

HydrauCalcXL

Version 2023b

www.hydraucalc.com

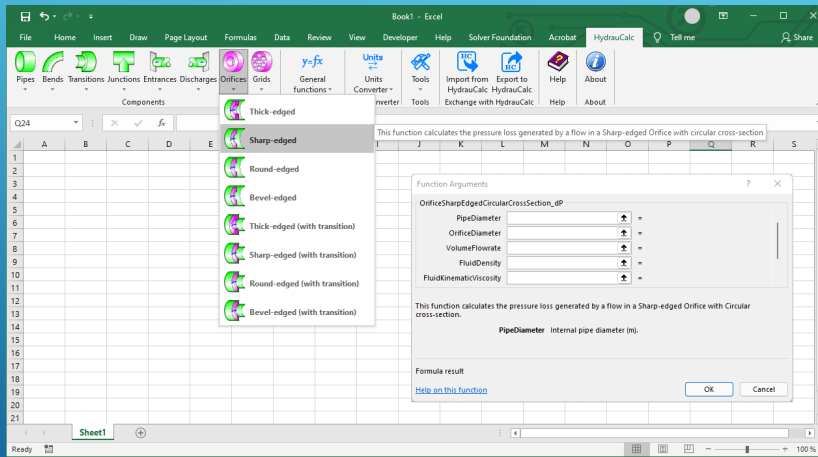
Qu'est-ce que HydrauCalcXL Add-in?

Qu'est-ce que HydraulCalcXL Add-in?

- ▶ HydraulCalcXL Add-in est une bibliothèque de fonctions qui a été développée pour calculer les pertes de pression de composants hydrauliques dans Microsoft Excel®. Cette bibliothèque permet l'appel direct de fonctions relatives au calcul de pertes de pression. Elle est issue de l'application HydraulCalc qui est basée principalement sur des références reconnues et respectées dans le domaine du calcul de débits et de pertes de pression.
- ▶ Les fonctions HydraulCalcXL peuvent être utilisées via l'interface utilisateur d'Excel®, tout comme les propres fonctions intégrées d'Excel®.
- ▶ L'utilisation conjointe de cette bibliothèque et du solveur intégré à Excel® (solveur de systèmes d'équations non-linéaires) permet de résoudre des problèmes d'écoulement itératifs et d'effectuer des analyses d'optimisation multi-variables de systèmes fluides.

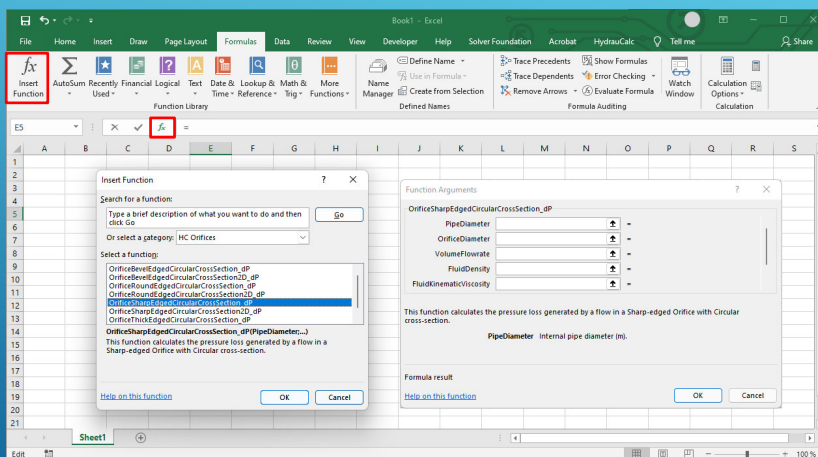
L'interface graphique Excel

Interface graphique Excel



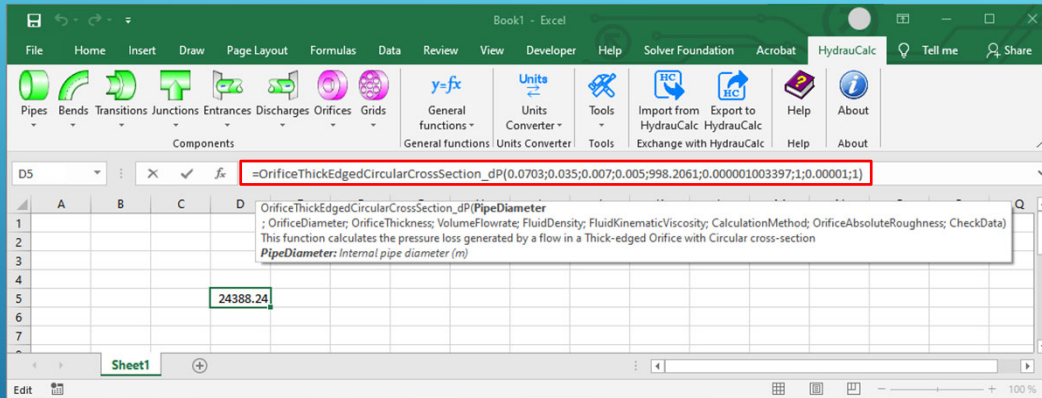
- ▶ L'onglet HydraulCalc comporte un ruban qui permet d'appeler les différentes fonctions de la librairie.
- ▶ A partir de cette interface, l'utilisateur insère les fonctions des composants qu'il souhaite évaluer.
- ▶ Cette interface est intuitive et très facile à utiliser.

Interface graphique Excel



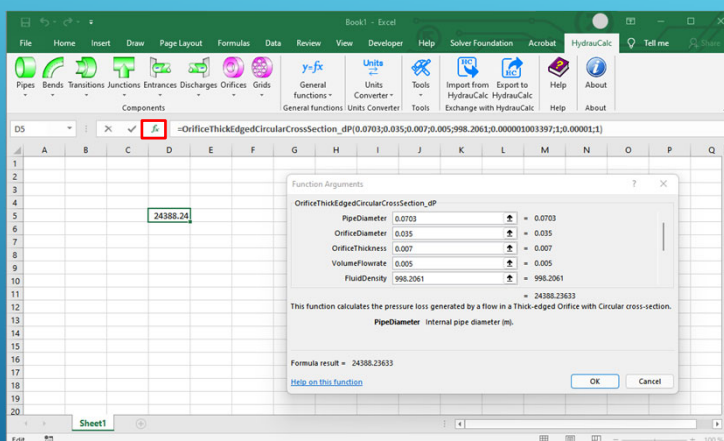
- ▶ Les fonctions de la librairie peuvent également être sélectionnées à partir des boutons "Insert Function" de l'onglet "Formulas" ou de la barre des fonctions.
- ▶ Cette interface est moins conviviale et moins facile à utiliser que la précédente.

Interface graphique Excel



Lorsque qu'une fonction est incréée dans une cellule du tableur, il est possible, par la suite, de modifier les paramètres de la fonction en l'affichant dans la barre des formules.

Interface graphique Excel



▶ Les paramètres des fonctions peuvent aussi être modifiés en sélectionnant le bouton "Insert Function" de la barre des fonctions.

Les fonctions de la bibliothèque HydrauCalcXL

Les fonctions de la bibliothèque HydrauCalcXL

Les fonctions de la bibliothèque sont accessibles via le ruban de l'onglet HydrauCalc.

