User Manual

SepSim V1.0

1. Introduction

This manual provides detailed guidance for using the SepSim V1.0 – Module: Liquid Carryover in Gas Prediction via cloud application. The app is designed for engineers to analyze separation performance of oil and gas separators. It is based on methods described in technical literature, notably the SPE Journal of Petroleum Technology articles 'Gas/Liquid Separators: Quantifying Separation Performance' (Parts 1 and 2), Pan & Hanratty (2002), and Taitel & Dukler (1976).

The app quantifies entrainment, calculates droplet size distributions, evaluates mist extractor performance, estimates pressure drops, and classifies flow regimes. The approach integrates theoretical models, empirical correlations, and digitized boundary data from industry-standard flow regime maps. This makes the tool suitable for design verification, troubleshooting, and training purposes.

2. System Requirements

No Special Requirement.

3. Methods

The methods implemented in the app are rooted in first principles of multiphase flow, augmented by empirical correlations for internals such as mesh pads, vane packs, and cyclones.

4. App Layout & Theme

Layout (Wide vs. Centered)

- The app supports a wide layout for maximum screen real estate (best for tables/plots) or a Centered layout for a compact view.
- Typical setting: wide layout for engineering dashboards.

Theme (Light / Dark / System)

- Choose Light or Dark for fixed appearance, or System to match your OS theme automatically.
- Theme affects charts, tables, and components for consistent visibility.

How to change these in the app

- Click the Settings (⚙) → Theme to switch Light/Dark/System.
- Layout (wide) is preconfigured by the app; no action needed by most users.

User Manual

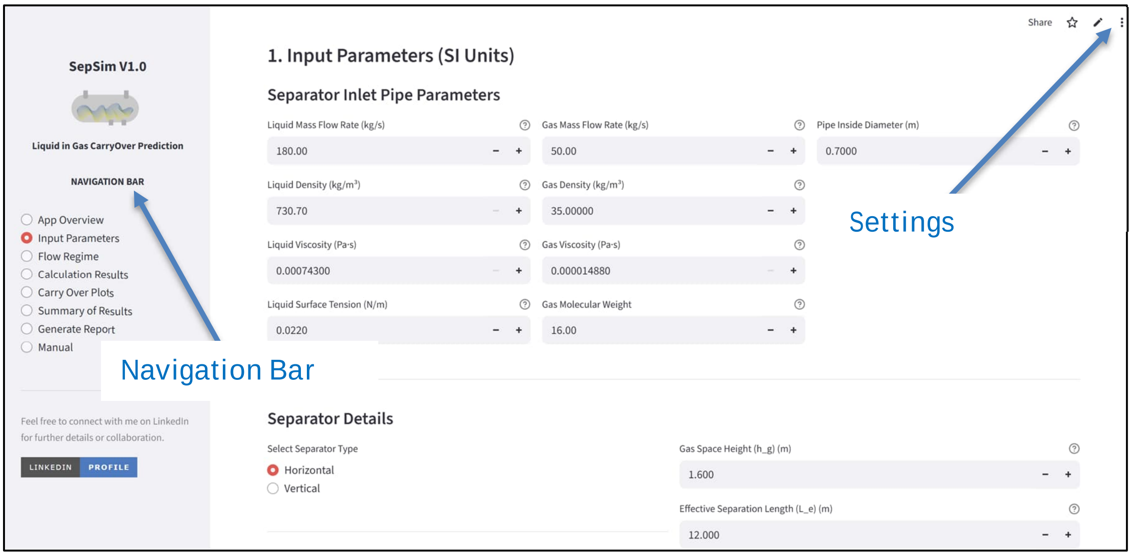
SepSim V1.0

Sidebar Navigation

- The left sidebar provides quick navigation between pages/sections (e.g., *Inputs*, *Calculations*, *Plots*, *PDF Report*).
- Use the sidebar menu (radio buttons) to jump directly to a section—your current selection controls what appears in the main panel.
- The sidebar may also include filters, sliders, and toggles relevant to the visible page.

