

HydrauCalcXL

2024a Release



www.hydraucalc.com

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What is HydrauCalcXL Add-in?

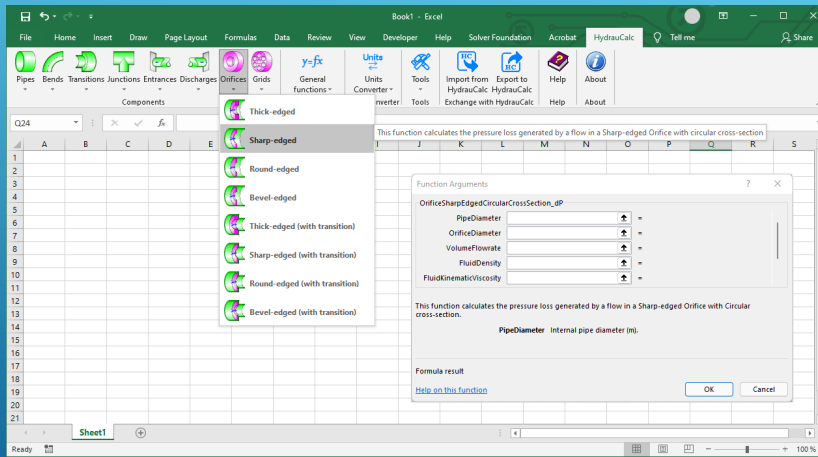
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What is HydrauCalcXL Add-in?

- ▶ HydrauCalcXL Add-in is a library of functions that has been developed to calculate the pressure losses of hydraulic components in Microsoft Excel®. This library allows the direct call of functions relating to the calculation of pressure losses. It comes from the HydrauCalc application which is based mainly on recognized and respected references in the field of flow and pressure losses calculation.
- ▶ The HydrauCalcXL functions can be used via the user interface of Excel, like the own integrated functions of Excel.
- ▶ The joint use of this library and the solver integrated in Excel® (solver of nonlinear systems of equations) makes it possible to solve iterative flow problems and to perform multi-variables optimization analyzes of fluid systems.

The Excel graphical interface

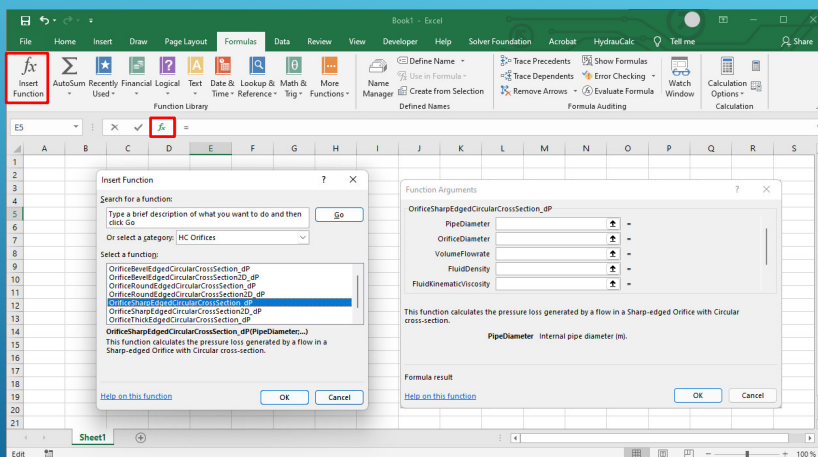
The Excel graphical interface (1)



- ▶ The HydraulCalc tab includes a ribbon that allows you to call up the different functions of the library.
- ▶ From this interface, the user inserts the functions of the components that he wishes to evaluate.
- ▶ This interface is intuitive and very easy-to-use.

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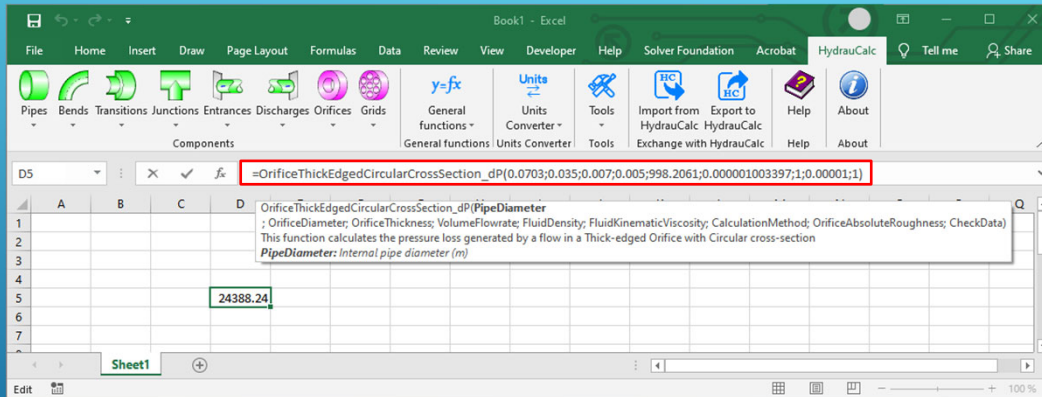
The Excel graphical interface (2)



- ▶ The functions of the library can also be selected from the "Insert Function" buttons of the "Formulas" tab or from the function bar.
- ▶ This interface is less friendly and less easy to use than the previous one.

