

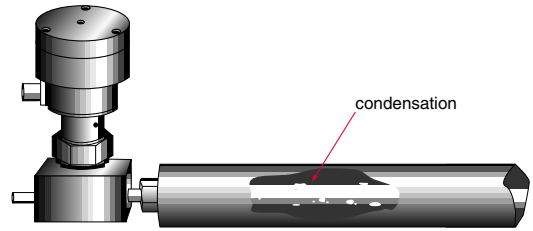
INCREASE TOOL UPTIME AND PROCESS YIELDS



Problem

Lines must be heated uniformly to prevent condensation in the gas delivery line or particle clogging in the pump line. Both gas and pump lines have unique thermal challenges due to many factors including poor conductivity of stainless steel, different thermal mass of plumbing components, or ambient temperature changes between the cleanroom and subfloor.

Condensation forms in gas lines when temperatures and/or pressure falls below the vapor state.



Unheated pump lines have sublimation buildup due to poor and uneven heating.



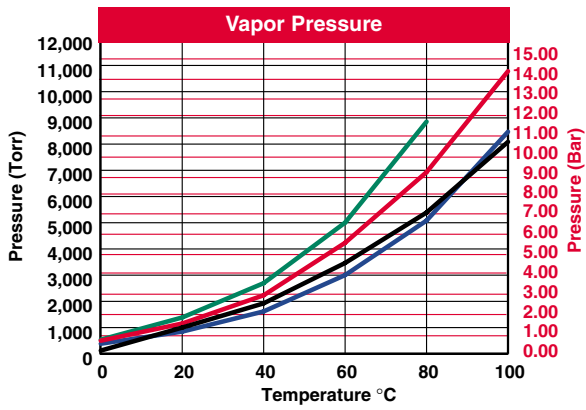
Heat trace can produce a ribboning effect of sublimation in areas that are uncovered.



Insufficient heating of ports results in clogged valves.



Solution

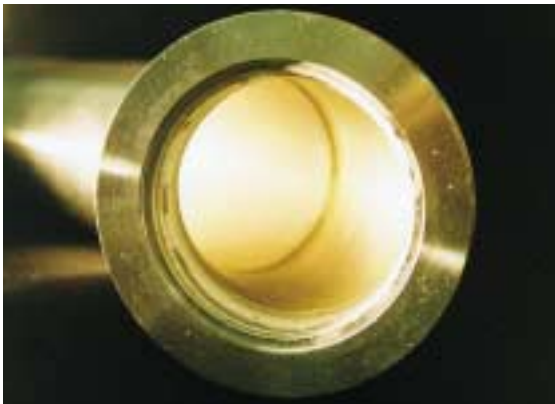


At low vapor pressures, controlling the gas line temperature above the vaporization point will prevent condensation from occurring in the line. Condensation occurs at different temperatures for various gases.

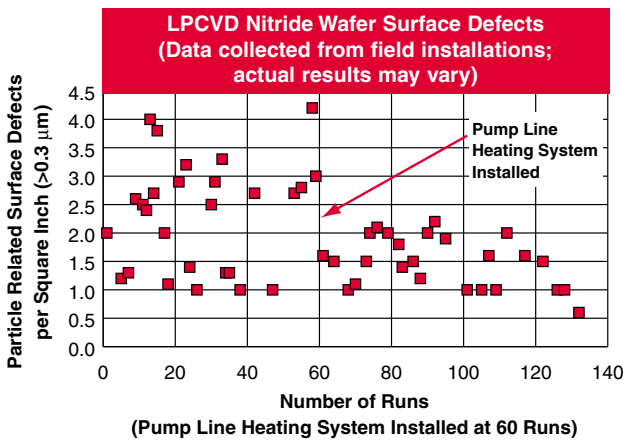
- Boron trichloride (BCl₃)
- Tungsten hexafluoride (WF₆)
- Dichlorosilane (SiH₂Cl₂)
- Chlorine trifluoride (ClF₃)

Uniform temperature coverage of the gas and pump line systems, including ports, flanges, valves, etc., where particle buildup might occur results in increased process yields and a reduction in unscheduled downtime.

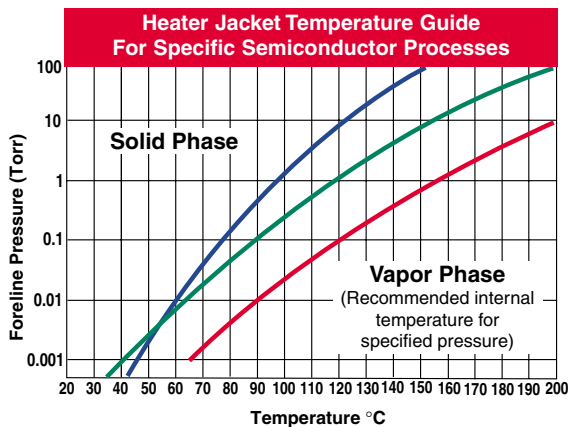
Application specific tests concluded in a minimum increase of 10 percent in performance yield improvement and a 60 percent reduction in maintenance cycles. However, actual results will vary with each application depending on chemistry, tool design, plumbing design and process variables.



Buildup is not present in a pipe after being properly heated with Watlow's pump line heaters. The heaters were removed and inspected on a normal preventative maintenance (PM) schedule.



Particle generation defects decrease as pump line temperature uniformity increase.



Process by-products exit the chamber in vapor phase, but sublimate in the foreline and vacuum pump when gas temperatures drop, forming solids.

- Aluminum Etch (AlCl₃)
- PECVD Nitride (NH₄)₂ SiF₆
- LPCVD Nitride (NH₄Cl)

Integrated System Solution



One supplier for thermal components; one supplier for thermal systems

The solution to achieving the optimum performance is through an intelligently designed heating system. Unlike other companies that just make heaters, sensors or controllers, Watlow designs and manufactures all of these thermal system components into a complete system.

Working with a partner whose products are found throughout the semiconductor manufacturing process offers a single responsible supplier that understands how thermal systems fit within the whole process. By integrating innovative heating, sensing, controlling and communications technologies, Watlow accepts responsibility for the total thermal system while meeting the growing expectations for tighter temperature tolerances.

From gas cabinet to scrubber, Watlow's standard gas and pump line heating systems combine thermal components that optimize chemical vapor deposition (CVD) and metal etch process performance. With unsurpassed system performance and temperature uniformity, Watlow can help reduce condensation and particle buildup, reduce maintenance related downtime and improve process yields. This complete system is constructed from Watlow's heaters, sensors and controllers that meet UL®, CE, NEC and SEMI S2-93 safety requirements. When used in conjunction with Watlow's communications software, the system offers engineers an ideal solution for improving and monitoring system performance.

Features and Benefits

Even heating up to 200°C (392°F) for uniform temperature profiles over the entire heated line

- Eliminates cold spots that result in condensation or particle buildup in the line

Precision electronic temperature controllers and software; flexible to changing process requirements

- Electronic controllers with PID temperature algorithms provide <1°C control stability

Cleanroom compatible silicone rubber construction

- Clean heaters will not contribute to particle generation

System components meet a combination of UL®, CE, NEC and SEMI S2-93 safety specifications

- Construction materials and electrical circuit comply to UL®, CE (EMI) and FM safety standards

Environmental safety

- Reducing particle buildup decreases potential of employee exposure to hazardous materials during normal cleaning cycles

Optional 94-VO flame retardant materials

- Fire-safe 94-HB or 94-VO material

Typical Applications

Gas delivery lines

- Boron trichloride, BCl_3
- Chlorine trifluoride, ClF_3
- Dichlorosilane, (DCS), SiH_2Cl_2
- Tetra ethyl orthosilicate, TEOS
- Tungsten hexafluoride, WF_6
- Process gas line qualification

