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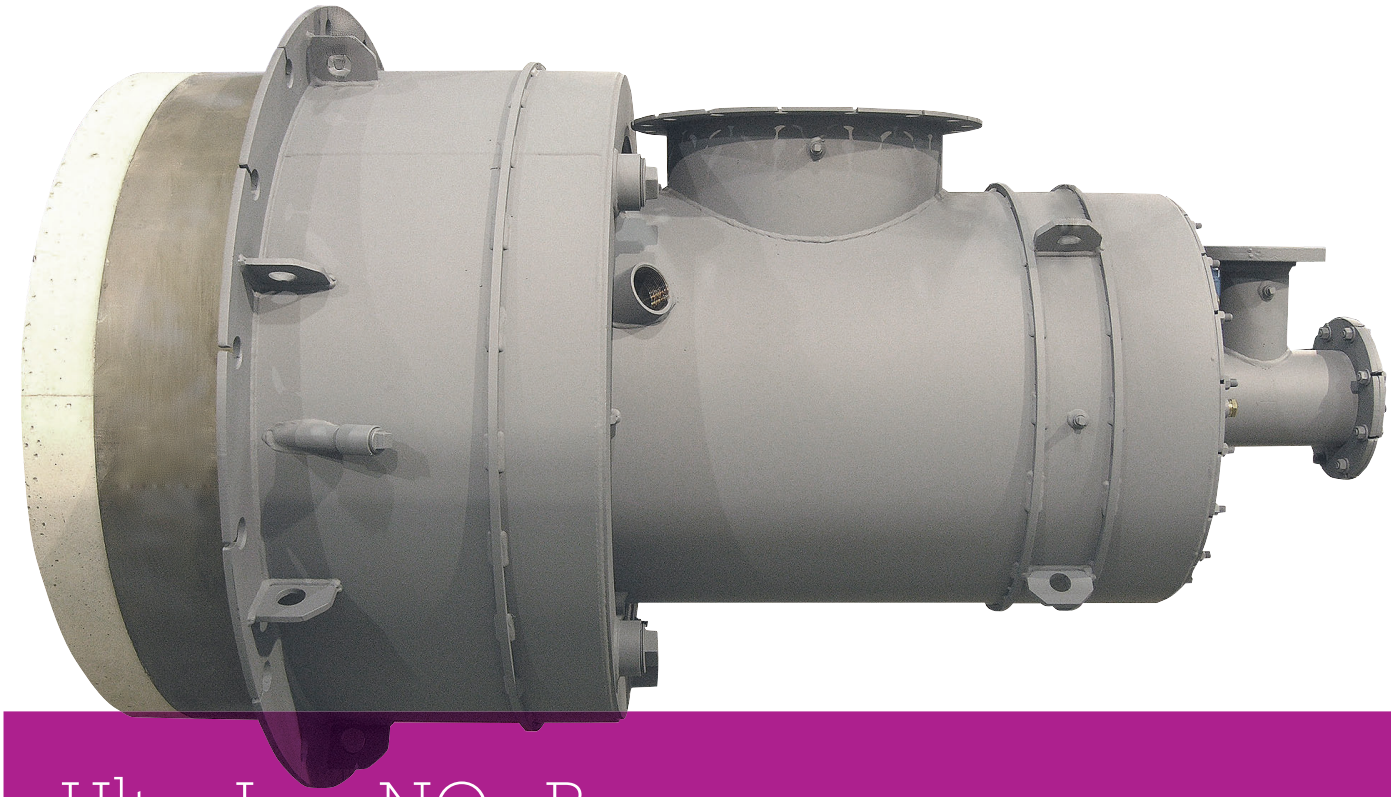
PROCESS TECHNOLOGIES

ENERGY | COMBUSTION

EcoFornax™ LE

North American 4211



Ultra-Low NOx Burners

- Sizes ranging from 4 to 300 million Btu/h HHV
- Natural gas, propane, low Btu wast, and other industrial fuel gases
- Produces luminous flame with moderate tile velocity
- Preheated air to 800°F

