taking the pressure out of fluid flow calculations

www.pipeflow.com

Pipe Flow Wizard

Software for Fluid Flow and Pressure Loss Calculations

Gases

Verification of Calculation Results For Compressible Isothermal Flow

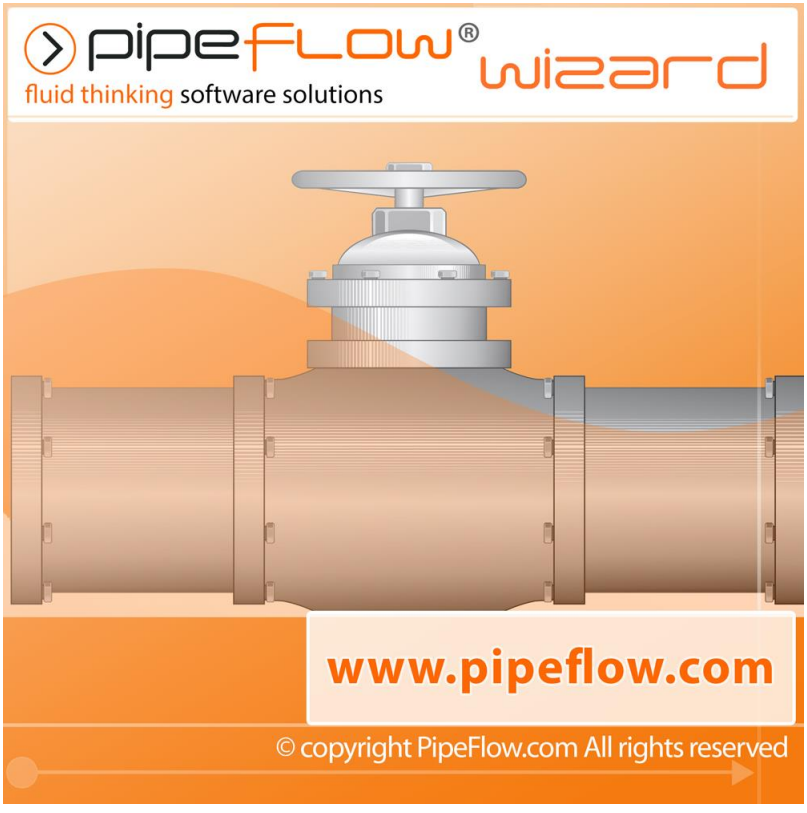


Table of Contents – Results Data: Systems Solved by Pipe Flow Wizard

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 data for compressible gas systems. 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 pressure drops, flow rates, diameter sizes and pipe lengths.

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

Fluid Properties for the pressure condition at the start of each pipe are calculated from the user defined fluid data using the **Ideal Gas Law** plus any specified **Compressibility Factor Z** to establish the density of the gas.

Ideal Gases are considered to be perfectly elastic. Ideal gases follow Boyle's Law & Charles's Law thus the gas density at various points in the system can be calculated using these equations.

Real Gases behave according to a modified version of the ideal gas law. The modifying factor is known as the **Gas Compressibility Factor Z.** Where natural gas pressures are higher than 115 psi.a (800 kPa.a) the gas compressibility factor may not be close to 1.00, so it can be advisable to use a gas compressibility factor based on the pressure in the pipe.

There are different methods that can be used to calculate a gas compressibility factor for a specific pressure condition. The California Natural Gas Association (CNGA) method provides such a calculation for natural gas. The Pipe Flow Wizard software includes the option to automatically use the CNGA method to determine the natural gas compressibility for the average conditions in each pipe. The CNGA factor is then applied when calculating the gas flow rate using a specific Isothermal Flow Equation that allows for gas compressibility. The CNGA compressibility factor is only applicable to natural gas and is not applicable to other gases such as air etc.

The General Fundamental Isothermal Flow Equation (sometimes known as just the **General Flow equation** or the **Fundamental Flow equation**) provides perhaps the most universal method for calculating isothermal flow rates, however it relies on the inclusion of an accurate friction factor. The Pipe Flow Wizard software calculates an accurate friction factor using the Colebrook-White equation.

In addition to the **General Flow Equation**, Pipe Flow Wizard provides the functionality to allow calculations based on alternative equations such as:

The **Complete Isothermal Flow Equation (as defined in Crane Technical Paper 410)**,

The **AGA Isothermal Flow Equation,**

The **Weymouth Isothermal Flow Equation**,

The **Panhandle A Isothermal Flow Equation,**

The **Panhandle B Isothermal Flow Equation.**

The **IGT Isothermal Flow Equation.**

Each of these equations can be used to calculate isothermal flow rates in pipes. Most of these equations use a Pipeline Efficiency factor (instead of a friction factor) and a Compressibility Factor. The software allows the user to specify the factors that are used in the calculations.

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: Air Pipeline Pressure Loss

Reference: Fluid Mechanics and Hydraulics, 3rd Ed, 1994,
McGraw-Hill; R. V. Giles, J. B. Evett PhD, C. Liu, page 238, Example 11.2

Pipe Flow Wizard Software: Find_Pressure_Case_01_Air_Pipeline_Pressure_Loss.pfwp

Calculation Problem:

Air at 18 °C flows isothermally through a 300 mm diameter pipe at a flow rate of 0.450 kN/s (equivalent to 45.887 kg/s). The pipe is smooth (friction factor = 0.0080).

If the pressure at the entry point is 550 kPa, find the pressure at a point 200 m downstream.

The calculation method used for the published data was based on the Complete Isothermal equation.

Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 18 °C, 0.0 kPa.g, Viscosity 0.0181 Centipoise.
Fluid Data: Software will calculate the compressed gas properties.
Pipe Data: Internal roughness 0.000001 mm
Friction factor=0.008014
Flow Rate: 45.887 kg/s (equivalent to 0.450 kN/s).

Calculation Method: Complete Isothermal Flow equation.
Standard Atmospheric Conditions: 20°C, 101.325 kPa.
Gas Model: Ideal Gas Law.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The published data stated the flow rate as a weight in kN/s rather than as a gas flow at standard conditions. Kg/s = (kN/s) x (1000/g) where g is acceleration due to gravity, normally 9.80665 m/s², hence a mass flow rate of 45.887 kg/s was used in the Pipe Flow Wizard calculation.

The published data relied on iteration of the downstream pressure value, until it produced an approximate balance when used in the gas flow equation, after which further iteration refinements were stopped.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure Drop (kPa)	317	318.72
Pressure 200m Downstream (kPa)	233	231.28

Case 02: Gas Pipeline Outlet Pressure

Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon Chapter 2, page 65 Example 15

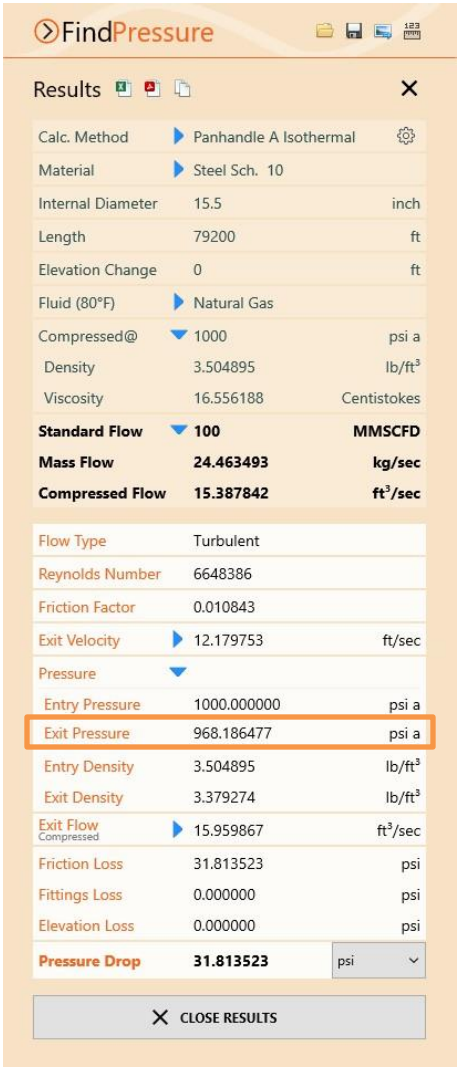
Pipe Flow Wizard Software: Find_Pressure_Case_02_Natural_Gas_Pipeline_Outlet_Pressure.pfwp

Calculation Problem:

Calculate the outlet pressure in a 15 mile natural gas pipeline, with an internal pipe diameter of 15.5 inches, where the required gas flow rate is 100 MMSCFD and the inlet pressure is 1000 psi absolute.

The pipeline efficiency value is 0.92.
The average gas temperature is 80 °F.
Gas gravity = 0.6, viscosity = 0.000008 lb/ft-sec.
Use the CNGA method to calculate gas compressibility factor Z.

The calculation method used for the published data was based on the Panhandle A equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Gas Specific Gravity 0.6 (0.045 lb/ft^3)
Viscosity 0.0119 centipoise (0.000008 lb/ft-sec)
@ 80 °F, 0.00 psi.g
Fluid Data: Software will calculate the compressed gas properties.
Pipe Data: Pipeline efficiency = 0.92.

Calculation Method: Panhandle A Isothermal equation.
Standard Atmospheric Conditions: 60 °F, 14.696 psi.a
Gas Model: Real Gas (Ideal Gas Law & CNGA compressibility factor)

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
Outlet Pressure (psi absolute)	968.35	968.19
Pressure Drop (psi)	31.65	31.81

Case 03: Gas Pipeline Inlet Pressure

Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon Chapter 2, page 67 Example 16

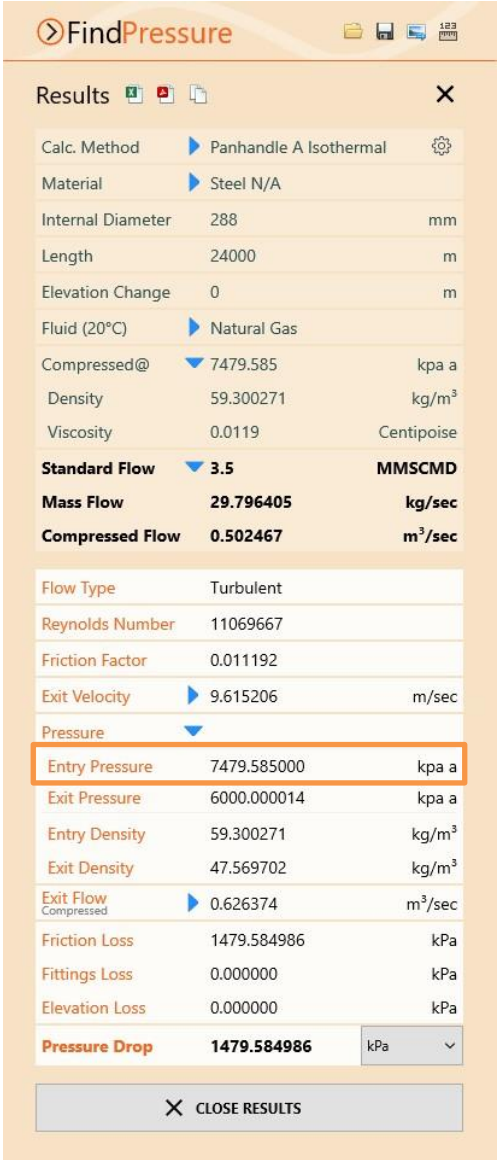
Pipe Flow Wizard Software: Find_Pressure_Case_03_Natural_Gas_Pipeline_Inlet_Pressure.pfwp

Calculation Problem:

Calculate the inlet pressure in a 24 km natural gas pipeline, with internal diameter 288 mm.