La bibliothèque comprend quatre types de fonctions :

- ❑ des fonctions de calcul de pertes de pression de composants de tuyauterie tels que tuyaux rectilignes, coudes, changements de section, bifurcations, diaphragmes, grilles, entrées de circuit, sorties de circuit (74 fonctions),
- ❑ des fonctions de calcul entre les différentes variables entrant dans les formules générales de pertes de pression (perte de pression, coefficient de perte de pression, coefficient de débit, débit volumique, débit massique, nombre de Reynolds, vitesse d'écoulement, ...) (103 fonctions),
- ❑ des fonctions de conversion d'unités de mesure entre elles (17 fonctions),
- ❑ des fonctions diverses (2 fonctions).

Les composants de tuyauterie

Les composants de tuyauterie disponibles

Tuyaux rectilignes :



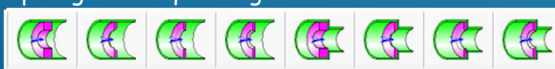
Coudes :



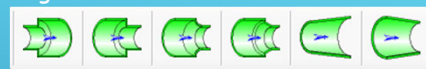
Bifurcations :



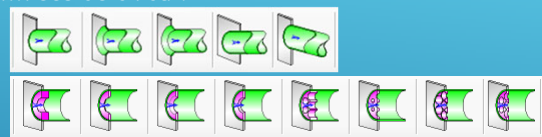
Diaphragmes d'équilibrage :



Changements de sections :



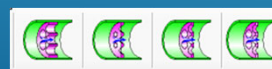
Entrées de circuit :



Sorties de circuit :



Grilles :



Arguments des fonctions de composants

Les arguments des fonctions de calcul de pertes de charge des composants sont :

- La géométrie du composant (longueur, diamètre intérieur, angle et rayon de courbure, rugosité absolue de parois , etc...).
- La caractéristique de l'écoulement (débit volumique).
- Les propriétés du fluide véhiculé (masse volumique et viscosité cinématique).

Exemple d'utilisation d'une fonction de composant

The screenshot illustrates the use of the `PipeStraightCircularCrossSection_dP` function in HydrauCalcXL. The spreadsheet shows the following data and formulas:

Cell	Value / Formula	Unit
B7	Density	998.1 kg/m³
B8	Kinematic Viscosity	9.800E-07 m²/s
B9	Volume flowrate	0.005 m³/s
B12	Diameter	0.0525 m
B13	Length	6 m
B14	Absolute roughness	5.0E-06 m
B15	Flow velocity (Formula: <code>=FlowVelocity_Qv_DICIRC(C7)</code>)	2.310 m/s
B16	Reynolds number (Formula: <code>=ReynoldsNumber_V_D_Mu(R7,C12,C8)</code>)	123796
B17	Pressure loss coefficient (Formula: <code>=PressureLossCoefficient_dP_Qv_D_ReDIT(C12,C7)</code>)	1.968
B18	Pipe pressure loss (Formula: <code>=PipeStraightCircularCrossSection_dP(C12,C13,C14,C7,C8,E7,C4)</code>)	5239 Pa

The **Function Arguments** dialog box for `PipeStraightCircularCrossSection_dP` shows the following inputs:

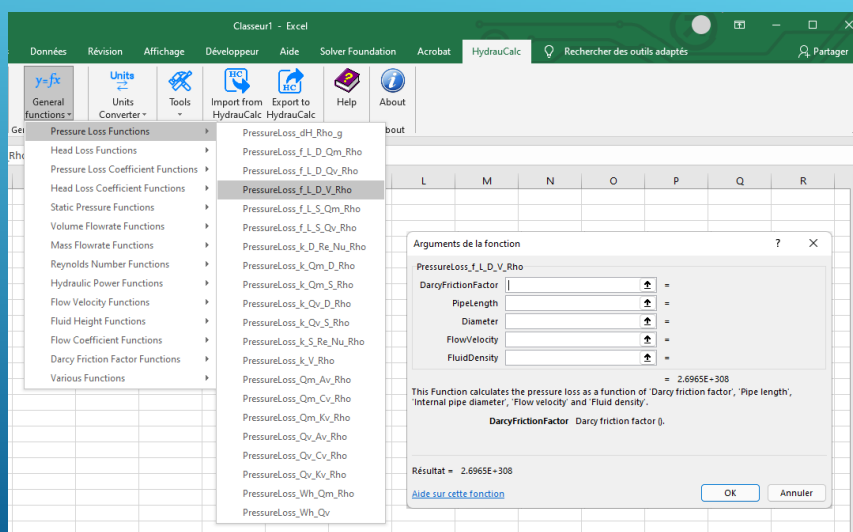
- InternalDiameter: 0.0525
- PipeLength: 6
- VolumeFlowrate: 0.005
- FluidDensity: 998.1
- FluidKinematicViscosity: 9.8000000E-07

The **Help** window for the `PipeStraightCircularCrossSection_dP` function provides the following details:

- Description:** This function calculates the pressure loss generated by a flow in a Straight pipe with Circular cross-section.
- Syntax:** `PipeStraightCircularCrossSection_dP(InternalDiameter, PipeLength, VolumeFlowrate, FluidDensity, FluidKinematicViscosity, CalculationMethod, AbsoluteRoughness, DarcyFrictionFactor, HazenWilliamsRoughnessCoefficient, CheckData)`
- Arguments:**
 - InternalDiameter:** Double: Internal pipe diameter (m)
 - PipeLength:** Double: Pipe length (m)
 - VolumeFlowrate:** Double: Volume flowrate (m³/s)
 - FluidDensity:** Double: Fluid density (kg/m³)
 - FluidKinematicViscosity:** Double: Fluid kinematic viscosity (m²/s)
 - CalculationMethod:** Int: CalculationMethod (1-7) [optional - default value = 2]
 - AbsoluteRoughness:** Double: Absolute roughness (m) [optional - used only if CalculationMethod = 1, 2 or 5]
 - DarcyFrictionFactor:** Double: Darcy friction factor (optional - used only if CalculationMethod = 4 or 6)
 - HazenWilliamsRoughnessCoefficient:** Double: Hazen-Williams roughness coefficient (optional - used only if CalculationMethod = 7)
 - CheckData:** Int: Check input data and results (0/1) [optional - default value = 0]

Les fonctions de formules générales

Les fonctions de formules générales



Exemple d'utilisation de fonctions de formules générales

The screenshot displays the HydraulCalcXL interface. The spreadsheet shows the following data:

1	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
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The 'Function Arguments' dialog shows the following values:

- PressureLoss: 6095.28926
- VolumeFlowrate [Qv]: 0.005
- Diameter: 0.0525
- FluidDensity [ρ]: 998.1
- Formula result: 2.286

The 'PressureLossCoefficient_dP_Qv_D_Rho function' dialog provides the following information:

Description: This function calculates the pressure loss coefficient as a function of 'Pressure loss', 'Volume flowrate', 'Internal pipe diameter' and 'Fluid density'.

