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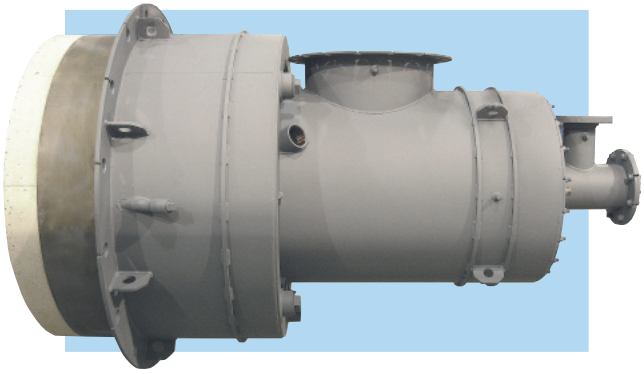
Ultra Low NOx MAGNA-FLAME™ LE BURNER

Bulletin 4211

March 2010

- **4 to 300 million Btu/hr**
- **For processes 1400 to 2400 F such as boilers, process heaters, and other applications requiring low excess air (10-15%)**
- **Ultra Low NOx with or without the use of Flue Gas Recirculation depending on emissions required**
- **Natural gas, propane, low Btu waste, and other industrial fuel gases**
- **Preheated air to 800 F**



The Magna-Flame LE Burner, available in sizes ranging from 4 to 300 million Btu/hr, produces a luminous flame with moderate tile velocity.

The 4211 LE was developed to meet increasingly more stringent low NOx emission requirements globally. It can easily meet the requirements of 15-20 ppm_V NOx without the need for flue gas recirculation or any other external thermal diluent. Additionally, FGR can be added to the 4211 to achieve even lower NOx emissions when needed. It has achieved 7 ppm_V (0.008 lb/million Btu/hr) in the field in a water tube boiler.

Operation

The LE is designed to operate at up to 15"wc combustion air pressure, split into two separate air connections for the primary air and the radial air. It is designed to operate with 8 psig natural gas fuel pressure, which is fed through three separate connections; primary, secondary, and radial. The radial gas is designed for start-up and stabilization of the primary (lean) core. The primary gas is fed to the mixers, which typically operate at 60-70% XSA. The secondary gas is fed into injectors integrated into the reaction chamber and mixes with the lean premix flame at the outlet of the reaction chamber. Final air/fuel ratio in the heater is typically 10-15% XSA (2-3% O_2 in the stack).

Stoichiometric turndown is about 4:1 with higher turndowns obtained by progressively increasing the excess air rate (thermal turndown). The minimum primary air pressure required for continuous operation is 0.75"wc.

Control

Control of the LE is done via electronic ratio control with full metering of the combustion air (or vitiated air stream when FGR is used) and the three fuel flows; primary, secondary, and radial. Typical control systems also utilize an oxygen sensor in the exhaust stream for O2 trim. When FGR is used an oxygen sensor may also be located in the air stream to measure vitiation.

Combustion air is measured with a Fives North American Model 8631 Venturi Air Meter or other means of air measurement and can also be controlled from either a control valve, IVD or VFD when appropriate. A separate radial air blower is normally required when a VFD is used on the primary air blower air is preheated or vitiated. Radial air may not be required on smaller capacity burners.

The critical element of primary air/fuel ratio control is done through the electronic ratio controller which then adjusts the secondary gas valve as needed to maintain the overall excess oxygen recorded by the O_2 sensor (O_2 trim). As input needs vary, the primary air/fuel ratio is maintained by cross-limiting the air and primary gas valves in order to prevent any excursions outside desired operating parameters.

For the tightest (lowest) emissions requirements, fully modulated radial gas and air control valves are required. Modulation may allow for thermal turndown as high as 20:1. When high turndown or ultra low NOx operation is not necessary, the radial gas may be controlled via a bypass solenoid valve which allows for a two position "high/low" setting. Large capacity burners require modulated radial air regardless of emissions requirements.

