taking the pressure out of fluid flow calculations

www.pipeflow.com

Pipe Flow Wizard

Software for Fluid Flow and Pressure Loss Calculations

Liquids

Verification of Calculation Results
For Non-Compressible Flow

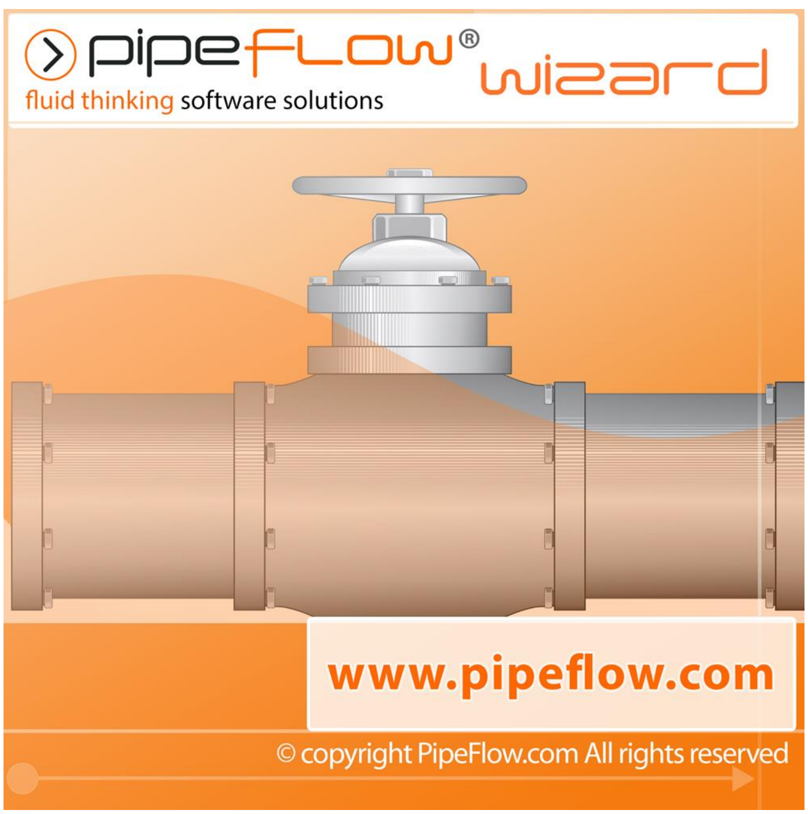


Table of Contents – Results Data: Systems Solved by Pipe Flow Wizard

Introduction

Pipe Flow Wizard is a software application that performs flow rate and pressure drop calculations for fluid flow in a pipe. The Pipe Flow Wizard software can 'Find Pressure Drop', 'Find Flow Rate', 'Find Diameter Size', and 'Find Length of Pipe' depending on the information available.

Each of the **Find Pressure, Find Flow, Find Diameter and Find Length** calculations produced by the Pipe Flow Wizard software can be verified by comparison against published results from a number of well-known sources. The information in this document provides a general description of a published problem, the **Reference Source**, the **Published Results Data**, the **Pipe Flow Wizard Results Data** and a commentary on the results obtained.

For each of the calculation problems detailed in this document, the results data produced by the **Pipe Flow Wizard software compares well with the published results data.**

Calculations

Friction Factors are calculated using the **Colebrook-White** equation.

Friction Loss for non-compressible fluids is calculated using the **Darcy-Weisbach** method, which provides accurate results for Newtonian fluids, including general process fluids.

The Pipe Flow Wizard software also **contains a separate compressible calculation engine** that allows for the solution of compressible systems (gases) with equations such as the General Fundamental Isothermal Flow equation, and others. There is a separate verification document that compares the results produced by the compressible calculation engine against published data.

Software Releases

The latest release of the Pipe Flow Wizard software has been completely rewritten to support use on Microsoft Windows (PCs), Mac OS (Apple Computers), and iOS (Apple Mobile Devices), including iPhone and iPad.

The original Pipe Flow Wizard software for Windows was released over 15 years ago and today **Pipe Flow Wizard software is used by engineers in over 100 countries worldwide.**

We have clients in a variety of industries including aerospace, chemical processing, education, food and beverage, general engineering, mining, petrochemical, pharmaceutical, power generation, water distribution, and wastewater processing.

Find Pressure

Case 01: Petroleum - Oil Pipeline Pressure Loss

Reference: Piping Calculations Manual, 2005, McGraw-Hill, E. Shashi Menon, P.E., Page 335, Example 6.16

Pipe Flow Wizard Software: Find_Pressure_Case_01_Petroleum_Oil_Pipeline_Pressure_Loss.pfwp

Calculation Problem:

Find the head loss in one mile of NPS16 pipeline
(0.250 inch wall thickness) at a flow rate of 4000 barrel/h.

Fluid Data:

Petroleum oil with 0.85 specific gravity and 10 cSt viscosity.

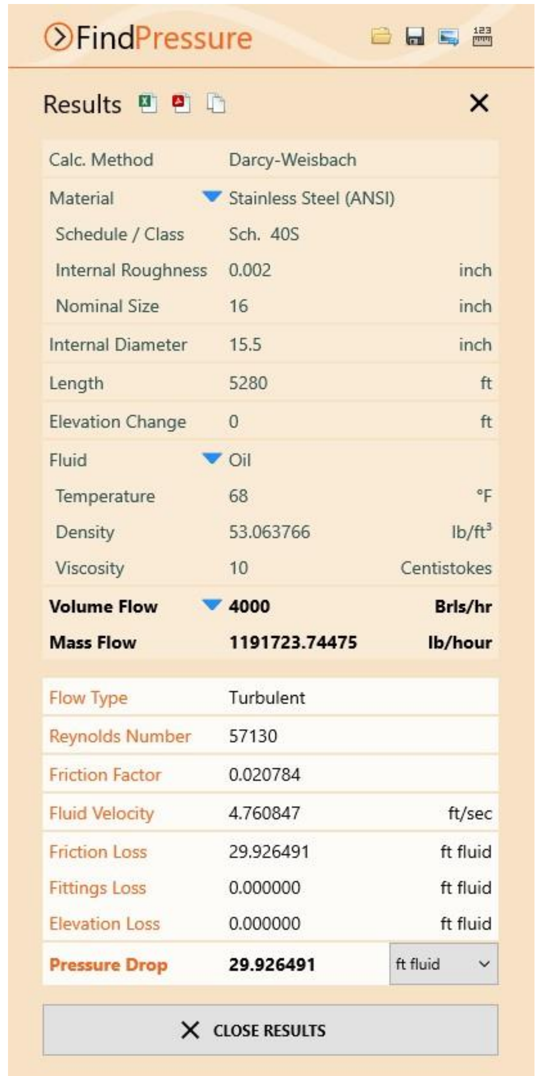
Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The published data rounds the fluid velocity to 2 decimal places and the friction factor to 4 decimal places.

The Pipe Flow Wizard software uses a velocity and a friction factor that are calculated to more decimal places, which accounts for the slight differences in calculated head loss.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Head Loss (ft. hd)	29.908	29.9265
Reynolds Number	57129	57130
Fluid Velocity (ft/s)	4.76	4.7608
Friction Factor	0.0208	0.020784

Case 02: Gasoline - Transport over 15 km

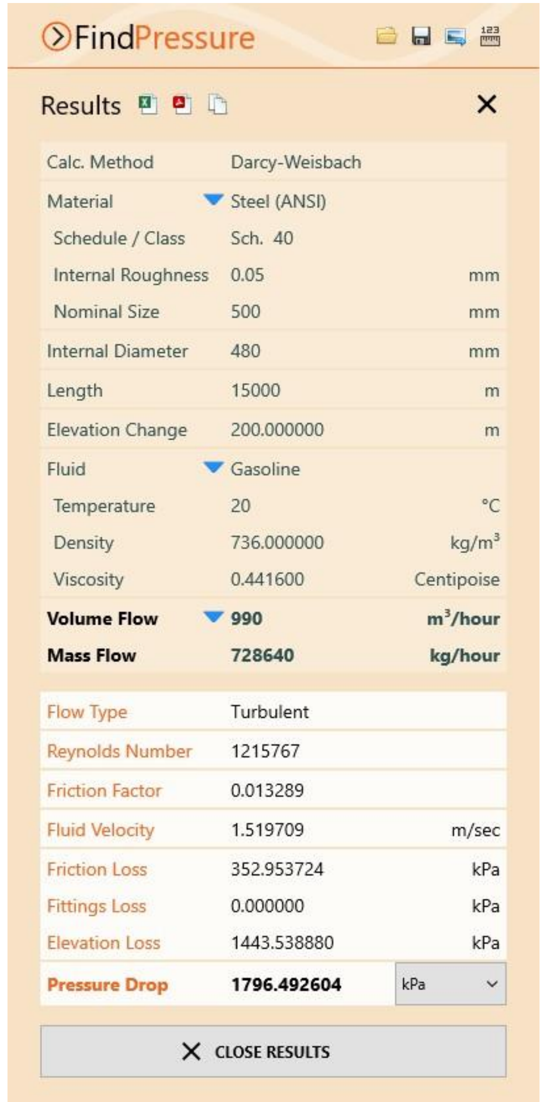
Reference: Piping Calculations Manual, 2005, McGraw-Hill, E. Shashi Menon, P.E., Page 337, Example 6.17

Pipe Flow Wizard Software: Find_Pressure_Case_02_Gasoline_Transport_Over_15km.pfwp

Calculation Problem:

A DN500 (10mm wall thickness) steel pipe, with an internal roughness of 0.05 mm, is used to transport gasoline over a 15 km distance. The delivery point is 200 m above the start of the pipeline. A delivery pressure of 4 kPa must be maintained at the delivery point.

