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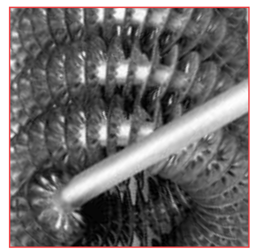
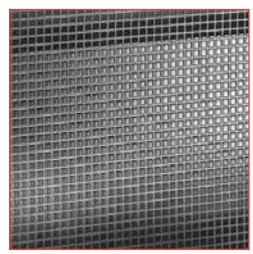
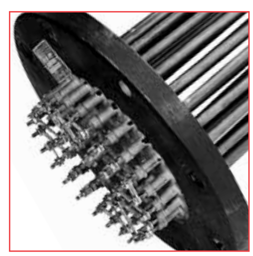
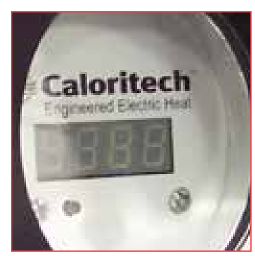
CCI Thermal Technologies INC.

Heating and Filtration Solutions









Caloritech™

Engineered Electric Heat

Engineered Products

Section D

Toll free: ph 800-925-4328 Local: ph 262-253-4800 Email: info@gordonhatch.com

Contents

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Circulation Heaters - EX

Application

Caloritech™ circulation heaters are suitable for use in forced flow and natural flow heating loops where a safe, Clean, reliable, and efficient heating source is required.

Liquid Heating

Virtually any liquid may be heated provided that the system design ensure that the heater vessel remains completely full of liquid when in use. Forced flow heating (with circulator pump) is mandatory when heating heavier liquids or heating liquids to high temperatures. Natural flow systems are generally limited to "side arm" water heating applications where the heater is mounted vertically and the top of the heater is well below the minimum tank liquid level.

Gas Heating

In gas heating applications, such as steam superheating, heating compressed air, nitrogen, ammonia, etc., flow must be sufficient to ensure that the maximum allowable vessel and sheath temperatures are not exceeded. CCI Thermal engineers will assist in the selection of the best heater for your particular application. Call, email or write factory, or contact your nearest Calroitech™ representative or distributor.

Registration

Circulation heaters may be classified as boilers or pressure vessels depending on fluid being heated, kW rating, vessel size, operating pressure and outlet temperature. Registration requirements are imposed by the jurisdiction where the heater is to be installed.

CCI Thermal registered vessels are authorized to bear the S, H or U stamp depending on the Code classification.

Figure 1 - Standard EX Unit Mounted on Optional Stand

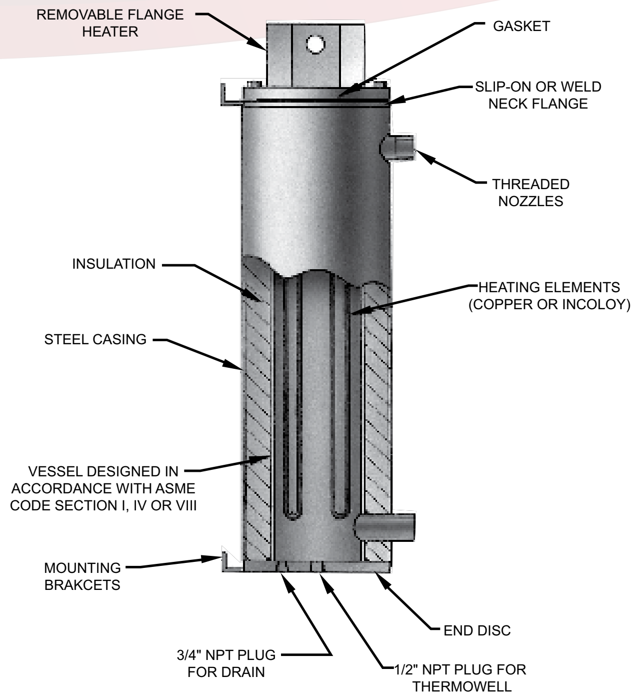

Figure 2 - Construction Details

Construction

Circulation heaters are essentially flange heaters mounted in welded vessels.

Standard sizes use steel vessels fitted with 150 lb. flanges. Units with larger vessels and heavier flanges are available.

For closed systems the heaters are designed to Sect. I, IV, or VIII of the ASME Code.

For high temperature use, heaters can be provided with stainless steel wetted parts and specially designed terminal boxes protected from excessive heat. Consult factory.

Built-In Limits and Thermostats

Built-in high limits and thermostats are available.

Standard built-in thermostat is a one pole device limited to 240V 25 amp. Whenever the heater voltage exceeds 240V or the heater current exceeds 25 amps or for three phase supply, the thermostat is intended for pilot duty only and is not factory wired to the elements. See Section F of the Caloritech™ catalog for selection of the contactor and control transformer you may require in these instances.

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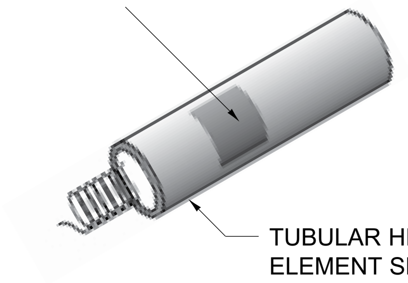
Watt Density

Watt density refers to the wattage output of a heater divided by the total surface area of the heated section of all heating elements in the heater.



Note:
All heat produced by the element is transferred to the work.

It is important to understand the basic terminal difference between an electric immersion heater and a steam or liquid heat exchanger. Unlike the steam or liquid heat exchanger, all of the heat produced by an electric heater will leave the heater. Even though the surface area in contact with the work is fixed, the heating element sheath temperature will continue to rise until the heat produced is equal to the heat transferred to the process.

A detailed understanding of this behaviour and the system parameters will allow the design of a suitable heater to heat virtually any liquid or gas with the only limitation being its ability to resist corrosion in highly active solutions.

As a general rule, low watt density heaters will provide longer service life than high density heaters, especially when the fluid being heated is viscous or stagnant. However, low density heaters are initially more expensive and in larger systems it is best to check with the factory for assistance in optimizing the heater selection.

See page D50 for recommended watt densities for some of the more common fluids.

CAUTION - IMPROPER SELECTION OF WATT DENSITY CAN RESULT IN DAMAGE TO THE PRODUCT AND FAILURE OF THE HEATER.

Installation

The heaters are generally suitable for horizontal or vertical vessel orientation as shown in Figures 3, 4 and 5.

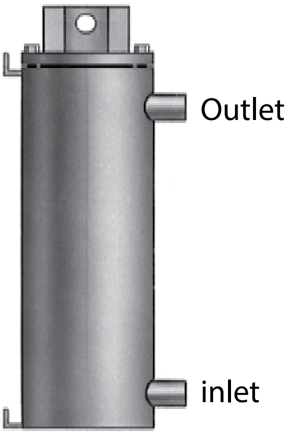


Figure 3 - Liquid Heating or Low Temperature Gas Heating (Vertical Installation)

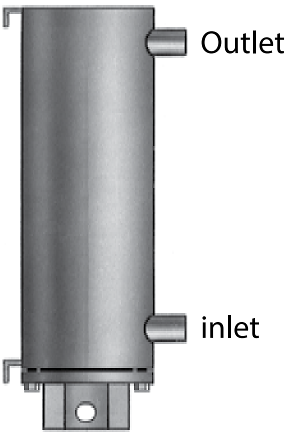


Figure 4 - High Temperature Gas Heating (Vertical Installation)

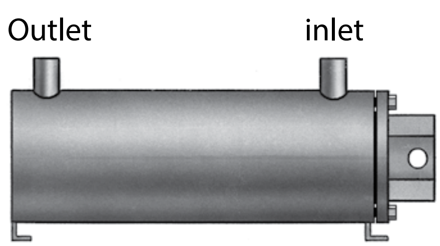
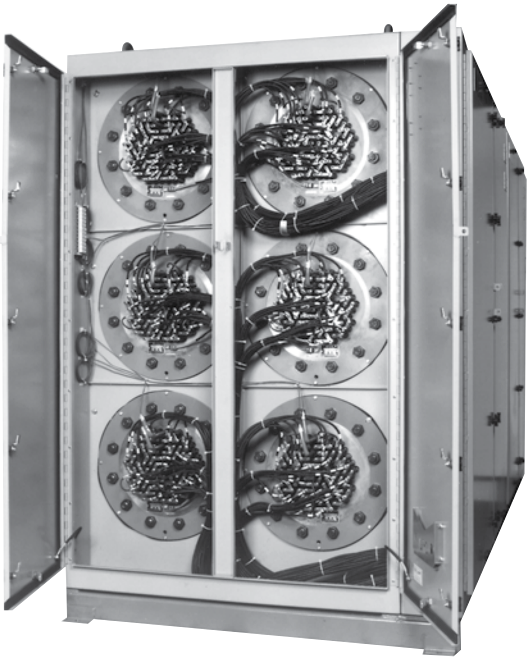


Figure 5 - Gas or Liquid Heating (Horizontal Installation)

EX

Circulation Heaters Custom Designed Assemblies

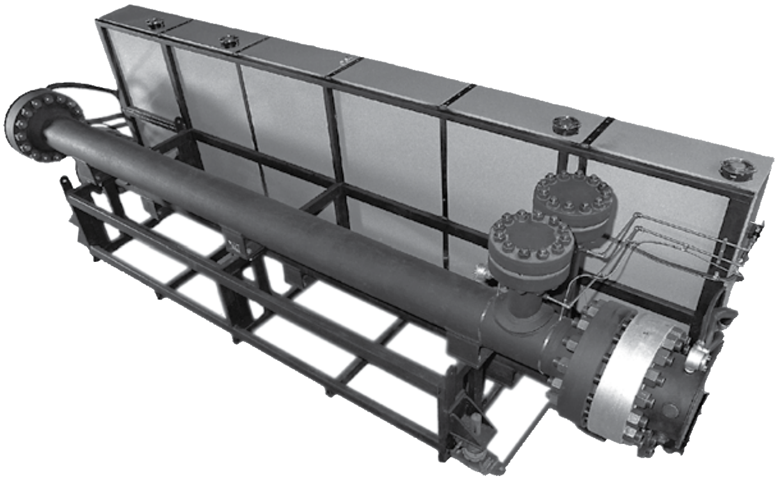
Skidded circulation heater assemblies are available for process heating in chemical processing, mining, refining, etc.



Our complete in-house capability... elements, vessels, CNC equipped machine shop, panel shop, CAD design... directed by a team of highly skilled professionals ensures that our products will provide value.

Registered engineers are available for start-up supervision anywhere in the world.

Multiple staged assemblies with control panel, valving, pumps or fans, chillers, expansion tanks, etc. can be engineered and fabricated by CCI Thermal using state-of-the-art technology and manufacturing procedures



If it can be done electronically, chances are we've done it before. Design proposals are submitted without cost or obligation on receipt of the bid request and specifications.

EX

Miniature Circulation Heaters

Miniature circulation heaters provide an economical source of heat in many applications. In stationary systems, these heaters do not normally require mounting support other than the inlet and outlet piping connections.

Construction

The basic construction of this series of heaters is a one inch or one and a quarter inch pipe fitted with a pipe “T” to accept a suitable screwplug heater. The pipe is insulated with 1 1/4” (32 mm) to 1 1/2” (38 mm) of FSK insulation protected by a 20-gauge steel casing.

Units are available with or without thermostats and with general purpose, moisture resistant or explosion-proof terminal housings.

If the outlet liquid or gas temperature exceeds 300°F (150°C), use the end away from the terminal box as the outlet. Otherwise, use the outside threaded connection as the system inlet.

Type EXC

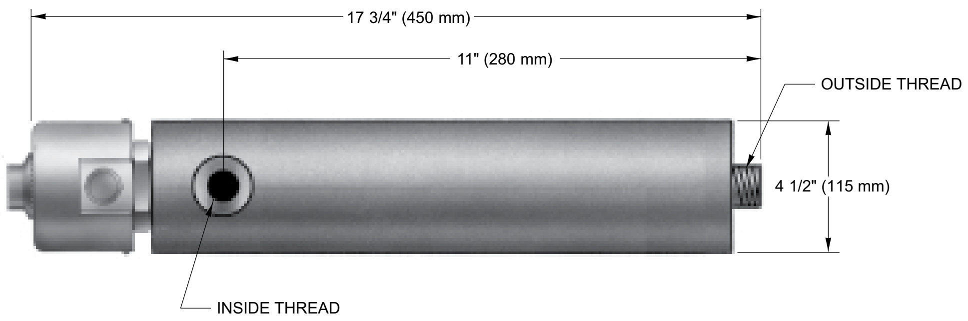
All wetted parts in brass or copper. Used for heating water, glycol water solutions or other liquids of low viscosity which will not corrode the heater materials.

Type EXF

Incoloy® elements with steel screwplug and vessel. Used for heating oils, low pressure steam, preheating instrument air, etc. Select lower watt density listings for heavier liquids.

Special Features

- Stainless steel wetted parts
- Moisture resistant or explosion-proof housings
- Special wattage (length will increase for same watt density)
- Special thermostat range



Miniature Circulation Heaters

kW	Standard Voltages 1 Phase only	Watt Density W/cm²	Watt Density W/in²	Without Thermostat Catalog Number	With Thermostat 50-250°F (10 - 120°C) Catalog Number	Net Weight lbs	Net Weight kg
Type EXC - Copper Sheath (Brass Plug & Vessel With 1" NPT Connections)							
1.0	120, 280, 240	80	12.4	EXC110P1	EXCT110P1	13.2	6
1.5	-			EXC115P1	EXCT115P1		
2.0	-			EXC120P1	EXCT120P1		
3.0	208,240			EXC130P1	EXCT130P1		
Type EXF - Incoloy® Sheath (Steel Plug & Vessel With 1 1/4" NPT Connections)							
0.6	120, 208, 240	15	2.3	EXF206P12	EXFT206P12	17.6	8
1.0	-	25	3.9	EXF210P12	EXFT210P12		

3” Circulation Heaters

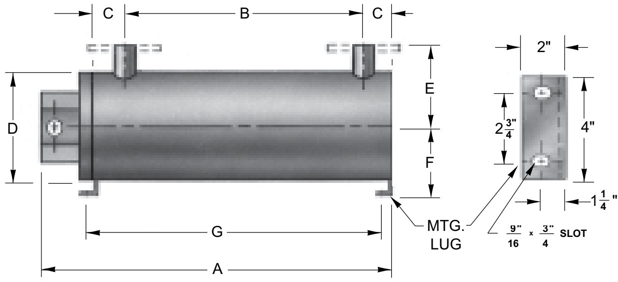
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
3”	41.7 (1060)	30.7 (780)	3.3 (85)	7.5 (790)	9.3 (235)	5.3 (135)	37.2 (945)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner’s name and address, installation location name and address.

kW	B' Dimensions Inlet/Outlet		Standard Voltages 208V, 240V		480V, 600V		Watt Density		Without Thermostat		With Thermostat 50°F to 250°F (10°C to 120°C)		Net Weight	
	in	mm	1Ø	3Ø	1Ø	3Ø	W/in²	W/cm²	Catalog Number	Part Number	Catalog Number	Part Number	lbs	kg
3" - 150 lb Flanged Steel Vessel With 1" (25 mm) Inlet And Outlet														
High Density - Copper Sheath														
6.0							60	9.3	EXC306F3	NWH-3-306	EXCT306F3		108.6	47.0
9.0							55	8.5	EXC309F3	NWH-3-309	EXCT309F3		105.8	48.0
12.0	30.7	780	✓	✓	✓	✓	54	8.4	EXC312F3	NWH-3-312	EXCT312F3	—	105.8	48.0
18.0							55	8.5	EXC618F3	—	EXCT618F3		112.4	51.0
24.0							54	8.4	EXC624F3	—	EXCT624F3		112.4	51.0
High Density - Incoloy® Sheath														
6.0							60	9.3	EXI306F3		EXIT306F3		108.6	47.0
9.0							55	8.5	EXI309F3		EXIT309F3		105.8	48.0
12.0	30.7	780	✓	✓	✓	✓	54	8.4	EXI312F3	—	EXIT312F3	—	105.8	48.0
18.0							55	8.5	EXI618F3		EXIT618F3		112.4	51.0
24.0							54	8.4	EXI624F3		EXIT624F3		112.4	51.0
Medium Density - Incoloy® Sheath														
3.0							30	4.6	EXF303F3	—	EXFT303F3		108.6	47.0
4.5	30.7	780	✓	✓	✓	✓	27	4.2	EXF304F3	—	EXFT304F3	—	105.8	48.0
6.0							27	4.2	EXF306F3	NWHO-3-306	EXFT306F3		105.8	48.0
Low Density - Incoloy® Sheath														
3.0	30.7	780	✓	✓	✓	✓	14	2.1	EXF303F332	NWHO-3L-303	EXFT303F332	—	105.8	48.0

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4” Circulation Heaters

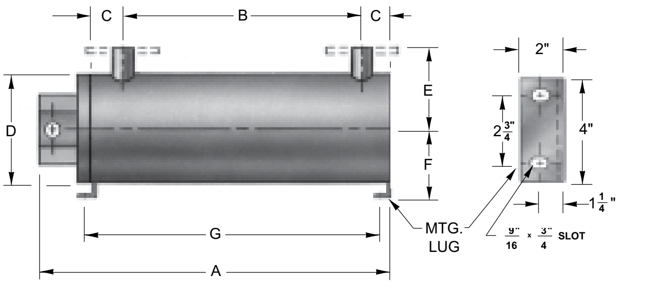
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
4”	48.0 (1220)	30.7 (780)	5.7 (145)	9.1 (230)	10.2 (260)	6.1 (155)	41.9 (1065)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner’s name and address, installation location name and address.

kW	B' Dimensions Inlet/Outlet in	mm	Standard Voltages 208V, 240V 1Ø	3Ø	480V, 600V 1Ø	3Ø	Watt Density W/in²	W/cm²	Without Thermostat Catalog Number	Part Number	With Thermostat 50°F to 250°F (10°C to 120°C) Catalog Number	Part Number	Net Weight lbs	kg
4" - 150 lb Flanged Steel Vessel With 1 1/2" (38 mm) Inlet And Outlet														
High Density - Copper Sheath														
12.0	30.7	780	✓	✓	✓	✓	60	8.4	EXC612F4	—	EXCT612F4	—	138.9	63.0
15.0							57	8.8	EXC615F4		EXCT615F4		141.1	64.0
18.0							55	8.5	EXC618F4		EXCT618F4		141.1	64.0
24.0							54	8.4	EXC624F4		EXCT624F4		141.1	64.0
18.0	30.7	780	✓	✓	✓	✓	60	9.3	EXC918F4	—	EXCT918F4	—	147.7	67.0
27.0							55	8.5	EXC927F4		EXCT927F4		149.9	68.0
36.0							54	8.4	EXC936F4		EXCT936F4		152.1	69.0
High Density - Incoloy® Sheath														
12.0	30.7	780	✓	✓	✓	✓	60	8.4	EXI612F4	—	EXIT612F4	—	138.9	63.0
15.0							57	8.8	EXI615F4		EXIT615F4		141.1	64.0
18.0							55	8.5	EXI618F4		EXIT618F4		141.1	64.0
24.0							54	8.4	EXI624F4		EXIT624F4		141.1	64.0
18.0	30.7	780	✓	✓	✓	✓	60	9.3	EXI918F4	—	EXIT918F4	—	147.7	67.0
27.0							55	8.5	EXI927F4		EXIT927F4		149.9	68.0
36.0							54	8.4	EXI936F4		EXIT936F4		152.1	69.0
Medium Density - Incoloy® Sheath														
6.0	30.7	780	✓	✓	✓	✓	30	4.6	EXF606F4	—	EXFT606F4	—	138.9	63.0
9.0							27	4.2	EXF609F4		EXFT609F4		143.3	65.0
12.0							27	4.2	EXF612F4		EXFT612F4		143.3	65.0
9.0	30.7	780	✓	✓	✓	✓	30	4.6	EXF909F4	—	EXFT909F4	—	149.9	68.0
13.5							27	4.2	EXF913F4		EXFT913F4		152.1	69.0
18.0							27	4.2	EXF918F4		EXFT918F4		154.3	70.0
Low Density - Incoloy® Sheath														
6.0	30.7	780	✓	✓	✓	✓	14	2.1	EXF606F432	—	EXFT606F432	—	143.3	65.0
9.0									EXF909F432		EXFT909F432		152.1	69.0

EX

5” Circulation Heaters

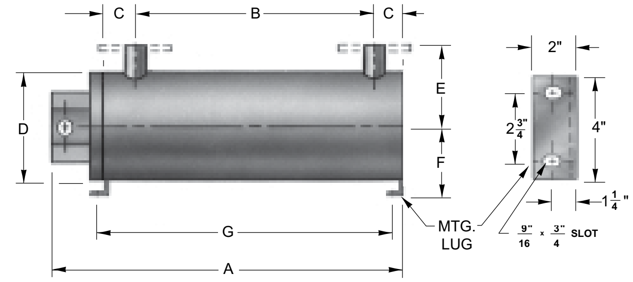
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
5”	48.0 (1220)	30.7 (780)	5.7 (145)	10.0 (255)	10.6 (270)	6.7 (170)	41.9 (1065)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner’s name and address, installation location name and address.

kW	B' Dimensions Inlet/Outlet in	B' Dimensions Inlet/Outlet mm	Standard Voltages 208V, 240V 1Ø	208V, 240V 3Ø	480V, 600V 1Ø	480V, 600V 3Ø	Watt Density W/in²	Watt Density W/cm²	Without Thermostat Catalog Number	Without Thermostat Part Number	With Thermostat 50°F to 250°F (10°C to 120°C) Catalog Number	With Thermostat Part Number	Net Weight lbs	Net Weight kg
5" - 150 lb Flanged Steel Vessel With 2" (51 mm) Inlet And Outlet														
High Density - Copper Sheath														
12.0	30.7	780	✓	✓	✓	✓	60	8.4	EXC612F5	—	EXCT612F5	—	138.9	63.0
15.0							57	8.8	EXC615F5	—	EXCT615F5		141.1	64.0
18.0							55	8.5	EXC618F5	—	EXCT618F5		141.1	64.0
24.0							54	8.4	EXC624F5	NWH-5-624	EXCT624F5		141.1	64.0
18.0	30.7	780	✓	✓	✓	✓	60	9.3	EXC918F5	—	EXCT918F5	—	147.7	67.0
27.0							55	8.5	EXC927F5		EXCT927F5		149.9	68.0
36.0							54	8.4	EXC936F5		EXCT936F5		152.1	69.0
High Density - Incoloy® Sheath														
12.0	30.7	780	✓	✓	✓	✓	60	8.4	EXI612F5	—	EXIT612F5	—	138.9	63.0
15.0							57	8.8	EXI615F5		EXIT615F5		141.1	64.0
18.0							55	8.5	EXI618F5		EXIT618F5		141.1	64.0
24.0							54	8.4	EXI624F5		EXIT624F5		141.1	64.0
18.0	30.7	780	✓	✓	✓	✓	60	9.3	EXI918F5	—	EXIT918F5	—	147.7	67.0
27.0							55	8.5	EXI927F5		EXIT927F5		149.9	68.0
36.0							54	8.4	EXI936F5		EXIT936F5		152.1	69.0
Medium Density - Incoloy® Sheath														
6.0	30.7	780	✓	✓	✓	✓	30	4.6	EXF606F5	—	EXFT606F5	—	138.9	63.0
9.0							27	4.2	EXF609F5	—	EXFT609F5		143.3	65.0
12.0							27	4.2	EXF612F5	NWHO-5-612	EXFT612F5		143.3	65.0
9.0	30.7	780	✓	✓	✓	✓	30	4.6	EXF909F5	—	EXFT909F5	—	149.9	68.0
13.5							27	4.2	EXF913F5		EXFT913F5		152.1	69.0
18.0							27	4.2	EXF918F5		EXFT918F5		154.3	70.0
Low Density - Incoloy® Sheath														
6.0	30.7	780	✓	✓	✓	✓	14	2.1	EXF606F532	—	EXFT606F532	—	143.3	65.0
9.0									EXF909F532		EXFT909F532		152.1	69.0

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6” Circulation Heaters

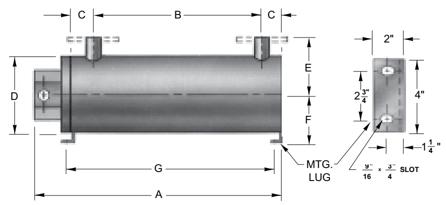
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
6”	48.0 (1220)	30.7 (780)	5.7 (145)	11.0 (280)	11.4 (290)	7.1 (180)	41.9 (1065)
	60.6 (1540)	43.3 (1100)	5.7 (145)	11.0 (280)	11.4 (290)	7.1 (180)	54.5 (1385)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner’s name and address, installation location name and address.

kW	B' Dimensions Inlet/Outlet in	B' Dimensions Inlet/Outlet mm	Standard Voltages 208V, 240V 1Ø	208V, 240V 3Ø	480V, 600V 1Ø	480V, 600V 3Ø	Watt Density W/in²	Watt Density W/cm²	Without Thermostat Catalog Number	Without Thermostat Part Number	With Thermostat 50°F to 250°F (10°C to 120°C) Catalog Number	With Thermostat Part Number	Net Weight lbs	Net Weight kg
6" - 150 lb Flanged Steel Vessel With 2" (51 mm) Inlet And Outlet														
High Density - Copper Sheath														
36.0	30.7	780	✓				55	8.5	EXC1236F6	—	EXCT1236F6		200.6	91.0
48.0	30.7	780	—	✓	✓	✓	54	8.4	EXC1248F6	NWH-6-1248	EXCT1248F6	—	202.8	92.0
60.0	43.3	1100	—				54	8.4	EXC1260F6	NHW-6-1260	EXCT1260F6		209.4	95.0
72.0	43.3	1100	—				53	8.2	EXC1272F6	NWH-6-1272	EXCT1272F6		211.6	96
45.0	30.7	780		✓			55	8.5	EXC1545F6		EXCT1545F6		205.0	93.0
60.0	30.7	780		✓			54	8.4	EXC1560F6		EXCT1560F6		211.6	96.0
75.0	43.3	1100	—	✓	✓	✓	54	8.4	EXC1575F6	—	EXCT1575F6	—	240.3	109.0
90.0	43.3	1100		—			53	8.2	EXC1590F6		EXCT1590F6		246.9	112.0
90.0	43.3	1100		—			54	8.4	EXC1890F6		EXCT1890F6		246.9	112.0
High Density - Incoloy® Sheath														
36.0	30.7	780	✓				55	8.5	EXI1236F6		EXIT1236F6		200.6	91.0
48.0	30.7	780	—	✓	✓	✓	54	8.4	EXI1248F6	—	EXIT1248F6	—	202.8	92.0
60.0	43.3	1100	—				54	8.4	EXI1260F6		EXIT1260F6		209.4	95.0
72.0	43.3	1100	—				53	8.2	EXI1272F6		EXIT1272F6		211.6	96.0
45.0	30.7	780		✓			55	8.5	EXI1545f6		EXIT1545f6		205.0	93.0
60.0	30.7	780	—	✓	✓	✓	54	8.4	EXI1560F6	—	EXIT1560F6	—	211.6	96.0
75.0	43.3	1100		✓			54	8.4	EXI1575f6		EXIT1575f6		240.3	109.0
90.0	43.3	1100					53	8.2	EXI1590F6		EXIT1590F6		246.9	112.0
90.0					✓		54	8.4	EXI1890F6		EXIT1890F6		246.9	112.0
120.0	43.3	1100	—	—	—	✓	70	10.9	EXI15120F6	—	EXIT15120F6	—	251.3	114.0
144.0					—		70	10.9	EXI18144F6		EXIT18144F6		260.2	118.0
Medium Density - Incoloy® Sheath														
18.0	30.7	780					27	4.2	EXF1218F6	NWHO-6-1218	EXFT1218F6		202.8	92.0
24.0	30.7	780	✓	✓	✓	✓	27	4.2	EXF1224F6	NWHO-6-1224	EXFT1224F6	—	207.2	94.0
30.0	43.3	1100					27	4.2	EXF1230F6	NWHO-6-1230	EXFT1230F6		233.7	106.0
36.0	43.3	1100					26	4.1	EXF1236F6	NWHO-6-1236	EXFT1236F6		238.1	108.0
22.5	30.7	780	✓				27	4.2	EXF1522F6		EXFT1522F6		209.4	95.0
30.0	30.7	780	✓	✓	✓	✓	27	4.2	EXF1530F6	—	EXFT1530F6	—	213.9	97.0
37.5	43.3	1100	✓				27	4.2	EXF1537F6		EXFT1537F6		240.3	109.0
45.0	43.3	1100	—				26	4.1	EXF1545F6		EXFT1545F6		246.9	112.0
Low Density - Incoloy® Sheath														
12.0	30.7	780					14	2.1	EXF1212F6	—	EXFT1212F6		202.8	90.0
18.0	43.3	1100	✓	✓	✓	✓	16	2.5	EXF1218F639	NWHO-6L-1218	EXFT1218F639	—	233.7	106.0
24	43.3	1100					18	2.7	EXF1224F647	—	EXFT1224F647		244.7	111
15	30.7	780					14	2.1	EXF1515F6		EXFT1515F6		209.4	95
22.5	43.3	1100	✓	✓	✓	✓	16	2.5	EXF1522F639	—	EXFT1522F639	—	242.5	110
30	43.3	1100					18	2.7	EXF1530F647		EXFT1530F647		253.5	115

