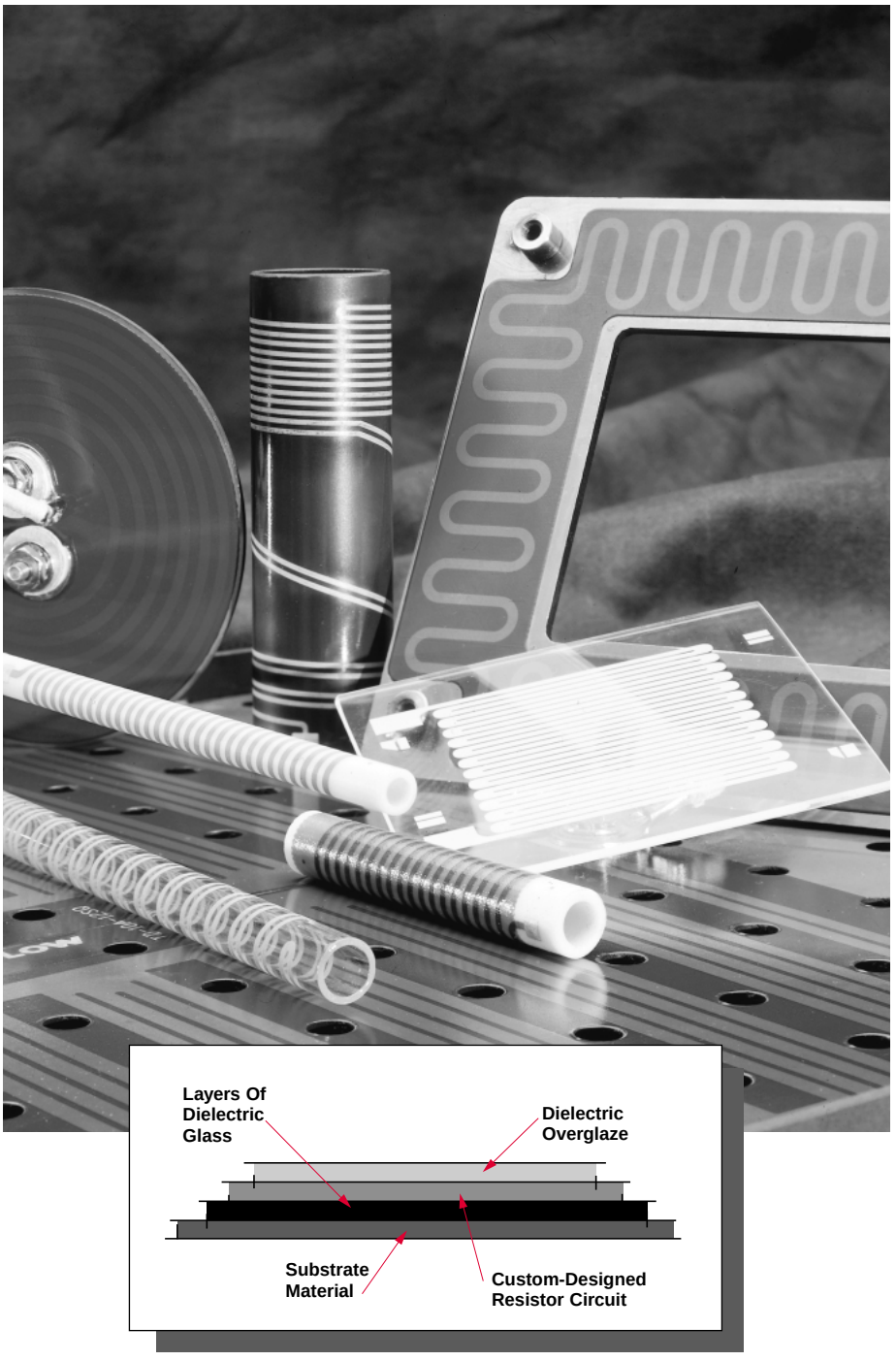
Thick Film Heaters

Thick Film Heating Technology

Watlow's thick film heating technology provides an innovative new way to deliver heat to various applications that require a compact heating solution. Greater control of your heating applications can now be achieved with this breakthrough technology that offers a high-performance, low-profile design that can be intimately fitted to flat and cylindrical surfaces.