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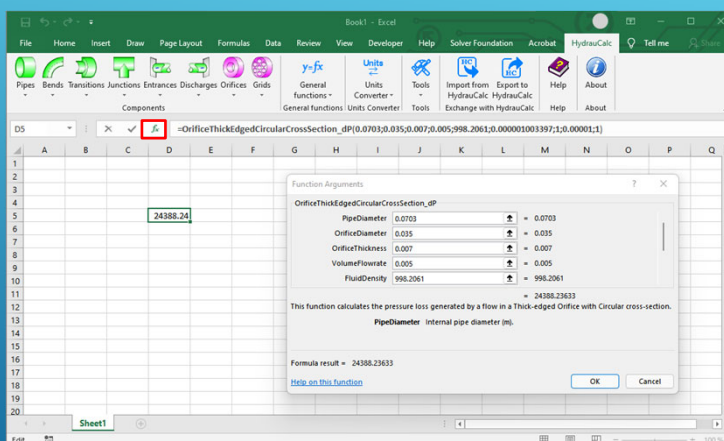
The Excel graphical interface (3)



When a function is inserted in a cell of the spreadsheet, it is possible, subsequently, to modify the parameters of the function by displaying it in the formula bar.

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The Excel graphical interface (4)



- ▶ Function parameters can also be changed by selecting the "Insert Function" button on the function bar.

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The Functions of the HydraulCalcXL Library

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The functions of the HydraulCalcXL library

The functions of the library are accessible via the ribbon of the HydraulCalcXL tab.

The library includes four types of functions:

- Functions for calculating pressure losses of piping components such as straight pipes, bends, transitions, junctions, pipeline entrances, pipeline discharges, orifices, grids (74 functions).
- Functions for calculation between the different variables entering into the general pressure loss formulas (pressure loss, pressure loss coefficient, flow coefficient, volume flow, mass flow, Reynolds number, flow velocity , ...) (103 functions).
- Functions to convert units of measure to each other (17 functions).
- Various functions (2 functions).

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Piping Components

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The available piping components

Straight pipes:



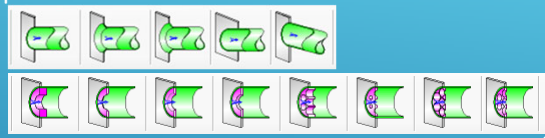
Transitions:



Bends:



Pipeline entrances:



Junctions:



Pipeline discharges:



Restriction orifices:



Grids:



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Component Function Arguments

The arguments of the component pressure drop calculation functions are:

- The geometry of the component (length, internal diameter, angle and radius of curvature, absolute roughness of the walls, etc.).
- The characteristic of the flow (volume flowrate).
- The properties of the conveyed fluid (density and kinematic viscosity).

Example of Using a Component Function

The screenshot displays the HydrauCalcXL interface. The spreadsheet shows the following data and formulas:

7	Density	998.1	kg/m ³
8	Kinematic Viscosity	9.800E-07	m ² /s
9	Volume flowrate	0.005	m ³ /s
12	Diameter	0.0525	m
13	Length	6	m
14	Absolute roughness	5.0E-06	m

Formulas used in the spreadsheet:

- Flow velocity: $=\text{FlowVelocity_Qv_DIE}(R2,C12)$ (Result: 2.310 m/s)
- Reynolds number: $=\text{ReynoldsNumber_V_D_Nu}(R2,C12,C8)$ (Result: 123736)
- Pressure loss coefficient: $=\text{PressureLossCoefficient_dp_Qv_D_f}(R2,C12,C7)$ (Result: 1.968)
- Pipe pressure loss: $=\text{PipeStraightCircularCrossSection_dp}(C12,C13,C10,C7,C8,E1,C4)$ (Result: 5239 Pa)

The help window for the **PipeStraightCircularCrossSection_dp** function is open, showing 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)`

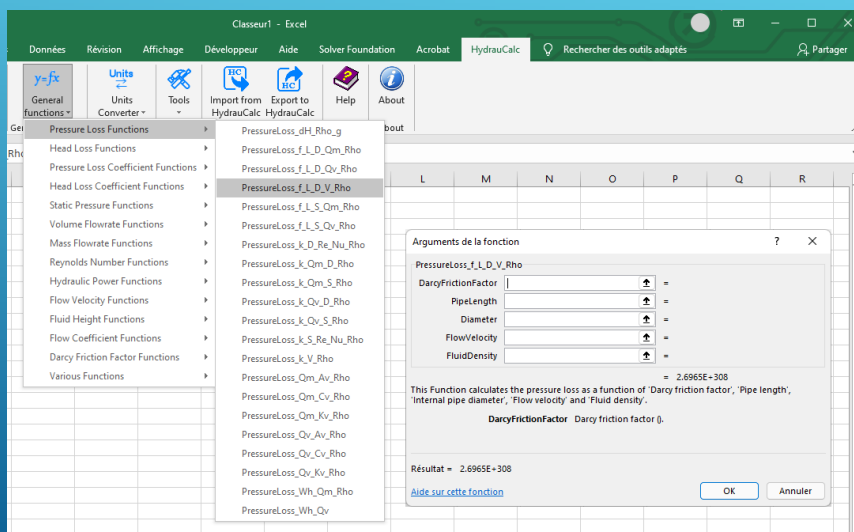
Arguments:

