Education Institute for

Equipment & Process Design

T-5004

Packed Tower Design and Principles

Packed Tower Data Input

Vapor inlet

Performance point	Design
Temperature	47
Pressure	
Gas flow	11332
Gas density	1,15
Gas viscosity	0,017
Gas molecular weight	30,22

Vapor Outlet

Performance point	Design
Temperature	45
Gas flow	11004
Gas density	1,11
Gas viscosity	0,017
Gas molecular weight	28,99

Liquid Inlet

Performance point	Design
Temperature	48
Pressure 3)	
Liquid flow	8197
Liquid density	989
Liquid viscosity	0,567
Liquid surface tension	68

Liquid Outlet

Performance point	Design
Temperature	37
Liquid flow	8524
Liquid density	964
Liquid viscosity	0,679
Liquid surface tension	61

Packed Tower ID Sizing

1.Determine the capacity term value

Choose a ΔP value and calculate the flow parameter

$$\frac{L_m}{G_m}\sqrt{\frac{\rho_v}{\rho_l}} = \frac{L}{G}\sqrt{\frac{\rho_v}{\rho_l}}$$

L_m = liquid mass flow rate (kg/s),
L = liquid mass velocity ($kg/(m^2.s)$),
G_m = gas (or vapour) mass flow rate (kg/s),
G = gas (or vapour) mass velocity ($kg/(m^2.s)$),
ρ_v = gas (or vapour) density at operating temperature and operating pressure of the contact section (kg/m^3),
ρ_l = liquid density at operating temperature and operating pressure of the contact section (kg/m^3).

Service	ΔP in mm H2O/m of packing
Absorbers/Regenerators	
Liquids with foaming tendency	8 to 20
Liquids with non foaming tendancy	20 to 40
Atmospheric and high pressure hydrocarbon fractionation (non foaming fluids)	40 to 80
Vacuum distillation	8 to 20
Minimum ΔP	8
Maximum ΔP	80

Calculation for this step

Inlet	Value
L	8197
G	11332
Lm	2.2769
Gm	3.14
F	0.024

Outlet	Value
L	8524
G	11004
Lm	2.36
Gm	3.05
F	0.026

2. Determine Capacity term or C from diagram below

$$C = \frac{G^2 (\mu_l)^{0.1} \left(\frac{\rho_w}{\rho_l}\right)^{0.1} F_p}{2.99\, \rho_v (\rho_l - \rho_v)}$$

ρ_v = gas (or vapour) density (kg/m^3),

ρ_l = liquid density at operating temperature and operating pressure of the contact section (kg/m^3),

