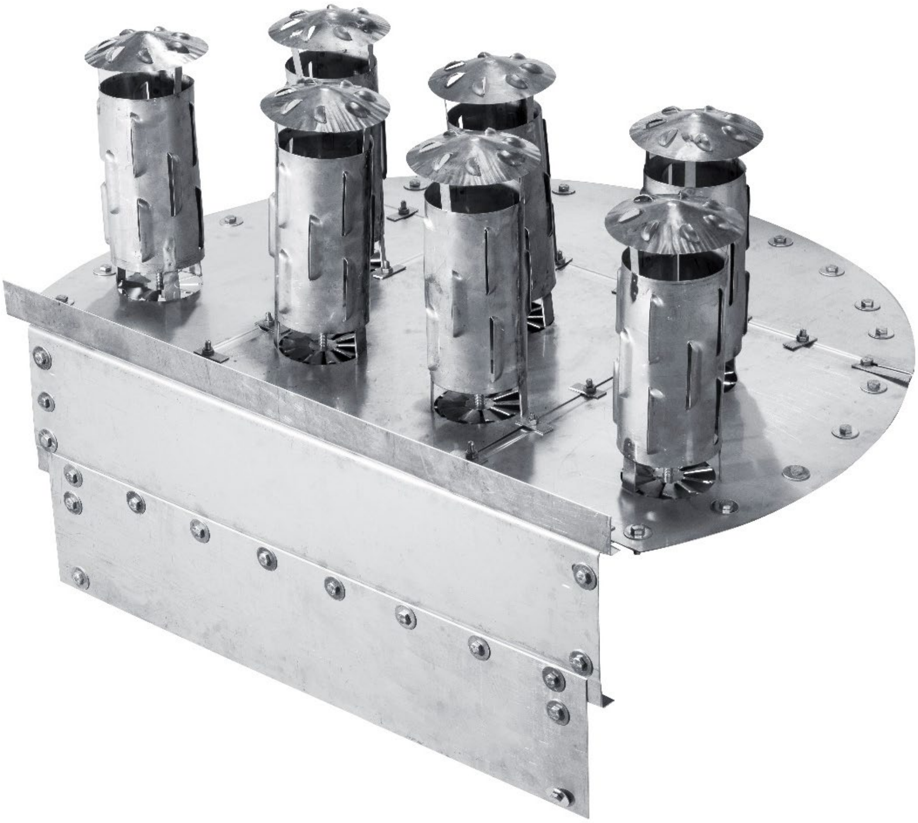
TRAYS



AZAR ENERGY
TABRIZ

CHEM GROUP

AZAR ENERGY Co.

Trays

For many years, column trays have been used in a wide range of separation processes in the petrochemical and chemical industries. Although trays have been replaced in part by random and structured packing, there are many mass transfer applications in which trays will be the preferred choice. Conventional absorption, distillation or fractionating trays consist of vapor / liquid contacting decks or trays with segmented liquid down flow areas. Column scan contain any number of trays installed vertically above each other. Each set of trays needs to be individually designed for the specific process and mechanical requirements anticipated with in the column.

Materials:

S.S.302, 304, 316, 316L, 317, 317L, carbon steel, aluminum, etc.

Application:

Trays are essentially used when:

- ✓ ‰ Towers are very large in diameter (Multi-pass Trays)
- ✓ ‰ Compounds contain solids or foulants
- ✓ ‰ There are many internal transitions
- ✓ ‰ Liquid loads are high ‰
- ✓ ‰ Lack of experience in the service
- ✓ ‰ Chemical Reaction/Absorption -use high weirs to provide greater residence time for absorption / chemical reaction.

Product design:

The design and manufacture of trays to meet the requirements the major operating companies and engineering contractors is restricted to a small number of specialist international vendors such as Azar Energy who have acquired and developed the experience and design tools to deliver a reliable and competitive product. Likewise, assembly and inspection of the trays inside the column should ideally be undertaken by specialist tray installers, like ourselves, or otherwise under our supervision.