- 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]

General formula functions

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General formula functions



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Example of using general formula functions

The screenshot shows a spreadsheet with the following data:

Density	998.1	kg/m ³	Pressure loss	6985	Pa
Kinematic Viscosity	9.80E-07	m ² /s	Flow velocity	2.392	m/s
Volume flowrate	0.005	m ³ /s	Pressure loss coefficient	2.286	
Diameter	0.0525	m			
Length	6	m			
Absolute roughness	5.0E-06	m			
Darcy friction factor	0.02				

The 'Function Arguments' dialog box for 'PressureLossCoefficient_dP_Qv_D_Rho' shows:

- PressureLoss: 6985.28626
- VolumeFlowrate: 0.005
- Diameter: 0.0525
- FluidDensity: 998.1
- Formula result: 2.286

The 'HydraulCalcXL - Help' window displays the following information for the 'PressureLossCoefficient_dP_Qv_D_Rho' function:

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

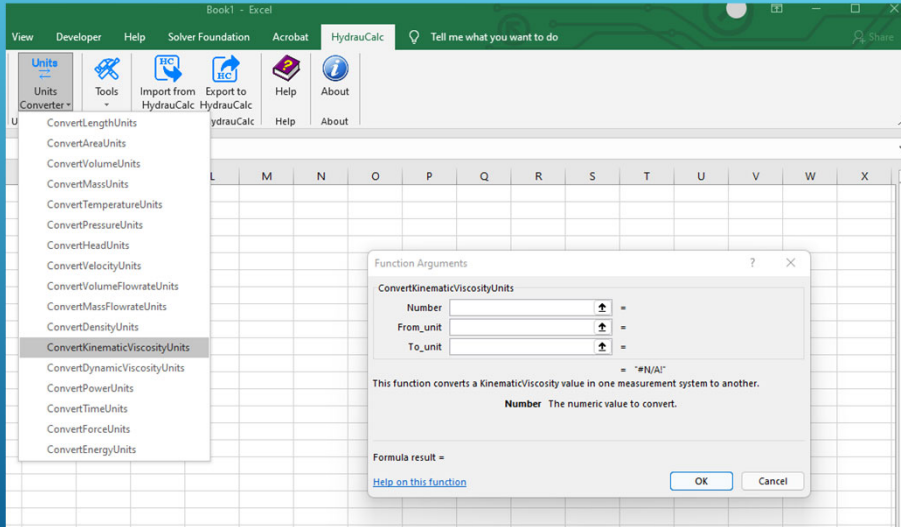
- PressureLoss [MP] Double: Pressure loss (Pa)
- VolumeFlowrate [Qv] Double: Volume flowrate (m³/s)
- Diameter [D] Double: Diameter (m)
- FluidDensity [ρ] Double: Fluid density (kg/m³)

Formula

$$k = \frac{dP}{0.5 \rho \frac{Qv^2}{(\pi D^2/4)^2}}$$

Functions for converting units of measurement

Functions for converting units of measurement

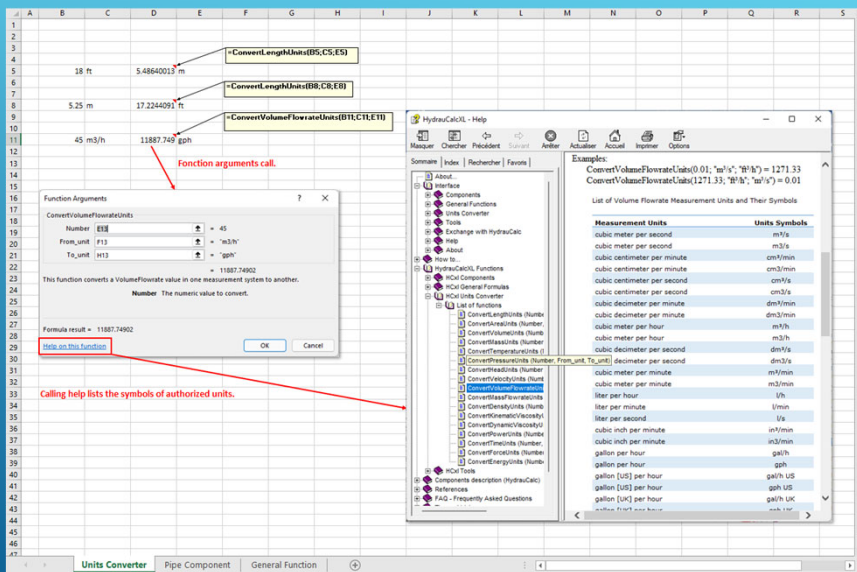


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Example of using measurement unit conversion functions



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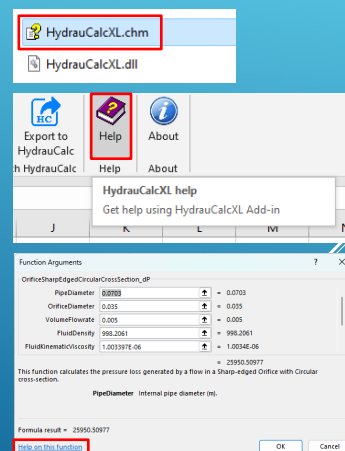
Technical documentation

