Bell–Delaware Method: Shell-Side Coefficient and Pressure Drop

Shell-side heat transfer coefficient and nozzle-to-nozzle pressure drop of a segmental-baffled E shell by the Bell–Delaware method with Taborek's curve fits.

Input parameters

Unit system: SI

Parameter	Value	Unit
Shell-side mass flow	144,000	kg/h
Shell inside diameter	600.00	mm
Diametral shell-to-bundle clearance	12.000	mm
Tube outside diameter	19.050	mm
Tube pitch	23.810	mm
Tube layout	Triangular 30°	
Number of tubes	600.00	
Central baffle spacing	250.00	mm
Inlet baffle spacing	400.00	mm
Outlet baffle spacing	400.00	mm
Baffle cut (fraction of shell diameter)	25.000	%
Number of baffles	18.000	
Pairs of sealing strips	2.0000	
Tube-to-baffle clearance (radial)	0.40000	mm
Shell-to-baffle clearance (radial)	1.6000	mm
Shell-side fluid viscosity	0.80000	mPa·s
Viscosity ratio bulk to wall	1.3000	
Specific heat	4.1800	kJ/(kg·K)
Thermal conductivity	0.61000	W/(m·K)
Density	996.00	kg/m³

Calculated results

Parameter	Value	Unit
Cross-flow area at the shell centreline	0.031436	m²
Fraction of tubes in cross flow	63.881	%
Tube-to-baffle leakage area	0.011769	m²
Shell-to-baffle leakage area	0.002011	m²
Window flow area	0.024392	m²
Reynolds number (tube OD, mass flux at S_m)	30,300	
Ideal tube bank j-factor	0.005875	
Ideal tube bank Fanning friction factor	0.10636	
Ideal tube bank coefficient	10,426	W/(m²·K)
Baffle window correction	1.0099	

Parameter	Value	Unit
Leakage correction (heat transfer)	0.61376	
Bypass correction (heat transfer)	0.95914	
Unequal spacing correction	0.96107	
Laminar flow correction	1.0000	
Product of the corrections	0.57138	
Shell-side heat transfer coefficient	5,957.3	W/(m²·K)
Tube rows crossed between baffle tips	14.549	
Effective rows crossed in one window	5.8196	
Leakage correction (pressure drop)	0.40338	
Bypass correction (pressure drop)	0.88382	
Ideal pressure drop, one baffle space	4.8495	kPa
Ideal pressure drop, one window	5.7527	kPa
Shell-side pressure drop, nozzle to nozzle (without nozzles)	76.311	kPa

Notes for this case

- Taborek's version of the Delaware method (E shell, single-segmental baffles, plain tubes).

Formula and method

$$h_o = j\, c_p G\, Pr^{-2/3} \phi\, J_c J_L J_B J_R J_S, \quad G = \dot{m}/S_m$$

$$\Delta P_f = \left[(n_b - 1)\Delta P_{ideal} R_B + n_b \Delta P_{w,ideal}\right] R_L + 2\Delta P_{ideal}\left(1 + \frac{N_{cw}}{N_c}\right) R_B R_S$$

$$J_L = 0.44(1 - r_s) + [1 - 0.44(1 - r_s)]e^{-2.2 r_l}, \quad R_L = e^{-1.33(1+r_s)r_l^p}, \quad J_B = e^{-C_J(S_b/S_m)(1-\sqrt[3]{2r_{ss}})}$$

Variables

$\dot{m}$	Shell-side mass flow	kg/s
D_s	Shell inside diameter	m
$D_s - D_{otl}$	Diametral shell-to-bundle clearance	m
D_o	Tube outside diameter	m
P_T	Tube pitch	m
θ_{tp}	Tube layout	-
n_t	Number of tubes	-
B	Central baffle spacing	m
B_{in}	Inlet baffle spacing	m
B_{out}	Outlet baffle spacing	m
B_c	Baffle cut (fraction of shell diameter)	-
n_b	Number of baffles	-
N_{ss}	Pairs of sealing strips	-
δ_{tb}	Tube-to-baffle clearance (radial)	m
δ_{sb}	Shell-to-baffle clearance (radial)	m
μ	Shell-side fluid viscosity	Pa·s
μ/μ_w	Viscosity ratio bulk to wall	-

c_p	Specific heat	J/(kg·K)
k	Thermal conductivity	W/(m·K)
ρ	Density	kg/m³
S_m	Cross-flow area at the shell centreline	m²
F_c	Fraction of tubes in cross flow	-
S_{tb}	Tube-to-baffle leakage area	m²
S_{sb}	Shell-to-baffle leakage area	m²
S_w	Window flow area	m²
Re	Reynolds number (tube OD, mass flux at S_m)	-
j	Ideal tube bank j-factor	-
f	Ideal tube bank Fanning friction factor	-
h_{ideal}	Ideal tube bank coefficient	W/(m²·K)
J_c	Baffle window correction	-
J_L	Leakage correction (heat transfer)	-
J_B	Bypass correction (heat transfer)	-
J_S	Unequal spacing correction	-
J_R	Laminar flow correction	-
ΠJ	Product of the corrections	-
h_o	Shell-side heat transfer coefficient	W/(m²·K)
N_c	Tube rows crossed between baffle tips	-
N_{cw}	Effective rows crossed in one window	-
R_L	Leakage correction (pressure drop)	-
R_B	Bypass correction (pressure drop)	-
ΔP_{ideal}	Ideal pressure drop, one baffle space	Pa
$\Delta P_{w,ideal}$	Ideal pressure drop, one window	Pa
ΔP_f	Shell-side pressure drop, nozzle to nozzle (without nozzles)	Pa

Method and standards

Ideal tube bank correlations corrected for window flow, leakage, bypass, laminar flow and unequal end spacing.

Assumptions and limits

- E shells with single-segmental baffles and plain tubes; baffle cuts 15–45 %.
- Accuracy about ±25 % for h_o and ±40 % for ΔP (Taborek).

Report details

Report reference	FCC-J97G-3BF1 (the same inputs always give the same reference)
Generated	23 November 2026, 18:00 UTC
Calculator	Bell–Delaware Method: Shell-Side Coefficient and Pressure Drop
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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