pipeFLOW®

taking the pressure out of fluid flow calculations

Liquid pressure drop

Verification of Calculation Results
For Non-Compressible Flow

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Table of Contents – Results Data: Systems Solved by Liquid Pressure Drop

Introduction

Pipe Flow Liquid Pressure Drop is a software application that calculates the pressure drop for liquids in a pipe due to pipe friction losses using the Darcy Weisbach equation with Colebrook-White friction factors. The pressure drop in the pipe is affected by items such as the internal roughness of the pipe material, internal pipe diameter, length of pipe, fluid flow rate, fluid density, fluid viscosity, and the length of pipe used.

The liquid pressure loss calculations produced by the Pipe Flow Liquid Pressure Drop 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 **App 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 Liquid Pressure Drop 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.

Software Releases

The Pipe Flow Liquid Pressure Drop App is currently available only on iOS (Apple Mobile Devices).

Pipe Flow Software produces a range of different software applications for calculating flow rates and pressure losses in pipe systems, including our premier Pipe Flow Expert software for Windows, which is used to design energy efficient piping and pumping systems.

Pipe Flow Software programs are 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.

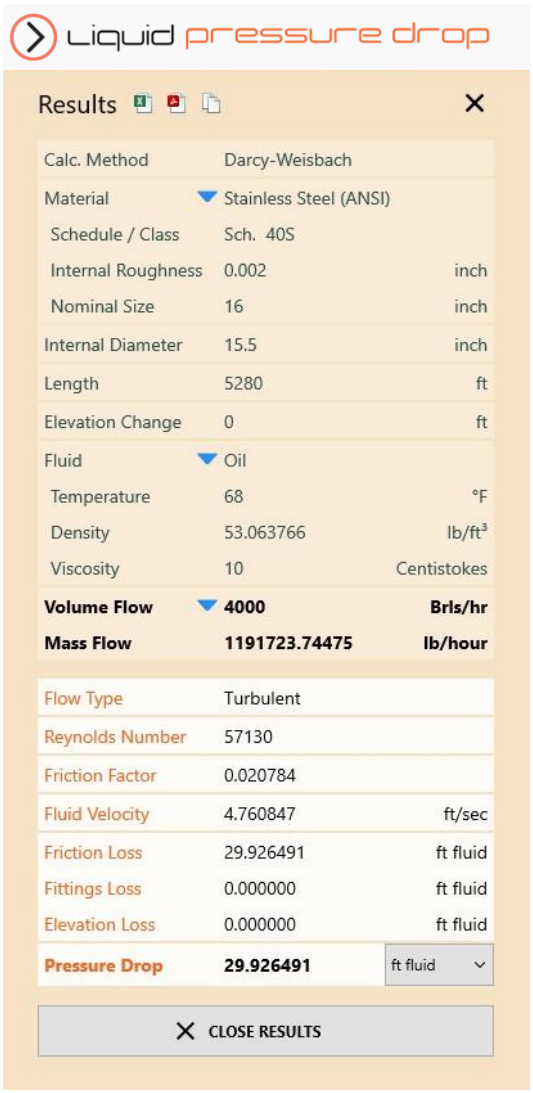
Case 01: Petroleum - Oil Pipeline Pressure Loss

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

Liquid Pressure Drop App: 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 App 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	App
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

