PROCESS GUIDE

PART 4 – SECTION 1 : VESSELS

S.S. 1.1 – COLUMNS AND FRACTIONATION SYSTEMS

CHAPTER V - MISCELLANEOUS

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1. HEAT TRANSFER AREA

1.1. General

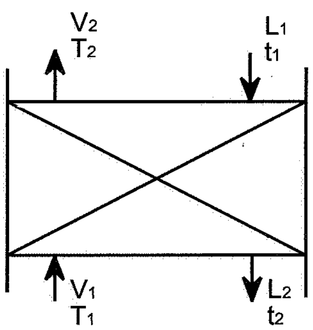
In some fractionation columns, in particular in the case of columns with several sidestreams, heat transfer trays are used to remove heat in some points in the column. This allows liquid and vapor loads to be balanced in the column, while reducing the overhead condenser load. Thus, calories are available at a much higher thermal level, which allows them to be recovered.

Trays used in heat transfer areas are not necessarily of the same type as those in adjacent fractionation areas.

1.2. Size and quantity of heat transfer trays

Determination of the number of heat transfer trays requires the following to be known :

- Column diameter and type of tray
- Conditions about the heat transfer section (liquid and vapor flowrate and temperature)
- Heat quantity to be exchanged (Q (kcal/h)



Calculation is as follows :

- Logarithmic mean temperature difference LMTD between T_1, T_2, t_1, t_2
- $L = \frac{L_1 + L_2}{2\,ND}$ (kg/h x m x pass) and $V = \frac{V_1 + V_2}{1.57\,D^2}$ (kg/h x m^2)

With :

L_1, L_2 : Liquid flowrate values in kg/h
V_1, V_2 : Vapor flowrate values in kg/h
D : Tray diameter in m
N : Number of passes of trays

Heat transfer coefficient H is deduced from this calculation (kcal/h x m^2 x °C) on the basis of Figure 1, and then the number of trays as a function of the quantity of heat to be exchanged Q (kcal/h) :

$$N = \frac{Q}{LMTD \times H \times 0.785 \times D^2}$$

This figure shall be compared to the number of trays specified in other units for similar services.

1.3. Height of a packed heat transfer zone

The method used essentially depends on the type of packing used. Data regarding a type of packing can be supplied in two ways :

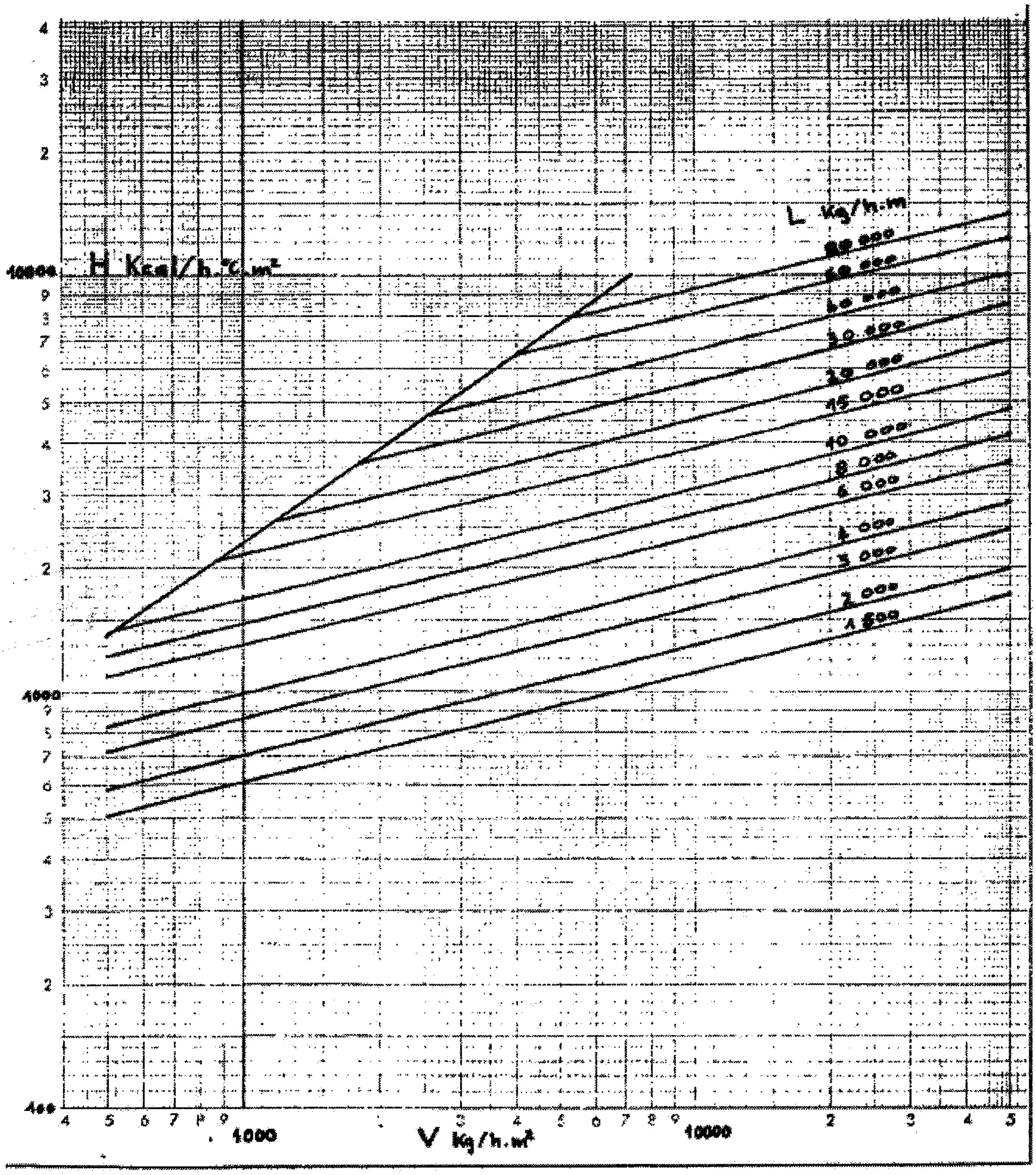
- Either as a height equivalent to an actual tray. In this case, the number of heat transfer trays shall be calculated according to the method set out above assuming that the tray is a single pass tray.
- Or as a heat transfer coefficient by unit of packing volume, which allows packing height to be calculated on the basis of the column diameter :

