Note Title 11.04.2016

Multiphase boosting.

radial impeller | mixed flow | axial flow

GVF

0 — 1

0.96 — 1: radial

0: pure liquid

1: pure gas

0 — 0.3: $\underbrace{\quad\quad}_{\text{radial}}$

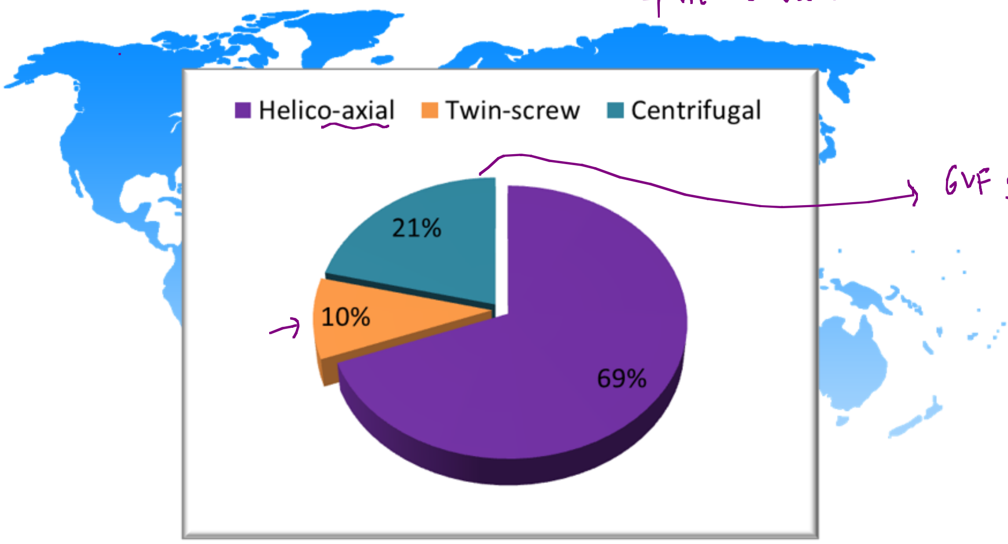
0 — 0.7: $\underbrace{\quad\quad\quad\quad}_{\text{mixed flow}}$

} can get $\uparrow \Delta p$ with few stages

$\underbrace{\quad\quad\quad\quad\quad\quad}_{\text{axial impeller}}$ get less Δp $\rightsquigarrow$ increase the number of stages

Subsea multiphase boosting around the world

52 subsea pumps in 23 locations in the World } ~ pumps in parallel, spare boosters



GVF $\lesssim$ 0.67

From http://www.offshore-mag.com/

helico-axial pump

(a) Impeller (b) Diffuser

GVF >, .95 wet gas compressor.

Counter rotating blades (Rotors).