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Calling the documentation

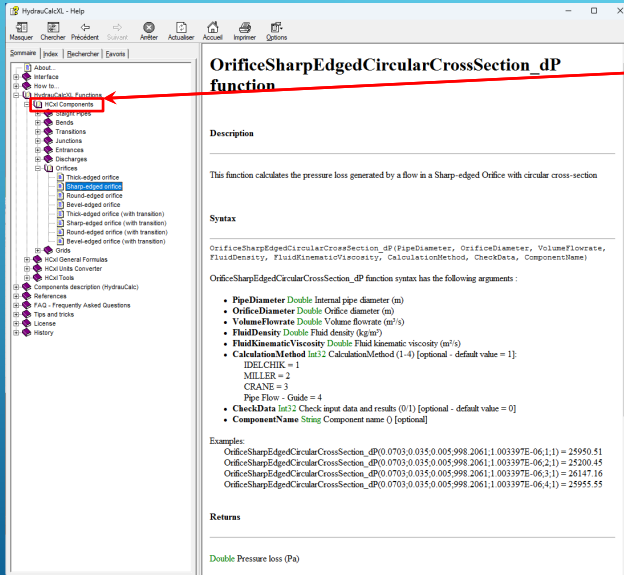
A help file containing documentation is associated with the HydrauCalcXL function library. This help can be displayed in the following ways:

- Directly selecting the help file with the "chm" extension.
- Using a button located in the HydrauCalcXL ribbon.
- From the argument entry window for functions incorporated into HydrauCalcXL. In this case the help file opens directly in the help section corresponding to the selected function.



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Documentation of component functions (1)

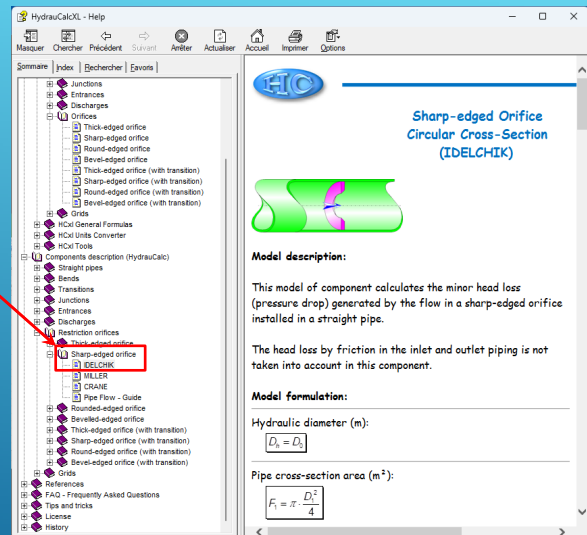
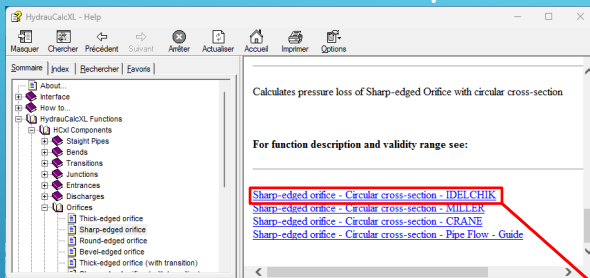


Component functions are described in the subtopics of the "HCxl Components" topic.

For each function we find:

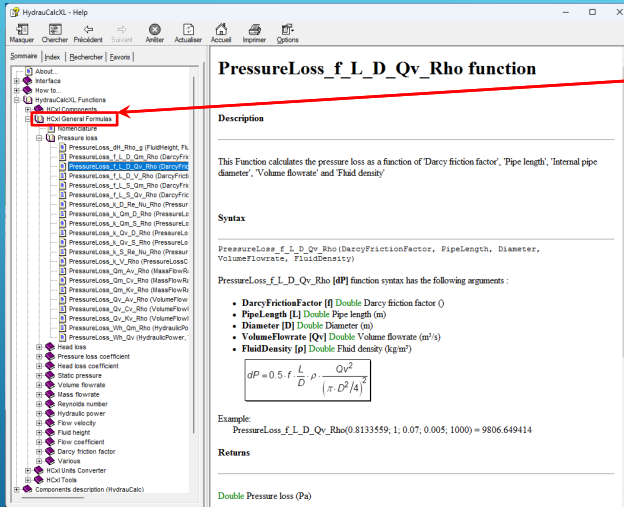
- A description of the function.
- The syntax of the function.
- The function parameters with their unit of measurement.
- Examples of using the function for different parameter values.

Documentation of component functions (2)



The component documentation also has links that point to topics describing the mathematical equations used for the chosen calculation method. These sections come from the HydraulCalc application documentation.

Documentation of general functions

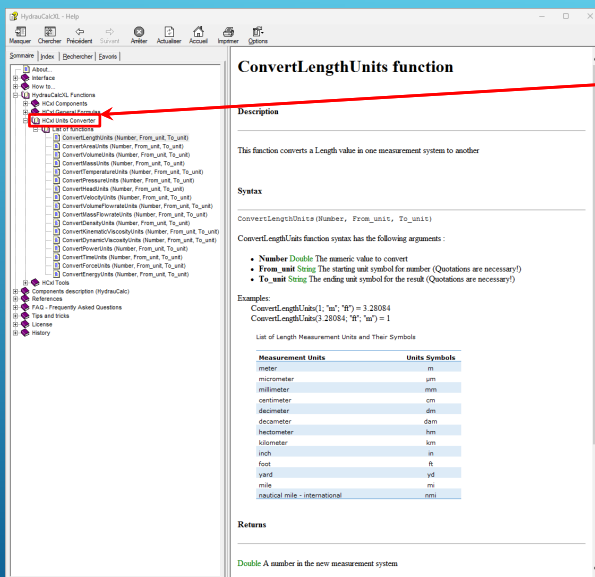


General functions are described in the subsections of the "HCxl General Formulas" section.

