Technical Reference

Related Formulas

MASS FLOW RATE = VOL FLOW RATE x DENSITY

CENTIPOSE = CENTISTOKES x SPECIFIC GRAVITY

SCFM = FACE AREA (ft^2) x FACE VELOCITY (sfpm)

$$\text{PRESSURE (psi)} = \frac{\text{FORCE (pounds)}}{\text{AREA (in}^2\text{)}}$$

$$\text{VOL FLOW RATE(gpm)} = \frac{\text{VOLUME (gallons)}}{\text{TIME (minutes)}}$$

$$\text{INPUT POWER (hp)} = \frac{\text{PRESSURE (psig) x FLOW (gpm)}}{1714}$$

$$\text{VEL THROUGH PIPING (ft/s)} = \frac{\text{0.3208 x FLOW RATE (gpm)}}{\text{INTERNAL AREA (in}^2\text{)}}$$

$$\text{SPECIFIC GRAVITY OF A FLUID} = \frac{\text{WT OF ONE CUBIC FT OF FLUID}}{\text{WT OF ONE CUBIC FT OF WATER}}$$

$$\text{PUMP OUTLET FLOW (gpm)} = \frac{\text{RPM x PUMP DISPLACEMENT (in /rev)}}{231}$$

$$\text{PUMP INPUT POWER (hp)} = \frac{\text{FLOW RATE OUTPUT (gpm) x PRESSURE (psig)}}{\text{1714 x OVERALL EFFICIENCY}}$$

$$\text{OVERALL PUMP EFFICIENCY (\%)} = \frac{\text{OUTPUT HORSEPOWER x 100}}{\text{INPUT HORSEPOWER}}$$

OVERALL PUMP EFFICIENCY (%) = VOL EFF. X MECHANICAL EFF.

$$\text{VOL PUMP EFFICIENCY (\%)} = \frac{\text{ACTUAL FLOW RATE OUTPUT (gpm) x 100}}{\text{THEORETICAL FLOW RATE OUTPUT (gpm)}}$$

$$\text{MECHANICAL PUMP EFFICIENCY (\%)} = \frac{\text{THEORETICAL TORQUE TO DRIVE x 100}}{\text{ACTUAL TORQUE TO DRIVE}}$$

$$\text{PUMP DISPLACEMENT (in}^3\text{/rev)} = \frac{\text{FLOW RATE (gpm) x 231}}{\text{PUMP RPM}}$$

$$\text{PUMP TORQUE (inlbs)} = \frac{\text{HORSEPOWER x 63025}}{\text{RPM}}$$

$$\text{PUMP TORQUE (inlbs)} = \frac{\text{PRESSURE (psig) x PUMP DISPLACEMENT (in /rev)}}{2\pi}$$

RESERVOIR COOLING CAPACITY (BTU/HR) = 2 x $\triangle$T BETWEEN RESERVOIR WALLS AND AIR (°F) x RESERVOIR AREA (ft^2)

HEAT IN HYDRAULIC SYSTEM DUE TO UNUSED FLOW/PRESSURE (BTU/HR = FLOW RATE(gpm) x 1.485 x PRESSURE DROP (psig)

Heat Transfer in Fluids

General

Most fluid power systems require a method of heat transfer (dissipation or absorption).

Producing Heat

The energy loss is caused by inefficiencies of the energy process. Some of these losses contribute to the fluid heating. Heat is also produced by passing pressurized fluid through orifices, valves, and piping where a pressure drop occurs. Keeping these pressure drops to a minimum conserves performance and reduces costs. The following table shows the types of systems that will have losses to the fluid and/or the reservoir:

System	% Loss
Simple circuits with minimal valves	25%
Simple circuits with cylinders	28%
Simple circuits with fluid motors	31%
Hydrostatic transmissions	35-40%
Servo based systems	55%
Low pressure fluid transfer systems	15%

These losses are expressed in unites of power, e.g., HP, KW and BTU/HR. Heat problems are usually expressed in HP or KW in terms of the work expanded and losses absorbed. Cooling problems are usually expressed in BTU/HR.

ttp-sales@apiheattransfer.com +1.262.554.8330

Conversion and Formula Summary

There are many conversions and formulas used in selecting oil coolers. This will be a brief summary of those most commonly used.