Calculate the pump pressure needed to deliver a flow rate of 990 m³/h.



Fluid Data:

Gasoline
Specific Gravity = 0.736
Viscosity = 0.6 Centistokes (0.4416 Centipoise)

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well. The published text uses a friction factor value of 0.013 read from the Moody diagram.

The Pipe Flow Wizard software uses a friction factor calculated to more decimal places which accounts for the slight difference in the pump pressure required.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pump Pressure Required (kPa)	1792	1796.49
Reynolds Number	1215768	1215767
Fluid Velocity (m/s)	Not stated	1.52
Friction Factor	0.013	0.013289

Case 03: SAE 10 Oil - Pressure Loss per Mile

Reference: 2500 Solved Problems in Fluid Mechanics and Hydraulics
1989, McGraw-Hill, Jack B. Evett, Ph. D., Cheng Liu, M.S., Page 211, Example problem 9.68

Pipe Flow Wizard Software: Find_Pressure_Case_03_SAE_10_Oil_Pressure_Loss_Per_Mile.pfwp

Calculation Problem:

A 6” wrought iron pipe carries SAE 10 oil at 68°F.

Calculate the pressure loss per mile of pipe.

Fluid Data:

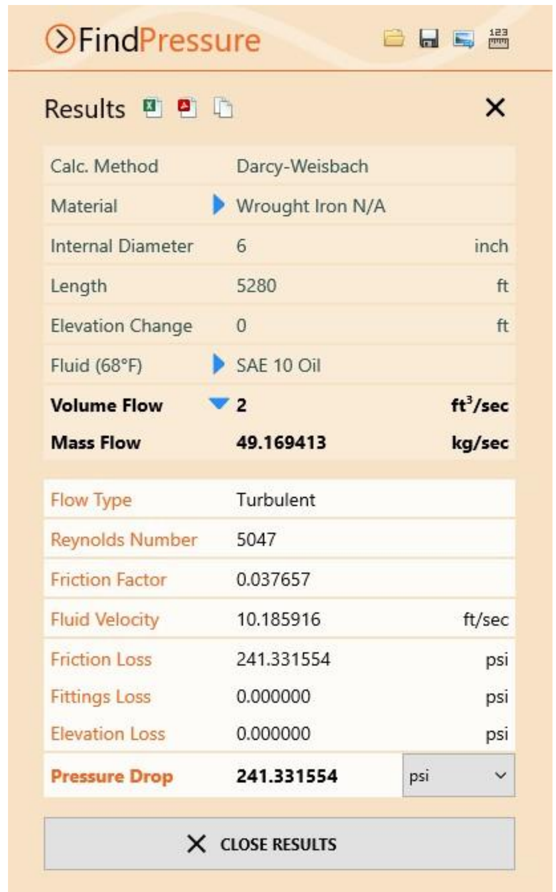
SAE 10 at 68°F.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The Pipe Flow Wizard software calculates the friction factor to a greater number of decimal places.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure Loss per mile. (psi)	244	241.33
Reynolds Number	5035	5047
Friction Factor	0.038	0.037657

Case 04: Water - Asbestos Cement Pipe Friction Loss

Reference: Basic Principles for the Design of Centrifugal Pump Installations
SIHI Group, 1998, SIHI-HALBERG. Page 134, Example of Head Loss Calculation

Pipe Flow Wizard Software: Find_Pressure_Case_04_Water_Asbestos_Cement_Pipe_Friction_Loss.pfwp

Calculation Problem:

Water flows along a 400 m long asbestos cement pipe at the rate of 360 m³/h.

The pipe designation is DN200.

Find the head loss in the pipe.

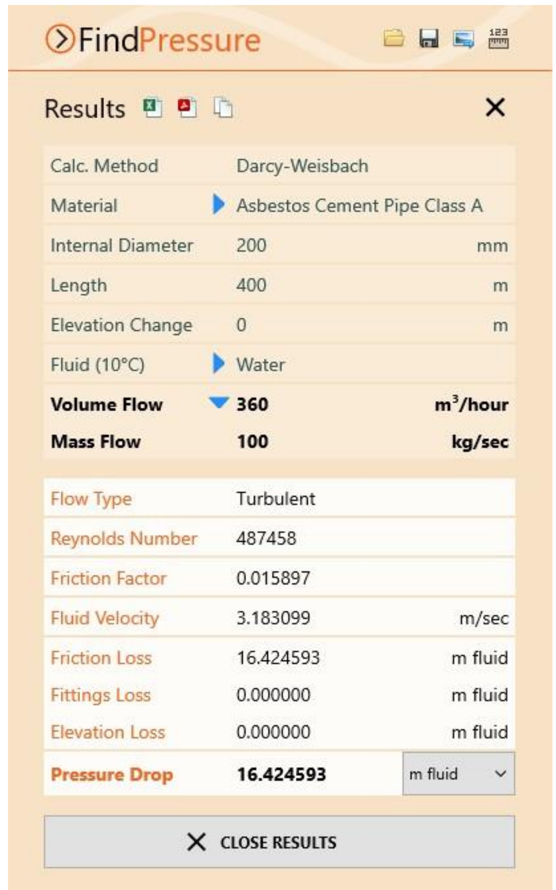
Fluid Data:

Water at 10°C.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Reynolds Number	4.9 x 10^5	487458
Fluid Velocity (m/s)	3.2	3.18
Total Head Loss in pipe (m. hd)	16.4	16.42

Case 05: Lubrication Oil - Laminar Flow Example 1

Reference: Flow of Fluids – Technical Paper No 410M, 1999, Crane Co. Page 3-12, Example 1

Pipe Flow Wizard Software: Find_Pressure_Case_05_Lubricating_Oil_Laminar_Flow_Example_1.pfwp

Calculation Problem:

A 6" diameter schedule 40 steel pipe carries lubricating oil of density 897 kg/m³ and viscosity 450 Centipoise.

Find the pressure drop per 100 meters.

Fluid Data:

Lubricating Oil
Viscosity = 450 Centipoise, Density = 897 kg/m³

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure Drop per 100 meters (bar)	1.63	1.628
Reynolds Number	825	824

Case 06: Lubrication Oil - Laminar Flow Example 2

Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page 3-12, Example 2

Pipe Flow Wizard Software: Find_Pressure_Case_06_Lubricating_Oil_Laminar_Flow_Example_2.pfwp

Calculation Problem:

A 3" diameter schedule 40 carries SAE 10 lube oil at a velocity of 5.0 ft/s

Find the flow rate and the pressure drop per 100 feet.