Product Overview | 4211 EcoFornax™ LE

- **Ultra Low NOx with or without the use of flue gas recirculation (FGR) depending on emissions required**
- **For processes 1400 to 2400°F such as boilers, process heaters, and other applications requiring**

APPLICATIONS

- **Thermal Fluid Heaters**
- **Boilers**
- **Process Heaters**
- **Incinerators**

The LE is designed to meet the increasingly-more-stringent global low emission requirements. 15-20 ppmdv NOx is easily achieved. FGR may be added to the 4211's oxidant stream to achieve even lower NOx emissions when needed. Current installations in water tube boilers at less than 7 ppmdv (0.008 lb/million Btu). Standard sizes are available with capacities ranging from 4-300 mm Btu/h HHV. Larger sizes also available.

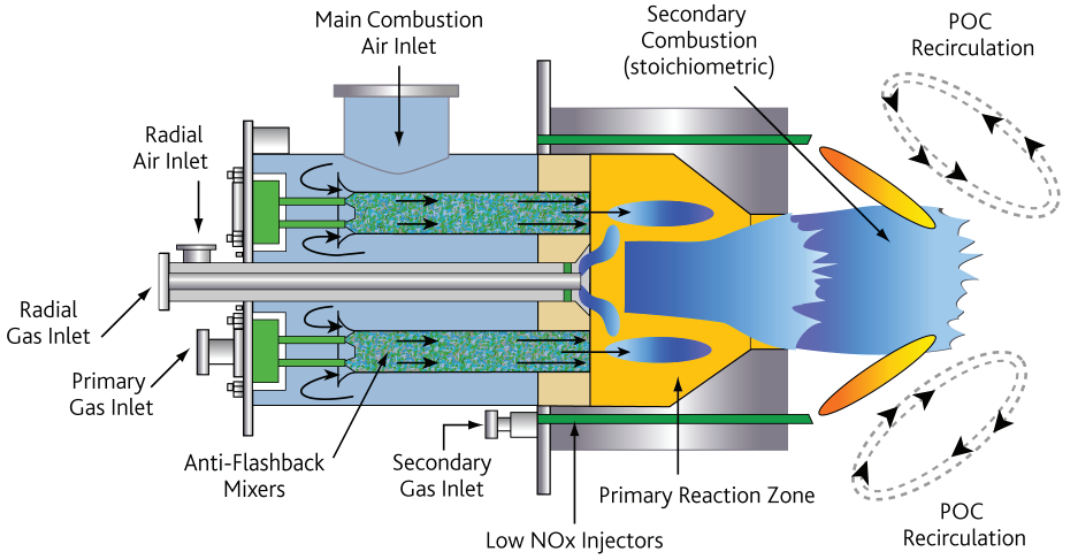


Figure 2. The Magna-Flame LE is a staged fuel burner design with lean burn primary combustion zone. The balance of the fuel is injected downstream.

OPERATION

The LE is a fuel-staged burner with a lean primary combustion zone. Secondary fuel is directly injected into the oxygen-rich primary zone POC where it combusts to achieve the final desired combustion ratio.

The LE's combustion air supply is split between main (primary) air and radial air connections. The fuel gas supply is divided between three gas connections: radial, primary, and secondary. The radial gas is used at start-up and for stabilization of the primary (lean) core. The primary gas feeds the mixers of the lean primary zone, typically operated at 60-70% XSA. The secondary gas exits injectors integrated into the primary zone reaction chamber structure to mix with the lean premix flame/POC at the outlet of the reaction chamber. Final air/fuel ratio is typically at 10-15% XSA (2- 3% O2 in the stack). Stoichiometric turndown is about 4:1. Higher turndowns are obtained by progressively increasing the excess air rate (thermal turndown). Typical design high fire air pressure is 15"w.c. max. Minimum primary air pressure required for continuous operation is 0.75"w.c. Typical design gas pressure is 8 psig.

