Chapter 8

Towers, Columns

Introduction to Towers and Columns

Towers are classified according to the type of "internals" in the tower, and according to the function performed by the tower.

- Towers may contain trays. If the tower contains trays, the vessel is called a tray tower, or synonymously a tray column.
- Tower may contain packing. If the tower contains a packing, the vessel is called a packed tower, or packed column.
- If the feed to the tower is a hydrocarbon mixture and the tower separates this mixture into two factions or streams, one stream containing the more volatile components of the feed and the other stream the less volatile components of the feed, the tower is called a fractionation tower. Other names for a fractionation tower are: fractionation column, fractionator, distillation tower and distillation column.
- If the feed to the tower is liquid, and the tower removes an undesirable gas which is dissolved in the feed, the tower is called a stripping tower. Other names for a stripping tower are stripping column and stripper.
- If the feed to the tower is a gas mixture containing one or more undesirable components which are removed within the tower by absorbing them with a suitable solvent, the tower is called an absorption tower. Other names for an absorption tower are: absorption column and absorber.
- If the feed to the tower is a gas or liquid mixture containing one or more undesirable components which are removed within the tower by adsorbing them onto solid catalyst pellets, the tower is called an adsorption tower. Other names for an adsorption tower are: adsorption column and adsorber.
- If the feed to the tower is a liquid mixture containing one or more undesirable components which are removed by absorbing them with another liquid, the tower is called an extraction tower or extraction column.

Towers are similar to vertical process vessels in that they are erected vertically and they are cylindrical in shape with heads at each end of the cylinder. Towers are, however, normally much taller then vertical process vessels. Typically the length to diameter ratio of a tower ranges from 3:1 to 20:1. Towers typically range in diameter from 3 to 20 FEET and in height from 20 to 150 FEET.

Tower/Column Applications

Towers are commonly used for the following purposes:

- Distillation
- Stripping
- Absorption
- Adsorption
- Extraction.

A description of these items follows.

Distillation — Distillation is a process which separates a mixture of materials into two or more desired parts. The device which performs this operation may be called a distillation tower, distillation column or fractionator. The operation of a distillation column depends on the fact that different materials boil at different temperatures. For example, water boils at 212 DEG F and ethyl alcohol (the active ingredient in liquor) boils at 173 DEG F. Distillation is not a new concept. The material which boils at the lower temperature is called the light or more volatile component. The material with the higher boiling point is called the heavy or less volatile component. In the case of ethyl alcohol and water, we are dealing with a two component or binary mixture. This is not the usual case. More commonly, the feed to a distillation column is a multi-component mixture. For example, crude oil contains hundreds of different components. The purpose of distilling crude oil is to separate it into what are called fractions or cuts. Each fraction or cut is not a pure component, but a mixture of components which may be used as is or refined further. Crude distillation normally is used to produce these fractions: raw gasoline, raw kerosene, gas oil and reduced crude.

Stripping — The process of extracting a material dissolved in a liquid phase and transferring it into a gas phase is called stripping or desorption. The stripping process is carried out in a device called a stripping tower or stripping column. The removal of ammonia from water is an example of the stripping process. Water with ammonia dissolved in it passes down the stripping tower. Air passing upward through the tower strips the ammonia from the water and the ammonia - air mixture exits from the top of the tower.

Absorption — The process of transferring a material from the gas phase to the liquid phase is called absorption. The liquid into which the gaseous component dissolves is called the absorbent. The device in which the absorption process takes place is called an absorption tower, absorption column or absorber. The removal of carbon dioxide and hydrogen sulfide from the natural gas with deithanolamine (DEA) is an example of the absorption process. Natural gas, CO_2 and $H_2$3 pass upward through the tower. DEA passing downwards absorbs the CO_2 and H_2S.

Adsorption — The process of transferring a material from either the gas or liquid phase to the solid phase is called adsorption. The solid to which the liquid or gaseous component attached itself is called the adsorbent. The device in which the adsorption process takes place is usually called an adsorption tower, adsorption column or adsorber. If the purpose of the adsorber is to remove water, the term drying tower or dryer is often used.

Extraction — The process of transferring material from one liquid phase to another immiscible liquid phase is called liquid - liquid extraction, solvent extraction or simply extraction. Immiscible liquids are liquids which do not dissolve in each other, or example, oil and water. If the two immiscible liquids are contacted countercurrently, the contacting device is called an extraction column, extraction tower or extractor.

Tower/Column Internals

Trays — Trays may be divided into two major categories; crossflow trays and counter flow trays. Crossflow trays get their name because liquid flows across the tray to a downcomer while vapor rises through perforations in the tray deck. There are three types of crossflow trays in common use today. They are the bubble cap, sieve tray, and valve tray. The bubble cap trays were used almost exclusively until about 1950. Since then, the use of bubble cap trays has almost disappeared because their complicated construction makes them heavy (resulting in heavier and more expensive tray supports) and expensive to fabricate.

Bubble cap trays get their name because vapor rises through holes in the tray and is collected underneath bubble caps. Each cap has slots in it through which the vapor from the tray below bubbles into the liquid on the tray.

