

DEP SPECIFICATION

**GAS/LIQUID, LIQUID/LIQUID AND GAS/LIQUID/LIQUID
SEPARATORS – TYPE SELECTION AND DESIGN RULES**

DEP 31.22.05.12-Gen.

February 2017

DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the selection and design of gas/liquid, liquid/liquid and three-phase (gas/liquid/liquid) separators.

Settling tanks, e.g., those used for the dewatering of crude, and basin-type settlers such as the API interceptor used for de-oiling of oil-contaminated surface water, are excluded from the scope of this DEP.

In this DEP two-phase and three-phase separators are also referred to as two-phase and three-phase settlers, respectively. The term "settling" will also be used for the separation of light-phase droplets in this DEP in order to be consistent with the term "settlers" which is used both for the separation of light-phase and heavy-phase droplets.

Design rules are given for the following types of separators:

- Knock-out drum
- Vessel with mesh pad demister
- Vessel with vane- type of demister
- Separators of the SMS family (SMS, SVS, SMSM, SMMS)
- Cyclone with tangential inlet (conventional cyclone)
- Cyclone with straight inlet and swirler ("Gasunie" cyclone)
- Vertical multicyclone separator with reversed-flow multicyclone bundle (conventional multicyclone separator)
- Filter separator
- Horizontal open settler (for both L/L and G/L/L separation)
- Plate pack settlers (both horizontal and vertical)
- Coalescers (with either a coalescer bed, mat or cartridges)

Users of this DEP should first consult (2) to make an initial selection of a suitable type of separator for a given duty. After selection of the desired separator, the design rules can be obtained from (3), (4), (5) or (6).

This is a revision of the DEP of the same number dated February 2012 and merges the content from DEP 31.22.05.11-Gen. dated February 2015; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of

this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
------	------------

Archimedes number

$$Ar = \frac{\rho_L}{\eta_L^2} \sqrt{\frac{\sigma^3}{g(\rho_L - \rho_G)}} \quad [-]$$

Flow parameter

The flow parameter used to characterise the type of gas/liquid feed into the vessel or the relative importance of the liquid load approaching the separator internal is:

$$\phi = Q_L / Q_G \sqrt{\frac{\rho_L}{\rho_G}} \quad [-]$$

Froude number

$$F_{r1} = V_1 \sqrt{\frac{\rho_1}{gL |\rho_2 - \rho_1|}} \quad [-]$$

Gas Load Factor

The gas load factor is also referred to as k-factor or Souders-Brown velocity.

$$\lambda = Q_G / A_G \sqrt{\frac{\rho_G}{\rho_L - \rho_G}}$$

This is a superficial gas velocity modified with a gas density scaling factor which accounts to a large extent for the effect of operating pressure.

Reynolds Number

$$R_e = d_H v_c \rho_c / \eta_c \quad [-]$$

Term	Definition
Schoepentoeter	A Shell trademark inlet flow device. It is used synonymously with vane inlet devices in general in this DEP

1.3.3 Abbreviations

Term	Definition
conc	Local volumetric fraction of dispersed phase
GOR	Gas to Oil Ratio
HAZOP	Hazards and Operability Analysis
HEMP	Hazards and Effects Management Process
HVU	Crude High Vacuum Units
ID	Inside Diameter
LOPA	Layer of Protection Analysis
max(x,y)	Maximum of the values x and y
min(x,y)	Minimum of the values x and y
NFA	Net Free Area fraction
PP	Polypropylene
SMS	Schoepentoeter Mistmat Swirldeck
SMSS	Schoepentoeter Mistmat1 Mistmat2 Swirldeck
SMSM	Schoepentoeter Mistmat Swirldeck Mistmat
SVS	Schoepentoeter Vane pack Swirldeck
TFC	Shell Twin-Flange Coalescer
TGU	Thermal Gasoil Units
TTL	Top Tangent Line
VBU	VisBreaker Units

1.3.4 Symbols and Terminology

The symbols and terminology used in the DEP are summarised in Table 1 through Table 5.

