HydrauCalcXL

2025a Release

www.hydraucalc.com

1

What is HydrauCalcXL Add-in?

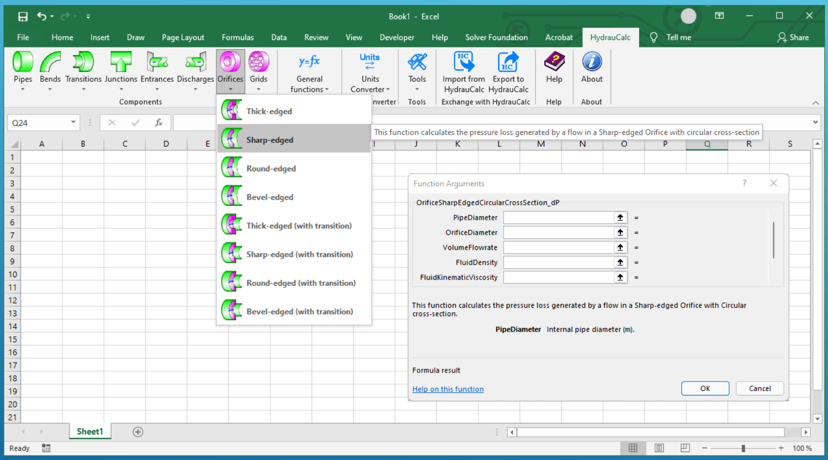
2

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)



This function calculates the pressure loss generated by a flow in a Sharp-edged Orifice with circular cross-section

Function Arguments

OrificeSharpEdgedCircularCrossSection_dP

PipeDiameter =
OrificeDiameter =
VolumeFlowrate =
FluidDensity =
FluidKinematicViscosity =

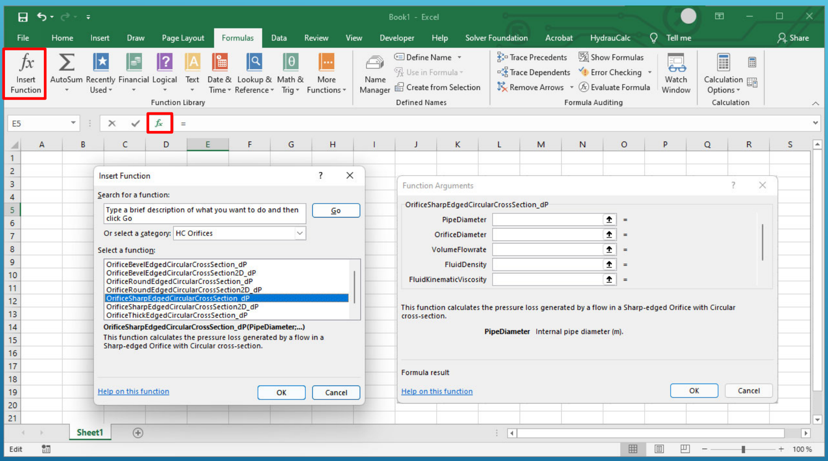
This function calculates the pressure loss generated by a flow in a Sharp-edged Orifice with Circular cross-section.

PipeDiameter Internal pipe diameter (m).

Formula result

- The HydrauCalc 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.

The Excel graphical interface (2)



Insert Function

Search for a function:

Type a brief description of what you want to do and then click Go

Or select a category: HC Orifices

Select a function:

OrificeBevelEdgedCircularCrossSection_dP
OrificeBevelEdgedCircularCrossSection2D_dP
OrificeRoundEdgedCircularCrossSection_dP
OrificeRoundEdgedCircularCrossSection2D_dP
OrificeSharpEdgedCircularCrossSection_dP
OrificeSharpEdgedCircularCrossSection2D_dP
OrificeThickEdgedCircularCrossSection_dP

OrificeSharpEdgedCircularCrossSection_dP(PipeDiameter;...)

This function calculates the pressure loss generated by a flow in a Sharp-edged Orifice with Circular cross-section.

Function Arguments

OrificeSharpEdgedCircularCrossSection_dP

PipeDiameter =
OrificeDiameter =
VolumeFlowrate =
FluidDensity =
FluidKinematicViscosity =

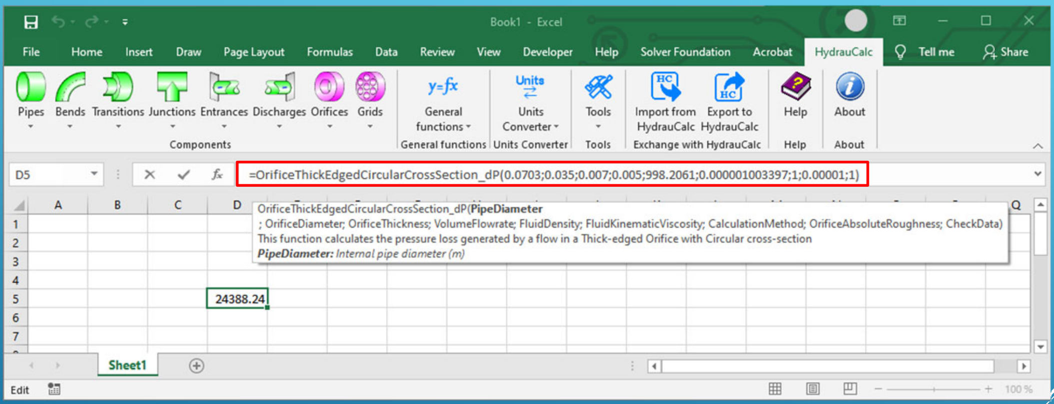
This function calculates the pressure loss generated by a flow in a Sharp-edged Orifice with Circular cross-section.

PipeDiameter Internal pipe diameter (m).

Formula result

- 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.

The Excel graphical interface (3)



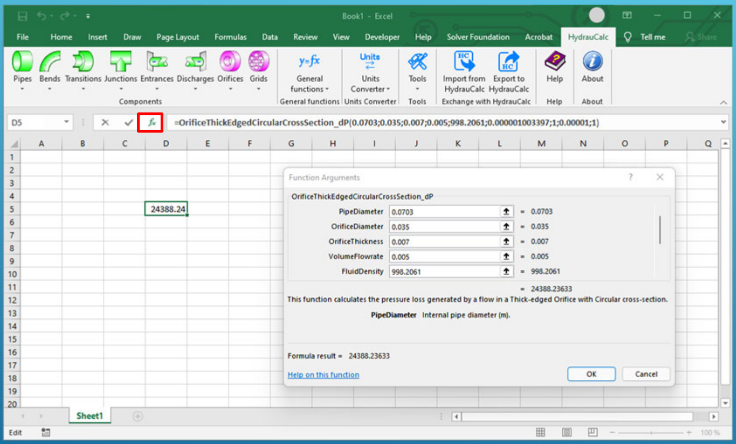
```
=OrificeThickEdgedCircularCrossSection_dP(0.0703;0.035;0.007;0.005;998.2061;0.000001003397;1;0.00001;1)
```

OrificeThickEdgedCircularCrossSection_dP(**PipeDiameter**
; OrificeDiameter; OrificeThickness; VolumeFlowrate; FluidDensity; FluidKinematicViscosity; CalculationMethod; OrificeAbsoluteRoughness; CheckData)
This function calculates the pressure loss generated by a flow in a Thick-edged Orifice with Circular cross-section
PipeDiameter: *Internal pipe diameter (m)*

24388.24

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.

The Excel graphical interface (4)



```
=OrificeThickEdgedCircularCrossSection_dP(0.0703;0.035;0.007;0.005;998.2061;0.000001003397;1;0.00001;1)
```

24388.24

OrificeThickEdgedCircularCrossSection_dP

PipeDiameter	0.0703	= 0.0703
OrificeDiameter	0.035	= 0.035
OrificeThickness	0.007	= 0.007
VolumeFlowrate	0.005	= 0.005
FluidDensity	998.2061	= 998.2061
		= 24388.23633

This function calculates the pressure loss generated by a flow in a Thick-edged Orifice with Circular cross-section.

PipeDiameter Internal pipe diameter (m).

Formula result = 24388.23633

Help on this function

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

The Functions of the HydrauCalcXL Library

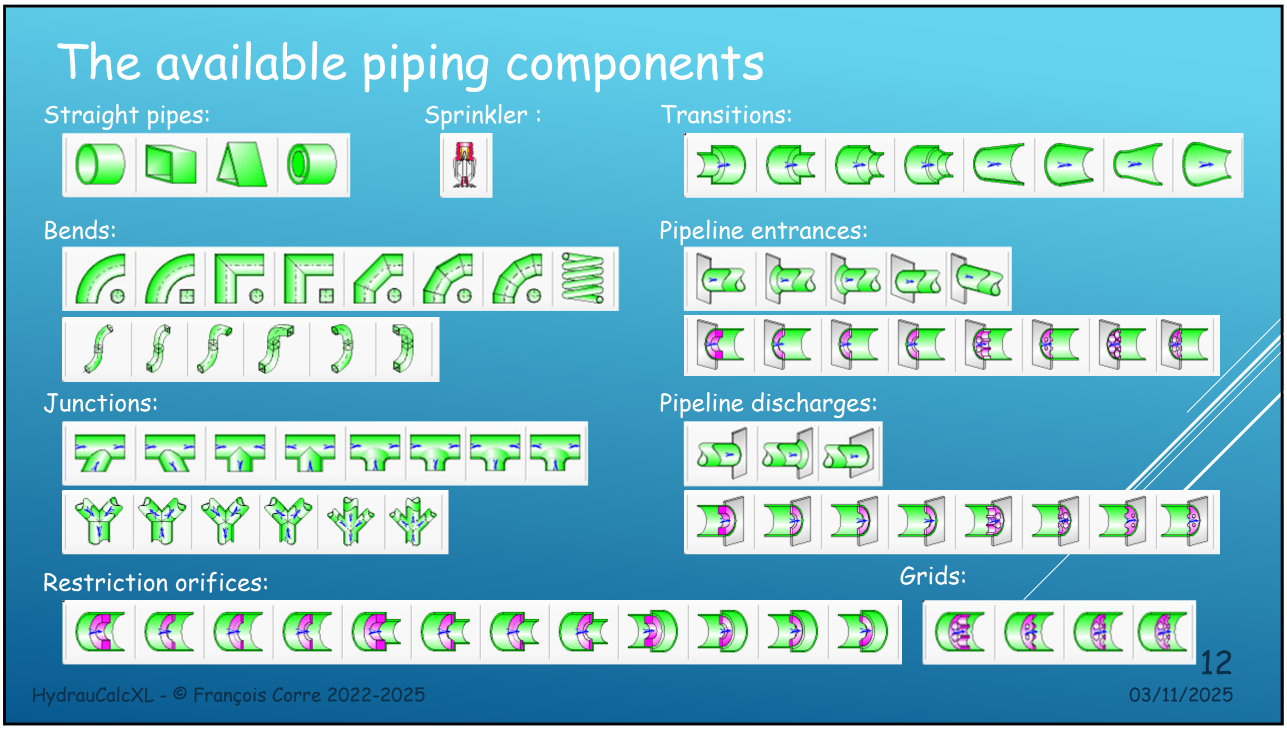
The functions of the HydrauCalcXL library

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

The library includes five types of functions:

- ❑ Functions for calculating pressure losses of piping components such as straight pipes, bends, transitions, junctions, pipeline entrances, pipeline discharges, orifices, grids.
- ❑ Functions for calculating the characteristics of the fluids integrated into HydrauCalcXL.
- ❑ 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 , ...).
- ❑ Functions to convert units of measure to each other.
- ❑ Various functions.

