fostoria®

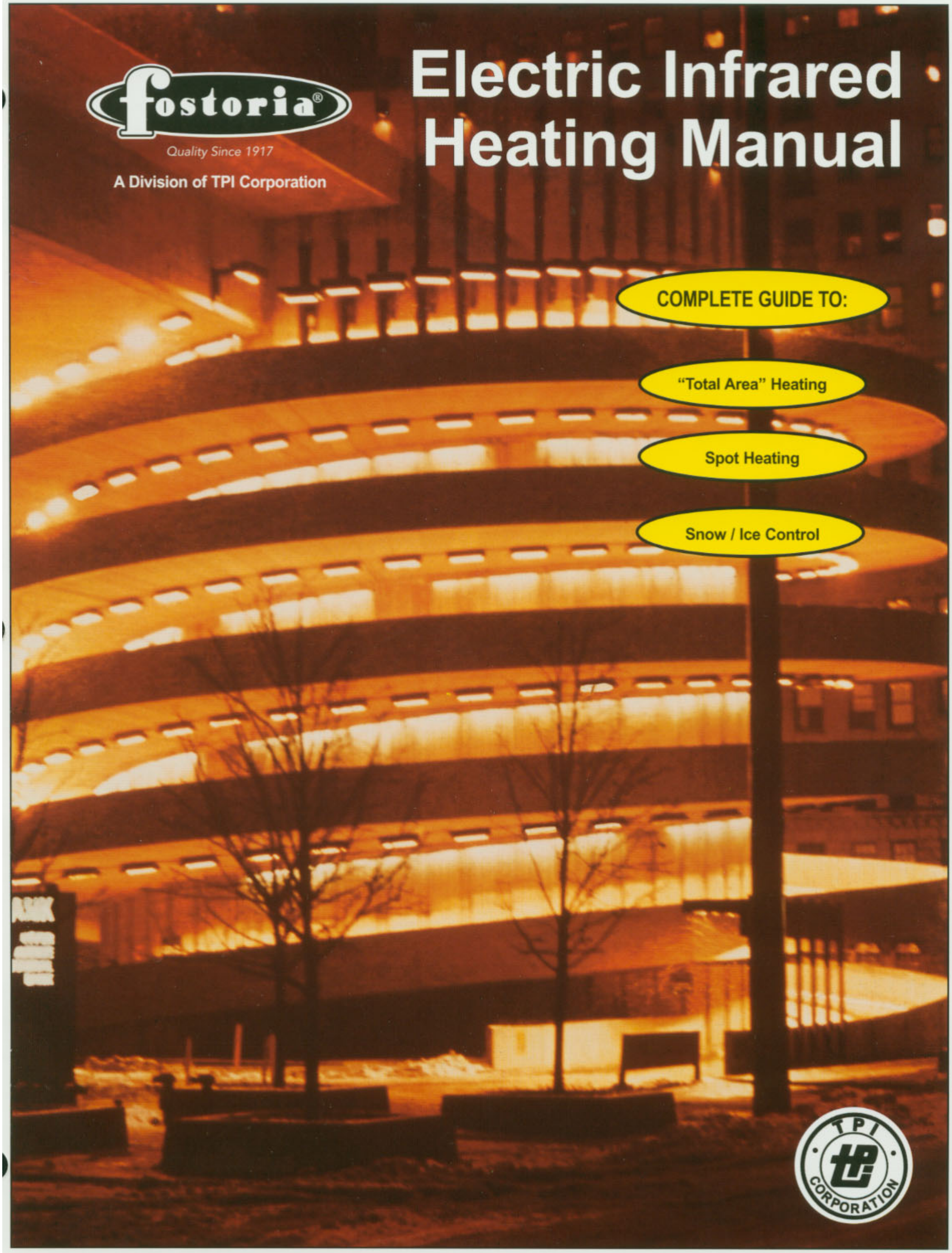
Quality Since 1917

A Division of TPI Corporation

Electric Infrared Heating Manual

COMPLETE GUIDE TO:

- "Total Area" Heating
- Spot Heating
- Snow / Ice Control



TPI CORPORATION

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A LOOK AT FOSTORIA

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Located in Northwest Ohio, Fostoria is a manufacturing area of 15 thousand population. This location provides easy access to major rail lines, air terminals, Interstate 75 and the Ohio Turnpike. Fostoria Industries' 130,000 sq. ft. facility is heated with **electric infrared comfort heat**. In addition, all painted parts pass through one of three electric infrared process heat ovens.

Fostoria Industries is the **largest** and **oldest** manufacturer of electric infrared equipment. In 1917 we began operations by manufacturing replacement fenders and running-boards for automobiles. We diversified in 1932 into the manufacturing of work lights. From our experience in designing reflectors, we quite naturally branched into another new product line in the late 1930's — electric infrared ovens. In 1959 we expanded to **electric infrared comfort heating** (people heating equipment) and were the **first** in the design of the equipment. As time passed and the infrared markets expanded, two separate sales department evolved.

Today the following Departments/Product Lines exist under one corporate head, and at two manufacturing locations in Fostoria and Findlay, OH.

Trimline Series

Mitey Midget

Heavy Duty Metal Sheath Overhead

2 or 3 Lamp MUL-T-Mount

Restaurant Patio

TYPICAL INFRARED USES

- Warehouses
- Airplane Hangars
- Baggage Rooms
- Auditoriums
- Bowling Areas
- Churches
- Factories
- High and Low Bay Industrial Buildings
- Ice Rink/Field Houses
- Soccer Arenas
- Car Washes
- Locker Rooms
- Swimming Pools
- Tennis Courts
- Work Stations
- Walkways
- Building Entrances
- Loading Areas/Docks
- Canopies/Gazebos/Porticos
- Auto Repair Shops
- Body Shops
- Quick Lube Stations
- Construction Sites
- Emergency Shower Areas
- Grocery Store Foyers
- Sports Stadiums
  - —Dugouts
  - —Bleachers
  - —Lodges/Press Boxes
- Drive-Up Service Windows
- Farm Buildings
- Freezer Doors
- Golf Driving Ranges
- Transportation Platforms
- Inter Building Walkways
- Transport Shelter Buildings/ Platforms
- Open Air Restaurants
- Isolated Service Booths
- Snow & Ice Control
- Crane Cabs
- Patios
- Pump Houses/Freeze Protection
- Parking Garage Ramps
- Outdoor Smoking Areas/ Shelters
- Hospitals
  - —Emergency Entrances
  - —Patient Drop Off/Pick Up
  - —Recovery Rooms
- Ski Resorts
- Animal Warming
  - —Zoos
  - —Dog Kennels
  - —Chicken/Pig Farrowing
- Recycling Stations/Plants
- Waste Water Treatment Plants

INFRARED HEAT COMPLIES WITH ASHRAE/IES STANDARD 90.1-1989

Radiant Heating Systems 9.4.6

9.4.6.1 Radiant heating systems shall be considered in lieu of convective or all-air heating systems to heat areas which experience infiltration loads in excess of 2 air changes per hour at design heating conditions.

9.4.6.2 Radiant heating systems should be considered for areas with high ceilings, for spot heating, and for other applications where radiant heating may be more energy efficient than convective or all-air heating systems.

THEORY OF INFRARED

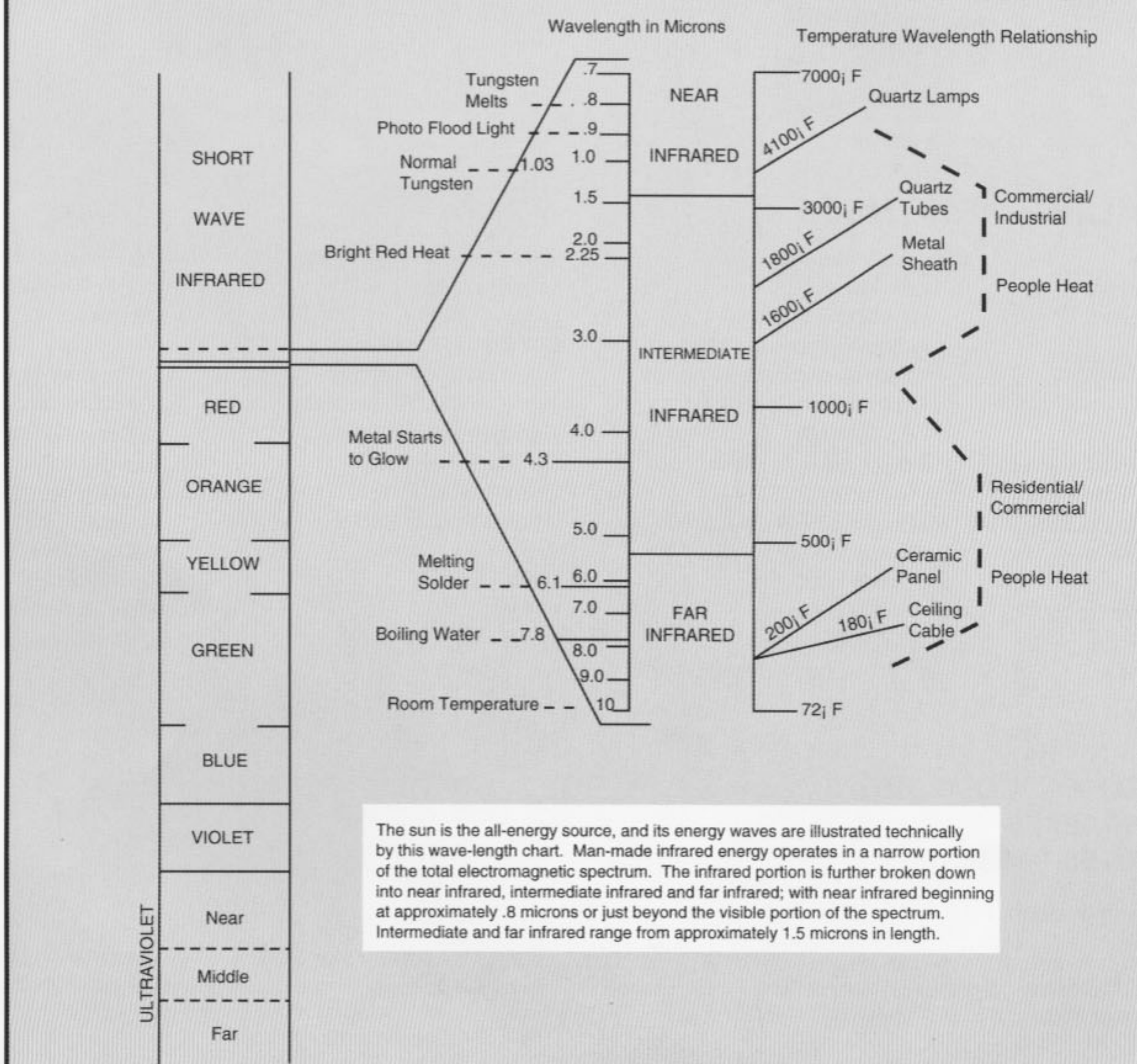
Infrared radiation is electromagnetic radiation which is generated in a hot source (quartz lamp, quartz tube, or metal rod) by vibration and rotation of molecules. The resulting energy is controlled and directed specifically to and on people or objects. This energy is not absorbed by air, and does not create heat until it is absorbed by an opaque object.

The sun is the basic energy source. Energy is projected 93,000,000 miles through space to heat the earth by the infrared process. This infrared energy travels at the speed of light, and converts to heat upon contact with a person, a building, the floor, the ground or any other opaque object. There is, however, **no** ultraviolet component (suntanning rays) in **electric infrared**.

Electric infrared energy travels in straight lines from the heat source. This energy is directed into specific patterns by optically designed reflectors. Infrared, like light, travels outward from the heat source, and diffuses as a function of the square of the distance. Intensity, therefore, would decrease in a proportional manner. So, at 20' from the heat source, intensity of the energy concentration is 1/4 the intensity developed at 10'. Also, at 20' distance from the heat source, the energy pattern of radiant heat will cover four times the area compared to the energy pattern coverage at a 10' distance.

For comfort heating, there must be reasonably even accumulated values of heat throughout the comfort zone. Proper mounting heights of the individual heaters, fixture spacing, reflector beam patterns, and heat source wattage must be specified to generate the proper heating levels at the task area. The amount of heat delivered is also adjusted by input controllers or by thermostats which respond to surrounding temperature levels and provide ON-OFF or PROPORTIONAL inputs.

ELECTRIC INFRARED AS PART OF THE ELECTROMAGNETIC SPECTRUM



The sun is the all-energy source, and its energy waves are illustrated technically by this wave-length chart. Man-made infrared energy operates in a narrow portion of the total electromagnetic spectrum. The infrared portion is further broken down into near infrared, intermediate infrared and far infrared; with near infrared beginning at approximately .8 microns or just beyond the visible portion of the spectrum. Intermediate and far infrared range from approximately 1.5 microns in length.

ADVANTAGES OF ELECTRIC INFRARED

1) HEATS PEOPLE WITHOUT HEATING AIR
Infrared travels through space and is absorbed by people and objects in its path. Infrared is not absorbed by the air. With convection heating the air itself is warmed and circulated ... however, warm air always rises to the highest point of a building. With Infrared heating, the warmth is directed and concentrated at the floor and people level where it is really needed.

2) ZONE CONTROL FLEXIBILITY
Infrared heating is not dependent upon air movement like convection heat. Infrared energy is absorbed solely at the area it is directed. Therefore it is possible to divide any area into separate smaller zones and maintain a different comfort level in each zone. For example, Zone A, with a high concentration of people, could be maintained at a 70 degree comfort level while at the same time Zone B, a storage area, could be kept at 55 degrees or even turned off completely.

3) STAGING
Another unique control feature of electric infrared that increases comfort conditions and saves energy consumption is staging. Where most systems are either "fully ON" or "fully OFF" the staging feature also allows only a portion of the equipment's total capacity to be used. For example, a two-stage control would work as follows: During the first stage, one heat source in every fixture would be energized. During the second stage, two heat sources in every fixture would be energized. For further control sophistication, a large area can be both zoned and staged. These systems, then, allow a more consistent and uniform means of maintaining a specific comfort level and avoid the "peak & valley" syndrome.

4) REDUCED OPERATING COSTS
The previous statements are advantages in themselves; but combined they account for an energy/fuel savings of up to 50 percent. Actual savings will vary from building to building depending on factors such as insulation, ceiling height and type of construction.

5) INSTANT HEAT
Electric infrared produces virtually instant heat (See Page 8,Graphs A, B, and C showing heat-up time of sources.) There is no need to wait for heat buildup. Turn the heaters on just prior to heating requirements.

6) NEGLIGIBLE MAINTENANCE
Electric infrared is strictly a resistance type heat. There are no moving parts or motors to wear out; no air filters or lubrication required. Periodic cleaning of the reflectors and heat source replacement is all that will be required.