The direct surface contact of the thick film heater allows the heat to be put precisely where it's needed. Thick film also provides superior heat transfer and fast thermal response. Glass-based films provide a non-porous surface that prevents moisture absorption.

Thick film resistance heaters are constructed of several layers of material. These materials consist of a substrate, a base dielectric material, a resistor, and a final dielectric layer.



Features and Benefits

- **Low profile, compact size** can be intimately fitted to flat and cylindrical surfaces.
- **UL®, CSA and CE pending.** Contact factory for current status of agency recognitions.
- **Direct contact with substrate** allows heater to respond faster and provide higher operating efficiency.
- **Precise heater circuit patterns** allow for designs with precision temperature uniformity.
- **Robust industrial heaters** designed to operate in 24 x 7 x 365 hour industrial applications.

Applications

- Digital printing and copiers
- Food processing
- Gas and fluid heating
- Life sciences
- Packaging, sealers and dispensers
- Plastics processing
- Semiconductor processing
- General applications that require high wattages and watt densities within a small area
- General applications that require precision distributed wattage patterns for optimal heater solution flexibility

Thick Film Heating Technology

Material Comparison Guide

Watlow's thick film heater technology provides an innovative way to heat numerous applications that allow only minimal space for heat input. This new technology offers a high-performance, low-profile, CAD-generated heater design that can be easily fitted to flat and cylindrical surfaces.

Substrate materials have different thermal expansion rates; therefore Watlow utilizes multiple dielectric and resistor ink combinations to match expansion characteristics. The specified substrate material chosen for the thick film heater is determined by the process compatibility, operating temperature and cycle rates. This easy-to-use, cross-reference guide will help in selecting the proper base material for specific applications.

Material:	Metals				Ceramics		Glass
Due to thick film technology advancements, please check with factory for latest information regarding available materials.	**Type 316 SS**	**Type 430 SS**	**Inconel® Alloy 600**	**Aluminum [Al]**	**Alumina [Al_2O_3] 96-99.9% purity**	**Aluminum Nitride [AlN]**	**Quartz Type GE 214**
Description:	Austenitic stainless steel; good corrosion resistance and strength.	Ferritic stainless steel; moderate cost; good thermal stability.	Excellent mechanical properties; high strength and workability; used in severely corrosive environments.	Good machinability and thermal conductivity; limited to 350°C max. temperature.	High mechanical strength and temperature resistance; high chemical and wear resistance; excellent thermal conductivity.	Good strength and thermal conductivity; excellent thermal stability and dielectric properties.	High temperature and thermal shock resistance; low thermal conductivity; ultra pure substrate.
Applications:	Semiconductor, food equipment, constant temp-erature baths	Food processing, packaging, plastics	Food processing, packaging, plastics	Semiconductor, life sciences, packaging	Semiconductor, digital printing, copying, life sciences, electronics	Semiconductor, life sciences, R&D	Semiconductor, life sciences, analytical equipment
Color:	N/A	N/A	N/A	N/A	White, Black	Gray	Transparent
Density (lb/ft³):	501.12	483.84	525.31	168.5	237.23	203.52	137.34
Dielectric constant:	N/A	N/A	N/A	N/A	9.3	8.9	3.75
Dielectric strength (V/in) @ 77°F (25°C):	N/A	N/A	N/A	N/A	2.54E+05	3.81E+05	1.27E+06
Electrical resistivity (ohm ft) @ 77°F (25°C):	2.42E-06	1.96E-06	3.38E-06	1.04E+01	N/A	3.28E+13	2.30E+06
% Elongation:	50	25	47	25	N/A	N/A	N/A
Specific heat BTU/lb*°F (KJ/kg*°C):	0.12 (0.50)	0.11 (0.46)	0.106 (0.444)	0.215 (0.900)	11.41 (47.77)	9.60 (40.19)	0.1600 (0.6699)
Thermal conductivity BTU/ft*hr*°F (KJ/cm*°C):	9.42 (0.586)	15.08 (0.940)	6.67 (0.416)	130 (8.100)	14.5 (0.903)	46.22 (2.88)	0.8089 (5.040)
Coefficient of thermal expansion (ppm/°C for ceramics, cm/cm * °C for others):	8.9	5.8	7.4	45.4	6.7	4.3	5.5×10^{-7}
Substrate softening temperature °F (°C):	1400 (760)	1300 (705)	1500 (815)	1000 (540)	N/A	*oxidize* 1472 (800)	3061 (1683)
Notes:	**Material pending.** Consult factory for material availability.	Stable to 20 gauge thickness with minimal warpage; this is the standard substrate.	**Material pending.** Consult factory for material availability.	**Material pending.** Consult factory for material availability.	Can be cut or cast as needed; excellent low cost ceramic.	**Material pending.** Consult factory for material availability.	Excellent corro-sion resistance; no dielectric coat available; choice material for corro-sive liquids; except hydrofluoric.