Table 1 Symbols

Term	Definition	Unit (SI)	Unit (USC)
A	Area	m ²	ft ²
Ar	Archimedes number:	-	-
c	constant		
D	Internal diameter of vessel ,skirt , large pipe, etc. (if no subscript, internal diameter of vessel)	m	ft
d	Diameter of small pipe, nozzle, bubble or droplet, plate distance (e.g., of plates in plate pack)	m	ft
Eff	Efficiency: $Eff = (Q_{L,out}/Q_{L,in}) * 100$	%	%
Fr	Froude number, see section 1.3.2	-	-
f	Derating factor	-	-
G	Gas		
g	Acceleration due to gravity	m/s ²	ft/s ²
h	Height	m	ft
K	Friction loss factor	-	-
L	Length	m	ft
M	Mass flow rate	kg/s	Lb/s
n	Number (number of vanes, number of cyclones, etc.).	-	-
P	Pressure	Pa	psi
Q	Volumetric flow rate	m ³ /s	ft ³ /s
Re	Reynolds number	-	-
t	thickness	m	ft
V	Volume	m ³	ft ³
v	Velocity	m/s	ft/s
W	Width	m	ft

Table 2 Level terminology

Term	Definition	Unit (SI)	Unit (USC)
NL _L	NL for L/L interface	m	ft
NL _{INT}	NL for G/L interface	m	ft
LA(H)	High level alarm	m	ft
LA(L)	Low level alarm	m	ft
LZA(HH)	High level trip	m	ft
LZA(LL)	Low level trip	m	ft
NL	Normal level	m	ft

Table 3 Greek symbols

Symbol	Definition	Unit (SI)	Unit (USC)
Δ	Difference (used in conjunction with other symbols)		
ε	Porosity (of wiremesh)	-	-
η	Dynamic viscosity	Pa.s	lb/(ft.s)
θ	Angle	degrees	degrees
κ	Ratio of the specific heats (C_p/C_v)	-	-
λ	Gas load factor	m/s	ft/s
ρ	Density	kg/m ³	lb/ft ³ (or lb/in ³)
σ	Gas/liquid interfacial tension	N/m	lb/s ²
ϕ	Flow parameter	-	-
φ	Phase fraction	-	-

Table 4 Subscripts

ax	Axial
bed	Coalescer bed
c	Continuous phase
Cf	Filter part of candle (in filter separators)
col	Collection compartment
coeff	Effective length of collection compartment
cont	Control requirements or specific control band
conc	Local volumetric fraction of dispersed phase

contot	Total control band
crit	Critical
crit50	Related to droplet with 50 % chance of removal in G/L separator
crit99	Related to droplet with 99 % chance of removal in G/L separator
cs	Cross section or cross-sectional area
ct	Candle tube (in filter separators)
d	Dispersed phase
db	Dispersion band
d	Droplet of heavy liquid phase
dl	Droplet of light liquid phase
Dp	Drain pipe
f	Front
feed	Related to feed flow
fp	Related to feed pipe
fp	(perforated) Front plate of L/L separation plate pack
fw	Front weir of a collection compartment
G	gas
H	hydraulic diameter
h	heavy liquid phase
HH_H	related to control band between LZA(HH) and LA(H)
H_L	related to control band between LA(H) and LA(L)
in	related to inlet
int, INT	L/L interface
L	Liquid
l	Light liquid phase
Laminar	Laminar flow
Loss	Part of plate pack front face available for flow
low	Lower part
L_LL	Related to control band between LA(L) and LZA(LL)
m	mixture
max	Maximum
min	Minimum
net	Effective area of plate pack
Noz	Nozzle
out	Outlet
out, l	At light phase outlet