7) CLEAN
Electric infrared, like other forms of electric heating, is the cleanest method of heating. There are no by-products of combustion as with fossil fuel burning units. Electric infrared adds nothing to the air nor takes anything from it.

8) SAFE
- UL listed
- No open flame
- No moving parts to malfunction
- No fuel lines to leak
- No toxic by-products of combustion

9) EFFICIENT
All Electric Heaters convert energy to heat at 100% efficiency.

METHODS OF HEAT TRANSFER

Radiant or infrared heating provides a unique method of achieving a desired comfort level at a specified area. To best understand infrared heating, a comparison with different methods of heat transfer should first be considered.

Heat transfer can be accomplished by any one of three methods, CONDUCTION, CONVECTION or RADIANT.

CONDUCTION is placing an object in physical contact with the source of heat, such as a hot water bottle against the body.

CONVECTION heat involves using a source of heat to warm the air and create a desired comfort level around people. Heated air is circulated by fans or blowers to generally surround a normally enclosed area. Home heating with a forced-air furnace is an example of CONVECTION heat.

RADIANT, or INFRARED, heat uses invisible electromagnetic waves from an energy source. The perfect example of electromagnetic infrared energy is heat from the sun. In an infrared system, these energy waves are created by a heat source - quartz lamp, quartz tube, metal rod - which are directed by optically designed reflectors toward or onto the object or person. A fire place is a more familiar form of radiant heat.

REFLECTORS AND BEAM PATTERNS

The method of transferring and directing the infrared energy to the work level is an important factor in the heating design and will greatly affect the efficiency of the heating system.

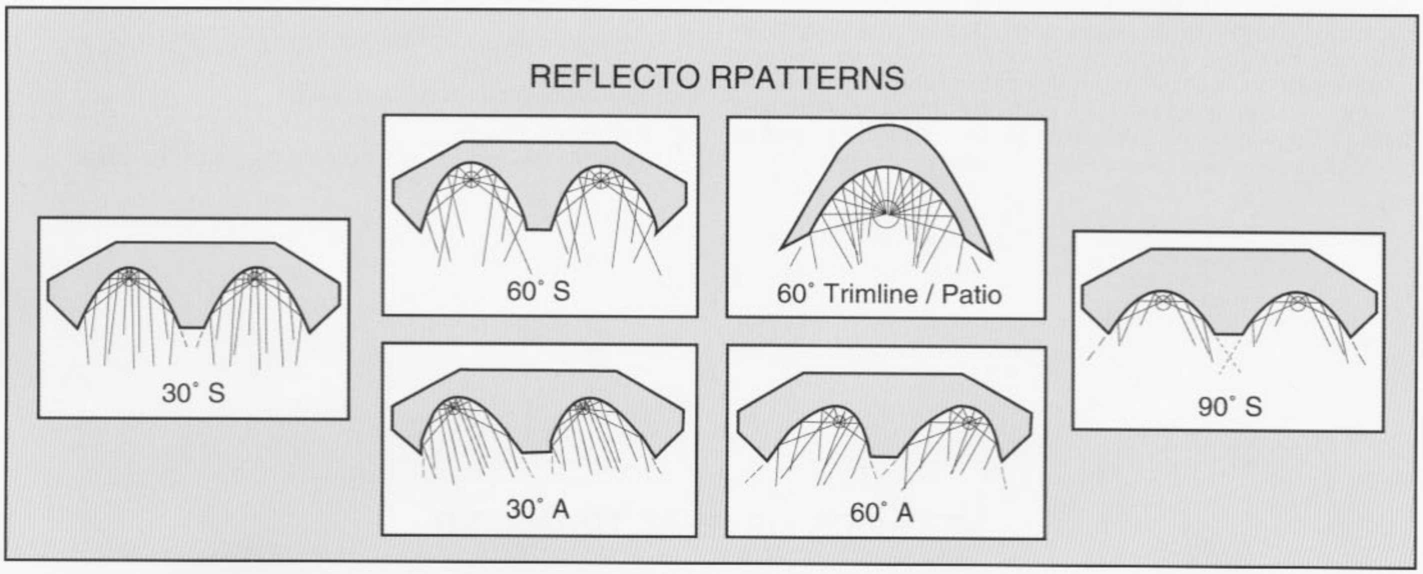
Reflectors are used to direct the radiant energy from the source to the work area. The higher the efficiency of the reflector, the more radiant energy will be transferred to the work level. The reflector efficiency is influenced by the reflector material, its shape and contour.

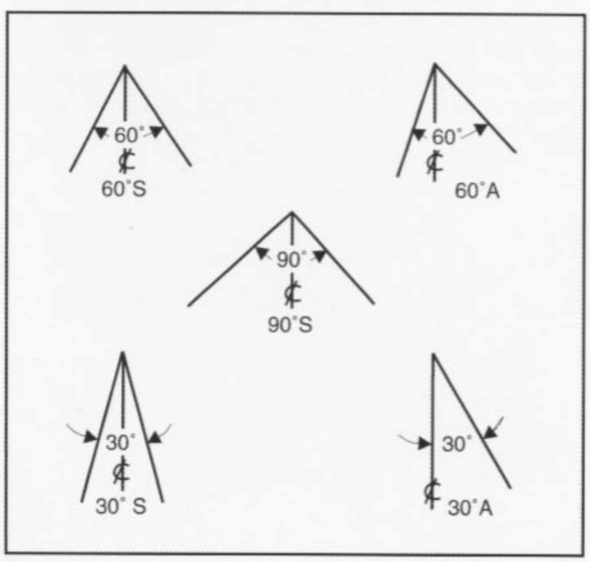
One method of measuring the efficiency of the material is by the emissivity factor. Emissivity is defined as the ratio of the amount of energy given off by radiation from a perfect black body; and is equal to the rate that material will absorb energy. The lower the emissivity number the less the material will absorb; hence the better the reflectivity of the material.

Few materials can be considered for use as reflectors in comfort heating equipment. They must have high reflectivity of infrared energy; resist corrosion, heat, moisture; and be easily cleaned.

Aluminum is a common reflector material and must be anodized to provide suitable reflectivity and withstand the heat levels present in an infrared heater. Gold anodized aluminum is best suited as a reflector material when the combined factors of cost, workability and weight are considered. Dirt will accumulate ON the surface and not IN the chemical composition with the gold. Within the infrared energy portion of the spectrum, clear anodized aluminum reflectors achieve approximately 89 percent reflectivity. Gold anodized aluminum reflectors achieve approximately 92 percent reflectivity. The most highly efficient reflector readily available is a specular gold plated material, which is rarely used due to the prohibitive cost of gold. Fostoria uses gold anodized aluminum for reflectors and end caps in their electric infrared heating equipment to provide the highest economical reflectivity and durability.

The beam pattern created by the reflector must be emphasized in the heating design. First the reflector must create a straight vertical line from the heat source to the work area. This is the pattern centerline. Secondly, the reflector will converge or concentrate the energy into a choice of wide, medium or narrow patterns. In the electric infrared comfort heat industry, reflectors are also designed for asymmetric, symmetric and offset patterns as shown below.





A specific heat pattern can be easily identified by the number of bends in the reflector in addition to the angle of the reflector.

Pattern	No. of Blends	Pattern	No. of Blends	Pattern	No. of Blends
30°A	9	60°A	7	90°A	5
30°S	9	60°S	8		
		60°S (Trimline/Patio) Molded Curve			

HEAT ELEMENT AND FIXTURE SELECTION CHART

This Chart is designed to aid in proper selection and usage of heat elements in the corresponding heat fixtures. Mounting heights shown should be used as a guide. Consult factory for specific or unusual applications

KEY:		FIXTURE MOUNTING HGT.	
1	Indoor	A	8' - 10'
2	Outdoor	B	11' - 12'
-	Not Recommended	C	13' - 15'
X	Will not physically fit the fixture	D	16' - 18'
		E	19' - 30'

FIXTURE	CLEAR OR RED QUARTZ LAMPS	QUARTZ TUBES	U-SHAPED METAL RODS
222 30, A30,	1C, D, & E, or 2A	-	X
60, A60	1B, C, & D, or 2A	-	X
90	1A, B	-	X
342 30, A30	1C, D, & E, or 2A, B	-	X
60, A60	1B, C, & D, or 2A	-	X
90	1B	-	X
462 30, A30	1C, D, & E, or 2A, B	-	X
60, A60	1C, D, or 2A	-	X
90	1B	-	X
223 30, A30	1C, D, & E, or 2A, B	-	X
60, A60	1B, C, & D, or 2A	-	X
90	1B	-	X
343 30, A30	1C, D, E or 2A, B	-	X
60, A60	1B, C, D - 2A, B	-	X
90	1B	-	X

FIXTURE	CLEAR QUARTZ LAMPS	RED QUARTZ LAMPS	QUARTZ TUBES	U-SHAPED METAL RODS
463 30, A30	1D, & E or 2B, C	X	-	X
60, A60	1C, D or 2A, B	X	-	X
90	1C	X	-	X
CH-46/CH-46C	X	X	*1A or 1B	X
CH-57/CH-57C	X	X	*1A or 1B	X
OVERHEAD HEAVY DUTY		X		
2 KW (120V-600v)	X	-	X	1A
4.5 KW (208V-600V)	X	X	X	1A or 1B
6 KW (208V-600V)	X	X	X	1A, B,or C
13.5 KW (208V-600V)	X	X	X	1B, C, or D
27 KW (208V-600V)	X	X	X	1C, 1D, 1E
RPH-208A	X	2A, 2B	X	X
RPH-240A	X	2A .2B	X	X

*Quartz Lamps are recommended for most indoor heating applications, and the only heat source for outdoor heating applications.

Please consult factory for assistance in heater selection and layout of application.

—SIZING GUIDE—

PORTABLE UNITS * *

	NON-PROTECTED		SEMI-PROTECTED	
	Below 35°F	Above 35°F	Below 35°F	Above 35°F
Fixture	Area Size - Square Feet		Area Size - Square Feet	
2.0KW	25	36	40	50
4.5KW	64	75	90	125
6.0KW	85	100	120	150
13.5KW	192	225	270	375

* * As a general rule, it is better to use two smaller units in place of one larger unit to achieve a more uniform coverage.

HEATING ELEMENTS

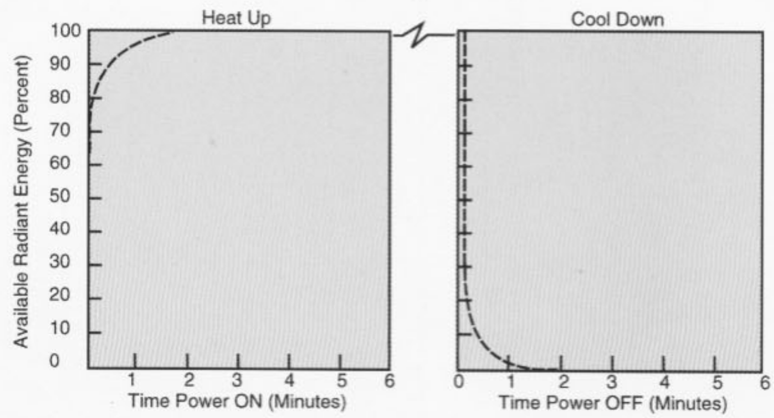
CLEAR QUARTZ LAMPS

- 3/8" diameter clear quartz envelope
- Coiled tungsten filament positioned on tantalum spacers; sealed porcelain end caps; gas filled Color temperature emitted: approximately 4100° F - high brightness (6 - 8 Lumens Per Watt)
- 96% radiant efficiency****
- Fastest heat-up and cool-down (Refer to Graph A)
- Moisture resistance: highest
- Mechanical ruggedness: average
- Available wattages: 500-3650; available voltages: 120-600
- Life expectancy: 5000 hours warranted, 4-year pro-rated
- May be used in series, if necessary

APPLICATIONS: All snow/ice control; all outdoor and most indoor applications; high bay applications; indoor area highly exposed to cold air infiltration.

MOUNTING HEIGHTS: 10' and ABOVE (Indoor), 10'and BELOW (Outdoor)

Graph A



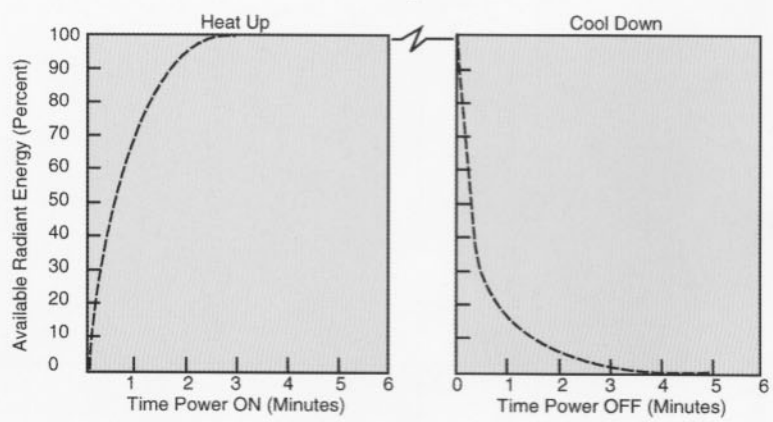
RED QUARTZ LAMPS

- 3/8" diameter red quartz envelope
- The red quartz lamp reduces visible "white" light up to 84%, while maintaining the same heat output.
- Coiled tungsten filament positioned on tantalum spacers; sealed porcelain end caps; gas filled Internal -Color temperature emitted: approximately 4100° F
- 96% radiant efficiency****
- Fastest heat-up and cool-down (Refer to Graph A)
- Moisture resistance: highest
- Mechanical ruggedness: average
- Available wattages: 1600 & 2500; available voltages: 208, 240, 480
- Life expectancy: 5000 hours warranted, 4-year pro-rated
- May be used in series, if necessary

APPLICATIONS: Indoor and outdoor areas where visibility is a factor.

