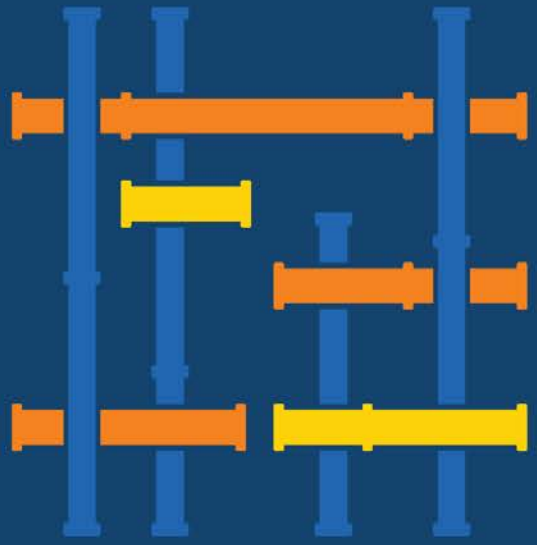

2020 AFPM SUMMIT

Excellence in Plant Performance

AFPM WEBINAR SERIES:

REBOILER CIRCUITS FOR TRAYED COLUMNS

APRIL 30, 2020

WHAT IS AFPM WEBINAR SERIES?

- As we embark in developing The Summit, Excellence in Plant Performance,
  there will be more opportunity for member engagement

- There will be one webinar a month until the August Summit :

  May 20 - 21, 2020 - “Learning Teams” - A Two Part Series

  - Michael Vopatek, Maintenance Manager, LyondellBasell
  - Sahika Korkmaz, Senior Human Performance Advisor, Chevron
  - Chelsea Miller, Human Performance Advisor, Chevron

  June - Gasoline Processing

  July - Operational Planning, Control & Automation Technologies

AFPM
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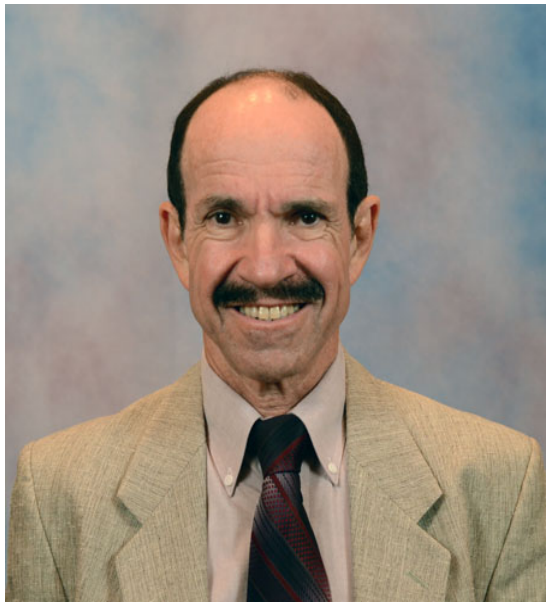

Henry Kister
Senior Fellow
Director of Fractionation Technology
Fluor

- 30 years experience in design, troubleshooting, revamping, field consulting, control and startup of fractionation processes and equipment
- Author of 3 books, distillation equipment chapter of Perry's Handbook, distillation chapter in the Kirk-Othmer Encyclopedia of Chemical Technology, over 120 articles
- Taught the IChemE-sponsored "Practical Distillation Technology" course over 530 times in 26 countries
- Recipient of several engineering awards
- BE and ME from the University of New South Wales in Australia
- Fellow of AIChE, IChemE, member of the US National Academy of Engineering
- Serves on the FRI Technical Advisory and Design Practices Committees

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Reboiler Circuits
Part 1: Reboiler Selection

Fractionation Research Inc.
Design Practices Committee

AFPM Webinar April 30, 2020

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Reboiler Circuits

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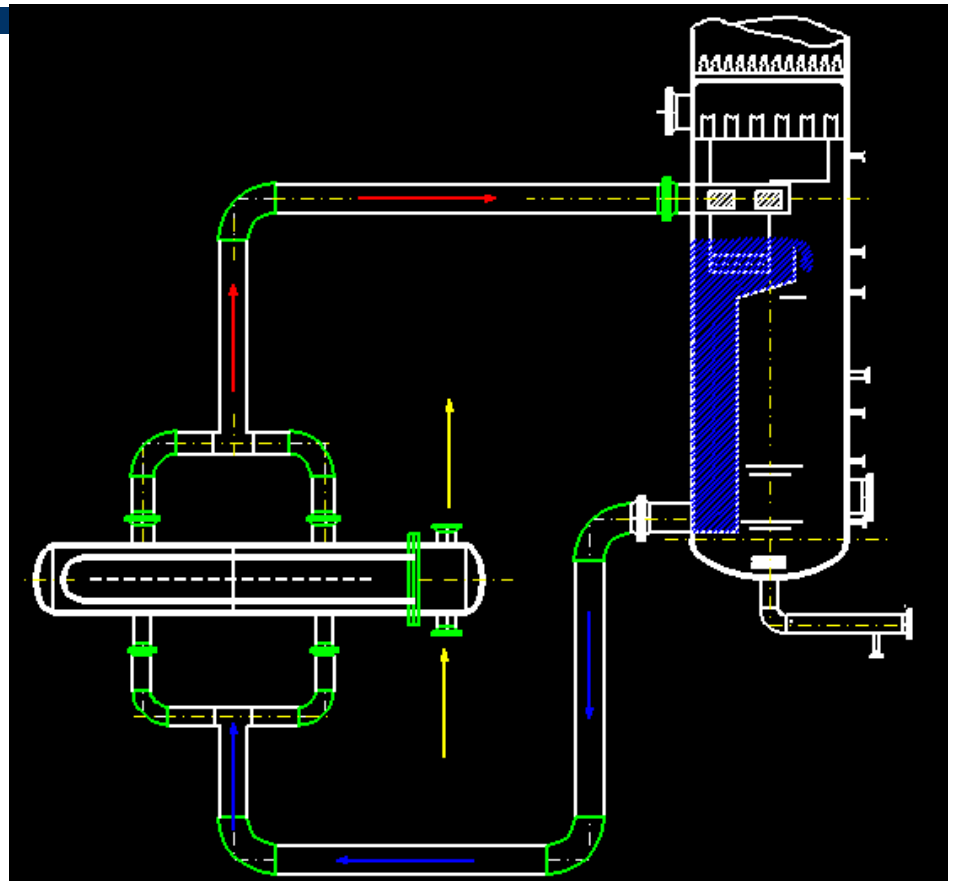
Introduction

- Tower bottoms and reboiler circuits should be considered as key tower internals
- Overall tower performance is dependent on a proper design of both tower bottoms and reboiler
- Taken together they are thought to be the second-most common cause of tower problems



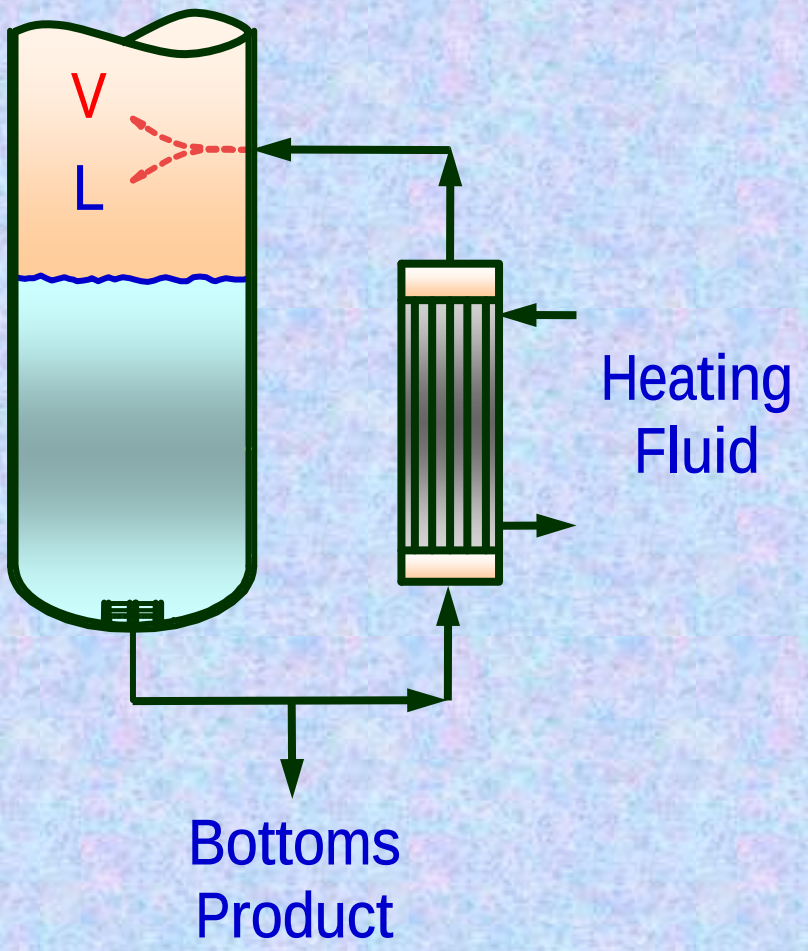
Example of a complex geometry: Recirculating horizontal Thermosiphon with constant head internal baffle.