If our product standard didn't meet your needs, Azar Energy is glad to work with your company and design it for your specific application. At Azar Energy Chem Group, decades of design, construction and manufacturing experience combine to ensure our column internals meet the requirements of your application.

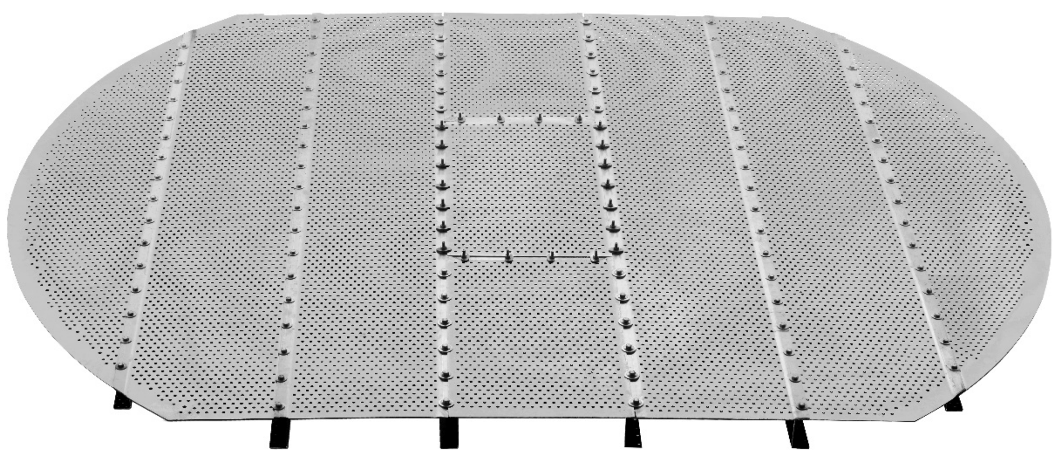
Contents

Sieve Trays

Sieve trays became a dominate tower internal for mass transfer columns in the 1950's owing to their simple shape and ease of manufacture. This made sieve trays a popular device for extensive research and as a result, a considerable amount of experience has been gained for tray design and its application. Sieve Trays have tray deck areas uniformly perforated with round holes. Tray designs with perforations as small as 6mm or as large as 25 mm are common with 13mm/19mm being the most frequently used. Vapor flow through the tray deck to contact the liquid is controlled by the number and size of the perforations. For efficient operation, the hole velocity must be sufficient to balance the head of liquid on the tray deck and thus prevent liquid from passing through the perforations to the tray below. On the other hand high hole velocities may cause severe liquid entrainment to the tray above. Consequently Sieve Trays have an arrow operating range, no more than 2:1.

Application

Sieve trays can be used in almost all services. Their capacity and efficiency are at least as high as that of other standard trays used commercially. Flexibility is generally around 2/1, but ranges up to a maximum of about 3/1. For greater than 3/1 flexibility, valve trays are a better choice. Sieve trays may be used in moderately fouling services, provided that large holes (3/4 to 1 in. [19 to 25 mm]) are used.



Fixed Valve Trays

Like sieve trays, valve trays have been in use as far back as the 1950's but nowadays have become the more popular choice because of their greater operating range properties. Valve trays are essentially flat perforated trays with moveable or fixed valve units with or without a cage structure covering the holes. Fixed valves are units with integral legs formed out of the tray deck. The open or vertical curtain area of the valve, through which vapor issues in a horizontal direction is defined by the restrictive legs integral with the valve unit or the leg-rise of the cage structure attached to the tray deck. The fixed valve tray is manufactured by punching and forming integral valves over the tray deck. By punching the fixed slots in a parallel to liquid flow arrangement, the fixed valve tray gives higher capacity than the sieve tray with a greater availability for turn down.

Application

For most towers, sieve trays with 2/1 or 3/1 flexibility are normally adequate and should be used. If greater flexibility is required, valve trays can be specified. Fixed valve trays can best be described as valve trays whose valve units are fixed in the fully open position. The flexibility or turndown of such devices is generally better than that of a sieve tray, e.g., fixed valve trays have a turndown ratio of 3/1, but not as good as that of a movable valve tray. Also, fixed valve trays are generally less expensive than movable valve trays. Fixed valve trays may be useful for extending run lengths in some fouling services (but not where sticky material is entrained from below).