Sieve trays are the cheapest trays to fabricate because of their simple design. They consist of a perforated plate through which vapor rises from the tray below, a weir to hold a liquid level on the tray, and a downcomer which acts as a downspout to direct the liquid to the tray below. The operation of the sieve tray depends on the vapor velocity through the perforations being high enough to keep the liquid flowing across the tray and not down through the same perforations the vapor is rising through. The drawback to the sieve tray is that it has a narrow operating range compared to the bubble cap tray and the valve tray. Too low a vapor velocity and the liquid falls through the holes to the plate below - a condition called dumping. Too high a velocity and vapor doesn't bubble through the liquid on the tray. Instead, the vapor pushes the liquid away from the hole so that there is no liquid-vapor contact. This condition is called coning.

Valve trays have liftable caps which operate like check valves. These caps make valve trays more expensive than sieve trays but they also increase the operating range of the tray. At low vapor velocities, the caps close and prevent dumping.

The other major category of trays is the counterflow type. These trays have no downcomers. The liquid falls through the same openings in the tray that the vapor from the tray below rises through. This type of tray is not widely used. The most popular of the counterflow type tray is the Turbogrid tray.

Packings — The second major category of tower internals is packings. Packings serve the same purpose as trays; they bring a gas or vapor stream into intimate contact with a liquid stream. Trays accomplish this by providing a very large wetted surface area for the gas or vapor to flow by. Packed towers would normally be selected instead of tray towers in the following instances:

1. For columns less than 2 FEET in diameter, packing is generally cheaper.

2. If highly corrosive fluids are being handled, packings are often advantageous because they can be made of ceramic, carbon, plastic or other highly resistant metallic or non-metallic material.

3. Packed towers are low pressure drop devices, therefore, they are often used for vacuum distillations.

The major disadvantages of packed towers are:

1. They have a narrower operating range than tray towers.

2. A packed tower must have a larger diameter than a tray tower to handle the same feed rate.

The most common types of packings are: Rashig rings, Berl saddles, Intalox saddles and Pall rings.

Adsorption towers are packed towers; however, their function is to transfer a material from the liquid or gas phase onto the surface of the solid adsorbent. Adsorbents are not packing types. Adsorbents are generally either a granular material or else spherical or cylindrical shaped pellets. Some common adsorbents are: Fuller's earthes (natural clays), activated clay, alumina, activated carbon and silica gel.

Description of Towers/Columns

"Towers" and "columns" are interchangeable name for the same device. These devices have one of two functions. One is to separate a mixture into two or more desired parts. The other function is to transfer a material from one phase to another phase.

Towers are classified according to the function performed. Examples are distillation, stripping or extraction. Towers are also classified by the type of device installed inside (internals) so the tower can perform its desired function. Tower internals consist of either trays or packings.

Towers are always erected vertically. They are usually tall and cylindrical in shape. Sometimes they are designed with the top of the tower one diameter and the bottom a different (usually larger) diameter. This gives the tower a "Coke bottle" shape and is called a double diameter tower.

The cylindrically shaped body of the tower is called the shell. The shell is closed at both ends with dome-shaped covers called heads. There are three head designs in common use:

- Torispherical, the most common of which is the ASME flanged and dished head
- Ellipsoidal, also called elliptical, elliptical dished or 2:1 ellipsoidal (because the ratio of the length of the major to the minor axis of this head is 2:1)
- Hemispherical.

Which kind of head to use is an economic decision. The torispherical head is the cheapest to fabricate, but is the thickest for a given pressure. The ellipsoidal head is more expensive to fabricate than the torispherical, but is thinner at the same pressure. The hemispherical head is the most costly to fabricate, but is the thinnest for a given pressure. Thus, the material cost decreases from the torispherical to hemispherical because the head gets thinner, but the fabricating costs increase. At pressures below 150 PSIG the torispherical head is generally the cheapest. From 150 PSIG to 500 PSIG, the ellipsoidal is usually selected. Above 150 PSIG, the hemispherical head becomes an economically viable alternative.

Openings are provided in the shell and heads of a tower so that process fluids can enter and leave. Other openings in the tower are provided for drains, purge connections and sample connections. These openings into the tower are called nozzles.

Nozzles range in diameter from 1 INCH for small drains, vents and sample connections to 24 INCHES [1,200 MM] or more for large process connections. The small (1 INCH) connections are usually made with pipe couplings, not with welding necks and flanges.

Workers must be able to enter the tower after it is erected to install and maintain the internals. Openings in the tower provided for this purpose are called manholes or manways. Manholes are just nozzles large enough for a man to pass through. Manholes range in diameter from 18 - 24 INCHES [1,200 MM].

A tower is normally supported by a steel cylinder the same diameter as the tower called a skirt. The skirt is welded to the tower at one end and bolted to the foundation at the other.

In addition to nozzles, manholes and skirts, other appurtenances may be attached to the tower. These other externals may include insulation clips for the support of insulation, lifting lugs which are eyelets to which rigging is attached so that the tower can be lifted and placed on its foundation, and various structural steel members for the support of platforms and ladders.

Materials of Construction

The tower shell and heads are usually fabricated out of carbon or low alloy steel plate.

As the name implies, the primary alloying element in carbon steel is carbon. All the other alloying elements in carbon steel are limited to concentrations less than 0.5%. The most common materials of construction for towers are the carbon steels A515 and A516.