The Piping Components



The available piping components

Straight pipes:

Sprinkler :

Transitions:

Bends:

Pipeline entrances:

Junctions:

Pipeline discharges:

Restriction orifices:

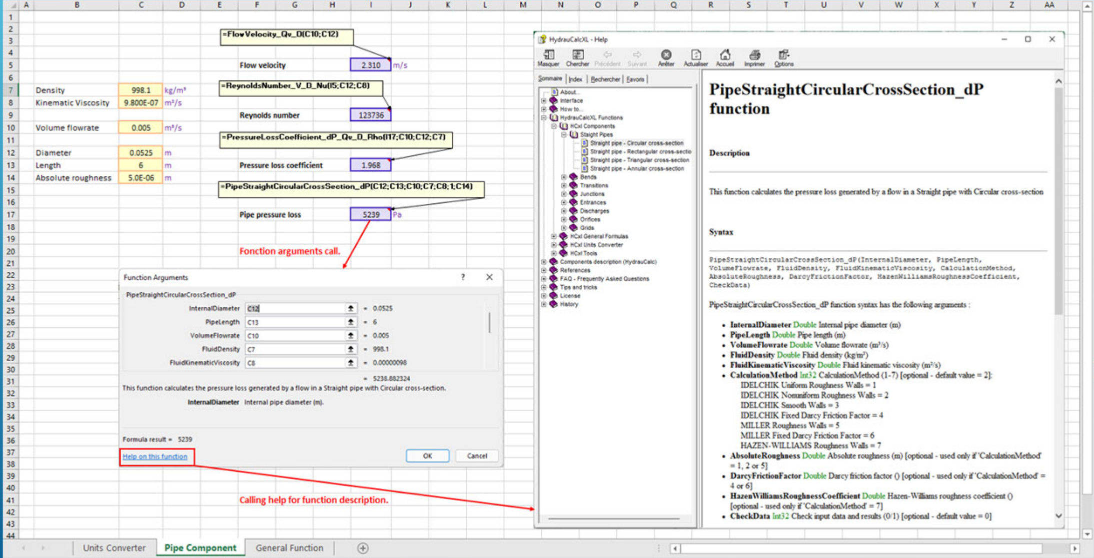
Grids:

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



Density	998.1	kg/m³
Kinematic Viscosity	9.800E-07	m²/s
Volume flowrate	0.005	m³/s
Diameter	0.0525	m
Length	6	m
Absolute roughness	5.0E-06	m

=FlowVelocity_Qv_D(C10;C12)
Flow velocity 2.310 m/s

=ReynoldsNumber_V_D_Nu(I5;C12;C8)
Reynolds number 123736

=PressureLossCoefficient_dP_Qv_D_Rho(I17;C10;C12;C7)
Pressure loss coefficient 1.968

=PipeStraightCircularCrossSection_dP(C12;C13;C10;C7;C8;1;C14)
Pipe pressure loss 5239 Pa

Fonction arguments call.

Function Arguments

PipeStraightCircularCrossSection_dP

InternalDiameter	C12	= 0.0525
PipeLength	C13	= 6
VolumeFlowrate	C10	= 0.005
FluidDensity	C7	= 998.1
FluidKinematicViscosity	C8	= 0.00000098
		= 5238.882324

This function calculates the pressure loss generated by a flow in a Straight pipe with Circular cross-section.

InternalDiameter Internal pipe diameter (m).

Formula result = 5239

Help on this function

Calling help for function description.

PipeStraightCircularCrossSection_dP function

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)
```

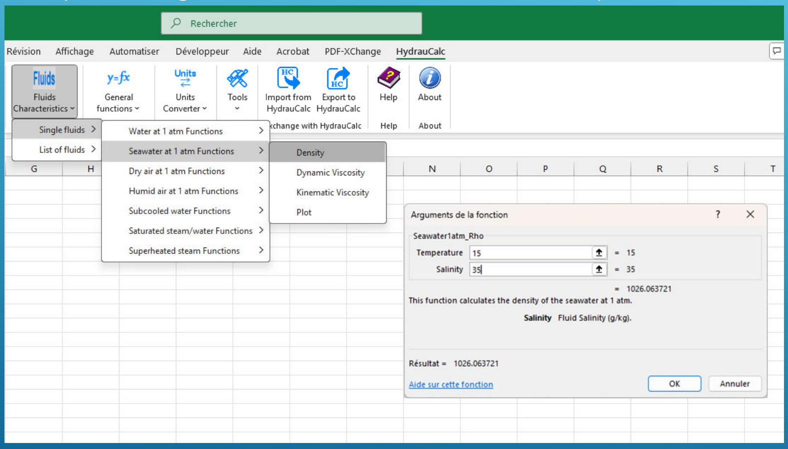
PipeStraightCircularCrossSection_dP function syntax has the following arguments :

- **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** Int32 CalculationMethod (1-7) [optional - default value = 2]:
  IDELCHIK Uniform Roughness Walls = 1
  IDELCHIK Nonuniform Roughness Walls = 2
  IDELCHIK Smooth Walls = 3
  IDELCHIK Fixed Darcy Friction Factor = 4
  MILLER Roughness Walls = 5
  MILLER Fixed Darcy Friction Factor = 6
  HAZEN-WILLIAMS Roughness Walls = 7
- **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** Int32 Check input data and results (0/1) [optional - default value = 0]

Functions of characteristics of fluids

Single fluids

Example of using the function to calculate the density of seawater



Seawater1atm_Rho

Temperature 15 = 15

Salinity 35 = 35

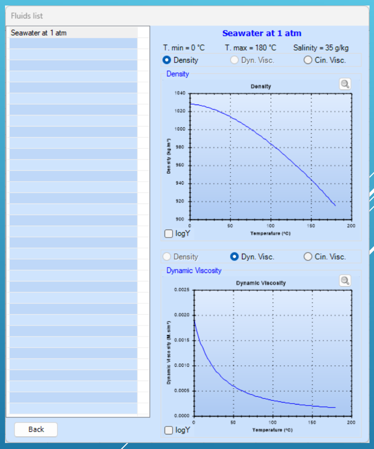
= 1026.063721

This function calculates the density of the seawater at 1 atm.

Salinity Fluid Salinity (g/kg).

Résultat = 1026.063721

Plotting seawater characteristics using the "Plot" submenu



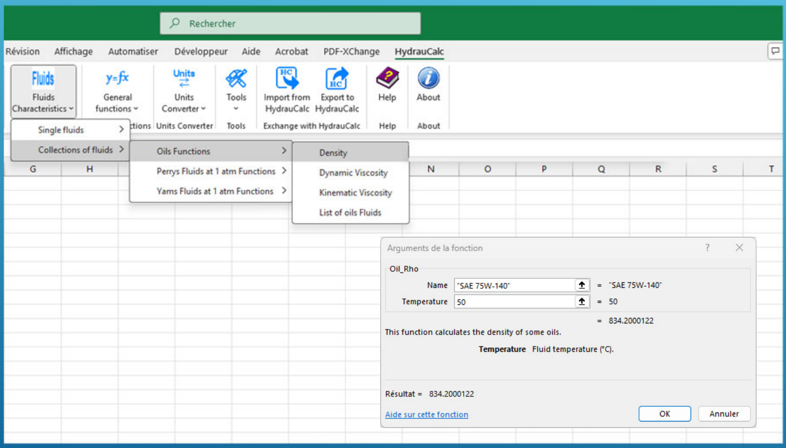
T. min = 0 °C T. max = 180 °C Salinity = 35 g/kg

● Density

● Dyn. Visc.

Collections of fluids

Example of using the function to calculate the density of an oil contained in the list of available oils



Oil_Rho

Name "SAE 75W-140" = "SAE 75W-140"

Temperature 50 = 50

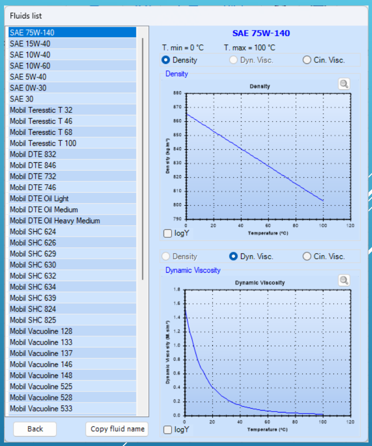
= 834.2000122

This function calculates the density of some oils.

Temperature Fluid temperature (°C).

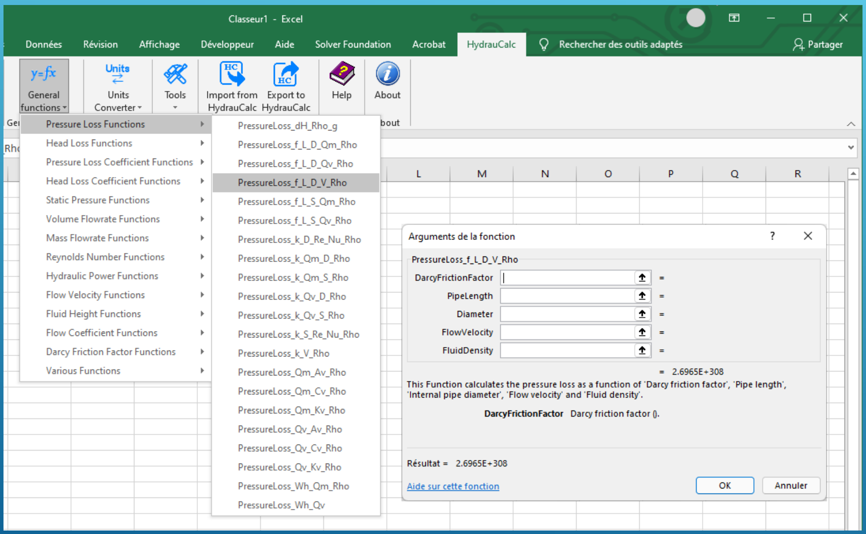
Résultat = 834.2000122

Plotting the characteristics of a selected oil using the "List of oils fluids" submenu



General formula functions

General formula functions



Arguments de la fonction

PressureLoss_f_L_D_V_Rho

DarcyFrictionFactor =
PipeLength =
Diameter =
FlowVelocity =
FluidDensity =

= 2.6965E+308

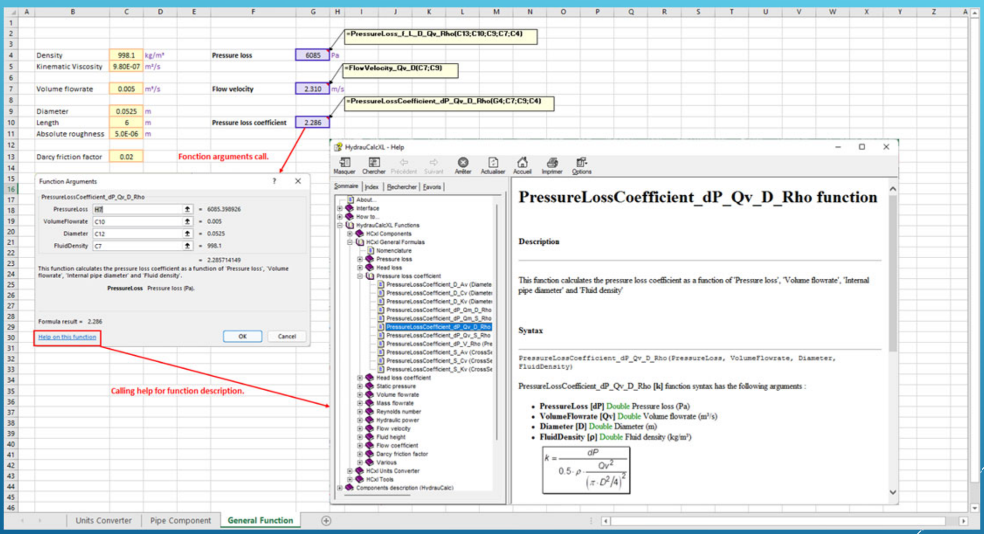
This Function calculates the pressure loss as a function of 'Darcy friction factor', 'Pipe length', 'Internal pipe diameter', 'Flow velocity' and 'Fluid density'.

DarcyFrictionFactor Darcy friction factor ().

Résultat = 2.6965E+308

Aide sur cette fonction

Example of using general formula functions



Row	B	C	D	F	G	H
4	Density	998.1	kg/m³	Pressure loss	6085	Pa
5	Kinematic Viscosity	9.80E-07	m²/s			
7	Volume flowrate	0.005	m³/s	Flow velocity	2.310	m/s
9	Diameter	0.0525	m			
10	Length	6	m	Pressure loss coefficient	2.286	
11	Absolute roughness	5.0E-06	m			
13	Darcy friction factor	0.02				

=PressureLoss_f_L_D_Qv_Rho(C13;C10;C9;C7;C4)

=FlowVelocity_Qv_D(C7;C9)

=PressureLossCoefficient_dP_Qv_D_Rho(G4;C7;C9;C4)

Function Arguments

PressureLossCoefficient_dP_Qv_D_Rho

PressureLoss H7 = 6085.398926
VolumeFlowrate C10 = 0.005
Diameter C12 = 0.0525
FluidDensity C7 = 998.1

= 2.285714149

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

PressureLoss Pressure loss (Pa).

Formula result = 2.286

Help on this function

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)
```

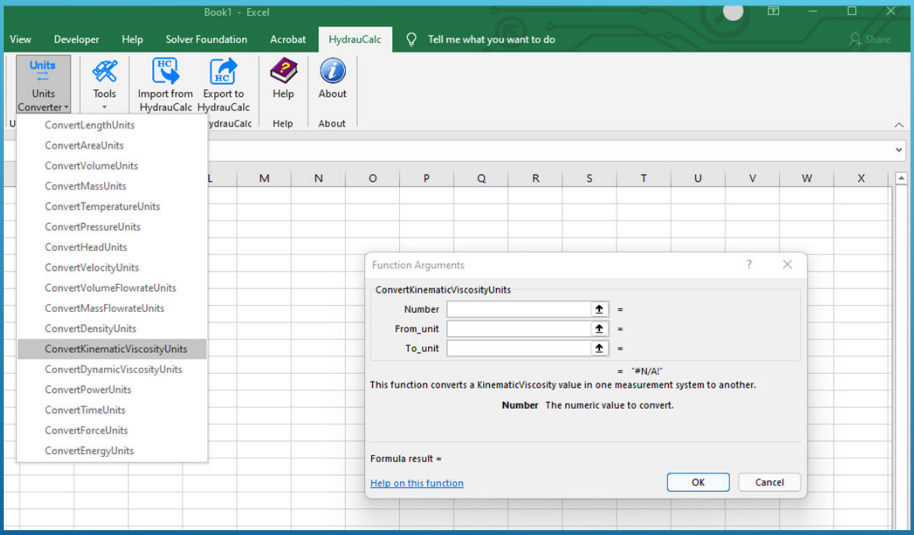
PressureLossCoefficient_dP_Qv_D_Rho **[k]** function syntax has the following arguments :

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

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

Functions for converting units of measurement

Functions for converting units of measurement



ConvertKinematicViscosityUnits

Number =
From_unit =
To_unit =

= "#N/A!"