Conversions

- HP = (BTU/HR) / 2545 = (BTU/min) / 42.4 = KW/.746, or BTU/HR = HP x 2545; BTU/min = HP x 42.4; KW = HP x .746
- GPM = (L/min) / 3.78 or L/min = GPM x 3.78
- °F = (1.8 x °C) + 32 or °C = (°F - 32) / 1.8
- Mobil Series: Air Velocity SFPM = SCFM/Face Area in FT^2, or SCFM = FT^2 Face Area x Face Velocity SFPM

Methods to Determine Heat Loads

- Hydraulic oil cooling: Assume 30% of the input horsepower will be rejected to heat. If the input horsepower is unknown, this formula may be used: BTU/HR = (System PSI) x (GPM Flow) x 1.8 x .3
- Hydrostatic oil cooling: Assume 25% of the input horsepower will be rejected to heat.
- Automatic transmission: Assume 30% of the engine horsepower will be rejected to heat.
- Engine oil cooling: Assume 10% of the engine horsepower will be rejected to heat.

Heat Loads

- BTU/HR = (Input Horsepower) x (2545) x (.25 – .5)
- BTU/HR = (System GPM Capacity) x (System Pressure) x (1.8) x (.25 –5)
- BTU/HR = (PSI Pressure Drop) x (GPM Oil Flow) x (1.5) x (% Time)
- BTU/HR = (Horsepower to Gearbox) x (2545 x (.05 – .5)
- BTU/HR = (Compressor HP) x (1.1) x (.85) x (2545)
- BTU/HR = (Max Temp. Rise °F/HR) x (Gallons of Oil Changing Temp.) x (3.5)
- BTU/HR = (GPM Oil Flow) x (Oil △T) x (210)

Conversions

°F = (1.8 x °C)+32

BAR = PSI ÷ 14.5

BTU/hr = WATTS ÷ .2931

BTU/min = KW ÷ .01757

ft^2 = in^2 ÷ 144

ft^2 = mm^2 ÷ 92900

GPM = L/min ÷ 3.78

HP = BTU/hr ÷ 2545

HP = BTU/min ÷ 42.41

HP = KW ÷ 0.746

in^2 = mm^2 ÷ 645.2

in^3 = GAL ÷ .004329

in^3 = LITERS ÷ .01639

m^3 = GAL ÷ 264.2

m^3 = LITERS ÷ 1000

mm = 25.4 x in

PSIG = PSIA - 14.7

1 ton = 12,000 BTU/HR

$$\frac{KW}{°C} = \frac{HP}{°F} \times 1.343$$

Temperature Changes

- Oil △T = (BTU/HR) / (GPM Oil Flow x 210)
- Water △T = (BTU/HR) / (GPM Water Flow x 500)
- 50/50 Ethylene Glycol △T = (BTU/HR) / (GPM Flow x 432)
- Air △T = (BTU/HR) / (SCFM Air Flow x 1.08)

Temperature Changes

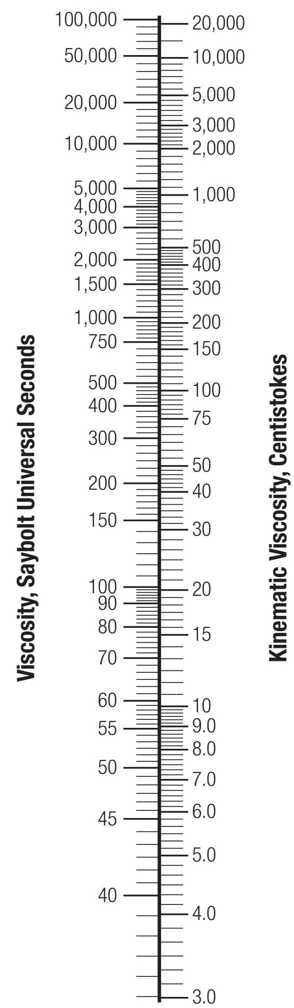
Water Cooled: $$\text{HP curve} = \frac{\text{HP Heat x 40 x Correction A}}{\text{(Oil outlet °F - Water inlet °F)}}$$

AO Series: (except AOL) $$\text{HP curve} = \frac{\text{HP Heat x 100}}{\text{(Oil outlet °F - Ambient air °F)}}$$

AOL Series: $$\text{HP curve} = \frac{\text{HP Heat x 100}}{\text{(Oil inlet °F - Ambient air °F)}}$$

Mobile Series: $$\text{BTU/HR curve} = \frac{\text{HP Heat x 2545 x 100}}{\text{(Oil inlet °F - Ambient air °F)}}$$

Centistokes to Saybolt Universal Seconds Conversion



Heresite Corrosion Protection

Heresite is a unique baked phenolic coating TTP uses to protect air cooled heat exchangers from external corrosion.