ow	Overflow weir of a collection compartment in horizontal three-phase settler with double weir
p	At constant pressure (as in C_p)
p	Droplet or particle
P	Related to physical properties of gas and liquid phases
perfpl	Perforated plate
pp	Plate pack for L/L separation
ret	Retention time
sch	Related to Schoepentoeter or vane inlet device
sd	Related to Swirl deck
set	Settling compartment or settling process
sonic	Related to sonic velocity
spec	Specified
st	Swirltube
tl	Transition from turbulent to laminar flow
turbulent	Turbulent flow
up	Underflow passage of front weir of heavy-phase compartment in horizontal three-phase settler with double weir
v	Vane
v	At constant volume (as in C_v)
vb	Vane box
vfb	Related to distance between bottom plate and vortex finder in cyclones
ves	Related to vessel
vo	Vane entrance opening (in Schoepentoeters)
w	weir
wire	Wire (of wiremesh)
wm	Wiremesh
ww	The two heavy-phase weirs in horizontal three-phase settler with weir configuration
1	Related to feed inlet or number of constant
η	related to dynamic viscosity of liquid
ϕ	related to flow parameter

Table 5 Superscript

*	density correction
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1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2012. The revisions include a complete restructuring to combine the contents of DEP 31.22.05.11-Gen. with this DEP 31.22.05.12-Gen. The changes are too numerous to list.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

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DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. SELECTION CRITERIA FOR GAS/LIQUID, LIQUID/LIQUID AND GAS/LIQUID/LIQUID (THREE-PHASE) SEPARATORS

2.1 GENERAL

1. The design shall be based on maximum gas, maximum liquid flow rates and slug volume while taking into account a design margin or surge factor and consistent with the control philosophy.

Typical values are given in Table 6 and Table 7.

2. Design margins may be reduced or eliminated (subject to the approval of the Principal) based on more detailed knowledge of system behaviour and dynamics (e.g., pipeline profile, pipeline holdup) and considerations of consequences of overload of separator by slugs generated by transient conditions.

2.2 TYPICAL DESIGN MARGINS FOR UPSTREAM APPLICATIONS

Table 6 Offshore applications

1. Separator handling natural-flowing production from:	Design margin
Direct vertical access (DVA) wells on their own platform	1.2
another platform or well jacket in shallow water	1.3
another platform or well in deep water	1.4
2. Separator handling gas lifted production from:	
DVA wells on their own platform	1.4
Wells on another platform, or well jacket	1.5
Subsea wells	1.5

Table 7 Onshore applications

1. Separator handling natural flowing production, or gas plant inlet separator in:	Design margin
flat or low rolling country	1.2
hilly country	1.3
2. Separator handling gas lifted production from:	
flat or low rolling country	1.2
hilly country	1.3

2.3 DESIGN MARGINS FOR REFINERIES AND CHEMICAL PLANTS

Typically design margins range from 1.15 to 1.25.

1. If two immiscible liquids are present in the feed and the flow rate of the lower density liquid is at least 5 % vol. of the total liquid flow rate, then the physical properties of the lighter liquid shall be used in the gas handling calculations.
2. Pressure drop calculations shall be based on maximum gas and liquid flow rates.
3. When two immiscible liquids are present, the pressure drop calculations shall take into account the apparent viscosity of the emulsion.

2.4 SELECTION CRITERIA AND STRATEGY

This section outlines various criteria and features which play a role in separator performance and selection. For Upstream production separators, refer to DEP 20.04.10.11-Gen. for selection of the overall process line-up, then use the below guidance for selection of individual separator types.

To facilitate the choice of a separator type for a given application, Table 8 and Table 9 summarise the performance characteristics of various gas-/liquid and liquid/liquid and gas/liquid/liquid separator.