8” Circulation Heaters

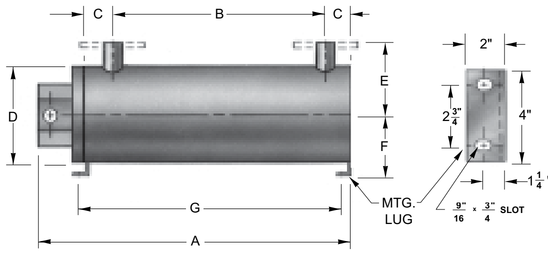
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
8”	62.2 (1580)	43.3 (1100)	6.5 (165)	13.6 (345)	13.0 (330)	8.5 (215)	56.1 (1425)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner’s name and address, installation location name and address.

kW	B' Dimensions Inlet/Outlet in	B' Dimensions Inlet/Outlet mm	Standard Voltages 208V, 240V 1Ø	Standard Voltages 208V, 240V 3Ø	Standard Voltages 480V, 600V 1Ø	Standard Voltages 480V, 600V 3Ø	Watt Density W/in²	Watt Density W/cm²	Without Thermostat Catalog Number	Without Thermostat Part Number	With Thermostat 50°F to 250°F (10°C to 120°C) Catalog Number	With Thermostat Part Number	Net Weight lbs	Net Weight kg
8" - 150 lb Flanged Steel Vessel With 2 1/2" (64 mm) Inlet And Outlet														
High Density - Copper Sheath														
54.0	43.3	1100	—	✓	✓	✓	55	8.5	EXC1854F8	—	EXCT1854F8	—	233.7	106.0
72.0							54	8.4	EXC1872F8		EXCT1872F8		240.3	109.0
90.0							54	8.4	EXC1890F8		EXCT1890F8		313.6	142.0
108.0							53	8.2	EXC18108F8		EXCT18108F8		317.5	144.0
81.0	43.3	1100	—	✓	✓	✓	55	8.5	EXC2781F8	—	EXCT2781F8	—	326.3	148.0
108.0				—	✓		54	8.4	EXC27108F8		EXCT27108F8		335.1	152.0
135.0				—	—		54	8.4	EXC27135F8		EXCT27135F8		346.1	157.0
162.0				—	—		53	8.2	EXC27162F8		EXCT27162F8		352.7	160.0
High Density - Incoloy® Sheath														
54.0	43.3	1100	—	✓	✓	✓	55	8.5	EXI1854F8	—	EXIT1854F8	—	233.7	106.0
72.0							54	8.4	EXI1872F8		EXIT1872F8		240.3	109.0
90.0							54	8.4	EXI1890F8		EXIT1890F8		313.6	142.0
108.0							53	8.2	EXI18108F8		EXIT18108F8		317.5	144.0
81.0	43.3	1100	—	✓	✓	✓	55	8.5	EXI2781F8	—	EXIT2781F8	—	326.3	148.0
108.0				—	✓		54	8.4	EXI27108F8		EXIT27108F8		335.1	152.0
135.0				—	—		54	8.4	EXI27135F8		EXIT27135F8		346.1	157.0
162.0				—	—		53	8.2	EXI27162F8		EXIT27162F8		352.7	160.0
120.0	43.3	1100	—	—	—	✓	70	10.9	EXI15120F8	—	EXIT15120F8	—	313.6	142.0
144.0							70	10.9	EXI18144F8		EXIT18144F8		319.7	145.0
168.0							70	10.9	EXI21168F8		EXIT21168F8		326.3	148.0
192.0							70	10.9	EXI24192F8		EXIT24192F8		332.9	151.0
216.0	43.3	1100	—	—	—	✓	70	10.9	EXI27216F8	—	EXIT27216F8	—	339.5	154.0
240.0							70	10.9	EXI30240F8		EXIT30240F8		346.1	157.0
Medium Density - Incoloy® Sheath														
36.0	43.3	1100	✓	✓	✓	✓	27	4.2	EXF1836F8	—	EXFT1836F8	—	304.2	138.0
54.0			—				26	4.1	EXF1854F8		EXFT1854F8		319.7	145.0
63.0			—				26	4.1	EXF2163F8		EXFT2163F8		328.5	149.0
72.0	43.3	1100	—	—	✓	✓	26	4.1	EXF2472F8	—	EXFT2472F8	—	335.1	152.0
81.0							26	4.1	EXF2781F8		EXFT2781F8		341.7	155.0
90.0							26	4.1	EXF3090F8		EXFT3090F8		348.3	158.0
Low Density - Incoloy® Sheath														
27.0	43.3	1100	✓	✓	✓	✓	16	2.5	EXF1827F8	—	EXFT1827F8	—	313.6	142.0
31.5							16	2.5	EXF2131F8		EXFT2131F8		317.5	144.0
36.0							16	2.5	EXF2436F8		EXFT2436F8		321.9	146.0
36.0							17	2.7	EXF1836F847		EXFT1836F847		321.9	146.0
40.5	43.3	1100	—	✓	✓	✓	16	2.5	EXF2740F8	—	EXFT2740F8	—	328.5	149.0
45.0							16	2.5	EXF3045F8		EXFT3045F8		335.1	152.0
54							17	2.7	EXF2754F8		EXFT2754F8		343.9	156.0

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10" Circulation Heaters

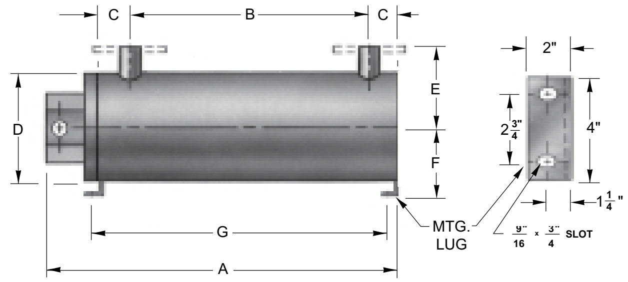
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
10"	65.0 (1650)	43.3 (1100)	7.1 (180)	16.0 (405)	14.8 (375)	9.9 (250)	57.1 (1450)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner's name and address, installation location name and address.

kW	B' Dimensions Inlet/Outlet		Standard Voltages 208V, 240V		Standard Voltages 480V, 600V		Watt Density		Without Thermostat		With Thermostat 50°F to 250°F (10°C to 120°C)		Net Weight	
	in	mm	1Ø	3Ø	1Ø	3Ø	W/in²	W/cm²	Catalog Number	Part Number	Catalog Number	Part Number	lbs	kg
10" - 150 lb Flanged Steel Vessel With 3" (76 mm) Inlet And Outlet														
High Density - Copper Sheath														
180.0	43.3	1100					63	9.8	EXC36180F10		EXCT36180F10		485.0	220.0
216.0	43.3	1100	—	—	—	✓	60	9.3	EXC36216F10	—	EXCT36216F10	—	498.2	226.0
252.0	43.3	1100					60	9.3	EXC42252F10		EXCT42252F10		520.3	236.0
High Density - Incoloy® Sheath														
180.0	43.3	1100					63	9.8	EXI36180F10		EXIT36180F10		485.0	220.0
216.0	43.3	1100	—	—	—	✓	60	9.3	EXI36216F10	—	EXIT36216F10	—	498.2	226.0
252.0	43.3	1100					60	9.3	EXI42252F10		EXIT42252F10		520.3	236.0
288.0	43.3	1100					80	12.3	EXI36288F10		EXIT36288F10		498.2	226.0
336.0	43.3	1100	—	—	—	✓	80	12.3	EXI42336F10	—	EXIT42336F10	—	520.3	236.0
384.0	43.3	1100					80	12.3	EXI48384F10		EXIT48384F10		542.3	246.0
Medium Density - Incoloy® Sheath														
108.0	43.3	1100			✓				EXF36108F10		EXFT36108F10		498.2	226.0
126.0	43.3	1100	—	—	—	✓	30	4.6	EXF42126F10	—	EXFT42126F10	—	520.3	236.0
144.0	43.3	1100			—				EXF48144F10		EXFT48144F10		537.9	244.0
Low Density - Incoloy® Sheath														
72.0	43.3	1100							EXF3672F10		EXFT3672F10		498.2	226.0
84.0	43.3	1100	—	✓	✓	✓	20	3.1	EXF4284F10	—	EXFT4284F10	—	520.3	236.0
96.0	43.3	1100							EXF4896F10		EXFT4896F10		537.9	244.0

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12" Circulation Heaters

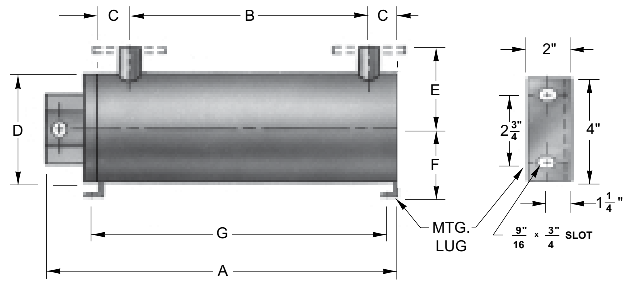
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
12"	65.1 (1655)	43.3 (1100)	7.1 (180)	19.0 (480)	16.1 (410)	11.5 (290)	57.1 (1450)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner's name and address, installation location name and address.

kW	B' Dimensions Inlet/Outlet in	B' Dimensions Inlet/Outlet mm	Standard Voltages 208V, 240V 1Ø	Standard Voltages 208V, 240V 3Ø	Standard Voltages 480V, 600V 1Ø	Standard Voltages 480V, 600V 3Ø	Watt Density W/in²	Watt Density W/cm²	Without Thermostat Catalog Number	Without Thermostat Part Number	With Thermostat 50°F to 250°F (10°C to 120°C) Catalog Number	With Thermostat Part Number	Net Weight lbs	Net Weight kg
12" - 150 lb Flanged Steel Vessel With 3" (76 mm) Inlet And Outlet														
High Density - Copper Sheath														
240.0	43.3	1100					63	9.8	EXC48240F12		EXCT48240F12		690.1	313.0
288.0	43.3	1100	—	—	—	✓	60	9.3	EXC48288F12	—	EXCT48288F12	—	709.9	322.0
324.0	43.3	1100					60	9.3	EXC54324F12		EXCT54324F12		727.5	330.0
360.0	43.3	1100					60	9.3	EXC60360F12		EXCT60360F12		718.7	326.0
High Density - Incoloy® Sheath														
240.0	43.3	1100					63	9.8	EXI48240F12		EXIT48240F12		690.1	313.0
288.0	43.3	1100	—	—	—	✓	60	9.3	EXI48288F12	—	EXIT48288F12	—	709.9	322.0
324.0	43.3	1100					60	9.3	EXI54324F12		EXIT54324F12		727.5	330.0
360.0	43.3	1100					60	9.3	EXI60360F12		EXIT60360F12		718.7	326.0
432.0	43.3	1100	—	—	—	✓	80	12.3	EXI54324F12	—	EXIT54324F12	—	727.5	330.0
480.0	43.3	1100					80	12.3	EXI60480F12		EXIT60480F12		743.0	337.0
Medium Density - Incoloy® Sheath														
144.0	43.3	1100							EXF48144F12		EXFT48144F12		709.9	322.0
162.0	43.3	1100	—	—	—	✓	30	4.6	EXF54162F12	—	EXFT54162F12	—	727.5	330.0
180.0	43.3	1100							EXF60180F12		EXFT60180F12		743.0	337.0
Low Density - Incoloy® Sheath														
96.0	43.3	1100		✓	✓				EXF4896F12		EXFT4896F12		709.9	322.0
108.0	43.3	1100	—	—	✓	✓	20	3.1	EXF54108F12	—	EXFT54108F12	—	727.5	330.0
120.0	43.3	1100		—	—				EXF60120F12		EXFT60120F12		743.0	337.0

14" Circulation Heaters

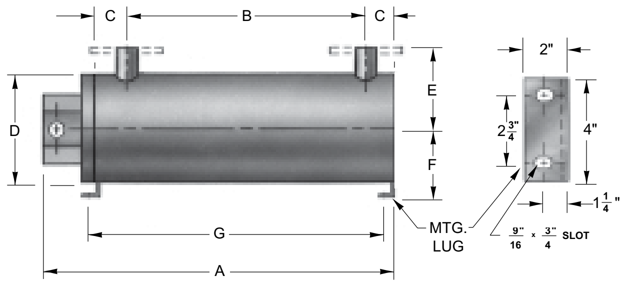
Type EXC
Used primarily for heating water or aqueous solutions which are not corrosive to the steel vessel or the copper sheathed elements.

Type EXI
May also be used to heat water, especially in rinse tanks and spray washing systems where the chemical additives would be corrosive to copper.

Type EXF
To heat circulated oils or process liquids which are not corrosive to steel and Incoloy®. To heat compressed air or other gases. Lower density heaters should be specified for high viscosity liquids or high temperature, low flow steam or gas heating systems. Consult factory for technical assistance.

Dimensions - in (mm)

Vessel Size	A	B	C	D	E	F	G
14"	66.2 (1680)	43.3 (1100)	7.8 (200)	21.0 (535)	17.5 (445)	12.6 (320)	58.6 (1490)



To Order Specify
Quantity, catalog number, voltage, phase, wattage, special features, fluid to be heated, operating temperature and pressure, ultimate owner's name and address, installation location name and address.

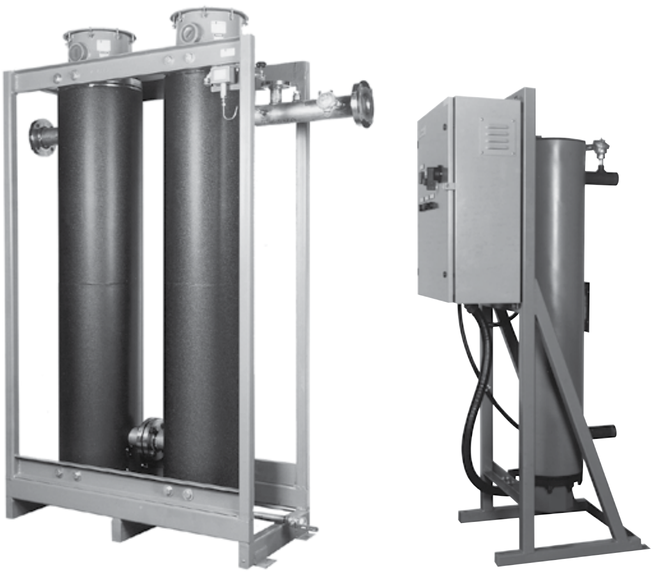
kW	B' Dimensions Inlet/Outlet in	B' Dimensions Inlet/Outlet mm	Standard Voltages 208V, 240V 1Ø	208V, 240V 3Ø	480V, 600V 1Ø	480V, 600V 3Ø	Watt Density W/in²	Watt Density W/cm²	Without Thermostat Catalog Number	Without Thermostat Part Number	With Thermostat 50°F to 250°F (10°C to 120°C) Catalog Number	With Thermostat Part Number	Net Weight lbs	Net Weight kg
14" - 150 lb Flanged Steel Vessel With 3" (76 mm) Inlet And Outlet														
High Density - Copper Sheath														
300.0	43.3	1100	—	—	—	✓	63	9.8	EXC60300F14	—	EXCT60300F14	—	877.4	398.0
360.0	43.3	1100					60	9.3	EXC60360F14		EXCT60360F14		903.9	410.0
432.0	43.3	1100					60	9.3	EXC72432F14		EXCT72432F14		934.8	424.0
504.0	43.3	1100					60	9.3	EXC84504F14		EXCT84504F14		967.8	439.0
High Density - Incoloy® Sheath														
300.0	43.3	1100	—	—	—	✓	63	9.8	EXI60300F14	—	EXIT60300F14	—	877.4	398.0
360.0	43.3	1100					60	9.3	EXI60360F14		EXIT60360F14		903.9	410.0
432.0	43.3	1100					60	9.3	EXI72432F14		EXIT72432F14		934.8	424.0
504.0	43.3	1100	—	—	—	✓	60	9.3	EXI84504F14	—	EXIT84504F14	—	967.8	439.0
576.0	43.3	1100					80	12.3	EXI72576F14		EXIT72576F14		934.8	424.0
672.0	43.3	1100					80	12.3	EXI84672F14		EXIT84672F14		967.8	439.0
Medium Density - Incoloy® Sheath														
180.0	43.3	1100	—	—	—	✓	30	4.6	EXF60180F14	—	EXFT60180F14	—	903.9	410.0
216.0	43.3	1100							EXF72216F14		EXFT72216F14		934.8	424.0
252.0	43.3	1100							EXF84252F14		EXFT84252F14		967.8	439.0
Low Density - Incoloy® Sheath														
120.0	43.3	1100	—	✓	✓	✓	20	3.1	EXF60120F14	—	EXFT60120F14	—	903.9	410.0
144.0	43.3	1100							EXF72144F14		EXFT72144F14		934.8	424.0
168.0	43.3	1100							EXF84168F14		EXFT84168F14		967.8	439.0

Special Features

Flange Heaters
See Section B of the Caloritech™ catalog for special flange heater features for use in circulation heater vessels.

Special Materials
Stainless steel or special alloy construction available for corrosive liquids of high temperature gas heating when outlet temperatures are in excess of 887°F (475°C).

Flanged Inlet and Outlet



Free Standing Frame
Circulation heaters may be mounted on factory supplied frame as shown.

Factory Mounted Control Panel
Custom designed, fully prewired control panels are available. See pages D27 to D33 for details.

Inlet and Outlet 180° Apart
To facilitate piping inlet and outlet piping may be positioned 180° apart or as required. Specify desired location of mounting lugs in relation to inlet and outlet. (Forward sketch to the factory to avoid mistakes)

Multistage Units
Circulation heaters can be supplied as multistage assemblies with either vertical or horizontal vessel orientation. See Figures 1 and 2.

Figure 1

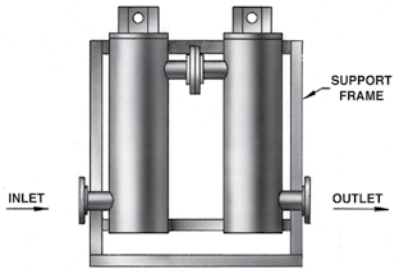
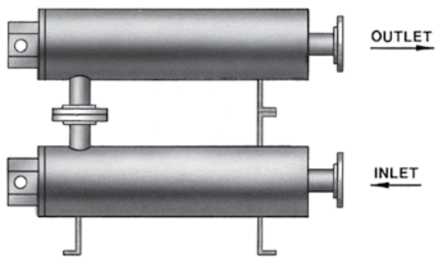


Figure 2



Higher Ratings
Units are available for operation at higher pressures or kilowatt ratings.

Cross Flow Baffles
Cross flow baffles improve heat transfer when heating viscous fluids and high temperature gases.

Valves
Pressure relief valves, bleed and drain valves are available.

Flow Switch

Differential Pressure Switch

Thermocouple
A built-in type J or K thermocouple mounted in the outlet pipe.

Built-In Controls
Mechanical or electronic high limit controls and temperature controls are available.

Larger Sizes
Vessel sizes to 36" (914 mm) diameter or larger are available with flanged inlets and outlets up to 16" (406 mm) diameter.

EX

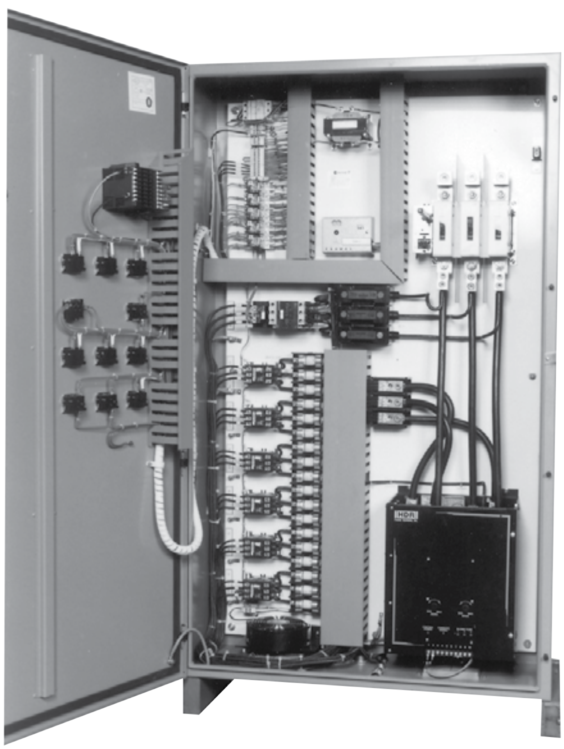
Liquid Heat Transfer Systems - FX

Applications

Caloritech™ hot oil heat transfer systems are custom designed to provide high temperature process heat without the necessity for high pressure design common to saturated steam transfer systems.

Accurate process temperatures up to 707°F (375°C) can be maintained in molds, platens, presses and jacketed vessels or pipes under practically negligible pressure conditions.

Ratings available to 3000 kW at 600V.



From the table below note the high steam operating pressure required whenever high process temperatures are needed. Even at 707°F (375°C) the Caloritech™ oil heat transfer system functions at a pressure less than 30 PSIG depending on the transfer fluid used.

Saturated Steam Pressure vs. Temperature

Pressure (PSIA)	°F	°C
250	467	242
500	510	265
750	545	285
1000	596	313
1500	635	335
2000	668	353
2500	707	375
3250	375	707

Construction

Type FX transfer systems are supplied as fully prewired and piped packaged assemblies customized to your specific application. You merely connect the process pipes to the system inlet and outlet, mount the separately supplied expansion tank, and connect to your electrical supply.

Each system comes equipped with low density EX type circulation heaters mounted on a structural steel frame. Centrifugal, direct drive pumps are standard. Positive displacement pumps are available on request.

Special inlet and outlet valves with high temperature packing and flanged connections are standard. Bypass, drain, fill and bleed valves are installed in the piping loop with all welded connections for 1/2" NPT pipes and larger.

A strainer is installed on the system inlet with an attached fill valve.

Other mechanical devices provided include an expansion tank with sight glass and vent, pressure gauge(s), low and high pressure switches or optional differential pressure switches.

Systems are available with motorized valves for heating and cooling applications.

Standard electrical controls include a fully prewired control panel with disconnect, HRC fusing, derated magnetic contractors, electronic indicating and fully adjustable temperature control, electronic high temperature limit control, optional step controller, switches and pilot lights.

Selection

Contact the factory or your nearest Caloritech™ agent or distributor to obtain complete specifications and prices for an FX electric heat transfer system custom designed to your specific needs.

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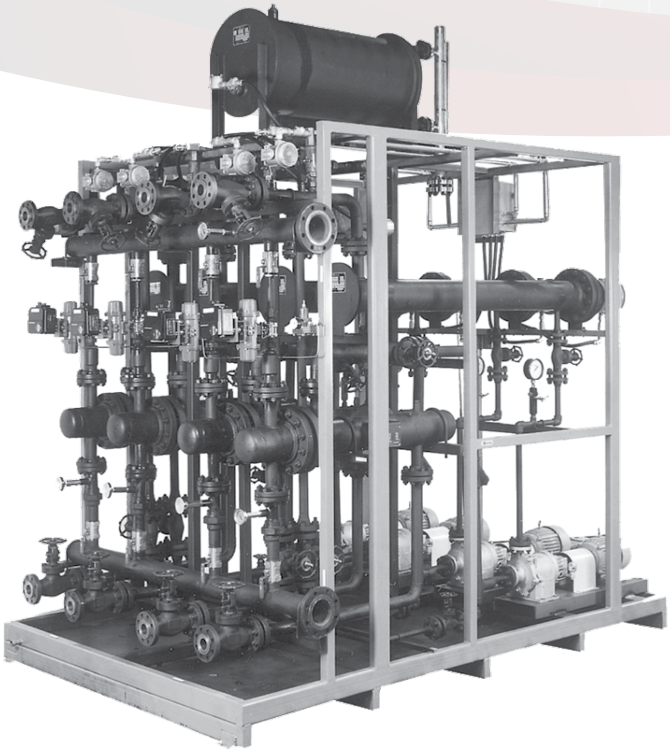
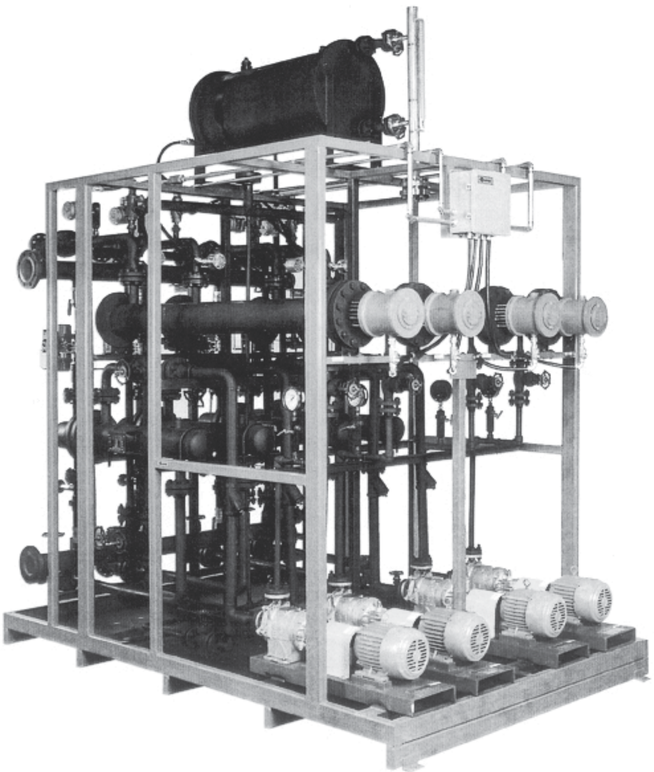
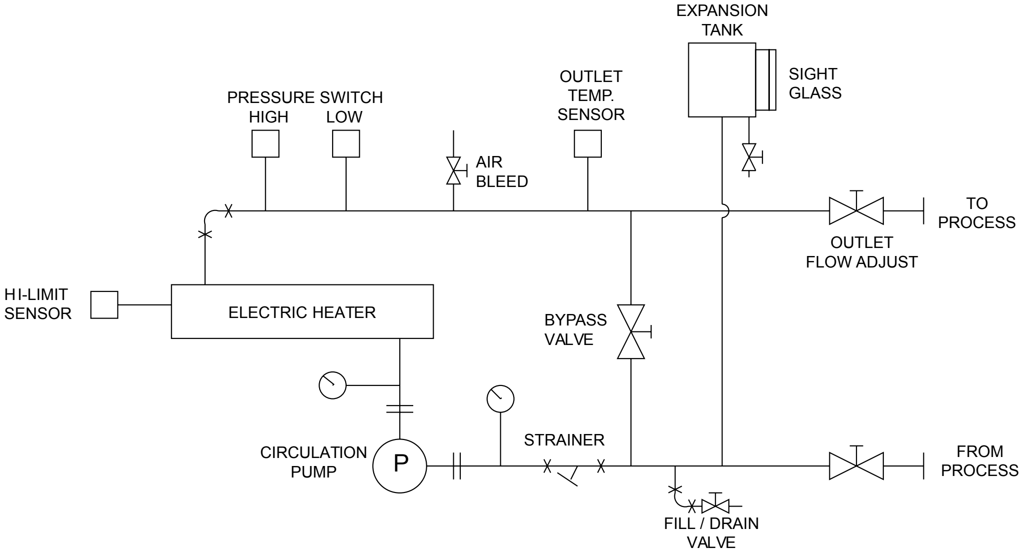




Flow Diagram

The heat transfer fluid is circulated through the electric heaters and the process in a closed loop. All components are connected with factory tested, leak proof joins. An expansion tank, vented to atmosphere and elevated above the system maintains a constant positive suction head on the pump. A bypass valve is used on cold start-up. The pump and heater are protected against external shut-off by an outlet high pressure switch. Loop temperature is automatically controlled.