MOUNTING HEIGHTS: 10' and ABOVE (Indoor), 10'and BELOW (Outdoor)

Graph B



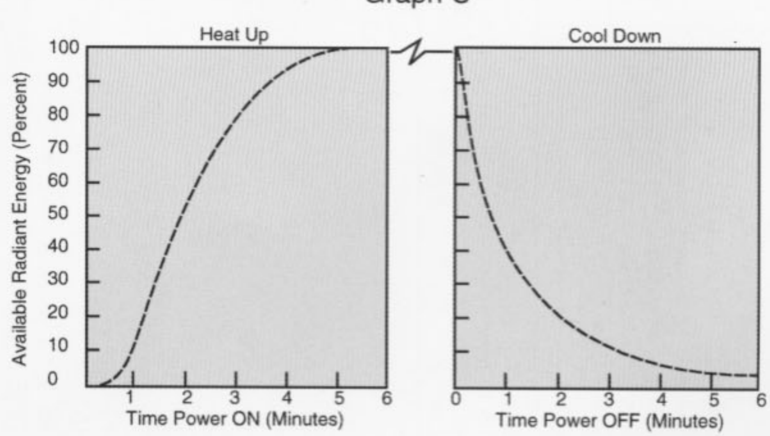
QUARTZ TUBES

- 3/8, 5/8, 7/8" diameter quartz envelope
- Nickel-chrome alloy coiled element with porcelain end caps and pigtail termination
- Color temperature emitted: approximately 1800° F - bright orange glow
- Approximately 60% radiant efficiency.**** Fast heat-up and cool-down (Refer to Graph B) Moisture resistance: high
- Mechanical ruggedness: good
- Available wattages: 450-3000; available voltages: 120-480
- Do not use in series
- Lowest cost per watt (average)
- Life expectancy: 5000 hours warranted, 4-year pro-rated

APPLICATIONS: Indoor spot heating and total area heating; Preferred when controlling application with percentage input timer

MOUNTING HEIGHTS: 12' and UNDER — Indoor Only

Graph C



STRAIGHT or U-SHAPED METAL RODS

- .430" diameter inconel metal sheath envelope
- Nickel-chrome alloy coiled element imbedded in magnesium-oxide insulating powder
- Color temperature emitted: approximately 1600° F - dull red glow.
- Approximately 50% radiant efficiency****
- Slowest heat-up and cool-down (Refer to Graph C)
- Moisture resistance: lowest
- Mechanical ruggedness: highest
- Available wattages: Straight rod - 1000 - 2200, U-Shaped rod - 1800 - 4500
- Available voltages: Straight rod - 120 - 277, U-Shaped rod - 120 - 600
- Do not use in series
- Life expectancy: 5000 hours warranted, 4-year pro-rated

APPLICATIONS: **Straight Rod** - Indoor spot heating; total area heating; desirable in unique cases when extreme high vibration condition exists.

APPLICATIONS: **U-Shaped Rod** - Indoor spot heating; total area heating; Also used in all FHK Series portable heaters.

FOR SUGGESTED MOUNTING HEIGHTS, SEE PAGES 8, 9 & 10

**** All electric heat is 100% efficient when compared to other fuel energies. RADIANT EFFICIENCY refers to the amount of INFRARED radiation given off - - i.e., a quartz lamp carrying a design load of 1600 watts will emit .96 x 1600 = 1536 watts as infrared energy and 64 watts in convection heat.

EFFECTS of UNDER and OVER-VOLTAGE on HEAT ELEMENTS

Operating any of the three heating elements **below** their design voltage has the following effects:

a) Lowers the delivered wattage/heat output (see Graph D).
b) Lowers the color temperature, therefore lowering the infrared efficiency (See Graph E).
c) Increases the life of the heating elements.

Operating any of the heating elements **above** their design voltage should be avoided, and will have the opposite or reverse effect of those shown above.

Some heating elements are intentionally used at under voltage design to increase the life of the elements. CAUTION should be used to insure that over-voltages do not exist in excess of 2 percent.

Reducing the voltage by "X" percent does not reduce the wattage by the **same** "X" percent. Refer to Graph D to determine proper voltage/wattage relationship. Graph D shows the relationship of wattage vs voltage for **under-voltage** applications.

NOTE: The wattage reduction also varies with the type of heating element.

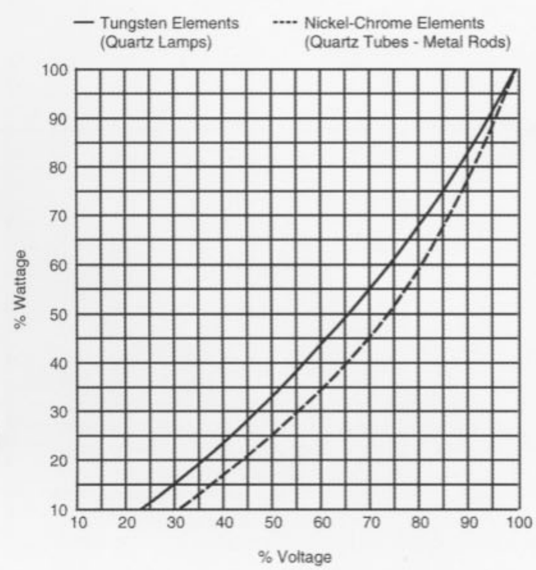
Usage of Graph D

1) Select proper graph (depending on the type of heat element being de-rated)
2) Divide "voltage applied" by "element design voltage" to determine "percentage of applied voltage"
3) Find this percentage on the horizontal axis of the graph. Move vertically from that point until it intersects with plotted line. Move directly left at the point of intersection to corresponding "percent of wattage" as shown on vertical axis.

Example 1 - Graph "D" (Quartz Lamp)
A #GF-1624H quartz lamp is designed to have an output of 1600 watts at 240V. If operated at 208V (86.67% of design voltage) it will have an output of (78% x 1600) = 1248 watts.

If operated at 120 volts (50% of design voltage) it will have an output of (33 1/3% x 1600) = 533 watts.

Graph D



Example 2 - Graph "D" (Metal Rod/Quartz Tube)
A #G71-3489 quartz tube is designed to have an output of 1600 watts at 240V. If operated at 208V (86.67% of design voltage) it will have an output of (71 % x 1600) = 1136 watts.

If operated at 120 volts (50.0% of design voltage) it will have an output of (25% x 1600) = 400 watts.

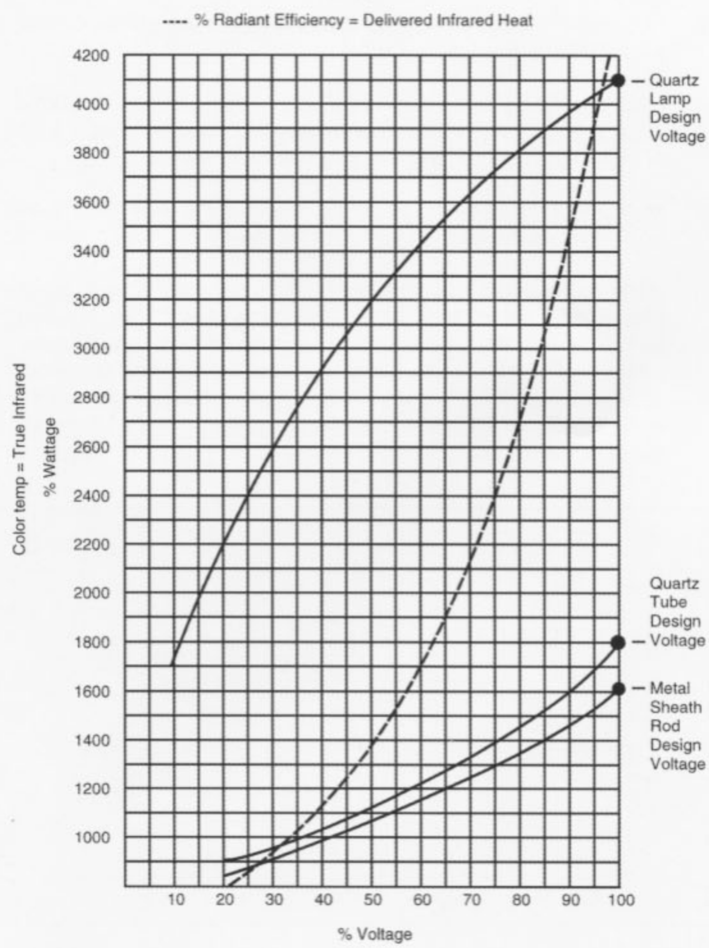
To determine the effects of using less than design voltage on either of the three heat sources, Graph E should be consulted.

For instance, if you wish to determine the effects of using a quartz lamp at half voltage, you can determine the resultant wattage (33-1/3%) from Graph D; you can further determine the operating temperature, or color temperature, (3150°F) of the element from Graph E, and the resultant radiant efficiency (85%) from Graph E.

By decreasing the voltage to 50 percent, there is not only a 2/3 reduction in actual wattage, but an additional decrease in RADIANT EFFICIENCY of 11 percent (96%-85%). Therefore the RADIANT output is now only 453 watts (85% of 533 watts) for a 1600 watt lamp operated at 1/2 voltage. This can direct you as to whether or not the half voltage operation will be a good choice for your specific application.

NOTE: It is seldom, but occasionally recommended to use heat sources at a lower than design voltage.

Graph E



INDOOR SPOT HEATING

An indoor spot heating design will maintain an isolated comfort level within a larger and cooler area. The ambient temperature of the surrounding areas must be considered to help determine proper input to the work area, but will not in turn be affected by the isolated heated area. Many times a series of spot heat areas can be incorporated within the total area to avoid maintaining a higher ambient temperature throughout the building.

Comfort levels will depend on the intensity of the wattage delivered. Wattage should be sufficient to balance normal body heat losses, and will depend on ambient conditions, dress, and activity of the individuals in the work area.

Since actual ambient temperatures are not maintained, several factors involved with indoor spot heating must be considered:

1) Beam patterns should always cross approximately 5' above floor level to provide even heat at the work area.

2) Avoid installing only one fixture directly over a person's head at a work station.

3) All spot heat applications, regardless of area size, should heat the person or object from two sides.

4) Fixtures should be mounted so that the long dimension of the heat pattern is parallel to the long dimensions of the area to be heated.

5) Spot heating systems can be controlled manually, or preferably, with a thermostat located away from the direct pattern of the heaters. Percentage timers may be used, but are not as effective.

6) Avoid mounting fixtures at heights less than 8'.

The estimator must also have the following specific information available before calculating the heating load and fixture layout:

1) Design voltage and phase to be employed.

2) Minimum practical mounting height for the heating equipment.

3) Specific dimensions of the area to be heated.

4) Specific statement of the heating task including the design temperature required.

Calculation Method for Indoor Spot Heat

1) If there is no heat in the building, determine the lowest potential outside design temperature and add 15 degrees to arrive at the lowest inside temperature. (Please see table 4, pages 21-24 for additional information.)

2) Determine the desired temperature to be maintained at the work area.

3) Subtract (1) from (2) to find the change in temperature level required or temperature rise.

4) Find (3) above (or the closest number to it) in Column 1 of Table 1, page 9. Select the "watts per square foot required" for the type of building and appropriate fixture mounting height.

5) Multiply (4) above by the total square feet of the area to be heated. This determines the total watts required.

6) Refer to the Heat Element and Fixture Selection Chart, pg. 5 Under "Key," select "Indoor" and "Mounting Height". (eg. 1, A thru E) Next, select the type of element and fixture best suited for the mounting height. **Quartz Lamps are recommended for most applications.** Note: In cases where the mounting height can be varied, the lowest practical mounting height (eg. An 8' - 12' range) should be selected.

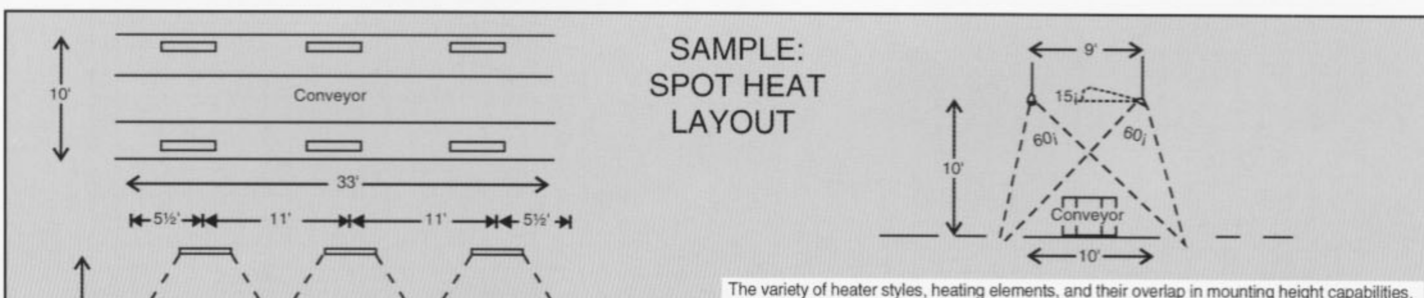
7) Increase the square footage of the area to be heated by 25%. (The increase in 25% is designed to ensure that the final layout has overlapping infrared that allows for a person or object to be heated from two different sides). From the slide guide, follow the chart to indicate the approximate floor coverage for the heater and heat pattern selected in Step (6).

8) Divide the total square feet of the area to be heated by the square foot coverage of the heat pattern found in (7). This will determine approximate number of heaters for the application. (Note: Do not exceed the width or length of the area when figuring total square feet for the fixture heat pattern).

9) To determine the wattage per heater, divide the number of heaters above into the total wattage load figured in Step 5.

10) To determine wattage per element, divide total wattage per heater (9) by the number of elements within each heater (1,2 or 3).

11) For further help, please contact the factory direct at 419/435-9201.



The variety of heater styles, heating elements, and their overlap in mounting height capabilities, many times offers the specifier with a choice of equipment for use on a specific application. In the above case, it would have been possible to also use the Heavy Duty overhead heaters. The Trimline series was selected since it also renders proper pattern overlap and watt density, and is the best economic alternative. The equipment cost per wattage is much less with the Trimline series in this example.

INDOOR SPOT HEATING (CONT'D.)

TABLE 1

Indoor Spot Heating — "Watts per Square Foot" Required

Desired Comfort Rise (Degrees F)	Tight Building No Draft		Average Conditions		Drafty (Open Areas)	
	MOUNTING HEIGHT					
	8' - 12'	13' - 15'	8' - 12'	13' - 15'	8' - 12'	13' - 15'
10°	7	9	10	13	15	18
15°	10	13	15	19	23	26
20°	14	17	20	25	30	35
25°	18	21	25	31	38	44
30°	21	26	30	38	45	53
35°	25	30	35	44	53	61
40°	28	34	40	50	60	70
45°	32	38	45	56	68	79
50°	35	42	50	63	75	88

Fostoria Mul-T-Mounts are being used at the Opryland Hotel in TN. These infrared heaters keep the semi exposed walkways and work stations warm for guest and employees throughout the winter months.

OUTDOOR SPOT HEATING

WATTS PER SQUARE FOOT REQUIRED		
TEMPERATURE RISE REQ'D	WATTS PER SQ. FT.	HEATER MOUNTING HEIGHT
10°	20	8-10'
15°	30	8-10'
20°	40	8-10'
25°	50	8-10'
30°	60	8-10'
35°	70	8-10'
40°	80	8-10'

An estimator must also have the following specific information available before calculating the heating load and fixture layout.

