# Practical Selection and Design Guide; for Gas Liquid Separator with Optimization

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By Manish V. Shah

# Gas Liquid Separator Practical Selection and Design Guide

Before starting Separator Design,
we should be aware of..

ENGINEERING DATA BOOK

FPS VERSION
Volumes I & II
Sections 1-26

1

**Specification for**
**Oil and Gas Separators**

2

API SPECIFICATION 12J (SPEC 12J)
SEVENTH EDITION, OCTOBER 1, 1989

# Gas Liquid Separator Practical Selection and Design Guide

**Before starting Separator Design,**

**we should be aware of..**

**LIQUID/LIQUID AND GAS/LIQUID/LIQUID SEPARATORS - TYPE SELECTION AND DESIGN RULES**

3

DEP 31.22.05.12-Gen.

January 2008
(DEP Circular 17/08 has been incorporated)

SULZER

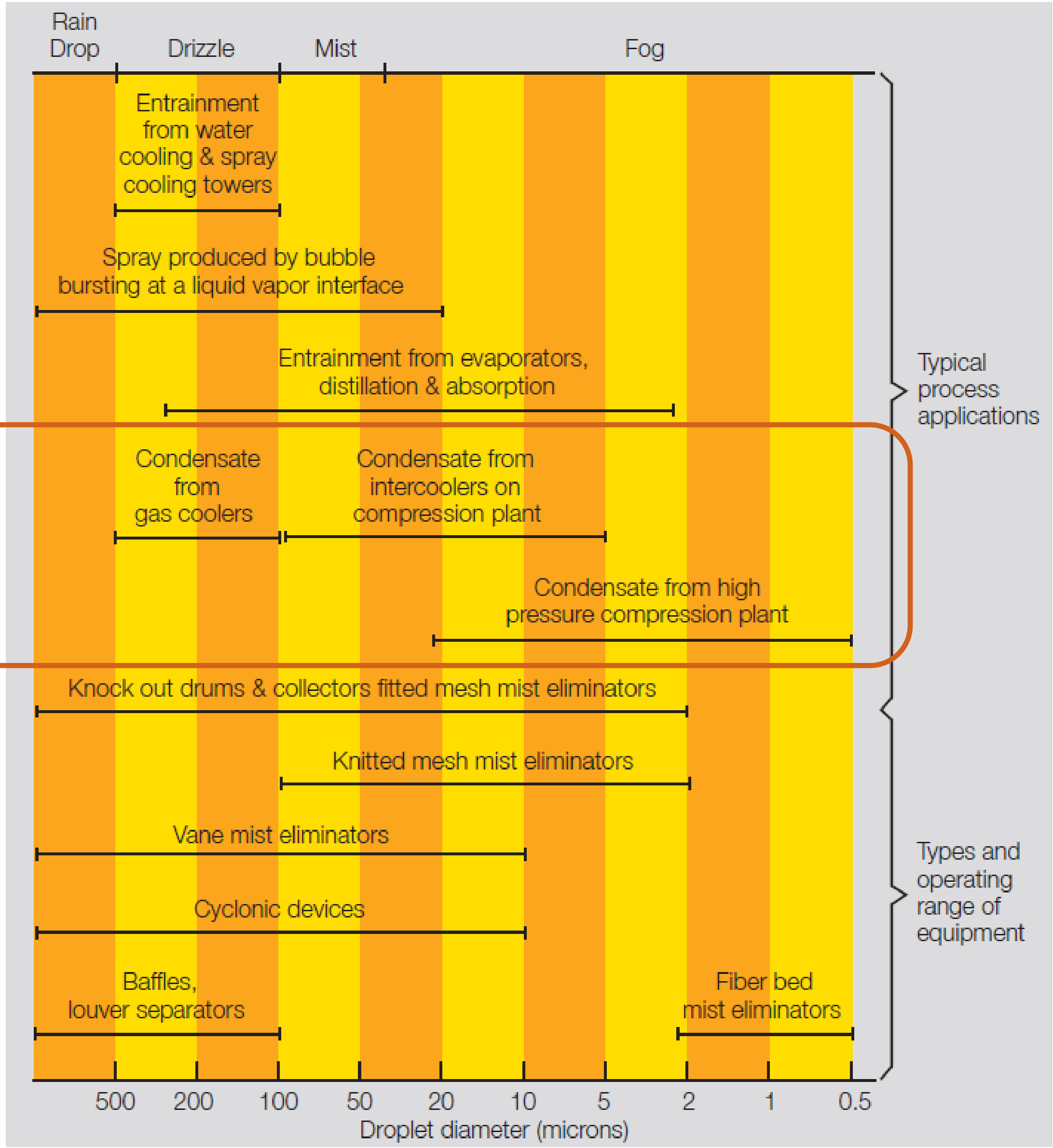
Sulzer Chemtech

4

**Gas/Liquid Separation Technology**

# Gas Liquid Separator Selection Guide

# Gas Liquid Separator Practical Selection and Design Guide




**Sulzer**

# Gas Liquid Separator Practical Selection and Design Guide

Separator type and orientation depends on

- Gas volumetric rate; & Gas to liquid volumetric ratio
- Slug volume
- Operating pressure and allowable pressure drop
- Turndown
- Feed source
- Separation efficiency required @ downstream unit
- Liquid property, fouling, viscous, solids etc..
- Space and head room available
- Offshore / Onshore application

# Gas Liquid Separator Practical Selection and Design Guide

## DEP : Vertical Vs Horizontal :

ORIENTATION

For gas/liquid separation, a vertical vessel should normally be selected for the following reasons:

- a smaller plan area is required (critical on offshore platforms);
- easier solids removal;
- liquid removal efficiency does not vary with liquid level (area in vessel available for gas flow remains constant);
- vessel volume is generally smaller.

However, a horizontal vessel should be chosen if:

- large liquid slugs have to be accommodated;
- head room is restricted;
- a low downward liquid velocity is required (for de-gassing purposes or for foam breakdown).



**High gas rate : Vertical type * High liquid rate : Horizontal type**

# Gas Liquid Separator Practical Selection and Design Guide

## Quiz 1 : - Compressor KO DRUM

| | Pressure, KPag | Gas rate, kg/hr | Liquid rate kg/hr | Gas Density kg/m3 | Liquid Density kg/m3 |
|---|---|---|---|---|---|
| Case 1 | 9000 | 1,55,000 | 1000 | 100 | 1000 |
| Case 2 | 4000 | 1,00,000 | 2500 | 66 | 1000 |
| Case 3 | 6000 | 60,000 | 2700 | 66 | 700 |
| Case 4 | 3000 | 40,000 | 3000 | 30 | 1000 |

**1) Which internal can be used for above service ?**
**a) No internal**
**b) Mist mat**
**c) Vane pack**

# Gas Liquid Separator Practical Selection and Design Guide

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**40,000 / 1,55,000 = ~ 26%**

1) **Which internal can be used for above service ?**

a) **No internal**

b) **Mist mat**

c) **Vane pack**

Quiz 2 : - Production separator with heavy waxy oil and little solids.

1) **Which internal can be used for above service ?**
a) **No internal**
b) **Mist mat**
c) **Vane pack**

# Gas Liquid Separator Practical Selection and Design Guide

| | Gravity separators/ knockout drums | Baffles/louvers | Vane packs – simple vanes | Vane packs – with drainage channels | Axial Cyclone separators | Knitted mesh mist eliminators | Candles/ fiber beds |
|---|---|---|---|---|---|---|---|
| Separation mechanism | Gravitational deposition | Inertial interception | Inertial interception | Inertial interception | Inertial interception | Inertial/direct interception | Direct interception/ diffusional deposition |
| Gas handling capacity | Low | High | High | High | Very high | Moderate | Low |
| Turndown capacity | Very high | 30 % | 30 %-50 % | 30 %-50 % | 30 % Higher with preconditioner | 25 % | Very high |
| Efficiency | Low except for large droplet sizes | Low except for large droplet sizes | High down to approx. 25 µm | High down to approx. 25 µm | High down to approx. 10 µm | Very high down to 3-5 µm | Very high at sub-micron droplet sizes |
| Liquid load capacity | Very high | Very high | Moderate | High | High | Moderate | Low |
| Solids handling capability | Very high | Very high | Moderate | Low | Moderate-high | Low | Very low |
| Liquid viscosity | Suitable for high viscosity | Suitable for high viscosity | Suitable for high viscosities/waxes | Prone to fouling with high liquid viscosities/waxes | Suitable for high viscosities/waxes | Prone to fouling with high liquid viscosities/waxes | Unsuitable for high liquid viscosities |
| Pressure drop | Very low | Very low | Low | Low | Moderate | Low | High |

*Table A: Summary of relative performance characteristics for mist elimination*

Three principles used to achieve physical separation of gas and liquids or solids are **momentum (impact / centrifugal), gravity settling, and coalescing**

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# Gas Liquid Separator Practical Selection and Design Guide

Almost all mist elimination equipment falls into one of four general classes:

- Knitted wire mesh pads (DEMISTER® mist eliminators)
- Vane assemblies (FLEXICHEVRON® mist eliminators)
- Fiberbed candles and panels (FLEXIFIBER® mist eliminators)
- Cyclone assemblies

## DEMISTER® Mist Eliminators

When the vessel size is not set by the mist eliminator (such as is normally the case for distillation towers, steam drums, or evaporators), the practical starting point is often the knitted wire mesh pad type. DEMISTER knitted mesh mist eliminators provide high separation efficiency at the lowest installed cost.

KOCH-OTTO YORK® DEMISTER® mist eliminator style 709 in stainless steel.

FLEXIFIBER® mist eliminator type IC-SRF.

FLEXICHEVRON® mist eliminator style VIII in FRP.

Cyclone mist eliminator assembly with mounting deck and liquid drain piping for a vertical vessel.

Picture courtesy of CDS Separation Technology.

## FLEXICHEVRON® Mist Eliminators

When the vessel size is set by the mist eliminator, then the benefits of high capacity FLEXICHEVRON mist eliminators could be the most cost effective overall solution.

The fouling resistant FLEXICHEVRON mist eliminator often offers the best solution if the mist contains solid particulates; viscous, sticky liquids; or if large slugs of liquid occur.

## FLEXIFIBER® Mist Eliminators

FLEXIFIBER mist eliminators are the only type that can effectively remove submicron size particles.

KOCH

# Gas Liquid Separator Practical Selection and Design Guide

## KOCH

Table 1. Selection Guide - Common Mist Elimination Equipment

| | Knitted Mesh | Vane | Fiberbed | Cyclone |
|---|---|---|---|---|
| Cost | 1 | 2-3 | 10 | 3-5 |
| Gas Capacity | 5 | 6-15 | 1 | 15-20 |
| Liquid Capacity | 5 | 10 | 1 | 10 |
| Particle Size (micron) | 3-10 | 10-40 | < 0.1 | 7-10 |
| Pressure Drop, WC | < 25 mm (1") | <10-90 mm (0.4" - 3.5") | 50-500 mm (2" - 20") | 200-240 mm (8" - 14") |
| Solid Handling | 3 | 10 | 1 | 8 |

Relative scale based on 1 as the lowest. Others are scaled.

