Column hydraulics: Benzene-toluene splitter

Tag C-100. Top pressure 110.00 kPa(a). Generated 2026-11-19 06:22 UTC.

Overall: All checks pass. Column height 22.90 m tangent to tangent; total pressure drop 23.97 kPa at normal load.

Section	Type	Diameter m	Governing flood % (design)	Section dP kPa	Status
Rectifying trays	Trays: sieve, 14	2.40	62.2	10.77	OK
Stripping trays	Trays: sieve, 16	2.40	71.9	13.20	OK

Design basis

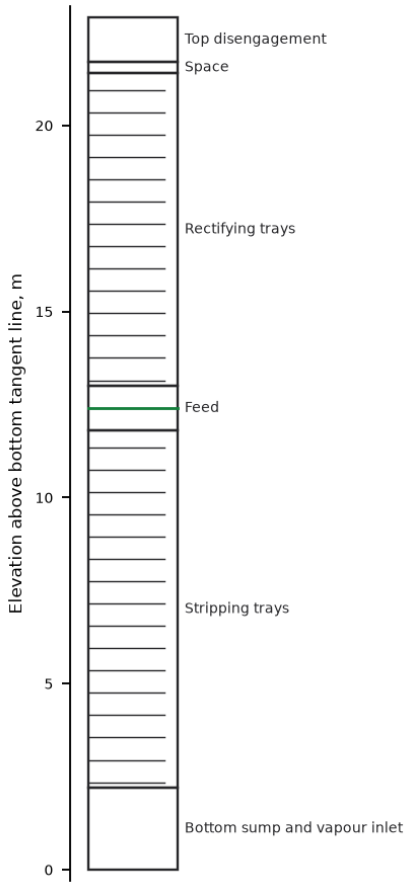
Limits and operating cases applied to every check. Section loads are normal-operation values; the minimum, design and maximum cases multiply them by the factors below.

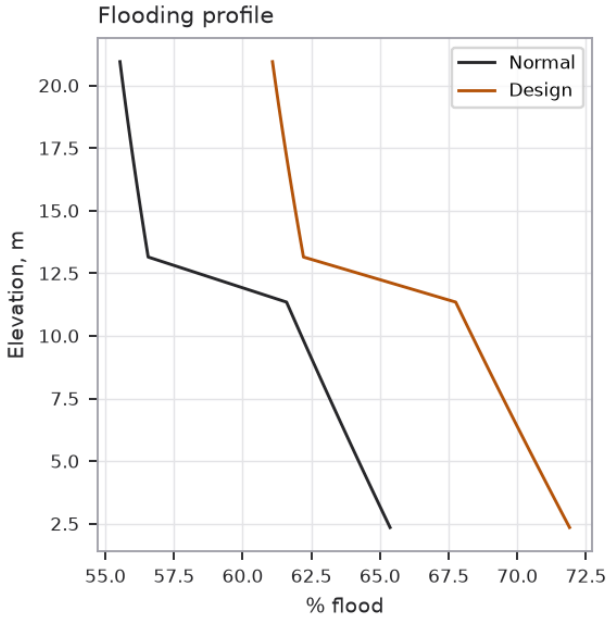
Criterion	Value	Unit	Meaning
System (foaming) factor	1.00	-	Derates flooding and downcomer velocities for foaming liquids (1 = non-foaming).
Downcomer froth density	0.50	-	Clear-liquid fraction of downcomer froth; lower means taller froth.
Tray jet flood limit	82.00	%	Highest percent of jet flood allowed at the design case.
Packing flood limit	80.00	%	Highest percent of flood allowed for packing at the design case.
Downcomer backup limit	80.00	% of TS + weir	Highest aerated froth height in the downcomer.
Downcomer velocity limit	100.00	% of design velocity	Highest liquid velocity entering the downcomer.
Minimum residence time	3.00	s	Least time liquid stays in the downcomer to release vapour.
Weir loading limit	90.00	m3/h per m	Highest liquid flow per metre of outlet weir.
Minimum weir crest	6	mm	Least liquid height over the weir at minimum load.
Weep index limit	1.00	-	Lowest weep screening index at minimum load.
Tray pressure drop limit	-	Pa per tray	Optional allowance per tray (blank = none).
Packing pressure drop limit	-	Pa/m	Optional allowance per metre of packing (blank = none).
Minimum case	0.70	x normal	Turndown rate: weeping, crest and wetting are checked here.
Design case	1.10	x normal	Design rate: flooding and downcomer limits are checked here.
Maximum case	1.20	x normal	Highest short-term rate, shown on envelopes.