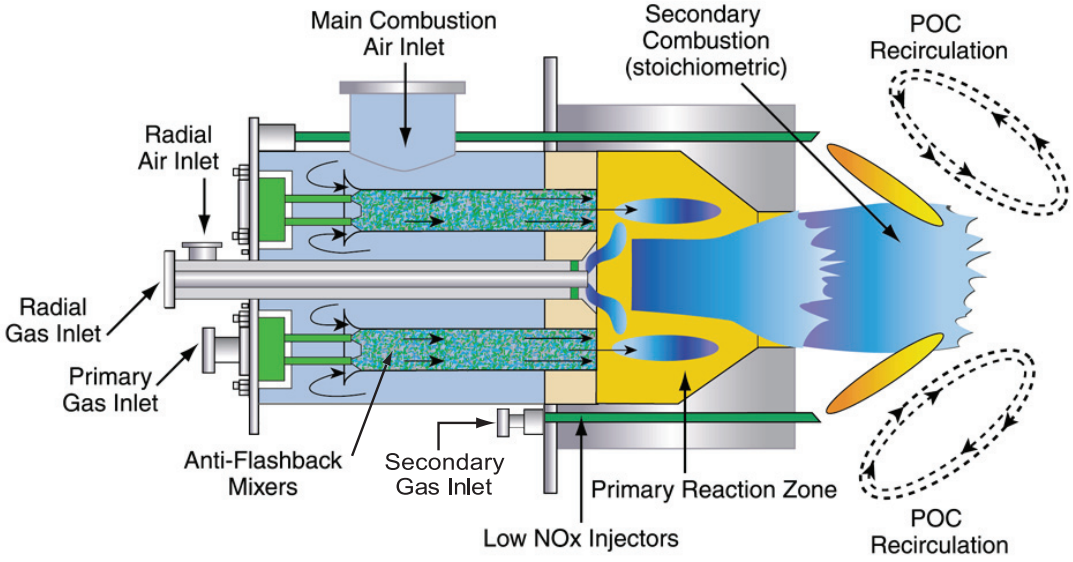


Figure 1. The Magna-Flame LE is a staged fuel burner design with lean burn primary combustion zone. The balance of the fuel is injected downstream.

Pilot and Flame Supervision

There is no 1400 F bypass required as dual flame supervisory detectors (UV) provide full compliance with NFPA86 specifications. The pilot UV initially provides assurance that the pilot and radial gas flames have been adequately established. The main UV then assures that the primary fuel flame has been established so that the secondary fuel valve can then be opened. Contact FivesNA for the specific requirements for flame supervision.

Table 1

Input at 10% XSA *(million Btu/hr)*	LE Designation Diameter *(feet)*	Main Air Flow	Pilot	Flame Length *(feet)*	Flame Diameter *(feet)*
4211-4	4.1	43,000	4020-2	5.0	2.0
4211-5	5.0	51,600	4020-3	6.0	2.0
4211-7	6.6	68,800	4020-3	6.5	2.0
4211-8	8.2	85,100	4020-4	7.5	2.3
4211-10	9.6	99,300	4020-4	8.0	2.3
4211-11	10.9	113,500	4020-4	9.0	2.3
4211-15	15.0	156,300	4020-5	10.5	2.5
4211-18	18.0	187,500	4020-5	12.0	2.8
4211-21	21.1	218,800	4020-5	12.5	2.8
4211-25	24.1	250,000	4020-6/5	13.0	3.0
4211-27	25.9	269,000	4020-6/5	13.5	3.0
4211-33	31.1	322,900	4020-6/5	14.5	3.3
4211-38	36.3	376,700	4020-6/5	15.0	3.5
4211-44	41.4	430,500	4020-6/5	15.5	3.8
4211-48	46.6	484,300	4020-6/5	16.5	4.0
4211-54	51.8	538,200	4020-6/5	17.0	4.3
4211-62	58.8	610,600	4020-6/5	18.0	4.5
4211-74	70.5	732,800	4020-6/5	20.0	4.8
4211-86	82.3	854,900	4020-7/6	21.5	5.0
4211-98	94.1	977,000	4020-7/6	22.5	5.5
4211-111	105.8	1,099,200	4020-7/6	23.5	5.8
4211-116	110.9	1,151,700	4020-7/6	24.0	6.0
4211-124	117.6	1,221,300	4020-7/6	24.5	6.0
4211-140	133.0	1,382,000	4020-7/6	25.0	6.3
4211-163	155.2	1,612,300	4020-7/6	27.0	6.5
4211-182	173.5	1,802,400	4020-7/6	29.0	7.0
4211-219	208.2	2,162,900	4020-7/6	31.0	7.5
4211-256	242.9	2,523,400	4020-7/6	33.0	7.8
4211-292	277.6	2,883,900	4020-7/6	35.0	8.0

A loss of the main UV signal will cause the secondary gas valve to close and re-establishes the 'pilot' UV in order to continue operation of the unit on primary and radial gas only. Loss of the pilot UV will result in the unit shutting down completely, and requiring a re-start of the safety sequence (see NFPA for specific requirements). If the main UV is only going to shut down the secondary gas, approved shutoff valves are required on the secondary gas piping and the controller needs to be designed accordingly.

