

## Ultra Pure Thick Film Quartz Heater Modules Are Ideal for Aggressive Chemical Heating



Watlow thick film quartz heater modules are intended for use in deionized (DI) water and aggressive chemical heating applications. This product employs Watlow's patented thick film on quartz technology to significantly advance the state-of-the-art in ultra pure process heating. The primary benefits of thick film heating include:

- Reduction in size of the heater modules over other 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® (PFA) heating systems
- Reduction of preventative maintenance (PM) and increased tool uptime
- Reduced cost of ownership

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. Due to the unique nature of a thick film circuit, these heaters can be designed to vary heat output across the entire surface.

**U.S. Patent # 6,037,574**

### Applications

Heating aggressive chemicals such as:

- Ammonium chloride
- Deionized water (DI)
- Hydrobromic acid
- Hydrochloric acid
- Hydrogen peroxide
- Nitric acid
- Phosphoric acid
- Piranha etch (sulfuric acid + hydrogen peroxide)
- RCA standard clean 1 (SC1) (DI + ammonium hydroxide + hydrogen peroxide)
- RCA standard clean 2 (SC2) (DI + hydrochloric acid + hydrogen peroxide)
- Sulfuric acid
- TMAH (Tetra Methyl Ammonium Hydroxide)



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Teflon® is a registered trademark of E.I. du Pont de Nemours & Company.



## Features

- High purity semiconductor grade GE 214 quartz
- Single tube power ratings up to 11kW, multi-tube systems up to 32.4kW
- Glassware fluid pressures up to 75 psi\*
- 30 liters (8 gallons) per minute, maximum flow rate
- 0.95 liters (0.25 gallon) per minute, minimum flow rate (for vertically oriented units)
- 11.4 liters (3.0 gallons) per minute, minimum flow rate (for horizontally oriented units)
- Primary element over-temperature sensor available as an RTD or thermocouple
- Redundant mechanical over-temperature snap switch
- Single- and multi-phase power forms 120-480V~(ac)
- UL® recognized - thick film heater on glassware level
- UR®, C-UR®, VDE, CE (pending)
- Options including enclosure materials, electrical interconnection and mounting configurations
- Quartz heater modules utilize materials that have been FM approved in a different geometric form
- Horizontal or vertical orientations available

## Benefits

- Eliminates risk of metal contamination
- Reduced preventative maintenance (PM) cycles
- Reduced cost of ownership
- Longer life
- Reduced element size; reduced system size
- Maximum efficiency in differing flow conditions
- Fast recovery due to direct heater contact
- Low element temperature, <450°C (842°F), no CDA-purge required
- Watt densities up to 15.5 W/cm<sup>2</sup> (100 W/in<sup>2</sup>)
- Fast response
- Compact package size
- Wattages to 21.6 kW for dual fluid paths
- 200°C (390°F) maximum process fluid temperature

**\*Note:** Refer to Flaretek® or Flarelock® II for manufacturer's pressure vs. temperature rating charts on external fittings. Use a surge suppressor and/or pressure regulator in applications exceeding manufacturer's ratings.

## Thick Film Quartz Heaters Outperform Traditional Heating Solutions

In-line thick film quartz tube heaters are the building blocks of thick film quartz heater modules, Watlow's state-of-the-art solution for aggressive chemical heating. Designed for applications with up to 15.5 W/cm<sup>2</sup> (100 W/in<sup>2</sup>), thick film quartz heaters are an excellent solution resulting in a smaller footprint, faster response to dynamic changes in flow and pressure and longer heater life than traditional technologies.

### Problems With Traditional Heating Technology vs. Watlow Thick Film Solutions

#### Wet Chemistry Heating - Teflon® vs. Quartz

Quartz glass is the preferred material for most semiconductor high purity wet processes due to its chemically stable and inert characteristics. Historically, Teflon® has also seen extensive service in wet chemistry processes due to its chemical resistance and inert properties. For example, Teflon® has been used to cover metallic heating elements in an effort to make them compatible with the purity requirements of semiconductor processes. Teflon®, however, has absorption and permeation characteristics which allow particulate migration from the heater sheath through the Teflon® cover, contaminating the process. Quartz does not exhibit these characteristics making it a superior material for insuring process purity in wet chemistry heating.

