Specifications / Design Details

Radiant Energy - source and transfer

The quantity of radiant energy the RadMax™ Burner system is capable of supplying is a function of the surface area, emissivity and temperature of the burner tile(s). The effective surface area of a Type 25, Type 50 or Type 13 burner tile is **0.37 ft² (0.034 m²)**. Emissivity is defined as the measure of the ability of a material to radiate energy. It is expressed as a number from 0.0 – 1.0. The nominal emissivity for the RadMax™ Burner tile is **0.92** @ 1500°F (815°C) or **0.94** at room temperature. The maximum operating temperature for the RadMax™ Burner tile is 1650°F (900°C).

To determine the radiant heat transfer or heat flux from the RadMax™ Burner system to the work, the temperature and emissivity of the work must be known. Refer to the following table to determine the maximum heat flux between one square foot of RadMax™ Burner and the work at a given temperature. Correct for the emissivity of the work by multiplying the value from the table by the work's emissivity. (The table is corrected for the burner tile's emissivity.)

For example, if we assume the work temperature is 200°F and its emissivity is 0.80, the energy transfer rates per square foot at various tile temperatures are as illustrated below.

RadMax™ Burner tile temperature = 1400°F
From the table below, we determine
the heat flux to be 18,600 Btu/ft²/hr x 0.80 emissivity

= 14,880 Btu/ft²/hr

RadMax™ Burner tile temperature = 1600°F
From the table below, we determine
the heat flux to be 28,000 Btu/ft²/hr x 0.80 emissivity

= 22,400 Btu/ft²/hr

Metric table appears on next page.

Radiant Heat Transfer Rate (in 1000's Btu/ft²/hr)

Temperature of Work °F [1]	Temperature of RadMax™ Burner Tile (°F) (Emissivity corrected for temperature)											
	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650
0	9.4	10.6	12.0	13.5	15.1	16.9	18.8	20.9	23.2	25.6	28.2	31.0
100	9.3	10.5	11.9	13.4	15.0	16.8	18.8	20.8	23.1	25.5	28.1	30.9
200	9.1	10.4	11.8	13.3	14.9	16.7	18.6	20.7	22.9	25.4	28.0	30.8
300	8.9	10.2	11.5	13.0	14.7	16.5	18.4	20.5	22.7	25.1	27.8	30.6
400	8.6	9.8	11.2	12.7	14.3	16.1	18.0	20.1	22.4	24.8	27.4	30.2
500	8.1	9.3	10.7	12.2	13.9	15.6	17.6	19.7	21.9	24.3	26.9	29.7
600	7.4	8.7	10.1	11.6	13.2	15.0	16.9	19.0	21.3	23.7	26.3	29.1
700	6.6	7.8	9.2	10.7	12.3	14.1	16.0	18.1	20.4	22.8	25.4	28.2
800	5.4	6.7	8.1	9.6	11.2	13.0	14.9	17.0	19.3	21.7	24.3	27.1
900	4.0	5.3	6.6	8.1	9.8	11.6	13.5	15.6	17.9	20.3	22.9	25.7
1000	2.2	3.5	4.8	6.4	8.0	9.8	11.7	13.8	16.1	18.5	21.1	24.0
1100	---	1.3	2.7	4.2	5.8	7.6	9.6	11.7	13.9	16.4	19.0	21.8
1200	---	---	---	1.5	3.2	5.0	6.9	9.0	11.3	13.7	16.4	19.2
1300	---	---	---	---	---	1.8	3.8	5.9	8.1	10.6	13.2	16.0
1400	---	---	---	---	---	---	---	2.1	4.4	6.8	9.5	12.3
1500	---	---	---	---	---	---	---	---	---	2.5	5.1	7.9
1600	---	---	---	---	---	---	---	---	---	---	---	2.8

[1] Emissivity = 1.0

Specifications / Design Details

Radiant Energy - source and transfer *(continued)*

To determine the radiant heat transfer or heat flux from the RadMax™ Burner system to the work, the temperature and emissivity of the work must be known. Refer to the following table to determine the maximum heat flux between one square meter of RadMax™ Burner and the work at a given temperature. Correct for the emissivity of the work by multiplying the value from the table by the work's emissivity. (The table is corrected for the burner tile's emissivity.)

For example, if we assume the work temperature is 93°C and its emissivity is 0.80, the energy transfer rates per square foot at various tile temperatures are as illustrated below.

RadMax™ Burner tile temperature = 760°C
From the table below, we determine
the heat flux to be 58 kW/m^2 x 0.80 emissivity

= 46.6 kW/m^2

RadMax™ Burner tile temperature = 870°C
From the table below, we determine
the heat flux to be 87.6 kW/m^2 x 0.80 emissivity