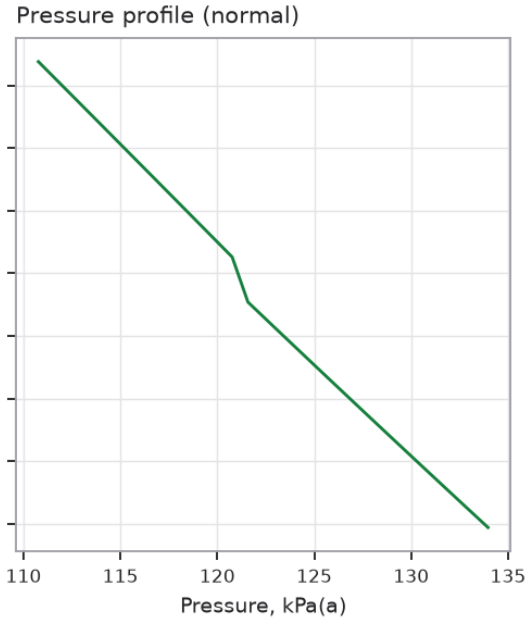
Column configuration

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Element	From m	To m	Diameter m
Bottom sump and vapour inlet	0.00	2.20	2.40
Stripping trays	2.20	11.80	2.40
Feed	11.80	13.00	2.40
Rectifying trays	13.00	21.40	2.40
Space	21.40	21.70	2.40
Top disengagement	21.70	22.90	2.40







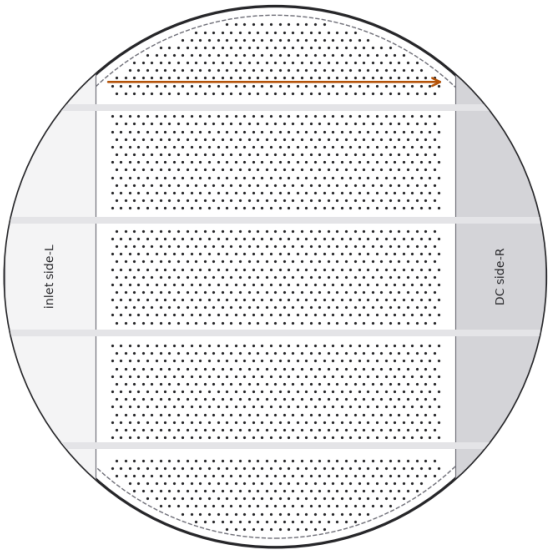
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Section Rectifying trays

Geometry

Item	Value	Item	Value
Tray type	sieve	Number of trays	14
Diameter	2.400 m	Tray spacing	600 mm
Passes	1	Weir height	45 mm
Downcomer area (tray A)	11.0 % of tower	Clearance	33 mm
Active area (A)	3.529 m2	Bubbling area (A)	3.036 m2
Units placed (A)	2041	Pitch	39.2 mm triangular
Open area / bubbling	8.52 %	Open area / active	7.33 %

Tray A plan: 2041 units, open area 8.5 % of bubbling area



Operating conditions and properties

Location	V kg/h	L kg/h	rhoV kg/m3	rhoL kg/m3	muV cP	muL cP	sigma mN/m
Top	35240	23490	2.930	812.0	0.0090	0.310	21.00
Bottom	37040	25530	3.280	800.0	0.0091	0.290	20.00

Cases: minimum x0.70, normal x1.00, design x1.10, maximum x1.20 on the loads above.

Checks

Check	Case	Value	Limit	Unit	Status
Jet flood	design	62.21	82.0	%	OK
Downcomer backup (aerated)	design	56.29	80.0	% of TS+hw	OK
Downcomer velocity	design	11.55	100.0	% of design	OK
Downcomer residence time	design	9.26	3.0	s	OK
Weir loading	design	19.60	90.0	m3/h per m	OK
Weir crest at minimum	minimum	14.24	6.0	mm	OK
Weep screening at minimum	minimum	1.21	1.0	-	OK
Downcomer seal	design	12.00	6.0	mm (weir minus clearance)	OK
Hole area / active area	geometry	7.33	5 to 15	%	OK

