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SX - 2 Heating and Cooling Coils

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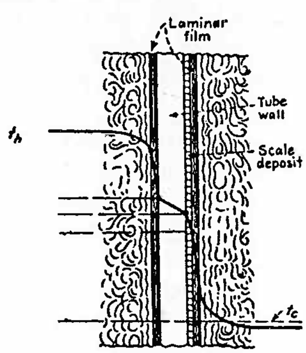
Introduction

Heat exchangers are available in all kind of sizes and shapes. Each one has its proper place in industrial heat transfer applications. There are out-of-tank heat exchangers, mostly shell and tube, and in-tank exchangers. In-tank heat exchangers are available in plate and tubular form.

We will familiarize you with the many advantages that in-tank tubular heat exchangers can offer. Their most outstanding one is their flexibility in design, manufacturing and installation.

Background Information

In almost all cases of heat transfer, resistance has to be overcome. Various resistances exist along the walls separating the hot and the cold media. The sum of these resistances is called "U" and consists of several factors.



Temperature drops through a tube wall, including inside and outside boundary layers.

On the very outside of the tubes a laminar sublayer of liquid exists which is defined as the external film coefficient.

Next, toward the center of the tube, scale deposits could be present. They create fouling factors which can severely effect the efficiency of any heat exchanger. Proper maintenance and frequent cleaning can greatly reduce the effect of these deposits and will therefore not be considered further.

The actual metal walls are next, offering resistance to heat transfer based on the thermal conductivity of the metal. There could be some internal scale deposits here. Finally, there is the inside laminar sublayer of fluid (the internal film coefficient).

The objective of each heat exchanger is to reduce the resistance to heat transfer. This can be accomplished in several ways.

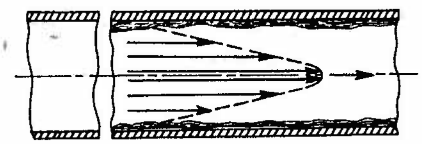
First, as mentioned above, the surfaces of a heat exchanger should be kept clean. Second, select metal with good heat conductivity values. Select metal tubes and avoid plastic if at all possible. In order to avoid plastic, which has very poor heat transfer properties, metal heat exchangers are offered in a wide variety of metals to accommodate many different chemical environments.

Changes in the thickness of the wall in thin wall tubing has only minor effects on heat transfer. The most important problem in achieving good heat transfer is related to the external and internal film coefficients. For this reason, you must consider the laminar and turbulent flow of liquids inside and outside of the heat exchanger tubes.

In order to illustrate the importance of proper flow behavior, calculations were carried out by the author, comparing an in-tank tubular heat exchanger with internal laminar flow with one with internal turbulent flow. Keeping all criteria identical and just using the required heat transfer area as the only variable, the results showed that a heat exchanger with internal laminar flow requires a heat transfer area of about 200 percent larger than one designed for turbulent flow. This is very important to remember when selecting a heat exchanger.

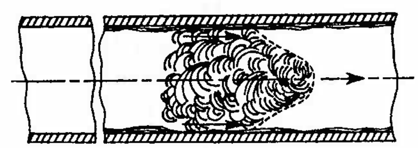
Laminar and Turbulent Flow

In laminar, or stream line flow, the



Laminar flow pattern inside a tube.

elements of the fluid flow parallel each other, without any large amount of mixing, and the resulting laminar boundary layer stays thick. All heat transfer is done by conduction, and the resistance to heat transfer is large.



Turbulent flow pattern inside a tube.

In turbulent flow, the fluid elements mix, setting up eddy motion and stripping the boundary layer from the wall, thereby ensuring that the boundary layer is small and the resistance to heat transfer is reduced.

Turbulent or laminar flows are defined by a Reynolds number. The Reynolds number is a dimensionless number and is a function of the fluid velocity inside the tubes, the tube diameter and the viscosity of the liquid. A number below 2500 indicates laminar flow and one above 2500 indicates development to or fully developed turbulent flow.

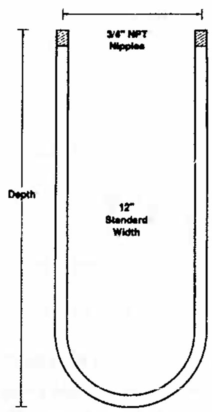
Fluids on the outside of the heat exchanger inside tanks, without work loads added, are completely at rest, and the boundary layer is as thick as the entire tank — surely very poor conditions for heat transfer. As the heat exchanger warms, so does the liquid adjacent to the tubes. The density of the fluid close to the heat exchanger walls changes, the fluid rises, some flow pattern develops and natural buoyancy creates a slowly developing free convection heat transfer pattern.

The heat transfer from the outside surface of the tubes to the fluid can be greatly improved without waiting for the conversion from free to forced convection to occur. This is done by introducing mechanical means to move the fluid inside the tank with the use of pumps, agitators or airspargers.

For enhanced outside heat transfer, MBA Manufacturing has introduced a heat exchanger unit containing an attached air sparge, demonstrating the versatility that can be accomplished with tubular in-tank heat exchangers.