= 70 kW/m^2

Radiant Heat Transfer Rate (in kW/m^2)

| Temperature of Work °C [1]	Temperature of RadMax™ Burner Tile (°C) (Emissivity corrected for temperature)												
	600	625	650	675	700	725	750	775	800	825	850	875	900
0	30.4	34.0	37.9	42.2	46.8	51.7	57.1	62.8	68.9	75.5	82.5	89.9	97.9
50	30.1	33.7	37.7	41.9	46.5	51.4	56.8	62.5	68.6	75.2	82.2	89.7	97.6
100	29.7	33.3	37.2	41.5	46.1	51.0	56.3	62.0	68.2	74.7	81.7	89.2	97.2
150	29.0	32.6	36.5	40.8	45.4	50.3	55.7	61.4	67.5	74.1	81.1	88.6	96.5
200	28.0	31.7	35.6	39.9	44.4	49.4	54.7	60.4	66.6	73.1	80.1	87.6	95.6
250	26.7	30.4	34.3	38.5	43.1	48.1	53.4	59.1	65.3	71.8	78.9	86.3	94.3
300	25.0	28.6	32.6	36.8	41.4	46.4	51.7	57.4	63.6	70.1	77.1	84.6	92.6
350	22.7	26.4	30.3	34.6	39.2	44.1	49.5	55.2	61.3	67.9	74.9	82.4	90.4
400	19.9	23.5	27.4	31.7	36.3	41.3	46.6	52.3	58.5	65.0	72.1	79.6	87.5
450	16.3	19.9	23.8	28.1	32.7	37.7	43.0	48.8	54.9	61.5	68.5	76.0	84.0
500	11.8	15.5	19.4	23.7	28.3	33.3	38.6	44.4	50.5	57.1	64.2	71.7	79.7
550	6.4	10.1	14.1	18.4	23.0	28.0	33.3	39.1	45.2	51.8	58.9	66.4	74.4
600	---	3.7	7.6	11.9	16.6	21.6	26.9	32.7	38.9	45.5	52.5	60.0	68.1
650	---	---	---	4.3	9.0	14.0	19.3	25.1	31.3	37.9	45.0	52.5	60.5
700	---	---	---	---	---	5.0	10.4	16.2	22.4	29.0	36.1	43.7	51.7
750	---	---	---	---	---	---	---	5.8	12.0	18.7	25.8	33.3	41.4
800	---	---	---	---	---	---	---	---	---	6.7	13.8	21.4	29.4
850	---	---	---	---	---	---	---	---	---	---	---	7.6	15.7

[1] Emissivity = 1.0

Specifications / Design Details

Absorption Charts and Wave Lengths

A second important consideration in any radiant application is the **wave length of radiation generated. As the heater surface temperature increases, the wave length of the radiant energy generated decreases.** To get the most efficiency from the radiant dryer, generate a wave length of infrared that will be absorbed by the product to be heated. It does little or no good to increase the generator surface temperature in order to get more energy released per square foot and generate wave lengths of radiation that passes through the product much like light passes through a window glass.

Select the proper range of wave lengths by using a radiation absorption chart for the product to be heated. The water absorption chart below will provide a graphic view of those wave lengths of infrared that will be most readily absorbed by water. As seen from the absorption curve, there are two ranges of wave length that fall under the maximum portion of the curve. The first range includes radiation from 5.3 to 7 microns in length and an emitter surface temperature range from 280°F to 530°F (140°C to 270°C). The second range of maximum efficiency is 2.55 to 2.9 microns in wave length and 1330°F to 1600°F (720°C to 870°C).

Many try to increase drying capacity by increasing the burner input and face temperature. As the chart indicates, system efficiency could drop by over 70% when going above 1600°F (870°).

KELVEN° CENTIGRADE° F° RANKIN°   MICRON-u   BTU-SQ-F.T-HR   RELATIVE H₂O ABSORPTION
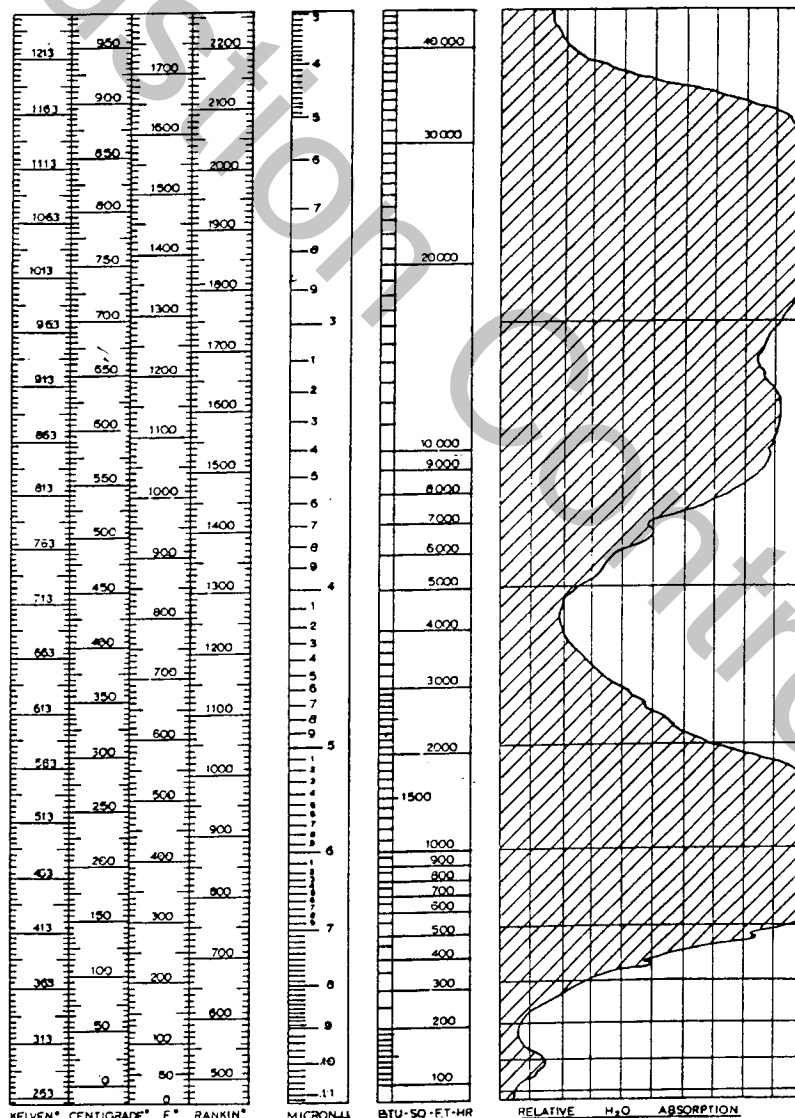
Specifications / Design Details