Low alloy steel contain one or more alloying elements besides carbon in concentrations from 0.5% to 10%. Alloying elements in concentrations greater than 10% make the steel a high alloy steel.

When extremely corrosive materials are to be handled, the tower may be fabricated out of a high alloy steel such as one of the stainless steels, a non-ferrous metal such as titanium or monel, or a non-metal such as FRP (fiberglass reinforced polyester). However, because these materials are either very expensive or else have design limitations such as low strength, claddings and linings are commonly used for corrosion resistance. Clad plate consists of a thin layer of corrosion resistant metal permanently bonded to an inexpensive carbon or low alloy steel backing. Linings differ from claddings in that there is not a permanent continuous bond between the corrosion resistant material and the backing material, and the corrosion resistant material is usually not a metal. Common lining materials are brick, cement, rubber and glass.

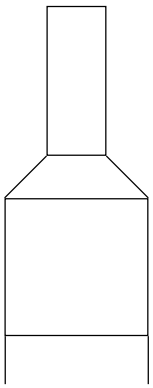
Shell and Head Design

Typically, many companies normally require that tower shells and heads be designed according to the latest edition of Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code. Towers manufactured in the United States will carry the ASME code stamp certifying that the vessel has been designed and fabricated to code standards. Towers manufactured outside the United States are to be designed and fabricated according to code standards as well, but need not carry the code stamp.

Towers which are unusually large, or towers which are required to operate at a very high pressure may be designed according to Section VIII Division 2 of the ASME Code. Division 2 requires complete stress analysis of the process vessel. This complete analysis allows the vessel to be designed with much smaller safety factors. This results in a vessel which has a thinner shell and head and is therefore cheaper to fabricate than the same vessel designed according to the rules of Division 1. Since a Division 2 design results in a cheaper vessel, why aren't all process vessels designed according to the rules of Division 2? Again it is a question of economics. A Division 2 design is so complex that the money spent in extra engineering time for the vessel can easily exceed the savings realized in the fabrication of the vessel. Only in very large or thick walled vessels is the economic advantage of a Division 2 clear-cut.

Double Diameter Towers (DDT)

Pressure/vacuum, includes vessel shell, heads, transition section, single base material, lined or clad, nozzles, manholes (one manhole below and above tray stack or packed section and one manhole every tenth tray or 25 FEET [7.6 M] of packed height), stiffening rings if desired, base ring, lugs, skirt or legs; tray clips, tray supports (if designated), distributor piping, plates, packing (if packing designated); variety of applications for plate and packed towers: absorption, desorption, distillation or stripping (via kettle or thermosiphon reboiler defined separately), extraction; applications for packed towers: gas and liquid adsorption; sections can be trayed, packed, empty. Ladders and platforms not included. (See Single Diameter Towers for tray stacks.)

Description	Type
Packed double diameter tower.	**PACKED** 

Application Symbol: Defines vessel function and related pipe/instrumentation model. Default: *ABSORB*
- ABSORB - Absorption
- DESORB - Desorption
- DISTIL - Distillation with thermosiphon reboiler (not included)
- DIS-RB - Distillation with kettler reboiler (not included)
- EXTRAC - Extraction
- GAS-AD - Gas adsorption
- LIQ-AD - Liquid adsorption
- STRIPP - Stripping with thermosiphone reboiler (not included)
- STR-RB - Stripping with kettle reboiler (not included)

Bottom Base Mat'l: For clad plate, specify the backing plate material (cladding is defined below). See Chapter 28 for materials.

Bottom Design Press.: Default: Specified top section pressure, or 50 PSIG [350 KPA]: negative for vacuum.

Bottom Design Temp.: Default: Specified top section temp or 250 DEG F [120 DEG C].

Bottom Packing Mat'l: See Chapter 28 for materials. Default: *NONE*

Bottom Packing Hgt.: Default: *0.0* FEET [*0.0* M]

Bottom Clad'g Mat'l: See Chapter 28 for materials. Default: *NONE*

Skirt Height: Default: 1.5 x bottom diameter; enter 0.0 if vessel hung in OPEN structure.

Bottom Manhole Diam.: Max: 48 INCHES [1,200 MM]

Bottom Sect'n Thick.: Base material thickness including corrosion allowance.

Bottom Corros'n All.: Default: 0.125 INCHES [3 MM] for CS, 0.0 for other materials.

Bottom Clad'g Thick.: Default: 0.125 INCHES [3 MM] if cladding material is specified; otherwise: 0.0.

Bot Stiff Ring Space: Default stiffeners designed for vacuum only, enter 0.0 if not required.

Top Base Material: For clad plate, specify the backing plate material (cladding is defined below). See Chapter 28 for materials. Default: *A 515*

Top Design Pressure: Default: Specified bottom sect'n pressure or 50 PSIG [350 KPA]; negative for vacuum.

Top Design Temp.: Default: Specified bottom section temperature or 250 DEG F [120 DEG C].