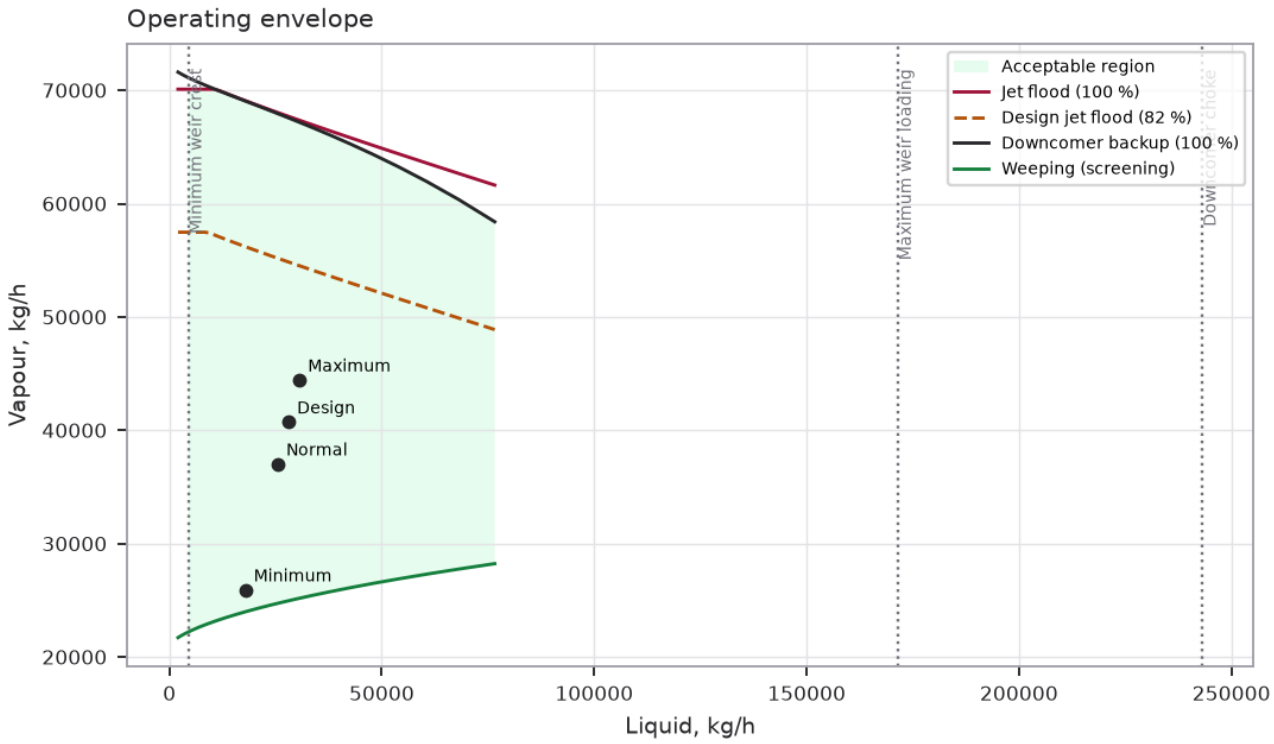
Results (governing trays: design 14, minimum 14)

Quantity	Minimum	Normal	Design
Jet flood %	39.6	56.6	62.2
Tray dP Pa	514	767	875
Clear liquid mm	29.6	25.6	24.5

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Quantity	Minimum	Normal	Design
Froth height mm	64	74	78
DC backup %	39.6	51.4	56.3
DC velocity %	7.3	10.5	11.5
Weir load m3/h/m	12.5	17.8	19.6
Weir crest mm	15.2	19.3	20.6
Weep index	1.21	2.81	3.54
Hole velocity m/s	8.49	12.13	13.35

Operating envelope (bottom of section)



Engineering interpretation

Hydraulic performance. At the design case (x1.10) the governing tray is tray 14 at 62.2 % jet flood. Tray pressure drop is 875 Pa (111 mm liquid). Throughput can rise to 145 % of normal before jet flood reaches its limit; turndown is limited by weeping (screening) at 64 % of normal (turndown ratio about 2.3:1).

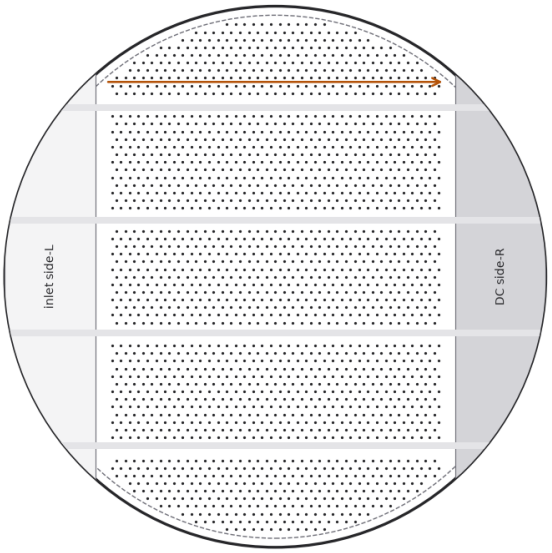
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Section Stripping trays

Geometry

Item	Value	Item	Value
Tray type	sieve	Number of trays	16
Diameter	2.400 m	Tray spacing	600 mm
Passes	1	Weir height	45 mm
Downcomer area (tray A)	11.0 % of tower	Clearance	33 mm
Active area (A)	3.529 m2	Bubbling area (A)	3.036 m2
Units placed (A)	2041	Pitch	39.2 mm triangular
Open area / bubbling	8.52 %	Open area / active	7.33 %

Tray A plan: 2041 units, open area 8.5 % of bubbling area



Operating conditions and properties

Location	V kg/h	L kg/h	rhoV kg/m3	rhoL kg/m3	muV cP	muL cP	sigma mN/m
Top	37350	51480	3.330	795.0	0.0092	0.280	19.50
Bottom	40950	54960	3.810	778.0	0.0095	0.250	18.00

Cases: minimum x0.70, normal x1.00, design x1.10, maximum x1.20 on the loads above.