Note: Maximum voltage, 240V; single- or three-phase. Dual voltages are available, consult Watlow.

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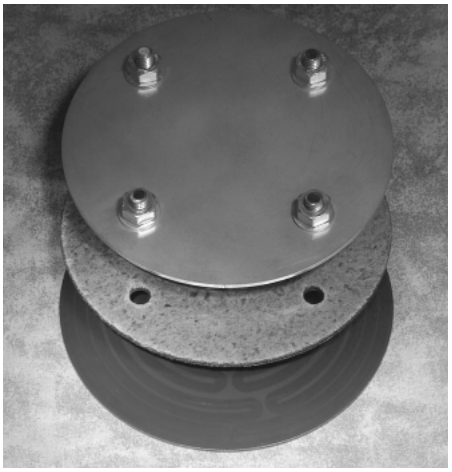
Thick Film Heating Technology

Conduction Heaters



Watlow's new 14 gauge, 430 series stainless steel thick film conduction heaters are ideal for use in many applications where fast response and uniformity are essential. These high-performance heaters use thick film technology to provide maximum temperature response in a compact package.

Thick film conduction heaters provide a low-profile heater in a variety of shapes. These shapes include two-dimensional circular, rectangular and square forms. Due to the direct surface contact, thick film heaters ensure greater heat transfer through thermally stable substrates and precision heater pattern.

This new technology can be applied in areas where space is at a premium or where conventional heaters cannot be used because of limited voltage and wattage combinations.

Features and Benefits

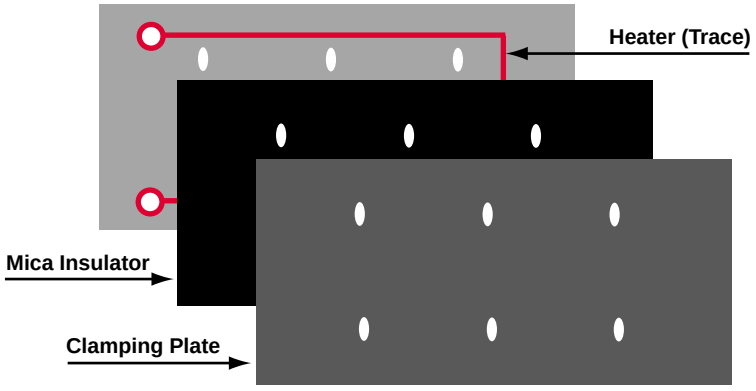
- **1025°F (550°C) maximum substrate temperature** allows for higher process temperatures than most conduction heater technologies.
- **UL®, CSA and CE pending.** Consult factory for current status of agency recognitions.
- **High watt densities for clamp-on applications** allow for precise, repeatable wattage distribution, and uniform temperature distribution
- **Threaded stud termination** produces strong, trouble-free connections.
- **Glass-based thick film technology** eliminates moisture problems and has low current leakage.