1) Dimensions/Square footage of area to be heated.
2) Minimum practical mounting height for the heating equipment
3) Desired temperature rise
4) Voltage Available

The Purple Parrot Cafe, in Hattiesburg, MS, has decreased over-crowding inside their bar area during the winter months by allowing customers to gather outside in the courtyard area. The owner markets his restaurant as a "New Orleans Style Courtyard" that stays warm year round with Fostoria Heaters.

The installed IR system is achieving 90% of total IR coverage for the outdoor area, giving this area 37 watts/sq. ft. By using this electric IR heating system, the customers receive a 30-35 F temperature rise for each individual heated area.

TOTAL AREA HEATING

Lead-in to Calculation/Layout Guides for 'Total Area' Heating

In electric infrared heating for 'total area' heat design, the actual fixture layout parallels closely the approach used in a general lighting system, but without as much permissible latitude. The allowable range of air temperature people accept as "comfortable" is very limited. Deviations of a few degrees from the preferred comfort temperature greatly affect a feeling of being too warm or too cold. For this reason, assumptions or rough approximations of critical factors in an indoor total heating system design must be minimized.

In electric infrared heating systems, it is important to know that air temperatures can be lower than temperatures with conventional heating systems, while giving the same degree of comfort to the occupants. The reason is that much of the heating affect on the occupants comes directly from the radiant energy produced by the heating elements. The infrared system also makes the temperature of the floor and surfaces higher than the surrounding air temperature.

The function of an electric infrared 'Total Area' heating system is to supply the right amount of heat where needed to maintain a constant desired comfort level. An effective heating system brings the room surfaces and air up to temperature and holds them constant despite changes in outside air temperature or variations in heat losses. If the infrared equipment is carefully selected and properly installed (to project heat downward in a uniform distribution pattern over the floor area), excellent 'Total Area' heating efficiency can be expected.

The following Calculation/Layout Guides for 'Total Area' Heating provide complete methods for determining the necessary heating load, proper equipment selection, and the exact fixture layout for an electric infrared heating system.

Copies of this Data Entry Form are available. Consult the factory for further details - all provided at no charge.

fostoria®

Quality Since 1917

TOTAL AREA HEATING

APPROXIMATE HEAT LOSS CALCULATION

Name of Job__________ Date__________

Location__________ Estimator__________

FACTS NEEDED BEFORE BEGINNING CALCULATION:

Bldg. Size Length X Width = Area (Sq.Ft.) Voltage & Phase Avail. (B)__________

Fixture Mounting Hgt.: (C)__________ ft. Ceiling Hgt.: (D)__________

Amount of Insulation Expressed In R Factors – (See Table 3): Ceiling (E)__________ Walls (F)__________

Air Change per Hour: (G)__________ (See Table 2) *Outside Design Temp (H)__________ (See Table 4)

Inside Desired Temp. (I)__________ Degrees F

CALCULATION:

1) "Inside Desired Temp." minus "Outside Design Temp." = Temp. Rise

(I)__________ - (H)__________ = __________(J) Degrees F

2) Air changes per Hour (G)__________ x __________(Cu. Ft.) = __________(K) Cu. Ft./Hr.

3) Heat Loss:

	"R" Factor	Area Sq. Ft. x	"U" Factor	=	BTU/Hr./Degree
Windows		Sq. Ft.		=	
Doors		Sq. Ft.		=	
Net Wall		Sq. Ft.		=	
Roof		Sq. Ft.		=	
Floor Perimeter	1.2346	Sq. Ft.	0.810	=	
			TOTAL	= (L)	

The above "U" factors can be Calculated from the "R" factors as shown in Table 3.

4) Air Change Heat Loss: (K)__________ Cu.Ft./Hr. x .018 = (M)__________

5) Watts/Per Hour/Per Degree = (L)__________ + (M)__________ = - / 3.414

6) Convention Heat Loss:
(N)__________ X (J)__________ = Con. Heat Loss/Watts Per Hr. = __________

TO USE THE FOLLOWING TABLE:

Pick the corresponding values for (A), (B) and (C) conditions and add them together. Example: An 18' ceiling height with an R factor of R-12 in the ceiling and an R-6 in the side walls would result in values of 15, 28, and 12 respectively, or a total value of 55 for all 3 conditions.

Filling in the above form provides us with all the necessary information to obtain a computerized heat loss printout. We can provide this service over the phone in minutes and later send you a written confirming printout. The above form should be used to manually compute the approximate indoor heat loss. This calculation determines the heat loss replacement necessary with convection heating. See page13 to adjust this heat loss using infrared.

TOTAL AREA HEATING (CONT'D.)

The hand calculation on the previous page is used to arrive at the standard heat loss when employing a conventional, forced hot air system. (Standard ASHRAE heat loss calculation may also be used to arrive at this figure.) Because electric infrared heats objects directly and not air, the amount of heat (KW) required will be **less** with infrared than with the forced air system. To determine **how much less** KW is required we must evaluate those conditions that affect the efficiency of infrared heating over forced air heating.

These conditions (A) (B) and (C) are listed below and are categorized by values. These conditions are listed in order from "easiest to heat and retain warm air" to "hardest" to do so. As the ceiling height increases the "wasted" cubic feet needed to be heated with forced air also increases. The poorer the insulation the more difficult it is to retain hot air heat. As these conditions worsen, the efficiency of infrared over forced air increases.

To use the following table:

Pick the corresponding values for (A), (B) and (C) conditions and add them together.

Example: An 18' ceiling height with an R factor of R-12 in the ceiling and an R-6 in the side walls would result in values of 15, 28 and 12 respectively, or a total value of 55 for all 3 conditions.

INFRARED EFFICIENCY FACTOR TABLE

CEILING (A) HEIGHT	VALUE	INSULATION IN 'R' FACTORS			
		(B) CEILING	VALUE	(C) WALLS	VALUE
10' or less	5	R - 40	7	R - 12 or more	3
11' - 15'	10	R - (30-39)	14	R - (10-11)	6
16' - 20'	15	R - (20-29)	21	R - (8-9)	9
21' - 25'	20	R - (10-19)	28	R - (6-7)	12
26' - 30'	25	R - (5-9)	35	R - (4-5)	15
31' - 35'	30	R - 4 or less	42	R - 3 or less	18

Total Values: 55 -- (Total A,B, and C Values). Choose multiplier below adjacent to the total value arrived at. Example in above cases: A 55 will give a usable multiplier of .80.

Total Values	Multiplier
0 - 20	.90
21 - 45	.85
46 - 65	.80
66 - 90	.75

Conventional Heat Loss x Appropriate Multiplier Above = Total Infrared KW Required at 14' Fixture Mounting Height (use this figure when mounting at 14' or less)

It is recommended to increase the KW load by 2 percent per foot for every foot above 14' that infrared heating fixtures are mounted. Therefore the following formula will adjust accordingly.

Total Infrared KW Required at 14' or less x 1 + (MH-14) (.02) Mounting Height = Total Infrared Required at higher than 14' Mounting Height*

* In no case should this figure be greater than the total KW required and computed for **convection heat loss** (regardless of fixture mounting height). When required mounting is above 30', consult factory.

'TOTAL AREA' HEATING — HEAT LOSS CALCULATION

— SAMPLE 1 —

LOCATION: Novato, California
BUILDING: 40' X 100' X 25' Height
VOLTAGE: 240V, 3 Phase
FIXTURE MOUNTING HEIGHT: 15'
INSULATION/BUILDING TYPE:

- Wall — Flat Metal (.83) with 1" Batts (wood fiber) Insulation (4.00) = R5 (approx.)
- Ceiling — 4" Batts (wood fiber) insulation (4.00)
- Doors — 4 overhead 12' X 8' each metal sheet (.83)
- Windows — 4 each single pane (.88) — 4' X 6' each

OUTSIDE DESIGN TEMPERATURE: 30° F
INSIDE DESIRED TEMPERATURE: 70° F

TOTAL AREA HEATING
Approximate Heat Loss Calculation - Indoor

Name of Job - SAMPLE 1 - Date OCT. 15, 1995

Location NOVATO, CA Estimator MJR

FACTS NEEDED BEFORE BEGINNING CALCULATION:

Bldg. Size (L X W)= (A) 4,000 sq.ft. (40 X 100) Voltage & Phase Avail. (B) 240V; 30 ø

Fixture Mounting Hgt.: (C) 15 ft. Ceiling Hgt.: (D) 25 ft.

Amount of Insulation Expressed in R Factors -(SeeTable3): Ceiling (E) R-16 Walls (F) R-5

Air Changes per Hour: (G) 0.77 (See Table 2) *Outside Design Temp. (H) 30°F (See Table 4)

Inside Desired Temp. (I) 70 °F

CALCULATION:

1)"Inside Desired Temp." minus "Outside Design Temp" = Temp. Rise

(I) 70 —(H) 30 = (J) 40 °F

2) Air Changes per Hour 0.77 X 100,000 Cu. Ft. = (K) 77,000 Cu. ft./hr.

3) Heat Loss: Area Sq. Ft. X "U" Factor = BTU/Hr./Degree

	Area		"U" Factor		BTU/Hr./Degree
Windows	96	Sq.Ft. X	1.13	=	108
Doors	384	Sq.Ft. X	1.20	=	460
Net Wall (7,000-96-384)	6,520	Sq.Ft. X	0.20	=	1,304
Roof	4,000	Sq.Ft. X	.0625	=	250
FloorPerimeter (Lineal)	280	Ft. X	.81	=	226
			Total	= (L)	2,348

The above "U" factors can be calculated from the "R" factors as shown in Table 3.

4) Air Change Heat Loss:

(K) 77,000 Cu.Ft./Hr. X .018 = (M) 1,386

5) (N) Watts/Per Hour/Per Degree = (L) 2,348 + (M) 1,386 ÷ 3.413 = (N) 1,094

6)Conventional Heat Loss:

(N) 1,094 X (J) 40 = Con. Heat Loss/Watts Per Hour = 43,760

SAMPLE 1 CALCULATION (CONT'D.)

The previous calculations are done to arrive at the standard heat loss when employing a conventional, forced hot air system. (Standard ASHRAE heat loss calculation may also be used to arrive at this figure.) Because electric infrared heats objects directly and not air, the amount of heat (KW) required will be less with infrared than with the forced air system. To determine how much less KW is required we must evaluate those conditions that affect the efficiency of infrared heating over forced air heating. These conditions (A) (B) and (C) are listed below and are categorized by values. These conditions are listed in order from "easiest to heat and retain warm air" to "hardest" to do so. As the ceiling height increases, the "wasted" cubic feet needed to be heated with forced air also increases. The poorer the insulation the more difficult it is to retain hot air heat. As these conditions worsen, the efficiency of infrared over forced air increases.

To use the following table:

Pick the corresponding values for(A),(B) and (C) conditions and add them together.

Example: A 25' ceiling height with an R factor of R-16 in the ceiling and an R-5 in the side walls would result in values of 20, 28 and 15 respectively, or a total value of 63 for all 3 conditions.

INFRARED EFFICIENCY FACTOR TABLE

CEILING (A) HEIGHT	VALUE	INSULATION IN 'R' FACTORS			
		(B) CEILING	VALUE	(C) WALLS	VALUE
10' or less	5	R - 40	7	R - 12 or more	3
11' - 15'	10	R - (30-39)	14	R - (10-11)	6
16' - 20'	15	R - (20-29)	21	R - (8-9)	9
21' - 25'	20	R - (10-19)	28	R - (6-7)	12
26' - 30'	25	R - (5-9)	35	R - (4-5)	15
31' - 35'	30	R - 4 or less	42	R - 3 or less	18

Total Values: 63 -- (Total A,B, and C Values). Choose multiplier below adjacent to the total value arrived at. Example in above cases: A 63 will give a usable multiplier of .80.

Total Values	Multiplier
0 - 20	.90
21 - 45	.85
46 - 65	.80
66 - 90	.75

43,760		.80		35,008
Conventional Heat Loss	x	Appropriate Multiplier Above	=	Total Infrared KW Required at 14' Fixture Mounting Height (use this figure when mounting at 14' or less)

It is recommended to increase the KW load by 2 percent per foot for every foot above 14' that infrared heating fixtures are mounted. Therefore the following formula will adjust accordingly.

35,008		(15-14)		35,708
Total Infrared KW Required at 14' or less	x 1 +	(MH-14) (.02) Mounting Height	=	Total Infrared Required at higher than 14' Mounting Height*

* In no case should this figure be greater than the total KW required and computed for **convection heat loss** (regardless of fixture mounting height). When required mounting is above 30', consult factory.

CHOOSING FIXTURE LAYOUT (SAMPLE 1)

1) Select proper "type" heating element for selected mounting height, (i.e., 15'). From information previously given, the "quartz lamp" is best suited.

2) Choose "type" of **heater** for selected mounting height. Cannot use "General Distribution Heater" at this height. "Trimline" is limited to spot heating only. "Heavy Duty Series" does not accept the "quartz lamp", which has been determined as the ideal heating element. Therefore, select the "Mul-T-Mount", 60° or A60° pattern best. Unit must accept 240V quartz lamp...select 222-60-TH or 222-A60-TH.

3) Coverage — A 222-60-TH mounted at 15' covers an area of approximately 18' x 18' = 324 sq. ft. (See Table 5, page 30, "Reflector and Heat Distribution Patterns.")

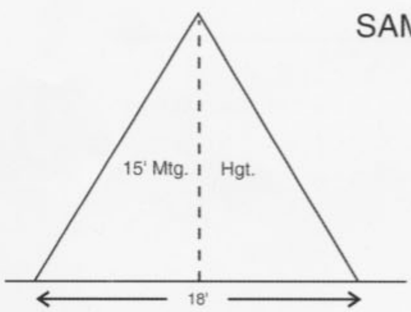
4) $\frac{\text{Total sq. ft. in building}}{\text{Coverage per heater}} = \frac{4000}{324} = 12.34$ or <u>12 units</u>

5) $\frac{35{,}708}{12}$ = watts necessary = approximately 2976 watts per heater. In this case we are limited to one type of **heating element**, i.e., Quartz Lamp, with 240V / 1600W rating, 2 per fixture, or 3200 watts per heater.

6) Select: 12 ea. 222-60-TH - 240V heaters. (2) 1600W / 240V lamps packed w/ heater.

The above calculation gives almost total blanket coverage if spaced **uniformly**. For "total area" heating it is not absolutely necessary to get blanket coverage nor an overlap of patterns. Uniformity of heaters, however, will produce the most comfortable environment.

