FLUENT® In-line Heater

High Performance Fluid Heating Solution Featuring Watlow's Thermal Spray Technology Improves System Performance

The FLUENT® in-line heater from Watlow® is a small, lightweight, high-performance heater that can replace both a traditional immersion type heater or a heater wrapped around a tube as part of a thermal system. Watlow's FLUENT heater is designed as an integrated solution that replaces multiple components in a system. This heater design reduces overall system cost and complexity. Because of its high watt density, it offers ultra-fast response leading to higher system performance. Featuring Watlow's patented layered heater technology, the heater makes use of its entire surface to produce heat, which optimizes heat transfer and temperature uniformity.

For Gas heating applications use Baffle option to increase turbulent flow and efficiency. Cases where baffles are typically removed are to lower pressure drop and for recirculating applications.

Features and Benefits

Small, lightweight, robust heater construction

- Replaces multiple components in a system
- Reduces overall system size
- Lowers total cost of ownership

Patented circuit patterning process

- Facilitates customizable heating profiles
- Enables distributed wattage and/or multiple zones
- Assures precise and repeatable power distribution

High watt density, low mass heater

- Contributes to fast response time
- Allows for efficient heat transfer
- Enables on-demand process start-up

Typical Applications

- Hemodialysis fluid heating
- Food cooking equipment
- Semiconductor purge and carrier gas heating
- Ink preheating systems
- On demand fluid heating

WATLOW®
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To be automatically connected to the nearest North American Technical Sales Office:
1-800-WATLOW2 • www.watlow.com
inquiry@watlow.com

International Technical Sales Offices:

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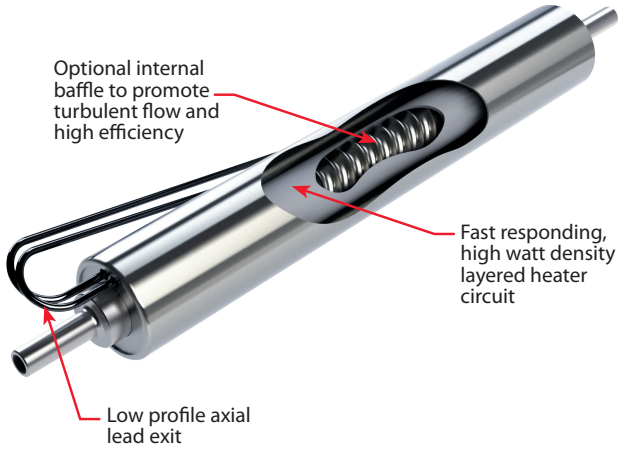
China	+86 21 3532 8532	**Italy**	+39 02 458 8841	**Singapore**	+65 6773 9488
France	+33 1 41 32 79 70	**Japan**	+81 3 3518 6630	**Spain**	+34 91 675 1292
Germany	+49 7253 9400 0	**Korea**	+82 2 2169 2600	**Taiwan**	+886 7 288 5168
				UK	+44 115 964 0777

Specifications

- Substrate tube material: 444 SS
- Fitting and baffle material: 316L SS
- Voltage up to 240V
- Amperage up to 15A per zone
- Resistance tolerance +10%, -5%
- Typical maximum watt densities
  - Air 150 W/in² (23 W/cm²)
  - Water 450 W/in² (70 W/cm²)
- Maximum pressure: 150psi (10.2 bar)
- Maximum temperature: 662°F (350°C) as measured by internal T/C
- UL®/cUL® and CE



Application Orientation

Gas Heating—
(Any orientation)

Liquid Heating—
(Heater must be vertical with inlet at the bottom)

For Gas heating applications use Baffle option to increase turbulent flow and efficiency. Cases where baffles are typically removed are to lower pressure drop and for recirculating applications.

Standard Product Offering: Base Heaters

Volts	Watts	Number of Heating Circuits	Outer Diameter in.	(mm)	Protection Tube Length in.	(mm)	Watt Density (W/in²)
240	500	1	1	(25)	3.00	(76)	210
120	250	1	1	(25)	4.25	(108)	57
240	1000	1	1	(25)	4.25	(108)	228
120	375	1	1	(25)	5.25	(133)	62
240	1500	1	1	(25)	5.25	(133)	247
120	500	1	1	(25)	6.50	(165)	63
240	2000	1	1	(25)	6.50	(165)	250
120	750	2	1	(25)	6.50	(165)	94
240	3000	2	1	(25)	6.50	(165)	375
120	1000	2	1	(25)	7.75	(197)	100
240	4000	2	1	(25)	7.75	(197)	400
240	500	1	1	(25)	6.50	(165)	63
120/240	1000/4000	1	1⅝	(41)	6.50	(165)	75/300
120/240	1500/6000	2	1⅝	(41)	10.00	(254)	61/245
120/240	2000/8000	2	1⅝	(41)	12.00	(304.8)	61/245

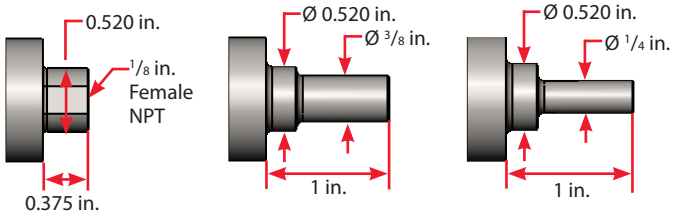
Note: Visit www.watlow.com/fluent for the latest list of standard designs and product information.