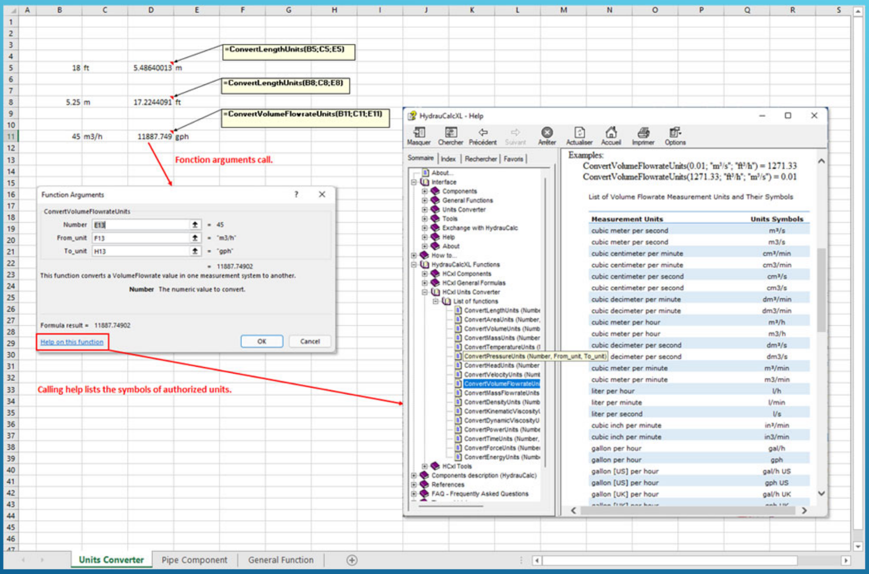
This function converts a KinematicViscosity value in one measurement system to another.

Number The numeric value to convert.

Formula result =

Help on this function

Example of using measurement unit conversion functions



B	C	D	E
18	ft	5.48640013	m
5.25	m	17.2244091	ft
45	m3/h	11887.749	gph

=ConvertLengthUnits(B5;C5;E5)

=ConvertLengthUnits(B8;C8;E8)

=ConvertVolumeFlowrateUnits(B11;C11;E11)

Fonction arguments call.

Function Arguments

ConvertVolumeFlowrateUnits

Number E13 = 45

From_unit F13 = "m3/h"

To_unit H13 = "gph"

= 11887.74902

This function converts a VolumeFlowrate value in one measurement system to another.

Number The numeric value to convert.

Formula result = 11887.74902

Help on this function

Calling help lists the symbols of authorized units.

Examples:

ConvertVolumeFlowrateUnits(0.01; "m³/s"; "ft³/h") = 1271.33

ConvertVolumeFlowrateUnits(1271.33; "ft³/h"; "m³/s") = 0.01

List of Volume Flowrate Measurement Units and Their Symbols

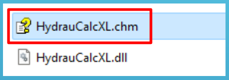
Measurement Units	Units Symbols
cubic meter per second	m³/s
cubic meter per second	m3/s
cubic centimeter per minute	cm³/min
cubic centimeter per minute	cm3/min
cubic centimeter per second	cm³/s
cubic centimeter per second	cm3/s
cubic decimeter per minute	dm³/min
cubic decimeter per minute	dm3/min
cubic meter per hour	m³/h
cubic meter per hour	m3/h
cubic decimeter per second	dm³/s
cubic decimeter per second	dm3/s
cubic meter per minute	m³/min
cubic meter per minute	m3/min
liter per hour	l/h
liter per minute	l/min
liter per second	l/s
cubic inch per minute	in³/min
cubic inch per minute	in3/min
gallon per hour	gal/h
gallon per hour	gph
gallon [US] per hour	gal/h US
gallon [US] per hour	gph US
gallon [UK] per hour	gal/h UK

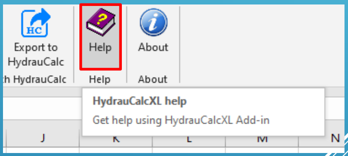
Technical documentation

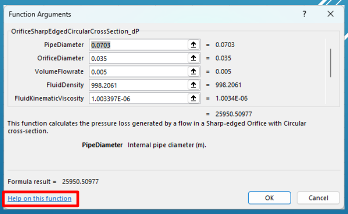
Calling the documentation

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.







OrificeSharpEdgedCircularCrossSection_dP

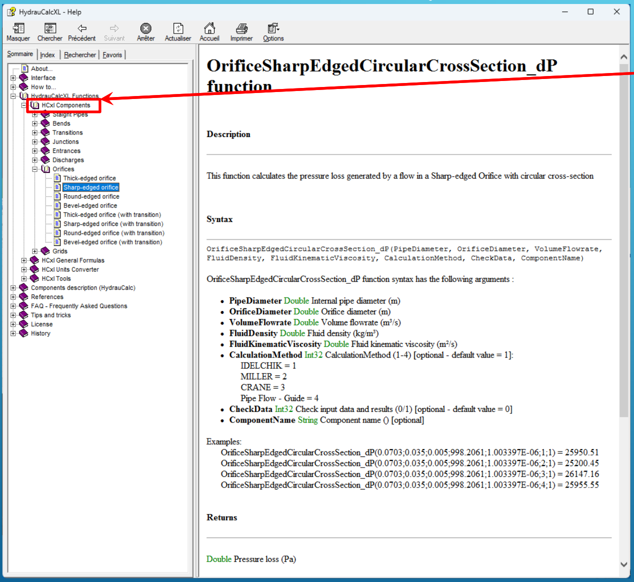
PipeDiameter 0.0703 = 0.0703
OrificeDiameter 0.035 = 0.035
VolumeFlowrate 0.005 = 0.005
FluidDensity 998.2061 = 998.2061
FluidKinematicViscosity 1.003397E-06 = 1.0034E-06
= 25950.50977

This function calculates the pressure loss generated by a flow in a Sharp-edged Orifice with Circular cross-section.

PipeDiameter Internal pipe diameter (m).

Formula result = 25950.50977

Documentation of component functions (1)



OrificeSharpEdgedCircularCrossSection_dP function

Description

This function calculates the pressure loss generated by a flow in a Sharp-edged Orifice with circular cross-section

Syntax

```
OrificeSharpEdgedCircularCrossSection_dP(PipeDiameter, OrificeDiameter, VolumeFlowrate,
FluidDensity, FluidKinematicViscosity, CalculationMethod, CheckData, ComponentName)
```

OrificeSharpEdgedCircularCrossSection_dP function syntax has the following arguments :

- **PipeDiameter** Double Internal pipe diameter (m)
- **OrificeDiameter** Double Orifice diameter (m)
- **VolumeFlowrate** Double Volume flowrate (m^3/s)
- **FluidDensity** Double Fluid density (kg/m^3)
- **FluidKinematicViscosity** Double Fluid kinematic viscosity (m^2/s)
- **CalculationMethod** Int32 CalculationMethod (1-4) [optional - default value = 1]:
  IDELCHIK = 1
  MILLER = 2
  CRANE = 3
  Pipe Flow - Guide = 4
- **CheckData** Int32 Check input data and results (0/1) [optional - default value = 0]
- **ComponentName** String Component name () [optional]

Examples:
OrificeSharpEdgedCircularCrossSection_dP(0.0703;0.035;0.005;998.2061;1.003397E-06;1;1) = 25950.51
OrificeSharpEdgedCircularCrossSection_dP(0.0703;0.035;0.005;998.2061;1.003397E-06;2;1) = 25200.45
OrificeSharpEdgedCircularCrossSection_dP(0.0703;0.035;0.005;998.2061;1.003397E-06;3;1) = 26147.16
OrificeSharpEdgedCircularCrossSection_dP(0.0703;0.035;0.005;998.2061;1.003397E-06;4;1) = 25955.55

Returns

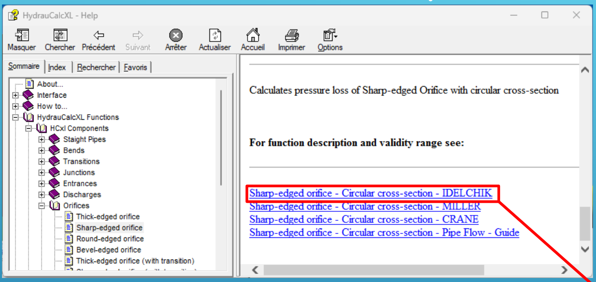
Double Pressure loss (Pa)

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.

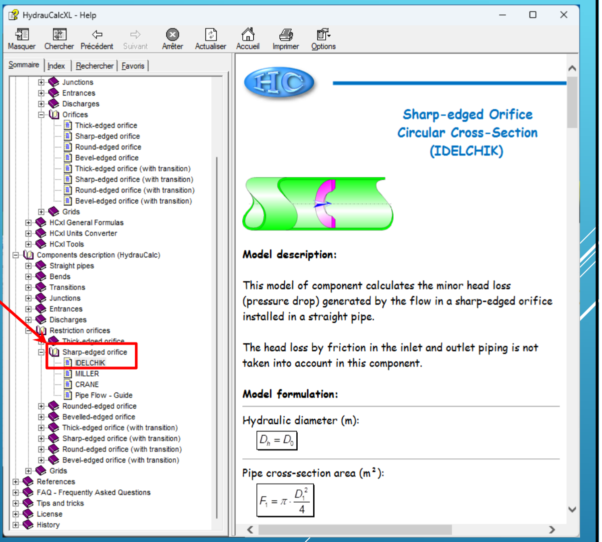
Documentation of component functions (2)



Calculates pressure loss of Sharp-edged Orifice with circular cross-section

For function description and validity range see:

Sharp-edged orifice - Circular cross-section - IDELCHIK
Sharp-edged orifice - Circular cross-section - MILLER
Sharp-edged orifice - Circular cross-section - CRANE
Sharp-edged orifice - Circular cross-section - Pipe Flow - Guide



Sharp-edged Orifice
Circular Cross-Section
(IDELCHIK)

Model description:

This model of component calculates the minor head loss (pressure drop) generated by the flow in a sharp-edged orifice installed in a straight pipe.

The head loss by friction in the inlet and outlet piping is not taken into account in this component.

Model formulation:

Hydraulic diameter (m):

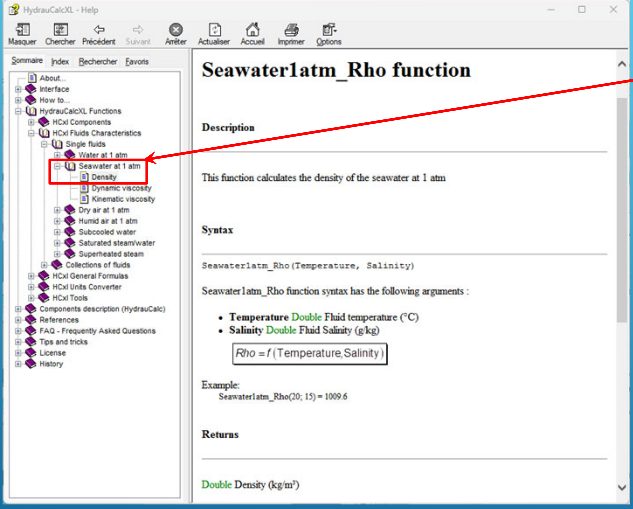
$$\boxed{D_h = D_0}$$

Pipe cross-section area (m²):

$$\boxed{F_1 = \pi \cdot \frac{D_1^2}{4}}$$

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 HydrauCalc application documentation.

