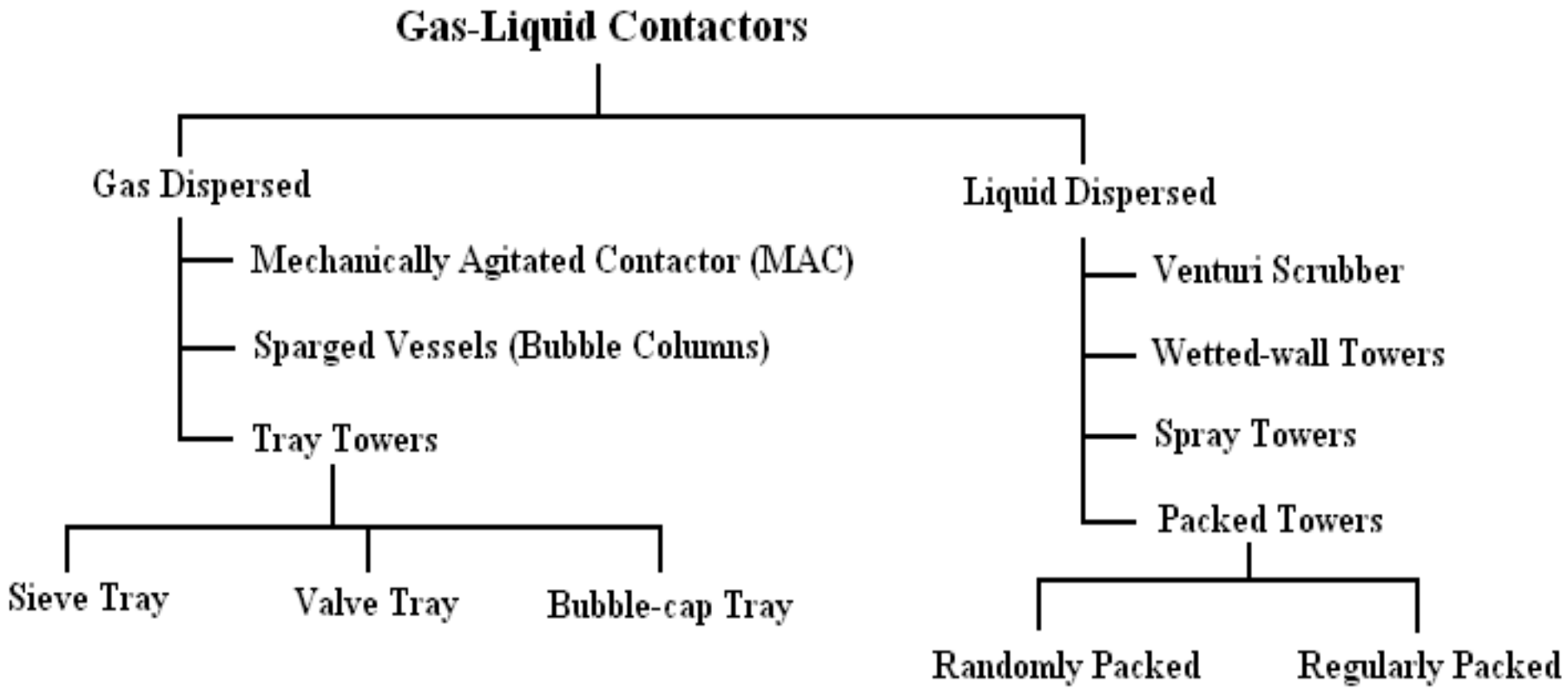
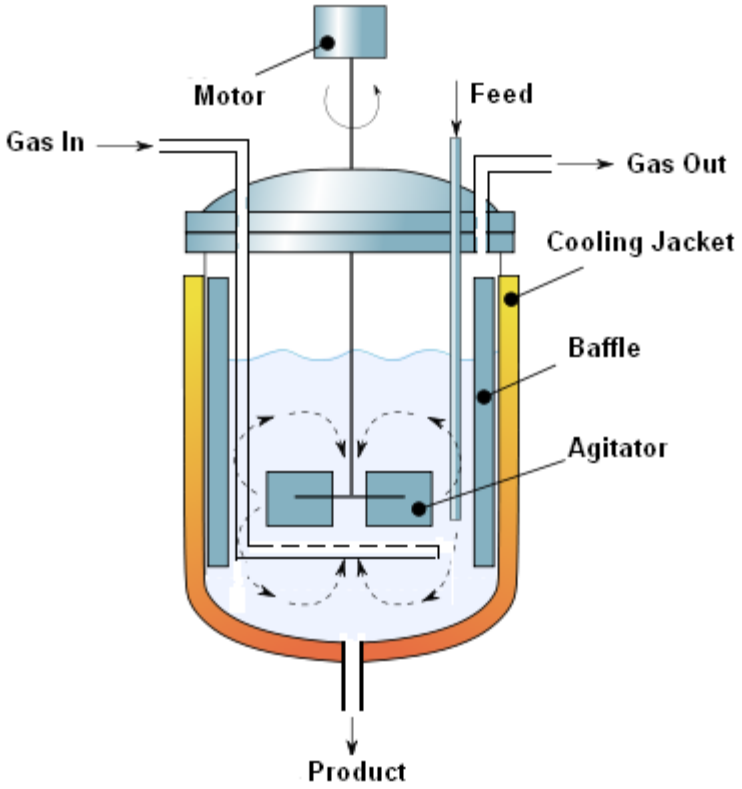
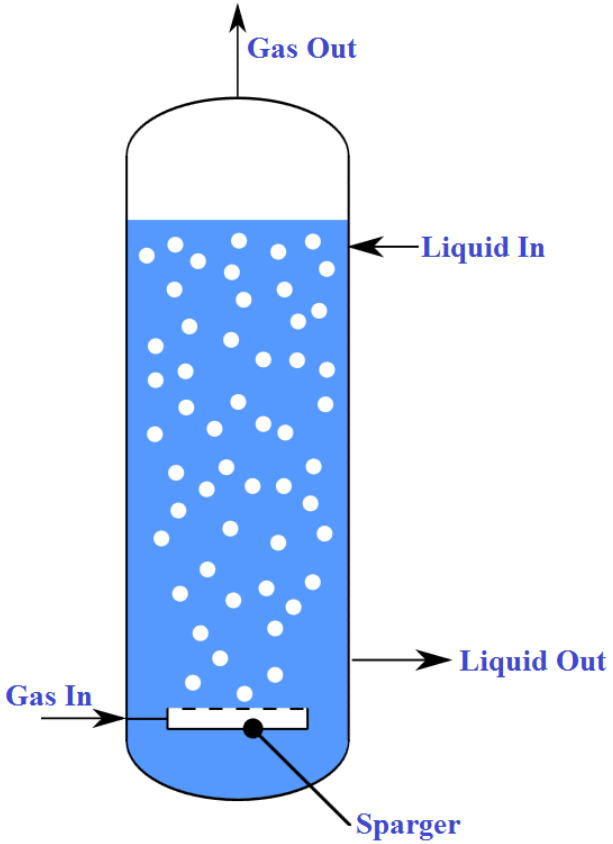
Equipment for Gas-Liquid Mass Transfer Operations


Gas-Liquid Contactors
Gas Dispersed
Mechanically Agitated Contactor (MAC)
Sparged Vessels (Bubble Columns)
Tray Towers
Sieve Tray
Valve Tray
Bubble-cap Tray
Liquid Dispersed
Venturi Scrubber
Wetted-wall Towers
Spray Towers
Packed Towers
Randomly Packed
Regularly Packed

Agitated Vessels and Sparged Vessels



Mechanically Agitated Contactor (MAC)



Bubble Column

Or, Sparged Vessel

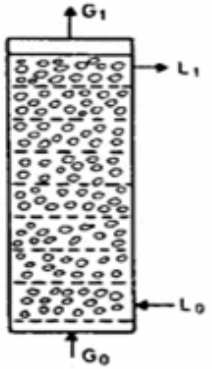
Agitated tanks are preferred where the gas flow rate is low and in the presence of suspended solids, either as a reactant or catalyst.

Agitated Vessels and Sparged Vessels

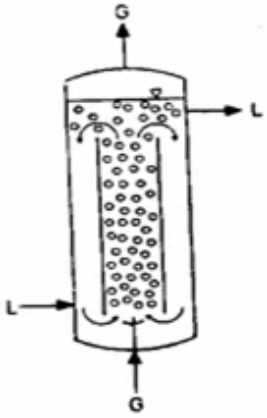
Gas and liquid can conveniently be contacted, with gas dispersed as bubbles, in agitated vessels **whenever multistage counter-current effects are not required.** This is particularly the case when a chemical reaction between the dissolved gas and a constituent of the liquid is required.

Examples: Carbonation of lime slurry, **hydrogenation of vegetable oils**, aeration of fermentation broths, as in the production of penicillin, production of citric acid from sugar beat by action of microorganisms, aeration of activated sludge for biological oxidation.

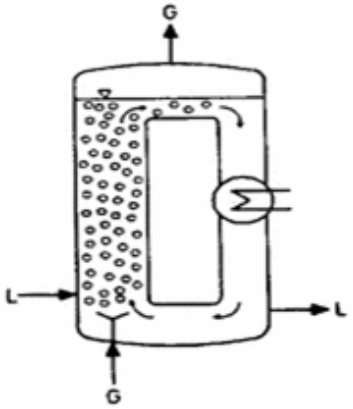
In most of the above processes, solids are suspended in the liquids. As the more complicated counter-current towers have a tendency to clog with such solids, the agitated vessels are usually more successful in such services, because solids can be suspended in the liquids easily.