The gas flow rate is 3.5 Mm^3/day and the final delivery pressure is 6000 kPa absolute. The average gas temperature is 20 °C, the pipeline efficiency is 0.92 and the compressibility factor is 0.90.

The calculation method used for the published data was based on the Panhandle A equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Gas Specific Gravity 0.6 (0.723 kg/m^3)
Viscosity 0.0119 centipoise
@ 20 °C, 0.00 kPa.g
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Pipeline efficiency = 0.92.
Flow Rate: 3.5 MMSCMD.

Calculation Method: Panhandle A Isothermal equation,
Standard Atmospheric Conditions: 15 °C, 101.325 kPa.
Gas Model: Real Gas (Ideal Gas Law with compressibility Z=0.9)

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The publication states the gas flow rate is 3.5 Mm^3/day. Here, the 'M' stands for 'one million', which is not the same as the 'M' in "standard condition" units i.e. MSCMD. In "standard condition" units a single 'M' stands for 'one thousand', and 'MM' stands for one million.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Inlet Pressure (kPa absolute)	7471	7480
Delivery Exit Pressure (kPa absolute)	6000	6000
Pressure Drop (kPa)	1471	1479

Case 04: Methane Compressor to Processing Unit

Reference: Chemical Engineering Volume 1, 6th Ed, 1999,
Elsevier, J M Coulson, J F Richardson, page 168 Example 4.3

Pipe Flow Wizard Software: Find_Pressure_Case_04_Methane_Compressor_Flow_Rate.pfwp

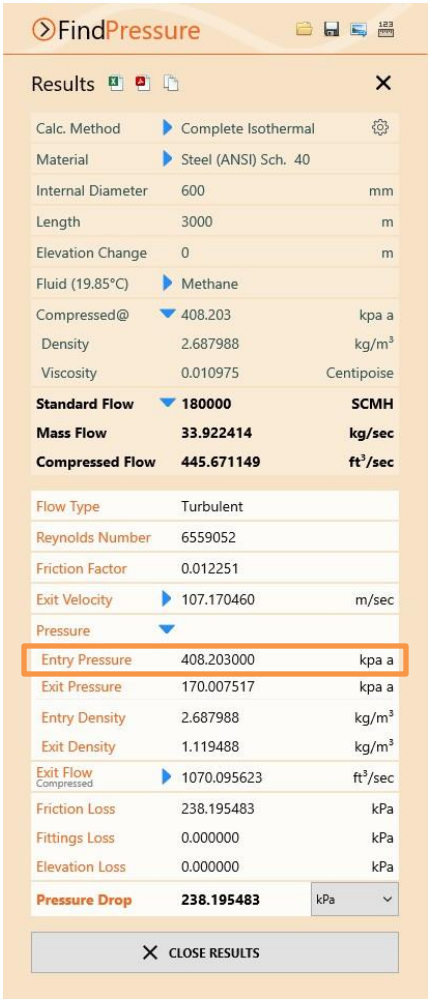
Calculation Problem:

A flow of 50 m^3/s (180000 m^3/h) of methane, starting at a temperature of 288 K and 101.3 kN/m^2 must be delivered along a 0.6 m diameter line, 3.0 km long with a relative roughness of 0.0001, linking a compressor and a processing unit.

The delivery pressure is to be 170 kN/m^2 (170 kPa) and the delivery temperature 288 K. The methane leaves the compressor at 297 K.

What pressure is needed at the compressor to achieve this flow rate?

The calculation method used for the published data was based on the Complete Isothermal equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Methane at 293 K average, 0.00 kPa.g,
Density 0.667218 kg/m^3
Viscosity 0.0108 centipoise.
Fluid Data: Software will calculate the compressed gas properties.
Pipe Data: Absolute roughness 0.06 mm.

Calculation Method: Complete Isothermal Flow equation.
Standard Atmospheric Conditions: 15°C, 101.325 kPa
Gas Model: Ideal Gas Law

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
Entry Pressure Required (kPa absolute)	405.00	408.203
Compressor Pressure (N/m^2)	405000	408203

Case 05: Natural Gas Pipeline Inlet Pressure

Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon, Chapter 3, page 118 Example 8, First part.

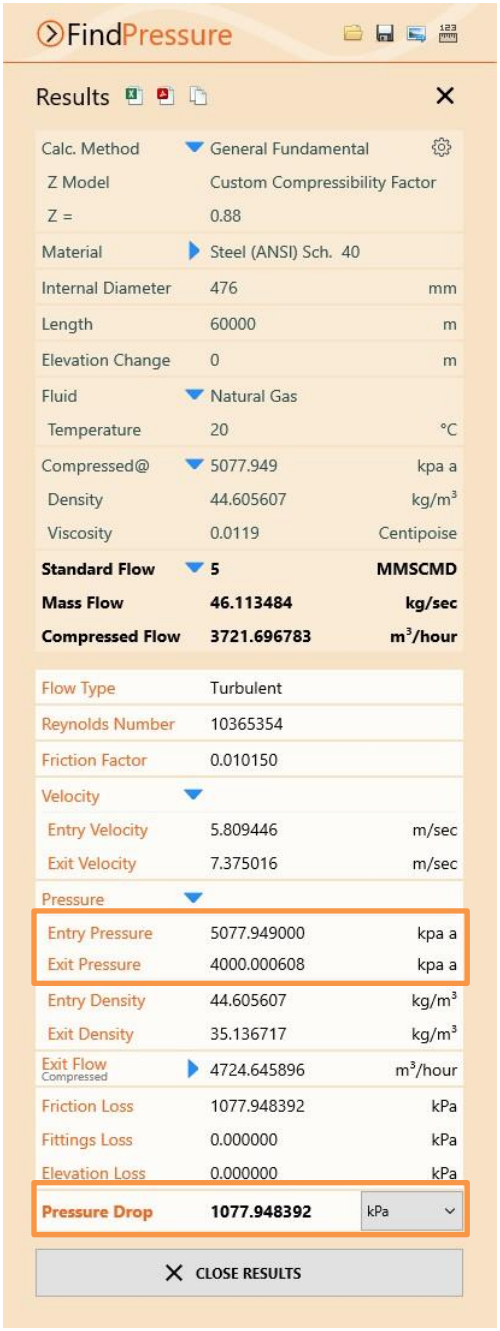
Pipe Flow Wizard Software: Find_Pressure_Case_05_Natural_Gas_Pipeline.pfwp

Calculation Problem:

A natural gas pipeline, internal diameter 476 mm, is 60 km long.
The gas flow rate is 5.0 Mm^3/day at 20 °C.
The pipe roughness is 0.015 mm.
Gas gravity is 0.65 and the compressibility factor is 0.88.

Calculate the inlet pressure required to achieve a delivery pressure of 4 MPa.a (4000 kPa.a).

The calculation method used for the published data was the General Flow equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Natural Gas
Specific Gravity 0.65 (0.783 kg/m^3)
Viscosity 0.0119 centipoise
@ 20 °C, 0.0 bar.g
Fluid Data: Software calculates the compressed gas properties.
Pipe Data: Absolute roughness 0.015 mm.

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 15°C, 101.325 kPa.
Gas Model: Real Gas (Ideal Gas Law & compressibility Z=0.88)

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
Inlet pressure (MPa absolute)	5.077	5.07795
Pressure Drop (MPa)	1.077	1.07795
Delivery Pressure (MPa)	4.0	4.0

Case 06: Gas Pipeline Outlet Pressure vs Length

Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon Chapter 2, page 80

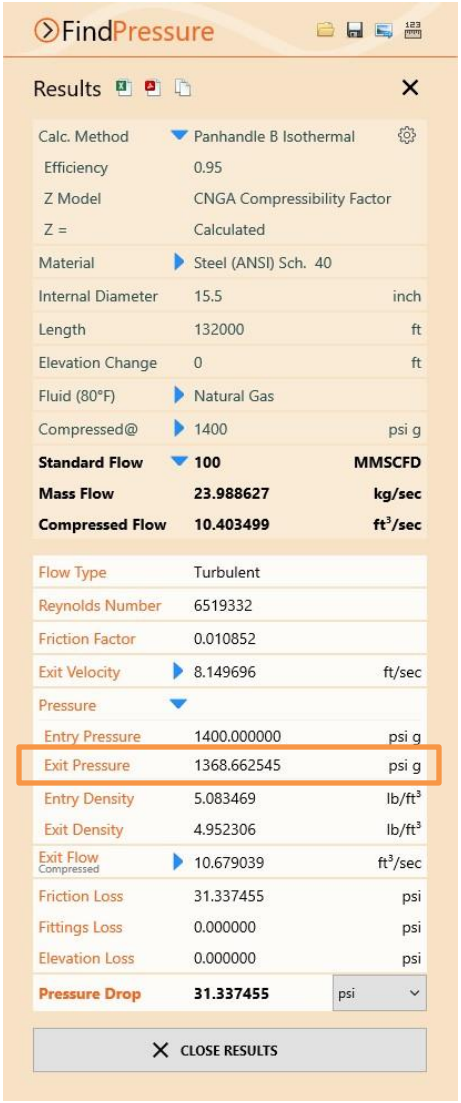
Pipe Flow Wizard Software: Find_Pressure_Case_06_Outlet_Pressure_vs_Length.pfwp

Calculation Problem:

For a gas pipeline, 100 miles in length and 15.5 inch internal diameter, use different flow equations to compare the outlet pressure at points 25 miles, 50 miles, 75 miles and 100 miles downstream from the start of the pipe for a gas flow rate of 100 MMSCFD.

The gas temperature is 80 °F, and the upstream pressure at the start of the pipe is fixed at 1400 psi.g.

The published data compares 5 different calculation equations: Panhandle A, Panhandle B, General with Colebrook-White, AGA and Weymouth. For details of pipeline efficiency and gas compressibility see comments in results table.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Natural Gas
Specific Gravity 0.6 (0.044 lb/ft^3)
Viscosity 0.0119 centipoise
@ 80 °F, 0.0 psi.g
Fluid Data: Software calculates the compressed gas properties.
Pipe Data: Roughness 700 micro-inches.

Calculation method: Various isothermal flow equations.
Standard Atmospheric Conditions: 60 °F, 14.696 psi.a.
Gas Model: Real Gas (Ideal Gas Law & CNGA compressibility factor)

A pipeline efficiency value of 0.95 was used in the Panhandle and Weymouth equations. The General Fundamental Isothermal Flow equation used Colebrook-White friction factors. The CNGA compressibility factor was used with all isothermal flow equations except for the AGA Ideal Gas Case.

Commentary:

See the Results Comparison Tables that follow.

The published results specified a pipe roughness (700 μ inches) for use in both the AGA & General Flow equations (with Colebrook-White friction factors) and a pipeline efficiency of 0.95 for used in the Panhandle & Weymouth equations. Reference to IR=0.0007 in the comparison tables means an internal roughness of 700 μ inches.

The published data did not specify if a compressibility factor had been used in the calculations, however most of the other example calculations in the published work included a compressibility factor. In the Pipe Flow Wizard software, the CNGA (Californian Natural Gas Association) method for automatic calculation of the compressibility factor was selected. The calculated results compare well with the published graph readings, indicating that a compressibility factor was used in the calculation of the published data for all equations except the published AGA results, which appear to have been based on assumption of the Ideal Gas Law with no compressibility.