# Gas Liquid Separator Practical Selection and Design Guide

Table 1: Performance comparison of the various G/L separators

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

A = very low
B = low
C = moderate
D = high
E = very high

∞ : Infinite
* : if double-pocket vanepack: N; for a single-pocket vanepack or in case of straight vanes: Y
** : if double-pocket vanepack: A; if single-pocket vanepack: B; if straight vanes: C
*** : depending on the degree of fouling, ranging from C to E

**VKO** Vertical knock-out drum (3.1)
**HKO** Horizontal knock-out drum (3.2)
**VW** Vertical wiremesh demister (3.3)
**HW** Horizontal wiremesh demister (3.4)
**VV1** Vertical in-line separator with vane pack (3.5.5)
**VV2** Vertical two-stage separator with vane pack (3.5.6)
**HV** Horizontal vane-type demister (3.6)
**SMS** Schoepentoeter-mistmat-swirldeck separator (3.7)
**SVS** Schoepentoeter-vane pack-swirldeck separator (3.7)
**SMSM** Schoepentoeter-mistmat-swirldeck-mistmat separator (3.7)
**CT** Cyclone with tangential inlet (conventional cyclone) (3.8)
**CS** Cyclone with straight inlet and swirler ("Gasunie" cyclone) (3.9)
**VRMC** Vertical separator with reversed-flow multicyclone bundle ( conventional multicyclone) (3.10)
**FS** Filter separator (3.13)

DEP

# Gas Liquid Separator Practical Selection and Design Guide

VERTICAL KNOCK-OUT DRUM

(Figure 3.1)

**Selection criteria**

**Application:**
– bulk separation of gas and liquid.

**Characteristics:**
– unlimited turndown;
– high slug handling capacity;
– liquid removal efficiency typically 90 %;
**Warning: poor removal efficiency of liquid from mist**
– very low pressure drop;
– insensitive to fouling.

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**Recommended use:**
– vessels where internals have to be kept to a minimum (e.g. flare knock-out drums);
– fouling service e.g. wax, sand, asphaltenes;
– foaming service.

**Non-recommended use:**
– where efficient demisting of gas is required.

**Typical process applications:**
– vent and flare stack knockout drums;
– production separator;
– bulk separator (e.g. upstream of gas coolers);
– flash vessel.

# Gas Liquid Separator Practical Selection and Design Guide

VERTICAL WIREMESH DEMISTER

(Figures 3.3 and 3.4)

**Selection criteria**

**Application:**
– demisting of gas.

**Characteristics:**
– high turndown ratio (factor 4);
– high slug handling capacity;
– liquid removal efficiency > 98 %;
– sensitive to fouling;
– low pressure drop.

**Recommended use:**
– for demisting service with a moderate liquid load in form of droplets;
– where slug handling capacity may be required.

– for compressor suction scrubbers, in non-fouling service, provided that precautions are taken to prevent the disengagement of loose wire cuttings.

**Non-recommended use:**
– fouling service (wax, asphaltenes, sand, hydrates)
– for viscous liquids where de-gassing requirement determines vessel diameter

**Typical process applications:**
– production/test separator (non-fouling, moderate GOR);
– inlet/outlet scrubbers for glycol contactors;
– inlet scrubbers for gas export pipelines;
– for small diameter and/or low pressure vessels, where extra costs of e.g. vane or SMS internals cannot be justified.

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**FIG. 7-12**

**Mesh Pad Separation Performance**

| | |
|---|---|
| Droplet removal efficiency: | 99–99.5% removal of 3–10 micron droplets. Higher removal efficiency is for denser, thicker pads and/or smaller wire/co-knit fiber diameter. |
| Gas capacity, K, ft/sec | 0.22–0.39. Generally, the lower capacities correspond to the mesh pad designs with the highest droplet removal efficiencies. |

GPSA

VERTICAL VANE-TYPE DEMISTER

**Types:**

1. IN-LINE SEPARATOR WITH HORIZONTAL FLOW VANE PACK (Figure 3.6a)
2. TWO-STAGE SEPARATOR WITH VERTICAL FLOW VANE PACK (Figure 3.6c)

**Selection criteria**

**Application:**
- demisting of gas.

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**Characteristics:**
- liquid removal efficiency > 96 %;
- moderate turndown ratio (factor 3);
- suitable for slightly fouling service (straight or single-pocket vanes only);
- not suitable for pressures above 70 bar;
- robust design;
- sensitive to liquid slugs (in-line separator cannot handle slugs at all).

**Recommended use:**
- typically for demisting service;
- in-line separator to be used only with relatively low flow parameter ($\phi_{feed} < 0.01$);
- two-stage separator to be used if $\phi_{feed} \geq 0.01$;
- attractive for slightly fouling service (straight or single-pocket vanes only);
- may be used where demister mats may become plugged, e.g. waxy crudes, sulphur recovery units.

**FIG. 7-16**

**Typical Vane Pack Separation Performance**

| | |
|---|---|
| Droplet removal efficiency: | 99% removal of droplets greater than 10–40 microns. Higher removal efficiency is for thicker packs, with closer vane spacings and more passes (bends). |
| Gas capacity, K, ft/sec | Horizontal flow: 0.9–1.0<br>Vertical up-flow: 0.4–0.5<br>The higher capacities are generally associated with pocketed vane designs. |

GPSA

**Non-recommended use:**
- heavy fouling service (heavy wax, asphaltenes, sand, hydrates);
- for viscous liquids where de-gassing requirement determines vessel diameter;
- the in-line vertical flow vane pack separator shall not be used where liquid slugging may occur or where $\phi_{feed} \geq 0.01$;
- if pressure exceeds 70 bar, due to the consequent sharp decline in liquid removal efficiency and insufficient turndown.

**Typical process applications:**
- demisting vessels with slightly fouling service.
- compressor suction scrubbers – where vane packs are preferred to demister mats since their construction is more robust. In view of the limited separation efficiency of vanepacks, this application should be limited to operating pressures well below 50 bar.

# Gas Liquid Separator Practical Selection and Design Guide

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| Case 4 | 3000 | 40,000 | 3000 | 30 | 1000 |

**40,000 / 1,55,000 = ~ 26%**

**1) Which internal can be used for above service ?**

**a) No internal X carries mist to compressor**

**b) Mist mat**

**c) Vane pack X 26 < 30 – 50 % turndown**

**Pressure > 50 bar**

# Gas Liquid Separator Practical Selection and Design Guide

Quiz 2 : - Production separator with heavy waxy oil and little solids.

1) **Which internal can be used for above service ?**
a) **No internal   Best option**
b) **Mist mat   X  It can block easily.**
c) **Vane pack , only if to reduce vessel size with moderate fouling**

# Gas Liquid Separator Design Guide

# Gas Liquid Separator Practical Selection and Design Guide

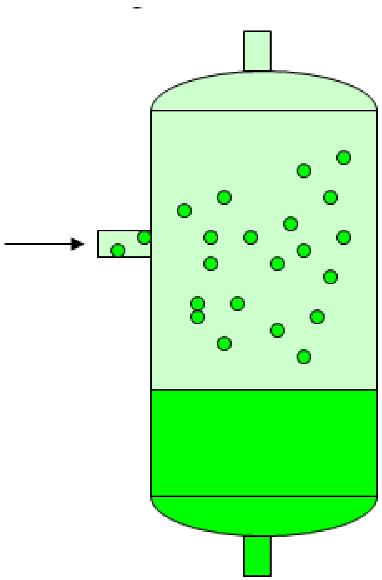
Two phase separator design is divided in following sections.

- Vessel Diameter
- Vessel Height
  - Gas space height
  - Liquid space height
- Nozzle sizing

# Separator Diameter Calculation

**Simplified Sauder-Brown equation:**

$$U_T = K\left(\frac{\rho_L - \rho_V}{\rho_V}\right)^{1/2}$$



Gas velocity < $U_T$

Gas velocity < Particle terminal fallir

K = empirical constant for separator sizing, m/sec

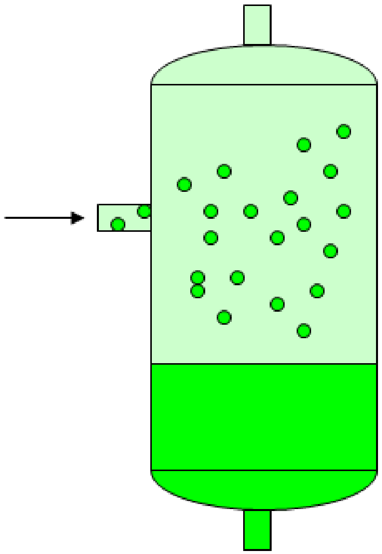
$\rho_V$ = gas phase density, kg/m$^3$

$\rho_L$ = liquid phase density, droplet or particle, kg/m$^3$

# Separator Diameter Calculation

Simplified Sauder-Brown equation:

$$U_T = K\left(\frac{\rho_L - \rho_V}{\rho_V}\right)^{1/2}$$



Gas velocity < $U_T$

Gravity Settling

Stoke's Law, Intermediate Law & Newton's Law

Particle size and Reynolds Number

# Gas Liquid Separator Practical Selection and Design Guide

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | AA | AE | AC | AD | AE | AF | AG | AH | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**Vertical Two-Phase Separator Sizing (Imperial Units)**

SEP-V-2P, Rev. 0 *(Edmonton modified version of Worley WS-CA-PR-008, Rev. 3, 12-Feb-03)*

Verification of SEP-V-2P Rev0.pdf *(Verification of Edmonton modified version)*

**SEP-V-2P**
**VERTICAL TWO-PHASE SEPARATOR SIZING**
**SI & IMPERIAL UNITS**

Spreadsheet Authors: Jeff Gornall / Gord Godwin
Spreadsheet Custodian: Bob Chomyc

**Calculation worksheet**

**CAUTION**

PRIOR TO USING THIS PROGRAM, PLEASE MAKE SURE THAT YOU UNDERSTAND HOW IT WORKS, THAT YOU HAVE READ THE "INSTRUCTIONS" AND "NOTES" WORKSHEETS AND THAT YOU HAVE A WORKING KNOWLEDGE OF EXCEL.

THIS IS A READ ONLY FILE. COPY IT TO YOUR OWN DIRECTORY AND RENAME IT PRIOR TO USING IT.

ALWAYS CHECK YOUR RESULTS FOR "REASONABLENESS".

IF YOU HAVE ANY QUESTIONS, COMMENTS OR SUGGESTIONS PLEASE CONTACT BOB CHOMYC @ 5357. YOU MAY ALSO CONTACT JEFF GORNALL (5487) OR GORD GODWIN (5495) REGARDING ANY QUESTIONS.