NOx and Face Temperature vs. Excess Air

This chart represents the relationship between NOx emissions and face temperature versus percent of excess air. Actual readings may vary according to operating conditions.
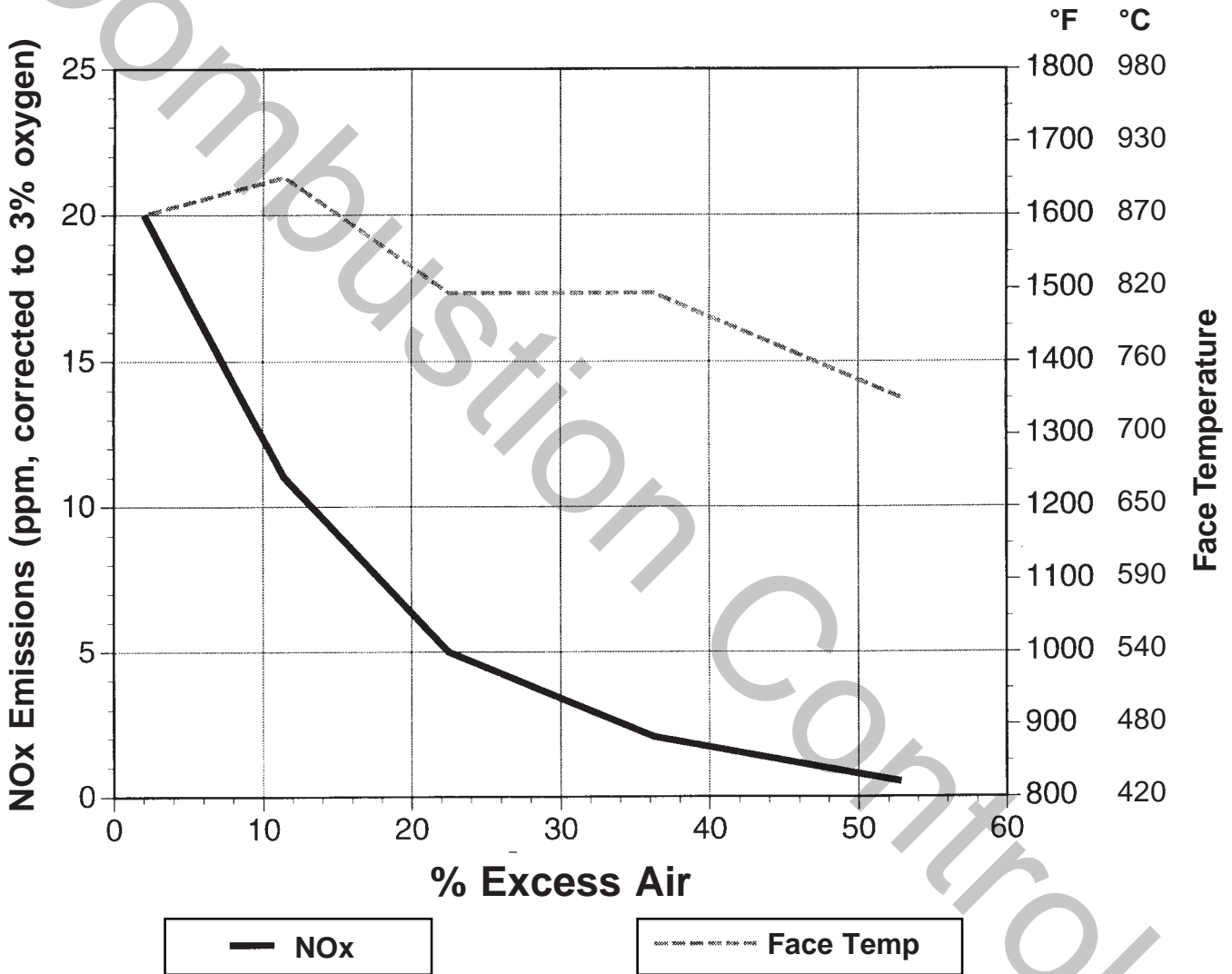
Specifications / Design Details

Sample Calculations

The following is a sample set of calculations to show the steps required to determine the number of burner heads and burner rows in a given application.