#### Thick Film Quartz Heating Technology vs. IR

Infrared (IR) heaters use a lamp element operating at an extremely high temperature to radiate energy through the quartz. IR heaters offer a good compromise between performance and size, however, these are less efficient and have a relatively short lamp life, typically about six months. The high operating temperature of the IR lamp represents an operating hazard and requires external cooling means to keep the enclosure and IR lamp termination area at safe limits. The efficiency of IR transmission through quartz is a function of the source (lamp) temperature. To achieve IR heat transfer efficiencies in the +90 percent range requires a source temperature of >2000°C (3632°F).

Watlow thick film quartz heating technology utilizes a specially formulated conductive ink which is permanently fused to, and becomes an actual part of, the quartz surface. This results in an element temperature many times less than that of the IR heater; no CDA purge is required for a touch safe package.

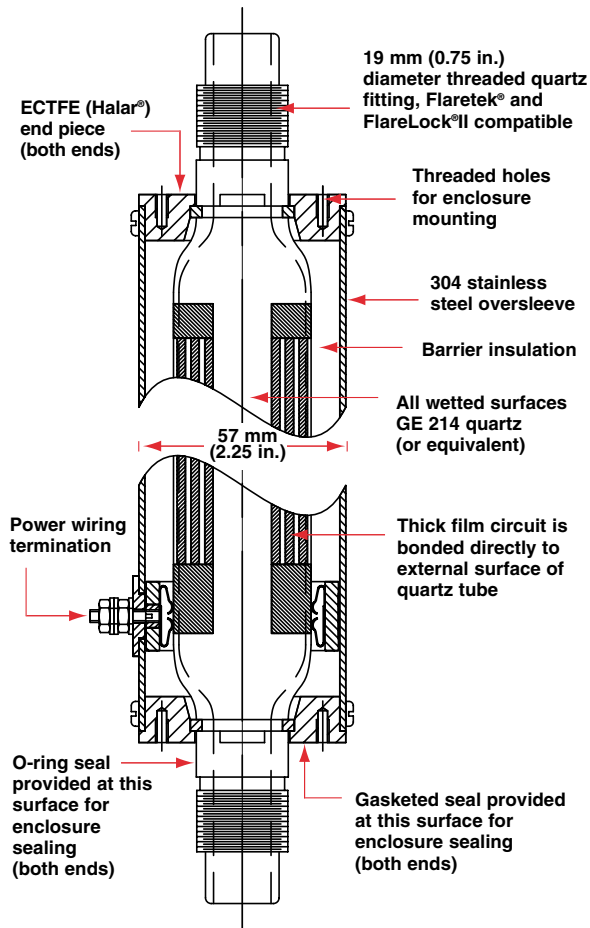
This packs an incredible amount of heat into a small package. The versatile nature of the design and manufacturing process allows Watlow engineers to put power virtually anywhere on the quartz surface. The thick film element itself adds an insignificant amount of mass to the parent quartz material so heat up and response time performance is equally impressive.

## Construction of Thick Film Quartz Heaters Provides High Heater Efficiencies and Design Flexibility

The construction of Watlow's single quartz heater module employs a standard 38 mm (1.50 in.) diameter heated quartz tube surrounded by an insulating barrier and a 300 series stainless steel oversleeve. An FM 4910 compliant end piece is used to provide the module mounting interface. Sealing provisions are provided in order to isolate the heater components from the operational environment when the module is incorporated into a heating system design.