Applications

- Designed for use in foodservice, industrial machines, life sciences, plastics and semiconductor applications. A clamp-on thick film heater provides the best possible combination of heat transfer, thermal efficiency and temperature uniformity. For example: clamping the thick film conduction heater on to a 316 stainless steel pan in foodservice applications for uniform cooking or heating oil.

Construction

Thick film conduction heaters designed for clamp-on applications are supplied as a three-part assembly; heater, mica insulator and clamping plate. Overall height of assembly is less than one inch.



Thick Film Heating Technology

Conduction Heaters

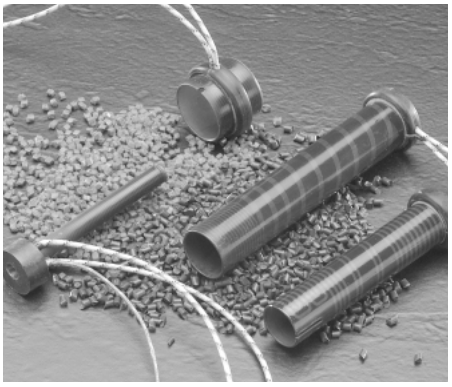
Stock Product List

Heater Size inch	Heater Size (mm)	Voltage	Wattage	W/in²	(W/cm²)	Approximate Assembly Weight lbs	Approximate Assembly Weight (kg)	Watlow Code Number
Round								
4.5	(114) dia	120	325	20.4	(3.2)	1.10	(0.50)	**Consult Factory**
6	(152) dia	120	850	30.1	(4.7)	2.74	(1.24)	
6	(152) dia	240	1125	39.8	(6.1)	2.74	(1.24)	
8	(203) dia	240	2000	39.8	(6.1)	4.91	(2.23)	
Square								
2.25 X 2.25	(57 X 57)	120	100	25	(3.9)	0.27	(0.12)	
4 X 4	(102 X 102)	120	400	25	(3.9)	1.61	(0.73)	**Consult Factory**
6 X 6	(152 X 152)	120	1250	34.7	(5.4)	3.74	(1.70)	
6 X 6	(152 X 152)	240	1450	40.3	(6.6)	3.74	(1.70)	
8 X 8	(203 X 203)	240	2500	39.1	(6.1)	6.36	(2.88)	
Rectangle								
2 X 4	(51 X 102)	120	240	30	(4.7)	0.47	(0.21)	**Consult Factory**
4 X 6	(102 X 152)	120	725	30	(4.7)	2.46	(1.12)	
6 X 8	(152 X 203)	240	1920	40	(6.2)	5.01	(2.27)	

Note: Size and wattage may vary with future design enhancements. Please consult factory for current wattage information.

Thick Film Heating Technology

Nozzle Heater



Because the hot runner nozzle is the final melt path between the manifold and the gate area, temperature uniformity is critical to avoid differences in melt viscosity. Whether it's hot spots causing thermal degradation of the plastic, or cold spots causing flow restrictions, both affect the final part quality and consistency from shot to shot.

Watlow's innovative thick film heating technology provides the injection molding industry with a patented (U.S. patent number 5,973,296) high-performance, low profile hot runner nozzle heater. The direct surface contact of the thick film material to the cylindrical stainless steel sleeve creates optimal heat transfer while the non-porous glass film prevents moisture absorption resulting in dielectric failure in other heaters.