Fore line and exhaust lines for CVD and metal etch

- Low Pressure Chemical Vapor Deposition (LPCVD) — TEOS, Ti Nitride
- Plasma Enhanced Chemical Vapor Deposition (PECVD) — TEOS, Ti Nitride, Tungsten, Oxynitride

Plasma Etch

- Aluminum etch
- Tungsten etch

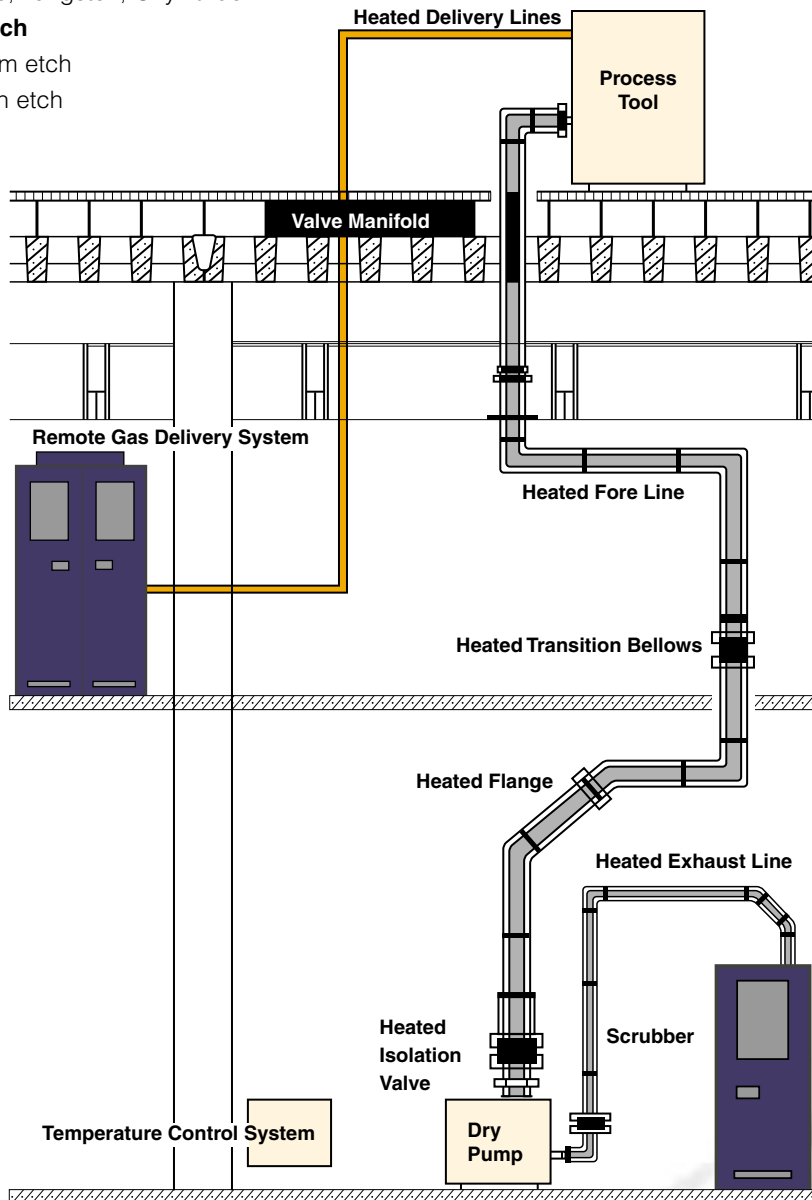
Optimum Line Heating and Process Performance

Both gas and pump lines have unique thermal challenges due to many factors including: poor conductivity of stainless steel, different thermal mass of plumbing components, or ambient temperature changes between cleanroom and the subfloor.

The secret to achieving the optimum performance is through an intelligently designed heating system.

Watlow designs and manufactures all thermal system components, including software, to work together resulting in optimum system performance. Watlow's expertise in providing thermal solutions allows engineers to utilize one supplier for complete thermal system needs including:

- Cleanroom compatible heaters that cover the entire line
- Heaters that fit tightly to line components, eliminating cold spots from loose-fitting heaters or uncovered lines
- Heaters can be customized with distributed watt densities, so lighter and heavier component parts are heated uniformly
- Electronic temperature controllers and integral thermocouple sensors to provide stable temperature control
- Safety limit controllers that meet FM and SEMI S2-93 guidelines
- Communications and software that can network with the tool or plant-wide LAN system



Only Watlow supplies complete line heating solutions from gas cabinet to scrubber.

Modular Pump Line Heaters



The tight contact fit of Watlow's pump line heaters provide superior, uniform heating of transfer lines.

Agency Certification, Recognition Compliance and Approvals

(Contact factory for specific application and approvals.)

- Complies with SEMI S2-93 standards
- UL® recognized for U.S. and Canadian safety standards
- CE
- NEC (National Electrical Code), Article #427-23

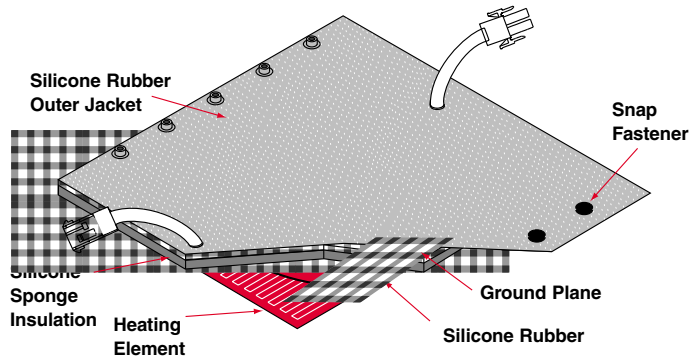
General Specifications

- Heater and jacket material: reinforced silicone rubber fabric
- Color: Insulation and outer jacket: gray Heater: red-orange
- Snap type fasteners: 13 mm (0.5 in.) nominal diameter metal construction with nylon cover; maximum operating temperature 200°C (392°F)
- Velcro® fasteners available
- See next page for available options

- 120 and 208V~(ac) standard. Consult factory for other voltages
- Power lead wires: 102 mm (4 in.) #18 AWG UL® 1180/CSA Teflon® insulated, rated 10A, lead wire pair encapsulated in reinforced silicone rubber sleeving
- Heaters interconnectable up to a 10A circuit
- **New low watt density:**
1-2 inch diameter, 0.23 W/cm² (1.5 W/in²)
3-4 inch diameter, 0.19 W/cm² (1.25 W/in²)



Sensor Pocket™ built-in to all straight length heaters 76 mm (3 in.) long and greater; one per heater.



Velcro® is a registered trademark of Velcro Industries B.V.

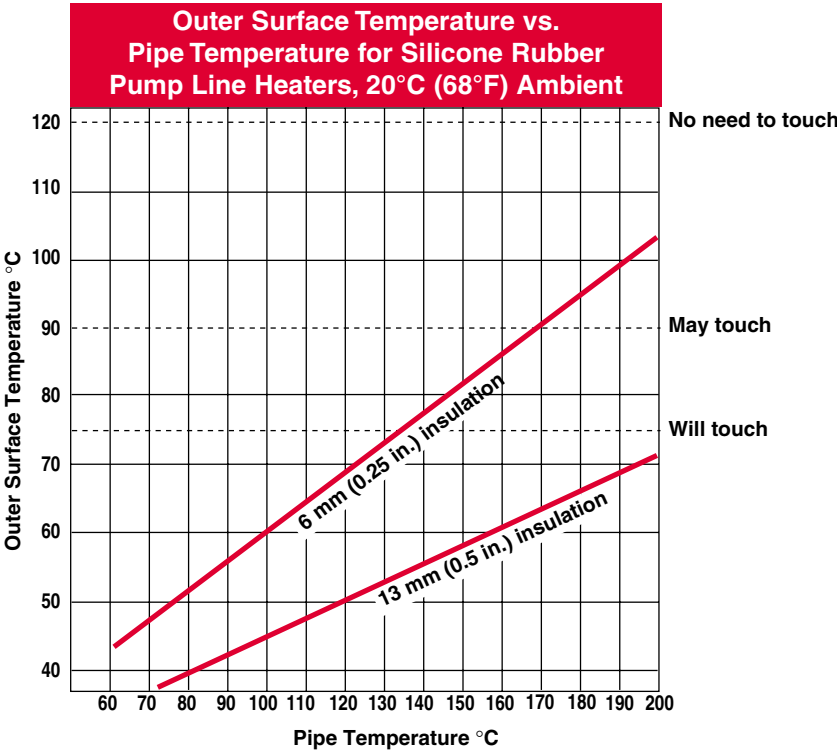
Teflon® is a registered trademark of E.I. du Pont de Nemours & Company.