Result Comparison:

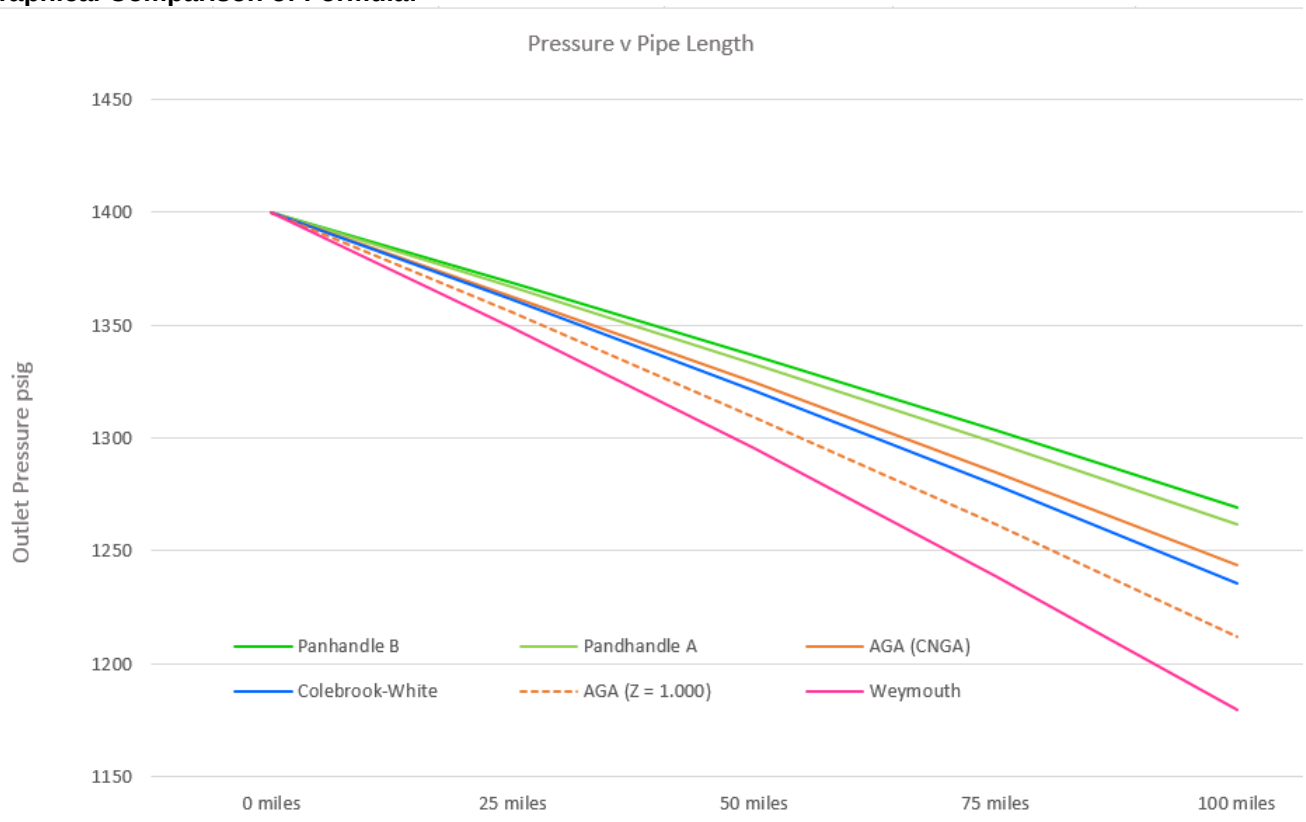
Published Graph Readings of Outlet Pressures (Psi.g):

Formula	Panhandle B	Panhandle A	General Colebrook-White	AGA	AGA Ideal Gas	Weymouth
Friction	Effic. = 0.95	Effic. = 0.95	IR =0.0007in	IR =0.0007in	IR =0.0007in	Effic. = 0.95
Assumed Compressibility	CNGA factor	CNGA factor	CNGA factor	CNGA factor	Ideal gas Z = 1.000	CNGA factor
25 miles	1368	1365	1359	Not available	1353	1345
50 miles	1335	1330	1318	Not available	1305	1289
75 miles	1303	1295	1276	Not available	1258	1234
100 miles	1270	1260	1235	Not available	1210	1178

Pipe Flow Wizard Calculated Results of Outlet Pressures (Psi.g):

Formula	Panhandle B	Panhandle A	General Colebrook-White	AGA	AGA Ideal Gas	Weymouth
Friction	Effic. = 0.95	Effic. = 0.95	IR =0.0007in	IR =0.0007in	IR =0.0007in	Effic. = 0.95
Compressibility	CNGA factor	CNGA factor	CNGA factor	CNGA factor	Ideal gas Z = 1.000	CNGA factor
25 miles	1368.66	1366.93	1361.00	1362.82	1355.35	1348.72
50 miles	1336.48	1332.91	1320.67	1324.42	1309.20	1295.10
75 miles	1303.37	1297.86	1278.88	1284.71	1261.38	1238.81
100 miles	1269.27	1261.69	1235.46	1243.54	1211.69	1179.44

Graphical Comparison of Formula:



Case 07: Fifty Mile Long Pipeline Inlet Pressure

Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon, Chapter 3, page 87 Example 1, Case A

Pipe Flow Wizard Software: Find_Pressure_Case_07_Pipe_Inlet_Pressure_50Miles.pfwp

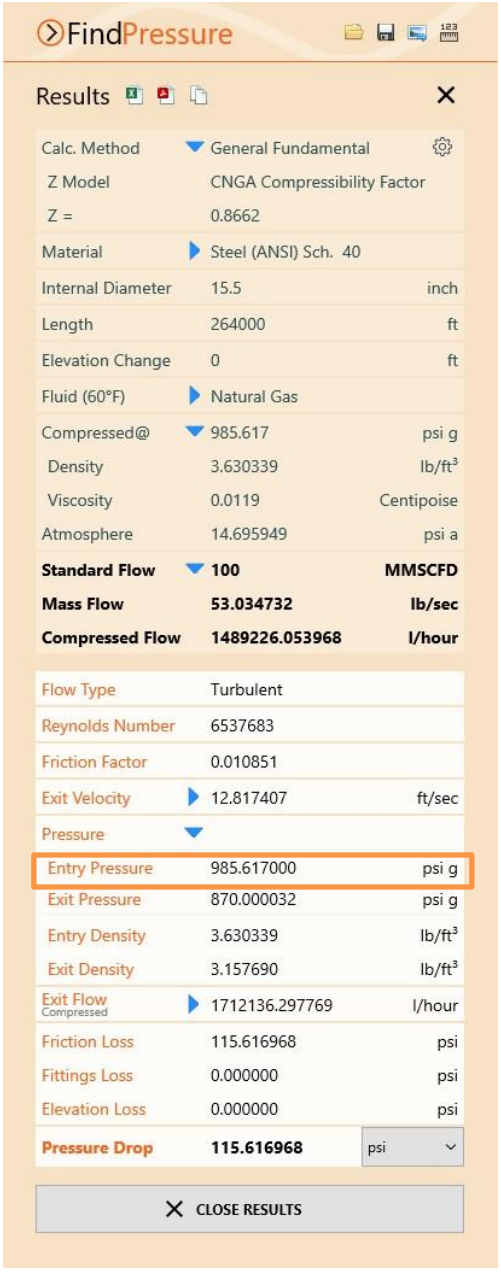
Calculation Problem:

A gas pipeline, 15.5 inch internal diameter, 50 miles long, transports natural gas (SG = 0.6 and viscosity = 0.0119 centipoise) at a flow rate of 100 MMSCFD at an inlet temperature of 60 °F.

Assuming isothermal flow, calculate the inlet pressure required if the required delivery pressure at the pipeline terminus is 870 psi.g.

Case A: No elevation changes along the pipeline length.

The calculation method used for the published data was based on the General Flow equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Natural Gas
Specific Gravity 0.6 (0.04582 lb/ft³)
Viscosity 0.01191 centipoise
@ 60 °F, 14.696 psi.a
Fluid Data: Software will calculate the compressed gas properties.
Pipe Data: Absolute roughness 0.0007 inches.

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 60 °F, 14.696 psi.a
Gas Model: Real Gas (Ideal Gas Law with CNGA calculated compressibility factor).

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The published result was calculated using a compressibility factor of 0.8662, which was derived using the CNGA formula. The Pipe Flow Wizard software automatically calculated the same CNGA 0.8662 compressibility factor.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Inlet Pressure (psi.g) for Case A	985.66	985.62

Case 08: Air Pressure Drop in Steel Pipe

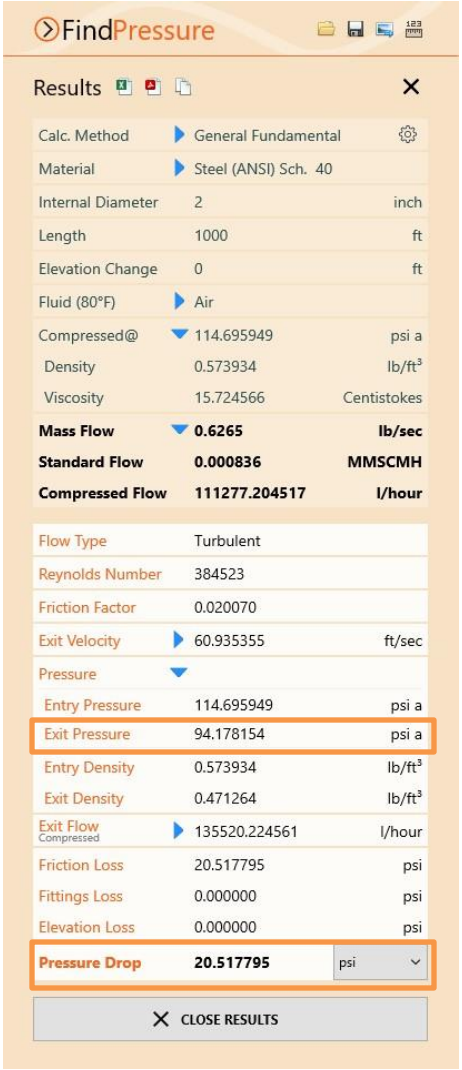
Reference: Piping Calculations Manual, 2005, McGraw-Hill, E. Shashi Menon, Chapter 5, page 265 Example 5.8

Pipe Flow Wizard Software: Find_Pressure_Case_08_Air_Flow_Pressure_Drop.pfwp

Calculation Problem:

Air flows at velocity of 50 ft/s in a 2" inside diameter pipe at 80°F, at an initial pressure of 100 psi.g. If the pipe is horizontal and 1000 ft long, calculate the pressure drop if the flow is isothermal.

Use a friction factor of 0.02. The calculation method used for the published data was based on the General Isothermal Flow Equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 80 °F, 0.0 psi.g
Density 0.0736 lb/ft^3, Viscosity 0.0185 centipoise.
Fluid Data: Software calculates the compressed gas properties.
Pipe Data: Internal Roughness 0.001853 inches (Steel Sch. 40)

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Ideal Gas Law.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The normal pipe roughness for mild steel pipe is 0.001811 inches, however this was adjusted to 0.001853 inches to give a friction factor of 0.02 as assumed in the published text.

Although the fluid data is defined for 80°F and 0.0 psi.g, the Pipe Flow Wizard software's compressible flow calculation engine automatically accounts for compression of the air to the 100 psi.g starting condition.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Outlet Pressure (psi.a)	94.18	94.178
Pressure Drop (psi)	20.52	20.518

Case 09: Air Flowing through Horizontal Pipe

Reference: Elementary Fluid Mechanics, 1940
John Wiley & Sons, Inc., John K. Vennard, page 163 “Illustrative Problem”

Pipe Flow Wizard Software: Find_Pressure_Case_09_Air_Through_Horizontal_Pipe.pfwp

Calculation Problem:

Air is pumped from a reservoir at 50 psi.a through a clean horizontal smooth pipe 3” in diameter and 2000 ft long. The conditions of flow are isothermal and the temperature of the gas is 100 degrees F.

