



BASIC DESIGN MANUAL
SPD0023ERN

DRUM

REV. : 2

DATE : 2010. 11. 20

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1. SCOPE

This manual covers the minimum requirements for the design of drums.

2. FORMAT

Drum design results shall be summarized in the following blank forms:

Data sheet pressure vessels

Form No. C-6110-104AA4

3. DESIGN CRITERIA

3.1 General

(1) Drums are provided mainly for the following purposes:

- 1) Vapor-liquid separation
- 2) Liquid-liquid separation
- 3) Vapor surge
- 4) Liquid surge

Hence, the engineers in charge shall design drums to be of optimum construction with the full understanding of their characteristics.

(2) Applications of vertical and horizontal vessels

The following guidelines shall be followed in the determination of vessel types (whether the vessel should be of a horizontal type or a vertical type).

Note that the term "Horizontal Vessel" used herein refers to vessels in which the liquid level is to be at the centerline as usual: Namely, 50% of the vessel volume is in the liquid phase and the other 50% is in the vapor phase.

1) Vapor-liquid ratio

In cases where the vapor-liquid ratio is large, vertical vessels are advantageous

In cases where the vapor-liquid ratio is small, horizontal vessels are advantageous.

In cases where the vapor-liquid ratio is extremely small, the vapor phase volumes of both horizontal and vertical vessels can be reduced to under 50%. Under such conditions, vertical vessels become preferable than horizontal vessels in some cases. Because, in the vertical vessels controllability of the liquid can be kept constantly.

2) Liquid flow fluctuation

In cases where the liquid flow to the vessel fluctuates frequently, vertical vessels are preferable to horizontal vessels.

3) Three phase separation

In cases where the three phase separation is required, horizontal vessels shall be used.

4) Re-vaporization

In cases of preventing for re-vaporization or re-mixing of fluids in vessels, vertical vessels are preferable.

(3) Length-diameter ratio

- 1) The length-diameter ratio should be economically 3:1 ~ 6:1 in the case of 2:1 semi-ellipsoidal heads and 2:1 ~ 4:1 in the case of semispherical heads, the higher the drum

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operating pressure and/or drum material class is, the larger the length-diameter shall be made.

- 2) Since drums are fabricated of 1,500 mm width plates in many cases, economically it is desired that the longitudinal dimensions of drums should be 1,500 mm x an integral number or 1/2, for instance, 750 mm, 1,500 mm, 2,250 mm and 3,000 mm.

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3.2 Vapor-Liquid Separator

3.2.1 Wire Mesh Mist Eliminator

(1) Mist eliminator application criteria

- 1) Vertical vessels whose "K" value (mentioned in subsequent paragraphs) is under 0.1 (which is 30% of the "K" value (0.35) usually used), need not be provided with any wire mesh pad. Fig. 3-1 shows various mist eliminator installations in process equipment.
- 2) In the following cases, mist eliminators shall be provided regardless of the flow velocity. The superficial flow velocity at the mist eliminator shall be kept at above a certain value to maintain the efficiency.
 - Where the loss of expensive materials must be minimized.
 - Where entrainment or carry-over of hazardous matter must be minimized.
 - Where subsequent equipment must be protected from the unfavorable effects of splashes entrained in the stream.
- 3) If the mist eliminators need to be designed for an excessively large size, the vessels shall be designed for a horizontal type. (See Fig. 3-1.)

(2) Allowable velocity

1) Basic equation

The flow velocity through the mist eliminator shall be calculated by the following equation:

$$u = K \times \frac{DR}{100} \sqrt{\frac{\rho_L - \rho_V}{\rho_V}}$$

or

$$K = \frac{100u}{DR} \sqrt{\frac{\rho_V}{\rho_L - \rho_V}}$$

Where, u : Linear velocity at wire mesh pad (ft/sec)
 K : Velocity constant (ft/sec)
 ρ_L : Liquid density (lb/ft³)
 ρ_V : Vapor density (lb/ft³)
 DR : Design rating specified in (c)(%)

- 2) Types of mist eliminators are as shown in Table 3-1. Normally 9 lb/ft³ eliminators should be used. (1) The value "K" shall be selected from those shown on Table 3-2.
- 3) Design rating
 - Mist eliminators shall be rated 85% in usual cases.
 - Mist eliminators shall be rated 50% in cases where there is a possibility of wire mesh being blocked by the dirty fluid.
 - Mist eliminators shall be rated 67% in cases where they are to be placed aslant or vertically.
- 4) Pressure drop (7)

Pressure drops in wire mesh pads are so small (2 mmHg or less) that they will not pose any

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problem in usual cases. The total pressure drop across wire mesh is the sum of the pressure drop across the dry mesh plus the additional pressure loss contributed by the liquid load within the mesh.

This may be expressed as:

$$\Delta P_T = \Delta P_D + \Delta P_L \quad (\text{in - H}_2\text{O})$$

The dry pressure drop, ΔP_D is calculated as follows:

$$\Delta P_D = 0.193 \frac{f_c l a \rho_G U^2}{g_c \varepsilon^3} \quad (\text{in - H}_2\text{O})$$

Where f_c is a function of Reynold's number:

$$\text{Re} = \rho_G U / a \mu$$

f_c , a , ε and ΔP_L are observed from Fig. 3-2.

a	: specific surface area	(ft ² /ft ³)
f_c	: Friction factor from Fig. 3-2	(-)
g_c	: Gravitational constant 32.2	(lb ft/lb -force sec ²)
l	: Wire mesh thickness	(ft)
L	: Liquid mass flow rate	(lb/hr ft ²)
ΔP	: Pressure drop across wire mesh without entrainment load	(lb/ft ²)
ΔP_D	: Pressure drop across wire mesh without entrainment load	(in. of water)
ΔP_L	: Pressure drop contributed by liquid load	(in. of water)
ΔP_T	: Pressure drop total across wire mesh with entrainment load	(in. of water)
Re	: Reynolds number defined by above equation	(-)
U	: Superficial gas velocity	(ft/sec)

Greek letters

ε	: Void fraction of wire mesh	(-)
ρ_G	: Gas density	(lb/ft ³)
ρ_L	: Liquid density	(lb/ft ³)
μ	: Viscosity	(lb/ft sec)

3.2.2 Vertical Separator

Refer to Figs. 3-4 and 3-5.

- (1) For limitations on the vapor velocity, see Para. 3.2.1.

In cases where wire mesh pads are to be provided, attention shall be paid to the fact that the vapor passage area will be reduced by the width of the support ring (which is usually 50 mm; namely, the inside diameter will be reduced by 100 mm).

- (2) The space above the demister can be kept to a minimum.

Recommended value is minimum 300 mm as usual. Pay attention to the configuration of vapor outlet nozzle.

- (3) Disengaging height

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The height provided under the wiremesh pad for vapor-liquid separation is called "disengaging height (Hd)". Criteria for determination of disengaging heights are as follows:

- 1) In cases where a wire mesh pad is provided:

Refer to Fig. 3-4.

The dimension from the top side of the feed nozzle to the underside of the wire mesh pad is the disengaging height (Hd).

The value "Hd" shall be the largest of the following:

- (i) $H_d \geq 12" + H_v$
- (ii) $H_d \geq 18"$ (minimum)
- (iii) $H_d \geq 0.25D$ (minimum)

Where,

H_d : Disengaging height (in)

H_v : Required height determined by the value "K" from Fig. 3-3 (in)

D : Drum inside diameter (in)

- 2) In cases where no wire mesh pad is provided:

Refer to Fig. 3-5.

The dimension from the top side of the feed nozzle to the top tangent line is the disengaging height (Hd).

The value "Hd" shall be the largest of the following:

- (i) $H_d \geq 18" + H_v$
- (ii) $H_d \geq 24"$ (minimum)
- (iii) $H_d \geq 0.25D$ (minimum)

The value H_v shall be read from Fig. 3-3.