CONSTRUCTION

The LE burner is sturdily constructed of steel, stainless steel, and refractory to withstand the operating environment. Optional corrosion-resistant alloy construction may be selected to handle fuel gases with sulfur or other corrosive constituents. Precision-cast silicon carbide/mullite-mix primary mixer tube extensions are cast into the dense refractory reaction chamber facing, keeping the metal mixer parts remote and protected from flame radiation and heat soak. The 3000°F dense castable reaction chamber wall structure contains the four stainless steel secondary injectors which protrude to discharge just past the hot face of the refractory. As the reaction chamber is typically of greater length than the furnace's refractory wall thicknesses, some portion of it will extend back from the burner mounting cold face. The mounting flange can be located to match the wall thickness for ease of installation. While this requires extra room for the burner footprint past the furnace wall, it allows a smaller overall furnace chamber with flame envelope containment.

Capacity | 4211 EcoFornax™ LE

VARIANTS

The GLE burner is a "pre-packaged LE" configured to fire oil field steam generators at 62.5, 85 or 100 MM Btu/h HHV. It is supplied with a pre-piped 4020 pilot, ignition cable, NEMA 4 ignition transformer; 3 pre-piped, pre-wired, pre-set, pressure switches (for purge, low combustion air, and low fire proving); and a junction box for wiring to the necessary control hardware, simplifying installation and field start-up.

The LEx burner is the LE without the secondary fuel injectors. It operates at excess air rates between 60-80% at a standard input ranging from 3 to 200 MM Btu/h HHV with larger sizes available (e.g. 400 MM Btu/h built for a calciner). It is intended for lower temperature applications where secondary air is normally employed to achieve process temperatures between 300-1600°F. LEx burners normally require an extended primary zone reaction chamber to protect the flame from the lower temperature secondary process stream. See Bulletin 4213 for more information.

LE Burner Capacity and Characteristics

LE Designation	Input at 10% XSA *(million Btu/hr)*[3]	Main Air Flow (scfh)	Pilot[1]	Flame Length *(feet)*[2]	Flame Diameter *(feet)*[2]
4211-4-5X1.5GG	4.1	43,000	4020-0-LP	5.0	2.0
4211-5-6X1.5GG	5.0	51,600	4020-0-LP	6.0	2.0
4211-7-8X1.5GG	6.6	68,800	4020-2-LP	6.5	2.0
4211-8-6X2GG	8.2	85,100	4020-2-LP	7.5	2.3
4211-10-7X2GG	9.6	99,300	4020-3-LP	8.0	2.3
4211-11-8X2GG	10.9	113,500	4020-3-LP	9.0	2.3
4211-15-5X3GG	15.0	156,300	4020-4-LP	10.5	2.5
4211-18-6X3GG	18.0	187,500	4020-4-LP	12.0	2.8
4211-21-7X3GG	21.1	218,800	4020-4-LP	12.5	2.8
4211-27-5X4GG	25.9	269,000	4020-5-LP	13.5	3.0
4211-33-6X4GG	31.1	322,900	4020-5-LP	14.5	3.3
4211-38-7X4GG	36.3	376,700	4020-5-LP	15.0	3.5
4211-44-8X4GG	41.4	430,500	4020-6-LP/5	15.5	3.8
4211-48-9X4GG	46.6	484,300	4020-6-LP/5	16.5	4.0
4211-54-10X4GG	51.8	538,200	4020-6-LP/5	17.0	4.3
4211-62-5X6GG	58.8	610,600	4020-6-LP/5	18.0	4.5
4211-74-6X6GG	70.5	732,800	4020-6-LP/5	20.0	4.8
4211-86-7X6GG	82.3	854,900	4020-7-LP/6	21.5	5.0
4211-98-8X6GG	94.1	977,000	4020-7-LP/6	22.5	5.5
4211-111-9X6GG	105.8	1,099,200	4020-7-LP/6	23.5	5.8
4211-124-10X6GG	117.6	1,221,300	4020-7-LP/6	24.5	6.0
4211-116-5X8WB	110.9	1,151,700	4020-7-LP/6	24.0	6.0
4211-140-6X8WB	133.0	1,382,000	4020-7-LP/6	25.0	6.3
4211-163-7X8WB	155.2	1,612,300	4020-7-LP/6	27.0	6.5
4211-182-5X10WB	173.5	1,802,400	4020-7-LP/6	29.0	7.0
4211-219-6X10WB	208.2	2,162,900	4020-7-LP/6	31.0	7.5
4211-256-7X10WB	242.9	2,523,400	4020-7-LP/6	33.0	7.8
4211-292-8X10WB	277.6	2,883,900	4020-7-LP/6	35.0	8.0