Documentation of fluids characteritics functions



Seawater1atm_Rho function

Description

This function calculates the density of the seawater at 1 atm

Syntax

`Seawater1atm_Rho(Temperature, Salinity)`

Seawater1atm_Rho function syntax has the following arguments :

- **Temperature** Double Fluid temperature (°C)
- **Salinity** Double Fluid Salinity (g/kg)

$$\boxed{Rho = f\left(\text{Temperature}, \text{Salinity}\right)}$$

Example:
Seawater1atm_Rho(20; 15) = 1009.6

Returns

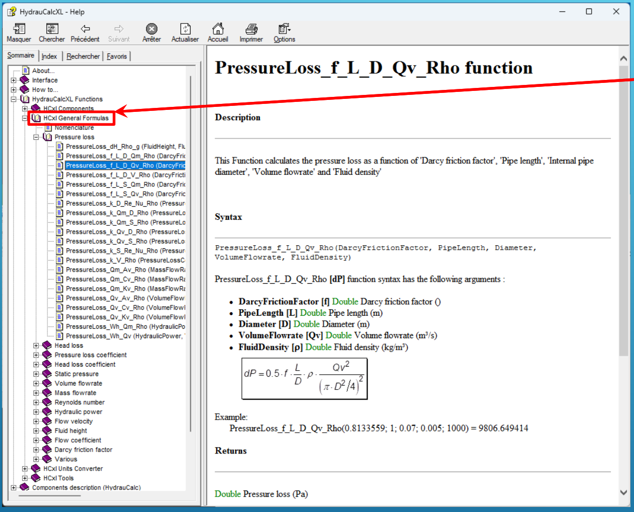
Double Density (kg/m³)

General functions are described in the subsections of the "HCxl Fluids Characteristics" 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 general functions



PressureLoss_f_L_D_Qv_Rho function

Description

This Function calculates the pressure loss as a function of 'Darcy friction factor', 'Pipe length', 'Internal pipe diameter', 'Volume flowrate' and 'Fluid density'

Syntax

```
PressureLoss_f_L_D_Qv_Rho(DarcyFrictionFactor, PipeLength, Diameter,
VolumeFlowrate, FluidDensity)
```

PressureLoss_f_L_D_Qv_Rho **[dP]** function syntax has the following arguments :

- **DarcyFrictionFactor [f]** Double Darcy friction factor ()
- **PipeLength [L]** Double Pipe length (m)
- **Diameter [D]** Double Diameter (m)
- **VolumeFlowrate [Qv]** Double Volume flowrate (m^3/s)
- **FluidDensity [ρ]** Double Fluid density (kg/m^3)

$$\boxed{dP = 0.5 \cdot f \cdot \frac{L}{D} \cdot \rho \cdot \frac{Qv^2}{\left(\pi \cdot D^2/4\right)^2}}$$

Example:
PressureLoss_f_L_D_Qv_Rho(0.8133559; 1; 0.07; 0.005; 1000) = 9806.649414

Returns

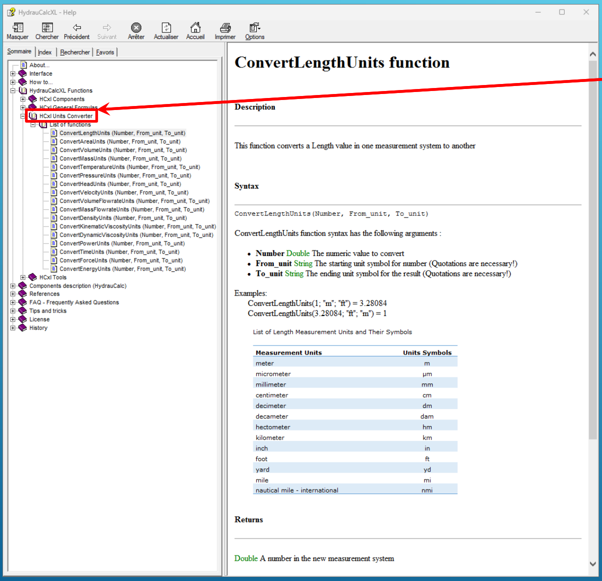
Double Pressure loss (Pa)

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



ConvertLengthUnits function

Description

This function converts a Length value in one measurement system to another

Syntax

```
ConvertLengthUnits(Number, From_unit, To_unit)
```

ConvertLengthUnits function syntax has the following arguments :

- **Number** Double The numeric value to convert
- **From_unit** String The starting unit symbol for number (Quotations are necessary!)
- **To_unit** String The ending unit symbol for the result (Quotations are necessary!)

Examples:
ConvertLengthUnits(1; "m"; "ft") = 3.28084
ConvertLengthUnits(3.28084; "ft"; "m") = 1

List of Length Measurement Units and Their Symbols

Measurement Units	Units Symbols
meter	m
micrometer	µm
millimeter	mm
centimeter	cm
decimeter	dm
decameter	dam
hectometer	hm
kilometer	km
inch	in
foot	ft
yard	yd
mile	mi
nautical mile - international	nmi

Returns

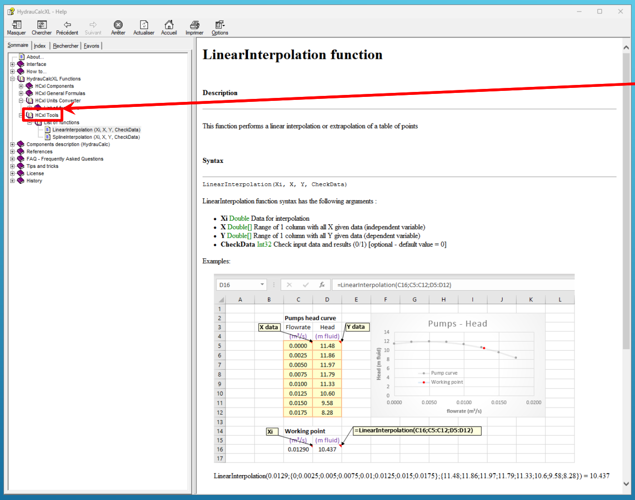
Double A number in the new measurement system

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



LinearInterpolation function

Description

This function performs a linear interpolation or extrapolation of a table of points

Syntax

`LinearInterpolation(Xi, X, Y, CheckData)`

LinearInterpolation function syntax has the following arguments :

- **Xi** Double Data for interpolation
- **X** Double[] Range of 1 column with all X given data (independent variable)
- **Y** Double[] Range of 1 column with all Y given data (dependent variable)
- **CheckData** Int32 Check input data and results (0/1) [optional - default value = 0]

Examples:

D16 =LinearInterpolation(C16;C5:C12;D5:D12)

	A	B	C	D
1				
2			**Pumps head curve**	
3			Flowrate	Head
4			(m³/s)	(m fluid)
5			0.0000	11.48
6			0.0025	11.86
7			0.0050	11.97
8			0.0075	11.79
9			0.0100	11.33
10			0.0125	10.60
11			0.0150	9.58
12			0.0175	8.28
13				
14			**Working point**	
15			(m³/s)	(m fluid)
16			0.01290	10.437
17				

LinearInterpolation(0.0129;{0;0.0025;0.005;0.0075;0.01;0.0125;0.015;0.0175};{11.48;11.86;11.97;11.79;11.33;10.6;9.58;8.28}) = 10.437

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

For each function we find:

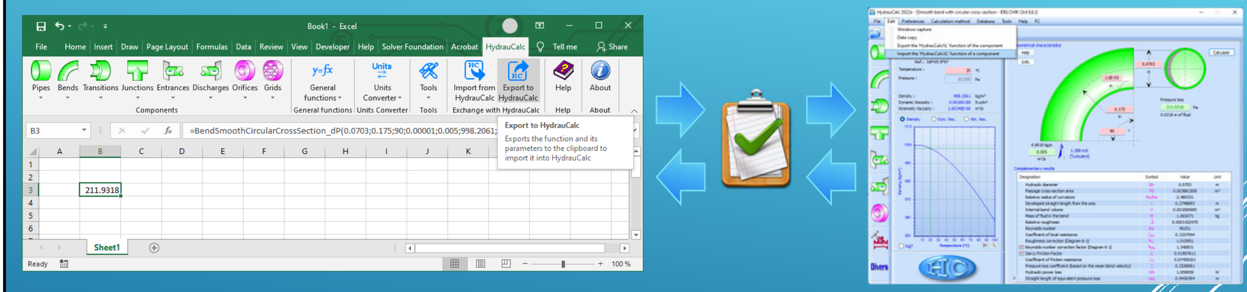
- ❑ A description of the function.
- ❑ The syntax of the function.
- ❑ The function parameters.
- ❑ An example of using the function.

Data exchange with the HydrauCalc application

Data exchange with HydrauCalc application

HydrauCalcXL library

HydrauCalc application



=BendSmoothCircularCrossSection_dP(0.0703;0.175;90;0.00001;0.005;998.2061

211.9318

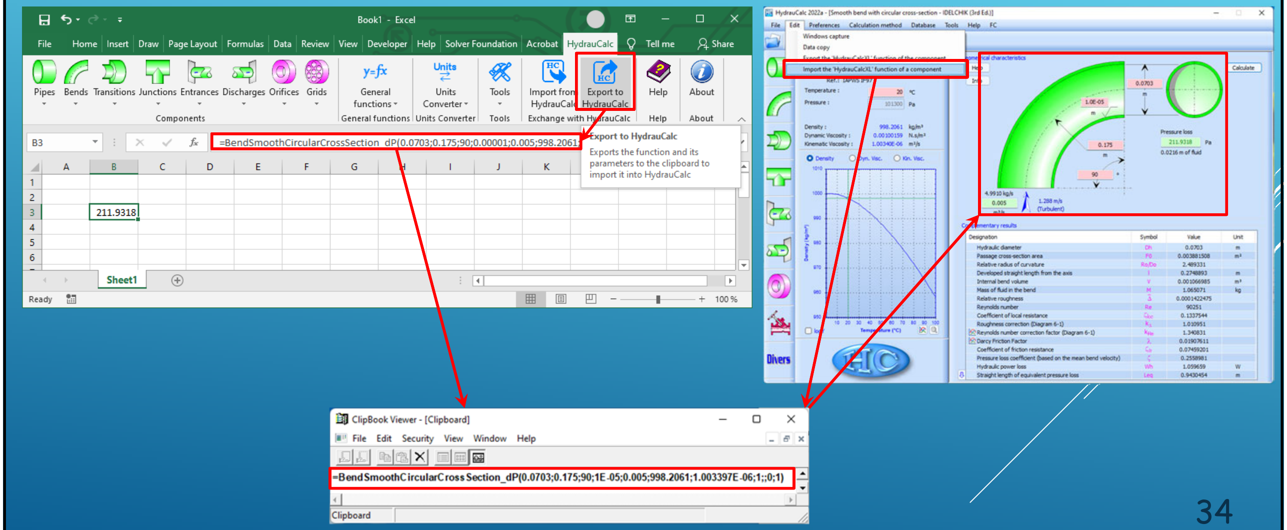
Export to HydrauCalc
Exports the function and its parameters to the clipboard to import it into HydrauCalc

Data can be exchanged between the "HydrauCalcXL" library and the "HydrauCalc" application via the clipboard.