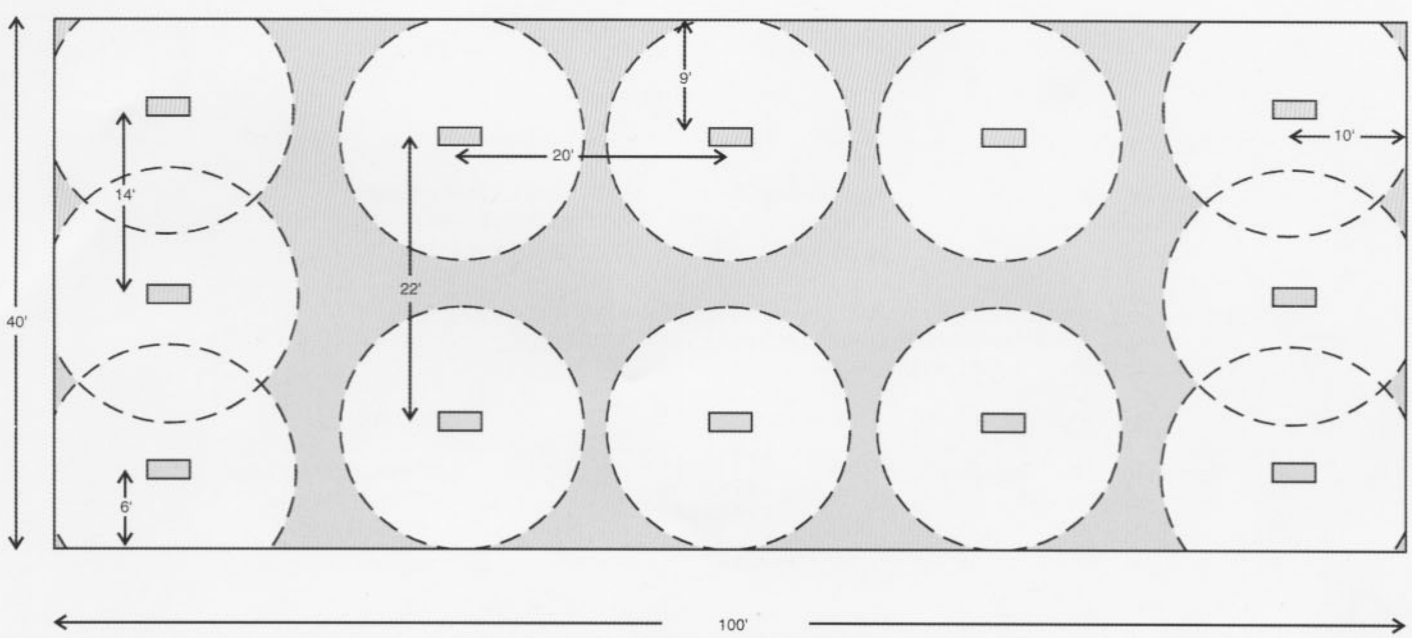
A widely used approach is to heat a building with a combination of perimeter units **and** center units. This method places heaters along the perimeter closer together (higher density) than those spaced uniformly in the center. Since more heat loss occurs on the outside walls, a higher wattage density must be located there to offset this higher heat loss. The ideal "control" for this type layout normally would have the perimeter units on one zone and the center units on another.



SAMPLE1 -- LAYOUT FOR 'TOTAL AREA' BUILDING HEAT
Novato, CA

Side View and Front View Pattern the Same --

See pages 30 thru 33 for Pattern Distribution



Shows Total Area Layout with Uniform Coverage with Slight Accent on Perimeter
Approximately 80% Direct Coverage

SNOW AND ICE CONTROL

Principles:

1) **ALWAYS** use clear quartz lamps as proper element selection. **NEVER** use any other element.

2) **ALWAYS** use the Mul-T-Mount series. The Mul-T-Mount units are UL listed for both semi-exposed and completely exposed areas.

3) For BEST results use the 30° symmetric or asymmetric units (30, A30). SATISFACTORY results can be obtained when using 60° symmetric or 60° asymmetric patterns in semi-protected or shielded areas. If 60° heat pattern is required for exposed areas, consult factory for watt density. **NEVER** use 90° pattern for snow and ice control.

4) Table B shows watt densities needed when units are mounted at 8' - 10'. For best results strive for this 8' - 10' level. Consult factory for densities required when mounting above 10'. **NEVER** mount above 14'.

5) Strive for blanket coverage.

Snow Control Factors

To determine the watt density of infrared required for any area, see Table 4 (located at the back of the manual) to obtain outside design temperature (Factor I) and annual snowfall (Factor II). From Table A, obtain the value for each factor, and add Factor I and Factor II together. Refer to Table B to obtain the watt density based on the **total** value.

Table A

Factor I		Factor II	
Outside Design Temp. °F	Value	Annual Snowfall	Value
-20° to -60°	4	80" to 115"	4
-10° to -19°	3	50" to 79"	3
0° to -9°	2	20" to 49"	2
+19° to +1°	1	10" to 19"	1
+40° to +18°	0	0" to 9"	0

Table B

	Watt Densities per Square Foot		
Total Value	*Exposed	*Semi-Protected	*Protected
8	200	185	160
7	175	160	145
6	125	110	100
5	110	100	90
4	100	90	85
3	95	80	75
2	90	70	65

*Exposed = Totally open area
*Semi-Protected = One side closed plus roof or overhang
*Protected = Three sides plus roof or overhang

Example: Albany, New York has an outside design temperature of - 6° or a Factor I value of 2. The yearly mean snowfall is 65.7 inches or a Factor II value of 3. The total value is 5; therefore the watt density needed for an exposed area is 110 watts per square foot.

POWER CONTACTOR PANELS (FPC SERIES)

Fostoria Power Contactor Panels FPC

Features:

- Nema 1 enclosure
- 3 main terminals for incoming line wires
- 1, 2, 4 or 6 magnetic 3-pole contactors
- Step-down transformer from line voltage to 120 volt for operating "Control Device(s)"
- Fusing for control transformer.
- Terminal blocks and wiring for easy hook-up of control devices

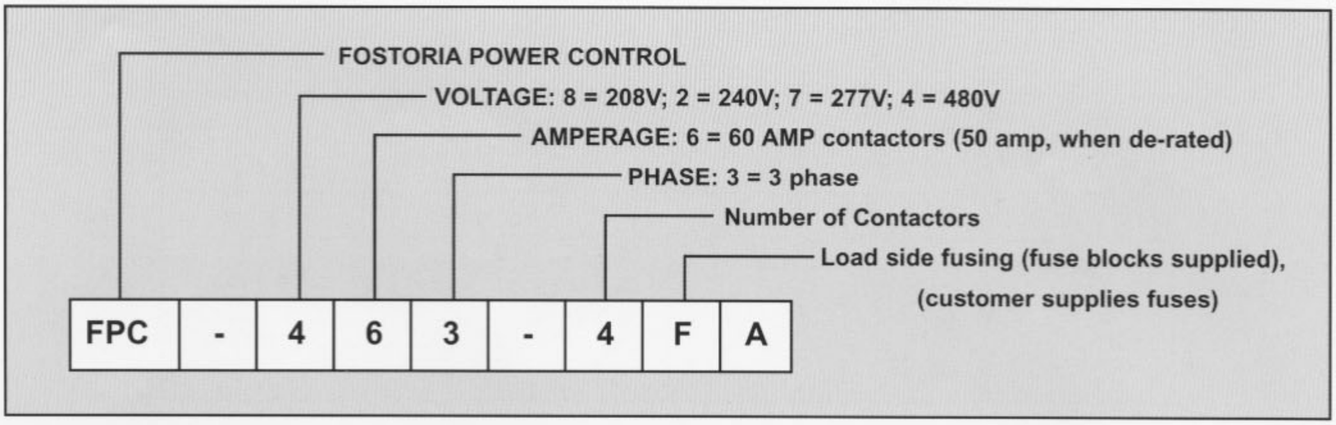
With any of the pre-wired "FPC" series panels, all that need be supplied by others is a main disconnect or circuit breaker, and appropriate size and type of fuses.

An "FPC" is necessary to handle the heating load (KW) in a given infrared installation. Infrared heaters do not have contactors built into the units. Thus it is necessary that they be supplied elsewhere. FPC Control Panels are available for 208, 240, 277, 480 volt applications to handle amp loads of/up to 50, 100, 200, & 300 amps.

Fostoria supplies a complete line of power control panels. These "FPC" panels, when used in conjunction with "control devices", make it possible to control the temperature at a level chosen by the user. The use of "FPCs" will reduce installation field wiring costs. Listed below are the standard "power control panels":

MODEL	MAX. KW at 208V	MAX. KW at 240V	MAX. KW at 480V	(3 Ø) Max Amps
FPC-263-1 FA	18	20		48
FPC-463-1 FA	-	-	40	48
FPC-263-2FA	35	40	-	96
FPC-463-2FA	-	-	80	96
FPC-263-4FA	70	80	-	192
FPC-463-4FA	-	-	160	192
FPC-263-6FA	105	120	-	288
FPC-463-6FA	-	-	240	288

NOTE: 208 and 277 volt FPC Panels also available.
To select the proper size "FPC" panel:



*(1) Determine the total number of amperes the infrared equipment will use, based on the total KW, voltage and phase of electrical installation.

(2) Select the "FPCs" that can handle the above amps, voltage and phase.

WHAT IF:

(a) Your line voltage or phase differs from above available models?
Answer: Determine the amps used based on your voltage and phase and go to Step (2) above, disregarding the listed voltage and phase. When ordering the "FPC", you must specify if voltage is other than 240, 208, 480, or 277 and if phase is other than 3-phase.

(b) Your amperage load is larger than any of the standard panels listed?
Answer: Fostoria can build a special panel capable of handling your load or you can purchase more than one standard panel, i.e., whose sum of handled amperage equals or is larger than your total. NOTE: special FPC's carry a higher price per kilowatt and require more lead time than standard FPCs.

(c) You have a power control panel requirement for something other than a Fostoria Infrared Heater?
Answer: Fostoria Power Control Panels may be used for any load that doesn't exceed the amp rating of the panel.

(d) A contractor or user suggests supplying his own panels?
Answer: Fostoria Industries should furnish all controlling devices. It is possible for a contractor to supply a panel that would work. However, Fostoria control panels generally save on installation costs and are definitely of high quality.

(e) The customer requests Fostoria to supply a main disconnect or circuit breaker?
Answer: Fostoria can supply any type of control panel requested. (See note in (b) above regarding special panels.)

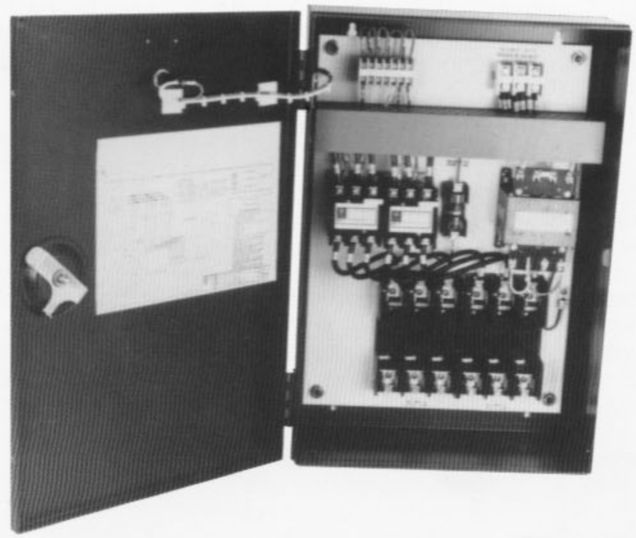
Power Control Options

Fostoria provides the contactor panels matched to the needs of application. A contactor panel is necessary to handle the heating KW load in a given infrared installation.

Since infrared heaters do not have contactors built into the units, it is necessary that they be supplied elsewhere. With a pre-wired "FPC" from Fostoria, all that need be supplied by the installer are fuses, and optional main disconnect or circuit breaker.

Features:

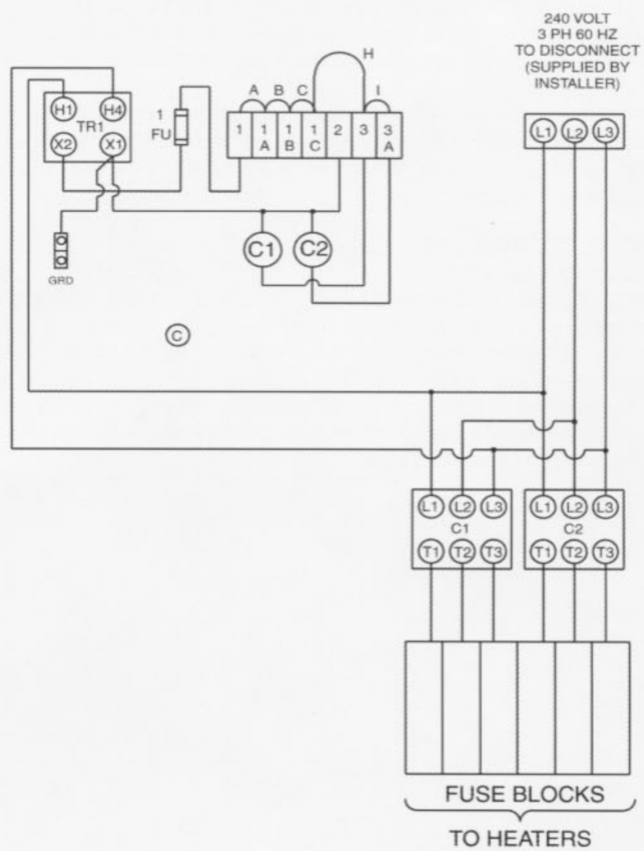
- Factory pre-wired for quick installation
- Max 50 amp branch circuit fusing
  - Fuses provided by installer
- Step-down transformer and secondary fusing for 120 volt control circuit.
- NEMA 1 enclosures
- Pre-wired for use with Fostoria:
  - Snow/Ice Detector
  - Time Delay Controller
  - Percentage Timer
  - Single or *two-stage thermo
  - stat;*(Requires a minimum of two contactors)
- FPC Panels are UL Listed



Example:
Model No. FPC-263-2FA

FPC-263-2FA CONTROL PANEL (Typical)

NOTE:
1. Remove Jumper "A" If Night Setback Is Used.
2. Remove Jumper "B" If Single-Stage Control Is Used For All Contactors
3. Remove Jumper "C" If Remote Switch Is Used.
4. Remove Jumpers "H & I" If Single-Stage Control Is Used For Each Pair Of Contactors.
5. Contactor Load Fusing To Be No Greater Than 50 AMPS.



POWER CONTACTOR PANELS (FPC SERIES) (CONT'D.)

ADDITIONAL CONTROL DEVICES

While FPC's handle the KW load, a "control device" is needed in conjunction with the panels to activate the contactors. The contactors open and close - thereby turning the equipment ON and OFF - according to the control device signal.