Typical application for Maxon RadMax™ Burner is preheating material for powder coating.
Material to be heated: Steel Sheet Metal, 10 Ga.
Dimensions: 4 ft. x 10 ft.
Temperature Requirements: $65°$ F = initial temp
                                    $400°$ F = final temp
Time to reach final temp: 1 minute
Belt Speed: 20 feet/minute

Step 1
Select operating temperature of Maxon RadMax™ Burner of $1500°$ F. (The RadMax™ operates between $1050°$ and $1650°$ F. Selecting $1500°$ F allows for a good "mid-range" should the operating temperatures require adjustment after installation.)

Step 2
Determine the radiant energy transfer for the operating temperatures in Btu/ft^2 hr. According to the chart on page 1403, for a product temperature of $400°$ F and an emitter temperature of $1500°$ F, the radiant energy transfer is 22,400 Btu/ft^2 hr. Keep in mind that this energy transfer is for only **one** side of the product.

Step 3
Heating the material the thickness of 16 gauge only, determine the weight per square foot of the material. For 16 gauge (.0598") cold rolled steel sheet, this value is 2.50 lb/ft^2.

Step 4
Determine the specific heat of the product. For steel, c_p = 0.11 Btu/lb $°$F.

Step 5
From the above information, we can now determine the heating capacity per square foot.

(2.50 lb/ft^2)(0.11 Btu/lb $°$F)($400°$ F - $65°$ F) =

       92.13 Btu/hr ft^2

Step 6
Applying the heat-up time of 1 minute we get:

92.13 Btu/hr ft^2 x 60 min/hr = 5,528 Btu/ft^2

This is based on an emissivity of 1.0, or 100% of the energy absorbed.

Step 7
Assuming an emissivity of 0.8, our design radiant density is (5,528 Btu/ft^2)/0.5 = **6,910 Btu/ft^2**
This is the radiant density required to heat our material from $65°$ F to $400°$ F in one minute.

Step 8
If we multiply this radiant density by the area of the material we get:

(6,910 Btu/ft^2)x(4 ft)x(10 ft) = 276,400 Btu/hr

We then divide by the radiant energy transfer (from Step 2) to get:

(276,400 Btu/hr) / (22,400 Btu/ft^2 hr) = 12.3 ft^2 of burner **required per side**

To determine the number of burner heads required, simply divide the total area per side by the area of the burner head, which is 0.37 ft^2.

(12.3 ft^2) / (0.37 ft^2/burner head) = 33.2 burner heads per side

Step 9
Determine and identify the zoning of the burner system, if any.

Step 10
Select the burner type (i.e., type 13, 25, or 50). For this particular application we choose (7) rows of the 5-25 RadMax™ Burner per side. This provides us with 35 burner heads at a length of approximately 56 inches per row (see page 1409).

NOTE: Powder coating requires material to be heated approximately the thickness of 16 gauge per side.

Step 11
Determine the fuel input to the burners.

(35 burner heads)x(25,000 Btu/hr burner head) =

875,000 Btu/hr per side x 2 = 1,750,000 Btu/hr

This is the **input** required to the burner. Select an appropriate premix system to provide this heat input.

Capacities and Specifications

RadMax™ Type 13/25/50 Burner Head

Manifold Pressure	"w.c.	2	3	4	4.5 (nominal)	5	6
Combustion Air Flow	SCFH	205	252	291	308	326	357
Maximum Capacity	Btu/hr	17,800	20,700	23,500	24,925	26,200	28,500
Fuel Flow at Maximum	SCFH	17.8	20.7	23.5	24.9	26.2	28.5
Minimum Capacity	Btu/hr	10,800	14,100	16,600	18,000	19,300	21,700
Fuel Flow at Minimum	SCFH	10.8	14.1	16.6	18.0	19.3	21.7
Face Temperature Range	°F	1050-1483	1110-1537	1130-1569	1150-1590	1173-1611	1200-1659

Direct Spark/Flame Sensor Port

Manifold Pressure	"w.c.	2	3	4	4.5 (nominal)	5	6
Combustion Air Flow	SCFH	66	77	87	93	97	106
Maximum Capacity	Btu/hr	5,340	6,210	7,050	7,478	7,860	8,550
Fuel Flow at Maximum	SCFH	5.3	6.2	7.1	7.5	7.9	8.6

RadMax™ Type 13/25/50 Burner Head (metric data)

Manifold Pressure	mbar	5.0	7.5	10.0	11.2 (nominal)	12.4	14.9
Combustion Air Flow	(n)m³/hr	5.80	7.15	8.25	8.72	9.23	10.12
Maximum Capacity	kW	5.2	6.1	6.9	7.3	7.7	8.4
Fuel Flow at Maximum	(n)m³/hr	0.50	0.59	0.67	0.71	0.74	0.81
Minimum Capacity	kW	3.2	4.1	4.9	5.3	5.7	6.4
Fuel Flow at Minimum	(n)m³/hr	0.31	0.40	0.47	0.51	0.55	0.61
Face Temperature Range	°C	566-806	599-836	610-854	621-866	634-877	649-904

Direct Spark/Flame Sensor Port

Manifold Pressure	mbar	5.0	7.5	10.0	11.2 (nominal)	12.4	14.9
Combustion Air Flow	(n)m³/hr	1.88	2.18	2.48	2.63	2.76	3.00
Maximum Capacity	kW	1.6	1.8	2.1	2.2	2.3	2.5
Fuel Flow at Maximum	(n)m³/hr	0.15	0.18	0.20	0.21	0.22	0.24

NOTE: Most systems are designed to nominal capacities. Reduced or extended capacities are possible. RadMax™ should not be installed in ovens/ chambers above 500°F. Contact Maxon for more information.