Pro Tips

- If you're on a small screen, collapse/expand the sidebar to maximize space.
- After changing inputs via the sidebar, revisit calculation/plot pages to refresh outputs before exporting the PDF.



5. Input Guidelines

Help Tool

Refer to the help icon near each input box for detailed guidance on parameter entry.

Fluid Assumption

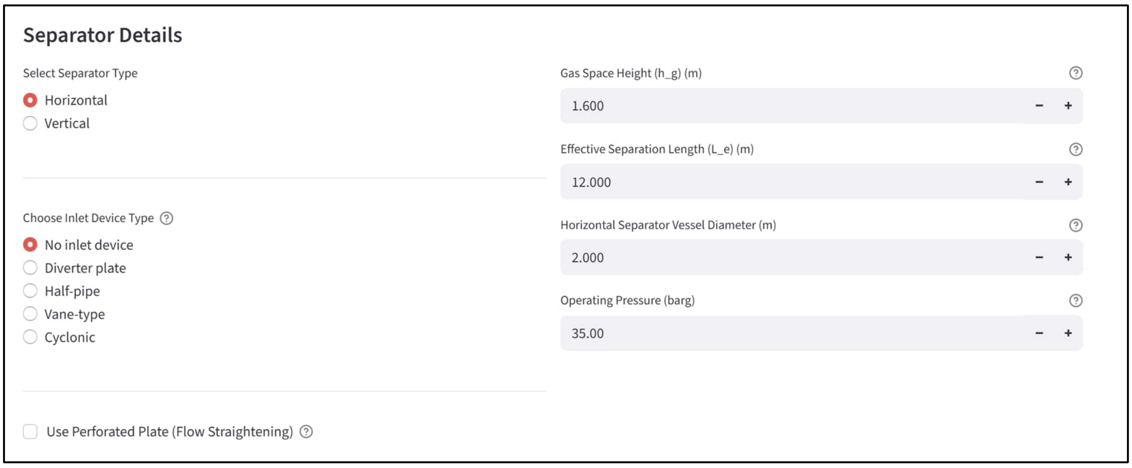
The current version of the application assumes the liquid phase is oil/condensate, which has a lower surface tension than the aqueous phase. This assumption governs the separation behaviour modelled in the tool.

User Manual

SepSim V1.0

Separator Dimensions and Pressure Data

- The user must provide the separator dimensional details in this section.
- Operating pressure is used to calculate the derating of the gas load factor (K), which directly influences separator capacity.



Inlet Device Selection

- The user can select the inlet device type from the available options.
- If calming baffles (perforated plates) are present, they can be specified here.
  - Perforated plates enhance the gravity section efficiency by improving flow distribution.
  - However, they may negatively impact mist extractor performance due to velocity reduction downstream.

