Good lighting is essential for this inspection and will prove valuable when performing the soap tests discussed in 10.8.2.

These units are usually built with integral channels and distribution manifolds, the thickness of which can be accurately measured with the UT instruments and then recorded. It is not advisable to use drilling equipment on the exchangers because the equipment could be easily damaged at these points. Welding of the alloys used in the units, such as aluminum and austenitic stainless steel alloys, requires welder skills not always readily available.

A.12 Inspection of Air-cooled Exchangers

Refer to API 661 for descriptions, minimum design criteria, and general information regarding air-cooled exchangers. API 510 and the principles of API 661 are to be followed in any ratings, repairs, and alterations of this type of exchanger. (See Annex C for a sample form for making an inspection report on an air-cooled exchanger.)

Tubes that are enclosed in fins cannot be inspected from the exterior. The best methods for inspecting the tubes are the internal-rotary, UT thickness devices, ET, or remote field ET. These methods work from the interior of the tubes. With competent operators and clean tubes, thicknesses and flaws can be found with these methods. The tubes should be thoroughly cleaned before any method is effective.

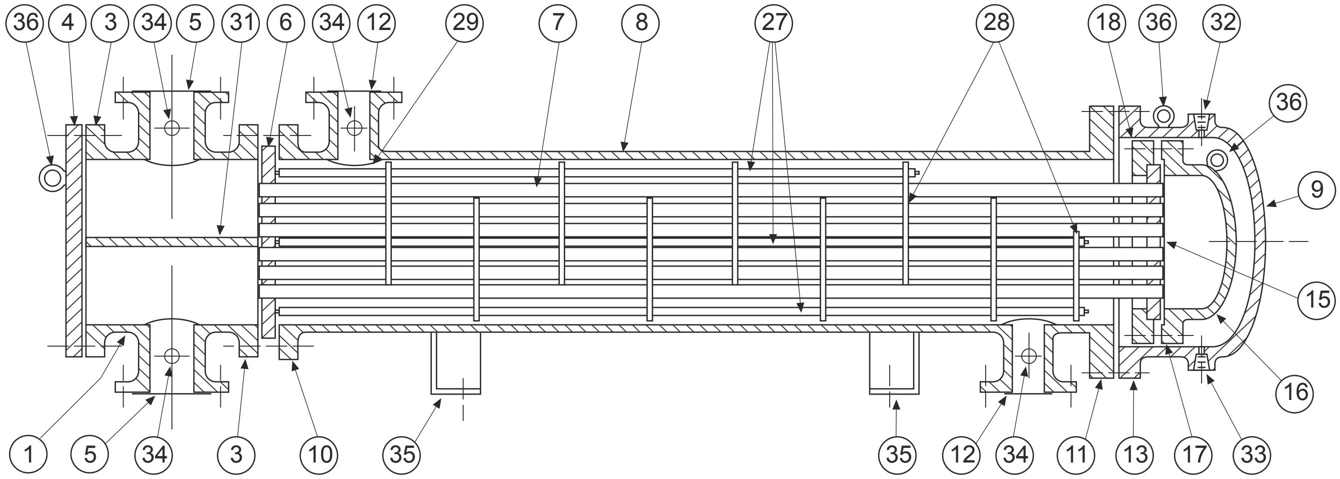
The external fins of the tubes should be checked for cleanliness. If the fins need cleaning, washing with clean water alone or clean water with soap may be sufficient. If not, care should be taken in selecting a cleaning solution. Usually, the fins are aluminum and they could be harmed if the wrong cleaning medium is used.

The exterior of the tubes should be inspected between the tubesheet and the start of the fins. Exchangers in intermittent service or in service cool enough to allow moisture to collect in this area are subject to external corrosion severe enough to cause leaks in this area. Coatings applied to this area will alleviate the problem of corrosion.

The insides of the tubes may be visually inspected near the tube-sheet ends of the air cooler. Fiber optic devices and borescopes are excellent devices for this type of inspection. A probe rod 0.125 in. (3.2 mm) or less in diameter and approximately 36 in. (91 cm) in length with a pointed tip bent at 90° to the axis of the rod also may help to locate pits or corrosion at the tube ends.