During selection, the separators are compared on the following points:

- *Gas handling capacity:*
 - *Maximum capacity (gas load factor)*
 - *Turndown ratio (is ratio of design flow and minimum flow)*
- *Liquid removal efficiency:*
 - *Overall*
 - *With respect to fine mist*
 - *With respect to the possible flooding above the maximal gas load factor (flooding will cause a sharp decrease in efficiency)*
- *Liquid handling capacity:*
 - *Slugs Droplets (overloading of separation internal)*
- *Liquid/liquid separation efficiency:*
 - *Overall*
 - *With respect to fine dispersed droplets*
 - *With respect to gas break out affecting liquid/liquid separation*
 - *With respect to the possible slugging which may cause a sharp decrease in efficiency*
- *Fouling tolerance:*
 - *Sand*
 - *Fouling material (e.g., wax and scale)*
- *Pressure drop*

1. The following selection strategy shall be used:

a. Define the requirements for the separator.

With the aid of Table 8 and Table 9, a number of separators can then be ruled out. Typical outlet qualities of upstream equipment are included in DEP 20.04.10.11-Gen.

b. Check whether there are limitations which will rule out horizontal or vertical vessels.

c. Check the appropriate design rules for each separator out of those remaining.

Based on these criteria, a final choice of separator can be made.

Table 8 Performance comparison of the various G/L separators

	VKO	HKO	VW	HW	VV1	VV2	HV	SMS SMMS ⁽⁴⁾	SVS	CT	CS	VRM C	FS
Gas handling													
max. capacity (λ)	B	B	C	C	D	D	D	E	E	E	E	E	C
turndown (max/min flow)	∞	∞	4	4	3	3	3	10	4	2	3	2	∞
Typical Liquid removal efficiency⁽⁵⁾													
overall, %	90-95	90-95	> 98	> 98	> 96	> 96	> 96	> 99	> 98	> 96	> 98	> 93	50-80
with respect to fine mist	A	A	E	E	C	C	C	E	D	B	D	B	E
flooding above $\lambda_{\max}$ (Y/N)	N	N	Y	Y	(1)	(1)	(1)	N	N	N	N	Y	Y
Liquid handling capacity													
as slugs	D	E	D	E	A	D	E	D	D	D	C	A	-
as droplets ($Q_{L,\max}$)	D	D	D	D	B	C	C	D	D	D	D	B	B
Fouling tolerance													
sand	E	E	B	B	(2)	(2)	(2)	B	C	E	C	C	B
sticky material	E	E	A	A	(2)	(2)	(2)	A	C	E	C	C	A
Pressure drop	A	A	B	B	B	B	B	C	C	D	D	D	(3)

A = very low

B = low

C = moderate

∞ : Infinite

(1) : if double-pocket vanepack: N; for a single-pocket vanepack or in case of straight vanes: Y

(2) : if double-pocket vanepack: A; if single-pocket vanepack: B; if straight vanes: C

(3) : depending on the degree of fouling, ranging from C to E

(4) : Design with older swirl tube versions might have a secondary demister and have a typical liquid removal efficiency of 98 %

(5) : This is a typical efficiency for this type of internal. Efficiencies can be better or lower depending on actual process conditions and physical properties of the fluids.

D = high

E = very high

VKO	Vertical knock-out drum	SVS	Schoepentoeter-vane pack-swirdeck separator
HKO	Horizontal knock-out drum	SMS	Schoepentoeter-mistmat-swirdeck separator
VW	Vertical flow wiremesh demister	SMMS	Schoepentoeter-mistmat-mistmat-swirdeck separator
HW	Horizontal flow wiremesh demister	CT	Cyclone with tangential inlet (conventional cyclone)
VV1	Vertical in-line separator with horizontal flow vane pack	CS	Cyclone with straight inlet and swirler ("Gasunie" cyclone)
VV2	Vertical two-stage separator with vertical flow vane pack	VRMC	Vertical separator with reversed-flow multicyclone bundle (conventional multicyclone)
HV	Horizontal vane-type demister	FS	Filter separator