Syntax: PressureLossCoefficient_dP_Qv_D_Rho (PressureLoss, VolumeFlowrate, Diameter, FluidDensity)

Arguments:

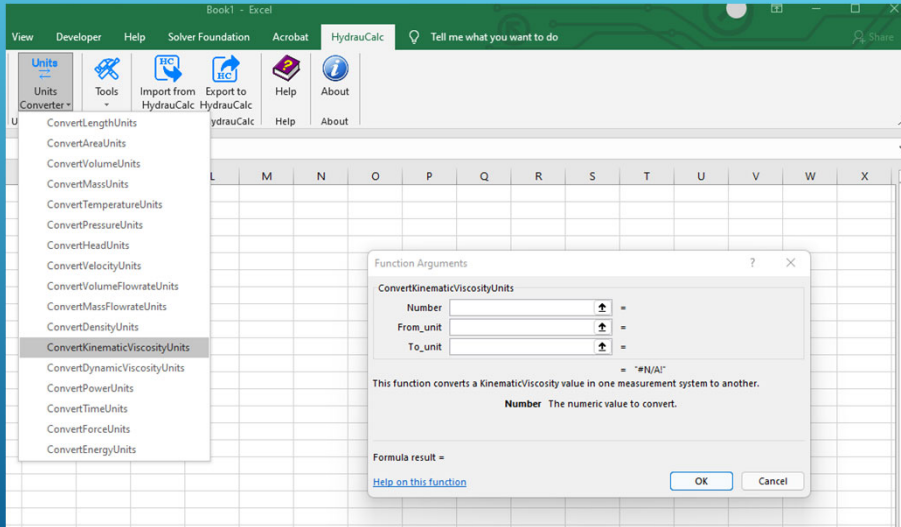
- PressureLoss [ΔP] Double: Pressure loss (Pa)
- VolumeFlowrate [Qv] Double: Volume flowrate (m³/s)
- Diameter [D] Double: Diameter (m)
- FluidDensity [ρ] Double: Fluid density (kg/m³)

Formula:

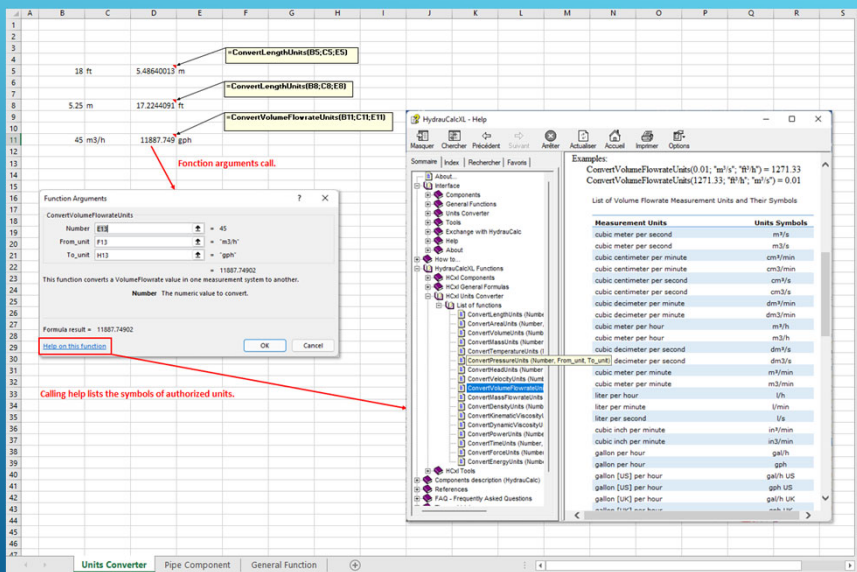
$$k = \frac{\Delta P}{0.5 \rho \frac{Q_v^2}{(\pi D^4/4)}}$$

Les fonctions de conversion d'unités de mesure

Les fonctions de conversion d'unités de mesure



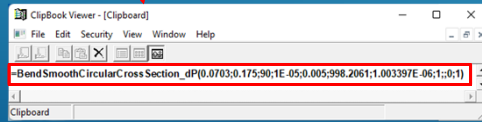
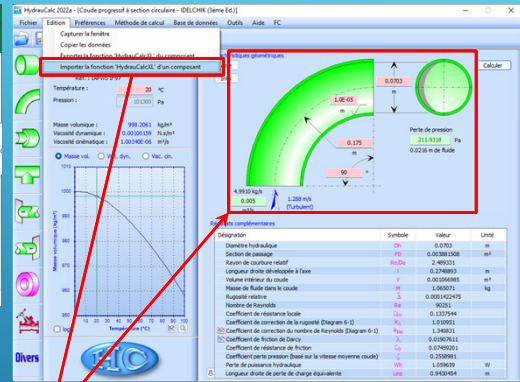
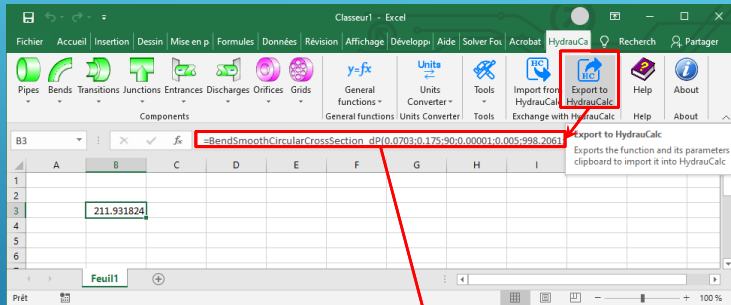
Exemple d'utilisation de fonctions de conversion d'unités de mesure



Exportation de données vers HydraulCalc

1 - Export de la fonction vers Clipboard

2 - Import de la fonction depuis Clipboard



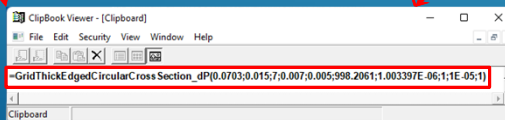
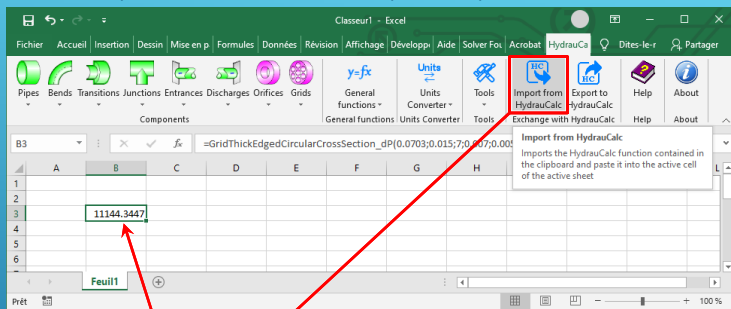
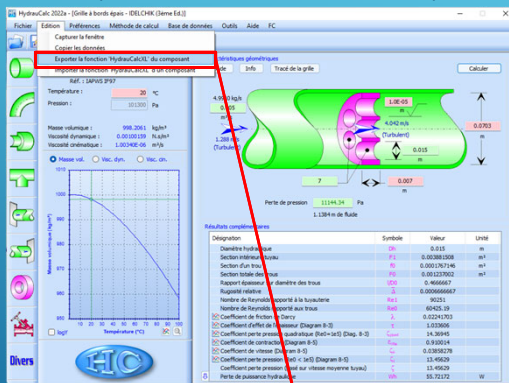
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Importation de données depuis HydraulCalc

1 - Export de la fonction vers Clipboard

2 - Import de la fonction depuis Clipboard



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Exemples de systèmes résolus à l'aide de HydraulCalcXL et du solveur Excel

- ▶ Recherche : la HMT de la pompe et le point de fonctionnement du système.
- ▶ Le débit de la pompe est une donnée d'entrée. Les fonctions intégrées à HydraulCalcXL permettent de calculer explicitement (calcul direct sans itérations) la perte de charge des composants.