Top Packing Mat'l: See Chapter 28 for materials. Default: *NONE*

Top Packing Height: Default: *0.0* FEET [*0.0* M]

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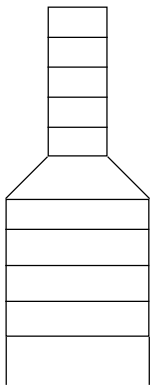
Double Diameter Towers (DDT) - continued

Description	Type

PACKED - continued

Top Cladding Material: See Chapter 28 for materials.
Default: *NONE*
Top Pipe Material: See Chapter 18 for pipe materials.
Top Manhole Diameter: Max: 48 INCHES [1,200 MM]
Top Sect'n Thickness: Base material thickness including corrosion allowance.
Top Corrosion Allow.: Default 0.125 INCHES [3 MM] for CS, 0.0 for other materials.
Top Cladding Thick.: Default: 0.125 INCHES [3 MM] if cladding material is specified; otherwise: 0.0.
Top Stiff Ring Space: Default stiffeners designed for vacuum only, enter 0.0 if not required.
Wind/Seismic Design: Default: Vessel designed for wind and seismic loads defined in project basis.
W+S - Wind and seismic design required
WIND - Wind design only
SEIS - Wind/seismic design
NONE - Delete wind and seismic design
Fluid Volume %: Max: 100; Default: *20*; For seismic design, fluid volume as a % of vessel volume (water assumed).
Design Vacuum - Gauge: If pressure and vacuum entered, design is for worst case. Default: pressure.
Weld Efficiency %: 50 - 100; ASME/JIS codes only, where allowed for thin wall vessels; Default: Area Design Basis.
Stress Relief: Default: See Area Design Basis.
CODE - Provide stress relief if code requires
YES - Provide stress relief
NO - No stress relief required
Mol Wgt Overhd Prod: Default: 50 for distillation and stripping applications; otherwise 30.
Sets Body Flange/Bot: Number of sets (pairs) of body flanges of same diameter as vessel.
Sets Body Flange/Top: Number of sets (pairs) of body flanges of same diameter as vessel.
Diameter Option: Defines desired diameter as ID or OD; Default: See Area Design Basis.
OD - Outside diameter
ID - Inside diameter

Double Diameter Towers (DDT) - continued

Description	Type
Trayed double diameter tower. Available tray types include: bubble cap, sieve, turbo grid, valve and clips and supports without trays.	**TRAYED** 

Tray Type: Default: *VALVE*
- VALVE - Valve trays
- BUBBL - Bubble cap trays
- TURBO - Turbo grid trays
- SIEVE - Sieve trays
- NONE. - No trays

Application Symbol: Defines vessel function and related pipe/instrumentation model; Default: *DISTIL*
- ABSORB - Absorption
- DESORB - Desorption
- DISTIL - Distillation with thermosiphon reboiler (not included)
- DIS-RB - Distillation with kettle reboiler (not included)
- EXTRAC - Extraction
- GAS-AD - Gas adsorption
- LIQ-AD - Liquid adsorption
- STRIPP - Stripping with thermosiphon reboiler (not included)
- STR-RB. - Stripping with kettle reboiler (not included)

Bottom Base Mat'l: For clad plate, specify the backing plate material (cladding is defined below). See Chapter 28 for materials. Default: *A 515*.

Bottom Design Press.: Default: Specified top section pressure, or 50 PSIG [350 KPA]; negative for vacuum.

Bottom Design Temp.: Default: Specified top section temperature or 250 DEG F [120 DEG C].

Bottom Trays/Packing: Specify tray material for trays or packing material for packed sections. See Chapter 28 for materials. Default: *A 515*.

No. Trays/Packed Hgt: Enter number of trays for trayed sections or packing height for packed sections. Default: *0.0*

Botttom Clad'g Mat'l: See Chapter 28 for materials. Default: *NONE*.

Bottom Pipe Mat'l: See Chapter 18 for pipe materials.

Skirt Height: Default: 1.5 x bottom diameter; enter 0.0 if vessel hung in OPEN structure.

Bottom Manhole Diam.: Max: 48 INCHES [1,200 MM]

Bottom Sect'n Thick.: Base material thickness including corrosion allowance.

Bottom Corros'n All.: Default: 0.125 INCHES [3 MM] for CS, 0.0 for other materials.

Bottom Clad'g Thick.: Default: 0.125 INCHES [3 MM] if cladding material is specified; otherwise: 0.0.

Bot Stiff Ring Space: Default stiffeners designed for vacuum only, enter 0.0 if not required.

Top Base Material: For clad plate, specify the backing plate material (cladding if defined below). See Chapter 28 for materials. Default: *A 515*.

Top Design Pressure: Default: specified bottom section pressure or 50 PSIG [350 KPA]; negative for vacuum.

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Double Diameter Towers (DDT) - continued