Pump Line Options

Description	CE	SEMI S2-93	UL® Listing	NEC	VDE
6 mm (0.25 in.) insulation w/HOT marking	x	x	x		x
13 mm (0.5 in.) insulation	o	o	o		o
Ground grid	o	o	o	x	o
AMP Mate-N-Lok® connectors ①	x	x	x		x
AMP CPC connectors ②	o	o	o		o
Jacket w/UL®94V-0 rating	o	o	o		o
Jacket w/UL®94-HB rating	x	x	x		x
Thermal cut-off	o	x	x		o

x = Minimum requirements
o = Optional features

- ① Male plug: AMP p/n 1-480698-0, w/sockets AMP p/n 350689-1. Female cap: AMP p/n 1-480699-0, w/pins AMP p/n 350690-1.
- ② Plug: AMP p/n 206060-1, w/socket AMP p/n 66101-3. Receptacle: AMP p/n 206153-1, w/pins AMP p/n 66099-3, w/ground pin p/n 164164-2 if ground grid option is chosen.



Use SEMI S2-93 standards to select the correct heater insulation thickness for an application.

Surface Temperature Limits (°C)

	Material Type		
	Highly Conductive (most metals)	Moderately Conductive (glass)	Slightly Conductive (most plastics)
Operator Accessible Areas			
Hand-held ^① or carried	50	55	65
Will touch ^②	55	65	75
May touch ^③	70	75	90
Service Areas			
Will touch ^②	55	65	75
No need to touch ^④	80	100	120

SEMI S2-93 guidelines for safety within the semiconductor industry suggest that all hot surfaces be physically shielded, isolated or insulated to protect against personnel contact. The chart to the left indicates the surface temperature limits for human touch. Watlow's gas and pump line heating systems are rated for operator accessible areas for 'most plastics.'

① Operator contact duration is in excess of five seconds.
 ② Operator or service personnel will touch the surface for less than five seconds at a time.
 ③ Surfaces where inadvertent contact is possible.
 ④ Surfaces not likely to be touched during normal operation.

Mate-N-Lok® is a registered trademark of AMP.

Modular Gas Line Heaters



Uniform heating of gas lines prevents condensation of gases including: BCl_3 , ClF_3 , DCS, HCl_3 , TEOS and Ti Nitride

Gas Delivery

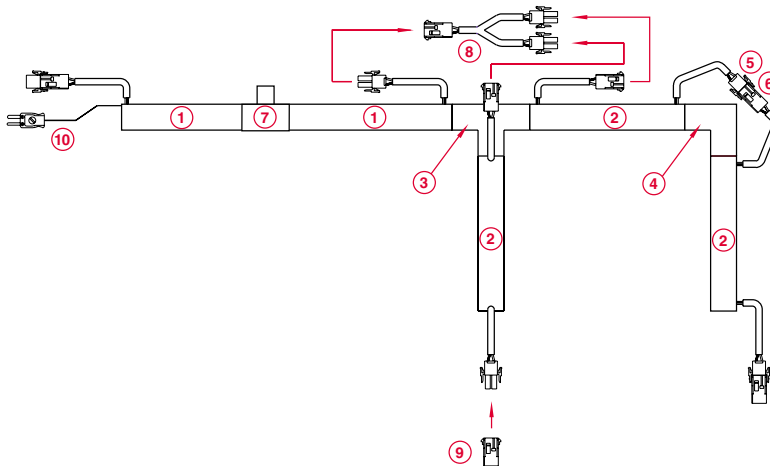
TEOS, BCl_3 , AlCl_3 , ClF_3 and DCS are gases that condense or liquefy due to a phase shift at low temperatures. The condensation occurs in the gas line and puddles in the shower head before being injected into the vacuum chamber. A substantial number of wafer defects will occur if liquefied gases are injected into the vacuum chamber. Uniform heating of the lines will prevent condensation. TEOS lines are typically heated above 90°C (194°F) and BCl_3 above 30°C (86°F), depending on pressure and flow rate. The optimum line temperature will vary depending on the process parameters. Refer to the "Vapor Pressure" chart on page 3.

Specifications

- Watt density: 0.39 W/cm^2 (2.5 W/in^2) on gas line O.D.
- UL[®] recognized for U.S. and Canadian safety standards
- Heaters and insulators meet UL[®]94-HB flammability requirements
- Insulated straight fillers for 100 percent line coverage—elbows and tees are trim-to-fit to proper length
- I.D. available 6, 10, 13, 19 mm (0.25, 0.375, 0.5, 0.75 in.)
- 120V standard, other voltages available

Upstream Gas Line Heater Assembly

- 1 229 mm (9 in.) heater with thermocouple. Heater leads have male plug on one end and a female cap on the other end. Heater materials UL[®] rated to 200°C (392°F).
- 2 152 mm (6 in.) heater. Heater leads, see 1.
- 3 Union tee insulator.
- 4 90° union elbow insulator.
- 5 Male plug, AMP p/n 1-480698-0 w/ sockets AMP p/n 350689-1.
- 6 Female cap, AMP p/n 1-480699-0 w/ pins AMP p/n 350690-1.
- 7 Valve or regulator.
- 8 Y Connector: one female cap on one end; two male plugs on the other end.
- 9 Dead plug (sealed).
- 10 Type J thermocouple w/ male mini-plug (optional).
- 11 High-temp plastic snaps 100°C (212°F).
- 12 10 mm (0.375 in.) wall, silicone rubber, closed cell sponge.



Integrated Control Systems



Watlow's integrated control systems provide stable and adjustable control of heated systems.

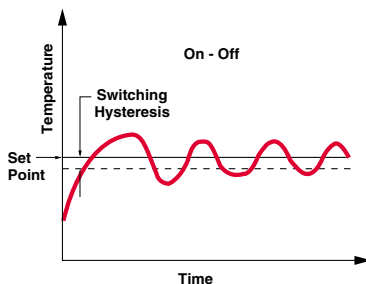
Control Systems

- Tight adjustable control to within 1°C (33.8°F)
- Adjustable set points
- High temperature alarms

The integration of electronic temperature control within gas and pump line heating systems is critical to providing superior system performance and achieving maximum results.

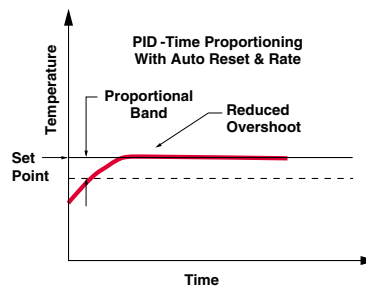
Temperature control systems provide process and maintenance engineers with maximum flexibility to modify temperature profiles as application requirements change.

In heating systems utilizing fixed set point control, as is the case with thermostatically controlled heaters, the on-off cycles cause fluctuations in temperature. Unstable temperature control can lead to unexpected condensation or sublimation.



Temperature of heated components with thermostat control. Note the continuous fluctuations.

Electronic temperature control with PID and time-proportioned power switching eliminates these fluctuations. Therefore, benefiting the process yielding tight temperature control by reducing overshoot of the set point, and elimination of temperature swings around the set point.



Temperature of heated components with electronic PID control. Fluctuations are virtually eliminated.