$$HG = \frac{Q}{LMTD \times HV \times 0.785 \times D^2}$$

With :

HG : Packing height (m)
Q : Quantity of heat to be exchanged (kcal/h)
LMTD : Logarithmic mean temperature difference between T_1, T_2, t_1, t_2
HV : Transfer coefficient per unit of volume (kcal/h x m^3 x °C)
D : Column diameter (m)

FIGURE 1 – Heat exchange trays



2. GLITSCH GRIDS

Information contained in the Vacuum Distillation Guide Document shall be used, as well as Vendors documents.

3. DISKS AND DOUGHNUTS AND SHED BAFFLES

Disks and doughnuts and shed baffles are currently used in fouling or coking services. They are also used in heat transfer zones in fractionation columns in catalytic cracking units. They can also be used in visbreaking or vacuum distillation stripping sections.

In case of performance of design studies regarding this type of tray, also refer to the following :

- FRI documents
- Documents available in TECHNIP FRANCE's Methods group.

3.1. Column diameter

If other types of trays are used in the column, the diameter can be maintained. In other cases, the diameter chosen shall be so as to obtain a velocity through the column section equal to 170% of Vc :

$$Vc = 0.048\sqrt{\frac{DL - Dv}{Dv}}$$

Vc : Critical velocity (m/s)
DL : Liquid density under operating conditions
Dv : Vapor density under operating conditions

Limits described below may also lead to modify the diameter if they are more severe.

3.2. Baffle specification

3.2.1. Distribution of areas

Vapor velocity through the flow section should be approximately equal to 250% of Vc (maximum : 300%). A gap between disks and doughnuts, or between adjacent baffles, may be authorized provided that its horizontal projection does not exceed 30% of spacing.

3.2.2. Spacing and number of baffles per tray

One shall act on the vertical spacing between adjacent baffles or on the number of baffles per tray in order to have a vapor velocity through the ring area between disks and doughnuts, or through the vertical area between adjacent baffles, that does not exceed 250% of Vc. It should be noted that shed baffles allow a smaller spacing to be obtained that with disks and doughnuts. Shed baffles shall therefore be particularly cost saving in large diameter columns. As a rule, spacing under 450 mm shall be prohibited for access reasons.

Minimum spacing between baffle tray zones and conventional tray zones shall be 900 mm. Larger spacing may be required by the complex character of transition zones or for downcomer operation reasons.