Features and Benefits

- **Uniform thermal profile and ability to pattern heater layout** results in uniform melt temperature for equal cavity filling and improved part quality; eliminates hot and cold spots.
- **Low thermal mass** allows quicker heat up and less thermal lag between the heater and the nozzle.
- **Extremely low radial profile** allows closer pitch – center-to-center distance – between nozzles for higher nozzle density and more parts per mold.
- **Moisture-resistant non-porous glass film construction** eliminates need for soft starting, minimizes current leakage and ultimately reduces cost by eliminating special need of GFI protection.
- **UL®, CSA and CE pending**. Contact factory for current status of agency approval.

Installation

The thick film nozzle heaters are designed with the optimum diametric clearance of 0.0015 inch (0.038 mm) above the actual nozzle. This clearance allows for easy insertion and removal of the heater and excellent heat transfer without the need for clamping, anti-seize or heat sink compound with the thick film nozzle heater.

Nozzle surface preparation may be necessary if the nozzle has any surface contamination or other irregularities. Cleaning of the used nozzle body surface is easily accomplished with light sand blasting of the surface and then a light buffing of the surface with a piece of emery cloth. After the cleaning operation the nozzle heater should slip on and off very easily. Forcing a heater on to a nozzle may result in heater damage and possible failure after it has been in operation.

Substrate I.D.

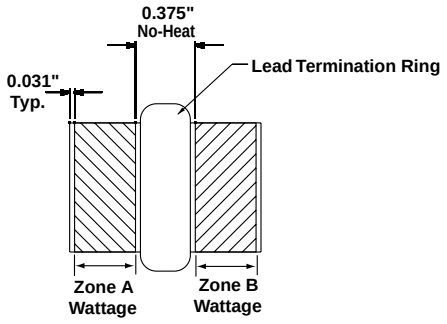
- 0.25 inch (6.35 mm) to 1.5 inch (38.1 mm)

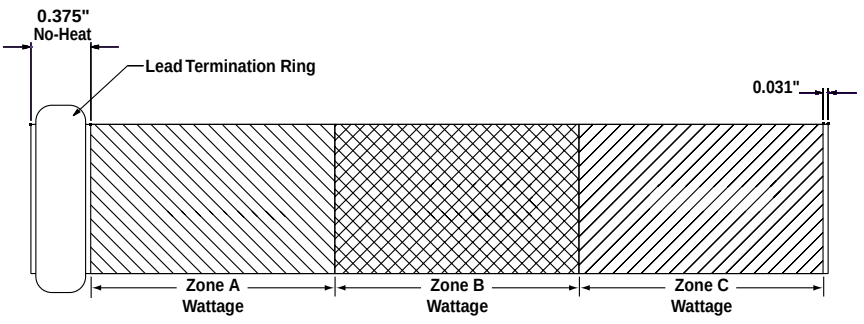
Substrate Length

- 1 inch (25.4 mm) to 8 inches (203.2 mm)

Consult factory for other diameters and lengths.

Distributed Wattage





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Nozzle Heater

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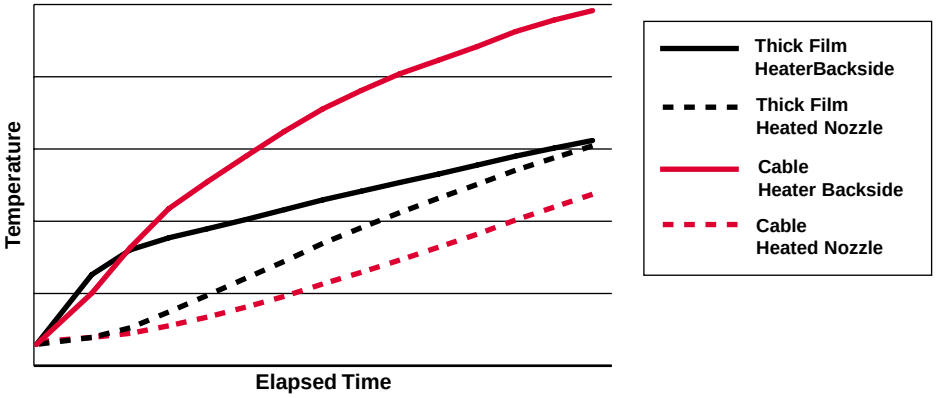
Thick Film Nozzle Heater Response Test
Thick Film vs. Axial Clamped Cable