Checks

Check	Case	Value	Limit	Unit	Status
Jet flood	design	71.90	82.0	%	OK
Downcomer backup (aerated)	design	70.34	80.0	% of TS+hw	OK
Downcomer velocity	design	25.56	100.0	% of design	OK
Downcomer residence time	design	5.23	3.0	s	OK
Weir loading	design	43.40	90.0	m3/h per m	OK
Weir crest at minimum	minimum	24.37	6.0	mm	OK
Weep screening at minimum	minimum	1.04	1.0	-	OK
Downcomer seal	design	12.00	6.0	mm (weir minus clearance)	OK
Hole area / active area	geometry	7.33	5 to 15	%	OK

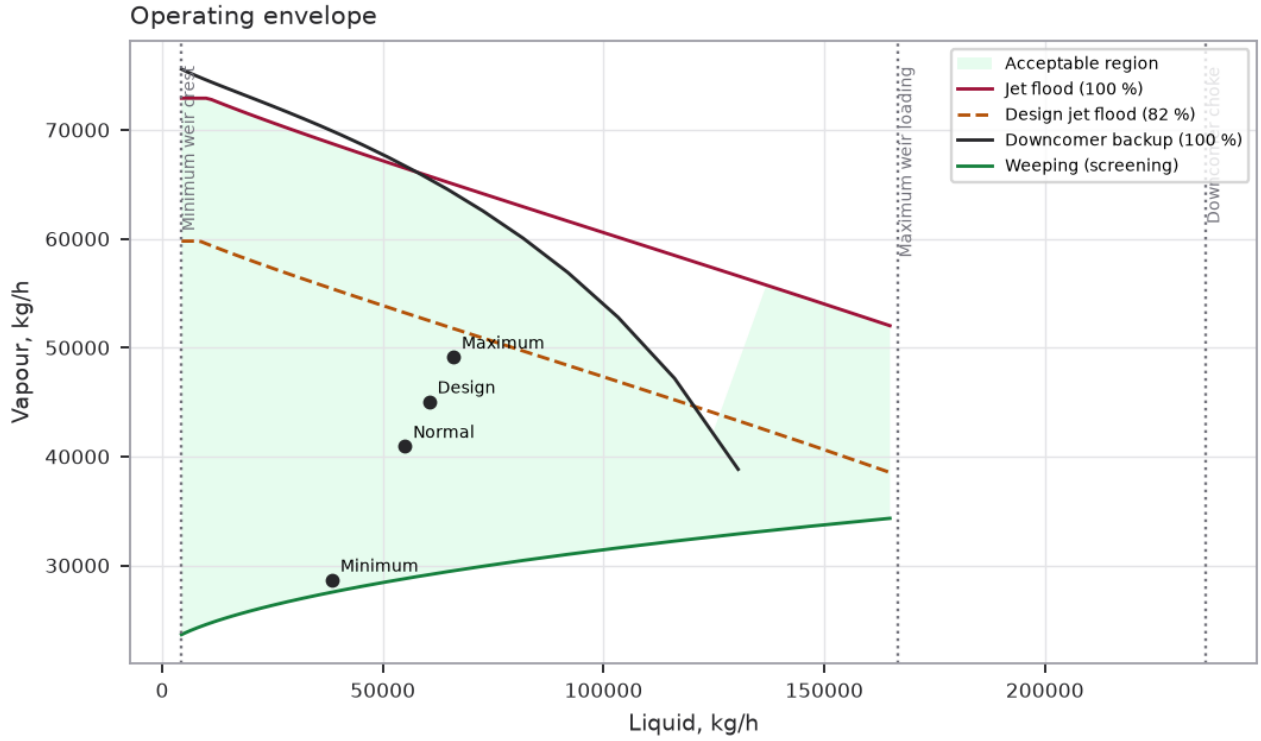
Results (governing trays: design 16, minimum 1)

Quantity	Minimum	Normal	Design
Jet flood %	43.1	65.4	71.9
Tray dP Pa	554	837	953
Clear liquid mm	34.9	31.9	31.0

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Quantity	Minimum	Normal	Design
Froth height mm	75	96	103
DC backup %	45.9	63.8	70.3
DC velocity %	14.9	23.2	25.6
Weir load m3/h/m	25.3	39.5	43.4
Weir crest mm	24.4	32.8	34.9
Weep index	1.04	2.44	3.03
Hole velocity m/s	8.44	11.55	12.70

Operating envelope (bottom of section)