Specifications

Control boxes (wall-mount)

- 1 to 16 zones of control
- 10A per zone maximum at 120V~(ac), 1 phase or 208V~(ac), 1 phase or 3 phase
- Type J or Type K thermocouple inputs (other sensor types available)
- Fused power input, fused control circuitry
- Data retention upon power failure via non-volatile memory
- Ambient temperature: 0-30°C (32-86°F)
- 0 – 90 percent RH, non-condensing
- Accuracy $\pm 1^\circ\text{C}$ under standard conditions
- 4 digit LED or alpha numeric display of temperature
- Redundant temperature safety limit controllers available
- Miniature thermocouple input connectors
- Internal terminal block power output connection standards. Options include AMP Universal Mate-N-Lok® or AMP CPC connectors
- RS-232 or RS-485 computer communications available
- Dimensions: consult factory

Control consoles (table-top-mount)

- 1 to 4 zones of control
- 10A per zone maximum
- 120V~(ac), 1 phase or 208V~(ac), 3 phase
- Type J or Type K thermocouple inputs (other sensor types available)
- IDE style fused power input
- GFCI line cord optional
- Data retention upon power failure via non-volatile memory
- Ambient temperature 0-30°C (32-86°F)
- 0 – 90 percent RH, non-condensing
- Accuracy ±1°C under standard conditions
- 4 digit LED display of temperature
- Miniature thermocouple input connectors
- AMP Universal Mate-n-Lok® power output connector standard. Options include AMP CPC connectors, or internal terminal block
- RS-232 or RS-485 computer communications available

- Dimensions:
 - 1 zone: 119.3 mm H x 76.2 mm W x 190.5 mm D (4.7 in. H x 3.0 in. W x 7.5 in. D)
 - 2 zone: 114.3 mm H x 152.4 mm W x 190.5 mm D (4.5 in. H x 6.0 in. W x 7.5 in. D)
 - 3 zone: 114.3 mm H x 304.8 mm W x 190.5 mm D (4.5 in. H x 12.0 in. W x 7.5 in. D)
 - 4 zone: 114.3 mm H x 304.8 mm W x 190.5 mm D (4.5 in. H x 12.0 in. W x 7.5 in. D)

Safety Approvals

UL®, CE and SEMI S2-93 depending upon the configuration.

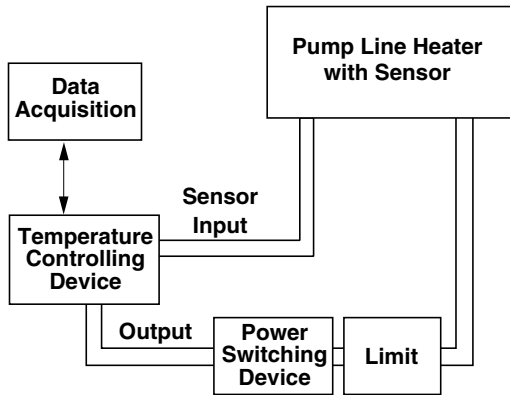
Software

WATVIEW AND ANAWIN® are 32-bit Windows®-based HMI (human-machine interface) software packages for setup and monitoring of control systems with the computer communications option. Both WATVIEW and ANAWIN include data

logging and graphing features as well as recipe and alarm management. "Developer" editions of these packages add the ability to create unique graphical interface screens to depict specific applications.

Extension Cables

- **Heater power extension cable:** Type SJ, 16-3 stranded
Enclosure connection: match heater output type on control system (ring terminals, AMP Universal Mate-N-Lok®, AMP CPC), 3-wire.
Heater connections: AMP Universal Mate-N-Lok®, AMP CPC connection, 2-position with separate ring terminal grounding lug.
- **Thermocouple extension cable:** FEP Teflon® insulated, 24 gauge stranded. Enclosure connection: miniature type thermocouple plug. Sensor connection: miniature type thermocouple jack. Thermocouple type as specified.



The thermal loop includes heaters, sensors and temperature controllers.



Watlow's temperature control consoles provide accurate and adjustable temperature control of thermal components in wafer processing applications.

Ordering Information

Safety Warning

Watlow heaters are designed for optimum process results. Proper usage does not include hazardous or outdoor locations; and total or partial immersion applications. For safety purposes, it is Watlow's recommendation that these heaters should only be installed on grounded metallic tubing systems or ground fault interruptor (GFI) protected circuits.

REDUCE SYSTEM COST
 With New Low Watt Density Pump Line Heaters and 208V~(ac) Option

Description	CE	SEMI S2-93	UL [®] Listing	NEC	VDE
6 mm (0.25 in.) insulation w/HOT marking	x	x	x		x
13 mm (0.5 in.) insulation	o	o	o		o
Ground grid	o	o	o	x	o
AMP Mate-N-Lok [®] connectors ^①	x	x	x		x
AMP CPC connectors ^②	o	o	o		o
Jacket w/UL [®] 94V-0 rating	o	o	o		o
Jacket w/UL [®] 94-HB rating	x	x	x		x
Thermal cut-off	o	x	x		o

x = Minimum requirements
o = Optional features

① Male plug: AMP p/n 1-480698-0, w/sockets AMP p/n 350689-1.
Female cap: AMP p/n 1-480699-0, w/pins AMP p/n 350690-1.

② Plug: AMP p/n 206060-1, w/socket AMP p/n 66101-3.
Receptacle: AMP p/n 206153-1, w/pin AMP p/n 66099-3, w/ground pin p/n 164164-2 if ground grid option is chosen.

Straight Heater Sections

- 6 mm (0.25 in.) or 13 mm (0.5 in.) silicone rubber sponge insulation available

- Trim-to-fit heaters have 1 inch cut-to-length section at one end
- Sensor Pocket allows installation of the process thermocouple on heater assembly



Tube O.D. mm (in.)	Length "L" mm (in.)	Watts	Amps @120V	Amps @208V	Features	Watlow Base Code Number*
38 (1.50)	51 (2.00)	15	0.13	0.08	—	020050A
38 (1.50)	51T (2.00T)	8	0.07	NA	Trim-to-fit	020050T
38 (1.50)	76 (3.00)	22	0.19	0.11	Sensor Pocket	030050A
38 (1.50)	76T (3.00T)	15	0.13	0.08	Trim-to-fit	030050T
38 (1.50)	102 (4.00)	29	0.25	0.14	Sensor Pocket	040050A
38 (1.50)	102T (4.00T)	22	0.19	0.11	Trim-to-fit	040050T
38 (1.50)	127 (5.00)	36	0.30	0.18	Sensor Pocket	050050A
38 (1.50)	127T (5.00T)	29	0.25	0.14	Trim-to-fit	050050T
38 (1.50)	152 (6.00)	43	0.36	0.21	Sensor Pocket	050060A
38 (1.50)	152T (6.00T)	36	0.30	0.17	Trim-to-fit	050060T
38 (1.50)	177 (7.00)	50	0.42	0.24	Sensor Pocket	050070A
38 (1.50)	203 (8.00)	57	0.48	0.27	Sensor Pocket	050080A
38 (1.50)	229 (9.00)	64	0.53	0.31	Sensor Pocket	050090A
38 (1.50)	254 (10.00)	71	0.59	0.34	Sensor Pocket	050100A
38 (1.50)	305 (12.00)	85	0.71	0.41	Sensor Pocket	050120A
38 (1.50)	457 (18.00)	128	1.07	0.62	Sensor Pocket	050180A
38 (1.50)	610 (24.00)	170	1.42	0.82	Sensor Pocket	050240A
38 (1.50)	762 (30.00)	213	1.78	1.03	Sensor Pocket	050300A
38 (1.50)	914 (36.00)	255	2.13	1.23	Sensor Pocket	050360A
38 (1.50)	914 (36.00)	Insulator	NA	NA	—	050360B

continued ➔

* To complete the code number, please reference build-to-code chart on page 20.