FX

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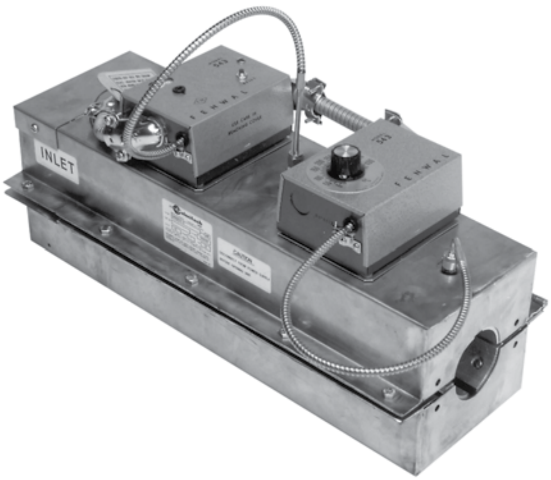
Custom Engineered Products

Electric heating technology can be applied to most applications where heat is required. Our corporate design experience began in 1920 and our body of knowledge has continued to build up since then.

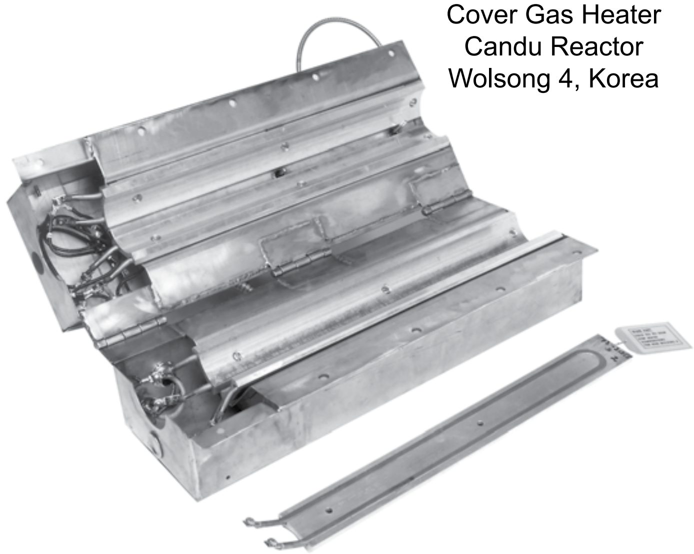
We have many thousands of custom designs on file from which our heating expertise has evolved.

Custom engineered equipment is expected to work the first time and we can guarantee performance.

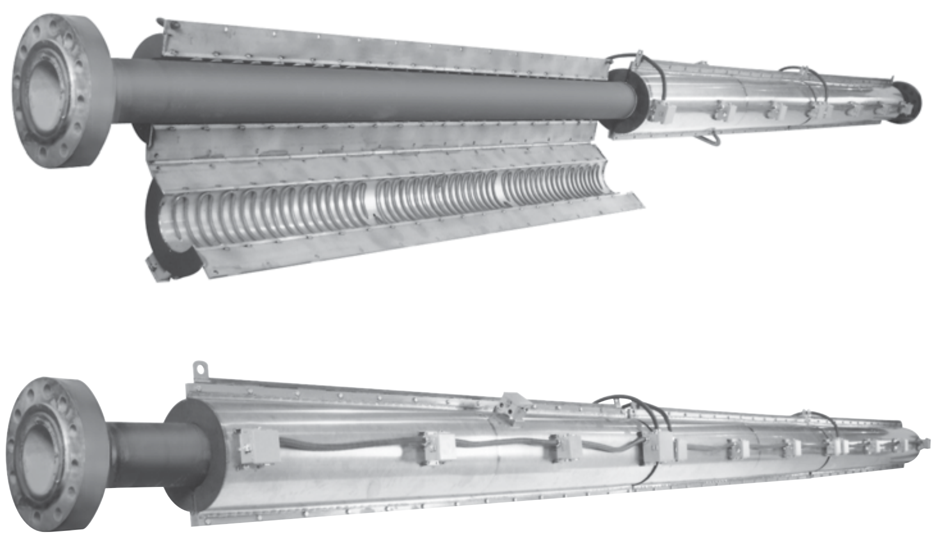
Almost all of the work is done in house; frames, vessels, control panels, heating elements, and CNC machining. Most important of all is the initial equipment design; our “design team” approach using experts in electrical, mechanical, chemical, mining, and metallurgical engineering, all graduate engineers, can be counted on to find the most reliable and effective method to get the job done.



Cover Gas Heater
Candu Reactor
Wolsong 4, Korea

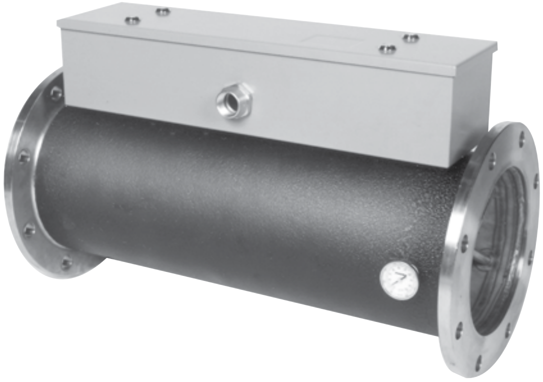


High Pressure Gas Preheater
480V 3Ø 58 kW

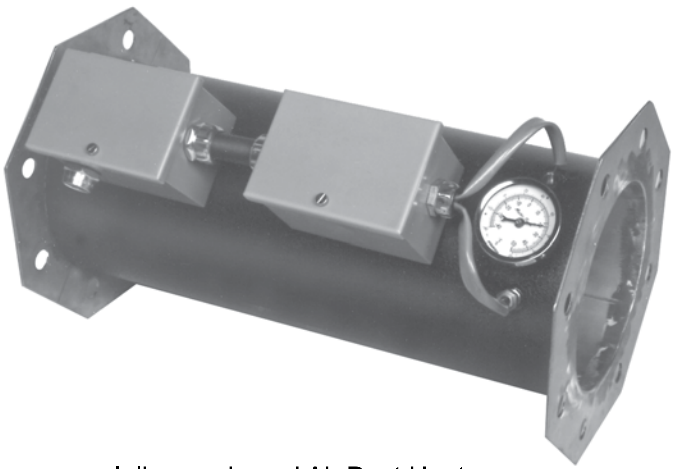


Custom Duct Heater
All Stainless Construction
2000 CFM
70°F (21°C)

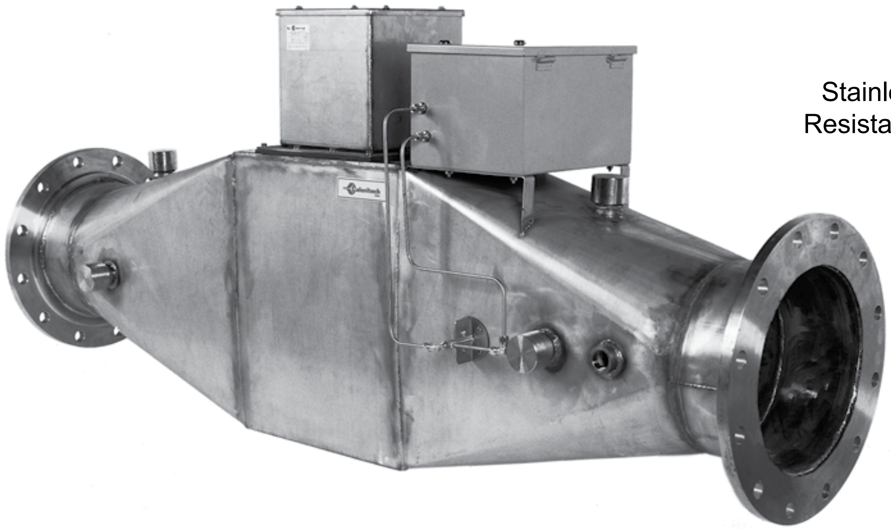
Mine Vent Duct Heater
600V 3Ø 320 kW
21500 SCFM
9’ x 5’



Inline Dehumidification
Duct Heater
Nuclear Quality Control
480V 3Ø 15 kW

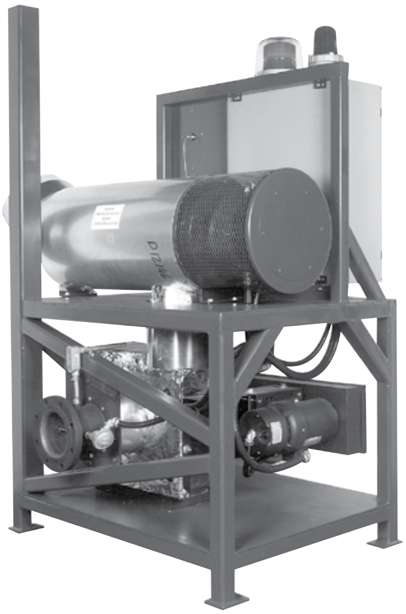


Inline packaged Air Duct Heater
Complete With Controls and
Temperature Gauge
480V 3Ø 6.5 kW 80°F (27°C)



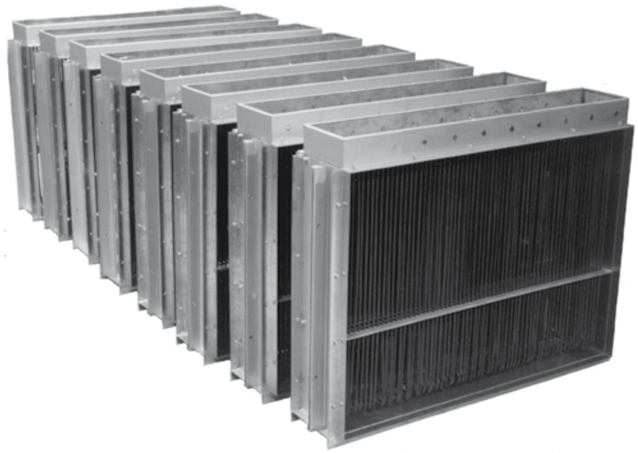
Stainless Steel Duct Heater Weather Resistant/Air Tight Construction Integral Control Package

Crucible Preheater
600V 22 kW
400 SCFM 482°F (250°C) Outlet

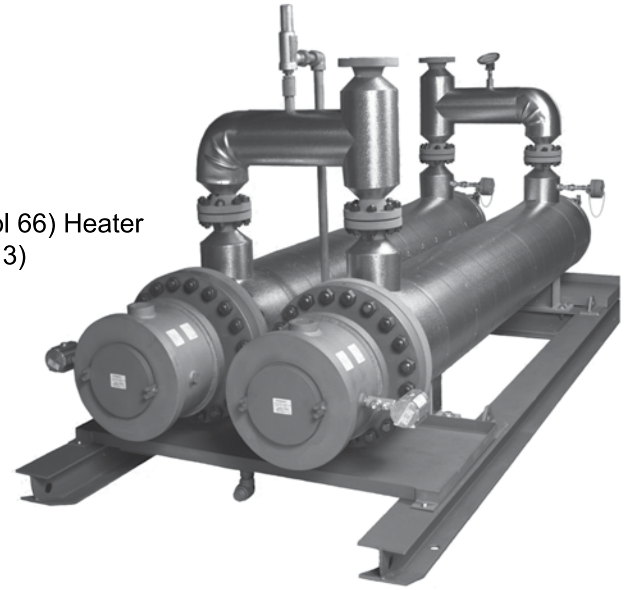


Portable Blower Heater
15kW 440V 3Ø 50HZ

120 kW Stainless Steel High Temperature Duct Heaters

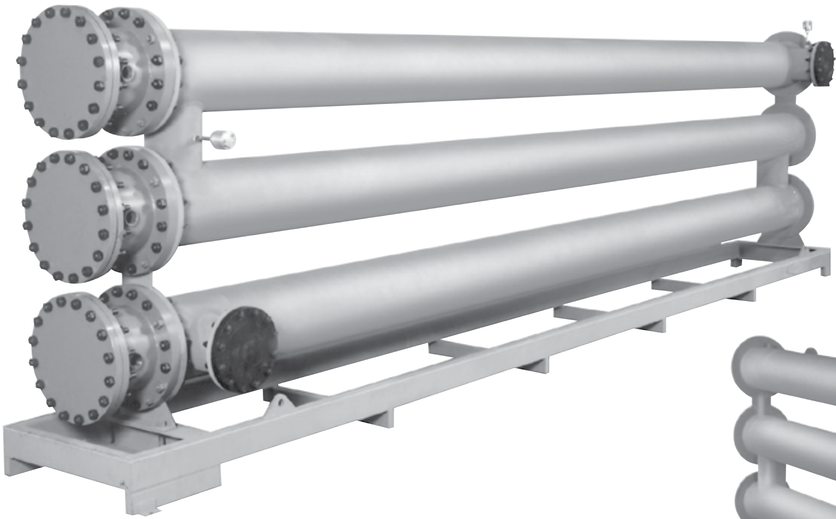


375 kW Duct Heaters For Generating Station

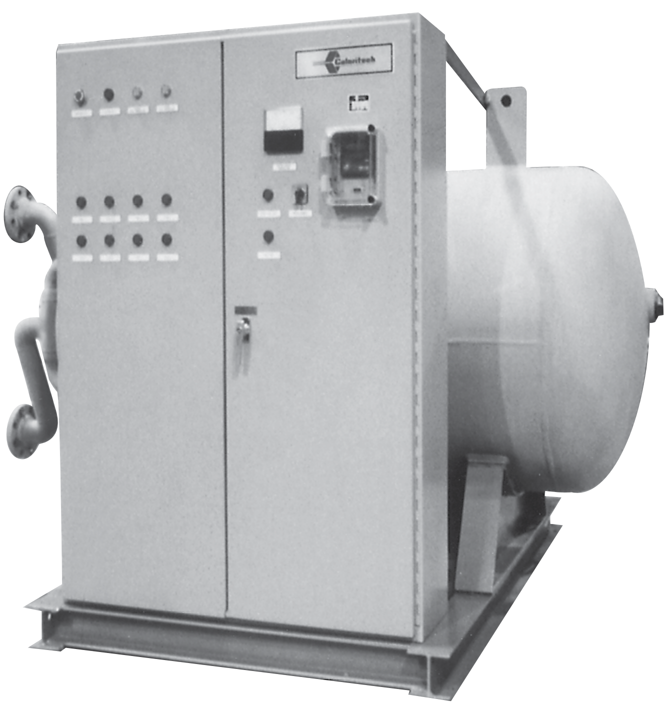


420 kw Hot Oil (Therminol 66) Heater Assembly (1 of 3)

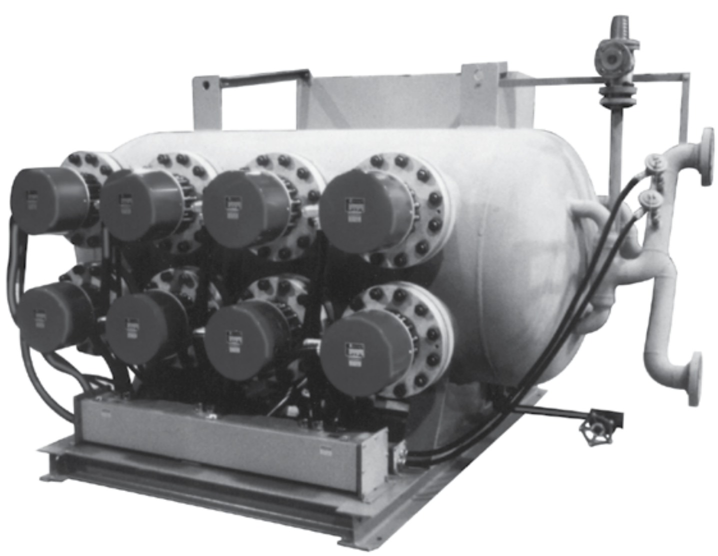
1250°F (677°C) Portable Superheater



Heavy Oil Pipe Well Heater
480V 3Ø 600 kW



Steam Superheater
600V 324 kW 150 PSIG
Operating Temperature 750°F (399°C)



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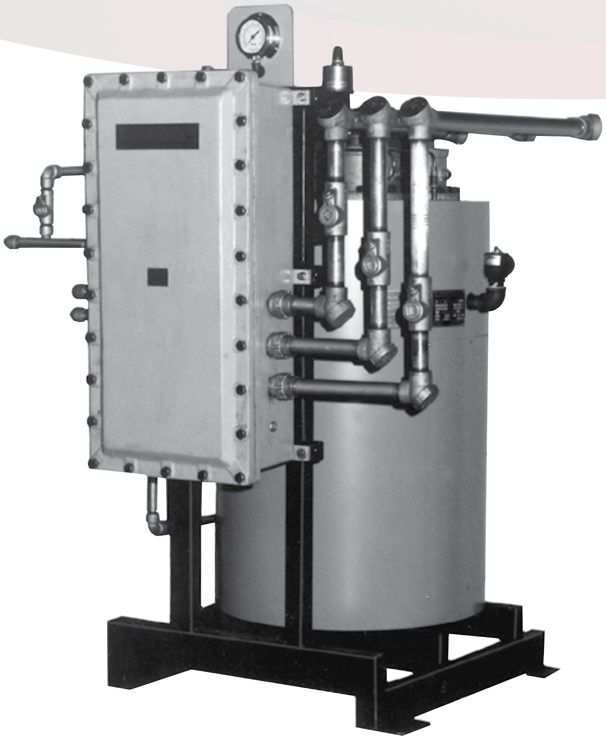
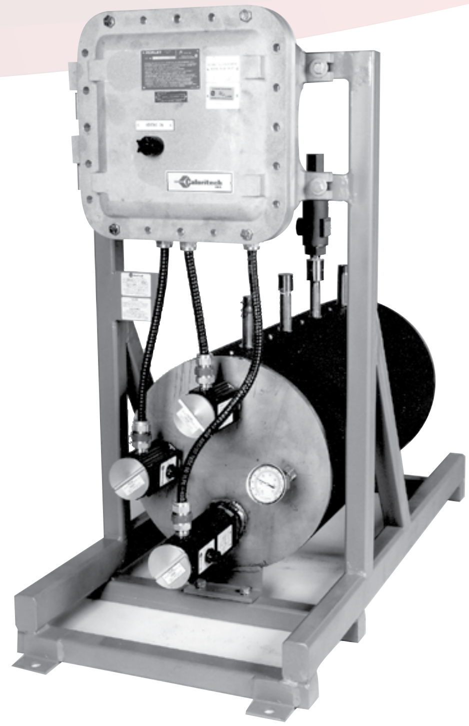
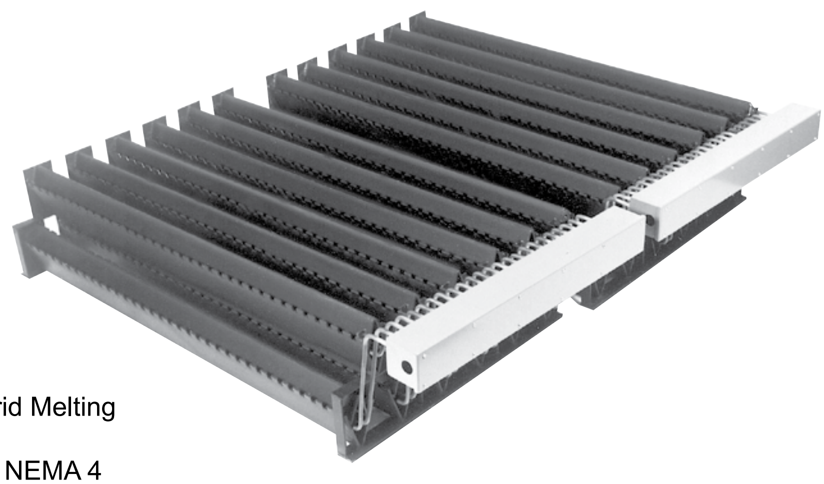


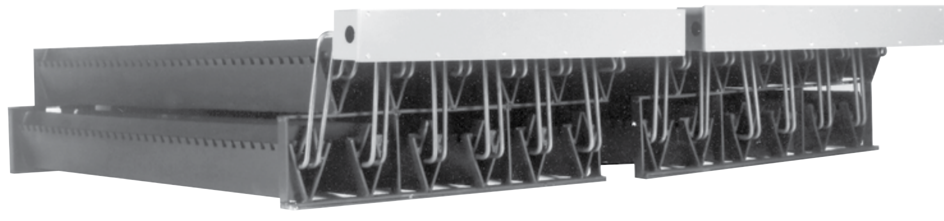
VSB-24-225X 600V 3PH 225kW
Steam Boiler
Explosion-Proof
Class I, Div 1, Group D



“Domestic” Water Heater For Hazardous
Locations
600V 6000W



Coal Tar Enamel Grid Melting
System
4-30 kW Modules, NEMA 4



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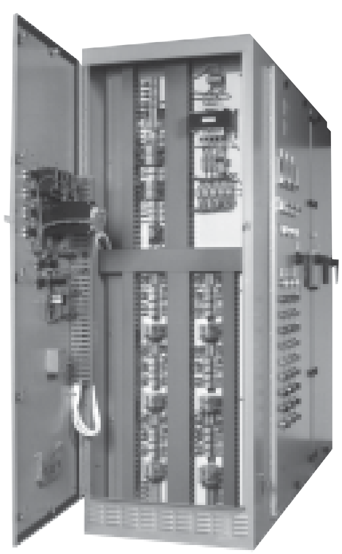
Electric Heating Control Panels

Caloritech™ control panels are designed for automatic control of electric heaters utilizing proven concepts and procedures developed from our experience with thousands of installations.

Our panels feature conservative designs with switching devices, fusing and internal wiring derated from the manufacturer's specified maximum allowable currents.

Approved panels are available up to 4000 Amps and 600V. We provide the design drawings, bills of material, replacement parts, operating instructions and component manuals.

The most basic model is the CPP-CPB which can accept remote mounted controls and make the balance of your wiring neat, reliable and cost effective. Complete standard packages with contactor power switching (CPA) or staged contactor (CPS) or solid state switching (CPE) allow your to select the degree of sophistication required to meet process and budget requirements.



Control panels can be built to meet various environmental requirements including dust, oil, water corrosive or hazardous materials.

Other optional features might include remote setpoint, proportioning, process variable retransmission, alarms, remote annunciation, dual energy and peak load controls, current/voltage/wattage metering and interfacing PLC's.

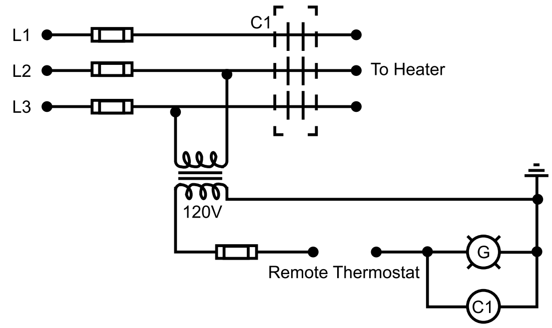
Type CPP Control Panels

The Caloritech™ Power Pack consists of a prewired contactor, transformer, pilot light and fuses in a Type 4 enclosure for a quick and convenient installation. Control circuits are 120 VAC.

Panels can be build to meet weather resistant or hazardous location specifications. Check factory for details.

To Order Specify

Catalog number and special features



Type CPP Control Panels

Enclosure size 12" x 10" x 5" (30 cm x 25 cm x 13 cm) deep

Primary Voltage	Fused Rating (Amps)	Load Rating (Amps)	Catalog Number
600V	30	24	CPP308
480V	30	24	CPP307
600V	50	40	CPP508
480V	50	40	CPP507
600V	60	48	CPP608
480V	60	48	CPP607

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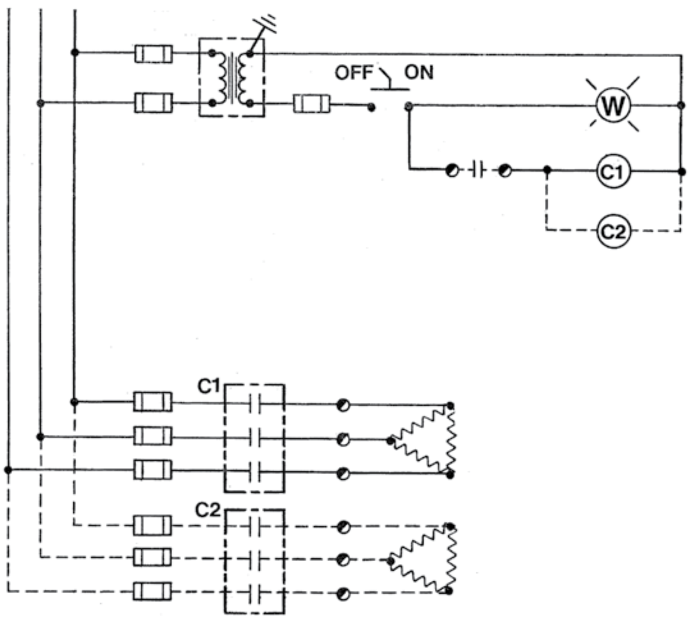
CPB & CPA Control Panels

Type CPB Control Panels

Type CPB panels are basic control units used to interface with electric heaters having remotely located thermostats, limit controls, percentage timers, or other control components. This series of panels does not include a disconnect switch but does include the following:

- Type 4 weather resistant enclosure with hinged door
- Fused magnetic contactor(s)
- On-off switch and pilot light
- Fused control circuit transformer with 120V secondary control voltage
- Terminal blocks for connection of externally located control devices



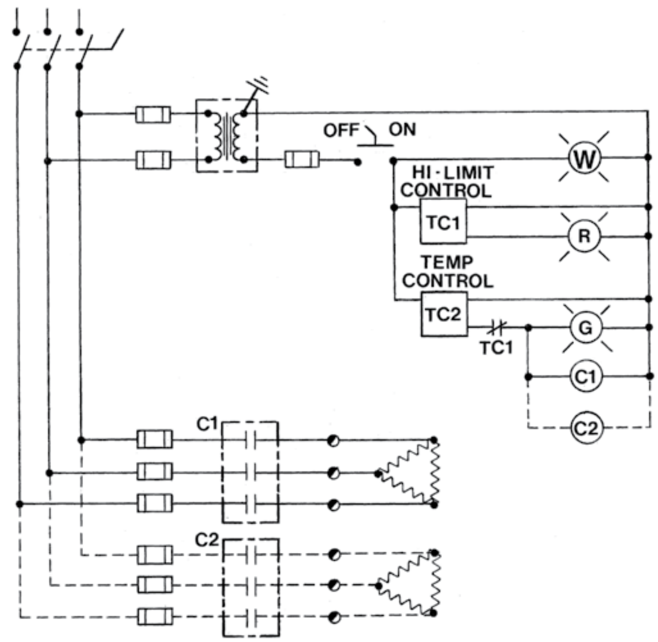
Type CPB Control Panels (Type 4 Enclosures) 208V, 240V, 480V, 600V, (1 or 3 Phase)

Fused Rating (Amps)	Max. Load (Amps)	No. of Circuits	Amps Per Circuit	Panel Size		Catalog Number
				in	cm	
30	24	1	24	16x12x6	41x30x15	CPB30
40	32	1	32	16x12x6	41x30x15	CPB40
50	40	1	40	16x12x6	41x30x15	CPB50
60	48	1	48	16x12x6	41x30x15	CPB60
80	64	2	32	20x16x6	51x41x15	CPB80
100	80	2	40	20x16x6	51x41x15	CPB100
150	120	3	40	24x20x6	61x51x15	CPB150
200	160	4	40	24x20x6	61x51x15	CPB200

Type CPA Controls

Type CPA fully packaged control panels are suitable for use in a variety of electric heater installations. The CPA series includes:

- Type 4 weather resistant enclosures with hinged doors
- Disconnect switch with door interlock
- Fused control circuit transformer with 120V secondary control voltage
- On-off switch
- Fused magnetic definite purpose contactor(s)
- Digital indicating configurable microprocessor based temperature control (Series UT320)
- Electronic high limit, manual or auto reset
- Pilot lights for “system on”, “heat on”, “high limit”



Type CPA Control Panels (Type 4 Enclosures) 208V, 240V, 480V, 600V, (1 or 3 Phase)

Disconnect Size (Amps)	Max. Load (Amps)	No. of Circuits	Amps Per Circuit	Panel Size		Catalog Number
				in	cm	
30	24	1	24	24x20x8	61x51x20	CPA30
60	48	1	48	24x20x8	61x51x20	CPA60
100	80	2	40	24x20x8	61x51x20	CPA100
200	160	4	40	36x24x8	91x61x20	CPA200

To Order Specify

Panel catalog number, voltage, phase, temperature range, type of sensor, optional high limits if required and any other special features.