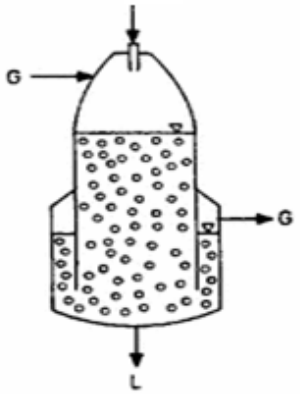
Cascade Bubble Column



Bubble Column with Internal Loop



Bubble Column with External Loop



Downflow Bubble Column

Oxidation of Acetaldehyde to Acetic Acid : Cascade Bubble Column

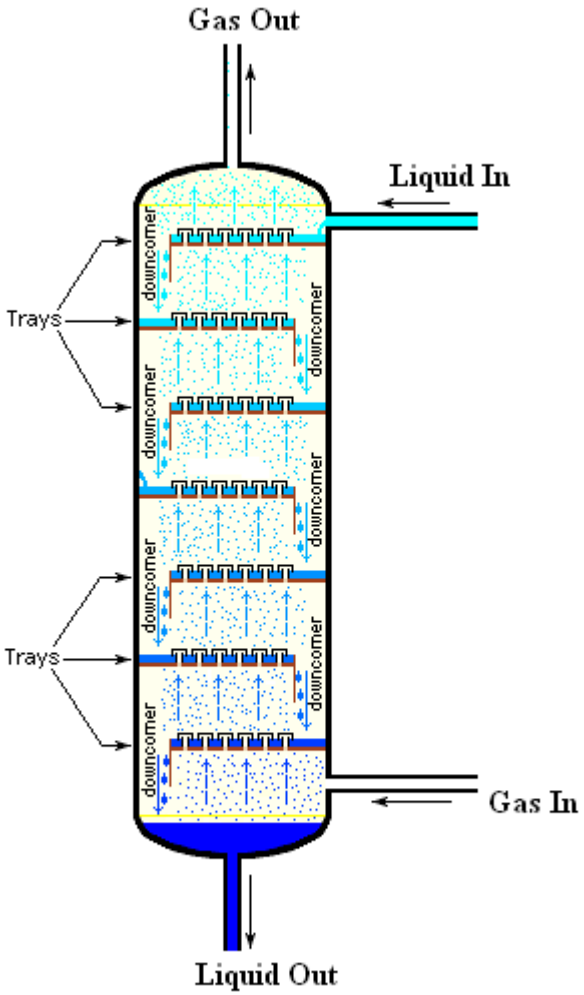
Biological Wastewater Purification (Aerobic) : Bubble Column with internal loop/ Downflow Bubble Column

Hydrogenation of Benzene to Cyclohexane : Bubble Column (slurry) with external loop

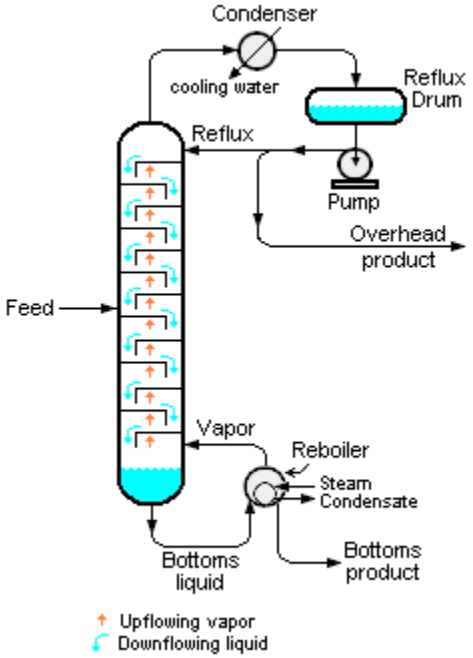
Fischer-Tropsch Synthesis in Liquid Phase : Slurry Bubble Column

