Bulletin 4748

North American Low NOx Reverse Annulus Single Ended Radiant Tube Burner (RASERT™)

The 4748 RASERT™ Advantage:

- Increased production through high flux annular combustion
- Fuel savings due to high efficiency integral heat exchanger
- Uniform radiant tube temperatures provide extended radiant tube life
- Low NOx, CO and CO_2 emissions achieved by efficient staged combustion, and integral flue gas recirculation
- Designed to be adaptable to existing straight radiant tubes
- Compatible with many existing control systems including simple cross-connected regulator systems
- Built-in air/fuel metering and gas limiting orifice valve mean easier installation and commissioning
- Direct spark ignition

REVERSE ANNULUS COMBUSTION

The 4748 is a unique low NOx, high efficiency single ended radiant tube burner. Unlike conventional SERT burners, combustion occurs in the annulus formed between the outer radiant tube and the inner flue tube. Combustion gases then turn 180° to reverse through the inner flue tube to the integral high efficiency heat exchanger having a return gas flow path to conventional SERT burners; hence the name Reverse Annulus Single Ended Radiant Tube burner, or "RASERT."

The 4748 RASERT has a number of advantages over conventional SERT's. Since the flame is in direct contact with the inside surface of the radiant tube, heat is transferred to the furnace more efficiently. The flame propagates outside the combustion tube rather than inside, resulting in less thermal stress on the combustion tube. RASERT is a patented design (#6,321,743) of the Gas Technology Institute (GTI) developed in collaboration with North American.

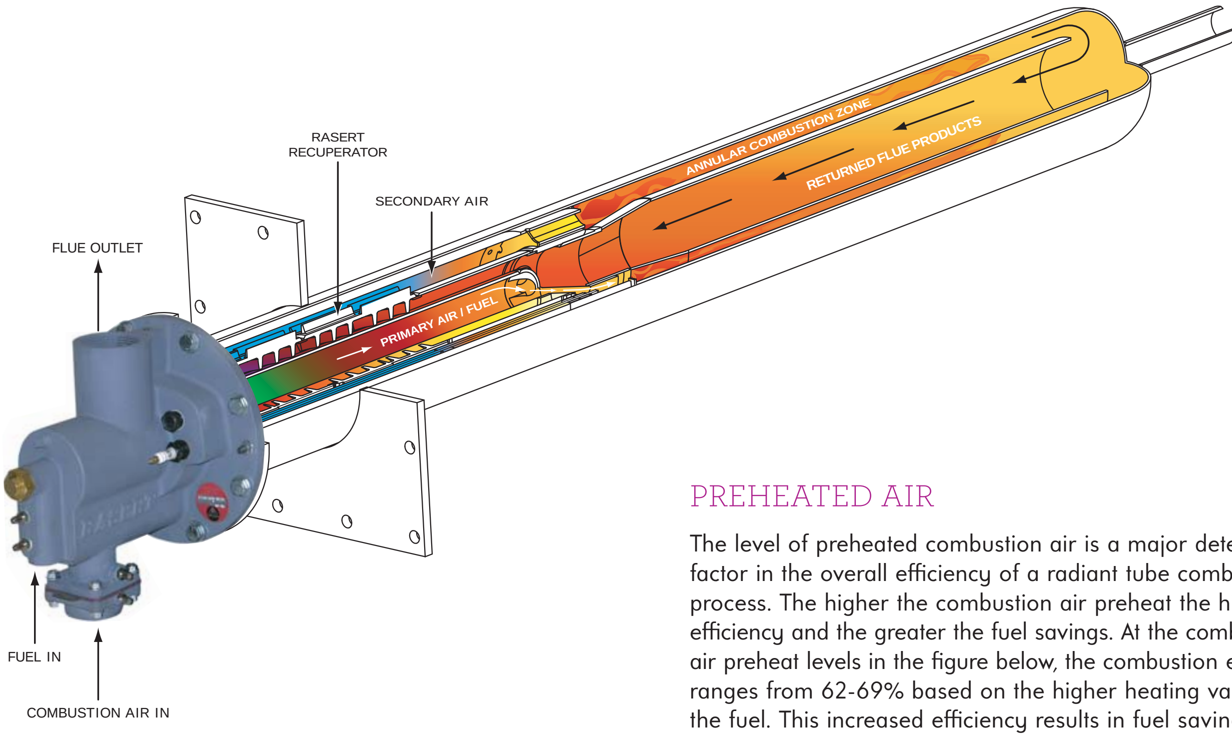
BURNER CAPACITY

The 4748-650 is available in one size. The minimum radiant tube inside diameter for this burner is noted in Table 1 below.