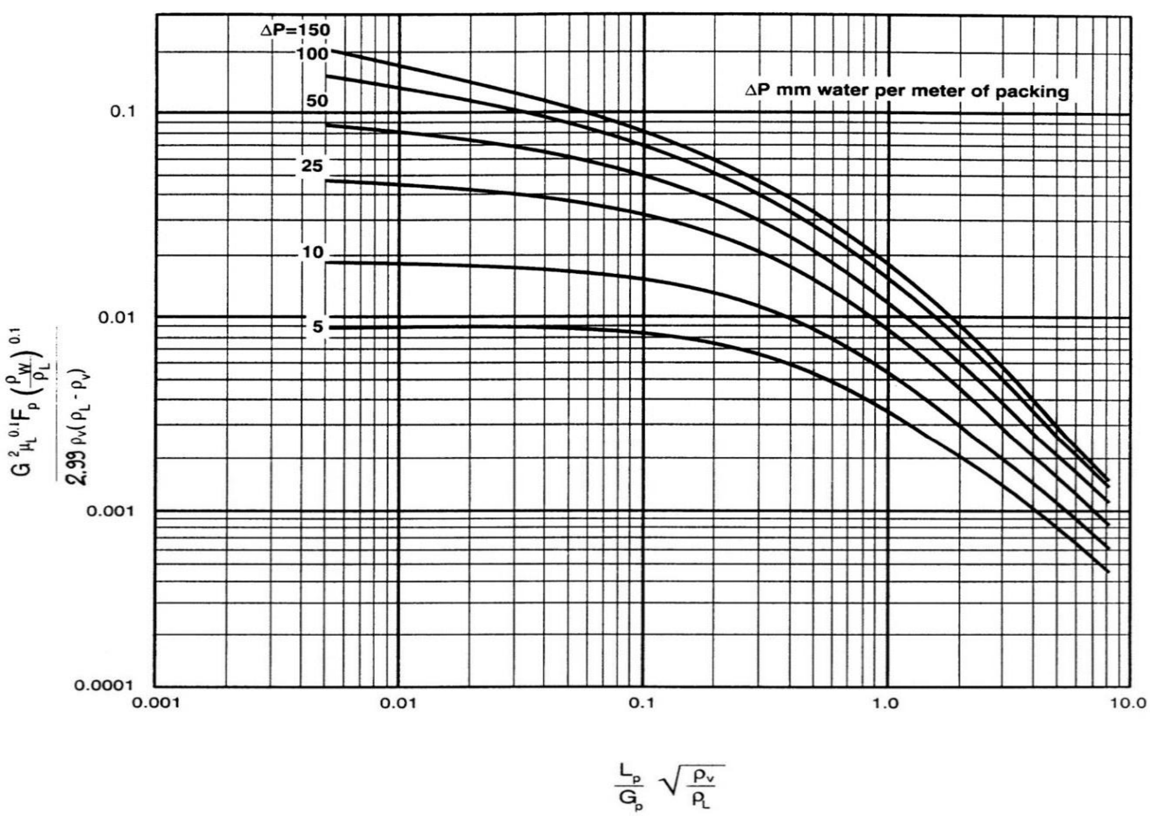
ρ_w = water density (= 1000 kg/m^3),

μ_l = liquid viscosity (cP or mPa.s),

G = gas (or vapour) mass velocity (kg/(m^2.s)),

F_p = packing factor (given by table on figure 18).