Construction

The 4211 LE burner is sturdily constructed of steel, stainless steel, and refractory where necessary to withstand the operating environment. The primary mixer tube extensions are constructed of a silicon carbide/mullite material that is then cast into a dense refractory which ensures that the metal parts are sufficiently protected from flame radiation. Options are available for corrosion resistant stainless steels as necessary to handle fuel gases with significant levels of sulfur or other corrosive agents.

The LE reaction chamber (or tile) is constructed of a 3000 F dense castable in addition to four stainless steel secondary injectors which protrude just past the hot face of the refractory. The reaction chamber for an LE is typically greater in length than the refractory wall of most furnaces; consequently a significant portion of it will extend back from the burner wall. While this requires extra room for the burner footprint outside the furnace it allows for a smaller overall combustion chamber (where the flame is contained). The mounting flange can be located to match the wall thickness for ease of installation.

Variants

The 4231 GLE burner is a pre-packaged LE designed to fire steam generators at 62.5 or 85 million Btu/hr. It is supplied with a pre-piped 4020 pilot, ignition cable, NEMA 4 ignition transformer; three pre-piped, pre-wired, and pre-set pressure switches for purge, low combustion air, and low fire; and a junction box for wiring to the necessary control hardware, simplifying installation and field start-up.

The 4213 LEx burner is designed to operate at excess rates between 60-80% at an input ranging from 3 to 400 million Btu/hr. It is intended for lower temperature applications where secondary air is normally employed to achieve process temperatures between 300-1600 F. It is similar to an LE burner but does not use secondary injectors and normally requires an extended reaction chamber to protect the flame from the low or ambient temperature secondary process stream. See Bulletin 4213 for more information.

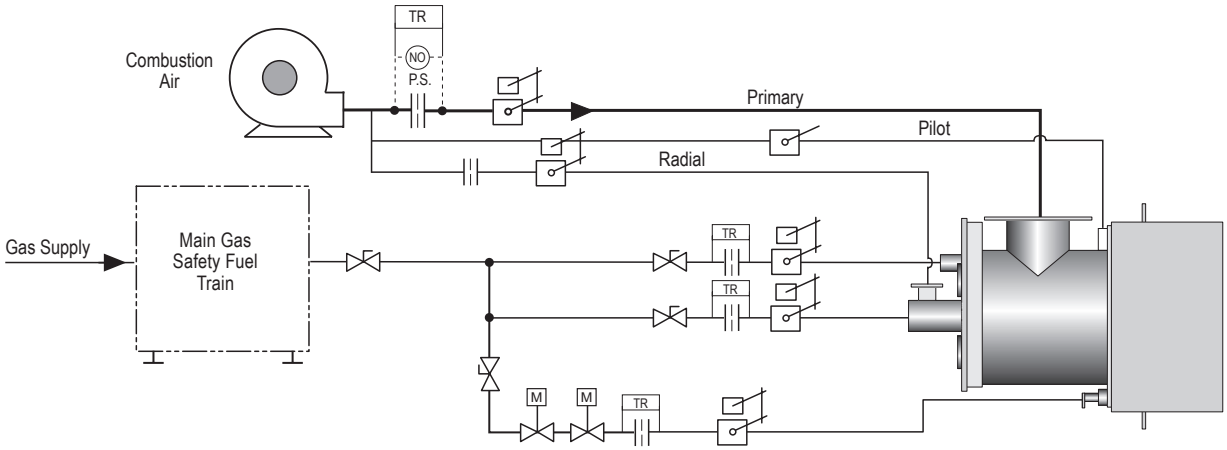


Figure 2. Typical Piping Schematic for MAGNA-FLAME™ LE Cold Air System.
Preheat or vitiated combustion air systems require a second blower for radial and pilot air. Fuel train components omitted for clarity.

The graph at right shows actual test results of a burner fired with 10% excess air. Other variables such as higher excess air, preheated air temperatures, firing rate, and furnace design can effect NOx emission levels.