CPS Control Panels (Contactor Stages)

The CPP, CPB and CPA panels on the previous pages switch all of the load(s) ON in one or optionally two stages as controlled from the main temperature control. If a greater amount of staging is required, the CPS panel is ideal. This series includes a modulating temperature control driving a step control which in turn brings on a number of contactor stages. Time delay between steps is adjustable to match the system dynamics.

CCI Thermal normally sizes stages between 35 to 40 Amps for best control and to optimize contactor and wire sizes.

The standard process control is the UT350 series. This control is configured to a 4-20 mA proportioning output to drive the step control. Other controls are available as options.

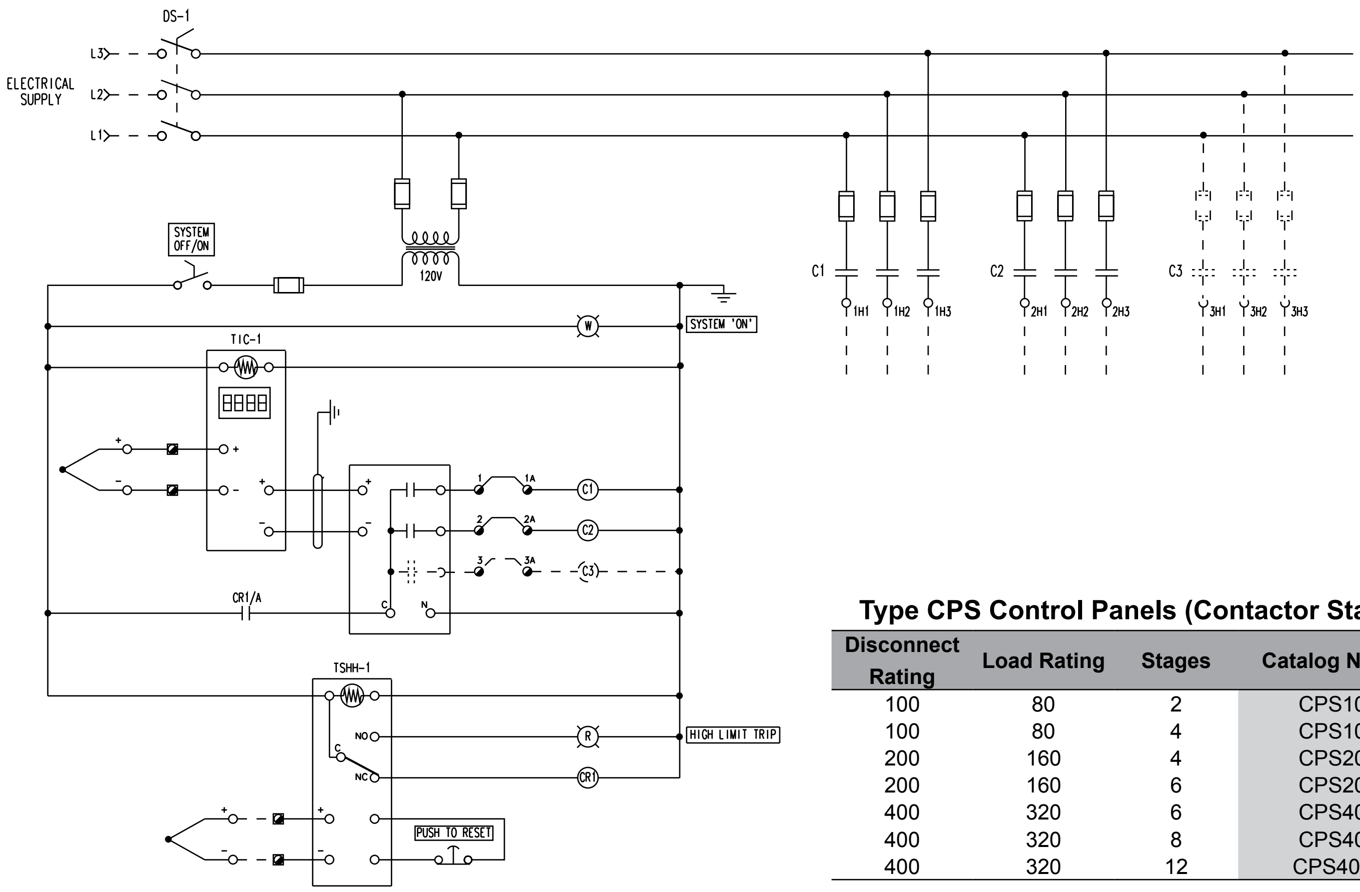
The high limit is a 543 manual reset, with K thermocouple for -4°F to 2012°F (-20°C to 1100°C).

CPS Features

- Type 12 dust tight enclosure
- Type 4 weather resistant encl. optional
- Door interlocked disconnect
- 2 to 12 fused contactors
- Fused control circuit transformer
- On/Off selector switch & pilot light
- Pilot lights for each stage
- High limit trip pilot light
- UT350-00 digital indicating control, field or factory configurable
- 54-302121-206 manual reset limit

To Order Specify

Panel catalog number, voltage, phase, number of stages, optional features and 921 configuration.



Type CPS Control Panels (Contactor Stages)

Disconnect Rating	Load Rating	Stages	Catalog Number
100	80	2	CPS1002
100	80	4	CPS1004
200	160	4	CPS2004
200	160	6	CPS2006
400	320	6	CPS4006
400	320	8	CPS4008
400	320	12	CPS40012

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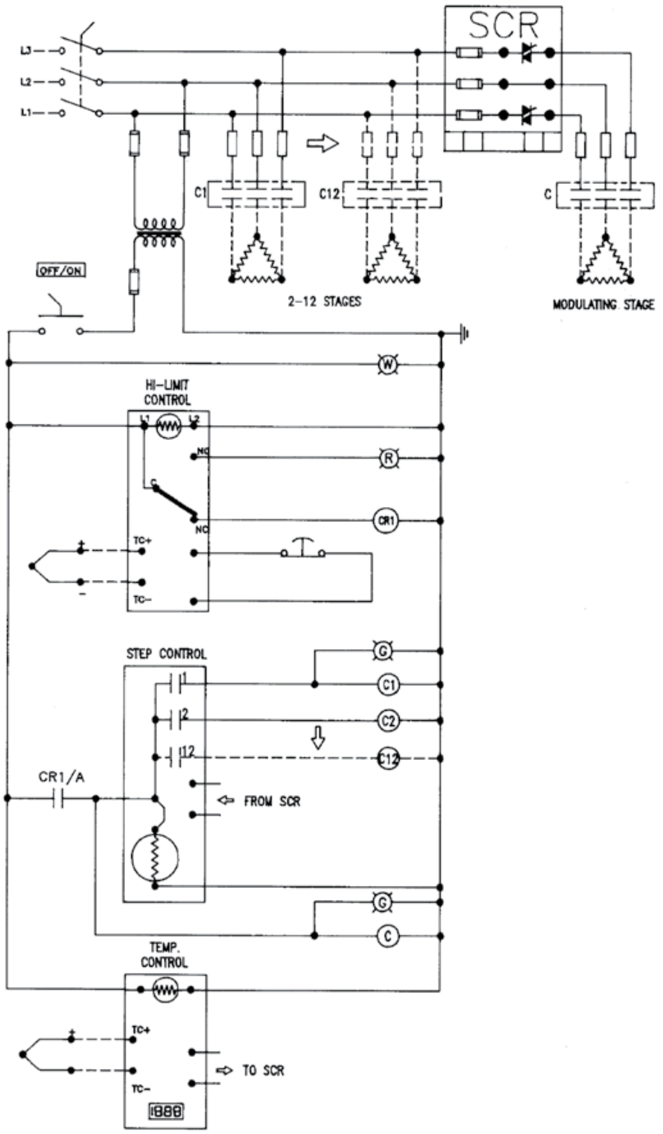
CPSS Control Panels (Base Load - SCR)

The CPSS control panel uses a combination of contactor stages controlled by a step control and an SCR solid state power control for fine tuning. Typically the SCR stage switches 20% to 30% of the total load with contactors making up the balance.

Standard features are shown below but other components and features are available to meet specific process requirements.



The control package automatically determines when extra base load contactor steps need to be brought in or dropped out. Many adjustments such as proportioning band, zero and span, and time delay between stages are field adjustable to fine tune to the process.

Features

- Type 12 dust tight enclosure
- Type 4 weather resistant encl. optional
- Door interlocked disconnect switch
- Fused contactors
- Fused control circuit transformer
- On/Off selector switch & pilot light
- I^2t fused SCR
- High limit trip pilot light
- Heating stages pilot light
- UT350-00 Process Control
- 54-302121-206 manual reset limit

To Order Specify

Panel catalog number, voltage, phase, optional features or modifications, types of scans and control configuration.

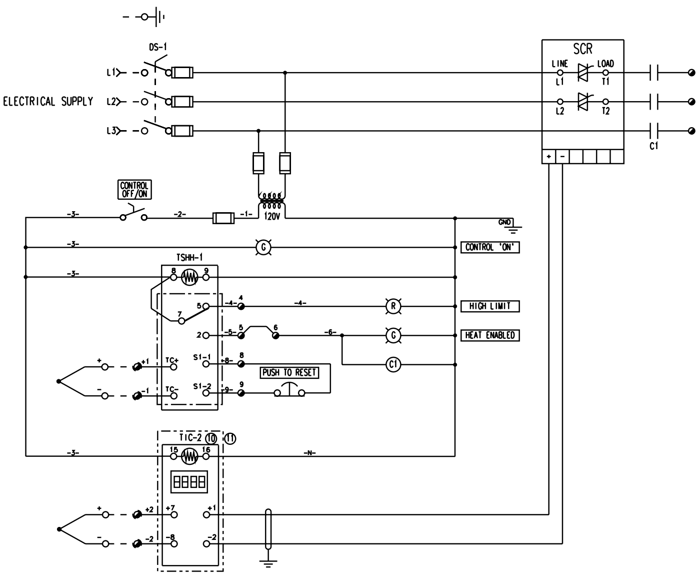
Type CPSS Control Panel (Baseload & SCR)

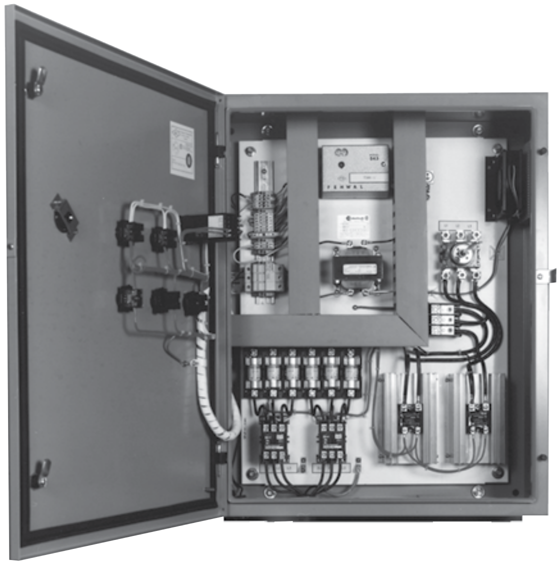
Disconnect Rating	Maximum Stages & Amps Base Loads	SCR Rating	Catalog Number
175A	4X30A	60A	CPSS1704 60
400A	6X50A	90A	CPSS4006 90
600A	8X60A	120A	CPSS6008 12
800A	10X60A	180A	CPSS8010 18
800A	12X50A	180A	CPSS8012 18

CPE Control Panels

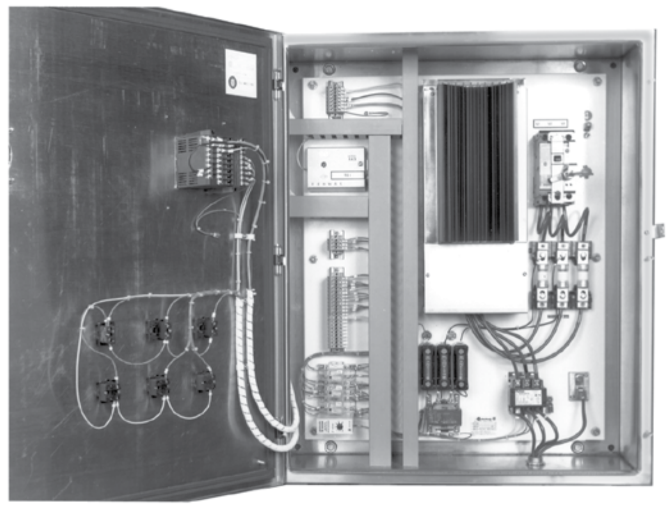
The CPE Control panel features full SCR control. Multiple backup contactors are used to protect and facilitate wiring to the process heater.

Where necessary, the Type 12 enclosures include fans and vents to keep ambient temperatures to a safe level. For type 4 or weather resistant applications check factory.





Standard features are show below but components and features are available to meet specific process requirements.



Features

- Type 12 dust tight enclosure
- I^2t fused SCR
- High limit trip pilot light
- UT350-00 process control
- 54-302121-206 manual reset limit

To Order Specify

Panel catalog number, voltage, phase, optional features or modifications, types of scans and control configuration.

Type CPE Control Panel

Disconnect Rating	Backup Contactors	SCR	Catalog Number
30A	1X30A	25A	CPE030
80A	2X30A	70A	CPE080
100A	2X50A	90A	CPE100
175A	3X50A	120A	CPE175
200A	4X50A	180A	CPE200
400A	8X50A	350A	CPE400
600A	10X60A	500A	CPE600
800A	14X60A	650A	CPE800

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CPG Control Panels Ground Fault Protection

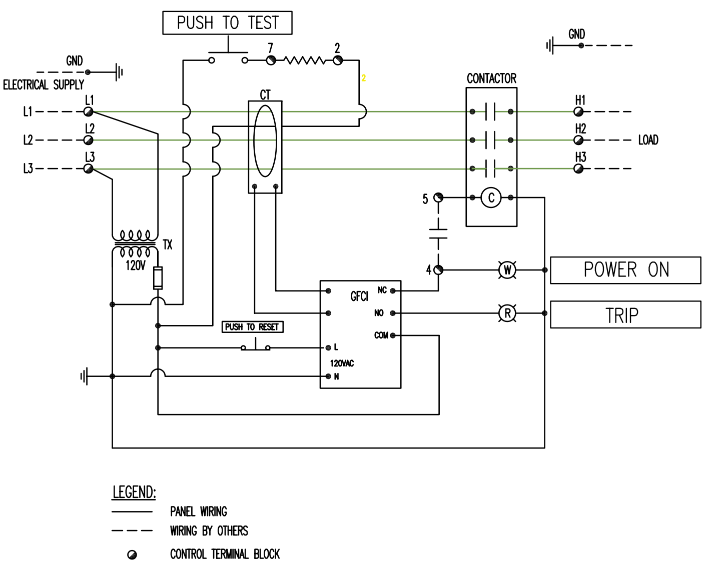
The CPG series control panels are specifically designed to provide ground fault protection of permanently installed commercial and industrial heating equipment such as infrared radiant heaters. The CPG control panel is designed to protect the heating equipment from damage due to excessive leakage currents. It is not suitable to provide shock protection.

A factory wired ground fault sensor continually monitors the circuit for harmful leakage currents and opens the circuit when a threshold value has been reached. The wide 10mA to 100mA adjustable setpoint of the ground fault sensor provides protection of single or multiple heaters.

The CPG control panel is to be used in conjunction with other devices providing main circuit isolation, overcurrent or short circuit protection

Features

- Type 4 weather resistant enclosure
- Fused control circuit
- Adjustable 10mA fault trip level
- Suitable for single or multiple heater connection
- Pilot lights for power on and trip indication
- Push to test button
- Push to reset button to clear fault trip
- Terminal block for connection of supply, load and remote switch relay
- Custom designed units are available to meet specific requirements



Typical Schematic Diagram

To Order Specify

Panel catalog number, voltage, phase, load and optional features required.

Type CPG Control Panels
208V, 240V, 480V, 600V (1 or 3 Phase)

Supply Voltage	Phase	Max. Load (Amps)	Panel Size		Catalog Number
			in	cm	
120	1	20	12x12x6	30x30x15	CPG2011
240	1	20	12x12x6	30x30x15	CPG2031
240	1	40	12x12x6	30x30x15	CPG4031
208	3	40	12x12x6	30x30x15	CPG4023
240	3	40	12x12x6	30x30x15	CPG4033
480	3	40	12x12x6	30x30x15	CPG4073
600	3	40	12x12x6	30x30x15	CPG4083

Optional Control Equipment

The panel configurations shown on the previous pages are some of the most popular variations CCI Thermal has built. However, many specifications or process requirements dictate that we custom build a panel to suit. Caloritech™ panels are built under our ISO:9001 quality program.
All panels are fully tested and meet required electrical approvals. Panels may include drawings, bills of material, and depending on the customer requirements, may include specific operating manuals, replacement parts lists, startup assistance, etc. Some available options are listed below:

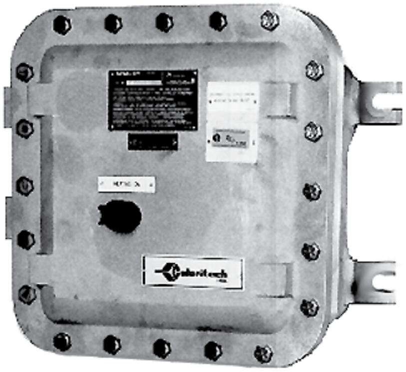
- Weather resistant enclosures
- Hazardous locations enclosures
- NEMA 4X or equivalent
- Breakers instead of disconnects or fuses
- Audible alarms or annunciation
- Input signals from transmitter, level or flow controls
- RTD sensors, different calibration thermocouples
- Retransmitted process variables
- Communications
- Remote set point
- Interface to PLC's
- Remote interlocks
- Time clocks
- Current, voltage, amperage, watt hour metering

Hazardous Location Panels

With the ***x-max***® line of enclosures (utilizing the unique "track and trolley" system), CCI Thermal can build economical control systems suitable for all hazardous locations.

The available models include basic push button stations, transformers, contactors, solid state relays and even windows for viewing digital displays.

For larger systems, other approved enclosures are available.



Although many process components must be located in the hazardous area, control components can often be located outside this area. It is good engineering design to do so when feasible.

However, when the need arises CCI Thermal has the experience and the capabilities to build safe, functional and cost effective systems for any location.

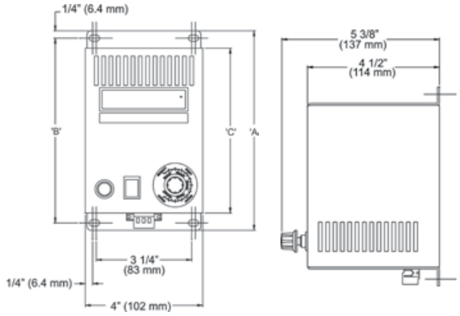
Click Here for Quote!

Fan Forced Enclosure Heater - PH

Application

Caloritech™ PH fan-forced enclosure heaters are designed to control the environment within enclosures by maintaining a stable temperature.

Effects of low temperatures such as corrosion, freezing or condensation will adversely affect the components inside control panels. The Caloritech™ PH enclosure heater will provide an optimal performance environment for the critical components contained within the control panel.



Catalog No.	Dimensions					
	A		B		C	
	in	mm	in	mm	in	mm
PH125/PH200	5.500	140	5.000	127	4.125	105
PH400/PH800	7.500	191	7.000	178	6.188	157

Features

- $_{C}$CSA$_{US}$ approved
- $_{C}$UL$_{US}$ certified
- light weight unit
- low maintenance
- aluminum alloy outer casing
- externally adjustable thermostat 0°F to 100°F (-18°C to 38°C)
- pilot light for “heat-on” indication
- high temperature safety protection
- fan on/auto switch to prolong motor life
- terminal strip provides quick installation and accepts both stranded and solid wire
- optional DIN rail mounts available

Selection

The wattage requirement is determined from a consideration of the surface area, insulation properties of the enclosure or space and the temperature difference between the ambient and the enclosure. For small enclosures (less than 100 ft² (9.3 m²) surface area) conservative values for heat loss areas shown in Table 1.

TABLE 1 - Temperature Difference

	Indoors	Outdoors
Uninsulated	5	7
Insulated (Min. 1”)	1	1.2
Watts/m² Per 5.5C°	**Indoors**	**Outdoors**
Uninsulated	54	75
Insulated (Min. 2.5 cm)	11	13

Example: To find wattage requirements in an uninsulated enclosure 2’ x 3’ x 1’ (0.61 m x 0.91 m x 0.3 m), which must be held at 40°F (4°C) in a 10°F (-12°C) outdoor ambient. Internal electrical components use 80 watts.

Surface Area (ft²) = 2[(2’ x 3’) + (2’ x 1’) + (3’ x 1’)] = 22 ft²
Surface Area (m²) = 2[(0.61m x 0.92m)+(0.61m x 0.3m)+(0.92m x 0.3m)
= 2.0404 m²

Heat Loss: From Table 1, an uninsulated outdoor enclosure requires 7 watts for each 10F° temperature difference (75 watts for each 5.5C° temperature difference).

Temperature Difference (F°) = 40°F – 10°F = 30F°
Temperature Difference (C°) = 4.4°C – -12.2°C = 16.6C°

Wattage Required = (30F° ÷ 10F°) x 7 x 22 ft² = 462 watts
or
Wattage Required = (16.6C° ÷ 5.5C°) x 75 x 2.0404 m² = 462 watts

Heater Wattage = Wattage required less component wattage or 462 - 80 = 382 watts

Use one PH400 rated at 400 watts. For enclosures requiring more than 800 watts, two or more PH heaters may be used.

Installation

The Caloritech™ PH fan-forced enclosure heater should be installed in the centre of the cabinet and as low as practicable for the best possible heat dissipation. The optimum efficiency is obtained when the unit is mounted in a vertical position allowing the top air vents to release the heated air in the most effective manner. The control panels should be sealed and free from dust and dirt. Do not install the heaters on wood, cardboard or other flammable panels. Heat sensitive components should not be placed near the heat discharge area. For larger enclosures, two or more heaters may be used.

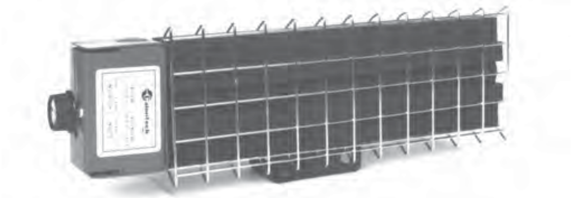
TABLE 2 - Type PH Fan-Forced Enclosure Heater

Catalog Number	Watts	Voltage	Hertz	Phase	Weight	
					lbs	kg
PH12511	125	120	60	1	2.2	1.0
PH12531	125	240	60	1	2.2	1.0
	105	220	50	1	2.2	1.0
PH20011	200	120	60	1	2.2	1.0
PH20031	200	240	60	1	2.2	1.0
	168	220	50	1	2.2	1.0
PH40011	400	120	60	1	3.0	1.4
PH40031	400	240	60	1	3.0	1.4
	336	220	50	1	3.0	1.4
PH80011	800	120	60	1	3.0	1.4
PH80031	800	240	60	1	3.0	1.4
	672	220	50	1	3.0	1.4

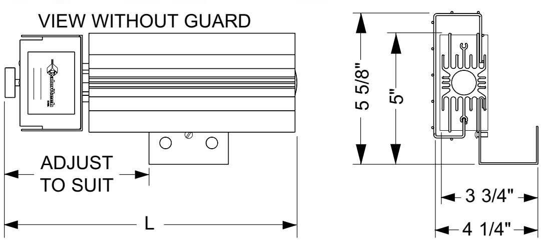
Control Panel & Pump House Heater - PXFT

Application

Caloritech™ PXFT heaters are designed to maintain a stable temperature inside control enclosures, pump houses or similar spaces. The standard units are not suitable for use outdoors, unprotected from the weather. All heaters have a built-in thermostat. The heater is also available without a thermostat on special order.



GUARD OPTIONAL ON SOME UNITS



Features

The PXFT heater uses a high surface area aluminum heat emitter to eliminate the need for a fan while providing low radiation and high convection heating to the enclosure. The thermostat rating is 25A at 240V, Single Pole, Single Throw, adjustable from 30°F to 120°F (0°C to 50°C). A movable bracket allows the heater to be floor or wall mounted with the terminal box located on the left or right side, top or bottom. Wire guards are provided standard with the PXFT-300,400 and 600 watt heaters, and are available as an option on the PXFT-050,125 and 200 watt units. Moisture resistant heaters (shown below) are available on special order.

Selection

The wattage requirement is determined from a consideration of the surface area, insulation properties of the enclosure or space and the temperature difference between the ambient and the enclosure. For small enclosures (less than 100 ft^2 (9.3 m^2) surface area) conservative values for heat losses are as shown in TABLE 1.