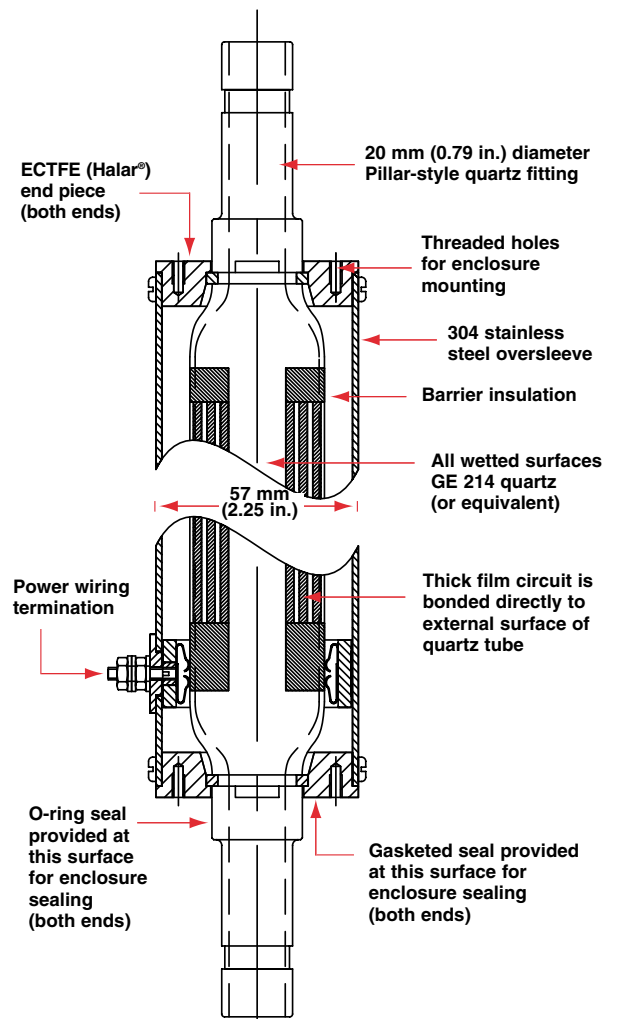
Power ratings and lengths may be varied as required to support virtually any combination of voltages and application requirements by combining multiple modules into a single array package. This modular approach allows higher capacity systems to be offered by combining the necessary configuration of heater modules with controllers and other customer options.

### Quartz Tube with Flaretek®-Style Fitting



Flaretek®-Style Fitting

### Quartz Tube with Pillar-Style Fitting



Pillar-Style Fitting

## Thick Film Quartz Heater Modules Available in Single, Dual, and Triple Configurations

Quartz heater modules can be stand-alone units or interconnected to form systems for DI water or acid applications.

Depending upon the process need, the design of the quartz module allows application requirements to drive not only the electrical and thermal solution, but also the physical size of the equipment.

Watlow quartz modules are designed for both vertical and horizontal applications.



Fully assembled, single-tube, vertical unit with Pillar-style fitting

### Standard Features

- Single-phase voltage
- Quartz end fittings compatible with standard 19 mm (0.75 in.) Flaretek® and Flarelock® II fittings
- 1828 mm (6.00 ft) long Teflon® lead wires within flexible Teflon® sleeve
- Redundant safety high limit - Pilot duty (dry contact mechanical switch)
- High limit sensor - Type J or K thermocouple (set limit control for 250°C (482°F))

### Options

- Quartz end fitting compatible with standard 19 mm Pillar-style fitting available
- 3-phase voltage
- Leak detector - Non-contact electro-optical switch (open collector)
- Teflon® (PFA) interconnects for arrays
- Kynar® 740 (PVDF) rated 130°C (266°F) - Recommended for acid applications other than hot phosphoric
- Halar® 901 (ECTFE) - Recommended for hot phosphoric applications
- Downstream process sensor assembly
- Fitting assembly also available
- High limit sensor - 100Ω RTD for dry-fire condition (set limit control for 250°C (482°F))

### Dual Quartz Module

Thick film quartz modules are also available as dual modules. The dual module can provide up to double the wattage without doubling the size of the package. The dual quartz modules are available in horizontal or vertical orientation, see page 6.



Two-tube horizontal unit



FLARETEK®-style inlet and outlet fittings on a dual module unit

### Triple Quartz Module

Many applications requiring higher kW can also be addressed using module assemblies configured with three fluid paths.