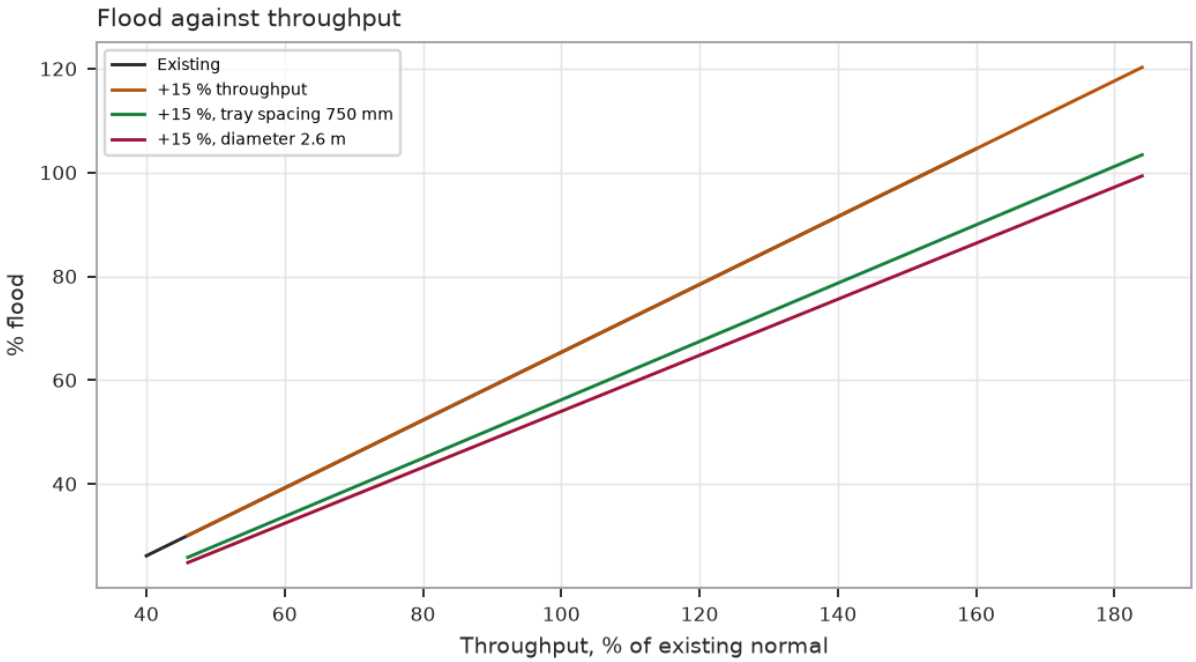
Engineering interpretation

Hydraulic performance. At the design case (x1.10) the governing tray is tray 16 at 71.9 % jet flood. Tray pressure drop is 953 Pa (125 mm liquid). Throughput can rise to 123 % of normal before downcomer backup reaches its limit; turndown is limited by weeping (screening) at 69 % of normal (turndown ratio about 1.8:1).

Debottlenecking comparison

Case	Flood %	dP section kPa	Capacity % of own loads	First limit
Existing	65.4	13.20	123	Downcomer backup
+15 % throughput	75.2	15.98	107	Downcomer backup
+15 %, tray spacing 750 mm	64.6	15.98	127	Downcomer backup
+15 %, diameter 2.6 m	62.1	11.89	128	Downcomer backup

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Assumptions and limitations

- Loads and properties vary linearly between the section top and bottom.

- Liquid splits between passes in proportion to bubbling area (equal L/V per pass).

- Vapour is evenly distributed over the bubbling area; spatial maldistribution and hydraulic gradient are not modelled.

- Tray results are correlation based (Fair, Bennett and others). They are sectional averages, not CFD.

- Valve tray dry pressure drop uses generic coefficients. The valve maker's data govern.

- Packing constants are literature values, flagged where they are not yet verified against the original table.

- The weep screen is a conservative pressure balance, not a weep-rate prediction.

- Results describe hydraulic capacity only. They do not confirm separation performance, mechanical design or a safe operating capacity.

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[seader] Seader, J.D., Henley, E.J. and Roper, D.K. Separation Process Principles, chapter 6 (tray and packed column hydraulics).

[francis] Francis weir formula for a straight, unconstricted weir, as used in Kister (1992) and Sinnott.

[orifice] Orifice equation: discharge through a sharp-edged opening, Q = Cd A (2 g h)^0.5.

[hetp_rules] Rules of thumb for HETP: structured HETP = 100 / a + 0.10 m (45 degree corrugation); random HETP = 18 d_p. Kister (1992) and later Kister papers; for screening only.

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Calculation trace: Rectifying trays