[1] Recommended pilot; not included
[2] Flame shape may vary based on reaction chamber length and internal profile
[3] Under some conditions, firing rate may be up to 15% higher than rated input

CONTROL

Input and air/fuel ratio control for the LE utilizes fully metered oxidant and fuel flows (minimum one air and three fuel streams) as inputs to an electronic ratio control system. An oxygen sensor in the exhaust stream is commonly used to provide O2 trim. An O2 sensor may also be used to determine the vitiation level when FGR is mixed with the combustion air.

Combustion air flow is measured with a North American 8631 Venturi Air Meter or other air flow determining device. Air flow control can be by control valve, blower IVD or VFD, as dictated by the air system design. A separate radial air blower is typically required when a VFD is used on the primary air blower or the primary air is preheated or vitiated. The critical primary air/ fuel ratio is maintained by the electronic ratio controller which also adjusts the secondary gas flow control valve as needed to maintain the overall excess oxygen at the exhaust O2 sensor. As input demand changes, the desired primary air/fuel ratio is maintained by cross-limiting the air and primary gas valves. To meet the lowest emissions requirements, fully modulated radial air and gas control valves are required, also allowing for thermal turndown as high as 20:1. When high turndown or ultimate ultra-low NOx operation is not a system requirement, 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 requirement.

PILOT and FLAME SUPERVISION

Dual UV flame detectors are used. The pilot UV detector monitors the adequate establishment of the pilot and radial flames at startup. The main UV detector monitors the establishment of the primary flame and allows opening of the secondary fuel supply safety shutoff valves. Loss of the main UV signal will cause the secondary gas valves to close and re-establishes the pilot UV detector to monitor the operation of the unit on primary and radial gas only. Loss of the pilot UV signal will result in the unit shutting down completely, and require a re-start of the safety sequence following the appropriate code requirements. Contact North American for the specific requirements for configuration of flame supervision equipment and fuel safety shut off valves for each application.