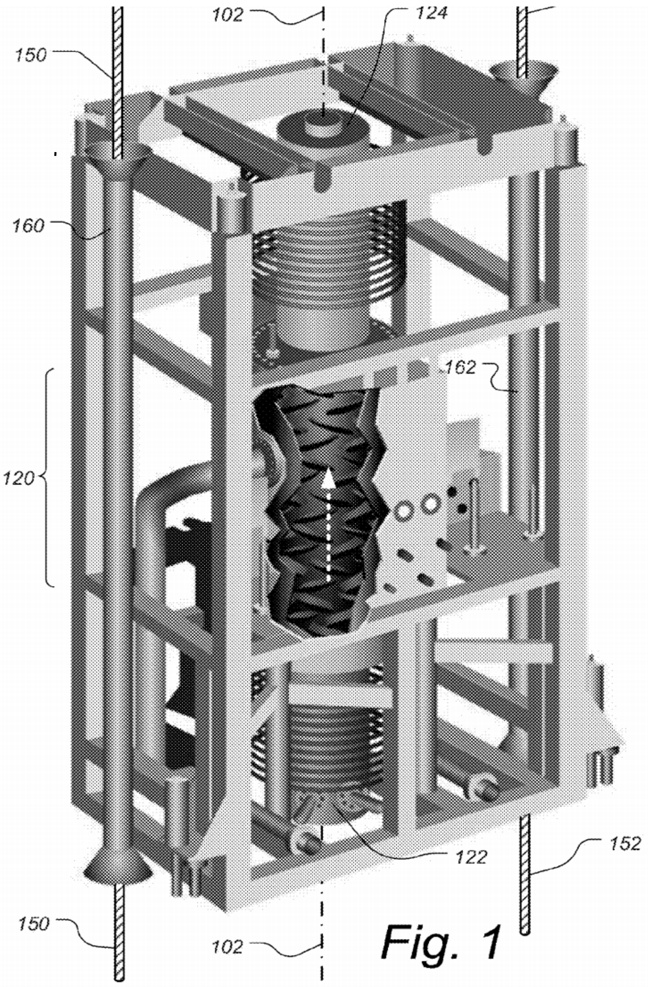


Fig. 1

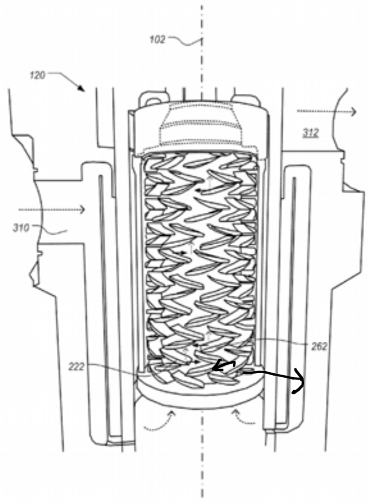
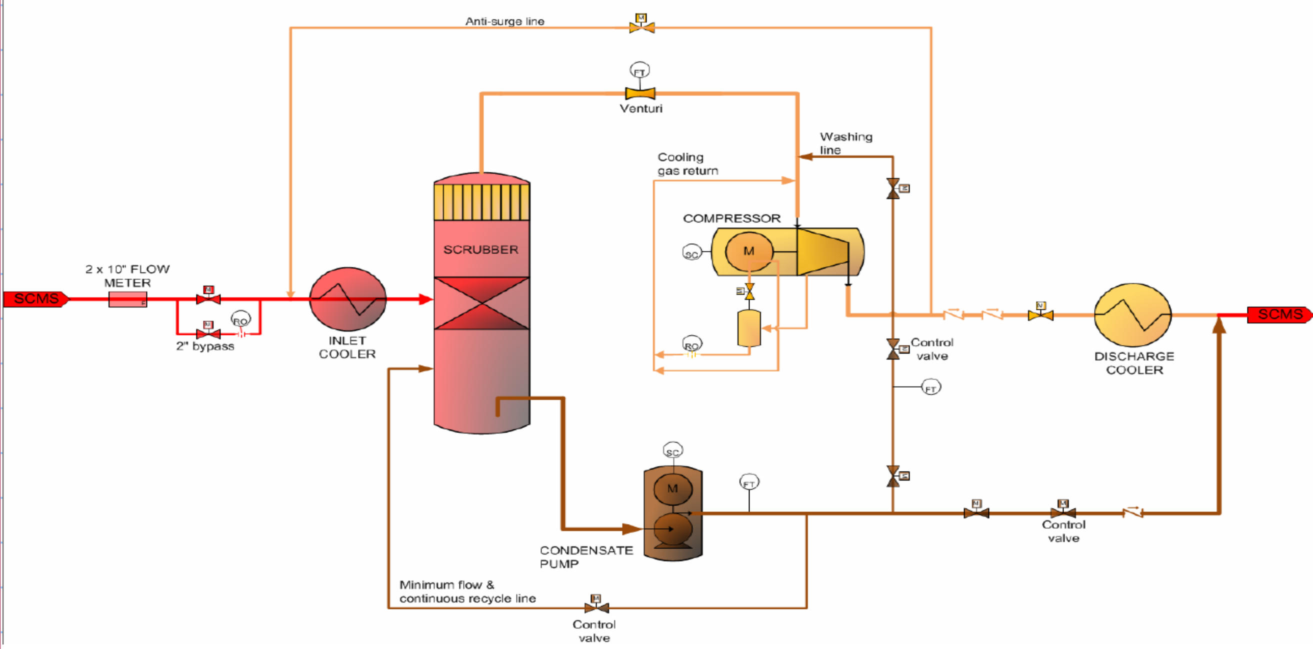