Following is a list of these control devices with a description of what each is, how it works, and its typical application.

Thermostats:

Thermostats (air temperature measuring devices) are the most common control device for maintaining specific comfort ranges indoors, whether for spot heating or total area heat control. Thermostats should be located in the area to be heated but not directly exposed to the beam pattern. Thermostats may be shielded by placing a cover over the top. Two stage models are generally considered to give the most economical results.

Commercial/Residential Thermostats:

(1) 1A22-3	Single stage, single pole
(2) 1D22-3	Single stage, double pole
(3) 1M22-3	Two stage (1 1/2° interval between stages), single pole
(4) 1A44-3	Two stage, double pole

All of the above thermostats carry a maximum 22 amp at 120, 250, 277V, AC rating; temperature control range is from 50 degrees F to 90 degrees F; dial shows a comfort range but has no definite degree-number setting; bi-metal sensing elements.

Commercial/Industrial Thermostats:

(1)	CKTD110	Single stage, single pole, 22 amp maximum rating at 125V-277V; 40° - 110° F range
(2)	A28AA	Two-stage (3° interval between stages) single pole; 16 amps at 125V; 125V - 277V
(3)	CKT121	Single stage, single pole with 6' line cord; 125V, 13 amp. max. rating.

The above units have a temperature control range from 30 degrees F to 110 degrees F; definite degree number-setting on dial; liquid-filled sensing element with double-throw, snap-acting contacts in dust-tight enclosure.

SPECIAL CONTROL DEVICES:

FPTC-2 Input Controller:

This unit is designed as a continuing controller that automatically is activated and deactivated according to a manually pre-set time period. Maximum time period is 4 minutes. Dial is set by choosing a percentage of ON-time. OFF-time will then be the remainder of time on the 4-minute cycle. EXAMPLE: Setting dial at 80 percent will activate heaters for 3 minutes and 12 seconds and deactivate heaters for 48 seconds.

USAGE: Spot heating only (especially where no warm air buildup can be expected).

FTDC-1 - Time Delay Controller:

The FTDC-1 controller energizes a specified load in an area where spot heating is required for intermittent periods of time. A push-button switch activates the heating load for a preset 30 -minute cycle. The system is de-energized once the timer has cycled; then the timer is automatically re-set. This is ideal for bus stops, loading docks and remote work stations.

FEC-Enclosed Contactors

(1) FEC-30-120
(2) FEC-30-240
40 amp resistance load, 32 amp full load. 120 or 240 volt coil voltage.

(3) FEC-60-120
(4) FEC-60-240
62 amp resistance load, 50 amp full load. 120 or 240 volt coil voltage.

The above enclosed contactors are general purpose magnetic contactors in a NEMA-1 enclosure. All are rated for loads up through 600 volts, at the maximum amperages noted. May be used in conjunction with many Fostoria control devices.

APS-3B Snow/Ice Detector:

The APS-3B is used only in conjunction with electric infrared snow melting systems. This control automatically activates the electric infrared equipment instantly after snow or ice storms begin. A moisture sensing head and a temperature sensor are wired to a control and timing circuit. If the moisture sensor detects precipitation at a temperature of 38°F or less, the system is activated. Once moisture has stopped, the timer will be energized to shut the system off approximately 15 minutes later. The temperature sensor will prevent activation of the moisture sensor when the precipitation is above freezing.

The control unit is in operation 24 hours a day, with no manual start or shut-off required.

SCR Controllers:

These units are used to control voltage input to infrared heaters. With a 24 volt potentiometer, soft start for high in rush & fuses, the SCR controllers enable customers to "dial up/down" a level of heat output desirable.

180-2-30iCF (open) 30 amp
180-2-30iCF (enclosed) 30 amp
180-2-80CF (enclosed) 80 amp

Variable Controller:

VHC-15 15 amp 208/240 volt
"inline" controller
Built in on/off switch
Design for a 2" x 4" electrical wall box

30-Time Controller:

FTC-30 28 amp 208/240 volt
30 minute timer for:
- Qtz. Lamps
- Qtz. Tubes
- Time Switch
- Knob Control

Ideal for restaurants, patios, smoking shelters, etc.

TABLE 2

Natural Air Change

Total Building* Volume (Cubic Feet)	Air Change Per Hour
25,000	1.50
50,000	1.12
100,000	.77
200,000	.56
300,000	.45
400,000	.39
500,000	.35

* Well constructed building with average number of windows.

The following Table 3 is to be used in conjunction with 'Total Area' Heating Calculations. This table lists the "R" factors for various types and thicknesses of materials. These numbers measure the **resistance to heat flow** through a specific type of material for a given thickness in terms of BTUs per hour per square foot with a 1 F temperature difference between the two sides. **To convert "R" factors to "U" factors divide 1 (one) by the "R" factor.** (Example: An "R" factor of .88 is a "U" factor of 1 divided by .88 or 1.136.) "R" factors are additive; so to calculate the **overall** "R" value of a combination of materials, simply determine the "R" value of each material and add these values together.

Definitions

"U" Factor: The number of British Thermal Units transferred in one hour by one square foot of the roof, ceiling, wall or floor with one degree Fahrenheit temperature difference between the air on the inside and the air on the outside of the roof, ceiling, wall, or floor.

"R" Factor: A rating of overall heat resistance. The **reciprocal** of the "U" factor.

TABLE 3

MATERIAL	DESCRIPTION	THICKNESS	"R" FACTOR
Glass	Single Pane		— .88
	Double Pane		— 2.22
	Triple Pane		— 3.56
	Glass Block (Avg.)	2"	— 2.50
		4"	— 3.22
	Translucent Curtainwall	—	2.50
Woods	Hardwoods (Maple, Oak)	1"	.91
	Softwoods (Fir, Pine)	1"	1.25
Insulating Materials/			
	Mineral Wool	5 1/4" - 6 1/2"	19.00
	Wood Fiber	8 1/2"	30.00
Board and Slabs:	Cellular Glass	1"	2.50
	Corkboard	1"	3.70
	Glass Fiber (Avg.)	1"	4.00
	Expanded Rubber (Rigid)	1"	4.55
	Expanded Polystyrene (Styrofoam)	1"	4.35
	Expanded Polyurethane	1"	6.25

MATERIAL	DESCRIPTION	THICKNESS	"R" FACTOR
Board and Slabs:	Rapco Foam	1 "	5.00
	Mineral Wool with Resin Binder	1 "	3.70
	Mineral Fiberboard, wet felted (Acoustical tile)	1 "	2.86
	Mineral Fiberboard, molded (Acoustical tile)	1 "	2.38
	Homosote	1 "	2.38
	Roof Insulation (preformed for above deck)	1 "	2.78
	Loose Fill:		
	Cellulose	1 "	3.70
	Mineral Wool (glass, slag, or rock)	1 "	3.70
	Sawdust or Shavings	1 "	2.22
	Silica Aerogel	1 "	6.25
	Vermiculite (Expanded)	1 "	2.13
	Wood Fiber (Avg.)	1 "	3.57
	Perlite (Expanded)	1 "	2.70
Masonry Materials:	Concretes:		
	Cement Mortar	1 "	.20
	Gypsum-Fiber Concrete	1 "	.60
	Stucco	1 "	.20
	Dry Wall	1/2 "	.50
Masonry Units:	Brick, Common (Avg.)	1 "	.20
	Brick Face (Avg.)	1 "	.11
	Concrete Blocks (three oval core)		
	Sand & Gravel aggregate	8 "	1.11
	Cinder aggregate	8 "	1.72
	Lightweight aggregate	8 "	2.00
	Stucco	1 "	.20
Siding Materials:	Asbestos-Cement Shingles	-	.21
	Wood (7 1/2" Exposure)	16 "	.87
	Wood (12" Exposure)	10 "	1.19
	Asbestos-Cement 1/4 ", lapped	-	.21
	Asphalt roll siding	-	.15
	Asphalt insulating siding 112 ' bd.	-	1.46
	Wood, plywood, %' lapped	-	.59
	Wood, bevel, 1/2' x 8" lapped	-	.81
	Sheet Metal, single sheet (avg.)	-	.83
	Architectural Glass	-	.10
Roofing:	Asbestos-Cement shingles	-	.21
	Asphalt shingles	-	.44
	Slate	1/2"	.05
	Built-up Roofing	3/8"	.33
Air Spaces:	Horizontal: Ordinary materials-vertical flow	3/4 " - 4 "	.80
	Vertical: Ordinary materials-horizontal flow	3/4 " - 4 "	.96
Exposed Doors:	Metal-Single Sheet	-	.83
	Wood	1 "	1.56
	Wood	2 "	2.33

TABLE 4

State	City	Mean Wind ***Speed: MPH	*Heating Degree Days	****Yearly Snowfall: Mean	**Outside Design Temperature
Alabama	Birmingham	7.0	2844	1.2	9
	Huntsville	10.0	3302	2.5	7
	Mobile	10.0	1684	0.5	18
	Montgomery	7.0	2269	0.4	15
Alaska	Anchorage	4.0	10911	70.2	-18
	Fairbanks	2.0	14344	68.8	-48
	Juneau	5.0	9007	108.2	-1
	Nome	4.0	14325	54.5	-35
Arizona	Flagstaff	9.0	7322	88.6	-10
	Phoenix	5.0	1552	0.0	30
	Tucson	7.0	1752	1.4	25
	Winslow	5.0	4733	11.1	3
Arkansas	Ft. Smith	9.0	3336	5.7	6
	Little Rock	9.0	3354	5.1	10
California	Bakersfield	5.0	2185	0.0	28
	Fresno	4.0	2650	0.1	26
	Los Angeles	6.0	1819	0.0	38
	Sacramento	3.0	2843	0.1	27
	San Diego	3.0	1507	0.0	39
	San Francisco/Oakland	8.2	3080	0.1	33
Colorado	Colorado Springs	7.0	6473	39.3	-9
	Denver	6.0	6016	59.0	-11
	Grand Junction	5.0	5605	26.3	3
	Pueblo	5.0	5394	30.9	-12
Connecticut	Hartford	7.0	6350	53.0	-6
	Bridgeport	14.0	5461	26.8	2
Delaware	Wilmington	9.1	4940	19.9	-5
D.C.	Washington DC	9.3	4211	16.3	14
Florida	Daytona Beach	7.0	902	0.0	27
	Jacksonville	6.0	1327	0.0	22
	Miami	10.0	206	0.0	39
	Orlando	8.0	733	0.0	29
	Pensacola	9.0	1578	0.3	15
	Tallahassee	3.0	1563	0.0	17
	Tampa	8.0	718	0.0	29
Georgia	Atlanta	12.0	3095	1.5	9
	Augusta	5.0	2547	0.9	13
	Columbus/Lawson	7.0	2378	0.4	14
	Macon	7.0	2240	1.0	14
	Rome	5.0	3342	2.0	4
	Savannah/Travis Fld.	7.0	1952	0.4	18
Idaho	Boise	6.0	5833	21.5	-4
	Lewiston	5.0	5464	17.9	3
	Pocatello	6.0	7063	40.0	-15
Illinois	Rockford	9.0	6845	34.1	-16
	Moline	9.0	6395	30.3	-14
	Peoria	9.0	6098	24.3	-12
	Springfield	10.0	5558	23.1	-11
	Chicago	10.0	6497	37.4	-12

TABLE 4 (CONT'D.)

State	City	Mean Wind ***Speed: MPH	*Heating Degree Days	****Yearly Snowfall: Mean	**Outside Design Temperature
Indiana	Evansville	7.0	4629	13.4	-4
	Fort Wayne	10.0	6209	31.5	-11
	Indianapolis	8.0	5577	21.6	-10
	South Bend	13.0	6462	68.5	-10
	Terre Haute	8.0	5366	N/A	-10
Iowa	Burlington	9.0	6149	25.7	-10
	Des Moines	11.0	6710	33.1	-15
	Sioux City	11.0	6953	30.6	-18
	Waterloo	9.0	7415	31.2	-20
Kansas	Dodge City	13.0	5046	18.2	-6
	Goodland	12.0	6119	33.6	-11
	Topeka	9.0	5243	20.8	-8
	Wichita	13.0	4687	15.1	-4
Kentucky	Lexington	8.0	4729	15.9	-4
	Louisville	10.0	4645	17.6	-1
Louisiana	Baton Rouge	8.0	1670	0.0	20
	Lake Charles	10.0	1498	0.0	23
	New Orleans	7.0	1465	0.0	23
	Shreveport	9.0	2167	0.0	16
Maine	Caribou	10.0	9632	112.9	-23
	Portland	7.0	7498	74.5	-13
Maryland	Baltimore	10.0	4729	21.2	4
Massachusetts	Boston	17.0	5621	42.1	0
	Worcester	14.0	6848	74.2	-6
Michigan	Alpena	5.0	8518	84.9	-17
	Detroit/Metro.	11.0	6419	39.9	-7
	Flint	8.0	7041	45.3	-10
	Grand Rapids	8.0	6801	76.6	-9
	Lansing	8.0	6904	48.7	-13
	Marquette	6.0	8351	107.3	-18
	Muskegon	10.0	6890	95.9	-5
	Sault Ste. Marie	7.0	9193	110.8	-22
Minnesota	Duluth	10.0	9756	77.8	-28
	International Falls	6.0	10547	60.1	-37
	Mpls./St. Paul	9.0	8159	46.1	-22
	Rochester	13.0	8227	44.4	-23
	St. Cloud	8.0	8868	43.1	-27
Mississippi	Jackson	7.0	2300	0.0	14
	Meridian	6.0	2388	0.0	13
Missouri	Columbia	11.0	5083	22.0	-8
	Kansas City	10.0	5357	20.0	-7
	St. Joseph	10.0	5440	19.2	-3
	St. Louis	12.0	4750	18.5	-5
	Springfield	10.0	4570	15.5	-4
Montana	Billings	10.0	7265	56.0	-19
	Butte	4.0	9760	N/A	-34
	Glasgow	8.0	8969	26.9	-29
	Great Falls	7.0	7652	57.8	-25
	Helena	5.0	8190	48.1	-24
	Kalispell	7.0	8554	67.0	-19
	Miles City	8.0	7889	32.3	-25
	Missoula	7.0	7931	49.2	-15

TABLE 4 (CONT'D.)