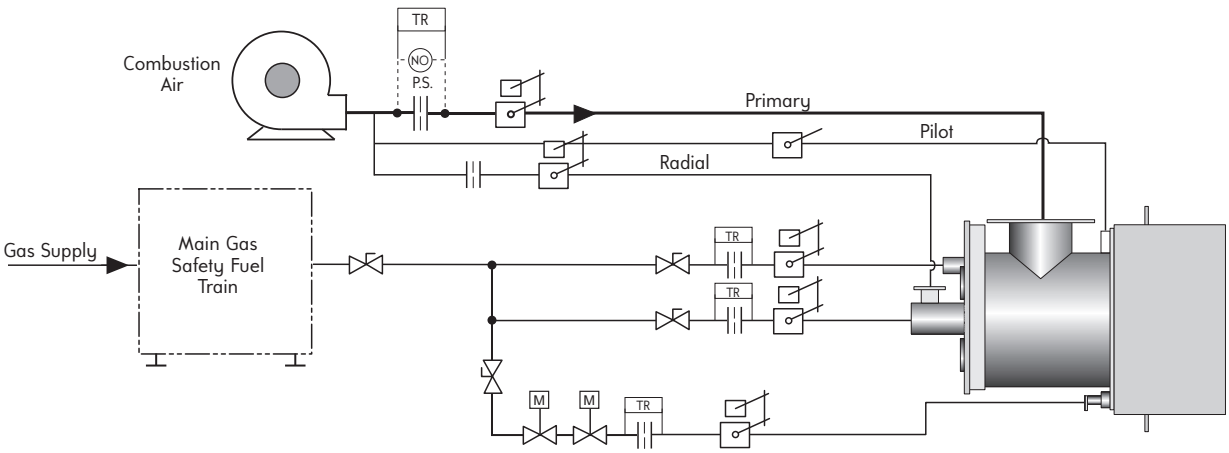


Figure 2. Typical Piping Schematic for LE Cold Air System.
Preheat or vitiated combustion air systems require a second blower for radial and pilot air. Fuel train components omitted for clarity.

Dimensions | 4211 EcoFornax™ LE

This graph 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.

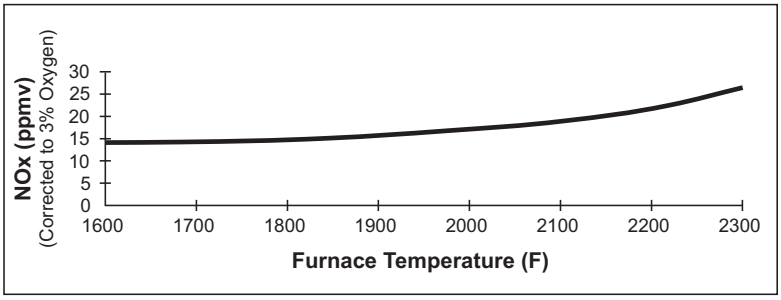
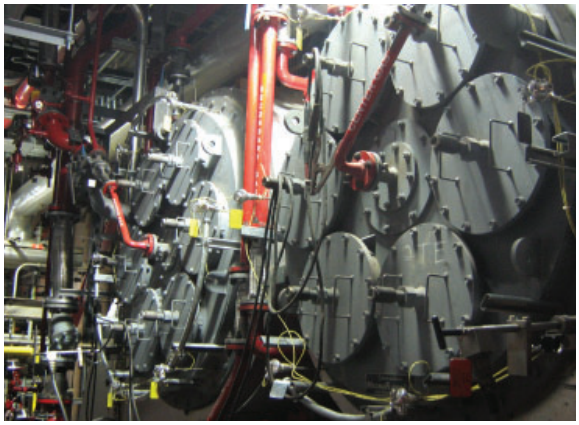
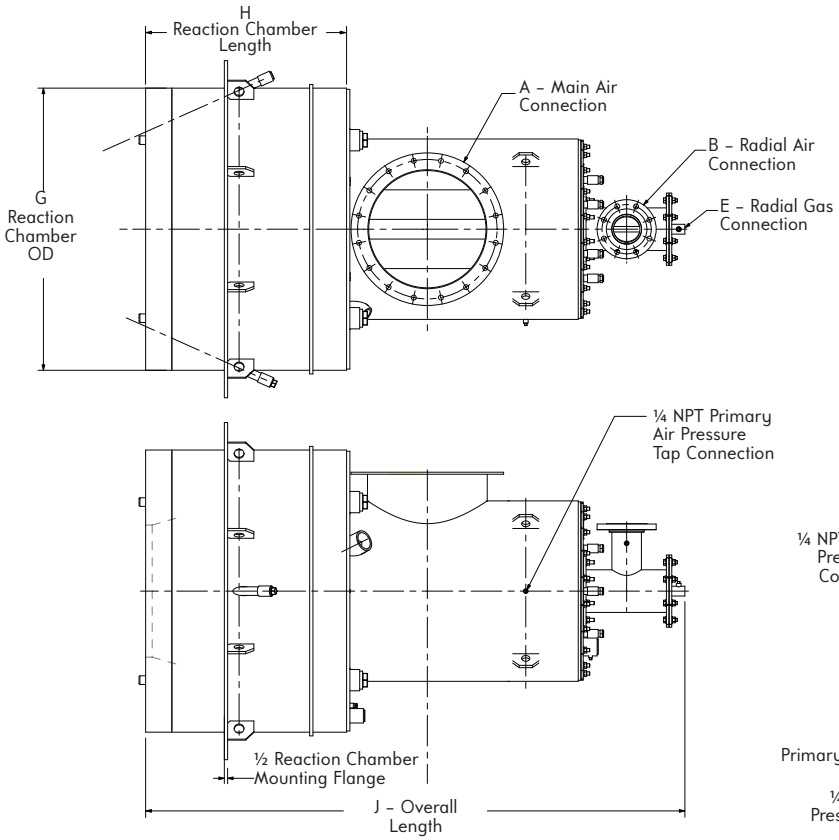