# Gas Liquid Separator Practical Selection and Design Guide

| Separator Type | K (m/s) | K (ft/s) |
|---|---|---|
| Separators with mesh pad demisters (1) [a] | 0.067 - 0.12 | 0.22 - 0.39 |
| Vane Pack (vertical upflow) [a] | 0.12 - 0.15 | 0.4 - 0.5 |
| Wet Steam [b] | 0.076 | 0.249 |
| Most Vapours under Vacuum [b] | 0.061 | 0.200 |

| Adjustment of K Factor for Oper. Pressure (kPa(a)) | % of Design [c] |
|---|---|
| 0 - 100 (2) | 100 |
| 500 | 94 |
| 1000 | 90 |
| 2000 | 85 |
| 4000 | 80 |
| 8000 | 75 |

**Notes GPSA 11 & 12+**

**Instructions**

| | |
|---|---|
| 9 | Select "Y" or "N" in cell M29 to include or omit a demister pad from the design, respectively. |
| 10 | Select "Y" or "N" in cell AD29 to include or omit the volume of the vessel bottom head, respectively. Select "E" or "H" in cell AD30 for semi-ellipsoidal heads or hemispherical heads, respectively. Note: If selected, the vessel head volume is included in the residence time from the bottom of the vessel to the NLL (cell M41). If omitted, the vessel head volume is ignored and the residence time is calculated from the bottom tan line (BTL) to the NLL. Including or omitting the volume of the vessel head in the calculation sheet will not affect the sizing or final dimensions of the vessel or the controllability of the level. It only affects the time required to drain the vessel from NLL, thus the default selection is "N". |

# Gas Liquid Separator Practical Selection and Design Guide

## LIST OF MODIFICATIONS FROM WS-CA-PR-008 REV. 3

This spreadsheet calculation, SEP-V-2P, has been created by modifying Worley Standard Calculation WS-CA-PR-008 Rev. 3, and adding Cover, Instructions, Notes, and Basis sheets. A validation document is available for the Worley calculation above and is titled "Verification of WS-CA-PR-008.pdf". Calculations WS-CA-PR-008 and SEP-V-2P are closely aligned with the Worley Offshore Design Guide, Gas-Liquid Separator Sizing, WS-DG-PR-011, Rev. 0, 23-Jun-03.

To create SEP-V-2P, the following modifications, excluding general formatting, were made from the original calculation WS-CA-PR-008:

a) "Oil rate" and "Water rate" inputs have been combined into a "Liquid rate" input.
b) "Temperature" & "Pressure" inputs have been added as reference information for the actual volume flows & densities.
c) "Oil density" and "Water density" inputs have been combined into a "Liquid density" input.
d) The "Standard Conditions" MACRO has been corrected to show a pressure of 14.7 psia.
e) The "K Values" MACRO has been modified to refer the user to the "Notes" worksheet.
f) The "Slug capacity required" input has been changed from a volume to a time basis.
g) The "Instructions" MACRO on the Imperial worksheet was corrected to call up the text box. The text box in both worksheets was updated to reference the correct input cells in the "Ht Above Inlet - Specified Minimums Table"
h) The "Demister Y/N" input (cell M29) has been unlocked to allow user selection and Height above Inlet cell T28 has been locked to protect the formula.
i) Data input cells have been merged to make them user friendly and less error prone.
j) "Include head volume (Y/N)" and "Head geometry (E/H)" inputs and functions have been added.
k) A "Residence time (bottom to NLL)" calculation cell has been added.
l) The worksheet title has been modified to provide control for the Edmonton version and to identify its origin.
m) In "Nozzles" section revised the "Required velocity" label to "Maximum velocity". Also, for the user entered nozzle diameters, revised the term "Min." to "Selected" or "Sel.".
n) The "Inlet to TTL Specified Minimums Table" has been renamed to "Ht Above Inlet - Specified Minimums Table". Within the table, the wording has been changed to "w/ Demister" and "w/o Demister" to standardize terminology.

# Gas Liquid Separator Practical Selection and Design Guide

Collect following data from Heat & Mass balance.

- ✓ Gas and liquid mass rate (kg/hr)
- ✓ Gas and liquid mass density (kg/m3)
- ✓ Operating pressure and temperature
- ✓ Liquid viscosity and gas molecular weight

- ✓ Tip : If liquid has two phases, then use density of light phase. This will give safe design.

$\rho_G$ and $\rho_L$ are the densities of the gas and liquid phase respectively (kg/m$^3$). 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 density of the lighter liquid shall be used in the above formula.

# Gas Liquid Separator Practical Selection and Design Guide

## Process Data Input

**Vertical Two-Phase Separator Sizing (Imperial Units)**

SEP-V-2P, Rev. 0 *(Edmonton modified version of Worley WS-CA-PR-008, Rev. 3, 12-Feb-03)*

Verification of SEP-V-2P Rev0.pdf *(Verification of Edmonton modified version)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Temperature | = | *32* | °C | Pressure | = | *4827* | kPag |
| Liquid rate | = | *40,000.0* | kg/hr | Liquid density | = | *737.6* | kg/m$^3$ |
| Vapour rate (Standard Conditions) | = | *120,000.0* | kg/hr | Vapour density | = | *55* | kg/m$^3$ |
| Vapour molecular weight | = | *22.0* | | Liquid vol. rate | = | 54.2 | m$^3$/hr |
| Vapour std. volume rate | = | 129,166.0 | std. m$^3$/hr | Vapour vol. rate | = | 2181.8 | m$^3$/hr |
| Vapour vol. rate (Q) | = | 0.606 | m$^3$/s | Liquid vol. rate ($Q_l$) | = | 0.015 | m$^3$/s |
| K Factor (K) | = | *0.095* | m/s | Mixture (inlet) density ($Q_m$) | = | 71.55 | kg/m$^3$ |
| Max. allowable velocity ($V_{max}$) | = | 0.33 | m/s | SQRT($\rho_L$-$\rho_g$/$\rho_g$) | = | 3.52 | |
| Diameter for vapour handling | = | 1518.5 | mm | Required vapour area ($A_{min}$) | = | 1.8 | m$^2$ |
| Slug capacity required | = | *1.33* | mins | Actual K (based on diameter used) | = | 0.095 | m/s |
| Manual override of diameter | = | *1520* | mm | Diameter used | = | **1520** | mm |
| Vessel cross section | = | 1.815 | m$^2$ | | | | |

## APPENDIX IV DESIGN MARGINS FOR SEPARATOR DESIGN

To determine the highest envisaged gas and liquid load for vessel design, design margins (surge factors) are required:

The design margins shall be supplied by the Principal.

Typical values are:

IN EXPLORATION AND PRODUCTION APPLICATIONS:

| **1. Offshore service** | **Design margin** |
|---|---|
| Separator handling natural-flowing production from: | |
| a) Direct Vertical Access (DVA) wells on their own platform | 1.2 |
| b) another platform or well jacket in shallow water | 1.3 |
| c) another platform or well in deep water | 1.4 |
| Separator handling gas lifted production from: | |
| a) DVA wells on their own platform | 1.4 |
| b) Wells on another platform, or well jacket | 1.5 |
| c) Subsea wells | 1.5 |

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| **2. Onshore service** | |
|---|---|
| Separator handling natural flowing production, or gas plant inlet separator in: | |
| a) flat or low rolling country | 1.2 |
| b) hilly country | 1.3 |
| Separator handling gas lifted production in: | |
| a) flat or low rolling country | 1.4 |
| b) hilly country | 1.5 |

IN REFINERIES AND CHEMICAL PLANTS:

The design margin ranges typically from 1.15 to 1.25.

# Gas Liquid Separator Practical Selection and Design Guide

Following cases to be checked for separator sizing

- Highest Volumetric Gas rate
- Highest Volumetric Liquid rate
- Lowest pressure case for higher volume
- Highest pressure case for difficult separation
- Lowest liquid density case for difficult separation

# Gas Liquid Separator Practical Selection and Design Guide

Selection of K value

- Type of internal
- Service
- Downstream requirement for gas quality
- Pressure correction
- Orientation correction
- Liquid loading correction

# Gas Liquid Separator Practical Selection and Design Guide

**Typical K Factors For Vendor Internals in Vertical Separators**

| Internal | K Factor (m/s) |
|---|---|
| None | 0.05 |
| Mist Mat | 0.1 |
| Vane Pack | 0.25 |
| Cyclones | 0.3 |

WP

K values for demisters should be reduced for increasing pressure (Ref 3), and GPSA (ref 2) gives an approximate reduction of 0.03 for every 7 bar increase above 7 barg.

**Adjustment of K Factor for Pressure**[6]

| Pressure, psig | Percent of Design Value |
|---|---|
| Atmospheric | 100 |
| 150 | 90 |
| 300 | 85 |
| 600 | 80 |
| 1,150 | 75 |

GPSA

**Typical Values of K for Vertical Separators**

| Height, feet | K, ft/sec |
|---|---|
| 5 | 0.12 – 0.24 |
| 10 or taller | 0.18 – 0.35 |

* assumes vessel is equipped with a wire-mesh mist extractor

GPSA

0.037 – 0.073 m/sec
0.055 – 0.107 m/sec

# Selecting K for Horizontal Vessel

$$K_{HOR} = K\left(\frac{L}{3}\right)^{0.56}$$

WP

$$AxialVelocity_{\max} = K_{HOR}\sqrt{\frac{(\rho_l - \rho_v)}{\rho_v}}$$

Where,

| | | | |
|---|---|---|---|
| | Axial Velocity$_{max}$ | = | Maximum allowable superficial axial vapour velocity, m/s |
| | K | = | Empirical constant (m/s) per section 2.1 |
| | K $_{HOR}$ | = | Adjusted constant (m/s) for horizontal separators |
| | $\rho_l$ | = | Density of liquid phase (kg/m$^3$) |
| | $\rho_v$ | = | Density of vapour phase (kg/m$^3$) |
| | L | = | Separator length (m) |

**Values of K for Horizontal Separators**

| Length, ft | K, ft/sec |
|---|---|
| 10 | 0.40 – 0.50 |
| Other | $K_{10}\left(\frac{L}{10}\right)^{0.56}$ |

* assumes vessel is equipped with a wire-mesh mist extractor

GPSA

# Selecting K based on type, service and operating pressure

| Separator Type | K (m/s) | K (ft/s) |
|---|---|---|
| Separators with mesh pad demisters (1) [a] | 0.067 - 0.12 | 0.22 - 0.39 |
| Vane Pack (vertical upflow) [a] | 0.12 - 0.15 | 0.4 - 0.5 |
| Wet Steam [b] | 0.076 | 0.249 |
| Most Vapours under Vacuum [b] | 0.061 | 0.200 |

| Adjustment of K Factor for Oper. Pressure (kPa(a)) | % of Design [c] |
|---|---|
| 0 - 100 (2) | 100 |
| 500 | 94 |
| 1000 | 90 |
| 2000 | 85 |
| 4000 | 80 |
| 8000 | 75 |

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1) The classic Otto York K-factor is 0.35 ft/s (0.107 m/s). Typical vertical separator designs should therefore be calculated with values from the upper end of the range shown. Values in the lower end of the range can be used when additional conservatism is required.
2) At low operating pressure (5 - 20 kPa(a)), DP is often the overriding consideration instead of demisting diameter.
3) Typically, use half of the above K-factors for sizing of vertical separators without wire demisters.
4) For glycol and amine solutions, multiply K by 0.6 - 0.8 [or use a value toward the low end of the above range].
5) For compressor suction scrubbers and expander inlet separators multiply by 0.7 - 0.8 [or use a value toward the low end of the above range].
6) Lieberman suggests, from observation, that for a mesh pad demister to work properly it should apparently have a K value of at least 0.15 - 0.20 ft/s [0.046 - 0.061 m/s] for the vapours to strike the demister's fibers with enough force "to encourage the droplets to coalesce". [d]

# Selecting K based on liquid loading

Derate the mist extractor K factor and use this reduced K value in Eq 7-8 to determine the vessel diameter. Guidelines as to determination of the appropriate deration factor are not well defined. A relatively low liquid loading application with steady flow, a low inlet velocity and a good inlet device should require minimal deration of the extractor K factor, i.e. deration factor approximately equal to 1. On the other hand, an application with significant liquid volumes, unsteady flow, high velocity inlet and a simple diverter plate inlet device may require a deration factor of 0.5. Normally, it would be more economic to improve the inlet flow condition/device than to significantly oversize the vessel relative to the mist extractor requirements.