The following information has been supplied to TTP by Heresite-Saekaphen Inc.

Introduction

The first HERESITE coating application to the exterior surfaces of finned tube coils took place over thirty years ago. Since that time, the HERESITE baked phenolic coating has effectively demonstrated its value in protecting heat transfer coils from corrosive attack, hereby increasing equipment service life. The excellent chemical and temperature resistance, coupled with the superior heat transfer properties of the HERESITE coating, lead to outstanding results.

Description

The HERESITE coating of finned tube coils is accomplished by a multiple coat application of dipping and baking, resulting in complete coating coverage of the fins, tubes, headers, casings, etc. Consequently, protection against corrosion is provided for the entire coil. Due to specialized surface preparation techniques, plus the good adhesive properties of the HERESITE coating, it is possible to efficiently HERESITE coat all the usual metals used in fabricating finned tube coils.

The HERESITE coating that is applied to finned tube coils is a Flexible Brown Baked Phenolic Coating. This coating is applied to either aluminum, copper or steel with equal results.

We feel it is important to emphasize that HERESITE baked phenolic coatings are manufactured and sold only by HERESITE-SAEKAPHEN, INC. Further, the application of the HERESITE baked phenolic coating to finned tube coils is performed only at our plant in, Manitowoc, Wisconsin.

Practically all types of finned tube coils used for oil, water, air, gas and process cooling (and heating), as well as large condensing coils can be HERESITE protected against damaging environments. Currently, the HERESITE coating of air-conditioning and industrial process coils exposed to corrosive fumes and salt atmosphere is on the increase.

HERESITE coating offers a more economical solution than special metals for these applications. For example, we understand that aluminum fin coils coated with HERESITE are more economical than copper fin coils. Special metal casing materials are unnecessary since the HERESITE coating is applied to the casing as well as to the finned tubes. Additionally, HERESITE coated aluminum fins will resist attack from most cleaning agents more successfully than copper fin coils. It is noted that the HERESITE coating is applied to both plate fin coils as well as spiral wound tubing.

Chemical Resistance

The HERESITE baked phenolic coating will withstand exposure to practically all corrosive and chemical fumes with the exception of strong alkalis such as sodium hydroxide, strong oxidizing agents such as aqua regia and concentrations of bromine, chlorine, and fluorine in excess of 100 parts per million. Complete chemical resistance data is shown on the following page.

Temperature Resistance

Maximum temperature resistance of 450°F. However, HERESITE baked phenolic coatings cannot be recommended for all chemical atmospheres at temperatures up to 450°F since corrosive activity and permeation may be greater at higher temperatures depending upon the chemicals involved. Excellent adhesion and flexibility enable HERESITE coating to withstand thermal shock. Also, the HERESITE lining will operate at sub zero temperatures without loss of chemical and mechanical properties.

Thermal Conductivity

The HERESITE baked phenolic coating is a good thermal conductor and its thermal conductivity is expressed as approximately 2000 BTU per hour per square foot per degree Fahrenheit based on an average 3 mil coating thickness. The “K” factor = 6.0.

Coil manufacturers have indicated there is no need to add additional heating or cooling surface due to the presence of the HERESITE coating.

Guide to Chemical Resistance of HERESITE Baked Phenolic Linings: HERESITE baked phenolic linings will withstand exposure to practically all corrosive atmospheres with the exception of strong alkalis, strong oxidizers and wet bromine, chlorine and fluorine in concentrations greater than 100 PPM. Due to the fact that resistance of HERESITE is dependent upon conditions of service, environment, fabrication details plus other factors, TTP should be consulted for specific recommendation.

HERESITE Advantages

- Elimination of costly metals
- Extended service life
- Smooth surface – reduced cleaning
- Complete coverage by dipping
- Good thermal conductor
- Good abrasion resistance
- Resistant to many corrosive environments
- Good temperature resistance