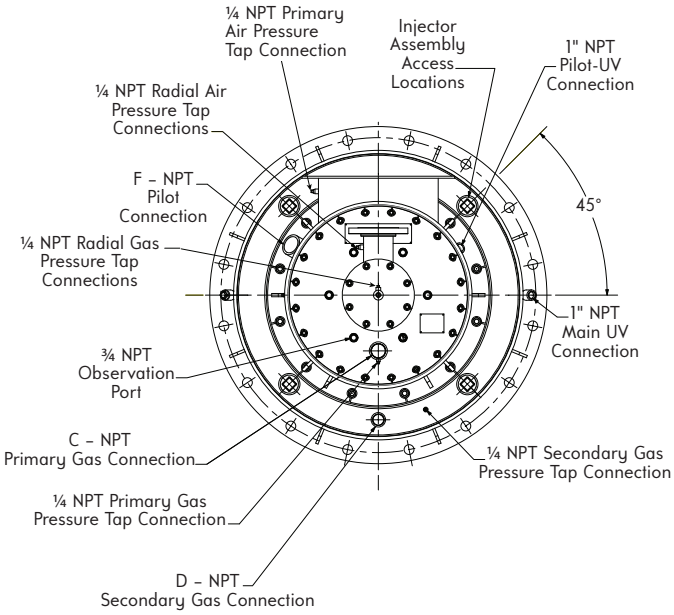
Figure 3. NOx Emissions vs. Furnace Temperature.



Custom engineered LE burners rated at 55 mmBtu/h HHV each are mounted on a field erected boiler wall. The burners are designed operate on 500°F combustion air and refinery fuel gas.

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.

