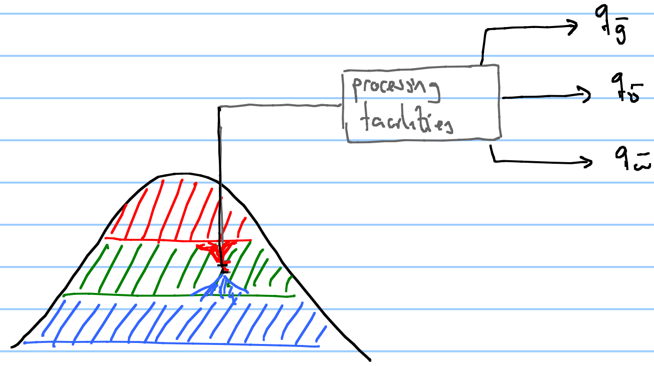
TPG4135. (Milan Stanko). week 2.



$\bar{g}$ standard conditions rate

Sm^3/d

field units

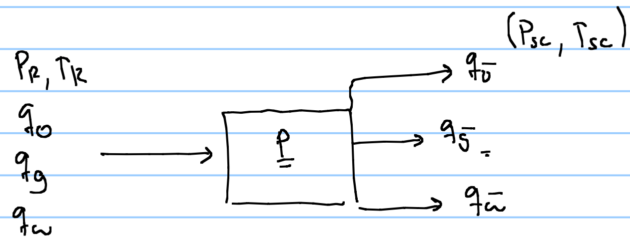
stb/d standard barrels ($\bar{o}$)

scf/d standard cubic feet ($\bar{g}$)

standard conditions (Norway)

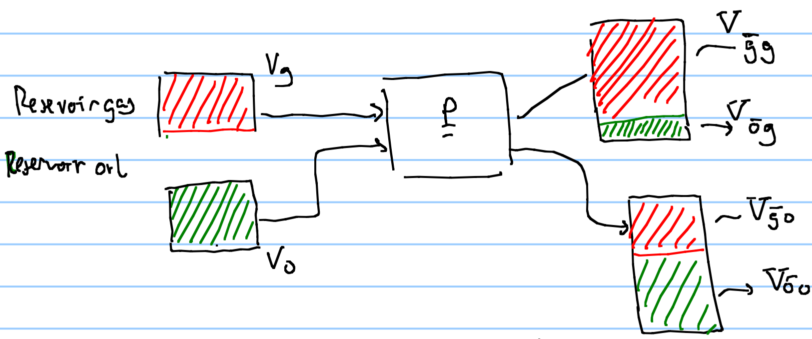
$p = 1.01325$ bara

$T = 15.56$ °C



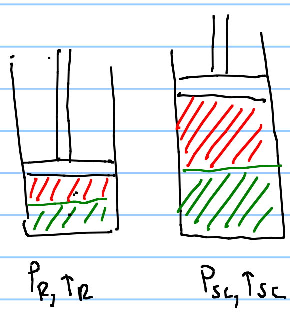
$p_{gauge} = p_{abs} - P_{atm}$

$[barg] = [bara] - 1.01325$ bara



In PE, we usually work with Black oil properties

simple approximation:
CCE constant composition expansion



oil volume factor

$$B_o = \frac{V_o(P,T)}{V_{\bar{o}o}}$$

gas-oil ratio

$$R_s = \frac{V_{\bar{g}o}}{V_{\bar{o}o}}$$

gas volume factor

$$B_g = \frac{V_g(P,T)}{V_{\bar{g}g}}$$

oil-gas ratio

$$r_s = \frac{V_{\bar{o}g}}{V_{\bar{g}g}}$$

more in detail TPG4145

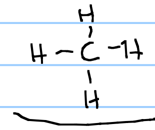
(Production, reservoir, drilling)

Petroleum fluid are made of several components

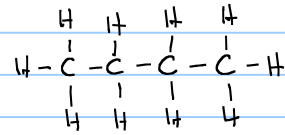
Alkanes $C_n H_{2n+2}$

non HC: CO_2, N_2, H_2S

HC: CH_4 (C_1), C_2 — LNG Liquified natural gas

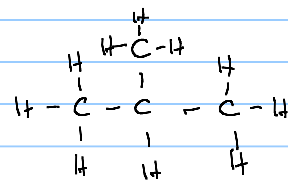


C_3, C_4 — LPG — Liquified petroleum gas



C_4H_{10}

iC_4, C_5, iC_5 — NGL Natural gas Liquids



C_4H_{10}

gas (q_g)

C_6, C_7, ..., C_{30} — surface oil (q_o)

from C_6 and above we use SCN single carbon number

H_2O

mole fraction of component is used to describe what your reservoir fluids / surface gas / surface oil are made of

$$x_i = \frac{\text{nr. moles of component "i"} \; (N_2, C_1, C_2) \ldots}{\text{Total nr. moles}}$$

	x_i
C_1	0.8
C_2	0.15
C_3	0.05
	$\Sigma = 1$

$\sum x_i = 1$

$$\underbrace{MW_m}_{\text{mixture}} = \sum x_i MW_i$$

- p = 80–200 barg (in Norway typical pressures)
- water "dew point" −18°C @ 69 bara
- WiG < 4 lb/MMscf
- cricondentherm < 40°C
- cricondenbar < 105 bara
- CO_2 < 2.5 mole %
- H_2S < 5 mole %

"wet" gas pipeline — offshore / onshore

well stream → separation of o, g, w and stabilization

- gas → Dehydration (H_2O) → compression → (1) → gas plant
  - gas plant: • conditioning • Dewpoint control • NGL extraction
    - → sales (Gassco) *
    - → LNG → tanker
    - → LPG
    - → NGL
  - compression → injection in reservoir
  - compression → gas lift
  - compression → power generation
- oil → oil dehydration, desalting, and stabilizing
  - → tanker/truck
  - → pipeline
- water (OiW content 500–1000 ppmV) → produced water treatment
  - → water injection (into reservoir) 100 ppm OiWv — EOR, Pressure maintenance, disposal
  - → disposal to sea
    - ↳ 40 ppm OiWv (OSPAR)
    - ~ 17 ppm (Norway)

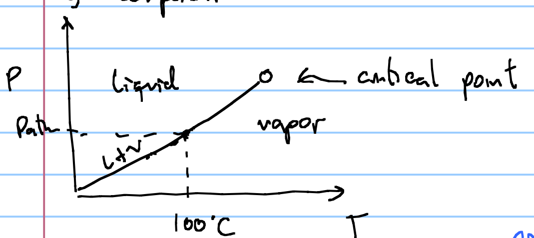
$\frac{1 \text{ L oil}}{1000000 \text{ L water}}$