Moving Valve Trays

Like sieve trays, valve trays have been in use as far back as the 1950's but nowadays have become the more popular choice because of their greater operating range properties. Valve trays are essentially flat perforated trays with moveable or fixed valve units with or without a cage structure covering the holes. Moveable valves are disk-shaped type devices which are enclosed within a cage structure or contain legs formed out of the valve disk. The open or vertical curtain area of the valve, through which vapor issues in a horizontal direction is defined by the restrictive legs integral with the valve unit or the leg-rise of the cage structure attached to the tray deck. At very low vapor rates, the valve discs rest on the tray deck to almost close off completely the tray deck perforations thus minimizing tray open area. As the vapor rate rises, the valve discs are lifted from the tray deck which increases the open area for vapor flow between the valve disc and the tray deck. The effective operating range of valve trays is dependent on specific service conditions as well as pressure drop limitations and can be as high as 10:1.

Application

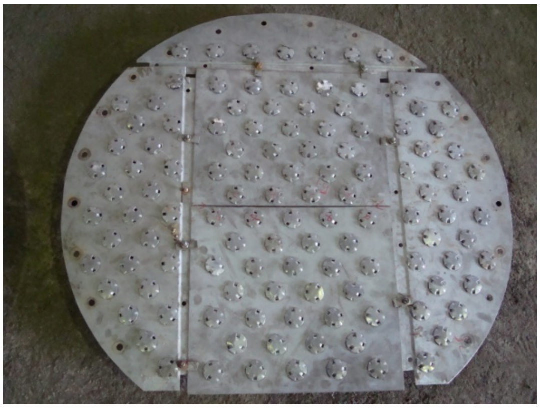
Several examples of services requiring wide flexibility are:

• When vapor rates change appreciably (and often unpredictably) over a given section of a tower.

• When a tower is utilized in blocked operation at varying rates and/or feed compositions.

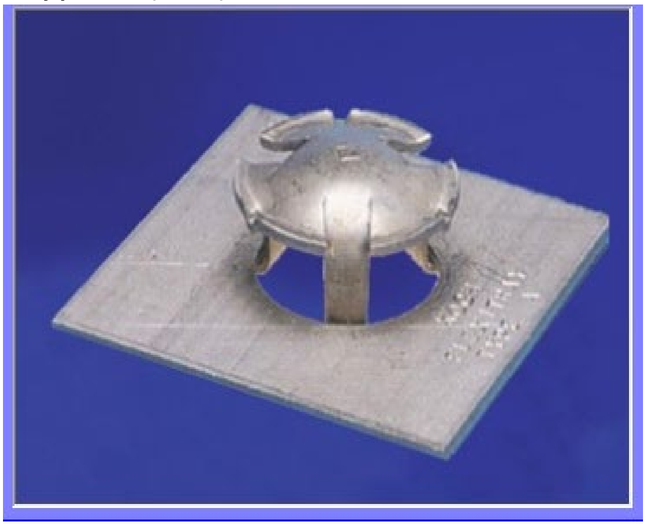
• When seasonal fluctuations in feed rate, customer demand, etc., necessitate operating a tower at very low rates (less than 30% of design).

• When servicing of auxiliary equipment necessitates operating the entire unit at low rates.