Types of Bubble Column

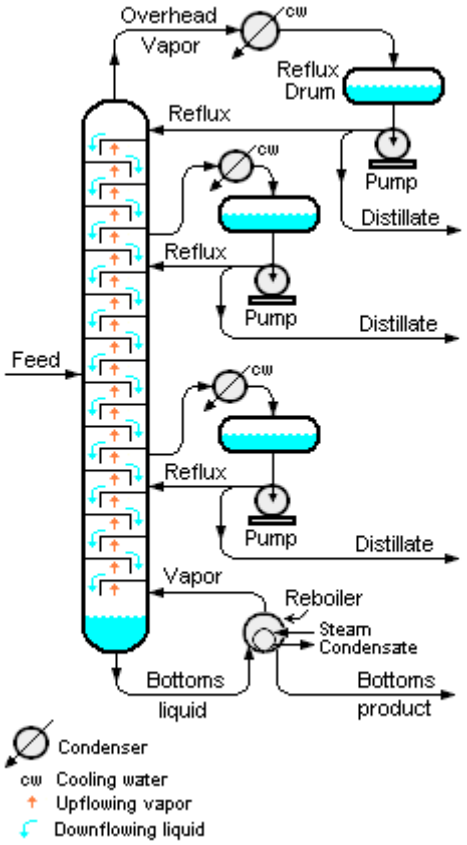
Tray Towers



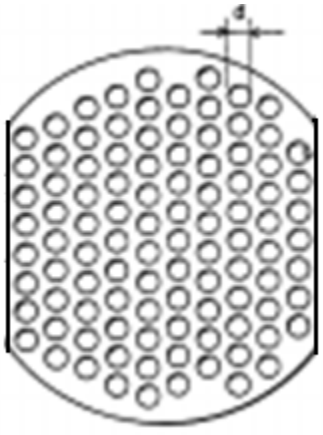
Absorption Column



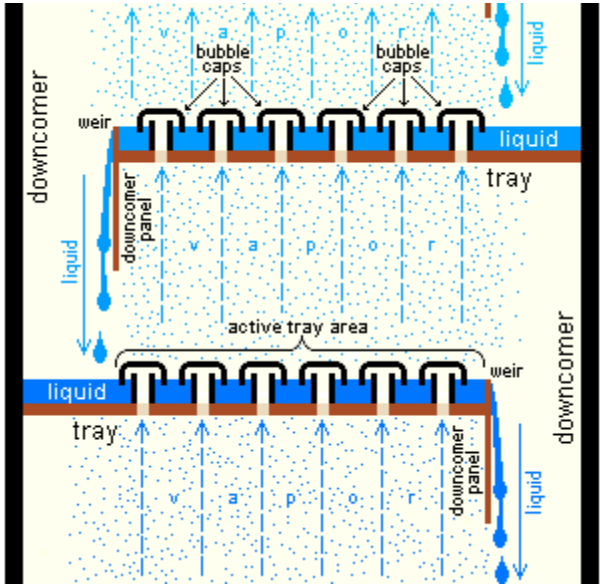
Distillation Column

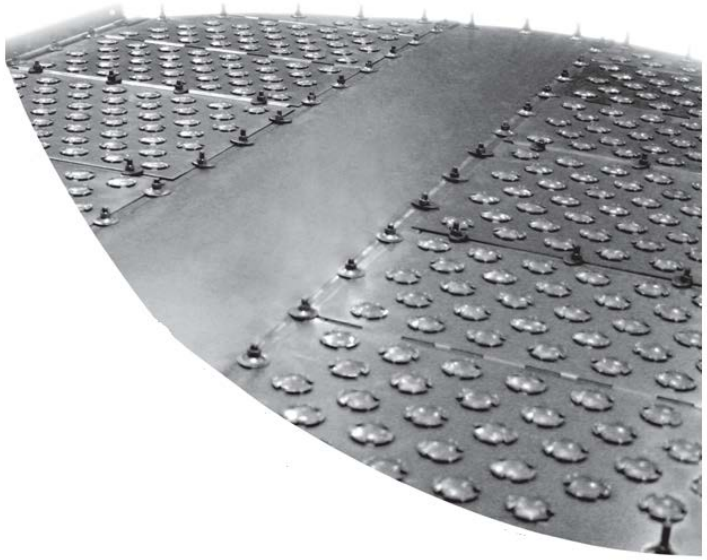


Distillation Column with Side Draw



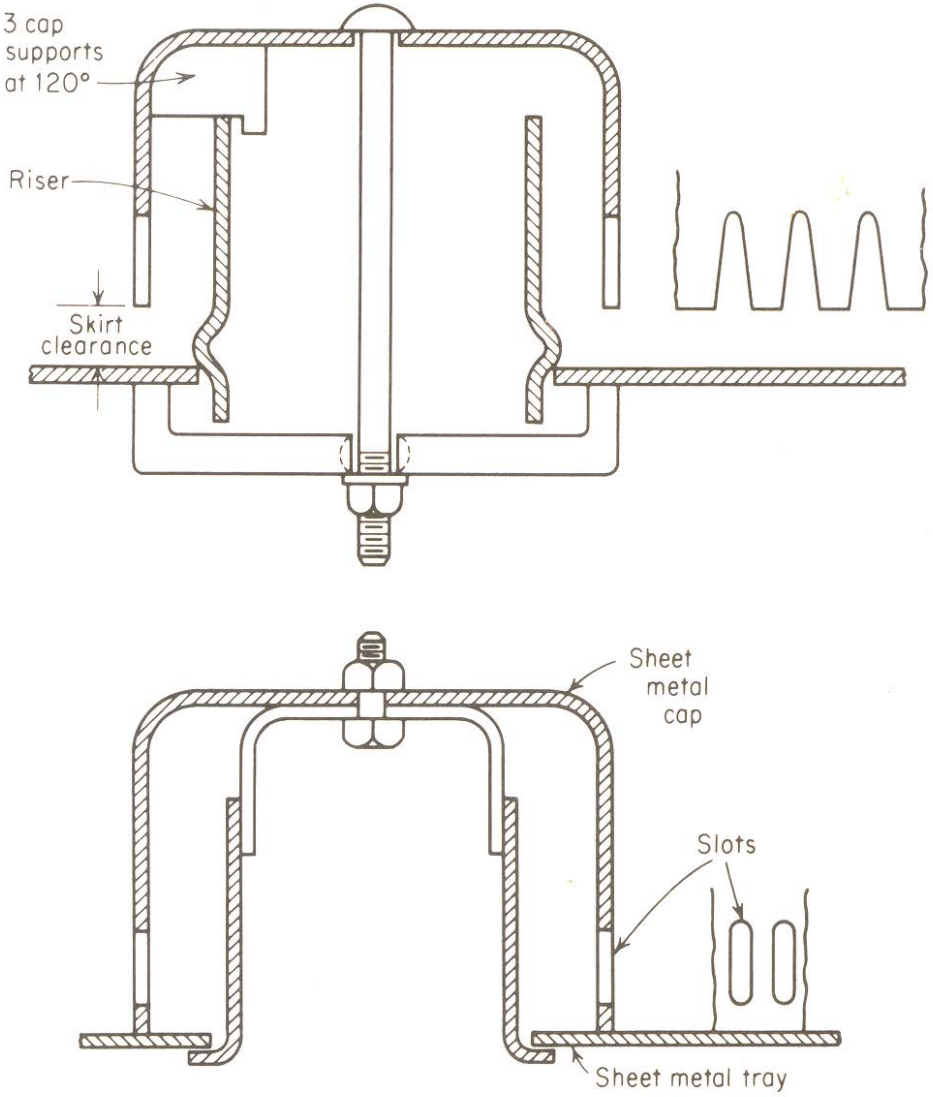
Sieve Tray





Valve Tray

Bubble-cap Tray

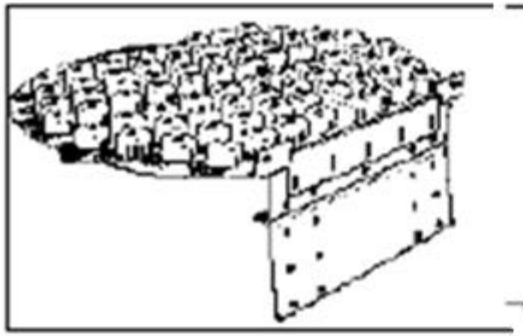


Typical Bubble-cap Design

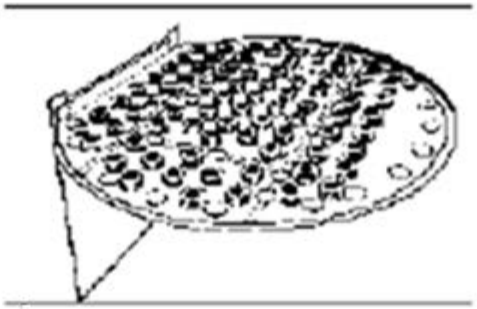
Single Valve

Selection of Trays

Bubble-caps, Valves or Sieves…



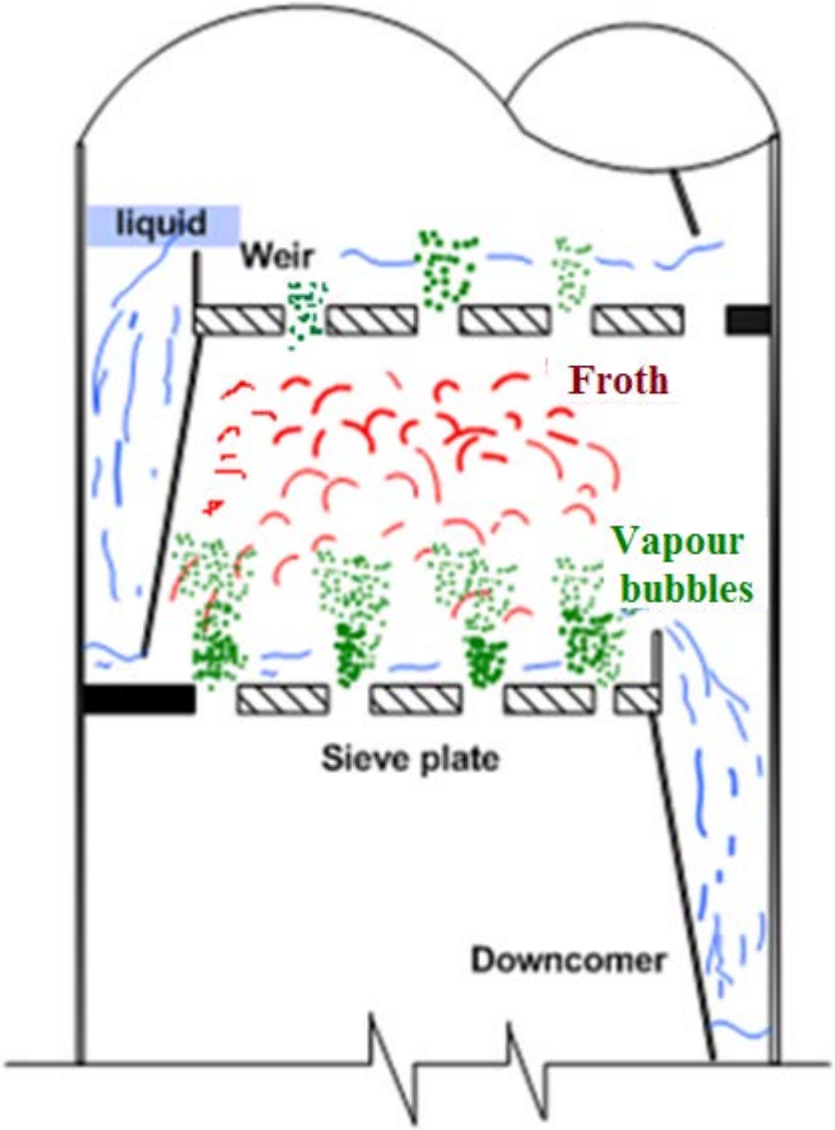
Bubble-cap tray



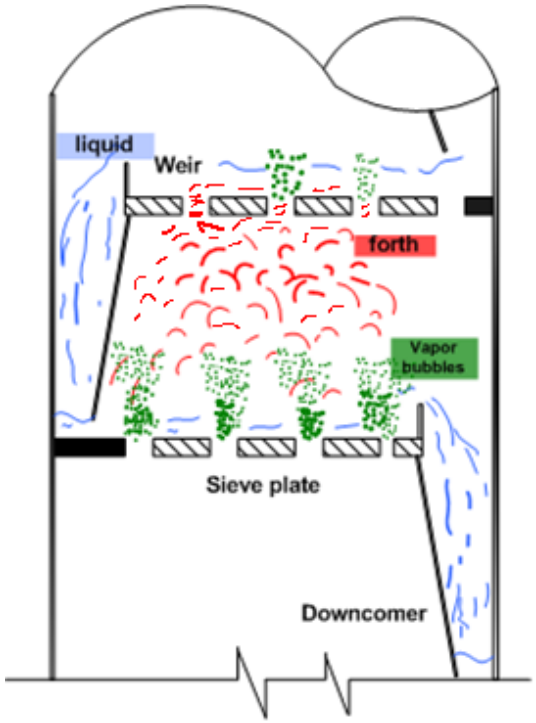
Valve tray

Sieve tray

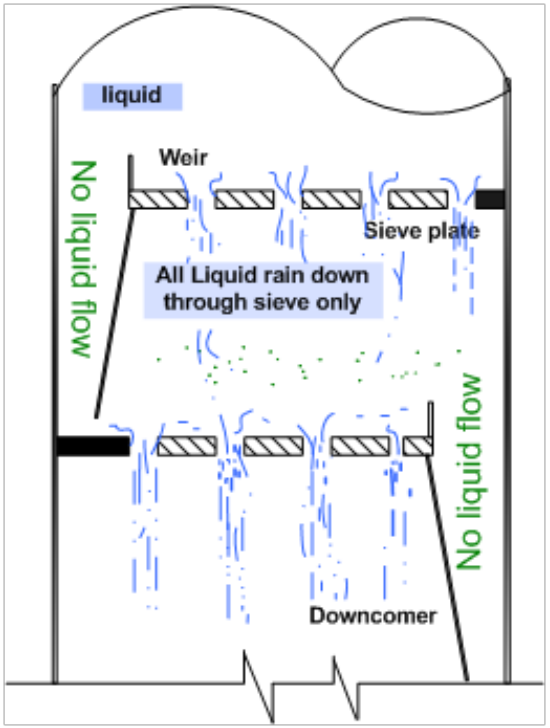
	Bubble-caps	Valves	Sieves
Relative cost	2.0	1.2	1.0
Pressure drop	Highest	Intermediate	Lowest
Efficiency	Highest	Highest	Lowest
Vapor capacity	Lowest	Highest	Highest
Typical turndown ratio	5	4	2



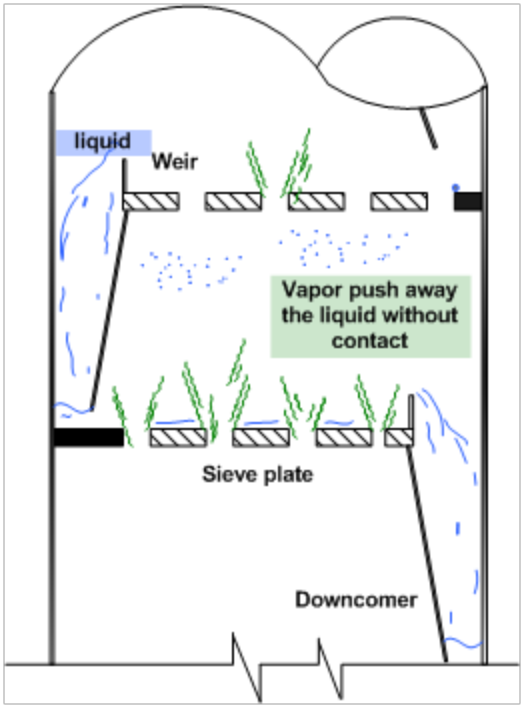
Gas and Liquid Flow in Sieve Tray Tower



Priming



Dumping

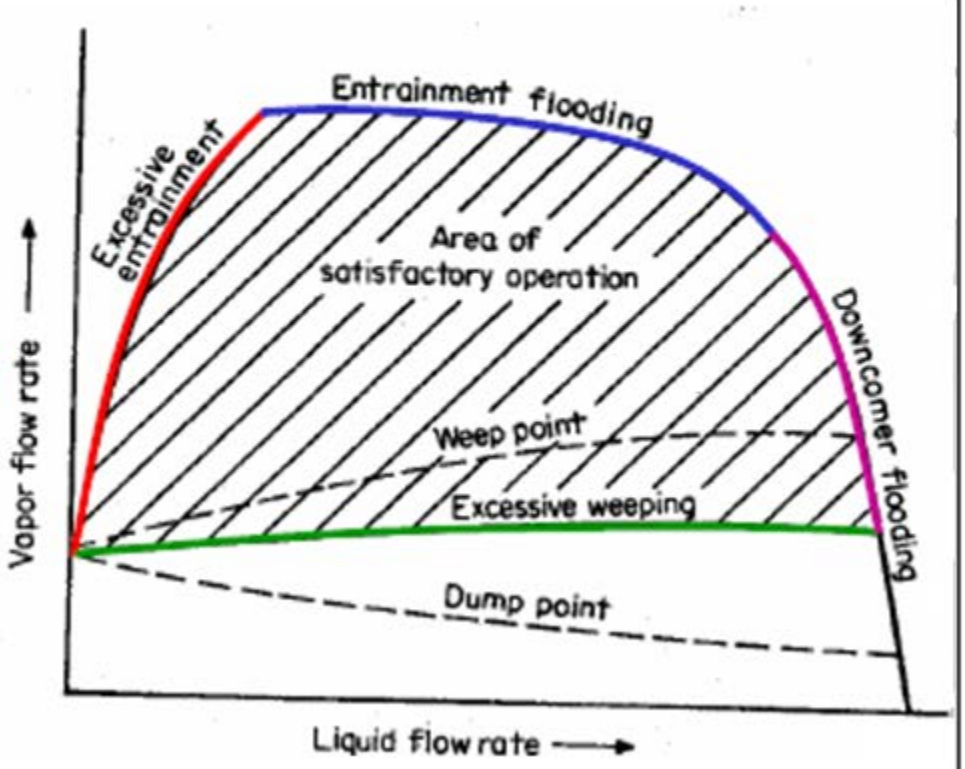


Coning

Tray Performance Constraints

Adverse vapor/liquid flow conditions can cause:

