FIG. 19-34

Horizontal Thermosyphon Reboiler

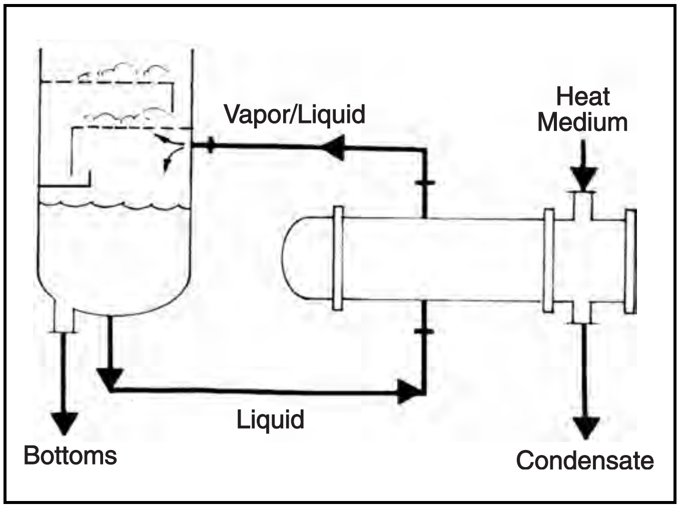


FIG. 19-35

Kettle Reboiler Arrangement

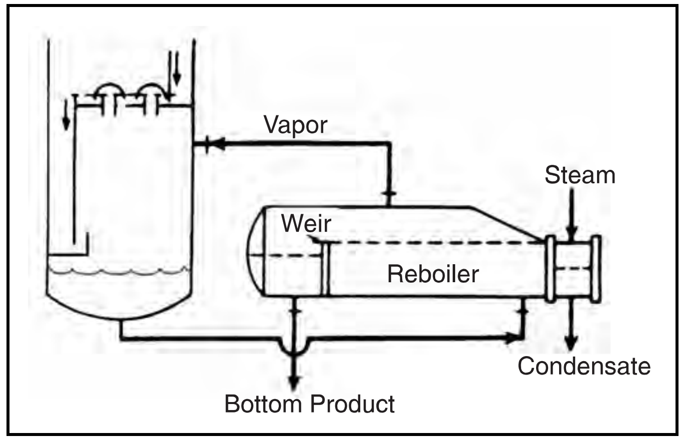


FIG. 19-36

Example Top Feed Nozzles[21]