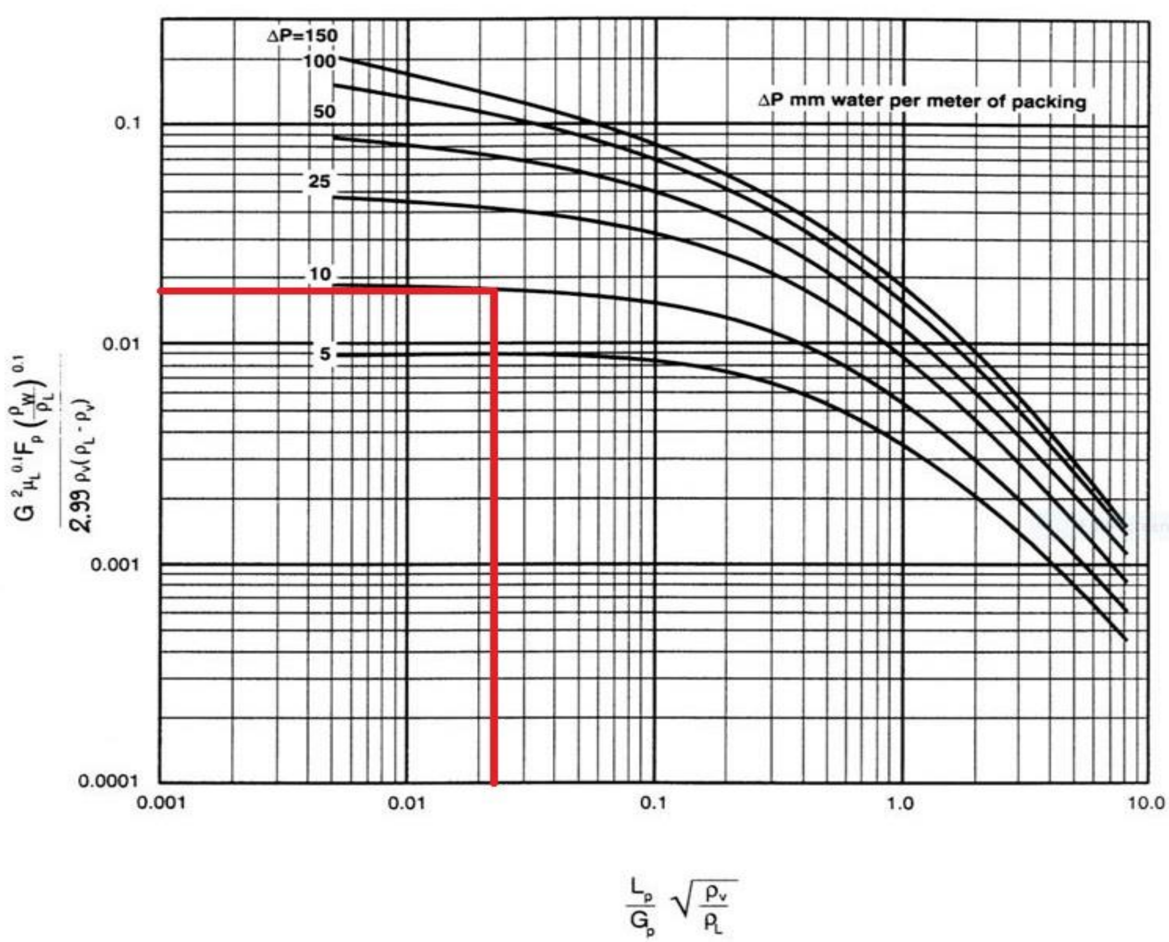
Packed Column Pressure Drop Correlation



Calculation for this step

Note that according to licensor requirement a dp of 10 mbar is chosen

Packed Column Pressure Drop Correlation



3.

3. Choose a packing type and determine the packing factor (Fp)

- The packing factors for various packings are shown in figure 18.
- Usually packings smaller than 25 mm (1 in) size are intended for column diameters of 300 mm or

smaller, packings of 25 mm to 37 mm (1 in to 1½ in) in size for column diameters from 300 mm to 900 mm, and packings from 50 mm to 75 mm (2 in to 3 in) in size for column diameters of 900 mm and more.

Packing Type	Material	Nominal Packing Size (mm)										
		6	9	12	15	18	25	31	37	50	75	87
IMTP®	Metal				51		40		24	18	12	
Hy-Pak™	Metal						45		29	26		16
Super Intalox Saddles®	Ceramic						60			30		
Super Intalox Saddles®	Plastic						40			28		18
Pall Rings	Plastic				75		55		40	26		17
Pall Rings	Metal				70		56		40	27		18
Intalox Saddles®	Ceramic	725	330	200		145	92		52	40	22	
Raschig Rings	Ceramic	1600	1000	580	380	255	155	125	95	65	37	
Raschig Rings	0.75 mm Metal	700	390	300	170	155	115					
Raschig Rings	1.50 mm Metal			410	300	220	144	110	93	62	32	
Berl Saddles	Ceramic	900		240		170	110		65	45		

Courtesy of Norton Co.

Calculation for this step

We select IMTP because of its wide applicability and suppose that ID is more than 900mm; as a result, a 2-inch (50mm) IMPT is selected with packing factor of 18 according to the table below.

Packing Type	Material	Nominal Packing Size (mm)										
		6	9	12	15	18	25	31	37	50	75	87
IMTP®	Metal				51		40		24	18	12	
Hy-Pak™	Metal						45		29	26		16
Super Intalox Saddles®	Ceramic						60			30		
Super Intalox Saddles®	Plastic						40			28		18
Pall Rings	Plastic				75		55		40	26		17
Pall Rings	Metal				70		56		40	27		18
Intalox Saddles®	Ceramic	725	330	200		145	92		52	40	22	
Raschig Rings	Ceramic	1600	1000	580	380	255	155	125	95	65	37	
Raschig Rings	0.75 mm Metal	700	390	300	170	155	115					
Raschig Rings	1.50 mm Metal			410	300	220	144	110	93	62	32	
Berl Saddles	Ceramic	900		240		170	110		65	45		

4. Calculate the gas (or vapour) mass velocity G with the capacity term C value determined in previous step.

$$G^2 = \frac{2.99\,\rho_v\left(\rho_l - \rho_v\right)C}{\left(\mu_l\right)^{0.1}\left(\dfrac{\rho_w}{\rho_l}\right)^{0.1} F_p}$$

5. Determine minimum inside diameter using following formula

$$D = \sqrt{\frac{G_m}{0.7854\,G}}$$

D	=	minimum diameter (m),
G_m	=	gas (or vapour) mass flowrate (kg/s),
G	=	gas (or vapour) mass velocity (kg/(m^2.s)).

