Farm Structures
FACTSHEET

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TUNING YOUR HEATING SYSTEM FOR MAXIMUM EFFICIENCY

PACKAGED BOILER / LOW TEMPERATURE WATER SYSTEMS

Packaged boiler is a term that refers to a complete unit which includes burner, blower, boiler, controls and all auxiliary equipment. The definition generally does not include small, natural draft water-heaters and boilers. This factsheet is aimed at operators of packaged boilers who are concerned about reducing cost of operation by maximizing the efficiency of the unit. Often the heating system is neglected while other measures to conserve energy are installed at considerable expense. A state-of-the-art micro-processor climate control system or heat retention curtains may be installed while the heating plant remains in poor operating condition.

Typically, a 100 hp boiler will consume $20,000 worth of natural gas in a single season while heating a 3,000 m^2 greenhouse. An improvement in operating efficiency of the heating plant of just 1% will reduce the energy expenditure by approximately $250 annually.

In order of priority, look for improvements in boiler efficiency in the following places in the heating system.

BURNER CONTROL

The fire side of the boiler is most important. The air-to-fuel ratio is critical for achieving optimum combustion efficiency. There is an optimum amount of excess air for each type of packaged boiler and fuel type. Only sufficient air should be supplied to completely combust the fuel since more than this amount increases the heat rejected to the flue.

Excess air for a given boiler changes with barometric pressure and the calorific value of the fuel burned so it is not possible to "tune" a boiler to operate continuously, under all conditions, at zero excess air. For a power boiler, the normal operating ranges are tabulated below:

Combustion Efficiency:	75	– 80%
Flue Gas Constituents	CO_2: 10.0	– 10.5%
	O_2: 2.5	– 3.5%
	CO: 0	– 300 ppm
Excess Air:	10.0	– 15.0%
Net Flue Gas Temperature	200	– 330° C

Combustion efficiency analysis should be performed at least once per year and preferably twice since the mechanical linkages that control the damper are subject to wear and slippage.

A stack thermometer should be installed in the flue so that a regular check can be made to determine if flue gas temperatures are creeping upward over time which is indicative of the boiler operating out of trim.

Have the boiler inspected thoroughly once per year to ensure the furnace boundary walls and flue work are airtight and not a source of air infiltration or exfiltration. Refractory brick, insulation and seals should also be checked.

WATER-SIDE MAINTENANCE

The most important consideration on the water side of the boiler is the layout of the piping to ensure that the heating load is matched to the length and size of radiator pipe which, in turn, is matched to the size of the boiler. Imbalance in the system leads to over firing of the boiler. It is desirable to operate the boiler at the capacity corresponding to its peak efficiency.

Having multiple boiler units or a single boiler with a variable turn-down ratio is important to meet the varying load conditions of a greenhouse.

Add a mixing valve for each heating zone. This affords great flexibility to balance heating loads in each zone by simply diverting cooler return water back into the supply header. Temperature in each zone can be more accurately controlled since pipe temperature can be more precisely controlled by the mixing valve. Over firing of the boiler is prevented.

As a guide, the following table of pipe sizes and temperatures will assist the operator to determine if there is sufficient radiator capacity in the greenhouse for the required heating load and for the size of the boiler in place.

HEAT OUTPUT FROM STANDARD (SCHEDULE 40) BARE STEEL PIPE (W/m OR BTU/(h, ft))

Nominal pipe size		Temp. difference between pipe and surrounding air (^{o}C)						Pipe volume	
mm	(in.)	40	50	60	70	80	90	L/m	(gal/ft)
19	0.75	-	-	-	-	-		0.28	0.023
25	1.0	55	70	90	110	130	150	0.56	0.045
32	1.25	70	90	110	135	160	190	0.97	0.078
38	1.5	80	100	130	160	185	220	1.32	0.106
50	2.0	100	120	60	190	220	260	2.16	0.174
75	3.0	150	180	220	270	320	380	4.77	0.384

Note 1.0 W/m = 1.04 BTU/(h, ft), which is nearly equal. In this table, nominal pipe size refers to the approximate inside diameter and volume is given in US gallons, as this measure is used in most equipment specifications.

Note that finned-tube convectors have four to five times the heat transfer capacity of bare pipe. Output will vary with fin size and spacing so consult your supplier for specifications.

Check for water leaks in the system and repair pump seals, hose clamps and valves whenever leaks occur. Leaks are a source of heat loss and as well they cause untreated make-up water to enter the system.

Treat the water. Water is a universal solvent which causes the slow destruction of all metal parts of the heating system. Even if plastic radiators are used, the boiler, valves and pumps are still affected. Corrosion inhibitors used today are safe and extremely effective.

The life of the system can be doubled if a water treatment regime is followed. A dirty system is one which inhibits heat transfer in the radiators and in the boiler tubes. Once a dirty system is flushed, cleaned and treated water is added, system efficiency has been known to improve by as much as 30%.

Auxiliary Equipment

Once the basics of operation and maintenance on both the fire side and water side of the heating system are well established, then and only then, should consideration be given to auxiliary equipment which can further improve the system efficiency.

Improved burner with a higher turn-down ratio. Most package boilers are equipped with burners with a turn-down ratio of 2:1 or 3:1 which allows a lower firing rate of 50% or 33% of full output. New burners available today can have turn-down ratios of 5:1 to 7:1 without dropping combustion efficiency significantly. Not only are such burners up to 2% more efficient, but the flexibility in firing rate is a great advantage. They are presently available for 250 hp. units and larger.

Oxygen trim systems are available for package boilers as small as 60 hp. An 0_2 analyzer in the flue calls for automatic trim adjustments to the damper which more precisely controls excess air. Fuel savings are in the order of 2%.

Heat exchanger (Recuperator) for recovering heat from the flue gas. The increase in the fuel to water efficiency will be in the order of 10 to 15%. The addition of such a device may result in derating of the boiler due to the flue gas pressure drop through the recuperator. Since the flue gas temperature is dropped to the dew-point temperature, considerable condensation occurs. This can cause rapid corrosion of unprotected metal parts in the flue and recuperator system and it will cause highly visible exhaust emissions. All installations require approval by the Provincial Gas Inspector.

REFERENCES

Natural Gas Combustion Efficiency-Measurement and Optimization, BC Hydro Factsheet B1108, 1981.

Natural Gas Combustion Fundamentals BC, Hydro Factsheet B1105, 1981.

Hot Water Heating for Farm Buildings, Alberta Agriculture Factsheet, 1984.

Boilers and Fired Systems, Energy Management Handbook, W.C. Turner, Ed., Wiley, Toronto, 1982.

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