Description	Type

TRAYED - continued

Top Design Temp.: Default: specified bottom section temperature or 250 DEG F [120 DEG C].
Top Trays/Packing: Specify tray material for trays or packing material for packed section. Default: *NONE*.
No. Trays/Packed Hgt.: Enter number of trays for trayed sections or packing height for packed sections. Default: *0.0*.
Top Cladding Mat'l: See Chapter 28 for materials. Default: *NONE*.
Top Pipe Material: See Chapter 18 for pipe materials.
Top Manhole Diameter: Max: 48 INCHES [1,200 MM]
Top Sect'n Thickness: Base material thickness including corrosion allowance.
Top Corrosion Allow.: Default: 0.125 INCHES [3 MM] for CS, 0.0 for other materials.
Top Cladding Thick.: Default: 0.125 INCHES [3 MM] if cladding material is specified; otherwise: 0.0.
Top Stiff Ring Space.: Default stiffeners designed for vacuum only, enter 0.0 if not required.
Wind/Seismic Design: Default: vessel design for wind and seismic loads defined in Project Basis.
W+S - Wind and seismic design required
WIND - Wind design only
SEIS - Seismic design only
NONE - Delete wind and seismic design
Fluid Volume %: For seismic design; fluid volume as a % of vessel volume (water assumed); Max: 100; Default: *20*.
Design Vacuum - Gauge: If pressure and vacuum entered, design is for worst case. Default: pressure.
Weld Efficiency %: Range: 50 - 100; ASME/JIS codes only, where allowed for thin wall vessels; Default: Area Basis.
Stress Relief: Default: See Area Design Basis.
CODE - Provide stress relief if code requires
YES - Provide stress relief
NO - No stress relief required
Mol Wgt Overhd Prod: Default: 50 for distillation and stripping applications; otherwise - 30.
Sets Body Flange/Bot: Number of sets (pairs) of body flanges of same diameter as vessel.
Sets body Flange/Top: Number of sets (pairs) of body flanges of same diameter as vessel.
Diameter Option: Default: See Area Design Basis.
OD - Outside diameter
ID - Inside diameter
ASME Design Basis: Applicable only for ASME code design. See following entries for fatigue data.
D1NF - ASME Division 1 - no fatigue analysis
D1F - ASME Division 1 - with fatigue analysis
D2NF - ASME Division 2 - no fatigue analysis
D2F - ASME Division 2 with fatigue analysis

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Double Diameter Towers (DDT) - continued

Description	Type
TRAYED - continued	
Start-up Cycles x 1000: ASME fatige only. Thousands of start-up cycles during the full equipment liefe; Min: 0.02; Default: *1.0*.	
Pressure Cycles x 1000: ASME fatigue only. Thousands of deviations from design pressure druing equipment life. Default: *0*.	
Pressure Amplitude %: ASME fatigue only. Amplitude of pressure deviation as percent of design pressure. Default: *0*.	
No. Hydrostatic Test: ASME fatigue only. Number of hydrostatic tests during the full equipment life. Default: *20*.	
Temp. Cycle x 1000: ASME fatigue only. Thousands of deviations from design temperature in equipment life. Default: *0*.	
Temp. Amplitude %: ASME fatigue only. Amplitude of temperature deviation as a percent of design temperature.	
Tray Thickness: Default: 0.1875 INCH [4.5 MM].	

Single Diameter Towers (TW)

Pressure/vacuum includes vessel shell, heads, single base material (lined or clad), nozzles, manholes (one manhole below and above tray stack or packed section and one manhole every tenth tray or 25 FEET [7.6 M] of packed height), jacket and nozzles for heating or cooling medium, base ring, lugs, skirt or legs; tray clips, tray supports (if designated), distributor piping, plates, packing (if packing designated); variety of applications for plate and packed towers: absorption, desorption, distillation or stripping (via kettle or thermosiphon reboiler defined separately), extraction; applications for packed towers: gas and liquid adsorption; trayed, packed, empty. Ladders and platforms not included.

Description

Packed single diameter tower.

If a packing type is not specified, a packed column is designed and costed with distributor and support plates for average density packing.

Application Symbol: Defines vessel function and related pipe/instrumentation model; Default: *ABSORB*
- ABSORB - Absorption
- DESORB - Desorption
- DISTIL - Distillation with thermosiphon reboiler (not included)
- DIS-RB - Distillation with kettle reboiler (not included)
- EXTRAC - Extraction
- GAS-AD - Gas adsorption
- LIQ-AD - Liquid adsorption
- STRIPP - Stripping with thermosiphon reboiler (not included)
- STR-RB - Stripping with kettle reboiler (not included)

Shell Material: For clad plate, specify the backing plate material (cladding is defined below). See Chapter 28 for materials. Default: *A 515*.

Design Press. - Gauge: If pressure and vacuum entered, design is for worst case. Default: pressure *15* PSIG [*100* KPA].

Design Vacuum - Gauge: If pressure and vacuum entered, design is for worst case. Default: pressure.

Design Temperature: Default: 400 DEG F [200 DEG C] for copper alloys; otherwise material: 650 DEG F [340 DEG C].

Packing Type: If packing type is not specified, no packing will be provided. See Chapter 28 for packing materials.

Total Packing Height: Max: tangent to tangent height less 1.0 FEET [0.3 M].

Cladding Material: See Chapter 28 for cladding materials. Default: *NONE*.

Skirt Height: Enter 0.0 skirt height if tower hung in OPEN structure; Default: 1.5 x diameter.

Wind/Seismic Design: Default: Vessel designed for wind and seismic loads defined in Project Basis.
- W+S - Wind and seismic design required
- WIND - Wind design only
- SEIS - Seismic design only
- NONE - Delete wind and seismic design

Fluid Volume %: For seismic design; fluid volume as a % of vessel volume (water assumed). Max: 100; Default: *20*.

Manhole Diameter: Max: 48 INCHES [1,200 MM].

Base Mat'l Thickness: Base material thickness including corrosion allowance.