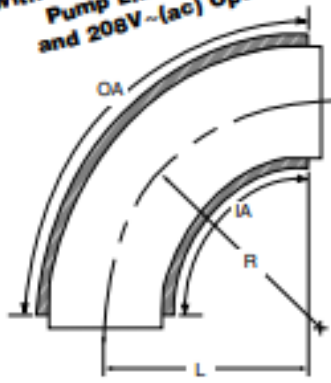


Tube O.D.		Length "L"		Watts	Amps @120V	Amps @208V	Features	Watlow Base Code Number*
mm	(in.)	mm	(in.)					
51	(2.00)	51	(2.00)	19	0.16	0.10	—	020066A
51	(2.00)	51T	(2.00T)	10	0.09	NA	Trim-to-fit	020066T
51	(2.00)	76	(3.00)	29	0.25	0.14	Sensor Pocket	030066A
51	(2.00)	76T	(3.00T)	19	0.16	0.10	Trim-to-fit	030066T
51	(2.00)	102	(4.00)	38	0.32	0.19	Sensor Pocket	040066A
51	(2.00)	102T	(4.00T)	29	0.25	0.14	Trim-to-fit	040066T
51	(2.00)	127	(5.00)	48	0.40	0.24	Sensor Pocket	050066A
51	(2.00)	127T	(5.00T)	38	0.32	0.19	Trim-to-fit	050066T
51	(2.00)	152	(6.00)	57	0.48	0.28	Sensor Pocket	060066A
51	(2.00)	152T	(6.00T)	47	0.39	0.23	Trim-to-fit	060066T
51	(2.00)	177	(7.00)	66	0.55	0.32	Sensor Pocket	066070A
51	(2.00)	203	(8.00)	76	0.63	0.37	Sensor Pocket	066080A
51	(2.00)	229	(9.00)	85	0.71	0.41	Sensor Pocket	066090A
51	(2.00)	254	(10.00)	95	0.79	0.46	Sensor Pocket	066100A
51	(2.00)	305	(12.00)	114	0.95	0.55	Sensor Pocket	066120A
51	(2.00)	457	(18.00)	170	1.42	0.82	Sensor Pocket	066180A
51	(2.00)	610	(24.00)	227	1.90	1.10	Sensor Pocket	066240A
51	(2.00)	762	(30.00)	283	2.36	1.37	Sensor Pocket	066300A
51	(2.00)	914	(36.00)	340	2.84	1.64	Sensor Pocket	066360A
51	(2.00)	914	(36.00)	Insulator	NA	NA	—	066360B
76	(3.00)	51	(2.00)	24	0.20	0.12	—	020096A
76	(3.00)	51T	(2.00T)	12	0.10	0.06	Trim-to-fit	020096T
76	(3.00)	76	(3.00)	36	0.30	0.18	Sensor Pocket	030096A
76	(3.00)	76T	(3.00T)	24	0.20	0.12	Trim-to-fit	030096T
76	(3.00)	102	(4.00)	48	0.40	0.24	Sensor Pocket	040096A
76	(3.00)	102T	(4.00T)	36	0.30	0.18	Trim-to-fit	040096T
76	(3.00)	12	(5.00)	59	0.50	0.29	Sensor Pocket	050096A
76	(3.00)	127T	(5.00T)	48	0.40	0.24	Trim-to-fit	050096T
76	(3.00)	152	(6.00)	71	0.60	0.35	Sensor Pocket	060096A
76	(3.00)	152T	(6.00T)	59	0.49	0.28	Trim-to-fit	060096T
76	(3.00)	177	(7.00)	83	0.69	0.4	Sensor Pocket	070096A
76	(3.00)	203	(8.00)	95	0.79	0.46	Sensor Pocket	080096A
76	(3.00)	229	(9.00)	106	0.88	0.51	Sensor Pocket	090096A
76	(3.00)	254	(10.00)	118	0.98	0.57	Sensor Pocket	096100A
76	(3.00)	305	(12.00)	142	1.19	0.69	Sensor Pocket	096120A
76	(3.00)	457	(18.00)	213	1.78	1.03	Sensor Pocket	096180A
76	(3.00)	610	(24.00)	283	2.36	1.37	Sensor Pocket	096240A
76	(3.00)	762	(30.00)	354	2.95	1.71	Sensor Pocket	096300A
76	(3.00)	914	(36.00)	425	3.55	2.05	Sensor Pocket	096360A
76	(3.00)	914	(36.00)	Insulator	NA	NA	—	096360B
102	(4.00)	51	(2.00)	32	0.27	0.16	—	020128A
102	(4.00)	51T	(2.00T)	16	0.14	0.08	Trim-to-fit	020128T
102	(4.00)	76	(3.00)	48	0.40	0.24	Sensor Pocket	030128A
102	(4.00)	76T	(3.00T)	32	0.27	0.16	Trim-to-fit	030128T
102	(4.00)	102	(4.00)	63	0.53	0.31	Sensor Pocket	040128A
102	(4.00)	102T	(4.00T)	48	0.40	0.24	Trim-to-fit	040128T
102	(4.00)	127	(5.00)	79	0.66	0.38	Sensor Pocket	050128A
102	(4.00)	127T	(5.00T)	63	0.53	0.31	Trim-to-fit	050128T
102	(4.00)	152	(6.00)	95	0.80	0.46	Sensor Pocket	060128A
102	(4.00)	152T	(6.00T)	79	0.66	0.38	Trim-to-fit	060128T
102	(4.00)	177	(7.00)	110	0.92	0.53	Sensor Pocket	070128A
102	(4.00)	203	(8.00)	126	1.05	0.61	Sensor Pocket	080128A
102	(4.00)	229	(9.00)	142	1.18	0.68	Sensor Pocket	090128A
102	(4.00)	254	(10.00)	157	1.31	0.75	Sensor Pocket	100128A
102	(4.00)	305	(12.00)	189	1.58	0.91	Sensor Pocket	120128A
102	(4.00)	457	(18.00)	283	2.36	1.37	Sensor Pocket	128180A
102	(4.00)	610	(24.00)	377	3.15	1.82	Sensor Pocket	128240A
102	(4.00)	762	(30.00)	472	3.94	2.27	Sensor Pocket	128300A
102	(4.00)	914	(36.00)	566	4.72	2.73	Sensor Pocket	128360A
102	(4.00)	914	(36.00)	Insulator	NA	NA	—	128360B

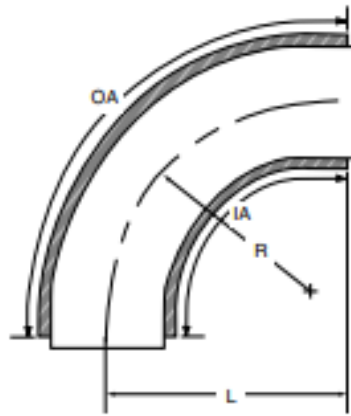
* To complete the code number, please reference build-to-code chart on page 20.