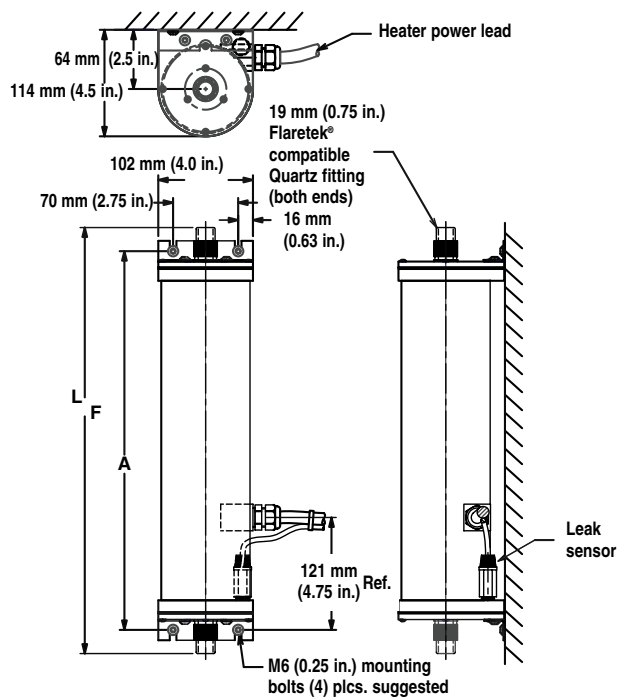
Wattages of up to 32.4 kW can be supplied, but all inquiries should be made to the factory on these custom designs.



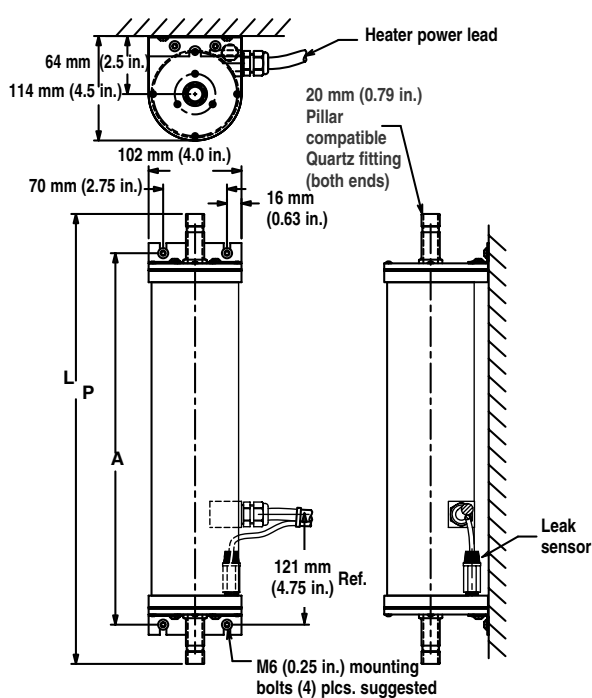
Three-tube vertical unit

Flaretek® and FlareLock® II are registered trademarks of Entegris, Inc. Halar® is a registered trademark of Ausimont USA. Kynar® is a registered trademark of ELF Atochem.