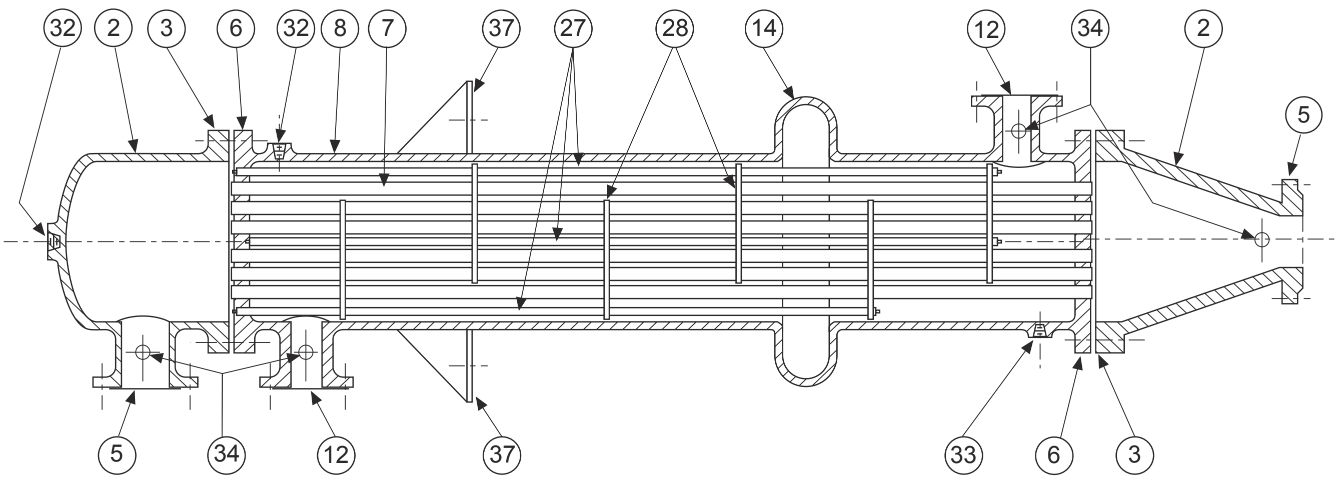
Erosion-corrosion at the tube inlets is a common problem with air-cooled heat exchangers. This damage can be found by visual inspection through the header-box plug holes, or directly if the header box has a removable cover plate. If suitable conditions exist, reflecting sunlight into the tubes with a mirror is useful in inspecting for erosion-corrosion.

The box-type header ends of the air cooler should be inspected using the same techniques as recommended for a pressure vessel. In addition, the sharp change of direction caused by its rectangular construction should be carefully checked for cracking. The header boxes with removable cover plates are obviously the easiest to inspect. A fiber optics scope may be the only way to check a header that has plug-type closures as opposed to a cover plate.