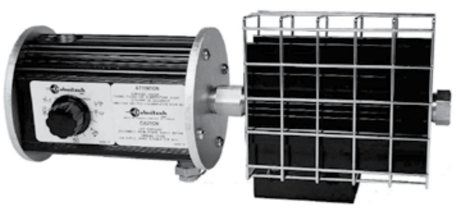


TABLE 1 - Temperature Difference

Watts/ft^2 Per 10F°	Indoors	Outdoors
Uninsulated	5	7
Insulated (Min. 1")	1	1.2
Watts/m^2 Per 5.5C°	**Indoors**	**Outdoors**
Uninsulated	54	75
Insulated (Min. 2.5 cm)	11	13

Example: To find wattage requirements in an uninsulated enclosure 2' x 3' x 1/2' (0.61 m x 0.91 m x 0.15 m), which must be held at 40°F (4°C) in a 10°F (-12°C) outdoor ambient.

Surface Area (ft^2) = 2 [(2' x 3') + (2' x 1/2') + (3' x 1/2')] = 17 ft^2
Surface Area (m^2) =
2[(0.61 m x 0.92 m)+(0.61 m x 0.15 m)+(0.92 m x 0.15m) = 1.5814 m^2

Heat Loss: From Table 1, an uninsulated outdoor enclosure requires 7 watts for each 10F° temperature difference.(75 watts for each 5.5C° temperature difference).

Temperature Difference (F°) = 40°F to 10°F = 30F°
Temperature Difference (C°) = 4.4°C – -12.2°C = 16.6C°

Wattage Required = (30F° ÷ 10F°) x 7 x 17 = 357 watts
or
Wattage Required = (16.6C° ÷ 5.5C°) x 75 x 1.5814 m^2 = 357 watts

Use one PXFT400 rated at 400 watts. For enclosures requiring more than 600 watts, two or more PXFT heaters can be used. Higher wattage heaters are available. Check factory.

Installation

Caloritech™ PXFT heater is approved for horizontal or vertical mounting on the floor or lower wall of the enclosure. Heaters must be installed using the mounting bracket provided to ensure minimum spacing between the heater and the wall or floor. Try to maximize the spacing between the heater and temperature sensitive components. Surface temperatures of the 50 watt and 125 watt units are about 212°F (100°C) and 338°F (170°C) respectively. The other units listed operate around 410°F (210°C).

To Order Specify

Quantity, catalog number, voltage and special features.

TABLE 2 - Type PXFT - Control Panel and Pump House Heaters

Watts	Standard Voltages	Length 'L' in (mm)	Catalog Number*	New Wt. lbs (kg)
50	120	8.375 (213)	PXFT050	2.6 (1.1)
125	120	8 375 (213)	PXFT125	2.6 (1.1)
200	120	8.375 (213)	PXFT200	2.9 (1.3)
300	120, 240	15.000 (381)	PXFT300	3.5 (1.6)
400	120, 240	21.750 (553)	PXFT400	5.5 (2.5)
600	120, 240	28.500 (724)	PXFT600	7.5 (3.4)

Note:
*For units without thermostat, omit 'T' in catalog number
Inventory - These heaters are normally stocked in limited quantities

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Technical Data - Thermocouples

The most common problems associated with thermocouple sensing controls are:

1. Using the wrong type of thermocouple
   Each instrument is calibrated to work with a particular thermocouple type. Connecting a 'K' thermocouple to a 'J' instrument will result in severe overshoot and probable heater damage.
2. Reversing of lead wires
   Thermocouple leads are polarized. The red wire is always negative. Reversing leads will cause reverse reading at the instrument and loss of control.
3. Using the wrong extension wire
   The correct thermocouple extension wire must be used. For example: type J thermocouple extension wires must be used with J thermocouples. Copper wire cannot be used. A mixture of copper and thermocouple wire creates extra thermocouple junctions which will cause unpredictable reading errors.

Refer to the following charts for proper physical identification:

Thermocouple Identification

TABLE 1 - Thermocouple Identification

ANSI Type	Description	Colours POS+	Colours NEG-	Jacket
J	Iron Constantan	White	Red	Black
K	Chromel Alumel	Yellow	Red	Yellow
T	Copper Constantan	Blue	Red	Blue
E	Chromel Constantan	Purple	Red	Purple
R	Platinum Rhodium 13%	Black	Red	Green
S	Platinum Rhodium 10%	Black	Red	Green
N	Nicrosil NISIL	Orange	Red	Brown

Thermocouple Output
TABLE 2 - Millivolt vs. Temperature

Temp °F	Temp °C	J (iron constantan) Millivolts	K (chromel alumel) Millivolts
0	-18	-0.885	-
32	0	-0.000	0.000
100	38	1.942	1.520
212	100	5.268	4.095
300	149	7.947	6.092
500	260	14.108	10.560
700	371	20.253	15.178
1000	538	29.515	22.251
1250	677	37.688	28.146
1500	816	46.503	33.913
2000	1093	63.392	44.856

Thermocouple Extension Wire Resistance

Thermocouple wires have the resistance outlined in the following chart (Table 3). Resistances should be kept as low as possible. Increase the gauge of wire for long runs. Although modern instrumentation will accept an input impedence up to 100 ohms or more, the signal degrades and the instrument becomes more susceptible to external interference.

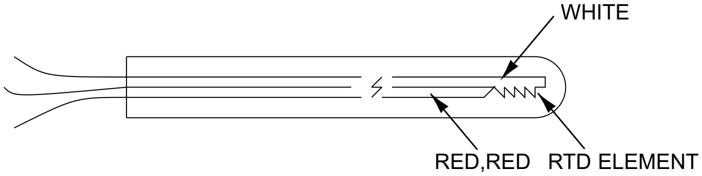
For long runs between sensing point and instrumentation of 50 meters (150 feet) or more, a transmitter should be considered.

TABLE 3 - Loop Resistance (2 Wires)

Calibration	Ohms per 33m (100') 8 GA	12 GA	14 GA	16 GA
JX Iron Constantan	2.15	5.42	8.63	13.71
KX Chromel Alumel	3.65	9.22	14.66	23.30
TX Copper Cosntantan	1.84	4.66	7.41	11.78
EX Chromel Constantan	4.36	11.01	17.51	27.83
Calibration	**Ohms per 33m (100') 18 GA**	**20 GA**	**22 GA**	**24 GA**
JX Iron Constantan	21.80	35.69	55.11	87.66
KX Chromel Alumel	37.07	58.97	93.68	149.00
TX Copper Constantan	18.74	29.82	46.91	75.34
EX Chromel Constantan	44.27	70.43	111.90	178.00

RTD's

RTD's are available in 2, 3 and 4 wire construction. The most common (as shown) is 3 wire. With instrumentation designed to accept 3 wire RTD's, the second red wire is used in a circuit to calculate lead wire resistance. This resistance is automatically deducted from the sensor reading to eliminate potential errors.



RTD Output

TABLE 4 - 100 Ω Platinum (.00385 Ω/Ω/°C)
Resistance vs Temperature

Temperature °F	Temperature °C	Ohms	Temperature °C	Temperature °F	Ohms
-40	-40	84.27	150	302	157.31
-4	-20	92.16	200	392	175.84
32	0	100.00	150	482	194.07
68	20	107.79	300	572	212.02
122	50	119.40	350	662	229.67
212	100	138.50	400	752	247.04

Technical Data - Electrical Circuits

Electrical Equations

Single phase relationships:

$$V = \sqrt{WR} = W/I = IR$$

$$RW/I^2 = V^2/W = V/I$$

$$I = V/R = W/V = \sqrt{W/R}$$

$$W = V^2/R = I^2R = VI$$

For current in electrically balanced three phase A.C. circuits:

$$I = \frac{W}{V(\sqrt{3})}$$

Note:
For circuits wired in 3 phase delta, wattage may be reduced to 1/3 by rewiring to a 3 phase wye connection.

Figure 1 - Three Phase Delta Connection

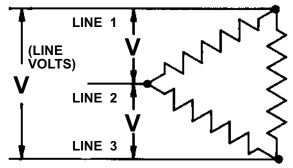


Figure 2 - Three Phase Wye or Star Connection

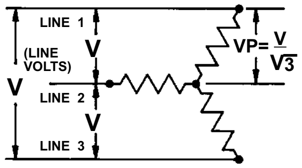


Figure 3 - Special Use of Two Pole Thermostat

Single phase circuit split with half of the current load across each thermostat contact.

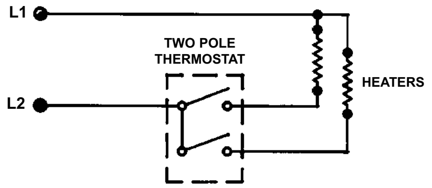


Figure 4 - Use of Contactor (Single Phase)

Single phase circuit for conditions where the line current exceeds the thermostat rating and a contactor is added.

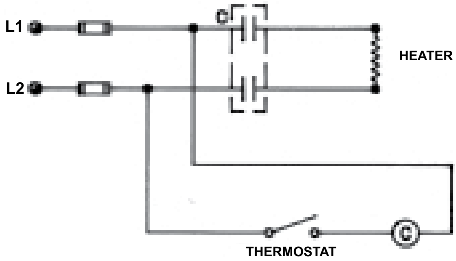


Figure 5 - Use of Contactor (Three Phase)

Three phase circuit for conditions where the line current exceeds the thermostat rating and a contactor is added.

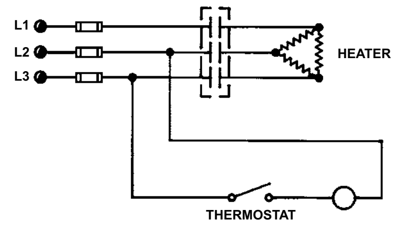


Figure 6 - Series to Parallel Delta Transformation

Special circuit with two thermostats and two contactors. When both contactors are closed, elements are wired in 3 phase parallel delta and circuit operates at full power. When only one of the contactors is closed, elements are wired in 3 phase series delta and the circuit operates at 1/4 power.

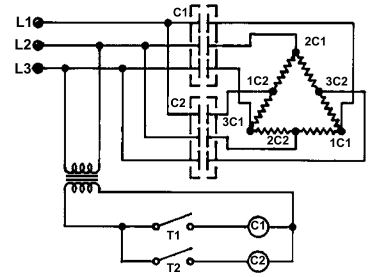
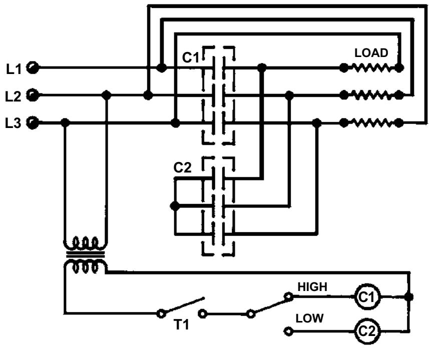


Figure 7 - Wye To Delta Transformation

Special circuit with two contactors, thermostat and two position switch.

When contactor 1 (C1) is closed, elements are wired in 3 phase delta and circuit operates at full power. When contactor 2 (C2) is closed, contactor 1 (C1) is opened, elements are wired in 3 phase wye and the circuit operates at 1/3 power.



CAUTION - CONTACTORS C1 AND C2 MUST BE MECHANICALLY INTERLOCKED IN THIS CONFIGURATION.

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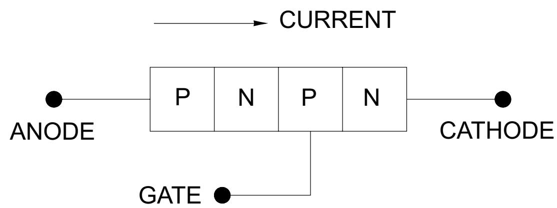
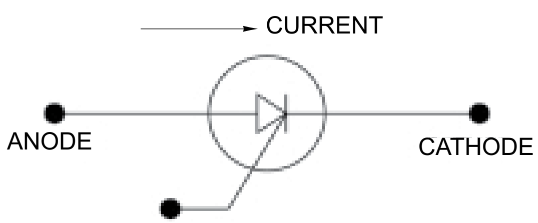
Technical Data - SCR's, Thyristors, Triacs & SSR's

An SCR (Silicon Controlled Rectifier) as a component is one commonly used type of **tyristor**. Essentially, it consists of four layers of silicon which, in their normal state, are non-conductive.

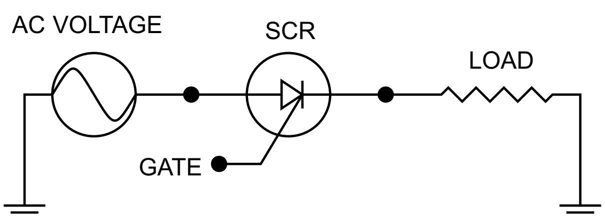
The SCR can be made to conduct by applying a very small current to its "gate". This feature allows a combination of SCR's to have broad application, one of which is the switching of resistive loads characteristic of electric heating. Diagrammatically, the SCR is represented as follows:



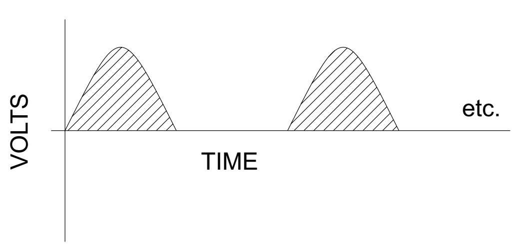
However, for electrical circuits, the SCR is depicted as follows:



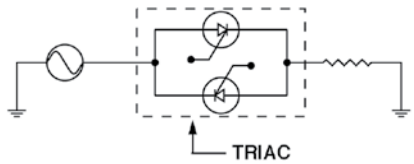
If we connect a supply voltage and load (resistance) to the above circuit the single SCR will act as a half wave rectifier, and at best, it will only allow the positive (+) part of the AC voltage to reach the load.



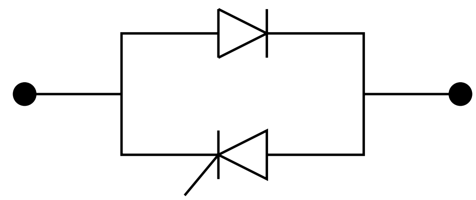
To allow the negative (-) part of the voltage waveform to get through to the load requires a second SCR of opposite polarity in parallel with the first.



For example, the circuit below allow the full waveform or a part of it to reach the load. Two SCR's combined in this fashion make up a **triac**. A triac is generally depicted as follows:



For single phase circuits, one triac will be sufficient to control the load. For three phase circuits, two triacs are normally used.



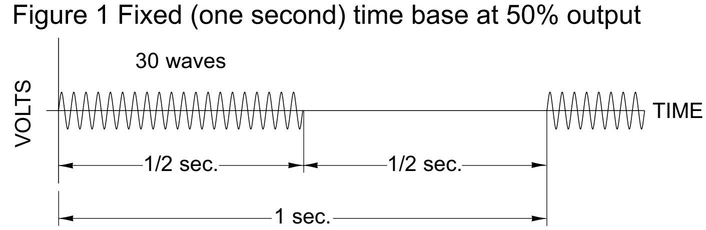
Controls are available which can apply a current to the gate at rapid intervals, blocking out some of the waveforms or a part of each waveform. The load output will then vary as a percentage of the blocked to the total cycles.

Two gate switching methods are in use to provide variable output from the load.

i) **Zero crossover fired** or **burst firing** where only full cycles of the voltage waveform are permitted to pass through the SCR to the load. Again, there are several variations as to how this can be done.

a)**Fixed time base** where the cycle interval is built into the controller at the factory and the power is switched through only one "on" and one "off" cycle during that time. For example, if the time base is 1 second, at 60 cycles per second, any sequential number of the 60 voltage waves could be allowed to pass through to the load. At 50% demand the first 30 waves would pass and the last 30 would be blocked.

Figure 1 Fixed (one second) time base at 50% output



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The SCR is equipped with circuitry (firing board) that will modify or proportion the “on” and “off” time during each subsequent cycle based on the amplitude of the temperature related signal it receives from an external controller.

Earlier SCR;s employed fixed time bases up to 90 seconds. However, typical controls now in use tend to have time bases set at ten seconds or less. Most Caloritech™ SCR’s have four second or one second fixed time bases.

SSR’s (solid state relays) employ a similar method of control except that the time base is set by an external controller which signals the SSR‘s built-in firing circuitry when it should fire (conduct).

b) **Variable time base** (also burst fired) where the time base depends on the demand. At 50% demand the time base would be 1/30 or a second or two cycles.

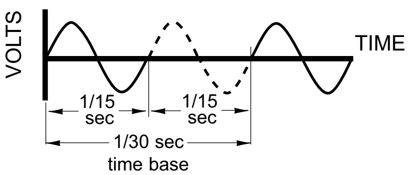


Figure 2 Variable time base at 50% output

at 75% demand the time base would be 1/15 of a second or four cycles, etc.

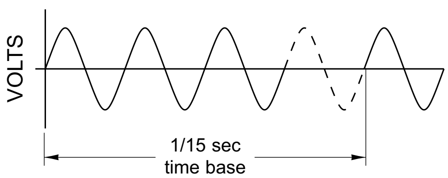
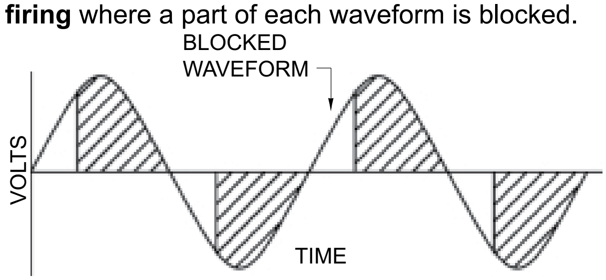


Figure 3 Variable time base at 75% output

Zero crossover firing is used to control resistive loads which change little with aging and temperature. Since the voltage is switched at zero amplitude, negligible radio frequency interference (RFI) is generated.

ii) A second method of gate switching is **phase angle firing** where a part of each waveform is blocked.



Phase angle firing is most frequently used on inductive loads with high inrush currents. If possible, it is best to avoid phase angle type SCR’s since RFI may be generated.

Fortunately, with Caloritech™ equipment we seldom have to resort to this type of control.

Advantages

SCR switching has as its main advantage the ability to switch loads at high speed. Properly employed, they can contribute to excellent system temperature control and prolong heater service life.

Protection

SCR’s can fail “ON” and it is vital to protect the device against short circuits at the load. Special I^2t semi-conductor fuses are utilized for this purpose. Back-up fused magnetic contactors are frequently employed as in Figure 4. These contactors can be de-energized by a limit device but in the normal state they remain the closed allowing the full load to be switched by the SCR.

With contactors, it si most economical to limit switching to 45 amps, and for this reason the load is usually divided into smaller circuits.

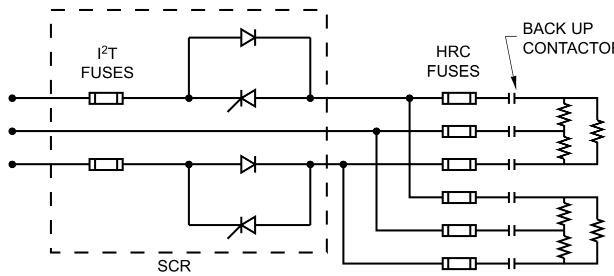


Figure 4 SCR with back-up contactors

Firing Boards

Packaged SCR’s incorporate a firing board which is essentially an electronic circuit that accepts various inputs from a temperature controller and converts these inputs into a corresponding gate signal.

Heat Sinks

All solid state switches have an internal resistance which is converted into heat when the SCR is in the conduction mode. High surface area aluminum heat sinks are used to transfer this heat away from the silicon wafer. For larger SCR’s, cooling fans are also required for this purpose.

SCR - As a Packaged Control

As a matter of convenience, current practice is to call the combination of component SCR’s, firing board, heat sink, fusing, fan, enclosure, interconnecting wire, etc. an SCR! It’s probably best to adopt this “control” meaning as opposed to the more limited (but more correct) “component” meaning.

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Power Requirement for Initial Heat-up

1. Heat absorbed by all materials:

$$\frac{\text{Weight of material (lb)} \times \text{Specific heat (Btu/lb-°F)} \times \text{Temperature difference (final - initial) (°F)}}{3412 \text{ (btu/kWh)}} = \_\_\_\_\_\_\_\_\_\_ \text{kWh}$$

Note: The above step must be repeated for each material heated. See Tables 1, 2, 3, and 4 on pages D38 and D39 for specific heats and weights.

2. Heat required for fusion or vaporization:

$$\frac{\text{Weight of material (lb)} \times \text{Heat of fusion or vaporization (Btu/lb-°F)}}{3412 \text{ (btu/kWh)}} = \_\_\_\_\_\_\_\_\_\_ \text{kWh}$$

Note: When the specific heat of a material changes at some temperature during the heat-up, due to melting (fusion) or evaporation (vaporization), perform Step 1 for the heat absorbed from the initial temperature up to the temperature at the point of change, add Step 2, then repeat Step 1 for heat absorbed from the point of change to the final operation temperature. See Tables 1, 2, 3, and 4 on pages D38 and D39 for heats of fusion and vaporization and temperatures at which these changes in state occur.

3. Heat required to replace average heat losses:

$$\frac{\text{Exposed surface area (sq. ft.)} \times \text{Heat loss at final operating temperature (W/sq.ft.)} \times \text{Time allowed for heat-up (hrs)}}{1000 \text{ (W/kW)}} \times \frac{1}{2}\left(\text{to obtain an average loss}\right) = \_\_\_\_\_\_\_\_\_\_ \text{kWh}$$

Note: See Figures 1 - 4 on pages D40 and D41 for normal heat losses

4. Heat to provide for contingencies, Safety Factor: 20% [Step 1 (kWh) + Step 2 (kWh) + Step 3 (kWh)] =__________kWh

Total Heat Requirement for Initial Heat-up: =__________kWh

Total Power Requirement for Initial Heat-up: $\frac{\text{Step 1 (kWh) + Step 2 (kWh) + Step 3 (kWh) + Step 4 (kWh)}}{\text{Time allowed for heat-up (hrs)}}$ =__________kWh

Power Requirement for Operating Heat

1. Heat absorbed by all materials added to the process:

$$\frac{\text{Weight of material (lb)} \times \text{Specific heat (Btu/lb-°F)} \times \text{Temperature difference (final - initial) (°F)}}{3412 \text{ (btu/kWh)}} = \_\_\_\_\_\_\_\_\_\_ \text{kWh}$$

Note: The above step must be repeated for each material heated. See Tables 1, 2, 3, and 4 on pages D38 and D39 for specific heats and weights.

2. Heat required for fusion or vaporization during process :

$$\frac{\text{Weight of material (lb)} \times \text{Heat of fusion or vaporization (Btu/lb-°F)}}{3412 \text{ (btu/kWh)}} = \_\_\_\_\_\_\_\_\_\_ \text{kWh}$$

Note: When the specific heat of a material changes at some temperature during the heat-up, due to melting (fusion) or evaporation (vaporization), perform Step 1 for the heat absorbed from the initial temperature up to the temperature at the point of change, add Step 2, then repeat Step 1 for heat absorbed from the point of change to the final operation temperature. See Tables 1, 2, 3, and 4 on pages D38 and D39 for heats of fusion and vaporization and temperatures at which these changes in state occur.

3. Heat required to replace average heat losses:

$$\frac{\text{Exposed surface area (sq. ft.)} \times \text{Heat loss at final operating temperature (W/sq.ft.)} \times \text{Working cycle time (hrs)}}{1000 \text{ (W/kW)}} \times \frac{1}{2}\left(\text{to obtain an average loss}\right) = \_\_\_\_\_\_\_\_\_\_ \text{kWh}$$

Note: See Figures 1 - 4 on pages D40 and D41 for normal heat losses

4. Heat to provide for contingencies, Safety Factor: 20% [Step 1 (kWh) + Step 2 (kWh) + Step 3 (kWh)] =__________kWh

Total Heat Requirement for Initial Heat-up: =__________kWh

Total Power Requirement for Initial Heat-up: $\frac{\text{Step 1 (kWh) + Step 2 (kWh) + Step 3 (kWh) + Step 4 (kWh)}}{\text{Time allowed for heat-up (hrs)}}$ =__________kWh

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Heating Liquids (Water)

An open steel tank, 2 ft. wide, 3 ft long, 2 ft deep and weighing 270 lbs, is filled with water to within 6 inches of the top. bottom and sides have 3 inches of insulation. Water is to be heated from 50°F to 150°F (10°C to 66°C) within 2 hours and, from then on, approximately 4 gallons per hour will be drawn off and replaced.

From Table 1 on page D42:
Specific Heat of Steel: 0.12 Btu/lb - °F

From Table 3 on Page D43:
Specific Heat of Water: 1.0 Btu/lb - °F

From Table 3 on page D43:
Weight of Water: 62.5 lb/cu. ft. (8.3 lb/gal)

Water in Tank:
(2 x 3 x 1.5) cu. ft. x 62.5 lb/cu. ft. = 563 lb

From Figure 3 on page D45:
Water surface loss at 150°F (66°C): 270 W/sq. ft.

From Figure 4 on page D45:
Insulated wall loss at 100°F (38°C) rise: 7 W/sq. ft.

Initial Heat-Up Requirement

1a. To heat water:
563 lb x 1.0 Btu/lb-°F x (150 - 50)°F / 3412 Btu/kWh = 16.5 kWh

1.b To heat tank:
270 lb x 0.12 Btuf/lb-°F x (150 - 50)°F / 3412 Btu/kWh = 0.95 kWh

2. Heat of fusion or vaporization: None

3a. Average water surface loss:
6 ft² x 270 W/ft² x 2 hrs. / 1000 W/kW x 2 = 1.62 kWh

3b. Average tank surface loss:
26 ft² x 7 W/ft² x 2 hrs. / 1000 W/kW x 2 = 0.18 kWh

4. Safety factor:
20% (16.5 + 0.95 + 1.62 + 0.18) = 3.85 kWh

Total Heat requirement = 23.10 kWh

Power required for Initial Heat-up:
23.10 kWh/2hrs. = 11.55 kW

Operating Requirement

1. To heat additional water:
4 gal/hr x 8.3 lb/gal x 1.0 Btuf/lb-°F x (150 - 50)°F / 3412 Btu/kWh = 0.97 kWh

2. Heat of fusion or vaporization: None

3a. Water surface loss:
6 ft² x 270 W/ft² / 1000 W/kW = 1.62 kWh

3b. Tank surface loss:
26 ft² x 7 W/ft² / 1000 W/kW = 0.18 kWh

4. Safety factor:
20% (16.5 + 0.95 + 1.62 + 0.18) = 0.55 kWh

Power Required for Operation = 3.32 kWh

Melting Solids (Paraffin)

An open top uninsulated steel tank, 1 1/2 ft wide, 2 ft long, 1 1/2 ft. deep, and weighing 140 lbs, contains 168 lb of paraffin to be heated from 70°F to 150°F (21°C to 66°C) in 2 hours. Steel drills, each weighing 0.157 lb. are to be placed in a 60 lb rack and dip coated in the melted paraffin. 150 drills can be processed per hour with 20 lb of paraffin.