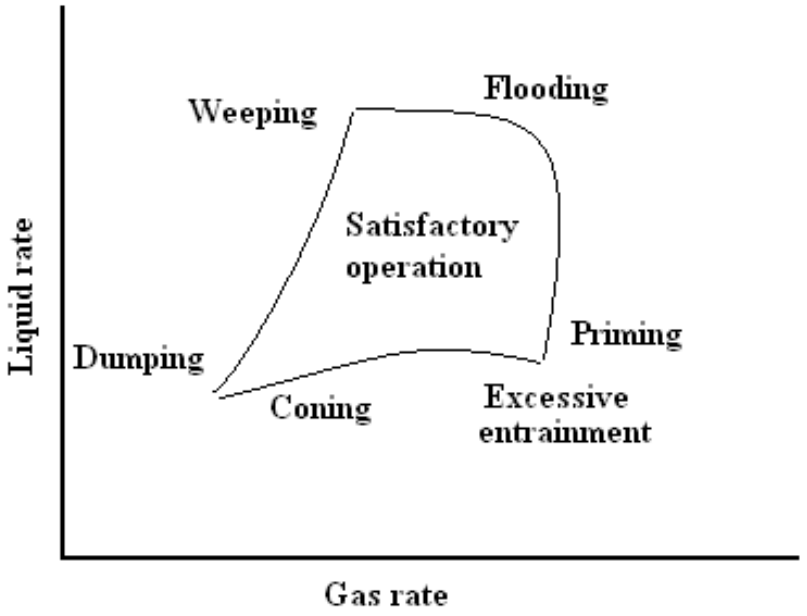
- Foaming
- Entrainment
- Flooding
- Weeping/dumping
- Downcomer flooding



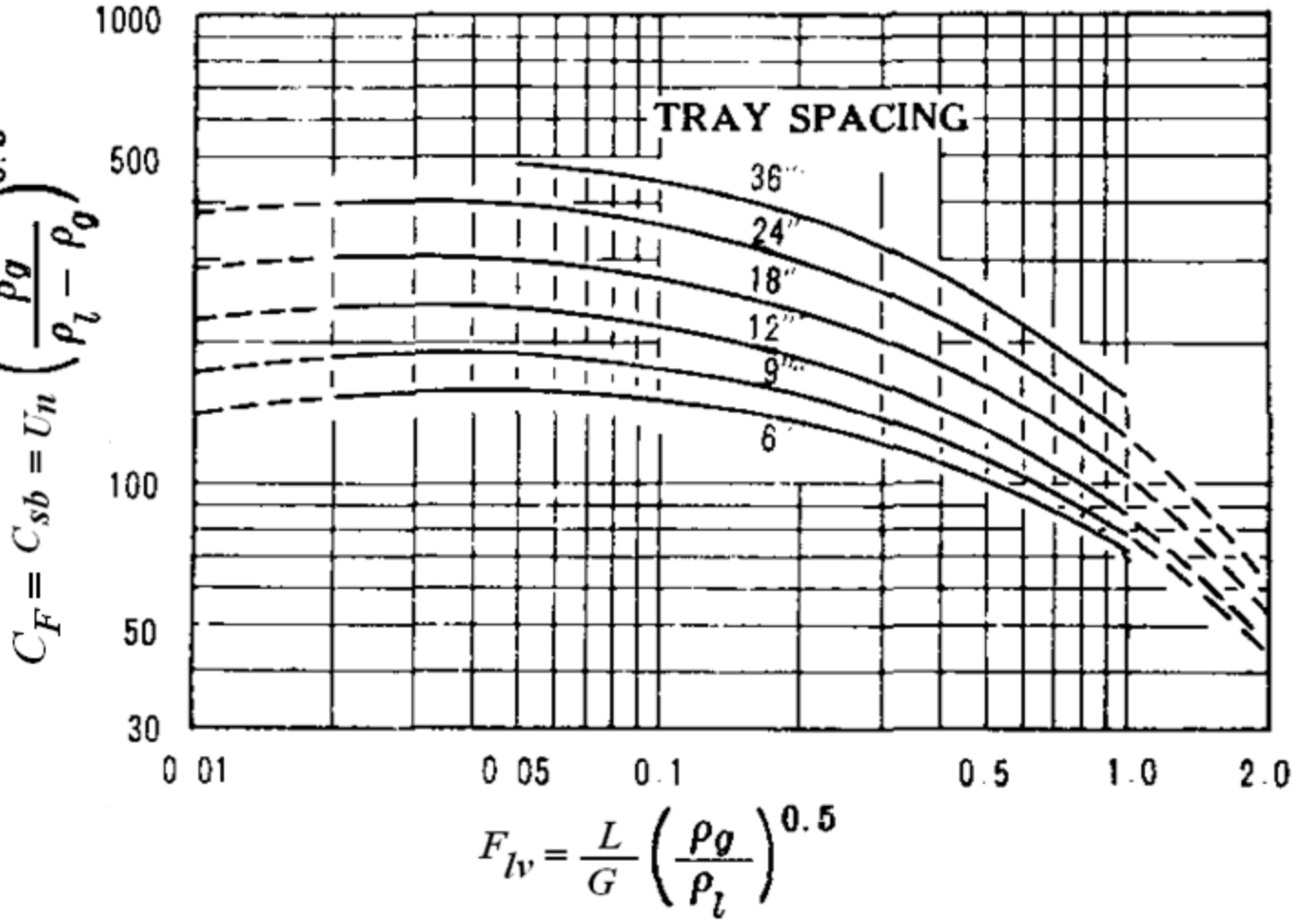
Tray Performance Constraints

Adverse vapor/liquid flow conditions can cause:

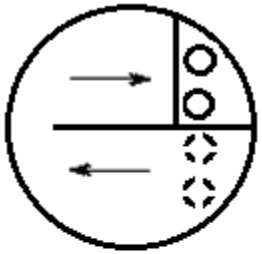
- Foaming
- Entrainment
- Flooding
- Weeping/dumping
- Downcomer flooding



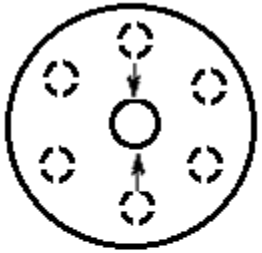
Operating Characteristics of Sieve Tray

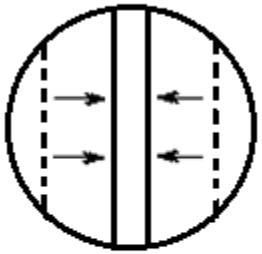


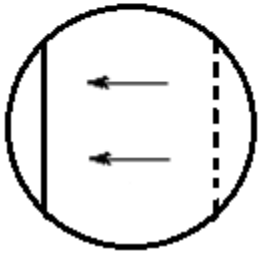
Correlation of flooding velocity in bubble-cap column and perforated plate column by Fair and Matthews