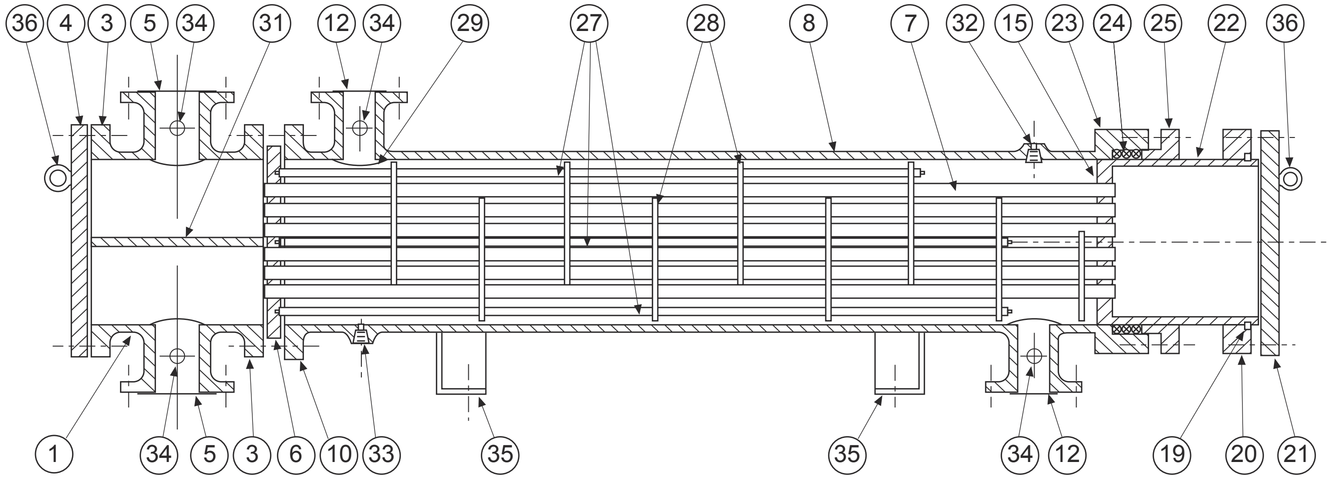
AES

Figure A.11—Heat Exchanger Parts



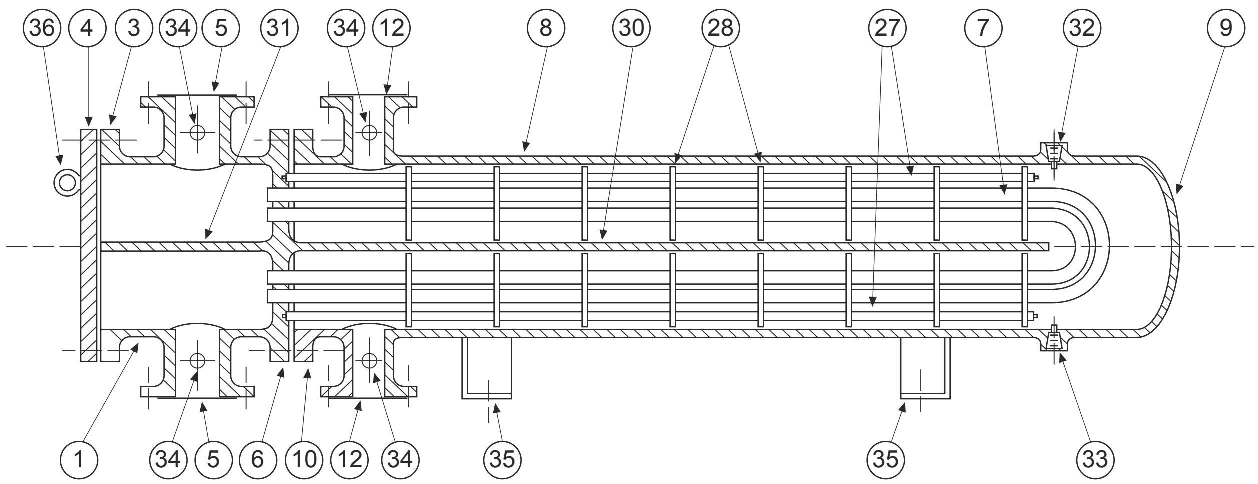
BEM

Figure A.11—Heat Exchanger Parts (continued)



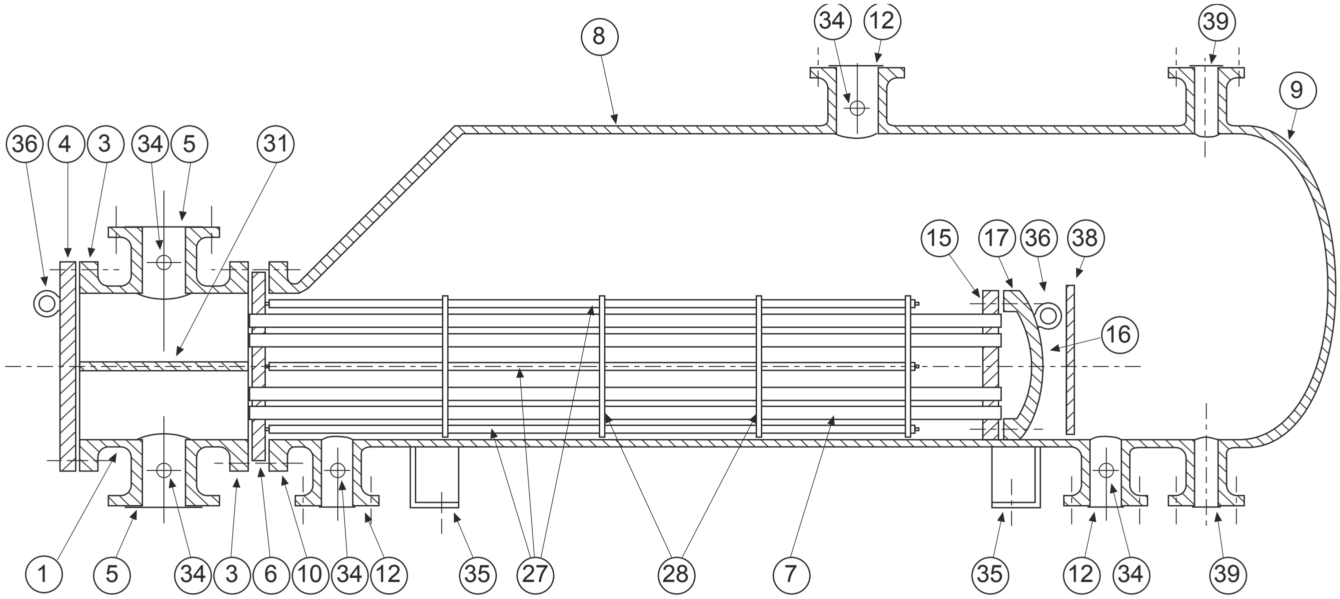
AEP

Figure A.11—Heat Exchanger Parts (continued)