### Single Tube Vertical Unit with Flaretek®-Style Fittings



### Single Tube Vertical Unit with Pillar-Style Fittings

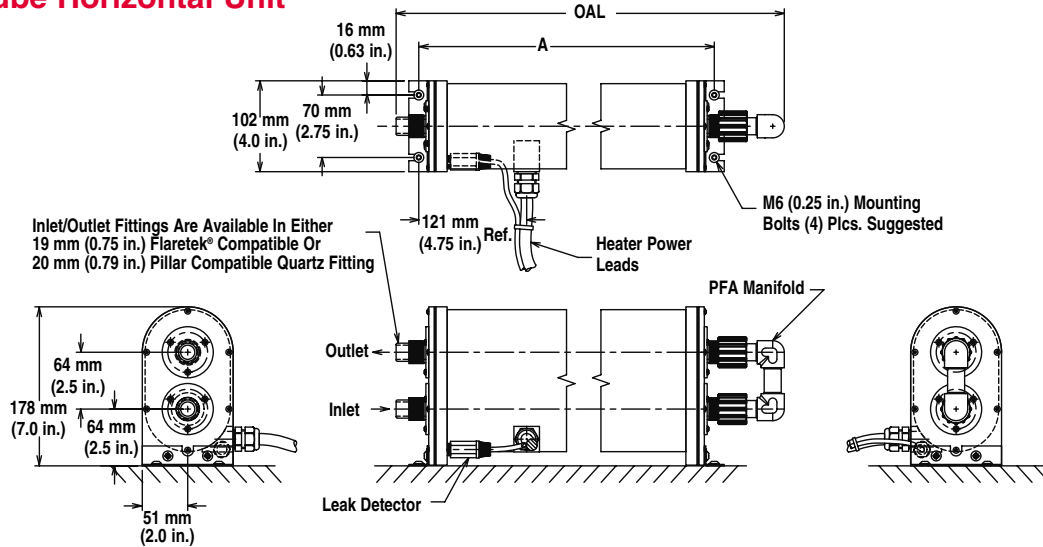


### Maximum Available Power (kW)

Minimum Overall Fluid Path Length				Power (kW)		A	
Flaretek®		Pillar		Horizontal Orientation	Vertical Orientation	mm	(inch)
Lf mm	Lf (inch)	Lp mm	Lp (inch)				
305	(12)	340	(13.38)	2.0	2.4	254	(10)
381	(15)	416	(16.38)	3.2	3.8	330	(13)
457	(18)	492	(19.38)	4.4	5.2	406	(16)
533	(21)	568	(22.38)	5.6	6.6	483	(19)
610	(24)	645	(25.38)	6.8	8.0	559	(22)
686	(27)	721	(28.38)	8.0	9.4	635	(25)
762	(30)	797	(31.38)	9.2	10.8	711	(28)
1016	(40 <sup>Ø</sup> )	Consult Factory		10.0	11.8	965	(38)
1092	(43 <sup>Ø</sup> )	Consult Factory		11.2	13.2	1041	(41)
1168	(46 <sup>Ø</sup> )	Consult Factory		12.4	14.6	1118	(44)
1245	(49 <sup>Ø</sup> )	Consult Factory		13.6	16.0	1194	(47)
1321	(52 <sup>Ø</sup> )	Consult Factory		14.8	17.4	1270	(50)
1397	(55 <sup>Ø</sup> )	Consult Factory		16.0	18.8	1346	(53)
1473	(58 <sup>Ø</sup> )	Consult Factory		17.2	20.2	1422	(56)
1549	(61 <sup>Ø</sup> )	Consult Factory		18.4	21.6	1499	(59)

**Notes:** ① Fluid path length includes a 19 mm (0.75 in.) Flaretek®- compatible all-PFA tube union.  
 Minimum flow rate: 11.4 LPM (3.0 GPM) for horizontal; 0.95 LPM (0.25 GPM) for vertical.  
 Consult factory for available voltage forms.

