

STOKER GAS
MATRIX BURNER
(SGMB)

BY

Kenneth L. Maloney, PhD., Inc.

433 LOCUST STREET

LAGUNA BEACH, CA 92651

Phone: 949.497.4698

Fax: 949.497.0883

kennethmaloneyphd@combustionexperts.com

www.combustionexperts.com

STOKER GAS MATRIX BURNER

Low Cost Gas Conversion for Stoker Boilers

Kenneth L. Maloney, Ph.D., Inc. is pleased to offer the new Stoker Gas Matrix Burner (SGMB) for Stoker Boiler conversions to natural gas firing. This is a low cost conversion for stokers that requires no modifications to the existing boiler and maintains the boilers coal firing capabilities.

THE CONCEPT

SGMB is a way to convert stoker boilers to burn natural gas without having to install burners in the side walls of the boilers. This method allows the stokers to remain intact and have the capability to be back on coal with minimum boiler downtime.

The SGMB is mounted on the existing grate of the stoker boiler. It uses the existing fans and requires no water wall tube bends. The conversion can be accomplished without dismantling the original stoker equipment. The boiler can be back on coal in only a few hours. Only the feeders are bricked over to prevent over heating.

The SGMB system is based on the principle of controlled mixing by the gas fuel rather than the forced mixing of high velocity swirling air. The SGMB system is designed such that the fuel/air mixing is provided by the large Reynolds number gas jets issuing into low Reynolds number combustion air in cross flow. This design offers a "naturally staged combustion" of the fuel and hence its low NO_x emission characteristic.

LOW NO_x BURNER SYSTEM

The SGMB system is a low NO_x burner system that uses:

1. Low individual burner heat release rates.
2. Staged combustion (air and fuel)
3. Flue Gas Recirculation (if installed on stoker)
4. Staged fuel configurations

to achieve very low NO_x emission levels on converted stoker boilers.

THE MATRIX DESIGN

Figure 1 shows the configuration of the SGMB design. The SGMB system uses a matrix of vertically fired gas burners. This feature eliminates the problems of long flame length and wall impingement. The SGMB does not require any pressure part modification since the SGMB system rests on the grate.

The SGMB modular firing system provides flexible heat release zones to tailor the balance of heat input to the radiant and convective section requirements of the boiler. This system provides the heat release low in the furnace so that the entire heat absorption surface of the boiler is used.

There are no cold corners or hot spots in superheaters or on waterwall tubes. This uniform distribution of heat release low in the furnace with short flame length avoids the problems that wall fired burner encounter with stoker retrofits.