Data export to HydrauCalc

1 – Export function to Clipboard

2 – Import function from Clipboard



=BendSmoothCircularCrossSection_dP(0.0703;0.175;90;0.00001;0.005;998.2061

211.9318

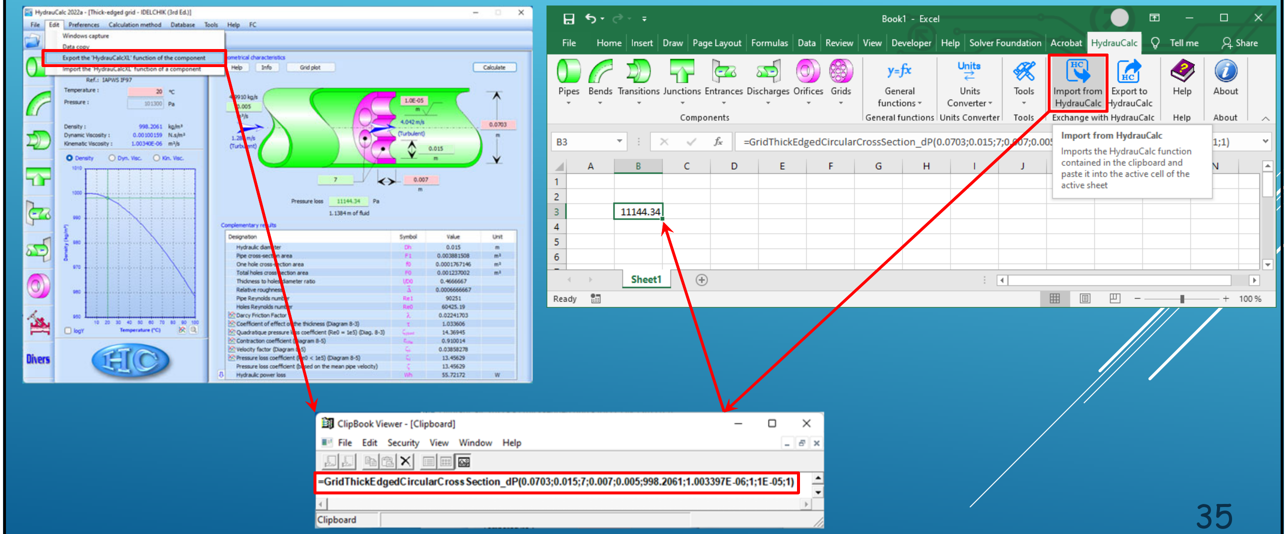
Export to HydrauCalc
Exports the function and its parameters to the clipboard to import it into HydrauCalc

=BendSmoothCircularCrossSection_dP(0.0703;0.175;90;1E-05;0.005;998.2061;1.003397E-06;1;;0;1)

Data import from HydrauCalc

1 – Export function to Clipboard

2 – Import function from Clipboard



Pressure loss 11144.34 Pa

1.1384 m of fluid

Complementary results

Designation	Symbol	Value	Unit
Hydraulic diameter	Dh	0.015	m
Pipe cross-section area	F1	0.003881508	m²
One hole cross-section area	f0	0.0001767146	m²
Total holes cross-section area	F0	0.001237002	m²
Thickness to holes diameter ratio	l/D0	0.4666667	
Relative roughness	$\bar{\Delta}$	0.0006666667	
Pipe Reynolds number	Re1	90251	
Holes Reynolds number	Re0	60425.19	
Darcy Friction Factor	λ	0.02241703	
Coefficient of effect of the thickness (Diagram 8-3)	τ	1.033606	
Quadratique pressure loss coefficient (Re0 = 1e5) (Diag. 8-3)	ζ_{quad}	14.36945	
Contraction coefficient (Diagram 8-5)	ε_{0Re}	0.910014	
Velocity factor (Diagram 8-5)	ζ_{φ}	0.03858278	
Pressure loss coefficient (Re0 < 1e5) (Diagram 8-5)	ζ_1	13.45629	
Pressure loss coefficient (based on the mean pipe velocity)	ζ	13.45629	
Hydraulic power loss	Wh	55.72172	W

B3 =GridThickEdgedCircularCrossSection_dP(0.0703;0.015;7;0.007;0.005…1;1)

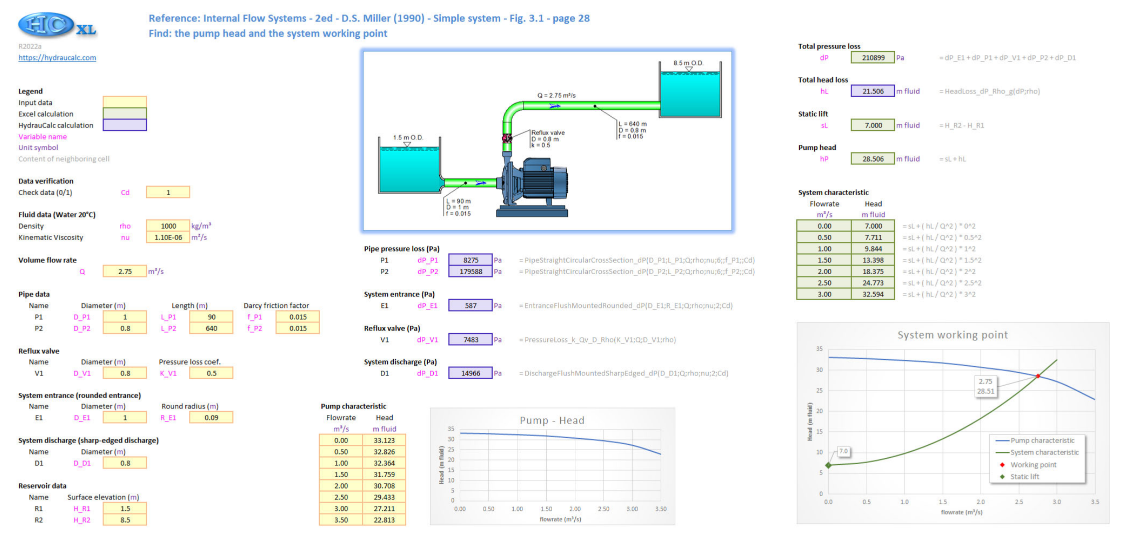
B3: 11144.34

Import from HydrauCalc
Imports the HydrauCalc function contained in the clipboard and paste it into the active cell of the active sheet

=GridThickEdgedCircularCrossSection_dP(0.0703;0.015;7;0.007;0.005;998.2061;1.003397E-06;1;1E-05;1)

Examples of systems solved using HydrauCalcXL and Excel solver

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



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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
HydrauCalc calculation
Variable name
Unit symbol
Content of neighboring cell

Data verification

Check data (0/1)	Cd	1

Fluid data (Water 20°C)

Density	rho	1000	kg/m^3
Kinematic Viscosity	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	D_P1	1	L_P1	90	f_P1	0.015
P2	D_P2	0.8	L_P2	640	f_P2	0.015

Reflux valve

Name	Diameter (m)		Pressure loss coef.	
V1	D_V1	0.8	K_V1	0.5

System entrance (rounded entrance)

Name	Diameter (m)		Round radius (m)	
E1	D_E1	1	R_E1	0.09

System discharge (sharp-edged discharge)

Name	Diameter (m)	
D1	D_D1	0.8

Reservoir data

Name	Surface elevation (m)	
R1	H_R1	1.5
R2	H_R2	8.5

Pipe pressure loss (Pa)

P1	dP_P1	8275	Pa	= PipeStraightCircularCrossSection_dP(D_P1;L_P1;Q;rho;nu;6;;f_P1;;Cd)
P2	dP_P2	179588	Pa	= PipeStraightCircularCrossSection_dP(D_P2;L_P2;Q;rho;nu;6;;f_P2;;Cd)

System entrance (Pa)

E1	dP_E1	587	Pa	= EntranceFlushMountedRounded_dP(D_E1;R_E1;Q;rho;nu;2;Cd)

Reflux valve (Pa)

V1	dP_V1	7483	Pa	= PressureLoss_k_Qv_D_Rho(K_V1;Q;D_V1;rho)

System discharge (Pa)

D1	dP_D1	14966	Pa	= DischargeFlushMountedSharpEdged_dP(D_D1;Q;rho;nu;2;Cd)

Pump characteristic

Flowrate m^3/s	Head m fluid
0.00	33.123
0.50	32.826
1.00	32.364
1.50	31.759
2.00	30.708
2.50	29.433
3.00	27.211
3.50	22.813

Total pressure loss

dP	210899	Pa	= dP_E1 + dP_P1 + dP_V1 + dP_P2 + dP_D1

Total head loss

hL	21.506	m fluid	= HeadLoss_dP_Rho_g(dP;rho)

Static lift

sL	7.000	m fluid	= H_R2 - H_R1

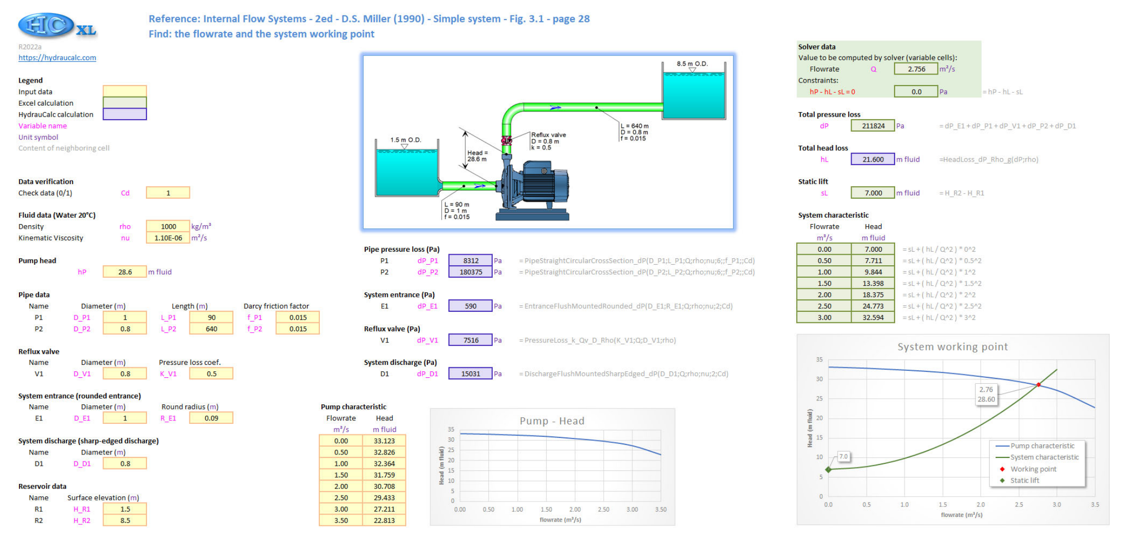
Pump head

hP	28.506	m fluid	= sL + hL

System characteristic

Flowrate m^3/s	Head m fluid	
0.00	7.000	= sL + (hL / Q^2) * 0^2
0.50	7.711	= sL + (hL / Q^2) * 0.5^2
1.00	9.844	= sL + (hL / Q^2) * 1^2
1.50	13.398	= sL + (hL / Q^2) * 1.5^2
2.00	18.375	= sL + (hL / Q^2) * 2^2
2.50	24.773	= sL + (hL / Q^2) * 2.5^2
3.00	32.594	= sL + (hL / Q^2) * 3^2

- 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.



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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
Content of neighboring cell

Data verification

Check data (0/1)	Cd	1

Fluid data (Water 20°C)

Density	rho	1000	kg/m^3
Kinematic Viscosity	nu	1.10E-06	m^2/s

Pump head

hP	28.6	m fluid

Pipe data

Name	Diameter (m)		Length (m)		Darcy friction factor	
P1	D_P1	1	L_P1	90	f_P1	0.015
P2	D_P2	0.8	L_P2	640	f_P2	0.015

Reflux valve

Name	Diameter (m)		Pressure loss coef.	
V1	D_V1	0.8	K_V1	0.5

System entrance (rounded entrance)

Name	Diameter (m)		Round radius (m)	
E1	D_E1	1	R_E1	0.09

System discharge (sharp-edged discharge)

Name	Diameter (m)	
D1	D_D1	0.8

Reservoir data

Name	Surface elevation (m)	
R1	H_R1	1.5
R2	H_R2	8.5

Pipe pressure loss (Pa)

P1	dP_P1	8312	Pa	= PipeStraightCircularCrossSection_dP(D_P1;L_P1;Q;rho;nu;6;;f_P1;;Cd)
P2	dP_P2	180375	Pa	= PipeStraightCircularCrossSection_dP(D_P2;L_P2;Q;rho;nu;6;;f_P2;;Cd)

System entrance (Pa)

E1	dP_E1	590	Pa	= EntranceFlushMountedRounded_dP(D_E1;R_E1;Q;rho;nu;2;Cd)

Reflux valve (Pa)

V1	dP_V1	7516	Pa	= PressureLoss_k_Qv_D_Rho(K_V1;Q;D_V1;rho)

System discharge (Pa)

D1	dP_D1	15031	Pa	= DischargeFlushMountedSharpEdged_dP(D_D1;Q;rho;nu;2;Cd)

Pump characteristic

Flowrate m^3/s	Head m fluid
0.00	33.123
0.50	32.826
1.00	32.364
1.50	31.759
2.00	30.708
2.50	29.433
3.00	27.211
3.50	22.813

Solver data
Value to be computed by solver (variable cells):

Flowrate	Q	2.756	m^2/s

Constraints:

hP - hL - sL = 0	0.0	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;rho)

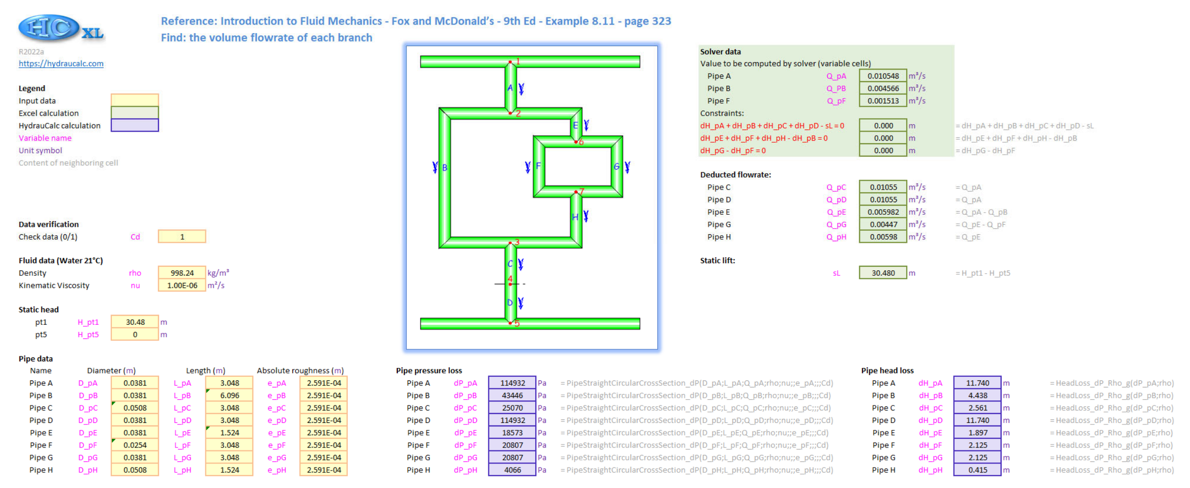
Static lift

sL	7.000	m fluid	= H_R2 - H_R1

System characteristic

Flowrate m^3/s	Head m fluid	
0.00	7.000	= sL + (hL / Q^2) * 0^2
0.50	7.711	= sL + (hL / Q^2) * 0.5^2
1.00	9.844	= sL + (hL / Q^2) * 1^2
1.50	13.398	= sL + (hL / Q^2) * 1.5^2
2.00	18.375	= sL + (hL / Q^2) * 2^2
2.50	24.773	= sL + (hL / Q^2) * 2.5^2
3.00	32.594	= sL + (hL / Q^2) * 3^2

- 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.