Reboiler Selection Considerations

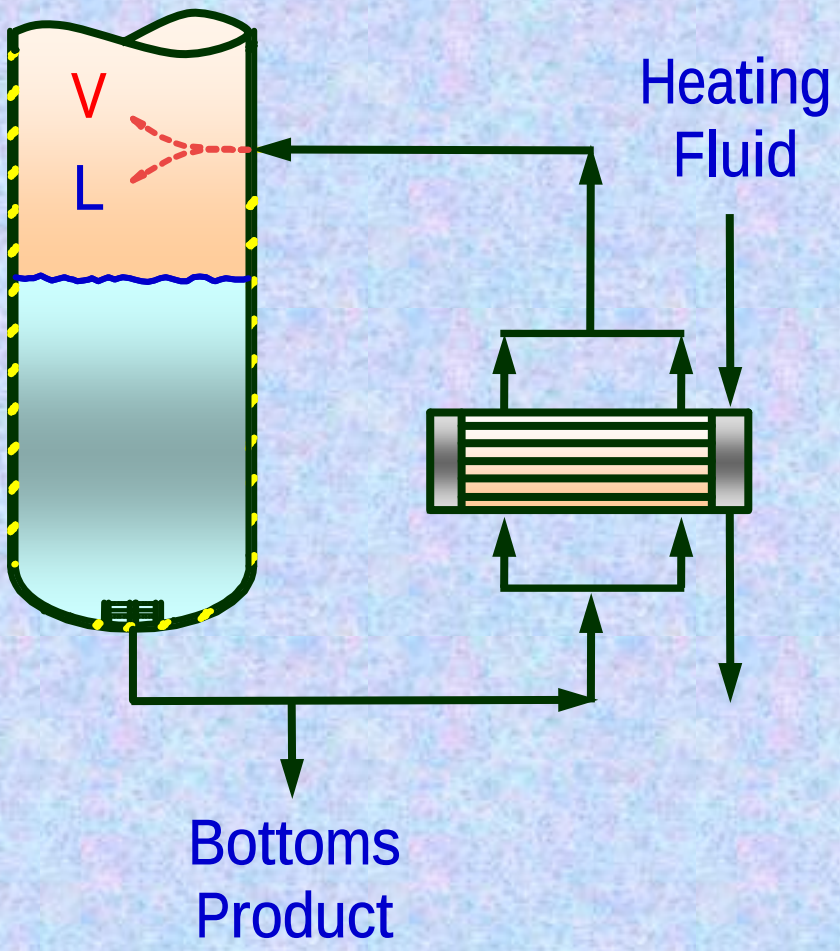
- Thermosiphons should be considered first
  - Gravity flow systems – utilize the density difference between the feeding liquid and mixed phase fluid in the return
  - Tend to be the most economical
    - Compact – smaller heat exchangers
    - Minimum plot space for vertical exchangers
    - Require no pumps
  - Low to moderate fouling tendency
  - Low residence times
  - Most widely used type in distillation
- Not applicable to all systems
  - High liquid viscosity (>10 cP)
  - Heavily fouling systems
  - Adequate driving head not available
  - Large operating load variation
  - When high reliability is critical

Thermosiphons can sometimes be problematic in vacuum where small liquid head variations largely impact the boiling point, leading to large & head-dependent preheat zone in the reboiler. Can be mitigated by a constant head and good design.

Circulating Vertical Thermosiphon



Circulating Horizontal Thermosiphon



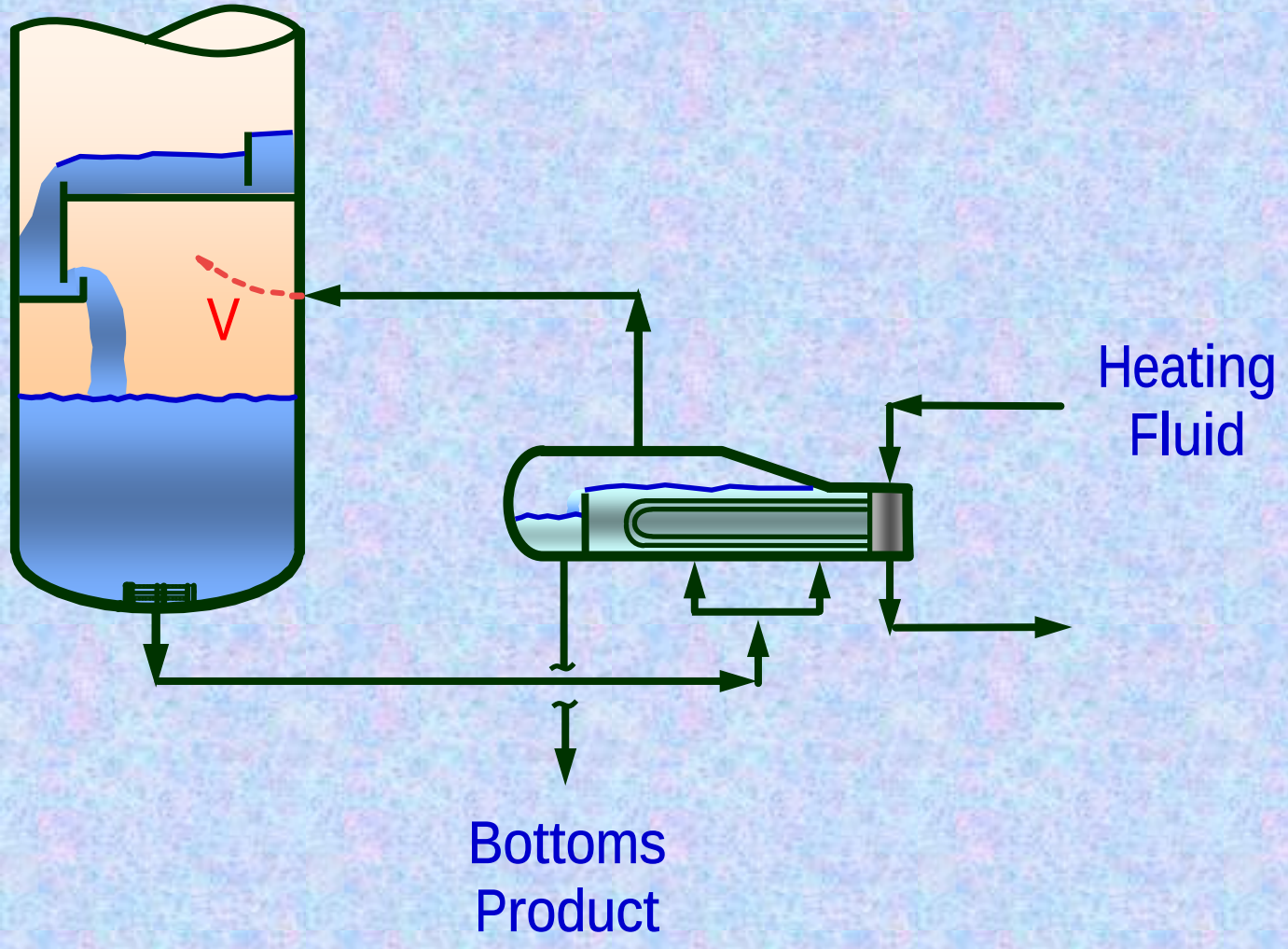
Vertical or Horizontal ?

- Literature gives confusing accounts
  - Vertical exchangers predominate in chemical industry
    - Limited in tube length
  - Horizontal are more common in refining applications

- Vertical Preferred
  - Minimum plot space
  - Minimum return piping
  - Fouling process side
  - High pressure process side
  - Less expensive

- Horizontal Preferred
  - Large heat transfer area
  - Minimize skirt height
  - Fouling heating side
  - High pressure heating medium
  - Better access for maintenance

Standard Kettle

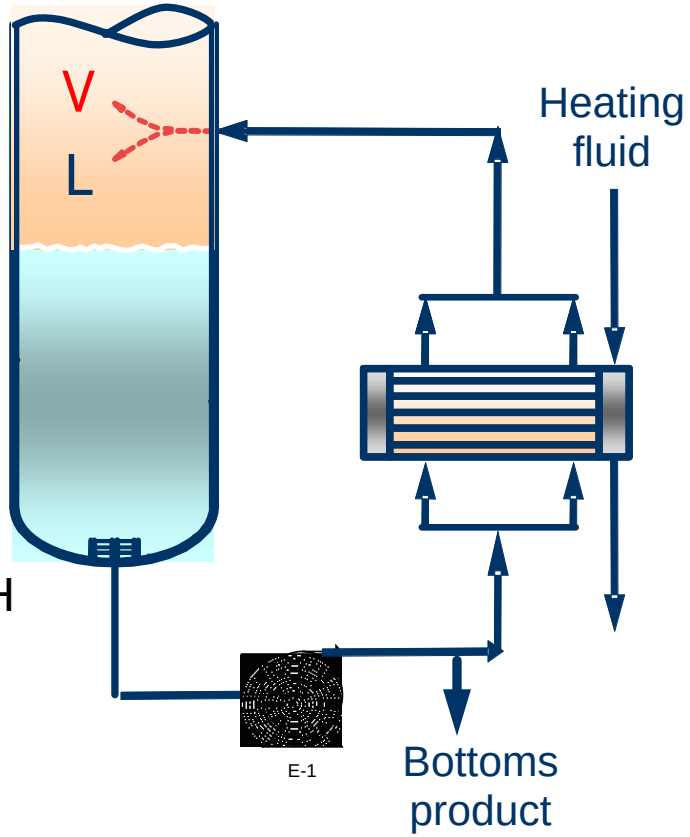


Kettle?

- Kettles are the next most widely used reboiler types
  - Reliability – composition instability & large flow operating load variation
  - Small driving head requirements (smaller skirt height)
  - Ability to handle large surface areas in a single shell
- Kettles have the following disadvantages:
  - High capital cost – low heat transfer rate
  - Not recommended for process fouling services
  - Not recommended for high viscosity liquids
  - High residence time

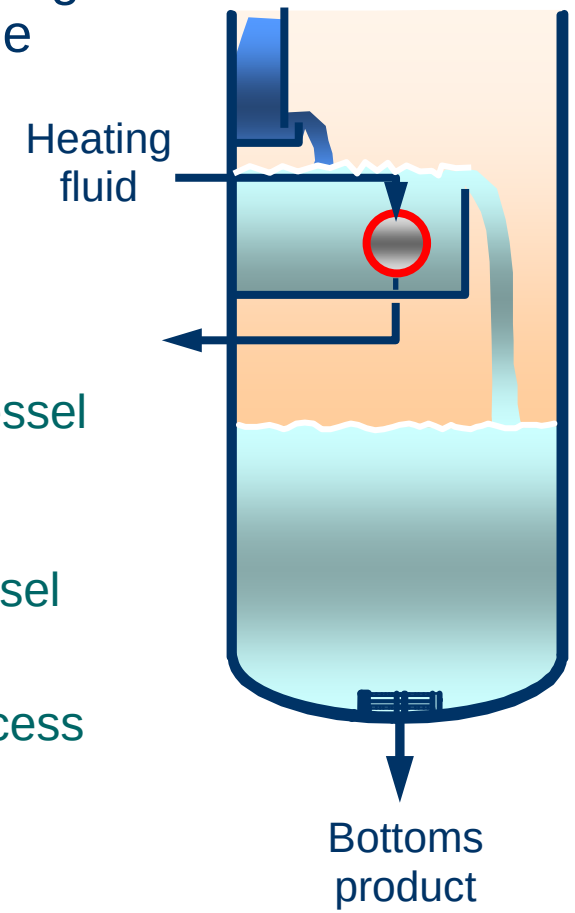
Forced Circulation?