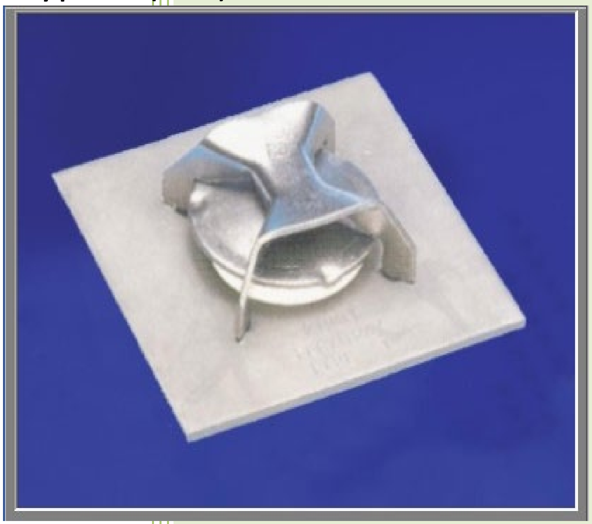



Common types of Moving and Fixed Valves

Type A (V-1)

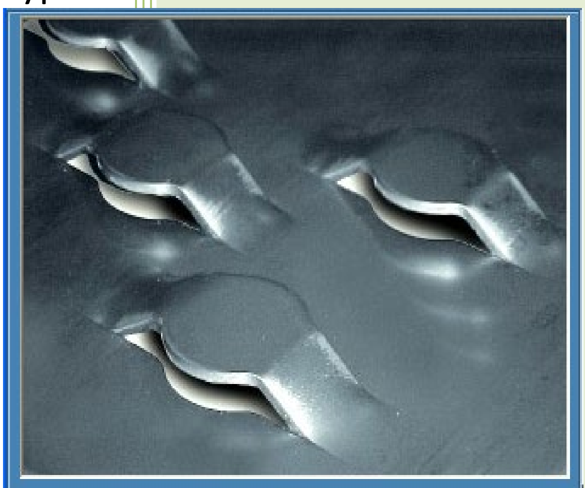


Type A (V-2)



Type VG-0

Type VG-10

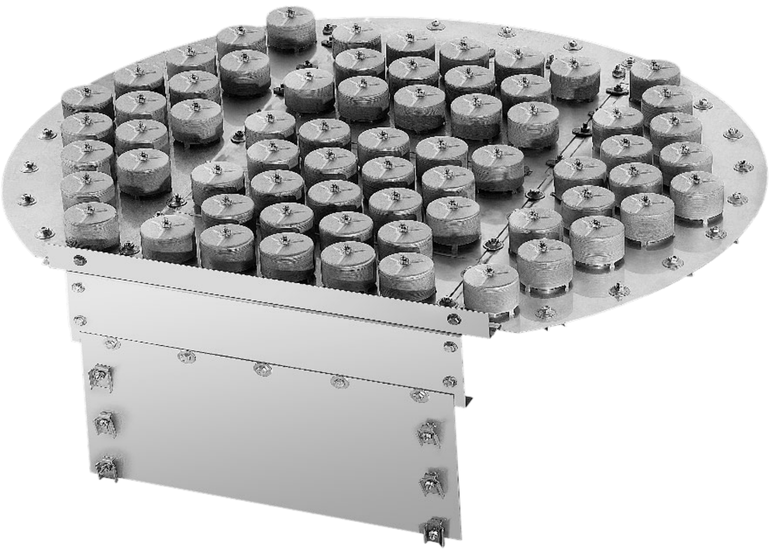


Bubble Cap Trays

Bubble cap trays consist of a flat perforated deck in which the holes are enclosed with vapor or gas chimney risers and caps in the form of inverted cups mounted on top of the risers. The caps can either be equipped with slots or holes, through which vapor escapes, or non-slotted where vapor is directed into the space between the bottom of the cap and tray floor (skirt clearance). Vapor is forced into the surrounding cross-flowing liquid such that aerated liquid is trapped on the tray floor to a depth at least equal to the weir height or riser height. This gives the bubble cap tray the advantage to operate at extremely low liquid and vapor rates.

Application

For most towers, sieve trays with 2/1 or 3/1 flexibility are normally adequate and should be used. If greater flexibility is required, and the system is non-fouling, valve trays should be specified. If the system is fouling or corrosion of valve trays is expected to be a serious problem, then bubble cap trays should be provided. The main disadvantage, besides cost, is that a large fraction of the vapor phase pressure drop is wasted as it occurs in the reversal area between the chimney riser and cap. Consequently it does not contribute to the mass transfer process. Bubble cap trays, generally, have the ability to handle wide ranges of liquid and vapor flow rates satisfactory due to their leak proof properties. This advantage is exploited in special applications such as gas scrubbers where a large amount of vapor must be in direct contact with the low liquid flow. Standard cap sizes of 75, 100 and 150 mm are available. Custom designs are also available.