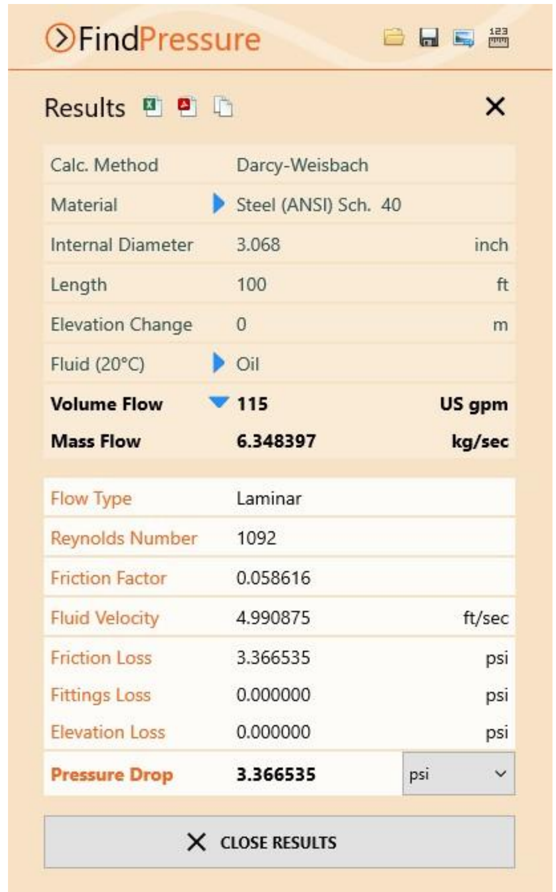
Fluid Data:

Oil, viscosity = 95 Centipoise, density = 54.64 lb/ft^3

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Flow Rate (US gpm)	115	115
Fluid Velocity (ft/s)	5.00	4.99
Reynolds Number	1100	1092
Pressure Drop per 100 feet (psi)	3.40	3.367

Case 07: Water - Reynolds Number for Smooth Wall Pipe

Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page 4-1, Example 4-1

Pipe Flow Wizard Software: Find_Pressure_Case_07_Water_Reynolds_Number_For_Smooth_Wall_Pipe.pfwp

Calculation Problem:

70 feet of 2” diameter plastic pipe (smooth wall) carries water at 80°F. The flow rate is 50 gpm (US).

Find the Reynolds number and the friction factor.

Fluid Data:

Water at 80°F

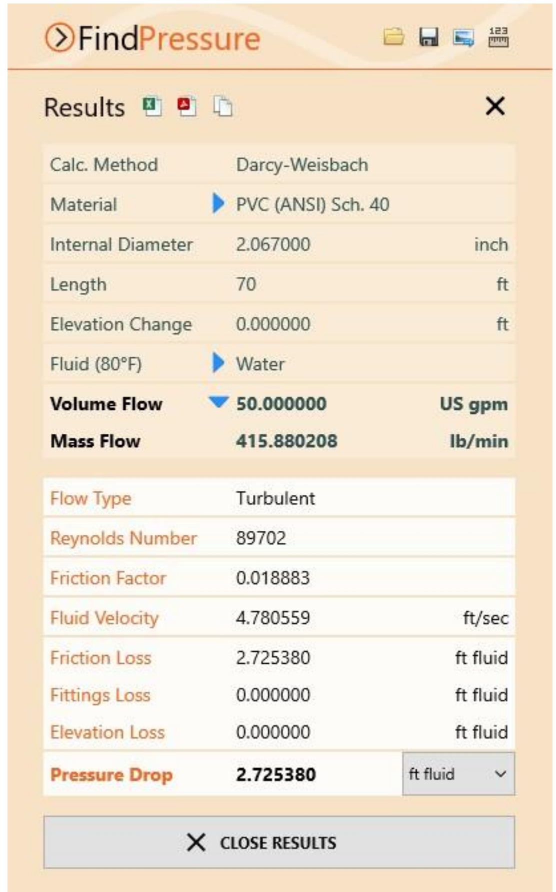
Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

Pipe Flow Wizard uses the same fluid density and viscosity as the published text to calculate the Reynolds number.

The published text friction factor has been read from a chart for water at 60°F.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Reynolds Number	89600	89702
Friction Factor	0.0182	0.018883

Case 08: SAE 70 Lube Oil - Laminar Flow in Valves

Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page 4-4, Example 4-8

Pipe Flow Wizard Software: Find_Pressure_Case_08_SAE_70_Lube_Oil_Laminar_Flow_In_Valves.pfwp

Calculation Problem:

200 feet of 8” diameter steel pipe (schedule 40) carries SAE 70 Lube Oil at 100°F.

The flow rate is 600 barrels per hour.

The piping includes an 8” globe valve.

Find the pressure loss in the pipe and the valve.

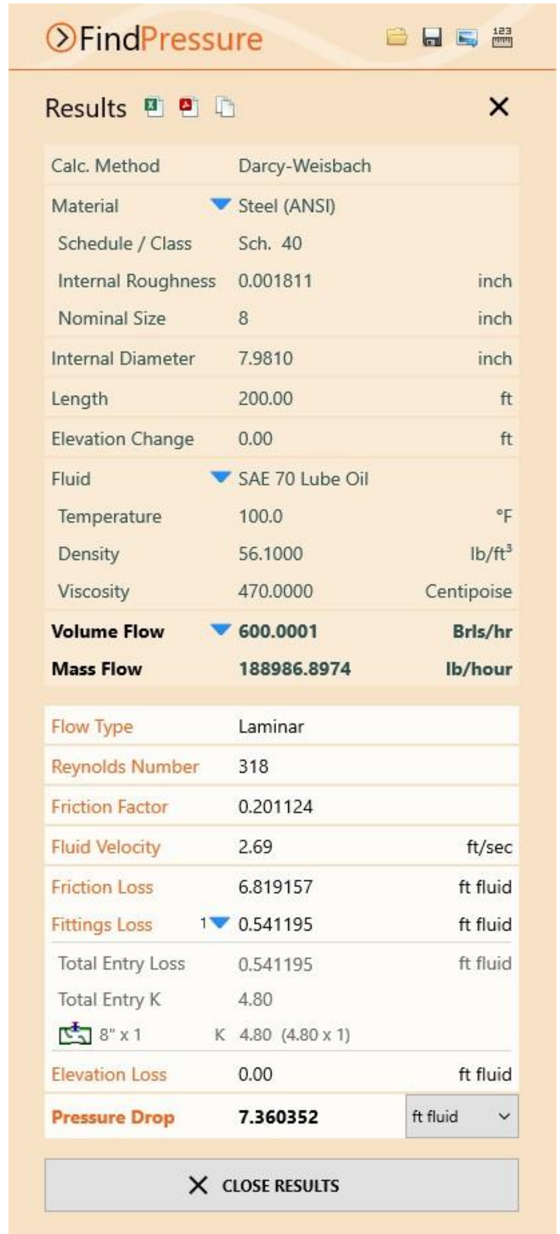
Fluid Data:

SAE 70 Lube Oil at 100°F

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure Loss (psi)	2.85	2.8675
Reynolds Number	318	318
Friction Factor	0.20	0.201124

Case 09: Water and Oil – Uncoated Cast Iron Pipe

Reference: Fluid Mechanics and Hydraulics – Third Edition 1994
Ranald V. Giles, Jack B. Evett, Ph.D., Cheng Liu, Page 149, Example problem 8.15

Pipe Flow Wizard Software: Find_Pressure_Case_09_Water_Oil_Cast_Iron_Pipe.pfwp

Calculation Problem:

1000 ft of new uncoated 12" internal diameter cast iron pipe carries:

(a) Water 60˚F at 5.00 ft/sec, and
(b) Medium fuel oil 60˚F at the same velocity.

Determine the pressure loss (head loss) in the pipe.

Fluid Data:

(a) Water at 60˚F
Kinematic Viscosity = 1.217 x 10^{-5} ft^2/sec.

(b) Medium Fuel Oil at 60˚F
Kinematic Viscosity= 0.858 ft^2/sec.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The Example used a relative roughness of 0.0008, and this value was also used in the Pipe Flow Wizard calculation.

The Friction factor in the published data was read from Diagram A-1, given in Appendix A (page 346).

The Pipe Flow Wizard software used the Colebrook- White equation to calculate the accurate friction factor.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard	Published Data	Pipe Flow Wizard
Fluid	Water	Water	Medium Fuel Oil	Medium Fuel Oil
Pressure Loss (ft head)	7.5	7.552	8.3	8.297
Reynolds Number	411000	410868	105000	105267
Friction Factor	0.0194	0.019438	0.0213	0.021356

Case 10: Water – Pressure Loss due to Friction

Reference: Piping Calculations Manual, 2005, McGraw-Hill, E. Shashi Menon, P.E., Page 16, Example 1.9

Pipe Flow Wizard Software: Find_Pressure_Case_10_Water_Pressure_Loss.pfwp

Calculation Problem:

Water flows through a 16 inch pipeline (0.375 inch wall thickness) at 3000 gal/min. Assume a pipe roughness of 0.002 inches.

Calculate the friction factor and head loss due to friction in 1000 ft of pipe length.

Fluid Data:

Water
Kinematic Viscosity of 1.0 cSt

Commentary:

See the Results Comparison Table below.

The problem does not give the temperature of water however it specifies a kinematic viscosity of 1.0 cSt.

The Pipe Flow Wizard calculation used water at 20°C which has a kinematic viscosity 0f 1.004008 cSt.