- Forced circulation – the reboiler feed liquid is pumped through either the tube side of a vertical or shell side of a horizontal exchanger
  - High heat transfer rate
  - Good for high viscosity liquids
  - System of choice for fouling systems
  - Good for instability type systems
  - Additional operating and capital cost
    - Pump – cost, maintenance, sparing
    - Controls
    - Piping, valves
    - Additional skirt height for pump NPSH
  - Safety – potential for leaks and fire



Internal Reboiler?

- Internal reboiler – exchanger tubes are submerged either in a tub or liquid bottom sump inside the tower
  - Not widely used
  - Clean system
  - Low heat transfer
  - Low surface area
  - Mechanical design of internal supports and vessel flange must be considered
  - Additional tower height
  - Difficult to maintain – access only through vessel
- Advantages:
  - Low capital cost – no pressure vessel, no process piping
  - No plot space



Reboiler Circuits
Part 2: Tower Bottom Arrangements

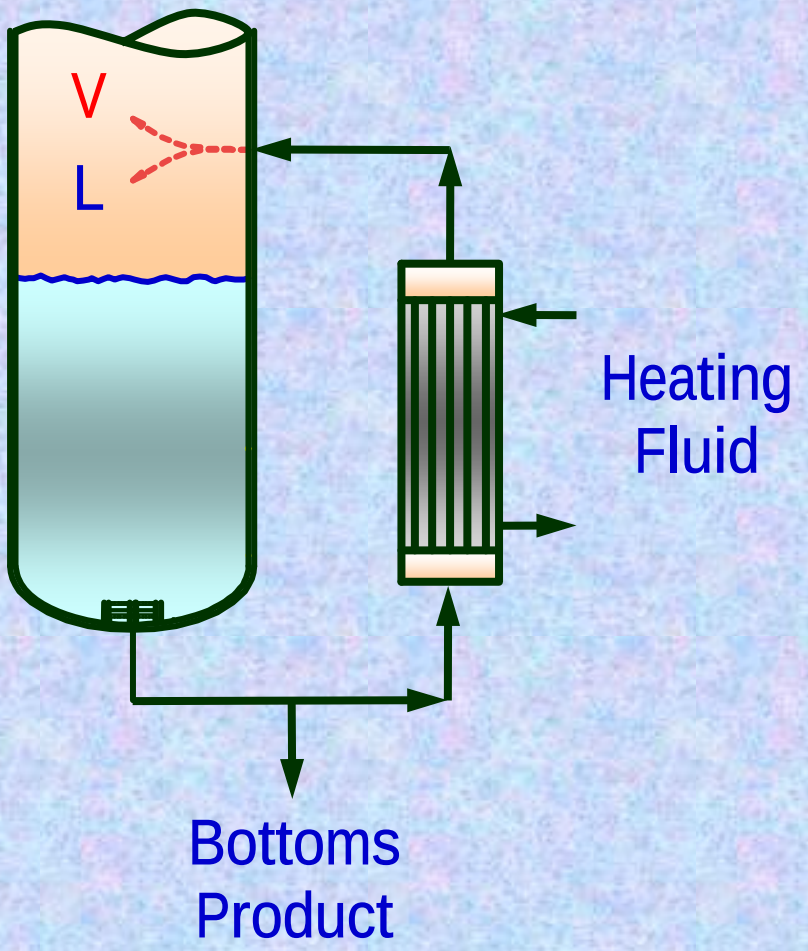
Fractionation Research Inc.
Design Practices Committee

AFPM Webinar April 30, 2020

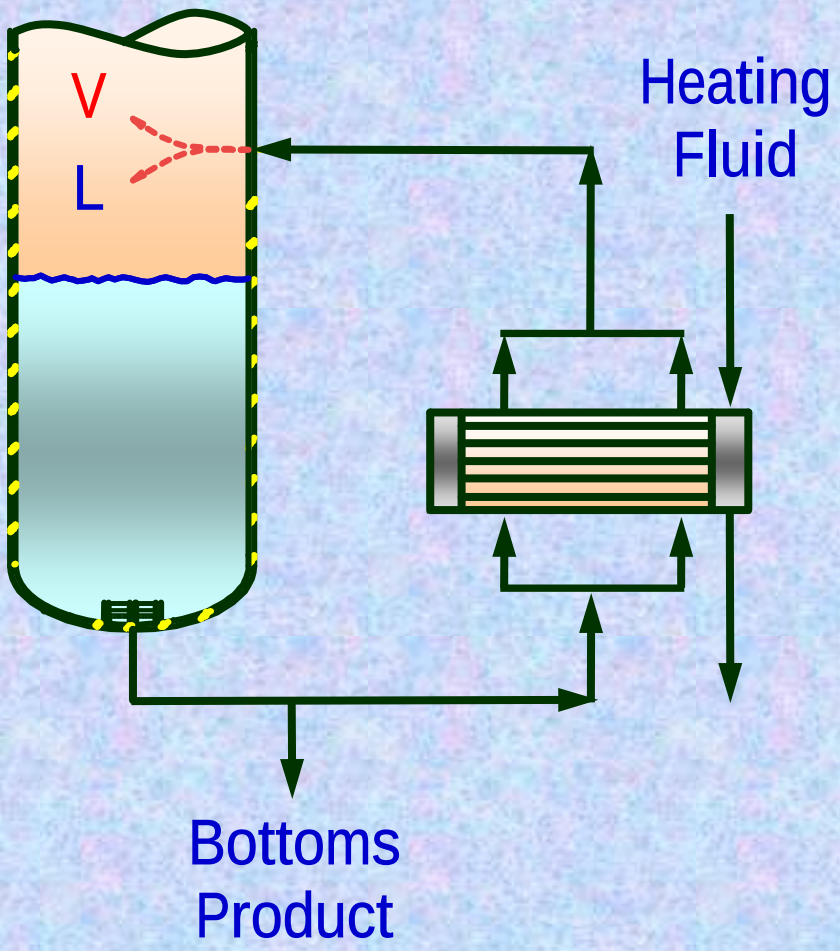
Recirculating Vs. Once-Through

- In once-through, bottom tray liquid traverses through reboiler once
- Recirculating portion of the reboiler effluent mixes with the reboiler feed