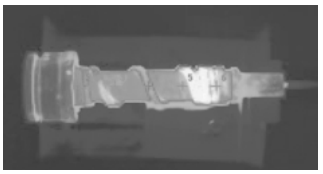


Watlow thick film technology heaters offer five distinct competitive advantages over cable heater technology:

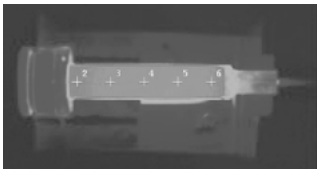
1. Uniform temperature profile
2. No requirement for clamping of the heater
3. High dielectric barrier with agency recognition pending UL®, CSA and CE – eliminates need for softstart
4. Lower heater operating temperatures
5. Precise and repeatable wattage distribution

Precise Wattage Distribution

Thick film nozzle heaters rated to 1025°F (550°C) provide superior temperature uniformity by putting the energy exactly where it is needed.



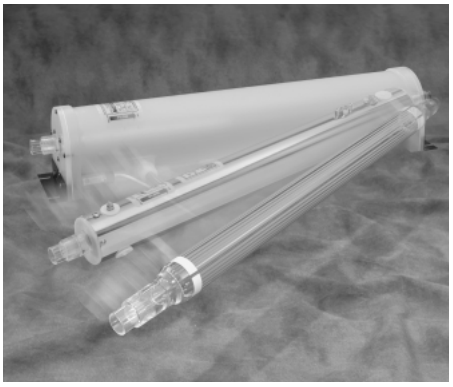
Temperature distribution using standard coiled cable heater.



Temperature distribution using thick film heating technology.

Thick Film Heating Technology

Ultra Pure, Thick Film Quartz Heater Modules



Watlow's new ultra pure, thick film quartz heater modules utilize a recently patented (U.S. patent number 6,037,574) thick-film-on-quartz technology. These high-watt density heater modules provide a superior heating method for deionized (DI) water and aggressive chemicals.

The primary benefits of thick film heating include:

- Reduction in the size of the heater modules by 50 percent or more of existing or current heating technologies, therefore saving space in expensive tools, cleanrooms and wafer fabs
- Elimination of the need for clean-dry-air (CDA) purge required in most infrared (IR) heating systems
- Reduction of the possibility of quartz devitrification that can occur in high temperature IR heating systems
- Elimination of potential metal contamination associated with Teflon® (PTFE) heating systems
- Reduction of preventative maintenance (PM) and increased tool uptime
- Reduced cost of ownership thru higher efficiency heat transfer

Watlow's thick film heating elements are applied directly onto the exterior surface of the quartz tubes, providing more efficient transfer of heat energy with rapid response to changes in flow and temperature.

These superior thick film heaters can be applied in areas where space is at a premium or where conventional heaters cannot be used because the voltage and wattage combination precludes using other types of resistive heaters.

The heaters can be supplied as single module units that you can integrate directly into a tool. Watlow can perform any level of integration from combining multiple modules within a single enclosure to providing a complete turnkey heater and control system.