Table 9 Screening of L/L and G/L/L separators

	L/L separators			G/L/L separators				
Separator types	L1	L2	C1	T1	T2	T3	T4	T5
L/L separation								
primary dispersion (Majority of dispersed droplets are above 30 µm (1.2 mils))	√	√		√	√	√	√	√
bulk separation	√			√	√		√	√
efficient separation		√				√		√
secondary dispersion (Majority of dispersed droplets are below 30 µm (1.2 mils))	X	X	√	X	X	X	X	X
ill-defined L/L interface (accommodate large dispersion band)	X	X			√ ¹	√ ¹		
G/L separation								
bulk separation				√	√	√		
efficient separation							√ ²	√ ²
Liquid handling controlled (in G/L/L separators)				√	√	√	X	X
Gas handling controlled (in G/L/L separators)						X	√	√
Fouling service	√		X	√	√			
High temperature			X					
√ : Recommended use X : Not recommended								
¹ Provided there is a double weir arrangement with no interface level control; also used if there are corresponding L/L separators.								
² If wiremesh or wiremesh / swirl deck assembly is installed.								
L1: Horizontal open two-phase settler L2: Horizontal two-phase settler with plate pack C1: Coalescer fitted with coalescer cartridges T1: Horizontal open three-phase settler with boot T2: Horizontal open three-phase settler with weir arrangement T3: Horizontal three-phase settler with plate pack and weir arrangement T4: Vertical three-phase settler T5: Vertical three-phase settler with plate pack								

3. DESIGN RULES FOR NOZZLES

3.1 PROCESS NOZZLES

3.1.1 Feed nozzles and connected piping

1. The use of valves, pipe expansions or contractions, bends, flow meters and other components which generate a sudden pressure drop should be avoided within 10 pipe diameters of the inlet nozzle.
 - a. If a valve in this pipe region cannot be avoided then a full-bore gate or ball type valve should be used, fully open in normal operation.
 - b. For inlet devices with swirling flow (e.g., cyclones), bends may be permitted in the horizontal plane only, and only with curvature in the same direction as the swirl of the inlet.
 - c. For inlet devices without swirling flow, bends may be permitted in the vertical plane only, through the axis of the feed nozzle.
 - i. If this results in a riser system just upstream of the vessel, slugging could occur in case of a high feed flow parameter and the vessel should be designed to accommodate this.
 - d. For vessels with normally no liquid in the feed, the requirement of a 10 diameters length of straight pipe may be relaxed to 3 diameters length.
2. Piping layout and location/design of any reducer in multiphase flow shall be such that no pockets exist where liquids can accumulate and generate slugs.
3. The feed nozzle shall be located on the top or in the head of the vessel.
Normally, the feed nozzle is elevated above LZA(HH), see (4.2) for requirements.
4. The feed nozzle shall have the same internal diameter as the upstream piping.
5. The following momentum criteria shall be met as applicable to the type of inlet selected:
 - a. No inlet, or deflector baffle: $\rho_m v_{m,in}^2 \leq 1500 \text{ Pa (1000 lb/ft.s}^2\text{)}$
 - b. Half-open pipe: $\rho_m v_{m,in}^2 \leq 3000 \text{ Pa (2000 lb/ft.s}^2\text{)}$
 - c. For the special case of an in-line vane separator see section (4.5.2).
 - d. For the special case of a reverse-flow multicyclone separator see section (5.1.3.4)
 - e. Schoepentoeter (and Schoepentoeter Plus): $\rho_m v_{m,in}^2 \leq 8000 \text{ Pa (5370 lb/ft.s}^2\text{)}$
 - f. Inlet cyclone: $\rho_m v_{m,in}^2 \leq 20000 \text{ Pa (13430 lb/ft.s}^2\text{)}$
6. For feeds with normally no liquid, the design margin may be omitted from the inlet momentum calculation.
7. In units or separators where the inlet velocity can be very high (typically exceeding 40 m/s) (131 ft/s) because of the low gas density, a Schoepentoeter shall be used as the feed inlet device with the following velocity limits:
 - a. To prevent erosion: $v_{G,in} \leq 70 \text{ m/s (230 ft/s)}$
 - b. To prevent choking or damage due to vibrations: $v_{G,in} \leq 0.8 v_{sonic,G}$
8. The Principal's distillation specialists shall be consulted for proprietary requirements beyond those stated in this DEP for feed inlet devices associated with Crude High Vacuum Units (HVUs).