Reference: Internal Flow Systems - 2ed - D.S. Miller (1990) - Simple system - Fig. 3.1 - page 28
Find: the pump head and the system working point

Legend

- Input data
- Excel calculation
- HydraulCalc calculation
- Variable name
- Unit symbol
- Content of neighboring cell

Data verification
Check data (Q/s)

Fluid data (Water 20°C)

rho	1000	kg/m ³
nu	1.10E-06	m ² /s

Volume flow rate

Q	2.75	m ³ /s
---	------	-------------------

Pipe data

Name	Diameter (m)	Length (m)	Darcy friction factor
P1	1	90	0.015
P2	0.8	640	0.015

Reflux valve

V1	0.8	0.5
----	-----	-----

System entrance (rounded entrance)

E1	1	0.09
----	---	------

System discharge (sharp-edged discharge)

D1	0.8	
----	-----	--

Reservoir data

Name	Surface elevation (m)
R1	1.5
R2	8.5

Pipe pressure loss (Pa)

P1	8275	Pa
P2	179588	Pa

System entrance (Pa)

E1	587	Pa
----	-----	----

Reflux valve (Pa)

V1	7483	Pa
----	------	----

System discharge (Pa)

D1	14956	Pa
----	-------	----

System characteristic

Flowrate (m ³ /s)	Head (m fluid)
0.00	7.000
0.50	7.711
1.00	8.984
1.50	13.398
2.00	18.375
2.50	24.773
3.00	32.594

Total pressure loss

dp	210899	Pa
----	--------	----

Total head loss

HL	21.506	m fluid
----	--------	---------

Static lift

SL	7.000	m fluid
----	-------	---------

Pump head

HP	28.506	m fluid
----	--------	---------

System working point

Pump - Head

- Recherche : le débit et le point de fonctionnement du système.
- La HMT de pompe est une donnée d'entrée. L'utilisation du solveur Excel est nécessaire pour résoudre le système et trouver le débit.

Reference: Internal Flow Systems - 2ed - D.S. Miller (1990) - Simple system - Fig. 3.1 - page 28
Find: the flowrate and the system working point

Legend
Input data
Excel calculation
HydrauCalc calculation
Variable name
Unit symbol
Context of neighboring cell

Data verification
Check data (d/f) Cd = 1

Fluid data (Water 20°C)
Density rho = 1000 kg/m³
Kinematic Viscosity nu = 1.0E-06 m²/s

Pump head
HP = 28.6 m fluid

Pipe data

Name	Diameter (m)	Length (m)	Darcy Friction factor
P1	0.91	90	0.015
P2	0.92	640	0.015

Reflux valve

Name	Diameter (m)	Pressure loss coef.
V1	0.92	0.5

System entrance (rounded entrance)

Name	Diameter (m)	Round radius (m)
E1	0.91	0.09

System discharge (sharp-edged discharge)

Name	Diameter (m)
D1	0.91

Reservoir data

Name	Surface elevation (m)
R1	1.5
R2	8.5

Pump characteristic

Flowrate (m³/s)	Head (m fluid)
0.00	33.123
0.50	32.826
1.00	32.364
1.50	31.759
2.00	30.788
2.50	29.413
3.00	27.211
3.50	22.812

Pipe pressure loss (Pa)

Name	Flowrate (m³/s)	Pressure loss (Pa)
P1	0.91	8312
P2	0.92	180375

System entrance (Pa)

Name	Flowrate (m³/s)	Pressure loss (Pa)
E1	0.91	590

Reflux valve (Pa)

Name	Flowrate (m³/s)	Pressure loss (Pa)
V1	0.92	7516

System discharge (Pa)

Name	Flowrate (m³/s)	Pressure loss (Pa)
D1	0.91	15031

Solver data
Value to be computed by solver (variable cells):
Flowrate Q = 2.256 m³/s
Constraints:
HP - HL - SL = 0 Pa = HP - HL - SL

Total pressure loss
dp = 211824 Pa = dp_E1 + dp_P1 + dp_V1 + dp_P2 + dp_D1

Total head loss
HL = 21.600 m fluid = HeadLoss_dp_Rho_g(dp/ρg)

Static lift
SL = 7.000 m fluid = H_R2 - H_R1

System characteristic

Flowrate (m³/s)	Head (m fluid)
0.00	7.000
0.50	7.711
1.00	5.844
1.50	13.398
2.00	18.375
2.50	24.773
3.00	32.584

System working point

- Recherche : le débit volumique de chaque branche.
- Ce problème illustre l'utilisation d'Excel pour résoudre un ensemble d'équations non linéaires couplées pour des débits inconnus.

Reference: Introduction to Fluid Mechanics - Fox and McDonald's - 9th Ed - Example 8.11 - page 323
Find: the volume flowrate of each branch

Legend
Input data
Excel calculation
HydrauCalc calculation
Variable name
Unit symbol
Context of neighboring cell

Data verification
Check data (d/f) Cd = 1

Fluid data (Water 23°C)
Density rho = 998.24 kg/m³
Kinematic Viscosity nu = 1.00E-06 m²/s

Static head

Point	Elevation (m)
p1	30.48
p5	0

Pipe data

Name	Diameter (m)	Length (m)	Absolute roughness (m)
Pipe A	0.0381	3.048	2.591E-04
Pipe B	0.0381	6.096	2.591E-04
Pipe C	0.0508	3.048	2.591E-04
Pipe D	0.0381	3.048	2.591E-04
Pipe E	0.0381	3.048	2.591E-04
Pipe F	0.0254	3.048	2.591E-04
Pipe G	0.0381	3.048	2.591E-04
Pipe H	0.0508	1.524	2.591E-04

Pipe pressure loss

Name	Flowrate (m³/s)	Pressure loss (Pa)
Pipe A	0.91	114932
Pipe B	0.92	43446
Pipe C	0.93	25070
Pipe D	0.94	114932
Pipe E	0.95	11573
Pipe F	0.96	20807
Pipe G	0.97	20807
Pipe H	0.98	4066

Pipe head loss

Name	Flowrate (m³/s)	Head loss (m)
Pipe A	0.91	11.740
Pipe B	0.92	4.438
Pipe C	0.93	2.561
Pipe D	0.94	11.740
Pipe E	0.95	1.897
Pipe F	0.96	2.125
Pipe G	0.97	2.125
Pipe H	0.98	0.415

Solver data
Value to be computed by solver (variable cells):
Pipe A Q_pA = 0.010548 m³/s
Pipe B Q_pB = 0.004566 m³/s
Pipe C Q_pC = 0.001513 m³/s
Pipe D Q_pD = 0.009582 m³/s
Pipe E Q_pE = 0.004427 m³/s
Pipe F Q_pF = 0.005988 m³/s
Pipe G Q_pG = 0.005988 m³/s
Pipe H Q_pH = 0.001513 m³/s

Constraints:
dH_pA + dH_pB + dH_pC + dH_pD - SL = 0
dH_pE + dH_pF + dH_pH - dH_pB = 0
dH_pG - dH_pF = 0

Deducted flowrate:
Pipe C Q_pC = 0.01055 m³/s = Q_pA
Pipe D Q_pD = 0.01055 m³/s = Q_pA
Pipe E Q_pE = 0.005982 m³/s = Q_pA - Q_pB
Pipe G Q_pG = 0.004427 m³/s = Q_pE - Q_pF
Pipe H Q_pH = 0.005988 m³/s = Q_pE

Static lift:
SL = 30.480 m = H_p11 - H_p15

- Recherche : le débit dans chaque tuyau.
- Ce problème illustre l'utilisation d'Excel pour résoudre un ensemble d'équations non linéaires couplées pour des débits inconnus.
- Cet exemple montre également l'utilisation des fonctions de conversion d'unités.