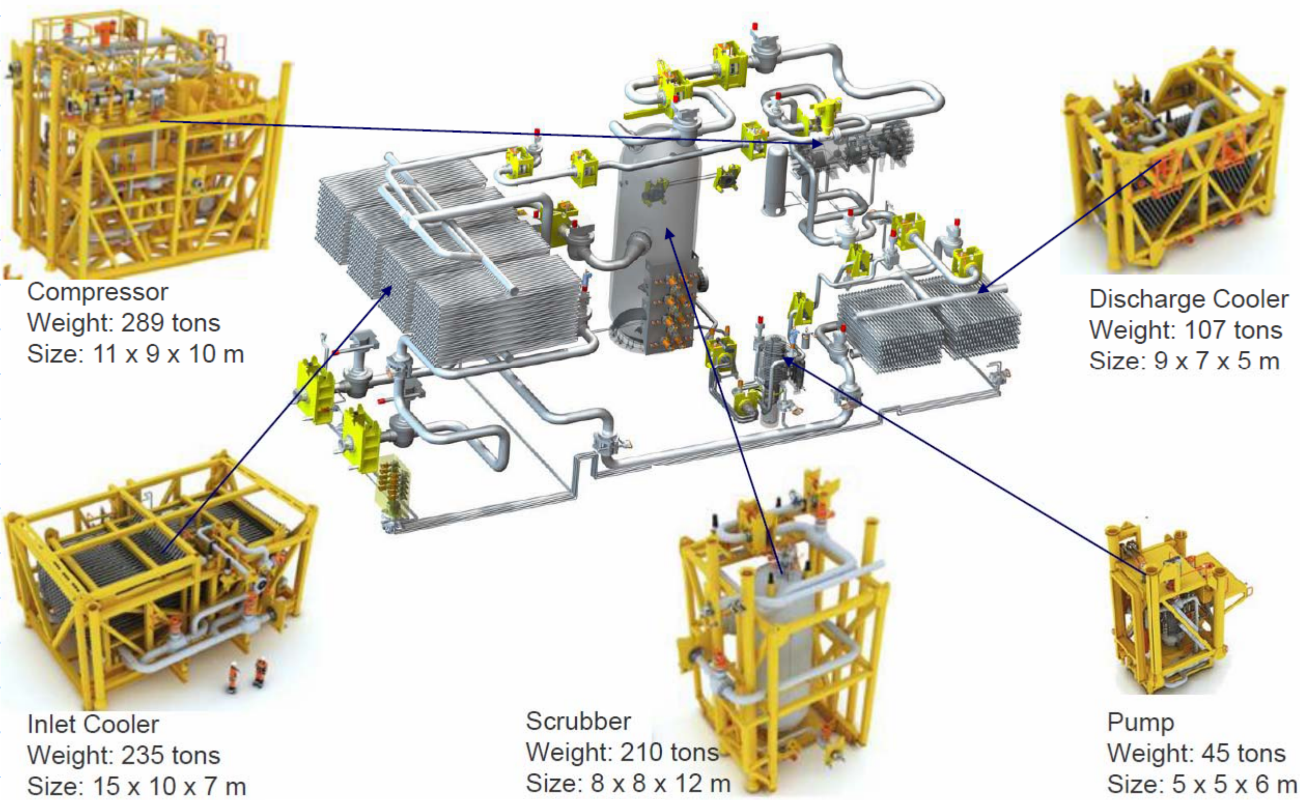
Fig. 3A

Aasgard dry gas compressor with separation before

Process Flow Diagram



Process Modules- Sizes and Dry Weights



Compressor
Weight: 289 tons
Size: 11 x 9 x 10 m

Discharge Cooler
Weight: 107 tons
Size: 9 x 7 x 5 m

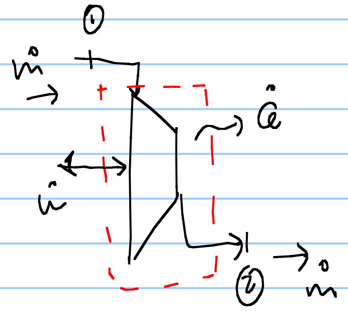
Inlet Cooler
Weight: 235 tons
Size: 15 x 10 x 7 m