Jet Trays

Jet trays have been used in the petroleum and chemical process industries since the early 1950's. Because of their high vapor and liquid handling capacity and low cost, they replaced bubble cap trays in many services. Since the mid-1960's, however, jet trays have been superseded by sieve trays and packing, which are more cost effective and have wider flexibility for most services. Nevertheless, jet trays are still important where very high liquid handling capacity is required, such as in the pump around sections of various heavy hydrocarbon fractionators operating near atmospheric pressure.

Application

For most new distillation towers, sieve trays or packing are usually the best choices. However, jet trays are recommended for heat transfer services, especially where high liquid loadings might require 3 or 4-pass sieve trays and hence complex transitions. For those cases, single or double-pass jet trays may be better. These services include pump arounds in atmospheric pipe stills; cat, coker and steam cracker primary fractionators; and visbreaker fractionators.

Jet trays should not be used in the following cases:

• Where the liquid rate is below 4 gpm/inch of diameter per pass (10 dm3/s/m of diameter/pass). Liquid rates below this value may result in spray regime operation with a consequent loss in tray efficiency.

• In towers less than 7 ft (2100 mm) in diameter. In these towers, the tray bubble area will become relatively small because of the down comer area required. This narrow bubble area, in turn, can result in high localized vapor velocities, which may increase entrainment and cause premature flooding.

• In vacuum towers because of their inherently high pressure drop and poor efficiency due to the low liquid rates usually encountered in these units.

Direct Contact Heat Transfer Trays

In large towers, such as pipe stills and catalytic cracking unit fractionators, one or more heat transfer or "pump around" sections are often provided to recover heat effectively from the tower. The use of pump arounds results in a better distribution of tower loadings than would be the case if the entire cooling duty were assigned to the overhead condenser. This, in turn, permits the use of smaller tower diameters in the upper sections of these columns and recovery of high temperature level heat. The heat is removed from the tower by direct contact heat transfer between the hot, ascending vapor and the descending liquid, which is externally cooled and returned, i.e., "pumped around."

For other, less frequently used types of direct contact heat transfer applications (such as condensable blow down drums, barometric condensers, FCCU slurry sections, steam cracker fractionator overhead condensers, and water cooling and condensing towers) can be applied.

Application

Since the factors affecting direct-contact, vapor-liquid heat transfer are similar to those affecting fractionation, it follows that fractionating trays are usually suitable for heat transfer service in nonfouling pump around sections. Indeed, it is often convenient to use the same tower diameter in the pump around section as in the fractionating section immediately above or below. While jet trays are frequently used in heavy hydrocarbon pump around service, the proper tray choice also depends on considerations of capacity, turndown, hydraulics and maintenance.

DualFlow Trays

Dualflow trays are essentially sieve trays without downcomers such that the entire tray active area is perforated with holes. Hole sizes range between 12.5 to 25mm in diameter. Tray action occurs through the continuous counter current passage of vapor and liquid through the tray holes. As the liquid and vapor load are increased, the tray liquid head increases up to a point where a pulsating liquid seal is established at sufficiently high loads. At these conditions, liquid momentarily leaks through holes in areas of wave crests, while vapor surges through holes in the area of between crests. As a result dualflow trays only have a very narrow efficient operating range. High open hole area dualflow trays have a higher capacity and lower pressure drop compared to conventional distillation trays at the same tray spacing and are best suited for processing fluids that form polymers or have a high solids content. The majority of commercial applications are common in small to moderate sized columns. They are seldom used in larger diameter columns because of difficulties in achieving the desired tray tolerances for levelness.