Face Temperature Range for Various Firing Rates

Legend:
- 2"w.c. Manifold Pressure
- 3"w.c. Manifold Pressure
- 4"w.c. Manifold Pressure
- 4.5"w.c. Manifold Pressure
- 5"w.c. Manifold Pressure
- 6"w.c. Manifold Pressure

Tile Temperature (F) vs. Fuel Flow - Natural Gas (SCFH)

Capacities and Specifications

Type 13 RadMax™ Burners

| Inlet Size	Number of Burner Heads	Nominal Capacity (Btu/hr)	Type 13 (end-to-end) Assembly		Manifold Size (in inches)
			Designation	Face Width (in inches)	
1-1/2"	2	50,000	2 - 13	31.62	2 x 2
	3	75,000	3 - 13	47.46	
	4	100,000	4 - 13	63.31	
	5	125,000	5 - 13	79.15	
	6	150,000	6 - 13	94.99	
	7	175,000	7 - 13	110.84	
	8	200,000	8 - 13	126.68	
2"	9	225,000	9 - 13	142.53	2 x 3
	10	250,000	10 - 13	158.37	

Type 25 and Type 50 RadMax™ Burners

Inlet Size	Number of Burner Heads	Nominal Capacity (Btu/hr)	Type 25 (end-to-end) Assembly		Type 50 (side-to-side) Assembly		Manifold Size (in inches)
			Designation	Face Width (in inches)	Designation	Face Width (in inches)	
1-1/2"	3	75,000	3 - 25	33.57	3 - 50	16.64	2 x 2
	4	100,000	4 - 25	44.82	4 - 50	22.27	
	5	125,000	5 - 25	56.07	5 - 50	27.89	
	6	150,000	6 - 25	67.32	6 - 50	33.52	
	7	175,000	7 - 25	78.57	7 - 50	39.14	
	8	200,000	8 - 25	89.82	8 - 50	44.77	
2"	9	225,000	9 - 25	101.07	9 - 50	50.39	2 x 3
	10	250,000	10 - 25	112.32	10 - 50	56.02	
	11	275,000	11 - 25	123.57	11 - 50	61.64	
	12	300,000	12 - 25	134.82	12 - 50	67.27	
	13	325,000	13 - 25	146.07	13 - 50	72.89	
2-1/2"	14	350,000	14 - 25	157.32	14 - 50	78.52	2 x 4
	15	375,000	15 - 25	168.57	15 - 50	84.14	
	16	400,000	---	---	16 - 50	89.77	
	17	425,000	---	---	17 - 50	95.39	
	18	450,000	---	---	18 - 50	101.02	
3" *	19	475,000	---	---	19 - 50	106.64	2 x 5
	20	500,000	---	---	20 - 50	112.27	
	21	525,000	---	---	21 - 50	117.89	
	22	550,000	---	---	22 - 50	123.52	
	23	575,000	---	---	23 - 50	129.14	
	24	600,000	---	---	24 - 50	134.77	
	25	625,000	---	---	25 - 50	140.39	
	26	650,000	---	---	26 - 50	146.02	