Reference: Fundamentals of Fluid Mechanics - Munson - 8th Ed - Example 8.14 - page 458
Find: the flowrate in each pipe

Legend
Input data
Excel calculation
Hydraulic calculation
Variable name
Unit symbol
Contents of neighbouring cell

Data verification
Check data (0%)

Fluid data (Water 20°C)
Density: 998 kg/m³
Gravitational acceleration: 9.81 m/s²

Pipes data

Pipe	Diameter	Length	SI units
P1	1 ft	1000 ft	0.3048 m / 304.8 m
P2	1 ft	500 ft	0.3048 m / 152.4 m
P3	1 ft	400 ft	0.3048 m / 121.9 m

Reservoir data

Reservoir	Surface elevation	SI units
R1	100 ft	30.48 m
R2	20 ft	6.1 m
R3	0 ft	0 m

Pipe head loss

Pipe	Head loss	SI units
P2	49.3	1.48 m
P3	6.83	2.08 m
P1	49.3	1.48 m

Solver data
Values to be computed by solver (variable cells)

Constrains:

$$\frac{P_1 - P_2}{\rho \cdot g} - \frac{V_1^2 - V_2^2}{2 \cdot g} + z_1 - z_2 - \sum (K_f + K_v) = 0$$

$$\frac{P_2 - P_3}{\rho \cdot g} - \frac{V_2^2 - V_3^2}{2 \cdot g} + z_2 - z_3 - \sum (K_f + K_v) = 0$$

Deduced flowrate:
Pipe 1: 0.544 m³/s

- Recherche : le coefficient de perte de charge des deux vannes de régulation pour permettre le débit souhaité dans chaque échangeur de chaleur et le point de fonctionnement de la pompe.
- Cet exemple montre un équilibrage de réseau simple.

Reference: AFT Fathom 10 - Examples - Pump Sizing and Selection with Flow Control Valves
Find: the pressure loss coefficient of the two control valves to allow a flowrate of 25 m³/s (0.006944 m³/s) in each heat exchanger

Legend
Input data
Excel calculation
Hydraulic calculation
Variable name
Unit symbol
Contents of neighbouring cell

Data verification
Check data (0%)

Fluid data (Water 20°C)
Density: 998 kg/m³
Gravitational acceleration: 9.81 m/s²

Pipes data

Pipe	Diameter	Length	SI units
P1	0.508	1.524	0.127 m / 1.524 m
P2	0.508	1.524	0.127 m / 1.524 m
P3	0.508	1.524	0.127 m / 1.524 m
P4	0.508	1.524	0.127 m / 1.524 m
P5	0.508	1.524	0.127 m / 1.524 m
P6	0.508	1.524	0.127 m / 1.524 m
P7	0.508	1.524	0.127 m / 1.524 m
P8	0.508	1.524	0.127 m / 1.524 m
P9	0.508	1.524	0.127 m / 1.524 m

Head data

Node	Head	SI units
H1	10.0	3.05 m
H2	10.0	3.05 m
H3	10.0	3.05 m
H4	10.0	3.05 m
H5	10.0	3.05 m
H6	10.0	3.05 m
H7	10.0	3.05 m
H8	10.0	3.05 m
H9	10.0	3.05 m

Pump data

Pump	Flow rate	Head	SI units
P1	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P2	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P3	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P4	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P5	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P6	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P7	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P8	0.006944	10.0	0.006944 m ³ /s / 3.05 m
P9	0.006944	10.0	0.006944 m ³ /s / 3.05 m

Results

Flow rate: 0.006944 m³/s
Head: 10.0 m

- Recherche : le débit volumique dans la boucle.
- Ce problème illustre l'utilisation du solveur d'Excel pour déterminer le débit dans la boucle.

HydrauCalcXL Reference: AFT Fathom 10 - Examples - Heat Exchanger System
Find: the volume flowrate in the loop

Legend
Input data
Excel calculation
HydrauCalc calculation
HydrauCalc model
Unit symbol
Control of neighboring cell

Data verification
Check data (F7)

Fluid data
Water 21 °C 1.018
Density $\rho = 999.1000 \text{ kg/m}^3$
Dynamic Viscosity $\mu = 0.0010027 \text{ Pa}\cdot\text{s}$
Kinematic Viscosity $\nu = 0.00100327 \text{ m}^2/\text{s}$

Pressure
Name: J4
P_{J4} = 70000 Pa

Pipe data

Name	Diameter (m)	Length (m)	Absolute roughness (m)
P1	0.1033	L _{P1}	0.0
P2	0.1033	L _{P2}	0.0
P3	0.1033	L _{P3}	0.0
P4	0.1033	L _{P4}	0.0
P5	0.1033	L _{P5}	0.0
P6	0.1033	L _{P6}	0.0
P7	0.1033	L _{P7}	0.0

Bend data

Name	Diameter (m)	Curvature radius (m)	Angle (°)	Absolute roughness (m)
J2	0.1033	C _{J2}	90	0.0
J3	0.1033	C _{J3}	90	0.0
J4	0.1033	C _{J4}	90	0.0
J5	0.1033	C _{J5}	90	0.0
J6	0.1033	C _{J6}	90	0.0
J7	0.1033	C _{J7}	90	0.0

Head Exchanger I1 - Pressure loss

Flowrate (m³/s)	Pressure loss (Pa)
0.0000	0
0.0020	2903
0.0040	11612
0.0060	26127
0.0080	44441
0.0100	67236

Pump J5 - Head

Flowrate (m³/s)	Head (m)
0.0000	6.000
0.0020	5.900
0.0040	5.790
0.0060	5.590
0.0080	4.800

Solver data
Value to be computed by solver (variable cells):
P_{J4} = P_{J5} (Pa) = 70000 Pa

System

Flowrate (m³/s)	Head (m)
0.0000	0
0.0020	6.0000000
0.0040	2.8103915
0.0060	4.3754009
0.0080	7.2508621

Pressure evolution

- Recherche : le coefficient de perte de charge des deux vannes de régulation pour permettre le débit souhaité dans chaque échangeur de chaleur et le point de fonctionnement des pompes.
- Ce problème illustre l'utilisation d'Excel pour résoudre un système en boucle fermée avec plusieurs pompes. De plus, les débits dans les branches des deux échangeurs doivent être équilibrés par des vannes de régulation.

HydrauCalcXL Reference: AFT Fathom 10 - Examples - Hot Water System
Find: the pressure loss coefficient of the control valve to allow a flowrate of 70 m³/h (0.01944 m³/s) in each heat exchanger and the working point of the pumps

Legend
Input data
Excel calculation
HydrauCalc calculation
HydrauCalc model
Unit symbol
Control of neighboring cell

Data verification
Check data (F7)

Fluid data
Water 21 °C 1.018
Density $\rho = 999.1000 \text{ kg/m}^3$
Dynamic Viscosity $\mu = 0.0010027 \text{ Pa}\cdot\text{s}$
Kinematic Viscosity $\nu = 0.00100327 \text{ m}^2/\text{s}$

Pressure
Name: J4
P_{J4} = 70000 Pa

Pipe data

Name	Diameter (m)	Length (m)	Absolute roughness (m)
P1	0.1033	L _{P1}	0.0
P2	0.1033	L _{P2}	0.0
P3	0.1033	L _{P3}	0.0
P4	0.1033	L _{P4}	0.0
P5	0.1033	L _{P5}	0.0
P6	0.1033	L _{P6}	0.0
P7	0.1033	L _{P7}	0.0
P8	0.1033	L _{P8}	0.0
P9	0.1033	L _{P9}	0.0
P10	0.1033	L _{P10}	0.0
P11	0.1033	L _{P11}	0.0
P12	0.1033	L _{P12}	0.0
P13	0.1033	L _{P13}	0.0
P14	0.1033	L _{P14}	0.0
P15	0.1033	L _{P15}	0.0
P16	0.1033	L _{P16}	0.0
P17	0.1033	L _{P17}	0.0
P18	0.1033	L _{P18}	0.0
P19	0.1033	L _{P19}	0.0
P20	0.1033	L _{P20}	0.0
P21	0.1033	L _{P21}	0.0
P22	0.1033	L _{P22}	0.0
P23	0.1033	L _{P23}	0.0
P24	0.1033	L _{P24}	0.0
P25	0.1033	L _{P25}	0.0
P26	0.1033	L _{P26}	0.0
P27	0.1033	L _{P27}	0.0
P28	0.1033	L _{P28}	0.0
P29	0.1033	L _{P29}	0.0