Typical Flow Rates Gas/Air 50-500 SLM

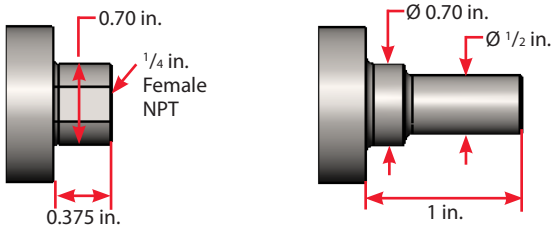
Typical Flow Rates Water 0-5000 L/M

Inlet/Outlet Fitting Options

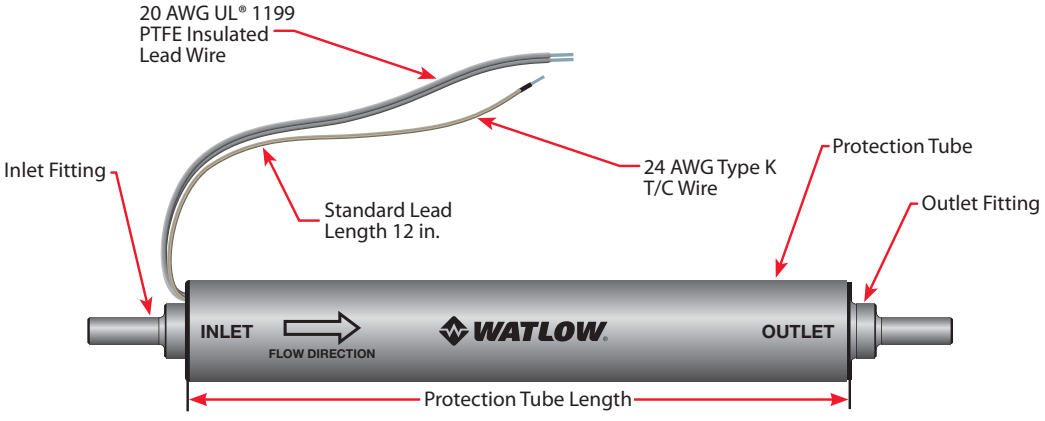
1 Inch Outer Diameter Heaters



1⅝ Inch Outer Diameter Heaters



Standard Construction

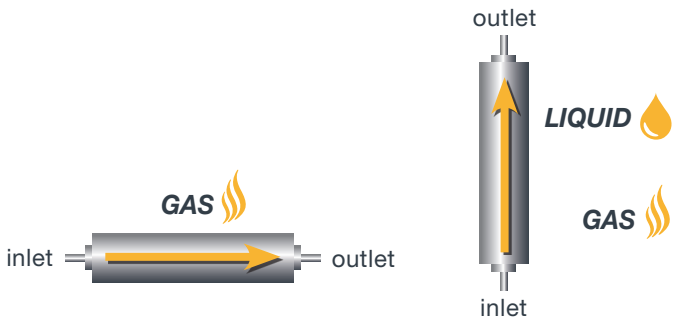


FLUENT® INSTALLATION

Mounting Orientation

- FLUENT® heater orientation must be vertical for liquids.
- Flow direction must always start at the inlet (lead exit) and flow to the outlet. When mounted vertically, the inlet side should be on the bottom.

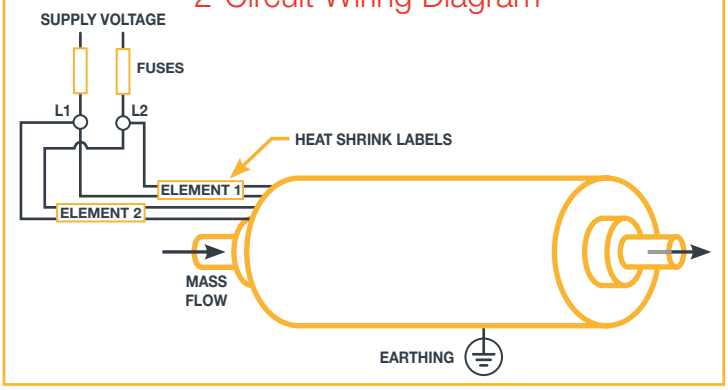
Application Orientation



Electrical Connection

- Do not apply more than the recommended voltage marked on the FLUENT heater.
- Grounding to any of the exterior metal components is recommended.
- A heater with multiple heating circuits should have the circuits connected in parallel and must be powered simultaneously.

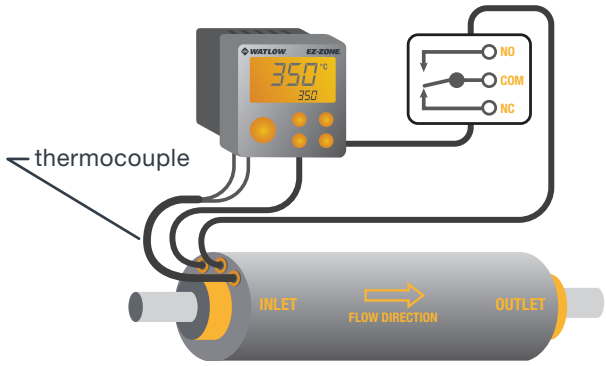
2-Circuit Wiring Diagram



Temperature Control

- The FLUENT heater should not be powered unless fluid flow is present.
- The integrated Type K thermocouple is mounted on the heating element and should only be used as a high limit sensor with a latching limit control.
- The maximum limit temperature setting is 350°C. A lower setting may be applicable and provide improved product protection.
- Fluid temperature sensing must be accomplished by a downstream sensor.