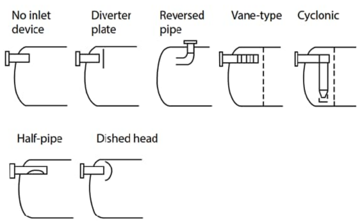
User Manual

SepSim V1.0

⚠ Warning – High Momentum

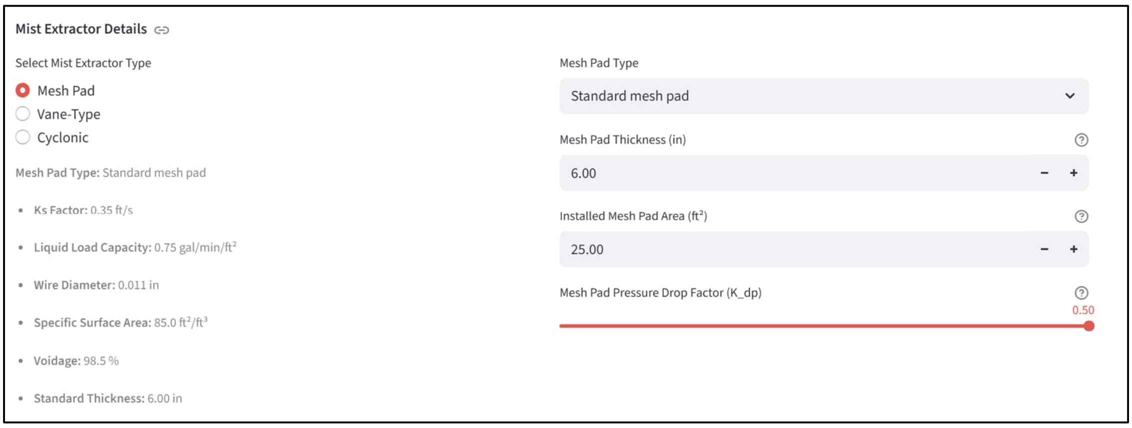
If the inlet momentum is too high, the application will trigger a high momentum warning. Excessive inlet momentum can shear droplets into smaller sizes, making separation more difficult. In such cases, a more suitable inlet device should be considered.

Inlet momentum (1747.82 lb/ft-sec^2) is above the maximum defined for 'No inlet device' (675.00 lb/ft-sec^2). Using minimum shift factor: 0.080.



Inlet Device Type	ρV^2, lb/ft-sec^2
No inlet device	700
Diverter plate	950
Half-pipe	1,400
Vane-type	5,400
Cyclonic	10,000

Mist Extractor Details



- For each mist extractor type, the user must specify the pressure drop factor (K_{dp}).
- The K_{dp} slider range is limited to practical values consistent with vendor data. For accurate prediction, always refer to vendor documentation.
- In this version, the base gas load factor (Ks) for mist extractors is predefined from references. Future versions will allow customization by the user.
- The mist extractor area is a key parameter for evaluating whether the operating point is within the acceptable range or entering the re-entrainment zone.

6. Methods

6.1 Droplet Settling Theory

The motion of liquid droplets in a gas stream is governed by the balance of three forces:

- Gravitational force (downward)
- Buoyancy force (upward)
- Drag force (resisting motion)

At equilibrium, the droplet reaches a terminal settling velocity, V_t which is determined iteratively:

$$V_t = \left(\frac{4gd_p(\rho_l - \rho_g)}{3C_d\rho_g}\right)^{0.5}$$

The drag coefficient Cd, is a function of the particle Reynolds number, and is calculated using the Schiller–Naumann correlation:

$$C_D = \begin{cases} 24\left(1 + 0.15Re^{0.687}\right)/\ Re & Re \leq 1000 \\ 0.44 & Re > 1000 \end{cases}$$

This formulation ensures accurate calculation of droplet settling velocity across laminar, transitional, and turbulent flow regimes.

6.2 Entrainment and Droplet Size Distribution

The Entrainment fraction(E) is estimated using empirical correlations such as Pan & Hanratty (2002), which relate entrainment to gas velocity and fluid properties.

$$\frac{(E/E_\mathrm{M})}{1 - (E/E_\mathrm{M})} = A_2\left(\frac{DU_\mathrm{G}^3\rho_\mathrm{L}^{0.5}\rho_\mathrm{G}^{0.5}}{\sigma}\right)\left(\frac{\rho_\mathrm{G}^{1-m}\mu_\mathrm{G}^m}{d^{1+m}g\rho_\mathrm{L}}\right)^{1/(2-m)}$$

The droplet size distribution (DSD) is represented by a log-normal distribution, parameterized by mean diameter and standard deviation. Shift factors are applied based on inlet device type (e.g., vane inlet, cyclonic inlet, half-open pipe), following methodologies described in SPE publications.