- API gravity $API = \frac{141.5}{\gamma_o} - 131.5$ (10 → 50)
  - $\rho_{o\,sc}$ 700–900; $\rho_{w_{sc}} \sim 1000 \ kg/m^3$
- WiO content (V) (0.5 – 1%) max 2% (Norway)
- salt content (10–30) PTB pounds per 1000 barrels
- Reid Vapor pressure RVP (TVP)
  - < 11 psia for tanker/truck (pounds per square inch)
  - 14.7 psia = Patm
  - < 111 psia for pipeline
- H_2S ~ 10–100 ppmw
  - ↳ weight

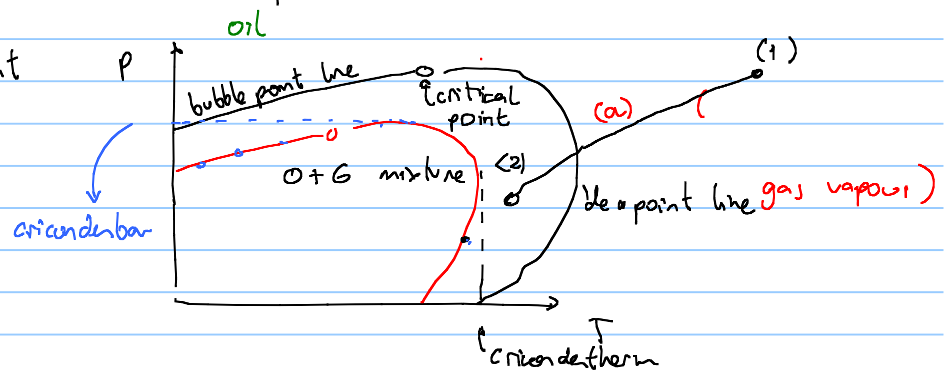
Phase behavior

phase envelope

single component



multi-component mixtures

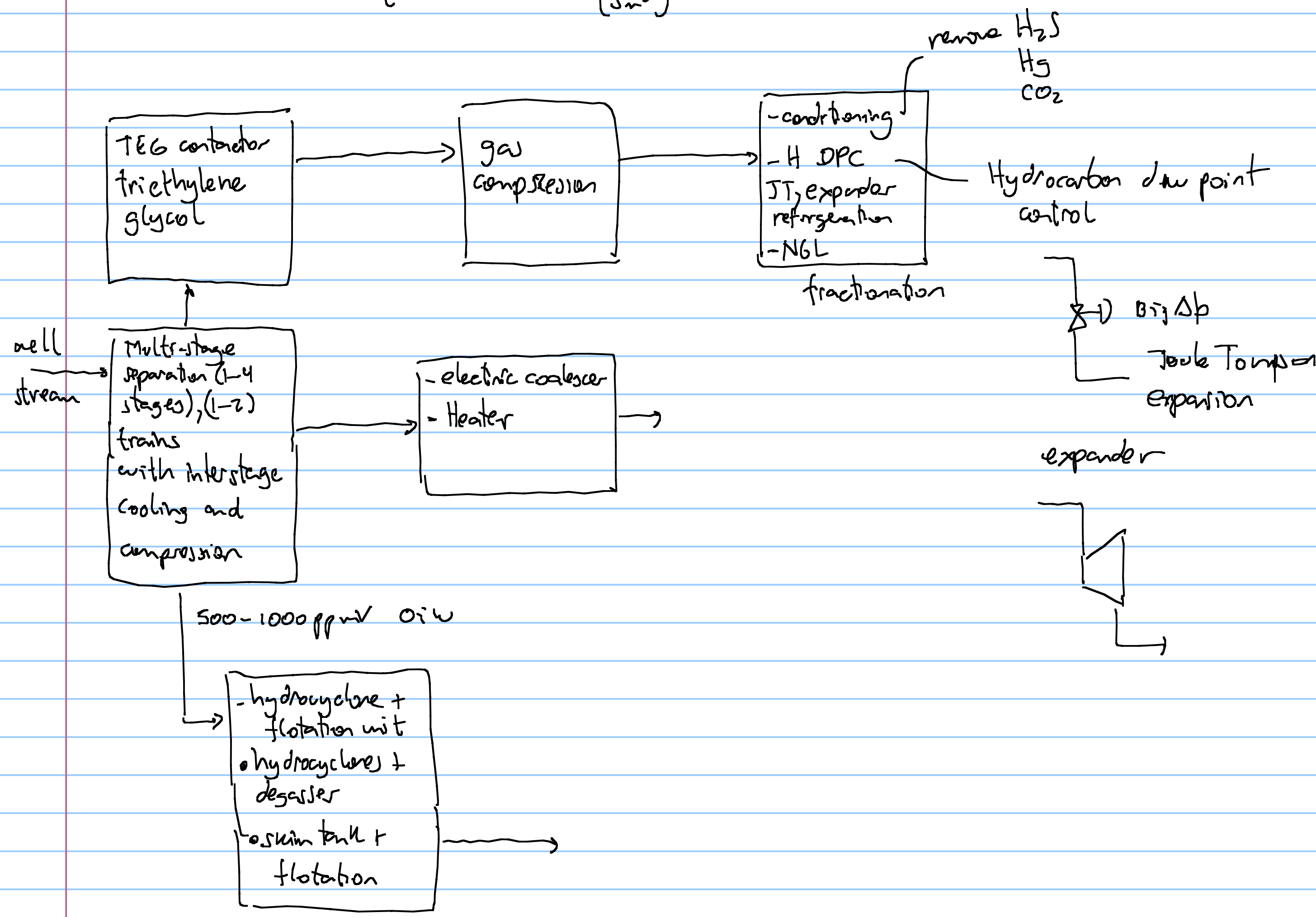


(1) is field (outlet of compression)