Scrubber
Weight: 210 tons
Size: 8 x 8 x 12 m

Pump
Weight: 45 tons
Size: 5 x 5 x 6 m

dry gas compression

First law of thermodynamic for steady state open systems



$$\dot{Q} - \dot{W} = \dot{m}\left[E_2 - E_1\right]$$

$$E = h + \cancel{\frac{v^2}{2}} + \cancel{z} \cdot g \approx h$$

↳ thermal, kynetic, potential

$$\underbrace{\cancel{\dot{Q}}}_{0} - \dot{W} = \dot{m}\left(h_2 - h_1\right)$$

specific enthapy

$$\dot{W} = \dot{m}\left(h_1 - h_2\right)$$

$$h = u + p \cdot v = u + \frac{p}{\rho}$$

$$\dot{W} = \dot{m}\left(u_2 + P_2 v_2 - u_1 + P_1 \cdot v_1\right)$$

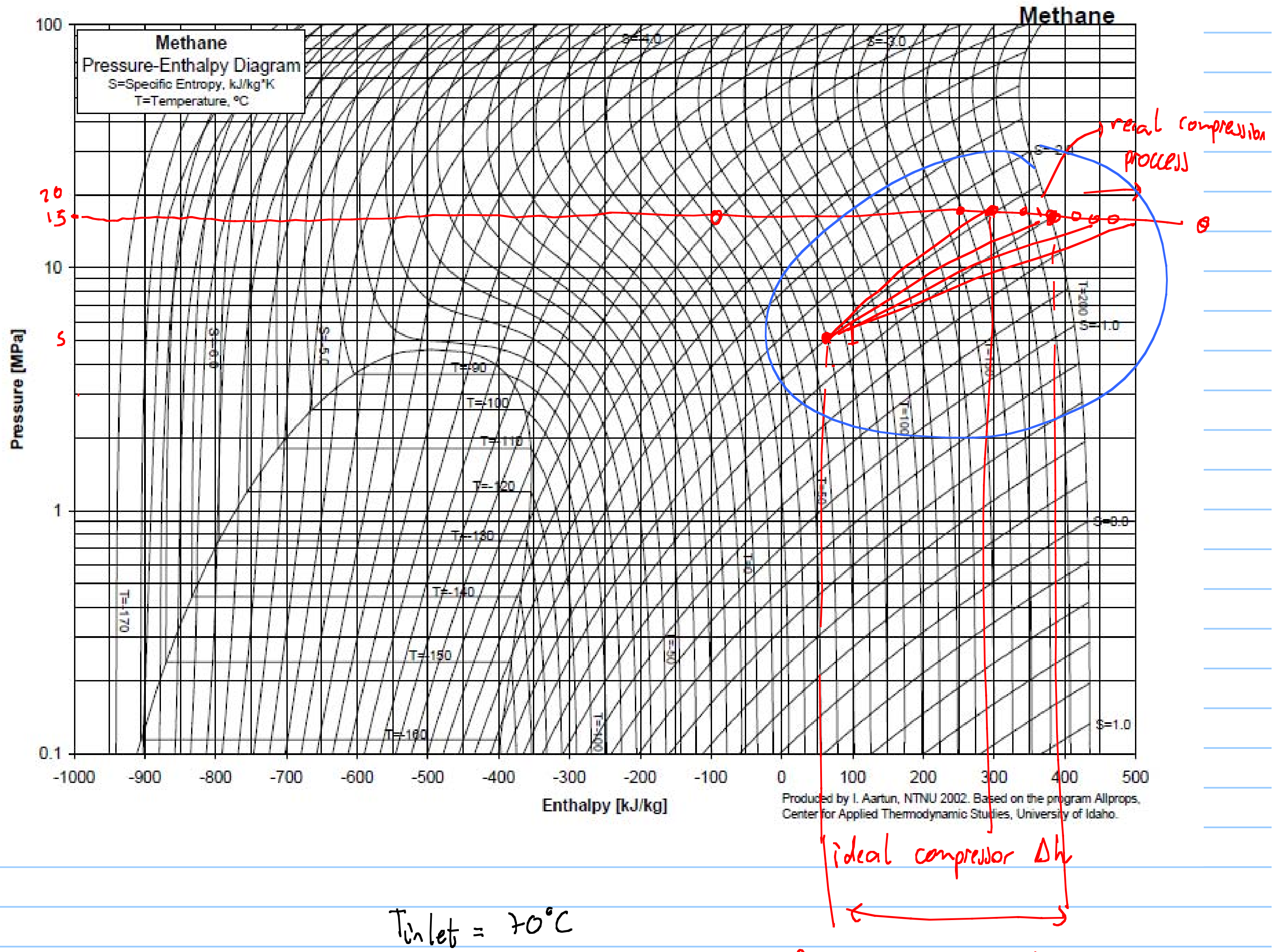
↳ $f(T)$

$P = \Delta P \cdot q$

assumption $v_1 \approx v_2$

$u_1, u_2 << P_2 v_1$

$$\dot{W} = \frac{\dot{m}}{\rho} \cdot \left(P_2 - P_1\right) = q\left(P_2 - P_2\right)$$



$T_{inlet} = 70°C$

$P_{inlet} = 50$ bara

$P_{outlet} = 150$ bara

$$\eta_{compressor} = \frac{\text{ideal compressor work}}{\text{real compressor work}}$$