Air capacities will be higher when starting the burner in a cold environment. Air flow will decrease as flue gases and tube temperatures increase. See page 4 for a detailed graph showing flue gas oxygen levels *vs.* radiant tube temperature. Furnace temperatures may cause slight variations in burner capacity. Page 4 has further information on radiant tube sizing.

Table 1

Burner designation	Air Capacity (scfh at 1650 F furnace temperature) with burner air supply pressure of				Radiant Tube inside diameter inches
	1 osi	4 osi	9 osi	16 osi	
4748-650	425	850	1300	1750	6.50 - 7.38



PRINCIPLES of OPERATION

When the combustion air enters the 4748 RASERT™ burner, it is split into primary and secondary air streams. The primary air, which is approximately 25% of the total air, is combined with all of the fuel and is used to induce FGR (flue gas recirculation) from the flue. This air/fuel/FGR mix then travels down a tube in the center of the burner's integrated recuperator towards the flame stabilizer.

The secondary air stream also induces and mixes with FGR in the burner body. It travels down the outside of the recuperator towards the flame stabilizer. The integrated recuperator preheats the combustion air, fuel and FGR with heat recovered from the waste flue gas as it travels in the annular gap between the primary air tube and the outer wall of the recuperator casting. The actual secondary air preheat achieved is dependent on the application, but it is generally over 1100°F in furnaces running at 1600°F.

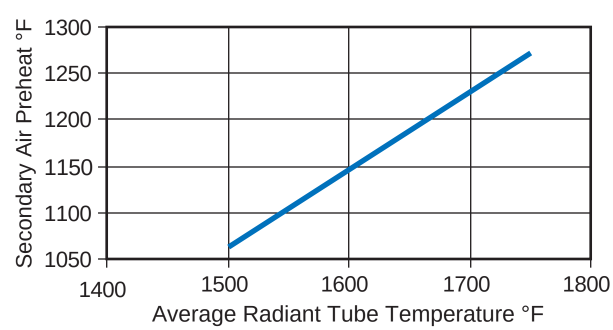
When the primary air (with added fuel and FGR) and secondary air reach the stabilizer they are reintroduced and ignited in the annular space around the combustion tube and inside the stabilizer can. The stabilizer is designed to delay some of the combustion so the flame can be spread out along the length of the radiant tube, which helps provide uniform temperature distribution.

When the products of combustion reach the end of the radiant tube they enter the center combustion tube and travel back towards the recuperator and burner. When the flue gas reaches the burner body some of it is used as FGR and the rest exits through the flue outlet.

PREHEATED AIR

The level of preheated combustion air is a major determining factor in the overall efficiency of a radiant tube combustion process. The higher the combustion air preheat the higher the efficiency and the greater the fuel savings. At the combustion air preheat levels in the figure below, the combustion efficiency ranges from 62-69% based on the higher heating value of the fuel. This increased efficiency results in fuel savings of up to 50% compared to conventionally fired ambient air burners.

The temperature of the preheated air generated by an internal recuperator is dependent on the flue gas temperature and flow, and the design of the heat exchanger element. The air in the 4748 RASERT burner is split into primary and secondary streams, that travel in separate paths through the heat exchanger elements. Approximately 75% of the air travels around the outside of the heat exchanger in the secondary air stream. The graph below shows a typical relationship of the secondary air temperature to the average radiant tube temperature, where the burner is operating at 16 osi air pressure with approximately 3% O_2 in the flue gas exiting the burner.



CONSTRUCTION

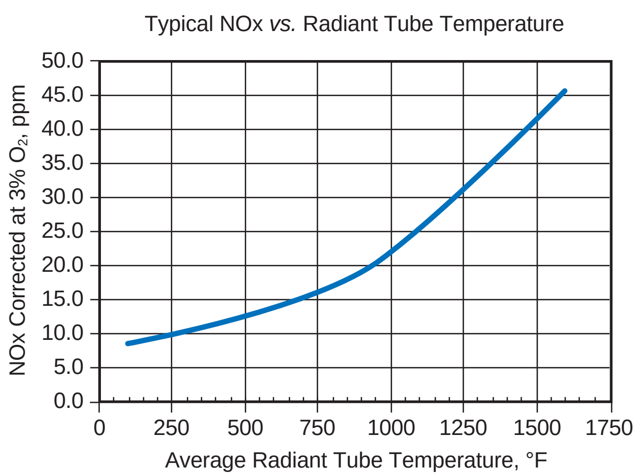
The burner body is constructed of sturdy ductile iron, and includes a built-in V-port fuel adjustment plug, observation ports, a flanged air connection, and built-in air and gas meters. The recuperator is made from a series of high temperature alloy investment castings, as is the stabilizer.