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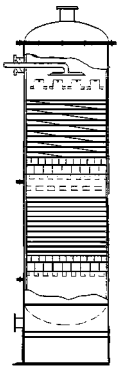
Type

PACKED



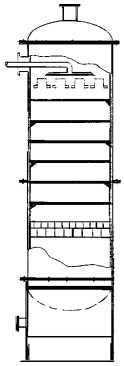
Single Diameter Towers (TW) - continued

Description	Type

PACKED - continued

Corrosion Allowance: Default: 0.125 INCHES [3 MM] for CS; 0.0 for other material. Double if jacketed.
No. Body Flange Sets: Number of sets (pairs) of body flanges of same diameter as vessel.
Weld Efficiency %: ASME/JIS Codes only, where allowed for thin wall vessels; Default: Area Basis; Range: 50 - 100.
Stress Relief: Default: See Area Design Basis.
CODE - Provide stress relief if code requries
YES - Provide stress relief
NO - No stress relief required
Cladding Thickness: Default: 0.125 INCHES [3 MM] if cladding material is specified, otherwise - 0.0.
Stiff'g Ring Spacing: Default stiffeners designed for vacuum only, enter 0.0 if not required.
Jacket Press. - Gauge: Jacket pressure or thickness required to obtain jacket. Default: No jacket.
Jacket Type: Default: *FULL*.
FULL - Full jacket
PIPE. - Half-pipe jacket
Jacket Thickness: Jacket pressure or thickness required to obtain jacket. Default: No jacket.
Jacket Material: See Chapter 28 for materials. Default: *CS*.
Head Type Symbol:
ELLIP - 2:1 eelipsoidal
HEMI - Hemispherical
TORI - Torispherical (ASME)
Mol Wgt Overhd Prod: Default: 50 for distillation and stripping applications, otherwise 30.
Diameter Option: Defines desired diameter as ID or OD; Default: See Area Design Basis.
OD - Outside diameter
ID - Inside diameter
ASME Design Basis: Applicable only for ASME code design. See following entries for fatigue data.
D1NF - ASME Division 1 - no fatigue analysis
D1F - ASME Division 1 - with fatigue analysis
D2NF - ASME Division 2 - no fatigue analysis
D2F - ASME Division 2 with fatigue analysis
Start-up Cycles x 1000: ASME fatige only. Thousands of start-up cycles during the full equipment liefe; Min: 0.02; Default: *1.0*.
Pressure Cycles x 1000: ASME fatigue only. Thousands of deviations from design pressure druing equipment life. Default: *0*.
Pressure Amplitude %: ASME fatigue only. Amplitude of pressure deviation as percent of design pressure. Default: *0*.
No. Hydrostatic Test: ASME fatigue only. Number of hydrostatic tests during the full equipment life. Default: *20*.
Temp. Cycle x 1000: ASME fatigue only. Thousands of deviations from design temperature in equipment life. Default: *0*.
Temp. Amplitude %: ASME fatigue only. Amplitude of temperature deviation as a percent of design temperature.

Single Diameter Towers (TW) - continued

Description	Type
Trayed single diameter tower. Available tray types include: bubble cap, sieve, turbo grid, valve and clips and supports without trays.	**TRAYED** 

Tray Type: Default: *VALVE*
- VALVE - Valve tray
- BUBBL - Bubble cap trays
- TURBO - Turbo grid trays
- SIEVE - Sieve trays
- NONE - No trays

Application Symbol: Defines vessel function and related pipe/instrumentation model; Default: *DISTIL*.
- ABSORB - Absorption
- DESORB - Desorption
- DISTIL - Distillation with thermosiphon reboiler (not included)
- DIS-RB - Distillation with kettle reboiler (not included)
- EXTRAC - Extraction
- STRIPP - Stripping with thermosiphon reboiler (not included)
- STR-RB - Stripping with kettle reboiler (not included)

Shell Material: For clad plate, specify the backing plate material (cladding is defined below). Default: *A 515*.

Vessel T-T Height: Default: 15 FEET [4.5 M] plus tray stack height.

Design Press. - Gauge: If pressure and vacuum entered, design is for worst case. Default: pressure *15* PSIG [*100* KPA].

Design Vacuum - Gauge: If pressure and vacuum entered, design is for worst case. Default: pressure.

Design Temperature: Default: 400 DEG F [200 DEG C] for copper alloys; otherwise material: 650 DEG F [340 DEG C].

Tray Material: See Chapter 28 for materials. Default: *A285C*.

Number of Trays: Min: 2

Tray Spacing: Range: 12 - 30 INCHES [305 -760 MM]; Default: *24* INCHES [*600* MM].

Cladding Material: See Chapter 28 for cladding materials. Default: *NONE*.

Skirt Height: Enter 0.0 skirt height if tower hung in OPEN structure; Default: 1.5 x diameter.

Wind/Seismic Design: Default: Vessel designed for wind and seismic loads defined in Project Basis.
- W+S - Wind and seismic design required
- WIND - Wind design only
- SEIS - Seismic design only
- NONE - Delete wind and seismic design

Fluid Volume %: For seismic design; fluid volume as a % of vessel volume (water assumed). Max: 100; Default: *20*.

Manhole Diameter: Max: 48 INCHES [1,200 MM].

Base Mat'l Thickness: Base material thickness including corrosion allowance.