From Table 1 on Page D42:
Specific Heat of Steel: 0.12 Btu/lb - °F

From Table 2 on page D42:
Specific heat of solid paraffin: 0.70 Btu/lb - °F

From Table 2 on page D42:
Melting Point of Paraffin: 133°F (56°C)

From Table 2 on Page D42:
Heat of Fusion of Paraffin: 63 Btu/lb

From Table 3 on Page D43:
Specific Heat of Melted Paraffin: 0.71 Btu/lb. - °F

From Figure 3 on Page D45:
Paraffin Surface Loss at 150°F (66°C): 70 W/ft.²

From Figures 1 & 2 on Page D44:
Steel Surface Loss at 150°F (66°C): 55 W/ft.²

Initial Heat-Up Requirement

1a. To heat tank:
140 lb x 0.12 Btu/lb-°F x (150 - 50)°F / 3412 Btu/kWh = 0.39 kWh

1.b To heat solid paraffin:
168 lb x 0.70 Btuf/lb-°F x (133 - 70)°F / 3412 Btu/kWh = 2.17 kWh

Fusion occurs at this point

1c. To heat melted paraffin:
168 lb x 0.71 Btuf/lb-°F x (150 - 133)°F / 3412 Btu/kWh = 0.59 kWh

2 Heat of fusion, to melt paraffin
168 lb x 63 Btuf/lb / 3412 Btu/kWh = 3.10 kWh

3a. Average paraffin surface loss:
6 ft² x 70 W/ft² x 2 hrs. / 1000 W/kWh x 2 = 0.21 kWh

3b. Average tank surface loss:
13.5 ft² x 55 W/ft² x 2 hrs. / 1000 W/kWh x 2 = 0.74 kWh

4. Safety factor:
20% (0.39 + 2.17 + 0.59 + 3.10 + 0.21 + 0.74) = 1.44 kWh

Total Heat requirement = 8.64 kWh

Power required for Initial Heat-up:
8.64 kWh/2hrs. = 4.32 kW

Operating Requirement

1a. To heat drills and rack:
(1500 x 0.157 + 60)lb/hr x 0.12 Btu/lb-°F x (150 - 50)°F / 3412 Btu/kWh = 0.83 kWh

1.b To heat additional solid paraffin:
20 lb x 0.70 Btuf/lb-°F x (133 - 70)°F / 3412 Btu/kWh = 0.26 kWh

Fusion occurs at this point

1c. To heat melted paraffin:
20 lb x 0.71 Btuf/lb-°F x (150 - 133)°F / 3412 Btu/kWh = 0.07 kWh

2 Heat of fusion, to melt additional paraffin
20 lb/hr x 63 Btuf/lb / 3412 Btu/kWh = 0.37 kWh

3a. Paraffin surface loss:
3 ft² x 70 W/ft² / 1000 W/kWh = 0.21 kWh

3b. Tank surface loss:
13.5 ft² x 55 W/ft² / 1000 W/kWh = 0.74 kWh

4. Safety factor:
20% (0.83 + 0.26 + 0.07 + 0.37 + 0.21 + 0.74)kW = 1.44 kWh

Power required for Operation: = 2.98 kWh

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Technical Data - Physical Constants

Properties of Metals

Material	Average Specific Heat Btu/(lb)(°F)	Latent Heat of Fusion Btu/lb	Density lbs/in³	Melting Point (Lowest) °F	Melting Point (Lowest) °C	Thermal Conductivity K (Btu)(in)/(hr)(sq. ft)(°F)	Thermal Expansion in/in/°F x10⁻⁶
Aluminum	.24	169	.098	1190	643	1540	13.1
Anitmony	.049	69	.239	1166	627	131	
Babbit - lead base	.039		.370	470	243	165.6	
Babbit - tin base	.071		.267	465	341	278.4	
Barium	.068		.130	1562	850		
Beryllium	.052		.066	2345	1285	1121.0	
Bismuth	.031	22.4	.353	520	271	59	
Boron	.309		.083	4172	2300		
Brass (80-20)	.091		.310	1700	927	82	
Brass (70-30)	.10		.304	1700	927	672	
Brass (yellow)	.096		.306	1710	932	830	11.2
Bronze (75/25)	.082	75	.313	1832	1000	180	
Cadmium	.055	23.8	.313	640	321	660	
Calcium	.149	140	.056	1564	851	912	
Carbon	.165		.080	6422	3550	173	
Chromium	.11		.260	2822	1550	484	
Cobalt	.099	115.2	.321	2696	1480	499	
Constantan	.098		.321				
Copper	.095	91.1	.322	1981	1083	2680	9.38
German Silver	.109		.311	1761	961	168	
Gold	.032	29.0	.698	1945	1063	2030	7.9
Incoloy®® 800	.13		.290	2500	1371	80	7.9
Incoloy®® 600	.126		.304	2500	1371	103	5.8
Incolol 600	.11		.304	2470	1354	109	5.8
Iron, Cast	.12		.260	2150	1177	346	6.0
Iron, wrought	.12		.278	2800	1538	432	
Lead, solid	.032	11.3	.410	620	327	240	16.4
Lead, liquid	.037		.387			108	
Linotype	.04		.363	480	249		
Lithium	.79	59	.212	367	186	516	
Magnesium	.27	160	.063	1202	650	1106	14
Manganese	.115	116	.268	2268	1242	80.6	
Mercury	.033	5.0	.488	-38	-39	60.8	
Molybdenum	.071	126	.369	4750	2621	980	2.94
Monel 400	.11		.319	240	1316	151	6.4
Nickel 200	.12	133	.321	2615	1435	520	5.8
Nichrome	.11		.302	2550	1399	104	7.3
Platinum	.035	49	.775	3225	1774	480	4.9
Potassium	.058	26.2	.434	146	63	720	
Rhodium	.059		.449	3570	1966	636	
Silicon	.162		.008	2570	1410	600	
Silver	.057	38	.379	1760	960	2900	10.8
Sodium	.295	49.5	.035	207	97	972	
Solder	.051	17	.323	361	183	310	13.1
Steel, mild	.122		.284	2760	1516	460	6.7
Stn. Stl. 304	.12		.286	2550	1399	105	9.6
Stn. Stl 430	.11		.275	2650	1454	155	6.0
Tantalum	.035		.60	5425	2996	375	3.57
Tin, liquid	.052		.253			218	
Tin, solid	.065	26.1	.263	450	232	455	13
Titanium 99.0%	.13		.164	3035	1668	112	4.7
Tungsten	.040	79	.697	6170	3410	1130	2.45
Type Metal	.040	14	.388	500	260	180	
Uranium	.028		.677	3075	1691	193.2	
Zinc	.096	43.3	.258	787	419	740	22.1
Zirconium	.067	108	.234	3350	1843	145	3.22

Properties of Non-Metallic Solids

Material	Average Specific Heat Btu/(lb)(°F)	Latent Heat of Fusion Btu/lb	Average Density lbs/in³	Melting Point (Lowest) °F	Melting Point (Lowest) °C	Thermal Conductivity K (Btu)(in)/(hr)(sq. ft)(°F)	Thermal Expansion in/in/°F x10⁻⁶
ABS Plastic	.35		.042				1.32
Acrylic	.34		.041				2.28
Alumina			.087				1.0
Aluminum Silicate	.2		.086	3690	2032	9.1	
Asbestos	.25		.021			.44	
Ashes	.2		.025			.49	
Asphalt	.40		.046			5.3	

Properties of Non-Metallic Solids (cont...)

Material	Average Specific Heat Btu/(lb)(°F)	Latent Heat of Fusion Btu/lb	Average Density lbs/in³	Melting Point (Lowest) °F	Melting Point (Lowest) °C	Thermal Conductivity K (Btu)(in)/(hr)(sq. ft)(°F)	Thermal Expansion in/in/°F x10⁻⁶
Bakelight, Pure Resin	.3 - .4		.045				
Barium Chloride	.10		.139	1697	925		
Beeswax		75	.035	62	144	1.67	
Boron Nitride	.33		.082	2999	5430	125	1 - 4
Brickwork	.22		.076			3 - 7	3 - 6
Calcium Chloride	.17	72	.091	1422	772		
Carbon	.28		.080	6700	3704	165	0.3 - 2.4
Canauba Wax	.8		.036				
Cellulose Acetate	.3 - .5		.047			1.2 - 2.3	61 - 83
Cement	.19		.054			2.04	
Ceramic Fiber	.27		.007				
Chalk	.215		.083			5.76	
Clay	.224		.052	3160	1738	9	
Coal (Coarse Anthercite)	.32		.046			11	
Coal Tars	.35 - .45		.045				
Coke	.265		.043				
Concrete (Cinder)	.16		.058			5.3	
Concrete (Stone)	.156		.083			9.5	
Cork	.5		.008			.36	
Cotton (Flax, Hemp)	.31		.053			.41	
Delrin	.35		.051			1.6	45
Diamond	.147		.127			13872	
Earth, Dry & Packed	.44		.054			.9	
Epoxy	.25 - .3		.045			1.2 - 2.4	
Ethyl Cellulose	.32 - .46		.041				
Fiberglass			.0004			.28	
Firebrick, Fireclay	.243		.083	2900	1593	6.6	
Firebrick, Silica	.258		.089	3000	1649	7.2	
Flourspar	.21						
Fluoroplastics	.28		.081			1.68	
Glass, crown	.161		.101			7.5	5
Granite	.192		.097			13 - 28	
Graphite	.20		.075			1.25	
Ice	.53	144	.0324	32	0	11	28.3
Isoprene	.48		.034			1.0	
Limestone	.217		.088			3.6 - 9	
Magnesia	.234		.130	5070	2799	.48	
Magnesite Brick	.222		.092			10.8 - 30	
Magnesium Silicate			.101			15.6	
Marble	.21		.097			14.4	
Marinite I @ 204°C (400°F)	.29		.027			.89	
Mica	.21		.102			3.0	18
MgO (Before Compacted)	.21		.085			3.6	
MgO (Compacted)	.209		.112			20	7.7
Nylon	.4		.040			1.5	61 - 63
Paper	.45		.034			.82	
Paraffin	.70	63	.032	133	56	1.6	
Phenolic Plastic	.35		.060			1.02	
Phenolic Resin, Cast	.3 - .4		.049			1.1	
Phenolic Sheet or Tube Laminated	.3 - .5		.045			2.4	
Pitch, Hard			.048	300	149		
Polycarbonate	.3		.044			1.38	
Polyester	.2 - .35		.046			3.96 - 5	
Polyethylene	.55		.035			2.3	94
Polypropylene	.46		.032			1.72	
Polystyrene	.32		.038			.7 - .10	33 - 44
Polyvinyl Chloride Acetate	.2 - .3		.049			.84 - 1.2	
Porcelain	.26		.087			6 - 10	

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Properties of Non-Metallic Solids (cont...)

Material	Average Specific Heat Btu/(lb)(°F)	Latent Heat of Fusion Btu/lb	Average Density lbs/in³	Melting Point (Lowest)		Thermal Conductivity K (Btu)(in) / (hr)(sq. ft)(°F)	Thermal Expansion in/in/°F x10⁻⁶
				°F	°C		
Potassium Chloride	.17		.072	1454	790		
Potassium Nitrate	.26		.076	633	334		
Quartz	.26		.080			9.6	
Rock Salt	.219			1495	813		
Rubber	.44		.044			1.1	340
Sand, Dry	.191		.191			2.26	
Sandstone	.22		.081				
Silica (Fused)	.316					10.0	
Silicon Carbide	.20 - .23		.069			105	
Silicone Rubber	.45		.045			1.5	
Soapstone	.22		.097			11.3	
Sodium Carbonate	.30		.078	520	271		
Sodium Chloride	.22		.078	1474	801		
Sodium Cyanide	.30		.054	1047	564		
Sodium Nitrate	.29		.082	584	307		
Sodium Nitrite	.30		.078	520	271		
Soil, Dry							
Steatite	.20		.094			17.5 - 23	4.5 - 5.5
Stone	.20						
Sugar	.30		.061	320	160		
Sulfur	.175	17	.075	246	119	1.9	36
Tallow			.035	90	32		
Teflon	.25		.078			1.7	55
Urea, Formaldehyde	.4		.056				
Vinyl	.3 - .5		.046			.8 - 2.0	28 - 100
Wood, Oak	.57		.029			1.1	

Properties of Liquids

Material	Average Specific Heat Btu/(lb)(°F)	Heat of Vaporization Btu/hr	Density lbs/ U.S. Gal.	Boiling Point		Thermal Conductivity K (Btu)(in) / (hr)(sq. ft)(°F)
				°F	°C	
Acetic Acid, 20%	.91	810	8.6	101	214	3.7
Acetic Acid, 100%	.48	175	8.7	118	245	1.14
Acetone, 100%	.514	225	6.5	56	133	1.15
Alcohol (allyl)	.665	293	7.4	97	207	
Alcohol (amyl)	.65	216	7.4	138	280	
Alcohol (butyl)	.687	254	6.1	118	244	
Alcohol (ethyl)	.60	367	6.6	78	173	1.3
Alcohol (propyl)	.57	295.2	6.7	98	208	
Ammonia, 100%	1.1	589	6.4	-33	-27	3.48
Asphalt	.42		8.3			5.04
Benzene	.42	170	7.5	79	175	1.04
Brine (25% CaCl)	.689		10.2			3.36
Brine (25% NaCl)	.786	730	9.9	104	220	2.88
Brine (25% NiCi)	.81	728	9.9	105	221	4.0
Carbon Tetrachloride	.21		13.2	77	170	
Caustic soda (18%)	.84	795	10.0	105	221	3.9
Corn Syrup, Dextrose	.65		11.7	111	231	
Cottonseed Oil	.47		7.9			1.2
Dowtherm A	.44	42.2	8.8	258	496	.96
Ether	.503	160	6.1	35	95	.95
Ethyl Acetate	.475	183.5	6.9	82	180	
Ethyl Bromide	.215	108	12.1	38	101	
Ethyl Chloride	.367	166.5	7.6	12	54	
Ethyl Iodide	.161	81.3	15.1	71	160	
Ethylene Bromide	.172	83	16.0	132	270	
Ethylene Chloride	.299	139	9.6	116	240	
Ethylene Glycol	.555		9.4	197	387	
Formic Acid	.525	216	9.3	101	213	
Freon 11	.208		12.3	24	74.9	.600
Freon 12	.232	62	10.9	-30	-21.6	.492
Freon 22	.300		10.0	-41	-41.36	.624
Fuel Oil #1	.47	86	6.8	227	440	1.008
Fuel Oil #2	.44		7.2			.96
Fuel Oil #3, #4	.425	67	7.4	304	580	.918
Fuel Oil #5, #6	.41		7.9			.852
Gasoline	.53	116	5.5 - 5.7	138	280	.936
Glycerine	.61		10.5	291	556	2.0
Heptane	.49	137.1	5.1	99	210	
Hexane	.60	142.5	5.1	63	155	
Hydrochloric 10%	.93		8.9	105	221	3.9
Ice	.50		7.5			3.96
Lard	.64		7.7			
Linseed Oil	.44		7.7	289	552	59.64
Mercury	.033	117	113.0	357	675	
Methyl Acetate	.47	176.5	7.3	56	133	
Methyl Chloroform	.26	95	11.1	74	165	

Properties of Liquids (cont...)

Material	Average Specific Heat Btu/(lb)(°F)	Heat of Vaporization Btu/hr	Density lbs/ U.S. Gal.	Boiling Point		Thermal Conductivity K (Btu)(in) / (hr)(sq. ft)(°F)
				°F	°C	
Methylene Chloride	.288	142	11.0	104	40	
Molasses	.60		11.7	220	104	
NaK (78% K)	.21		6.2	1446	786	167.0
Napthalene	.396	103	7.2	424	218	
Nitric Acid, 7%	.92	918	8.6	220	104	3.8
Nitric Acid, 95%	.50	207	12.5	187	86	
Nitrobenzene	.35	142.2		412	211	
Oil (SAE10-30)	.43		7.4			
Oil (SAE40-50)	.43		7.4			
Olive Oil	.47		7.8	570	299	
Paraffin (Melted)	.71		6.3			1.0
Perchlorethylene	.21	90	13.5	250	121	
Phenol	.56		8.9	346	174	
Phosphoric 10%	.93.		8.7			
Phosphoric 20%	.85		9.2			
Potassium (K)	.18	893	6.0	1400	760	320.0
Propane (Comp)	.576		0.02	-48.1	45	1.81
Sea Water	.94		8.6			
Sodium (Na)	.30	1810	6.8	1621	883	580.0
Sodium Hydroxide						
30% Solution	.84		11.1			
50% Solution	.78		12.8			
Soybean Oil	.24 - .33		7.7			
Starch			12.8			
Sucrose, 40% Sugar	.66		9.8	214	101	
Sucrose, 60% Sugar	.74		10.8	218	103	
Sulfur, Melted 260°C (500°F)	.24	120	15.0	832	444	
Sulfuric Acid, 10%	.92		9.9	216	102	4.0
Sulfuric Acid, 20%	.84		9.5	218	103	
Sulfuric Acid, 60%	.52		12.5	282	139	2.88
Sulfuric Acid 98%	.35	219	15.3	625	329	1.8
Therminol FR-2	.30		12.1	648	342	.70
Toluene	.42.		7.2			1.032
Trichloroethylene	.23	103	12.2	188	87	.84
Transformer Oils	.42		7.5			.9
Turpentine	.41	123	7.6	318	159	.90
Vegetable Oil	.43		7.7			1.1
Water	1.0	970	8.3	212	100	4.2
Xylene	.411	149.2	7.2	288	142	

Properties of Gases

Gas	Specific Heat Btu/lb(°F)	Density lbs/ft³	Thermal Conductivity K (Btu)(in) / (hr)(sq. ft)(°F)
Acetylene	.35	.073	.129
Air at 80°F (27°C)	.240	.073	.18
Air at 400°F (204°C)	.245	.046	.27
Alcohol, Ethyl (Vapor)	.4534		
Alcohol, Methyl (Vapor)	.4580		
Ammonia	.523	.044	.16
Argon	.125	.102	.12
Butane		.1623	.0876
Butylene		.148	
Carbon Dioxide	.199	.113	.12
Carbon Monoxide	.248	.072	.18
Chlorine	.115	.184	.06
Chloroform	.1441		.046
Chloromethane	.24	.1309	.0636
Ethyl Chloride		.1703	.066
Ethyl Ether	.4380		.0924
Ethylene	.40	.0728	.1212
Helium	1.25	.011	1.10
Hydrochloric Acid	.191	.0946	
Hydrogen	3.39	.0052	.13
Hydrogen Sulfide	.2451	.096	.091
Methane	.528	.041	.25
Nitric Oxide	.231	.0779	.1656
Nitrogen	.248	.072	.19
Nitrous Oxide	.221	.1143	.1056
Oxygen	.218	.082	.18
Sulphur Dioxide	.152	.172	.07
Water Vapor 212°F (100°C)	.482	.0372	.16

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Technical Data - Physical Constants/Heat Losses

Properties of Air

Temperature °F	Temperature °C	Specific Heat (Btu/lb. °F)	Density (lb./ft.^{3})
0	-17.8	.240	.086
50	10.0	.240	.078
100	37.8	.240	.071
150	65.6	.241	.065
200	93.3	.242	.060
250	121.0	.243	.056
300	148.9	.244	.052
350	176.7	.245	.049
400	204.0	.247	.046
500	260.0	.249	.041
600	315.6	.252	.037
700	371.1	.254	.034
800	426.6	.257	.032
900	482.2	.260	.029
1000	537.8	.262	.027
1100	593.3	.265	.025
1200	648.9	.267	.024

Thermal Conductivity of Industrial Insulation

Type of Insulation	Maximum Service Temp.		Typical K Values - Btu/hr/sq. ft./°F/in — Mean Temperature (°F) Between Inner and Outer Insulation Surface					
	°F	°C	100	200	300	500	700	900
Mineral Wool Blanket Flexible Felt	450	232	.26	.34	.45			
Minteral Wool Block and Board resin binder	600	316	.28	.35	.43			
85% Magnesia Block and Board	600	316	.36	.38	.42	.46		
Foam Glass Block and Board	800	427	.41	.48	.55			
Calcium Silicate Low Density	1200	649	.38	.41	.44	.52	.62	.72
Mineral Wool Blanket Metal Reinforced	1200	649	.29	.35	.42	.56		
Silican Lime Block and Board	1200	649	.33	.38	.43	.53	.64	.75
Mineral Wood Block and Board Inorganic Binder	1600	871	.34	.39	.44	.54	.64	
Calcium Silicate High Density	1800	982				.63	.74	.95

Viscosities

Material	SSU 40°F 4.4°C	SSU 80°F 26.7°C	SSU 120°F 49°C	CENTIPOISE 40°F 4.4°C	CENTIPOISE 80°F 26.7°C	CENTIPOISE 120°F 49°C
Asphalt RS-1 MS-1 SS-1	400	160			86	34
Asphalt RC-0 MC-0 SC-0	950	340				
Asphalt RC-3 MC-3 SC-3	40000	7000				
Asphalt RC-5 MC-5 SC-5	500000	45000				
Asphalt 100-120 Penetration	3500 at 250°F (121°C)					
Asphalt 40-50 Penetration	8000 at 250°F (121°C)					
Benzene				.8	.62	.46
Gasoline				.7	.55	.44
No.1 Fuel Oil (Kerosene)	40	36		3.3	2.1	1.4
No.2 Fuel Oil - PS100	43	36	33	4.6	2.6	1.6
No.3 Fuel Oil - PS-200	84	52	41	15.0	7.0	4.0
No.4 Fuel Oil	480	125	62	92.0	24.00	9.6
No.5 Fuel Oil - PS300		1600	370		390.0	75.0
No.6 Fuel Oil - Bunker C		4500	650		1000.0	155.0
Transformer Oil - Light	170	72	49	34.2	12.1	6.3
Transformer Oil - Medium	460	145	70	89.0	28.2	11.9
34°API Mid-Continent Crude	88	51	37	15	6.5	3.0
28°API Gas Oil	135	59	48	25	9.0	6.0
Quench and Tempering Oil						
SAE-5W	550	160	74			
SAE-10W	1500	265	120	170	50	22
SAE-20	2900	500	170			
SAE-30	5000	870	260	1200	200	60
SAE-40	8500	1400	380			
SAE-50	23000	3600	720		400	100

Figure 1 Heat losses from uninsulated smooth solid surfaces 60°F to 180°F (16°C to 82°C). Assumed external ambient temperature of 70°F (21°C)

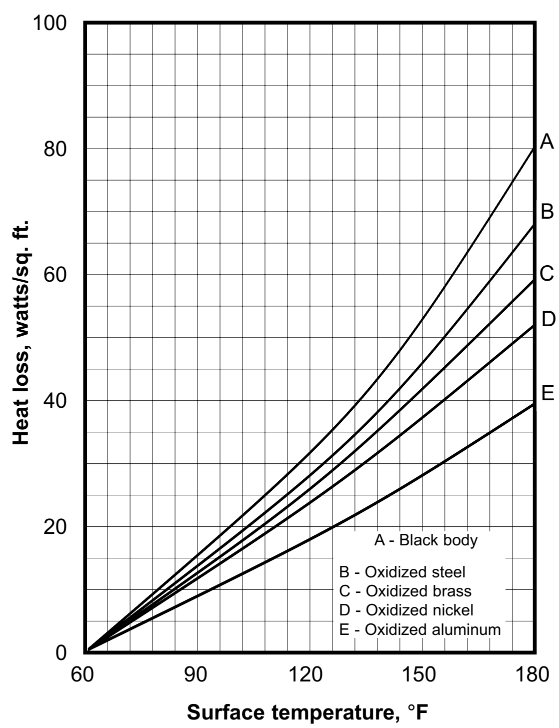
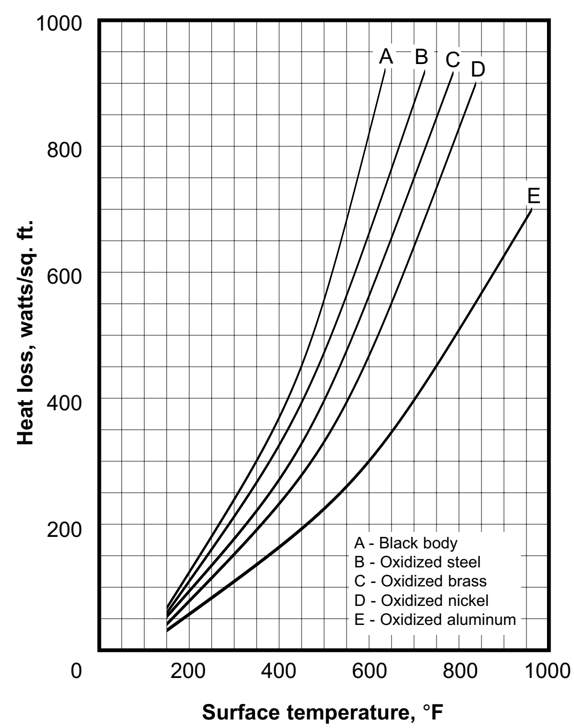


Figure 2 Heat losses from uninsulated smooth solid surfaces 150°F to 1000°F (66°C to 538°C). Assumed external ambient temperature of 70°F (21°C)



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Technical Data - Heat Losses

Figure 3 Heat losses from liquid surfaces. Assumed external ambient temperature of 70°F (21°C).

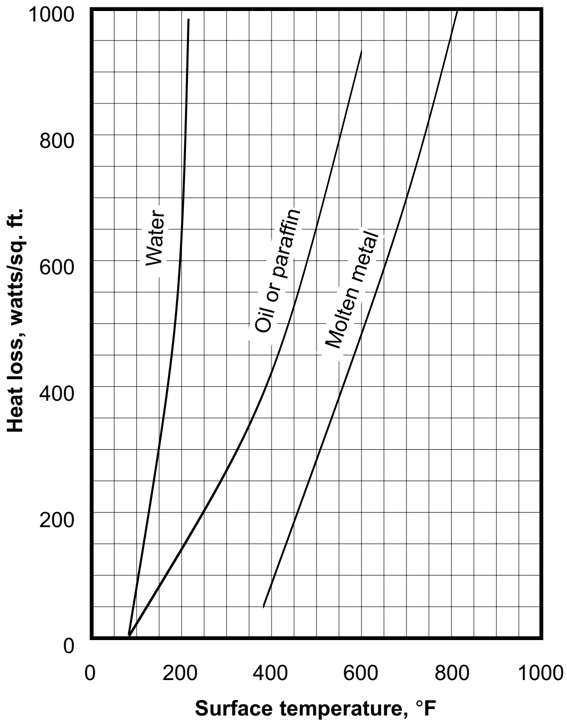
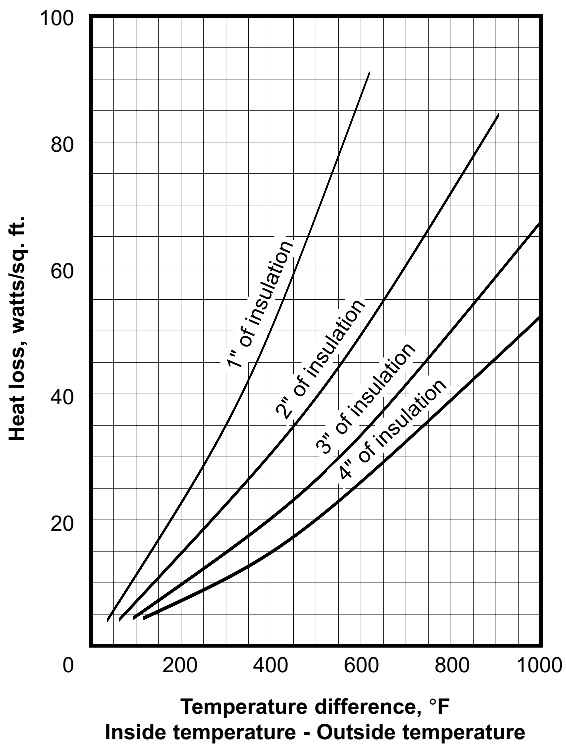


Figure 4 Heat losses from insulated walls. Curves are for standard high-grade material, such as 85% magnesia, Rockwool, etc.



Wind Velocity and Heat Loss

Wind velocity will increase surface heat losses. Table 1 can be used as a guide for estimating the factors to be applied to the still air heat losses from Figures 1, 2, & 4.

TABLE 1 Wind Velocity Factors

Wind Velocity (MPH)	Well Sealed Insulated Surface			Uninsulated Surface Temperature (°F)		
	1" (25 mm)	2" (51 mm)	3" (76 mm)	200	600	1000
5	–	–	–	1.7	1.5	1.3
10	–	–	–	2.1	1.7	1.4
15	1.1	–	–	2.4	2.0	1.6
20	1.2	1.1	–	2.7	2.3	1.7
25	1.3	1.2	1.1	3.0	2.6	1.8
30	1.4	1.3	1.2	3.3	3.0	1.9

Heat Losses From Insulated Pipes

To find the heat loss from the insulated pipes, in watts/ft. multiply the appropriate factor from Table 2 by the °F difference between the pipe holding temperature and the minimum ambient temperature.