3.2.3. Weirs

Each baffle is sloped downwards with a 1 inch slope per foot. Weir height shall be equal to 1/3 the baffle slope. Six to eight radial weirs shall be installed at regular intervals on disks and doughnuts in order to ensure liquid proper distribution. Their height should be equal to that of weirs. In case of utilization of slotted weirs, these distribution weirs must reach the top of slots.

3.2.4. Liquid flowrate

If the liquid flowrate is lower than 9 m^3/h per meter of weir, one shall specify a weir with V slots and distribution orifices shall be drilled in the tray along the weir. Neither weir nor distribution orifice shall be needed in case of very fouling service. Orifices shall have a minimum diameter of 1/2" in order to prevent clogging. Pitch shall be approximately equal to twice the diameter of orifices. The number of orifices shall be calculated using the following formula :

$$n = \frac{1.017 \times Q}{S \times \sqrt{h}}$$

With :

n : Number of orifices
S : Surface area of an orifice in square inches
Q : m^3/h of liquid
h : Liquid height above orifices in inches (maximum 2")

The distance between the bottom of the weir and the bottom of slots is two inches higher than the required liquid height above orifices. Slots must not be fully filled for maximum liquid flowrate. The following formula, drawn up for 90° V slots, may be used :

Q : $0.05 \times (H)^{2.5}$
Q : Liquid flowrate in m^3/h x slot
H : Liquid height above the bottom of the slot (cm)

3.3. Head channels

Liquid head channels must be provided at that top of the baffle tray section. These head channels must be suitable for the type of baffle used and incorporated in the disk or higher shed baffle.

The following may be used :

- Either a baffle allowing liquid flow-through, underneath it (twice the diameter of the feed nozzle).
- Or a weir, slotted if applicable, calculated in this case as a downcomer.

3.4. Number of baffle trays

3.4.1. Washing oil systems

In washing oil systems of vacuum flash towers, three baffle trays, or two disks and one doughnut, shall be used. However, a minimum liquid flowrate of 2.5 $m^3/h.m^2$ is necessary to ensure proper contact with vapors and to prevent coking at high temperature.

3.4.2. Heat transfer

Experience has demonstrated that the actual transfer surface in a heat transfer zone using disks and doughnuts or shed baffles is the total of horizontal flowing areas. The total surface area is calculated according to the conventional formula :

$$S = \frac{Q}{H \times LMTD}$$

With :

S : Total transfer area (m^2)
Q : Quantity of heat to be transferred (kcal/h)
LMTD : Logarithmic mean temperature difference between T_1, T_2, t_1, t_2
H : Transfer coefficient (kcal/h x m^2 x °C)

Transfer coefficient H shall be read on Figure 2 after having calculated average liquid and vapor velocity through available flow area.