* Maximum inlet size for bottom inlet is 2-1/2" NPT
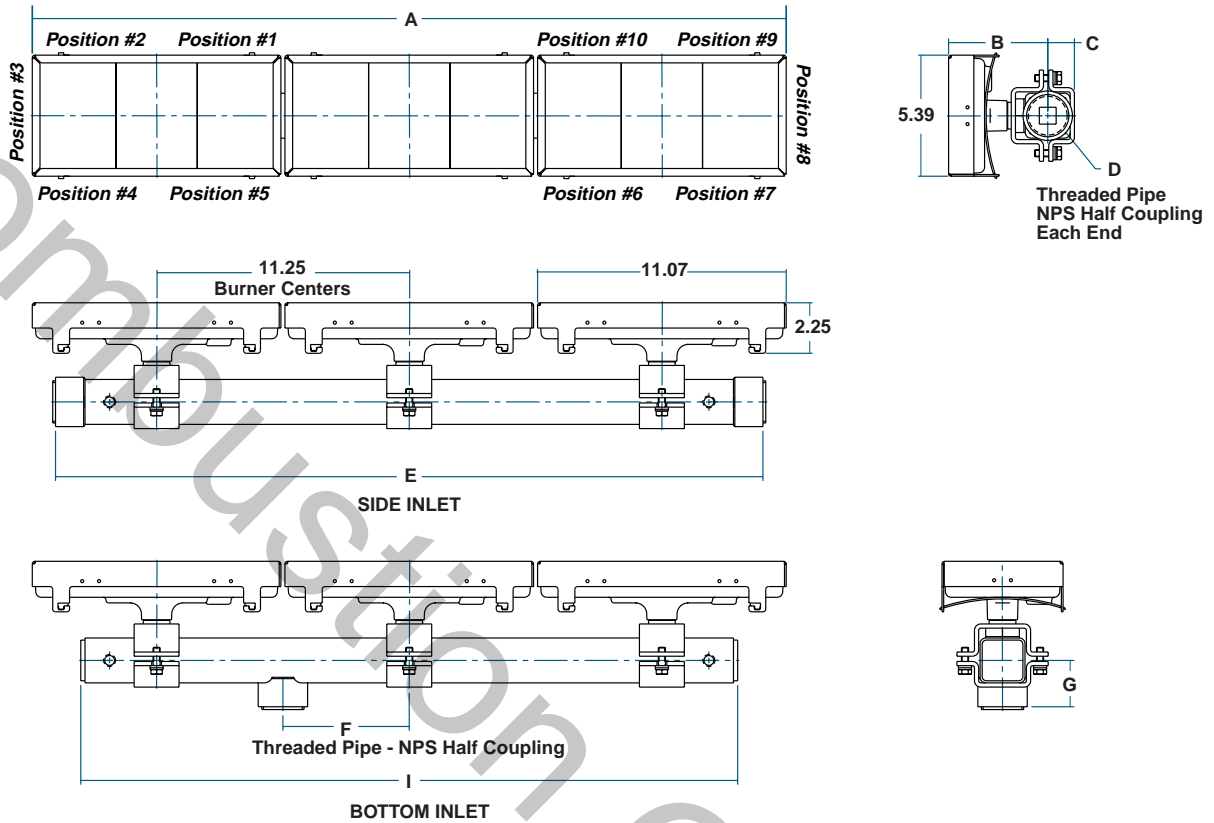
Dimensions *(in inches)*