- (4) The dimension between the feed nozzle and high liquid level (HLL) shall be the larger of the following values:

Nozzle center to HLL 300 mm minimum

Nozzle bottom to HLL 150 mm minimum

- (5) The liquid phase volume shall be determined in accordance with Para. 3.5 If liquid-liquid separation is required, checks shall be conducted in accordance with Para. 3.3.

3.2.3 Horizontal separator

- (1) Vapor velocity

In order to avoid the entrainment of liquid droplets with the vapor, it is necessary to check the vapor velocity which is given by:

$$U_h = 5.45 \times 10^{-3} \frac{L}{H} \frac{S_o - S_v}{\mu_g} \quad (\text{for the metric system})$$

$$U_h = 1.79 \times 10^{-2} \frac{L}{H} \frac{S_o - S_v}{\mu_g} \quad (\text{for the British system})$$

Where,

U_h : Horizontal vapor velocity (m/sec.) or (ft/sec)

L : Distance between vapor inlet nozzle (m) or (ft)

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and vapor outlet nozzle

H : Height of vapor section (m) or (ft)
(the section above the high level)

S_o : Specific gravity of oil

S_v : Specific gravity of vapor

μ_g : Viscosity of vapor (cP)

The above formulas will be satisfactory for most horizontal separators, because the ratio of vapor load to liquid is small.

$D_p = 100$ microns, is assumed as a basis. D_p is the diameter of a droplet

(2) Vapor space

The areas used for calculating the vapor velocity in a horizontal drum are the vertical cross-sectional area above the normal liquid level and high liquid level. The normal liquid level is usually set at the center line of the drum, but not compulsive.

The minimum vapor space above the high liquid level in horizontal drums should not be less than 20% of the drum diameter or 12 inches, whichever is the greater.

(3) The liquid phase volume shall be determined in accordance with Para. 3.5. If liquid-liquid separation is required, checks shall be conducted in accordance with Para. 3.3.

(4) Wire mesh demister

In some cases, a wire-mesh demister may be installed as shown in Fig. 3-6. For the installation of a wire-mesh demister, refer to Para. 3.2.1 describing the inside diameter of the vertical separator.

The dimension between the high-liquid level and the underside of the wire mesh pad shall be 6 inches (150 mm) minimum.

(5) Boots

1) Boots shall be sized for a minimum residence time of five minutes as a guideline : their diameters shall be the same as the commercial pipe sizes as far as possible.

The height-diameter ratio shall be 2:1 ~ 5:1, it shall be determined with consideration given to operability and the minimum sizes of level instruments and equipment.

2) Boot diameters shall be 250 mm ϕ (10 inches) minimum because good operability cannot be provided if the boots are smaller than 250 mm ϕ (10 inches ϕ)

3) Maximum boot diameters shall be 1/3 of the drum inside diameter. Boot diameters larger than this, if required, shall be called to the attention of the mechanical engineers in charge. Should the boot installation be mechanically impracticable, the drum shall be designed to be a liquid-liquid separator, which is discussed in the following paragraph.

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3.3 Liquid-Liquid Separator

Refer to Appendix A attached.

For normal liquid droplet separation, droplet diameters ranging from 500 to 1,000 microns are assumed as a guide for the design for vertical separators, and droplet diameter of about 100 microns are assumed as a guide for the design of horizontal separators.

3.3.1 Vertical Separator

(1) Liquid velocities

The terminal velocity U_t of any droplet moving in a medium can be calculated from Stokes' law i.e.,

$$U_t = \frac{gD_p^2(\rho_h - \rho_l)}{18\mu}$$

Where,

U_t	: Terminal velocity of liquid droplet	(m/sec)	(ft/sec)
g	: Acceleration of gravity	(m/sec ²)	(ft/sec ²)
D_p	: Diameter of droplet	(m)	(ft)
ρ_h	: Density of droplet	(kg/cm ³)	(lb/ft ³)
ρ_l	: Density of the continuous phase	(kg/m ³)	(lb/ft ³)
μ	: Viscosity of continuous phase	(kg/m sec)	(lb/ft sec)

The settling rate of each phase from the other phase should be calculated to decide which phase is limiting.

(2) Construction

Typical constructions of vertical liquid-liquid separators are shown in Fig. 3-7. Feed nozzles shall be so arranged that the liquid-liquid interface may not be disturbed.

3.3.2 Horizontal Separator

(1) Liquid velocity

The liquid velocity can be determined by the equation given below, where D_p is assumed to be 100 microns.

$$\frac{L}{V_h} \geq \frac{H_l}{U_t}$$

$$U_t = 1.79 \times 10^{-2} \frac{S_h - S_l}{\mu} \quad (\text{for British system})$$

$$U_t = 5.47 \times 10^{-3} \frac{S_h - S_l}{\mu} \quad (\text{for metric system})$$

where,

L	: Distance between the inlet nozzle and outlet nozzle	(m)	(ft)
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V_h	: Horizontal liquid velocity	(m/sec)	(ft/sec)
H_l	: Height of the liquid space	(m)	(ft)
U_t	: Terminal velocity of the heavier fine particles	(m/sec)	(ft/sec)
S_h	: Specific gravity of the heaviers	(-)	
S_l	: Specific gravity of the lighters	(-)	
μ	: Viscosity of the lighters	(cP)	

(2) Construction

Typical constructions of horizontal liquid-liquid separators are shown in Fig. 3-8.

For boot design, see Para. 3.2.3.

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3.4 Special Vessels

3.4.1 Dehydrators

(1) Sand filters

The quantity of sand to be packed into a sand filter per given flow rate is indicated below on the assumption that the particle sizes of the sand range from 8 to 16 meshes.

The ratio of the diameter to the packed height is assumed to be 1:1.

Flow Rate	100 bbl/hr (oil)	100 m ³ /hr (oil)
Naphtha	75 ft ³ (sand)	13 m ³ (sand)
Kerosene	150 ft ³ (sand)	25 m ³ (sand)

Note : The above values are for non-patented sand filters.

(2) Salt filters

The packed height of rock salt for salt filter is 3,000 mm regardless of the diameter of the vessel involved. The standard flow rates for liquid to be treated are given below, for which the particle sizes of the rock salt are assumed to range from 6 to 10 mm.

Unit	British system bbl/hr ft ²	Metric system m ³ /hr m ²
Flow rate	5.5	9.4

3.4.2 Steam Drum

(1) The size of the steam drum should be determined in accordance with the following items.

Normally, a horizontal type steam drum is used. (See Fig. 3-9 (a)).

- 1) The emergency low liquid level (E.L.L.L.) alarm is to be set to a level 300 mm above the bottom of the steam drum.
- 2) A minimum 3-minute holdup. should be allowed between E.L.L.L. and L.L.L. (low liquid level).
- 3) A 5-minute holdup should be allowed between L.L.L. and H.L.L. (high liquid level).
- 4) A minimum 3-minute holdup should be allowed between H.L.L., and E.H.L.L..(emergency high liquid level)
- 5) H.L.L. should be taken as the center line of the steam drum.
- 6) The minimum diameter of the steam drum should be 1,000 mm.

(2) Configuration of steam drum (See Fig. 3-9 (b))

1) Vapor-liquid separating mechanism around outlet nozzle

- External type (to be installed outside the steam drum).....Cyclone

The water content in the outlet steam can be removed to a maximum extent of 0.5 wt%.

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- Internal type (to be installed in the steam drum)

Wire mesh : Wire mesh is used for comparatively low pressure below 10 kg/cm²G and can remove water in the outlet steam to a maximum extent of 0.5 wt%. The wire mesh is 150 mm and is commonly made of monel.

Purifier : Refer to the catalog of the VD Anderson Co., which is represented by Mitsui and Co. in Japan. The purifier can remove water in the outlet steam to a maximum extent of 0.2 wt%.

