill secondary air holes and ports before assembling the burner head to allow the holes to be properly deburred. The flame will be self piloting if the port holes are spaced $\frac{1}{16}$ inch apart (edge to edge). This helps to control flame lift off and allows the burner to achieve greater gas flows (more BTU's). Any burner over 50,000 BTU/hr should probably use $\frac{3}{8}$ in. secondary air tubes with about $\frac{3}{16}$ space between the outside of the burner and the firebox to make sure the burner receives enough secondary air. The attached diagram shows a top view of a typical burner with the gas-air mixture entering from the bottom.

Total Port Area

The total number of holes are multiplied by the single hole area to determine total port area (see attached table for drill hole area). In our example burner, we lay out the hole pattern and arrive at 312 holes. If we drill a 0.062 hole (area 0.00307 sq. in.) we get a total port area of $312 \times 0.00307 = 0.958$ sq. in. This is a very useful number which allows us to determine other burner dimensions.

Burner Heat Output

Good propane burning occurs in the range of 18,000 to 40,000 BTU/hr per sq. in. of port area. In our example, 0.958 sq. in. of port area gives a burner with $0.958 \times 40,000 = 38,300$ BTU/hr max. rating. Propane is 21,660 BTU/lb so this burner will use $38,300 / 21,660 = 1.8$ lbs per hour. From IMLEC coal firing information in Model Engineer, 1 in. scale locos need from 70,000 to 100,000 BTU/ hr. depending on the locomotive size. This would require from $70,000 / 40,000 = 1.75$ sq. in. to $100,000 / 40,000 = 2.5$ sq. in. of burner port area. Since your own burner BTU requirements may not be easy to assess, my advice would be to put as many holes as you can fit into your burner head and calculate the total port area with a hole size in the range of 0.040 to 0.062. Maximum hole size is about 0.116 in. A more stable flame for a given port area is achieved with smaller holes, (i.e. 200 small holes is better than 100 large ones). Once you have a total port area and BTU/hr rating you can proceed to finalize the burner design as follows:

Venturi Throat Diameter – (see burner body diagram)

Venturi throat area = 0.2 to 0.3 x total port area: in our example $0.3 \times 0.958 = 0.3$ sq. in.

Venturi diameter = $2 \times \text{sqrt.}(\text{area}/3.1417)$: in our example $2 \times \text{sqrt.}(0.3/3.1417) = 0.62$ in. This is not a critical number. Factors ranging from 0.3 to 0.6 result in only 5% deviation from maximum air injection.

Venturi Length

The tapered section after the throat has an included angle of 4 degrees and is quite critical for good air entrainment. The length of this tapered section plus the straight mixing tube should be about 6 x venturi throat diameter (not critical) : in our example $6 \times 0.62 = 3.7$ in. minimum. Mixing tube diameter should be the closest standard tube size that has a cross sectional area similar to the total port area. Theoretically, the mixing tube cross sectional area should be slightly larger than the port area to cause a slight restriction in flow and produce a positive static pressure in the burner head. This only becomes important as the burner is operated at its lowest gas-air flow. Flashback occurs only when the flow of gas through the ports is slower than the flame burning speed.

Air Shutter Area (Primary Air Inlet)

Properly designed gas jet burners are capable of injecting the required primary air with quite small primary air openings. For example, in “Propane Firing of Miniature Locomotives” by Dave Giles the recommended opening is only 0.21 x the total port area. The best suggestion here is to drill primary air holes about 0.3 x total port area and test the burner. The shutter should be adjusted for a blue flame on medium gas pressure. The gas should then be able to be turned down or turned up to maximum burner capacity without having to readjust the shutter. If yellow tipped flames occur at maximum shutter opening, the primary air holes should be enlarged.

5. Orifice Dimension

From the above discussion our example burner rating is 38,300 Btu/hr.