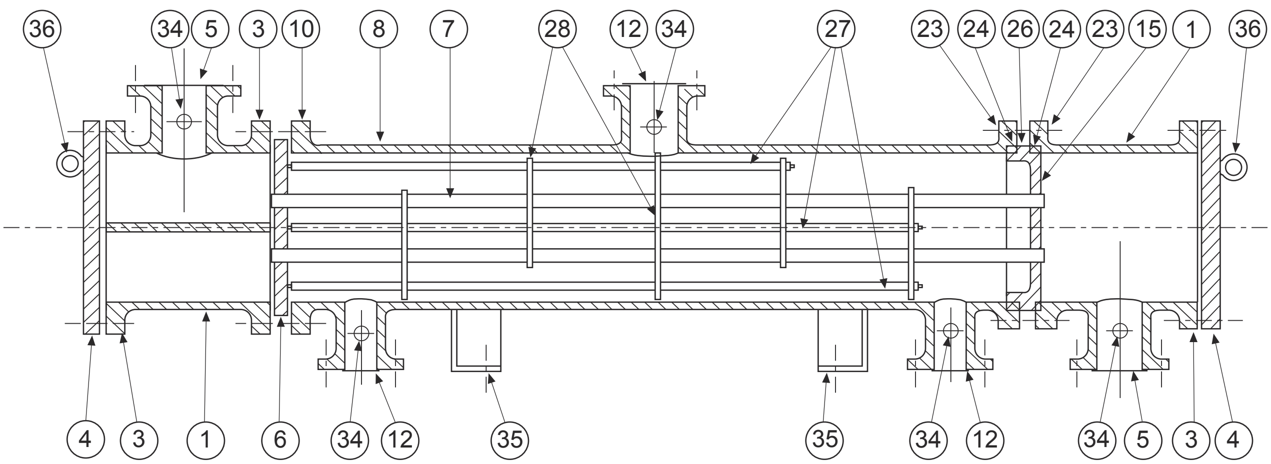
CFU

Figure A.11—Heat Exchanger Parts (continued)



AKT

Figure A.11—Heat Exchanger Parts (continued)



AJW

Figure A.11—Heat Exchanger Parts (continued)