GPSA

# Sulzer K Values

| Equipment Type | K-Value m/s | ft/s |
|---|---|---|
| Gravity | 0.07 | 0.23 |
| Sulzer Mellachevron – simple profiles | 0.13 – 0.17 | 0.42 – 0.56 |
| Sulzer Mellachevron – high capacity profiles with drainage channels | 0.15 – 0.45 | 0.49 – 1.46 |
| Sulzer KnitMesh Mist Eliminator | 0.08 – 0.107 | 0.26 – 0.35 |
| Sulzer KnitMesh VKR Mist Eliminator | 0.08 – 0.15 | 0.26 – 0.49 |
| Shell SMS, SMSM | 0.25 | 0.82 |

# Sulzer K Values

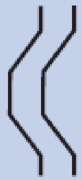
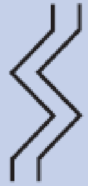
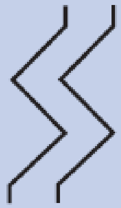
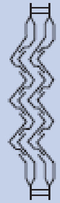
| | Mellachevron – simple vanes | | | Mellachevron – Complex profiles with drainage channels | | |
|---|---|---|---|---|---|---|
| Type | C – profile | Z - profile | C or Z - profile with large vane spacing | Complex profile - integral drainage channel | Z-profile with drainage hooks | Z-profile with large vane spacing |
| Profile |  |  |  |  |  |  |
| Flow Direction | Vertical | Vertical | Vertical | Vertical or horizontal | Horizontal | Horizontal |
| Installation | No housing | No housing | No housing | Housing and drainage system required. | Housing and drainage system required. | Housing and drainage system required. |
| Gas handling capacity (K-values) | 0.17 m/s | 0.14 m/s | 0.14 – 0.17 m/s | 0.17 – 0.45 m/s | 0.30 m/s | 0.30 m/s |
| Turndown capability | ≈ 30 - 50 % | ≈ 30 - 50 % | ≈ 30 - 50 % | ≈ 30 - 50 % | ≈ 30 - 50 % | ≈ 30 - 50 % |
| Efficiency | Medium down to ≈ 30 – 40 μ | Medium – High down to ≈ 25 μ | Low – Medium down to ≈ 30 – 50 μ | High down to ≈ 10 – 15 μ | Medium down to ≈ 25 – 30 μ | Low – Medium down to ≈ 35 – 40 μ |
| Liquid load capacity | Moderate | Moderate | High | Moderate to High | High | Very High |
| Solids handling capability | Moderate to High | Moderate | High | Low | Low | Low to Moderate |
| Liquid viscosity | Suitable for high viscosities/waxes | Suitable for high viscosities/waxes | Very suitable for high viscosities/waxes | Prone to fouling with high viscosities/waxes | Prone to fouling with viscosities/waxes | Suitable for high viscosities/waxes |
| Typical applications | Vacuum, general use, fouling service | Desalination, general use, fouling service | As for C and Z profiles but high fouling / low pressure drop services | Debottlenecking, offshore, clean services, gas & steam processing | Horizontal scrubbers | As for C and Z profiles but high fouling / low pressure drop services |
| Pressure drop | Very low | Low | Very low | Moderate | Low | Low |

*Table C: Sulzer Mellachevron Mist Eliminator Styles*

**Appendix F**

Fabian, et al. Demystifying the Selection of Mist Eliminators - Part 1, Chemical Engineering, November 1993.

**EFFECT OF PRESSURE ON THE ALLOWABLE K FACTOR**

| Absolute pressure, kPa | K factor, % of design value |
|---|---|
| 5‡ | 60–100 |
| 20‡ | 60–100 |
| 50 | 100 |
| 100 | 100 |
| 500 | 94 |
| 1,000 | 90 |
| 2,000 | 85 |
| 4,000 | 80 |
| 8,000 | 75 |

‡At low pressures (5–20 kPa), pressure drop is often the overriding design consideration, instead of capacity.

**FEATURES OF TRADITIONAL IMPINGEMENT-TYPE MIST ELIMINATORS**

| Eliminator type | DEMISTER® | FLEXICHEVRON® | FLEXIFIBER® |
|---|---|---|---|
| Cost | Lowest | 2-3 times wire-mesh unit | Highest |
| Efficiency | 100% (for droplets larger than 3-10 μm) | 100% (for mists >20-40 mm | Up tp 99% (for <3 μm) |
| Pressure drop | < 25 mm $H_20$ | < 15 mm $H_20$ | 100-300 mm $H_20$ |
| Gas Capacity | Very good | Up to twice that of a wire-mesh unit | Lowest |
| Liquid Capacity | Good | Best | Lowest |
| Solids | Good | Best | Soluble particles with sprays only |

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GPSA

The K capacity factor for mesh pads is often derated for higher pressure operation, Fig. 7-13. All factors being equal, this is normally due to the reduction in surface tension of the liquid phase that occurs with increasing pressure.

# Practical Selection and Design Guide

**Table VIII.1 Variation of the physical properties of a $C_6^-$ mixture, and its effect on (relative) maximum droplet size and gas handling capacity of an open separator**

| Pressure | Gas density | Surface tension | $(\sigma/\rho_g)^{0.6}$. (relative to properties at 20 bar) | $\lambda$ SIMILAR TO K |
|---|---|---|---|---|
| | | | | |
| 20 | 18.7 | 28.9 | 1.0 | 0.07 |
| 40 | 39.6 | 22.0 | 0.54 | 0.052 |
| 60 | 60.7 | 16.4 | 0.35 | 0.042 |
| 80 | 84.7 | 11.7 | 0.23 | 0.034 |
| 100 | 108.4 | 8.1 | 0.16 | 0.028 |



DEP

# GAS LIQUID SEPARATOR PRACTICAL SELECTION AND DESIGN GUIDE

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Temperature | = | 32 | °C | Pressure | = | 4827 | kPag |
| Liquid rate | = | 40,000.0 | kg/hr | Liquid density | = | 737.6 | kg/m$^3$ |
| Vapour rate Standard Conditions | = | 120,000.0 | kg/hr | Vapour density | = | 55 | kg/m$^3$ |
| Vapour molecular weight | = | 22.0 | | Liquid vol. rate | = | 54.2 | m$^3$/hr |
| Vapour std. volume rate | = | 129,166.0 | std. m$^3$/hr | Vapour vol. rate | = | 2181.8 | m$^3$/hr |
| Vapour vol. rate (Q) | = | 0.606 | m$^3$/s | Liquid vol. rate ($Q_l$) | = | 0.015 | m$^3$/s |
| K Factor K | = | 0.095 | m/s | Mixture (inlet) density ($Q_m$) | = | 71.55 | kg/m$^3$ |
| Max. allowable velocity ($V_{max}$) | = | 0.33 | m/s | SQRT($\rho_L$-$\rho_g$/$\rho_g$) | = | 3.52 | |
| Diameter for vapour handling | = | 1518.5 | mm | Required vapour area ($A_{min}$) | = | 1.8 | m$^2$ |
| Slug capacity required | = | 1.33 | mins | Actual K (based on diameter used) | = | 0.095 | m/s |
| Manual override of diameter | = | 1520 | mm | Diameter used | = | 1520 | mm |
| Vessel cross section | = | 1.815 | m$^2$ | | | | |

- Enter K value based on type of internal, service, pressure liquid loading and orientation.
- Run all cases as mentioned earlier.
- Arrive biggest separator Diameter for vapour & liquid loadings.

