pipeFLOW®

taking the pressure out of fluid flow calculations

GAS PIPE LENGTH

Verification of Calculation Results
For Compressible Flow

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Introduction

Pipe Flow Gas Pipe Length is a software application that calculates the maximum length of a pipe for a given gas flow rate before a specified pressure drop is reached. Friction losses are calculated using specialist compressible isothermal flow equations. The pressure drop in the pipe is affected by items such as the internal roughness of the pipe material, size of internal diameter, pipe length, gas flow rate, pressure at the start of the pipe, and the gas density at the entry condition.

The gas flow rate calculations produced by the Pipe Flow Gas Flow Rate 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 **App 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 Gas Flow Rate 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 Gas Pipe Length 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 Gas Pipe Length software calculates an accurate friction factor using the Colebrook-White equation.

In addition to the **General Flow Equation**, Pipe Flow Gas Pipe Length 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 Pipe Flow Gas Pipe Length 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: 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

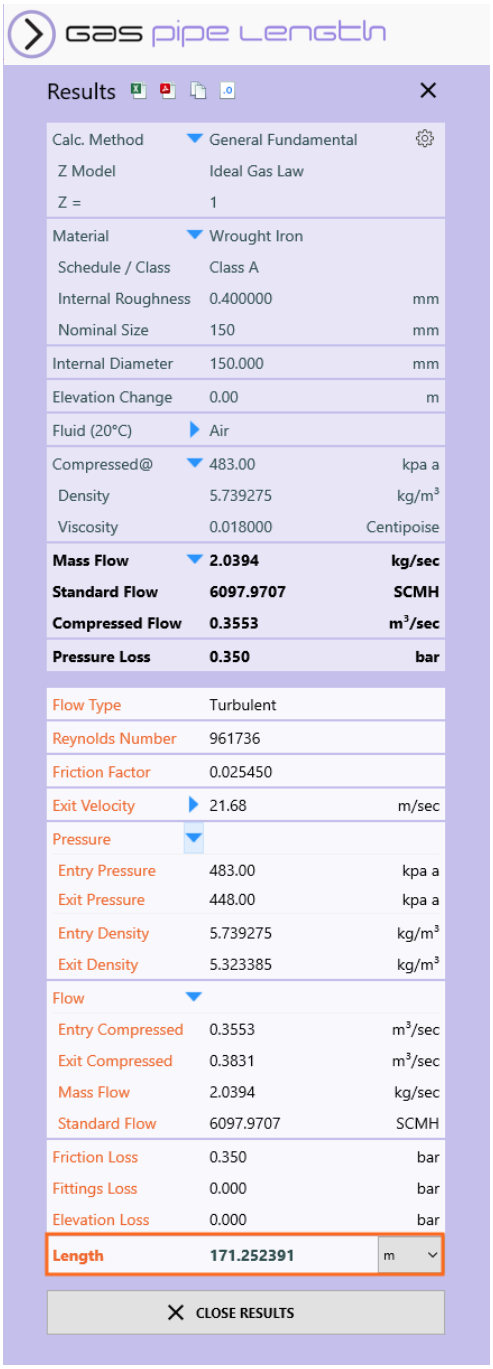
Gas Pipe Length App: Find_length_Case_01_Wrought_Iron_Pipe_Length.pfwl

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 Gas Pipe Length 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 Gas Pipe Length gives the friction factor to more decimal places.

Results Comparison:

Data Item	Published Data	App
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