Note

3 week lead time adder

HERESITE

HERESITE is **resistant** to Fumes of the Following

acetates - all
acetic acid
acetone
acetylene
acrylonitrile
alcohols - all
aldehydes - all
alum
amines - all
ammonia
ammonium hydroxide
ammonium nitrate
aniline
benzoic acid
benzol
boric acid
brine
butane
carbolic acid
carbonates - all
carbon monoxide
carbon tetrachloride
chlorides - all
chlorinated solvents - all
chlorine - less than 100 ppm
chloroform
chromic acid
citric acid
coke oven gas
esters - all
ethers - all
ethylene oxide
fatty acids
fluosilicic acid
formaldehyde
formic acid
freon
fuels - all
gases - inert
gases - manufactured
gases - natural
glycerin
glycols - all
hydrocarbons - all
hydrochloric acid
hydrogen
iodides - all
ketones - all
lacquers
lactic acid
maleic acid
malic acid
methanol
methylene chloride
naphthalene
nitrates - all
nitric acid (dilute)
nitrates - all
nitrobenzene
nitrogen fertilizers
oils, mineral and vegetable - all
oxalic acid
oxygen
perchloric acid (dilute)
phenol
phosphoric acid
picric acid
propane
salicylic acid
silicic acid
steam vapor
stearic acid
sulfate liquors
sulfonic acid
sulfur dioxide
sulfuric acid
sulfurous acid
surfactants
tannic acids
tetraethyl lead
toluene
trisodium phosphate
urea
saltwater
water
xylene

HERESITE is **not resistant** to Fumes of the Following

aluminum fluoride
ammonium fluoride
aqua regia
bleaching compounds
brass plating solutions
bromine - over 100 ppm
bronze plating solutions
cadmium cyanide
calcium hypochlorite
caustic soda
chlorine - over 100 ppm
cyanide plating solutions
fluorine - over 100 ppm
hydrofluoric acid (conc.)
hydrogen peroxide
hypochlorites
nitric acid (conc.)
nitrogen oxides
potassium hydroxide
sodium fluoride (conc.)
sodium hydroxide (conc.)

ttp-sales@apiheattransfer.com +1.262.554.8330

High Elevation – Air Cooled Oil Coolers

When sizing air cooled heat exchangers for high elevation applications, consideration should be given to the loss in performance because of the lower density of the cooling air. Use one of the following formulas that has an added factor CE1 or CE1 to offset this loss of performance. The net result of these calculations is a larger cooler.

C_{E1}

1. For AO, ACOC, AOVH, Air or Gas Aftercoolers (Air Cooled) coolers, AOC - Industrial and RM

$$\frac{\text{Horsepower to be removed x 2545 x Cv x CE1}}{\text{°F (Oil Leaving - Ambient Air Entering)}}$$

C_{E2}

2. For AOL, BOL, MA, OCA, ACOC(H), AOC - Mobile, MF, DF, DH, AOHM and AOVHM

Horsepower at Elevation = Horsepower Heat Load x C_{E2}

Elevation	C_{E1}	C_{E2}
0	1.00	1.00
1000	1.03	1.02
2000	1.05	1.04
3000	1.08	1.07
4000	1.10	1.08
5000	1.12	1.10
6000	1.14	1.11
7000	1.16	1.12
8000	1.18	1.12
9000	1.20	1.13
10000	1.22	1.14
11000	1.24	1.14
12000	1.25	1.15
13000	1.27	1.15
14000	1.28	1.15
15000	1.30	1.16

Shell & Tube Recommendations

Installation

The satisfactory use of this heat exchange equipment is dependent upon precautions which must be taken at the time of the installation.

1. Connect and circulate the hot fluid in the shell side (over small tubes) and the cooling water in the tube side (inside small tubes). Note piping diagrams.
2. If an automatic water regulating valve is used, place it on the INLET connection of the cooler. Arrange the water outlet piping so that the exchanger remains flooded with water, but at little or no pressure. The temperature probe is placed in the hydraulic reservoir to sense a system temperature rise. Write the factory for water regulating valve recommendations.
3. There are normally no restrictions as to how this cooler may be mounted. The only limitation regarding the mounting of this equipment is the possibility of having to drain either the water or the oil chambers after the cooler has been installed. Both fluid drain plugs should be located on the bottom of the cooler to accomplish the draining of the fluids. Drains are on most models.
4. It is possible to protect your cooler from high flow and pressure surges of hot fluid by installing a fast-acting relief valve in the inlet line to the cooler.
5. It is recommended that water strainers be installed ahead of this cooler when the source of cooling water is from other than a municipal water supply. Dirt and debris can plug the water passages very quickly, rendering the cooler ineffective. Write the factory for water strainer recommendations.
6. Fixed bundle heat exchangers are generally not recommended for steam service. For steam applications, a floating bundle exchanger is required. Note: When installing floating bundle unit, secure one end firmly and opposite end loosely to allow bundle to expand and contract. Consult factory for selection assistance.
7. Piping must be properly supported to prevent excess strain on the heat exchanger ports. If excessive vibration is present, the use of shock absorbing mounts and flexible connectors is recommended.