Applications

Aggressive chemicals

- Acids
- Alkalines
- DI water

Standard Features

- Single-phase voltage
- Fire Retardant Polypropylene (FRPP) Rated 180°F (82°C) - Recommend for DI water applications
- Quartz end fittings compatible with standard ¾" Flaretek® and Flarelock® II fittings
- 2 meter long Teflon® lead wires within flexible Teflon® sleeve
- High limit sensor - 100Ω RTD for dry-fire condition (set limit control for 750° F/400°C)
- Redundant safety high limit - Pilot duty (dry contact mechanical switch)

Options

- 3-phase voltage
- Leak detector - Non-contact electro-optical switch (open collector)
- High limit sensor - Type J or K thermocouple
- Teflon® (PFA) Flaretek® and Flarelock® II interconnects for arrays
- Quartz end fittings compatable with Nippon Pillar Series 300 20 mm fittings
- Kynar® 740 (PVDF) rated 265°F (130°C) - Recommended acid applications other than hot phosphoric
- HALAR® 901 (ECTFE) - Recommended for hot phosphoric applications
- In stream process sensor

Thick Film Heating Technology

Ultra Pure, Thick Film Quartz Heater Modules

Continued

Maximum Single Quartz Modules Dimensions

- Length = Tube length + 4 inches with external fittings
- Width including flanges = 4 inches
- Depth including flanges = 4.5 inches

Notes: Consult factory for available voltage forms.
① Fluid path length includes a ¾ inch (19 mm) Flaretek®-compatible all-PFA tube union.
kW ratings are rounded to the nearest whole number.

Important: Minimum fluid flow rate (on a per-tube basis) is 0.25 GPM @ 10 psig minimum for vertical arrays.

Quick Estimates of Wattage Requirements

Horizontal Array Configuration - Maximum Available Power (kW) per Array

Minimum Overall Fluid Path Length		Total Number of Series Fluid Paths in the Horizontal Array			
inch	(mm)	1	2	3	4
12	(305)	2	4	6	8
15	(381)	3	6	9	13
18	(457)	4	9	13	17
21	(533)	6	11	17	22
24	(610)	7	14	20	27
27	(686)	8	16	24	32
30	(762)	9	18	27	37
40①	(1016)	10	20	30	40
43①	(1092)	11	22	33	44
46①	(1168)	12	25	37	49
49①	(1245)	14	27	41	54
52①	(1321)	15	29	44	59
55①	(1397)	16	32	48	64
58①	(1473)	17	34	51	68
61①	(1549)	18	37	55	73

Notes: Minimum flow rate is 3.0 GPM for horizontal configurations. Multiple horizontal fluid paths are to be plumbed in a series. Consult factory for available voltage forms.
① Fluid path length includes a ¾ inch (19 mm) Flaretek®-compatible all-PFA tube union.
kW ratings are rounded to the nearest whole number.

Vertical Array Configuration - Maximum Available Power (kW) per Array

Minimum Overall Fluid Path Length		Total Number of Parallel Fluid Paths in the Vertical Array						
inch	(mm)	1	2	3	4	6	9	12
12	(305)	2	5	7	9	14	21	27
15	(381)	4	7	11	15	22	33	44
18	(457)	5	10	15	20	31	46	61
21	(533)	7	13	20	26	39	59	78
24	(610)	8	16	24	32	48	71	95
27	(686)	9	19	28	37	56	84	112
30	(762)	11	22	32	43	65	97	129
40①	(1016)	12	23	35	47	70	105	140
43①	(1092)	13	26	39	52	78	117	157
46①	(1168)	14	29	43	58	87	130	173
49①	(1245)	16	32	48	63	95	143	190
52①	(1321)	17	35	52	69	104	155	207
55①	(1397)	19	37	56	75	112	168	224
58①	(1473)	20	40	60	80	121	181	241
61①	(1549)	22	43	65	86	129	194	258

For heating flowing water, simply calculate:

kW = GPM x temperature rise (°F) x 0.16

or

kW = Liters/minute x temperature rise (°C) x 0.076

For heating recirculation applications heating water in baths, simply calculate:

$$kW = \frac{\text{Gallons x temperature rise (°F)}}{\text{375 x Heat up time (hours)}}$$ or $$kW = \frac{\text{Liters x temperature rise (°C)}}{\text{790 x Heat up time (hours)}}$$