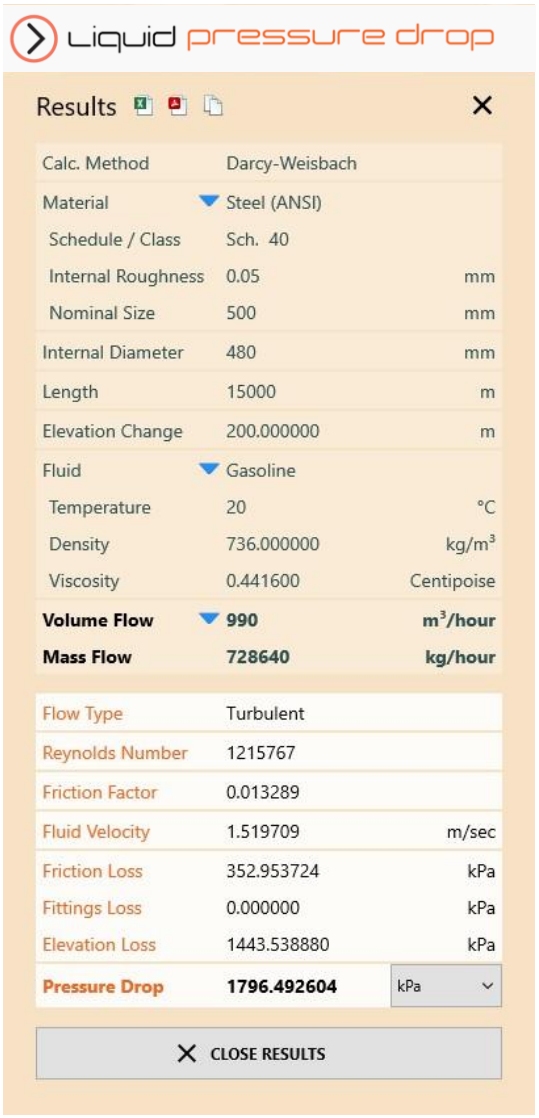
Reference: Piping Calculations Manual, 2005, McGraw-Hill, E. Shashi Menon, P.E., Page 337, Example 6.17

Liquid Pressure Drop App: 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 App 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	App
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

Liquid Pressure Drop App: 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 App calculates the friction factor to a greater number of decimal places.

Results Comparison:

Data Item	Published Data	App
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

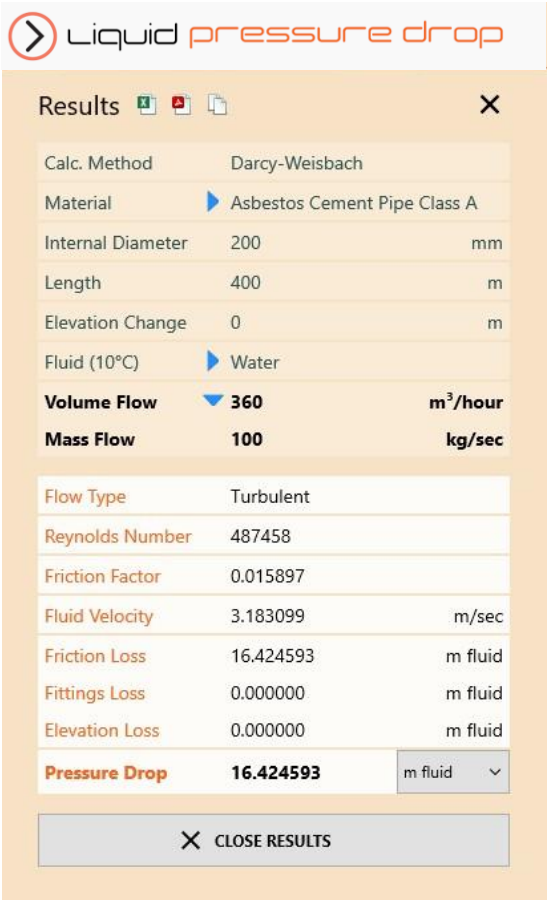
Liquid Pressure Drop App: Find_Pressure_Case_04_Water_Asbestos_Cement_Pipe_Friction_Loss.pfwp

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	App
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

Liquid Pressure Drop App: 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	App
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

Liquid Pressure Drop App: 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	App
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

Liquid Pressure Drop App: 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.

The App 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	App
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

Liquid Pressure Drop App: 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	App
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