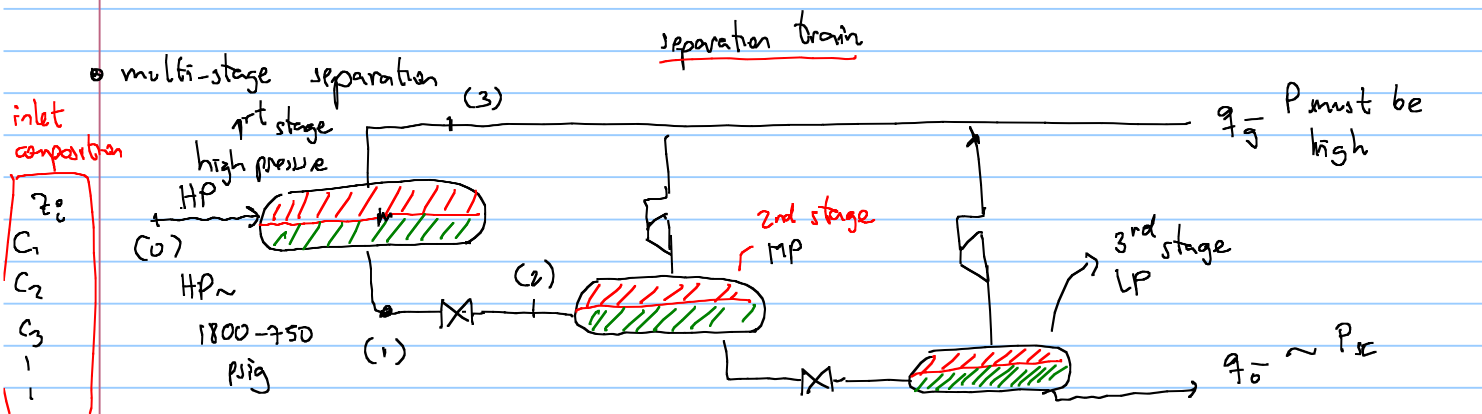
(2) is entry to processing plant

we need to move the gas phase envelope "smaller"

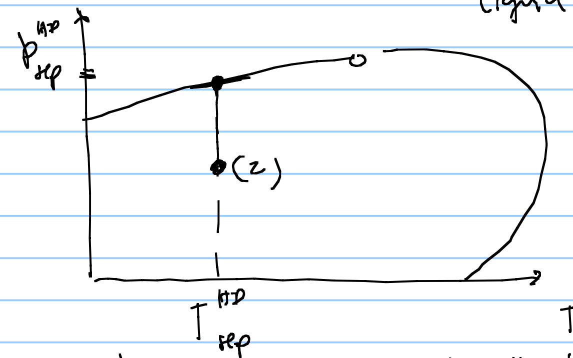
* Export gas specs
- dewpoint −10°C (50 barg)
- CO_2 < 2.5 mole %
- H_2S < 5 ppm
- Calorific value
- Wobbe index $\left[\frac{kJ}{Sm^3}\right]$



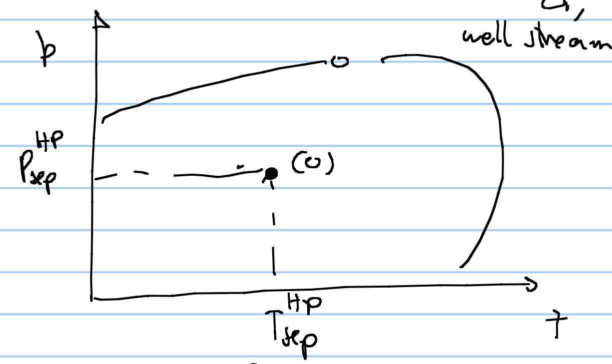
• multi-stage separation



phase envelope of (1) { composition of separator liquid

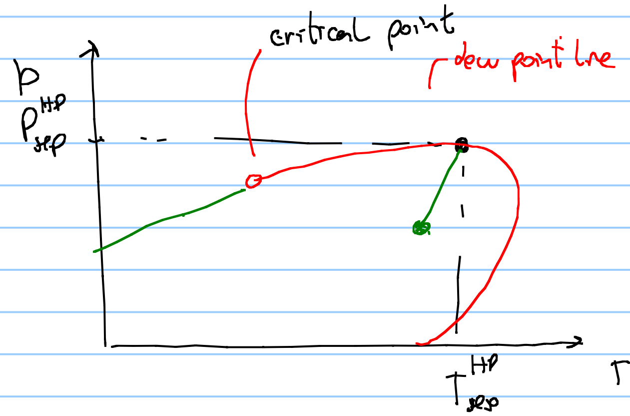


phase envelope of (0) Composition z_i, well stream

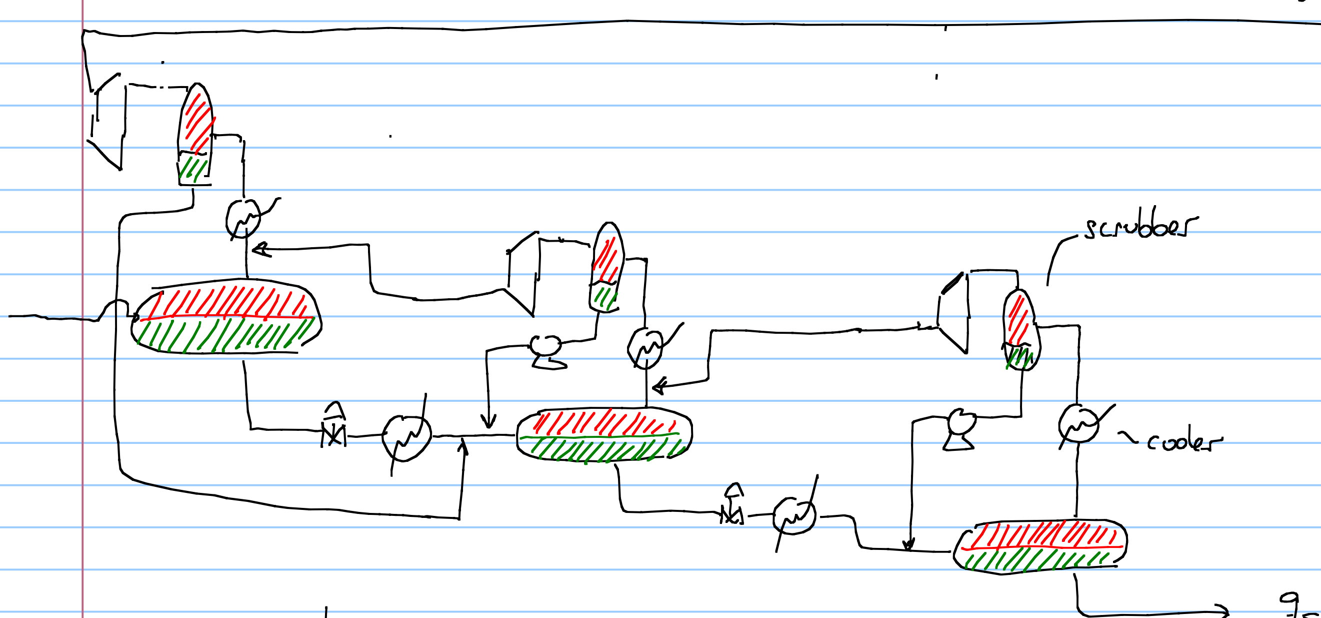


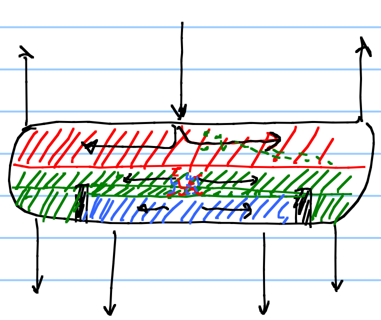
(1) and (2) have the same composition, therefore have same envelope!