This enables the application to model how different inlet devices modify the initial spectrum of entrained droplets.

$$f_v(d_p) = \frac{\delta d_{max}}{\sqrt{\pi} d_p (d_{max} - d_p)} \exp(-\delta^2 z^2)$$

6.3 Gas Gravity Separation Section

The gas gravity separation section is evaluated using settling theory combined with the F-factor to account for flow maldistribution.

- Droplet removal efficiency is determined by comparing the settling time of a droplet with the residence time available in the separator's gravity section.
- Perforated plates, inlet devices, and maldistribution are accounted for by applying derating factors to the effective velocity field.

6.4 Mist Extractor Performance

Mist extractors enhance separation efficiency for fine droplets. Three types are modeled:

- Mesh pads: Capture efficiency based on single-fiber theory.
- Vane packs*: Efficiency based on inertial impaction as droplets follow curved flow paths around vanes. Parameters include vane spacing, bend angle, and gas velocity.
- Cyclones: Efficiency modeled by the Stokes number, relating droplet inertia to centrifugal forces.

For the mist extractor types described above, droplet capture efficiency is estimated using established literature correlations. These values represent a conservative baseline (minimum performance). In actual operating conditions, the measured efficiency is typically higher than the estimates provided by the application.

⚠️ Note: Pocketed vanes generally exhibit higher efficiency compared to simple vanes; however, in this program, the calculation method remains the same for both options.
For detailed design and vendor-specific guarantees, always refer to manufacturer documentation.

6.5 Flow Regime Determination

The flow regime is determined using the Taitel & Dukler (1976) flow regime map, based on gas and liquid superficial velocities.

- Transition boundaries are digitized for stratified, slug/intermittent, dispersed bubble, and annular regimes.

- The operating point calculated from input conditions is plotted on this map to classify the prevailing flow regime.

Best Practice: Operation should aim for the stratified regime, where entrainment is minimized. Transition into the annular regime leads to significantly higher entrainment and carryover, and should be avoided whenever possible during design and operation.

7. Main Panel – Results Display

The Main Panel dynamically updates to present the results of your calculations in both graphical and tabular formats.

📊 7.1 Plots

- Droplet Size Distribution (DSD) Plots

  Multiple plots are generated to visualize the cumulative droplet volume (undersize/oversize) at different stages of separation:

  - Original DSD
  - Adjusted DSD (after adjusting for inlet device)
  - DSD after gravitational settling
  - DSD after the mist extractor

  The number of points used to generate the Droplet Size Distribution (DSD) plots is user-adjustable, allowing control over the resolution and smoothness of the plotted curves.

  - Range: 10 to 100 points
  - Default Setting: 20 points (minimum resolution, faster plotting)

  Using fewer points (e.g., 10–30) provides quicker plot generation but with lower resolution, while selecting higher values (50–100) produces smoother, more detailed curves suitable for technical reports and presentations.

  ⚠️ Note: Reducing the number of points affects only the curve smoothness; the overall distribution trend and interpretation remain valid.

- Flow Regime Map

  A graphical map showing the calculated two-phase flow regime based on superficial velocities. The computed operating point is highlighted, indicating whether the flow is Stratified, Dispersed Bubble, Intermittent, or Annular.