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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	
Content of neighboring cell	

Data verification

Check data (0/1)	Cd	1	

Fluid data (Water 21°C)

Density	rho	998.24	kg/m³
Kinematic Viscosity	nu	1.00E-06	m²/s

Static head

pt1	H_pt1	30.48	m
pt5	H_pt5	0	m

Pipe data

Name		Diameter (m)		Length (m)		Absolute roughness (m)
Pipe A	D_pA	0.0381	L_pA	3.048	e_pA	2.591E-04
Pipe B	D_pB	0.0381	L_pB	6.096	e_pB	2.591E-04
Pipe C	D_pC	0.0508	L_pC	3.048	e_pC	2.591E-04
Pipe D	D_pD	0.0381	L_pD	3.048	e_pD	2.591E-04
Pipe E	D_pE	0.0381	L_pE	1.524	e_pE	2.591E-04
Pipe F	D_pF	0.0254	L_pF	3.048	e_pF	2.591E-04
Pipe G	D_pG	0.0381	L_pG	3.048	e_pG	2.591E-04
Pipe H	D_pH	0.0508	L_pH	1.524	e_pH	2.591E-04

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 F	Q_pF	0.001513	m³/s	
Constraints:				
dH_pA + dH_pB + dH_pC + dH_pD - sL = 0		0.000	m	= dH_pA + dH_pB + dH_pC + dH_pD - sL
dH_pE + dH_pF + dH_pH - dH_pB = 0		0.000	m	= dH_pE + dH_pF + dH_pH - dH_pB
dH_pG - dH_pF = 0		0.000	m	= dH_pG - dH_pF

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	0.00447	m³/s	= Q_pE - Q_pF
Pipe H	Q_pH	0.00598	m³/s	= Q_pE

Static lift:

sL	30.480	m	= H_pt1 - H_pt5

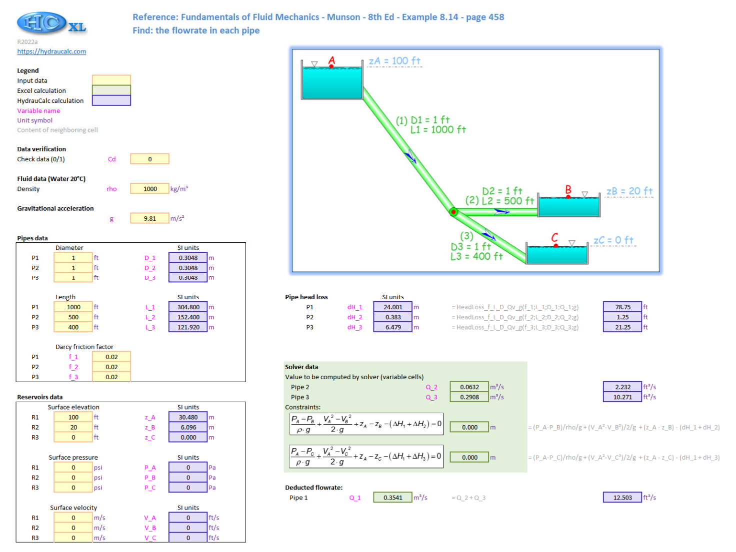
Pipe pressure loss

Pipe A	dP_pA	114932	Pa	= PipeStraightCircularCrossSection_dP(D_pA;L_pA;Q_pA;rho;nu;;e_pA;;;Cd)
Pipe B	dP_pB	43446	Pa	= PipeStraightCircularCrossSection_dP(D_pB;L_pB;Q_pB;rho;nu;;e_pB;;;Cd)
Pipe C	dP_pC	25070	Pa	= PipeStraightCircularCrossSection_dP(D_pC;L_pC;Q_pC;rho;nu;;e_pC;;;Cd)
Pipe D	dP_pD	114932	Pa	= PipeStraightCircularCrossSection_dP(D_pD;L_pD;Q_pD;rho;nu;;e_pD;;;Cd)
Pipe E	dP_pE	18573	Pa	= PipeStraightCircularCrossSection_dP(D_pE;L_pE;Q_pE;rho;nu;;e_pE;;;Cd)
Pipe F	dP_pF	20807	Pa	= PipeStraightCircularCrossSection_dP(D_pF;L_pF;Q_pF;rho;nu;;e_pF;;;Cd)
Pipe G	dP_pG	20807	Pa	= PipeStraightCircularCrossSection_dP(D_pG;L_pG;Q_pG;rho;nu;;e_pG;;;Cd)
Pipe H	dP_pH	4066	Pa	= PipeStraightCircularCrossSection_dP(D_pH;L_pH;Q_pH;rho;nu;;e_pH;;;Cd)

Pipe head loss

Pipe A	dH_pA	11.740	m	= HeadLoss_dP_Rho_g(dP_pA;rho)
Pipe B	dH_pB	4.438	m	= HeadLoss_dP_Rho_g(dP_pB;rho)
Pipe C	dH_pC	2.561	m	= HeadLoss_dP_Rho_g(dP_pC;rho)
Pipe D	dH_pD	11.740	m	= HeadLoss_dP_Rho_g(dP_pD;rho)
Pipe E	dH_pE	1.897	m	= HeadLoss_dP_Rho_g(dP_pE;rho)
Pipe F	dH_pF	2.125	m	= HeadLoss_dP_Rho_g(dP_pF;rho)
Pipe G	dH_pG	2.125	m	= HeadLoss_dP_Rho_g(dP_pG;rho)
Pipe H	dH_pH	0.415	m	= HeadLoss_dP_Rho_g(dP_pH;rho)

- 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.



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

Legend

Input data	🟨
Excel calculation	🟩
HydrauCalc calculation	🟪
Variable name	
Unit symbol	
Content of neighboring cell	

Data verification

Check data (0/1)	Cd	0

Fluid data (Water 20°C)

Density	rho	1000	kg/m³

Gravitational acceleration

g	9.81	m/s²

Pipes data

	Diameter			SI units	
P1	1	ft	D_1	0.3048	m
P2	1	ft	D_2	0.3048	m
P3	1	ft	D_3	0.3048	m
	Length			**SI units**	
P1	1000	ft	L_1	304.800	m
P2	500	ft	L_2	152.400	m
P3	400	ft	L_3	121.920	m

	Darcy friction factor	
P1	f_1	0.02
P2	f_2	0.02
P3	f_3	0.02

Reservoirs data

	Surface elevation			SI units	
R1	100	ft	z_A	30.480	m
R2	20	ft	z_B	6.096	m
R3	0	ft	z_C	0.000	m
	Surface pressure			**SI units**	
R1	0	psi	P_A	0	Pa
R2	0	psi	P_B	0	Pa
R3	0	psi	P_C	0	Pa
	Surface velocity			**SI units**	
R1	0	m/s	V_A	0	ft/s
R2	0	m/s	V_B	0	ft/s
R3	0	m/s	V_C	0	ft/s

Pipe head loss

		SI units				
P1	dH_1	24.001	m	= HeadLoss_f_L_D_Qv_g(f_1;L_1;D_1;Q_1;g)	78.75	ft
P2	dH_2	0.383	m	= HeadLoss_f_L_D_Qv_g(f_2;L_2;D_2;Q_2;g)	1.25	ft
P3	dH_3	6.479	m	= HeadLoss_f_L_D_Qv_g(f_3;L_3;D_3;Q_3;g)	21.25	ft

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

Pipe 2	Q_2	0.0632	m³/s	2.232	ft³/s
Pipe 3	Q_3	0.2908	m³/s	10.271	ft³/s

Constraints:

$$\frac{P_A - P_B}{\rho \cdot g} + \frac{V_A^2 - V_B^2}{2 \cdot g} + z_A - z_B - (\Delta H_1 + \Delta H_2) = 0$$

0.000 m = (P_A-P_B)/rho/g + (V_A²-V_B²)/2/g + (z_A - z_B) - (dH_1 + dH_2)

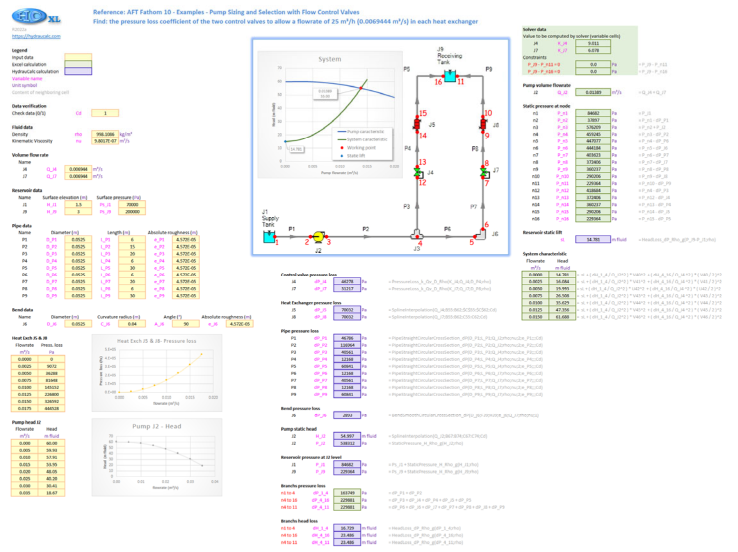
$$\frac{P_A - P_C}{\rho \cdot g} + \frac{V_A^2 - V_C^2}{2 \cdot g} + z_A - z_C - (\Delta H_1 + \Delta H_3) = 0$$

0.000 m = (P_A-P_C)/rho/g + (V_A²-V_C²)/2/g + (z_A - z_C) - (dH_1 + dH_3)

Deducted flowrate:

Pipe 1	Q_1	0.3541	m³/s	= Q_2 + Q_3	12.503	ft³/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 (0.0069444 m³/s) in each heat exchanger

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Legend

Input data

Excel calculation

HydrauCalc calculation

Variable name

Unit symbol

Content of neighboring cell

Data verification

Check data (0/1)	Cd	1

Fluid data

Density	rho	998.1086	kg/m³
Kinematic Viscosity	nu	9.8017E-07	m²/s

Volume flow rate

Name			
J4	Q_J4	0.006944	m³/s
J7	Q_J7	0.006944	m³/s

Reservoir data

Name		Surface elevation (m)		Surface pressure (Pa)
J1	H_J1	1.5	Ps_J1	70000
J9	H_J9	3	Ps_J9	200000

Pipe data

Name		Diameter (m)		Length (m)		Absolute roughness (m)
P1	D_P1	0.0525	L_P1	6	e_P1	4.572E-05
P2	D_P2	0.0525	L_P2	15	e_P2	4.572E-05
P3	D_P3	0.0525	L_P3	20	e_P3	4.572E-05
P4	D_P4	0.0525	L_P4	6	e_P4	4.572E-05
P5	D_P5	0.0525	L_P5	30	e_P5	4.572E-05
P6	D_P6	0.0525	L_P6	6	e_P6	4.572E-05
P7	D_P7	0.0525	L_P7	20	e_P7	4.572E-05
P8	D_P8	0.0525	L_P8	6	e_P8	4.572E-05
P9	D_P9	0.0525	L_P9	30	e_P9	4.572E-05

Bend data

Name		Diameter (m)		Curvature radius (m)		Angle (°)		Absolute roughness (m)
J6	D_J6	0.0525	C_J6	0.04	A_J6	90	e_J6	4.572E-05

Heat Exch J5 & J8

Flowrate m³/s	Press. loss Pa
0.0000	0
0.0025	9072
0.0050	36288
0.0075	81648
0.0100	145152
0.0125	226800
0.0150	326592
0.0175	444528