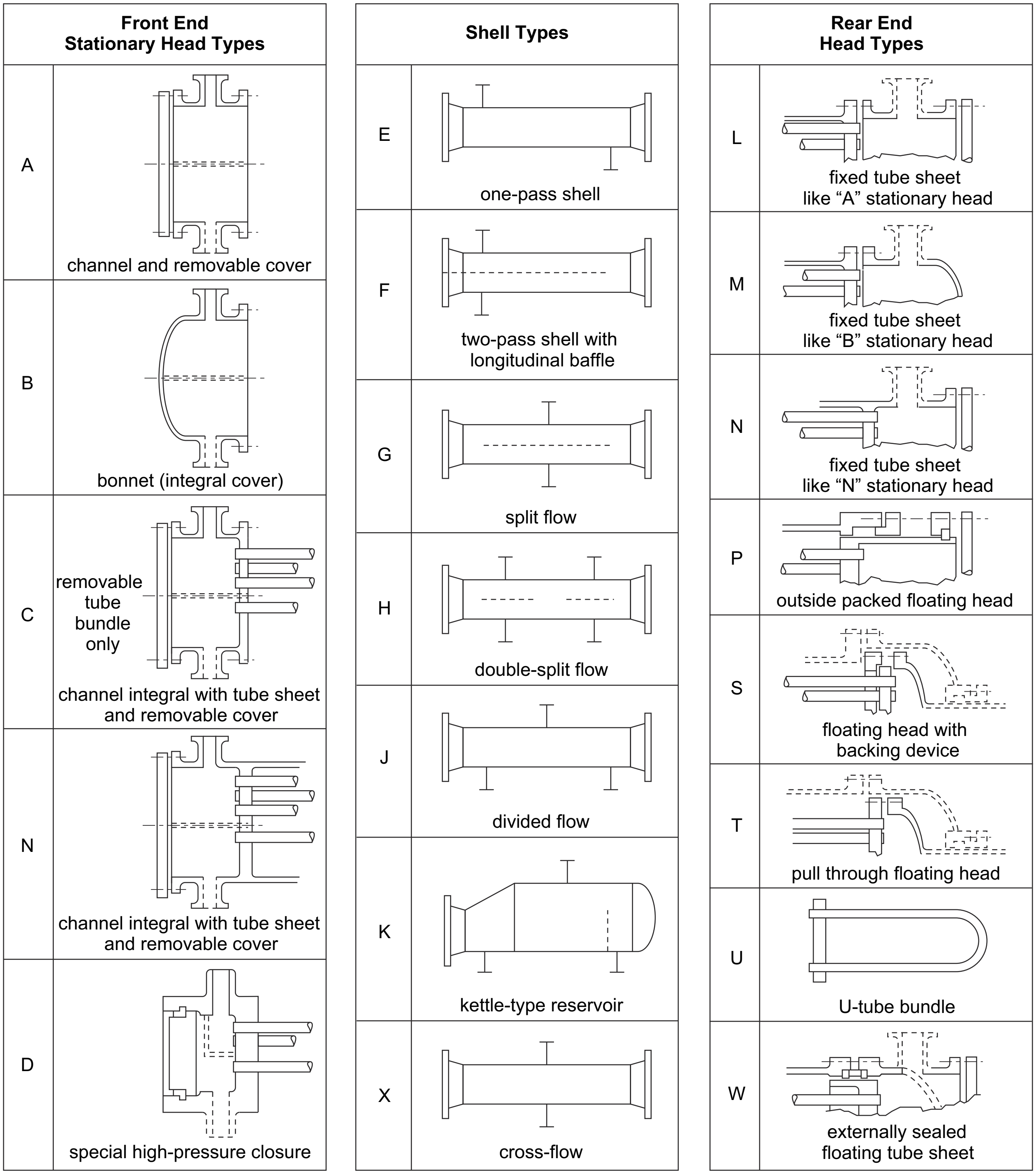


Figure A.12—Heat Exchanger Types

Annex B
(informative)

Towers

B.1 General

Towers all either directly enrich a gas or liquid, strip a gas or liquid, or fractionate a liquid. These processes are collectively called "mass transfer". Towers or columns (the terms tower and column are used interchangeably within the petrochemical industry) come in a wide variety of shapes and sizes, but the one thing they all have in common is base purpose, that is, they all, at the very basic level, promote, cause, contain, allow, encourage, or otherwise make "mass transfer" happen. The difference in concentration of a particular molecule is the prime mover in mass transfer. Molecules move from an area of high concentration to an area of low concentration. The mass transfer in a tower is usually from a liquid to a gas or from a gas to a liquid. The most common types of towers use contacting elements such as trays or packing to facilitate mass transfer between a gas and a liquid (see Figure B.1 and Figure B.2). Both packing and trays accomplish this by increasing the available surface area for the gas/liquid contact.

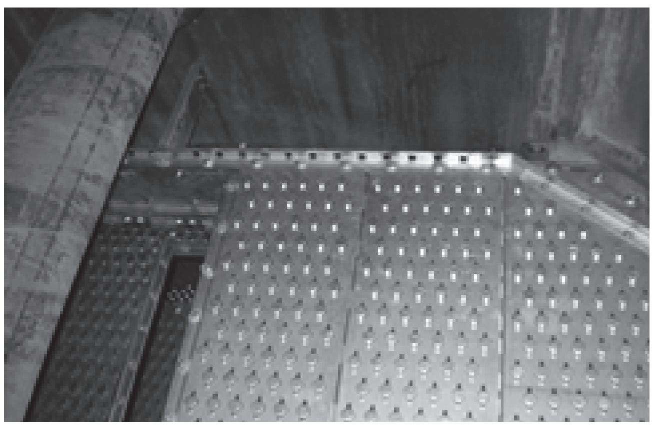


Figure B.1—Typical Trays in a Tower-

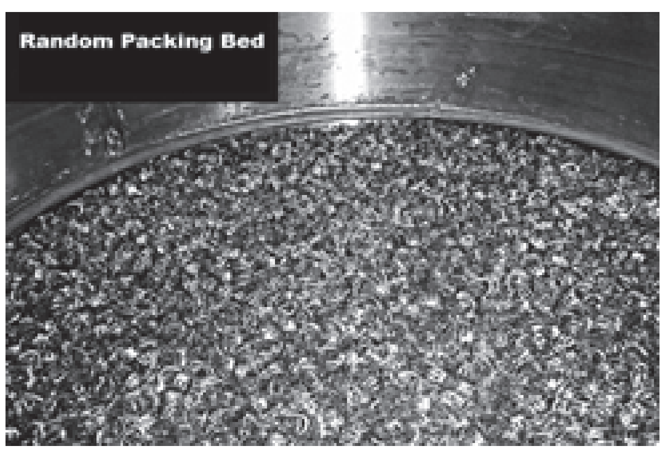


Figure B.2—Random Packing in a Tower

In addition to increasing contact area (and increasing contact time), trays allow additional distillation to take place at each tray.

Tray decks both increase the available contact area and provide additional distillation stages to take place as the hot gases rise through the tray perforations. Liquid levels are maintained on the trays via weirs, and a vapor seal is maintained via downcomers. Figure B.3 diagrams how the trays with downcomers work.