The problem description did not specify a pipe material. The Pipe Flow Wizard software calculation used Steel Schedule 40 with a pipe roughness of 0.002 inches.

The published data and the calculated results compare well.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure Drop due to Friction (psi)	2.12	2.122
Reynolds Number	622131	619659
Friction Factor	0.0144	0.014442

Case 11: Oil – Laminar Flow in Pipeline

Reference: Analysis of Flow in Pipe Networks, 1976, Roland W. Jeppson Page 32, Examples 1 and 2

Pipe Flow Wizard Software: Find_Pressure_Case_11_Oil_Laminar_Flow.pfwp

Calculation Problem:

A flow rate of 150 gpm (0.00947 m³/s) of oil occurs in a 4-inch (0.1016 m) pipe line.

Determine the Reynolds number and head loss per 1000ft (304.8m).

Fluid Data:

Oil
Viscosity $\mu = 1.5 \times 10^{-3}$ lb-sec/ft² (0.0718 N·sec/m²)
Density $\rho = 1.7$ slug/ft³ (876 kg/m³).

Commentary:

See the Results Comparison Table below.

The problem does not specify the pipe material data. We used Steel Schedule 40 with an internal roughness of 0.001811.

The published data and the calculated results compare well.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure Loss (ft head)	30.2	30.244
Reynolds Number	1450	1447

Case 12: Oil – Head loss in Cast Iron Pipeline

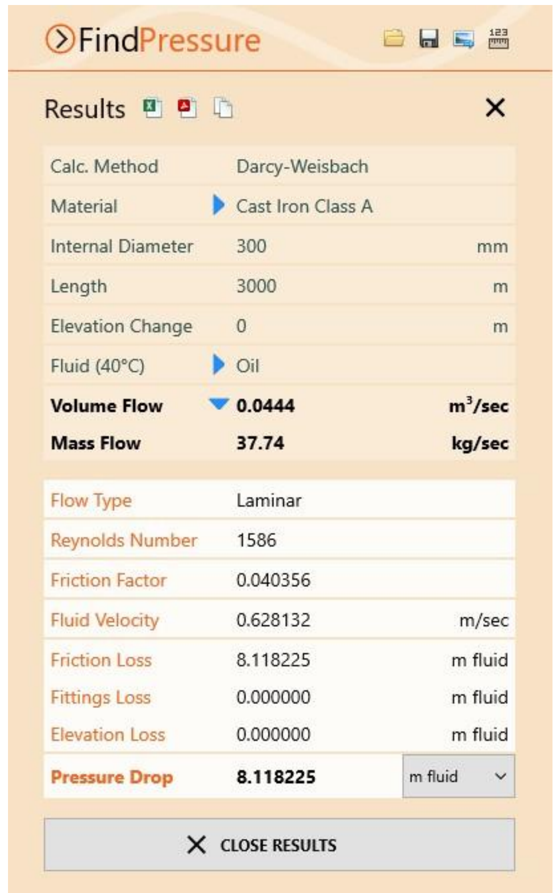
Reference: Fluid Mechanics and Hydraulics – Third Edition, 1994,
Ranald V. Giles, Jack B. Evett, Ph.D., Cheng Liu, Page 149, Example problem 8.11

Pipe Flow Wizard Software: Find_Pressure_Case_12_Oil_Head_Loss_Cast_Iron_Pipeline.pfwp

Calculation Problem:

Oil Flows through 3000 m of 300 mm cast iron pipe at the rate of 0.0444 m^3/s.

What is the lost head in the pipe?



Fluid Data:

Oil
Absolute Viscosity = 0.101 $N \cdot s/m^2$
Specific Gravity = 0.850.

Commentary:

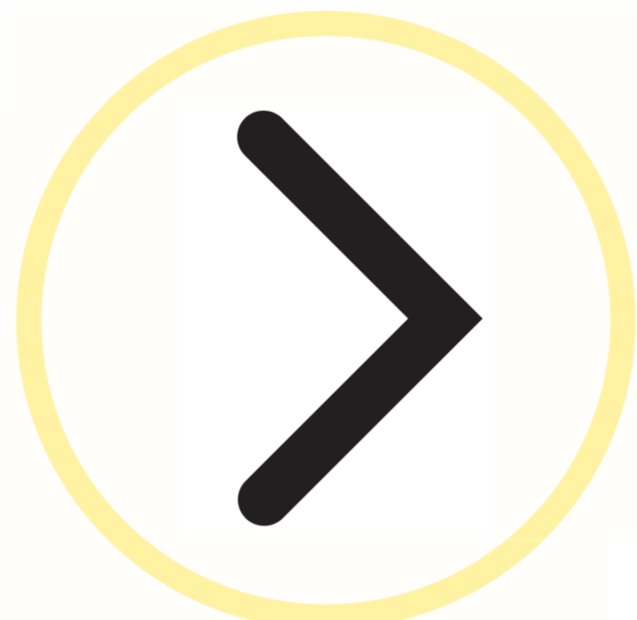
See the Results Comparison Table below.

The published data and the calculated results compare well.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure Loss (m head)	8.14	8.118
Reynolds Number	1582	1586
Friction Factor	0.0405	0.040356

Find Flow



Case 01: Water - Large Diameter Cast Iron Pipe

Reference: 2500 Solved Problems in Fluid Mechanics and Hydraulics, 1989,
McGraw-Hill, Jack B. Evett, Ph. D., Cheng Liu, M.S. , Page 209, Example problem 9.64

Pipe Flow Wizard Software: Find_Flow_Case_01_Water_Large_Diameter_Cast_Iron_Pipe.pfwf

Calculation Problem:

A 96” diameter, new cast iron pipe, has a frictional pressure loss of 1.5 ft. hd per 1000 ft of length, when carrying water at 60°F.

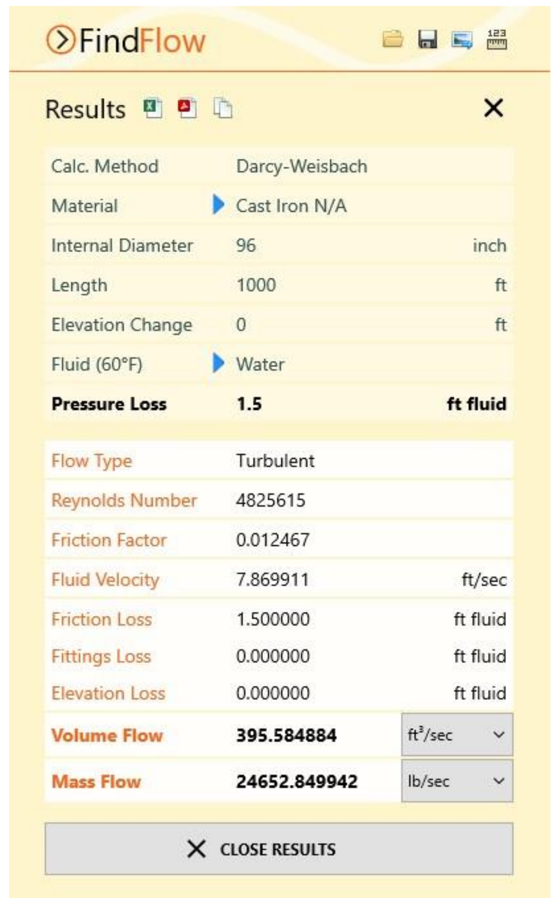
Calculate the discharge capacity of the pipe.

Fluid Data: Water at 60°F (v = 1.21 x 10^{-5} $ft^{2/s}$).

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Flow Capacity (ft^3/s)	397	395.58
Pressure Loss per 1000 ft. (ft. hd)	1.5	1.5
Friction Factor	0.0124	0.012467

Case 02: Ethanol - Laminar Flow

Reference: 2500 Solved Problems in Fluid Mechanics and Hydraulics, 1989, McGraw-Hill, Jack B. Evett, Ph. D., Cheng Liu, M.S., Page 207, Example problem 9.54

Pipe Flow Wizard Software: Find_Flow_Case_02_Ethanol_Laminar_Flow.pfwf

Calculation Problem:

Ethanol at 20°C is transferred from an upper tank to a lower tank via a 2 mm pipe.

The upper tank has 0.6 m of fluid above the exit pipe which itself is 1.2 m long, with 0.8 m of this pipe dipping into the fluid in the lower tank.

Calculate the flow rate between the tanks.