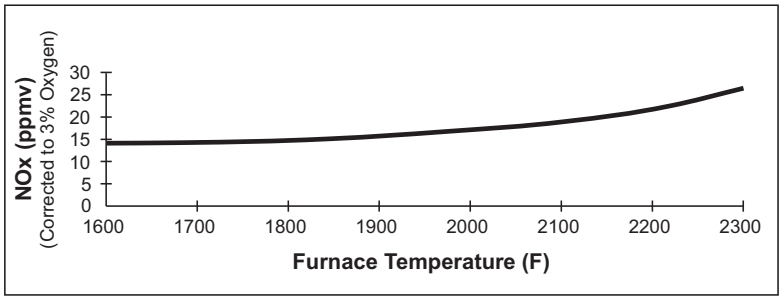
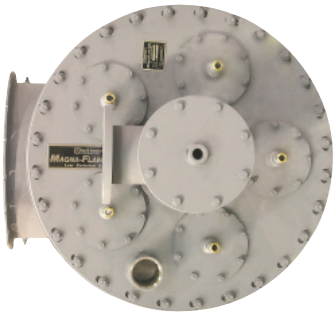


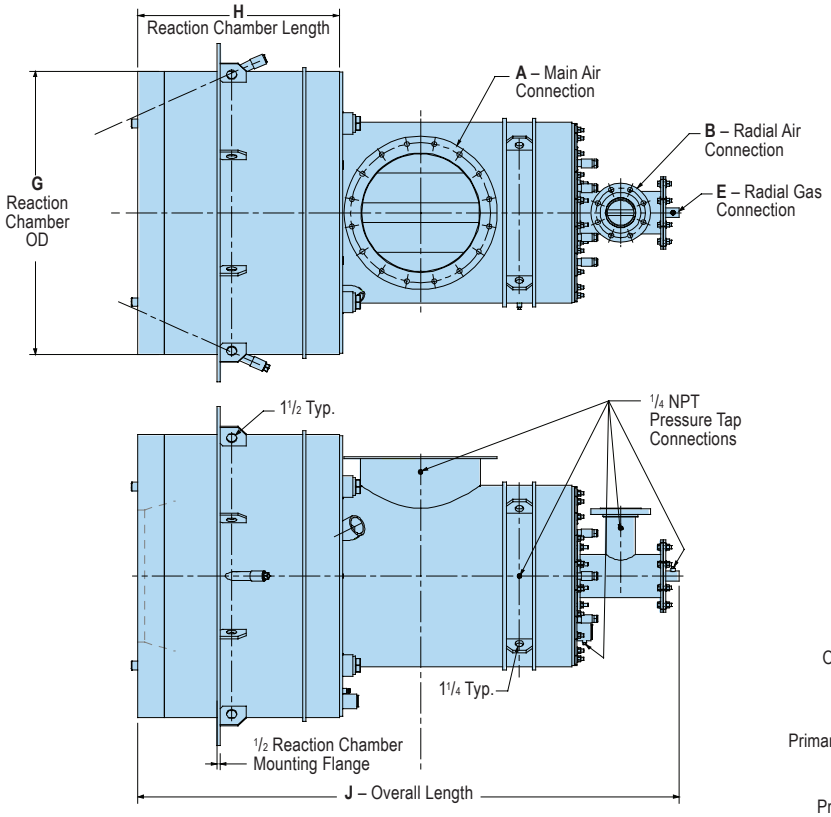
Figure 3. NOx Emissions *vs.* Furnace Temperature.

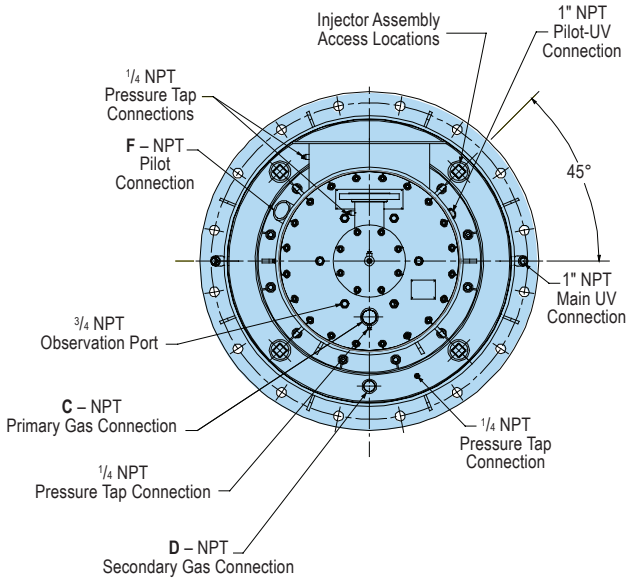
Packaged boiler at a southern U.S. chemical plant equipped with 4211-72 burner firing at 70 million Btu/hr, achieving less than 0.01 lb/million Btu NOx and 0.015 lb/million Btu CO.



DIMENSIONS
in inches

DIMENSIONS SHOWN ARE SUBJECT TO CHANGE. PLEASE OBTAIN CERTIFIED PRINTS FROM FIVES NORTH AMERICAN COMBUSTION, INC. IF SPACE LIMITATIONS OR OTHER CONSIDERATIONS MAKE EXACT DIMENSION(S) CRITICAL.