Service

Each heat exchanger has been cleaned at the factory and should not require further treatment. It may be well to inspect the unit to be sure that dirt or foreign matter has not entered the unit during shipment. The heat exchanger should be mounted firmly in place with pipe connections tight.

Caution

If sealant tape is used on pipe threads, the degree of resistance between mating parts is less, and there is a greater chance for cracking the heat exchanger castings. Do not overtighten. When storing the unit, be sure to keep the oil and water ports sealed. If storage continues into cold winter months, the water chamber must be drained to prevent damage by freezing.

Performance information should be noted and recorded on newly installed units so that any reduction in effectiveness can be detected. Any loss in efficiency can normally be traced to an accumulation of oil sludge, or water scale.

Recommendations

Replace gaskets when removing end castings. It is recommended that gaskets be soaked in oil to prevent corrosion and ensure a tight seal.

Salt water should not be used in standard models. Use salt water in special models having 90/10 copper-nickel tubes, tube sheets*, bronze bonnets and zinc anodes on the tube side. Brackish water or other corrosive fluids may require special materials of construction.

When zinc anodes are used for a particular application, they should be inspected two weeks after initial startup.

At this time, by visual inspection of the anode, determination of future inspection intervals can be made, based on the actual corrosion rate of the zinc metal.

The zinc anodes must be replaced when 70% of the zinc volume has been consumed.

It may be necessary to drain the water chambers of the exchanger to protect it from damage by freezing temperatures. Drains are provided in most standard models.

The oil chamber of the exchanger may become filled with sludge accumulation and require cleaning. It is recommended that the unit be flooded with a commercial solvent and left to soak for one-half hour. Backflowing with the solvent or regular oil will remove most sludge. Repeated soaking and backflowing may be required, depending on the degree of sludge buildup.

It may be necessary to clean the inside of the cooling tubes to remove any contamination and/or scale buildup. It is recommended that a fifty-fifty percent solution of inhibited muriatic acid and water may be used. For severe problems, the use of a brush through the tubes may be of some help. Be sure to use a soft bristled brush to prevent scouring the tube surface causing accelerated corrosion. Upon completion of cleaning, be certain that all chemicals are removed from the shellside and the tubeside before the heat exchanger is placed into service.

When ordering replacement parts or making an inquiry regarding service, mention model number, serial number, and the original purchase order number.

**Available on HC/SSC/SSCA Series models only.*

ttp-sales@apiheattransfer.com +1.262.554.8330

Maximum Shell & Tube Flow Rates

CAUTION

Incorrect installation can cause this product to fail prematurely, causing the shell side and tube side fluids to intermix. Maximum allowable flow rates are as charted below.

B Series Model No. Example: B-702-A4-F

Unit Size	Shell Side (GPM) / Baffle Spacing					Tube Side (GPM)		
	A	B	C	D	E	0	T	T
400	9.6	—	—	—	—	25		
700	17	29	29	—	—	61	31	15
1000	24	48	69	69	—	146	73	37
1200	29	57	115	115	—	224	112	56
1600	37	75	149	253	—	363	181	91
2000	—	—	187	347*	457*	652	326	163

*281 GPM maximum for all B-2005-D **500 GPM maximum for all B-20080-E and 562 GPM maximum for all B2006-E6 or B-2006-E10
562 GPM maximum for all B-2006-E6 or B-2006-E10

A Series Model No. Example: A-1024-2-6-F

Unit Size	Baffle Spacing	Shell Side (GPM)	Tube Side (GPM)		
			0	T	F
SA-400	.75	7	18	—	—
	2	19			
600	1	14	48	24	12
	1.5	21			
	2	29			
	4	29			
800	1.5	29	87	43	21
	2	38			
	3	57			
	4	69			
1000	1.5	32	146	73	37
	2	42			
	3	60			
	4	69			
1200	2	51	224	112	56
	3	77			
	4	103			
	6	115			
1600	26	66	280	203	101
	3	100			
	4	133			
	6	200			