3.1.2 Gas outlet nozzle and connected piping

1. The gas outlet nozzle should be fitted on the top of the vessel.
 - a. In a vertical separator, it should be fitted in the middle of the top head.
2. The gas outlet nozzle shall not be smaller than the downstream piping.
3. The momentum through the gas outlet nozzle should satisfy $\rho G v^2 G_{out}$ less than or equal to 4500 Pa (3022 lb/ft.s²).
4. The piping leading from the gas outlet nozzle shall have the same diameter as the nozzle for a distance of minimum 2 pipe diameters downstream the nozzle before any bends, reducers, valves or other components.

3.1.3 Liquid outlet nozzles and connected piping

1. The diameter of liquid outlet nozzles should be chosen such that the liquid velocity does not exceed 1 m/s (3.3 ft/s).
 - a. Nozzle velocities up to 2.5 m/s (8 ft/s) may be accepted for revamps, provided that the nozzle velocity and minimum liquid static height above the nozzle satisfies $Fr_L < 1$.
2. The diameter of a liquid outlet nozzle shall be at least 0.05 m (2 in).
3. Liquid outlet nozzles shall be equipped with a vortex breaker in accordance with Standard Drawing S 10.010.
4. The piping leading from a liquid outlet nozzle shall have the same diameter as the nozzle for a distance of minimum 2 pipe diameters downstream the nozzle before any bends, reducers, valves or other components.

3.2 MANWAYS

1. Manhole inner diameter should be designed as per applicable pressure vessel code.
 - a. For vessels with diameter 1.2 m (48 in) and below, body flanges should be evaluated as an option.
2. For horizontal vessels with a weir, one manhole shall be placed upstream of the weir arrangement.

3.3 INSTRUMENT NOZZLES

1. Instrument nozzles shall be minimum DN 50 (NPS 2).
2. Instrument nozzle location and orientation should be evaluated versus plugging or clogging by components in the feed stream (e.g., solids, wax, asphaltenes, scale).
3. Level instrument nozzles, including nozzles for instrumented level process shutdown, shall be located in the outlet section of the vessel so that no pressure drop from internals can influence the measured level relative to the level near the outlets.
4. Level instrument nozzles shall be mounted on the vessel wall, not on process nozzles.
5. Level instrument nozzles should be mounted on the cylindrical part of the vessel, not in the end caps.

