MISSISSIPPI STATE UNIVERSITY EXTENSION

Varying Manifold Gas Pressure and Its Effects on Radiant Brooder Performance

Gas pressure in lines that supply poultry houses is reduced at two or three different places, depending on the type of fuel supplied to the house. For houses that use propane, the first-stage regulator is located on the tank, the second-stage regulator is usually outside of the house and close to the middle of the brood area, and the third-stage regulator is in the gas control valve on the brooder. Houses that use natural gas will usually have only the second- and third-stage regulators. Regulators on brooders control brooder manifold pressure, or the pressure of the gas just before it is burned.

This publication presents data on the effects of varying manifold pressure on radiant brooder combustion efficiency, gas consumption, heat input, and total radiant power. Data presented here are for five new radiant brooders tested with natural gas in a controlled environment (Table 1). The low-pressure brooders were tested at rated manifold pressure, 1-inch water column (" WC) below rated (low), and 1" WC above rated (high). The high-pressure brooders were tested at rated manifold pressure, 1 psi below rated (low), and 1 psi above rated (high).

Table 1. Rated power and supply pressure requirements for each of the round radiant brooders tested.

Brooder abbrev.	Brand	Model	Rated power (Btu/h)	Rated manifold pressure	Low/High pressure
CT	Chore Time	Ultra-Ray	40,000	7" WC	low
SR	Space Ray	SRB40 EZ	40,000	4" WC	low
HH	Hired Hand	Super Glo	40,000	5" WC	low
LBHP	L.B. White	Infraconic I-40	40,000	5 psi (138.5" WC)	high
CTHP	Chore Time	Ultra-Ray HP	40,000	5 psi (138.5" WC)	high

Combustion Efficiency

Combustion occurs when fossil fuels, such as natural gas, propane, coal, or gasoline, are burned in the presence of oxygen. Fossil fuels are primarily comprised of carbon and hydrogen and, when burned, produce byproducts such as carbon dioxide (CO_2), water, carbon monoxide (CO), sulfur dioxide (SO_2), nitrous oxides (NO_x), and particulate matter (PM).

Net combustion efficiency is expressed as a percent of energy in fuel that is converted into usable heat:

$$\%\ net\ combustion\ efficiency = 100\% - \left(\frac{dry\ gas\ and\ latent\ heat\ losses/lb\ fuel}{fuel\ heating\ value/lb\ fuel} \times 100\right)$$

Energy in the fuel that is not converted into usable heat is usually referred to as heat loss. Primary heat loss during brooder operation is via heated dry exhaust gases and water vapor. Dry exhaust gases, such as carbon dioxide, oxygen (O_2), and nitrogen (N_2), are heated during the combustion process. Energy in the fuel is used to heat these gases and is not converted into useful radiant heat. Water is also formed during the combustion process, and heat in the fuel is used to change the liquid water to water vapor. This heat (also called latent heat) is usually not recovered and is considered a loss in combustion efficiency. Gross combustion efficiency accounts for dry gas losses only and is, therefore, generally higher than net combustion efficiency:

$$\%\ gross\ combustion\ efficiency = 100\% - \left(\frac{dry\ gas\ losses/lb\ fuel}{fuel\ heating\ value/lb\ fuel} \times 100\right)$$

Figures 1 and 2 show the effect of varying manifold pressure on the gross and net combustion efficiency of the brooders tested. Gross combustion efficiencies for all brooders at rated manifold pressure were greater than 94 percent. For the low-pressure brooders, mean net efficiency at rated operating pressure was 84.3 ± 0.8 percent. For high-pressure brooders, mean net efficiency at rated operating pressure was 88.8 ± 3.3 percent.