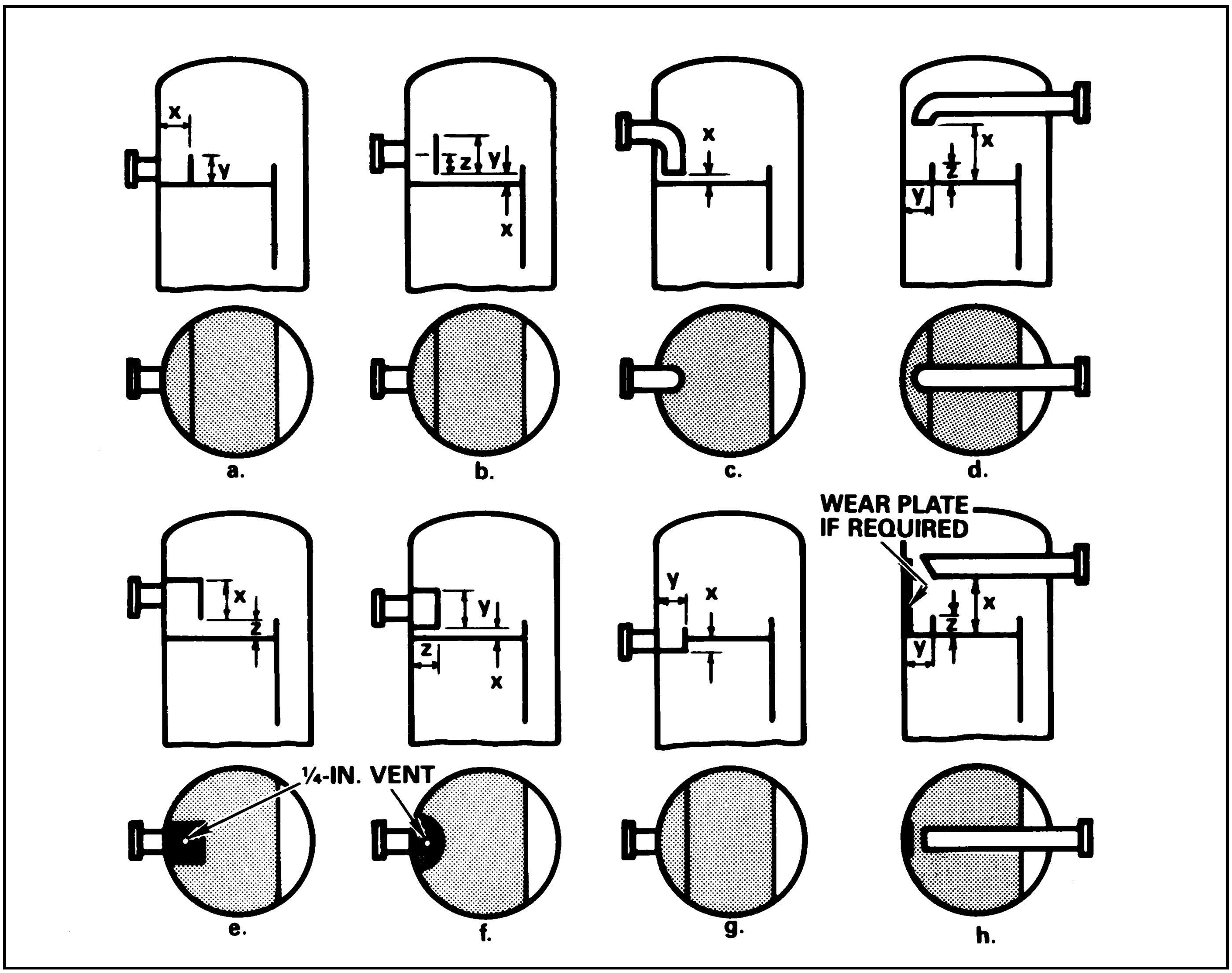


FIG. 19-37

Design Parameters for Top Feed Nozzles[21]

Dimensions for top feed/reflux inlet arrangements								
	See Fig. 19-36							
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**
Maximum nozzle dia., in.	6	–	–	6	–	–	6	–
Note	3	3	–	–	1	1	–	2
Pure-liquid feed								
Dimension x, in.	W_d	h_{cl}	$d_n/2$	>12	$2d_n$	$d_n/2$	4	>12
Dimension y, in.	4 to 6	$2d_n$	–	W_d	$2d_n$	$2d_n$	W_d	W_d
Dimension z, in.	–	d_n	–	4 to 6	d_n	$1.5d_n$	–	4 to 6
Vapor/liquid feed	NS		NS			NS	NS	
Dimension x, in.		$2d_n$		>12	$2d_n$			>12
Dimension y, in.		$2d_n$		W_d	$2d_n$			W_d
Dimension z, in.		d_n		4 to 6	$2d_n$			4 to 6

d_n = Inlet pipe dia., in.
h_{cl} = Clearance under downcomer, in.
W_d = Downcomer width, in.
NS = Not suitable

Note 1: Drill a ¼-in. vent hole on top.

Note 2: Wear plate may be required.

Note 3: Ensure nozzle enters behind the baffle. If it does not, hydraulic jump could be a problem.

Internal inlet pipes should be removable for maintenance.

in the reboiler such that the tube bundle is always submerged. Vapor disengaging space is provided in the exchanger. The vapor is piped back to the column to provide stripping vapor for the bottom tray. Bottom product is drawn from the reboiler.