phase envelope of (3) { HP separator gas



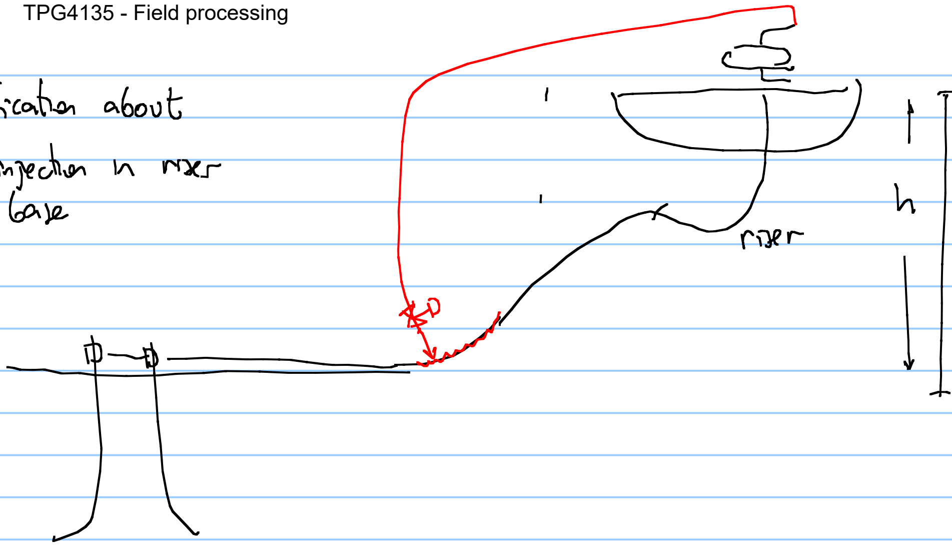
compressor doesn't accept liquid





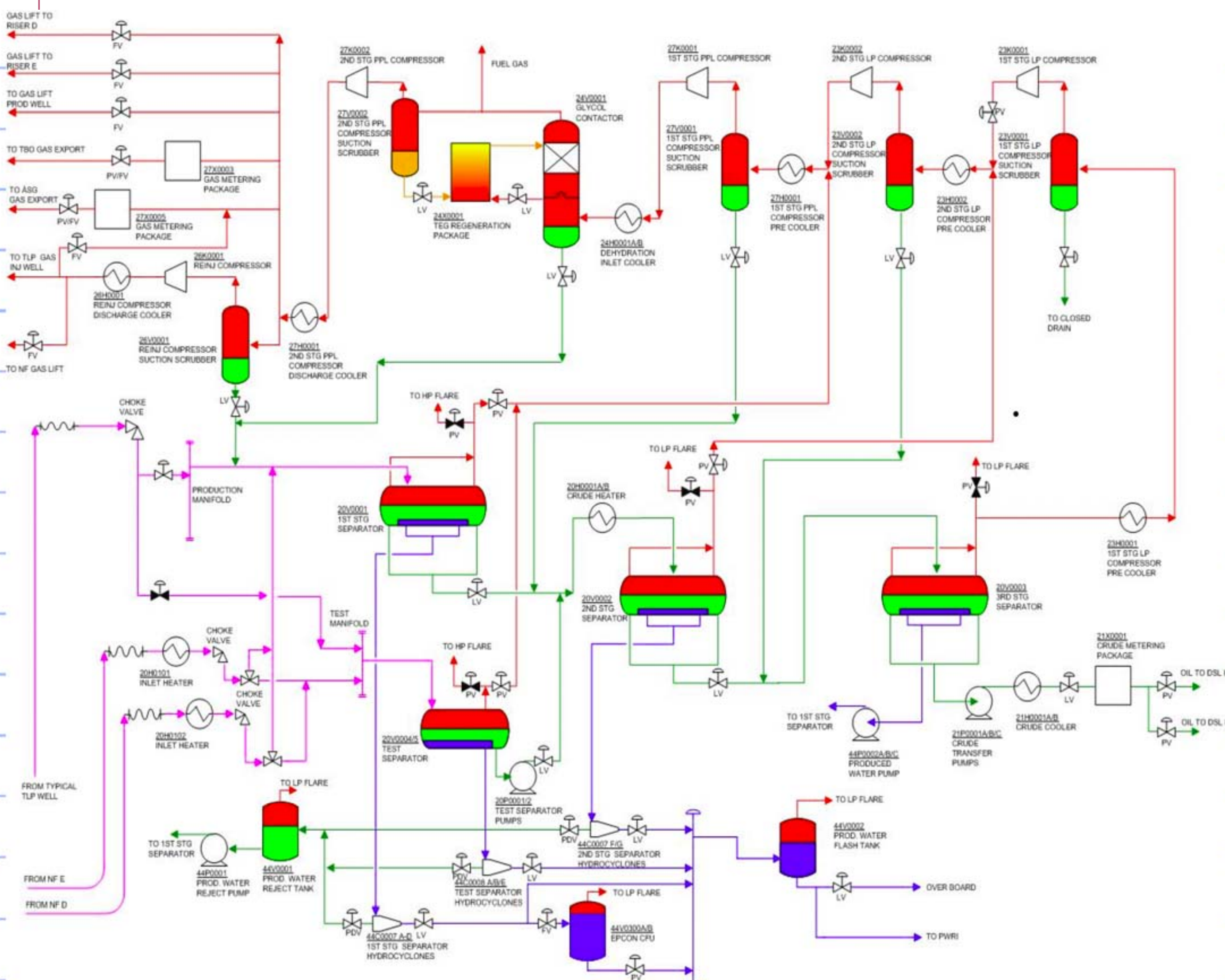
three-phase separator

clarification about gas injection in riser base



$\Delta p \propto \rho_{mix} \cdot g \cdot h$

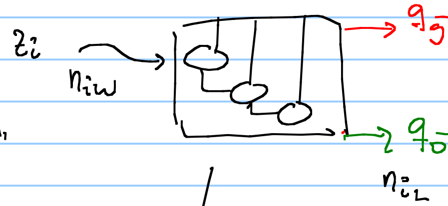
make it lighter by injecting gas



well stream z_i
(reservoir stream)

