PV Newsletter

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TEMA Designations

The shell and tube type exchangers constitute the bulk of the unfired heat transfer equipment in the wide range of industries. Tubular Exchanger Manufacturers Association (TEMA) provides the recommended method to designate the size and type of the heat exchanger by numbers and letters. With some modifications, these systems are used worldwide.

Designating Size

The TEMA Standards size-numbering system is straight-forward and simple. In this system, the size number indicates the shell diameter (ID) in inches (millimeters) rounded to the nearest integer, and straight tube length (L) in inches (millimeters). For all but kettle-type reboilers, the size number is the port ID through which the bundle enters (ID'), the shell diameter (ID), and the length (L) in the form ID'/ID x L. For U-tube exchangers, the straight tube length is the distance from the outermost tubesheet face to the bend line. For straight-tube units, tube length is the length over the outermost tubesheet faces.

Example: What is the size number of a closed feedwater heater with a 24-ft (7315-mm) straight-length U-tubes and a 48-in (1219-mm) OD shell, ½ in (12.7-mm) thick?

US Units

Diameter	48 - (2 x 1/2) = 47
Length	24 x 12 = 288
Size Number	47-288

Metric Units

Diameter	1219 - (2 x 12.7) = 1194
Length	7315
Size Number	1194-7315

Describing Exchanger Types

The TEMA system consists of a general expression of these three variables: a front head, shell and rear head. Constants that indicate component types are substituted for each variable.

For the variable *front head*, the constants and their meanings are:

A Channel with removable cover
B Bonnet with integral cover
C Channel integral with tubesheet and having a removable cover when the tube bundle is removable
N Channel integral with tubesheet and having a removable cover when the tube bundle is not removable
D Special high pressure closure

For shell, the constants and their meanings are:

E One-pass shell

F	Two-pass shell
G	Split flow
H	Double split flow
J	Divided flow
K	Kettle type
X	Cross-flow

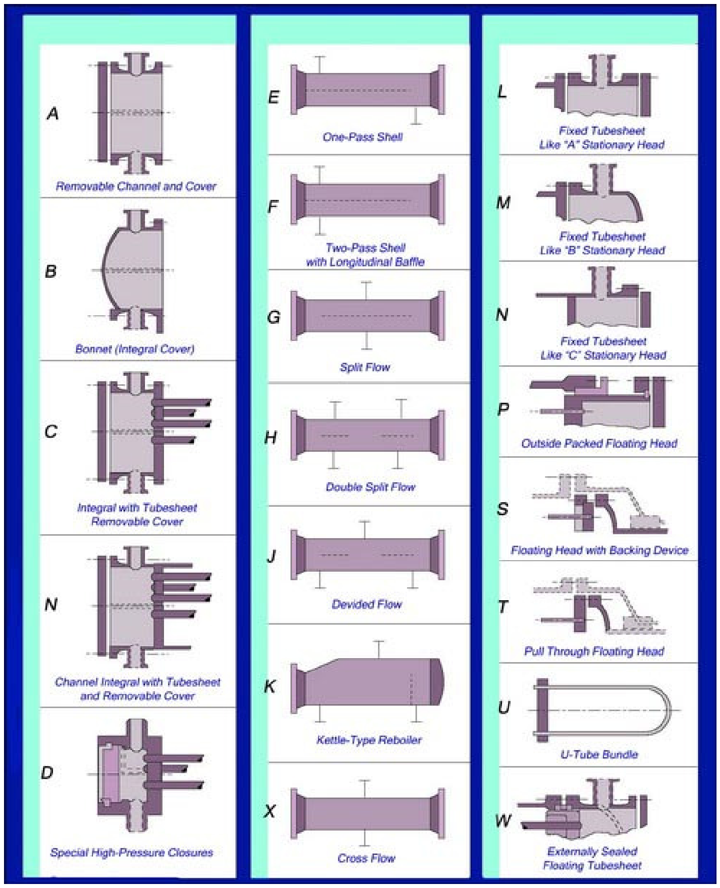

Figure 1: TEMA Expression for Designating Exchanger Types

For rear heads, the constants and their meanings are:

L	Fixed tubesheet like A stationary head
M	Fixed tubesheet like B stationary head
N	Fixed tubesheet like N stationary head
P	Outside-packed floating head
S	Floating head with backing device
T	Pull-through floating bundle
U	U-tube bundle
W	Externally sealed floating tubesheet

Figure 1 illustrates and shows how to substitute the constants in the TEMA expression to indicate an exchanger's configuration. The TEMA standards allow manufacturers to use any system to denote special types. Table 1 shows the possible configurations that the TEMA expression can indicate with these constants. The italicized types are rarely used.