For each function we find:

- A description of the function.
- The syntax of the function.
- The function parameters with their unit of measurement.
- The mathematical equation used for the function.
- An example of using the function.

Documentation of unit conversion functions

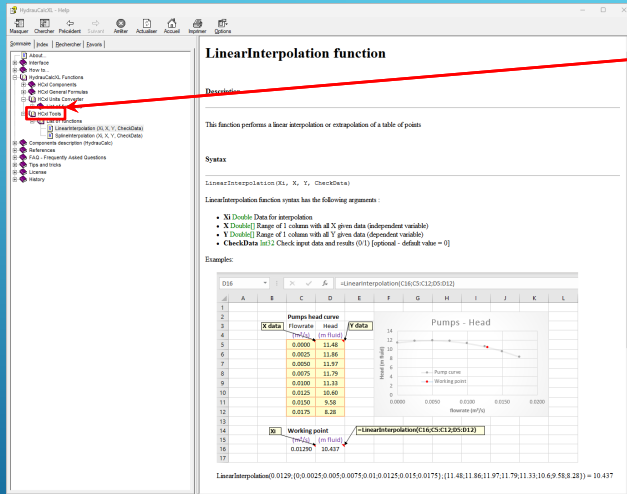


Unit conversion functions are described in the subtopics of the "HCxl Units Converter" topic.

For each function we find:

- A description of the function.
- The syntax of the function.
- The function parameters.
- Examples of using the function.
- The list of available units and their symbols to enter.

Documentation of tool functions



Tool functions are described in the subtopics of the "HCxl Tools" topic.

For each function we find:

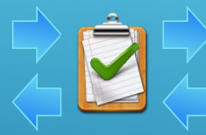
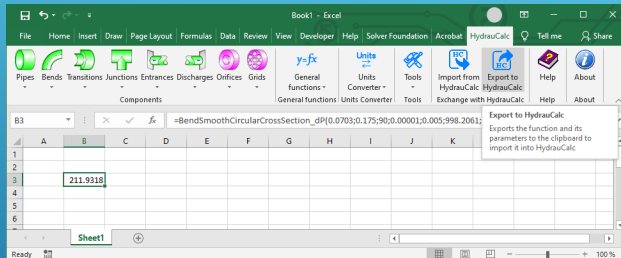
- ❑ A description of the function.
- ❑ The syntax of the function.
- ❑ The function parameters.
- ❑ An example of using the function.

Data exchange with the HydraulCalc application

Data exchange with Hydracalc application

HydracalcXL library

Hydracalc application



Data can be exchanged between the "HydracalcXL" library and the "Hydracalc" application via the clipboard.

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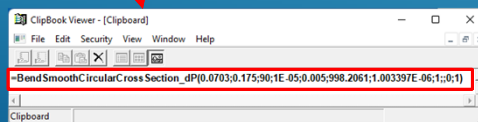
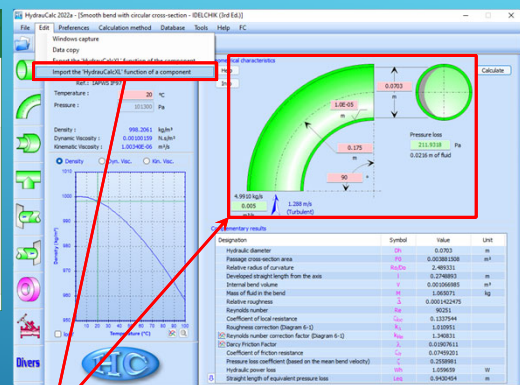
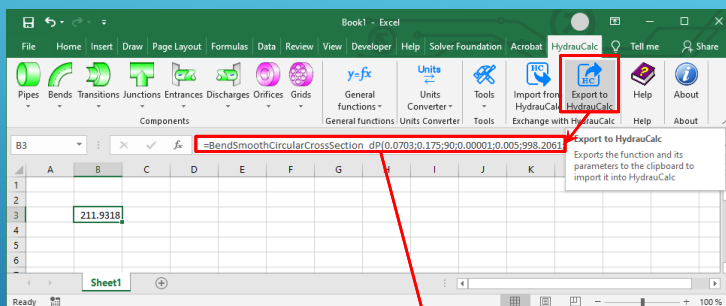
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Data export to Hydracalc