In addition, the purifier can guarantee the maximum allowable total solids in the steam, which is set at 1 ppm.

2) Steam/water inlet nozzles

In cases where the number of nozzles is increased, the method given in Fig. 3-9 (c) is used.

3) Fresh water inlet nozzle

The fresh water inlet nozzle should be separated from the circulation water outlet nozzle and the blow down nozzles. The area of the holes should be larger than that of the nozzles.

4) Blow-down nozzles

The blow-down nozzles should be so arranged that the water can be blown down as uniformly as possible from within the steam drum. Continuous blow-down should be withdrawn from immediately below the low liquid level.

Intermittent blow-down should be withdrawn from the bottom of the steam drum.

3.4.3 Instrument Air Receiver

The volume of the instrument air receiver should be determined by assuming a proper holding time to meet the plant conditions. Here, the holding time is defined as the time during which the pressure varies from the lower limit pressure under normal operation to the minimum operable pressure.

The volume of the instrument air receiver can be calculated by the equation given below.

$$V_v = Q_v \times t \frac{P}{P_1 - P_2} \frac{T}{273}$$

Where,

V_v :	Volume of air receiver	(m ³)
Q_v :	Required flow rate of air	(Nm ³ /min.) at 0 °C and 1 atm
P :	Atmospheric pressure	(1.03 kg/cm ² abs.)
P_1 :	Lower limit pressure under normal operation	(kg/cm ² G)
P_2 :	Minimum Operable pressure	(kg/cm ² G)
t :	Holding time of air	(min.)
T :	Temperature of air during operation	(°K)

Generally,

P_1 , P_2 and t assume the following values.

P_1 : 7 kg/cm²/G

P_2 : 2.5 kg/cm²G (applicable only to instrument air)

5 kg/cm²G (Also applicable to process air)

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t : 10 min.

3.4.4 Fuel Gas Balance Drum

The volume of the fuel gas balance drum can be calculated by the equation given below.

$$V_v = \frac{Q_v' \times t}{\frac{P}{P_1 - P_2} \times \frac{T}{273}}$$

Where,

- V_v : Volume of fuel gas balance drum (m³)
- Q_v : Required flow rate of fuel gas (Nm³/min.)
- P : Atmospheric pressure (1.03 kg/cm² abs.)
- ***P₁ : Lower limit pressure under normal operation (kg/cm²G)
- **P₂ : Minimum operable pressure (kg/cm²G)
- *t : Usable time of fuel gas
- T : Operation temperature (°K)
- Q_v' : Flow rate of fuel gas, which can be maintained (m³/min)
even when of all the fuel gas inlet lines, the one feeding the largest quantity is assumed to have been brought to a stop.

The above equation is based on the following assumptions.

- (1) Fuel gas consumption is fixed.
 - (2) Of the fuel gas sources, the largest one will fail. Gas supplies from all other sources will continue.
 - (3) The fuel gas supply will not be backed up. Hence, the consumption must be met by the gas held in the fuel gas balance drum only.
- * : This value should be determined by the state of readiness to augment the fuel supply in cases where the supply of off-gas from the process is insufficient.
Normally, 5 ~ 10 minutes are used.
 - ** : The value for P₂ is calculated from the equation given below.
P₂: (Pressure Drop in Burner) + (Pressure Drop in Control Valve) + (Pressure Drop in Piping)
The burner pressure varies from one fuel to other. However, the generally used pressure is about 1.5 kg/cm²G. For P₂, a pressure ranging from 2.0 to 2.5 kg/cm²G should be used.
 - ***: There has been a case where a refinery used 4.0 kg/cm² abs, 4.5 kg/cm² abs, and 5.2 kg/cm² abs. The value for P₁ is determined by such factor as burner type, fuel gas composition, etc.

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3.5 Holding Time

Refer to SEM-9418E, Tower, para. 5.4.1

3.6 Nozzle

3.6.1 Distributor and Baffle

(1) Inlet distributor

Distributors and/or baffles are provided to carry out separation effectively or to prevent disturbance of the vapor-liquid interface. (See Fig. 3-10).

Baffles and distributors are used for the following applications:

All liquid feed: for one liquid phase

All liquid feed: for two liquid phase

Vapor-liquid mixed feed

Distributors are fabricated of commercial pipes.

(2) Baffle

Baffles shown in Fig. 3-10 are used for gas containing mist or gas liquid mixture.

3.6.2 Miscellaneous Nozzles

For the following nozzles, see SEM-9418E, Tower, Para. 5.7.

Manhole

LC-LG nozzle

Vent, drain

Vortex breaker

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Appendix A. Terminal Velocity Equation

A-1. Terminal Velocity of a Spherical Fine Particle Settling under the Influence of Gravity

The terminal velocity of a spherical fine particle setting under the influence of gravity can be determined by Stokes' law.

$$U_t = \frac{4}{3} \frac{g D_p}{C_D} \frac{\rho_l - \rho_v}{\rho_v} \quad (\text{A-1})$$

$$U_t = K \frac{\rho_l - \rho_v}{\rho_v} \quad (\text{A-2})$$

Where,

U_t	: Terminal velocity	(m/sec)	or	(ft/sec)
g	: Acceleration of gravity	(m/sec ²)	or	(ft/sec ²)
D_p	: Diameter of fine particle	(m)	or	(ft)
C_D	: Drag coefficient	(-)		
ρ_l	: Density of liquid	(kg/m ³)	or	(lb/ft ³)
ρ_v	: Density of vapor	(kg/m ³)	or	(lb/ft ³)
K	: Entrainment coefficient	(m/sec)	or	(ft/sec)

Based on the theory and experimental results, C_D can be expressed approximately as follows. It should be noted that C_D is given as a function of Reynolds number, Re only, where the velocity is the relative velocity of the fine particle to its surrounding fluid.

$$C_D = 24/Re \text{ for } Re < 2 \quad (\text{Stokes' law})$$

$$C_D = 10/\sqrt{Re} \text{ for } 2 < Re < 500 \quad (\text{Allen's law})$$

$$C_D = 0.44 \text{ for } Re > 500 \quad (\text{Newton's law})$$

Substituting these for C_D in Eq. A-1,

$$U_t = \frac{g D_p^2 (\rho_l - \rho_v)}{18\mu} \quad (Re < 2)$$

$$U_t = \left[\frac{4}{225} \frac{(\rho_l - \rho_v)^2 g^2}{\mu \rho_v} \right]^{1/3} D_p \quad (2 < Re < 500)$$

$$U_t = \sqrt{3g D_p \frac{\rho_l - \rho_v}{\rho_v}} \quad (Re > 500)$$

A-2. Application to Vertical Vapor-Liquid Separator

(1) The value "K" in Eq. A-2 is used for design of usual vapor-liquid separators.

Determination of the value "K" is empirical.

Various literature (1), (2), (4), (5) and (8) show recommended values but herein E. E. Ludwig's thought (1) is followed in cases where wire mesh is provided and A. H. Younger's (5) thought (K

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= 0.1 ft/sec) is followed in cases where no wire mesh is provided.

(2) Several types of wire-mesh demisters are manufactured. The most widely used ones are given in Table 3-1.

(3) Various reports (1), (4), (6) and (8) have been presented with respect to disengaging heights (provided under wire mesh pads for vapor-liquid separation).

According to them, disengaging heights of 12 ~ 18 inches are sufficient. In this manual, it is required that disengaging heights should be 18 inches minimum in cases where wire mesh is provided.

This height must be corrected for the vapor velocity in each individual case. (4)

Provision of baffles must be considered. The reason for this is that the duty of vapor liquid separation in the disengaging zone can be reduced by directing the liquid flow downwards.

Also, consideration has been given to avoid the unfavorable effects on wire mesh pad due to the coning of feed stream (9) in cases where no baffle is provided.

The same thought has been followed even in cases where no wire mesh is provided.