Kettle reboilers are attractive due to the ease of control. No two-phase flow or circulation rate considerations are required. The kettle is also equivalent to a theoretical tray. Due to the vapor disengagement requirement, kettles are constructed with an expanded shell. The additional cost of this shell is offset to some extent by a reduced tower skirt requirement.

Column Internals

The most common causes of startup and operating problems are the column internals. These items are usually small details that are often overlooked and later become operating difficulties. Correct location and orientation of inlet and outlet nozzles and other internal considerations must be addressed to eliminate problems. Kister[21] presented a series of articles which discussed these areas in detail.

Top Feed Nozzles — Fig. 19-36 illustrates various arrangements used for top-tray feed and reflux nozzles. Fig. 19-37 lists factors and restrictions in each design. For cost reasons, arrangements of Fig. 19-36a, b, c, e, and f are preferred. However, for a two-phase stream only b, d, e, and h are suitable. Most installations use arrangement a or c for all-liquid feed while b and e are popular for a two-phase feed.

Tray sections and baffles that are contacted by an entering feed should be strengthened. Feed nozzles and internal liquid distributors should be anchored to the tower shell. Feed lines containing two phase flow should be designed to minimize slugging which causes column instability and possible tray damage. For liquid feeds, the nozzle velocity should not exceed 3 ft/sec.

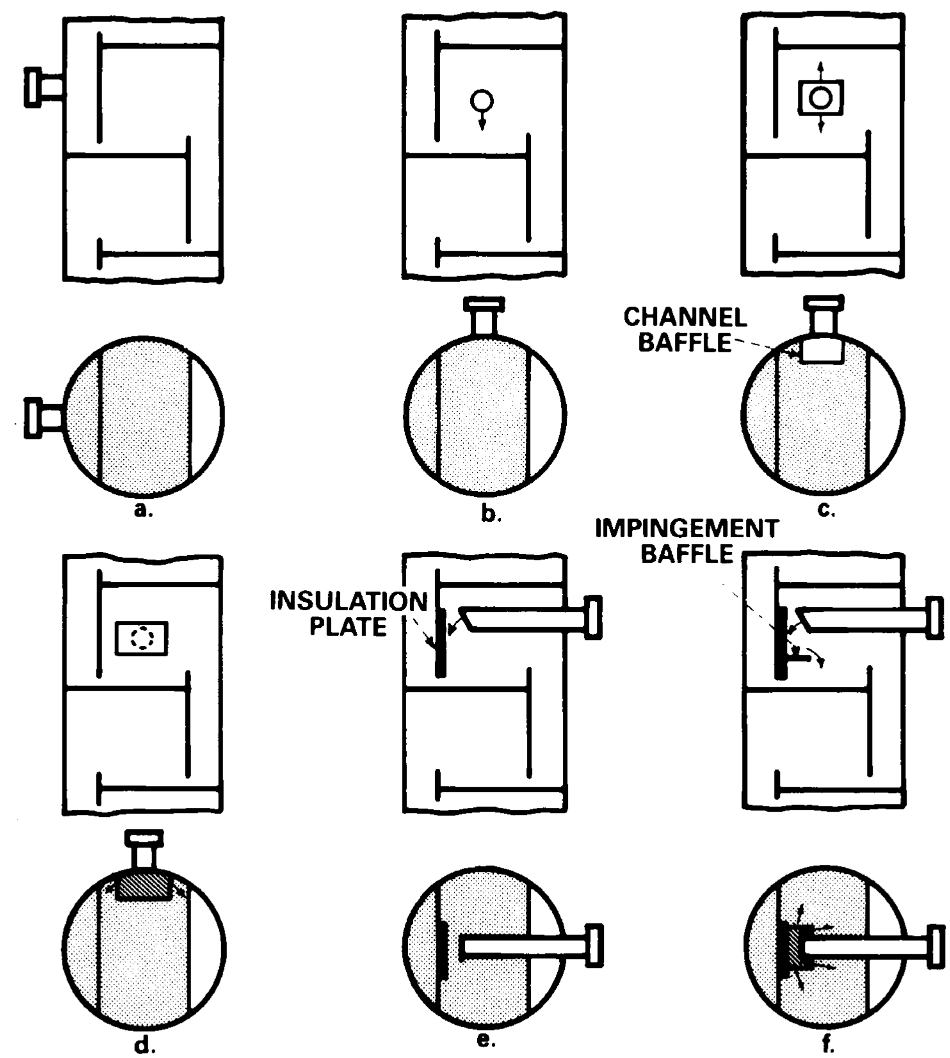
Intermediate Feed Nozzles — Fig. 19-38 shows various methods for introducing intermediate column feeds. Fig.19-39 summarizes the application area for each design. Fig. 19-38a is only suitable for subcooled liquids. Vapor containing or hot feeds would cause flashing in the downcomer and loss of capacity. Fig. 19-38b is only suitable for low-velocity liquid feeds and is seldom recommended. Fig. 19-38c and d show a similar nozzle location with a baffle to direct the feed stream. These are both designed for two-phase streams with d being the preferred arrangement. Fig. 19-38c can be used for virtually any feed except for high velocity feeds where a baffle plate is added as in Fig. 19-38f.