Bend data

Name	Diameter (m)	Curvature radius (m)	Angle (°)	Absolute roughness (m)
J2	0.1033	C _{J2}	90	0.0
J3	0.1033	C _{J3}	90	0.0
J4	0.1033	C _{J4}	90	0.0
J5	0.1033	C _{J5}	90	0.0
J6	0.1033	C _{J6}	90	0.0
J7	0.1033	C _{J7}	90	0.0
J8	0.1033	C _{J8}	90	0.0
J9	0.1033	C _{J9}	90	0.0
J10	0.1033	C _{J10}	90	0.0
J11	0.1033	C _{J11}	90	0.0
J12	0.1033	C _{J12}	90	0.0
J13	0.1033	C _{J13}	90	0.0
J14	0.1033	C _{J14}	90	0.0
J15	0.1033	C _{J15}	90	0.0
J16	0.1033	C _{J16}	90	0.0
J17	0.1033	C _{J17}	90	0.0
J18	0.1033	C _{J18}	90	0.0
J19	0.1033	C _{J19}	90	0.0
J20	0.1033	C _{J20}	90	0.0
J21	0.1033	C _{J21}	90	0.0
J22	0.1033	C _{J22}	90	0.0
J23	0.1033	C _{J23}	90	0.0
J24	0.1033	C _{J24}	90	0.0
J25	0.1033	C _{J25}	90	0.0
J26	0.1033	C _{J26}	90	0.0
J27	0.1033	C _{J27}	90	0.0
J28	0.1033	C _{J28}	90	0.0
J29	0.1033	C _{J29}	90	0.0
J30	0.1033	C _{J30}	90	0.0
J31	0.1033	C _{J31}	90	0.0
J32	0.1033	C _{J32}	90	0.0
J33	0.1033	C _{J33}	90	0.0
J34	0.1033	C _{J34}	90	0.0
J35	0.1033	C _{J35}	90	0.0
J36	0.1033	C _{J36}	90	0.0
J37	0.1033	C _{J37}	90	0.0
J38	0.1033	C _{J38}	90	0.0
J39	0.1033	C _{J39}	90	0.0
J40	0.1033	C _{J40}	90	0.0
J41	0.1033	C _{J41}	90	0.0
J42	0.1033	C _{J42}	90	0.0
J43	0.1033	C _{J43}	90	0.0
J44	0.1033	C _{J44}	90	0.0
J45	0.1033	C _{J45}	90	0.0
J46	0.1033	C _{J46}	90	0.0
J47	0.1033	C _{J47}	90	0.0
J48	0.1033	C _{J48}	90	0.0
J49	0.1033	C _{J49}	90	0.0
J50	0.1033	C _{J50}	90	0.0
J51	0.1033	C _{J51}	90	0.0
J52	0.1033	C _{J52}	90	0.0
J53	0.1033	C _{J53}	90	0.0
J54	0.1033	C _{J54}	90	0.0
J55	0.1033	C _{J55}	90	0.0
J56	0.1033	C _{J56}	90	0.0
J57	0.1033	C _{J57}	90	0.0
J58	0.1033	C _{J58}	90	0.0
J59	0.1033	C _{J59}	90	0.0
J60	0.1033	C _{J60}	90	0.0
J61	0.1033	C _{J61}	90	0.0
J62	0.1033	C _{J62}	90	0.0
J63	0.1033	C _{J63}	90	0.0
J64	0.1033	C _{J64}	90	0.0
J65	0.1033	C _{J65}	90	0.0
J66	0.1033	C _{J66}	90	0.0
J67	0.1033	C _{J67}	90	0.0
J68	0.1033	C _{J68}	90	0.0
J69	0.1033	C _{J69}	90	0.0
J70	0.1033	C _{J70}	90	0.0
J71	0.1033	C _{J71}	90	0.0
J72	0.1033	C _{J72}	90	0.0
J73	0.1033	C _{J73}	90	0.0
J74	0.1033	C _{J74}	90	0.0
J75	0.1033	C _{J75}	90	0.0
J76	0.1033	C _{J76}	90	0.0
J77	0.1033	C _{J77}	90	0.0
J78	0.1033	C _{J78}	90	0.0
J79	0.1033	C _{J79}	90	0.0
J80	0.1033	C _{J80}	90	0.0
J81	0.1033	C _{J81}	90	0.0
J82	0.1033	C _{J82}	90	0.0
J83	0.1033	C _{J83}	90	0.0
J84	0.1033	C _{J84}	90	0.0
J85	0.1033	C _{J85}	90	0.0
J86	0.1033	C _{J86}	90	0.0
J87	0.1033	C _{J87}	90	0.0
J88	0.1033	C _{J88}	90	0.0
J89	0.1033	C _{J89}	90	0.0
J90	0.1033	C _{J90}	90	0.0
J91	0.1033	C _{J91}	90	0.0
J92	0.1033	C _{J92}	90	0.0
J93	0.1033	C _{J93}	90	0.0
J94	0.1033	C _{J94}	90	0.0
J95	0.1033	C _{J95}	90	0.0
J96	0.1033	C _{J96}	90	0.0
J97	0.1033	C _{J97}	90	0.0
J98	0.1033	C _{J98}	90	0.0
J99	0.1033	C _{J99}	90	0.0
J100	0.1033	C _{J100}	90	0.0

Head Exchanger I1 - Pressure loss

Flowrate (m³/s)	Pressure loss (Pa)
0.0000	0
0.0020	2903
0.0040	11612
0.0060	26127
0.0080	44441
0.0100	67236

Pumps J5, J7 & J10 - Head

Flowrate (m³/s)	Head (m)
0.0000	6.000
0.0020	5.900
0.0040	5.790
0.0060	5.590
0.0080	4.800