## Two Tube Horizontal Unit

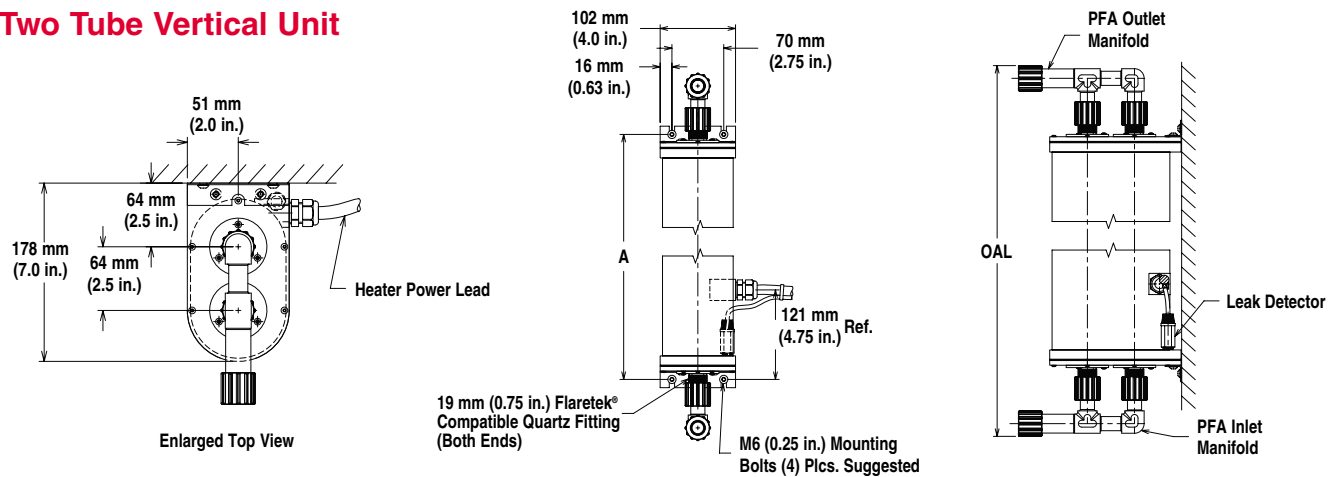


## Maximum Available Power for Two Tube Horizontal Enclosure

Flaretek® Inlet/Outlet Fittings		Pillar Inlet/Outlet Fittings		Power (kW)	A	
Quartz Weldment Length	OAL	Quartz Weldment Length	OAL			
mm (inch)	mm (inch)	mm (inch)	mm (inch)		mm (inch)	mm (inch)
305 (12)	358 (14.1)	340 (13.38)	376 (14.8)	4.0	254	(10)
381 (15)	434 (17.1)	416 (16.38)	452 (17.8)	6.4	330	(13)
457 (18)	511 (20.1)	492 (19.38)	528 (20.8)	8.8	406	(16)
533 (21)	587 (23.1)	568 (22.38)	605 (23.8)	11.2	483	(19)
610 (24)	663 (26.1)	645 (25.38)	681 (26.8)	13.6	559	(22)
686 (27)	739 (29.1)	721 (28.38)	757 (29.8)	16.0	635	(25)
762 (30)	815 (32.1)	797 (31.38)	833 (32.8)	18.4	711	(28)

**Note:** Minimum flow rate is 11.4 LPM (3.0 GPM) @ 10 psig minimum. Consult factory for available voltage forms.

## Two Tube Vertical Unit



## Maximum Available Power for Two Tube Vertical Enclosure

Flaretek® Inlet/Outlet Fittings		Pillar Inlet/Outlet Fittings		Power (kW)	A	
Quartz Weldment Length	OAL	Quartz Weldment Length	OAL			
mm (inch)	mm (inch)	mm (inch)	mm (inch)		mm (inch)	mm (inch)
305 (12)	425 (16.8)	Consult Factory		4.8	254	(10)
381 (15)	502 (19.8)	Consult Factory		7.6	330	(13)
457 (18)	578 (22.8)	Consult Factory		10.4	406	(16)
533 (21)	654 (25.8)	Consult Factory		13.2	483	(19)
610 (24)	730 (28.8)	Consult Factory		16.0	559	(22)
686 (27)	806 (31.8)	Consult Factory		18.8	635	(25)
762 (30)	883 (34.8)	Consult Factory		21.6	711	(28)

**Note:** Minimum flow rate (on a per tube basis) is 0.95 LPM (0.25 GPM) @ 10 psig minimum. Consult factory for available voltage forms.

## Thick Film Quartz In-Line Heater Modules Stock List

Part Number	Module Size	Wattage	Voltage	Orientation	Fitting Style	Lead Length	List Price
TQ-117-8-1	18" Single	5.2 kW	208, 1ph	Vertical	¼" Flaretek® compatible	36"	Consult factory
TQ-117-9-1	18" Single	5.2 kW	208, 1ph	Vertical	19 mm Pillar	1000 mm	Consult factory
TQ-117-10-1	30" Single	9.2 kW	480, 3ph	Vertical or Horizontal	¼" Flaretek® compatible	36"	Consult factory
TQ-117-11-1	15" Double	6.4 kW	208, 1ph	Horizontal	¼" Flaretek® compatible	36"	Consult factory
TQ-117-13-1	24" Single	6.8 kW	480, 3ph	Vertical or Horizontal	¼" Flaretek® compatible	36"	Consult factory*