A-3. Application of these Equation to Vertical Liquid-Liquid Separators

Using Allen's and Stokes' equations, the terminal velocity of the heavier particles can be calculated. Typical application of these equations to the separation of water from oil is given in the following tables.

(1) $D_p = 400 \sim 500$ microns

Physical Properties of Hydrocarbon		Oil Fraction	Maximum Liquid Velocity	
Sp.Gr .	μ (cP)		ft/sec	m/sec
0.70	0.5	Naphtha	0.1	0.03
0.80	1.5	Kerosene	0.05	0.015
0.85	5.0	Gas oil	0.01	0.003
0.90	10.0	Vac. gas oil	0.005	0.0015

(2) $D_p = 1,000$ microns (1 mm)

Physical Properties of Hydrocarbon		Oil Fraction	Maximum Liquid Velocity	
Sp.Gr .	μ (cP)		ft/sec	m/sec
0.70	0.5	Naphtha	0.25	0.08
0.80	1.5	Kerosene	0.13	0.04
0.85	5.0	Gas oil	0.06	0.02
0.90	10.0	Vac. gas oil	0.02	0.005

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A-4. Horizontal Separators

The following equation is based on Stokes' equation described in Appendix A-1.

$$U_t = \frac{gD_p^2(\rho_h - \rho_l)}{18\mu}$$

Where,

- g : Acceleration of gravity (9.8 m/sec²) or (32.2 ft/sec²)
- D_p : Diameter of the heavier particle (m) or (ft)
- ρ_h : Density of the lighter fraction (kg/m³) or (lb/ft³)
- ρ_l : Density of the heavier fraction (kg/m³) or (lb/ft³)
- μ : Viscosity of the lighter fraction (kg/m sec) or (lb/ft sec)

Substituting 9.8 m/sec² for g and 100 microns for D_p, converting the densities to specific gravities, and expressing the viscosity in centipoise,

$$\begin{aligned}
 U_t &= \frac{gD_p^2(\rho_h - \rho_l)}{18\mu} \\
 &= 5.45 \times 10^{-3} \frac{S_h - S_l}{\mu} \quad (\text{m/sec}) \\
 &= 1.79 \times 10^{-2} \frac{S_h - S_l}{\mu} \quad (\text{ft/sec})
 \end{aligned}$$

D_p = 100 microns is based on A. D. Sheiman's report (6). Sheiman states in his report that heavier particles of D_p = 3 ~ 100 microns have settling velocities describable for Stokes' equation.

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Tabl 3-1 Identification of Wire Mesh Types

Density lb/ft ³	Surface Area (Note 1) ft ² /ft ³	Void Fraction –	Wire Diameter inches	York	Manufacture's Type				Application
					Divmet	Metex	Nihon Mesh	Naniwa Special Mesh	
12	110	0.977	0.011 (Note 3)	421	4210	Xtradense	SL	3311	High efficiency, Relatively clean, Moderate velocity, Use in 4" pad
9 (Note 2)	85	0.982	0.011 (Note 3)	431	4310	Nu- standard	N	3383	Standard efficiency, General purpose, Use in 4" pad
8	140	0.984	0.006	326	3260	–	SN	–	Fine mist removal, Use in 4"~ 6" pad
5	46	0.990	0.011 (Note 3)	931	9310	HI- throuput	H	3346	High through-put or low density, for service containing solids or "dirty" material, Use in 6" pad
13.7	275	0.972	5 strand each 0.122mm	–	–	–	T	4060	Very high efficiency, 10" and 12" recommends for special applications such as fine mists, oil vapor mist.

Note 1 : If the mesh is made of nickel, monel or copper, multiply the density values by 1.13, referenced stainless steel.

Note 2 : Normally, 9 lb/ft³ mesh is used.

Note 3 : Nihon Mesh Kogyo Co. fabricates with 0.254 mm wire

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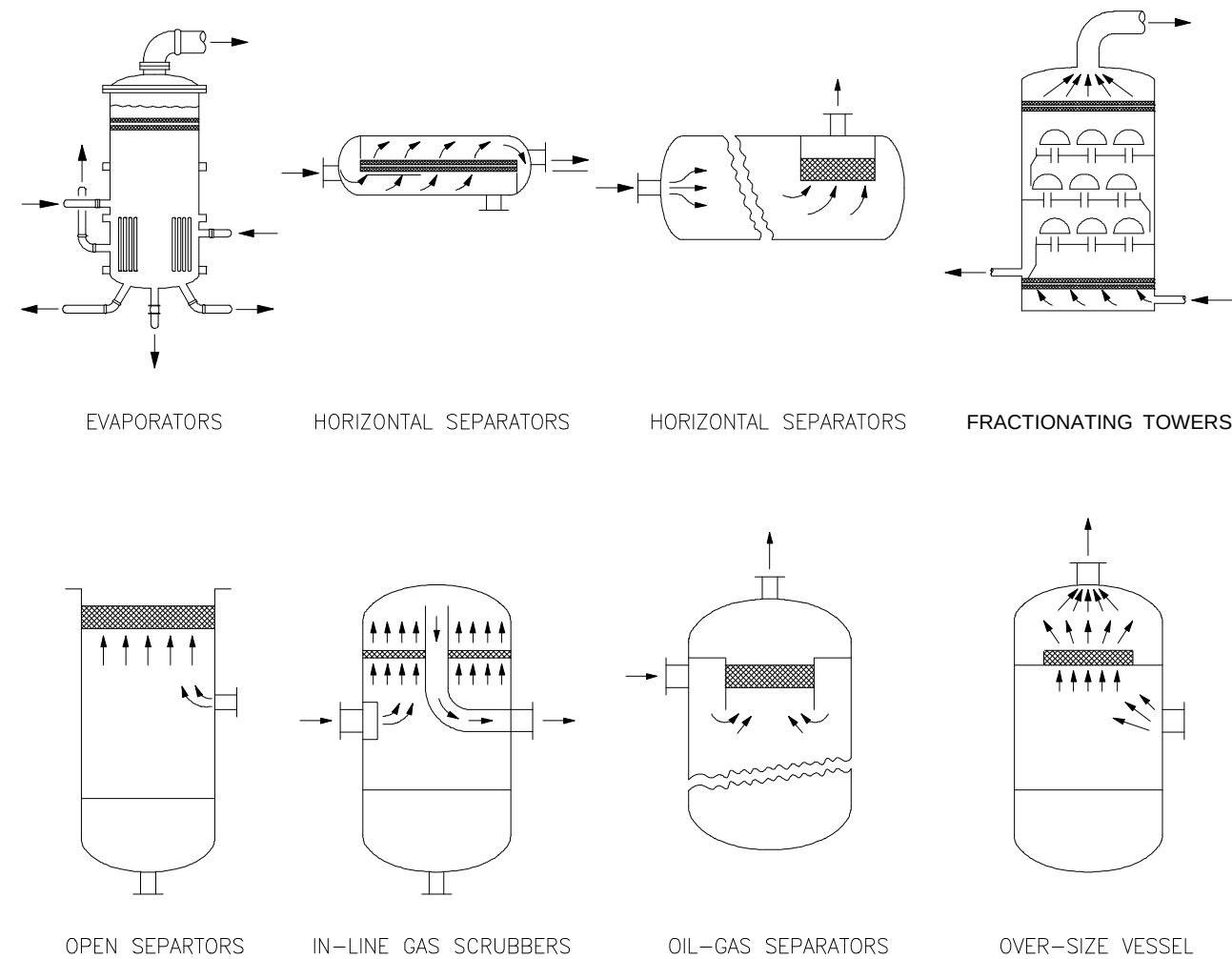
Table 3-2 "K" Values for Knitted Mesh

Service Conditions	"K"	General Type Mesh
Clean fluids, moderate liquid load, fits 90% of process situations	0.35 to 0.36	- Standard
	0.35	- High Efficiency
	0.25	- Very High Efficiency
High viscosity, dirty suspended solids	0.40	- Low density or Herringbone, high through-put
Vacuum operations;		
2" Hg. abs.	0.20	- Standard or
16" Hg. abs	0.27	- High Efficiency
Corrosive Chemical	0.21	- Plastic coated wire, or plastic strand

For most situations very good performance can be expected for all velocities from 30 to 100 percent of the optimum allowable design velocity. The minimum allowable safe design velocity is 10 percent of the value calculated by the equation. The flooding velocity of the mesh is usually about 120 percent to 140 percent of the maximum allowable velocity.