Minimum High Limit Circuit Requirements



Other Specifications

- Maximum pressure rating: 150 PSI (10.3 bar)
- This is intended to be used as a quick start guide. Full documentation on these and other topics can be found in the product guide at http://fluent.watlow.com/

FLUENT In-line Heaters

Technical Information

Standard Product Offering: Base Heaters

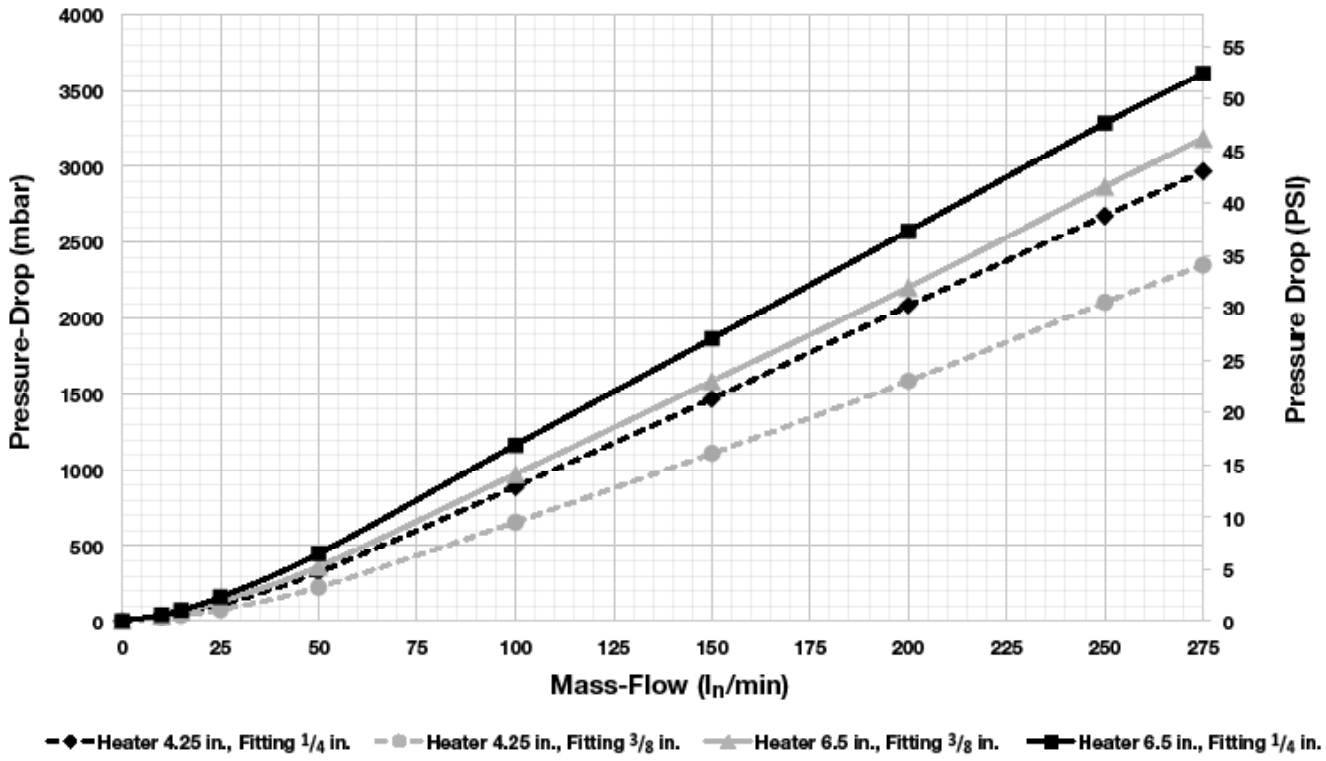
Volts	Watts	Protection Tube Length in.	(mm)	Number of Heating Circuits	Watt Density (W/in²)
240	500	3.00	(76)	1	210
120	250	4.25	(108)	1	57
240	1,000	4.25	(108)	1	228
120	375	5.25	(133)	1	62
240	1,500	5.25	(133)	1	247
120	500	6.50	(165)	1	63
240	2,000	6.50	(165)	1	250
120	750	6.50	(165)	2	94
240	3,000	6.50	(165)	2	375
120	1,000	7.75	(197)	2	100
240	4,000	7.75	(197)	2	400
240	500	6.50	(165)	1	63

Note: Visit www.watlow.com/fluent for the latest list of standard designs and product information.

How to Specify a Standard Product:

- Select a base heater from the chart to the left.
- Choose the desired inlet and outlet fittings from page 446.