With a flow rate of 40 lb/min what is the pressure 2000 ft downstream?

The calculation method used for the published data was the Simplified version of the Complete Isothermal Equation, which neglects the term 2*ln(V2/V1) since this is normally small compared to f*(L/D).

Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 100 °F, 0.0 psi.g
Density 0.071 lb/ft^3, Viscosity 0.0191 centipoise.
Fluid Data: Software calculates the compressed gas properties.
Pipe Data: Internal diameter 3 inches
Internal roughness 0.000001 inches.

Calculation Method: Complete Isothermal Flow equation.
Standard Atmospheric Conditions: 68 °F, 14.696 psi.a
Gas Model: Ideal Gas Law

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The published result was calculated using a friction factor of 0.0145 (which was read from a graph).

The Pipe Flow Wizard software used a pipe roughness of 0.000001 inches, calculating a friction factor of 0.014818.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Pressure 2000 feet downstream (psi.a)	39.3	38.959
Friction Factor	0.0145	0.014818

Case 10: Gas Pipeline Inlet Pressure vs Flow Rate

Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon Chapter 2, page 81

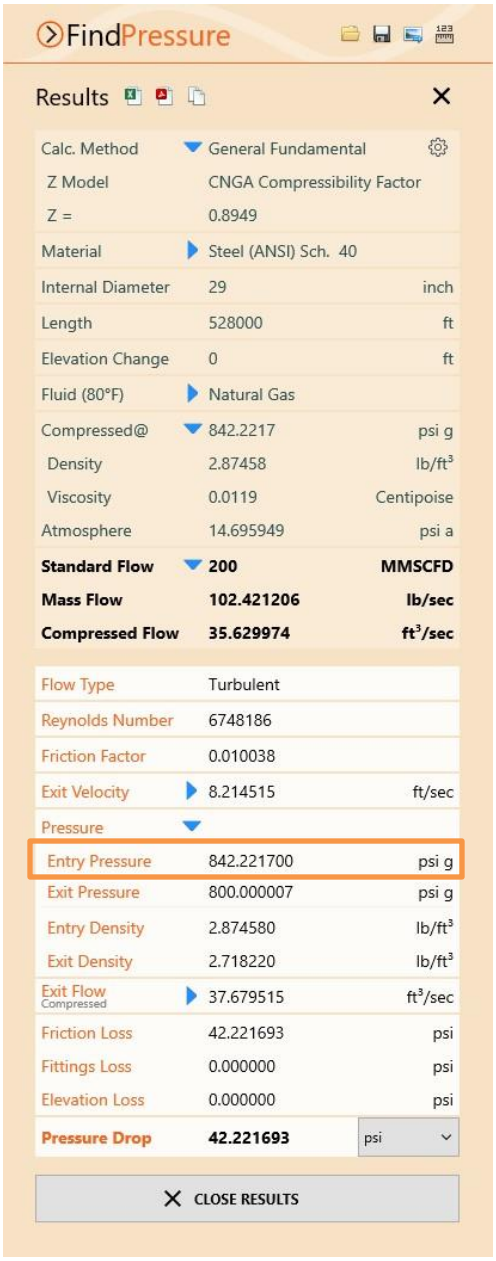
Pipe Flow Wizard Software: Find_Pressure_Case_10_Inlet_Pressure_vs_Flow_Rate.pfwp

Calculation Problem:

For a 100 mile long gas pipeline, 29.0 inch internal diameter, use different flow equations to compare the inlet pressure for gas flow rates of 200, 300, 400, 500 and 600 MMSCFD.

The gas temperature is 80 °F, and the delivery pressure at the end of the pipe is fixed at 800 psi.g.

The published data used 5 different calculation methods for comparison: Panhandle A, Panhandle B, General with Colebrook-White, AGA and Weymouth. For details of pipeline efficiency and gas compression see comments in results table.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Gas specific gravity 0.6 at 80 °F, 0.00 psi.g, Density 0.044 lb/ft^3, Viscosity 0.0119 centipoise.
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Roughness 700 micro-inches.

Calculation Method: Various Isothermal flow equations.
Standard Atmospheric Conditions: 60 °F, 14.696 psi.a
Gas Model: Real Gas (Ideal Gas Law with CNGA compressibility)

The General Fundamental Flow equation used Colebrook-White friction factors. The Panhandle and Weymouth equations used a pipeline efficiency value of 0.95.

The CNGA compressibility factor was used with all isothermal flow equations except for the AGA Ideal Gas case.

Commentary:

See the Results Comparison Table to compare data for each of the different flow rates specified in the calculation problem.

The published results specified a pipe roughness (700 μ inches) for use in both the AGA & General Flow equations (with Colebrook-White friction factors) and a pipeline efficiency of 0.95 for use in the Panhandle & Weymouth equations. Reference to IR=0.0007in in the results means an internal roughness of 700 μ inches was used.

The published data did not specify if a compressibility factor had been used in the calculations, however most of the other example calculations in the published work included a compressibility factor. In the Pipe Flow Wizard software, the CNGA (Californian Natural Gas Association) method for automatic calculation of the compressibility factor was selected. The calculated results compare well with the published graph readings, indicating that a compressibility factor was used in the calculation of the published data for all equations except the published AGA results, which appear to have been based on assumption of the Ideal Gas Law with no compressibility.

Results Comparison:

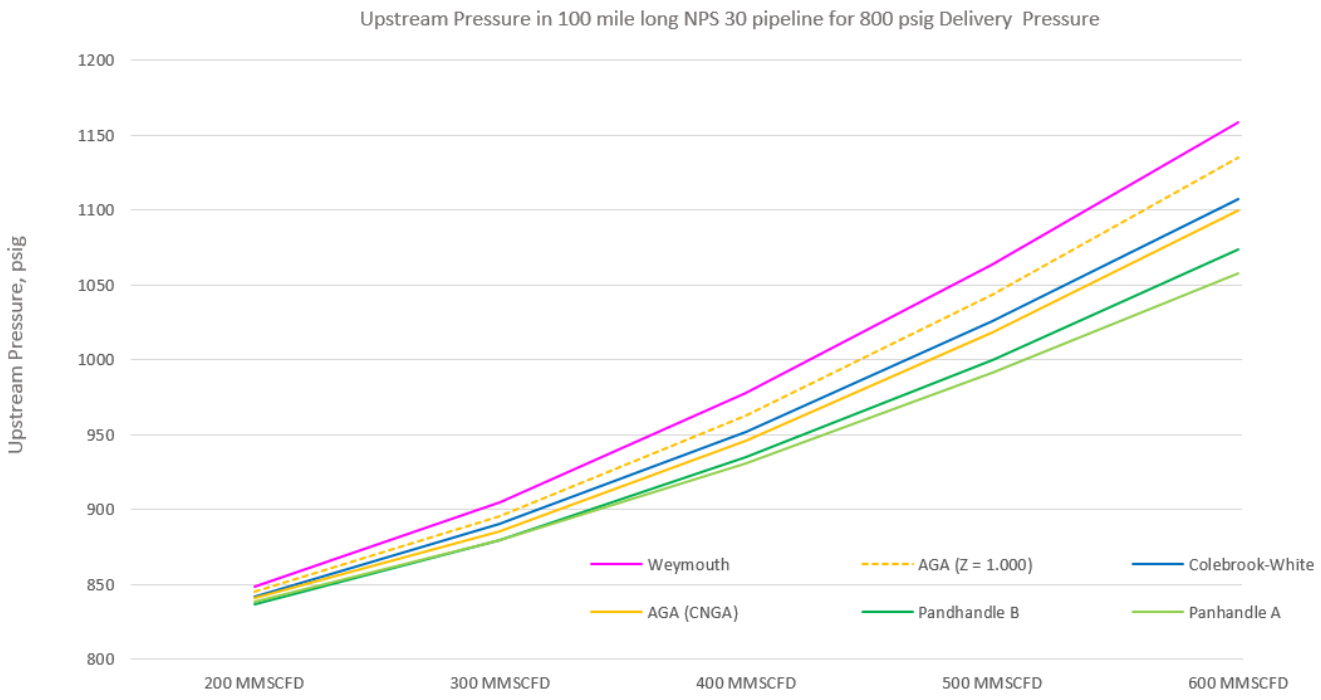
Published Graph Readings of Inlet Pressures (Psi.g):

Formula	**Panhandle A**	**Panhandle B**	**General** Colebrook-White	**AGA**	**AGA Ideal Gas**	**Weymouth**
Friction	Effic.=0.95	Effic.=0.95	IR=0.0007in	IR=0.0007in	IR=0.0007in	Effic.=0.95
Assumed Compressibility	CNGA factor	CNGA factor	CNGA factor	CNGA factor	Ideal gas Z = 1.000	CNGA factor
200 MMSCFD	837	837	844	Not available	846	850
300 MMSCFD	882	882	894	Not available	900	909
400 MMSCFD	942	947	960	Not available	977	987
500 MMSCFD	1010	1020	1040	Not available	1060	1080
600 MMSCFD	1074	1093	1132	Not available	1156	1172

Pipe Flow Wizard Calculated Results of Inlet Pressures (Psi.g):

Formula	**Panhandle A**	**Panhandle B**	**General** Colebrook-White	**AGA**	**AGA Ideal Gas**	**Weymouth**
Friction	Effic. = 0.95	Effic. = 0.95	IR =0.0007in	IR =0.0007in	IR =0.0007in	Effic. = 0.95
Compressibility	CNGA factor	CNGA factor	CNGA factor	CNGA factor	Ideal gas Z = 1.000	CNGA factor
200 MMSCFD	838.52	836.83	842.22	840.77	845.42	848.24
300 MMSCFD	879.52	879.32	890.07	885.53	895.30	904.63
400 MMSCFD	931.13	934.57	952.06	946.26	963.02	977.63
500 MMSCFD	991.03	1000.09	1025.33	1018.52	1043.74	1063.43
600 MMSCFD	1057.28	1073.64	1107.33	1099.75	1134.72	1158.78

Graphical Comparison of Formula:



Case 11: Air – Flow Through 100m Lengths of Steel Pipes

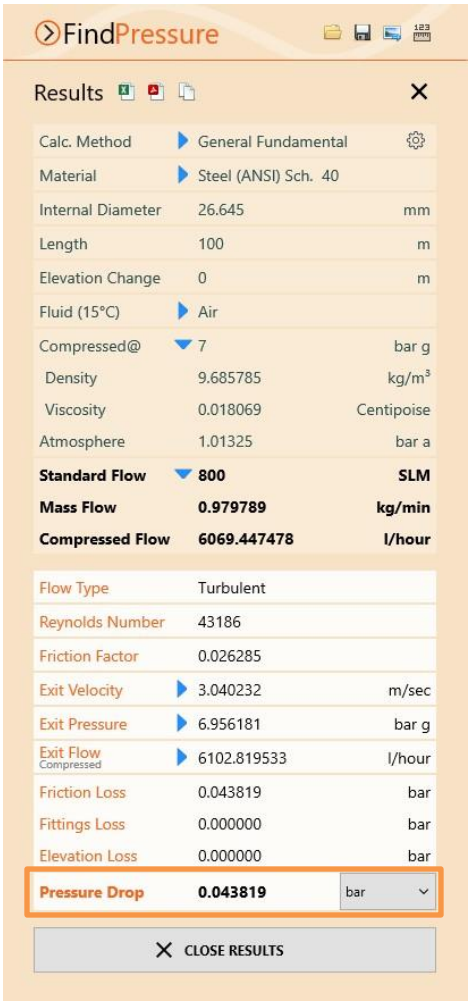
Reference: Flow of Fluids – Technical Paper No 410M, 1999, Crane Co. Appendix B-14.