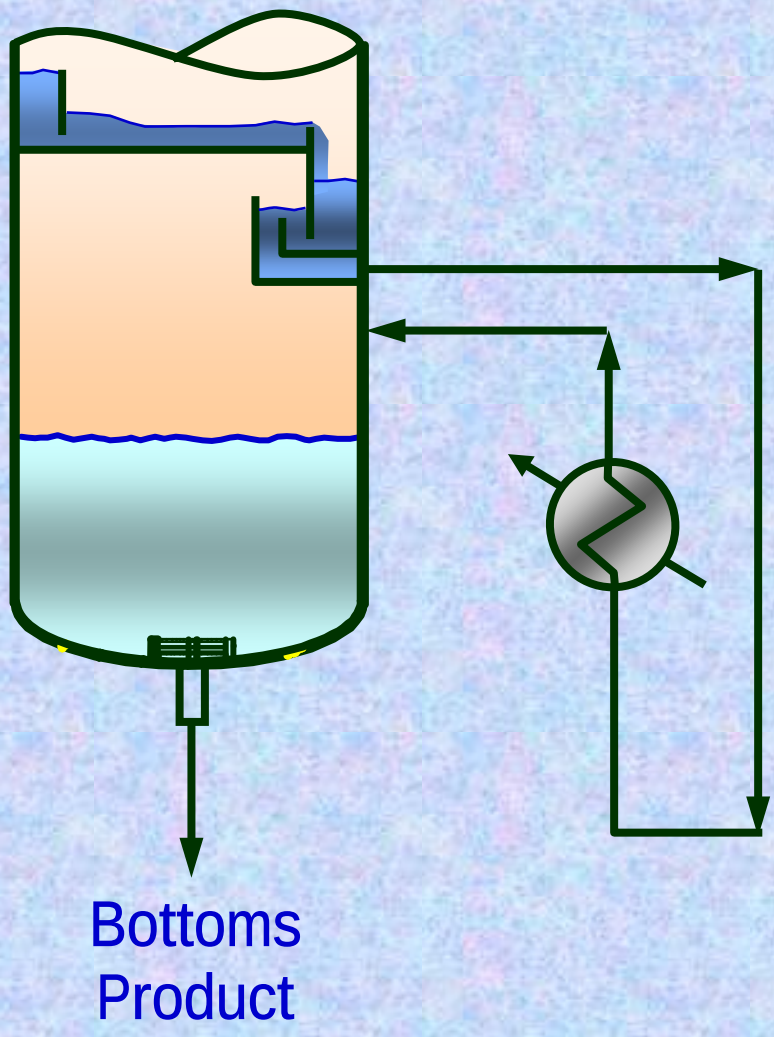
Circulating Vertical Thermosiphon



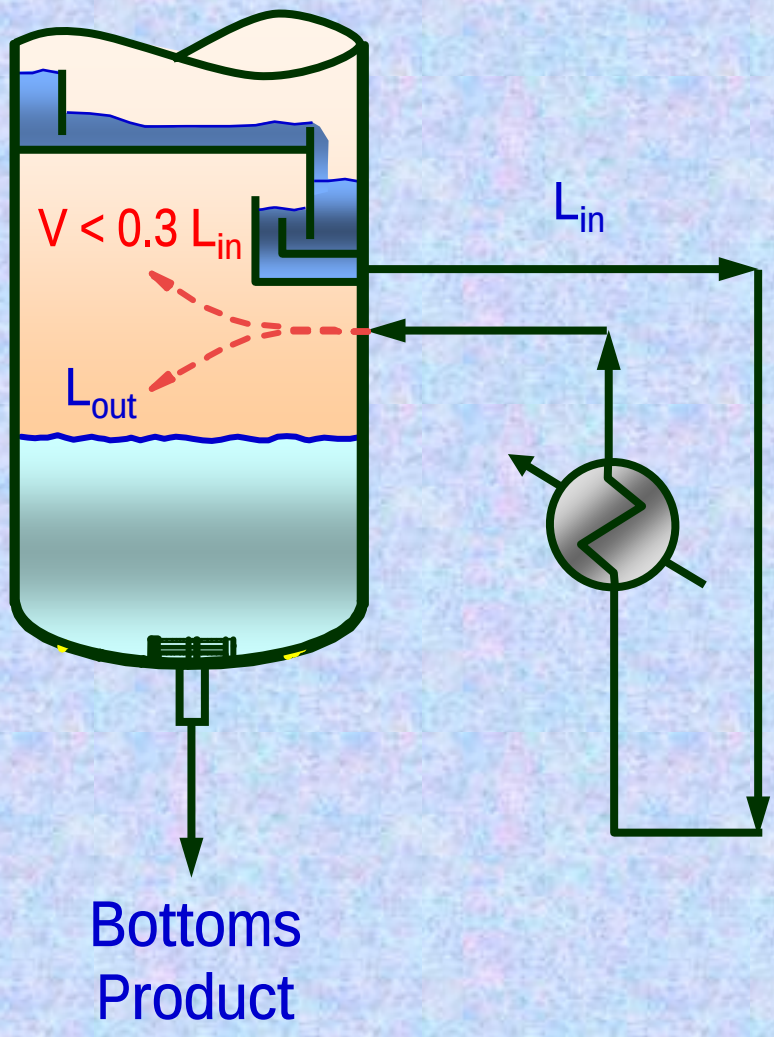
Circulating Horizontal Thermosiphon



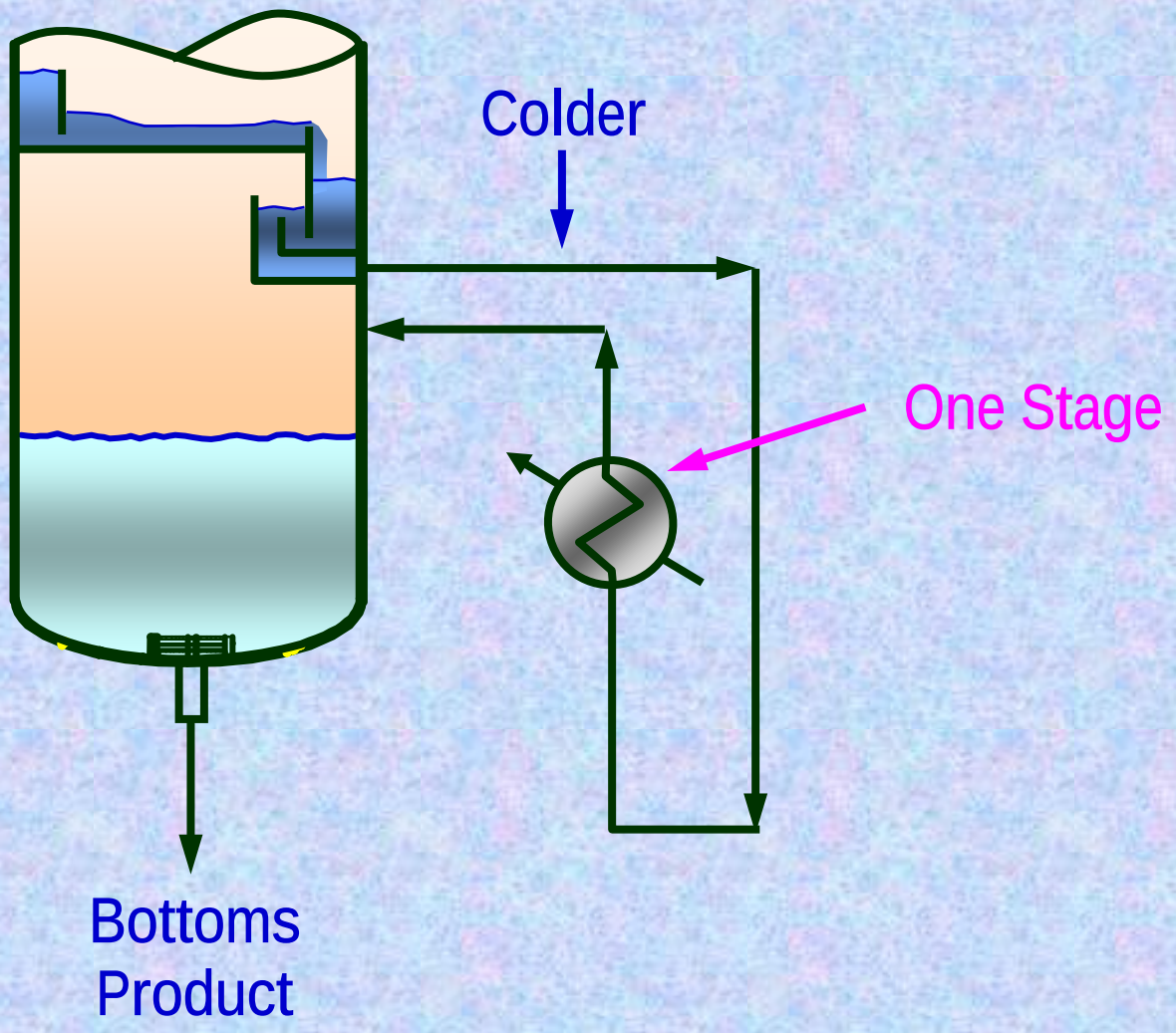
Once Through Thermosiphon Trapout



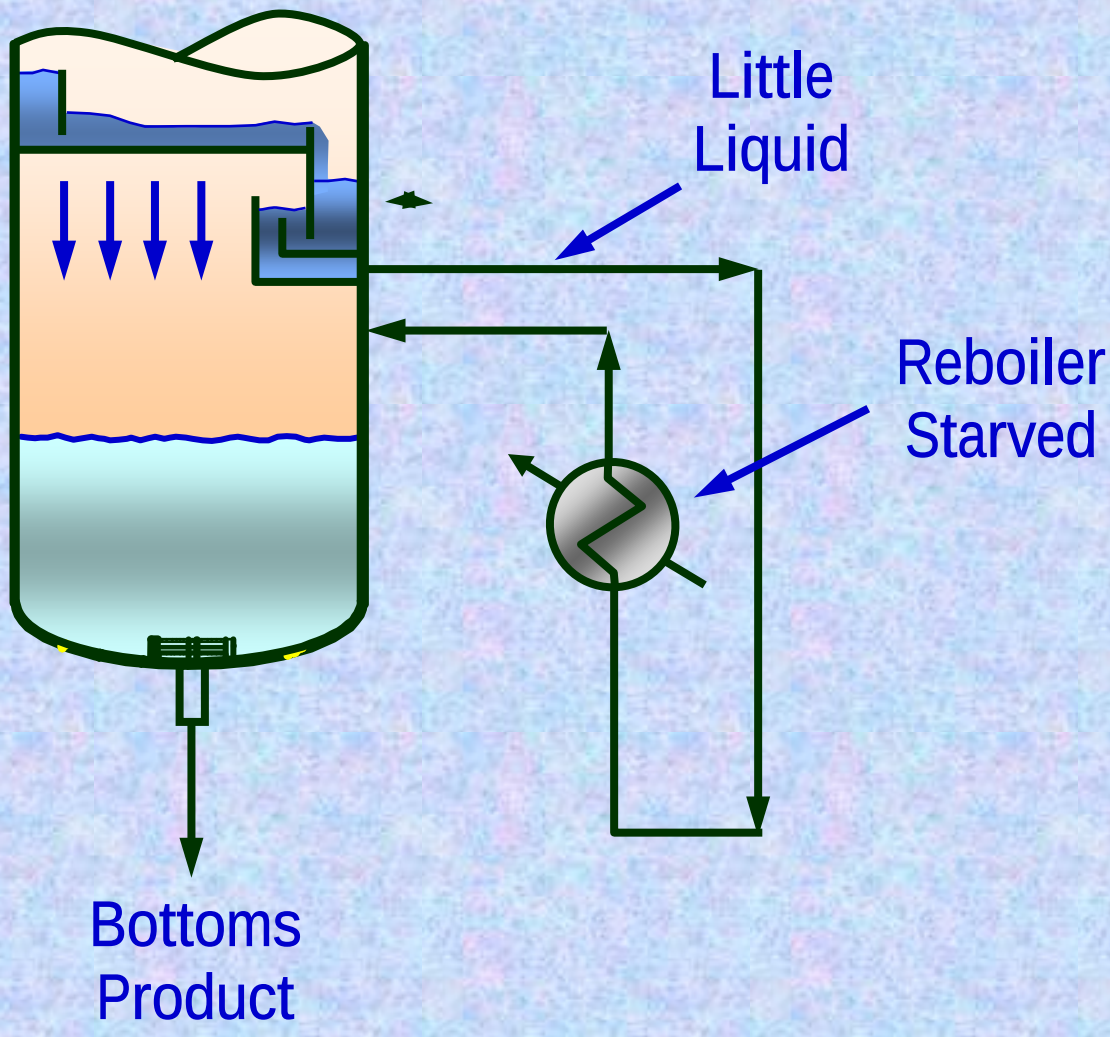
Once Through Thermosiphon Trapout