Position

Process and power plant heat exchangers may operate with their axial centerlines vertical, horizontal, or at some angle in between. Closed feedwater heaters operate either vertically or horizontally. TEMA system does not have an operating position designator, but it is customary to indicate horizontal positions with “H”, and vertical positions with “V”. For pitched units, indicate the degrees pitched off the vertical with “HP_^{o}” or off the vertical with “V_^{o}”.

What are the uses of different stationary head (front end) types?

TEMA “A” channel – This type of channel is bolted to the tubesheet. If bundle is removable then the tubesheet is sandwiched between channel flange and shell flange. This channel has a removable cover allowing access to the tube ends without removing the channel. This type of channel is commonly used when frequent tube side cleaning is required. This type of channel may be specified when tube side fouling is 0.0002 hr-ft^2-°F/Btu or more.

TEMA “B” channel – This type of channel is bolted to the tubesheet. If bundle is removable then the tubesheet is sandwiched between channel flange and shell flange. This channel has an integral cover. This channel is used when chemical cleaning or infrequent cleaning of tube side is required. Since the channel cover is integral, access to the tube ends will require removal of the channel and dismantling of the tube side connection. This is suitable where tube side fluid is relatively clean. This type of channel is usually cheaper than “A” type. This channel may be used when tube side fouling is less than 0.0002 hr-ft^2-°F/Btu.

TEMA “C” channel – This type of channel has integral tubesheet and removable channel cover. The channel is bolted to the shell flange. C type channel is often used as high pressure closure or where elimination of gasketed joint between channel and tubesheet is beneficial.

TEMA “N’ channel – This type of channel has integral tubesheet with removable cover. This type of channel is generally used with fixed tubesheet design. This type of channel is cheaper than “A” type.

TEMA “D” channel – This is a special high pressure closure. The selection of high pressure closure is dependent on the exchanger diameter. For large diameter, hemispherical heads are used in place of “D” type channel.

What are the main features of different types of shells?

E-type shell

- It has one shell pass with shell side fluid entering at the one end of the shell and exiting at the other end of the shell.
- This is the most common shell type used in the industry. This type of shell is easy to fabricate.
- Other shell types are used only when “E” type proves less effective.

F-type shell

- F-type shell is a two pass shell and has a longitudinal baffle that divides shell into two passes.
- Both inlet and outlet nozzles are attached at the same end. The shell side fluid enters at one end, traverses the entire length of the exchanger through one-half the shell cross sectional area, turns around and flows through the second pass, then finally leaves at the end of the second pass.
- The amount of heat transferred is more than an E-type shell but at the cost of increased pressure drop. F-type shell produces approximately 8 times the pressure drop as E-type shell.
- Vertical baffle cuts are used with F-type shell.
- F-type shells are used for temperature cross situations (cold stream outlet temp. is higher than hot stream outlet temp.) avoiding E-type shells in series.

- F-type shell with two tube side passes provides true countercurrent flow arrangement where larger temperature cross can be achieved.
- Physical leakage and the thermal leakage across the longitudinal baffle are the main concerns with this design. Special considerations must be taken into the design to account for these leakages.

G-type shell

- G-type shell is a split flow design. The inlet and outlet nozzles are located at the center with a full support plate located under the nozzles. A longitudinal baffle divides shell in two halves.
- G-type shell produces approximately same pressure drop as E-type shell.
- The temperature correction factor with G-type shell is higher than multi-tube pass E-type shell.
- This type of shell is more suitable for phase change application where bypass around the longitudinal baffle and counter-current flow are less important than flow distribution.
- G-type shell is frequently used for horizontal thermosyphon reboiler or condensing service where available pressure drop is limited.

H-type shell

- H-type shell is similar to G-type shell except that there are two inlet nozzles, two outlet nozzles, and two horizontal baffles resulting in a double split flow unit.
- This configuration is used when pressure drop is very limited. The pressure drop is 1/8 of E-type shell.

J-type shell

- J-type shell is divided flow shell wherein the shell side fluid enters the shell at the center and divides into two flow paths, one flowing to the left and the other to the right and each leaving separately at both ends of the shell. This configuration is known as J 1-2 shell.
- Alternatively, the fluid may divide into two streams as it enters the shell at two ends of the shell, flows towards the center of the shell and leave as a single stream. This configuration is known as J 2-1 shell.
- There are no longitudinal baffles in J-type shell.
- This type is used when the available pressure drop is very limited. The pressure drop is 1/8 of E-type shell.