Pump head J2

Flowrate m³/s	Head m fluid
0.000	60.00
0.005	59.93
0.010	57.91
0.015	53.95
0.020	48.05
0.025	40.20
0.030	30.41
0.035	18.67

Control valve pressure loss

J4	dP_J4	46278	Pa	= PressureLoss_k_Qv_D_Rho(K_J4;Q_J4;D_P4;rho)
J7	dP_J7	31217	Pa	= PressureLoss_k_Qv_D_Rho(K_J7;Q_J7;D_P8;rho)

Heat Exchanger pressure loss

J5	dP_J5	70032	Pa	= SplineInterpolation(Q_J4;B55:B62;$C$55:$C$62;Cd)
J8	dP_J8	70032	Pa	= SplineInterpolation(Q_J7;B55:B62;C55:C62;Cd)

Pipe pressure loss

P1	dP_P1	46786	Pa	= PipeStraightCircularCrossSection_dP(D_P1;L_P1;Q_J2;rho;nu;2;e_P1;;;Cd)
P2	dP_P2	116964	Pa	= PipeStraightCircularCrossSection_dP(D_P2;L_P2;Q_J2;rho;nu;2;e_P2;;;Cd)
P3	dP_P3	40561	Pa	= PipeStraightCircularCrossSection_dP(D_P3;L_P3;Q_J4;rho;nu;2;e_P3;;;Cd)
P4	dP_P4	12168	Pa	= PipeStraightCircularCrossSection_dP(D_P4;L_P4;Q_J4;rho;nu;2;e_P4;;;Cd)
P5	dP_P5	60841	Pa	= PipeStraightCircularCrossSection_dP(D_P5;L_P5;Q_J4;rho;nu;2;e_P5;;;Cd)
P6	dP_P6	12168	Pa	= PipeStraightCircularCrossSection_dP(D_P6;L_P6;Q_J7;rho;nu;2;e_P6;;;Cd)
P7	dP_P7	40561	Pa	= PipeStraightCircularCrossSection_dP(D_P7;L_P7;Q_J7;rho;nu;2;e_P7;;;Cd)
P8	dP_P8	12168	Pa	= PipeStraightCircularCrossSection_dP(D_P8;L_P8;Q_J7;rho;nu;2;e_P8;;;Cd)
P9	dP_P9	60841	Pa	= PipeStraightCircularCrossSection_dP(D_P9;L_P9;Q_J7;rho;nu;2;e_P9;;;Cd)

Bend pressure loss

J6	dP_J6	2893	Pa	= BendSmoothCircularCrossSection_dP(D_J6;F39;H39;e_J6;Q_J7;rho;nu;1)

Pump static head

J2	H_J2	54.997	m fluid	= SplineInterpolation(Q_J2;B67:B74;C67:C74;Cd)
J2	P_J2	538312	Pa	= StaticPressure_H_Rho_g(H_J2;rho)

Reservoir pressure at J2 level

J1	P_J1	84682	Pa	= Ps_J1 + StaticPressure_H_Rho_g(H_J1;rho)
J9	P_J9	229364	Pa	= Ps_J9 + StaticPressure_H_Rho_g(H_J9;rho)

Branchs pressure loss

n1 to 4	dP_1_4	163749	Pa	= dP_P1 + dP_P2
n4 to 16	dP_4_16	229881	Pa	= dP_P3 + dP_J4 + dP_P4 + dP_J5 + dP_P5
n4 to 11	dP_4_11	229881	Pa	= dP_P6 + dP_J6 + dP_J7 + dP_P7 + dP_P8 + dP_J8 + dP_P9

Branchs head loss

n1 to 4	dH_1_4	16.729	m fluid	= HeadLoss_dP_Rho_g(dP_1_4;rho)
n4 to 16	dH_4_16	23.486	m fluid	= HeadLoss_dP_Rho_g(dP_4_16;rho)
n4 to 11	dH_4_11	23.486	m fluid	= HeadLoss_dP_Rho_g(dP_4_11;rho)

Solver data

Value to be computed by solver (variable cells)

J4	K_J4	9.011		
J7	K_J7	6.078		

Constraints

P_J9 - P_n11 = 0	0.0	Pa	= P_J9 - P_n11
P_J9 - P_n16 = 0	0.0	Pa	= P_J9 - P_n16

Pump volume flowrate

J2	Q_J2	0.01389	m³/s	= Q_J4 + Q_J7

Static pressure at node

n1	P_n1	84682	Pa	= P_J1
n2	P_n2	37897	Pa	= P_n1 - dP_P1
n3	P_n3	576209	Pa	= P_n2 + P_J2
n4	P_n4	459245	Pa	= P_n3 - dP_P2
n5	P_n5	447077	Pa	= P_n4 - dP_P6
n6	P_n6	444184	Pa	= P_n5 - dP_J6
n7	P_n7	403623	Pa	= P_n6 - dP_P7
n8	P_n8	372406	Pa	= P_n7 - dP_J7
n9	P_n9	360237	Pa	= P_n8 - dP_P8
n10	P_n10	290206	Pa	= P_n9 - dP_J8
n11	P_n11	229364	Pa	= P_n10 - dP_P9
n12	P_n12	418684	Pa	= P_n4 - dP_P3
n13	P_n13	372406	Pa	= P_n12 - dP_J4
n14	P_n14	360237	Pa	= P_n13 - dP_P4
n15	P_n15	290206	Pa	= P_n14 - dP_J5
n16	P_n16	229364	Pa	= P_n15 - dP_P5

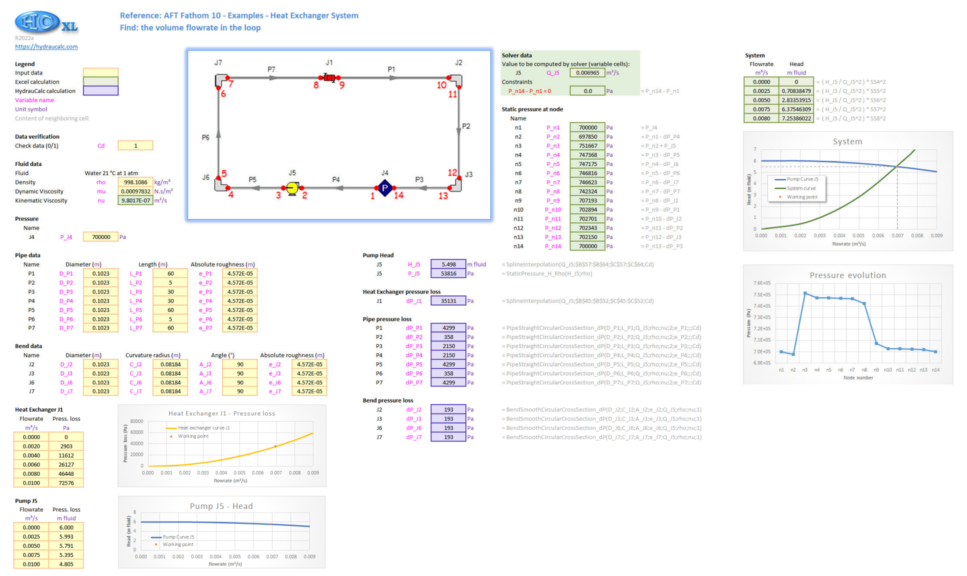
Reservoir static lift

sL	14.781	m fluid	= HeadLoss_dP_Rho_g(P_J9-P_J1;rho)

System characteristic

Flowrate m³/s	Head m fluid	
0.0000	14.781	= sL + (dH_1_4 / Q_J2^2) * V40^2 + (dH_4_16 / Q_J4 ^2) * (V40 / 2)^2
0.0025	16.084	= sL + (dH_1_4 / Q_J2^2) * V41^2 + (dH_4_16 / Q_J4 ^2) * (V41 / 2)^2
0.0050	19.993	= sL + (dH_1_4 / Q_J2^2) * U42^2 + (dH_4_16 / Q_J4 ^2) * (U42 / 2)^2
0.0075	26.508	= sL + (dH_1_4 / Q_J2^2) * V43^2 + (dH_4_16 / Q_J4 ^2) * (V43 / 2)^2
0.0100	35.629	= sL + (dH_1_4 / Q_J2^2) * V44^2 + (dH_4_16 / Q_J4 ^2) * (V44 / 2)^2
0.0125	47.356	= sL + (dH_1_4 / Q_J2^2) * V45^2 + (dH_4_16 / Q_J4 ^2) * (V45 / 2)^2
0.0150	61.688	= sL + (dH_1_4 / Q_J2^2) * V46^2 + (dH_4_16 / Q_J4 ^2) * (V46 / 2)^2

- 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

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Legend

Input data

Excel calculation

HydrauCalc calculation

Variable name

Unit symbol

Content of neighboring cell

Data verification

Check data (0/1)	Cd	1

Fluid data

Fluid		Water 21 °C at 1 atm	
Density	rho	998.1086	kg/m³
Dynamic Viscosity	mu	0.00097832	N.s/m²
Kinematic Viscosity	nu	9.8017E-07	m²/s

Pressure

Name			
J4	P_J4	700000	Pa

Pipe data

Name		Diameter (m)		Length (m)		Absolute roughness (m)
P1	D_P1	0.1023	L_P1	60	e_P1	4.572E-05
P2	D_P2	0.1023	L_P2	5	e_P2	4.572E-05
P3	D_P3	0.1023	L_P3	30	e_P3	4.572E-05
P4	D_P4	0.1023	L_P4	30	e_P4	4.572E-05
P5	D_P5	0.1023	L_P5	60	e_P5	4.572E-05
P6	D_P6	0.1023	L_P6	5	e_P6	4.572E-05
P7	D_P7	0.1023	L_P7	60	e_P7	4.572E-05

Bend data

Name		Diameter (m)		Curvature radius (m)		Angle (°)		Absolute roughness (m)
J2	D_J2	0.1023	C_J2	0.08184	A_J2	90	e_J2	4.572E-05
J3	D_J3	0.1023	C_J3	0.08184	A_J3	90	e_J3	4.572E-05
J6	D_J6	0.1023	C_J6	0.08184	A_J6	90	e_J6	4.572E-05
J7	D_J7	0.1023	C_J7	0.08184	A_J7	90	e_J7	4.572E-05

Heat Exchanger J1

Flowrate m³/s	Press. loss Pa
0.0000	0
0.0020	2903
0.0040	11612
0.0060	26127
0.0080	46448
0.0100	72576

Pump J5

Flowrate m³/s	Press. loss m fluid
0.0000	6.000
0.0025	5.993
0.0050	5.791
0.0075	5.395
0.0100	4.805

Pump Head

J5	H_J5	5.498	m fluid	= SplineInterpolation(Q_J5;$B$57:$B$64;$C$57:$C$64;Cd)
J5	P_J5	53816	Pa	= StaticPressure_H_Rho(H_J5;rho)

Heat Exchanger pressure loss

J1	dP_J1	35131	Pa	= SplineInterpolation(Q_J5;$B$45:$B$52;$C$45:$C$52;Cd)

Pipe pressure loss

P1	dP_P1	4299	Pa	= PipeStraightCircularCrossSection_dP(D_P1;L_P1;Q_J5;rho;nu;2;e_P1;;;Cd)
P2	dP_P2	358	Pa	= PipeStraightCircularCrossSection_dP(D_P2;L_P2;Q_J5;rho;nu;2;e_P2;;;Cd)
P3	dP_P3	2150	Pa	= PipeStraightCircularCrossSection_dP(D_P3;L_P3;Q_J5;rho;nu;2;e_P3;;;Cd)
P4	dP_P4	2150	Pa	= PipeStraightCircularCrossSection_dP(D_P4;L_P4;Q_J5;rho;nu;2;e_P4;;;Cd)
P5	dP_P5	4299	Pa	= PipeStraightCircularCrossSection_dP(D_P5;L_P5;Q_J5;rho;nu;2;e_P5;;;Cd)
P6	dP_P6	358	Pa	= PipeStraightCircularCrossSection_dP(D_P6;L_P6;Q_J5;rho;nu;2;e_P6;;;Cd)
P7	dP_P7	4299	Pa	= PipeStraightCircularCrossSection_dP(D_P7;L_P7;Q_J5;rho;nu;2;e_P7;;;Cd)

Bend pressure loss

J2	dP_J2	193	Pa	= BendSmoothCircularCrossSection_dP(D_J2;C_J2;A_J2;e_J2;Q_J5;rho;nu;1)
J3	dP_J3	193	Pa	= BendSmoothCircularCrossSection_dP(D_J3;C_J3;A_J3;e_J3;Q_J5;rho;nu;1)
J6	dP_J6	193	Pa	= BendSmoothCircularCrossSection_dP(D_J6;C_J6;A_J6;e_J6;Q_J5;rho;nu;1)
J7	dP_J7	193	Pa	= BendSmoothCircularCrossSection_dP(D_J7;C_J7;A_J7;e_J7;Q_J5;rho;nu;1)