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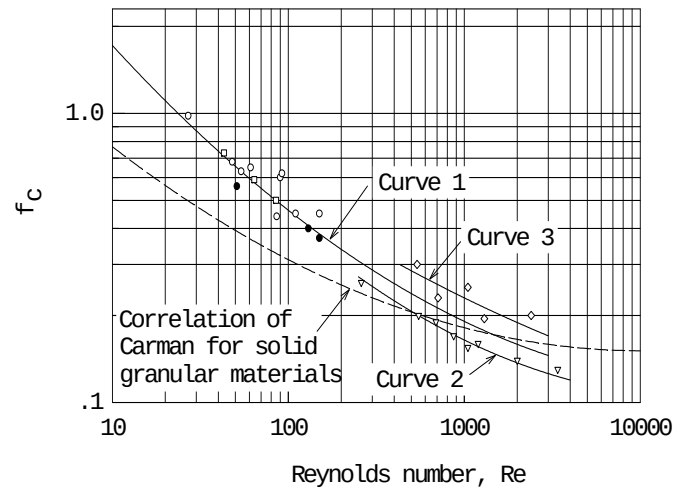
Fig. 3-1. Typical Mesh Installation in Process Equipment



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Fig. 3-2. Pressure Drop in Wire Mesh Pad⁽⁷⁾

(a) Friction factor for wire mesh entrainment separator without entrainment load



Note

- Use curve-1 in the figure (a).
- See also Table 3-2 for the void fraction and the specific surface area.

(b) Pressure drop correction for entrainment load

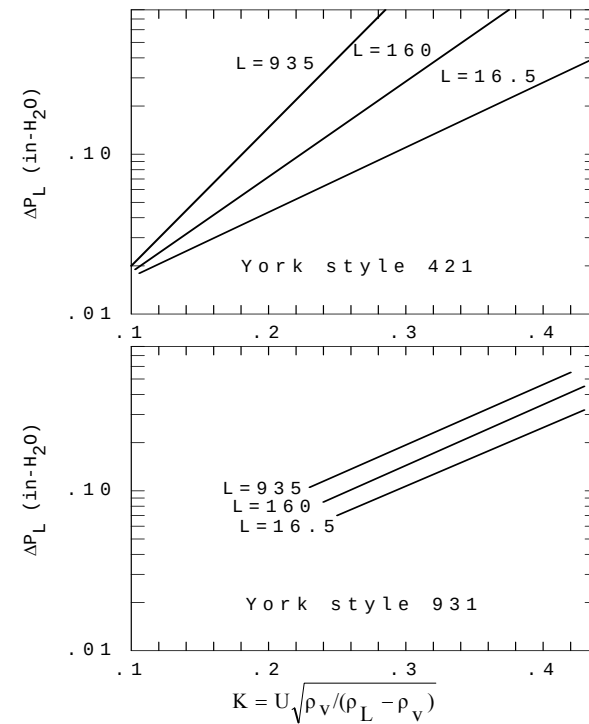
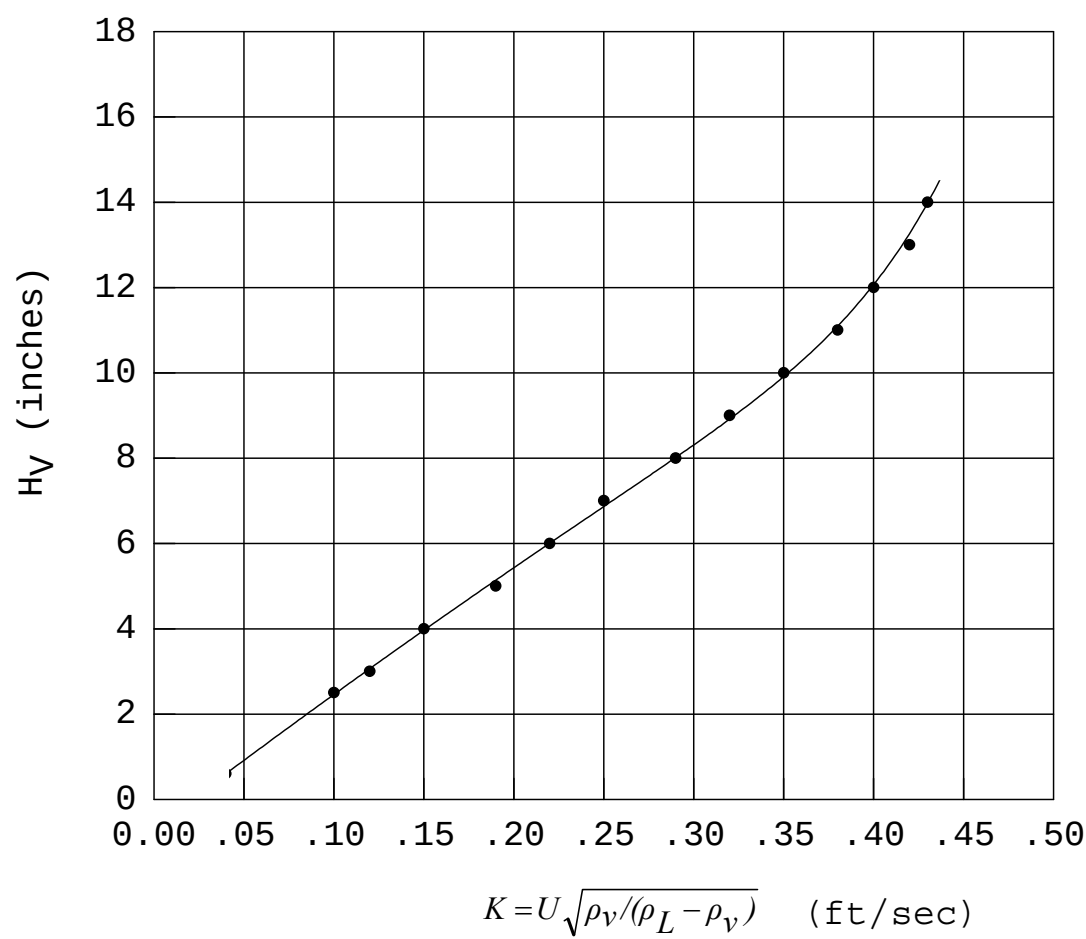