4. DESIGN RULES FOR INTERNALS

4.1 GENERAL

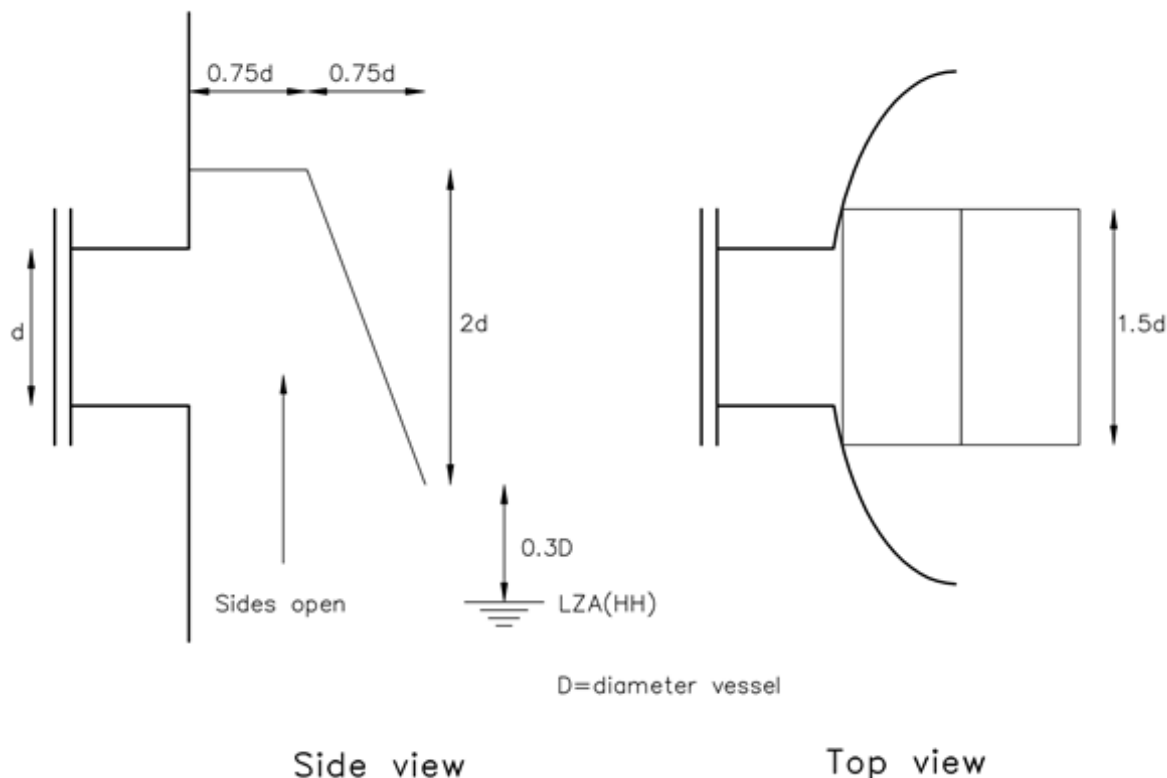
1. All internals shall be removable through the manways.
2. Internals should be fastened securely to the vessel by supporting lugs, and bolted to these with double nuts.

4.2 INLETS

The choice between Schoepentoeter and half-open pipe will be a trade-off between the required separation efficiency of the inlet internal and costs.

When a simple deflector plate arrangement is used as feed inlet device, then typical dimensions for side feed inlet nozzle are provided in Figure 1.

Figure 1 Deflector plate arrangement for feed inlet of vertical knock-out drum



1. For vertical vessels (G/L) with diameter less than 0.5 m (1 ft 8 in), the feed nozzle should be fitted with a half-open pipe inlet device, with the opening directed downwards
2. For vertical vessels (G/L) with diameter of 0.5 m (1ft 8 in) and larger and inlet nozzle sizes of 0.15 m (6 in) and larger, either a half-open pipe or a Schoepentoeter inlet device should be used.
3. For horizontal vessels (G/L), a Schoepentoeter inlet device should be used.
4. If a half-open pipe is used, its last section should be horizontal, pointing opposite to the flow direction in the vessel and with its opening directed upwards.
5. If the separation efficiencies of inlet devices are required for calculating the flow parameter downstream of a wiremesh demister, ϕ_{wm} , the following formulae shall be used:
 - a. If a Schoepentoeter is used, $\phi_{wm} = 0.05\phi_{feed}$
 - b. If a half-open pipe is used, assume $\phi_{wm} = 0.2\phi_{feed}$
 - c. If a simple deflector baffle or open nozzle is used, assume $\phi_{wm}=0.5\phi_{feed}$
6. For the design of Schoepentoeters, refer to DEP 31.20.20.31-Gen.
7. For L/L separators, one of the following options may be used for the inlet device:
 - a. an elbowed pipe directed towards the vessel head;