Pipe Flow Wizard Software: Find_Pressure_Case_11_Air_Flow_Through_100m_Lengths_Of_Steel_Pipes.pfwp

Calculation Problem:

Compressed air at 7 bar gauge and 15°C flows through 100 meters long schedule 40 steel pipes.

Find the pressure drop in each of the following pipe sizes:
Steel Schedule 40 1.0”, 1.5”, 2.0”, 2.5”, 3.0”



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 15 °C, 7.0 bar.g,
Density 9.685785 kg/m³, Viscosity 0.018069 cP.
Fluid Data: Software calculates the compressed gas properties.
Pipe Data: Schedule 40 Steel, various sizes.
Roughness 0.046 mm.

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 15 °C, 101.325 kPa absolute
Gas Model: Ideal Gas Law

Commentary:

The published data and the calculated results compare well but differ slightly, with pressure drop comparisons varying by up to 0.04 bar (or about 5.5% of the total pressure drop). We believe the published results were calculated using the Darcy-Weisbach equation (since Pipe Flow Wizard results produced using its non-compressible calculation engine give almost exactly the same figures), whereas the Pipe Flow Wizard results below were generated using the software’s more accurate compressible calculation engine together with the General Fundamental Isothermal flow equation (which is better suited for compressible air flow calculations).

Results Comparison:

Pipe Details Steel Schedule 40	Free Air m³/min	Compressed Flow m³/min	Published Pressure Drop (Bar)	Pipe Flow Wizard Pressure Drop (Bar)
1.0” Diameter, 100 m long	0.800	0.101	0.044	0.0438
1-1/2” Diameter, 100 m long	10.000	1.264	0.640	0.6673
2.0” Diameter, 100 m long	20.000	2.528	0.685	0.71803
2-1/2” Diameter, 100 m long	32.000	4.046	0.682	0.7226
3.0” Diameter, 100 m long	30.000	3.793	0.197	0.2004

Case 12: Air – Flow Through 100ft Lengths of Steel Pipes

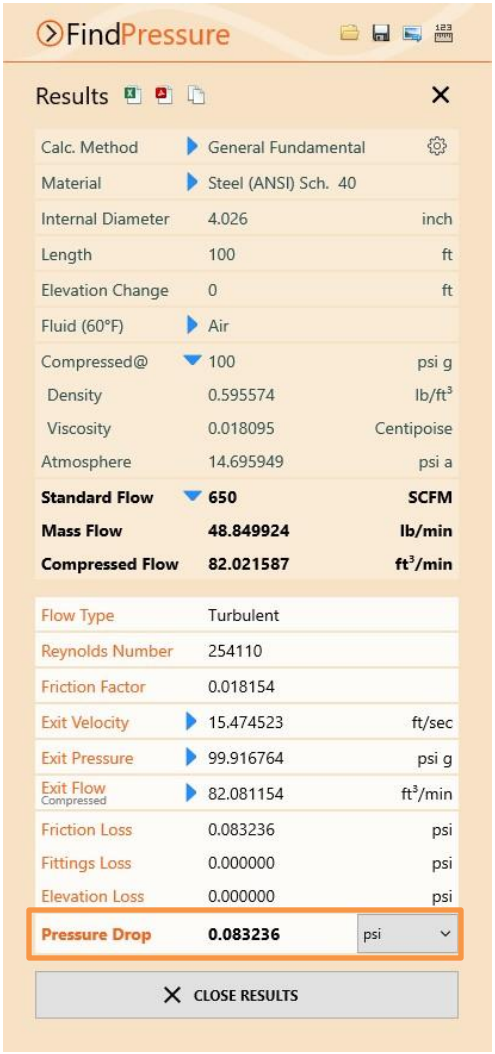
Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Appendix B-15.

Pipe Flow Wizard Software: Find_Pressure_Case_12_Air_Flow_Through_100ft_Lengths_Of_Steel_Pipes.pfwp

Calculation Problem:

Compressed air at 100 psi gauge and 60°F flows through 100 feet long schedule 40 steel pipes.

Find the pressure drop in each of the following pipe sizes:
Steel Schedule 40 4.0”, 6.0”, 8.0”, 10.0”, 12.0”



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 60°F, 0 psi.g and,
Density 0.595574 lb/ft³, Viscosity 0.018095 cP.
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Schedule 40 Steel, various sizes.
Roughness 0.001811 in.

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 60 °F, 14.696 psi absolute
Gas Model: Ideal Gas Law

Commentary:

The published data and the calculated results compare well.

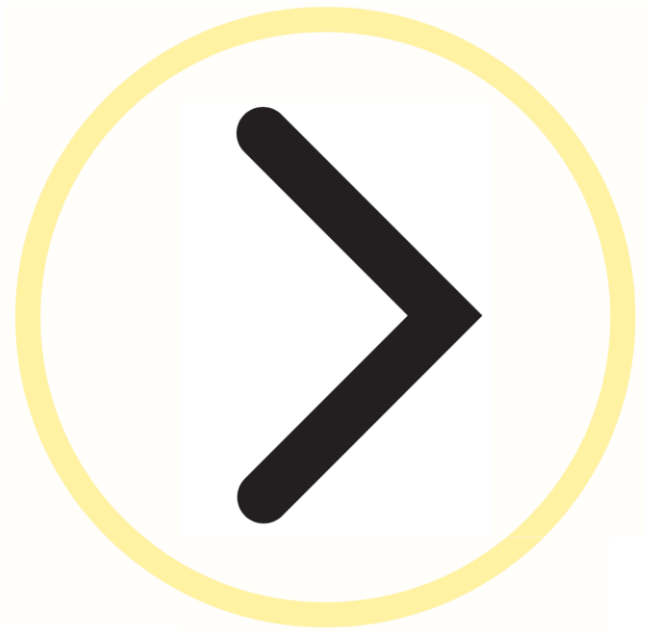
The density of air at 100 psi.g and 60°F used in the published results was not specified, and the published results were based on a non-compressible calculation since the pressure drop was small.

The Pipe Flow Wizard software automatically calculated the density of the compressed air at 100 psi.g to be 0.595574 lb/ft³ and it used this in the compressible flow equation to calculate the results.

Results Comparison:

Pipe Details Steel Schedule 40	Free Air ft³/min	Compressed Flow ft³/min	Published Data Pressure Drop (psi)	Pipe Flow Wizard Pressure Drop (psi)
4.0” Diameter, 100 ft long	650	83.3	0.086	0.0832
6.0” Diameter, 100 ft long	14000	1794	4.21	4.223
8.0” Diameter, 100 ft long	16000	2051	1.33	1.312
10.0” Diameter, 100 ft long	24000	3076	0.918	0.9029
12.0” Diameter, 100 ft long	28000	3588	0.505	0.4957

Find Flow



Case 01: Mass Flow of Air

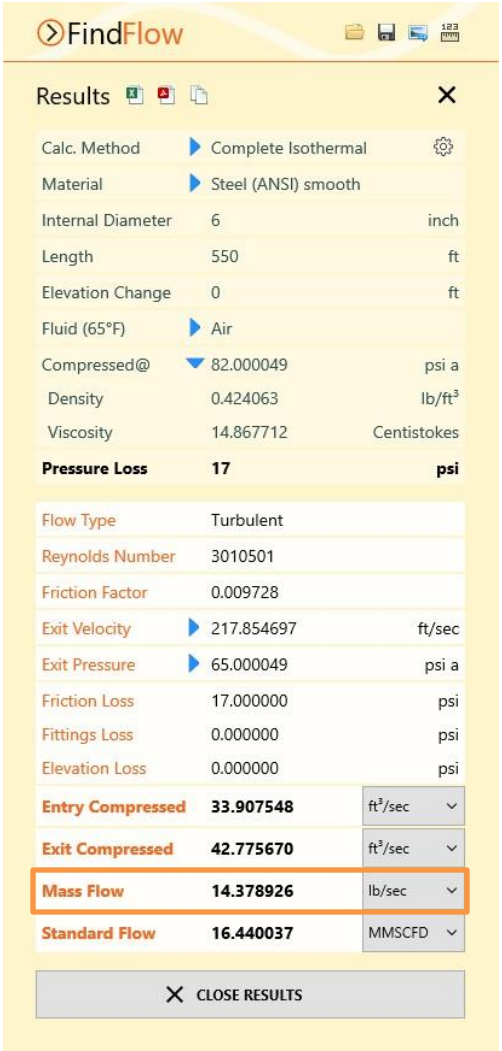
Reference: Fluid Mechanics and Hydraulics, 3rd Ed, 1994,
McGraw-Hill; R. V. Giles, J. B. Evett PhD, C. Liu page 237, Example 11.1

Pipe Flow Wizard Software: Find _Flow_Case_01_Mass_Flow_Air.pfwf

Calculation Problem:

Find the mass flow rate of air flowing isothermally through a 6-inch diameter pipe, at 65 °F, where the inlet pressure is 82 psi absolute, and at a distance of 550 feet downstream of the inlet, the pressure is 65 psi absolute.

The pipe surface is smooth (the problem specifies an assumed friction factor of 0.0095) and the calculation method used for the published data was the Complete Isothermal Flow equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 65 °F, 0.0 psi.g, Viscosity 0.0181 centipoise
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Roughness 0.000001 inches
Friction factor = 0.00973

Calculation Method: Complete Isothermal Flow equation.
Standard Atmospheric Conditions: 68°F, 14.696 psi.a
Gas Model: Ideal Gas Law.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The published data used several rounded numbers in the calculation.

In the Pipe Flow Wizard software calculation, the pipe's internal roughness value was set to a very small value (much lower than the usual internal roughness for any of the common pipe materials). This was done to simulate the very "smooth" pipe that was used in the published literature (friction factor of 0.0095).

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Mass Flow (lb/sec)	14.5	14.379

Case 02: Gas Pipeline Flow Rate

Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon Chapter 2, page 62 Example 13

Pipe Flow Wizard Software: Find_Flow_Case_02_Natural_Gas_Pipeline_Flow_Rate.pfwf

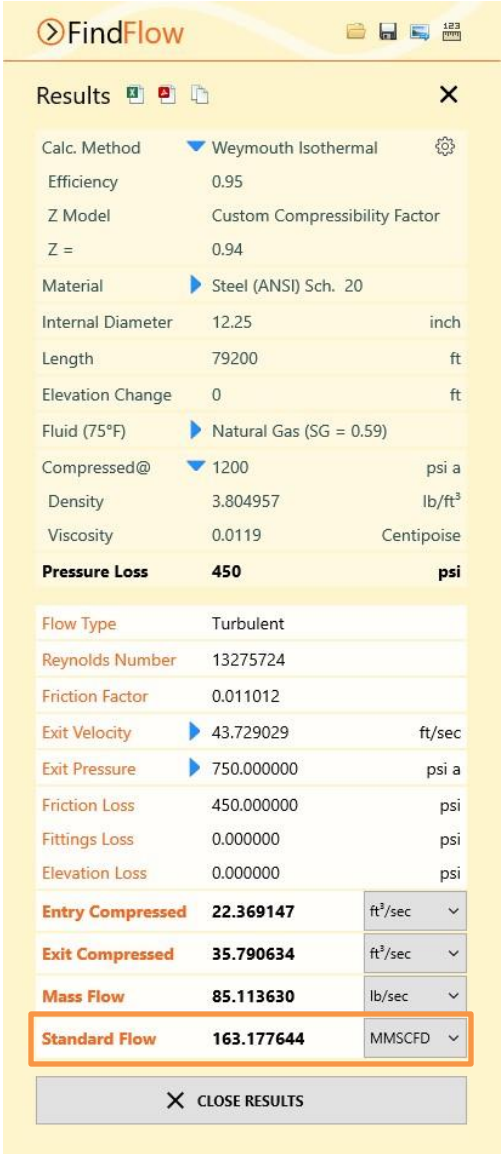
Calculation Problem:

Calculate the flow rate in a gas pipeline system, 15 miles long, with a 12.25 inch internal pipe diameter.