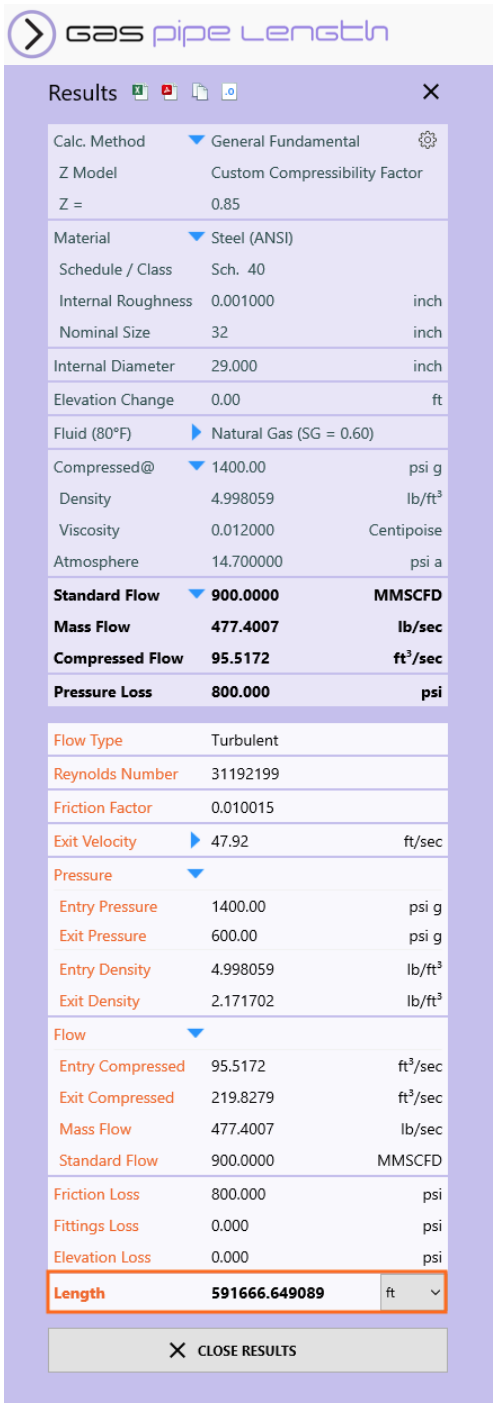
Gas Pipe Length App: Find_length_Case_02_Gas_Compressor_Stations.pfwl

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 Gas Pipe Length 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	App
Length (miles)	112.31	111.996

Case 03: Length of Steel Air Pipe

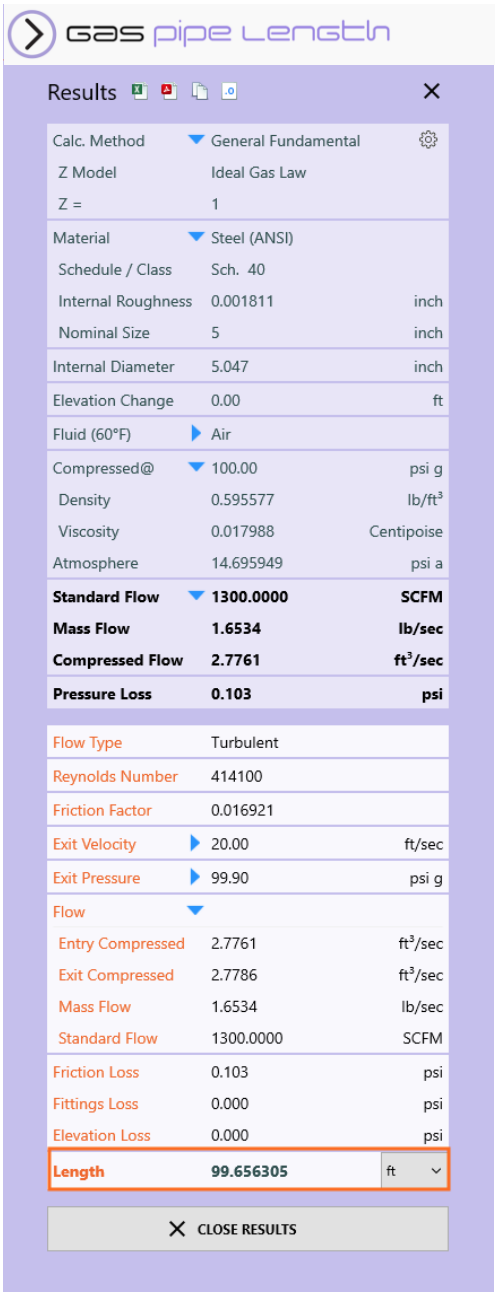
Reference: Flow of Fluids – Technical Paper No 410, 1988, Crane Co. Page B-15.

Gas Pipe Length App: 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 Gas Pipe Length 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	App
Length (ft)	100	99.66

References

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