# Gas Liquid Separator Practical Selection and Design Guide

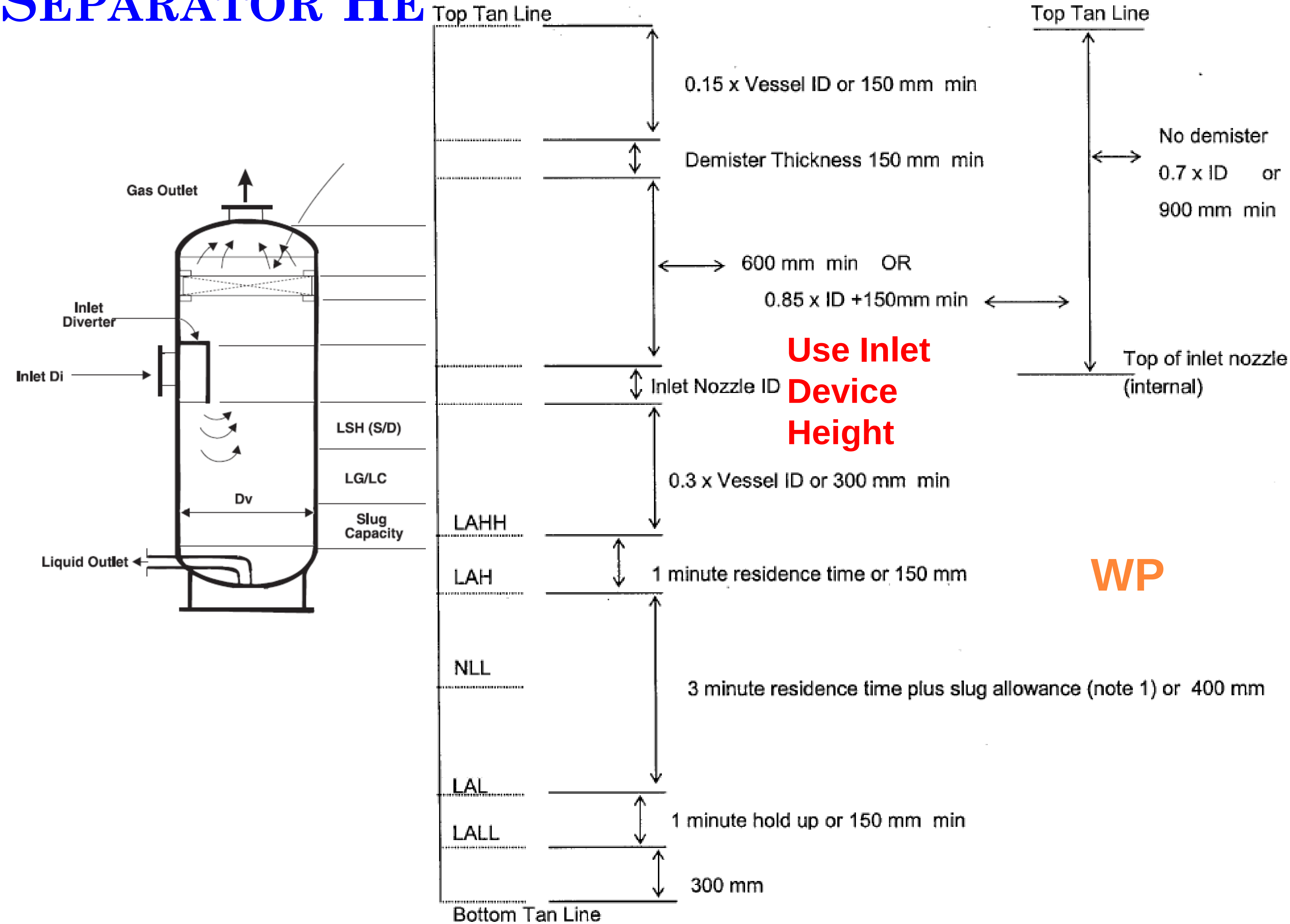
Weight / Space / Cost Optimisation

For following cases

- High gas rate
- High design / operating pressure
- Exotic / Expensive MOC
- Low liquid with clean service
- Space constraint (Offshore platform)

Use vane pack / cyclone Internal; to reduce size of the separator; and thus weight & cost of the separator.

# SEPARATOR HEIGHT CALCULATION



GAS Height Calculation depends on :

1) With / without Internals

2) Type of Internals (distance between internal and feed pipe)

3) Type of feed device (distance between HHL & feed pipe and distance between internal & feed pipe)

4) Mist / Foaming service ??

Liquid Height Calculation :

1) Check liquid discharge is on
   Level Control OR
   On Off Control between high & low level

(do not use spread-sheet defaults, one can go badly wrong)

2) Find surge volume / time

3) Degassing service ??

Liquid Height Calculation :

4) Check P & ID for

number of levels, alarms and trips

number of instruments installed

5) Find type of level measurement

Magnetic type, radar, differential pressure .....

Different types of instruments has different minimum distance requirements

Liquid Height Calculation :

6) Most important liquid control & hold-up volume is based on (A) service (Production separator, KO drum, flash drum) and (B) downstream equipment requirement, i.e.

Feed to pump

Feed to vessel / column

Feed to exchanger

Liquid Height Calculation :

7) Check P & I D for other nozzles; i.e. , size & locations for PSV, manhole etc.. This can effect vessel height.

## GPSA

**Typical Retention Times for Gas/Liquid Separator**

| Application | Retention Time, minutes |
|---|---|
| Natural Gas – Condensate separation | 2 – 4 |
| Fractionator Feed Tank | 10 – 15 |
| Reflux Accumulator | 5 – 10 |
| Fractionation Column Sump | 2 |
| Amine Flash Tank | 5 – 10 |
| Refrigeration Surge Tank | 5 |
| Refrigeration Economizer | 3 |
| Heat Medium Oil Surge Tank | 5 – 10 |

**FIG. 7-21**

**API 12J Retention Times for Gas-Oil Separators**

| Oil Gravity | Liquid Retention Time, min |
|---|---|
| > 35 | 1 |
| 20 – 35 | 1 to 2 |
| 10 – 20 | 2 to 4 |

| Service | Holdup Time, min. (NLL - LLL) | Surge Time, min. (NLL - HLL) |
|---|---|---|
| **A. Unit Feed Drum** | 10 | 5 |
| **B. Separators** | | |
| 1. Feed to column | 5 | 3 |
| 2. Feed to other drum or tankage | | |
| a. With pump or through exchanger | 5 | 2 |
| b. Without pump | 2 | 1 |
| 3. Feed to fired heater | 10 | 3 |
| **C. Reflux or Product Accumulator** | | |
| 1. Reflux only | 3 | 2 |
| 2. Reflux and product (1) | 3+ | 2+ |
| **D. Column Bottoms** | | |
| 1. Feed to another column | 5 | 2 |
| 2. Feed to other drum or tankage | | |
| a. With pump or through exchanger | 5 | 2 |
| b. Without pump | 2 | 1 |
| 3. Feed to fired reboiler (2) | 5 - 8 | 2 - 4 |
| **E. Compressor Suction/Interstage Scrubber** | | |
| 1. 3 min. from HLL (alarm) to high level shutdown | | |
| 2. 10 min. from bottom tangent line to HL | | |
| **F. Fuel Gas Knockout Drum** | | |
| 1. 20 ft. slug in the incoming fuel gas line between NLL and high level shutdown | | |
| **G. Flare Knockout Drum** | | |
| 1. 20 to 30 min. to HLL | | |

| Adjustment of Holdup/Surge Times for Personnel and Instrumentation (Optior | Factor |
|---|---|
| **A. Personnel** | |
| a. Experienced | 1.0 |
| b. Trained | 1.2 |
| c. Inexperienced | 1.5 |
| **B. Instrumentation** | |
| a. Well Instrumented | 1.0 |
| b. Standard Instrumentation | 1.2 |
| c. Poorly Instrumented | 1.5 |

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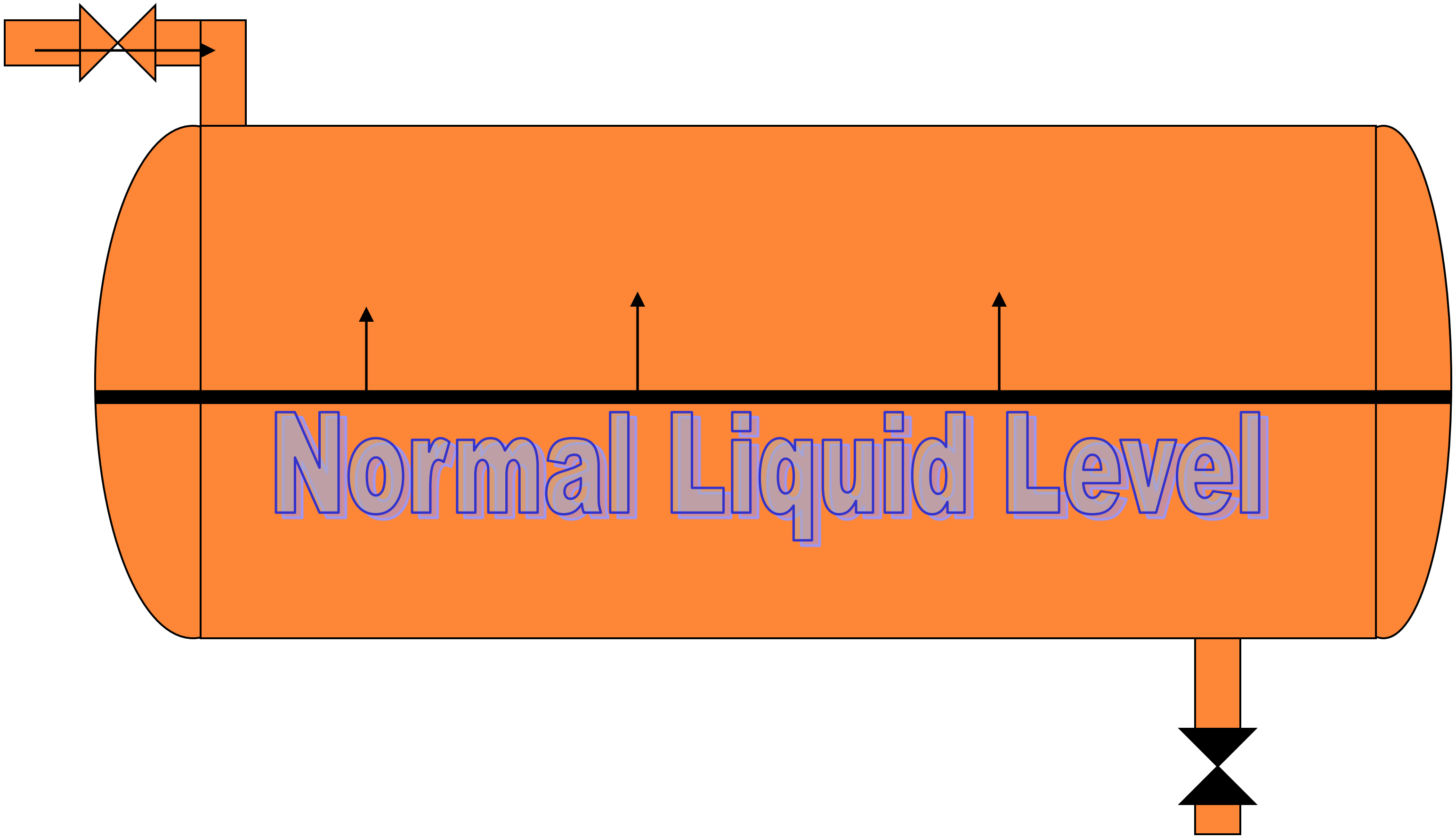
1) Based on reflux (3 min.) plus appropriate holdup time of overhead product, as per B. 1 - 3.