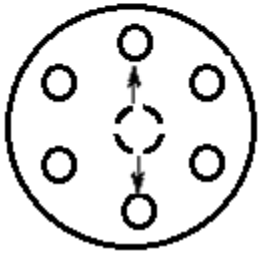
(a) Reverse flow



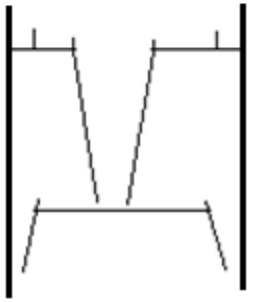


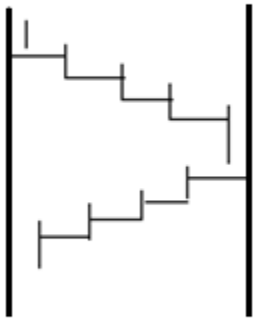


(b) Cross flow

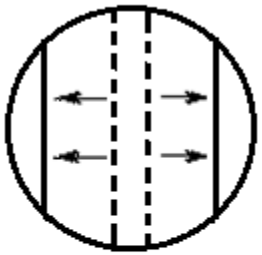


(C) Radial Flow





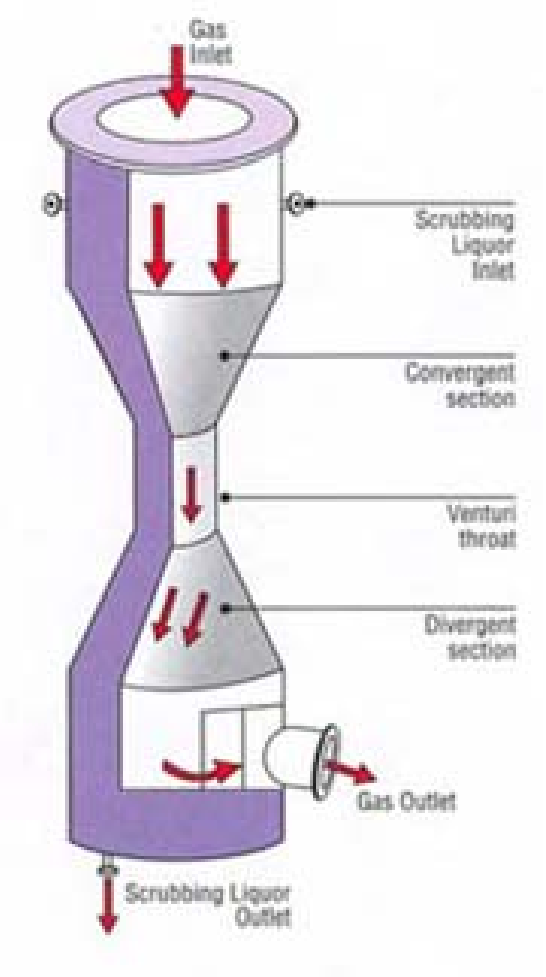
(e) Cascade trays

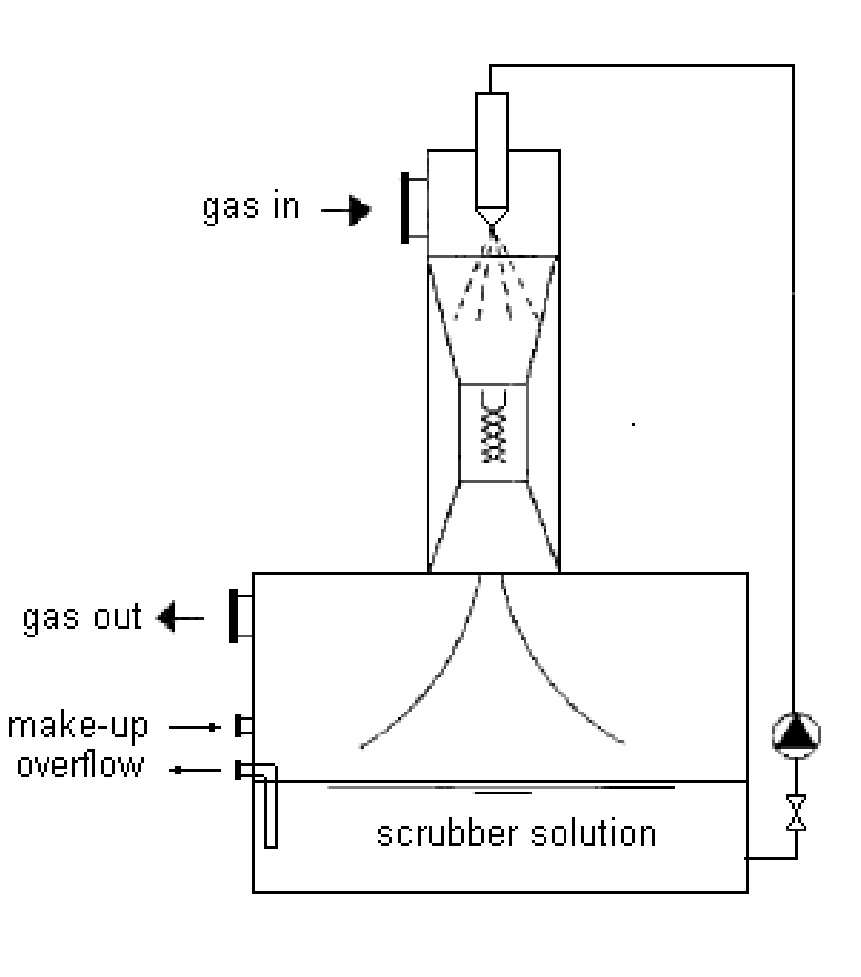


(d) Split flow

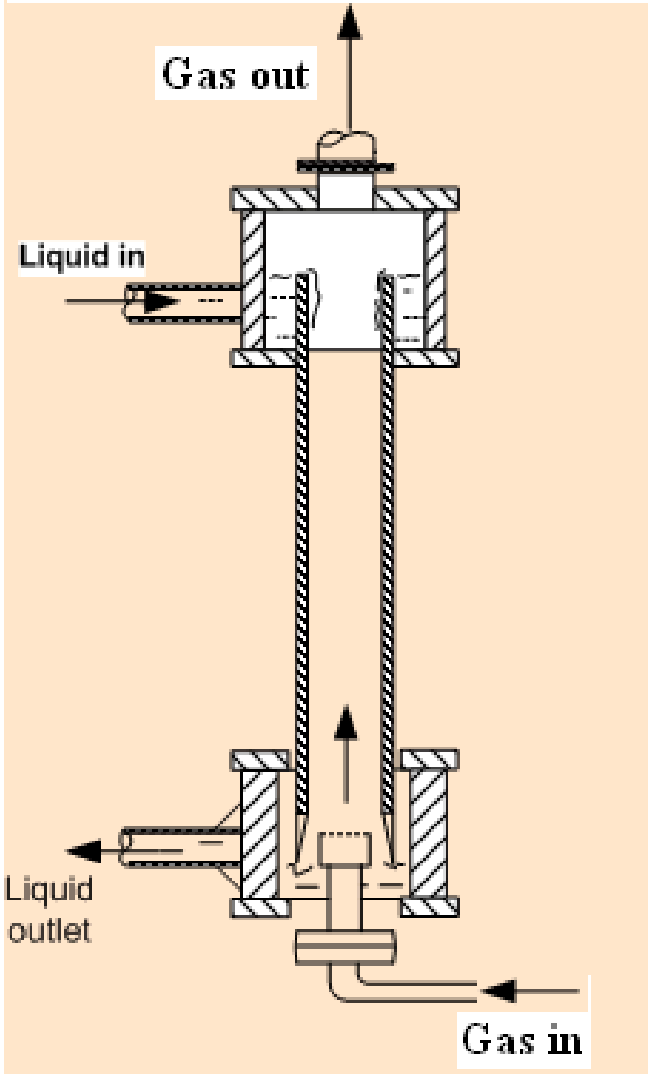
Tray Arrangements

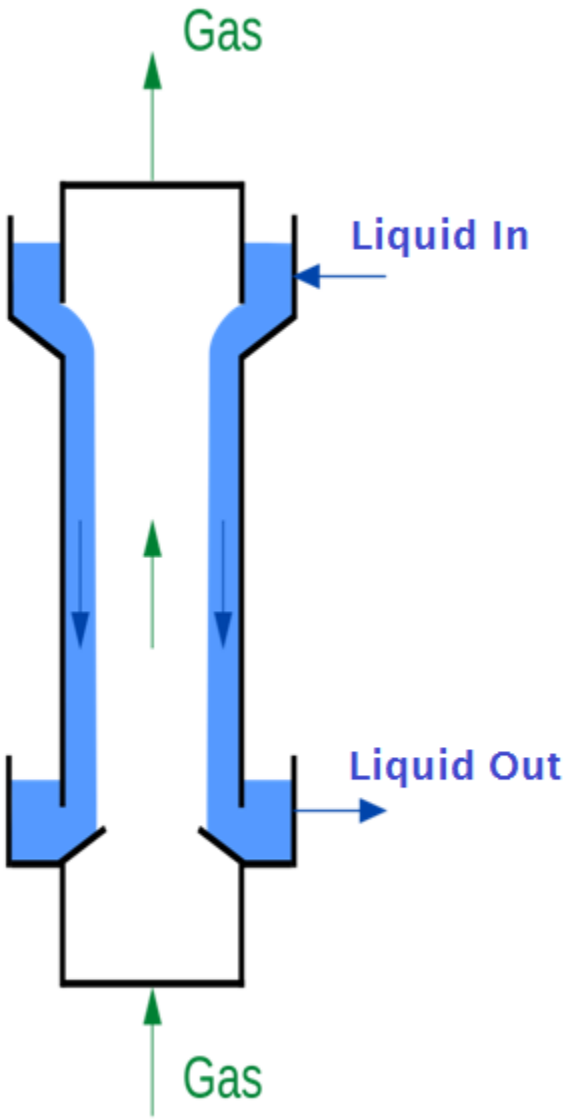
Liquid Dispersed Type Gas-Liquid Contactors