\* Includes leak detector

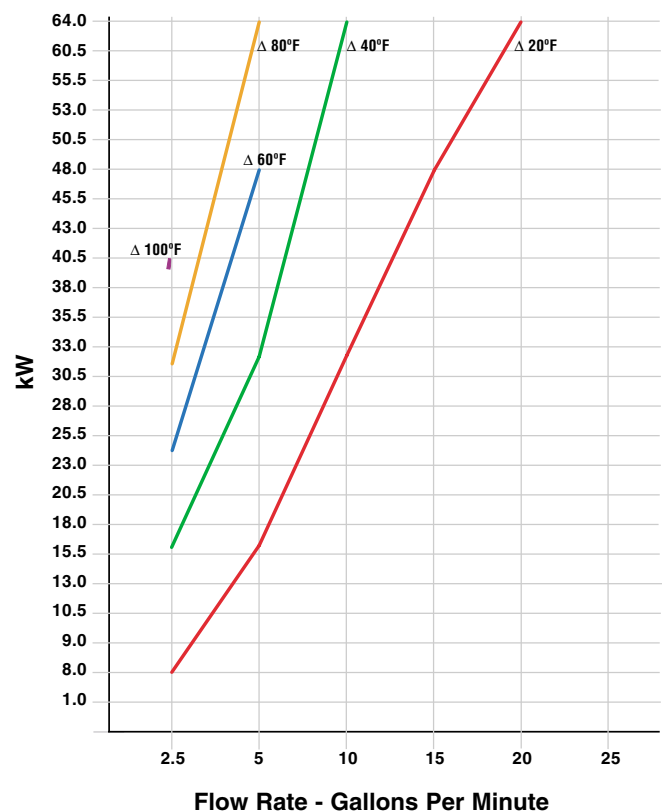
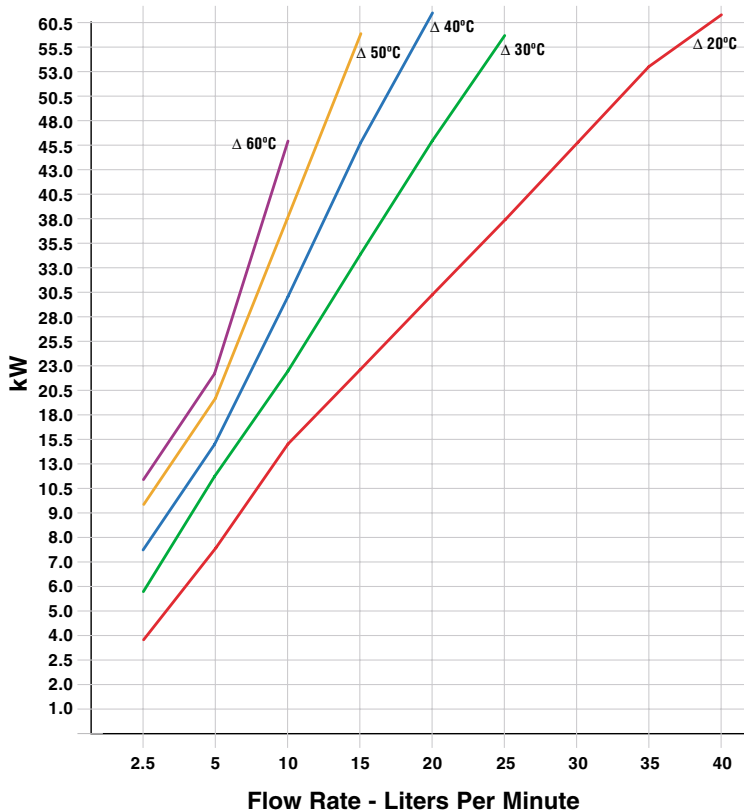
Common features include:

- Pilot duty 24V thermostat
- ANSI Type J high limit T/C
- Kynar® (PVDF) enclosure

Options:

- (to be specified at time of order)
- leak detector
  - process sensor

## Quick Estimates of Wattage Requirements (for Deionized Water)



**Note:** Locate the application flow rate on x-axis of the appropriate chart and follow the vertical line upward until it intersects the target temperature rise. At that point move left, horizontally, to the y-axis to capture the approximated wattage requirement.