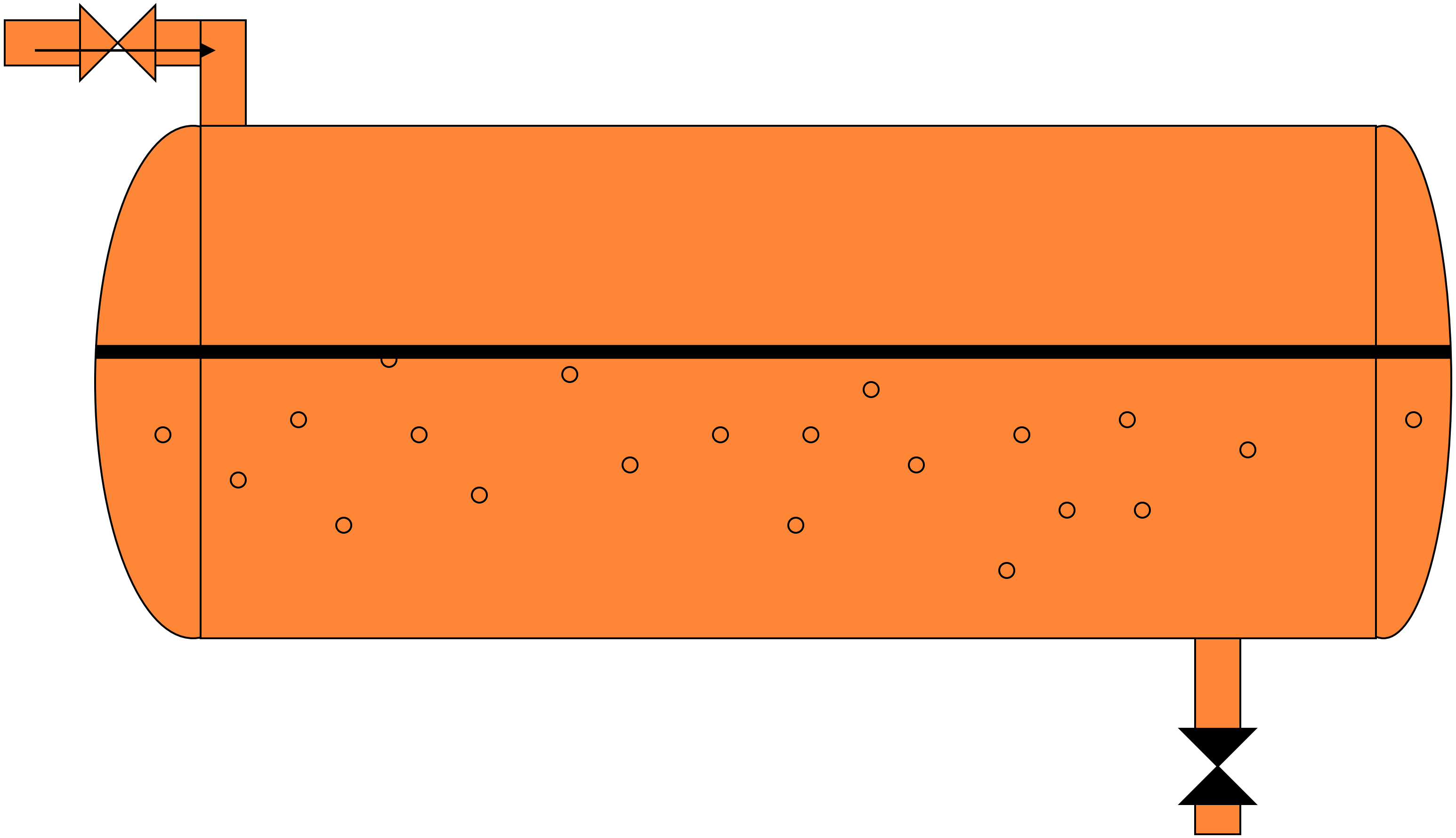
2) Based on reboiler vapour expressed as liquid (3 min.) plus appropriate holdup time for the bottoms product, as per D. 1 & 2.