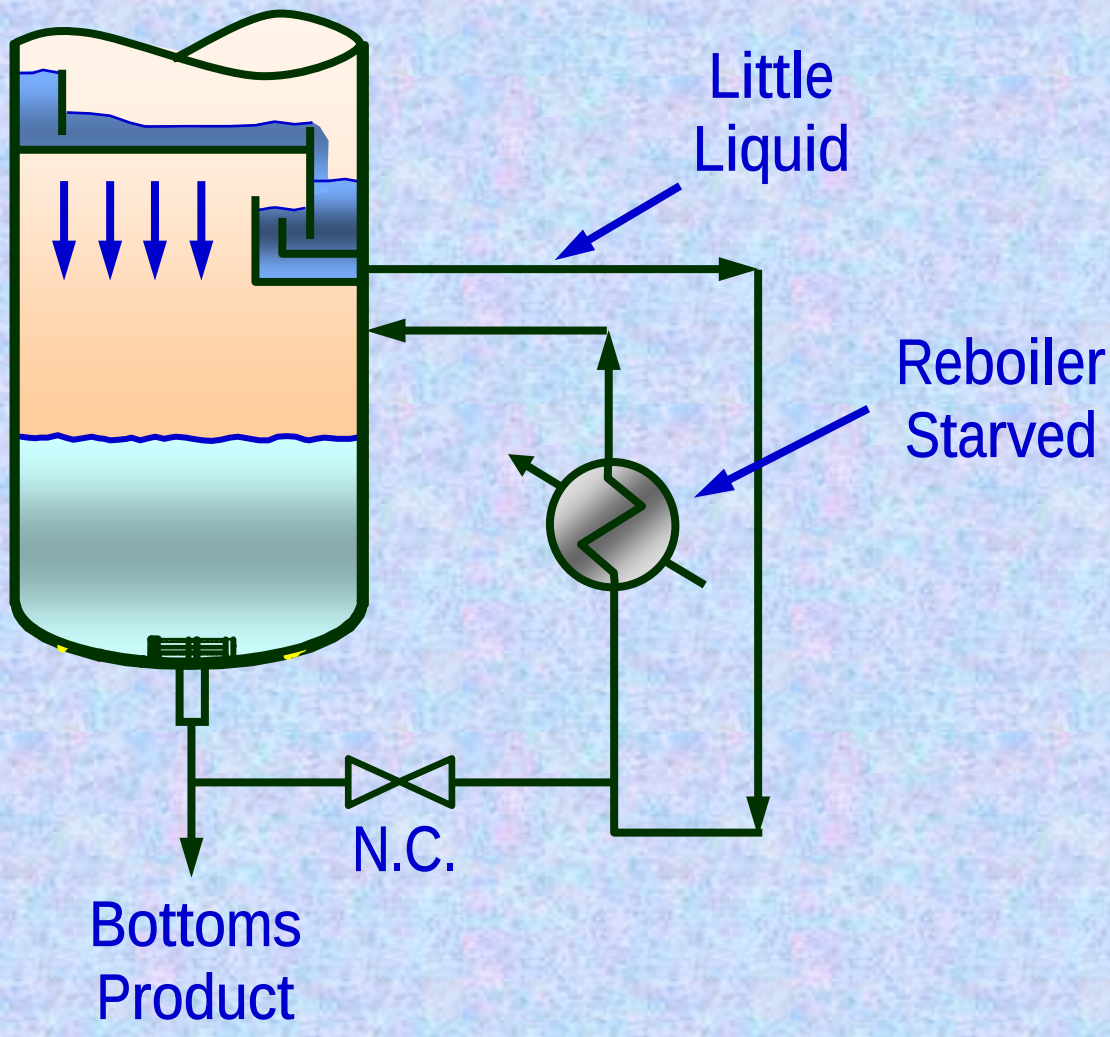
Once Through Thermosiphon Trapout



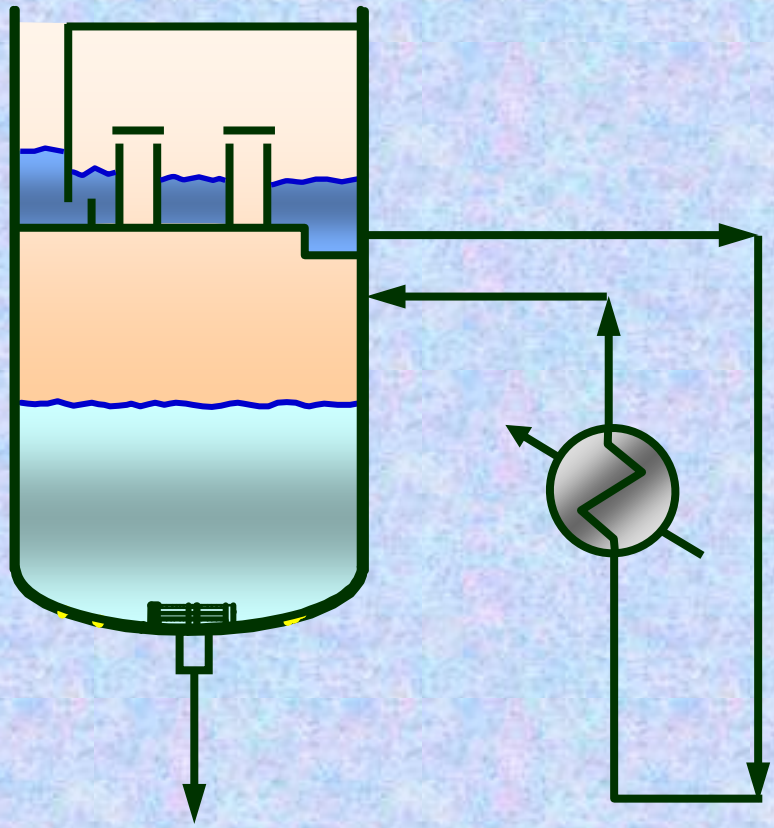
Once Through Thermosiphon Trapout



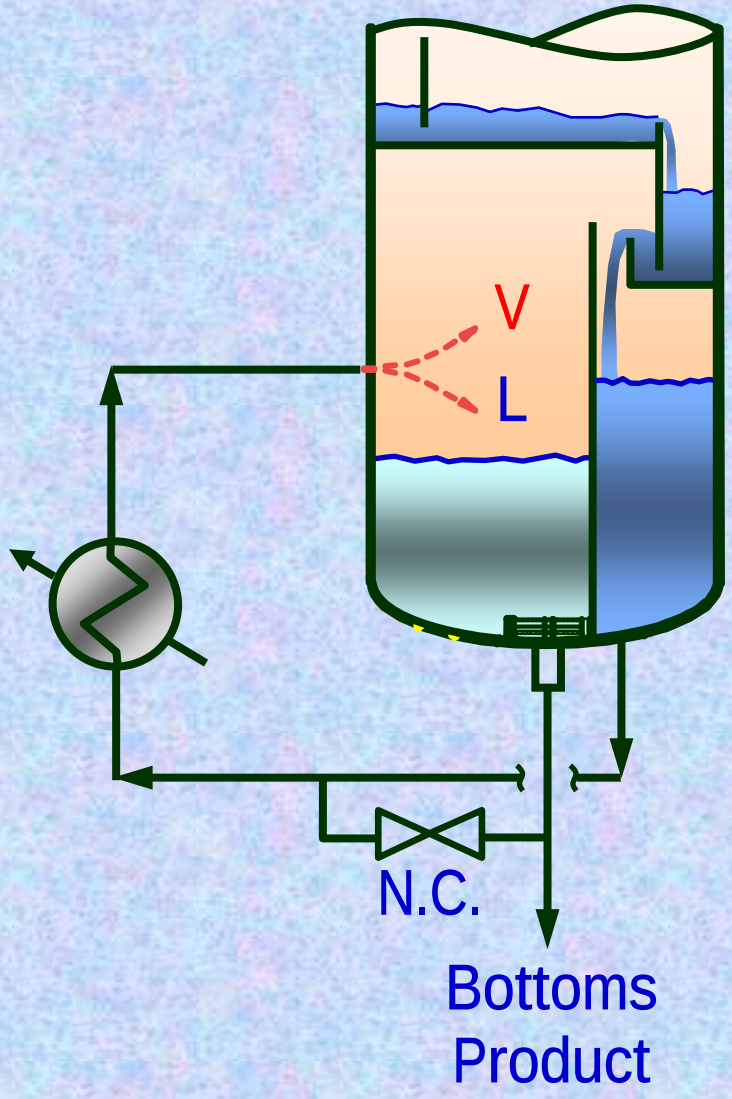
Once Through Thermosiphon Trapout



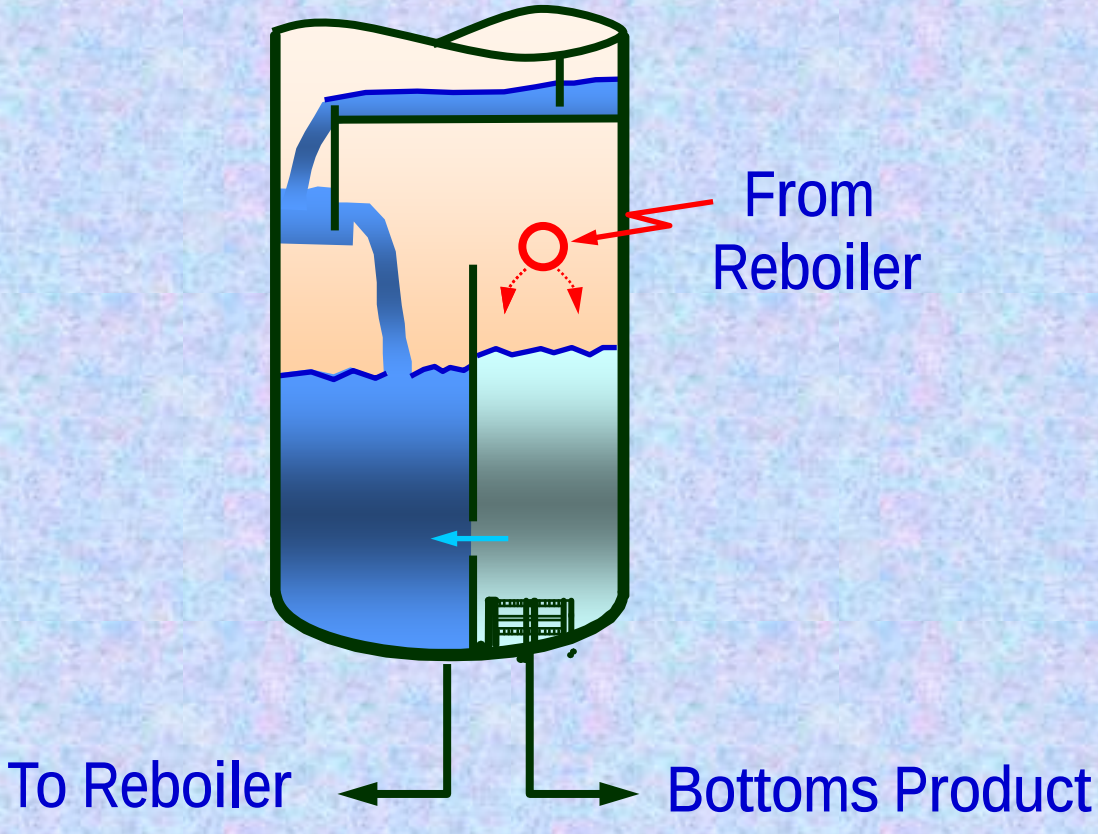
Once Through Thermosiphon Collector Tray