Application

The absence of downcomers provides both advantages and disadvantages. Because the entire plate is active, dualflow trays possess higher capacity than that of a sieve or valve tray. But, even at design liquid and vapor rates, efficiency is usually lower. However, for high pressure, high vapor density systems, the peak tray efficiency approach that of a sieve tray. Dualflow trays are particularly well-suited for the fractionation of polymerizable compounds or high solids content systems (i.e., slurries) because of the self-cleaning nature of the tray. Consequently, dualflow trays may be used to debottleneck existing towers only when a considerable sacrifice in efficiency can be tolerated. The major disadvantage of dualflow tray is their poor turndown ratio resulting from the rapid fall off in efficiency as the vapor loading is decreased. Therefore, the dualflow tray must be properly designed and the operating vapor and liquid rate ranges must be kept small.

Drawoff (Chimney) Trays

Chimney trays are used to provide good vapor distribution to the internals above, liquid collection and mixing for drawoff or internal reflux, and liquid holdup. In columns containing packing or grid, especially in vacuum towers where pressure drop is critical, good chimney tray design is essential to provide uniform vapor distribution while minimizing pressure drop. If trays are used above the chimney tray, vapor distribution is not critical since the pressure drop of the trays will normally even out the vapor flow.

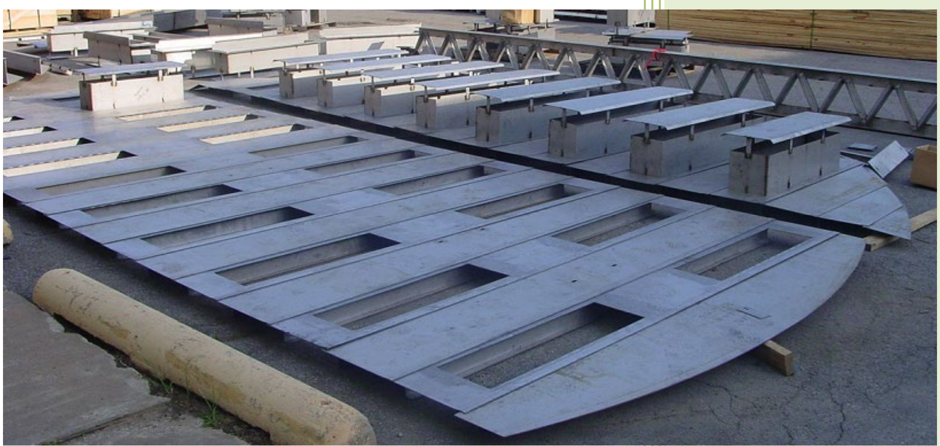
Application

A chimney tray should be used when

(a) Appreciable liquid holdup is required, as for product surge or for water settling,

(b) When leakage cannot be tolerated for process reasons, such as, in water wash sections where leakage into amine or caustic solutions is unacceptable, or

(c) When a drawoff box would occupy excessive tray cross-sectional area.



HiFi Trays

HiFi trays are designed to handle large liquid loads typically for flow parameters larger than 0.1. They are used for applications where the liquid loads are high and cannot be accommodated by the Calming section trays.

The major advantage is that the box downcomers provide an outlet weir length double or triple what chordal downcomer trays can provide. This lowers the effective weir loading by 50 % to 70 % substantially lowering the crest over weir on the tray and pressure drop. This results in a significant capacity boost over conventional trays.

Application

For a given column diameter, they allow for:

- Highest number of passes
- Large downcomer area
- Long weir length
- High hydraulic capacity
- Low tray spacing
- High NTS per column height

EDV Valve Tray

A new high efficiency type of valve trays design is based on traditional trays. It features improved design of a valve and a tray as a whole, increased capacity, efficiency and operation flexibility.

Top protrusions make vapor dispersion more uniform and finer, which improves efficiency. The anti-spin valve hole prevents valve rotating like V1 valve, and valve falling from the hole, which occurs when the valve legs become overly worn.