NOx SUPPRESSION TECHNOLOGIES

The annular combustion in the North American RASERT™ burner inherently results in lower combustion temperatures hence lower NOx emissions. Additionally, other NOx suppression techniques, including air staging and self recirculating FGR (flue gas recirculation) are used. Air staging works by adding the air to the fuel in controlled "stages" which delays combustion, and reduces the concentration of oxygen in the hottest part of the flame. It also helps maintain temperature uniformity on the radiant tube.

The 4748 design internally entrains FGR into the combustion air streams. The addition of FGR lowers the peak flame temperature by reducing the concentration of oxygen in the combustion air. The reduction of peak temperature greatly lowers the amount of NOx generated in the flame.

The graph below shows typical NOx in the flue of a 4748-650 RASERT burner, operating with 140 cfh natural gas. The flue gases exit the burner at approximately 1050°F and the burner combustion air is preheated to approximately 1200°F.



LIGHTING ARRANGEMENTS

Ignition on the 4748 burner is provided by a direct spark igniter located on the main burner body. The spark should be turned on before opening the burner gas valve. After the burner is lit, the spark must be turned off for proper burner operation. During the ignition period, a continuous 6000 volt (minimum) spark is required. Spark distributor systems and half wave transformers are not as reliable as conventional continuous ignition transformers. The 4748 can not be lit with a torch at the exhaust exit in a cold tube.

FLAME SUPERVISION

An air purged sight tube is available that will allow UV flame detectors to be used with the North American 4748 RASERT. The sight tube is purged with air from a small tube attached to the burner body. The use of the air purge will increase the NOx by approximately 10%. The sight tube has a ½" NPT male fitting which will fit many UV flame detector cells without additional adapters. See Bulletin 8832 for additional choices of flame detectors and adapters, which must be ordered separately.

The RASERT burner has been tested as explosion resistant as defined in NFPA86 2003 Section 3.3.16.

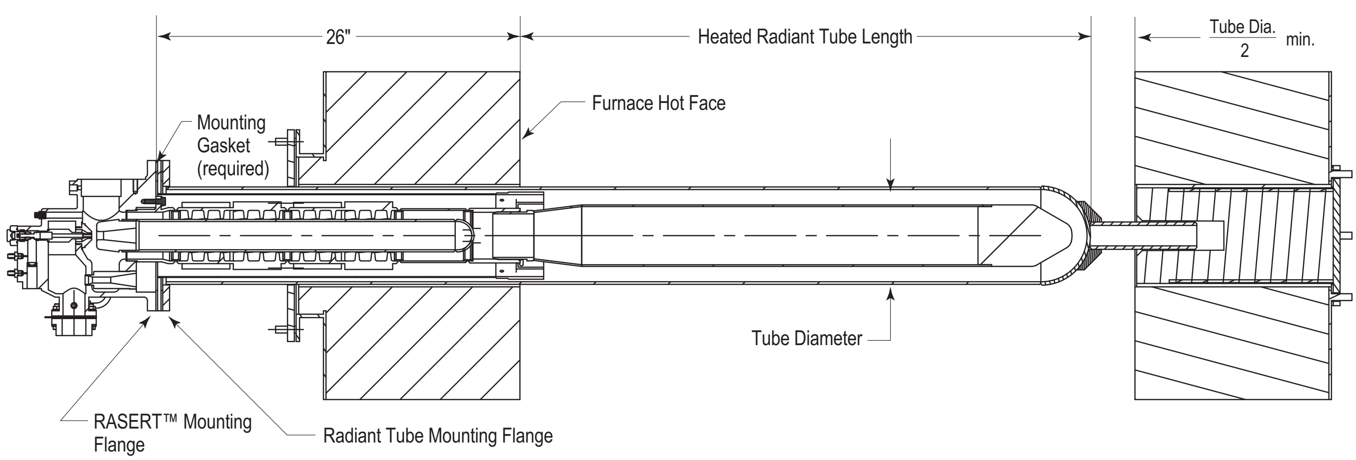
INSTALLATION CONSIDERATIONS

The radiant tube mounting flange should be located 26 inches from the hot face of the furnace wall. This will ensure that the stabilizer is "inside the furnace" and not in the furnace wall. If the radiant tube is not long enough to meet this requirement, a spool piece should be added to the radiant tube to make up the distance.