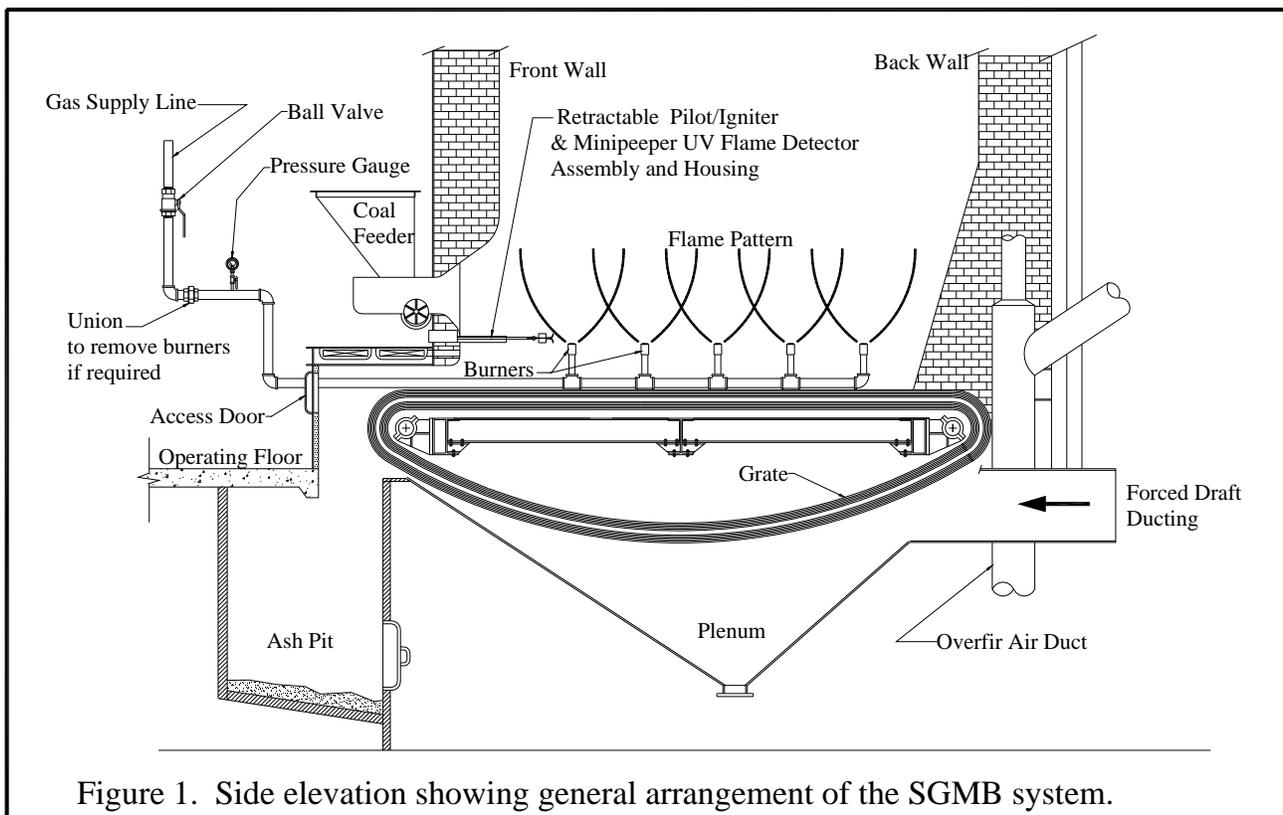


Figure 1. Side elevation showing general arrangement of the SGMB system.

The SGMB can be retrofit to all types and sizes of stoker fired boilers including spreader stokers with traveling grates, vibrating grates and dump grates as well as traveling chain grates and underfeed stokers with single, double and multiple retorts. The size of the piping train and the number of burners required will vary depending on boiler capacity, grate configuration and location/elevation of headers. As can be seen in Figure 1, the SGMB retrofit can be accomplished without any modifications to the stoker equipment.

THE BENEFITS

The following is a list of benefits:

1. Flexible flame pattern.
2. Low NO_x as a result of:
 - A) Low heat release rate per burner. The low heat release rate minimizes the formation of hot eddy zones in the flame and reduces NO_x formation from these eddy zones.
 - B) Staged combustion. The flames are “staged” by controlling the natural gas/air mixing rate. The air from the stoker grate is co-flowing with the flame once the fuel jet has turned downstream and provides a natural staging effect. Also, since the flames are vertically fired, the air/fuel ratio in each cell can be controlled very accurately. There are no buoyancy effects to change the mixing pattern as happens in wall fired systems. The existing overfire air system can also be used to stage the flames for lower NO_x emissions.
 - C) Flue gas recirculation in the main combustion air can also be used to reduce NO_x even further. Because gas firing requires less air than coal firing, the FD fan can be used to convey the flue gas and air into the boiler. There is no need for an additional FGR fan.
3. No changes to coal stoker.
4. No water wall tubes to bend.
5. Nothing is removed from stoker boiler.
6. Can be back on coal in only a few hours.
7. Uses existing FD, ID and OFA fans.
8. Keeps the fire low in the furnace which simulates stoker firing.
9. Low Cost.
10. Heat release pattern can be easily changed.
11. Low excess air firing.
12. Large turn down ration (10:1)

THE HARDWARE

The SGMB system has the same Natural Gas Piping Train (Figure 2) and Burner Management System (Figure 3) that the standard register burners have. The burner management system can have as many safety features as required by the insurer of the boiler. The piping train supplied can be either NFPA or IRI approved depending on the customers requirements. These items are identical to the ones supplied with standard register burners. The big difference is in the burner designs and the cost of installation.