Fluid Data: Ethanol at 20°C (μ= 1.20 x 10^{-3} Pa · s)
Density = 788 kg/m^3

Commentary:

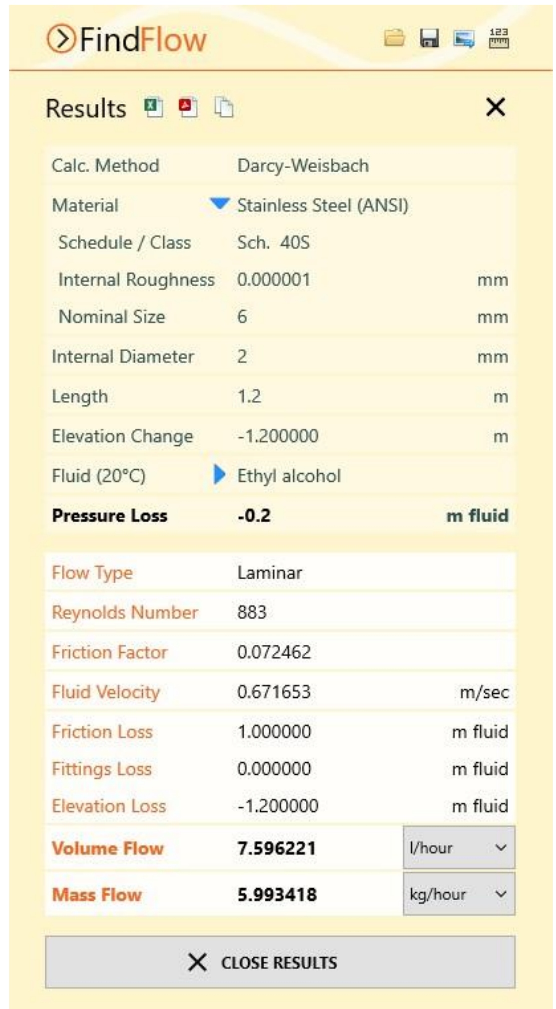
See the Results Comparison Table below.

The published data and the calculated results compare well. The published text does not list an internal roughness for the pipe.

The flow in this problem is laminar, so the friction factor is independent of the inner roughness of the pipe.

The calculated Reynolds number of 883 indicates that the flow type is well within the laminar flow range.

Two pipes with different internal roughness values (0.046000 mm and 0.000001 mm) were used in several Pipe Flow Wizard calculations to confirm that the variation in the internal roughness of the pipe did not affect the flow rate calculation.



Results Comparison:

Data Item	Published data	Pipe Flow Wizard
Flow from upper tank (l/hr) – Pipe 1	7.59	7.596
Flow from upper tank (l/hr) – Pipe 2	7.59	7.596

Case 03: Water – Flow Between Two Reservoirs

Reference: Analysis of Flow in Pipe Networks, 1976, Roland W. Jeppson Page 35, Example 4

Pipe Flow Wizard Software: Find_Flow_Case_03_Water_Flow_Between_Two_Reservoirs.pfwf

Calculation Problem:

A 4-inch PVC pipe 6000 ft long is used to convey water at 68°F between two reservoirs whose surface elevations differ by 150 ft.

What is the flow rate?

Fluid Data: Water at 68°F.

Commentary:

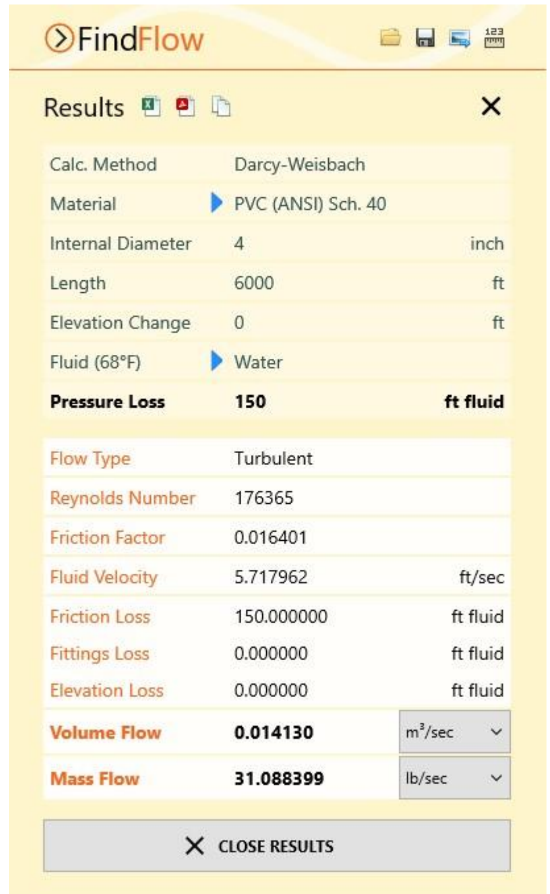
See the Results Comparison Table below.

The published data and the calculated results compare well.

The published problem obtains the result by first assuming a value for the flow rate and then it uses this to calculate the Reynolds number. The Reynolds number is then used to obtain a value for the friction factor, by reading it from the Moody diagram.

The published solution then iterates the flow rate to achieve the final value which agrees with the head loss specified.

Note: For the published solution, only a small number of iterations are performed, and it is therefore likely that the published Reynolds number and friction factor are not as accurate as those calculated by the Pipe Flow Wizard software.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Flow Rate (m^3/s)	0.0141	0.014130
Reynolds Number	157000	176365
Friction Factor	0.0165	0.016401

Case 04: Water – Elevated Pipeline with Fittings

Reference: Chemical Engineering, 1999,
J.M. Coulson, J. F. Richardson with J.R. Backhurst, J.H. Harker, Page 92, Example 3.8

Pipe Flow Wizard Software: Find_Flow_Case_04_Water_Elevated_Pipeline_With_Fittings.pfwf

Calculation Problem:

Water in a tank flows through an outlet 25 m below the water level into a 0.15 m diameter horizontal pipe (e/d = 0.01), 30 m long, with a 90° elbow which leads to a horizontal pipe of the same diameter, 60 m long, containing a fully open globe valve and discharging to atmosphere 10 m below the level of the water in the tank.

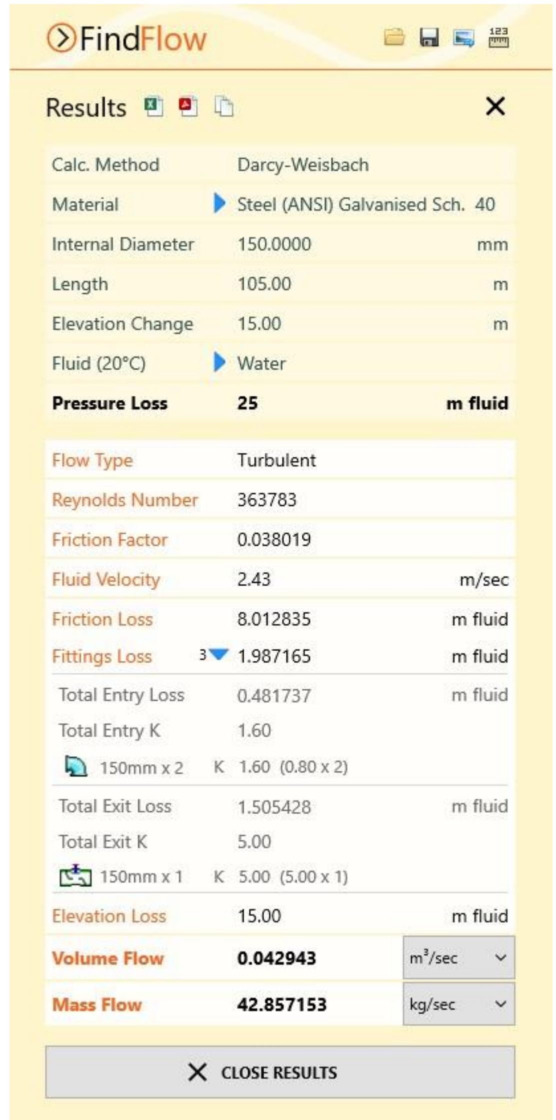
What is the initial rate of discharge?

Fluid Data: Water with viscosity of 1mN s/m^2.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Flow Rate (m^3/s)	0.043	0.042943
Velocity (m/s)	2.45	2.430079
Reynolds Number	367000	363783
Friction θ $\left(\phi = \frac{f}{2} = \frac{f'}{8}\right)$	0.0045	0.004752 derived from ($\frac{f'}{8} = \frac{0.038019}{8}$)

Note: *f* = fanning friction factor, *f'* = Moody chart friction factor (as shown by Pipe Flow Wizard)

Case 05: Water – Flow Through Reduced Port Ball Valve

Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page 4-3, Example 4-6

Pipe Flow Wizard Software: Find_Flow_Case_05_Water_Flow_Through_Reduced_Port_Ball_Valve.pfwf

Calculation Problem:

200 ft of 3" diameter steel pipe (schedule 40) carries water at 60°F.