Pressure Drop - Air - With Internal Baffle @ 250°C

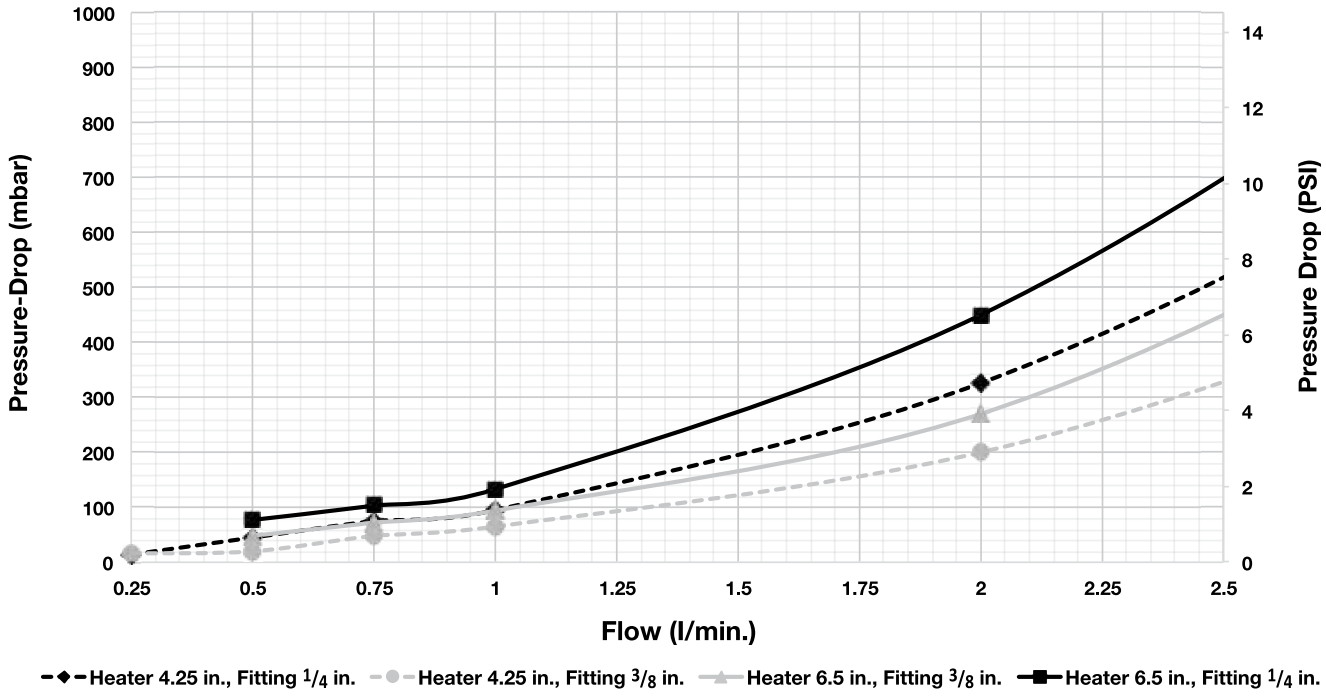


Note: Internal baffle is required for all gas heating applications.

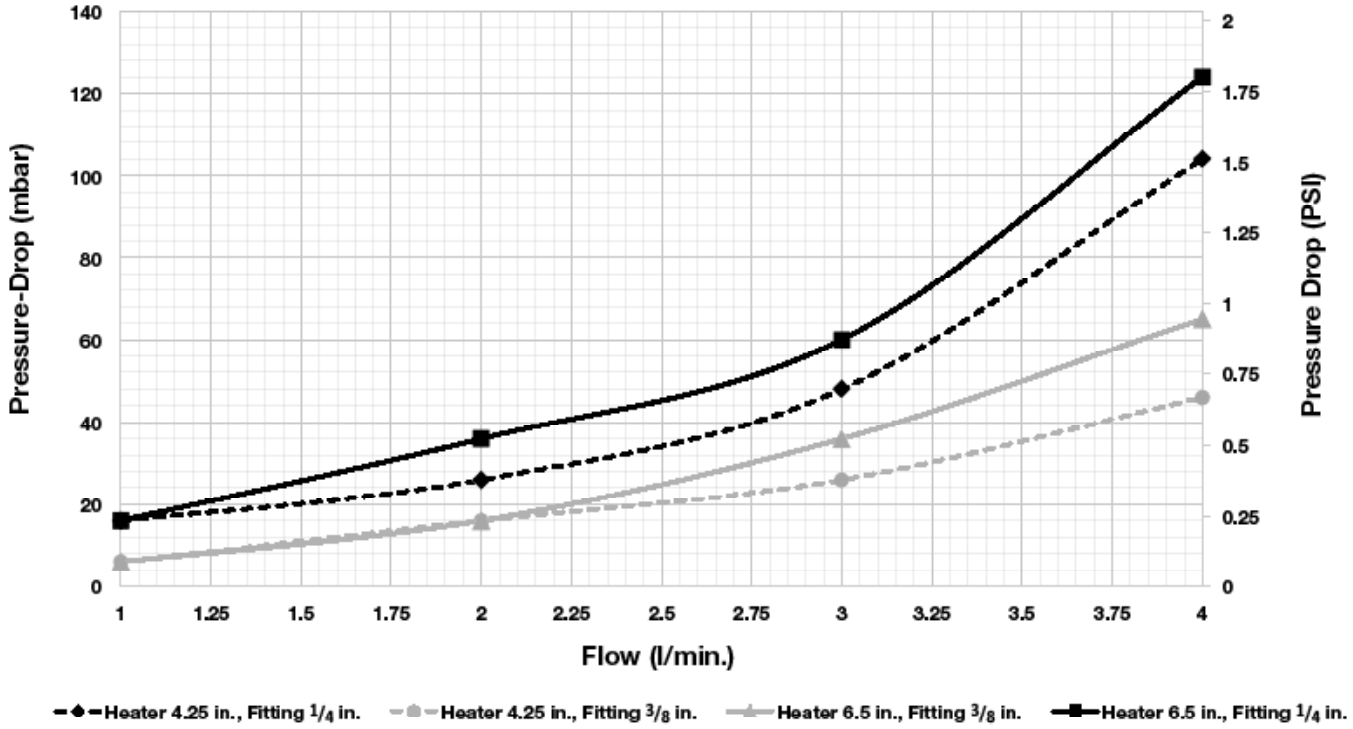
FLUENT In-line Heaters

Technical Information

Pressure Drop - Water - With Internal Baffle



Pressure Drop - Water - Without Internal Baffle



Heater internal temperature will vary based on flow rate, heater watt density and presence of the internal baffle, which increases turbulent flow. General guidelines for baffle consideration:

- For flow rates below 1 l/min, baffle should always be used to prevent an over-temperature condition.
- For flow rates over 1 l/min, removing the baffle is possible but will result in a higher internal temperature.