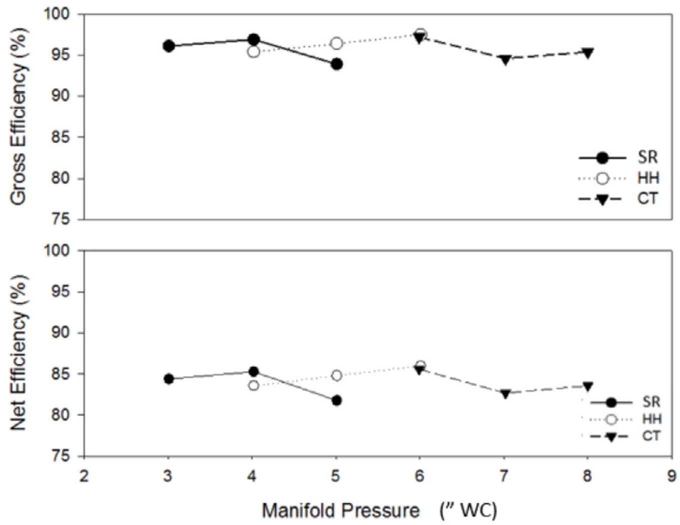

Figure 1 data

Brooder Type	Manifold Pressure (in H_2O)	Gross Efficiency (%)	Net Efficiency (%)
SR	3	96.1	84.1
SR	5	97	85.2
SR	5	93.8	81.7
HH	4	95.5	83.4
HH	5	96.6	84.8
HH	6	97.4	85.9
CT	6	97.2	84.4
CT	7	94.6	82.5
CT	8	95.5	84.3

Figure 1. Effect of varying manifold pressure on gross and net combustion efficiency of low-pressure radiant brooders. The central point in each line graph represents the rated manifold pressure for the respective brooder.

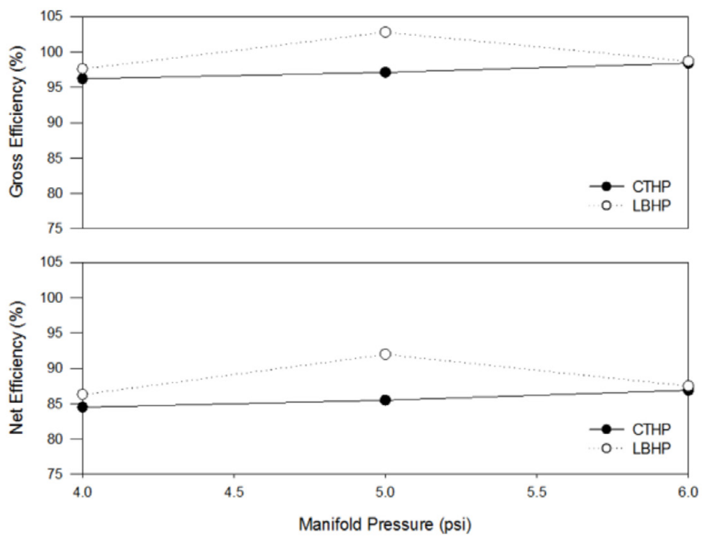

Figure 2 data

Brooder Type	Manifold Pressure (psi)	Gross Efficiency (%)	Net Efficiency (%)
CT	4	96.5	84.1
CT	5	98	85
CT	6	97.4	86.4
LB	4	98.5	86.8
LB	5	103.8	92.5
LB	6	97.5	87.6

Figure 2. Effect of varying manifold pressure on gross and net combustion efficiency of high-pressure radiant brooders. The middle point in each line graph represents the rated manifold pressure for the respective brooder.

Gas Consumption and Heat Input

Figure 3 shows the effect of varying manifold pressure on brooder gas consumption and heat input.

Heat input is the product of gas consumption (ft^3/hr) and heating value of the gas (Btu/ft^3) and is a measure of the total amount of energy available to the brooder from the gas. The heating value of the commercial supply gas used for the low-pressure brooders was 990 Btu/ft^3. The tank gas used to supply the high-pressure brooders had a heating value of 1,011 Btu/ft^3.

Mean gas consumption at rated operating pressure was 34.0 ± 3.9 ft^3/hr for the low-pressure brooders and 36.8 ± 1.2 ft^3/hr for the high-pressure brooders. For the low-pressure brooders, mean gas consumption increased 11 percent above rated at the high manifold pressure settings and decreased 11 percent below rated at the low settings. Mean gas consumption for the high-pressure brooders increased 5 percent above rated at the high-pressure settings and decreased 7 percent below rated at the low settings. Gas consumption increased with increasing manifold pressure for all the brooders tested.