REDUCE SYSTEM COST
With New Low Watt Density Pump Line Heaters and 208V-(ac) Option

90° Radius Elbow Heaters



Without tangent

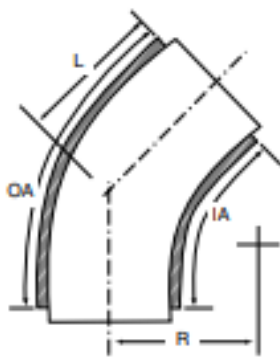


With tangent

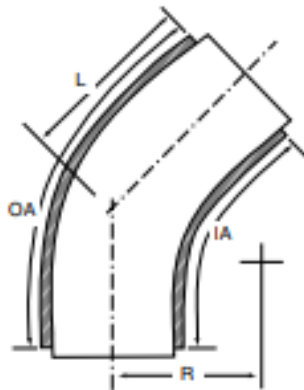
- 6 mm (0.25 in.) or 13 mm (0.5 in.) silicone rubber sponge insulation available
- With or without tangents
- Will fit both butt-weld and flanged style tubing elbows

Tube O.D.	Length "L"	Radius (R)		Outer Arc Length (OA)	Inside Arc Length (IA)	Amps @120V	Amps @208V	Watlow Base Code Number*
mm (in.)	mm (in.)	mm (in.)	Watts					
38 (1.50)	51 (2.00)	57 (2.25)	26	4.21	1.85	0.22	0.13	042050A
38 (1.50)	68 (2.68)	57 (2.25)	36	5.58	3.22	0.30	0.18	050055A
51 (2.00)	70 (2.75)	76 (3.00)	45	5.78	2.64	0.38	0.22	057066A
51 (2.00)	97 (3.81)	76 (3.00)	65	7.91	4.77	0.55	0.32	066079A
76 (3.00)	102 (4.00)	114 (4.50)	84	8.42	3.71	0.70	0.41	089097A
76 (3.00)	148 (5.81)	114 (4.50)	127	12.05	7.33	1.06	0.62	097125A
102 (4.00)	140 (5.50)	152 (6.00)	149	11.56	5.28	1.25	0.72	116128A
102 (4.00)	199 (7.81)	152 (6.00)	222	16.18	9.00	1.85	1.07	128166A

45° Radius Elbow Heaters



Without tangent



With tangent

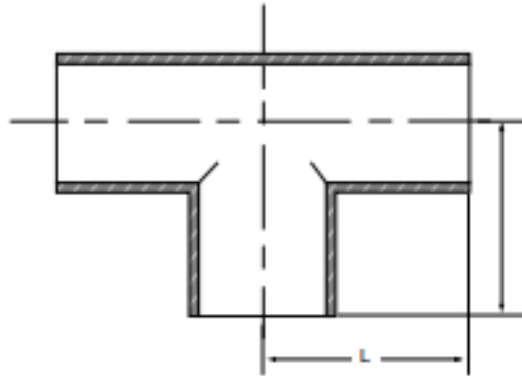
- 6 mm (0.25 in.) or 13 mm (0.5 in.) silicone rubber sponge insulation available
- With or without tangents
- Will fit both butt-weld and flanged style tubing elbows

Tube O.D.	Length "L"	Radius (R)		Outer Arc Length (OA)	Inside Arc Length (IA)	Amps @120V	Amps @208V	Watlow Base Code Number*
mm (in.)	mm (in.)	mm (in.)	Watts					
38 (1.50)	18 (0.69)	57 (2.25)	14	1.85	0.67	0.12	NA	018050A
38 (1.50)	35 (1.38)	57 (2.25)	23	3.23	2.04	0.20	0.12	032050A
51 (2.00)	26 (1.00)	76 (3.00)	23	2.64	1.07	0.20	0.12	026066A
51 (2.00)	52 (2.06)	76 (3.00)	44	4.77	3.20	0.37	0.22	047066A
76 (3.00)	35 (1.37)	114 (4.50)	43	3.71	1.35	0.36	0.21	042097A
76 (3.00)	81 (3.18)	114 (4.50)	85	7.33	4.97	0.71	0.41	078097A
102 (4.00)	51 (2.00)	152 (6.00)	75	5.28	2.14	0.63	0.37	057128A
102 (4.00)	110 (4.31)	152 (6.00)	148	9.90	6.76	1.24	0.72	104128A

* To complete the code number, please reference build-to-code chart on page 20.

REDUCE SYSTEM COST
 With New Low Watt Density
 Pump Line Heaters
 and 208V~(ac) Option

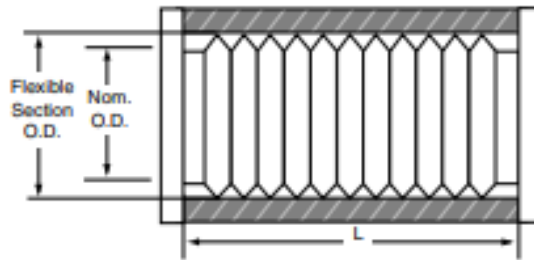
Tee Section Heaters



- 6 mm (0.25 in.) or 13 mm (0.5 in.) silicone rubber sponge insulation available
- Will fit both butt-weld and flanged style tee sections

Tube O.D.		Length "L"		Watts	Amps @120V	Amps @208V	Watlow Base Code Number*
mm	(in.)	mm	(in.)				
38	(1.50)	51	(2.00)	38	0.32	0.19	047064A
51	(2.00)	70	(2.75)	69	0.58	0.34	062081A
76	(3.00)	76	(3.00)	89	0.75	0.43	095120A
102	(4.00)	92	(3.63)	140	1.17	0.69	125155A

Bellows Section Heaters



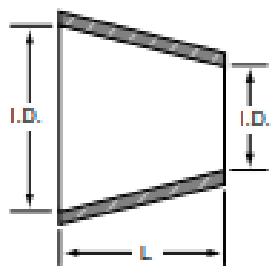
- 6 mm (0.25 in.) or 13 mm (0.5 in.) silicone rubber sponge insulation available
- Will fit both butt-weld and flanged style flexible sections

Tube O.D.		Bellows Section O.D.		Length "L"		Watts	Amps @120V	Amps @208V	Watlow Base Code Number*
mm	(in.)	mm	(in.)	mm	(in.)				
38	(1.50)	49	(1.92)	76	(3.00)	26	0.22	0.13	030056A
38	(1.50)	49	(1.92)	76T	(3.00T)	18	0.15	0.09	030056T
38	(1.50)	49	(1.92)	152	(6.00)	51	0.43	0.25	056060A
38	(1.50)	49	(1.92)	152T	(6.00T)	44	0.37	0.21	056060T
51	(2.00)	63	(2.47)	76	(3.00)	34	0.29	0.17	030077A
51	(2.00)	63	(2.47)	76T	(3.00T)	24	0.2	0.12	030077T
51	(2.00)	63	(2.47)	152	(6.00)	68	0.57	0.33	060077A
51	(2.00)	63	(2.47)	152T	(6.00T)	59	0.49	0.28	060077T
76	(3.00)	96	(3.77)	76	(3.00)	44	0.37	0.22	030117A
76	(3.00)	96	(3.77)	76T	(3.00T)	30	0.25	0.14	030117T
76	(3.00)	96	(3.77)	152	(6.00)	88	0.74	0.43	060117A
76	(3.00)	96	(3.77)	152T	(6.00T)	74	0.62	0.36	060117T
76	(3.00)	96	(3.77)	305	(12.00)	175	1.46	0.85	117120A
102	(4.00)	121	(4.75)	76	(3.00)	56	0.47	0.27	030149A
102	(4.00)	121	(4.75)	76T	(3.00T)	38	0.32	0.18	030149T
102	(4.00)	121	(4.75)	152	(6.00)	111	0.93	0.54	060149A
102	(4.00)	121	(4.75)	152T	(6.00T)	94	0.78	0.45	060149T
102	(4.00)	121	(4.75)	305	(12.00)	222	1.85	1.07	120149A

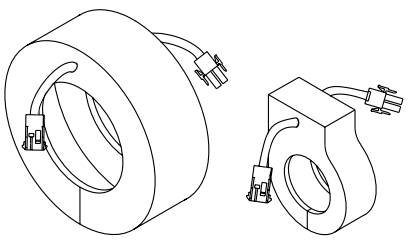
* To complete the code number, please reference build-to-code chart on page 20.