If the pipe holding temperature is above 200°F (93°C), multiply the above answer by 1.2

TABLE 2 Heat Loss Factors For Pipe

Pipe Size	Insulation Thickness and Factors						
	1/2" (13 mm)	1" (25 mm)	1 1/2" (38 mm)	2" (51 mm)	2 1/2" (64 mm)	3" (76 mm)	4" (102 mm)
1/2	0.086	0.054	0.043	0.037			
1/4	0.102	0.062	0.048	0.041			
1	0.123	0.073	0.056	0.047			
1 1/4	0.142	0.083	0.063	0.052			
1 1/2	0.164	0.094	0.070	0.058			
2	0.192	0.109	0.081	0.066			
2 1/2	0.229	0.128	0.093	0.076			
3	0.259	0.142	0.107	0.083			
3 1/2	0.287	0.157	0.113	0.091			
4	0.316	0.172	0.123	0.098	0.083	0.073	0.060
4 1/2	0.347	0.189	0.134	0.107	0.090	0.079	0.065
5	0.417	0.219	0.155	0.121	0.103	0.089	0.073
6	0.472	0.250	0.174	0.136	0.114	0.099	0.080
7	0.526	0.275	0.192	0.151	0.126	0.109	0.088
8	0.571	0.305	0.212	0.166	0.137	0.119	0.095
9	0.634	0.338	0.234	0.183	0.151	0.130	0.104
10	0.634	0.338	0.234	0.183	0.151	0.130	0.104
12	0.776	0.397	0.275	0.212	0.175	0.149	0.119
14	0.834	0.431	0.298	0.230	0.190	0.162	0.128
16	0.961	0.498	0.334	0.258	0.212	0.181	0.142
18	1.088	0.555	0.379	0.289	0.289	0.200	0.156
20	1.190	0.598	0.416	0.319	0.319	0.219	0.171
24	1.430	0.731	0.490	0.374	0.374	0.259	0.200

Technical Data - Galvanic Corrosion

Table 1 is the galvanic series of commonly used metals when immersed in sea water. This list will vary slightly when a different electrolyte forms the galvanic couple.

Metals which are grouped show negligible corrosion when joined.

For galvanic corrosion to occur the following conditions must be met.

i) Two or more electrochemically dissimilar metals are present and in electrical contact (which is not necessarily physical contact).

ii) The metals must be in contact with an electrolyte.

Quite often other types of corrosion are incorrectly attributed to galvanic corrosion. If the foregoing conditions are met and the corrosion is localized near the junction of the metals, it was probably caused by galvanic effects. Otherwise, look elsewhere.

The best on can do is to try to avoid designs which involve electrically coupled metals. This is not always practical. However the choice of metals can help to lesson corrosive effects. Try to select metals as close together as possible on the galvanic series.

Keep in mind that the least noble or more active metal will deplete during corrosion. Never couple a small anode with a large cathode.

Quite often it is practical to electrically insulate the metals from one another. If it is determined that dissimilar uninsulated metals must be used, make the anodic part of heavier material. Also, design the part for easy replacement.

Useful Corrosion Terminology

- **Bimetallic Corrosion** - Galvanic Corrosion.
- **Corrosion-Erosion** - Corrosion which is increased because of the abrasive action of a moving stream.
- **Crevice Corrosion** - Localized corrosion resulting from the formation of a concentration cell in an crevice formed between a metal and a nonmetal or between two metal surfaces.
- **Fretting Corrosion** - Fretting refers to metal deterioration caused by repetitive slip at the interface between two surfaces.
- **Hydrogen Embrittlement** - Embrittlement of a metal caused by hydrogen.
- **Impingement Attack** - Erosion-corrosion caused by turbulence or impinging flow at certain points.
- **Intergranular Corrosion** - Corrosion which occurs preferentially at grain boundaries.
- **Pitting** - Highly localized corrosion resulting in deep penetration at only a few spots.
- **Scaling** - High temperature corrosion resulting in formation of thick corrosion product layers.
- **Stress Corrosion** - Corrosion which is accelerated by stress.

TABLE 1 Galvanic Series of Commonly Used Metals When Exposed to Sea Water

Active or Least Normal ↑

Magnesium
Magnesium Alloys
Zinc
Galvanized Steel

Aluminum 1100

Aluminum 6053
Alclad

Cadmium

Aluminum 2024 (4.5 Cu, 1.5 Mg 0.6 Mn)

Mild Steel
Wrought Iron
Cast Iron

13% Chromium Stainless Steel Type 410 (Active)
18-8 Stainless Steel Type 304 (Active)
18-12-3 Stainless Steel Type 316 (Active)

Lead-Tin Solders
Lead
Tin

Manganese Bronze
Naval Brass

Nickel (Active)
76 Ni - 30 Mo - 6 Fe - 1 Mn

Yellow Brass
Admiralty Brass
Aluminum Brass
Red Brass
Copper
Silicon Bronze
70:30 Cupro Nickel
G-Bronze
M-Bronze
Silver Solder
Nickel (Passive)
76 Ni - 16 Cr - 7 Fe Alloy (Passive)
67 Ni - 33 Cu Alloy (Monel)

13% Chromium Stainless Steel Type 410 (Passive)
Titanium
18-8 Stainless Steel Type 304 (Passive)
18-12-3 Stainless steel Type 316 (Passive)
Silver

Graphite
Gold
Platinum

↓ Passive or More Noble

Technical Data - Corrosion Guide

The sheath materials in the following tables are to be used as a guide only and not as a firm recommendation. Such factors as temperature of solution, percentage of concentration, watt density and contamination are all factors in corrosion rates which make it impossible to make an absolute recommendation. For further information on corrosiveness of a solution, check the supplier of your solution.

Due to the above factors which are beyond our control, CCI Thermal cannot be responsible for electric heater failure due to corrosion.

WARNING - CERTAIN SOLUTIONS, DUE TO THE VISCOSITY OR FLAMMABILITY ARE NOT SUITABLE FOR HEATING WITH DIRECT IMMERSION HEATERS UNLESS SPECIAL PRECAUTIONS ARE TAKEN. CHECK FACTORY IF YOU REQUIRE ASSISTANCE IN THE SELECTION OF A SAFE AND RELIABLE HEATING METHOD FOR YOUR APPLICATIONS.

Legend:
- A - Good
- F - Fair
- C - Depends on Conditions
- X - Unsuitable

Solution	Iron and Steel	300 Series Stainless	Monel	Incoloy®	Inconel	Copper	titanium	Aluminum	Quartz	Teflon
Aluminum Potassium Sulphate		A-316				A				
Acetic Acid, Crude	X	F	F	C	C	F		F		
Pure			A	C	C	F		A		
Vapor			F	C	C	F	F	C		
150 PSI; 400°F (204°C)			F	C	C	F		C		
Aerated	X	F-316 X-304	X		X	X	A	C		
No Air		C	A		X	F	A	C		
Acetone	C	A	A	A	A	A	A	F	A	
Alboloy Process	A									
Allyl Alcohol		A	A	A	A	A	A	F		
Alcohol	F	A-316	A	A	A	A	A	F	A	
Alkaline Solutions	A	A-304								
Alkaline Cleaners		A-304								
Alkaline soaking Cleaners	A									
Alum										
Aluminum (Molten)										
Aluminum Acetate	X	A-316	F		F	F	A			
Aluminum Bright Dip									A	A
Aluminum Chloride	X	X	X	X	X	X	X	X	A	A
Aluminum Cleaners	C	A	A	A	A	X	F	X	X	
Aluminum Potassium Sulphate (Alum)		C-316 X-304	F		F	A	F	X		
Aluminum Sulphate	X	F	F	X	X	F	A	X	A	
Ammonia	X	X	X	C	F	X	A	C	A	
Ammonia Gas, Cold	A	A	A		A	C	A	A		
Hot	C	C	C		A	X				
Ammonia and Oil	A									
Ammonium Acetate	A	A	A	A	A	X		A		

Solution	Iron and Steel	300 Series Stainless	Monel	Incoloy®	Inconel	Copper	titanium	Aluminum	Quartz	Teflon
Ammonium Bifluoride	X	X	X	X	X	X	X	X	X	A
Ammonium Chloride	C	F	F	C	C	X	A	X	A	A
Ammonium Hyrdoxide	A	A	AC	A	A	X	A	C	X	
Ammonium Nitrate	A	A	C	X	X	X	X	F	A	
Ammonium Persulphate	X	F	X		X	X		X	A	A
Ammonium Sulphate	A	A	A	F	F	F	A	X	A	
Anhydrous Ammonia	A					X				
Aniline	F	A	F	F	F	X	A	F	A	
Aniline, Aniline Oil	A	A	A	F	F	X	A	X	A	
Aniline, Dyes		A	A							
Anodizing Solutions 10% Chromic Acid 96°F (36°C)	C	A					A			
Sodium Hydroxide Alkaline	A			A			A			
Nickel Acetate			A							
Arsenic Acid	X	C	X	X	X	X	X	X	A	A
Asphalt	A	A	X	A	A	X`	A	X	A	
Barium Chloride		F-304 X-316			A			X		
Barium Hydroxide		A		F	F	X	X	X	A	
Barium Sulphate	F	F	F	F	F	F	A		A	
Barium Sulphide		A	A			X				
Barium Sulphite		F-304								
Black Nickel									A	A
Black Oxide		A-304								
Bonderizing	C	A		C	C		A		A	A
Boric Acid	X	C	C	C	C	C	A	X	A	A
Brass Cyanide		A-304								
Bright Nickel							A		A	
Brine (Salt Water)			A		F					
Bronze Plating	A	A-304								
Butanol (Butyl Alcohol)	A	A	A	A	A	A	A	F	A	A
Cadmium Black									A	
Cadmium Fluoborate										A
Cadmium Plating				A	A					
Calcium Chlorate	F	F	F	F	F	C			A	
Calcium Chloride	F	F	F	F	F	F	A	C	A	A
Carbonic Acid, Phenol	C	A	A	F	F	X	A	F		
Carbon Dioxide, Dry	A	A	A	A	A	A	AX	A	A	X
Wet	F	A	A	A	A	F	X	A	A	X
Carbon Tetrachloride	C	C	A	A	A	C	A	X	A	
Carbonic Acid	C	A-304	C	F	A	C	A	C	A	A
Castor Oil	A	A	A	A	A		A	A	A	A
Caustic Etch	A	A	A	X	X	X	A	X	A	X
Caustic Soda (Lye) (Sodium Hydroxide)	X	C-316 X-304	C	C	F	X	C	X	X	A
2%	F	F-316 X-304	A	A	A	F	A	X		
10 - 30 %, 210°F (99°C)	F	A	A	A	A	F	A	X		
76%, 180°F (82°C)	X	F	F	A	A	X	F	X		
Chlorine, Dry	A	A	A	C	F	A	F	X	A	F
Wet	X	X	X	X	X	X	X	X	A	X
Chloroacetic Acid	X	X		C	C	X	A	X	A	A
Chromic Acetate									A	
Chromic Acid	C	A	F	X	X	X	A	X	A	X
Chrome Plating				X	X		A		A	X
Citric Acid	X	A	A	F	F	A	A	C	A	A
Clear Chromate		A-316								
Cobalt Acetate 130°F (54°C)			A	F	F					
Cobalt Nickel									A	

Corrosion Guide (cont...)

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Cobalt Plating		A-304								
Coconut Oil			F							
Cod Liver Oil		A		A	A			A		
Copper Acid							A		A	
Copper Bright		A								
Copper Bright Acid									A	
Copper Chloride	F	X	F	X	X	C	A	C	A	A
Copper Cyanide	A			X	X			X	A	A
Copper Fluoborate		F	F	F	F					A
Copper Nitrate	X	F	X	X	X	X		X	A	A
Copper Plating	A									
Copper Sulphate	X	A	A	F	F	C		X	A	
Creosote	A	A	A	F	F	A		C	A	
Deionized Water	X	A	A	A	A	X		X		
Deoxidizer (Etching)									A	
Diethylene	F	A	F	F	F	F	A	F	A	A
Diphenyl 300°F - 350°F (149°C - 177°C)	A				A			A		
Disodium Phosphate 25% 180°F (82°C)	A				A		A		A	A
Dowtherm A	A			A						
Electro Polishing									A	
Electroless Nickel							A		A	
Electroless Tin (Acid)									A	
(Alkaline)		A-316					A			
Ethers	A		A	F	F	A	A	F	A	
Ethyl Chloride	A	A	A	F	A	A	A	F	A	A

Solution	Iron and Steel	300 Series Stainless	Monel	Incoloy®	Inconel	Copper	titanium	Aluminum	Quartz	Teflon
Ethylene Gycol 300°F (149°C)		A	A	F	F		A	A	A	A
Fatty Acids	X	A-316	F	F	F	X	A	A	A	
Ferric Chloride	X	X	X	X	X	X	A	X	A	A
Ferric Sulphate	X	F-304 A-316	X	C	C	X	A	X	A	
Flourine Gas, Dry	C	C	A	C	A	X	A	X	C	
Formaldehyde	F	A	A	F	F	F	A	F	A	
Formic Acid	X	F	C	F	C	F	X	X	A	
Freon	C	C	A	A	A	A		A		
Fuel Oil	A	A	A	F	F	A	A	A		
Fuel Oil, Acid	C	C	A	C	C	C	A	X		
Gasoline, Refined	A	A	A	F	F	A		A	A	
Gasoline, Sour	C	A	A	X	X	C		C	A	
Gasoline, Glycerol	A	A	A	A	A	F		A	A	
Gold - Acid	A						A		A	
Gold - Cyanide		A								
Grey Nickel							A		A	A
Hydrochloric Acid < 150°F (66°C)	X	X	C	X	X	X	X	X	A	
> 150°F (66°C)	X	X	C	X	X	X	X	X	A	A
Hydrocyanic Acid (No Air)	X	F	F	F	F	X		F	A	
Hydrofluoric Acid, Cold < 65%	X	X	F	X	X	C	X	X	X	A
> 65%	F	X	A	X	X	F	X	X		
Hot < 65%	X	X	C			X		X		
> 65%	C	X	A	X	X	F	X	X		
Hydrogen Peroxide	X	A	F	F	F	X	A	A	A	
Indium									A	A
Iron Phosphate (Parkerizing)	C	A								
Isopropanol	C		A		A	F				
Kerosene	A	A	A	A	A	A		A		
Lacquer Solvents	C	A	A	F	F	C	A	A	A	
Lard	F									
Lead Acetate	X	A	A	A	A	X	A	X	A	
Lead Acid Salts		A-304								
Lime Saturated Water	F	A-316	F	F	F	F		X	X	
Linseed Oil	A	A	A	F	F	A	A	F		
Magnesium Chloride	F	F	F	F	A	F	A	X	A	
Magnesium Hydroxide	A	A	A	A	A	X		F	A	
Magnesium Nitrate	F	F	F	F	X	F	F	F	A	
Magnesium Sulphate	A	A	A	F	A	A	A	F	A	
Mercuric Chloride	C	X	X	X	X	X	F	X	A	
Mercury	A	A	A	A	F	X	X	X	A	
Methyl Alcohol, Methanol	A	A	A	F	A	A	A	C	A	
Methyl Bromide	C	A	F	F	F	F	A	X	A	
Methyl Chloride	A		A	C	C	A	A	X	A	
Methylene Chloride	X	C	C	C	F	C	A	C	A	
Mineral Oils	A	A	A	A	A	A	A	A	A	
Muriato									A	A
Naptha	A	A	A	A	A	A	A	A	A	A
Napthalene	A			F	F		A	F		
Nickel Acetate Seal		A-316								
Nickel Chloride		F	C	C	F	X	F	X	A	A
Nickel Copper Strike (Cyanide Free)		A								
Nickel Plating, Bright							A		A	A
Nickel Plating, Dull									A	A
Nickel Plating, Watts Solution							A		A	A
Nickel Sulphate	X	A	C	C	C	X		X	A	A
Nitric Acid, Crude	X	C	X	X	X	X		X	A	A
Concentrated	X	F	X	X	X	X		X	A	A

Solution	Iron and Steel	300 Series Stainless	Monel	Incoloy®	Inconel	Copper	titanium	Aluminum	Quartz	Teflon
Diluted	X	A	X	X	X	X		X	A	A
Nitric Hydrochloric Acid	X	X	X	X	X	X	X	X	A	A
Nitric 6% Phosphoric Acid		C-316							A	A
Nitric Sodium Chromate		A-316							A	A
Nitrobenzene	A	A	A	A	A	F	A	A	A	
Oakite No. 20	A									
Oakite No. 23	A									
Oakite No. 24	A									
Oakite No. 30	A									
Oakite No. 51	A									
Oakite No. 67		A-304								
Oakite No. 90 @ 82°C (180°F)	A									
Oleic Acid	C	A	A	F	A	X	F	C	A	A
Oxalic Acid	C	C	A	X	F	C	X	F	A	A
Paint Stripper (High Alkaline Type)	A									
Paint Stripper (Solvent Type)		A-316								
Paraffin	A	A				A		A		
Parkerizing										
Perchlorethylene		A		F	A		A	C	A	
Petroleum Oils, Crude < 260°C (500°F)		A		F	A		A	C	A	
> 260°C (500°F)	A	A	X			X		A		
> 538°C (1000°F)	X	C A-347	X			X		X		
Phenol										
Phenol 85%, 120°F (49°C)	C	A		F	F		A	A		
Phosphate		A-316								X
Phosphate Cleaner		A-304								X
Phosphatizing		A-316								X
Phosphoric Acid, Crude	C	C	X			X		X		
Pure < 45%	X	A	F	A	A	F	X	C		
> 45% Cold	X	A	F	A		F	X	X		
Hot	X	X-304 C-316	C	A	F	C	X	X		
Photo Fixing Bath		A	C							
Potassium Bichromate (Potassium Dichromate)	C	A-316	F	F			F	F	A	A
Potassium Chloride	A	A	A	C	F	A	A	X	A	
Potassium Cyanide	A	A	A	F	F	X	X	X	A	A
Potassium Hydrochloride									A	A
Potassium Hydroxide	C	F	A	C	F	X	X	X	X	A
Potassium Nitrate (Salt Peter)	F	F	F	F	F	F	A	A	A	
Potassium Sulphate	A	F	A	F	F	A	A	A	A	A
Prestone 177°C (350°F)	A		A							
Sea Water	X	C	A	F	F	X	A	X	A	
Silver Bromide	X	X	C			X	A	X	A	A
Silver Cyanide	C	A	F	A		X		X	A	
Silver Nitrate	X	C	X	C	C	X	A	X	A	
Soap Solutions	A	A	A			C		X		
Sodium - Liquid Metal	C	A-304	C	A	A	X		X	X	
Sodium Bisulphate	X	X	C		F	F		C		
Sodium Bromide	F	C	F	F	F	F		X	A	A
Sodium Carbonate < 20%	A			F	F		A	X	C	A
Sodium Chlorate	X	F	A	F	A	A	A	F	A	A
Sodium Chloride	A	F-304 A-316	A	F	A	F	C	X	A	
Sodium Citrate	X	F				X		X	A	A
Sodium Dichromate (Sodium Bichromate)	F	F				X	C	C	A	
Sodium Disulphate	X	X	C		C		C	C	A	
Sodium Hydroxide	A	F	A	A	A	X	A			
Sodium Hypochlorite	X	X	C	X	X	C	A	X	A	A
Sodium Nitrate	A	F-304 A-316	A	A	A	F	A	C	A	
Sodium Peroxide	C	A	A		F			C		
Sodium Phosphate	C	A-316	A	F	A	F	A	X	A	A

Solution	Iron and Steel	300 Series Stainless	Monel	Incoloy®	Inconel	Copper	titanium	Aluminum	Quartz	Teflon
Sodium Salicylate	F	F	F	F	F	F			A	A
Sodium Silicate	A	A-316	A	F	F	C		X	A	A
Sodium Stannate	C	F	F	F	F				A	A
Sodium Sulphate	A	A	A	F	F	A	C	F	A	A
Sodium Sulphide	A	A	F	C	C	X	C	C	C	A
Solder Bath	X	X	X	X	X	X	X	X	X	X
Soybean Oil		A								
Steam < 500°F	A	A	A	A	A	A				
< 500°F - 1000°F (260°C - 538°C)	C	A	C	A	A	C				
> 1000°F (538°C)	X	A	X	A	A	X				
Stearic Acid	C	A	A			C		C	A	
Sugar Solution	A	A	A	A	A	A	A	A	A	A
Sulphur	A	F	X	A	A	X	A	A	A	
Sulphur Chloride	X	C-304 X-316	X	C	F	X		X	A	A
Sulphur Dioxide	X	C-304 X-316	C		F	X		C		
Sulphuric Acid < 10% Cold	X	F	C		X	C		C		
Hot	X	F-316 X-304	C		F	X		C		
10 - 75% Cold	X	X-304 F-316	C		X	X	X	X		
Hot	X	X	C		X	X	X	X		
75 - 95% Cold	C	A	C		X	X	X	X		
Hot	F	X	C			X	X	X		
Fuming	C	C-304 F-316	X	C	C	X		X		
Sulphurous Acid	A	C-316 X-304	X		C	C	A	C		
Tannic Acid		F	A		A	A	A	C	A	
Tar	A	A		A	A			A		
Tartaric Acid		C-304 A-316	C		F		F	C		
Tetrachlorethylene	A		F	A		A	C	A		
Thermoil Grandodine	F									
Tin (Molten)	F	F	X		X	X	A	X		X
Tin-Nickel Plating									A	A
Tin Plating - Acid										A
Tin Plating - Alkaline	A	A-304								
Toluene	A	A	A	A	A	C	A	A		
Triad Solvent	C									
Trichloroethane	A	A-304	F	F	F	F	A	F	A	
Trichlorothylene	C	C	A	A	A	C	A	F	A	
Triethylene Glycol	A	A	A	A	A	A	A	A	A	
Trioxide (Pickle)									A	A
Trisodium Phosphate	A	C	C			C		X	X	X
Turpentine	C	A	A			C		A		
Urea Ammonia Liquor 48°F (8°C)	A									
Vegetable Oil	C	A	A	A		X		F		
Vinegar	C	F-304 A-316	A					C		
Water, Fresh	C		A	A	A	A	A		A	
Distilled, Lab Grade	X	A	C	A	A	X				
Return Condensate	A	A	A	A	A	A				
Whiskey and Wines	X	F-304 A-316	A	A	A	A				
Yellow Dichromate		A-316							A	
X-Ray Solution		A								
Zinc (Molten)		X	X	X	X	X	X	X		X
Zinc Chloride	C	X	A	F	F	X	F	X	A	A
Zinc Plating Acid									A	
Zinc Plating Cyanide	A	A-304								
Zinc Sulphate	C	A	A	A	A	X	A	C		

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Technical Data - Typical Watt Densities

1. Watt density is determined by dividing the heater wattage by the total surface area of all heated surfaces on the element. Remember that electric heating elements will continue to increase their surface temperature until all heat produced by the element is transferred to the work.
2. Typical watt densities shown in the table below are based on non-circulated liquids unless noted otherwise.
3. Use of watt density lower than listed will prolong heater service life.
4. This data is for use as a general guideline only. System conditions may exist that may mandate densities lower or higher than listed. Certain substances of high viscosity and low heat transfer may be subject to coking if density is too high.

Material Being Heated		Max. Watts/ sq. in	Operating Temperature	
			°F	°C
Acetaldehyde		14	180	82
Acetone		14	130	54
Acid Solutions (Mild)	Acetic	40	180	82
	Boric	40	257	125
	Carbonic	40	180	82
	Chromic	40	180	82
	Citric	25	180	82
	Fatty Acids	25	150	66
	Lactic	10	122	50
	Malic	14	120	49
	Nitric	25	167	75
	Phenol - 2-4 Disulfonic	40	180	82
	Phosphoric	28	180	82
	Phosphoric (Aerated)	26	180	82
	Proponic	40	180	82
	Tannic	30/40	160/180	71/82
Alkaline Solutions		44	212	100
Aluminum Acetate		14	122	50
Aluminum Potassium Sulfate		40	212	100
Ammonium Acetate		28	167	75
Amyl Acetate		28	240	116
Amyl Alcohol		24	212	100
Aniline		26	350	177
Asphalt		4-10	200-500	93-260
Barium Hydroxide		40	212	100
Benzene, Liquid		14	150	66
Butyl Acetate		14	225	107
Calcium Bisulfate		20	400	204
Calcium Chloride		5-8	200	93
Carbon Monoxide		25	—	—
Carbon Tetrachloride		25	160	71
Caustic Soda	2%	50	210	99
	10%	28	210	99
	75%	26	180	82
Citrus Juices		26	185	85
Degreasing Solution		25	275	135
Dextrose		25	212	100
Dowtherm A	1 ft. sec. or more	23	750	399
	non-flowing	10	750	399
Dowtherm E		12-18	400	204
Dyes & Pigments		23	212	100
Electroplating Baths	Cadmium	40	180	82
	Copper	40	180	82
	Dilute Cyanide	40	180	82
	Sodium Cyanide	40	180	82
	Potassium Cyanide	40	180	82
Ethylene Glycol		30	300	149
Formaldehyde		12	180	82
Freon Gas		2-5	300	149
Fuel Oils	Grades 1 & 2 (distilate)	23	200	93
	Grades 4 & 5 (residual)	14	200	93

Material Being Heated		Max. Watts/ sq. in	Operating Temperature	
			°F	°C
Fuel Oils	Grades 6 & bunker C (residual)	8	160	71
Gasoline		25	300	149
Gelatin	Liquid	25	150	66
	Solid	6	150	66
Glycerine		10	500	260
Glycerol		26	212	100
Grease	Liquid	26	—	—
	Solid	5	—	—
Heat Transfer Oils	Static	18	500	260
		14	600	316
	Circulating	24	500	260
		22	600	316
Hydrazine		18	212	100
Linseed Oil		50	150	66
Lubrication Oil	SAE 10	26	250	121
	SAE 20	24	250	121
	SAE 30	23	250	121
	SAE 40	16	250	121
	SAE 50	14	250	121
Magnesium Chloride		40	212	100
Magnesium Sulfate		40	212	100
Manganese Sulfate		40	212	100
Methylamine		22	180	82
Methylchloride		20	180	82
Mineral Oil		25	200	93
		18	400	204
Molasses		5	100	100
Molten Salt Bath		25-30	800-900	427-482
Naptha		12	212	100
Oil Draw Bath		25	600	316
Paraffin or Wax (liquid state)		20	150	66
Perchloroethylene		25	200	93
Potassium Chlorate		40	212	100
Potassium Chloride		40	212	100
Potassium Hydroxide		23	160	71
Soap, Liquid		24	212	100
Sodium Acetate		45	212	100
Sodium Cyanide		45	140	60
Sodium Hydride		30	720	382
Sodim Hydroxide				
Sodium Phosphate		40	212	100
Sulfur, Molten		10	600	316
Therminols		26	500	260
		23	600	316
		15	650	343
Toluene		25	212	100
Trichlorethylene		25	150	66
Turpentine		22	300	149
Vegetable Oil & Shortening		40	400	204
Water (Process)		60-90	212	100

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Technical Data - Pressure Ratings

Practical Flow Velocities in Pipe

Flow/Service	PSIG	Velocity
Saturated Steam	0-25	4000-6000 ft/min
	25 and up	6000-10000 ft/min
Superheated Steam	200 and up	7000-20000 ft/min
Water/Boiler Feed	–	8-15 ft/sec
Water/Pump Suction	–	4-7 ft/sec
Water/Drain	–	4-7 ft/sec
Water/General Service	–	4-10 ft/sec

Allowable Pressure Ratings for Pipes and Flanges

The information included on this page is to be used as a guide only in the pre-selection of pipe and flange sizes for various temperatures and pressures.