📋 7.2 Results Table

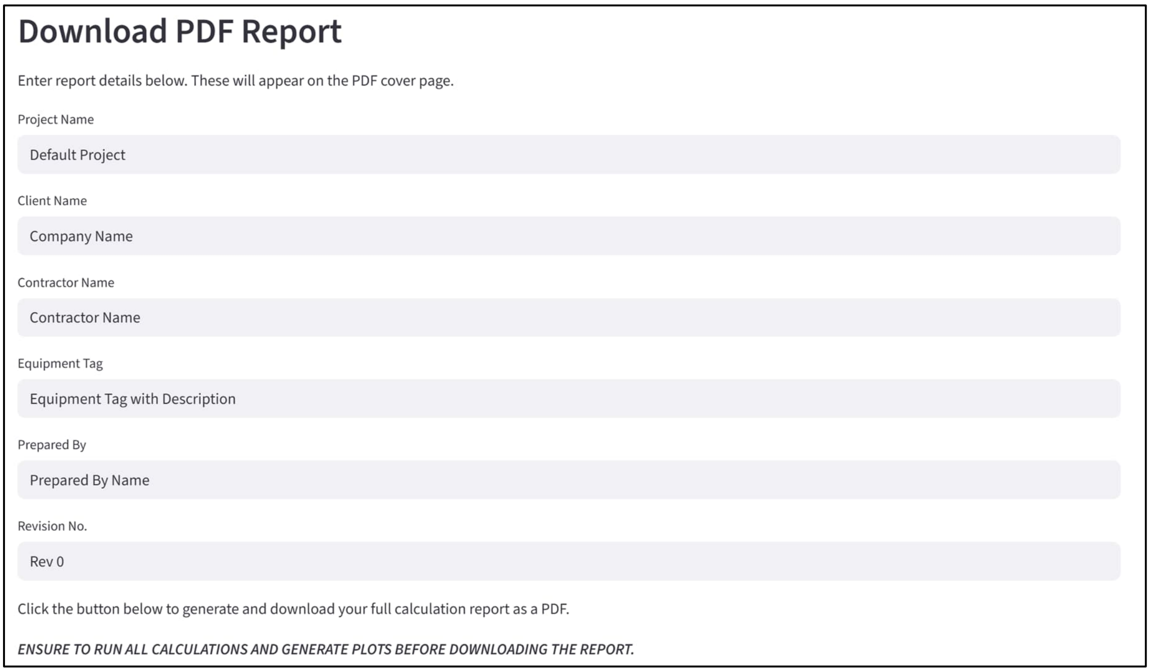
The results are summarized in a detailed table that includes:

- Inlet Device Performance: Entrained liquid mass flow rate and separation efficiency of the inlet device.
- Gravity Section Performance: Entrained liquid mass flow rate and efficiency after the gravity settling section.
- Mist Extractor Performance: Entrained liquid mass flow rate and efficiency of the mist extractor.
- Overall Separator Performance: Total entrained liquid carried over and overall separation efficiency.
- Design Parameters: Final derated Ks, liquid loading, and excess liquid loading — essential for assessing separator sizing and performance.

8. Generate Report:

The application allows you to generate a professional PDF report containing:

- All input parameters
- Output tables
- Plots and Charts



Download PDF Report

Enter report details below. These will appear on the PDF cover page.

Project Name

Default Project

Client Name

Company Name

Contractor Name

Contractor Name

Equipment Tag

Equipment Tag with Description

Prepared By

Prepared By Name

Revision No.

Rev 0

Click the button below to generate and download your full calculation report as a PDF.

ENSURE TO RUN ALL CALCULATIONS AND GENERATE PLOTS BEFORE DOWNLOADING THE REPORT.

On the Generate Report page, please enter the following details:

- Project Name
- Client Name
- Contractor Name
- Equipment Tag
- Prepared By
- Revision Number

✅ **Important:** Before clicking the **Prepare PDF** button, make sure you have:

- Visited all calculation pages
- Generated the required plots
- Reviewed the inputs

✅ This step is necessary to ensure that all changes are correctly captured in the PDF report.

9. References

1. Taitel, Y., & Dukler, A. E. (1976). A Model for Predicting Flow Regime Transitions in Horizontal and Near Horizontal Gas-Liquid Flow. AIChE Journal.

2. Pan, L., & Hanratty, T. J. (2002). Correlation of entrainment for annular flow in horizontal pipes. International Journal of Multiphase Flow.

3. Gas/Liquid Separators: Quantifying Separation Performance (Part 1), JPT, 2020.

4. Gas/Liquid Separators: Quantifying Separation Performance (Part 2), JPT, 2020.

Credits

I would like to thank my son, whose encouragement sparked my interest in developing this application and whose valuable input helped me refine its design, flow, and coding.