The upstream pressure is 1200 psi absolute and the delivery pressure required at the end of the pipe is 750 psi absolute. The pipe internal roughness is 700 micro-inches. Use a compressibility factor of 0.94 and a pipeline efficiency of 0.95.

The calculation methods used in the published data are:

i) Weymouth equation
ii) General Flow equation



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Gas specific gravity 0.59 (0.044 lb/ft^3)
75 °F, 0.0 bar.g, Viscosity 0.0119 centipoise.
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Roughness 700 micro-inches

Calculation Method: Weymouth equation (Efficiency = 0.95)
General Flow equation
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Real Gas (Ideal Gas Law, compressibility Z=0.94)

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

Comparing the result from the General Flow equation against the result from the Weymouth equation shows that the result from the Weymouth equation is quite conservative.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Gas Flow Rate, Weymouth equation, MMSCFD	163.26	163.178
Gas Flow Rate, General Flow equation, MMSCFD	192.98	192.984

Case 03: IGT (Institute of Gas Technology) Equation Flow Rate

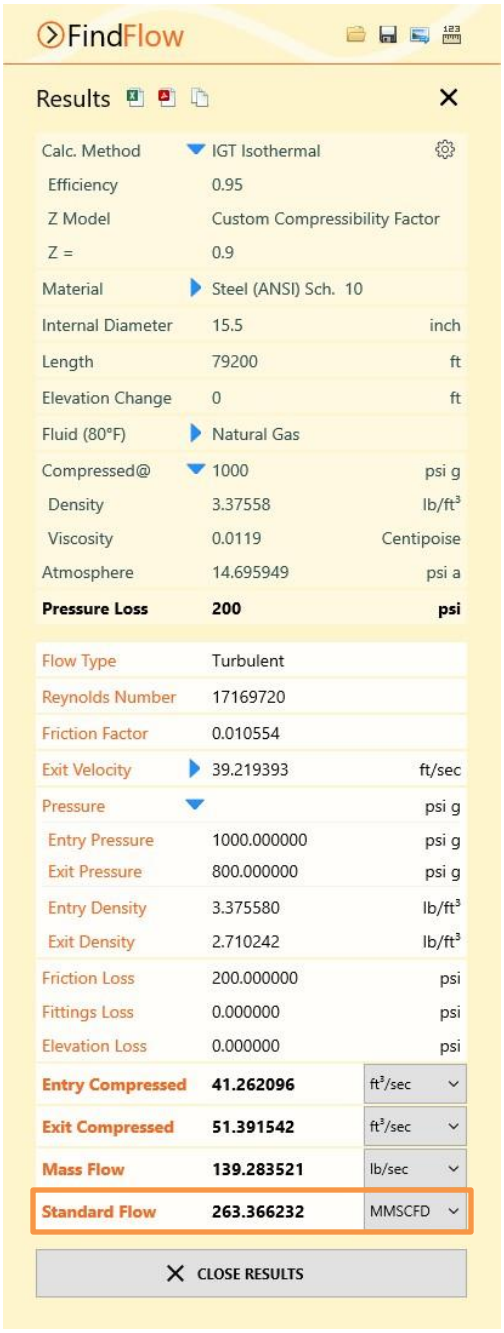
Reference: Gas Pipeline Hydraulics, 2005, CRC Press, E. Shashi Menon, Chapter 2, page 71 Example 19

Pipe Flow Wizard Software: Find_Flow_Case_03_IGT_Equation.pfwf

Calculation Problem:

Find the flow rate in a natural gas pipeline 15 miles long.
The pipe is NPS 16 with a 0.250 inch wall thickness.
The inlet & outlet pressures are 1000 psi.g and 800 psi.g, respectively. The pipeline efficiency is 0.95.
Average gas temperature is 80 °F.
Gas Specific Gravity = 0.6, Viscosity = 0.000008 lb/ft-sec.
The compressibility factor Z = 0.90

Use the IGT (Institute of Gas Technology) equation to calculate the flow rate in the pipe.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Gas with specific gravity 0.6 (0.044 lb/ft³), 80 °F, 0.00 psi.g, Viscosity 0.0119 centipoise.
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Roughness 700 micro-inches.

Calculation Method: IGT Isothermal Flow equation.
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Real Gas (Ideal Gas Law with compressibility Z=0.9)

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 MMSCFD	263.1	263.366

Case 04: Flow Rate of Natural Gas Through Pipeline

Reference: Gas Pipeline Hydraulics, 2013, CRC Press, E. Shashi Menon, Chapter 2, page 97 Example 2.20

Pipe Flow Wizard Software: Find_Flow_Case_04_Natural_Gas_Flow_Rate.pfwf

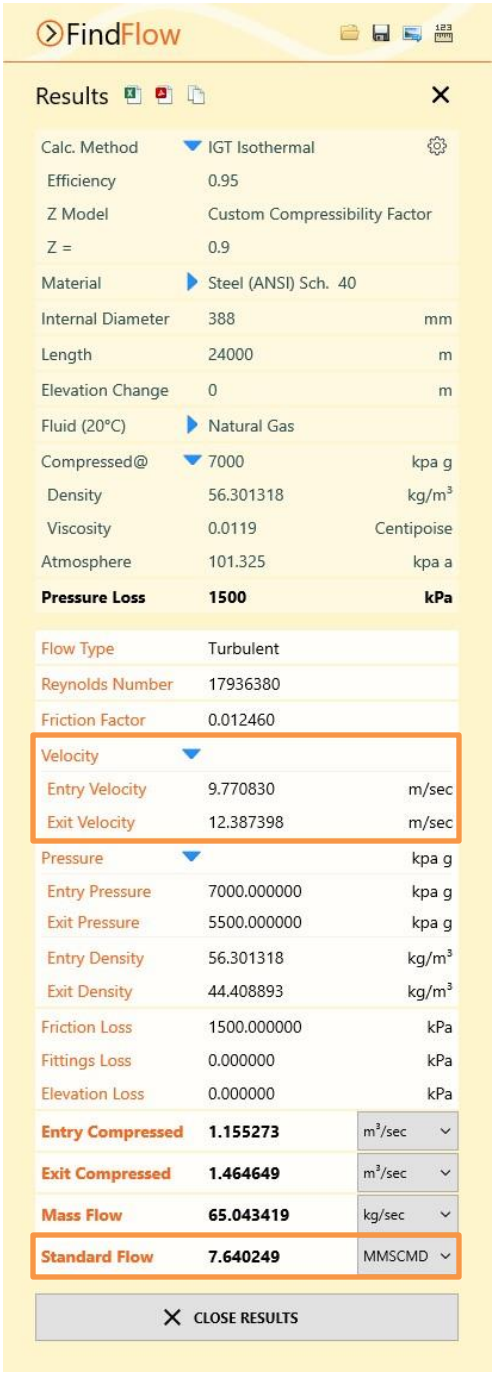
Calculation Problem:

A Natural gas pipeline, 24km long, is used to transport gas at an inlet pressure of 7000 kPa.g and an outlet pressure of 5500 kPa.g.

Calculate the flow rate using the IGT equation.
(IGT is Institute of Gas Technology)

Assume a pipeline efficiency of 0.95
and a compressibility factor Z of 0.9

Calculate the gas velocity at the inlet and outlet of the pipe.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Natural Gas at 20 °C, 0.0 bar.g
Gas with specific gravity of 0.6
Viscosity 0.00119 centipoise
Fluid Data: Software calculates compressed gas properties.
Pipe Data: DN 400 with 6mm wall thickness.

Calculation Method: IGT Isothermal Flow equation (Effic=0.95)
Standard Atmospheric Conditions: 15°C, 101.325 kPa.a
Gas Model: Real Gas (Ideal Gas Law with compressibility Z=0.9)

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 MMSCMD	7.67	7.640
Inlet Velocity (m/s)	9.78	9.771
Outlet Velocity (m/s)	12.4	12.387

Case 05: Pumping Hydrogen Gas from a Reservoir

Reference: Chemical Engineering Volume 1, 6th Ed, 1999,
Elsevier, J M Coulson, J F Richardson, page 375 Example 8.10

Pipe Flow Wizard Software: Find_Flow_Case_05_Hydrogen_Reservoir_Pump.pfwf

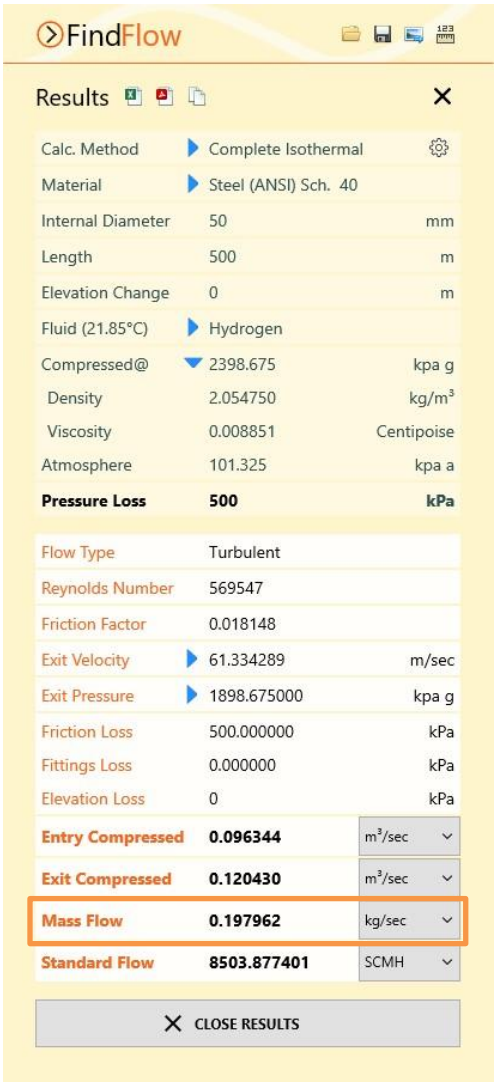
Calculation Problem:

Hydrogen is pumped from a reservoir at 2 MN/m^2 through a clean horizontal mild steel pipe 50 mm in diameter and 500 m long. The pressure of the gas is raised to 2.5 MN/m^2 by a pump at the start of the pipe. The downstream pressure at the end of the pipe is 2 MN/m^2.

The conditions of flow are isothermal, and the temperature of the gas is 295 K.

What is the flow rate of hydrogen?

The calculation method used for the published data was the Complete Isothermal equation with Ideal Gas Law.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Hydrogen at 21.85 °C, 0.0 bar.g
Density 0.083279 kg/m^3, Viscosity 0.008851 cP.
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Internal diameter 50 mm, roughness 0.05 mm.