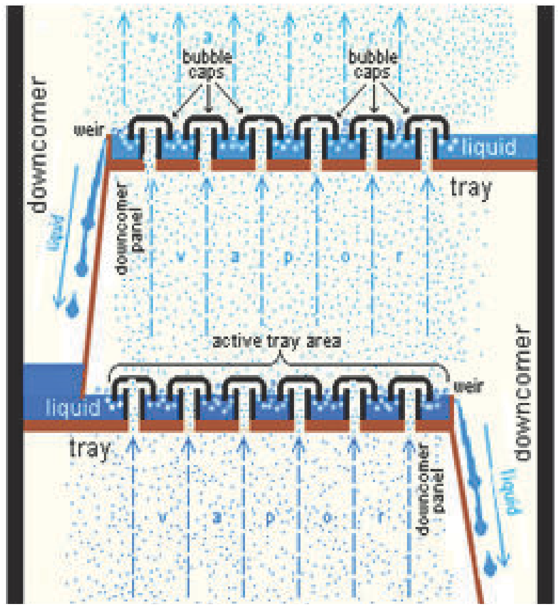


Figure B.3—Trays with Downcomers

Gases/vapors, released from the feed liquid (after being heated), travel up the column through the tray perforations (the bubble cap depicted in Figure B.4 is a type of tray perforation) while liquid flows across the trays and down the tower via the downcomers from the feed inlet down to the stripping section (countercurrent flow). The area above the feed inlet is known as the rectification or enrichment section. The enrichment section utilizes a liquid reflux of condensed overhead gas to further enrich the overhead product.

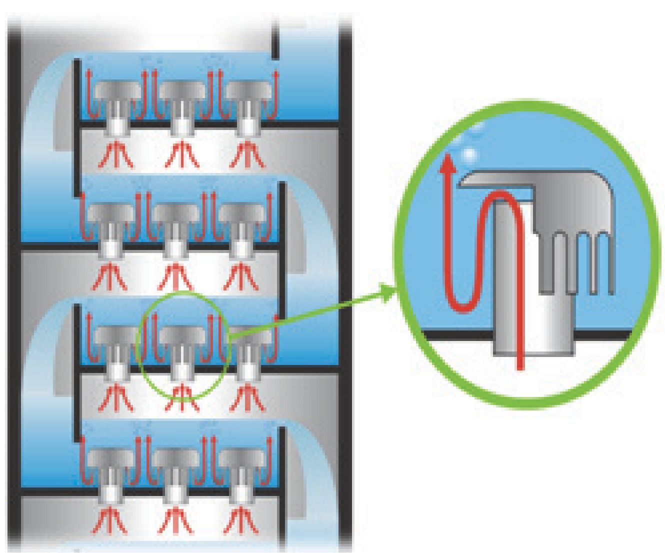


Figure B.4—Bubble Cap Flow Path

Most of the towers used in the petrochemical industry utilize the distillation-type stripping process described above and depicted in Figure B.5; however, in cases where distillation is impractical, liquid–liquid extraction accomplishes mass transfer utilizing the difference between the chemical structures of two liquids. Liquid–liquid extraction necessitates recovery of solvent or raffinate via distillation stripping. Some other types of mass transfer operations that utilize distillation-type stripping are stripping, absorption (also known as scrubbing), and dehydration. Fractionation uses simple distillation via selective cooling to remove and collect those fractions of the feed that boil and condense at different temperatures. The heat source needed to cause phase change (liquid to gas) can be fired heaters, steam injection, steam reboilers, or reboilers using preheated process streams.

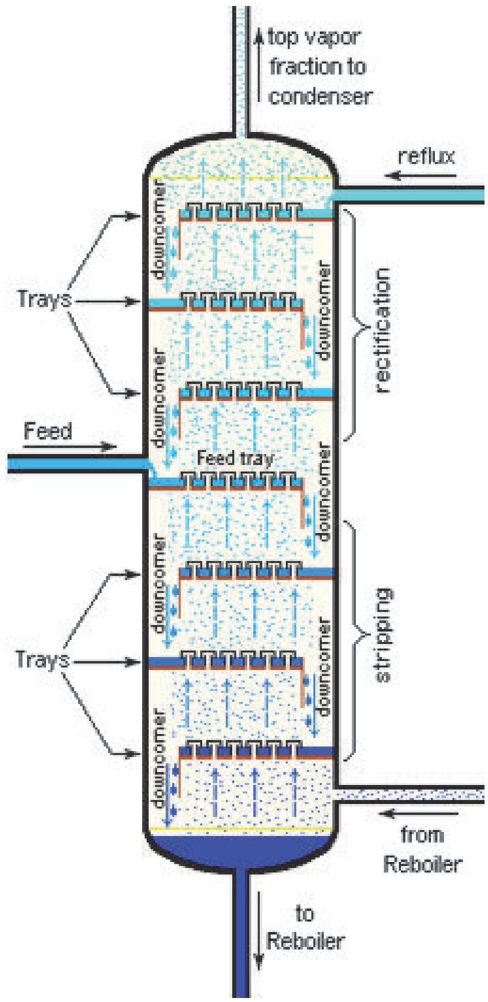


Figure B.5—Tower Stripping and Rectification Section

B.2 Trayed Towers

B.2.1 General

Trayed towers consist of cylindrical shell courses with both top and bottom heads, with nozzles where appropriate, filled with tray decks to facilitate the gas/liquid contact. They may also include conical transition sections, internal sumps/baffles, demisters, inlet distributors, or a variety of other components. Multiple towers may even be fabricated as a single pressure vessel, stacked on top of each other.