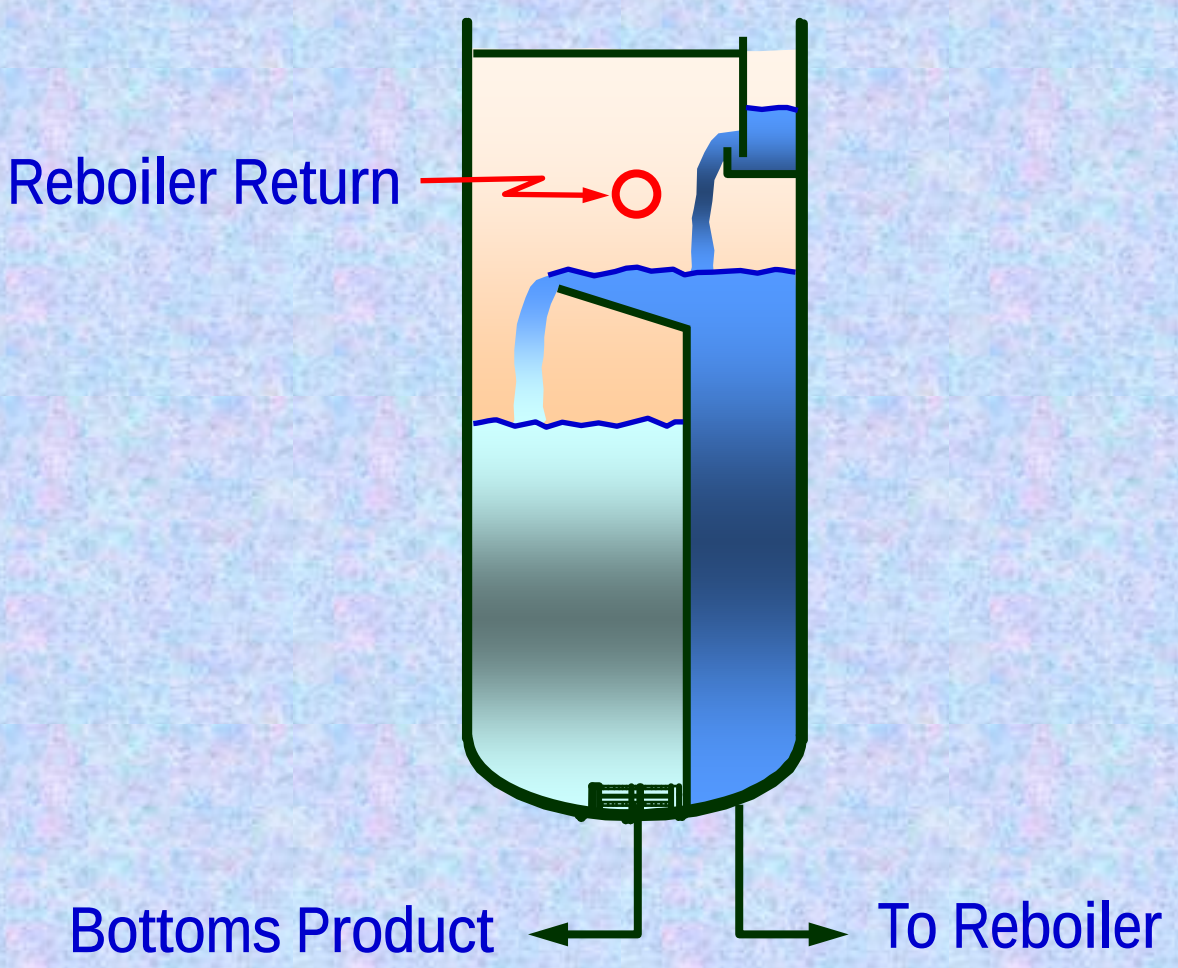
Once Through with Baffle



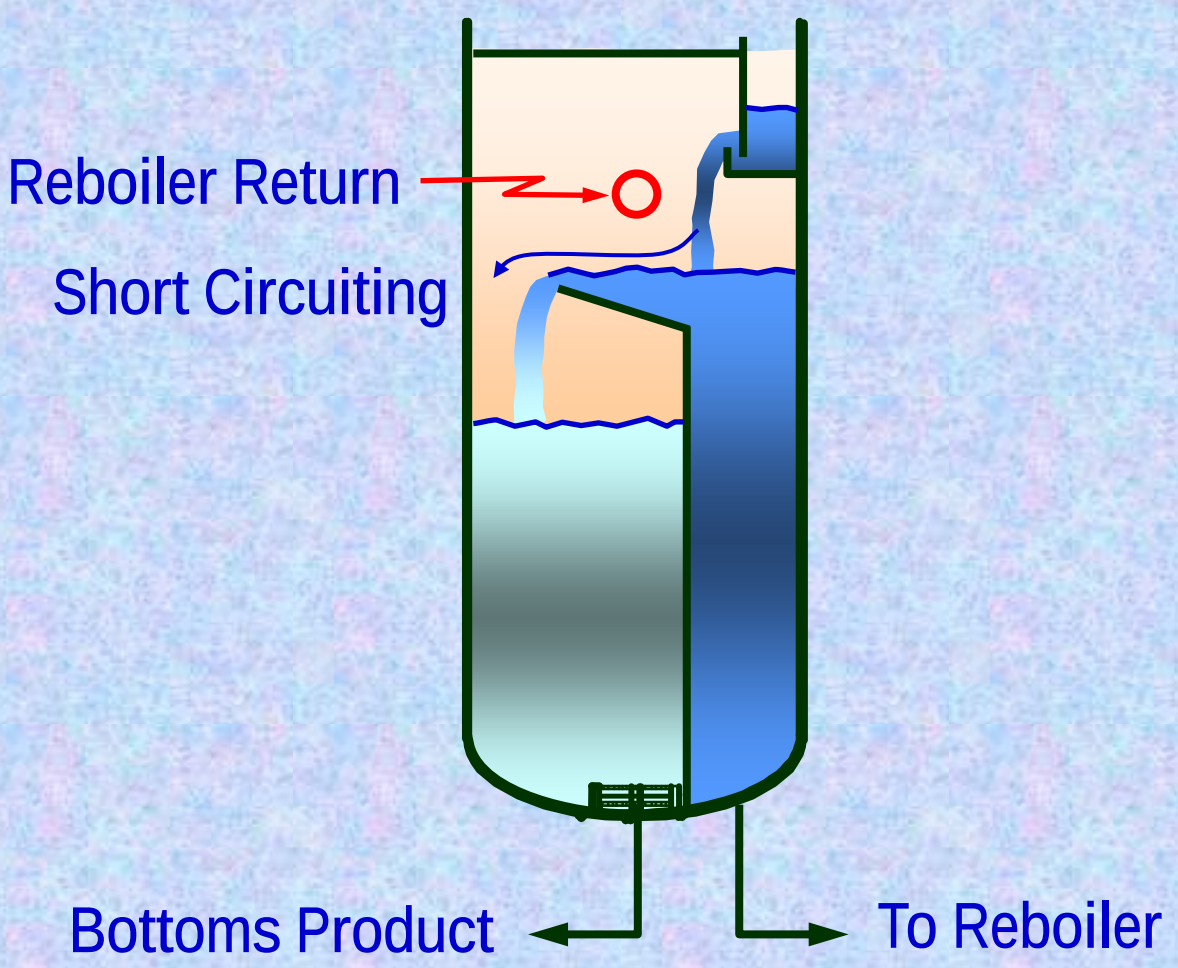
Preferential Baffle



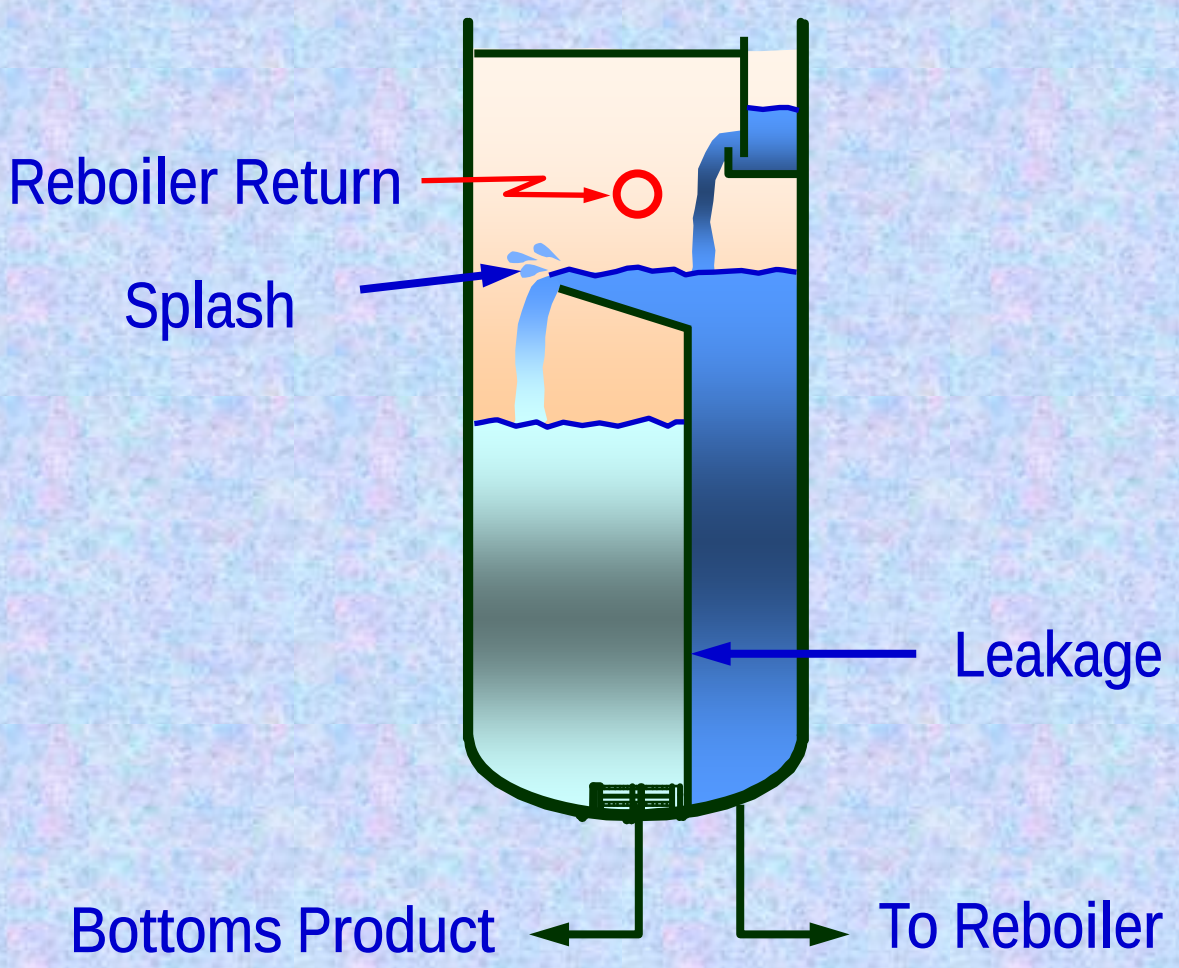
Constant Head with Reboiler Baffle



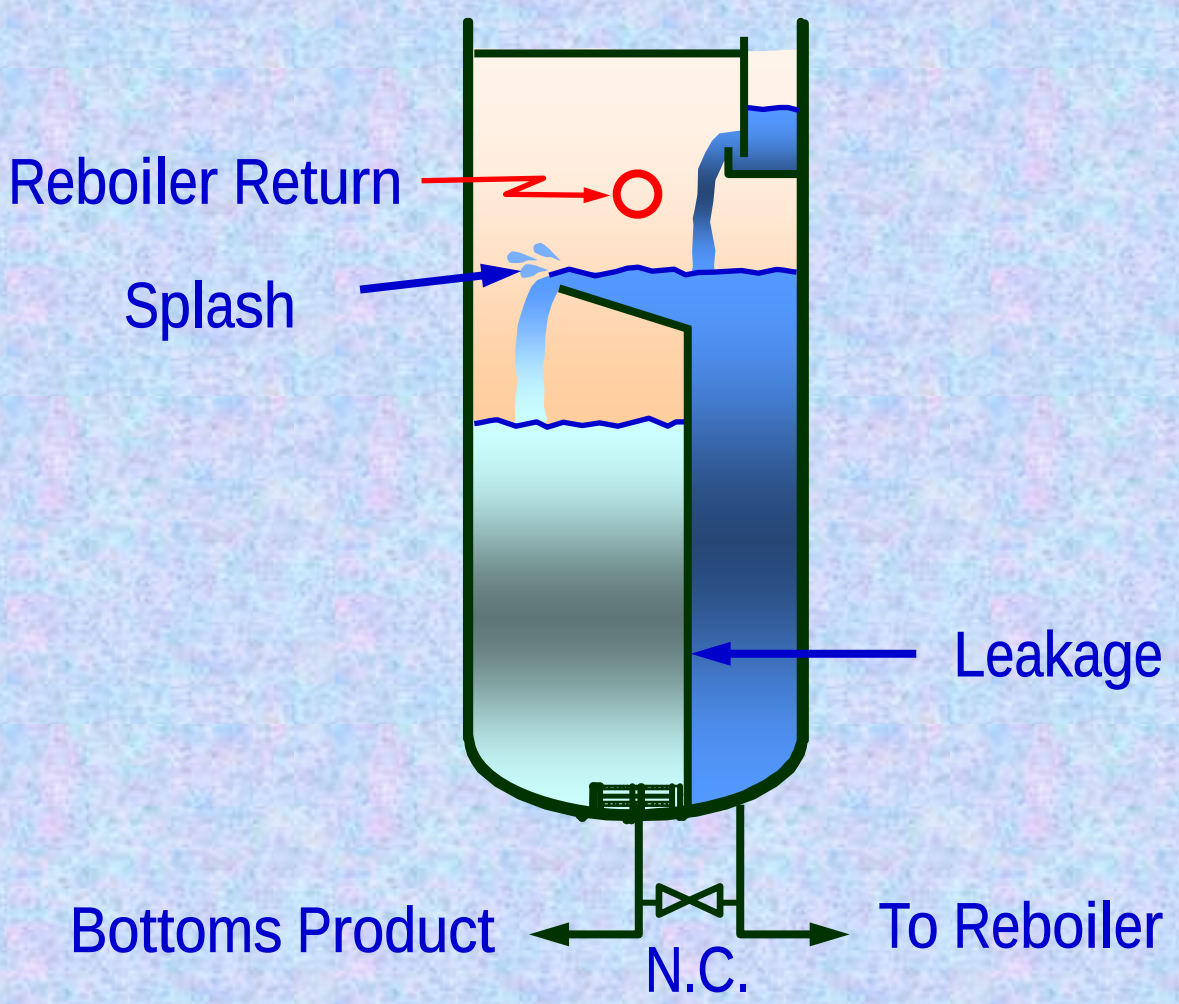
Constant Head with Reboiler Baffle



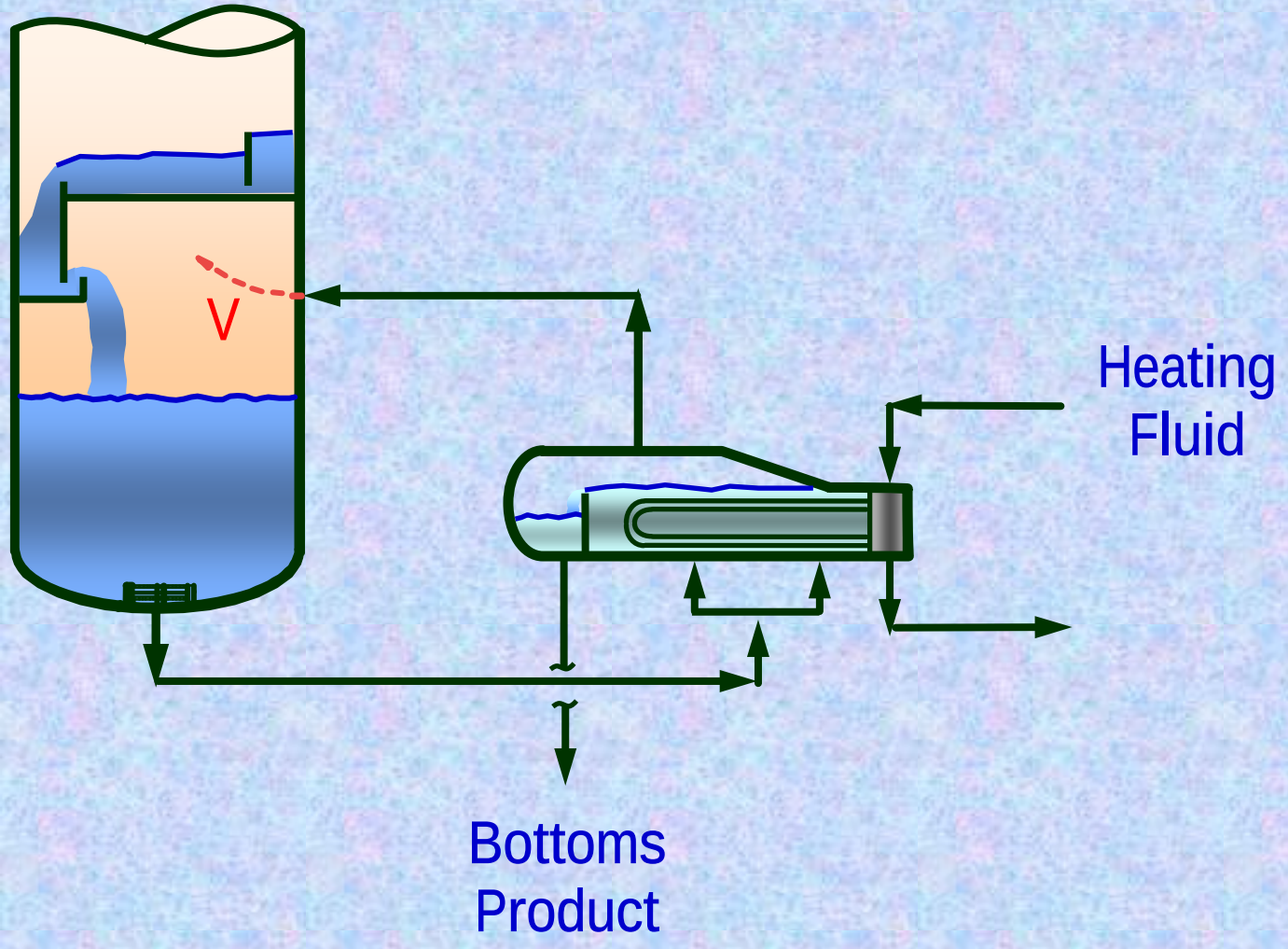
Constant Head with Reboiler Baffle