When calculating thickness requirements in accordance with the ASME code for safe pressure vessel design, stress values may often be less than shown in Table 1.

TABLE 1 Approximate Allowable Stress for Pipe in PSIG

Temperature		Pipe Material and Type			
°F	°C	A53 Welded Steel	A106B Seamless Steel	A312 304 S.S. Welded	A312 316 S.S. Welded
100	**38**	**14,600**	**17,100**	**17,000**	**17,000**
300	**149**	**14,600**	**17,100**	**16,100**	**17,000**
500	**260**	**14,600**	**17,100**	**14,800**	**15,300**
650	**343**	**14,600**	**17,100**	**13,800**	**14,100**
700	**371**	**13,300**	**15,600**	**13,500**	**13,900**
900	**482**	**5,000**	**5,900**	**12,400**	**13,200**
1100	**593**	**–**	**–**	**8,300**	**10,500**
1300	**704**	**–**	**–**	**3,100**	**3,500**

Determination of Approximate Pipe Wall thickness (t_N) For Various Pressures and Temperatures

$$t_N = \frac{.5PD}{SE - .6P} \quad (1.143)$$

t_N = Nominal pipe wall thickness (page D52) not including corrosion allowance

P = Max. pressure (PSIG)

D = Inside pipe **diameter** (in.)

S = Allowable stress from Table 1

E = Joint efficiency (assume a value of 1.0 for seamless pipe or welded pipe where full radiography is done)

Flange Pressure - Temperature Ratings

Maximum Allowable Pressure (PSIG)								
Metal	Temp. °F	Temp. °C	150 lb	300 lb	400 lb	600 lb	900 lb	1500 lb
Carbon Steel	100	38	285	740	990	1480	2220	3705
	200	93	260	675	900	1350	2025	3375
	300	149	230	665	875	1315	1970	3280
	400	204	200	635	845	1270	1900	3170
	500	260	170	600	800	1200	1795	2995
	600	316	140	550	730	1098	1640	2735
	650	343	125	535	715	1075	1610	2685
	700	371	110	535	710	1065	1600	2665
	750	399	95	505	670	1010	1510	2520
	800	426	80	410	550	825	1235	2060
	850	454	65	270	355	535	805	1340
	900	482	50	170	230	345	515	860
	950	510	35	105	140	205	310	515
	1000	538	20	50	70	105	155	260
304 Stainless Steel	100	38	275	720	960	1440	2160	3600
	200	93	235	600	800	1200	1800	3000
	300	149	205	540	720	1080	1620	2700
	400	204	190	495	660	995	1490	2485
	500	260	170	465	620	930	1395	2330
	600	316	140	435	580	875	1310	2185
	700	371	110	425	565	850	1275	2125
	800	426	80	495	540	805	1210	2015
	900	482	50	390	520	780	1165	1945
	1000	538	20	320	430	640	965	1605
	1100	593	—	255	345	515	770	1285
	1200	649	—	155	205	310	465	770
	1300	704	—	85	115	170	255	430
	1400	760	—	50	65	90	145	240
	1500	816	—	25	35	55	80	135
316 Stainless Steel	100	38	275	720	960	1440	2160	3600
	200	93	235	620	825	1240	1860	3095
	300	149	215	560	745	1120	1680	2795
	400	204	195	515	685	1030	1540	2570
	500	260	170	480	635	955	1435	2390
	600	316	140	450	600	900	1355	2255
	700	371	110	430	580	870	1305	2170
	800	426	80	420	565	845	1265	2110
	900	482	50	415	555	830	1245	2075
	1000	538	20	350	465	700	1050	1750
	1100	593	—	305	405	610	915	1525
	1200	649	—	185	245	370	555	925
	1300	704	—	115	155	235	350	585
	1400	760	—	75	100	150	225	380
	1500	816	—	40	55	85	125	205
304L 316L Stainless Steel	100	38	230	600	800	1200	1800	3000
	200	93	195	505	675	1015	1520	2530
	300	149	175	455	605	910	1360	2270
	400	204	160	415	550	825	1240	2065
	500	260	145	380	510	765	1145	1910
	600	316	140	360	480	720	1080	1800
	700	371	110	345	460	685	1030	1715
	800	426	80	330	440	660	985	1645

Reference ASME/ANSI B16.5 - 1998

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Technical Data - Metal & Wire Gauges/Pipe Sizes

Sheet Metal Gauges in Approximate Decimals of an Inch

No. of Sheet Metal Gauge	Manufacturers' Standard Gauge for Steel		300 Series Stainless Steel		Galvanized Sheet Steel Thk.
	Thk.	lbs./ft²	Thk.	lbs./ft²	
9	0.1495	6.2500	—	—	0.532
10	0.1345	5.6250	0.134	5.628	0.1382
11	0.1196	5.000	0.119	4.998	0.1233
12	0.1046	4.3750	0.103	4.326	0.1084
13	0.0897	3.7500	—	—	0.0934
14	0.0747	3.1250	0.074	3.108	0.0785
15	0.0673	2.8125	—	—	0.0710
16	0.0598	2.5000	0.059	2.478	0.0635
17	0.0538	2.2500	—	—	0.0575
18	0.0478	2.0000	0.047	1.974	0.0516
19	0.0418	1.7500	—	—	0.0456
20	0.0359	1.5000	0.035	1.470	0.0396
21	0.0329	1.3750	—	—	0.0366
22	0.0299	1.2500	0.030	1.260	0.0336
23	0.0269	1.1250	—	—	0.0306
24	0.0239	1.0000	0.024	1.008	0.0276
25	0.0209	0.87500	—	—	0.0247
26	0.0179	0.75000	0.019	0.798	0.0217
27	0.0164	0.68750	—	—	0.0202
28	0.0149	0.62500	—	—	0.0187
29	0.0135	0.56250	—	—	0.0172
30	0.0120	0.50000	—	—	0.0157
31	0.0105	0.43750	—	—	0.0142
32	0.0097	0.40625	—	—	0.0134
33	0.0090	0.37500	—	—	—
34	0.0082	0.34375	—	—	—
35	0.0075	0.31250	—	—	—
36	0.0067	0.28125	—	—	—

80-20 NiCr Wire Properties (650 OHMS circ. mil./ft)

B & S	Diameter		OHMS/FT	B & S	Diameter		OHMS/FT
	in	mm	77°F (25°C)		in	mm	77°F (25°C)
13	.072	1.828	0.125	25	.0179	0.455	2.029
14	.064	1.626	0.158	26	.0159	0.404	2.571
15	.057	1.448	0.200	27	.0142	0.361	3.224
16	.051	1.295	0.250	28	.0126	0.320	4.094
17	.045	1.143	0.321	29	.0113	0.287	5.090
18	.040	1.016	0.406	30	.0100	0.254	6.500
19	.036	0.914	0.501	31	.0089	0.226	8.206
20	.032	0.813	0.635	32	.0080	0.203	10.160
21	.0285	0.724	.800	33	.0071	0.180	12.890
22	.0253	0.643	1.015	34	.0063	0.160	16.330
23	.0226	0.574	1.273	35	.0056	0.142	20.730
24	.0201	0.511	1.609	36	.0050	0.127	26.000

Dimension of Steel Pipe

Diameter in Inches Nominal (O.D.)	Schedule No.	Wall Thickness in	Wall Thickness mm
1/8 (0.405)	10S	0.049	1.245
	40ST, 40S	0.068	1.727
	80XS, 80S	0.095	2.413
1/4 (0.54)	10S	0.065	1.651
	40ST, 40S	0.088	2.235
1/4 (0.54) cont...	80XS, 80S	0.119	3.023

Diameter in Inches Nominal (O.D.)	Schedule No.	Wall Thickness in	Wall Thickness mm
6 (6.625)	5S	0.109	2.759
	10S	0.134	3.404
	40ST, 40S	0.280	7.112
	80XS, 80S	0.432	10.97
	120	0.562	14.28
6 (6.625) cont...	160	0.719	18.26
	XX	0.864	21.95

Diameter in Inches Nominal (O.D.)	Schedule No.	Wall Thickness in	Wall Thickness mm
3/8 (0.675)	10S	0.065	1.651
	40ST, 40S	0.091	2.311
	80XS, 80S	0.126	3.200
1/2 (0.84)	5S	0.065	1.651
	10S	0.083	2.108
	40ST, 40S	0.109	2.769
	80XS, 80S	0.147	3.734
	160	0.188	4.775
	XX	0.294	7.468
3/4 (1.05)	5S	0.065	1.651
	10S	0.083	2.108
	40ST, 40S	0.113	2.870
	80XS, 80S	0.154	3.912
	160	0.219	5.563
	XX	0.308	7.823
1 (1.315)	5S	0.065	1.651
	10S	0.109	2.769
	40ST, 40S	0.133	3.378
	80XS, 80S	0.179	4.546
	160	0.250	6.350
	XX	0.358	9.093
1 1/4 (1.66)	5S	0.065	1.651
	10S	0.109	2.769
	40ST, 40S	0.140	3.556
	80ST, 80S	0.191	4.851
	160	0.250	6.350
	XX	0.382	9.703
1 1/2 (1.9)	5S	0.065	1.651
	10S	0.109	2.769
	40ST, 40S	0.145	3.683
	80XS, 80S	0.200	5.080
	160	0.281	7.137
	XX	0.400	10.16
2 (2.375)	5S	0.065	1.651
	10S	0.109	2.769
	40ST, 40S	0.154	3.912
	80ST, 80S	0.218	5.537
	160	0.344	8.738
	XX	0.436	11.07
2 1/2 (2.875)	5S	0.083	2.108
	10S	0.120	3.048
	40ST, 40S	0.203	5.156
	80XS, 80S	0.276	7.010
	160	0.375	9.525
	XX	0.552	14.02
3 (3.5)	5S	0.083	2.108
	10S	0.120	3.048
	40ST, 40S	0.216	5.486
	80XS, 80S	0.300	7.620
	160	0.438	11.13
	XX	0.600	15.24
3 1/2 (4.0)	5S	0.083	2.108
	10S	0.120	3.048
	40ST, 40S	0.226	5.740
	80XS, 80S	0.318	8.077
4 (4.5)	5S	0.083	2.108
	10S	0.120	3.048
	40ST, 40S	0.237	6.020
	80SX, 80S	0.337	8.560
	120	0.438	11.13
	160	0.531	13.49
	XX	0.674	17.12
5 (5.563)	5S	0.109	2.769
	10S	0.134	3.404
	40ST, 40S	0.258	6.553
	80XS, 80S	0.375	9.525
	120	0.500	12.70
	160	0.625	15.88
	XX	0.750	19.05

Diameter in Inches Nominal (O.D.)	Schedule No.	Wall Thickness in	Wall Thickness mm
8 (8.625)	5S	0.109	2.759
	10S	0.148	3.759
	20	0.250	6.350
	30	0.277	7.036
	40ST, 40S	0.322	8.179
	60	0.406	10.31
	80XS, 80S	0.500	12.70
	100	0.594	15.09
	120	0.719	18.26
	140	0.812	20.63
	XX	0.875	22.23
	160	0.906	23.01
10 (10.75)	5S	0.134	3.404
	10S	0.165	4.191
	20	0.250	6.350
	30	0.307	7.798
	40ST, 40S	0.365	0.365
	80S, 60XS	0.500	12.70
	80	0.594	15.09
	100	0.719	18.26
	120	0.844	21.44
	140, XX	1.000	25.40
	160	1.125	28.58
12 (12.75)	5S	0.156	3.962
	10S	0.180	4.572
	20	0.250	6.350
	30	0.330	8.382
	ST, 40S	0.375	9.525
	40	0.406	10.31
	XS, 80S	0.500	12.70
	60	0.562	14.28
	80	0.688	17.48
	100	0.844	21.44
	120, XX	1.000	25.40
	140	1.125	28.58
	160	1.312	33.33
14 (14)	5S	0.156	3.962
	10S	0.188	4.775
	10	0.250	6.350
	20	0.312	7.925
	30, ST	0.375	9.525
	40	0.438	11.13
	XS	0.500	12.70
	60	0.594	15.09
	80	0.750	19.05
	100	0.938	23.83
	120	1.094	27.79
	140	1.250	31.75
	160	1.406	35.71
16 (16)	5S	0.165	4.191
	10S	0.188	4.775
	10	0.250	6.350
	20	0.312	7.925
	30, ST	0.375	9.525
	40, XS	0.500	12.70
	60	0.656	16.66
	80	0.844	21.44
	100	1.031	26.19
	120	1.219	30.96
	140	1.438	36.53
	160	1.594	40.49
18 (18)	5S	0.165	4.191
	10S	0.188	4.775
	10	0.250	6.350
	20	0.312	7.925
	ST	0.375	9.525
	30	0.438	11.13
	XS	0.500	12.70
	40	0.562	14.28
	60	0.750	19.05
	80	0.938	23.83
	100	1.156	29.36
	120	1.375	34.93
	140	1.562	39.68
	160	1.781	45.24

Technical Data - Hazardous Locations

Atmospheric Conditions and Temperature Codes

The information listed on this page is to be used only as a general guide. Consult the latest edition of the Code to check the suitability of the explosion-proof heater to your needs.

For detailed information concerning the installation of electrical equipment in hazardous locations, refer to either the Canadian Electrical code Par 1 Section 18, available from the Canadian Standards Association, or the National Electrical Code Chapter 5 Articles 500 through 503, available from the National Fire Protection Association.

Where electrical equipment is required by Section 18 or Chapter 5 to be approved for the class of location, it shall also be approved for the specific gas, vapour, or dust that will be present. Such approval may be indicated by one or more atmospheric group designations which have been established for the purpose of testing and approval.

Note that the maximum external temperature of the equipment shall not exceed the minimum ignition temperature of the atmosphere as listed in Table 2.

For Example:
Assume the maximum heater temperature is listed as T2C or 446°F (230°C). This heater would not be suitable for use in atmospheres containing octanes but would be suitable for use in atmospheres containing gasoline.

For octanes, select a heater having a temperature code that does not exceed 403°F (206°C).

TABLE 1 Equipment Maximum Temperature

Temperature Code	Maximum External Temperature	
	°C	°F
T1	842	450
T2	572	300
T2A	536	280
T2B	500	260
T2C	446	230
T2D	419	215
T3	392	200
T3A	356	180
T3B	329	165
T3C	320	160
T4	275	135
T4A	248	120
T5	212	100
T6	185	85

TABLE 2 Atmospheric Conditions

Atmosphere	Min. Ignition Temp. Limit	
	°F	°C
Group A Containing		
Acetylene	581	305
Group B Containing		
Butadiene	788	420
Ethylene Oxide	804	429
Hydrogen	932	500
Manufactured Gases Containing More Than 30% Hydrogen (By Volume)	932	500
Propylene Oxide	930	499
Group C Containing		
Acetaldehyde	347	175
Cyclopropane	928	498
Diethyl Ether	320	160
Ethylene	842	450
Unsymmetrical Dimethyl Hydrazine (UDMH 1, 1-Dimethyl Hydrazine)	480	249
Group D Containing		
Acetone	869	465
Acrylonitrile	898	481
Alcohol (See Entyl Alcohol)		
Ammonia	1204	651
Benzene	928	498
Benzine (See Petroleum Naphtha)		
Benzol (See Benzene)		
Butane	549	287
1-Butanol (Butyl Alcohol)	649	343
2-Butanol (Secondary Butyl Alcohol)	761	405
Butyl Acetate	797	425
Isobutyl Acetate	790	421
Ethane	882	472
Ethanol (Ethyl Alcohol)	685	363
Ethyl Acetate	799	426
Ethylene Dichloride	775	413
Gasoline	536	280
Heptanes	399	204
Hexanes	433	223
Isoprene	743	395
Methane	999	537
Methanol (Methyl Alcohol)	725	385
3-Methyl-2-Propanol (Isoamyl Alcohol)	662	350
Methyl Ethyl Ketone	759	404
Methyl Isobutyl Ketone	838	448
2-Methyl-1-Propanol (Isobutyl Alcohol)	779	415
2-Methyl-2-Propanol (Tertiary Butyl Alcohol)	892	478
Naphtha (See Petroleum Naphtha)		
Natural Gas	900	482
Octanes	403	206
Pentanes	500	260
1-Pentanol (Amyl Alcohol)	572	300
Petroleum Naphtha	550	288
Propane	810	432
1-Propanol (Propyl Alcohol)	774	412
2-Propanol (Isopropyl Alcohol)	750	399
Propylene	851	455
Styrene	914	490
Toluene	896	480
Vinyl Acetate	756	402
Vinyl Chloride	882	472
Xylenes	865	463
Group E Comprising		
Atmospheres containing metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics		
Group F Comprising		
Atmospheres containing carbon blac, coal, or coke dust		
Group G Comprising		
atmospheres containing flour, starch, or grain dust, and other dusts of similarly hazardous characteristics		

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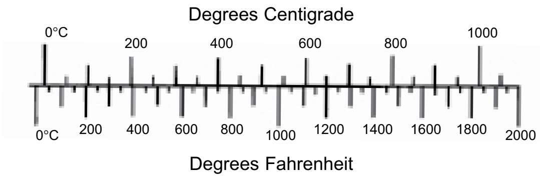
Technical Data - Conversion Data

°F = 9/5°C + 32
°C= 5/9 (°F - 32)

°R = °F + 460
°K - °C + 273



Common Conversion Factors

To Convert From	To	Multiply By
Heat Transfer		
p.c.u./(hr)(ft^2)(°C)	B.t.u./(hr)(ft^2)(°F)	1.
kg-cal./(hr)(m^2)(°C)	B.t.u./(hr)(ft^2)(°F)	0.2048
g-cal./(sec.)(cm^2)(°C)	B.t.u./(hr)(ft^2)(°F)	7,380.
watts/(cm^2)(°C)	B.t.u./(hr)(ft^2)(°F)	1,760.
watts/(in^2)(°F)	B.t.u./(hr)(ft^2)(°F)	490.
B.t.u./(hr)(ft^2)(°F)	p.c.u./(hr)(ft^2)(°C)	1.
B.t.u./(hr)(ft^2)(°F)	kg-cal./(hr)(m^2)(°C)	4.88
B.t.u./(hr)(ft^2)(°F)	g-cal./(sec.)(cm^2)(°C)	0.0001355
B.t.u./(hr)(ft^2)(°F)	watts/(cm^2)(°C)	0.000568
B.t.u./(hr)(ft^2)(°F)	watts/(in^2)(°F)	0.00204
B.t.u./(hr)(ft^2)(°F)	hp/(ft^2)(°F)	0.000394
B.t.u./(hr)(ft^2)(°F)	joules/(sec.)(m^2)(°C)	5.678
kg-cal./(hr)(m^2)(°C)	joules/(sec.)(m^2)(°C)	1.163
watts/(m^2)(°C)	joules/(sec.)(m^2)(°C)	1.0
Viscosity		
centipoises	g/(sec.)(cm) or poise	0.01
centipoises	lb/(sec.)(ft.)	0.000672
centipoises	lb/(hr)(ft.)	2.42
centipoises	kg/(hr)(m)	3.60
centipoises	(newton)(sec.)/m^2	0.001
lb/(sec)(ft)	(newton)(sec.)/m^2	1.488
Thermal Conductivity		
g-cal./(sec.)(cm^2)(°C/cm)	B.t.u./(hr)(ft^2)(°F/in)	2903.0
watts/(cm^2)(°C/cm)	B.t.u./(hr)(ft^2)(°F/in)	694.0
g-cal/(hr)(cm^2)(°C/cm)	B.t.u./(hr)(ft^2)(°F/in)	0.8064
B.t.u./(hr)(ft^2)(°F/ft)	joules/(sec.)(m^2)(°C)	1.731
B.t.u./(hr)(ft^2)(°F/in)	joules/(sec.)(m^2)(°C)	0.1442

Special Conversion Factors

To Convert From	To	Multiply By
Atmospheres	mm Mercury (0°C/32°F)	760.
Atmospheres	Newtons sq. meter	101,325.
Atmospheres	Ft. Water (3.9°C/39.1°F)	33.90
Atmospheres	Ins. Mercury (0°C/32°F)	29.921
Atmospheres	Pounds/sq. in	14.696
Bars	Pounds/sq in	14.504
Boiler H.P.	Kilowatts	9.803
Btu	Calories (gram)	252.
Btu/hr	Watts	0.29307
Btu/sec.	Watts	1,054.4
Btu/sq. ft./min	Kilowatts/sq. ft.	0.1758
Circular Mills	Square Inces	7.854×10^{-7}
Cubic Feet Water	Pounds	62.37
Cubic Feet/Minute	cm/sec	472.0
Cubic Feet/Minute	U.S. Gallons/sec.	0.1247
Cubic Feet/Second	U.S. Gallons/min.	448.8
Feet/Min.	Miles/Hour	0.011364
Gallons (U.S.)	Gallons (Imperial)	0.8327
H.P. (British)	Watts	745.7
Pounds	Grains	7,000.

S.I. Conversions

Basic Conversion Factors

Velocity			**Power**		
1 fps	=	0.3048 m/s	1 Btu/h(int.)	=	0.29307 W
1 fpm	=	0.00508 m/s	1 Btu/s(int.)	=	1.05506 kW
1 mph	=	0.44704 m/s	1 HP mech. (UK)	=	0.74570 kW
1 mph	=	1.60934 km/h	1 HP boiler	=	9.8095 kW
Length			**Density**		
1 inch	=	25.4 mm	1 lb/ft^3	=	16.01846 kg/m^3
1 foot	=	0.3048 m	1 lb/gal(imp.)	=	99.77633 kg/m^3
1 mile	=	1.60934 km	1 lb/gal(US)	=	119.82640 kg/m^3
Area			**Thermal Conductivity**		
1 sq. inch	=	6.4516 cm^2	1 Btu.ft/ft^2h.°F	=	1.73073 W/m°C
1 sq. foot	=	0.09290 m^3	1 Btu.in/ft^2h.°F	=	0.14423 W/m°C
Volume			**Volumetric Flow**		
1 $inch^3$	=	16.38706 cm^3	1 ft^3/s	=	0.028317 m^3/s
1 $foot^3$	=	0.02832 m^3	1 ft^3/s	=	101.9406 m^3/s
Capacity Imp. Measure			**Kinematic Viscosity**		
1 fluid oz.	=	28.41306 ml	1 ft^2/sq	=	0.092903 m^2/s
1 gallon	=	4.54609 l	1 centistoke (cSt)	=	1.0×10^{-6} m^2/s
Weight or Mass			**Dynamic Viscosity**		
1 oz.	=	28.34952 g	1 centipoise (cP)	=	0.001 Pa-s
1 lb.	=	0.45359 kg	1 lb./ft.s	=	1.488164 Pa-s
Pressure			**Heat Transfer**		
1 psi	=	6.89476 kPa	1 Btu/ft^2h.°F	=	5.67826 w/m^2°C
1 bar	=	10^5Pa	1 kcal/m^2h.°F	=	1.163 W/m^2°C
Energy			**Specific Energy**		
1 kWh	=	3.6 MJ	1 Btu/lb.	=	2.326 kJ/kg
1 watt-hour	=	3.6 kJ	1 cal/g	=	4.1868 kJ/kg
Frequency			**Specific Heat**		
1 cps	=	1 Hz	1 btu/lb.°F	=	4.1868 kJ/kg°C

Derived Units with Special Names

Measurement	Unit	Symbol	Derivation
Frequency	hertz	Hz	s-1
Force	newton	N	kg•m/s^2
Pressure	pascal	Pa	N/m^2
Energy	joule	J	N•m
Power	watt	W	J/s
Electric Potential	volt	V	W/A
Electric Resistance	ohm	Ω	V/A
Electric Conductance	siemens	S	1/ Ω
Electric Charge	coulomb	C	A•s
Capacitance	farad	F	C/V
Magnetic Flux	weber	Wb	V•s
Magnetic Flux Density	tesla	T	Wb/m^2
Inductance	henry	H	Wb/A
Luminous Flux	lumen	lm	cd•sr
Illumination	lux	lx	lm/m^2
Temperature	Celsius Degree	°C	K - 273.15
Pressure	bar	bar	10^5 Pa
Volume	liter	l	dm^3

The Preferred Prefixes

Prefix	Symbol	Meaning	Prefix	Symbol	Meaning
tera-	T	10^{12}	milli-	m	10^{-3}
giga-	G	10^{9}	micro-	μ	10^{-6}
mega-	M	10^{6}	nano-	n	10^{-9}
kilo-	k	10^{3}	pico-	p	10^{-12}
deci-	d	10^{-1}	femto-	f	10^{-15}
centi-	c	10^{-2}	atto-	a	10^{-18}

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PLEASE ADHERE TO INSTRUCTIONS PUBLISHED IN THIS MANUAL.
Failure to do so may be dangerous and may void certain provisions of your warranty.
For further assistance, please call:

Oakville: 1-800-410-3131

(U.S.A. and Canada)

Please have model and serial numbers available before calling.

WARRANTY: Under normal use the Company warrants to the purchaser that defects in material or workmanship will be repaired or replaced without charge for a period of 18 months from date of shipment, or 12 months from the start date of operation, whichever expires first. Any claim for warranty must be reported to the sales office where the product was purchased for authorized repair or replacement within the terms of this warranty.

Subject to State or Provincial law to the contrary, the Company will not be responsible for any expense for installation, removal from service, transportation, or damages of any type whatsoever, including damages arising from lack of use, business interruptions, or incidental or consequential damages.

The Company cannot anticipate or control the conditions of product usage and therefore accepts no responsibility for the safe application and suitability of its products when used alone or in combination with other products. Tests for the safe application and suitability of the products are the sole responsibility of the user.

This warranty will be void if, in the judgment of the Company, the damage, failure or defect is the result of:

- vibration, radiation, erosion, corrosion, process contamination, abnormal process conditions, temperature and pressures, unusual surges or pulsation, fouling, ordinary wear and tear, lack of maintenance, incorrectly applied utilities such as voltage, air, gas, water, and others or any combination of the aforementioned causes not specifically allowed for in the design conditions or
- any act or omission by the Purchaser, its agents, servants or independent contractors which for greater certainty, but not so as to limit the generality of the foregoing, includes physical, chemical or mechanical abuse, accident, improper installation of the product, improper storage and handling of the product, improper application or the misalignment of parts.

No warranty applies to paint finishes except for manufacturing defects apparent within 30 days from the date of installation.

The Company neither assumes nor authorizes any person to assume for it any other obligation or liability in connection with the product(s).

The Purchaser agrees that all warranty work required after the initial commissioning of the product will be provided only if the Company has been paid by the Purchaser in full accordance with the terms and conditions of the contract.

The Purchaser agrees that the Company makes no warranty or guarantee, express, implied or statutory, **(INCLUDING ANY WARRANTY OF MERCHANTABILITY OR WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE)** written or oral, of the Article or incidental labour, except as is expressed or contained in the agreement herein.

LIABILITY: Technical data contained in the catalog or on the website is subject to change without notice. The Company reserves the right to make dimensional and other design changes as required. The Purchaser acknowledges the Company shall not be obligated to modify those articles manufactured before the formulation of the changes in design or improvements of the products by the Company.

The Company shall not be liable to compensate or indemnify the Purchaser, end user or any other party against any actions, claims, liabilities, injury, loss, loss of use, loss of business, damages, indirect or consequential damages, demands, penalties, fines, expenses (including legal expenses), costs, obligations and causes of action of any kind arising wholly or partly from negligence or omission of the user or the misuse, incorrect application, unsafe application, incorrect storage and handling, incorrect installation, lack of maintenance, improper maintenance or improper operation of products furnished by the Company.