Trayed towers come in several different configurations, from cascade-type trays such as disk and donut trays to sieve trays, bubble cap trays, and high-capacity valve trays.

B.2.2 Cascade Trays

The two most common types of cascade trays are shed trays and disk/donut trays. Cascade trays utilize a different approach to gas/liquid contact than regular trays. Shed trays may be anything from angle iron to half pipes. Large numbers of shed trays are arranged in rows, installed perpendicular to each other and to the gas and liquid flow such that breakup of the falling liquid takes place. Gas flow up through the droplets of liquid is the primary source of contact for mass transfer. In disk/donut trays (see Figure B.6) the disks and donuts are installed in alternating sequence, with the donuts mounted to the shell and the disks suspended in the center of the tower, with both the disks and the donuts being perpendicular to the gas and liquid flow. As liquid repeatedly cascades from the disks to the donuts, sheeting and breakup of the liquid takes place.

Figure B.6—Disk/Donut Tray

Baffle trays (sometimes called "splash trays") are solid baffles, installed on alternating sides, perpendicular to the gas/liquid flows. These individual trays each typically obstruct about 60 % of the tower to ensure that the falling liquid impacts the tray below. The baffle tray arrangement is depicted in Figure B.7.

Contact with the falling and/or splashing droplets is the main source of liquid/vapor contact for all cascade-type trays. Internals associated with cascade trayed towers are usually limited to simple pipe inlet distribution with steam spargers in the bottom to provide heating and gas flow volume.

B.2.3 Sieve Trays

Sieve trays are tray plates with perforations in them similar to a sieve (see Figure B.8), hence the name. No valves are present. Sieve trays can be subdivided into single-flow and dual-flow trays. Single flow refers to the flow through the tray perforations. On single-flow trays, the primary flow path of the liquid is across the tray and down the downcomer to the tray below.

The downcomers act to transport the liquid to the next tray, and promote disengagement of the gas and the liquid. The primary flow path of the gas on single-flow trays is through the tray perforations. The perforations in single-flow sieve tray are sized with this in mind. Single-flow sieve trays are customarily used where light-to-moderate fouling by precipitates and/or polymers is anticipated.