1 - Export function to Clipboard

2 - Import function from Clipboard



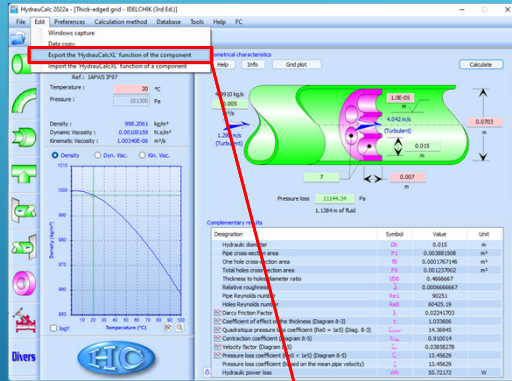
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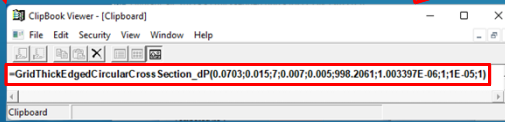
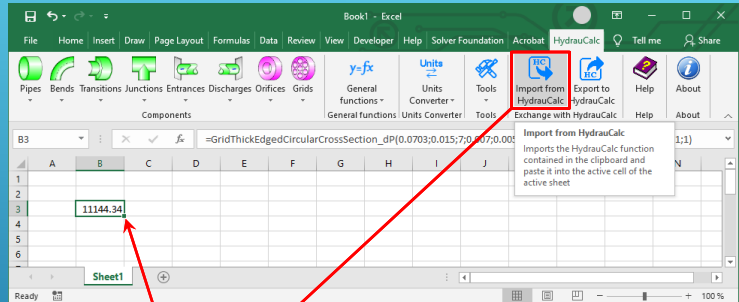
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Data import from HydraulCalc

1 - Export function to Clipboard



2 - Import function from Clipboard



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Examples of systems solved using HydraulCalcXL and Excel solver

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- Find: the pump head and the system working point.
- The pump flowrate is an input data. The functions integrated into HydraulCalcXL allow you to calculate explicitly (direct calculation without iterations) the pressure drop of the components.

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: Yellow
 Excel calculation: Green
 HydraulCalc calculation: Blue
 Variable name: Purple
 Unit symbol: Red
 Content of neighboring cell: Grey

Data verification
 Check data (Q/I) Cd: 1

Fluid data (Water 20°C)
 Density rho: 1000 kg/m³
 Kinematic Viscosity nu: 1.10E-06 m²/s

Volume flow rate
 Q: 2.75 m³/s

Pipe data

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

Reflux valve

Name	Diameter (m)	Pressure loss coef.
V1	0.8	0.5

System entrance (rounded entrance)

Name	Diameter (m)	Round radius (m)
E1	1	0.09

System discharge (sharp-edged discharge)

Name	Diameter (m)
D1	0.8

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	30.768
2.50	29.433
3.00	27.211
3.50	22.813

Pump - Head (Graph)

System characteristic

Flowrate (m³/s)	Head (m fluid)
0.00	7.000
0.50	7.711
1.00	9.844
1.50	13.398
2.00	18.375
2.50	24.773
3.00	32.594

System working point (Graph)

Pressure loss summary:

- Total pressure loss: 210899 Pa
- Total head loss: 21.506 m fluid
- Static lift: 7.000 m fluid
- Pump head: 28.506 m fluid

- Find: the flowrate and the system working point.
- The pump head is an input data. The use of the Excel solver is necessary to resolve the system and find the flowrate.

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: Yellow
 Excel calculation: Green
 HydraulCalc calculation: Blue
 Variable name: Purple
 Unit symbol: Red
 Content of neighboring cell: Grey

Data verification
 Check data (Q/I) Cd: 1

Fluid data (Water 20°C)
 Density rho: 1000 kg/m³
 Kinematic Viscosity nu: 1.10E-06 m²/s

Pump head
 HP: 28.6 m fluid

Pipe data

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

Reflux valve

Name	Diameter (m)	Pressure loss coef.
V1	0.8	0.5

System entrance (rounded entrance)

Name	Diameter (m)	Round radius (m)
E1	1	0.09

System discharge (sharp-edged discharge)

Name	Diameter (m)
D1	0.8

Reservoir data

Name	Surface elevation (m)
R1	1.5
R2	8.5

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Flowrate (m³/s)	Head (m fluid)
0.00	33.123
0.50	32.826
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2.00	30.768
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3.50	22.813

Pump - Head (Graph)

System characteristic

Flowrate (m³/s)	Head (m fluid)
0.00	7.000
0.50	7.711
1.00	9.844
1.50	13.398
2.00	18.375
2.50	24.773
3.00	32.594

System working point (Graph)

Solver data
 Value to be computed by solver (variable cells):
 Flowrate: 2.256 m³/s
 Constraints:
 HP - HL = 0: 0.0 Pa

Pressure loss summary:

- Total pressure loss: 211824 Pa
- Total head loss: 21.600 m fluid
- Static lift: 7.000 m fluid

- ▶ Find: the volume flowrate of each branch.
- ▶ This problem illustrates the use of Excel to solve a set of coupled, nonlinear equations for unknown flowrates.