Mean heat input at rated manifold operating pressure was 33,600 ± 3,834 Btu/hr for the low-pressure brooders and 37,232 ± 1,244 Btu/hr for the high-pressure brooders. Measured mean heat input for all brooders tested was lower than the rated heat input of 40,000 Btu/hr. Since heat input is governed by gas consumption and the heating value of gas, which is a constant, the percent changes in heat input from varying manifold pressures are the same as for gas consumption. Mean heat input increased with increasing manifold pressure for all the brooders tested.

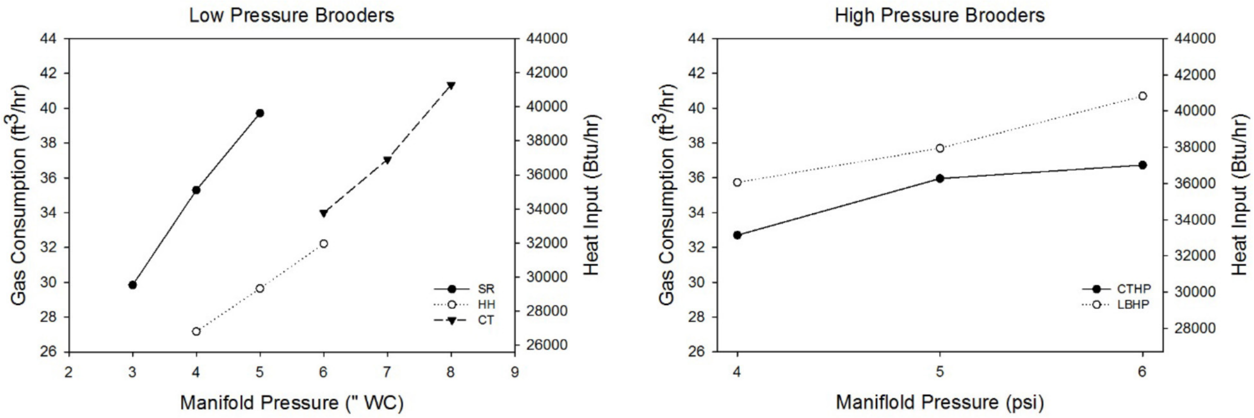

Figure 3. Effect of varying manifold pressure on gas consumption and heat input of low- and high-pressure round radiant brooders. The middle point in each line graph represents the rated manifold pressure for the respective brooder.

Figure 3 data

Brooder Type	Manifold Pressure (in H_2O)	Gas Consumption (ft^3/hr)
SR	3	29.8
SR	4	35.3
SR	5	39.7
HH	4	27.2
HH	5	29.6
HH	6	32.2
CT	6	34.0
CT	7	37.1
CT	8	41.3

Brooder Type	Manifold Pressure (psi)	Gas Consumption (ft^3/hr)
CT HP	4	32.7
CT HP	5	36.0
CT HP	6	36.7
LB HP	4	35.7
LB HP	5	37.7
LB HP	6	40.7

Total Radiant Power

Figure 4 shows the effect of varying manifold pressure on total radiant power at the measuring plane. The measuring plane consisted of 160 radiant flux measurements 6 inches above the litter and within 16 feet of the center of each brooder tested. It was constructed to approximate the amount of heat from a radiant brooder that reaches the birds. See the reference listed on page 4 for more details on the data-collection system and sampling methodology.

Mean total radiant power at rated manifold operating pressure was 8,516 ± 1,767 Btu/hr for the low-pressure brooders and 9,937 ± 3,578 Btu/hr for the high-pressure brooders. For all of the heaters except CTHP, total radiant power at the measuring plane increased with increasing manifold pressure. For the low-pressure brooders, mean radiant power increased 10 percent above rated at the high manifold pressure settings and decreased 14 percent below rated at the low settings. For the high-pressure brooders, mean heat input decreased 14 percent below rated at the low-pressure settings. At the high-pressure setting, there was a 0.6 percent decrease in mean radiant output from rated for the high-pressure brooders.