FLUENT® Product Guide

General

The purpose of this product guide (the "Guide") is for Watlow Electric Manufacturing Company ("Watlow®") to convey certain recommendations, advisories and requirements regarding your purchase and use of the product(s) described below (the "Product"). This guide is not intended to be an exhaustive list of recommendations, advisories or requirements for the use of the product. Please visit Watlow's website (http://www.watlow.com/) or contact Watlow customer service (1-800-WATLOW2) for more information regarding Watlow's products. To ensure the proper use of the product, each user of the product should carefully review this guide. FAILURE TO COMPLY WITH THE INFORMATION PROVIDED HEREIN SHALL CAUSE YOU TO ASSUME ALL RISK AND LIABILITY ARISING OUT OF SUCH FAILURE.

Product Description

This guide applies to Watlow FLUENT® in-line heaters. The product can be distinguished via marking on the outer metal sheath.

FLUENT® model number
Nominal operating voltage and total power
product serial number
patent site

Safety

The following markers utilized throughout this guide shall have the meanings set forth below:

DANGER – *This is a danger statement that is related to the use of this product. Failure to heed these messages will result in serious personal injury or death.*

WARNING – *This is a warning statement that is related to the use of this product. These statements warn of actions that may result in physical injury or death.*

WARNING – Risk of Electric Shock – *This is a warning statement that warns of the presence of electrical voltages, which can cause physical injury or death.*

CAUTION – *This is a caution statement that is related to the use of this product. These statements caution against actions, which may damage the product or associated equipment.*

DANGER – *Care should be taken to read and completely understand this guide before installing and wiring the product. The product is designed to become hot while in operational use. The end user must conduct their own risk assessment to identify if there is any residual risk pertaining to direct contact with hot surfaces. There is potential risk of rupture or other malfunction of the product if it is not installed in accordance with this guide or other installation instructions provided by Watlow. It is the end user's responsibility to ensure that the product is properly selected and installed in accordance with applicable recommendations given within this guide. Note: this guide does not cover all foreseeable end-use applications, therefore, consult your local Watlow representative with any additional questions or concerns.*

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10-25338-05FEB19

WARNING – Risk of Electric Shock – *Any installation and maintenance performed on this product shall be performed by a qualified electrician in accordance with applicable national and local electrical codes.*

It is the end user's responsibility to ensure that proper precautions are taken to ensure that necessary personal protective equipment is utilized by persons installing and maintaining any equipment.

Pre Installation

The following sets forth general safety instructions and requirements relating to the use of the product.

CAUTION – *Watlow products are built to comply with UL® and CSA dielectric requirements. However, due to atmospheric conditions, it may be necessary to validate by performing a dielectric test prior to startup. (Refer to megohm test under the Installation section.)*

1. Upon receipt of the product, inspect for any damage occurring during shipment. If you have any concerns about the condition of the product, do not install such product and contact your Watlow representative prior to taking further action with the product.
2. Upon receipt of the product, confirm that the product received is the same as the product that was ordered. In the event of a discrepancy, please contact your Watlow representative prior to taking further action with the product.

Installation

Proper product selection and installation will help to ensure heat transfer efficiency, safety and increased product life. The following sets forth instructions and requirements relating to the installation of the product.

1. Megohm pre-check

WARNING – Risk of Electric Shock – *The bake-out procedures listed below should only be performed by qualified personnel. If the procedure calls for connecting electric power to the product, this shall only be performed by a qualified electrician, in accordance with applicable national and local electrical codes.*

During shipping and/or storage, the possibility of moisture absorption by the insulation material within a heater element is possible. To determine if the proper megohm value is present, use a 500VDC (minimum) megohm meter to measure the insulation resistance between the product power terminals and the product's outer protection tube. This value should be greater than 200 megohms when the unit is at room temperature.

If a low megohm value exists, bake the product in an oven at 177°C (350°F) ± 27°C (50°F) for a duration of 12 to 24 hours. After baking, repeat the megohm insulation resistance test to verify that 200 megohms insulation resistance has been achieved. If the product fails a second insulation resistance test, contact your Watlow representative or customer service at the phone number indicated in this guide.

CAUTION – *Do not exceed 204°C (400°F) if an oven bake-out is performed.*

2. Heater orientation and mounting

When flowing liquids through the product, it should be mounted vertically with the inlet (side with the lead exits) on bottom and the outlet on top. Failure to mount the product in this orientation can cause overheating and failure of the product. For gaseous fluids, any product orientation is possible as long is it is not downwards. The direction of the flow must go from inlet (lead exit) to outlet.