**Source:** Monnery & Svrcek, Successfully Specify Three-Phase Separators, Chemical Engineering Progress - Sept 1994.

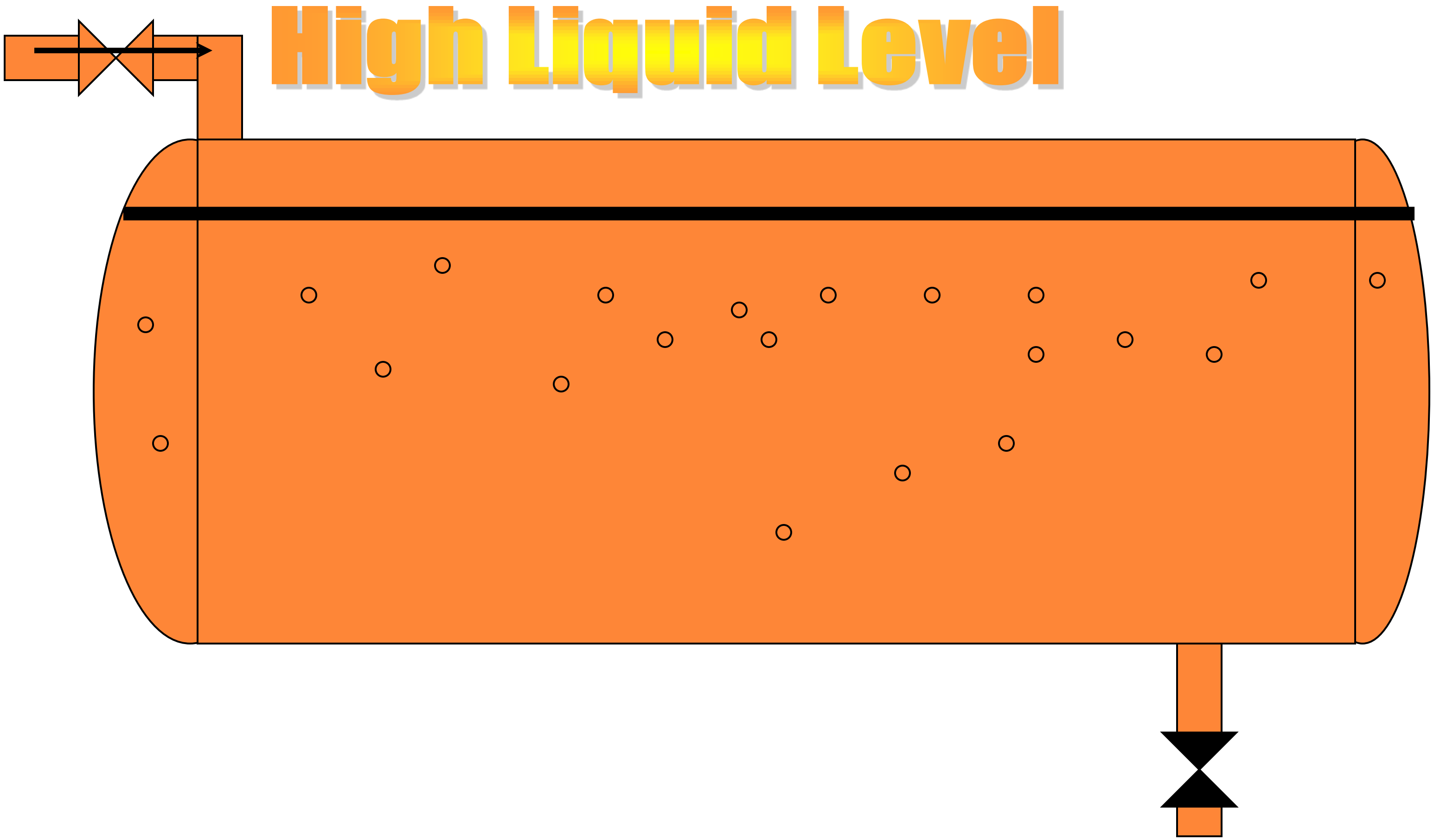
# Surge



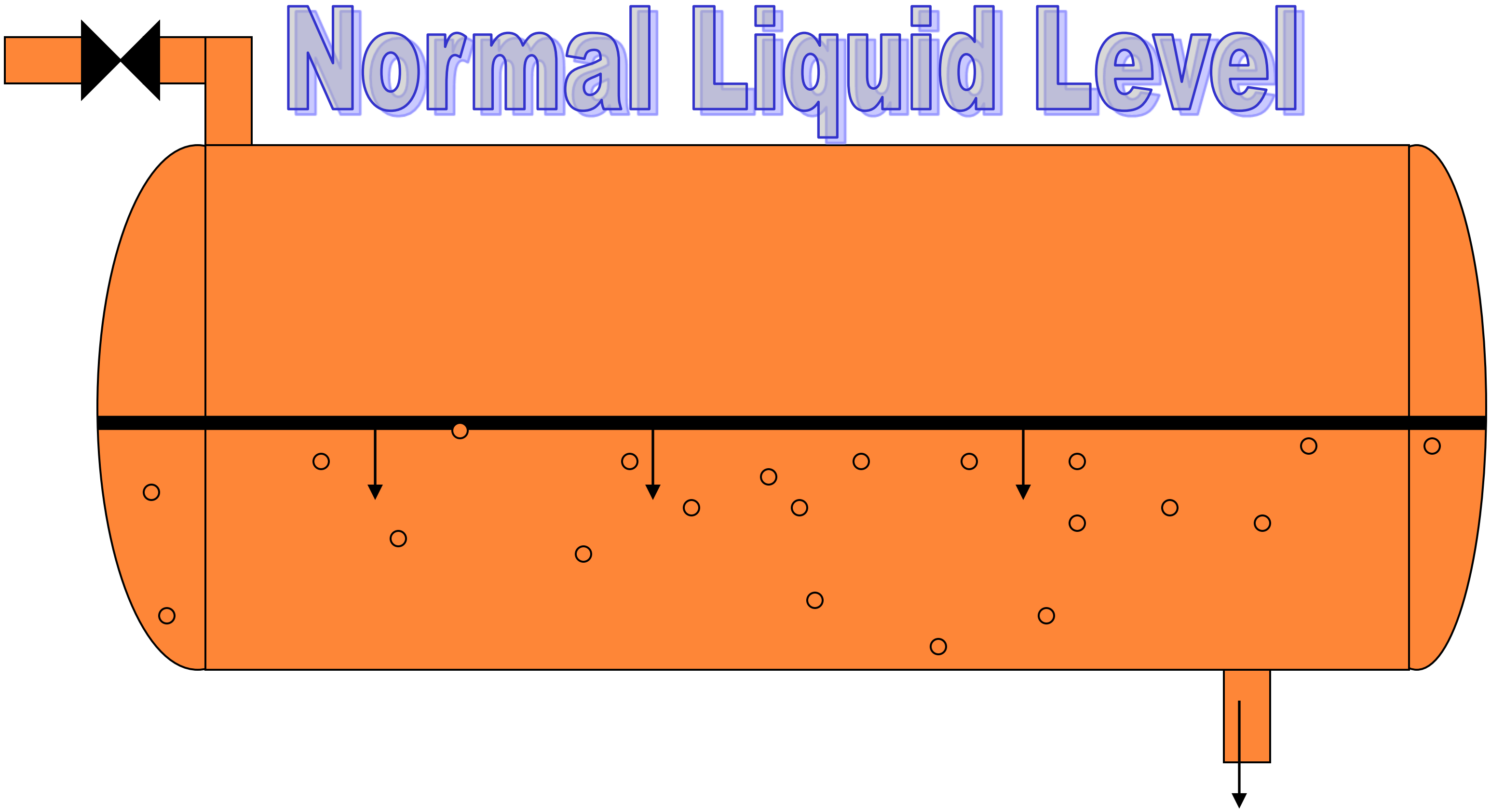
# Surge



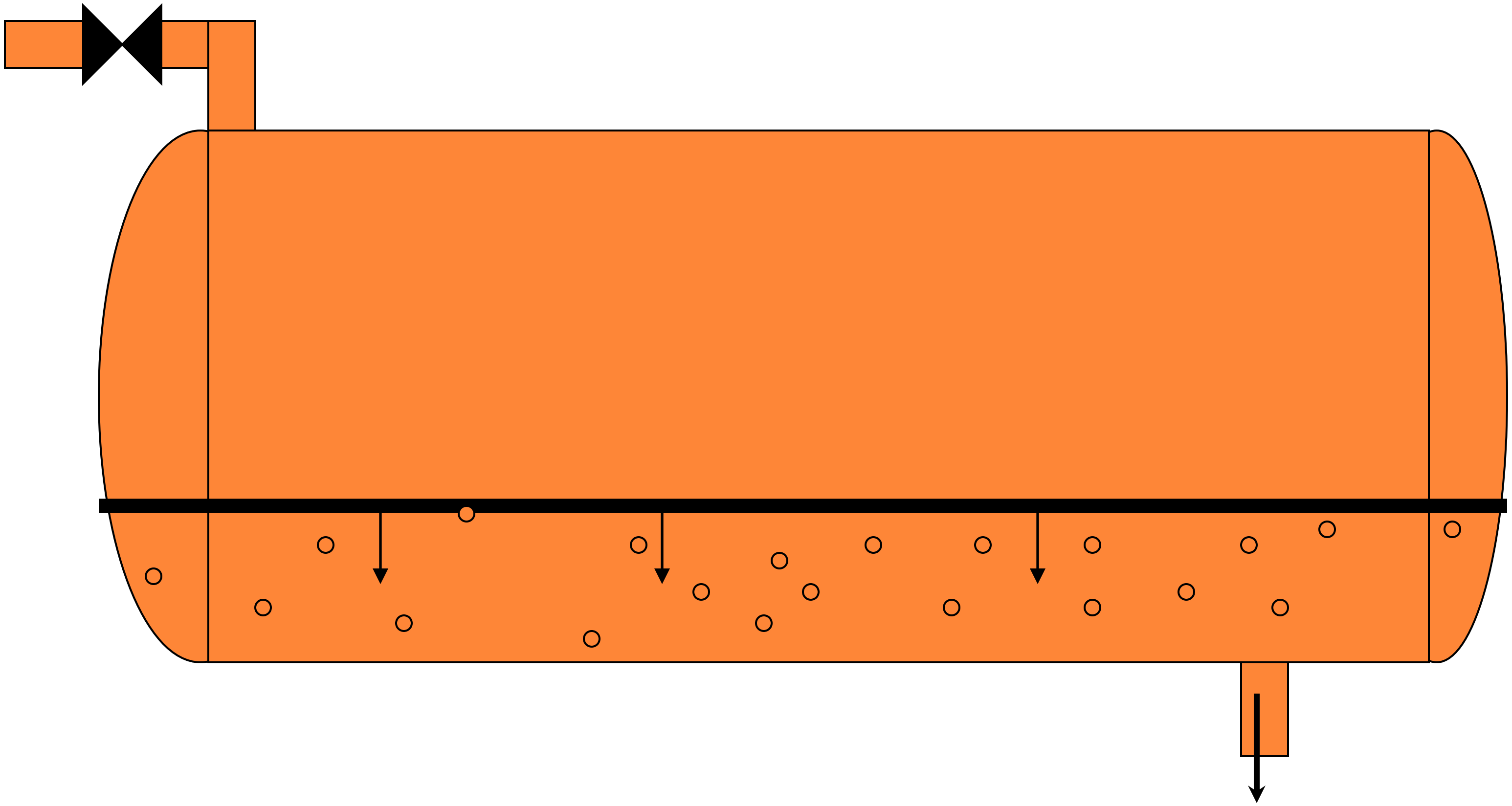
# Surge



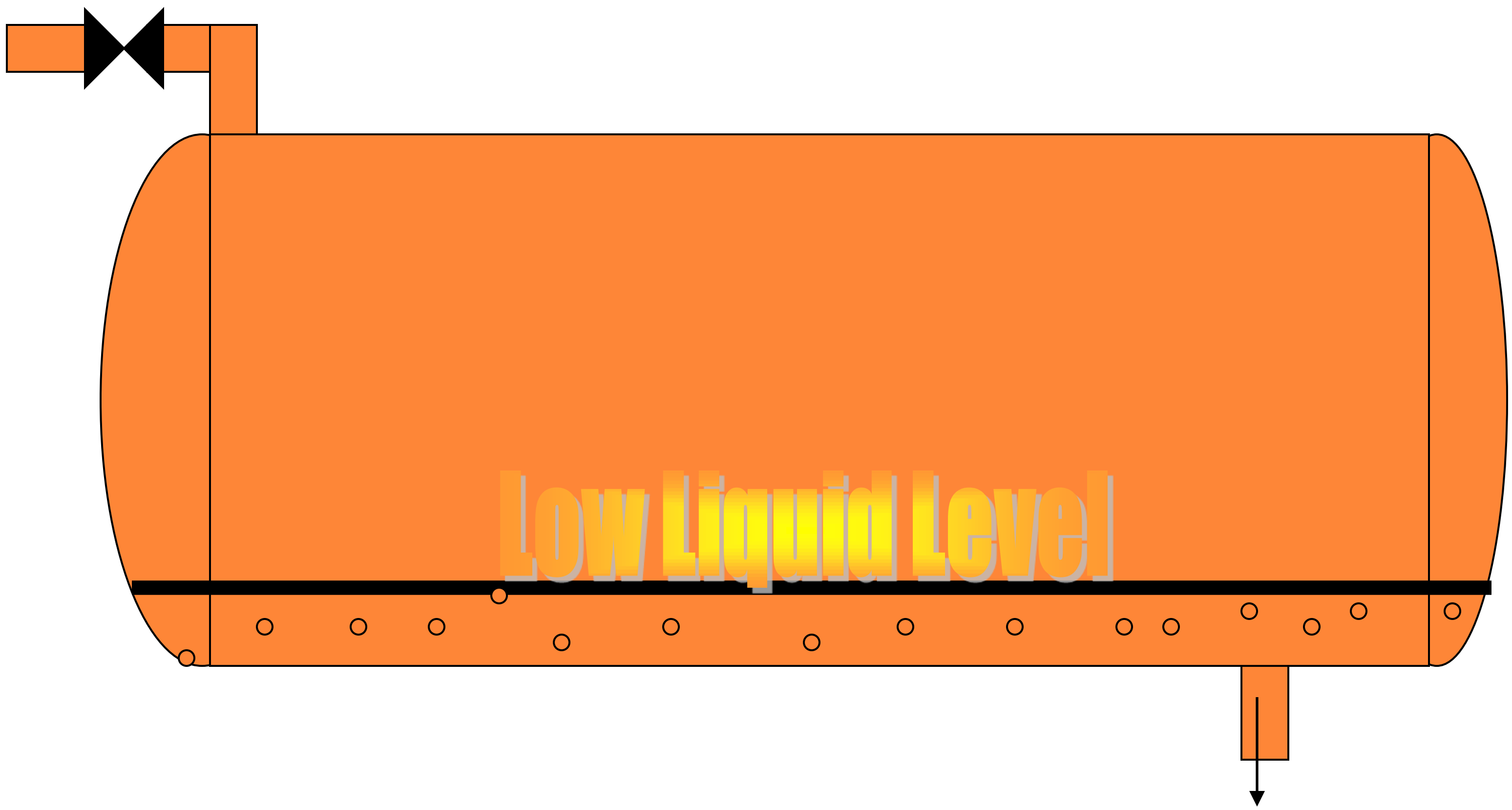
# Holdup



# Holdup



# Holdup



# Liquid Levels Definition

| | |
|---|---|
| NLL | Normal Liquid Level<br>Liquid level maintained by controls during operation |
| HLL | High Liquid Level<br>First liquid level above NLL to trigger an alarm |
| HHLL | High High Liquid Level<br>Second liquid level above NLL to trigger a shutdown |
| LLL | Low Liquid Level<br>First liquid level below NLL to trigger an alarm |
| LLLL | Low Low Liquid Level<br>Second liquid level below NLL to trigger a shutdown |
| Hold-up time (Residence Time) | Time to fill separator from empty to NLL at design liquid feed rate. |
| Surge Time | Time to fill separator from NLL to HLL at design liquid feed rate. |

# Gas Liquid Separator Practical Selection and Design Guide

**Table 3. Low liquid level height.**

| Vessel diameter | Vertical LLL | | Horizontal LLL |
|---|---|---|---|
| | < 300 psia | > 300 psia | |
| ≤ 4 ft | 15 in. | 6 in. | 9 in. |
| 6 ft | 15 in. | 6 in. | 10 in. |
| 8 ft | 15 in. | 6 in. | 11 in. |
| 10 ft | 6 in. | 6 in. | 12 in. |
| 12 ft | 6 in. | 6 in. | 13 in. |
| 16 ft | 6 in. | 6 in. | 15 in. |

**Table 5. L/D ratio guidelines.**

| Vessel Operating Pressure (psig) | L/D |
|---|---|
| $0 < P \leq 250$ | 1.5-3.0 |
| $250 < P \leq 500$ | 3.0-4.0 |
| $500 < P$ | 4.0-6.0 |

Typical vertical separator L/D ratios are normally in the 2–4 range.

**GPSA**

Typical L/D ratios for horizontal separators normally fall in the range of 2.5–5.

Note 1 : For a Test Separator, the residence times are minimised (typically 1.5 minutes between LAL and LAH). This to avoid separation of oil and water in the vessel and enable more accurate water cut measurement of the mixed oil/water stream in the liquid outlet line.