State	City	Mean Wind ***Speed: MPH	*Heating Degree Days	****Yearly Snowfall: Mean	**Outside Design Temperature
Nebraska	Grand Island	11.0	6425	29.0	-14
	Lincoln	9.0	6218	28.4	-11
	Norfolk	11.0	6981	28.8	-18
	North Platte	7.0	6747	29.9	-16
	Omaha	10.0	6049	32.0	-14
	Scottsbluff	8.0	6774	38.0	-19
Nevada	Elko	4.0	7483	38.9	-13
	Ely	11.0	7814	47.6	-15
	Las Vegas	7.0	2601	1.4	25
	Reno	3.0	6022	26.5	5
New Hampshire	Concord	4.0	7360	64.8	-18
New Jersey	Atlantic City	9.0	4940	15.8	0
	Newark	13.0	5034	27.3	4
	Trenton	8.0	4952	22.7	2
New Mexico	Albuquerque	8.0	4292	10.5	6
New York	Albany	5.0	6962	65.7	-18
	Binghamton	13.0	7285	86.9	-9
	Buffalo	12.0	6927	92.9	-6
	New York/LaGuardia	18.0	4909	26.2	6
	Rochester	10.0	6719	86.9	-7
	Syracuse	7.0	6678	110.7	-13
North Carolina	Asheville	11.0	4237	17.4	3
	Charlotte	6.0	3218	5.3	10
	Greensboro/Winston-Salem	4.0	3825	8.7	14
	Raleigh/Durham	8.0	3514	6.8	9
	Wilmington	7.0	2433	1.9	17
North Dakota	Bismarck	7.0	9044	38.7	-30
	Fargo	8.0	9271	35.5	-27
	Grand Forks	7.0	9871	N/A	-25
Ohio	Akron/Canton	11.0	6224	47.8	-7
	Cincinnati	9.0	5070	23.9	-3
	Cleveland	12.0	6154	52.2	-6
	Columbus	9.0	5702	27.7	-6
	Dayton	11.0	5641	27.8	-8
	Mansfield	13.0	5818	41.2	-8
	Toledo	10.0	6381	38.9	-10
	Youngstown	10.0	6426	57.6	-8
Oklahoma	Oklahoma City	10.0	3695	8.8	6
	Tulsa	11.0	3680	9.1	3
Oregon	Baker	N/A	7087	N/A	-1
	Eugene	8.0	4739	7.6	16
	Medford	3.0	4930	8.7	15
	Pendleton	6.0	5240	17.7	-1
	Portland	13.0	4632	7.4	18
Pennsylvania	Allentown	9.0	5827	31.5	-2
	Erie	14.0	6851	83.3	-4
	Harrisburg	8.0	5224	34.5	2
	Philadelphia	10.0	4865	20.2	3
	Pittsburgh	10.0	5930	45.3	-6
	Williamsport	8.0	5982	43.8	-6
Rhode Island	Providence	12.0	5972	38.0	-2

TABLE 4 (CONT'D.)

State	City	Mean Wind ***Speed: MPH	*Heating Degree Days	****Yearly Snowfall: Mean	**Outside Design Temperature
South Carolina	Charleston	7.0	2146	0.0	18
	Columbia	5.0	2598	1.7	13
	Greenville	6.0	3163	5.7	11
South Dakota	Aberdeen	11.2	8616	36.4	-9
	Huron	9.0	8054	39.5	-25
	Pierre	11.0	7283	N/A	-20
	Rapid City	9.0	7324	39.3	-17
	Sioux Falls	8.0	7838	39.1	-23
Tennessee	Bristol	6.0	4306	15.6	-1
	Chattanooga	7.0	3505	4.0	7
	Knoxville	7.0	3478	12.2	4
	Memphis	10.0	3227	5.5	9
	Nashville	8.0	3696	10.9	1
Texas	Abilene	12.0	2610	4.5	10
	Amarillo	14.0	4183	14.3	-1
	Austin	12.0	1737	1.0	20
	Brownsville	13.0	650	0.0	31
	Dallas/Ft. Worth	13.0	2382	2.9	14
	El Paso	5.0	2678	4.7	14
	Galveston	11.0	1224	0.3	31
	Houston	8	1434	0.4	72
	San Antonio	10.0	1570	0.5	19
Utah	Ogden	9.0	6412	43.8	1
	Salt Lake City	7.0	5983	58.3	-3
Vermont	Burlington	6.0	7876	79.3	-19
Virginia	Lynchburg	8.0	4233	18.1	5
	Norfolk	12.0	3488	7.0	14
	Richmond	7.0	3939	13.9	6
	Roanoke	10.0	4307	24.1	4
Washington	Olympia	5.0	5530	19.2	10
	Seattle	10.0	5185	14.6	19
	Spokane	7.0	6835	53.3	-7
	Walla Walla	6.0	4835	20.0	1
	Yakima	7.0	6009	24.5	-2
W. Virginia	Bluefield	6.0	5613	55.8	-6
	Charleston	7.0	4590	29.6	-2
	Huntington	8.0	4624	24.1	-2
Wisconsin	Green Bay	10.0	8098	44.6	-19
	LaCrosse	7.0	7417	42.9	-21
	Madison	8.0	7730	40.2	-18
	Milwaukee	13.0	7444	45.9	-12
Wyoming	Casper	9.0	7555	73.9	-22
	Cheyenne	10.0	7255	51.2	-15

FOOTNOTES:

* **Heating Degree Days** - A unit based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of a building in winter. For any one day, when the mean temperature is less than 65^{O} F, there exist as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65^{O} F. These heating degree days (as listed in above chart) were compiled during the 1941-1970 period as published by the *National Climate Center.*

** **Outside Design Temperature** - This figure represents the temperature which will include 99 percent of all the winter-hour fahrenheit temperatures. A base of 2160 hours (total hours in Dec., Jan., and Feb.) was used. Therefore, using this figure as a design temperature will, on an average, cover all but 22 hours of expected winter temperatures. ***ASRAE 1998 COOLING AND HEATING-LOAD CALCULATIONS PRINCIPLES.***

*** **Mean Wind Speed: MPH** - This figure was arrived at through existing and comparable exposures. This information was obtained from the ***ASRAE 1998 COOLING AND HEATING-LOAD CALCULATIONS PRINCIPLES.*** (This figure is for reference only - not required in computation)

**** **Yearly Snowfall: Mean** - This mean value is for the period beginning 1944 through 1977. This information was obtained from the ***Local Climatological Data, 1977.***

fostoria® SUN-MITE®

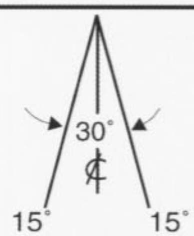
ELECTRIC INFRARED

REFLECTOR AND HEATDISTRIBUTION PATTERNS

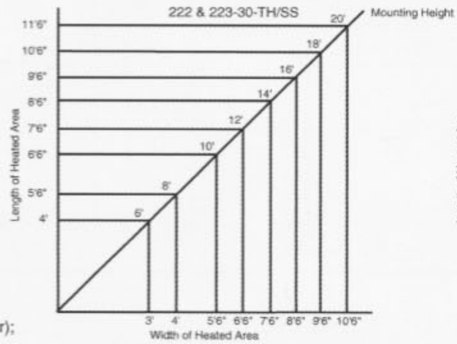
Table 5

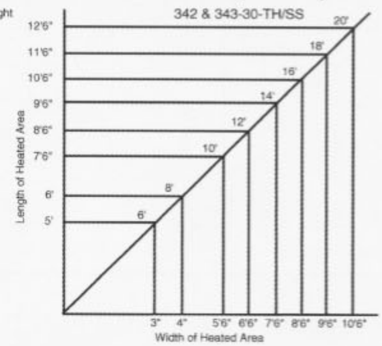
The graphs shown can be used in conjunction with other material pertaining to Electric Infrared heating and snow melting to aid in the selection of proper fixtures for the application being considered.

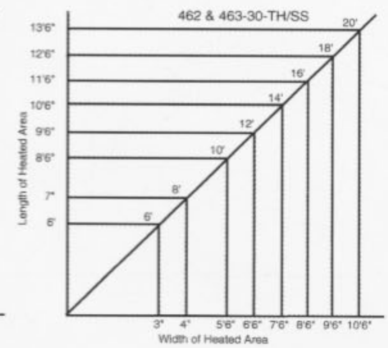
MUL-T-MOUNT - NARROW BEAM (30˚ S)



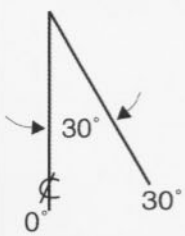
30¡ SYMMETRIC - Narrowest beam fixture available. 'Total Area' and spot heating. Ideal for snow melting. Recommended for 14' to 30' mounting heights (indoor); 10' and under (outdoor).



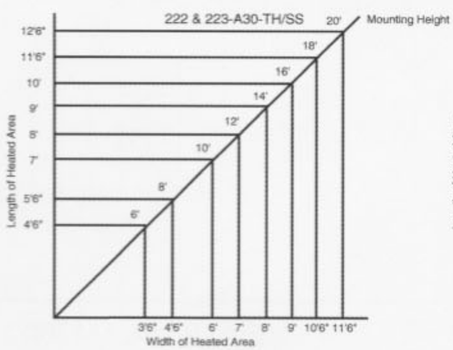


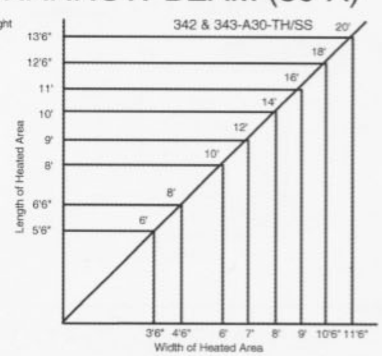


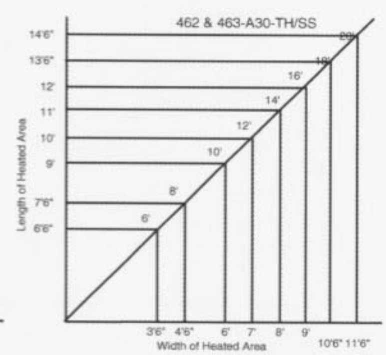
MUL-T-MOUNT - NARROW BEAM (30˚A)



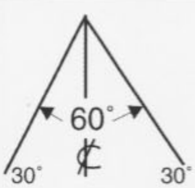
30¡ ASYMMETRIC-0˚ to 30¡ perimeter heating; snow melting close to buildings. Recommended for 14' to 30' mounting heights (indoor); 10' under (outdoor).



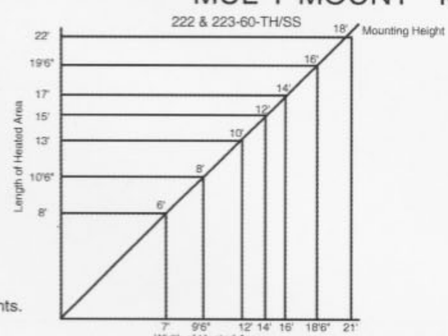


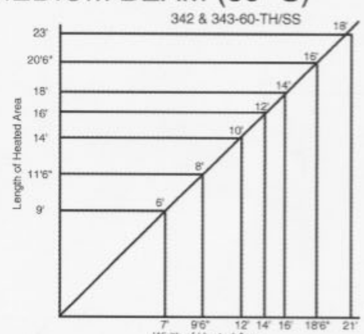


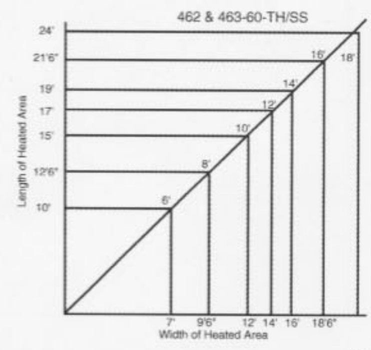
MUL-T-MOUNT - MEDIUM BEAM (60˚ S)



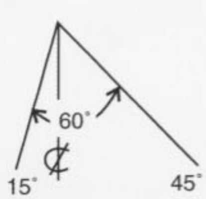
60˚ SYMMETRIC- 'Total Area' and spot heating. Recommended for 12' to 18' mounting heights.



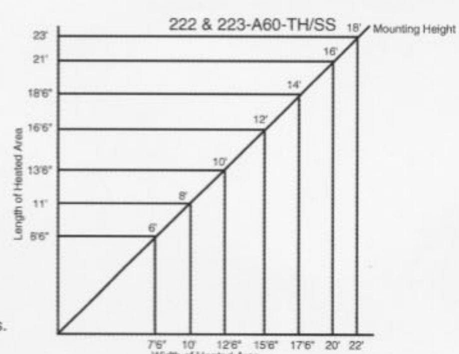


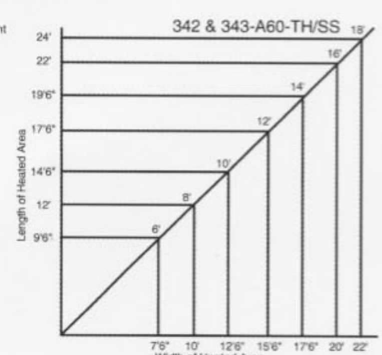


MUL-T-MOUNT - MEDIUM BEAM (60˚ A)



60˚ASYMMETRIC- Perimeter heating. Recommended for 12' to 18' mounting heights.





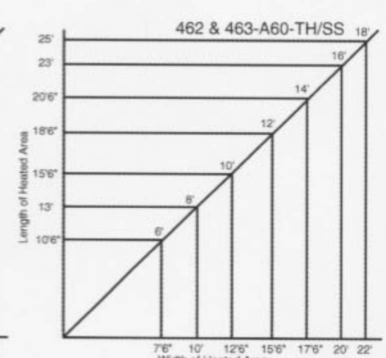
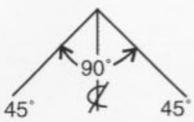


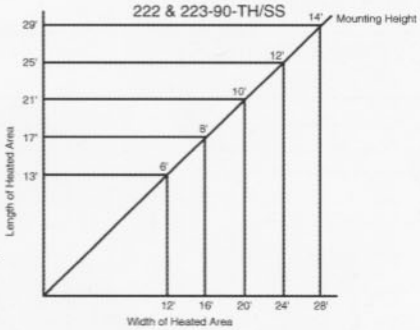
Table 5 (Continued)

MUL-T-MOUNT - WIDE BEAM (90˚)

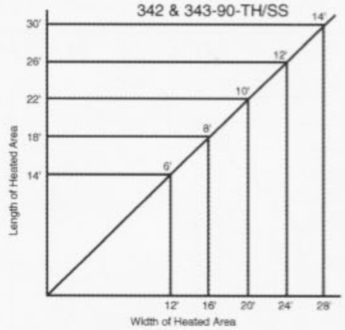


90˚ SYMMETRIC - In-door 'Total Area' and spot heating. Recommende for 8' to 12' mounting heights.