z_i : mole fraction of component "i"

	z
CO_2	
N_2	
H_2S	
C_1	
C_2	

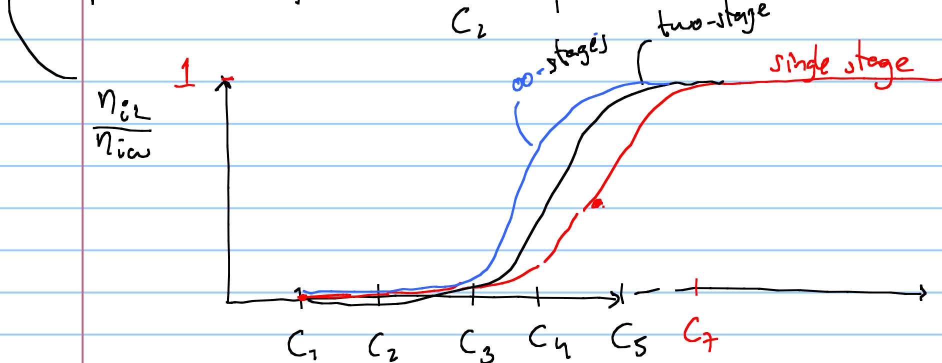


R_p
GOR

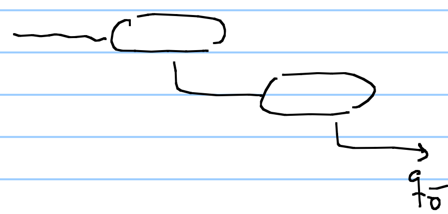
$$R_p = \frac{q_g}{q_o}$$

must design separation process to maximize $\left(\frac{1}{R_p}\right)$

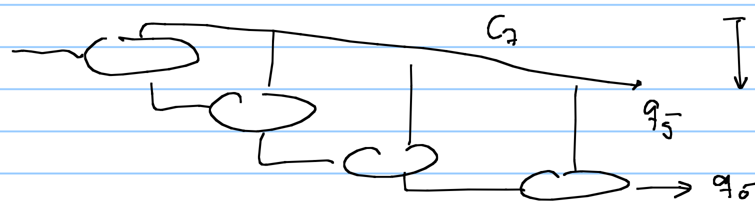
number of moles of component "i" in liquid