Id	Quantity	Equation	Value	Unit	Ref
QV	Vapour volumetric flow	Q_V = V / rhoV	3.4505	m3/s	
QL	Liquid volumetric flow	Q_L = L / rhoL	0.0098	m3/s	
FLV	Flow parameter F_LV	F_LV = (L/V) (rhoV/rhoL)^0.5	0.0441	-	fair1961
CSB	Fair capacity factor C_SB	C_SB = 0.0105 + 8.127e-4 TS^0.755 exp(-1.463 F_LV^0.842), TS in mm	0.1020	m/s	lygeros1986
Fsig	Surface tension correction	(sigma / 20 mN/m)^0.2	1.0000	-	fair1961
A.Fha	Hole area factor (tray A)	F_ha = 5 A_h/A_a + 0.5 if A_h/A_a < 0.10, else 1	0.8663	-	fair1961
A.uNF	Flooding velocity on net area (tray A)	u_NF = C_SB F_sigma F_ha SF ((rhoL - rhoV)/rhoV)^0.5	1.3775	m/s	fair1961
A.uN	Vapour velocity on net area (tray A)	u_N = Q_V / (A_T - A_dc)	0.8570	m/s	
A.flood	Jet flood (tray A)	flood = 100 u_N / u_NF	62.2129	%	fair1961
A.uh	Hole (orifice) velocity (tray A)	u_h = Q_V / A_h	13.3459	m/s	
A.Co	Orifice coefficient C_o (tray A)	C_o = 0.74 (A_h/A_a) + exp(0.29 t/d_h - 0.56)	0.6590	-	hughmark1957
A.dPdry	Dry tray pressure drop (tray A)	dP_dry = rhoV u_h^2 / (2 C_o^2)	672.6580	Pa	hughmark1957
A.hd	Dry tray head h_d (tray A)	h_d = dP_dry / (rhoL g)	0.0857	m liq	
A.hsig	Surface tension head (tray A)	h_sigma = 6 sigma / (g rhoL d_h)	0.0012	m liq	kister1992
A.Ks	Capacity factor on bubbling area (tray A)	K_s = u_a (rhoV/(rhoL - rhoV))^0.5	0.0729	m/s	bennett1983
A.alpha	Effective froth density (tray A)	alpha_e = exp(-12.55 K_s^0.91)	0.3140	-	bennett1983
A.hcl	Clear liquid height, panel P1 (tray A)	h_cl = alpha_e [h_w + C (q_L/(L_w alpha_e))^0.67], C = 0.501 + 0.438 exp(-137.8 h_w)	0.0245	m liq	bennett1983
A.how	Weir crest, panel P1 (tray A)	h_ow = 0.664 (q_L/L_w)^(2/3)	0.0206	m liq	francis
A.ht	Total tray head (tray A)	h_t = h_d + h_cl + h_sigma (area-weighted over panels)	0.1115	m liq	bennett1983
A.dPt	Total tray pressure drop (tray A)	dP_t = h_t rhoL g	874.6890	Pa	
A.weep	Weep screening index (tray A)	I_w = (h_d + h_sigma) / h_cl (lowest panel)	3.5419	-	kister1992
udcmax	Downcomer design velocity	u_dc,max = SF min(250, 41 (rhoL - rhoV)^0.5, 7.5 TS^0.5 (rhoL - rhoV)^0.5) gpm/ft2	0.1698	m/s	kister1992
hud	Head loss under downcomer side-R (tray A)	h_ud = 0.165 (Q_dc / A_ud)^2, A_ud = clearance x inlet length	0.0045	m liq	kister1992
hdc	Clear liquid backup in downcomer side-R	h_dc = h_t(receiving tray) + h_w + h_ow + h_ud	0.1815	m liq	kister1992
backup	Aerated downcomer backup	backup = 100 (h_dc / phi_dc) / (TS + h_w)	56.2906	% of TS+hw	kister1992
choke	Downcomer velocity / design velocity (side-R)	100 u_dc / u_dc,max	11.5474	%	kister1992
tres	Downcomer residence time (side-R)	t = A_dc h_dc / Q_dc	9.2600	s	sinnott
min.QV	Vapour volumetric flow	Q_V = V / rhoV	2.1958	m3/s	
min.QL	Liquid volumetric flow	Q_L = L / rhoL	0.0062	m3/s	
min.FLV	Flow parameter F_LV	F_LV = (L/V) (rhoV/rhoL)^0.5	0.0441	-	fair1961
min.CSB	Fair capacity factor C_SB	C_SB = 0.0105 + 8.127e-4 TS^0.755 exp(-1.463 F_LV^0.842), TS in mm	0.1020	m/s	lygeros1986
min.Fsig	Surface tension correction	(sigma / 20 mN/m)^0.2	1.0000	-	fair1961
min.A.Fha	Hole area factor (tray A)	F_ha = 5 A_h/A_a + 0.5 if A_h/A_a < 0.10, else 1	0.8663	-	fair1961
min.A.uNF	Flooding velocity on net area (tray A)	u_NF = C_SB F_sigma F_ha SF ((rhoL - rhoV)/rhoV)^0.5	1.3775	m/s	fair1961
min.A.uN	Vapour velocity on net area (tray A)	u_N = Q_V / (A_T - A_dc)	0.5453	m/s	
min.A.flood	Jet flood (tray A)	flood = 100 u_N / u_NF	39.5900	%	fair1961
min.A.uh	Hole (orifice) velocity (tray A)	u_h = Q_V / A_h	8.4928	m/s	
min.A.Co	Orifice coefficient C_o (tray A)	C_o = 0.74 (A_h/A_a) + exp(0.29 t/d_h - 0.56)	0.6590	-	hughmark1957