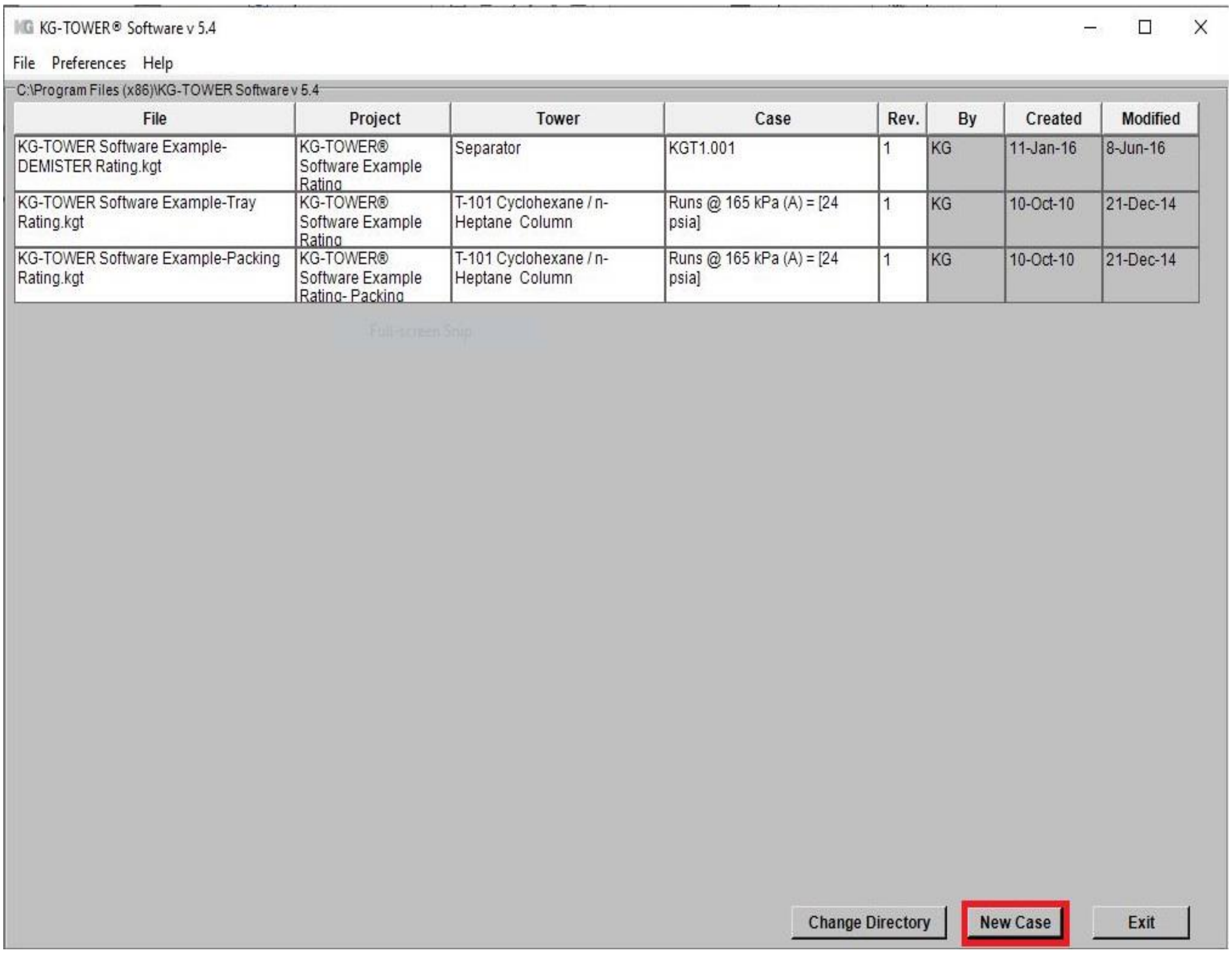
Calculation for this step

Inlet Parameter	Value
ρl	989 kg/m3
ρv	1.15 kg/m3
C	0.0175
Fp	18
G^2	3.49
G	1.86
D	1464 mm