REDUCE SYSTEM COST
 With New Low Watt Density
 Pump Line Heaters
 and 208V ~ (ac) Option

Reducers



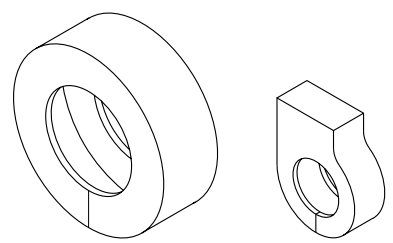
Tube I.D. 2 to I.D. 1 mm (in.)	Length "L" mm (in.)	Watts	Amps @120V	Amps @208V	Watlow Base Code Number*
51 (2.00) to 38 (1.50)	35 (1.38)	12	0.10	0.06	020062A
76 (3.00) to 51 (2.00)	61 (2.42)	24	0.20	0.12	034090A
102 (4.00) to 51 (2.00)	66 (2.63)	31	0.26	0.15	044103A
102 (4.00) to 76 (3.00)	66 (2.60)	36	0.30	0.18	040121A



- available
- For both KF screw flanges and ISO clamp flanges

Tube O.D. inch	Nominal Pipe O.D. mm (in.)	Watts @120V	Amps @120V	Amps @ 208V	Watlow Base Code Number*
KF-40	38 (1.50)	10	0.09	NA	035040A
KF-50	51 (2.00)	15	0.13	NA	045050A
ISO-80	76 (3.00)	70	0.59	0.34	020176A
ISO-100	102 (4.00)	82	0.69	0.40	020204A

Flange Insulators

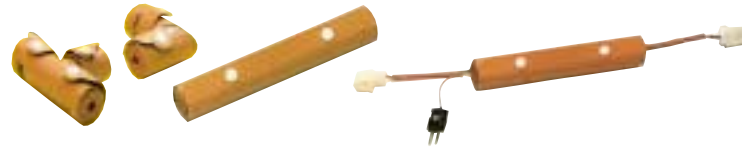


- 6 mm (0.25 in.) or 13 mm (0.5 in.) silicone rubber sponge insulation available
- For both KF screw flanges and ISO clamp flanges

Tube O.D. inch	Nominal Pipe O.D. mm (in.)	Watlow Base Code Number*
KF-40	38 (1.50)	035040B
KF-50	51 (2.00)	045050B
ISO-80	76 (3.00)	020176B
ISO-100	102 (4.00)	020204B

* To complete the code number, please reference build-to-code chart on page 20.

Standard Gas Line Diameter



6 mm (0.25 in.) O.D. Tubing (Stock)

6 mm (0.25 in.) Heater I.D. x Length mm (in.)	Description	Volts	Watts	Amps	Watlow Code Number	
					without T/C	with Type J T/C
152 (6)	Heated straight	120	12	0.10	008060C1	008060C1A
229 (9)	Heated straight	120	18	0.15	008090C1	008090C1A
305 (12)	Heated straight	120	24	0.20	008120C1	008120C1A
457 (18)	Heated straight	120	36	0.30	008180C1	008180C1A
610 (24)	Heated straight	120	48	0.40	008240C1	008240C1A
914 (36)	Heated straight	120	72	0.60	008360C1	008360C1A
457 (18)	Straight insulator	NA	Trim-to-fit	Insulator	008180C0	
* Elbow	90° Union Elbow insulator	NA	Trim-to-fit	Insulator	008020C0	
* T	Union Tee insulator	NA	Trim-to-fit	Insulator	008030C0	

10 mm (0.375 in.) O.D. Tubing

10 mm (0.375 in.) Heater I.D. x Length mm (in.)	Description	Volts	Watts	Amps	Watlow Code Number	
					without T/C	with Type J T/C
152 (6)	Heated straight	120	18	0.15	012060C1	012060C1A
229 (9)	Heated straight	120	27	0.23	012090C1	012090C1A
305 (12)	Heated straight	120	36	0.30	012120C1	012120C1A
457 (18)	Heated straight	120	54	0.45	012180C1	012180C1A
610 (24)	Heated straight	120	71	0.60	012240C1	012240C1A
914 (36)	Heated straight	120	107	0.90	012360C1	012360C1A
457 (18)	Straight insulator	NA	Trim-to-fit	Insulator	012180C0	
* Elbow	90° Union Elbow insulator	NA	Trim-to-fit	Insulator	012020C0	
* T	Union Tee insulator	NA	Trim-to-fit	Insulator	012030C0	

13 mm (0.5 in.) O.D. Tubing (Stock)

13 mm (0.5 in.) Heater I.D. x Length mm (in.)	Description	Volts	Watts	Amps	Watlow Code Number	
					without T/C	with Type J T/C
152 (6)	Heated straight	120	24	0.20	016060C1	016060C1A
229 (9)	Heated straight	120	36	0.30	016090C1	016090C1A
305 (12)	Heated straight	120	48	0.40	016120C1	016120C1A
457 (18)	Heated straight	120	72	0.60	016180C1	016180C1A
610 (24)	Heated straight	120	96	0.80	016240C1	016240C1A
914 (36)	Heated straight	120	144	1.20	016360C1	016360C1A
457 (18)	Straight insulator	NA	Trim-to-fit	Insulator	016180C0	
* Elbow	90° Union Elbow insulator	NA	Trim-to-fit	Insulator	016020C0	
* T	Union Tee insulator	NA	Trim-to-fit	Insulator	016030C0	

* For use on Micro-Fit® weld fittings.

Micro-Fit® is a registered trademark of CAJON Company, A SWAGELOK® Company.

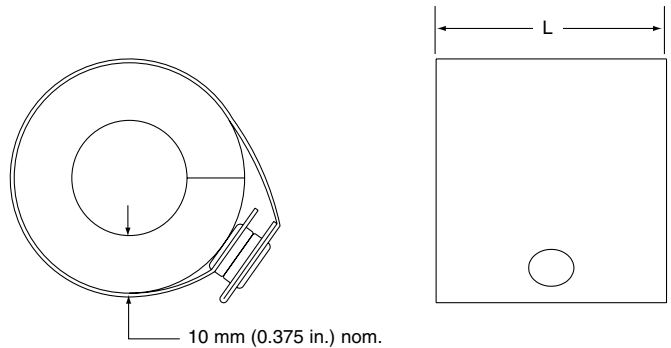
Standard Gas Line Diameter
(continued)

19 mm (0.75 in.) O.D. Tubing

19 mm (0.75 in.) Heater I.D. x Length mm (in.)	Description	Volts	Watts	Amps	Watlow Code Number	
					without T/C	with Type J T/C
152 (6)	Heated straight	120	36	0.30	024060C1	024060C1A
229 (9)	Heated straight	120	54	0.45	024090C1	024090C1A
305 (12)	Heated straight	120	71	0.60	024120C1	024120C1A
457 (18)	Heated straight	120	107	0.90	024180C1	024180C1A
610 (24)	Heated straight	120	142	1.19	024240C1	024240C1A
914 (36)	Heated straight	120	213	1.78	024360C1	024360C1A
457 (18)	Straight insulator	NA	Trim-to-fit	Insulator	024180C0	
* Elbow	90° Union Elbow insulator	NA	Trim-to-fit	Insulator	024020C0	
* T	Union Tee insulator	NA	Trim-to-fit	Insulator	024030C0	

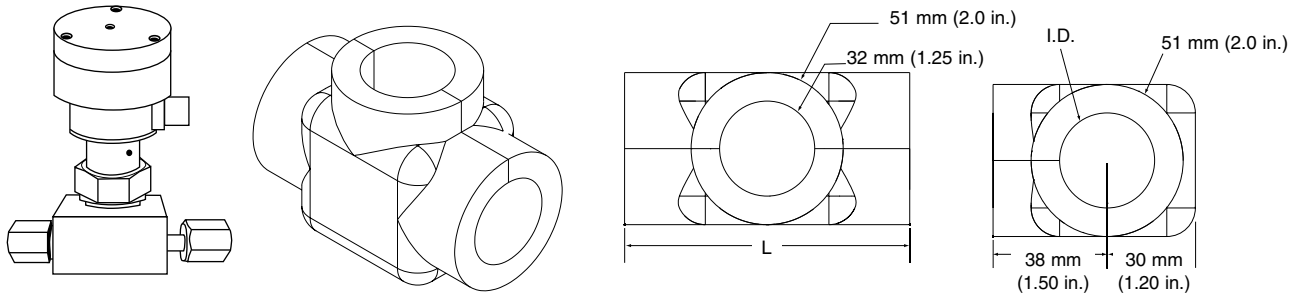
Standard Designs

VCR Union Heaters/Insulators



I.D. x Length mm (in.)	Description	Volts	Watts	Amps	Watlow Code Number	
					without T/C	with Type J T/C
22 x 44 (0.875 x 1.75)	6 mm (0.25 in.) VCR Union heater	120	10	0.09	01702783	01702783A
19 x 38 (0.75 x 1.5)	6 mm (0.25 in.) VCR Union insulator	NA	NA	NA	02401580	NA
32 x 38 (1.25 x 1.5)	13 mm (0.5 in.) VCR Union heater	120	12	0.10	03901581	0301581A
32 x 38 (1.25 x 1.5)	13 mm (0.5 in.) VCR Union insulator	NA	NA	NA	03901580	NA