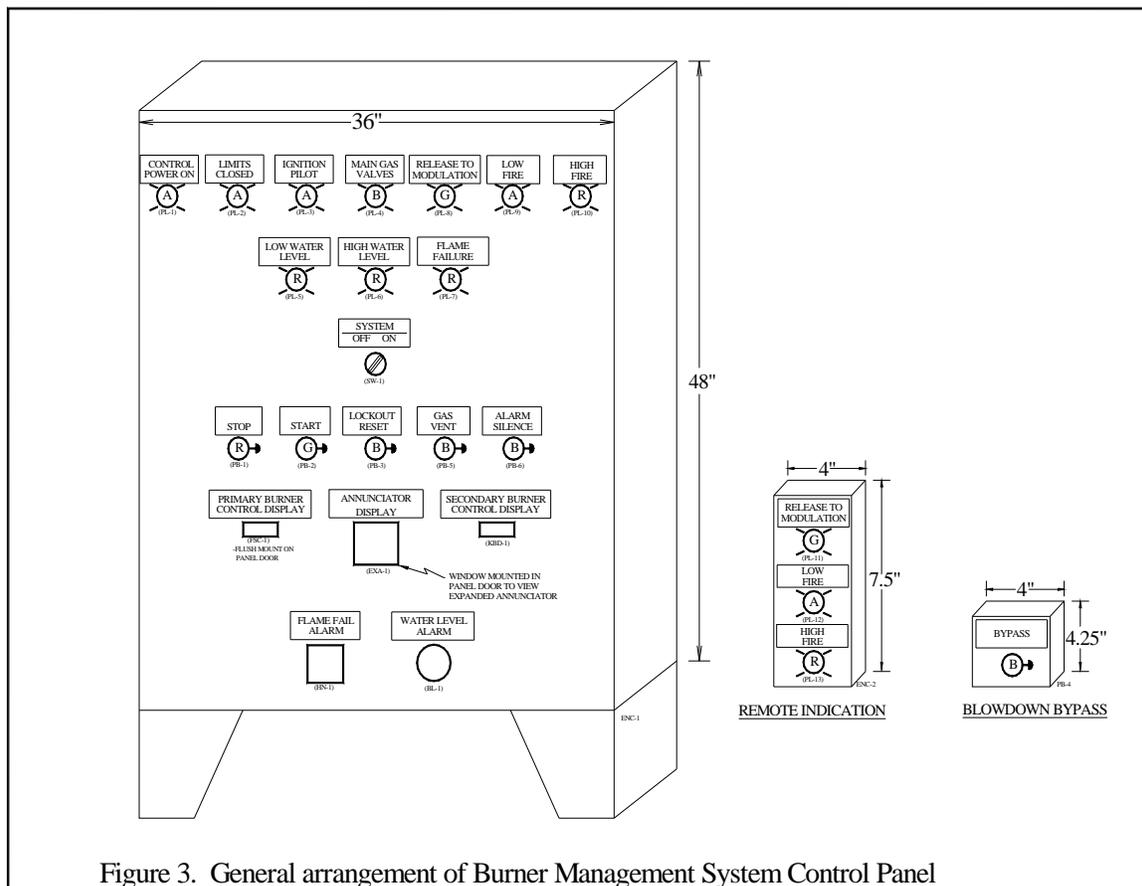
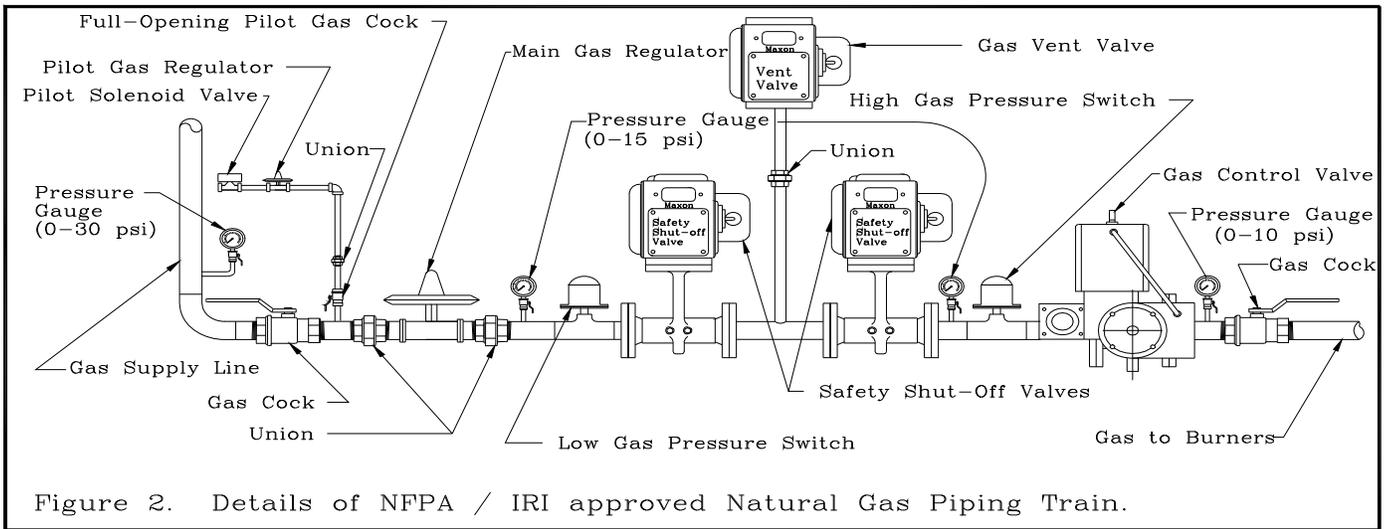
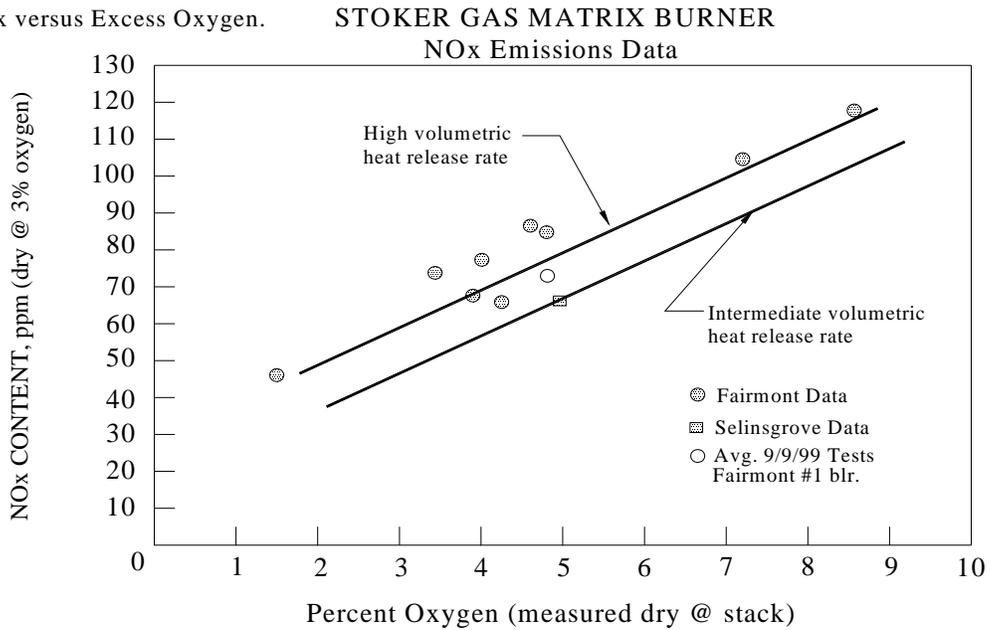