Conclusions

Increasing manifold pressure increased gas consumption and heat input, but it showed a less discernible trend with combustion efficiency. Heat input for all heaters tested was less than the rated 40,000 Btu/hr. Total radiant output also increased with increasing manifold pressure for all but one of the brooders tested. Total radiant output for all the brooders ranged from 19 to 33 percent of respective heat inputs, which indicates that 33 percent or less of the heat energy available in the fuel is reaching chick level as usable radiant heat.

While higher manifold pressures resulted in increased heat input and total radiant output, it comes at the cost of increased gas consumption. Currently, there is no data available on the effects of adjusting manifold pressure above or below rated levels on long-term fuel consumption, heater run times, chick comfort, bird performance, or brooder wear.

The purpose of this publication is to quantify the extent that varying manifold pressures affect combustion efficiency, gas consumption, heat input, and total radiant output. It is not to suggest tampering with existing manifold pressures. If you suspect that incorrect inlet or manifold pressures may be decreasing the effectiveness of your radiant brooders, contact a qualified gas brooder service person, who can help diagnose any problems.

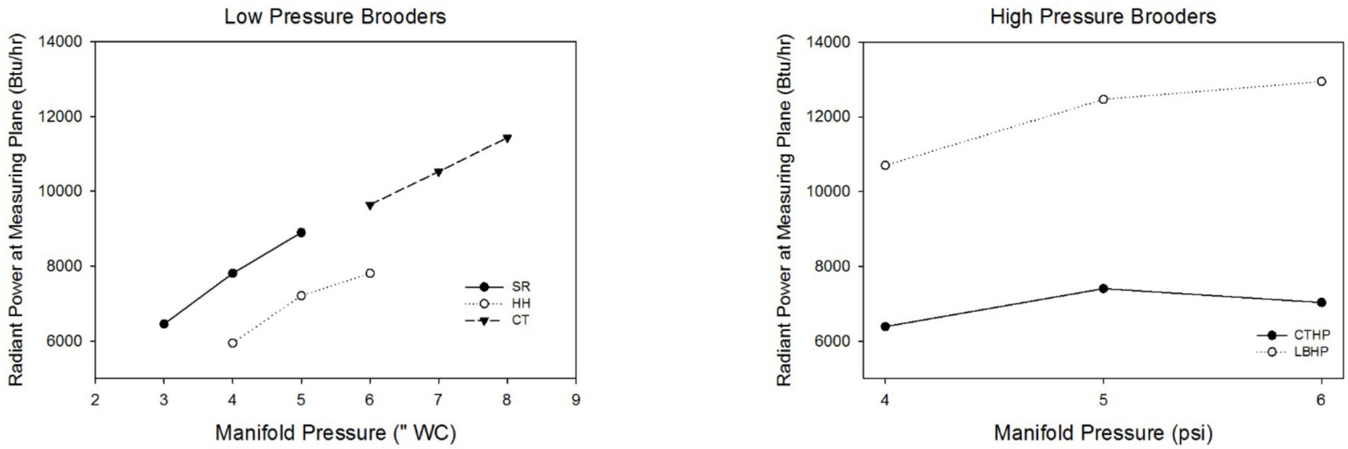

Figure 4. Effect of varying manifold pressure on total radiant power at the measuring plane of low- and high-pressure round radiant brooders. The middle point in each line graph represents the rated manifold pressure for the respective brooder.

Figure 4 data

Brooder Type	Manifold Pressure (in H_2O)	Radiant Power at Measuring Plane (Btu/hr)
SR	3	6458
SR	4	7809
SR	5	8899
HH	4	5944
HH	5	7213
HH	6	7809
CT	6	9640
CT	7	10528
CT	8	11432

Brooder Type	Manifold Pressure (psi)	Radiant Power at Measuring Plane (Btu/hr)
CT HP	4	6393
CT HP	5	7407
CT HP	6	7035
LB HP	4	10701
LB HP	5	12467
LB HP	6	12946

Reference

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Reviewed by **Jessica Drewry**, PhD, Associate Professor, Agricultural and Biological Engineering. Written by John Linhoss, PhD, former Extension Associate, MSU Agricultural and Biological Engineering; Joseph Purswell, PhD, Research Agricultural Engineer, USDA ARS Poultry Research Unit; and Daniel Chesser, PhD, Assistant Professor, MSU Agricultural and Biological Engineering.

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