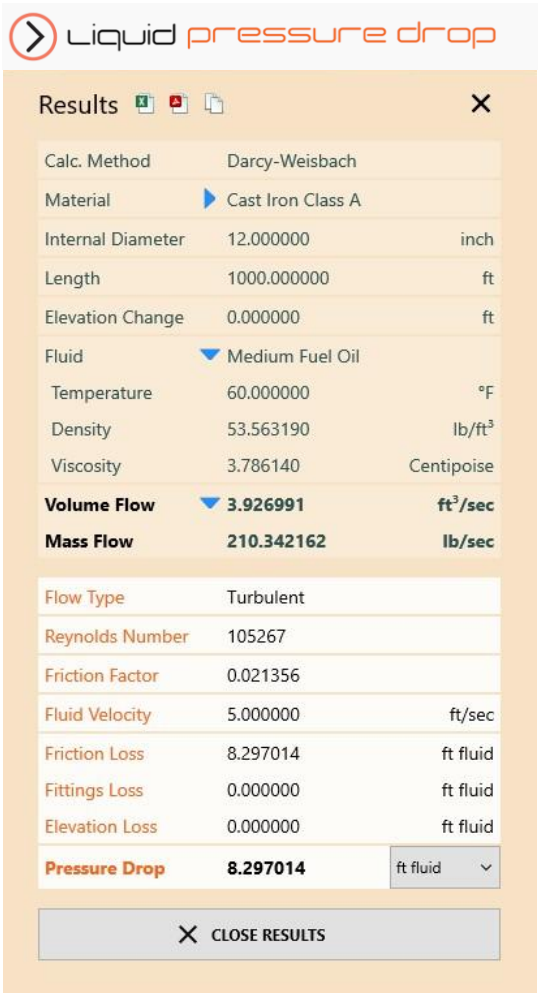
Liquid Pressure Drop App: Find_Pressure_Case_09_Water_Oil_Cast_Iron_Pipe.pfwp

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 Liquid Pressure Drop calculation.

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

The App used the Colebrook- White equation to calculate the accurate friction factor.

Results Comparison:

Data Item	Published Data	App	Published Data	App
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

Liquid Pressure Drop App: 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 Liquid Pressure Drop 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 App 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	App
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

Liquid Pressure Drop App: Find_Pressure_Case_11_Oil_Laminar_Flow.pfwp

Calculation Problem:

A flow rate of 150 gpm (0.00947 m^3/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/ft^2 (0.0718 N·sec/m^2)
Density $\rho = 1.7$ slug/ft^3 (876 kg/m^3).

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	App
Pressure Loss (ft head)	30.2	30.244
Reynolds Number	1450	1447

Case 12: Oil – Head loss in Cast Iron Pipeline

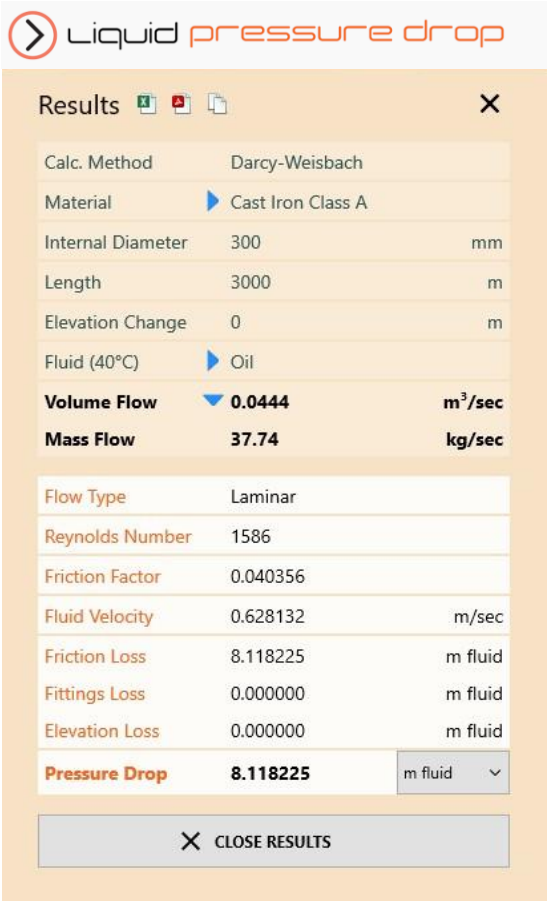
Reference: Fluid Mechanics and Hydraulics – Third Edition, 1994,
Ranald V. Giles, Jack B. Evett, Ph.D., Cheng Liu, Page 149, Example problem 8.11

Liquid Pressure Drop App: 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	App
Pressure Loss (m head)	8.14	8.118
Reynolds Number	1582	1586
Friction Factor	0.0405	0.040356

References

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