The head of fluid in the supply tank is 22 ft.

The piping includes 6 standard 90° elbows and a flanged ball valve with a conical seat.

Find the fluid velocity in the pipe and the rate of discharge.

Fluid Data: Water at 60°F

Commentary:

See the Results Comparison Table below.

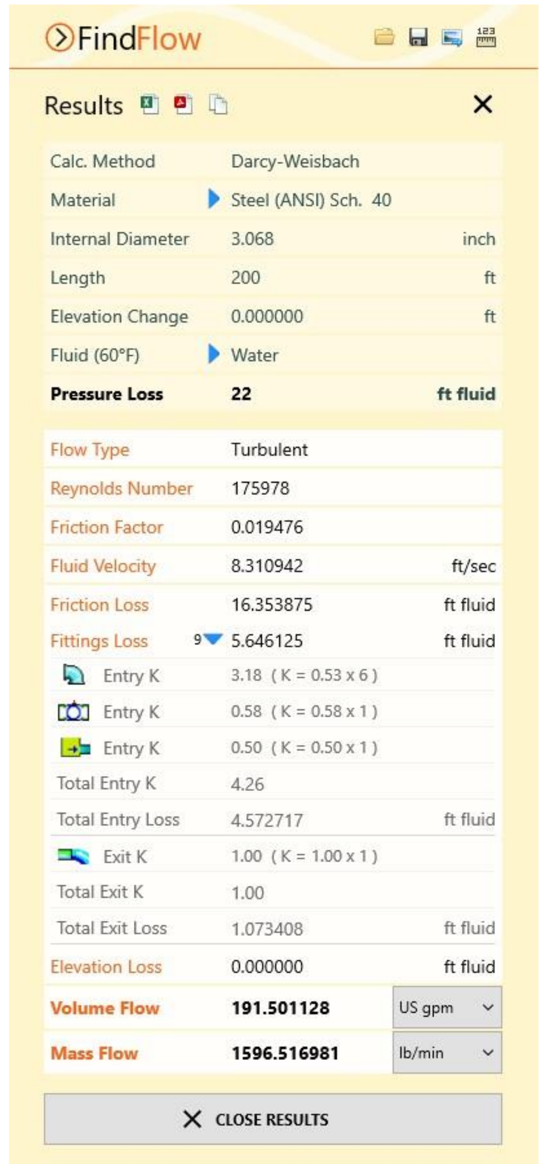
The published data and the calculated results differ by 2.3%.

The published data uses an assumed friction factor of 0.018 for a 3" diameter steel pipe.

As a final check, in the published data, the friction factor is read from a chart as less than 0.02, and the text concludes that the difference in the assumed friction factor and the friction factor read from the chart, is small enough so as not to require any further correction.

If the chart is read accurately the real friction factor is 0.0195. The Pipe Flow Wizard software calculated a friction factor of 0.019476

A new valve fitting was created in Pipe Flow Wizard to model the flanged ball valve as this item is not included in the database of standard valves and fittings.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Fluid Velocity in Pipe (ft/s)	8.5	8.311
Rate of Discharge (gpm US)	196	191.50
Reynolds Number	Not calculated	175978
Friction Factor	0.018 (assumed)	0.019476

Case 06: SAE 10 Lube Oil - Laminar Flow in Valves

Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page 4-4, Example 4-7

Pipe Flow Wizard Software: Find_Flow_Case_06_SAE_10_Lube_Oil_Laminar_Flow_In_Valves.pfwf

Calculation Problem:

200 feet of 3” diameter steel pipe (schedule 40) carries SAE 10 Lube Oil at 60°F.

The head of fluid in the supply tank is 22 ft.
The piping includes 6 standard 90° elbows and a flanged ball valve with a conical seat.

Find the fluid velocity in the pipe and the rate of discharge.

Fluid Data: SAE 10 Lube Oil at 60°F

Commentary:

See the Results Comparison Table below.

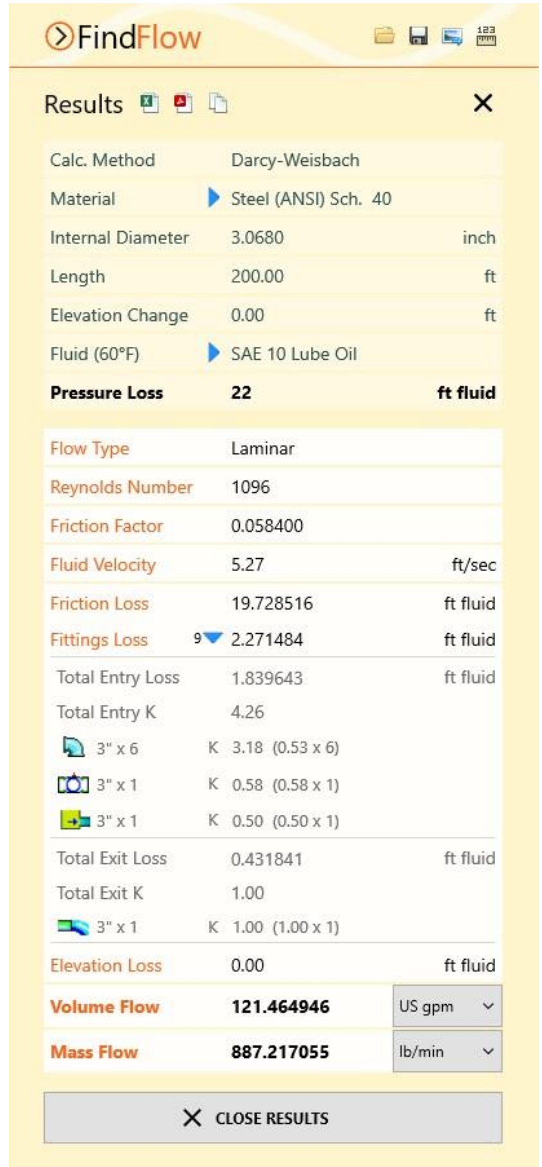
The published data and the calculated results differ by 3%.

The published text acknowledges that the problem has two unknowns and requires a trial and error solution.

The published data results are for the initial assumed velocity. The published result is therefore likely to be slightly inaccurate.

The Pipe Flow Wizard software performs numerous iterations to find a solution which is accurate to within 0.0004 ft head of pressure loss.

A new valve fitting was created in Pipe Flow Wizard to model the flanged ball valve as this item is not included in the database of standard valves and fittings.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Fluid Velocity in Pipe (ft/s)	5.13	5.27
Rate of Discharge (gpm US)	118	121.46
Reynolds Number	1040 (1st Iteration)	1096
Friction Factor	0.062 (1st Iteration)	0.05840

Find Diameter

Case 01: Design of a Uniform Pipeline

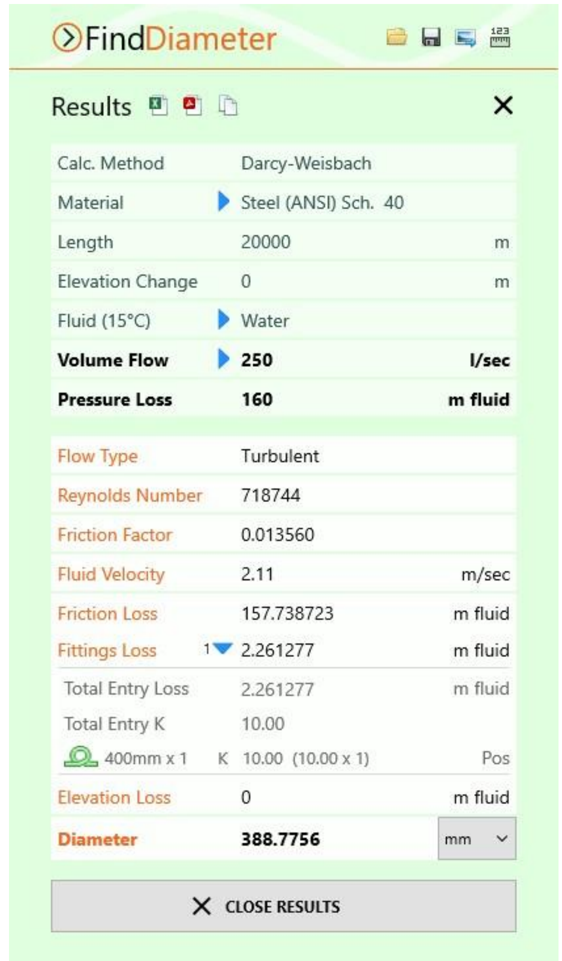
Reference: Nalluri & Featherstone's Civil Engineering Hydraulics sixth edition, 2016, Martin Marriott, Page 105, Example 4.7

Pipe Flow Wizard Software: Find_Diameter_Case_01_Pipeline_Diameter_Between_Two_Reservoirs.pfwd

Calculation Problem:

A uniform pipeline of length 20 km is to be designed to convey water at a minimum rate of 250 L/s from an impounding reservoir to a service reservoir, the minimum difference in water level between which is 160 m. Local losses, including entry loss and velocity head, total $10V^2/2g$.