Flexibility In Design, Manufacturing and Installation

Various shapes and configurations for tubular in-tank heat exchangers, or coils as they are generally known, are available, and all of these can be varied to meet specific heat transfer requirements.

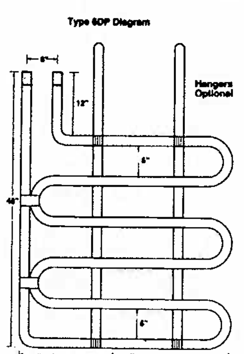


Standard U-Coil, depth and width are variable.

First, the smallest and simplest in-tank tubular heat exchanger are known as U-Coils.

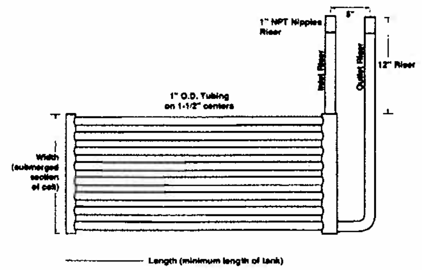
These coils are used for minimum heat-transfer requirements and are available in different lengths and widths to accommodate individual applications.

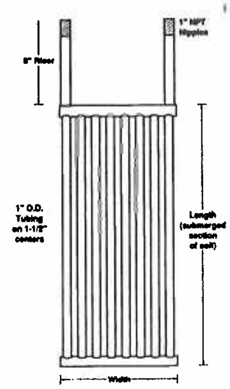
Serpentine coils are available for somewhat more demanding heat transfer requirements. They can be provided with as many loops as required, and the lengths of the coils are variable.



Standard Serpentine Coil, length, width and number of loops are variable.

While the design of U-coils and Serpentine coils is fairly straightforward, the design of grid coils provides a wide range of adjustability to ensure maximum heat transfer. Grid coils come in two basic styles — vertical and horizontal.





Standard horizontal and vertical grid coil, length, width and number of heat transfer tubes are variable.

Grid coils, as shown here, consist of two parallel manifolds — mostly 2" diameter tubing — connected with a series of 1" diameter tubes on all coils. Inlet and outlet connections are provided with male pipe nipples to allow for ease of installation.

Flexibility in Design

Design for Turbulent Flow

Theoretical background information and the design of grid coils will now be put together to illustrate how to achieve the desired heat-transfer properties for an in-tank tubular heat exchanger.

The manifolds on grid coils are baffled internally to achieve serpentine flow of the heating liquid through the exchanger. The location of these baffles varies on many grid coils. They are placed strategically to match the liquid flow to an appropriate tubular cross-sectional area.

Remember the Reynolds number, which is, among other things, a function of liquid flow and cross sectional area, and also remember how important turbulent flow is.

Here, the theoretical knowledge can be applied to practical applications. By strategically placing baffles inside manifolds, each coil ensures turbulent flow inside the heat transfer tubes. Baffles can be placed to achieve single, double, triple or more tube flow, all a function of the amount of heating liquid available in individual applications. This always ensures turbulent flow and maximum heat transfer. No pre-designed in-tank heat exchanger can provide this kind of flexibility.

Design for Steam Application

Tubular coils for steam application are somewhat different in design than coils for liquid flow, especially in the placing of baffles inside the manifolds. The main concern is to ensure that the entire coil is being used as a steam exchanger, and not just that part of the coil that is flooded permanently with condensate.

This can be achieved by limiting the size of the tubular in-tank heat exchanger to a heat transfer surface area not to exceed 25 sq ft. If more than 25 sq ft of surface area is required in the specific application, a grid coil should be divided into several individual heat transfer zones, none of which should exceed 25 sq ft. Through strategically placed baffles and sectional inlet arrangements the unit becomes a multi-zoned heat exchanger, with condensate rejected from the unit through a single return pipe.

Design for Corrosion Resistance

The selection of a special metal for a specific solution is obviously important. However, with so many proprietary solutions on the market, it sometimes might be advisable to consult with the supplier of these chemicals and follow their recommendations.

A common problem encountered on in-tank heat exchangers is corrosion caused by stray currents. Preventing metal-to-metal contact inside a tank and installing di-electric couplings on coil inlet and outlet connectors can often eliminate this problem.

Unintended changes in the concentration of chemical solution inside the tank can, under certain circumstances, result in severe corrosion. Overcoming this problem requires close monitoring of the solution. It has to be ensured that the solution inside the tank is in constant movement through agitators or through the thru-put of parts to be treated. Some in-tank heat exchangers are manufactured using solid metal sheets. Such a heat exchanger can easily separate one part of the tank from an other, especially in small and restricted areas. This can allow the concentration level to rise.

Grid coils do not create this problem. Through their design, they not only enhance heat transfer, they also enhance free circulation of liquid inside tanks. Therefore, they are less subject to corrosion than other in- tank heat exchangers.

Another often observed type of corrosion occurs on the inlet and outlet tubes (where they break through the surface of a liquid). Liquid boiling at these points cause chemicals to concentrate. A solution to this problem is to install insulating sleeves on critical points. These sleeves consist of a tube larger in diameter than the inlet and outlet tubes, sealed hermetically on both ends. This provides air insulation, and boiling of the solution at these points is avoided.