Solver data

Value to be computed by solver (variable cells):

J5	Q_J5	0.006965	m³/s	

Constraints

P_n14 - P_n1 = 0	0.0	Pa	= P_n14 - P_n1

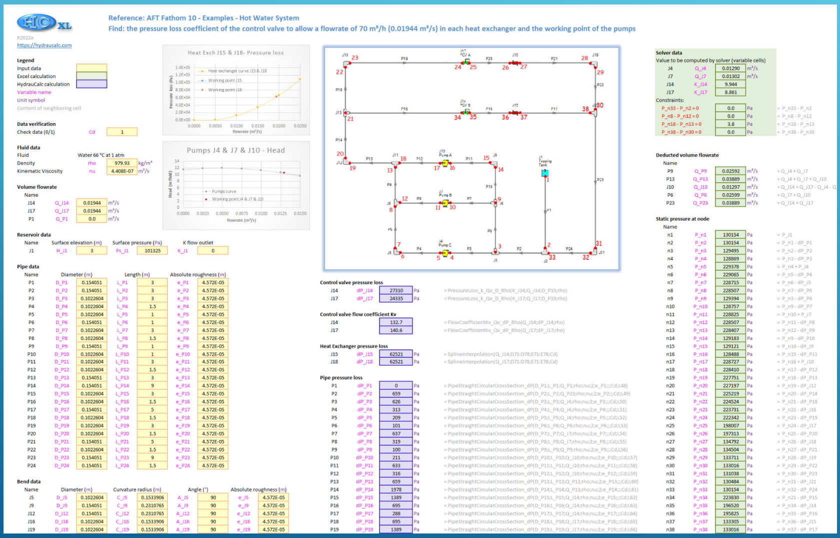
Static pressure at node

Name				
n1	P_n1	700000	Pa	= P_J4
n2	P_n2	697850	Pa	= P_n1 - dP_P4
n3	P_n3	751667	Pa	= P_n2 + P_J5
n4	P_n4	747368	Pa	= P_n3 - dP_P5
n5	P_n5	747175	Pa	= P_n4 - dP_J6
n6	P_n6	746816	Pa	= P_n5 - dP_P6
n7	P_n7	746623	Pa	= P_n6 - dP_J7
n8	P_n8	742324	Pa	= P_n7 - dP_P7
n9	P_n9	707193	Pa	= P_n8 - dP_J1
n10	P_n10	702894	Pa	= P_n9 - dP_P1
n11	P_n11	702701	Pa	= P_n10 - dP_J2
n12	P_n12	702343	Pa	= P_n11 - dP_P2
n13	P_n13	702150	Pa	= P_n12 - dP_J3
n14	P_n14	700000	Pa	= P_n13 - dP_P3

System

Flowrate m³/s	Head m fluid	
0.0000	0	= (H_J5 / Q_J5^2) * S54^2
0.0025	0.70838479	= (H_J5 / Q_J5^2) * S55^2
0.0050	2.83353915	= (H_J5 / Q_J5^2) * S56^2
0.0075	6.37546309	= (H_J5 / Q_J5^2) * S57^2
0.0080	7.25386022	= (H_J5 / Q_J5^2) * S58^2

- 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

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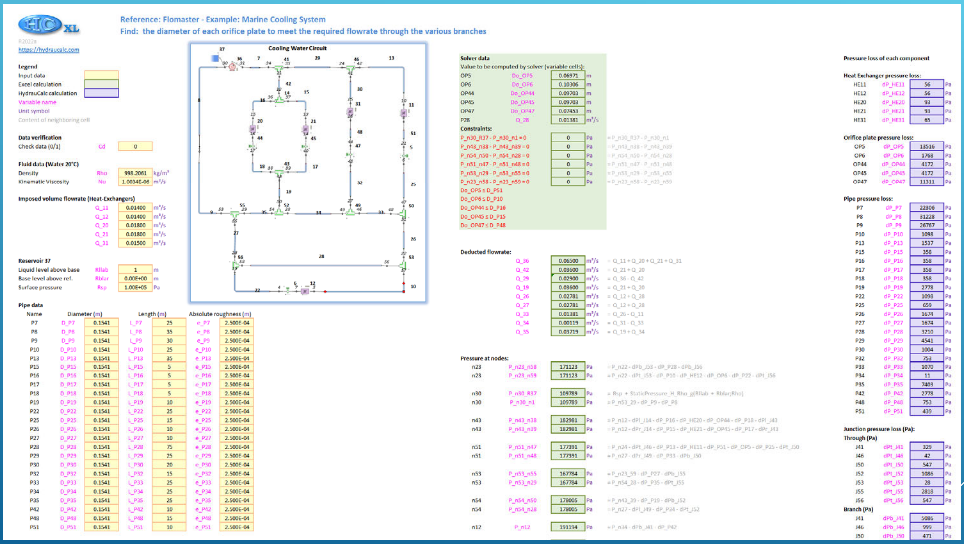
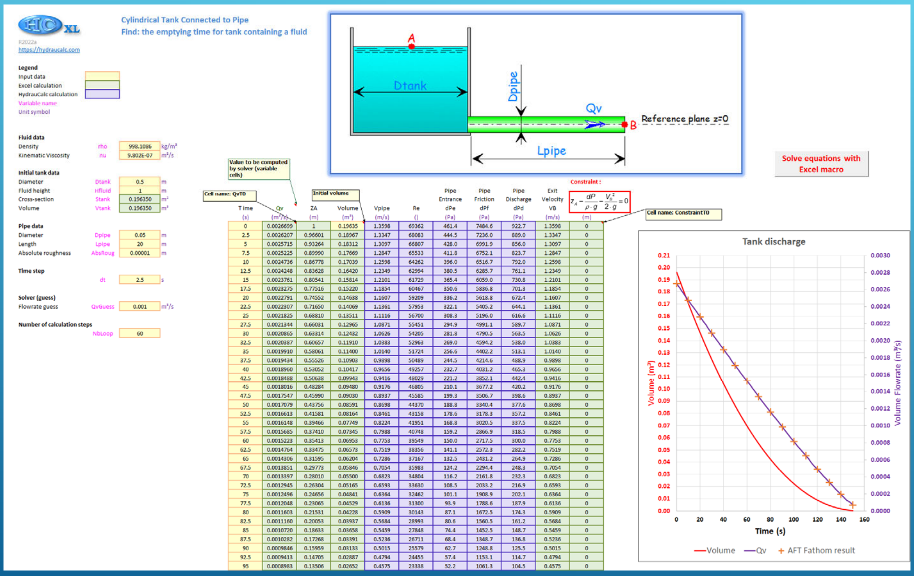
- Find: the diameter of each orifice plate to meet the required flowrate through the each heat exchanger.
- This problem illustrates the use of Excel solver to solve a complex closed loop system. In addition, the flows in the branches of the five exchangers are to be balanced by restriction orifices.



Reference: Flomaster - Example: Marine Cooling System

Find: the diameter of each orifice plate to meet the required flowrate through the various branches

- 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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Cylindrical Tank Connected to Pipe
Find: the emptying time for tank containing a fluid

Legend
Input data
Excel calculation
HydrauCalc calculation
Variable name
Unit symbol

Fluid data

Density	rho	998.1086	kg/m³
Kinematic Viscosity	nu	9.802E-07	m²/s

Initial tank data

Diameter	Dtank	0.5	m
Fluid height	Hfluid	1	m
Cross-section	Stank	0.196350	m²
Volume	Vtank	0.196350	m³

Pipe data

Diameter	Dpipe	0.05	m
Length	Lpipe	20	m
Absolute roughness	AbsRoug	0.00001	m

Time step

dt	2.5	s

Solver (guess)

Flowrate guess	QvGuess	0.001	m³/s

Number of calculation steps

NbLoop	60

Value to be computed by solver (variable cells)
Cell name: QvT0
Initial volume
Constraint :
Cell name: ConstraintT0

Time (s)	Qv (m³/s)	ZA (m)	Volume (m³)	Vpipe (m/s)	Re ()	Pipe Entrance dPe (Pa)	Pipe Friction dPf (Pa)	Pipe Discharge dPd (Pa)	Exit Velocity VB (m/s)	$z_A - \frac{dP}{\rho \cdot g} - \frac{V_B^2}{2 \cdot g} = 0$ (m)
0	0.0026699	1	0.19635	1.3598	69362	461.4	7484.6	922.7	1.3598	0
2.5	0.0026207	0.96601	0.18967	1.3347	68083	444.5	7236.0	889.0	1.3347	0
5	0.0025715	0.93264	0.18312	1.3097	66807	428.0	6991.9	856.0	1.3097	0
7.5	0.0025225	0.89990	0.17669	1.2847	65533	411.8	6752.1	823.7	1.2847	0
10	0.0024736	0.86778	0.17039	1.2598	64262	396.0	6516.7	792.0	1.2598	0
12.5	0.0024248	0.83628	0.16420	1.2349	62994	380.5	6285.7	761.1	1.2349	0
15	0.0023761	0.80541	0.15814	1.2101	61729	365.4	6059.0	730.8	1.2101	0
17.5	0.0023275	0.77516	0.15220	1.1854	60467	350.6	5836.8	701.3	1.1854	0
20	0.0022791	0.74552	0.14638	1.1607	59209	336.2	5618.8	672.4	1.1607	0
22.5	0.0022307	0.71650	0.14069	1.1361	57953	322.1	5405.2	644.1	1.1361	0
25	0.0021825	0.68810	0.13511	1.1116	56700	308.3	5196.0	616.6	1.1116	0
27.5	0.0021344	0.66031	0.12965	1.0871	55451	294.9	4991.1	589.7	1.0871	0
30	0.0020865	0.63314	0.12432	1.0626	54205	281.8	4790.5	563.5	1.0626	0
32.5	0.0020387	0.60657	0.11910	1.0383	52963	269.0	4594.2	538.0	1.0383	0
35	0.0019910	0.58061	0.11400	1.0140	51724	256.6	4402.2	513.1	1.0140	0
37.5	0.0019434	0.55526	0.10903	0.9898	50489	244.5	4214.6	488.9	0.9898	0
40	0.0018960	0.53052	0.10417	0.9656	49257	232.7	4031.2	465.3	0.9656	0
42.5	0.0018488	0.50638	0.09943	0.9416	48029	221.2	3852.1	442.4	0.9416	0
45	0.0018016	0.48284	0.09480	0.9176	46805	210.1	3677.2	420.2	0.9176	0
47.5	0.0017547	0.45990	0.09030	0.8937	45585	199.3	3506.7	398.6	0.8937	0
50	0.0017079	0.43756	0.08591	0.8698	44370	188.8	3340.4	377.6	0.8698	0
52.5	0.0016613	0.41581	0.08164	0.8461	43158	178.6	3178.3	357.2	0.8461	0
55	0.0016148	0.39466	0.07749	0.8224	41951	168.8	3020.5	337.5	0.8224	0
57.5	0.0015685	0.37410	0.07345	0.7988	40748	159.2	2866.9	318.5	0.7988	0
60	0.0015223	0.35413	0.06953	0.7753	39549	150.0	2717.5	300.0	0.7753	0
62.5	0.0014764	0.33475	0.06573	0.7519	38356	141.1	2572.3	282.2	0.7519	0
65	0.0014306	0.31595	0.06204	0.7286	37167	132.5	2431.2	264.9	0.7286	0
67.5	0.0013851	0.29773	0.05846	0.7054	35983	124.2	2294.4	248.3	0.7054	0
70	0.0013397	0.28010	0.05500	0.6823	34804	116.2	2161.8	232.3	0.6823	0
72.5	0.0012945	0.26304	0.05165	0.6593	33630	108.5	2033.2	216.9	0.6593	0
75	0.0012496	0.24656	0.04841	0.6364	32462	101.1	1908.9	202.1	0.6364	0
77.5	0.0012048	0.23065	0.04529	0.6136	31300	93.9	1788.6	187.9	0.6136	0
80	0.0011603	0.21531	0.04228	0.5909	30143	87.1	1672.5	174.3	0.5909	0
82.5	0.0011160	0.20053	0.03937	0.5684	28993	80.6	1560.5	161.2	0.5684	0
85	0.0010720	0.18633	0.03658	0.5459	27848	74.4	1452.5	148.7	0.5459	0
87.5	0.0010282	0.17268	0.03391	0.5236	26711	68.4	1348.7	136.8	0.5236	0
90	0.0009846	0.15959	0.03133	0.5015	25579	62.7	1248.8	125.5	0.5015	0
92.5	0.0009413	0.14705	0.02887	0.4794	24455	57.4	1153.1	114.7	0.4794	0
95	0.0008983	0.13506	0.02652	0.4575	23338	52.2	1061.3	104.5	0.4575	0

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