Solver data
Value to be computed by solver (variable cells):
P_{J4} = P_{J5} (Pa) = 70000 Pa
P_{J7} = P_{J10} (Pa) = 70000 Pa
K_{J1} = 0.0000
K_{J2} = 0.0000
K_{J3} = 0.0000
K_{J4} = 0.0000
K_{J5} = 0.0000
K_{J6} = 0.0000
K_{J7} = 0.0000
K_{J8} = 0.0000
K_{J9} = 0.0000
K_{J10} = 0.0000
K_{J11} = 0.0000
K_{J12} = 0.0000
K_{J13} = 0.0000
K_{J14} = 0.0000
K_{J15} = 0.0000
K_{J16} = 0.0000
K_{J17} = 0.0000
K_{J18} = 0.0000
K_{J19} = 0.0000
K_{J20} = 0.0000
K_{J21} = 0.0000
K_{J22} = 0.0000
K_{J23} = 0.0000
K_{J24} = 0.0000
K_{J25} = 0.0000
K_{J26} = 0.0000
K_{J27} = 0.0000
K_{J28} = 0.0000
K_{J29} = 0.0000
K_{J30} = 0.0000
K_{J31} = 0.0000
K_{J32} = 0.0000
K_{J33} = 0.0000
K_{J34} = 0.0000
K_{J35} = 0.0000
K_{J36} = 0.0000
K_{J37} = 0.0000
K_{J38} = 0.0000
K_{J39} = 0.0000
K_{J40} = 0.0000
K_{J41} = 0.0000
K_{J42} = 0.0000
K_{J43} = 0.0000
K_{J44} = 0.0000
K_{J45} = 0.0000
K_{J46} = 0.0000
K_{J47} = 0.0000
K_{J48} = 0.0000
K_{J49} = 0.0000
K_{J50} = 0.0000
K_{J51} = 0.0000
K_{J52} = 0.0000
K_{J53} = 0.0000
K_{J54} = 0.0000
K_{J55} = 0.0000
K_{J56} = 0.0000
K_{J57} = 0.0000
K_{J58} = 0.0000
K_{J59} = 0.0000
K_{J60} = 0.0000
K_{J61} = 0.0000
K_{J62} = 0.0000
K_{J63} = 0.0000
K_{J64} = 0.0000
K_{J65} = 0.0000
K_{J66} = 0.0000
K_{J67} = 0.0000
K_{J68} = 0.0000
K_{J69} = 0.0000
K_{J70} = 0.0000
K_{J71} = 0.0000
K_{J72} = 0.0000
K_{J73} = 0.0000
K_{J74} = 0.0000
K_{J75} = 0.0000
K_{J76} = 0.0000
K_{J77} = 0.0000
K_{J78} = 0.0000
K_{J79} = 0.0000
K_{J80} = 0.0000
K_{J81} = 0.0000
K_{J82} = 0.0000
K_{J83} = 0.0000
K_{J84} = 0.0000
K_{J85} = 0.0000
K_{J86} = 0.0000
K_{J87} = 0.0000
K_{J88} = 0.0000
K_{J89} = 0.0000
K_{J90} = 0.0000
K_{J91} = 0.0000
K_{J92} = 0.0000
K_{J93} = 0.0000
K_{J94} = 0.0000
K_{J95} = 0.0000
K_{J96} = 0.0000
K_{J97} = 0.0000
K_{J98} = 0.0000
K_{J99} = 0.0000
K_{J100} = 0.0000

System

Flowrate (m³/s)	Head (m)
0.0000	0
0.0020	6.0000000
0.0040	2.8103915
0.0060	4.3754009
0.0080	7.2508621

Pressure evolution

- Recherche : le diamètre de chaque diaphragme pour répondre au débit requis à travers chaque échangeur de chaleur.
- Ce problème illustre l'utilisation du solveur d'Excel pour résoudre un système complexe en boucle fermée. De plus, les débits dans les branches des cinq échangeurs doivent être équilibrés par des diaphragmes d'équilibrage.

Reference: Fiomaster - Example: Marine Cooling System
Find: the diameter of each orifice plate to meet the required flowrate through the various branches

Legend
Fluid data
Head calculation
HydraulCalc calculation
Simulation input
Units symbol

Fluid data
Density: 980.265 kg/m³
Kinematic viscosity: 0.000001 m²/s

Head data (Water H₂O)
Head loss (Water H₂O): 0
Head loss (Water H₂O): 0

Imposed volume flowrate (Heat Exchangers)

HE1	0.01000	m ³ /s
HE2	0.01000	m ³ /s
HE3	0.01000	m ³ /s
HE4	0.01000	m ³ /s
HE5	0.01000	m ³ /s

Reservoir H₂O
Liquid level above base: 1 m
Base level above ref.: 0.00000 m
Surface pressure: 1.00000 Pa

Pipe data

Name	Diameter (m)	Length (m)	Absolute roughness (m)
P1	0.1541	1.00	0.000004
P2	0.1541	1.00	0.000004
P3	0.1541	1.00	0.000004
P4	0.1541	1.00	0.000004
P5	0.1541	1.00	0.000004
P6	0.1541	1.00	0.000004
P7	0.1541	1.00	0.000004
P8	0.1541	1.00	0.000004
P9	0.1541	1.00	0.000004
P10	0.1541	1.00	0.000004
P11	0.1541	1.00	0.000004
P12	0.1541	1.00	0.000004
P13	0.1541	1.00	0.000004
P14	0.1541	1.00	0.000004
P15	0.1541	1.00	0.000004
P16	0.1541	1.00	0.000004
P17	0.1541	1.00	0.000004
P18	0.1541	1.00	0.000004
P19	0.1541	1.00	0.000004
P20	0.1541	1.00	0.000004
P21	0.1541	1.00	0.000004
P22	0.1541	1.00	0.000004
P23	0.1541	1.00	0.000004
P24	0.1541	1.00	0.000004
P25	0.1541	1.00	0.000004
P26	0.1541	1.00	0.000004
P27	0.1541	1.00	0.000004
P28	0.1541	1.00	0.000004
P29	0.1541	1.00	0.000004
P30	0.1541	1.00	0.000004
P31	0.1541	1.00	0.000004
P32	0.1541	1.00	0.000004
P33	0.1541	1.00	0.000004
P34	0.1541	1.00	0.000004
P35	0.1541	1.00	0.000004
P36	0.1541	1.00	0.000004
P37	0.1541	1.00	0.000004
P38	0.1541	1.00	0.000004
P39	0.1541	1.00	0.000004
P40	0.1541	1.00	0.000004
P41	0.1541	1.00	0.000004
P42	0.1541	1.00	0.000004
P43	0.1541	1.00	0.000004
P44	0.1541	1.00	0.000004
P45	0.1541	1.00	0.000004
P46	0.1541	1.00	0.000004
P47	0.1541	1.00	0.000004
P48	0.1541	1.00	0.000004
P49	0.1541	1.00	0.000004
P50	0.1541	1.00	0.000004
P51	0.1541	1.00	0.000004
P52	0.1541	1.00	0.000004
P53	0.1541	1.00	0.000004
P54	0.1541	1.00	0.000004
P55	0.1541	1.00	0.000004
P56	0.1541	1.00	0.000004
P57	0.1541	1.00	0.000004
P58	0.1541	1.00	0.000004
P59	0.1541	1.00	0.000004
P60	0.1541	1.00	0.000004
P61	0.1541	1.00	0.000004
P62	0.1541	1.00	0.000004
P63	0.1541	1.00	0.000004
P64	0.1541	1.00	0.000004
P65	0.1541	1.00	0.000004
P66	0.1541	1.00	0.000004
P67	0.1541	1.00	0.000004
P68	0.1541	1.00	0.000004
P69	0.1541	1.00	0.000004
P70	0.1541	1.00	0.000004
P71	0.1541	1.00	0.000004
P72	0.1541	1.00	0.000004
P73	0.1541	1.00	0.000004
P74	0.1541	1.00	0.000004
P75	0.1541	1.00	0.000004
P76	0.1541	1.00	0.000004
P77	0.1541	1.00	0.000004
P78	0.1541	1.00	0.000004
P79	0.1541	1.00	0.000004
P80	0.1541	1.00	0.000004
P81	0.1541	1.00	0.000004
P82	0.1541	1.00	0.000004
P83	0.1541	1.00	0.000004
P84	0.1541	1.00	0.000004
P85	0.1541	1.00	0.000004
P86	0.1541	1.00	0.000004
P87	0.1541	1.00	0.000004
P88	0.1541	1.00	0.000004
P89	0.1541	1.00	0.000004
P90	0.1541	1.00	0.000004
P91	0.1541	1.00	0.000004
P92	0.1541	1.00	0.000004
P93	0.1541	1.00	0.000004
P94	0.1541	1.00	0.000004
P95	0.1541	1.00	0.000004
P96	0.1541	1.00	0.000004
P97	0.1541	1.00	0.000004
P98	0.1541	1.00	0.000004
P99	0.1541	1.00	0.000004
P100	0.1541	1.00	0.000004