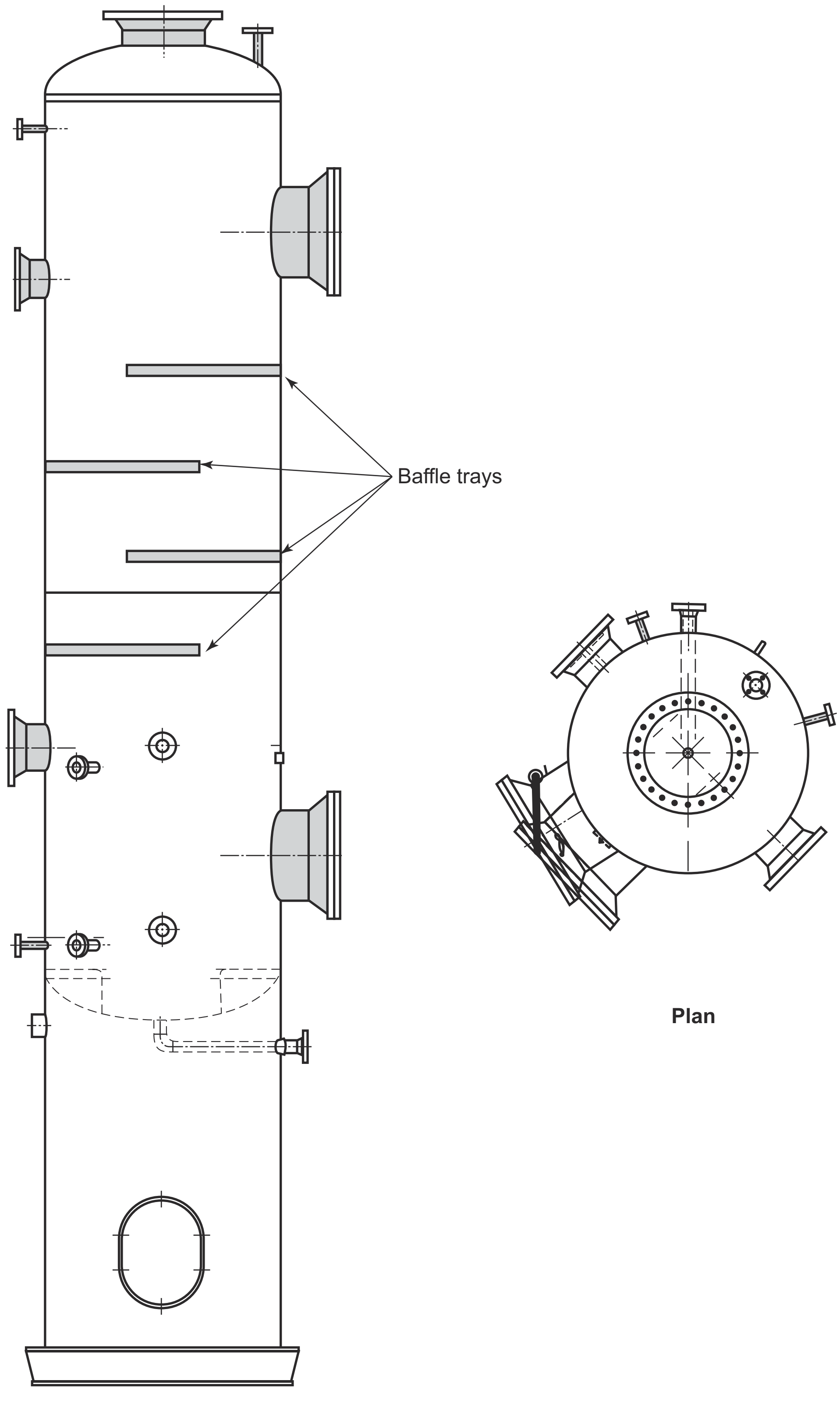


Figure B.7—Baffle Tray Arrangement

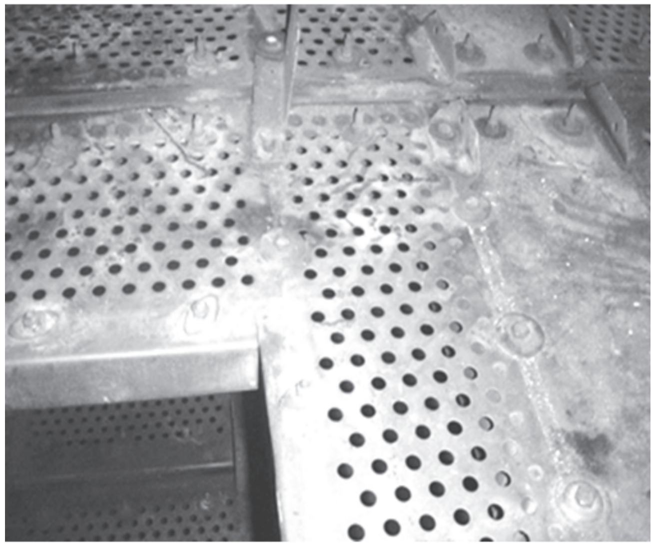


Figure B.8—Figure Tray

Dual flow also refers to flow through the tray perforations. On dual-flow trays, there are no downcomers. The primary flow path of both the descending liquid and the ascending gas is through the tray perforations. In response to liquid falling from above and gas bubbling from below, the standing liquid on the tray forms waves throughout the liquid. Gas flow up is primarily at the wave troughs, and liquid flow down through the perforations is primarily at the wave crests. Jet tabs similar in appearance to very small upward facing scoops are utilized to promote even liquid flow throughout the sieve tray. Ripple trays are a type of dual-flow tray that magnifies the crest/trough relationship via the corrugated design of the tray panels. Dual-flow trays are customarily used for processes that exhibit heavy fouling due to the formation of precipitates or polymers. Both types of sieve trays have better anti-fouling characteristics than standard valve trays, but should operate in a very limited range of operating conditions to be efficient.

Sieve trays need to be installed and maintained level. Sieve trays that are not level can rapidly lose efficiency due to blow through where areas of the liquid level on the tray are shallow. Figure B.9 show a sieve tray that has been distorted.

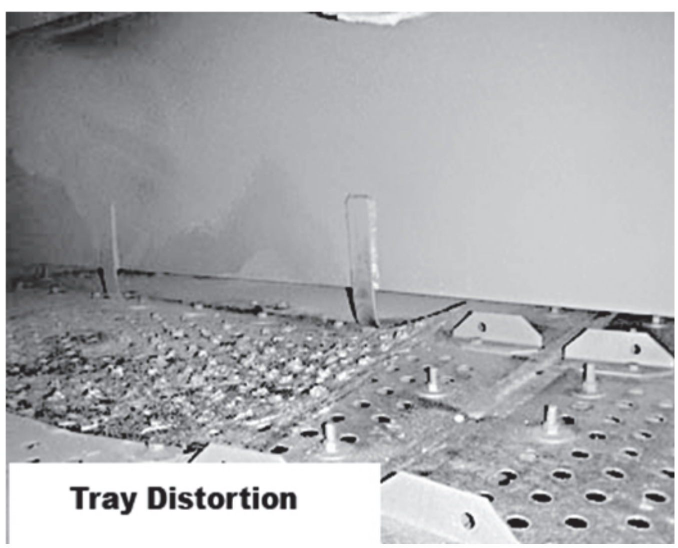


Figure B.9—Sieve Tray Distortion