Corrosion Allowance: Default: 0.125 INCHES [3 MM] for CS; 0.0 for other material. Double if jacketed.

No. Body Flange Sets: Number of sets (pairs) of body flanges of same diameter as vessel.

Continued on next page

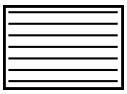
Single Diameter Towers (TW) - continued

Description	Type

TRAYED - continued

Weld Efficiency %: ASME/JIS Codes only, where allowed for thin wall vessels; Range: 50 - 100; Default: Area Basis.
Stress Relief: CODE, YES, NO; Default: See Area Design Basis.
Cladding Thickness: Default: 0.125 INCHES [3 MM] if cladding material is specified, otherwise - 0.0.
Stiff'g Ring Spacing: Default stiffeners designed for vacuum only, enter 0.0 if not required.
Jacket Press. - Gauge: Jacket pressure or thickness required to obtain jacket. Default: No jacket.
Jacket Type: Default: *FULL*
FULL - Full jacket
PIPE - Half-pipe jacket
Jacket Thickness: Jacket pressure or thickness required to obtain jacket. Default: No jacket.
Jacket Material: See Chaper 28 for materials. Default: *CS*.
Head Type Symbol:
ELLIP - 2:1 ellipsoidal
HEMI - Hemispherical
TORI - Torishpherical (ASME)
Mol Wgt Overhd Prod: Default: 50 for distillation and stripping applications, otherwise 30.
Diameter Option: Defines desired diameter as ID or OD; Default: See Area Design Basis.
OD - Outside diameter
ID - Inside diameter
ASME Design Basis: Applicable only for ASME code design. See following entries for fatigue data.
D1NF - ASME Division 1 - no fatigue analysis
D1F - ASME Division 1 - with fatigue analysis
D2NF - ASME Division 2 - no fatigue analysis
D2F - ASME Division 2 with fatigue analysis
Start-up Cycles x 1000: ASME fatige only. Thousands of start-up cycles during the full equipment liefe; Min: 0.02; Default: *1.0*.
Pressure Cycles x 1000: ASME fatigue only. Thousands of deviations from design pressure druing equipment life. Default: *0*.
Pressure Amplitude %: ASME fatigue only. Amplitude of pressure deviation as percent of design pressure. Default: *0*.
No. Hydrostatic Test: ASME fatigue only. Number of hydrostatic tests during the full equipment life. Default: *20*.
Temp. Cycle x 1000: ASME fatigue only. Thousands of deviations from design temperature in equipment life. Default: *0*.
Temp. Amplitude %: ASME fatigue only. Amplitude of temperature deviation as a percent of design temperature.
Tray Thickness: Default: 0.1875 INCH [4.5 MM]

Single Diameter Towers (TW) - continued

Description	Type
Tray stack only, for single- and double-diameter towers. Optional tray types include: bubble-cap, turbo grid, seive and valve. **Material Selection:** See Chapter 28 for materails. Default: *CS*. **Number of Trays:** Min: 1. **Type:** BUBBL - Bubble cap trays TURBO - Trubo grid trays SIEVE - Sieve trays VALVE - Valve trays **Tray Spacing:** Range: 12 - 30 INCHES [305 - 750 MM]; Default: 24 INCHES [600 MM]. **Tray Thickness:** Default: 0.1875 INCH [4.5 MM]	**TRAY STACK** 
Direct contact heat exchanger tower includes distributors, packing supports, nozzles; may include packing. **Shell Material:** For clad plate, specify the backing plate material (cladding is defined below). See Chapter 28 for materials. Default: *A 515*. **Gas Inlet Flow Rate:** Range: 30,000 - 300,000 LB/H [13,610 - 136,000 KG/H]; Enter either flowrate or diameter and height. **Diameter:** Enter either flowrate or diameter and height. **Vessel T-T Height:** Enter either flowrate or diameter and height. **Design Press. - Gauge:** If pressure and vacuum entered, design is for worst case. Default: pressure 15 PSIG [100 KPA]. **Design Vacuum - Gauge:** If pressure and vacuum entered, design is for worst case. Default: pressure. **Design Temperature:** Default: 400 DEG F [200 DEG C] for copper alloys; other material: 650 DEG F [340 DEG C]. **Operating Temp.:** Enter maximum gas temperature. **Packing Type No. 1:** Default: *68PVC*. See Chapter 28 for packing materails. **Packing Height No. 1:** Max: Tangent to tangent height less 1.0 FEET [0.3 M]. **Packing Type No. 2:** Default: None for OPEN top, else 68PVC. See Chapter 28 for packing materials. **Packing Height No. 2:** Max: Tangent to tangent height less height of packing No. 1. **Cladding Material:** See Chapter 28 for cladding materials. Default: *NONE*. **Skirt Height:** Enter 0.0 skirt height if tower hung in OPEN structure; Default: 1.5 x diameter. **Wind/Seismic Design:** Default: Vessel designed for wind and seismic loads defined in Project Basis. W+S - Wind and seismic desgin required WIND - Wind display only SEIS - Seismic disign only NONE - Delete wind and seismic design **Fluid Volume %:** For seismic design, fluid volume as a % of vessel volume (water assumed). Max: 100; Default: *20*. **Manhole Diameter:** Max: 48 INCHES [1,200 MM].	**DC HE TW**