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Id	Quantity	Equation	Value	Unit	Ref
min.A.dPdry	Dry tray pressure drop (tray A)	dP_dry = rhoV u_h^2 / (2 C_o^2)	272.3990	Pa	hughmark1957
min.A.hd	Dry tray head h_d (tray A)	h_d = dP_dry / (rhoL g)	0.0347	m liq	
min.A.hsig	Surface tension head (tray A)	h_sigma = 6 sigma / (g rhoL d_h)	0.0012	m liq	kister1992
min.A.Ks	Capacity factor on bubbling area (tray A)	K_s = u_a (rhoV/(rhoL - rhoV))^0.5	0.0464	m/s	bennett1983
min.A.alpha	Effective froth density (tray A)	alpha_e = exp(-12.55 K_s^0.91)	0.4641	-	bennett1983
min.A.hcl	Clear liquid height, panel P1 (tray A)	h_cl = alpha_e [h_w + C (q_L/(L_w alpha_e))^0.67], C = 0.501 + 0.438 exp(-137.8 h_w)	0.0296	m liq	bennett1983
min.A.how	Weir crest, panel P1 (tray A)	h_ow = 0.664 (q_L/L_w)^(2/3)	0.0152	m liq	francis
min.A.ht	Total tray head (tray A)	h_t = h_d + h_cl + h_sigma (area-weighted over panels)	0.0656	m liq	bennett1983
min.A.dPt	Total tray pressure drop (tray A)	dP_t = h_t rhoL g	514.3600	Pa	
min.A.weep	Weep screening index (tray A)	I_w = (h_d + h_sigma) / h_cl (lowest panel)	1.2122	-	kister1992
min.udcmax	Downcomer design velocity	u_dc,max = SF min(250, 41 (rhoL - rhoV)^0.5, 7.5 TS^0.5 (rhoL - rhoV)^0.5) gpm/ft2	0.1698	m/s	kister1992
min.hud	Head loss under downcomer side-R (tray A)	h_ud = 0.165 (Q_dc / A_ud)^2, A_ud = clearance x inlet length	0.0018	m liq	kister1992
min.hdc	Clear liquid backup in downcomer side-R	h_dc = h_t(receiving tray) + h_w + h_ow + h_ud	0.1276	m liq	kister1992
min.backup	Aerated downcomer backup	backup = 100 (h_dc / phi_dc) / (TS + h_w)	39.5620	% of TS+hw	kister1992
min.choke	Downcomer velocity / design velocity (side-R)	100 u_dc / u_dc,max	7.3483	%	kister1992
min.tres	Downcomer residence time (side-R)	t = A_dc h_dc / Q_dc	10.2270	s	sinnott

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Calculation trace: Stripping trays

Id	Quantity	Equation	Value	Unit	Ref
QV	Vapour volumetric flow	Q_V = V / rhoV	3.2841	m3/s	
QL	Liquid volumetric flow	Q_L = L / rhoL	0.0216	m3/s	
FLV	Flow parameter F_LV	F_LV = (L/V) (rhoV/rhoL)^0.5	0.0939	-	fair1961
CSB	Fair capacity factor C_SB	C_SB = 0.0105 + 8.127e-4 TS^0.755 exp(-1.463 F_LV^0.842), TS in mm	0.0938	m/s	lygeros1986
Fsig	Surface tension correction	(sigma / 20 mN/m)^0.2	0.9791	-	fair1961
A.Fha	Hole area factor (tray A)	F_ha = 5 A_h/A_a + 0.5 if A_h/A_a < 0.10, else 1	0.8663	-	fair1961
A.uNF	Flooding velocity on net area (tray A)	u_NF = C_SB F_sigma F_ha SF ((rhoL - rhoV)/rhoV)^0.5	1.1344	m/s	fair1961
A.uN	Vapour velocity on net area (tray A)	u_N = Q_V / (A_T - A_dc)	0.8156	m/s	
A.flood	Jet flood (tray A)	flood = 100 u_N / u_NF	71.9020	%	fair1961
A.uh	Hole (orifice) velocity (tray A)	u_h = Q_V / A_h	12.7022	m/s	
A.Co	Orifice coefficient C_o (tray A)	C_o = 0.74 (A_h/A_a) + exp(0.29 t/d_h - 0.56)	0.6590	-	hughmark1957
A.dPdry	Dry tray pressure drop (tray A)	dP_dry = rhoV u_h^2 / (2 C_o^2)	707.7970	Pa	hughmark1957
A.hd	Dry tray head h_d (tray A)	h_d = dP_dry / (rhoL g)	0.0928	m liq	
A.hsig	Surface tension head (tray A)	h_sigma = 6 sigma / (g rhoL d_h)	0.0011	m liq	kister1992
A.Ks	Capacity factor on bubbling area (tray A)	K_s = u_a (rhoV/(rhoL - rhoV))^0.5	0.0759	m/s	bennett1983
A.alpha	Effective froth density (tray A)	alpha_e = exp(-12.55 K_s^0.91)	0.3009	-	bennett1983
A.hcl	Clear liquid height, panel P1 (tray A)	h_cl = alpha_e [h_w + C (q_L/(L_w alpha_e))^0.67], C = 0.501 + 0.438 exp(-137.8 h_w)	0.0310	m liq	bennett1983
A.how	Weir crest, panel P1 (tray A)	h_ow = 0.664 (q_L/L_w)^(2/3)	0.0349	m liq	francis
A.ht	Total tray head (tray A)	h_t = h_d + h_cl + h_sigma (area-weighted over panels)	0.1249	m liq	bennett1983
A.dPt	Total tray pressure drop (tray A)	dP_t = h_t rhoL g	953.0580	Pa	
A.weep	Weep screening index (tray A)	I_w = (h_d + h_sigma) / h_cl (lowest panel)	3.0255	-	kister1992
udcmax	Downcomer design velocity	u_dc,max = SF min(250, 41 (rhoL - rhoV)^0.5, 7.5 TS^0.5 (rhoL - rhoV)^0.5) gpm/ft2	0.1698	m/s	kister1992
hud	Head loss under downcomer side-R (tray A)	h_ud = 0.165 (Q_dc / A_ud)^2, A_ud = clearance x inlet length	0.0220	m liq	kister1992
hdc	Clear liquid backup in downcomer side-R	h_dc = h_t(receiving tray) + h_w + h_ow + h_ud	0.2268	m liq	kister1992
backup	Aerated downcomer backup	backup = 100 (h_dc / phi_dc) / (TS + h_w)	70.3385	% of TS+hw	kister1992
choke	Downcomer velocity / design velocity (side-R)	100 u_dc / u_dc,max	25.5618	%	kister1992
tres	Downcomer residence time (side-R)	t = A_dc h_dc / Q_dc	5.2271	s	sinnott
min.QV	Vapour volumetric flow	Q_V = V / rhoV	2.1809	m3/s	
min.QL	Liquid volumetric flow	Q_L = L / rhoL	0.0126	m3/s	
min.FLV	Flow parameter F_LV	F_LV = (L/V) (rhoV/rhoL)^0.5	0.0892	-	fair1961
min.CSB	Fair capacity factor C_SB	C_SB = 0.0105 + 8.127e-4 TS^0.755 exp(-1.463 F_LV^0.842), TS in mm	0.0945	m/s	lygeros1986
min.Fsig	Surface tension correction	(sigma / 20 mN/m)^0.2	0.9949	-	fair1961
min.A.Fha	Hole area factor (tray A)	F_ha = 5 A_h/A_a + 0.5 if A_h/A_a < 0.10, else 1	0.8663	-	fair1961
min.A.uNF	Flooding velocity on net area (tray A)	u_NF = C_SB F_sigma F_ha SF ((rhoL - rhoV)/rhoV)^0.5	1.2562	m/s	fair1961
min.A.uN	Vapour velocity on net area (tray A)	u_N = Q_V / (A_T - A_dc)	0.5416	m/s	
min.A.flood	Jet flood (tray A)	flood = 100 u_N / u_NF	43.1173	%	fair1961
min.A.uh	Hole (orifice) velocity (tray A)	u_h = Q_V / A_h	8.4353	m/s	
min.A.Co	Orifice coefficient C_o (tray A)	C_o = 0.74 (A_h/A_a) + exp(0.29 t/d_h - 0.56)	0.6590	-	hughmark1957