**WP**

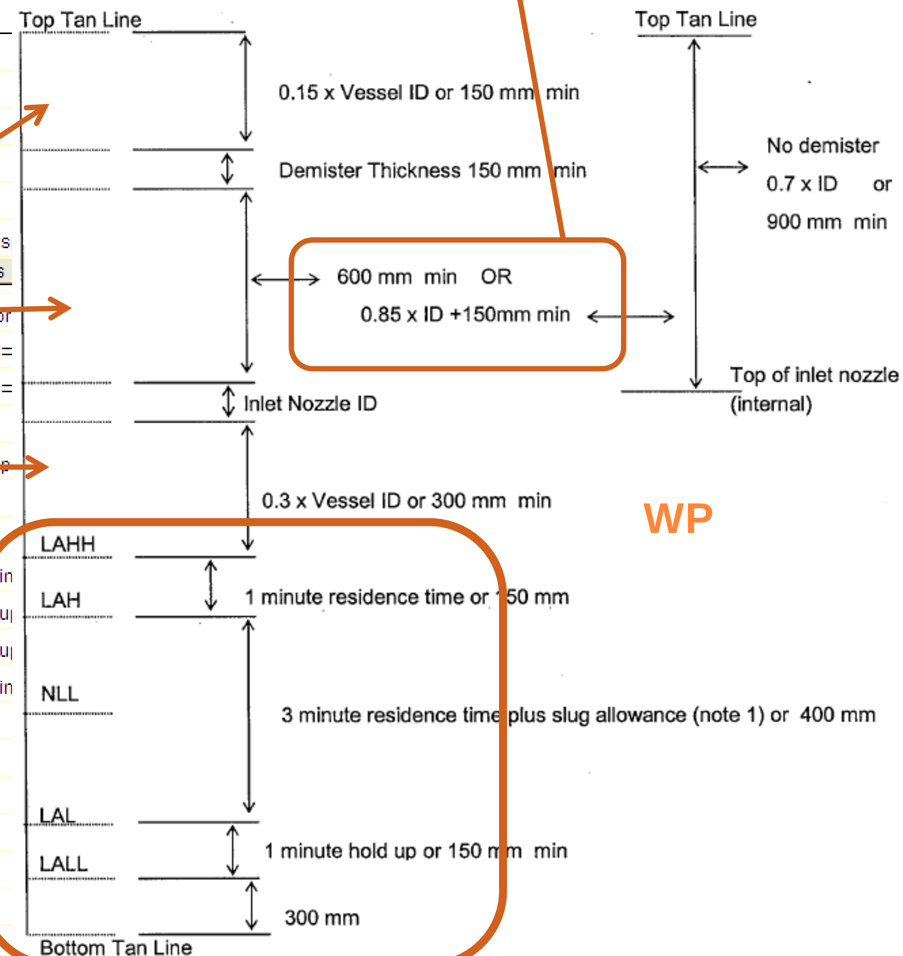
The ratio of the calculated diameter to calculated height should be reviewed. This is generally kept in the range 3 to 5.

| Ht Above Inlet - Specified Minimums Table | |
|---|---|
| with Demister | 600 mm |
| w/o Demister | 900 mm |

| Holdup time for control | | | | | | |
|---|---|---|---|---|---|---|
| HLL to HHLL | = | 1.0 | mins | | | |
| LLL to HLL | = | 3.0 | mins | | | |
| LLLL to LLL | = | 1.0 | mins | | | |
| | | | | | | |
| Height to TTL | = | 228 | mm | 150 | mm | 0.15 x diameter or s |
| Allowance for Demister | = | 150 | mm | 150 | mm | Instructions |
| Height above inlet to Demister | = | 1064 | mm | 600 | mm | 600 mm min or |
| Demister (Y/N) | = | Y | | Include head volume (Y/N) | | = |
| Head volume | = | 0.00 | $m^3$ | Head geometry (E/H) | | = |
| Inlet nozzle height | = | 483 | mm | | | inlet nozzle ID |
| Height to inlet from HHLL | = | 456 | mm | 300 | mm | 0.3 x diameter or sp |
| | | | | Specified Min. | | |
| Height HLL to HHLL | = | 498 | mm | 150 | mm | specified hold up tin |
| Height NLL to HLL | = | 747 | mm | 200 | mm | half specified holdu |
| Height LLL to NLL | = | 747 | mm | 200 | mm | half specified holdu |
| Height LLLL to LLL | = | 498 | mm | 150 | mm | specified hold up tin |
| Height BTL to LLLL | = | 300 | mm | 300 | mm | specified min |
| Total liquid height (from BTL) | = | 2790 | mm | 1000 | mm | |
| Residence time (bottom to NLL) | = | 3.1 | mins | | | |

**Note**
**Slug Volume is 88.7 % of Control Volume between NLL and HLL.**

| Total tan-tan height | = | **5171** | mm | TOTAL | L/D Ratio |
|---|---|---|---|---|---|

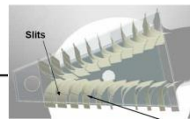



WP



## Calculate Total height, and check surge volume% & L/D ratio, otherwise increase diameter or liquid (vessel) height.

WP For New Design

| Inlet Nozzle | Momentum Limit |
|---|---|
| No internal | Max. Momentum, $\rho_M V_M^2$ = 1000 kg/(m·s$^2$) |
| Half-open pipe | Max. Momentum, $\rho_M V_M^2$ = 1500 kg/(m·s$^2$) |
| Proprietary internal on inlet nozzle   | Typical Max. Momentum, $\rho_M V_M^2$ = 6000 kg/(m·s$^2$). (Vendor to advise) |

| Vapour Outlet Nozzle | Momentum Limit |
|---|---|
| | Max. Momentum, $\rho_v V_v^2$ = 3750 kg/(m·s$^2$) |

| Liquid Outlet Nozzle | Velocity Limit |
|---|---|
| | Max. Velocity, 1 m/s |

GAS OUTLET NOZZLE

The diameter of the gas outlet nozzle, $d_2$, should normally be taken equal to that of the outlet pipe, but the following criterion shall be satisfied:

DEP

$$\rho_G v^2_{G,out} \leq 4500 \qquad \text{[Pa]}$$

In High Vacuum Units this criterion may result in a high outlet velocity, leading to a pressure drop which is too high. In that case the gas outlet nozzle shall be sized such that the pressure drop requirements between column and downstream system are met.

LIQUID OUTLET NOZZLE

The diameter of the liquid outlet nozzle, $d_3$, shall be chosen such that the liquid velocity does not exceed 1 m/s. The minimum diameter is 0.05 m (2 in). The nozzle shall be equipped with a vortex breaker in accordance with Standard Drawing S 10.010.

FEED INLET NOZZLE

The internal nozzle diameter, $d_1$, may be taken equal to that of th momentum criterion (dependent on the inlet device, if any) shall be s

– If **no** inlet device is used:

DEP

$$\rho_m v^2_{m,in} \leq 1\,400 \qquad \text{[Pa]}$$

where:

$\rho_m$ is the mean density of the mixture in the feed pipe

$$\rho_m = (M_G + M_L)/(Q_G + Q_L) \qquad \text{[kg/m}^3\text{]}$$

and $v_{m,in}$ is the velocity of the mixture in the inlet nozzle

$$v_{m,in} = (Q_G + Q_L)/(\pi\, d_1^2 / 4) \qquad \text{[m/s]}$$

– If a **half-open pipe** is used as inlet device:

$$\rho_m v^2_{m,in} \leq 2100 \qquad \text{[Pa]}$$

– If a **Schoepentoeter** is used as inlet device:

$$\rho_m v^2_{m,in} \leq 8000 \qquad \text{[Pa]}$$

The pressure drop across the Schoepentoeter approximates to:

$$\Delta p_{sch} = 0.08 * \rho_m v^2_{m,in} \qquad \text{[Pa]}$$

In High Vacuum Units or in any other unit or separator where the in high because of the low gas density, the use of a Schoepentoeter mandatory. The following velocity limits shall also be satisfied:

DEP For debottlenecking

- To prevent erosion:

$$v_{G,in} \leq 70 \qquad \text{[m/s]}$$

- To prevent choking or damage due to vibrations:

$$v_{G,in} \leq 0.8 v_{sonic,G}$$

# Gas Liquid Separator Practical Selection and Design Guide

**Inlet Nozzle type is selected on following criteria**

- **Gas & Liquid loadings and ratio**
- **Separation quality required by inlet device**
- **To maintain reasonable ratio of vessel dia. to inlet pipe dia.**
- **Vessel Height can be reduced by providing proprietary device**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Nozzles:** | | | | | | | |
| Inlet Device | | ○ No Inlet Device | | ○ Half-open Pipe | ◉ Proprietary Device | | |
| $\rho_m V_m^2$ | = | 6000 | | Min. ID mm | = | 294 | mm |
| Maximum velocity | = | 9.16 | m/s | Selected inlet diameter | = | *483* | mm |
| Vapour Outlet Nozzle | | | | | | | |
| $\rho_v V_v^2$ | = | *3750* | | Min. ID | = | 306 | mm |
| Maximum velocity | = | 8.26 | m/s | Sel. vap. outlet diam. | = | *330.2* | mm |
| Liquid Outlet Nozzle | | | | | | | |
| Maximum velocity | = | *1* | m/s | Min. ID | = | 138.5 | mm |
| | | | | Sel. liquid outlet diam. | = | *146.3* | mm |

**Check sizing of all nozzles for different cases.**
**Nozzles sizing case is NOT same as Vessel governing case.**
**Gas and liquid outlet nozzle's governing case are generally different.**

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THANK YOU

# Selection Check list

**Select Separator type and orientation based on following criteria**

- Gas volumetric rate & Gas to liquid volumetric ratio
- Slug volume
- Operating pressure and allowable pressure drop
- Turndown
- Feed source
- Separation efficiency required @ downstream unit
- Liquid property, fouling, viscous, solids etc..
- Space and head room available / Offshore / onshore application

## Do's & Don't

**a) Do not use vane pack for high turndown (< 30% design flow)**
**b) Do not use wire or knitted mesh for fouling service**
**c) Do not use vane pack above 50 bar operating pressure**
**d) Vertical flow vane pack is not suitable for slug service.**

- ✓ Is feed gas requires de-foaming ?
- ✓ Is liquid feed requires degassing?
- ✓ Is liquid heating required to prevent wax deposition ?
- ✓ Is solid handling required for this service ?

# Design Check list

- ➢ If liquid has two phases, then use density of light phase to calculate vessel diameter. This will give safe design.
- Apply flow margin based on service

Following cases to be checked for separator and nozzles sizing

- Highest Volumetric Gas rate
- Highest Volumetric Liquid rate
- Lowest pressure case for higher volume
- Highest pressure case for difficult separation
- Lowest liquid density case for difficult separation

**Select of K value based on following criteria**

- ✓ Type of internal
- ✓ Service
- ✓ Downstream requirement for gas quality
- ✓ Pressure correction

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- ✓ Orientation correction
- ✓ Liquid loading correction

**Liquid Height Calculation :**

1) Check liquid discharge is on Level Control OR On Off Control between high & low level.

**(do not use spread-sheet defaults, one can go badly wrong)**

2) Find surge volume / time

3) Degassing service ?? (more holding time)

4) Check P & ID for number of levels, alarms and trips number of instruments installed

5) Find type of level measurement, Magnetic type, radar, differential pressure .....

Different types of instruments has different minimum distance requirements

6) Most important liquid control & hold-up volume is based on (A) service (separator, KO drum, flash drum) and (B) downstream equipment requirement, i.e.

a) Feed to pump, b) Feed to vessel / column or c) Feed to exchanger

7) Check P & I D for other nozzles; i.e. , size & locations for PSV, manhole etc.. This can affect vessel height.

- ✓ **Check L/D ratio based on orientation**
- ✓ **Check layout for footprint and head room availability**
- ✓ **Check API 12 J before preparing process data sheet.**

- ❖ Check possibility of Weight / Space / Cost Optimisation by using vane pack / cyclone Internal for following cases
- High gas rate
- High design / operating pressure
- Exotic / Expensive MOC
- Low liquid with clean service
- Space constraint (Offshore platform)