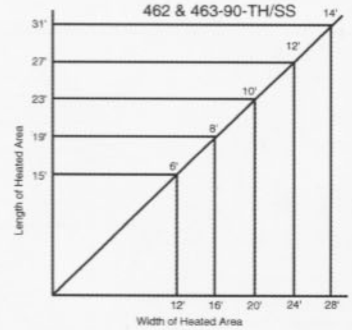
222 & 223-90-TH/SS



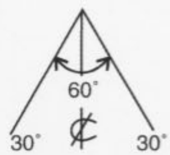
342 & 343-90-TH/SS



462 & 463-90-TH/SS

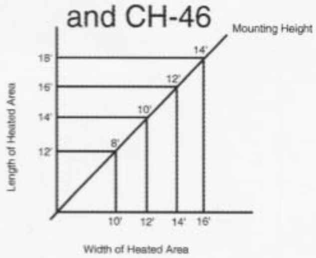


TRIMLINE FIXTURES - MEDIUM BEAM (60˚)

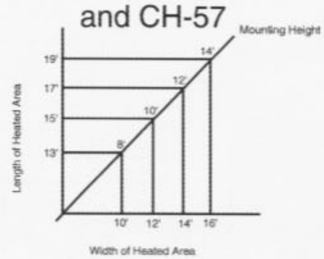


60˚ SYMMETRIC - In-door spot heating. Recommended for 8' to 14' mounting heights.

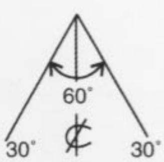
CH-46C and CH-46



CH-57C and CH-57

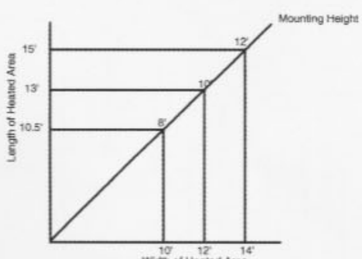


RESTAURANT / PATIO HEATER - MEDIUM BEAM (60˚)



60˚ SYMMETRIC - Spot heating. Recommended for 8' to 12' mounting heights (indoor); 10' & below (outdoor)

RPH - 208A
RPH - 240A

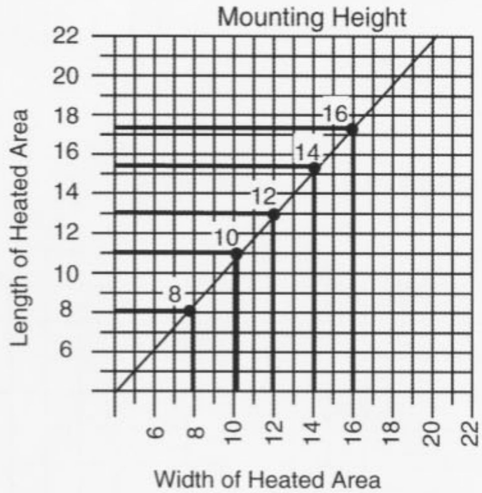


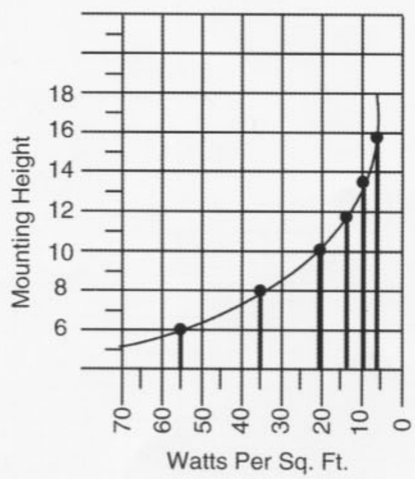
fostoria® SUN-MITE®

ELECTRIC INFRARED HEAT DISTRIBUTION PATTERNS for HEAVY DUTY METAL SHEATH RADIANT HEATERS

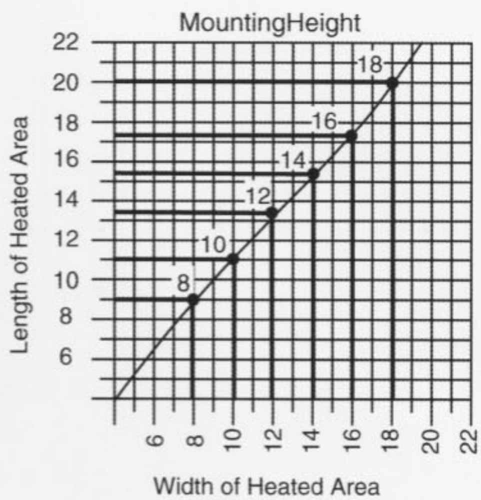
Table 5 (Continued)

2 KW METAL SHEATH OVERHEAD HEATERS





4.5 KW METAL SHEATH OVERHEAD HEATERS



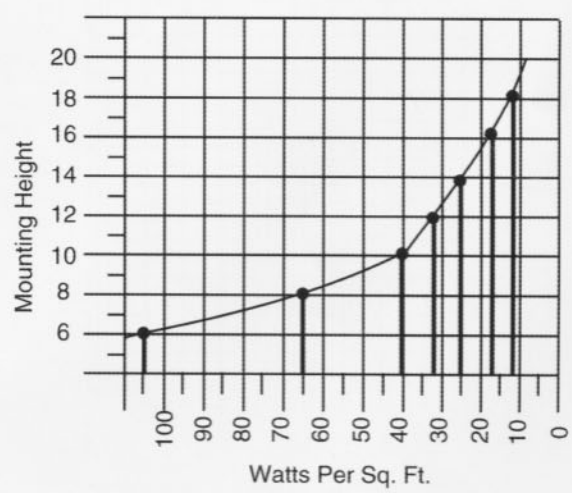
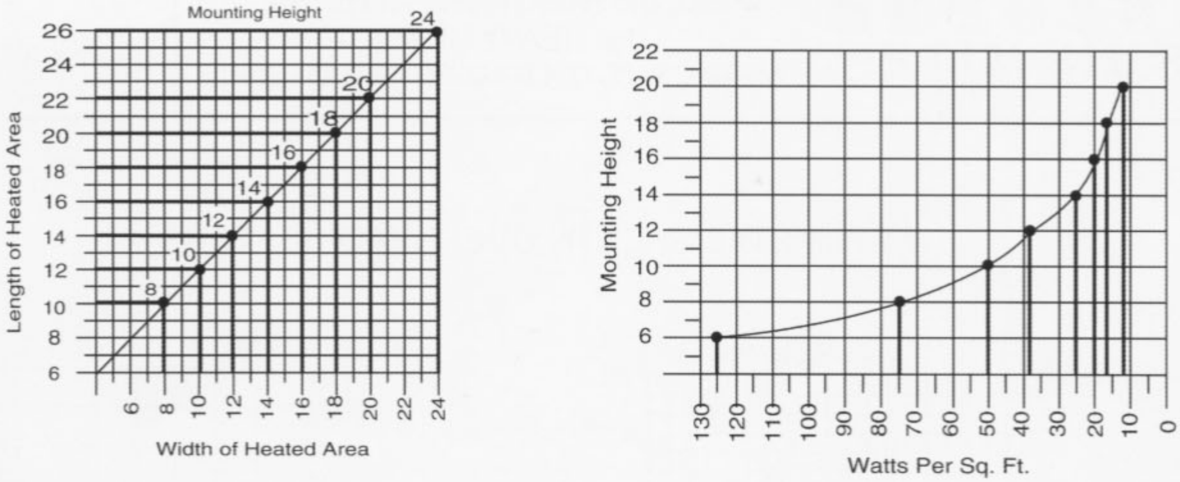
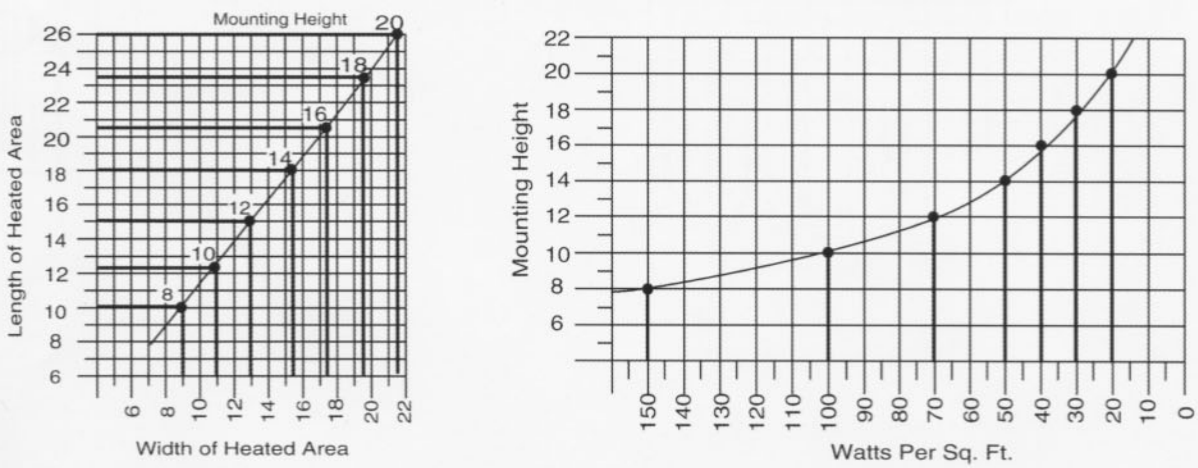


Table 5 (Continued)

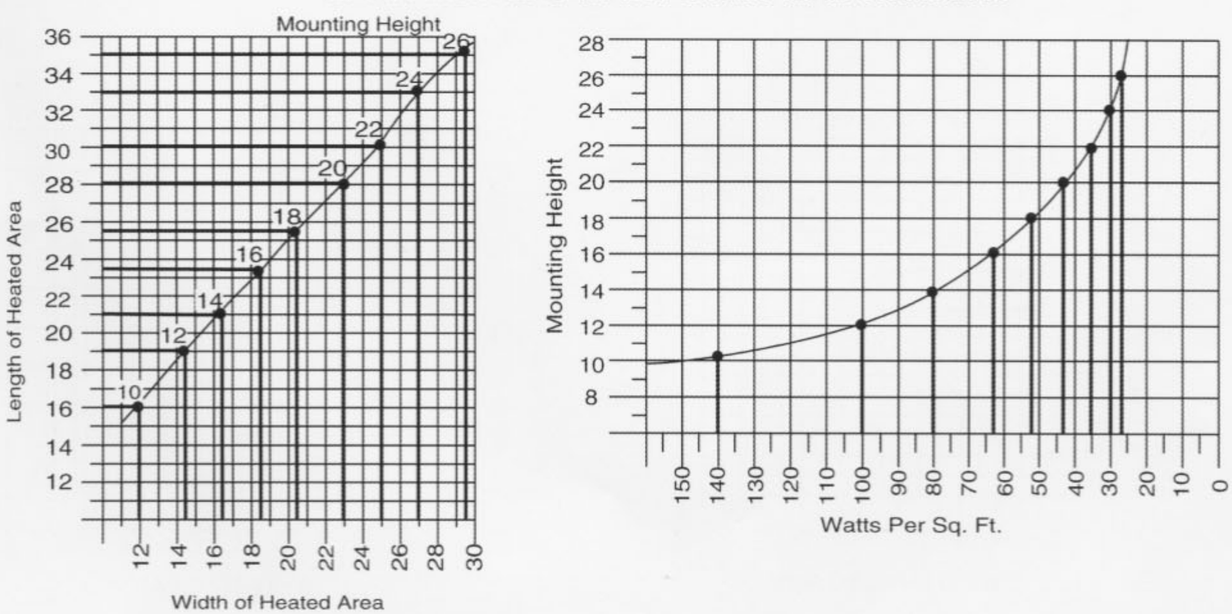
6 KW METAL SHEATH OVERHEAD HEATERS



13.5 KW METAL SHEATH OVERHEAD HEATERS



27 KW METAL SHEATH OVERHEAD HEATERS



Types of Infrared Applications

Infrared Snow & Ice Control System

Community Hospital Gives A Warm Welcome

The hospital wanted their new main entrance and emergency entrance to stay warm and safe for their patients and visitors. Fostoria designed a specific combination of infrared heaters and controls for that purpose.

Infrared Indoor Spot Heating System

Overhead Infrared for Comfort & Production

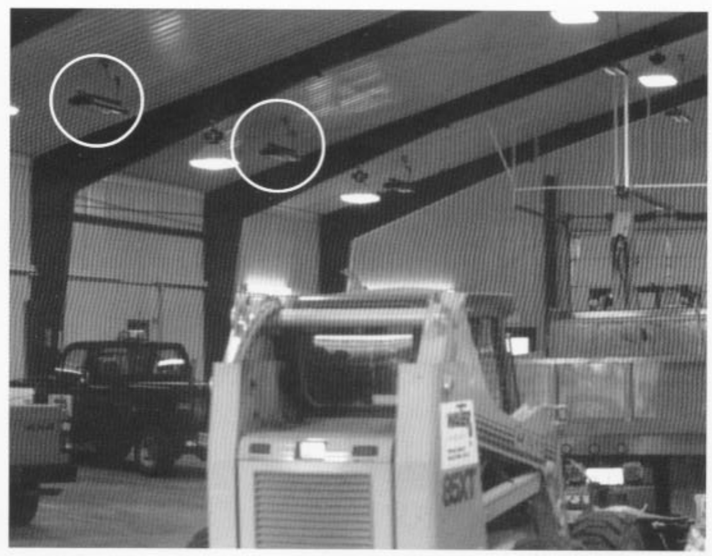
Fostoria Industries' Stainless Steal Mul-T-Mount units took care of Howard Industries' (Laurel, MS) need for indoor spot heating in its production areas throughout the plant. Twenty four of our four foot, 3-lamp, stainless steel, infrared heaters were positioned throughout the facility to keep employees and machinery warm throughout the day.

UL listing on the Mul-T-Mount heaters allows for installation of indoor and totally exposed outdoor areas. It is also the only electric infrared heater UL listed for recessed applications, lending itself to a variety of optional installations.

Infrared Outdoor Spot Heating System

Detroit metro Takes the Chill Out of Flying

Fostoria Mul-T-Mount heaters have reduced the liabilities to the Airport and livery vehicles that commute back and forth picking up the waiting pedestrians. They have successfully increased the level of accommodating services, and improved the safety of customers and employees coming in and out of the terminals



Infrared Total Area Heating System

Warm & Ready to Work

Fostoria Mul-T-Mount heaters are keeping the employees and equipment at the Brown County Rural Water Assoc. warm and ready for their daily duties and throughout the winter months on a moments notice.

Types of Infrared Applications

Infrared snow & ice control for entryways.

Infrared for the comfort of hotel guests, doormen, bellhops and vendors.

Infrared snow & ice control for parking garage ramps.

Infrared heating for outdoor restaurant seating comfort.

Infrared for heating outdoor winter recreation

Infrared is ideal to heat partially exposed walkways or smoking areas.

fostoria®

Quality Since 1917

TPI CORPORATION

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