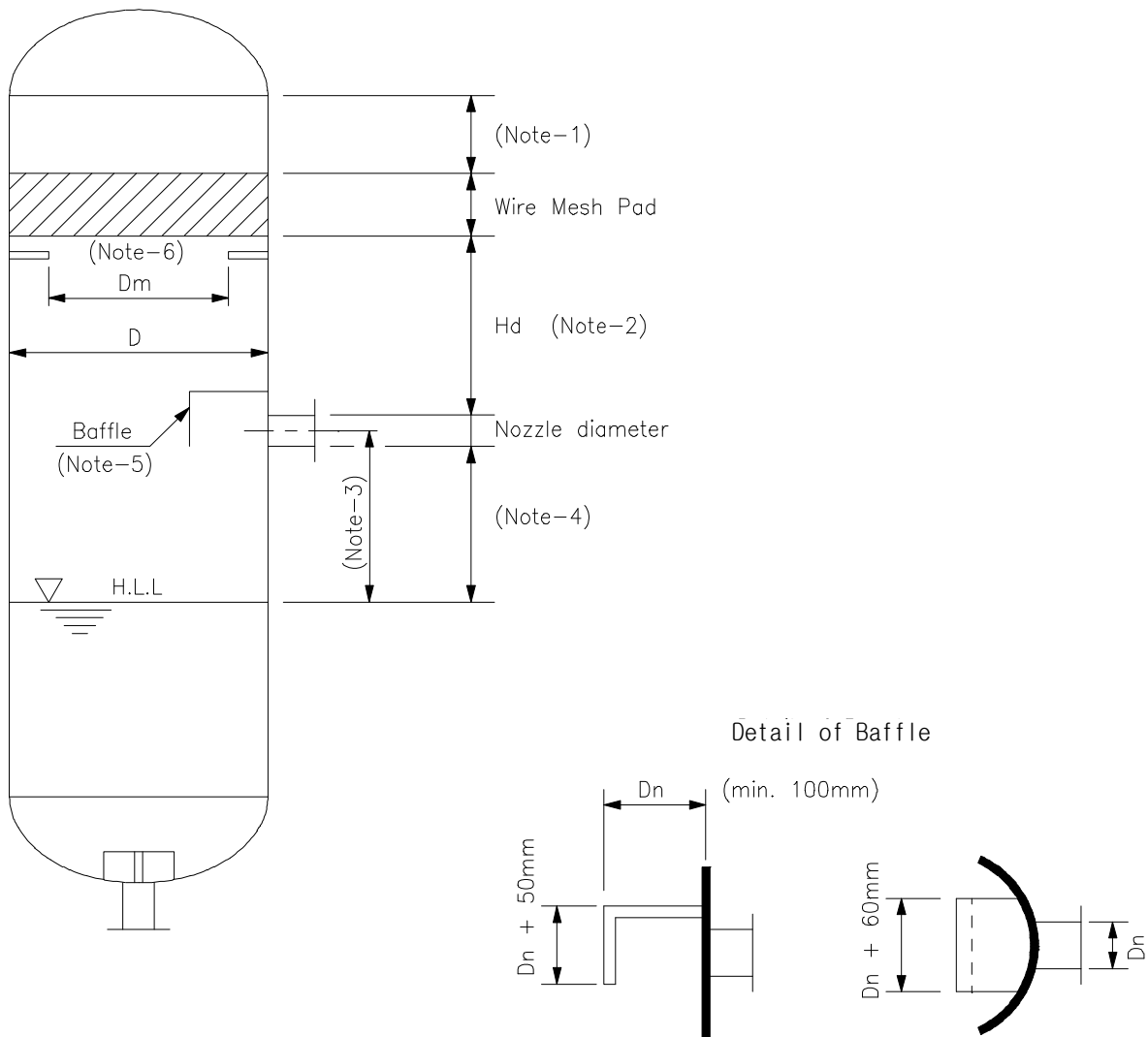
Fig. 3-3. Vapor Velocity Correction⁽⁴⁾



U : Design (rated) superficial vapor velocity (ft/sec)

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Fig. 3-4. Vertical Vessel with Wire Mesh Pad



(Note 1) Minimum 300 mm (12 inches)

(Note 2) Of the following, the largest value shall be used:

$$H_d \geq 12" + H_v \quad (H_v : \text{from Fig. 3-3})$$

$$H_d \geq 18"$$

$$H_d \geq 0.25D \quad (D = \text{Drum diameter, inches})$$

(Note 3) Minimum 300 mm (12 inches)

(Note 4) Minimum 150 mm (6 inches)

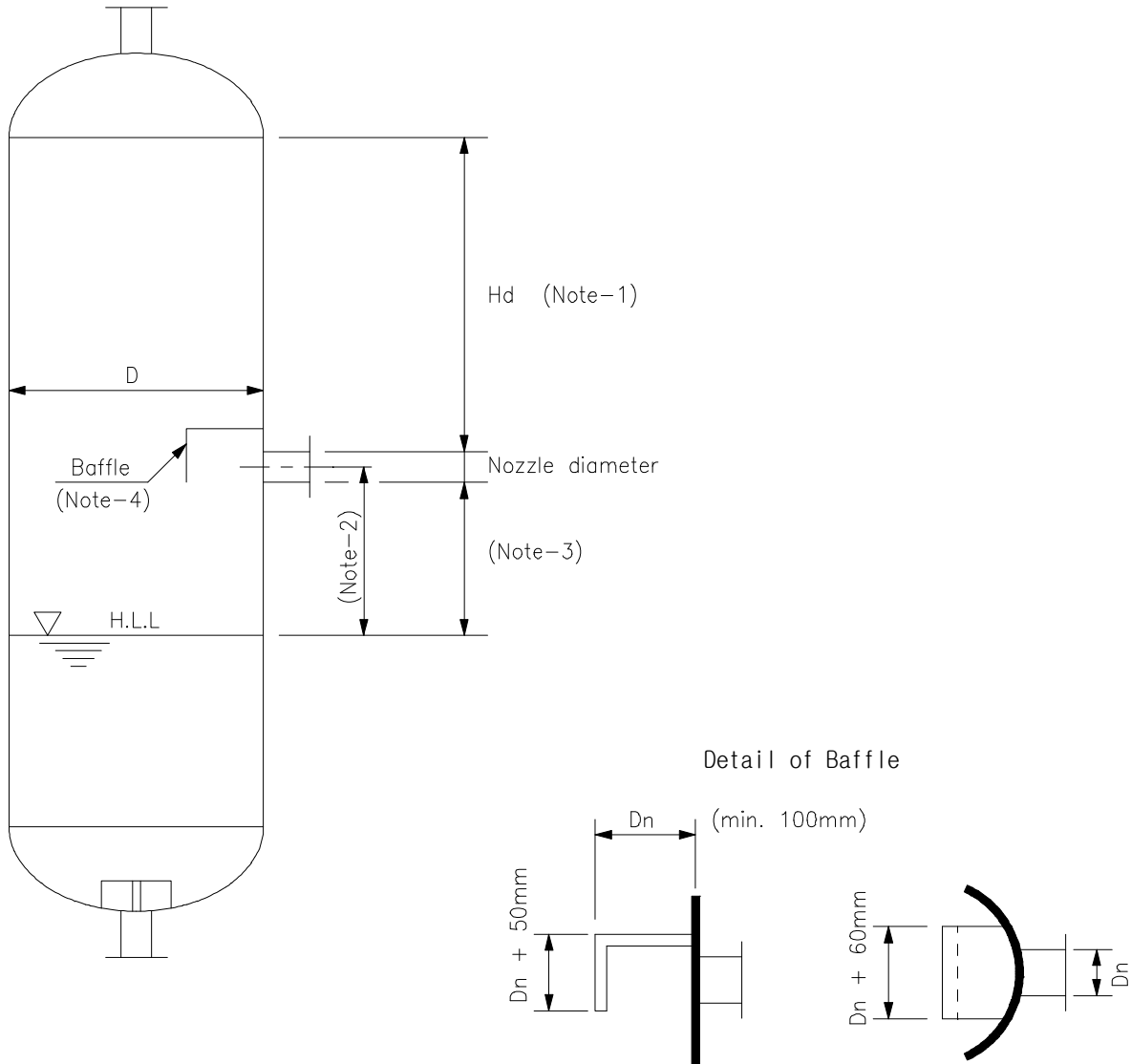
(Note 5) Baffle or Flash Guide (See, SEM-9418E, Tower, Para. 5.3.1)

(Note 6) $(D - D_m) \geq 100 \text{ mm (4 inches)}$ for support ring

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Fig. 3-5. Vertical Vessel without Wire Mesh Pad

Wire mesh pad need not be provided only in cases where $K = u\sqrt{\rho_v / (\rho_L - \rho_v)}$ is under 0.1 ft/sec.