VCR Valve Heaters



Tube Diameter mm (in.)	I.D. mm (in.)	Fitting Type	Length mm (in.)	Watts	Amps @ 120V	Watlow Code Number
6 (0.25)	22 (0.875)	Male VCR Valve heater	76 (3.00)	18	0.15	03104786
6 (0.25)	22 (0.875)	Female VCR Valve heater	121 (4.75)	28	0.24	04704893
13 (0.5)	32 (1.25)	Male VCR Valve heater	95 (3.75)	27	0.23	03804782
13 (0.5)	32 (1.25)	Female VCR Valve heater	165 (6.51)	47	0.39	04706690

Note: Heaters fit Nupro® BN and BK series valves.

Accessories

- Y-adapters and dead plugs
 - Sensor Pocket thermocouple: 305 mm (12 in.) long, Type J or K,
 - Interconnects with Watlow temperature control consoles
- Teflon® insulated, #24 AWG, 2-prong mini-plug connector

Part	Description	Watlow Code Number
Y Connector*	Power splitter: 1 female, 2 male	Z5303-2
Y Connector*	Power splitter: 2 female, 1 male	Z6333
Female Dead Plug*	Insulating plug for last connector in chain	Z5309-2
Male Dead Plug*	Insulating plug for last connector in chain	Z6332
Type J Thermocouple	305 mm (12 in.) 24 ga. Type J Teflon® with mini plug	Z5786
Type J Thermocouple Extension	3048 (10 ft.) Type K Teflon® thermocouple with mini plug and mini jack	Z6271
Type K Thermocouple	305 mm (12 in.) 24 ga. Type K Teflon® with mini plug	Z5639
Adapter*	Female to male	Z6334
Adapter*	Male to female	Z6335
Power Extension*	152 mm (6 in.)	Z6374
Power Extension*	914 mm (3 ft.)	A000136
Power Extension*	1828 mm (6 ft.)	A000137
Power Extension*	3048 mm (10 ft.)	A000138
Strap Extension	25 mm (1 in.) long Pump Line strap extension	010010116
Strap Extension	51 mm (2 in.) long Pump Line strap extension	010020113
Strap Extension	76 mm (3 in.) long Pump Line strap extension	010030124

*All connectors use AMP Mate-N-Lok® connectors.

Line Measurement

Use the following guidelines to develop an approximate measurement that can be used for component selection and control zone layout. To measure quickly, start at one end of the line and work your way down measuring one component at a time. Drawings of each component are not necessary if detailed measurement notes are taken.

Diameter: Verify the diameter of your pump line by measuring the circumference (distance around the outside of the tubing) of a common straight section within the line. Divide the circumference by Π (3.14) to yield the diameter.

Straight Sections: Measure the length of a straight section referencing the backside of the flange or the centerline of the butt-weld joint.

90° Elbows: Measure the "L" dimension as shown*, from the backside of the flange (or centerline of the butt-weld joint) to the centerline of the opposing leg. Measure the outer and inner arc length between the backsides of the flanges (or the centerline of the butt-weld joints). Also, note if the elbow is a "smooth" radius, or if it has "extended tangents" on each end.

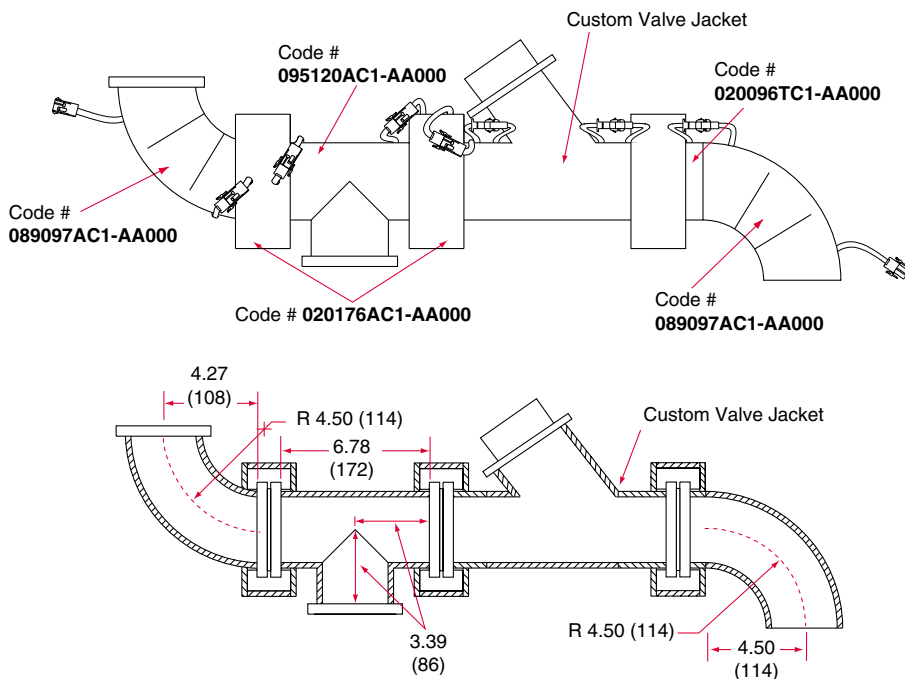
45° Elbows: Measure the outer and inner arc length between the backsides of the flanges (or the centerline of the butt-weld joints).

Tee: Measure the length "L" as shown*.

Flexible Section (bellows): Measure the outer diameter (by measuring the major circumference) and the length as shown*. Note: the length must be measured under compression (with full vacuum pulled). If there is a noticeable "twisting" in the flexible section, adjustment of the line may be needed for proper heater installation.

Flange: Note flange type and dimensions.

Valves and other shapes: Watlow has a large selection of existing heater designs for valves, reducers and other miscellaneous shapes. Please contact your local Watlow representative or distributor for help.



Tube dimensions are shown. Heater dimensions are slightly shorter to accommodate flanges.

***Please reference the part list for dimension drawings.**

Temperature Control Zones

Use the following guidelines when grouping sets of heaters into individual circuits, or zones.

- The maximum amperage per zone is 10 amps. Please use the part number list to calculate the total amperage for your pump line.
- Split the zones at natural break points, such as at a flange, elbow, or valve.
- Each flow component (such as a throttle valve) needs to be controlled with a separate control circuit. This is

due to the difference in mass and the temperature sensitive seals internal to these components.

- Temperature sensors (thermocouples) can be placed easily in any straight heater three inches long and up. These heaters have the built-in Sensor Pocket which allows for semi-permanent installation of the sensor.
- When choosing where to place the temperature sensor for each zone, start at the process tool or pump, placing a sensor two to four feet

from the outlet of the process. From there, look for the natural breaks in the line as discussed above.

- Use trim-to-fit heaters to round out uneven straight sections.
- A pump line temperature control console can be used to control the temperature of each zone. Note that the pump line temperature control console is provided with extension cables for both the power and the thermocouple. The length of these cables can be specified in the console's part number.