MAIN ADVANTAGES:

- 40% (or more) higher capacity
- 10-20% more efficiency
- >10% lower pressure drop
- 30-50% greater flexibility
- Minimum modification in reconstruction
- Easy to install and maintain

Centrifugal Trays

One of the most modern trays that are designed by using latest science and modern technologies is centrifugal trays with mechanism of centrifugal force and special design in order to separate phases. Some of the features of this kind of tray include high capacity, efficiency, mechanical resistance and also reduction of foaming and priming. These trays have considerable differences with common trays from the viewpoint of geometrical construction, so that this varying construction has great influence on the extent of separation, range and their operational quality. The centrifugal tray belongs to a new generation of mass transfer trays that can increase the capacity and efficiency profile of tray columns significantly. This increase is achieved by a special vapor and liquid distribution and also contact system installed on this tray.

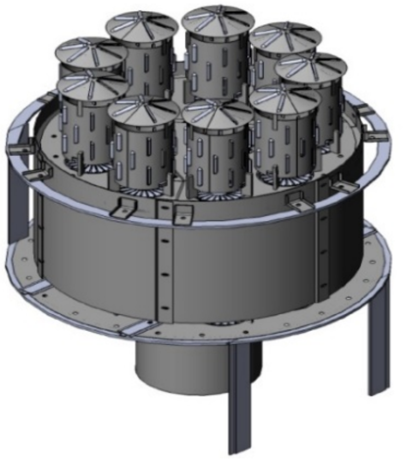
Materials of Construction

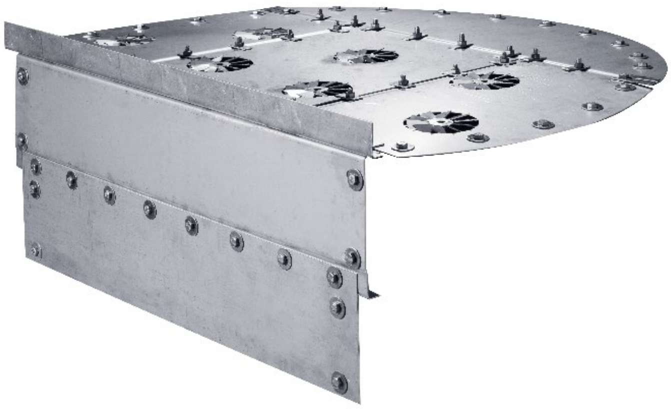
All types of trays including centrifugal ones are offered in various materials of construction.

- Carbon steel
- Stainless steels, including Austenitic, Ferritic, Martensitic; types 409/410/430/304/316 are available
- Titanium
- Monel

Performance of centrifugal trays

In these trays vapor passes through angular tracks upward with swirling pattern. Swirling vapor leads to suction of liquid on the tray and entrains liquid inside risers. The vapor carries liquid drops and move upwards with swirling flow pattern and mass transfer phenomena happens. To separate the phases, there are some symmetric tracks on side walls and cap of the riser. The liquid passes through them under the effect of centrifugal force and density difference with vapor. In each aperture of risers, by repeating this mass transfer phenomena, liquid passes the way to down comer.





Observational study of flow patterns in centrifugal trays shows that in this kind of trays, gas and liquid passes longer path compared with other trays and it causes increase in residence time, contact area, mass transfer and efficiency.

Azar Energy Pilot Plants

Azar Energy Co. has three pilots for testing trays. Table 1 shows the specification of these pilot towers. One of these pilots (A1 in table 1) is for testing centrifugal trays and two for other tray types.

Table 1: specification of pilots of Azar Energy

Column	Diameter (m)	NO. of Trays	Tray Spacing (m)
A1	1.22	5	0.61
A2	1.22	4	0.61
B1	3	3	0.61

The hydraulic tests of trays are done in these pilots at operating condition and determine the trays operating windows. It is possible to change the trays in each pilot and have comparisons between trays performance at same operating conditions.

Some important tests which are done in these pilots, are as following:

1) Tray pressure drop
2) Weeping
3) Entrainment
4) Liquid holdup
5) Clear liquid height
6) Froth height

In our pilots many new types of trays were examined compared by each other. Depending on the operating and processing conditions the company suggests one of these types of trays.