The fire tube inside the radiant tube must be engineered for each application. Besides identifying the proper material, it must be sized for the outlet of the burner, the length of the furnace, and the inside diameter of the radiant tube.

The flue gas exits the burner from a connection on the main burner body, and is sized to fit standard pipe. To find the specific size see the dimension chart on sheet 4748-1. The exhaust connection will typically be a "stub stack", discharging at an air break into a collection header. Additional exhaust system back pressure should be avoided as it will effect burner capacity and NOx suppression.

Typical RASERT Mounting



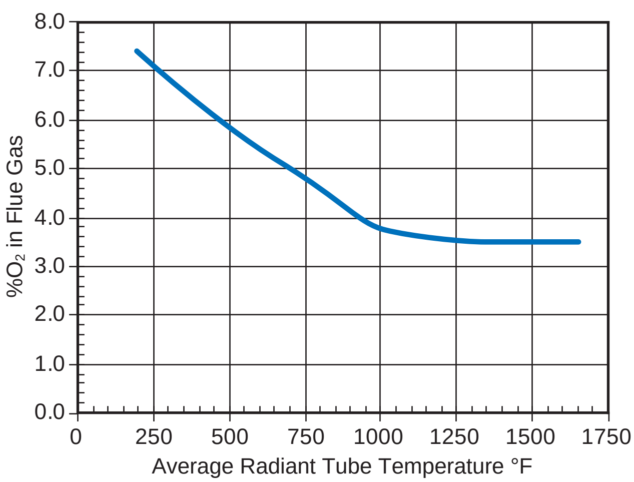
CONTROL and ADJUSTMENT

The 4748 burner fuel/air ratio can be controlled with a simple cross-connected ratio regulator such as the North American 7216. For firing rate control the burner can use conventional on-ratio turndown, StepFire™ or pulse firing. Since most of the pressure drop through the burner is taken in the relatively cool orifices in the burner body before the full preheat temperature is reached, the ratio will not shift as much as it dœs in typical hot air burner systems.

When setting up the burner for the first time the high fire ratio should be set so the exhaust gas is 6-8% O_2. Once the process gets to its maximum temperature the fuel/air ratio can be re-set to the final desired setting of 3-4% O_2 in the exhaust. The low fire ratio may need to be set at a higher O_2 level to avoid CO when the burner gœs to low fire.

The graph below shows the decrease in O_2 recorded in the flue stack as the radiant tube heats up from a cold start to a 1650°F tube temperature.

Typical Flue gas O_2 *vs.* Average Tube temperature O_2



HEAT FLUX and BURNER SIZING

There are a number of important considerations when matching a 4748 RASERT to a radiant tube. The most obvious is the diameter of the burner and the I.D. of the radiant tube, but it is also important to not over fire the tube.

The heat flux of the tube is the amount of heat that is being transferred through the tube. It is often expressed as Btu/hr transferred per square inch of effective tube surface area (Btu/hr/in^2). The total amount of heat transferred through the tube can be found by multiplying the burner input by the available heat. (example: 140 cfh gas × 1,000 Btu/cf × 68% available heat = 95,200 Btu/hr) The effective tube surface area is simply the area of the radiant tube inside the furnace, and dœs not include tube surface inside the walls. (*Example*: 7.56 × p × 58" = 1378 in^2.) So for this example tube and firing rate: 95,200 Btu/hr/1378 in.^{2} = 69.1 Btu/hr/in^2.

The maximum heat flux possible is dependent on a number of factors including maximum tube temperature, tube uniformity, and inner and outer tube material. The peak temperature on a radiant tube determines the material selection. The combustion tube on a 4748 RASERT will run approximately 125°F hotter than the radiant tube temperature. The more uniform the temperature distribution on the radiant tube, the more heat can be transferred to the furnace load without over-firing the tube. In a 1500°F furnace heat flux should generally be kept under 85 Btu/hr/in^2. As the furnace temperature increases the maximum heat flux that can be applied to the tube decreases. At a furnace temperature of 1850°F the heat flux should be no higher than 50 Btu/hr/in^2.

ORDERING INFORMATION

Each RASERT configuration must be individually quoted. Information required to quote burners includes the quantity and firing rate of each burner, radiant tube diameter and length, furnace wall thickness (drawings preferred) and furnace temperature. Contact a North American Sales Representative or our Cleveland Office for more information.

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. Parts of this product may exceed 160F in operation and present a contact hazard. Fives North American Combustion, Inc. urges compliance with National Safety Standards and Insurance Underwriters' recommendations, and care in operation.

fives ultimate machines ultimate factory

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