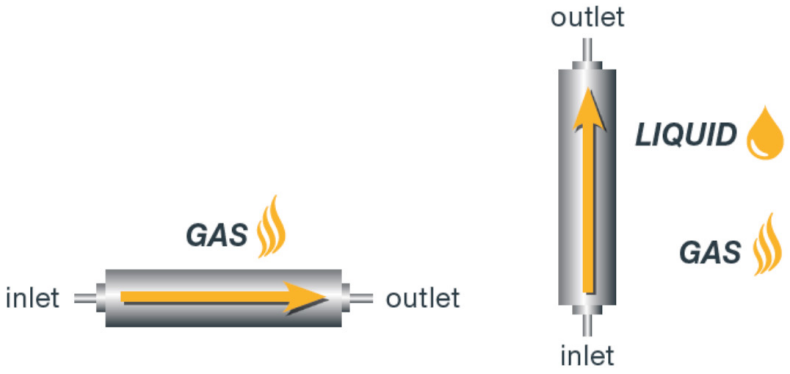
CAUTION – *Failure to orient the product in the correct position or flow the fluid from the inlet (lead exit) to the outlet can result in failure of the product.*

WARNING – *Electric heaters are capable of developing high temperatures, so to minimize the risk of fire extreme care should be taken to locate the product in a safe environment. Mounting products in atmospheres containing combustible gases and vapors should be avoided. You must ensure that combustible materials are maintained far enough away from the product to ensure that they are free of the effects of high temperatures.*

This product is not suitable for use in hazardous (classified) locations.

The best way to mount the product in place should be determined by the end user.

Application Orientation



3. Protection of heater elements from over temperature

The use of a temperature controller to regulate the heating process and prevent product failure is critical to ensure safe operation. It is the end user's responsibility to ensure safety of the installation. The maximum heater engine operating temperature for the product is 350°C as measured by the integrated thermocouple. This thermocouple must be connected to a controller that provides a latching high limit at a maximum value of 350°C. The high limit set point should be reduced if the normal operating conditions allow for it. The recommended high limit temperature set point is the value of the integrated thermocouple during normal operating conditions plus 30°C.

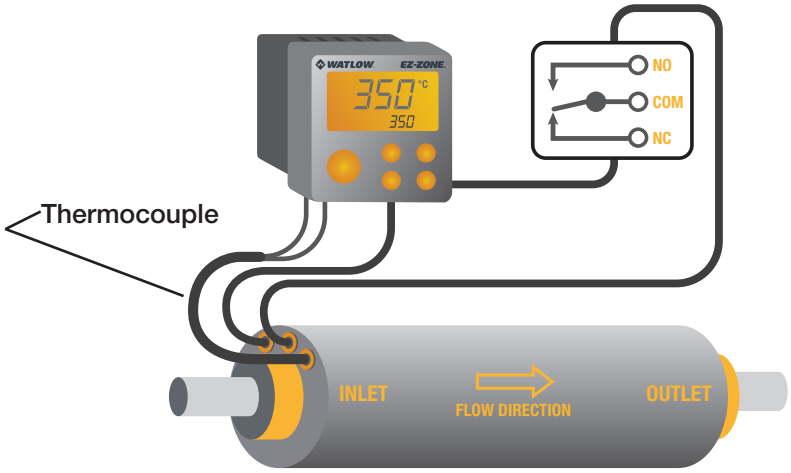
WARNING – *Install high temperature controller protection using the integrated thermocouple. The high limit must be latching and the temperature set point should not exceed 350°C. Failure to install temperature controller protection could result in damage to equipment, property and/or injury to personnel.*

CAUTION – *Failure of components in a temperature control loop, such as the sensor, heater control relay or main temperature controller, can result in damage to a product in process, a product failure and/or damaging fire. To protect against this possibility, over-temperature protection must be provided to interrupt or remove power from the heater circuit during abnormal conditions. To limit this risk, perform a functional test of all temperature limiting devices on a regular interval.*

CAUTION – *Certain heating applications may accompany volumetric expansion and/or phase change. In all cases, ensure that appropriate safeguards against over-pressurization are included in system design.*

All temperature limit devices must have appropriate third-party approval and be applied in the classification for which it was tested and approved. The high temperature limiting device(s) should function independently from the process temperature controller. This is a high performance product and requires a PID controller with a fast relay (refresh rate of 10Hz or better) in order to be controlled effectively.

Minimum High Limit Circuit Requirements



4. Mass flow conditions

This product should never be operated when there is no mass flow present. It is the responsibility of the end user to ensure that there is mass flow through the product when it is operated. Operating the product without mass flow can cause the product to fail.

CAUTION – *Running the product without mass flow can result in product failure.*

WARNING – *This product is not designed for use with combustible or hazardous materials. Doing so may have unintended consequences that may result in product failure, damage to equipment, or physical injury or death. The end user is responsible for any unintended consequences due to combustible or hazardous materials.*

5. Termination

Do not handle the product by the lead wires or sensor wires!

Handling by the leads can compromise electrical and/or mechanical integrity of the product.

In order to maintain termination integrity, the termination area should be kept below 200°C (392°F). Do not allow oil, moisture or other possible contaminants to come in contact with the heater lead wires. Mass flow through the Product helps keep the termination area cool during operation.

WARNING – Risk of Electric Shock – *The installation and wiring of this product shall only be done by a qualified electrician, in accordance with applicable national and local electrical codes. It is the end user's responsibility to ensure that proper precautions are taken in reference to applicable personal safety equipment needed by those installing and maintaining equipment.*

Never interrupt the protective earth circuit/ground. Any interruption or disconnection of the protective earth circuit used by this product will create a dangerous situation and could result in an electric shock that in some situations could lead to serious injuries! It is the end user's responsibility to properly size the ground wire for the protective earth/safe ground and to assure that the impedance of this is low enough to assure a person's safety.