Continued on next page

Single Diameter Towers (TW) - continued

Description	Type
DC HE TW - continued	
Base Mat'l Thickness: Base material thickness including corrosion allowance. **Corrosion Allowance:** Default: 0.125 INCHES [3 MM] for CS, 0.0 for other material, double if jacketed. **No. Body Flange Sets:** Number of sets (pairs) of body flanges of same diameter as vessel. **Weld Efficiency %:** ASME/JIS codes only, where allowed for thin wall vessels; Default: See Area Basis; Range: 50 - 100%. **Stress Relief:** Default: See Area Design Basis. CODE - Provide stress relief if code requires YES - Provide stress relief NO - No stress relief required **Cladding Thickness:** Default: 0.125 INCHES [3 MM] if cladding material is specified, otherwise 0.0. **Stiff''g Ring Spacing:** Default stiffeners designed for vacuum only, enter 0.0 if not required. **Jacket Press. - Gauge:** Jacket pressure or thickness required to obtain jacket. Default: No jacket. **Jacket Type:** Default: *FULL* FULL - Full jacket PIPE - Half-pipe jacket **Jacket Thickness:** Jacket pressure or thickness required to obtain jacket. Default: No jacket. **Jacket Material:** See Chapter 28 for materials. Default: *CS*. **Head Type Symbol:** ELLIP - 2:1 ellipsoidal HEMI - Hemispherical TORI - Torispherical (ASME) OPEN - Open top/TORI bottom **Diameter Option:** Defines desired diameter as ID or OD; Default: See Area Design Basis. OD - Outside diameter ID - Inside diameter	
Temperature swing adsorbtion unit includes vessel pair(s), distributors, packing supports, and valve skid; may include heater (steam or electric), packing. **Shell Material:** For clad plate, specify the backing plate material (cladding is defined below). See Chapter 28 for materials. Default: *A 515*. **Gas Inlet Flow Rate:** Enter either flowrate or diameter and height; Range: 30,000 - 300,000 LB/H [13,610 - 136,000 KG/H]. **Diameter:** Enter either flowrate or diameter and height. **Vessel T-T Height:** Enter either flowrate or diameter and height. **No. of Vessel Pairs:** Number of vessel pairs in configuration, one vessel per pair absorbing at a time. **Design Press. - Gauge:** If pressure and vacuum entered, design is for worst case. Default: pressure 15 PSIG [100 KPA]. **Design Vacuum - Gauge:** If pressure and vacuum entered, design is for worst case. Default: pressure.	**TS ADSORB**

Continued on next page

Single Diameter Towers (TW) - continued

Description	Type

TS ADS0RB - continued

Design Temperature: Default: 400 DEG F [200 DEG C] for copper alloys; other material: 650 DEG F [340 DEG C].
Packing Type No. 1: See Chapter 28 for packing materials; Default: *13XMS*.
Packing Height No. 1: Max: Tangent to tangent height less 1.0 FEET [0.3 M].
Packing Type No. 2: Default: *ALMNA* (Alumina).
Packing Height No. 2: Max: Tangent to tangent height less height of packing No. 1.
Cladding Material: See Chapter 28 for cladding materials. Default: *NONE*.
Skirt Height: Enter 0.0 skirt height if tower hung in OPEN structure; Default: 1.5 x diameter.
Wind/Seismic Design: Default: Vessel designed for wind and seismic loads defined in Project Basis.
W+S - Wind and seismic design required
WIND - Wind design only`
SEIS - Seismic design only
NONE - Delete wind and seismic design
Fluid Volume %: For seismic design, fluid volume as a % of vessel volume (water assumed). Max: 100; Default: *20*.
Manhole Diameter: Max: 48 INCHES [1,200 MM].
Base Mat'l Thickness: Base material thickness including corrosion allowance.
Corrosion Allowance: Default: 0.125 INCHES [3 MM] for CS, 0.0 for other material, double if jacketed.
No. Body Flange Sets: Number of sets (pairs) of body flanges of same diameter as vessel.
Weld Efficiency %: ASME/JIS codes only, where allowed for thin wall vessels; Range: 50 - 100%; Default: See Area Basis.
Stress Relief: Default: See Area Design Basis.
CODE - Provide stress relief if code requires
YES - Provide stress relief
NO - No stress relief required
Cladding Thickness: Default: 0.125 INCHES [3 MM] if cladding material is specified, otherwise 0.0.
Stiff''g Ring Spacing: Default stiffeners designed for vacuum only, enter 0.0 if not required.
Jacket Press. - Gauge: Jacket pressure or thickness required to obtain jacket. Default: No jacket.
Jacket Type: Default: *FULL*
FULL - Full jacket
PIPE - Half-pipe jacket
Jacket Thickness: Jacket pressure or thickness required to obtain jacket. Default: No jacket.
Jacket Material: See Chapter 28 for materials. Default: *CS*.
Head Type Symbol:
ELLIP - 2:1 ellipsoidal
HEMI - Hemispherical
TORI - Torispherical (ASME)
OPEN - Open top/TORI bottom
Diameter Option: Defines desired diameter as ID or OD; Default: See Area Design Basis.
OD - Outside diameter
ID - Inside diameter