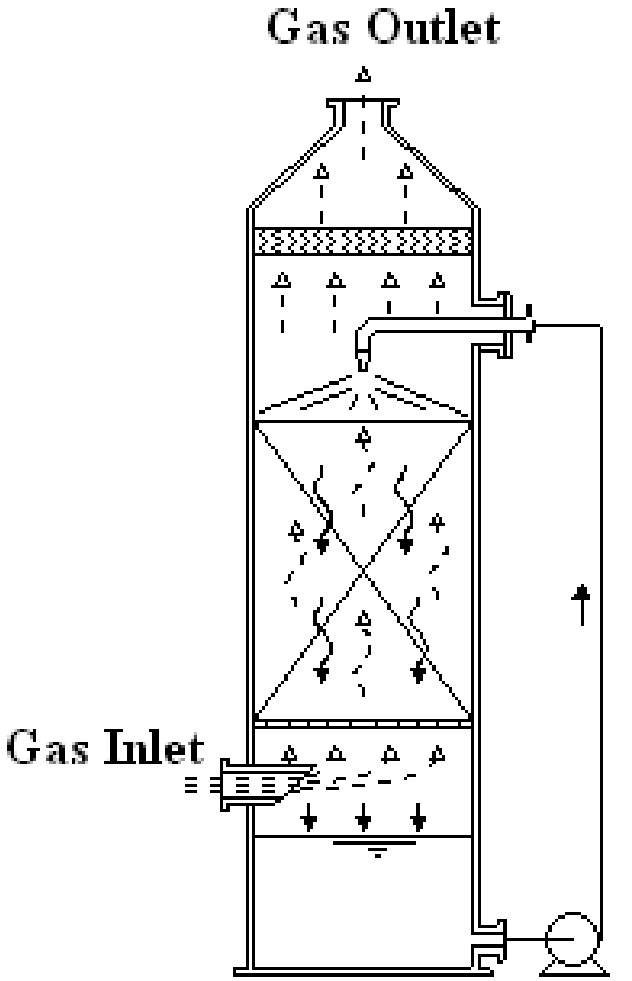


Venturi Scrubber

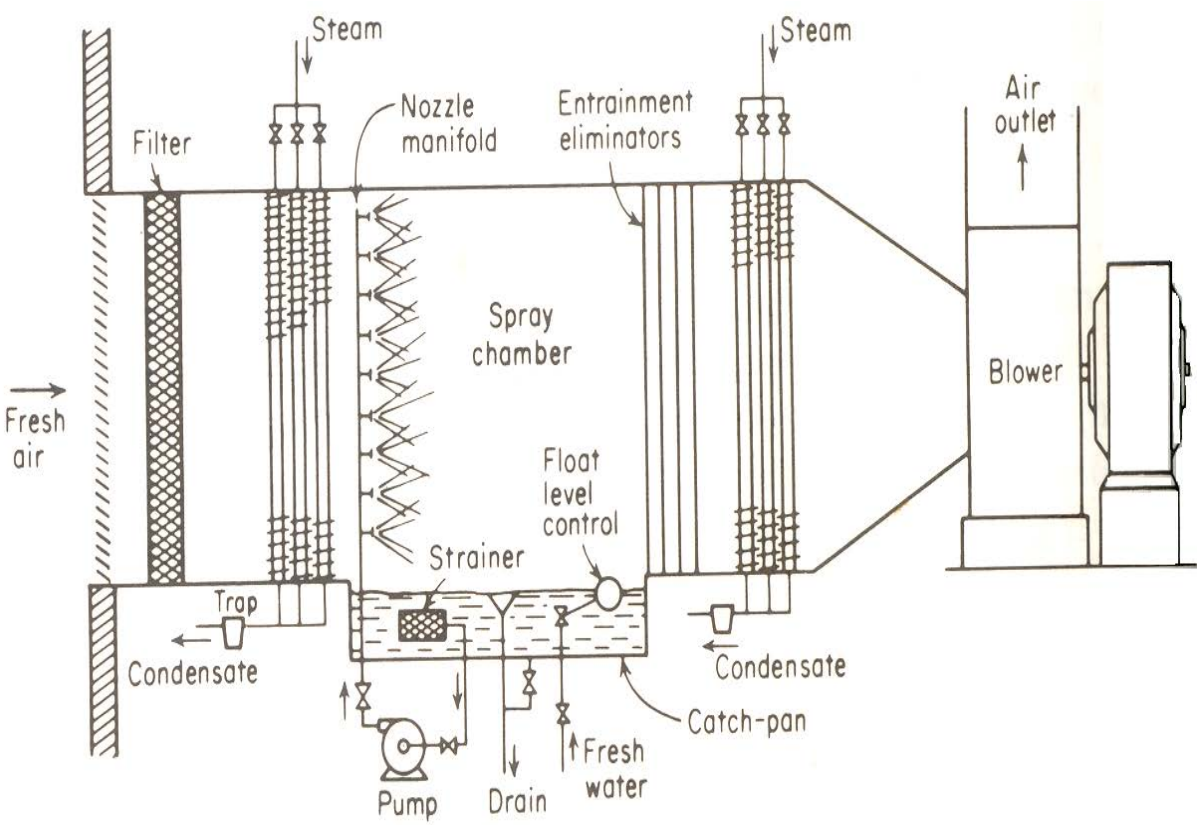




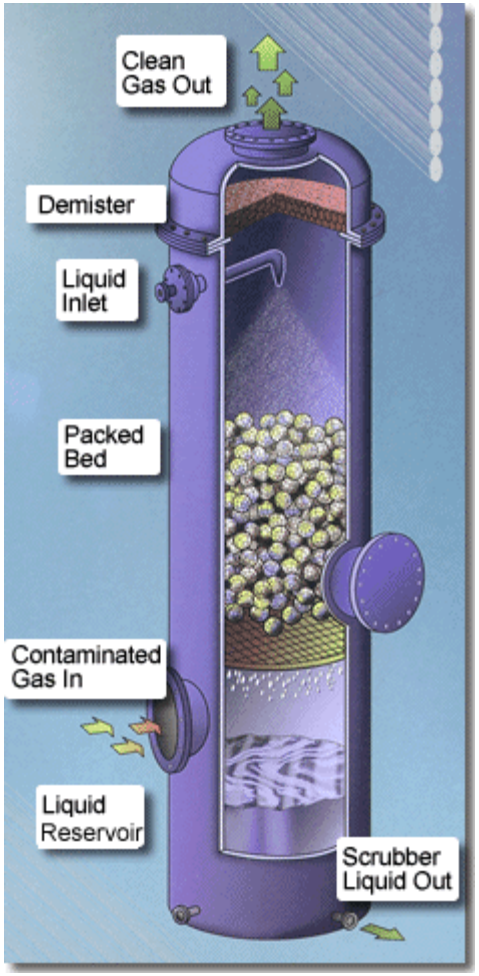
Wetted-wall Column

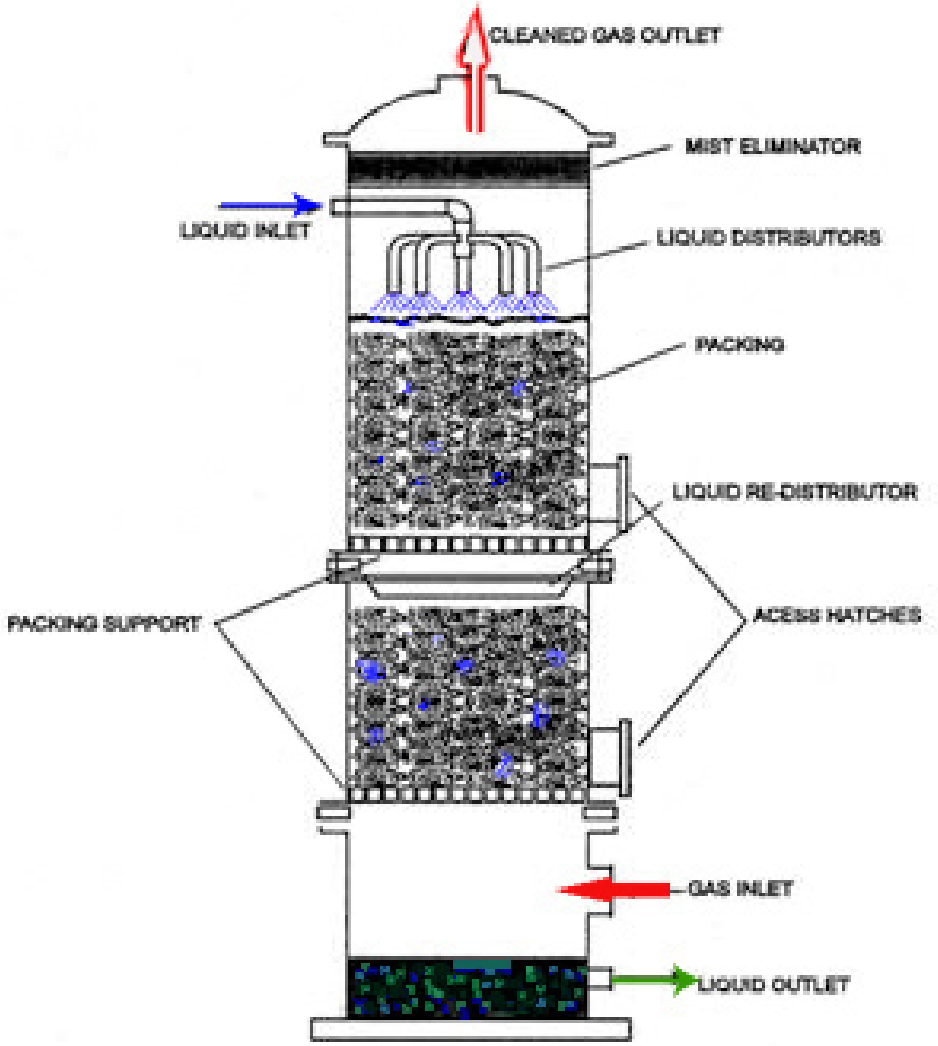


Spray Tower

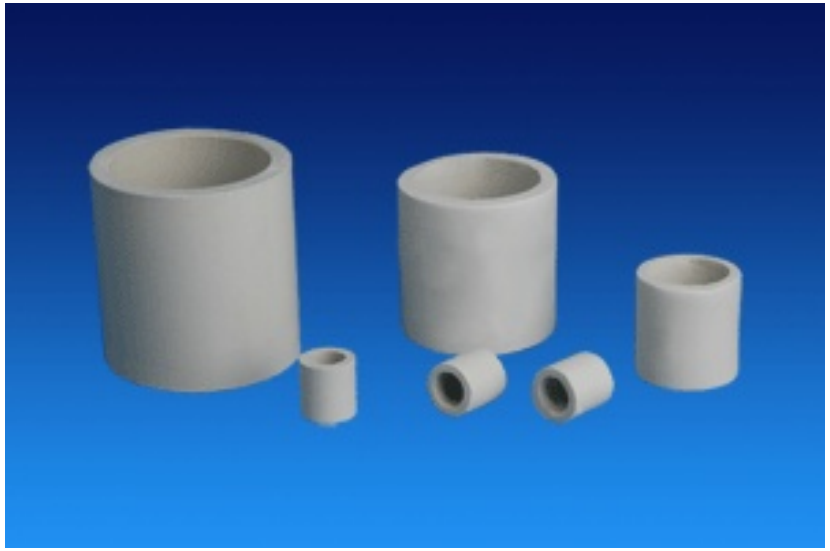


Spray Chamber



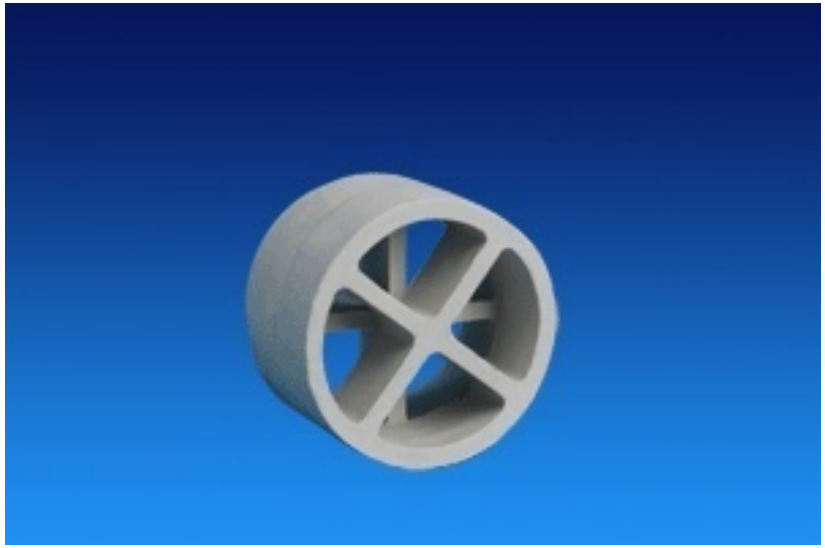


Packed Towers

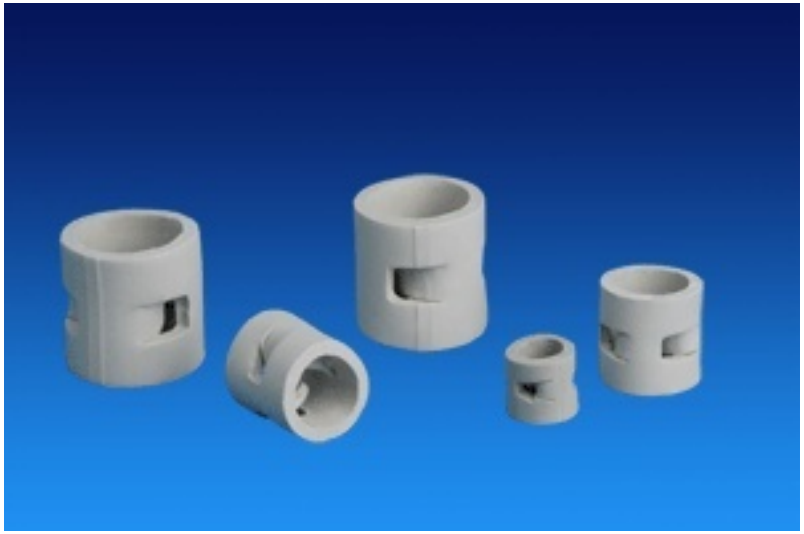


Raschig Ring

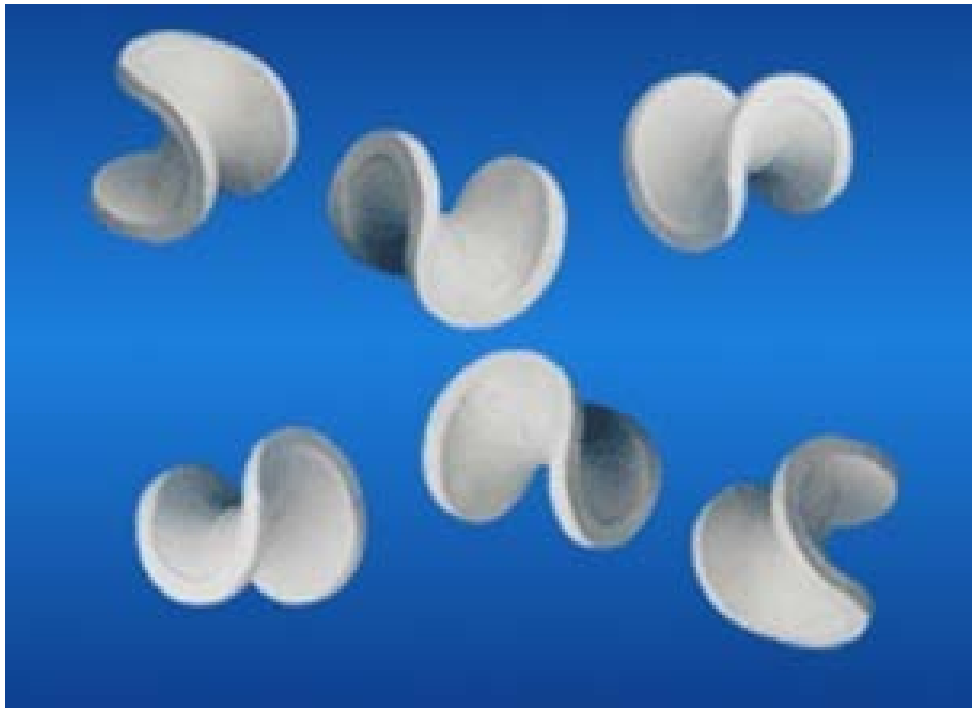
Lessing Ring



Cross Partition Ring

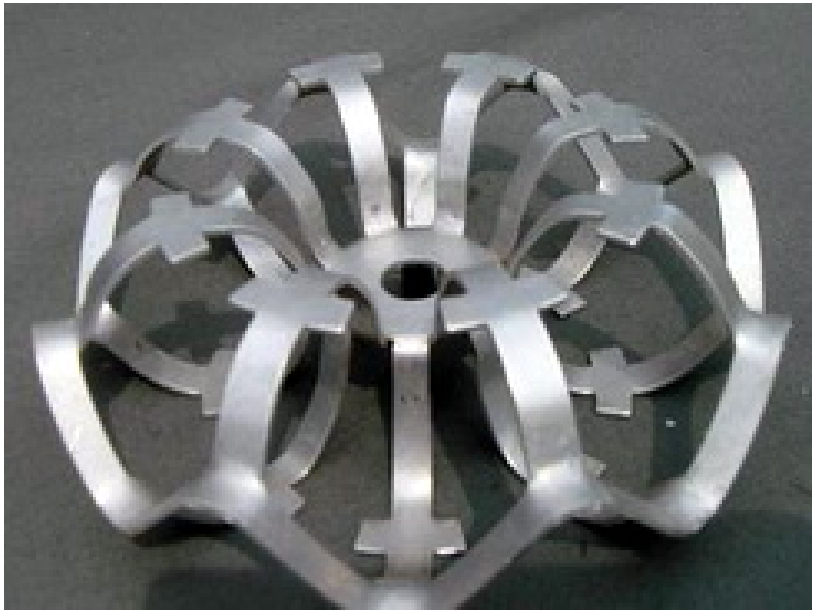


Pall Ring



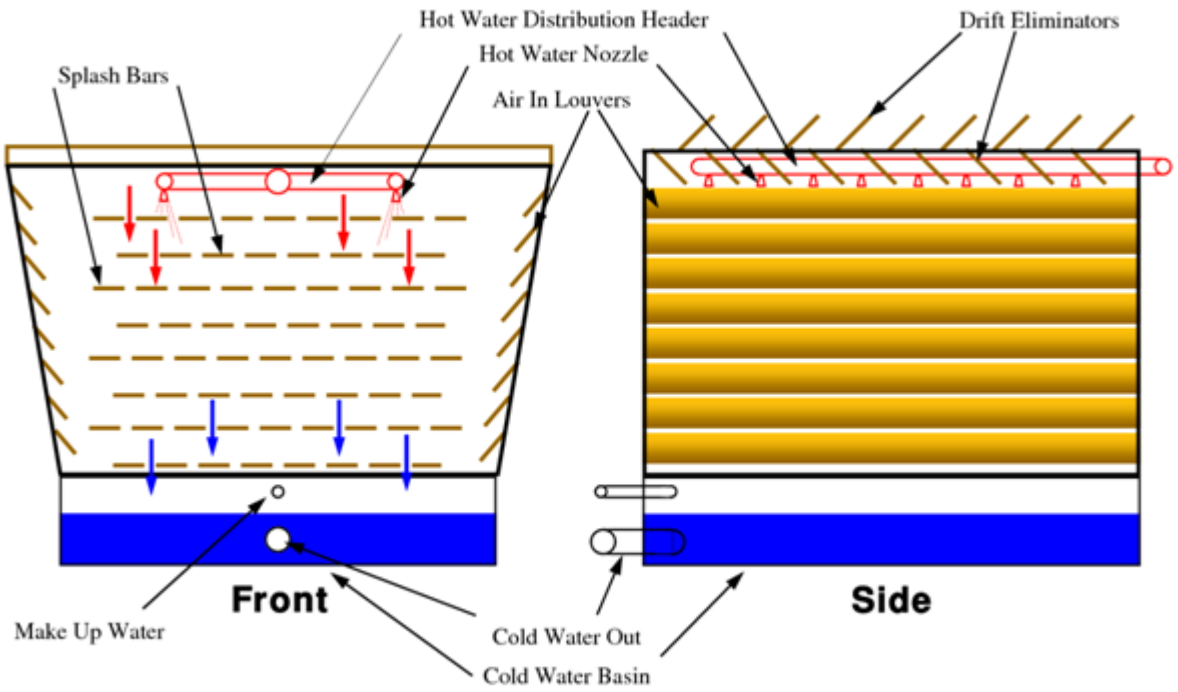
Berl Saddle

Intalox Saddle



Metal Tellerettes

Plastic Tellerettes

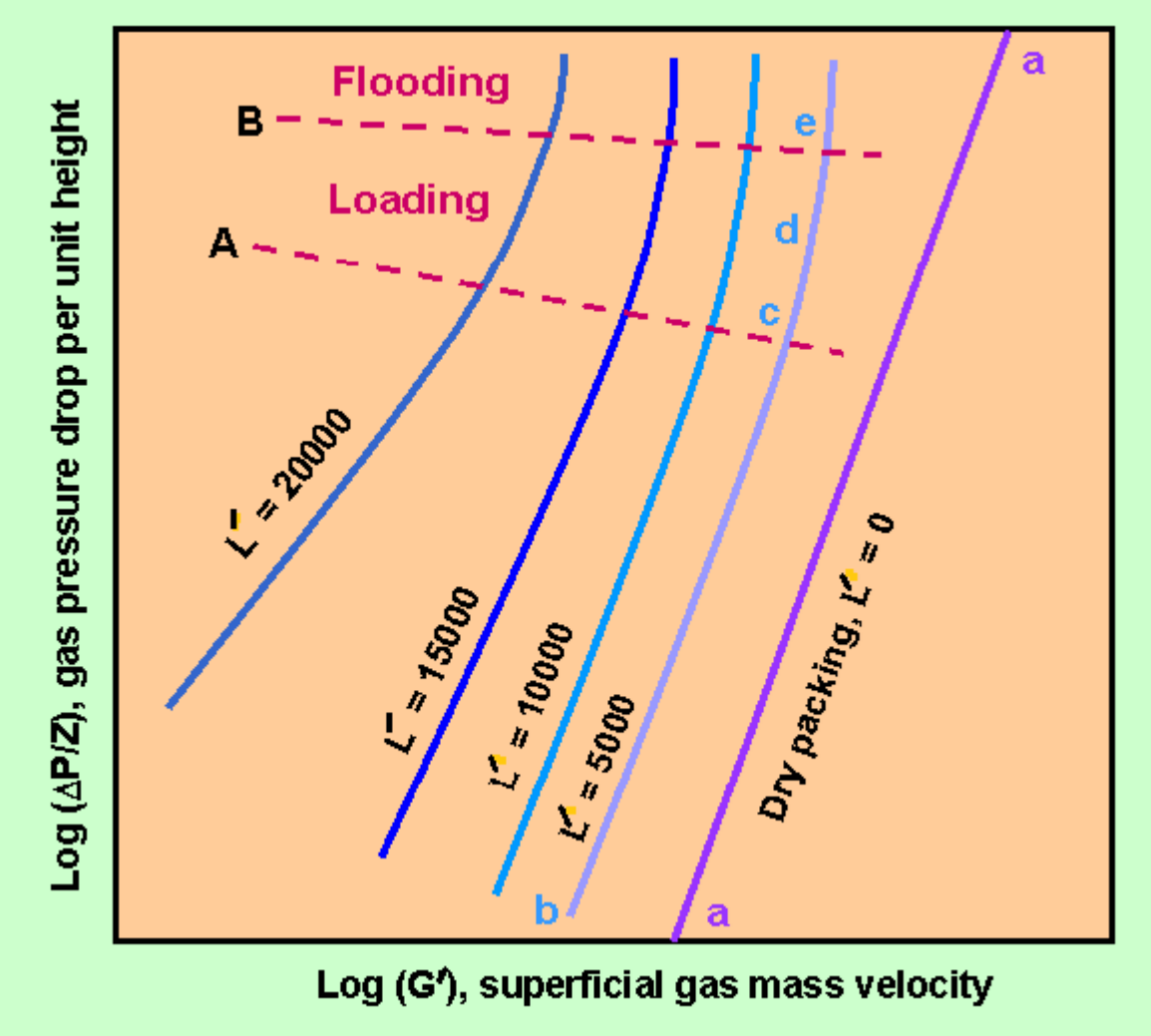


Atmospheric Crossflow Cooling Tower