In some equipment or installations a GFI style breaker or circuit may need to be installed to ensure the safe operation of the product. Determining if this is a requirement is the responsibility of the end user.

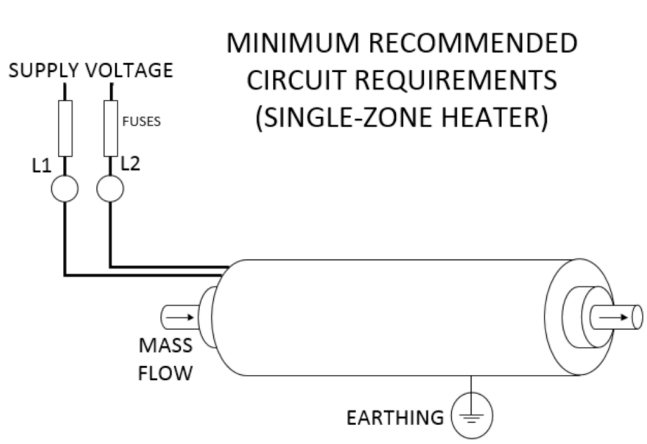
The mains/line voltage applied to the product must always be equal to or less than the voltage rating marked on the heater's outer tube. Some heaters are supplied as dual voltage (e.g. 120V/240V) units and hence the end user needs to check the wiring diagram supplied with the product to ensure that the product is wired correctly for their supply voltage.

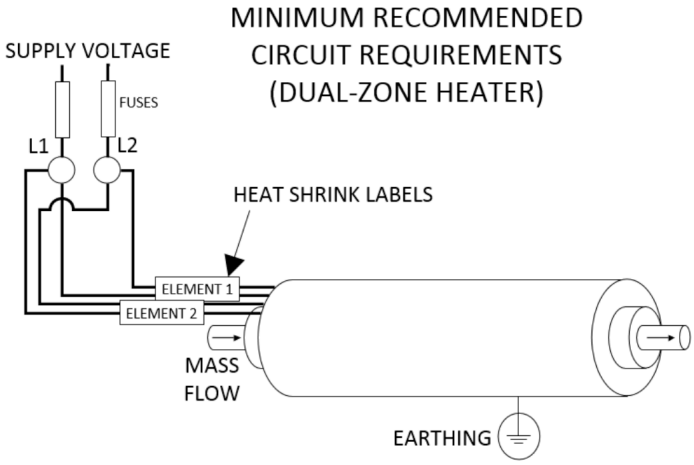
The use of a disconnect switch or circuit breaker is highly recommended and will allow the isolation of the product when maintenance is required.

WARNING – *It is the end user's responsibility to properly size and install the feeder wires to the product. Feeder wire should be properly selected based on amperage, electrical power rating, ambient temperature and type of environment.*

It is the end user's responsibility to ensure that the bending radius of the lead wires provided with the product are large enough to prevent any damage.

Minimum Circuit Requirements





Notes:

1) Above depictions represent the basic protection requirements in a simple circuit.
2) Heating elements considered "live" must be isolated from protective ground circuit.

Other wire configurations such as dual voltage or three phase are possible with this product. The end user should check with their Watlow representative if there is any concern about the wire configuration. At a minimum, all wires exiting the product must be terminated to prevent live wires.

The tables below list standard specifications for the standard lead wires used in various FLUENT heaters.

Wire Specifications

	Lead Wire Specifications	
Wire Insulation	**Ø1.0 in. (25.4 mm) Outer Tube**	**Ø1.625 in. (41.3 mm) Outer Tube**
PTFE Insulated (UL® 1199)	20 AWG (7/28), SPC, 600V	18 AWG (726), SPC 600V

Standard thermocouple wire specifications

Watlow PN K24-1-304, Type K, fiberglass insulated, solid 24 AWG wire. Other types of thermocouples may be provided; please contact your Watlow representative or customer service for additional information.

Earthing/grounding

This product must be connected to an earth ground circuit. Earthing can be achieved through a connection to the outer protection tube or the inlet/outlet fittings. It is the end user's responsibility to ensure that there is an adequate connection and all components are rated correctly.

WARNING – Risk of Electric Shock – *Never interrupt the protective earth circuit/ground. Any interruption or disconnection of the protective earth circuit used by this product will create a dangerous situation and could result in an electric shock that in some situations could lead to serious injuries! It is the end user's responsibility to properly size the ground wire for the protective earth ground.*

6. Miscellaneous

This product is not intended to be a pressure vessel. The maximum rated pressure of this product is 150 psi (10.3 bar).

WARNING – *The maximum pressure rating of this product is 150 psi (10.3 bar). Exceeding this pressure can cause the product to expand and rupture resulting in failure of the product. This can also lead to damage to the equipment, physical injuries and/or death.*

After installation of the product, it is strongly recommended that the end user ensure that their equipment fully complies with all European New Approach Directives applicable to that equipment, this may include the EMC Directive.

This product is rated to IP63 and should not be submerged.

CAUTION – *This product is not designed to be submersed in any fluid.*

Freeze protection is required for this product if it will operate in environments below the fluid freezing temperature. This expansion can cause the product to rupture and no longer operate as intended.

CAUTION – *Operating this product without freeze protection in an environment below the fluid freezing temperature can cause the product to fail and not function properly.*

Do not modify the product in any way.