Flexibility In Installation

Effective heat transfer means saving money. Highly efficient heat exchangers are small, require a minimum amount of space and are cost efficient per square foot of heat transfer area. In order to achieve these objective in heat transfer, several physical conditions have to be met, like turbulent flow inside and outside the heat exchanger surfaces. This requires a high degree of versatility and flexibility in the design and manufacturing process. No pre-designed or pre-manufactured heat exchanger can provide these criteria, only custom-designed tubular heat exchangers can achieve this.

The flexibility in design and manufacturing of these tubular in-tank heat exchangers guarantees to accommodate and fit existing and new systems and not the other way around (systems accommodating and fitting pre-designed heat exchangers).

To summarize, tubular in-tank heat exchangers provide the user with the following advantages:

- virtual guarantee of turbulent flow inside heat-exchanger tubes
- excellent free- and forced-convection heat transfer on outside heat exchanger tubes
- design features that reduce corrosion
- guarantee of unrestricted mixing of solutions inside tanks
- high degree of flexibility in design and physical configurations
- availability in a wide selection of highly conductive metals
- low cost per square foot of heat transfer area
- ease of installation, maintenance, and repair

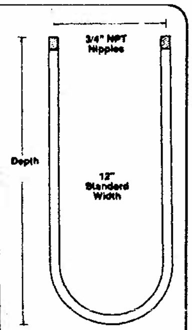
For general information, some coil selection charts have been provided. Coils shown on these charts are standard sizes; however, as outlined, all dimensions and configurations can be modified and adjusted to accommodate specific and individual requirements.

SX-2 U-COILS are especially suited for heating and cooling application where a limited amount of heat transfer is required and/or where small tanks are involved.

SX-2 U-COILS are supplied in standard lengths, varying from 15" to 60". Other sizes are available upon request.

COIL SELECTION CHART

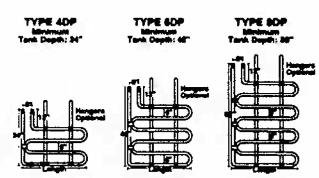
COIL STYLE	DEPTH IN INCHES	HEAT TRANSFER AREA IN SQUARE FEET
U	18"	.8
U	24"	1.1
U	30"	1.4
U	36"	1.6
U	42"	1.9
U	48"	2.1
U	54"	2.4
U	60"	2.7



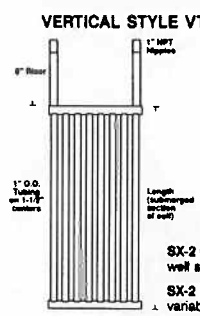
U-Coils

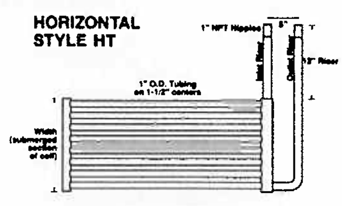
COIL SELECTION CHART

COIL STYLE	LENGTH IN INCHES						
	24"	36"	48"	60"	72"	84"	96"
	HEAT TRANSFER AREA IN SQUARE FEET						
4 DP	2.75	3.75	4.75	5.75	6.75	7.75	8.75
6 DP	4.25	5.75	7.25	8.75	10.25	11.75	13.25
8 DP	6.00	8.10	10.20	12.30	14.40	16.50	18.60



Serpentine Coils





SX-2 GRID COILS are the most versatile heating/cooling coils. They are well suited where medium to large amounts of heat transfer is required.

SX-2 GRID COILS are supplied in seven standard designs in variable lengths. Other designs are available upon request.

COIL SELECTION CHART

COIL STYLE	LENGTH IN INCHES											
	24"	30"	36"	48"	60"	72"	84"	96"	108"	120"	132"	144"
	HEAT TRANSFER AREA IN SQUARE FEET											
8 HT	4.6	5.6	6.7	8.8	10.9	13.7	15.1	17.2	19.2	21.3	23.4	25.5
12 HT	6.8	8.4	10.0	13.2	16.3	19.5	22.6	25.7	28.9	32.0	35.2	38.3
14 HT	8.9	10.7	12.5	15.2	18.9	22.6	26.3	29.9	33.6	37.2	40.8	44.5
16 HT	9.4	11.5	13.6	17.8	22.0	26.1	30.3	34.5	38.7	42.9	47.1	51.3
20 HT	11.5	14.2	16.8	22.0	27.2	32.5	37.7	42.9	48.2	53.4	58.6	63.9
24 HT	13.7	16.8	20.0	26.3	32.5	38.8	45.1	51.4	57.7	64.0	70.3	76.6
28 HT	15.8	19.5	23.2	30.6	38.0	45.4	52.8	60.2	67.6	75.0	82.4	89.8

Grid coils

References:
Heat Transfer, J.P. Holman, McGraw-Hill
Heat Transmission, W.II McAdams, McGraw-Hill
Steam, Babcock & Wilcox

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