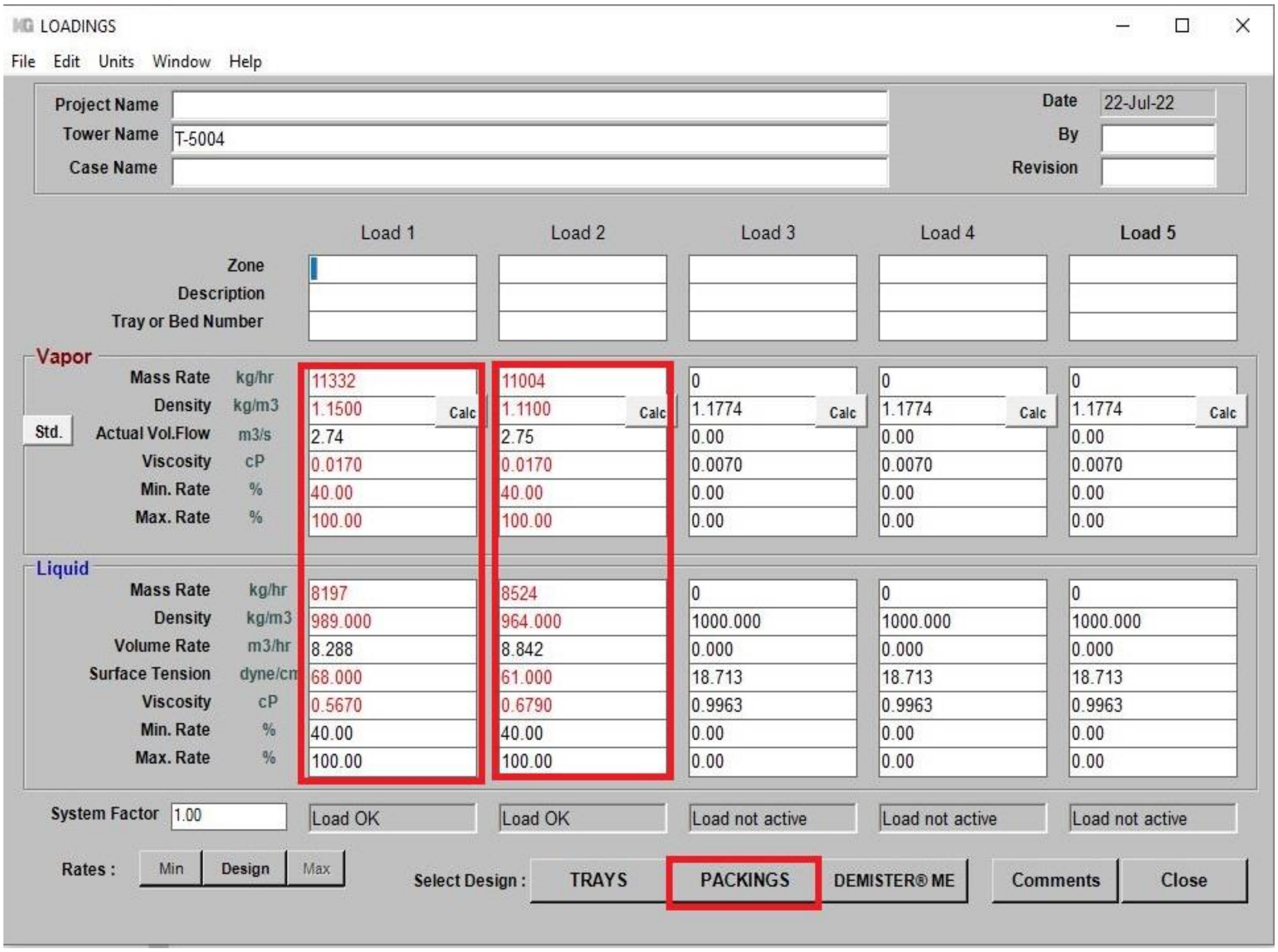
Outlet Parameter	Value
ρl	964kg/m3
ρv	1.11 kg/m3
C	0.0175
Fp	18
G^2	3.27
G	1.81
D	1466 mm