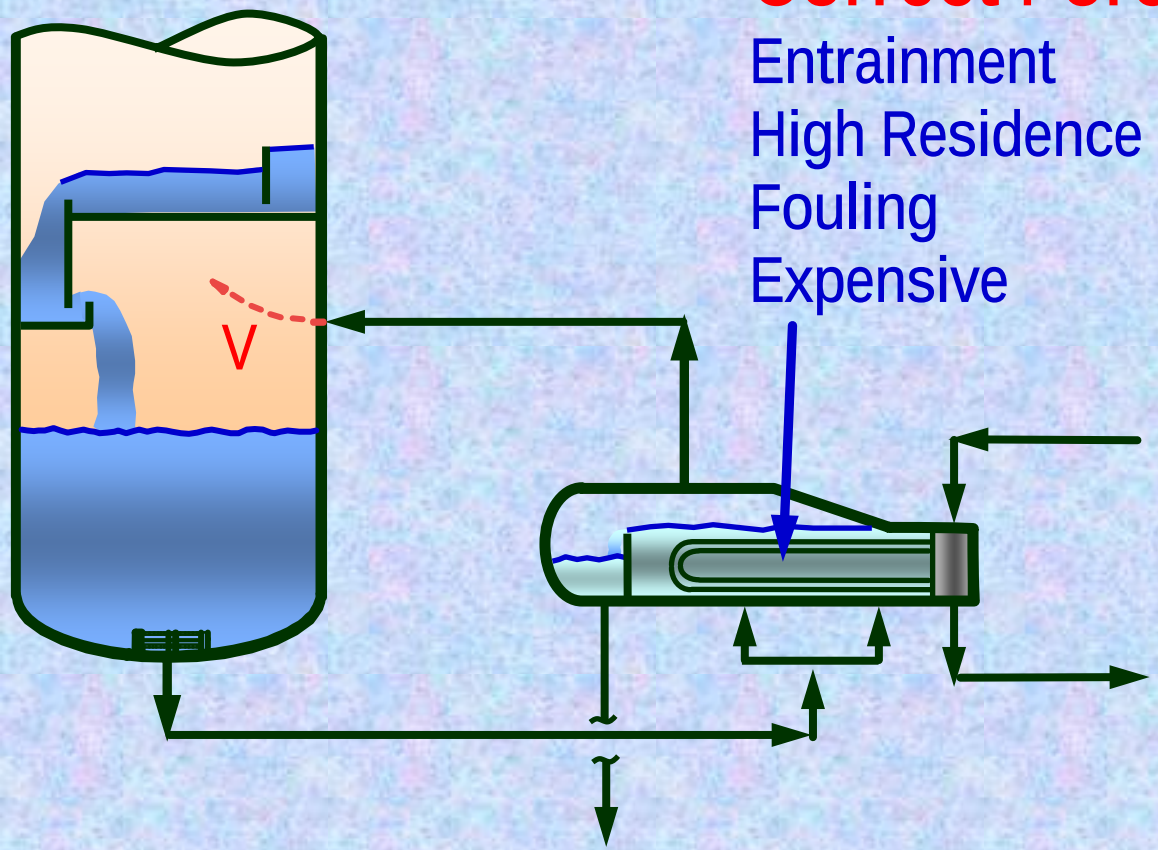
Constant Head with Reboiler Baffle



Standard Kettle



Standard Kettle



Correct Force Balance

Entrainment

High Residence Time

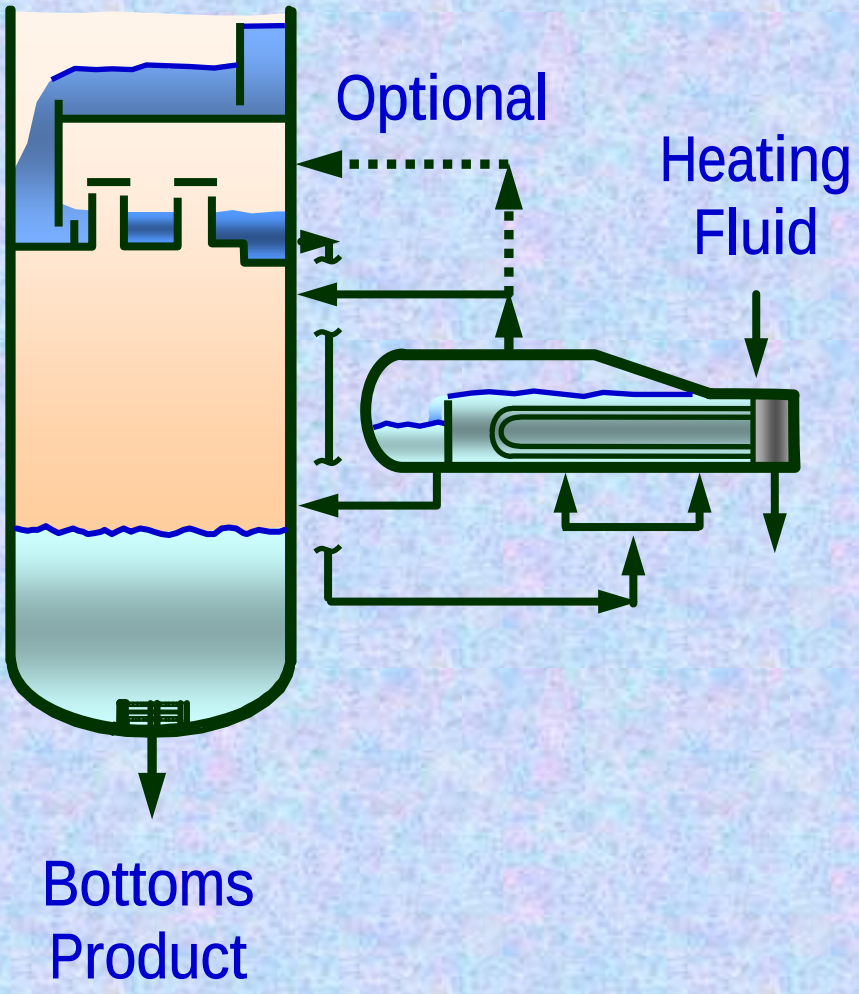
Fouling

Expensive

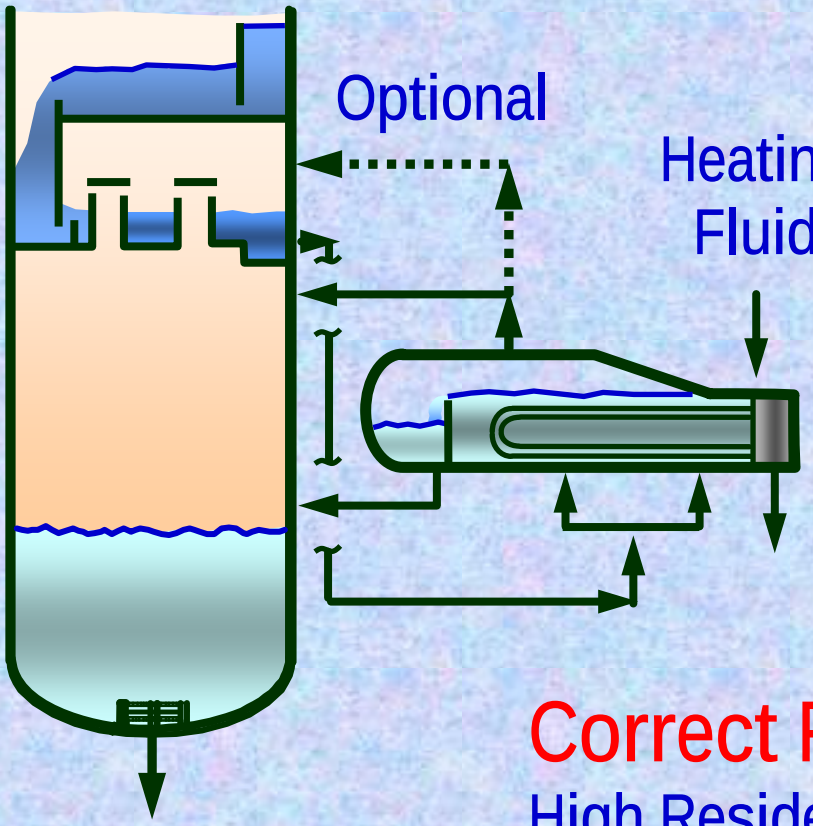
Heating Fluid

Bottoms Product

Trapout Kettle



Trapout Kettle



Correct Force Balance

High Residence Time

Fouling

Expensive