K-type shell

- K-type shell is a special cross-flow shell also known as kettle type shell.
- The tube bundle is far smaller than the kettle diameter. It has integral vapor-disengagement space for boiling liquid.
- In some application, a weir plate is used to help maintain the liquid level above the tube bundle.
- This type of shell is used where shell side vaporization occurs such as chillers, reboilers, steam generators etc.

X-type shell

- This shell provides cross flow where fluid flows over the bundle once. The fluid enters the shell from the top or bottom of the shell and exits from the opposite side of the shell.
- The fluid may be introduced through multiple nozzles or a single nozzle. If multiple nozzles are used then they are located strategically to achieve better flow distribution.
- The pressure drop across the bundle is extremely low. Usually most of the pressure drop is in the nozzles.
- This configuration is used for gas application or condensing application at low pressure or vacuum service.
- Full support plates are employed along the tube length for structural integrity as there are no baffles.

How does the heat exchanger performance compare for different types of shell?

The table below shows relative performance of different types of shell. E-type shell is used for the basis and numbers below in the table show rough estimate of the relative orders of magnitude. The actual performance will depend on the manufacturing clearances, type of rear head, number of tube passes and other geometrical parameters such as tube pitch, layout angles, baffle type, baffle cut etc.

Shell Type	E	F	G	H	J
h_o	1	$(2)^{0.55}$	1	$(1/2)^{0.55}$	$(1/2)^{0.55}$
ΔP_s	1	8	1	1/8	1/8
F_t	1	1	<1	<1	<1

h_o Shell side film coefficient
ΔP_s Shell side pressure drop
F_t Temperature correction factor for LMTD

Table below summarizes different TEMA types with special features.

Type of design	Fixed tube sheet	U-tube	Packed lantern-ring floating head	Internal floating head (split backing ring)	Outside-packed floating head	Pull-through floating head
T.E.M.A. rear-head type	L or M or N	U	W	S	P	T
Relative cost increases from A (least expensive) through E (most expensive)	B	A	C	E	D	E
Provision for differential expansion	Expansion joint in shell	Individual tubes free to expand	Floating head	Floating head	Floating head	Floating head
Removable bundle	No	Yes	Yes	Yes	Yes	Yes
Replacement bundle possible	No	Yes	Yes	Yes	Yes	Yes
Individual tubes replaceable	Yes	Only those in outside row†	Yes	Yes	Yes	Yes
Tube cleaning by chemicals inside and outside	Yes	Yes	Yes	Yes	Yes	Yes
Interior tube cleaning mechanically	Yes	Special tools required	Yes	Yes	Yes	Yes
Exterior tube cleaning mechanically:						
Triangular pitch	No	No‡	No‡	No‡	No‡	No‡
Square pitch	No	Yes	Yes	Yes	Yes	Yes
Hydraulic-jet cleaning:						
Tube interior	Yes	Special tools required	Yes	Yes	Yes	Yes
Tube exterior	No	Yes	Yes	Yes	Yes	Yes
Double tube sheet feasible	Yes	Yes	No	No	Yes	No
Number of tube passes	No practical limitations	Any even number possible	Limited to one or two passes	No practical limitations§	No practical limitations	No practical limitations§
Internal gaskets eliminated	Yes	Yes	Yes	No	Yes	No

NOTE: Relative costs A and B are not significantly different and interchange for long lengths of tubing.
*Modified from page a-8 of the Patterson-Kelley Co. Manual No. 700A, Heat Exchangers.
†U-tube bundles have been built with tube supports which permit the U-bends to be spread apart and tubes inside of the bundle replaced.
‡Normal triangular pitch does not permit mechanical cleaning. With a wide triangular pitch, which is equal to 2 (tube diameter plus cleaning lane)/$\sqrt{3}$, mechanical cleaning is possible on removable bundles. This wide spacing is infrequently used.
§For odd number of tube side passes, floating head requires packed joint or expansion joint.

Sources:

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2. Singh K.P. and Soler A.I., *Mechanical Design of Heat Exchangers and Pressure Vessels*
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4. Mukherjee R., *Effectively design shell and tube heat exchangers*
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****** END OF THE ARTICLE ******

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CoDesign Engineering specializes in the core business of providing training and consultancy for design and fabrication of ASME code pressure vessels, and the ecosystem that includes piping, welding, valves, geometric dimensioning and tolerancing, process improvement, and engineering management. Some of the training courses (lasting from two days to five days) that we provide include:

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- ASME Section IX - Welding Technology
- Engineering Management

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