## Quick Estimates of Wattage Requirements

For heating flowing water, simply calculate:

$$\text{kW} = \text{GPM} \times \text{temperature rise (}^\circ\text{F)} \times 0.16$$

or

$$\text{kW} = \text{Liters/minute} \times \text{temperature rise (}^\circ\text{C)} \times 0.076$$

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

$$\text{kW} = \frac{\text{Gallons} \times \text{temperature rise (}^\circ\text{F)}}{375 \times \text{Heat up time (hours)}}$$

or

$$\text{kW} = \frac{\text{Liters} \times \text{temperature rise (}^\circ\text{C)}}{790 \times \text{Heat up time (hours)}}$$

# Performance and Reliability Testing—IR vs. Thick Film—Proves Superiority of Thick Film Quartz Modules

## Performance Testing

Watlow's quartz heater module was tested in direct comparison to an IR heater to provide evidence of the performance and efficiency advantages of thick film technology.

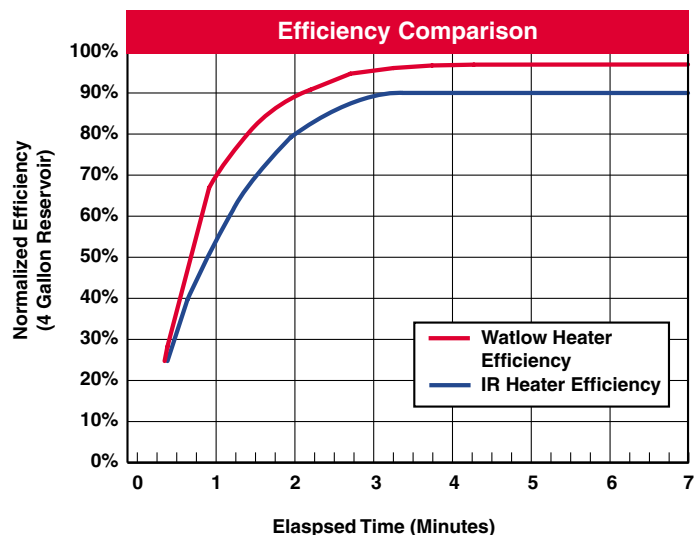
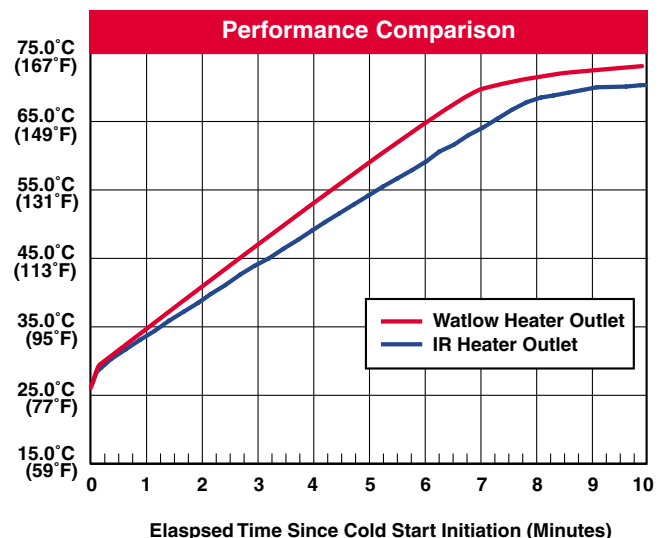
Testing was performed on a wet bench heating DI water. The normalized performance comparison graph illustrates the thermal response of the system using each heater. The thermal load consisted of 15.1 liters (4 gallons) of water circulating through a diaphragm pump, the in-line heater, a diverter valve and back to a holding tank (reservoir). Temperatures were sensed at the outlet of the in-line heater and the bulk tank. The Watlow heater provided a faster heat up time. It outperformed the IR heater by achieving the process set point of 65°C (149°F) in 6.5 minutes; whereas, the IR heater required 7.25 minutes.

This efficiency comparison was created by normalizing the nominal power outputs of the respective heaters and calculating the efficiency based upon the work performed at the reservoir. Elapsed time for the efficiency test was equal for both systems at which both were at 100 percent power.

As shown in the efficiency comparison graph the Watlow heater demonstrated a five to ten percent improvement in efficiency.

## Reliability Testing

Reliability testing of the core technology used in the thick film quartz heater module has been conducted. Reliability targets of three years or 9,000 hours of continuous operation were validated through this testing.



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