LE Designation	A main air connection	B radial air-flat flange	C primary gas connection *	D secondary gas connection *	E radial/center gas connection	F pilot connection	G Approx reaction chamber diameter	H Approx reaction chamber length	J Approx overall length	Approx Weight
4211-4	6" ansi	n/a	1" npt	1/2" npt	1/2" npt	1-1/4" npt	19.38	18.5	40.0	1500
4211-5	8" ansi	n/a	1" npt	1/2" npt	1/2" npt	1-1/2" npt	20.63	20.5	45.0	1700
4211-7	8" ansi	n/a	1" npt	3/4" npt	1/2" npt	1-1/2" npt	21.13	23.5	48.0	1800
4211-8	10" ansi	n/a	1" npt	3/4" npt	1/2" npt	2" npt	22.38	23.5	50.0	2000
4211-10	10" ansi	n/a	1" npt	3/4" npt	1/2" npt	2" npt	23.38	26.5	50.0	2450
4211-11	12" ansi	n/a	1" npt	1" npt	1/2" npt	2" npt	24.88	26.5	50.0	2770
4211-15	12" ansi	3" ansi	1-1/2" npt	1" npt	1/2" npt	2-1/2" npt	28.13	26.5	65.0	2950
4211-18	14" ansi	3" ansi	1-1/2" npt	1" npt	1/2" npt	2-1/2" npt	31.13	31.5	70.0	3200
4211-21	14" ansi	3" ansi	2" npt	1" npt	1/2" npt	2-1/2" npt	33.38	31.5	70.0	3300
4211-25	16" rpm	3" ansi	2" npt	1" npt	1/2" npt	2-1/2" npt	33.88	31.5	70.0	3400
4211-27	16" rpm	3" ansi	2" npt	1" npt	1/2" npt	2-1/2" npt	33.88	34.5	80.0	3500
4211-33	18" rpm	3" ansi	2-1/2" npt	1-1/2" npt	3/4" npt	2-1/2" npt	35.13	34.5	80.0	3750
4211-38	18" rpm	3" ansi	2-1/2" npt	1-1/2" npt	3/4" npt	2-1/2" npt	37.25	34.5	80.0	4000
4211-44	20" rpm	3" ansi	2-1/2" npt	1-1/2" npt	3/4" npt	2-1/2" npt	40.13	36.5	85.0	4800
4211-48	22" rpm	4" ansi	3" raised	2" npt	1" npt	2-1/2" npt	44.75	36.5	85.0	5500
4211-54	24" rpm	4" ansi	3" raised	2" npt	1" npt	2-1/2" npt	48.63	36.5	85.0	5900
4211-62	24" rpm	4" ansi	3" raised	2" npt	1" npt	2-1/2" npt	48.63	36.5	105.0	6400
4211-74	26" rpm	4" ansi	3" raised	2-1/2" npt	1" npt	2-1/2" npt	49.75	36.5	105.0	6700
4211-86	28" rpm	6" ansi	4" raised	2-1/2" npt	1-1/2" npt	3" npt	52.50	36.5	105.0	7000
4211-98	30" rpm	6" ansi	4" raised	3" raised	2" npt	3" npt	55.50	36.5	105.0	7300
4211-111	30" rpm	6" ansi	4" raised	3" raised	2" npt	3" npt	58.63	36.5	105.0	7600
4211-116	30" rpm	6" ansi	4" raised	3" raised	2" npt	3" npt	61.50	36.5	120.0	8200
4211-124	36" rpm	6" ansi	4" raised	3" raised	2" npt	3" npt	64.50	36.5	120.0	8500
4211-140	36" rpm	6" ansi	4" raised	3" raised	2" npt	3" npt	64.50	42.5	130.0	11000
4211-163	38" rpm	8" ansi	6" raised	4" raised	2-1/2" npt	3" npt	68.38	42.5	130.0	12000
4211-182	40" rpm	8" ansi	6" raised	4" raised	2-1/2" npt	3" npt	71.38	42.5	140.0	14000
4211-219	44" rpm	8" ansi	6" raised	4" raised	2-1/2" npt	3" npt	78.75	42.5	140.0	15000
4211-256	44" rpm	8" ansi	6" raised	4" raised	2-1/2" npt	3" npt	83.50	42.5	140.0	16000
4211-292	46" rpm	8" ansi	8" raised	6" raised	3" raised	3" npt	88.63	45.0	140.0	17000

* indicates raised face ansi flange where applicable

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