R_p for multistage will be lower than for single stage

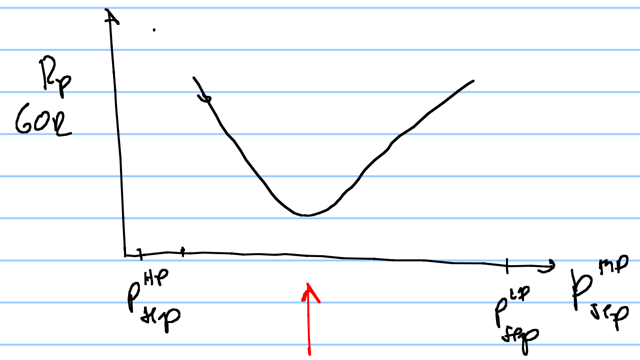


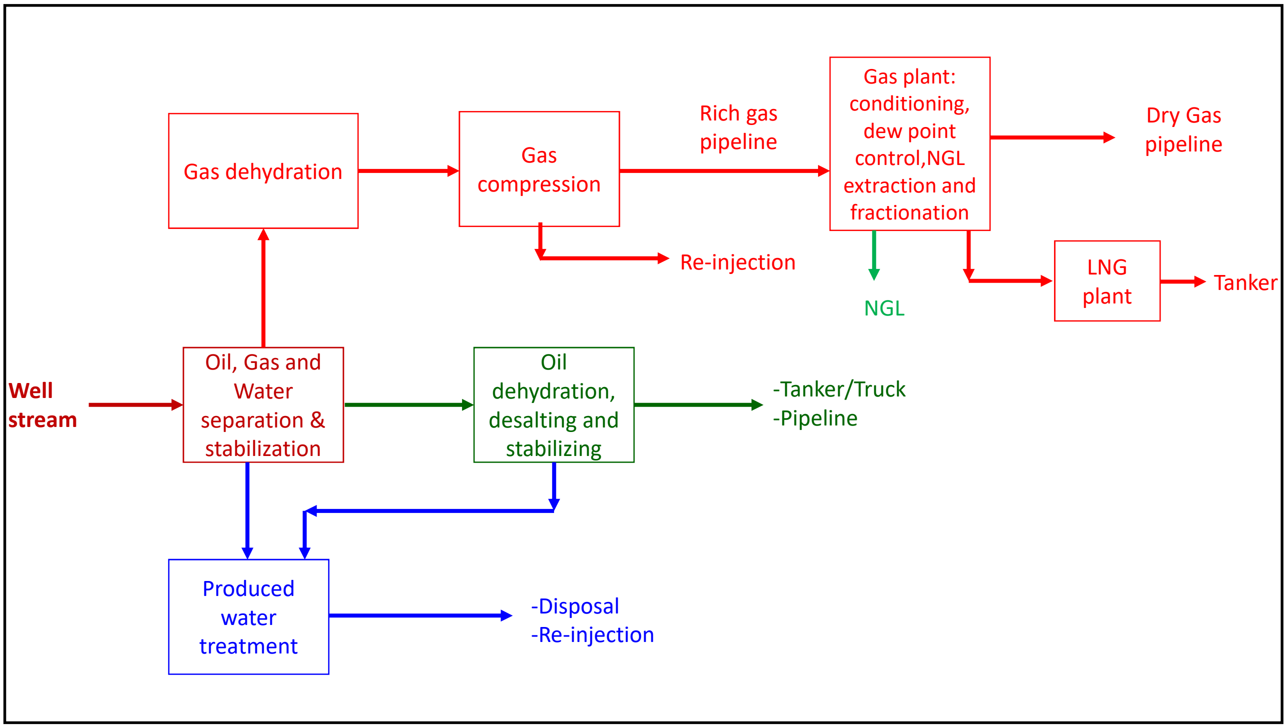
C_1
C_2
C_3
C_4
C_5
C_7

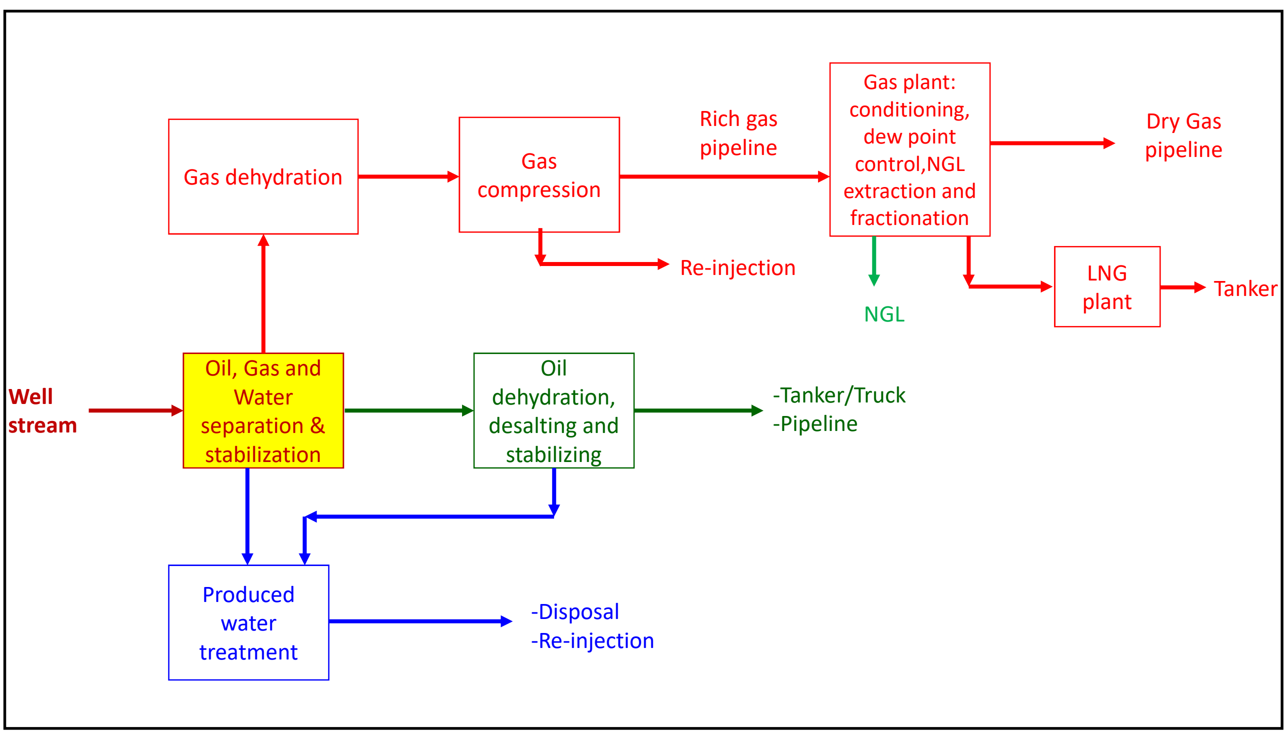


- R_p is affected by → nr stages → more stages gives lower R_p
  → HP separator p higher pressure give lower R_p, but it gives overall lower rates
  → MP separator p

q_o, q_g depends on $(P_R - P_{sep})$


Rp
GOR
p^{HP}_{sep}
p^{LP}_{sep}
p^{MP}_{sep}


Gas dehydration
Gas compression
Rich gas pipeline
Gas plant: conditioning, dew point control,NGL extraction and fractionation
Dry Gas pipeline
Re-injection
NGL
LNG plant
Tanker
Well stream
Oil, Gas and Water separation & stabilization
Oil dehydration, desalting and stabilizing
-Tanker/Truck
-Pipeline
Produced water treatment
-Disposal
-Re-injection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Produced water treatment
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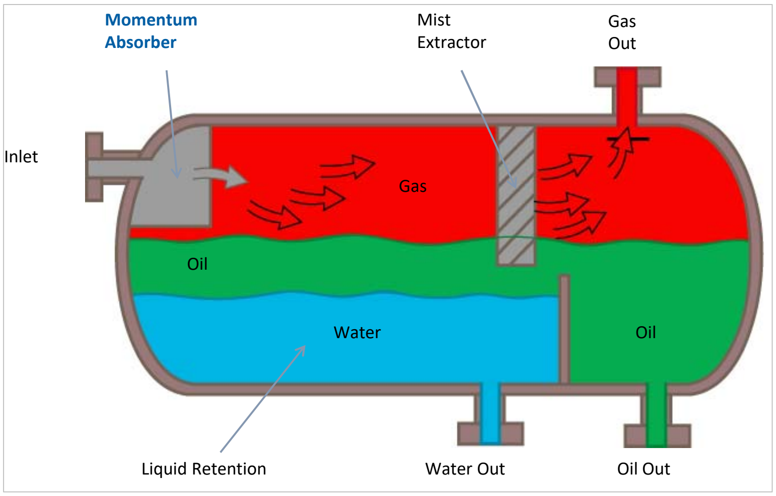
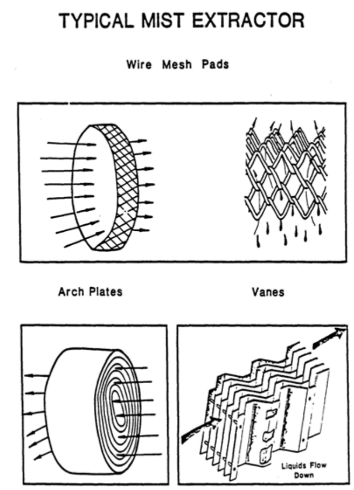
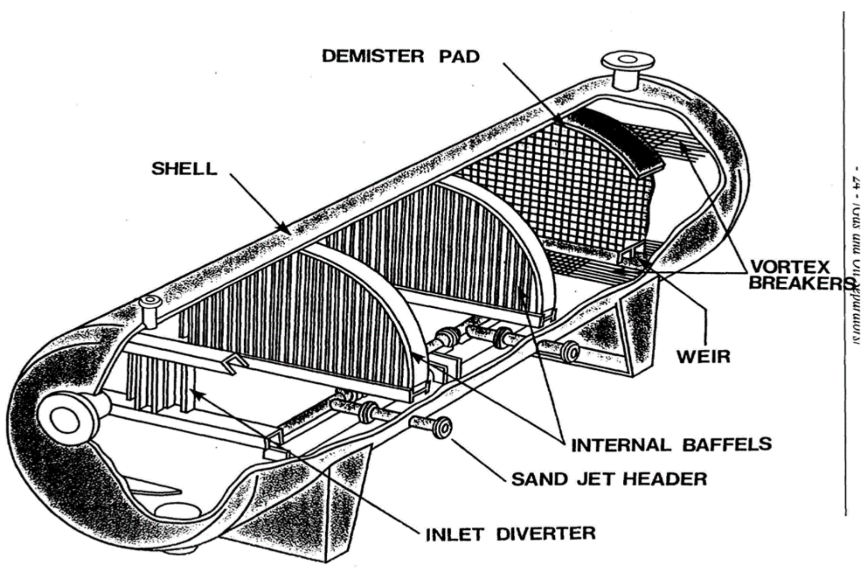
Horizontal separator