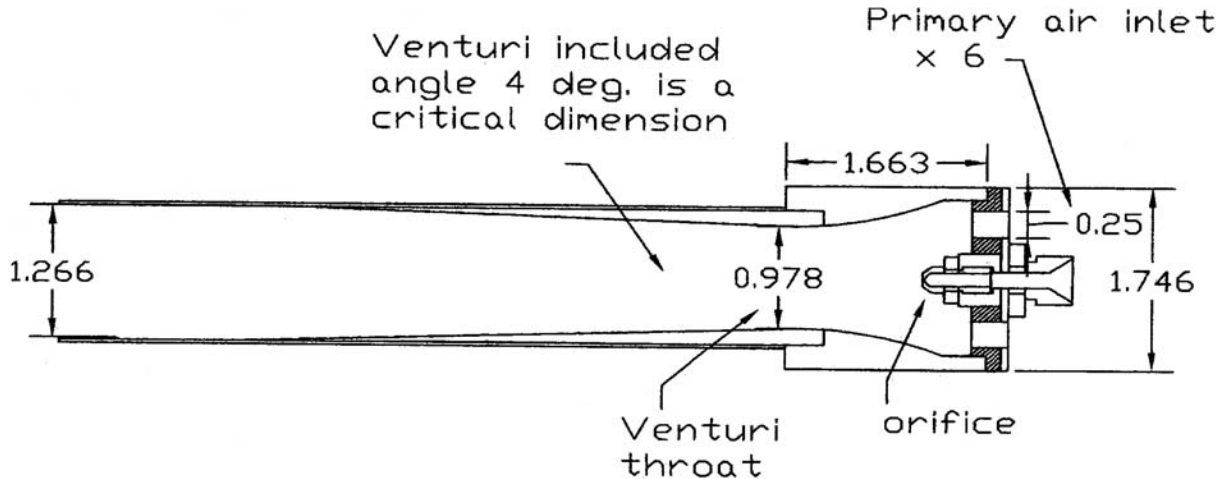
Propane has 2500 Btu/cu. ft.

Our burner will need $38,300/2500 = 15$ cu. ft. per hour

From the table @ 20 psi propane we read off an orifice drill size of #70.

If you want to use less propane pressure, say 10 psi, a larger orifice #66 would be used.

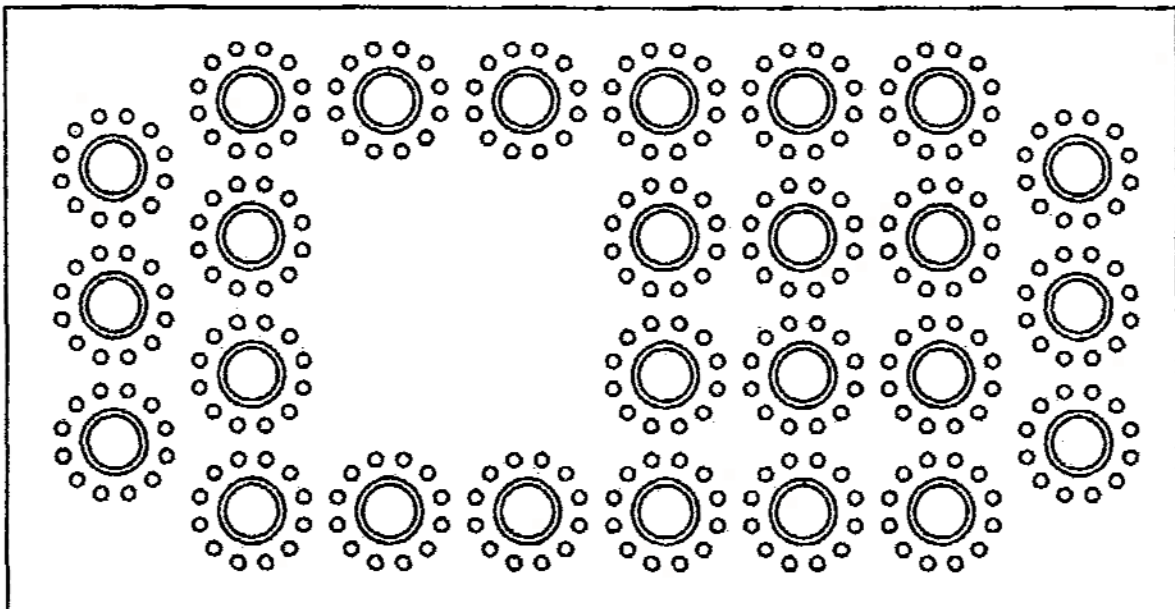
6. Orifice Position



Location of the orifice hole should be from 0.7 to 1.4 inches behind the venturi throat. The approach to the venturi throat is usually curved at about a 3 to 4 in radius. This can be approximated with a series of angle cuts or by hand turning with a round nosed wood turning chisel. The burner shown uses an aluminum venturi.

Most of this information was obtained from *The Gas Engineers Handbook*.

Top view of a plate burner with $12 \times 26 = 312$ holes



Thanks for this information, Bob.

From Granny's Kitchen

How to tell if it's brass or bronze. Bronze is richer, more golden in colour than brass which is usually a yellow colour. If there is any doubt in your mind, try an easy test. Using the smallest drill bit that you have, drill a small hole in an unimportant area of the material and look at the metal turnings that come out. If they are long and stringy, the fittings are probably bronze. If the turnings are small (like snow flakes), then the metal is probably brass and even more probably a leaded brass.