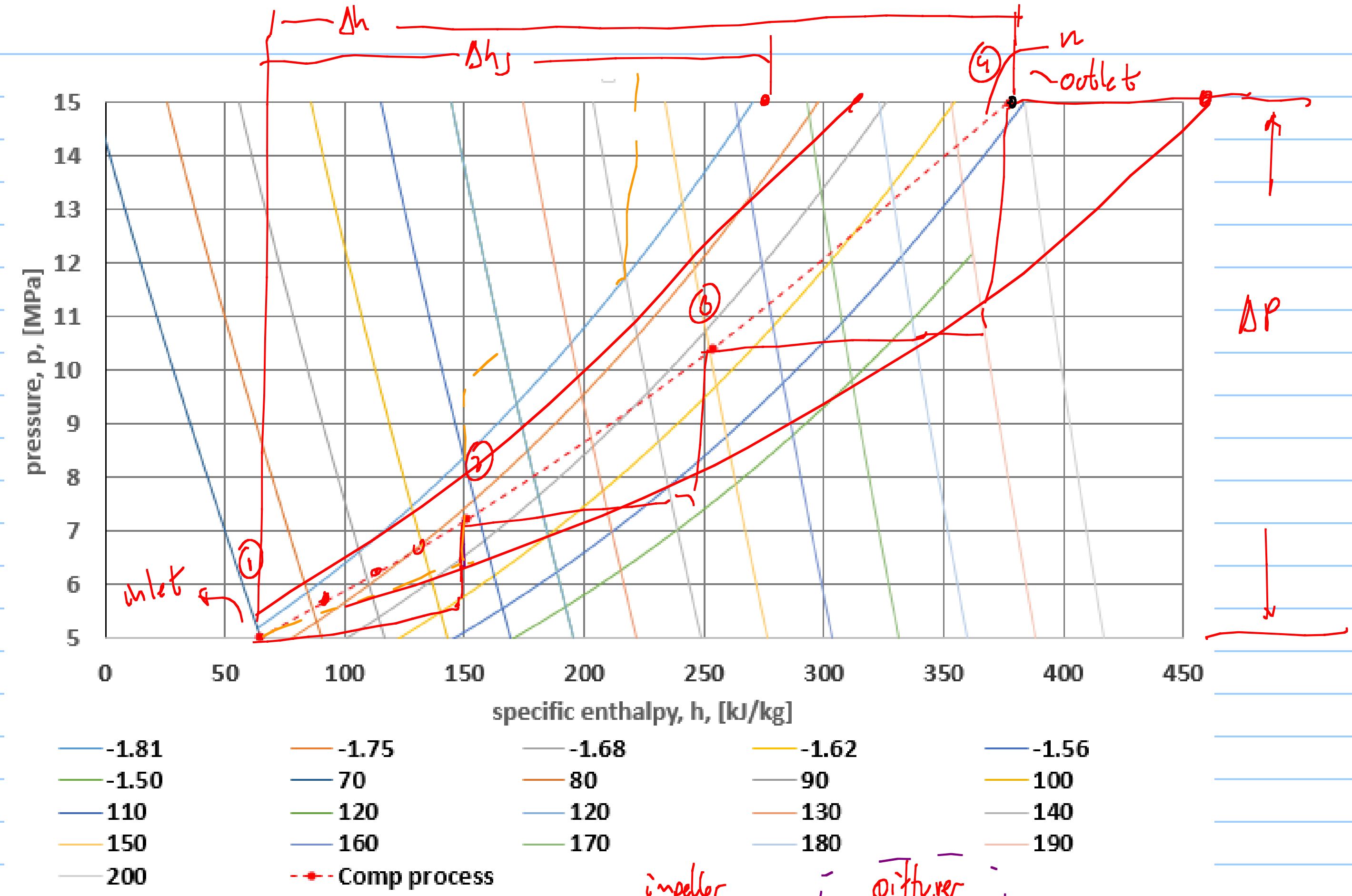
↳ adiabatic efficiency

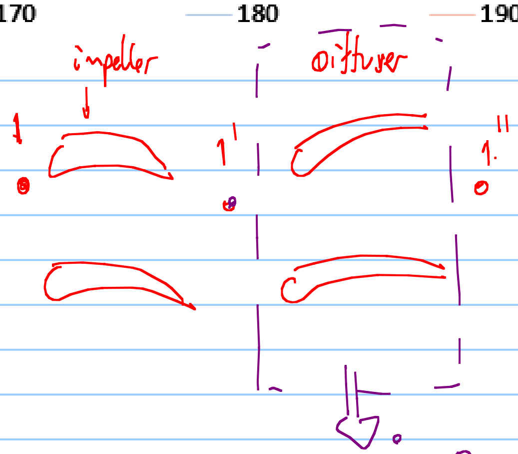
$$\eta_{com} = \frac{\Delta h_s}{\Delta h_r}$$

$$\eta_{adia} = \frac{h_{2s} - h_1}{h_2 - h_1}$$

polytropic coefficient

$Pv^n = $ const.





$\dot{w} = 0$

$\dot{q} = 0$

$h_1' = h_1''$

$r_p = \text{constant}$

$$\frac{P_{stage\,1}}{P_{int}} = \frac{P_{stage\,2}}{P_{stage\,1}} = \frac{P_{outlet}}{P_{stage\,2}} = r_p$$

when I have a multiphase mixture?

mass fraction of component i

$$h_i = \Sigma x_i h_i$$

$$h_i = x h_g + (1-x) h_f$$

efficiency

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$ for a polytropic process

$\sim P_2, T_1 \sim$

1 inlet compressor

2 outlet compressor

Constraints on the compressor operation

simplified analysis i need an representative efficiency

$n \quad f(\eta_p) \quad \eta_p = 0.70$

0.80

detailed analysis

- P_{suc}
- minimum flow ~ surge
- maximum flow → choked flow / sonic flow in the machine
- frequency
- Required power
- T_{outlet}
  - integrity of downstream piping
    $T \leq 150°C$
  - integrity seals
    $T \leq 180°C$
  - hydrate inhibitors: to avoid evaporation
    $T_{out} \leq 140°C$