Horizontal Separator

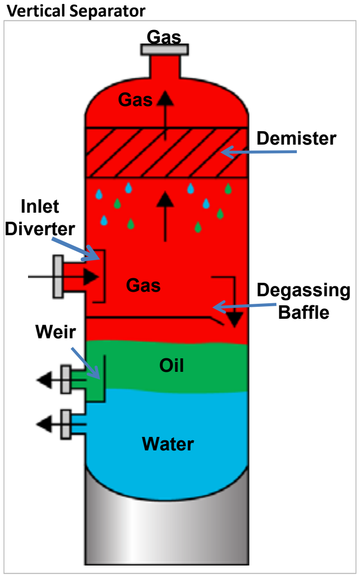


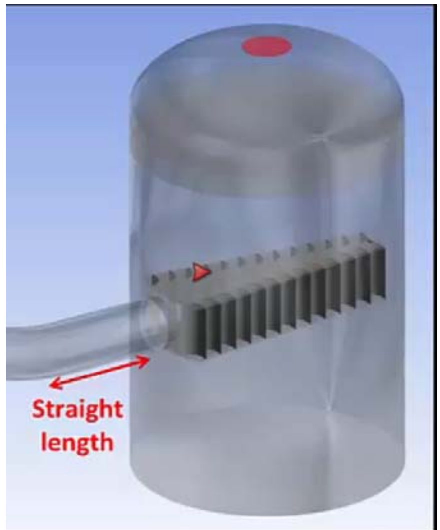


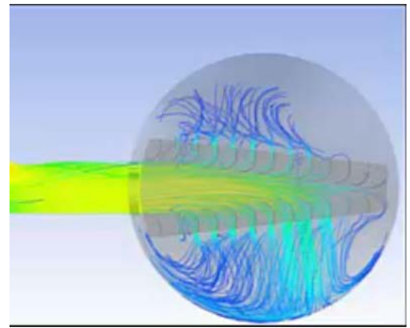
Horizontal separator

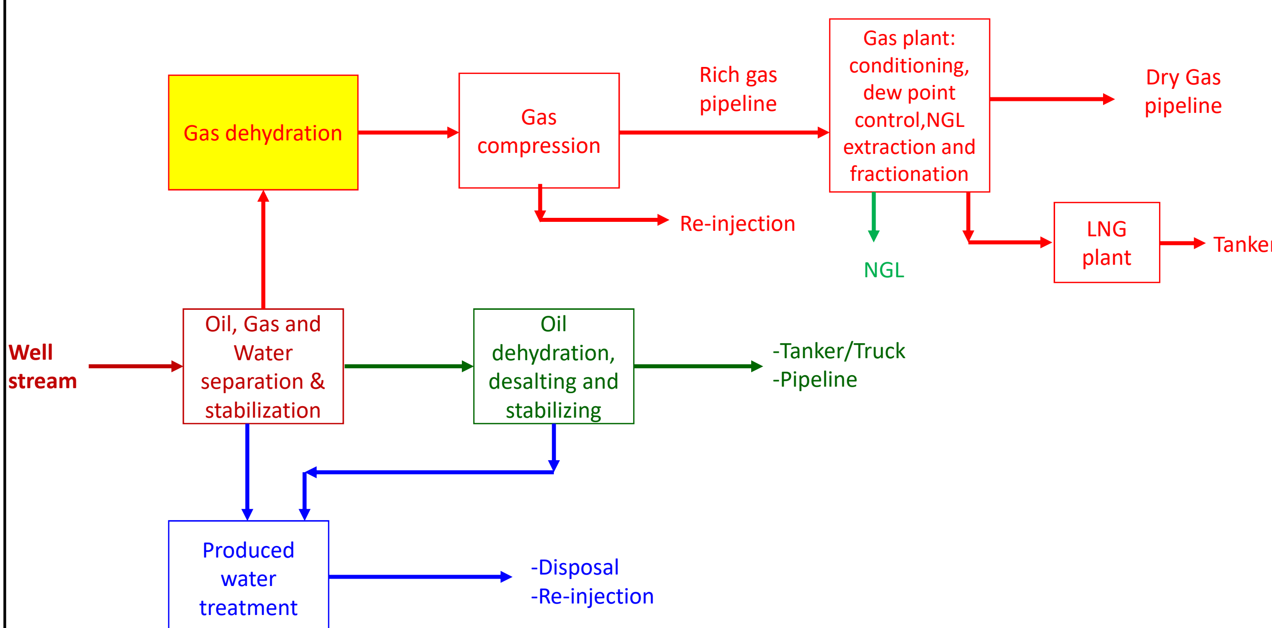


Vertical separator

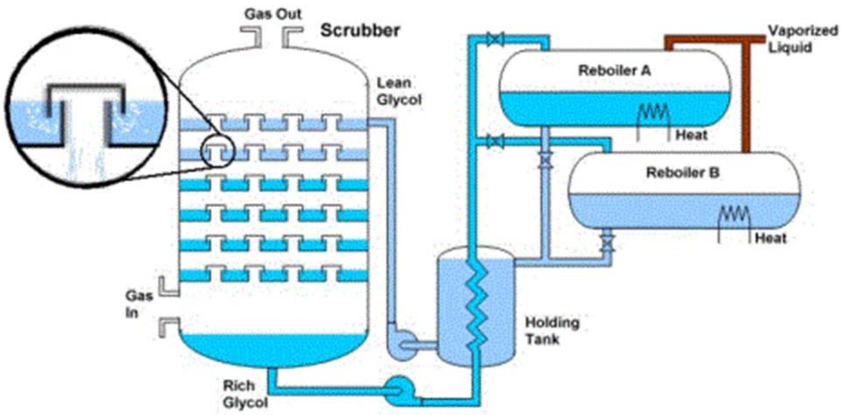