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: Yellow
 Excel calculation: Orange
 Hydraulic calculation: Purple
 Variable name: Blue
 Unit symbol: Green
 Content of neighboring cell: Grey

Data verification
 Check data (0/1): $cd = 1$

Fluid data (Water 21°C)
 Density $\rho = 998.24 \text{ kg/m}^3$
 Kinematic Viscosity $\nu = 1.00E-06 \text{ m}^2/\text{s}$

Static head
 $h_{p1} = 30.48 \text{ m}$
 $h_{p5} = 0 \text{ m}$

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	1.524	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

Pipe	dp (Pa)	Formula
Pipe A	114932	= PipeStraightCircularCrossSection_dp(D_pA,L_pA,rho,nu,epsilon_pA,cd)
Pipe B	43446	= PipeStraightCircularCrossSection_dp(D_pB,L_pB,rho,nu,epsilon_pB,cd)
Pipe C	25070	= PipeStraightCircularCrossSection_dp(D_pC,L_pC,rho,nu,epsilon_pC,cd)
Pipe D	114932	= PipeStraightCircularCrossSection_dp(D_pD,L_pD,rho,nu,epsilon_pD,cd)
Pipe E	18573	= PipeStraightCircularCrossSection_dp(D_pE,L_pE,rho,nu,epsilon_pE,cd)
Pipe F	20807	= PipeStraightCircularCrossSection_dp(D_pF,L_pF,rho,nu,epsilon_pF,cd)
Pipe G	20807	= PipeStraightCircularCrossSection_dp(D_pG,L_pG,rho,nu,epsilon_pG,cd)
Pipe H	4066	= PipeStraightCircularCrossSection_dp(D_pH,L_pH,rho,nu,epsilon_pH,cd)

Pipe head loss

Pipe	dh (m)	Formula
Pipe A	11.740	= HeadLoss_dp_Rho_g(dp_pA,rho)
Pipe B	4.438	= HeadLoss_dp_Rho_g(dp_pB,rho)
Pipe C	2.561	= HeadLoss_dp_Rho_g(dp_pC,rho)
Pipe D	11.740	= HeadLoss_dp_Rho_g(dp_pD,rho)
Pipe E	1.857	= HeadLoss_dp_Rho_g(dp_pE,rho)
Pipe F	2.125	= HeadLoss_dp_Rho_g(dp_pF,rho)
Pipe G	2.125	= HeadLoss_dp_Rho_g(dp_pG,rho)
Pipe H	0.415	= HeadLoss_dp_Rho_g(dp_pH,rho)

Solver data
 Value to be computed by solver (variable cells)
 Pipe A $Q_{pA} = 0.010548 \text{ m}^3/\text{s}$
 Pipe B $Q_{pB} = 0.004566 \text{ m}^3/\text{s}$
 Pipe F $Q_{pF} = 0.001513 \text{ m}^3/\text{s}$

Constraints:
 $Q_{pA} + Q_{pB} + Q_{pC} + Q_{pD} - Q_{pE} = 0$
 $Q_{pE} + Q_{pF} + Q_{pG} - Q_{pH} = 0$
 $Q_{pG} - Q_{pH} = 0$

Deducted flowrate:
 Pipe C $Q_{pC} = 0.01055 \text{ m}^3/\text{s}$
 Pipe D $Q_{pD} = 0.01055 \text{ m}^3/\text{s}$
 Pipe E $Q_{pE} = 0.005982 \text{ m}^3/\text{s}$
 Pipe G $Q_{pG} = 0.00447 \text{ m}^3/\text{s}$
 Pipe H $Q_{pH} = 0.00598 \text{ m}^3/\text{s}$

Static lift:
 $sl = 30.480 \text{ m}$

- ▶ Find: the flowrate in each pipe.
- ▶ This problem illustrates use of Excel to solve a set of coupled, nonlinear equations for unknown flowrates.
- ▶ This example demonstrates also the use of unit conversion functions.

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

Legend
 Input data: Yellow
 Excel calculation: Orange
 Hydraulic calculation: Purple
 Variable name: Blue
 Unit symbol: Green
 Content of neighboring cell: Grey

Data verification
 Check data (0/1): $cd = 0$

Fluid data (Water 20°C)
 Density $\rho = 1000 \text{ kg/m}^3$
 Gravitational acceleration $g = 9.81 \text{ m/s}^2$

Pipes data

Pipe	Diameter	Length	Surface elevation
P1	1 ft	1000 ft	100 ft
P2	1 ft	500 ft	20 ft
P3	1 ft	400 ft	0 ft

Reservoirs data

Reservoir	Surface elevation	Surface pressure	Surface velocity
R1	100 ft	0 psi	0 m/s
R2	20 ft	0 psi	0 m/s
R3	0 ft	0 psi	0 m/s

Pipe head loss

Pipe	dh (ft)	Formula
P1	78.75	= HeadLoss_L_L_D_Or_gf(L_p1,D_p1,rho,g)
P2	1.25	= HeadLoss_L_L_D_Or_gf(L_p2,D_p2,rho,g)
P3	21.25	= HeadLoss_L_L_D_Or_gf(L_p3,D_p3,rho,g)

Solver data
 Value to be computed by solver (variable cells)
 Pipe 1 $Q_1 = 0.9631 \text{ m}^3/\text{s}$
 Pipe 2 $Q_2 = 0.2568 \text{ m}^3/\text{s}$
 Pipe 3 $Q_3 = 0.3221 \text{ m}^3/\text{s}$

Constraints:
 $P_1 - P_2 - \frac{\rho V_1^2 - V_2^2}{2g} + z_1 - z_2 - h_L = -(\Delta H_1 + \Delta H_2) = 0$
 $P_1 - P_3 - \frac{\rho V_1^2 - V_3^2}{2g} + z_1 - z_3 - h_L = -(\Delta H_1 + \Delta H_3) = 0$

Deducted flowrate:
 Pipe 1 $Q_1 = 0.3541 \text{ m}^3/\text{s}$
 Pipe 2 $Q_2 = 0.2568 \text{ m}^3/\text{s}$
 Pipe 3 $Q_3 = 0.3221 \text{ m}^3/\text{s}$

- Find: the pressure loss coefficient of the two control valves to allow the desired flowrate in each heat exchanger and the working point of the pump.
- This example shows simple system flow balancing.