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Id	Quantity	Equation	Value	Unit	Ref
min.A.dPdry	Dry tray pressure drop (tray A)	dP_dry = rhoV u_h^2 / (2 C_o^2)	272.8180	Pa	hughmark1957
min.A.hd	Dry tray head h_d (tray A)	h_d = dP_dry / (rhoL g)	0.0350	m liq	
min.A.hsig	Surface tension head (tray A)	h_sigma = 6 sigma / (g rhoL d_h)	0.0012	m liq	kister1992
min.A.Ks	Capacity factor on bubbling area (tray A)	K_s = u_a (rhoV/(rhoL - rhoV))^0.5	0.0466	m/s	bennett1983
min.A.alpha	Effective froth density (tray A)	alpha_e = exp(-12.55 K_s^0.91)	0.4628	-	bennett1983
min.A.hcl	Clear liquid height, panel P1 (tray A)	h_cl = alpha_e [h_w + C (q_L/(L_w alpha_e))^0.67], C = 0.501 + 0.438 exp(-137.8 h_w)	0.0349	m liq	bennett1983
min.A.how	Weir crest, panel P1 (tray A)	h_ow = 0.664 (q_L/L_w)^(2/3)	0.0244	m liq	francis
min.A.ht	Total tray head (tray A)	h_t = h_d + h_cl + h_sigma (area-weighted over panels)	0.0711	m liq	bennett1983
min.A.dPt	Total tray pressure drop (tray A)	dP_t = h_t rhoL g	553.9380	Pa	
min.A.weep	Weep screening index (tray A)	I_w = (h_d + h_sigma) / h_cl (lowest panel)	1.0372	-	kister1992
min.udcmax	Downcomer design velocity	u_dc,max = SF min(250, 41 (rhoL - rhoV)^0.5, 7.5 TS^0.5 (rhoL - rhoV)^0.5) gpm/ft2	0.1698	m/s	kister1992
min.hud	Head loss under downcomer side-R (tray A)	h_ud = 0.165 (Q_dc / A_ud)^2, A_ud = clearance x inlet length	0.0075	m liq	kister1992
min.hdc	Clear liquid backup in downcomer side-R	h_dc = h_t(receiving tray) + h_w + h_ow + h_ud	0.1479	m liq	kister1992
min.backup	Aerated downcomer backup	backup = 100 (h_dc / phi_dc) / (TS + h_w)	45.8648	% of TS+hw	kister1992
min.choke	Downcomer velocity / design velocity (side-R)	100 u_dc / u_dc,max	14.9108	%	kister1992
min.tres	Downcomer residence time (side-R)	t = A_dc h_dc / Q_dc	5.8430	s	sinnott

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