Type 13 RadMax™ Burner

SIDE INLET
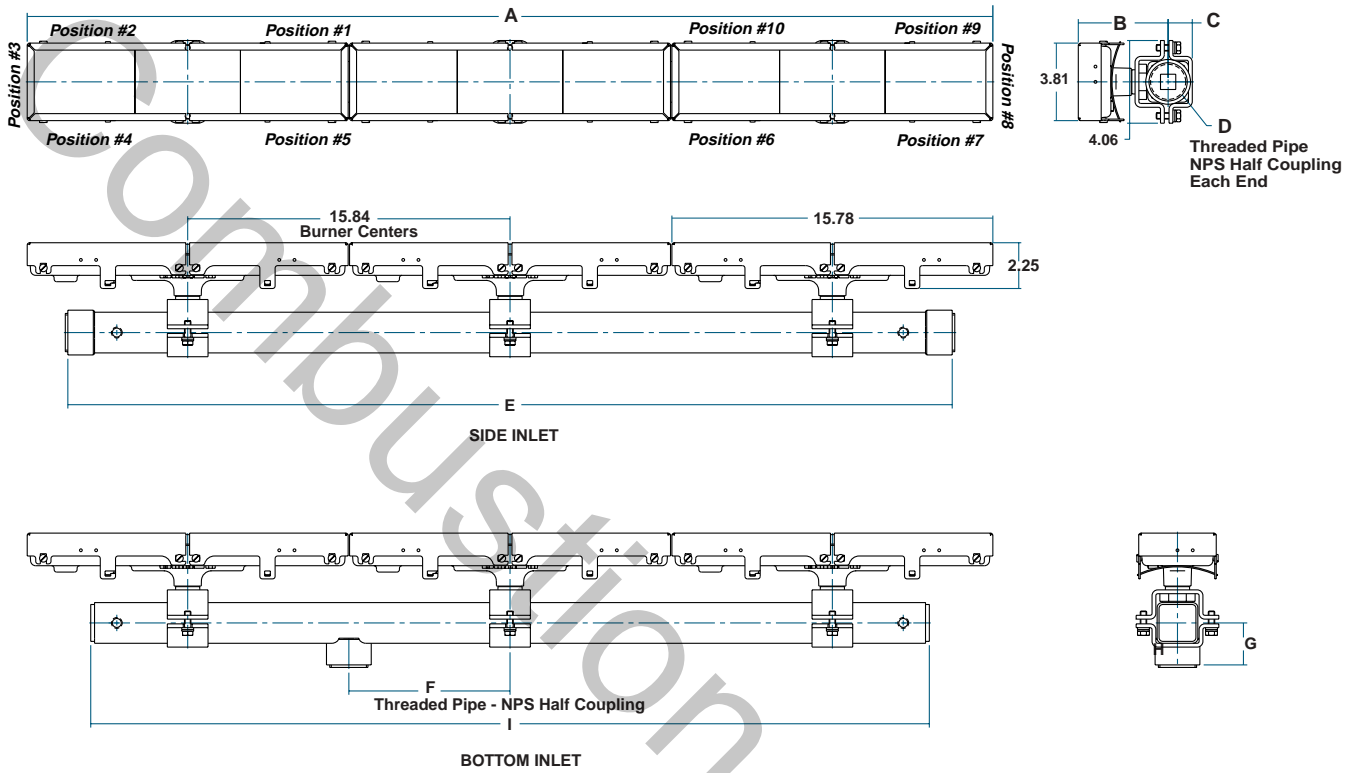
BOTTOM INLET

Type 13 RadMax™ Burner

Burner Size	A	B		C	D	E	F Bottom Inlet Only	G Bottom Inlet Only	H # of Inlets (Bottom Inlet)	I
		Standard	Extended Length							
2-13	31.62	4.42	5.42	1.19	1-1/2" NPT	27.63	0.00	2.06	1	25.38
3-13	47.46	4.42	5.42	1.19	1-1/2" NPT	43.47	7.92	2.06	1	41.22
4-13	63.31	4.42	5.42	1.19	1-1/2" NPT	59.31	0.00	2.06	1	57.06
5-13	79.15	4.42	5.42	1.19	1-1/2" NPT	75.16	7.92	2.06	1	72.91
6-13	94.99	4.42	5.42	1.19	1-1/2" NPT	91.00	15.84	2.06	2	88.75
7-13	110.84	4.42	5.42	1.19	1-1/2" NPT	106.84	23.77	2.06	2	104.59
8-13	126.68	4.42	5.42	1.19	1-1/2" NPT	122.69	31.69	2.06	2	120.44
9-13	142.53	4.92	5.92	1.69	2" NPT	138.66	39.61	2.62	2	136.28
10-13	158.37	4.92	5.92	1.69	2" NPT	154.50	47.53	2.62	2	152.13

Dimensions *(in inches)*

Type 25 RadMax™ Burner

Threaded Pipe
NPS Half Coupling
Each End
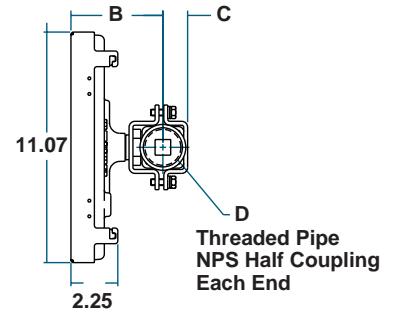
SIDE INLET

Threaded Pipe - NPS Half Coupling

BOTTOM INLET

Type 25 RadMax™ Burner

Burner Size	A	B		C	D	E	F Bottom Inlet Only	G Bottom Inlet Only	H # of Inlets (Bottom Inlet)	I
		Standard	Extended Length							
3-25	33.57	4.42	5.42	1.19	1-1/2" NPT	31.50	5.63	2.06	1	29.25
4-25	44.82	4.42	5.42	1.19	1-1/2" NPT	42.75	0.00	2.06	1	40.50
5-25	56.07	4.42	5.42	1.19	1-1/2" NPT	54.00	5.63	2.06	1	51.75
6-25	67.32	4.42	5.42	1.19	1-1/2" NPT	65.25	0.00	2.06	1	63.00
7-25	78.57	4.42	5.42	1.19	1-1/2" NPT	76.50	16.88	2.06	2	74.25
8-25	89.82	4.42	5.42	1.19	1-1/2" NPT	87.75	22.50	2.06	2	85.50
9-25	101.07	4.92	5.92	1.69	2" NPT	99.13	28.13	2.62	2	96.75
10-25	112.32	4.92	5.92	1.69	2" NPT	110.38	22.50	2.62	2	108.00
11-25	123.57	4.92	5.92	1.69	2" NPT	121.63	28.13	2.62	2	119.25
12-25	134.82	4.92	5.92	1.69	2" NPT	132.88	33.75	2.62	2	130.50
13-25	146.07	4.92	5.92	1.69	2" NPT	144.13	39.38	2.62	2	141.75
14-25	157.32	5.42	6.42	2.19	2-1/2" NPT	158.63	33.75	3.75	2	153.00
15-25	168.57	5.42	6.42	2.19	2-1/2" NPT	169.88	39.38	3.75	2	164.25

Dimensions *(in inches)*

Type 50 RadMax™ Burner

A

Position #1   Position #8
Position #2
Position #3
Position #7 Position #6
Position #4   Position #5