Pressure loss of each component

Heat Exchanger pressure loss

HE1	0.00000	Pa
HE2	0.00000	Pa
HE3	0.00000	Pa
HE4	0.00000	Pa
HE5	0.00000	Pa

Orifice plate pressure loss

OP1	0.00000	Pa
OP2	0.00000	Pa
OP3	0.00000	Pa
OP4	0.00000	Pa
OP5	0.00000	Pa
OP6	0.00000	Pa
OP7	0.00000	Pa
OP8	0.00000	Pa
OP9	0.00000	Pa
OP10	0.00000	Pa
OP11	0.00000	Pa
OP12	0.00000	Pa
OP13	0.00000	Pa
OP14	0.00000	Pa
OP15	0.00000	Pa
OP16	0.00000	Pa
OP17	0.00000	Pa
OP18	0.00000	Pa
OP19	0.00000	Pa
OP20	0.00000	Pa
OP21	0.00000	Pa
OP22	0.00000	Pa
OP23	0.00000	Pa
OP24	0.00000	Pa
OP25	0.00000	Pa
OP26	0.00000	Pa
OP27	0.00000	Pa
OP28	0.00000	Pa
OP29	0.00000	Pa
OP30	0.00000	Pa
OP31	0.00000	Pa
OP32	0.00000	Pa
OP33	0.00000	Pa
OP34	0.00000	Pa
OP35	0.00000	Pa
OP36	0.00000	Pa
OP37	0.00000	Pa
OP38	0.00000	Pa
OP39	0.00000	Pa
OP40	0.00000	Pa
OP41	0.00000	Pa
OP42	0.00000	Pa
OP43	0.00000	Pa
OP44	0.00000	Pa
OP45	0.00000	Pa
OP46	0.00000	Pa
OP47	0.00000	Pa
OP48	0.00000	Pa
OP49	0.00000	Pa
OP50	0.00000	Pa

Pipe pressure loss

P1	0.00000	Pa
P2	0.00000	Pa
P3	0.00000	Pa
P4	0.00000	Pa
P5	0.00000	Pa
P6	0.00000	Pa
P7	0.00000	Pa
P8	0.00000	Pa
P9	0.00000	Pa
P10	0.00000	Pa
P11	0.00000	Pa
P12	0.00000	Pa
P13	0.00000	Pa
P14	0.00000	Pa
P15	0.00000	Pa
P16	0.00000	Pa
P17	0.00000	Pa
P18	0.00000	Pa
P19	0.00000	Pa
P20	0.00000	Pa
P21	0.00000	Pa
P22	0.00000	Pa
P23	0.00000	Pa
P24	0.00000	Pa
P25	0.00000	Pa
P26	0.00000	Pa
P27	0.00000	Pa
P28	0.00000	Pa
P29	0.00000	Pa
P30	0.00000	Pa
P31	0.00000	Pa
P32	0.00000	Pa
P33	0.00000	Pa
P34	0.00000	Pa
P35	0.00000	Pa
P36	0.00000	Pa
P37	0.00000	Pa
P38	0.00000	Pa
P39	0.00000	Pa
P40	0.00000	Pa
P41	0.00000	Pa
P42	0.00000	Pa
P43	0.00000	Pa
P44	0.00000	Pa
P45	0.00000	Pa
P46	0.00000	Pa
P47	0.00000	Pa
P48	0.00000	Pa
P49	0.00000	Pa
P50	0.00000	Pa
P51	0.00000	Pa
P52	0.00000	Pa
P53	0.00000	Pa
P54	0.00000	Pa
P55	0.00000	Pa
P56	0.00000	Pa
P57	0.00000	Pa
P58	0.00000	Pa
P59	0.00000	Pa
P60	0.00000	Pa
P61	0.00000	Pa
P62	0.00000	Pa
P63	0.00000	Pa
P64	0.00000	Pa
P65	0.00000	Pa
P66	0.00000	Pa
P67	0.00000	Pa
P68	0.00000	Pa
P69	0.00000	Pa
P70	0.00000	Pa
P71	0.00000	Pa
P72	0.00000	Pa
P73	0.00000	Pa
P74	0.00000	Pa
P75	0.00000	Pa
P76	0.00000	Pa
P77	0.00000	Pa
P78	0.00000	Pa
P79	0.00000	Pa
P80	0.00000	Pa
P81	0.00000	Pa
P82	0.00000	Pa
P83	0.00000	Pa
P84	0.00000	Pa
P85	0.00000	Pa
P86	0.00000	Pa
P87	0.00000	Pa
P88	0.00000	Pa
P89	0.00000	Pa
P90	0.00000	Pa
P91	0.00000	Pa
P92	0.00000	Pa
P93	0.00000	Pa
P94	0.00000	Pa
P95	0.00000	Pa
P96	0.00000	Pa
P97	0.00000	Pa
P98	0.00000	Pa
P99	0.00000	Pa
P100	0.00000	Pa

Through (m³/s)

T1	0.01000	m ³ /s
T2	0.01000	m ³ /s
T3	0.01000	m ³ /s
T4	0.01000	m ³ /s
T5	0.01000	m ³ /s
T6	0.01000	m ³ /s
T7	0.01000	m ³ /s
T8	0.01000	m ³ /s
T9	0.01000	m ³ /s
T10	0.01000	m ³ /s
T11	0.01000	m ³ /s
T12	0.01000	m ³ /s
T13	0.01000	m ³ /s
T14	0.01000	m ³ /s
T15	0.01000	m ³ /s
T16	0.01000	m ³ /s
T17	0.01000	m ³ /s
T18	0.01000	m ³ /s
T19	0.01000	m ³ /s
T20	0.01000	m ³ /s
T21	0.01000	m ³ /s
T22	0.01000	m ³ /s
T23	0.01000	m ³ /s
T24	0.01000	m ³ /s
T25	0.01000	m ³ /s
T26	0.01000	m ³ /s
T27	0.01000	m ³ /s
T28	0.01000	m ³ /s
T29	0.01000	m ³ /s
T30	0.01000	m ³ /s
T31	0.01000	m ³ /s
T32	0.01000	m ³ /s
T33	0.01000	m ³ /s
T34	0.01000	m ³ /s
T35	0.01000	m ³ /s
T36	0.01000	m ³ /s
T37	0.01000	m ³ /s
T38	0.01000	m ³ /s
T39	0.01000	m ³ /s
T40	0.01000	m ³ /s
T41	0.01000	m ³ /s
T42	0.01000	m ³ /s
T43	0.01000	m ³ /s
T44	0.01000	m ³ /s
T45	0.01000	m ³ /s
T46	0.01000	m ³ /s
T47	0.01000	m ³ /s
T48	0.01000	m ³ /s
T49	0.01000	m ³ /s
T50	0.01000	m ³ /s

Function pressure loss (Pa)

F1	0.00000	Pa
F2	0.00000	Pa
F3	0.00000	Pa
F4	0.00000	Pa
F5	0.00000	Pa
F6	0.00000	Pa
F7	0.00000	Pa
F8	0.00000	Pa
F9	0.00000	Pa
F10	0.00000	Pa
F11	0.00000	Pa
F12	0.00000	Pa
F13	0.00000	Pa
F14	0.00000	Pa
F15	0.00000	Pa
F16	0.00000	Pa
F17	0.00	

HydraCalcXL

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