Figure 4. NO_x versus Excess Oxygen.



SGMB TESTING RESULTS

The results of our SGMB installation at Fairmont PUC, Fairmont, MN are described below and in the attached Figure 4, a plot of NO_x vs. O₂.

The number 3 boiler at Fairmont was tested with the SGMB system during the period from February 3 to 13, 1997 and again September 23, 1998. During these running periods boiler performance and emission data were obtained. NO_x emissions ranged from 47 ppm, (corrected to 3% excess O₂ dry) at 1.5% O₂ to 117 ppm at 8.7% O₂ (0.039 to 0.097 pounds per million BTU). In the range of expected operation from 3.5% O₂ to 4.0% O₂, the NO_x ranged from 74 to 78 ppm (0.0613 to 0.0646 pounds per million BTU). On 9/9/99 Unit #1 at Fairmont PUC was tested. The average of the tests is shown as a circle, on Figure 4 above, at 73 ppm NO_x corrected to 3% O₂ dry at 4.86% O₂. This confirms the previous testing on the #3 boiler at Fairmont.

We expect to be able to reduce the NO_x still further if required. Flue gas recirculation and overfire air will reduce these values by approximately half.

All burner management systems worked as planned on the SGMB systems and the turndown on the burner was only limited by the ability of the boiler to maintain drum pressure. ASME boiler efficiencies ranged from 80% to 83%, depending on excess air and stack temperature, for all of the SGMB installations.

Fairmont Utilities has 2 SGMB systems operating on 100,000 pph Spreader Stokers with traveling grates.

Kutztown University in Kutztown, Pa. has an SGMB system on a 35,000 pph traveling chain grate stoker.

Selinsgrove Center in Selinsgrove, Pa. has an SGMB system on a 35,000 pph traveling chain grate stoker.