B   C

11.07

D
Threaded Pipe
NPS Half Coupling
Each End

2.25

5.62
Burner
Centers

5.39

E
SIDE INLET

G

F
Threaded Pipe - NPS Half Coupling

I
BOTTOM INLET
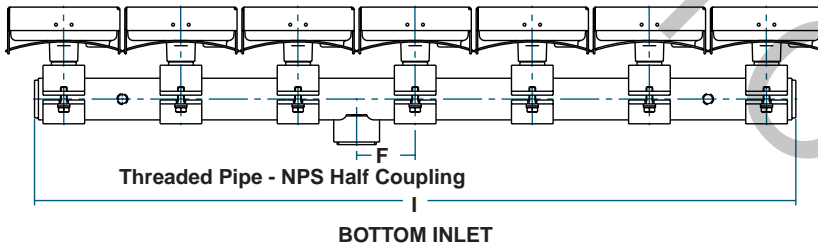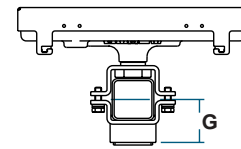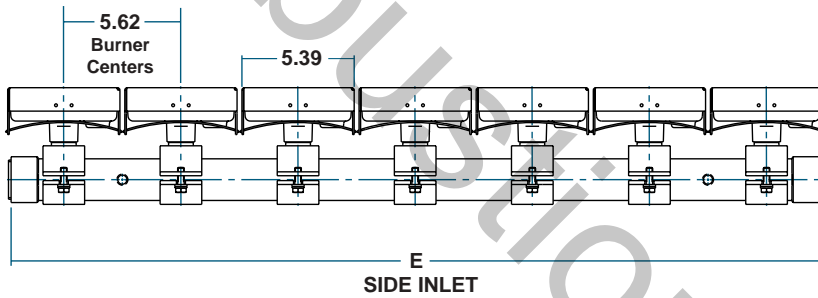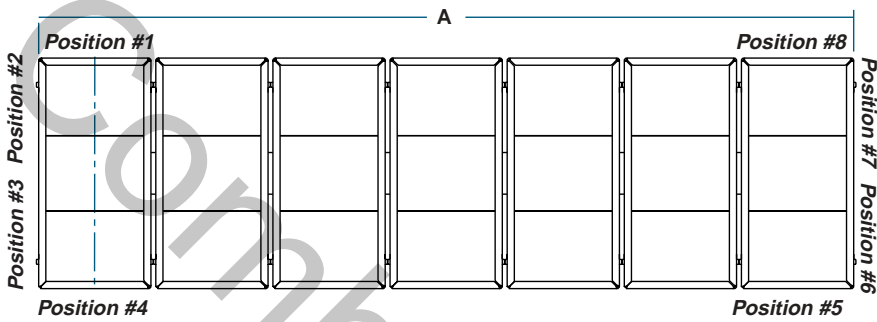
See Page 1413 for additional dimensions

Dimensions *(in inches)*

Type 50 RadMax™ Burner

Burner Size	A	B		C	D	E	F Bottom Inlet Only	G Bottom Inlet Only	H # of Inlets (Bottom Inlet)	I
		Standard	Extended Length							
3-50	16.64	4.42	5.42	1.19	1-1/2" NPT	16.31	2.81	2.06	1	14.06
4-50	22.27	4.42	5.42	1.19	1-1/2" NPT	21.94	0.00	2.06	1	19.69
5-50	27.89	4.42	5.42	1.19	1-1/2" NPT	27.56	2.81	2.06	1	25.31
6-50	33.52	4.42	5.42	1.19	1-1/2" NPT	33.75	0.00	2.06	1	30.94
7-50	39.14	4.42	5.42	1.19	1-1/2" NPT	38.81	2.81	2.06	1	36.56
8-50	44.77	4.42	5.42	1.19	1-1/2" NPT	44.44	0.00	2.06	1	42.19
9-50	50.39	4.92	5.92	1.69	2" NPT	50.19	2.81	2.62	1	47.81
10-50	56.02	4.92	5.92	1.69	2" NPT	55.81	0.00	2.62	1	53.44
11-50	61.64	4.92	5.92	1.69	2" NPT	61.44	2.81	2.62	1	59.06
12-50	67.27	4.92	5.92	1.69	2" NPT	67.06	16.88	2.62	2	64.69
13-50	72.89	4.92	5.92	1.69	2" NPT	72.69	19.69	2.62	2	70.31
14-50	78.52	5.42	6.42	2.19	2-1/2" NPT	81.56	16.88	3.75	2	75.94
15-50	84.14	5.42	6.42	2.19	2-1/2" NPT	87.19	19.69	3.75	2	81.56
16-50	89.77	5.42	6.42	2.19	2-1/2" NPT	92.81	22.50	3.75	2	87.19
17-50	95.39	5.42	6.42	2.19	2-1/2" NPT	98.44	25.31	3.75	2	92.81
18-50	101.02	5.42	6.42	2.19	2-1/2" NPT	104.06	28.13	3.75	2	98.44
19-50	106.64	5.92	6.92	2.69	3" NPT*	111.81	25.31	3.75	2	108.06
20-50	112.27	5.92	6.92	2.69	3" NPT*	117.44	28.13	3.75	2	113.69
21-50	117.89	5.92	6.92	2.69	3" NPT*	123.06	30.94	3.75	2	119.31
22-50	123.52	5.92	6.92	2.69	3" NPT*	128.69	33.75	3.75	2	124.94
23-50	129.14	5.92	6.92	2.69	3" NPT*	134.31	30.94	3.75	2	130.56
24-50	134.77	5.92	6.92	2.69	3" NPT*	139.94	33.75	3.75	2	136.19
25-50	140.39	5.92	6.92	2.69	3" NPT*	145.56	36.56	3.75	2	141.81
26-50	146.02	5.92	6.92	2.69	3" NPT*	151.19	33.75	3.75	2	147.44

*Maximum inlet size for bottom inlet is 2-1/2" NPT

Notes