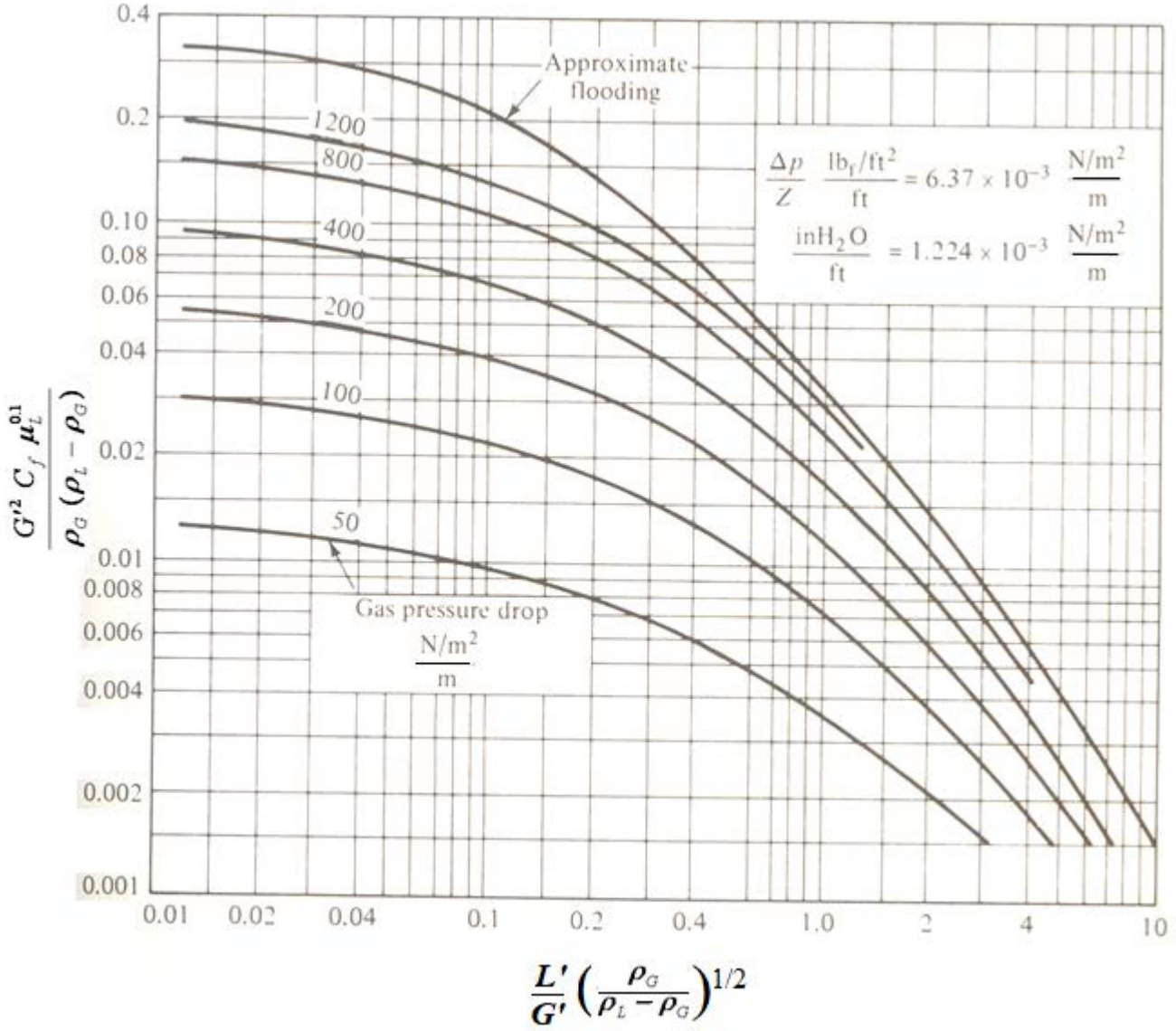
Desirable Characteristics of Packings

A tower packing or fill should possess the following characteristics:

- **Provide large interfacial surface between liquid and gas. The surface of packing per unit volume of packed space (a_p) should be large.**
- **Possess desirable fluid flow characteristics. This ordinarily means that the fractional void volume, ε, or fraction of empty space, in the packed bed should be large.**
- **Be chemically inert to fluids being processed.**
- **Have structural strength to permit easy handling and installation.**
- **Represent low cost.**



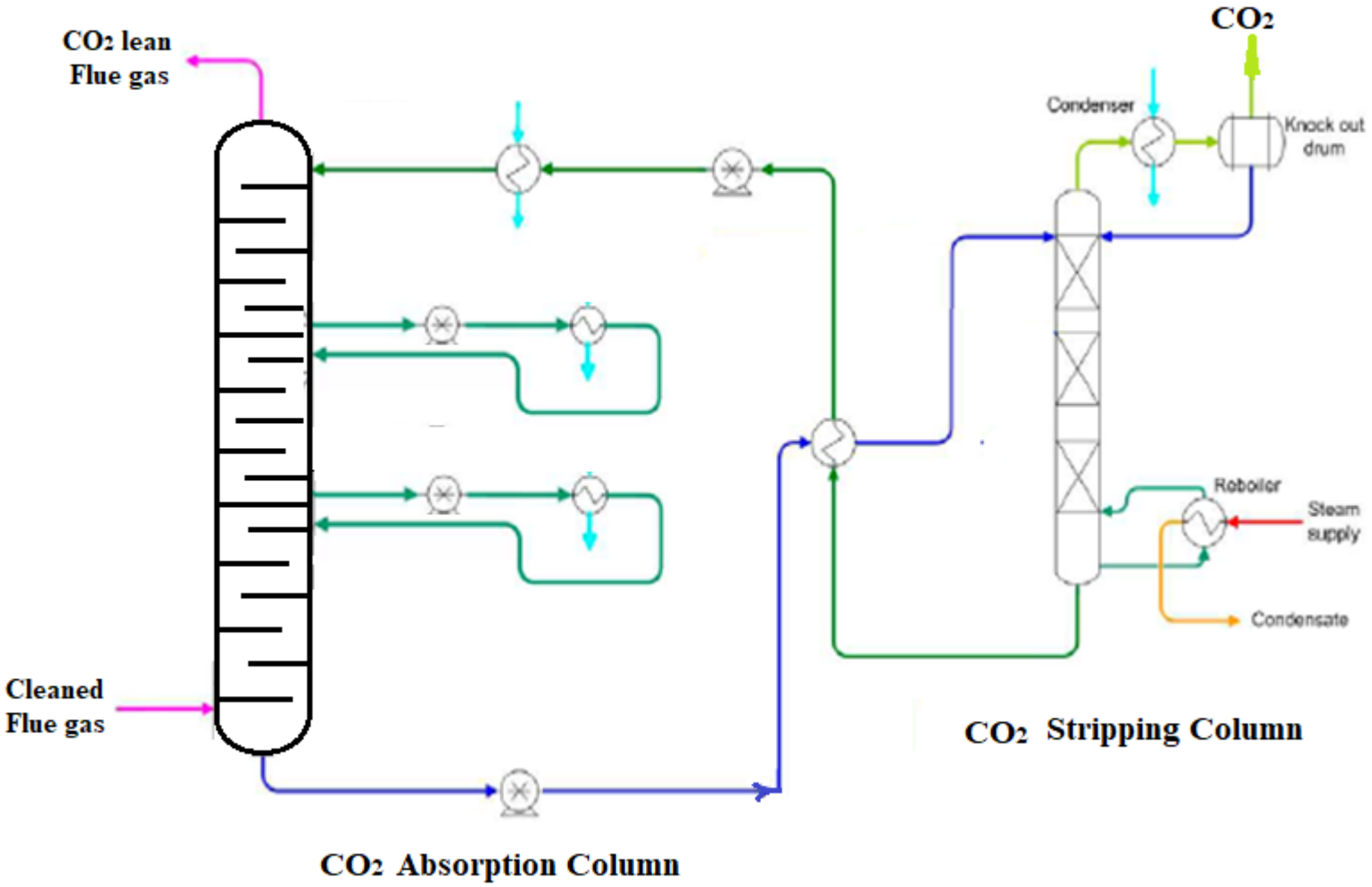
Loading and Flooding in Packed Towers