Bottom Vapor Inlet[22] — The optimum vapor inlet below the bottom tray is shown at location A in Fig. 19-40. The vapor is introduced parallel to the bottom downcomer at a recommended spacing of 24 in. below the bottom tray. A vapor inlet nozzle, causing impingement of the vapor stream against the downcomer and/or liquid overflow as shown by location B, should be provided with vapor inlet baffle or piping. The vapor velocity can be controlled by the hood outlet area. For multipass trays, it is very important to feed each compartment equally and allow for vapor equalization between sections.

Liquid Outlet — Sufficient residence time must be provided in the liquid draw-off sump. Fig. 19-41 presents recommended residence times for various situations. These guidelines are intended to provide sufficient times for vapor disengagement, to smooth out column upsets, and to give operating personnel time to correct operating problems. For

FIG. 19-38

Example Intermediate Feed Nozzle Arrangements[21]



large residence time requirements, an external vessel should be considered in lieu of a large sump volume.

Bottom Sump Arrangements — A common design practice is to divide the bottoms sump into a reboiler-feed compartment and bottoms-drawoff compartment by installing a preferential baffle. Typical arrangements are shown in Fig. 19-42. The baffle has the advantage of providing an additional theoretical tray, supplying a constant head to the reboiler, and increasing the bottoms-outlet sump residence time. The installation of such a baffle is recommended when thermosyphon reboilers are used.

Each sump must have its own drainage facilities. This can frequently be achieved by drilling a hole through the baffle, or by using an external dump line at a low point to interconnect the liquid outlet lines from each compartment.

Either one of the arrangements shown in Fig. 19-42a or b is satisfactory. The arrangement of Fig. 19-42b has slightly better mass-transfer characteristics; however, it is somewhat more complicated than that of Fig. 19-42a. A baffle similar to that on the left-hand side of Fig. 19-42b can also be incorporated in arrangements such as shown in Fig. 19-42c and d.

The arrangement of Fig. 19-42d is preferable to that of Fig. 19-42c for two-pass trays. The latter forces the vapor to flow through a curtain of liquid while ascending to the first tray, which may cause entrainment or premature flooding.