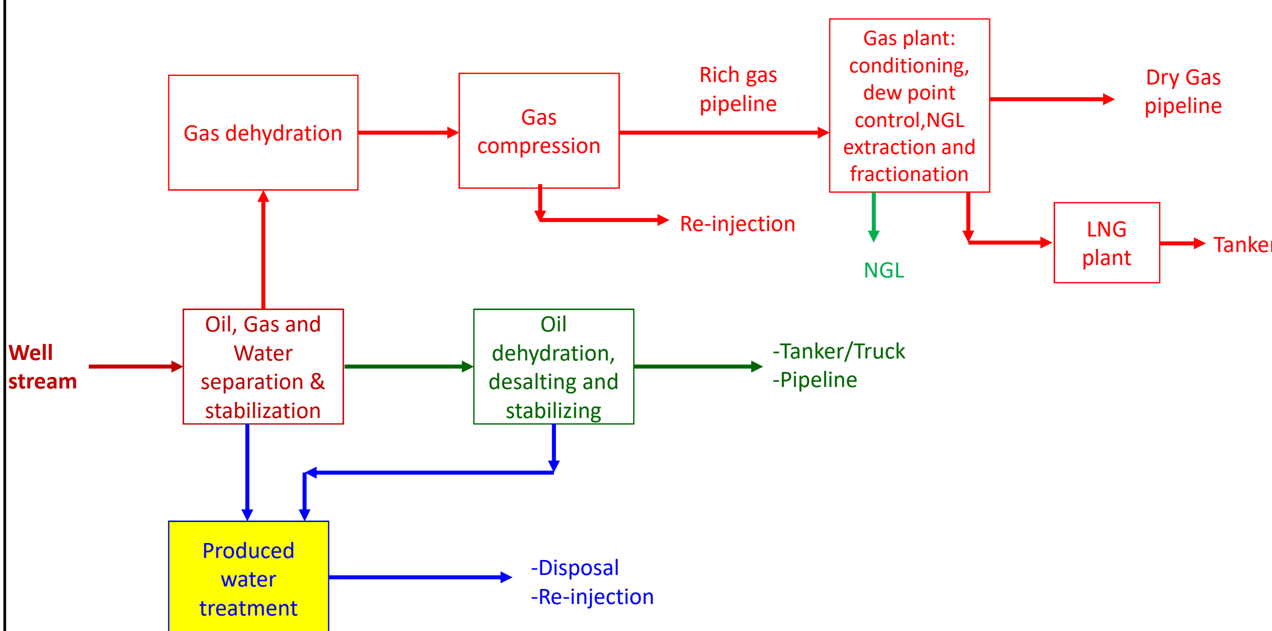




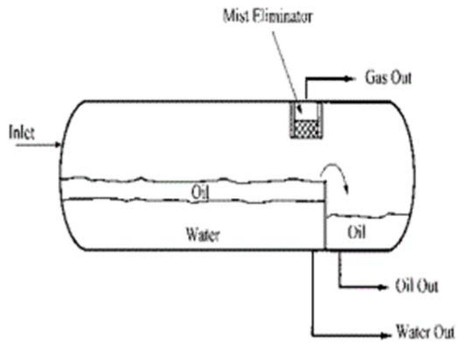


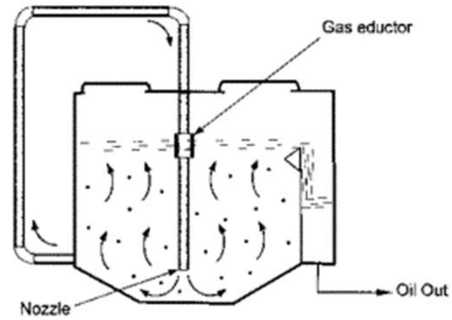
TEG dehydration



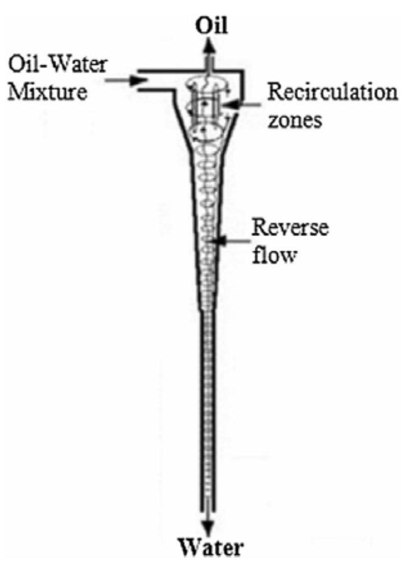


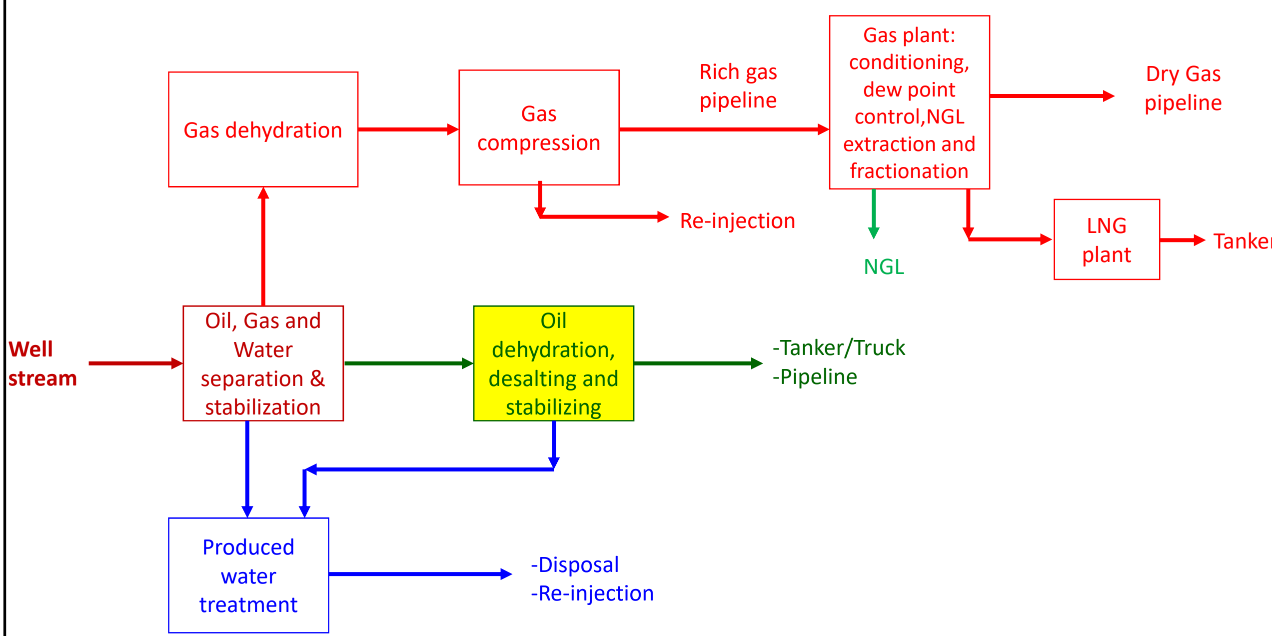
Skim tank + flotation unit





Hydrocyclone





Electrostatic coalescer