Ensure that any surrounding components or materials have an adequate temperature rating. Insulation around the product may be required if placed in close proximity to heat sensitive components.

WARNING – *The exterior components of this product may become hot during operation and may exceed a touch safe temperature. The end user must ensure that all surrounding components have adequate temperature rating and insulation. Failure to do so can lead to fire, personal injury and/or death.*

Start Up

The following sets forth instructions and requirements relating to the initial startup of the product:

CAUTION – *Before energizing the product, the following items should be checked with the main/line voltage disconnected. Failure to do so could result in damage to the product, equipment and/or operator injury when it is energized.*

1. *Electrical terminations are tight and wiring is per wiring diagram supplied (if applicable).*
2. *Proper disconnecting means and fusing have been installed.*
3. *The voltage rating of the product is the same as that being applied.*
4. *Leg to leg voltage is equal (for 3-phase units).*
5. *Megohm value of the heater elements are within acceptable limits.*
6. *Proper temperature controls and safety limiting devices are in place with proper set point(s).*
7. *The product is properly grounded.*
8. *Assure that the correct fluid flow has been started and is being maintained to ensure that heater. elements do not overheat and fail once the product is energized.*

WARNING – *After applying power to the product, make sure that the system is being controlled properly before leaving it to run unattended. Failure to do this could result in the product overheating in a "run away" condition that could lead to damage to equipment, fire or personal injury.*

Troubleshooting

The information provided below contains potential causes and corrections for functional problems with the product. This is a non-exhaustive list of potential problems and corrections and is not meant to cover all potential issues. Please do not hesitate to contact your Watlow representative if you have any questions regarding the performance of your product.

WARNING – Risk of Electric Shock – *High voltage is present when the product is energized and hence troubleshooting of this product shall only be done by qualified personnel.*

It is the end user's responsibility to ensure that proper precautions are taken in reference to applicable personal safety equipment needed by those installing and maintaining equipment.

Problem	Cause/Correction
No power available to product	Check disconnect switch to ensure it is in the "ON" position and that fuses are not blown. Replace fuses if they are blown.
Fuses blowing	Check heater electrical rating. Verify line voltage is within specification. Check fuse rating. Fuses should be at least 25 percent more than full load amperage. Disconnect product power source. Check the heater resistance to ground. This should be no less than one megohm. Refer to 'megohm pre-check' in the Installation section of this guide.
Not enough power/application not heating to desired temperature	Verify line voltage is within specification. If voltage is correct, check full line current draw. If line current is lower than designed, the heater circuit may be wired incorrectly or the temperature controller and/or power switching settings may need to be adjusted to deliver a greater duty cycle percentage. Heat losses to other system components and to the ambient environment may be higher than initially calculated/estimated. A higher wattage heater or additional thermal insulation in the system may be required.

Preventative Maintenance

WARNING – Risk of Electric Shock – *High voltage is present when the product is energized and hence preventative maintenance of this product shall only be done by qualified personnel.*

Turn all power off to the product and "lock out/tag out" the power disconnect switch(es) for the product before preforming any preventative maintenance.

It is the end user's responsibility to ensure that proper precautions are taken in reference to applicable personal safety equipment needed by those installing and maintaining equipment.

WARNING – *The product, vessel and system can remain hot for a long period of time after the power has been removed, so make sure the equipment has cooled down to a safe temperature before preforming any preventative maintenance.*

Thermal cycling, corrosion and vibration can cause degradation of the thermal system and electrical interfaces. Follow system designer's guidelines for periodic checking of the condition of the installed product and the electrical connections.

Replacement Parts

When ordering replacement parts from your Watlow representative, please reference the part number(s) indicated on the Watlow product(s).

If your Watlow representative is not known, please visit our website http://www.watlow.com and use the interactive "Sales and Distributor Locater" tool to identify and contact your local Watlow distributor for ordering replacement parts.

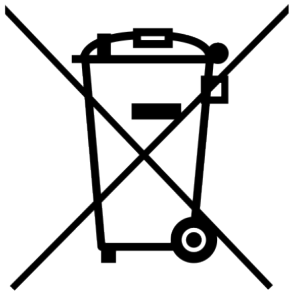
Patent Information

This Watlow product is protected by patents in the U.S. and elsewhere. Additional patents may be pending in the U.S. and elsewhere.

U.S. Patent Numbers: 9,029,742
7,361,869

Disposal and Recycling

This product is classified under the RoHS and W.E.E.E. directives as electronic components with respect to disposal, and as such, must be recycled as per the requirements of the national regulations of the end user.



Terms and Conditions and Product Returns

Unless otherwise expressly agreed to in writing by Watlow, Watlow's standard terms and conditions shall apply to your purchase and use of the product in all respects. Such terms and conditions include, but are not limited to, applicable warranty obligations and payment terms. The terms and conditions may be found attached to any order acceptance or bid prepared by Watlow. For a copy of such terms and conditions, please contact Watlow's customer service department or visit our website http://www.watlow.com.

In the event that you desire to make a warranty claim against any product because it does not comply with the warranty provisions provided under the applicable terms and conditions, please contact Watlow customer service to obtain a Return Material Authorization (RMA) number before returning any item for repair or replacement. The following information is needed to process a returned product:

- Customer name
- Contact name
- Part number
- Quantity
- Reason for return
- Customer account number
- Phone number
- Email address
- P.O. number
- Application information
- MSDS sheet of material(s) that came in contact with product, if used