HC / SSC Series Model No. Example: HC-1024-2-6-F

Unit Size	Baffle Size	Shell Side (GPM)	Tube Side (GPM)		
			0	T	F
600	1.38	19	48	24	12
	2	29			
	3	29			
800	1.38	26	84	42	21
	1.7	31			
	2	38			
	3	57			
	4	69			
1000	1.38	24	146	23	37
	2	41			
	3	64			
	5	69			
1200	2.5	60	224	112	56
	3	77			
	3.62	93			
	5	115			
	6	115			
1700	3.	125	465	232	116
	4	143			
	4.5	161			
	5	179			
	6	215			
	7	251			
	8.4	253			

EC Series Model No. Example: EC-1236-6-F

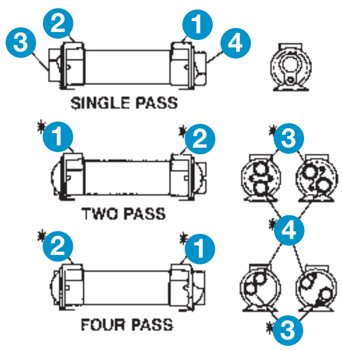
Unit Size	Baffle Size	Shell Side (GPM)	Tube Side (GPM)		
			0	T	F
1000	4	55	66	33	15
	6	70			
	8	70			
1200	4	65	120	60	28
	6	100			
	8	115			
	12	115			
1700	4	90	220	110	52
	6	140			
	8	190			
	12	255			

K / EK Series Model No. Example: EK or K-712-F

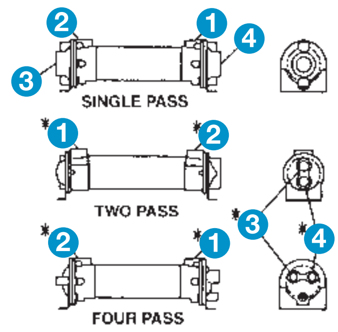
Unit Size	Shell Side (GPM)	Tube Side (GPM)	
		0	T
500	20	13	—
100	70	24	12
1000	100	56	28

Piping Hook-up

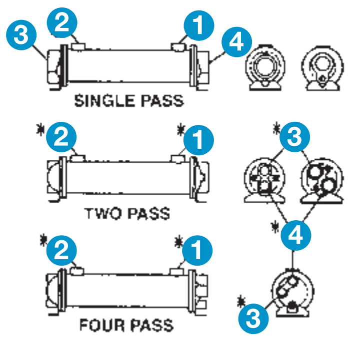
A Series



B Series

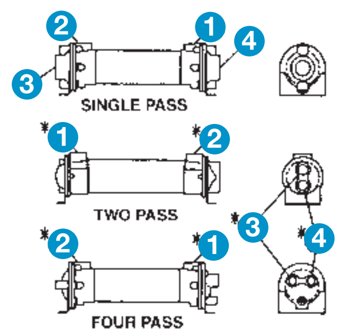


HC / SSC / EC Series

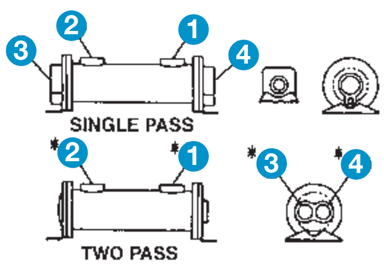


EC bonnet rotation is slightly different from what is shown. See Series literature for details.

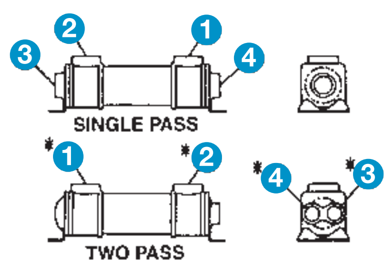
SLE / SL / R Series



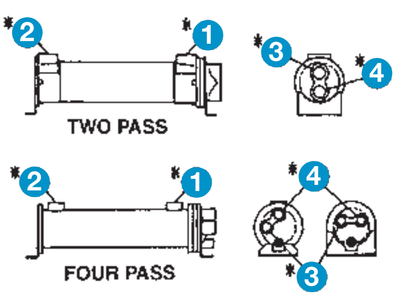
EK / EKS / EKM Series



K / KN Series



U / UC / UR Series



Note baffle location when inserting bundle into shell assembly after cleaning.

1 Hot Fluid In

2 Cooled Fluid Out

3 Cooling Water In

4 Cooling Water Out

*Note: For all two pass and four pass heat exchangers: connections 1 and 2 may be reversed, and connections 3 and 4 may be reversed with no effect on performance.