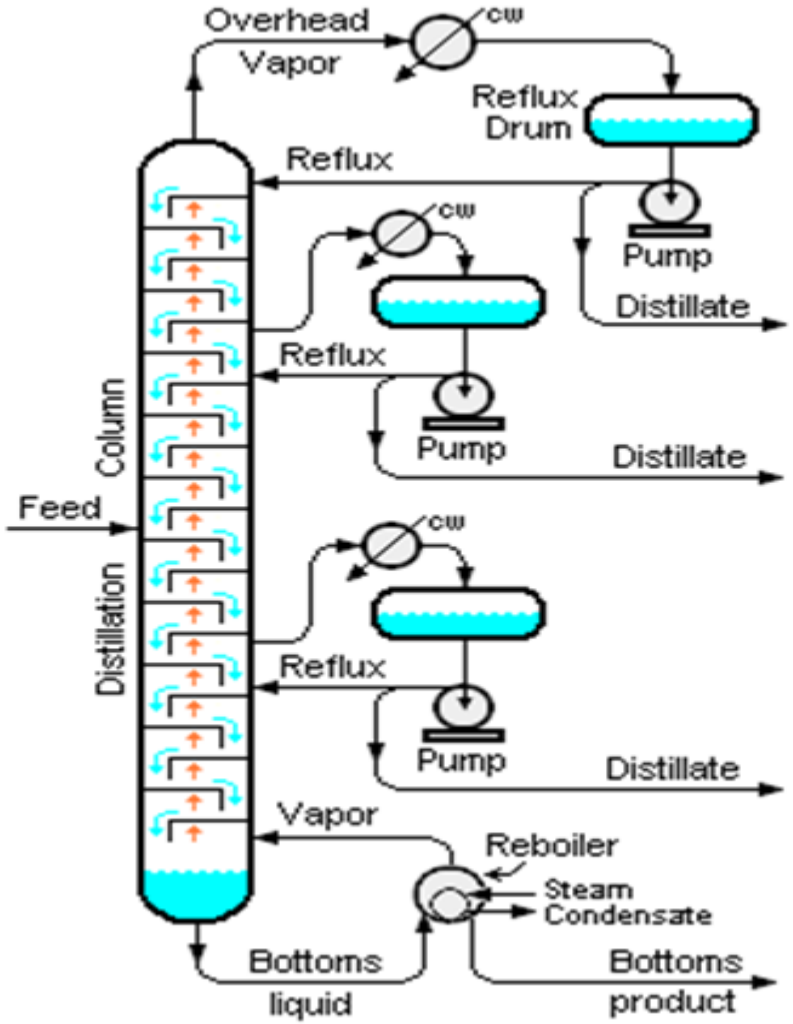
Pressure Drop and Flooding in Random-packed Towers

Tray Towers Vs. Packed Towers

1. Gas Pressure Drop: Packed towers require smaller pressure drop.
2. Liquid hold-up: Packed towers provide substantially smaller liquid hold up.
3. Liquid/Gas ratio: Very low values of L/G ratio are best handled in tray Towers; high values in packed towers.
4. Liquid cooling: Tray towers are suitable.
5. Side streams: More readily removed from tray towers.
6. Foaming systems: Packed towers are more suitable.
7. Corrosion: Packed towers are more suitable.
8. Cleaning : Frequent cleaning is easier with tray towers.



Tray Tower with inter-tray Liquid Cooling



Tray Tower with Side Draw

Thank you