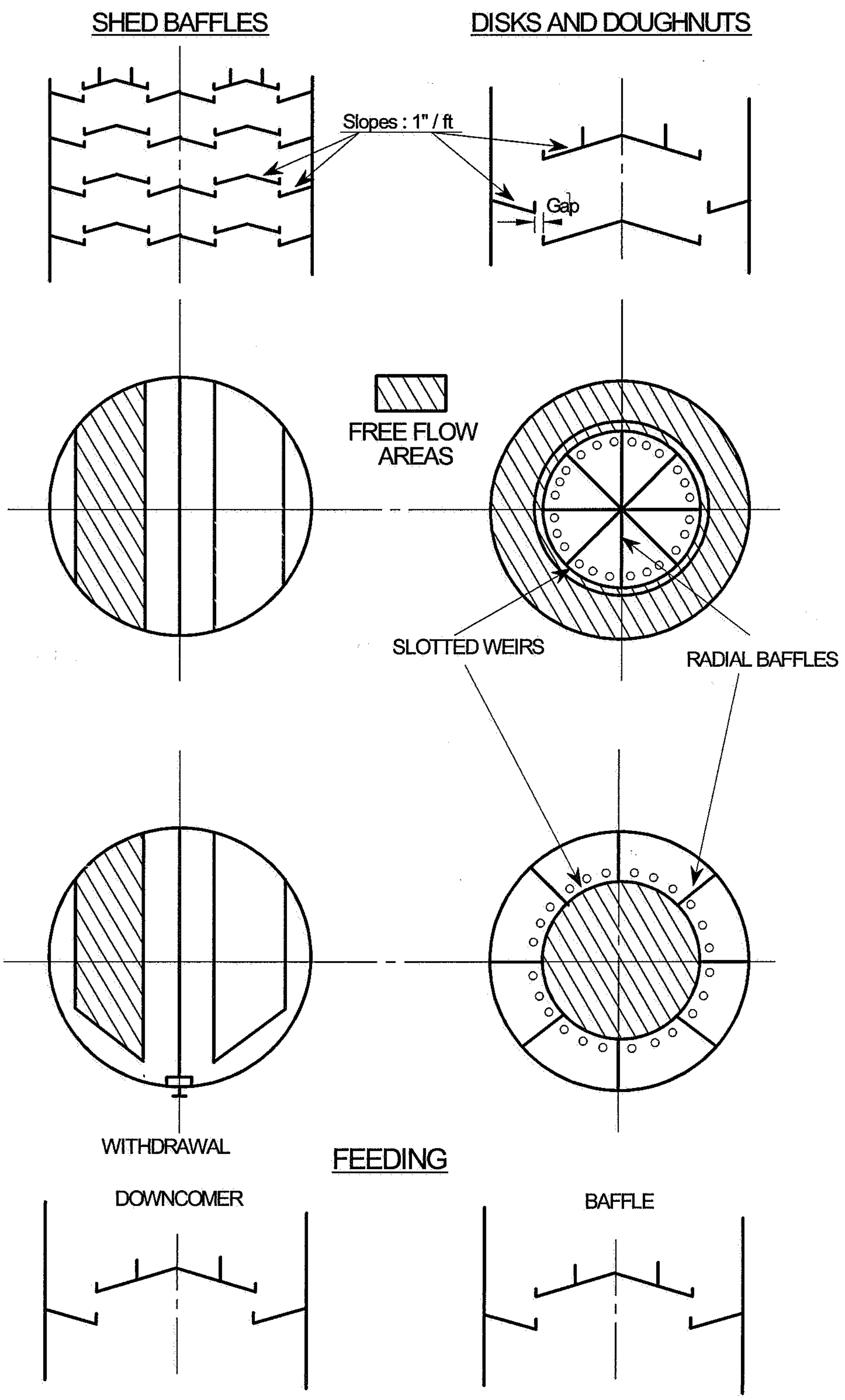
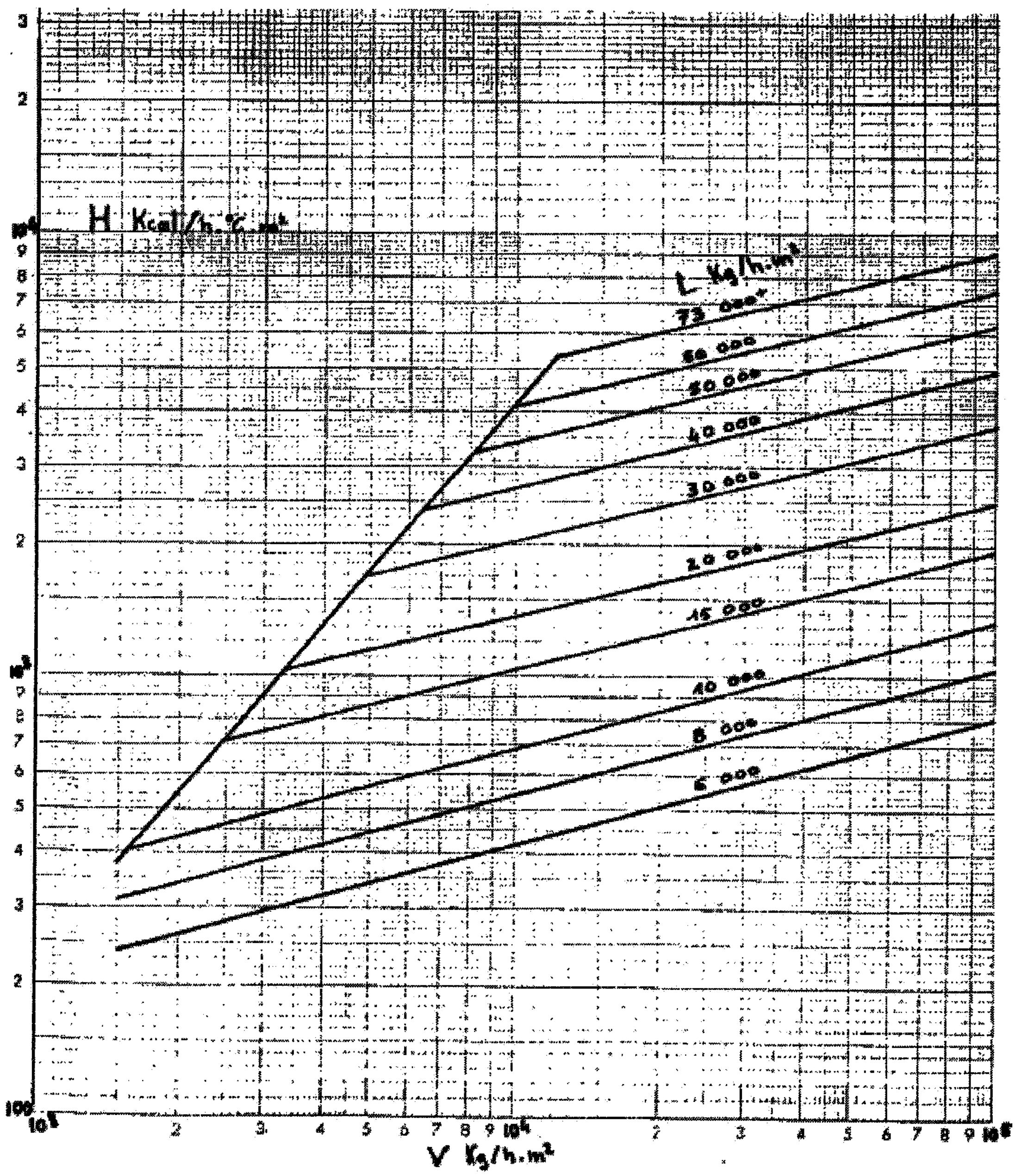
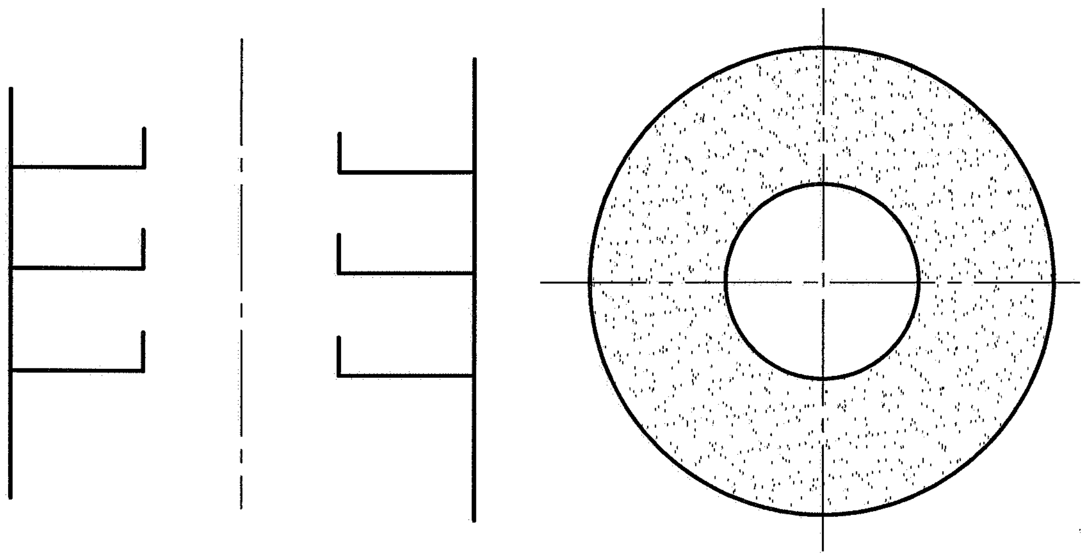

SHED BAFFLES
DISKS AND DOUGHNUTS
Slopes : 1" / ft
Gap
FREE FLOW AREAS
SLOTTED WEIRS
RADIAL BAFFLES
WITHDRAWAL
FEEDING
DOWNCOMER
BAFFLE

FIGURE 2 – **Disks and doughnuts or shed baffles**



4. PERFORATED TRAYS WITH CHIMNEYS

In columns such as vacuum driers, for which liquid-vapor contact is not requested, but needing thorough dispersion of liquid in order to promote vapor separation, the type of tray presented below can be used.



Chimney area shall be determined in order to prevent vapor velocity from exceeding 250% of critical velocity Vc.

The number of orifices, with a diameter equal to 10-12 mm, shall be determined considering a liquid height on the tray of 25 mm, using the following general formula:

$$Q = 5.05 \cdot 10^{-4}\ K\ S\ \sqrt{h}$$

With :

K : 0.6
Q : Flowrate in m^3/h
S : Total area of orifices (mm^2)
h : Liquid height on the tray (mm)

The number of trays in a column is approximately 4.