(Note 1) Of the following, the largest value shall be used:

$$H_d \geq 18" + H_v \quad (H_v ; \text{ from Fig. 3-3})$$

$$H_d \geq 24"$$

$$H_d \geq 0.25D \quad (D = \text{Drum diameter, inches})$$

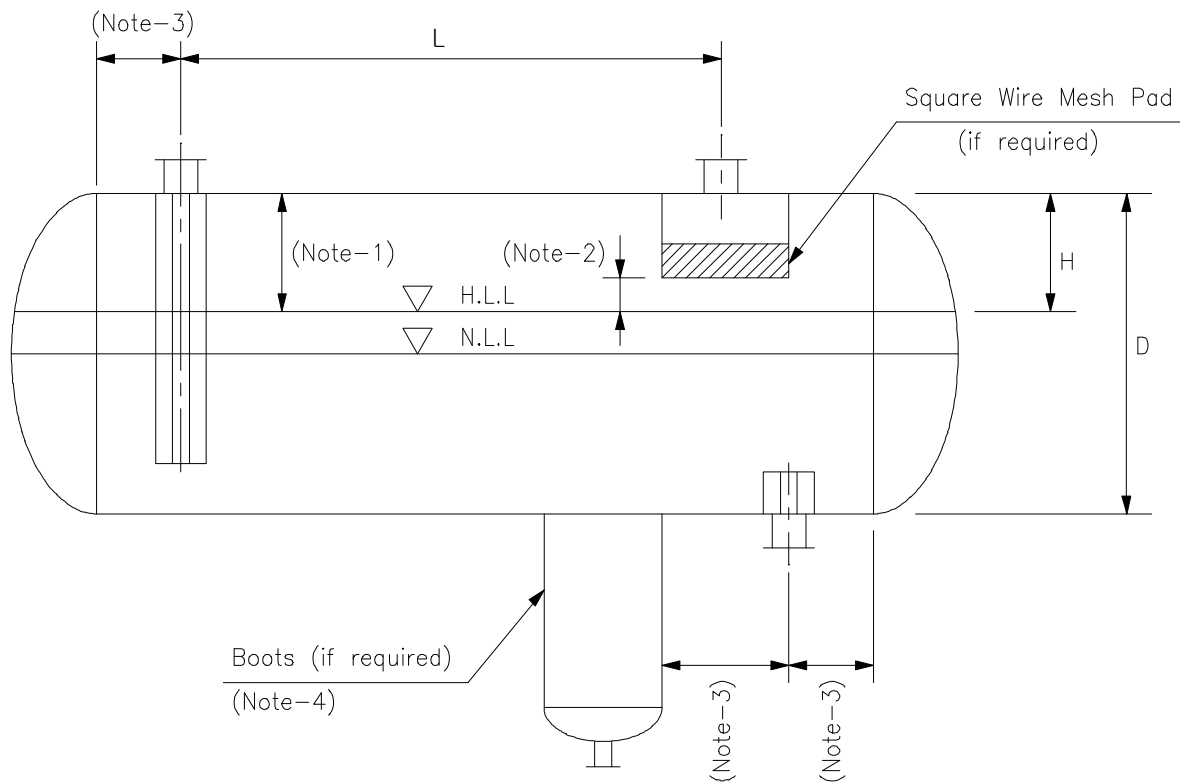
(Note 2) Minimum 300 mm (12 inches)

(Note 3) Minimum 150 mm (6 inches)

(Note 4) Baffle or Flash Guide (See [SEM-9418E, Tower](#), Para. 5.3.1)

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Fig. 3-6. Horizontal Separator



(Note 1) 20% of drum diameter or 300 mm (12 inches), whichever is the greater.

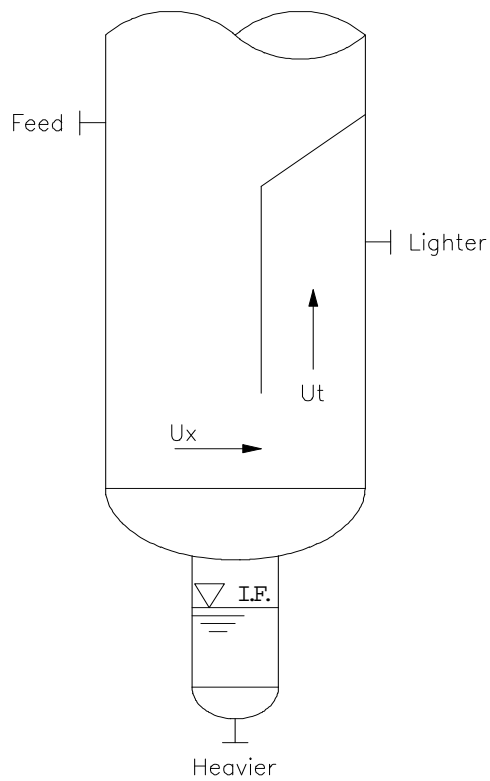
(Note 2) Minimum 150 mm (6 inches)

(Note 3) Minimum

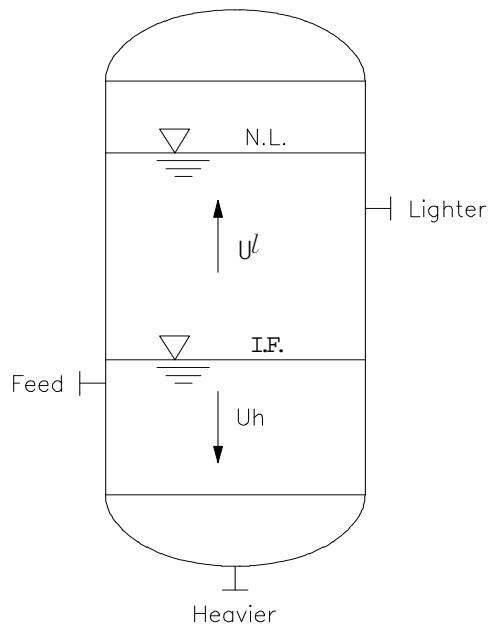
(Note 4) See Para. 3.2.3 (5)

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Fig. 3-7. Vertical Liquid-Liquid Separator



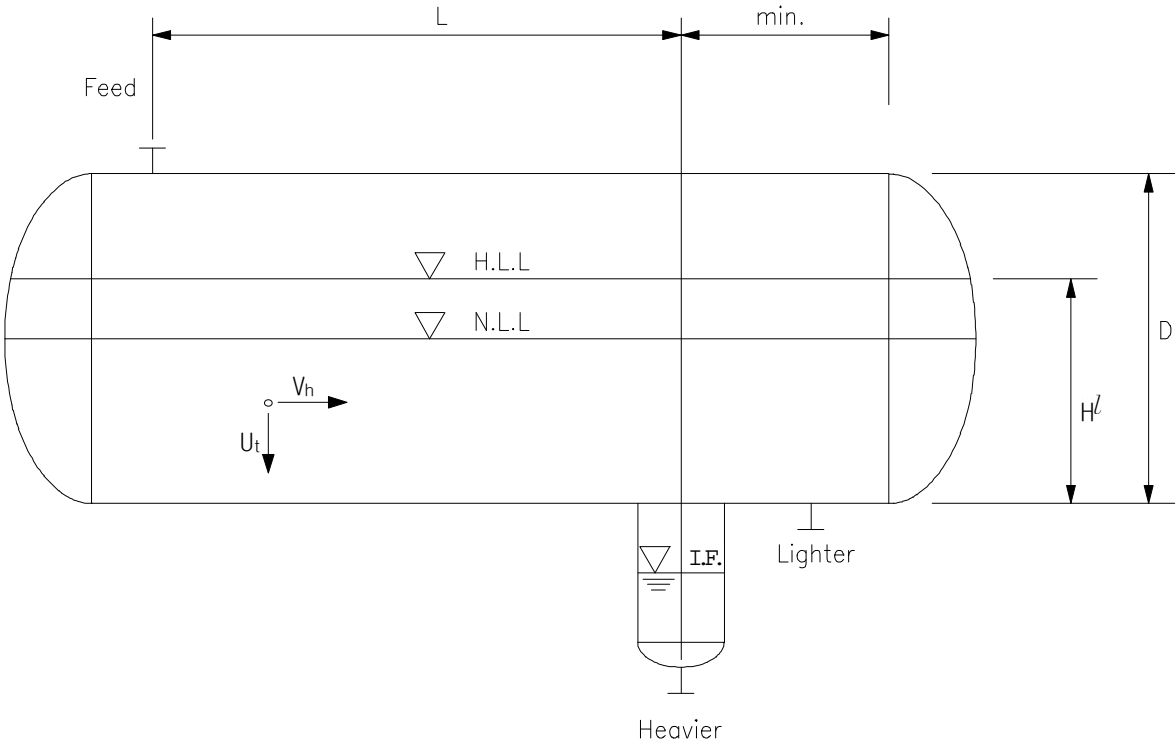
U_x is assumed to be equal to terminal velocity U_t, i.e.,
 $U_x = U_t$