Calculation Method: Complete Isothermal Flow equation.
Standard Atmospheric Conditions: 20°C, 1.01325 bar absolute.
Gas Model: Ideal Gas Law

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 (kg/second)	0.200	0.198

Case 06: Carbon Dioxide – Flow Through a Pipe

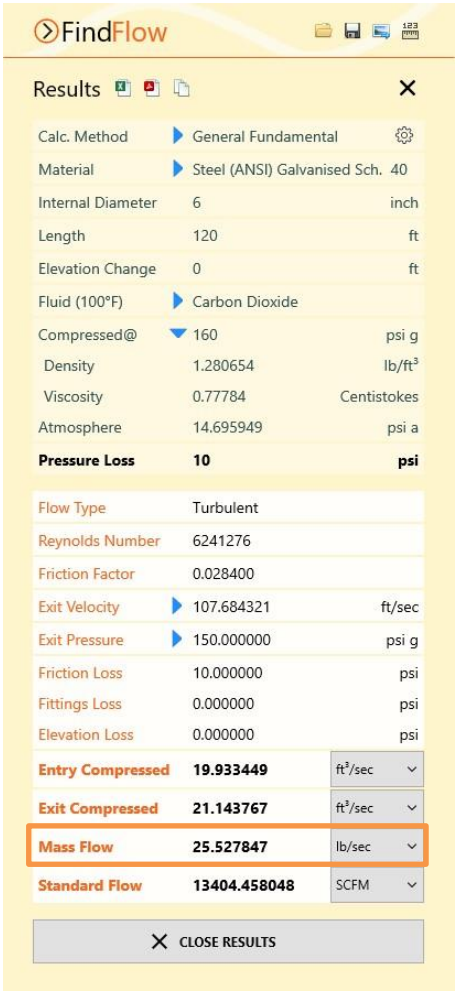
Reference: 2500 Solved Problems in Fluid Mechanics and Hydraulics, 1989, McGraw-Hill, Jack B. Evett, Ph. D., Cheng Liu, M.S., Page 483, Example problem 16.78

Pipe Flow Wizard Software: Find_Flow_Case_06_Carbon_Dioxide_Flow_Through_A_Pipe.pfwf

Calculation Problem:

Carbon Dioxide at temperature of 100°F flows through a pipe with 6" internal diameter. The pipe internal roughness is 0.002 ft (0.024 inch). The flow is isothermal. The pressure at the start of a 120 ft long horizontal pipe section is 160 psi.g and the pressure at the end of the section is 150 psi.g.

Calculate the weight of flow (mass flow rate) of the air.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Carbon Dioxide at 155 psi gauge and 100 °F
Density 1.244000 lb/ft^3, Viscosity 0.015500 centipoise.
The reference fluid properties can be been defined for any pressure condition, however they must always be defined at the required temperature condition.

Fluid Data: The Pipe Flow Wizard software automatically calculates the compressed gas properties.

Pipe Data: Internal diameter 6 inch. Roughness 0.0024 inches.

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 68 °F, 14.696 psi absolute
Gas Model: Ideal Gas Law

Commentary:

The published data and the calculated results compare well.

The published text assumes an initial Reynolds Number greater than 1000000 and a friction factor of 0.0285 to estimate the weight of flow as 25.3 lb/sec. The weight of flow is then used to recalculate the Reynolds Number as 5000000 and this is taken as confirmation of the previously calculated weight of flow.

The Pipe Flow Wizard software uses the Colebrook-White equation to calculate friction factors and these are generally considered to be more accurate than a value read from a Moody Chart.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Weight of Flow (lb/sec)	25.3	25.528
Reynolds Number	5000000	6241276
Friction Factor	0.0285	0.0284

Find Diameter

Case 01: Minimum Pipe Diameter

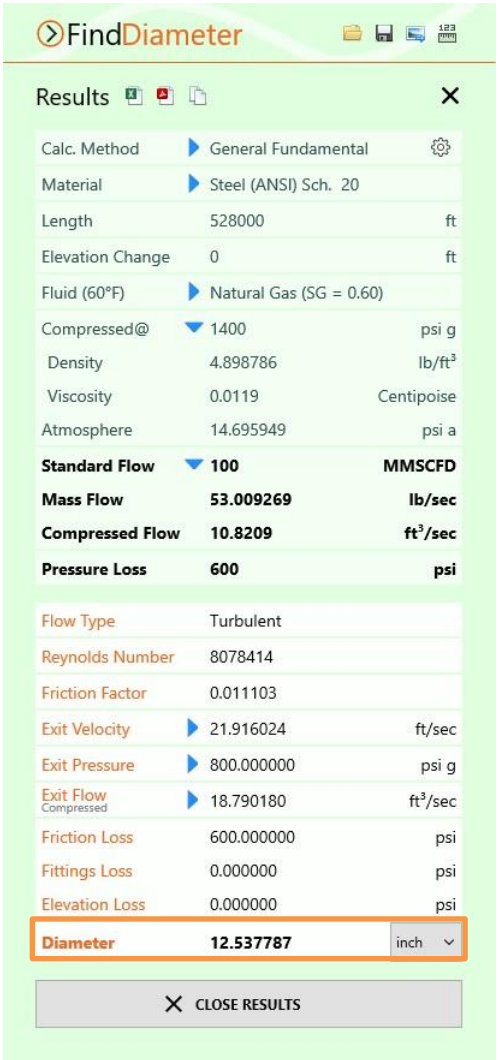
Reference: Gas Pipeline Hydraulics, 2013
E. Shashi Menon, Ph. D., P.E, Pramila S. Menon, M. B. A., Chapter 3, page 128 Example 3.3

Pipe Flow Wizard Software: Find_Diameter_Case_01_Minumum_Pipe_Diameter.pfwd

Calculation Problem:

A pipeline 100 miles long transports natural gas, at a temperature of 60 °F. The inlet pressure is 1400 psi.g and the delivery pressure required is 800 psi.g. The required flowrate is 100 MMSCFD. Assume a compressibility factor of 0.9 and a 95% pipeline efficiency. The pipe roughness is 700 micro inches.

Find the minimum pipe diameter needed using the AGA, General with Colebrook-white, Panhandle B and Weymouth equations.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Gas Specific Gravity 0.6 (0.0458 lb/ft³)
Viscosity 0.0119 centipoise
@ 60 °F, 0.00 psi.g
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Internal roughness 0.000700 inches.

Calculation Method: AGA equation
General Flow equation
Panhandle B equation
Weymouth equation
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Real Gas (Ideal Gas Law with compressibility Z=0.90)

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

Colebrook-white refers to the method used to calculate friction factors in the General Isothermal Flow equation.

Results Comparison:

Data Item	Published Data	Equation	Pipe Flow Wizard
Pipe Diameter	12.47 inches	AGA	12.461 inches
Pipe Diameter	12.55 inches	General	12.538 inches
Pipe Diameter	11.93 inches	Panhandle B	11.930 inches
Pipe Diameter	13.30 inches	Weymouth	13.304 inches

Case 02: Natural Gas Flow Rate vs Pressure Drop In Steel Pipe

Reference: Fluid Flow Handbook, 2002, McGraw-Hill, Jamal M. Saleh, Ph D., PE, Chapter 9, page 9.14 Ex. 9.5.1

Pipe Flow Wizard Software: Find_Diameter_Case_02_Diameter_of_Pipeline_78_miles_long.pfwd

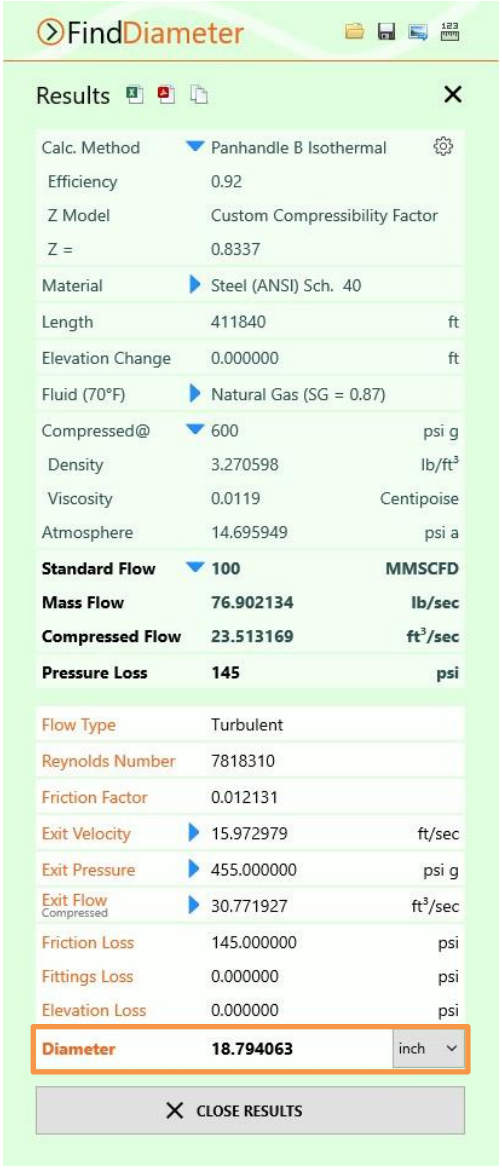
Calculation Problem:

Find the inside diameter of a steel pipe used to transport natural gas (SG = 0.87) a distance of 78 miles when the following requirements are specified.

The inlet pressure is 600 psi.g and the maximum allowable pressure drop is 145 psi.g.

Assume isothermal flow, a pipeline efficiency of 0.92, and a compressibility factor Z = 0.8337 (calculated from Papay's correlation).

The calculation method used for the published data was the Panhandle B equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Natural Gas at 70 °F, 0.0 psi.g
Density 0.650 lb/ft^3, Viscosity 0.0119 centipoise
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Internal diameter 18.812 inches (nominal 20")
Roughness 0.001811 inches (Steel Schedule 40)

Calculation Method: Panhandle B Isothermal equation.
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Real Gas (Ideal Gas Law & compressibility Z=0.8337)

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
Internal Diameter	18.80 inches	18.794 inches

Case 03: Diameter of an Air Pipeline

Reference: Piping Calculations Manual, 2005, McGraw-Hill, E. Shashi Menon, P.E., Page 288, Example 5.17

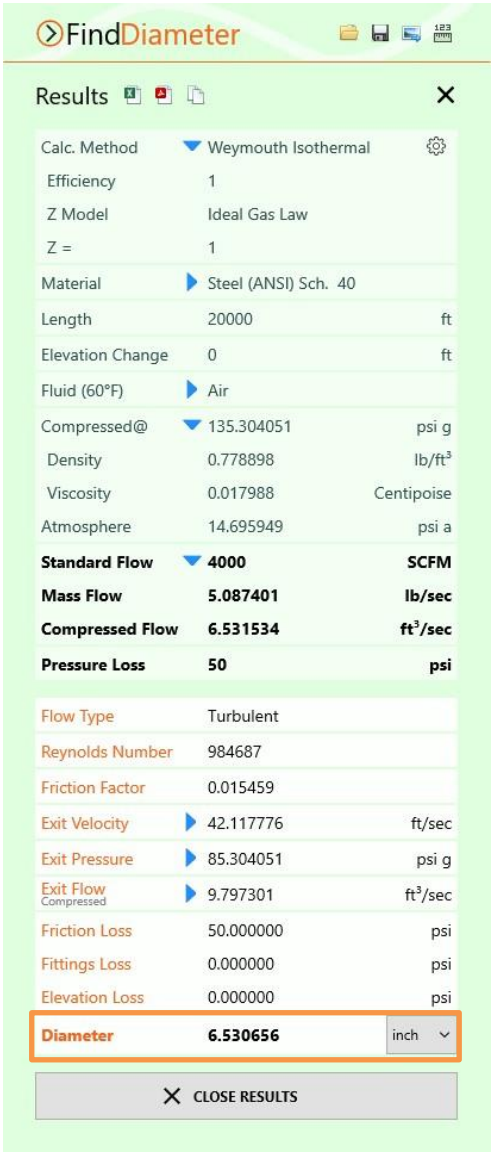
Pipe Flow Wizard Software: Find_Diameter_Case_03_Diameter_of_Air_Pipeline.pfwd

Calculation Problem:

A pipeline 20,000 ft in length allows air at 4000 SCFM.
The initial pressure is 150 psi.a.