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/h (0.0006848 m³/s) in each heat exchanger

The screenshot displays the HydraulCalcXL software interface. It features a central system diagram with a pump (P1) and two heat exchangers (HE1, HE2) connected by pipes. The software provides detailed data for each component, including pipe diameters, lengths, and roughness. It also shows the pump's head vs. flow rate curve and the system's pressure loss vs. flow rate curve. The working point of the pump is indicated on the system curve. The interface includes a legend, data verification section, and various data tables for pipe, pump, and system properties.

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- Find: the volume flowrate in the loop.
- This problem illustrates the use of Excel solver to find the flowrate in a simple closed loop system.

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

The screenshot displays the HydraulCalcXL software interface for a heat exchanger system. It features a central system diagram with a pump (P1) and two heat exchangers (HE1, HE2) connected by pipes. The software provides detailed data for each component, including pipe diameters, lengths, and roughness. It also shows the pump's head vs. flow rate curve and the system's pressure loss vs. flow rate curve. The working point of the pump is indicated on the system curve. The interface includes a legend, data verification section, and various data tables for pipe, pump, and system properties.

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- Find: the pressure loss coefficient of the two control valves to allow the desired flowrate in each heat exchanger and the working point of the pumps.
- This problem illustrates the use of Excel to solve a closed loop system with multiple pumps. In addition, the flows in the branches of the two exchangers are to be balanced by control valves.

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

Key data from the screenshot:

- Head data:** Head loss vs. flow rate graph showing a peak at 70 m³/h.
- Pumps 14 & 17 & 110 - Head:** Performance curves for the pumps.
- Pipe data:** Table with columns for Name, Diameter (m), Length (m), and Absolute roughness (m).
- Heat exchanger pressure loss:** Table with columns for Name, Flow rate (m³/h), and Pressure loss (Pa).
- Control valve pressure loss:** Table with columns for Name, Flow rate (m³/h), and Pressure loss (Pa).
- Pressure at nodes:** Table with columns for Node, Pressure (Pa), and Flow rate (m³/h).

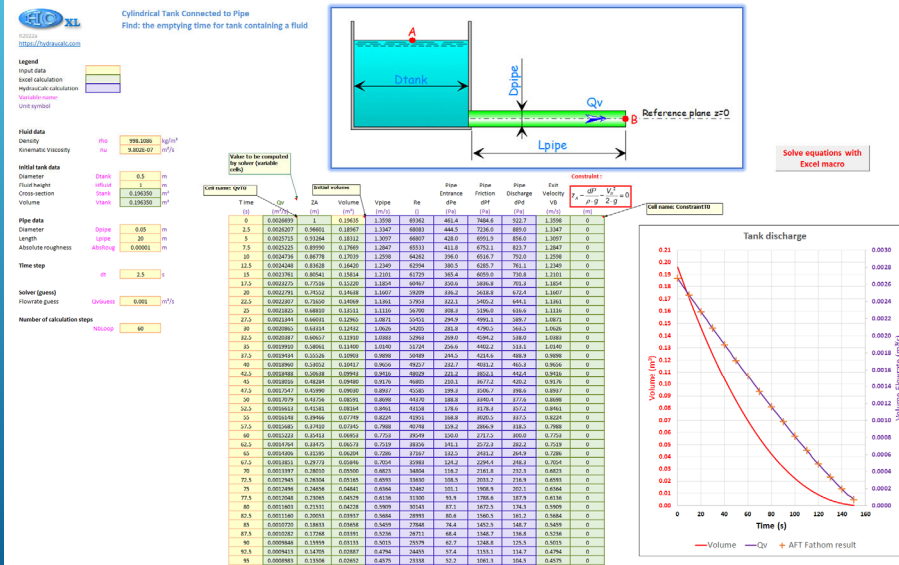
- Find: the diameter of each orifice plate to meet the required flowrate through the each heat exchanger.
- This problem illustrates the use of Excel solver to solve a complex closed loop system. In addition, the flows in the branches of the five exchangers are to be balanced by restriction orifices.

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

Key data from the screenshot:

- Head data:** Head loss vs. flow rate graph showing a peak at 70 m³/h.
- Pumps 14 & 17 & 110 - Head:** Performance curves for the pumps.
- Pipe data:** Table with columns for Name, Diameter (m), Length (m), and Absolute roughness (m).
- Heat exchanger pressure loss:** Table with columns for Name, Flow rate (m³/h), and Pressure loss (Pa).
- Control valve pressure loss:** Table with columns for Name, Flow rate (m³/h), and Pressure loss (Pa).
- Pressure at nodes:** Table with columns for Node, Pressure (Pa), and Flow rate (m³/h).
- Orifice plate pressure loss:** Table with columns for Name, Flow rate (m³/h), and Pressure loss (Pa).

- Find: the emptying time for tank containing a fluid.
- This problem illustrates the use of the Excel Solver to perform the transient analysis of a system.



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