Chart | 4211 EcoFornax™ LE

LE Designation	A main air connection *	B radial air (flat) [2]	C primary gas connection [1]	D secondary gas connection [1]	E radial/center gas connection [1]	F pilot connection	F burner center line to main air	G Approx reaction chamber diameter	H Approx reaction chamber length	J Approx overall length	Approx Weight
4211-4-5X1.5GG	6" ansi	n/a	1" raised	½" npt	½" npt	¾" npt	12.25	19.38	18.5	30.0	240
4211-5-6X1.5GG	8" ansi	n/a	1" raised	½" npt	½" npt	¾" npt	12.38	20.63	20.5	30.0	250
4211-7-8X1.5GG	8" ansi	n/a	1" raised	¾" npt	½" npt	1¼" npt	12.38	21.13	23.50	30.0	260
4211-8-6X2GG	10" ansi	n/a	1" raised	¾" npt	½" npt	1¼" npt	13.00	22.38	23.50	42.0	430
4211-10-7X2GG	10" ansi	n/a	1" raised	¾" npt	½" npt	1½" npt	13.50	23.38	26.50	42.0	450
4211-11-8X2GG	12" ansi	n/a	1" raised	1" raised	½" npt	1½" npt	14.25	24.88	26.50	42.0	470
4211-15-5X3GG	12" ansi	3" ansi	1½" raised	1" raised	¾" npt	2" npt	15.88	28.13	26.50	48.0	650
4211-18-6X3GG	14" ansi	3" ansi	1½" raised	1" raised	¾" npt	2" npt	16.75	31.13	31.50	54.0	700
4211-21-7X3GG	14" ansi	3" ansi	2" raised	1" raised	¾" npt	2" npt	18.00	33.38	31.50	56.0	750
4211-27-5X4GG	16" rpm	3" ansi	2" raised	1" raised	1" raised	2½" npt	18.13	33.88	34.50	68.0	100
4211-33-6X4GG	18" rpm	3" ansi	2½" raised	1½" raised	1" raised	2½" npt	18.75	35.13	34.50	68.0	1200
4211-38-7X4GG	18" rpm	3" ansi	2½" raised	1½" raised	1½" raised	2½" npt	19.19	37.25	34.50	68.0	1400
4211-44-8X4GG	20" rpm	3" ansi	2½" raised	1½" raised	1½" raised	2½" npt	21.13	40.13	36.50	68.0	1600
4211-48-9X4GG	22" rpm	3" ansi	3" raised	2" raised	1½" raised	2½" npt	22.50	44.75	36.50	68.0	1800
4211-54-10X4GG	24" rpm	3" ansi	3" raised	2" raised	1½" raised	2½" npt	24.00	48.63	36.50	68.0	2100
4211-62-5X6GG	24" rpm	3" ansi	3" raised	2" raised	1½" raised	2½" npt	24.00	48.63	36.50	88.0	2100
4211-74-6X6GG	26" rpm	4" ansi	3" raised	2½" raised	2" raised	2½" npt	24.56	49.75	36.50	88.0	2200
4211-86-7X6GG	28" rpm	4" ansi	4" raised	2½" raised	2" raised	3" npt	25.94	52.50	36.50	88.0	2450
4211-98-8X6GG	30" rpm	4" ansi	4" raised	3" raised	2" raised	3" npt	26.25	55.50	36.50	88.0	2900
4211-111-9X6GG	30" rpm	4" ansi	4" raised	3" raised	2" raised	3" npt	31.00	58.63	36.50	88.0	3500
4211-124-10X6GG	36" rpm	6" ansi	6" raised	3" raised	2½" raised	3" npt	36.00	61.50	36.50	88.0	3650
4211-116-5X8WB	30" rpm	6" ansi	6" raised	3" raised	2½" raised	3" npt	36.00	64.50	36.50	108.0	6000
4211-140-6X8WB	36" rpm	6" ansi	6" raised	3" raised	2½" raised	3" npt	40.50	64.50	42.50	108.0	6200
4211-163-7X8WB	38" rpm	6" ansi	6" raised	4" raised	2½" raised	3" npt	44.00	68.38	42.50	108.0	6400
4211-182-5X10WB	40" rpm	8" ansi	6" raised	4" raised	3" raised	3" npt	44.00	71.38	42.50	108.0	6600
4211-219-6X10WB	44" rpm	8" ansi	6" raised	4" raised	3" raised	3" npt	46.00	78.75	42.50	108.0	6800
4211-256-7X10WB	44" rpm	8" ansi	8" raised	6" raised	3" raised	3" npt	48.00	83.50	42.50	108.0	7000
4211-292-8X10WB	46" rpm	8" ansi	8" raised	6" raised	3" raised	3" npt	50.00	88.63	45.00	108.0	7200

* rectangular air flanges available
[1] indicates 150# raised face ANSI flange where applicable
[2] indicates a fabricated flange conforming to 150# ANSI dimensions where applicable
[3] lengths and weights vary based on application

WARNING: Situations dangerous to personnel and property may exist with the operation and maintenance of any combustion equipment. The presence of fuels, oxidants, hot and cold combustion products, hot surfaces, electrical power in control and ignition circuits, etc., are inherent with any combustion application. Components in combustion systems may exceed 160°F (71°C) surface temperatures and present hot surface contact hazard. Fives North American Combustion, Inc. suggests the use of combustion systems that are in compliance with all Safety Codes, Standards, Regulations and Directives; and care in operation.

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