Determine the diameter of a standard commercially available lined spun iron pipeline which will provide the required flow when in new condition (k= 0.03mm).



Fluid Data: Water.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The final row shows the Pipe Flow Wizard software calculated diameter at 388.78 mm for the minimum flow rate of 250 L/s, which would lead to the selection of a pipe with a 400mm diameter.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard	With Local Losses	At Flow Rate
Inner Diameter	350 mm	350.05 mm	0	191.1 L/s
Inner Diameter	400 mm	400.01 mm	0	271.5 L/s
Inner Diameter	400 mm	400.02 mm	$10V^2/2g$	269.4 L/s
Inner Diameter	Not Calculated	388.78 mm	$10V^2/2g$	250 L/s

Case 02: Pump – Storage Power Scheme – Pipeline design

Reference: Nalluri & Featherstone's Civil Engineering Hydraulics sixth edition, 2016, Martin Marriott, Page 110, Example 4.10

Pipe Flow Wizard Software: Find_Diameter_Case_02_Pipeline_Diameter_Four_Pump_Turbine.pfwd

Calculation Problem:

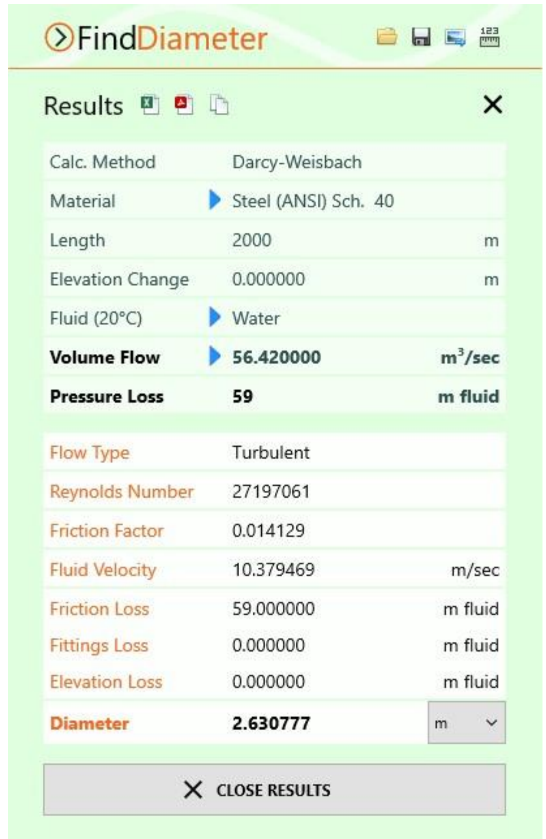
The four pump turbine units of a pumped storage hydroelectric scheme are each to be supplied by a high-pressure pipeline of length 2000 m. The minimum gross head (difference in level between upper and lower reservoirs) is 310 m and the maximum head is 340 m.

The upper reservoir has a usable volume of 3.25 x10^6 m^3 which could be released to the turbines in a minimum period of 4 hours.

Maximum power output required/turbine = 110 MW
Turbogenerator efficiency = 80%
Effective roughness of pipeline = 0.6 mm

Taking minor losses in the pipeline, power station, and draft tube to be 3.0 m, determine the minimum diameter of pipeline to enable the maximum specified power to be developed.

The book calculated a flow rate of 56.42 m^3/s is required to achieve a maximum power of 110 MW.



Fluid Data: Water.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The book uses a slight variation on the Colebrook white equation, and this likely explains the small difference in calculated diameters.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Inner Diameter	2.65 m	2.63 m

Case 03: Water - Galvanized Steel Pipe

Reference: Mechanics of Fluids 9th edition, 2012, Bernard S. Massey, John Ward-Smith Page 256, Example 7.3

Pipe Flow Wizard Software: Find_Diameter_Case_03_Galvanized_Steel_Pipeline_Diameter.pfwd

Calculation Problem:

A galvanized steel pipe carries water over a distance of 180 m at 85 L/s with head loss of 9 m**.**

Determine the size of galvanized steel pipe needed.

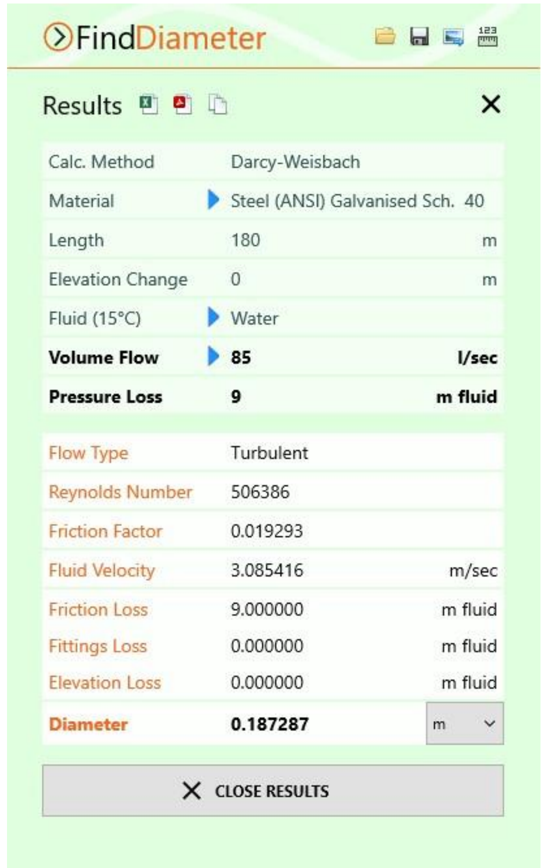
Fluid Data: Water at 15°C, viscosity = 1.14 mm^2/s.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The published problem reports a fanning friction factor which is one quarter of the Darcy friction factor reported by the Pipe Flow Wizard software.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Inner Diameter	0.1867m	0.187287 m
Reynolds Number	508000	506386
Friction Factor	0.0048	0.00482325

Case 04: Heavy Fuel Oil – Sizing a Horizontal Pipe

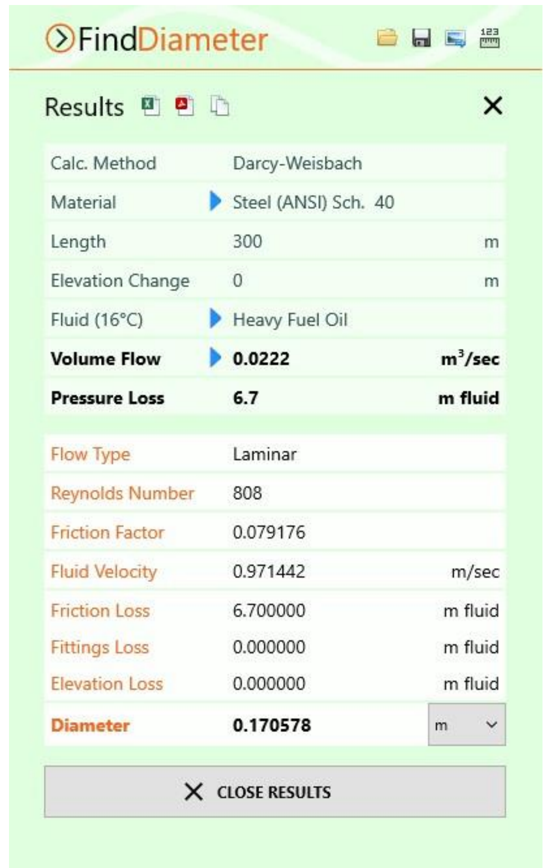
Reference: Fluid Mechanics and Hydraulics – Third Edition, 1994,
Ranald V. Giles, Jack B. Evett, Ph.D., Cheng Liu, Page 149, Example problem 8.11

Pipe Flow Wizard Software: Find_Diameter_Case_04_Horizontal_Oil_Pipe_Size.pfwd

Calculation Problem:

A 300 m length of horizontal pipe carries 0.0222 m^3/s of heavy fuel oil with an available head loss of 6.7 m.

What size pipe should be installed?