If the pressure drop is limited to 50 psi, determine the approximate pipe diameter required.

The calculation method used for the published data was the Weymouth equation.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 60 °F, 0.0 psi.g
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Roughness 0.001811 inches (Steel Schedule 40)

Calculation Method: Weymouth Isothermal Flow equation.
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Ideal Gas Law.

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
Internal Diameter	6.53 inches	6.531 inches

Case 04: Designing a Free Air Pipeline

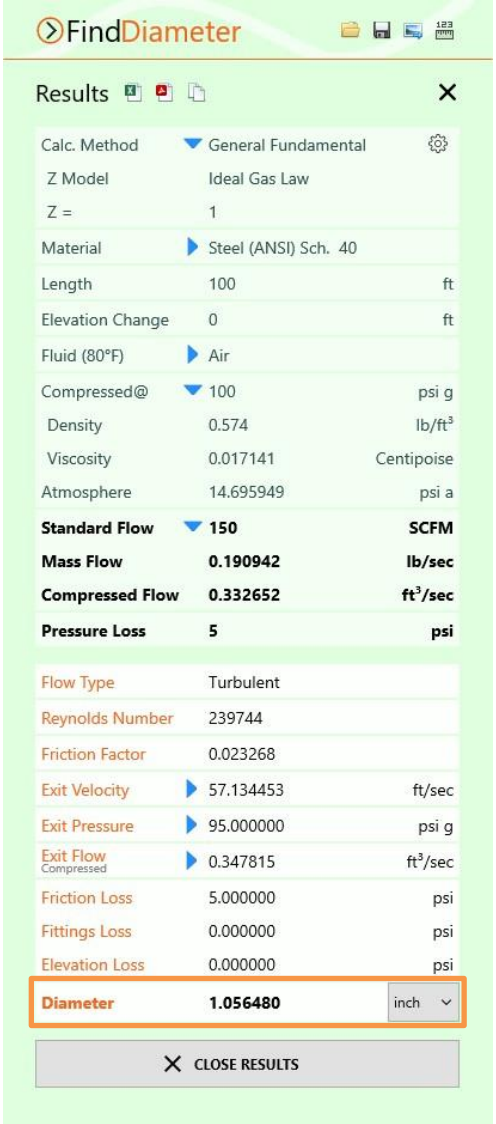
Reference: Piping Calculations Manual, 2005, McGraw-Hill, E. Shashi Menon, P.E., Page 281, Example 5.15

Pipe Flow Wizard Software: Find_Diameter_Case_04_Free_Air_Pipeline.pfwd

Calculation Problem:

A pipe is to be designed to carry 150CFM free air at 100 psi.g and 80°F.

If the pressure loss must be limited to 5 psi per 100 ft of pipe, what is the minimum pipe diameter required?



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Free Air at 80 °F, 100 psi.g
Density 0.574 lb/ft^3, Viscosity 0.017141 centipoise.
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Roughness 0.0018 inches

Calculation Method: General Isothermal Flow Equation.
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Ideal Gas Law.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The published example guesses an internal diameter and then proceeds to check if this meets the pressure drop restriction, iterating to an approximate solution.

The problem specifies that the pressure loss must be limited to a value of 5 psi per 100 ft and so a pressure drop of 5 psi was used in the Pipe Flow Wizard software to calculate the exact answer.

Results Comparison:

Data Item	Published data	Pipe Flow Wizard
Inner Diameter	1.049 inches	1.056 inches
Pressure Drop (per 100ft)	5.05 psi	5.00 psi

Find Length

Case 01: Length of a Wrought Iron Pipe

Reference: Fluid Mechanics and Hydraulics, 3rd Ed, 1994, Schaums, McGraw-Hill; R. V. Giles, J. B. Evett PhD, C. Liu, page 155, Example 8.25

Pipe Flow Wizard Software: Find_length_Case_01_Wrought_Iron_Pipe_Length.pfwl

Calculation Problem:

A horizontal wrought iron pipe of 150 mm internal diameter is transporting 20 N of air per second (2.0394 kg/s) from A to B.

At A the pressure is 483 kPa absolute, and at B the pressure must be 448 KPa absolute.

What is the length of pipe from A to B?

Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 20°C, 0.0 kPa.g
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Roughness 0.0004 m (0.4 mm)

Calculation method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 20 °C, 101.325 KPa.a
Gas Model: Ideal Gas Law.

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

This example gives a friction factor as read from a diagram; Pipe Flow Wizard gives the friction factor to more decimal places.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Length	173 m	171.25 m
Reynolds Number	968000	961736
Friction Factor	0.025	0.02545

Case 02: Compressor Stations for a Gas Transmission Pipeline

Reference: Gas Pipeline Hydraulics (paperback), 2013
E. Shashi Menon, Ph. D., P.E, Pramila S. Menon, M. B. A., Chapter 3, page 208 Example 4.11

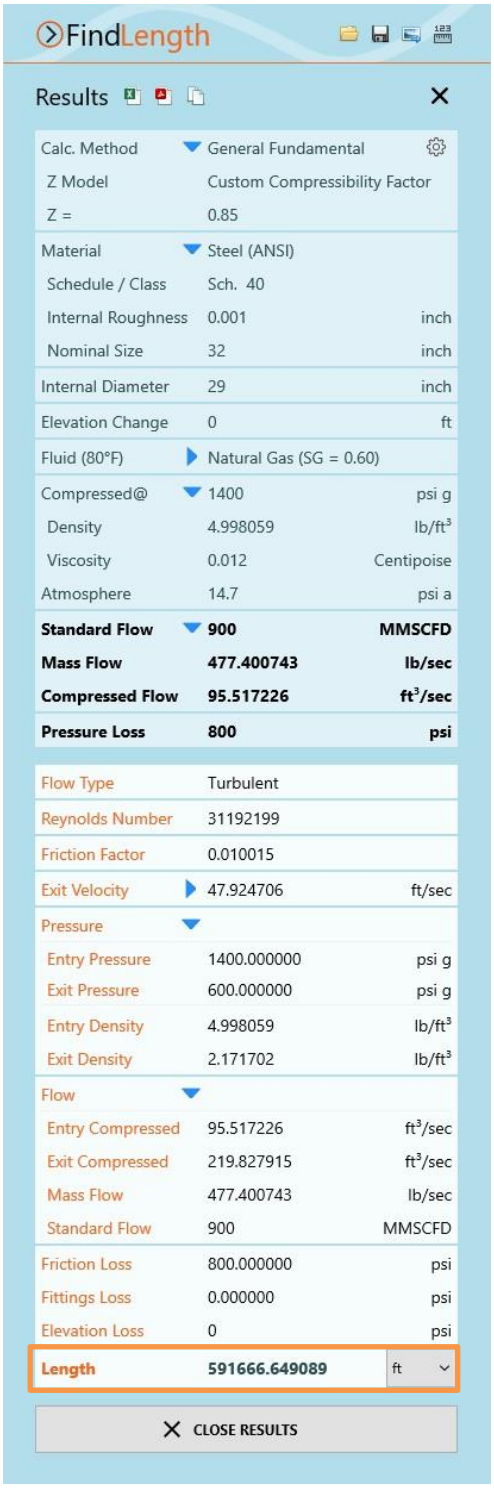
Pipe Flow Wizard Software: Find_length_Case_02_Gas_Compressor_Stations.pfwl

Calculation Problem:

A gas transmission, NPS 30 pipeline, has a compressor station that will be placed in the line before delivering the gas to a final location downstream named Douglas. The inlet flow rate of 900 MMSCFD equals the delivery flow rate at Douglas. The delivery pressure required is 600 psi.g and the MOP (Maximum Operating Pressure) of the pipeline is 1400 psi.g throughout.

Neglect the effects of elevation and assume a constant gas flow temperature of 80 °F, a constant transmission factor F=20, and a compressibility factor Z = 0.85 throughout the pipeline.

Find the maximum distance (in miles) from Douglas that the compressor station at 1400 psi.g can be located.



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Gas Specific Gravity of 0.6, 80 °F, 0.0 psi.g
Fluid Data: Software calculates compressed gas properties.
Pipe Data: NPS 30, 0.5 inch wall thickness.
Internal roughness 0.00100 inches.

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Real Gas (Custom Compressibility Factor Z=0.85)

Commentary:

See the Results Comparison Table below.

The published data and the calculated results compare well.

The example specifies a transmission factor, F=20, and in order to achieve this value, we set the internal roughness of the pipe to be 0.001 inch.

Note: Transmission Factor $F = \frac{2}{\sqrt{f}}$ where f is the friction factor.

Results Comparison:

Data Item	Published Data	Pipe Flow Wizard
Length (miles)	112.31	111.996

Case 03: Length of Steel Air Pipe

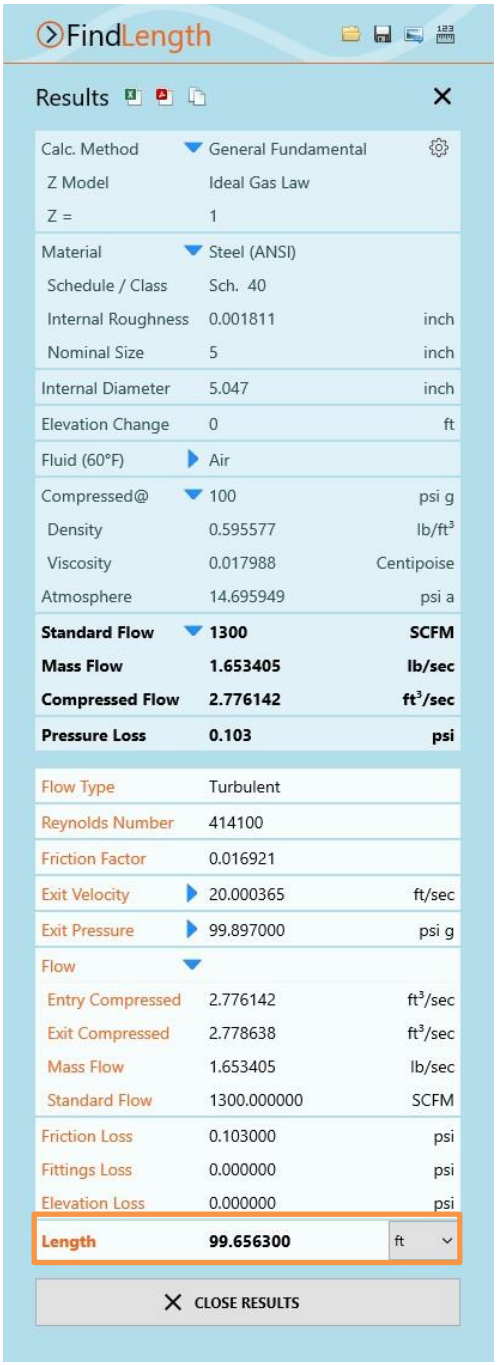
Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page B-15.

Pipe Flow Wizard Software: Find_Length_Case_03_Air_Steel_Pipe.pfwl

Calculation Problem:

Air compressed at 100 psi.g flows through a nominal 5 inch schedule 40 steel pipe at a flow rate of 1300 SCFM.

If the pressure drop in the pipe is 0.103 lbs/inch^2 (psi), what is the length of pipe?



Pipe Flow Wizard Software Calculation Data:

Fluid Ref: Air at 60°F, 0.0 psi.g.
Fluid Data: Software calculates compressed gas properties.
Pipe Data: Steel (ANSI) Sch.40
Roughness 0.001811 inches

Calculation Method: General Isothermal Flow equation.
Standard Atmospheric Conditions: 60°F, 14.696 psi.a
Gas Model: Ideal Gas Model (Compressibility Z=1.00)

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	99.66

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