U_h or U_l, whichever is the larger, is made equal to the terminal velocity U_t

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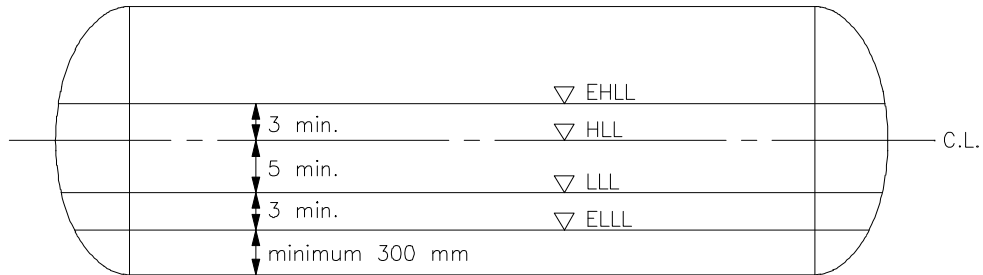
Fig. 3-8. Horizontal Liquid-Liquid Separator



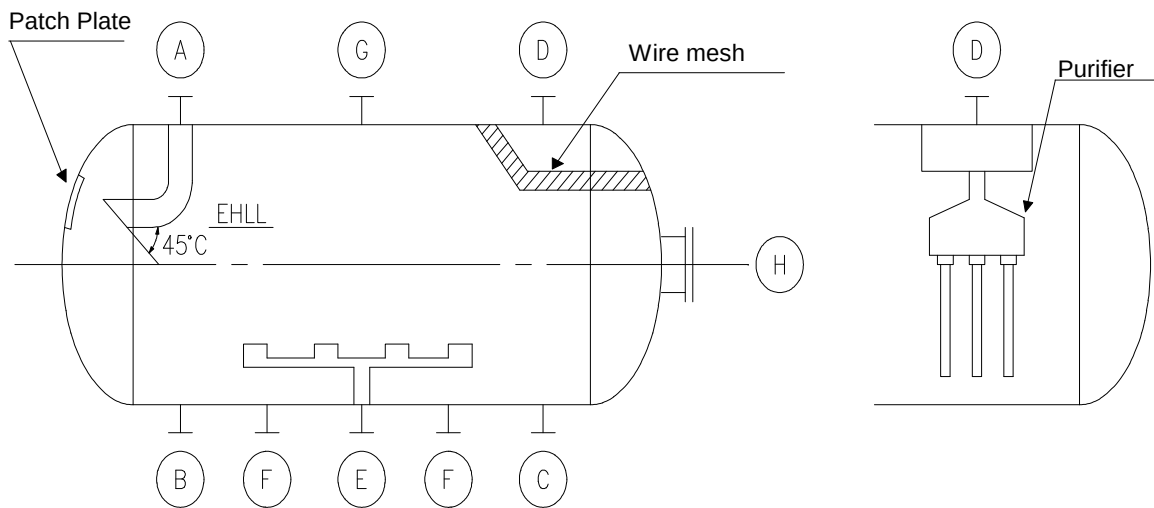
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Fig. 3-9. Steam Drum

(a) Holding Time

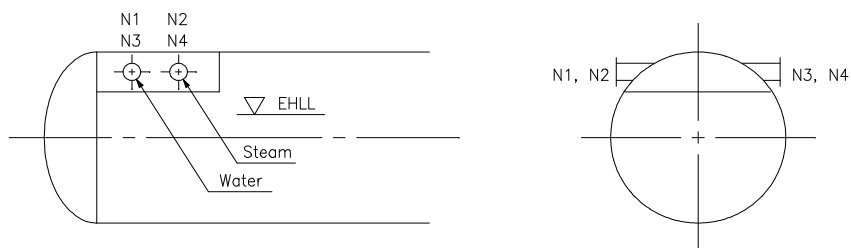


(b) Typical Layout



- | | |
|------------------------------|----------------------------|
| (A) Steam/water inlet | (E) Continuous blow down |
| (B) Fresh water inlet | (F) Intermittent blow down |
| (C) Circulation water outlet | (G) S.V nozzle |
| (D) Steam Outlet | (H) Manhole |

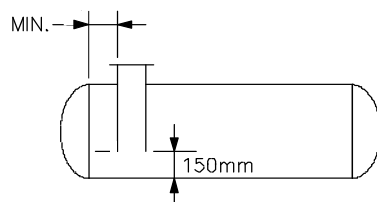
(c) Multi-Nozzle



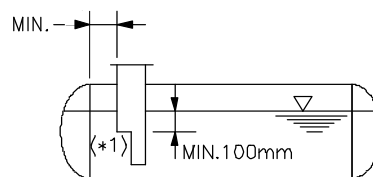
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Fig. 3-10. Distributor and Baffle

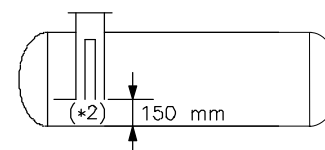
All Liquid (one liquid phase)



All Liquid (two liquid phase)

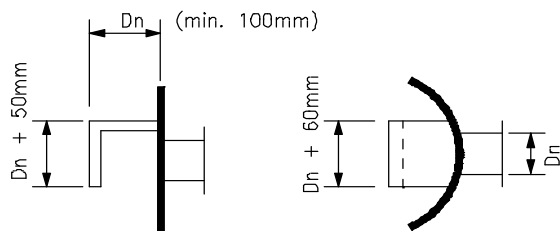
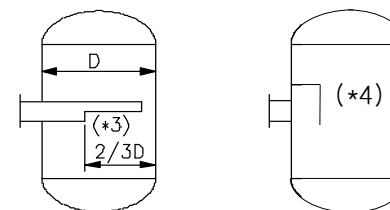


Vapor Liquid Mixture



Note :

- (*1) The open area should be equal to the cross-sectional area of the nozzle or larger
- (*2) The slit area on two sides should be equal to the cross-sectional area of the nozzle or larger
- (*3) The notch should be made along the pipe center line.
- (*4) Baffle



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5. 작성 내력

개정번호	개 정 일 자	개정 페이지	개 정 사 유
0	98.04.17	All	신규제정 - 작성부서 : 공정팀 - 작성자 : 오흥남 김용수 - 검토자 : 이봉일 조석범 노재철 - 승인자 : 오성국
1	04.07.30	1,7,12,13,20, 22,23,25	개정 - 작성부서 : 공정팀 - 작성자 : 이원재 - 검토자 : 박종현 노재철 오명환 이의덕 - 승인자 : 정찬설
2	2010.11.20	All	Document number revision - Prepared by : Y.S. Seo - Reviewed by : H. Sung, J.C. Ro, H.H. Kwak, M.H. Oh, S.U. Hong - Approved by : E.D. Lee