Fluid Data: Heavy Fuel Oil at 16°C
Viscosity = 0.000205 m^2/s
Specific Gravity = 0.912.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Inner Diameter	0.170 m	0.171 m
Reynolds Number	812	808

Find Length

Case 01: Length of Steel Water Pipe

Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page B-14

Pipe Flow Wizard Software: Find_Length_Case_01_Water_Steel_Pipe.pfwl

Calculation Problem:

A nominal 4 inch steel sch. 40 pipe carries water with a flow rate of 1.1140 ft^3/sec and velocity of 12.6 ft/sec.

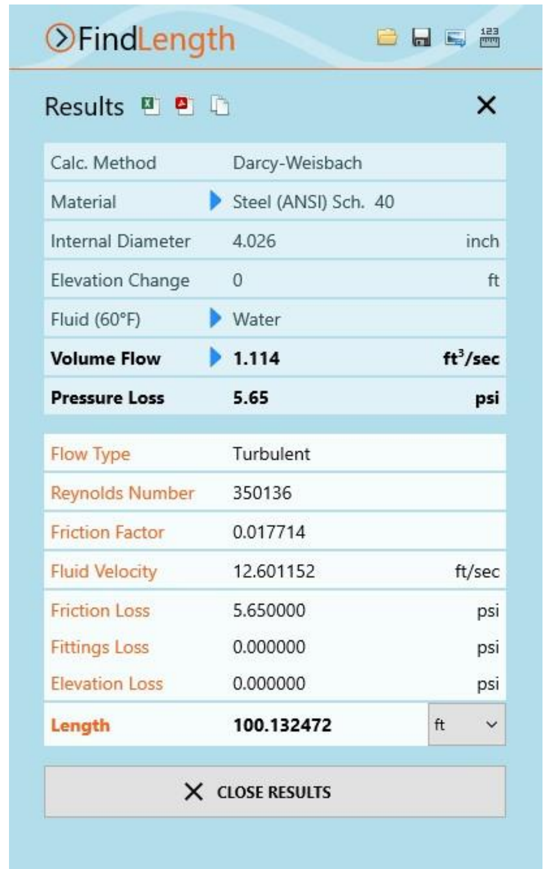
If the pressure drop is given to be 5.65 lbs/inch^2, what is the length of pipe?

Fluid Data: Water at 60°F

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Length (ft)	100	100.132

Case 02: Water Pipeline length

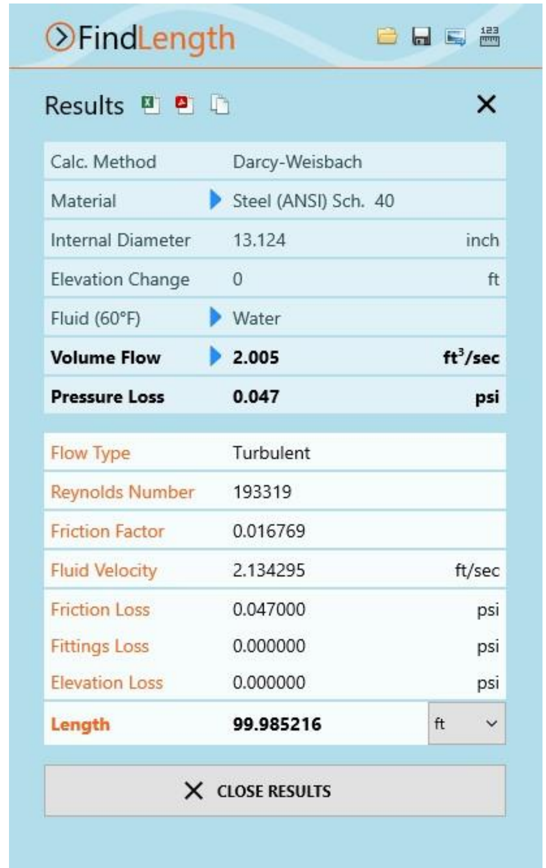
Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page B-14

Pipe Flow Wizard Software: Find_Length_Case_02_Water_Steel_Pipe.pfwl

Calculation Problem:

A nominal 14 inch steel sch. 40 pipe carries water with a flow rate of 2.005 ft^3/sec and velocity of 2.13 ft/sec.

If the pressure drop is given to be 0.047 lbs/$inch^2$, what is the length of pipe?



Fluid Data: Water at 60°F

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Length (ft)	100	99.99

Case 03: Pipeline Between Two Reservoirs with Fittings

Reference: Nalluri & Featherstone's Civil Engineering Hydraulics sixth edition, 2016
Martin Marriott, Page 96, Example 4.2

Pipe Flow Wizard Software: Find_length_Case_03_Reservoir_Pipeline_Fittings.pfwl

Calculation Problem:

A uniform, 200 mm diameter pipeline with an internal roughness of 0.03 mm, conveys water at 15°C between two reservoirs with a flow rate of 48.41 L/s.

The difference in water level between the reservoirs is 50 m.

There is an entry head loss of $0.5V^2/2g$, a valve with a head loss of $10V^2/2g$ and a velocity head of $\alpha V^2/2g$, where $\alpha = 1.0$.

Calculate the pipe length required.

Fluid Data: Water.at 15°C.

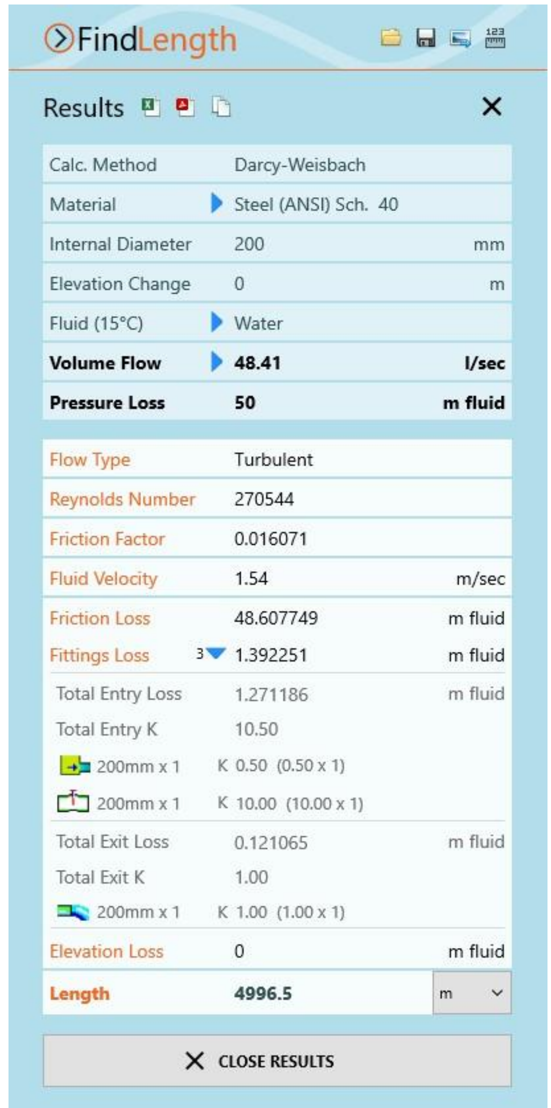
Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

This published problem states the length of pipe and uses this to calculate the steady discharge between the reservoirs, and this is only given to two decimal places.

The Pipe Flow Wizard software used the given discharge flow rate and the given head loss data to calculate the length of pipe that produced these conditions.



Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Length	5000 m	4996.5 m

References

1. Piping Calculations Manual, 2005, McGraw-Hill
   E. Shashi Menon, P.E

2. 2500 Solved Problems in Fluid Mechanics and Hydraulics, 1989, McGraw-Hill
   Jack B. Evett Ph. D., Cheng Liu M.S.

3. Basic Principles for the Design of Centrifugal Pump Installations**,** SIHI Group, 1998, SIHI-HALBERG

4. Flow of Fluids – Technical Paper No 410M, 1999, Crane Co.

5. Flow of Fluids – Technical Paper No 410, 1988, Crane Co.

6. Analysis of Flow in Pipe Networks, 1976, Ann Arbor Science Publishers Inc.
   Rowland W. Jeppson.

7. Chemical Engineering, Sixth Edition, 1999, Elsevier Butterworth Heinemann
   J.M. Coulson, J. F. Richardson with J.R. Backhurst, J.H. Harker.

8. Nalluri & Featherstone's Civil Engineering Hydraulics sixth edition, 2016,
   Martin Marriott

9. Mechanics of Fluids 9th edition, 2012
   Massey, John Ward-Smith

10. Fluid Mechanics and Hydraulics – Third Edition, 1994
    Ranald V. Giles, Jack B. Evett, Ph.D., Cheng Liu