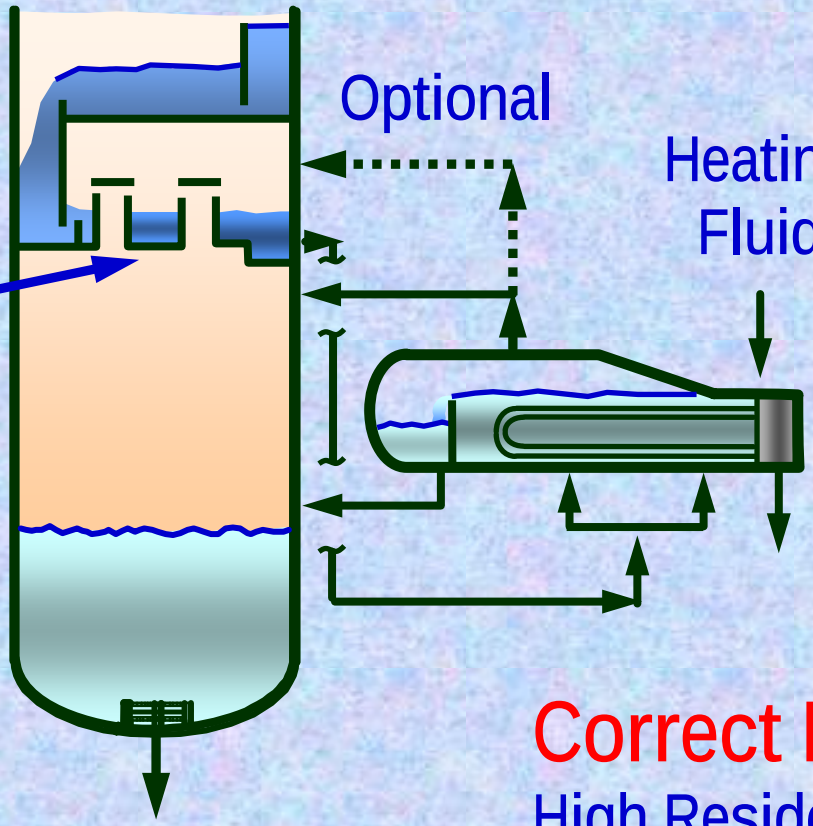
Trapout Kettle

If Trapout NOT Chimney tray…

Leakage

Reboiler Starved

Undersized Draw



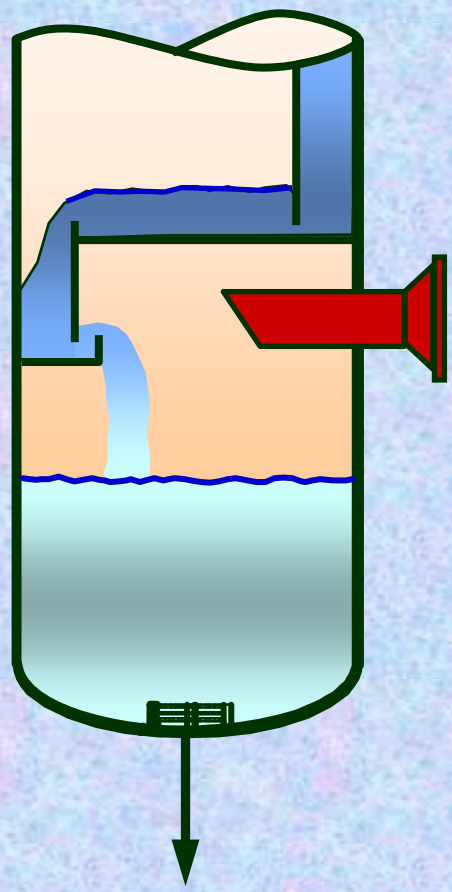
Correct Force Balance

High Residence Time

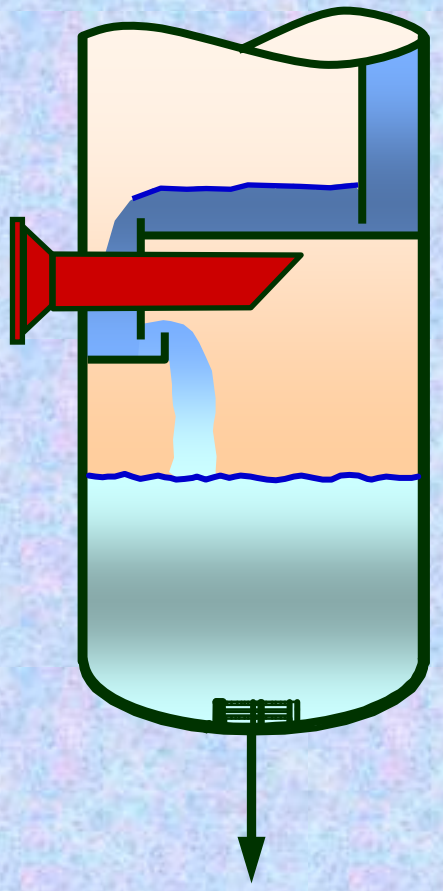
Fouling

Expensive

Poor Vapor Return Orientation
NOT RECOMMENDED



Vapor Return Through Downcomer
NOT RECOMMENDED



Questions?