6. KG TOWER Confirmation

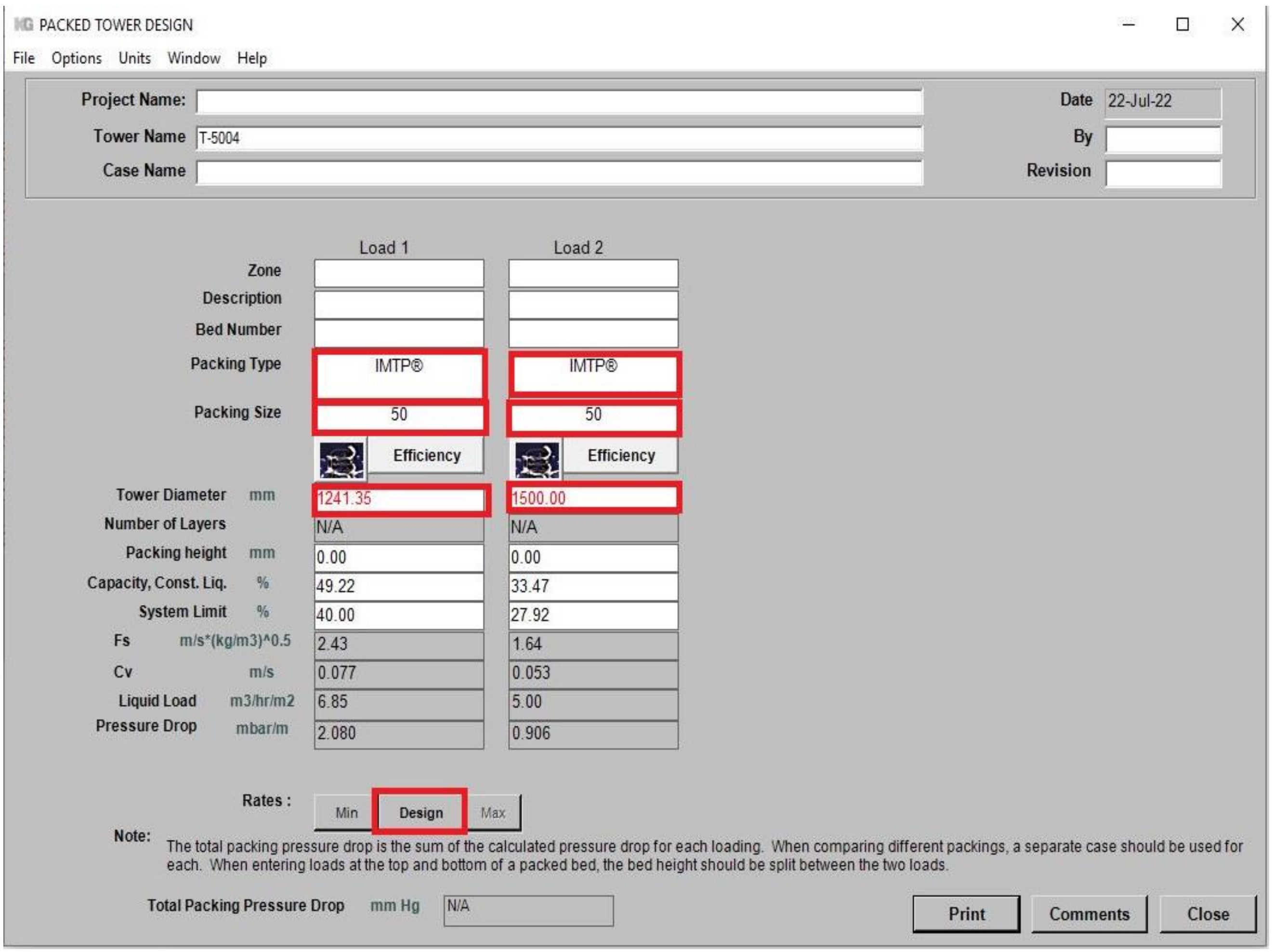
Open the software and select a new case



Fill-up box 1 and 2 and then click ***Packing***



Fill-up the box accordingly and Click ***Options*** and select ***Constant liquid***



Comparison

Haldor Topsoe	Excel Sheet	KG Tower
1500	1465	1250

Notice that if the height of the tower is 5 m then the total dp according to KG Tower is 10 mbar it means that the minimum ID for the packed tower is 1250.