Draw-off Arrangements—Total draw-off is normally accomplished with a chimney tray or draw pan as indicated in Fig. 19-43. The chimney tray has an advantage over the draw pan because it catches tray weepage during startup and at low vapor rates. Chimneys are normally sized for approximately 15% of tower area. The chimneys should be located or hooded to prevent liquid flow downward through the chimney. Elevating the draw nozzles flush with the draw tray in many cases eliminates the need for weep holes. A spill-over baffle can be provided for the draw pan to maintain tower circulation for

FIG. 19-39

Intermediate Feed Nozzle Applications[21]

	See Fig. 19-38					
	a	b	c	d	e	f
Cold-liquid feed	Yes	Yes	Yes	Yes	Yes	Yes
Vapor/liquid feed	No	No	Yes	Yes	Yes	Yes
Vapor feed	No	No	Yes	Yes	Yes	Yes
Hot feed	No	Yes	Yes	Yes	Yes*	Yes*
High-velocity feed	No	No	No	Yes	No	Yes
High-pressure application	No	Yes	Yes	Yes	Yes	Yes
Downcomer capacity critical	No	Yes	Yes	Yes	Yes	Yes
*Assuming insulation plate is provided.						

cases where a draw-off may not be required during operation. A vortex breaker is suggested for outlet nozzles.

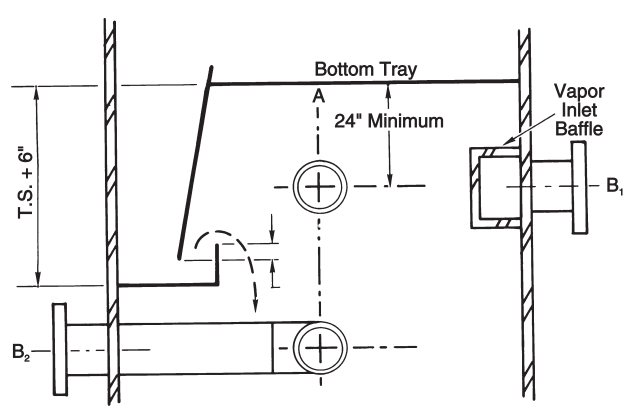
If the liquid on the chimney tray seals the downcomer from the tray above, particular care must be taken with the design of this downcomer. The liquid in the downcomer is aerated, while most of the liquid on the tray is degasified. The degasified liquid on the tray produces a greater hydrostatic head than the column of aerated liquid in the downcomer. This effect is aggravated if two phases are separated. If these effects are not allowed for, and sufficient height is not provided, downcomer backup may exceed the spacing between the liquid level and the tray above, and lead to premature flooding.

Fig. 19-44 shows two types of partial draw-off arrangements. When a chimney tray is used, a partition (sometimes insulated by application of two plates) can be provided to allow a draw-off and return on the same tray. Elevating the partition will determine total separation or recycling. The return nozzle should be located above the liquid level if vapor content is expected.

Partial draw from a recessed pan is frequently used. The draw pan saves shell length at the sacrifice of surge capacity. It is advisable to provide a positive downcomer seal.

FIG. 19-40

Bottom Vapor Inlet[22]



Water draw-off has been successfully accomplished by using the design shown in Fig. 19-45. The perforated plate normally contains 25% of the pan area as hole area. Water draw pans are usually sloped for multipass trays in large towers. A weld-in pan with a flush fitting draw nozzle is recommended.

Mechanical Design

Special care should be given to designing the trussing structure at heavily loaded areas, such as draw pan and draw trays where additional liquid levels are anticipated.

Where total draw-off arrangements are required, it is generally recommended that seal welding should be applied in lieu of gasketing, as gasketing may not maintain its sealing effectiveness at operating conditions. For large towers and higher temperatures, expansion joints should be provided. Good inspection can, in many cases, detect errors which could lead to column operation problems. It is, therefore, important

FIG. 19-41

Residence Time for Liquid in the Sump[21]

Operating condition	Minimum residence time, min
Liquid is withdrawn by level control and feeds another column directly by pressure.	2
Liquid is withdrawn by level control and pumped away. Spare pump starts manually.	3
Liquid is withdrawn by level control and pumped away. Spare pump starts automatically.	1
Liquid is withdrawn by level control and feeds a unit that is some distance away or that has its instruments on a different control board.	5-7
Liquid is withdrawn by flow control.	3-5
Liquid flows through a thermosyphon reboiler without a level controller, to maintain a level in the sump.	1