taking the pressure out of fluid flow calculations



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pipe Lensth

Verification of Calculation Results For Compressible Flow

www.pipeflow.com

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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 | Арр |
|-----------------|----------------|----------|
| Length | 173 m | 171.25 m |
| Reynolds Number | 968000 | 961736 |
| Friction Factor | 0.025 | 0.02545 |

| Calc. Method General Fundamental Image: Calca C | Results 😐 😐 🛛 | <u>.</u> | × |
|---|--------------------|----------------------------------|------------|
| Z Model Ideal Gas Law Z = 1 Material Wrought Iron Schedule / Class Class A Internal Roughness 0.400000 mm Nominal Size 150 mm Internal Diameter 150.000 mm Elevation Change 0.00 m Fluid (20°C) Air Compressed@ 483.00 kpa a Density 5.739275 kg/m³ Viscosity 0.018000 Centipoise Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Compressed Flow 0.3553 m³/sec Pressure Loss 0.025450 bar Friction Factor 0.025450 centry Compressed Fixt Velocity 21.68 m/sec Pressure 483.00 kpa a Entry Pressure 483.00 kpa a Entry Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow V centry Compressed 0.3553 Flow V centry Compressed 0.3831 m³/sec Prixt Density 5.323385 kg/m³ Entry Compressed 0.3831 m³/sec <th>Calc. Method</th> <th>General Fundamental</th> <th>ŵ</th> | Calc. Method | General Fundamental | ŵ |
| Z = 1 Material Wrought Iron Schedule / Class Class A Internal Roughness 0.400000 mm Nominal Size 150 mm Internal Diameter 150.000 mm Elevation Change 0.00 m Fluid (20°C) Air Compressed@ 483.00 kpa a Density 5.739275 kg/m³ Viscosity 0.018000 Centipoise Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Compressed Flow 0.3553 m³/sec Pressure Loss 0.025450 bar Friction Factor 0.025450 centro Entry Pressure 483.00 kpa a Entry Pressure 483.00 kpa a Entry Pressure 483.00 kpa a Entry Onsity 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow V centro Entry Compressed 0.3553 m³/sec Flow V centro Entry Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Entry Compressed 0.3553 | Z Model | Ideal Gas Law | |
| MaterialWrought IronSchedule / ClassClass AInternal Roughness0.400000Nominal Size150Internal Diameter150.000Internal Diameter150.000Elevation Change0.00Fluid (20°C)AirCompressed@483.00kg/m3Kg/m3Viscosity0.018000CentipoiseMass Flow2.0394Kg/m3Kg/secStandard Flow6097.9707SCMHCompressed Flow0.3553Pressure Loss0.350barFlow TypeTurbulentReynolds Number961736Friction Factor0.025450Exit Velocity21.68Pressure483.00kg/m3Exit Velocity5.739275Kg/m3Exit Density5.739275Scaladsm3/secProwFlow | Z = | 1 | |
| Schedule / ClassClass AInternal Roughness0.400000mmNominal Size150mmInternal Diameter150.000mmElevation Change0.00mFluid (20°C)AirmmCompressed@483.00kpa aDensity5.739275kg/m³Viscosity0.018000CentipoiseMass Flow2.0394kg/secStandard Flow6097.9707SCMHCompressed Flow0.3553m³/secPressure Loss0.350barFlow TypeTurbulentmReynolds Number961736mFriction Factor0.025450mEntry Pressure483.00kpa aEntry Pressure483.00kpa aEntry Compressed0.3553m³/secFlowFlowFlowFlowFriction Factor0.25450Exit Velocity21.68Pressure483.00Kpa aEntry CompressedGas31m³/secFlowFlowFlowFlowFlowFlowFlowFlowFlowFlowFlowFlowFlowFlowFlowFlowEntry Compressed0.350 <td>Material</td> <td> Wrought Iron </td> <td></td> | Material | Wrought Iron | |
| Internal Roughness0.400000mmNominal Size150mmInternal Diameter150.000mmElevation Change0.00mFluid (20°C)ÀrirmmCompressed@483.00kpa aDensity5.739275kg/m³Viscosity0.018000CentipoiseMass Flow2.0394kg/secStandard Flow6097.9707SCMHCompressed Flow0.3553m³/secPressure Loss0.350barFlow TypeTurbulentReynolds Number961736Friction Factor0.025450Exit Velocity21.68Pressure483.00kpa aEntry Pressure483.00Kapa aEntry Compressed0.3553FlowFlowFlowFlowFlowFlowFlowFriction Factor0.3553Kg/m³Entry Pressure483.00Kpa aEntry Compressed0.3553Mass Flow2.0394Kg/secStandard Flow6097.9707SCMHFriction Loss0.300BarLengthIttings Loss0.000BarLengthItength171.25291Itength171.25291 | Schedule / Class | Class A | |
| Nominal Size150mmInternal Diameter150.000mmElevation Change0.00mmFluid (20°C)AirAirCompressed@483.00kpa aDensity5.739275kg/m³Viscosity0.018000CentipoiseMass Flow2.0394kg/secStandard Flow6097.9707SCMHCompressed Flow0.3553m³/secPressure Loss0.350barFlow TypeTurbulentReynolds Number961736Friction Factor0.025450Exit Velocity21.68Pressure483.00kpa aEntry Pressure448.00kpa aEntry Compressed0.3553FlowEntry Compressed0.3553Row2.0394Kg/secStandard Flow6097.9707SCMHFriction Loss0.350barFittings Loss0.000Compressed0.000Compressed0.000 | Internal Roughness | 0.400000 | mm |
| Internal Diameter 150.000 mm Elevation Change 0.00 m Fluid (20°C) Air Compressed@ 483.00 kpa a Density 5.739275 kg/m ³ Viscosity 0.018000 Centipoise Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Compressed Flow 0.3553 m ³ /sec Pressure Loss 0.350 bar Flow Type Turbulent Reynolds Number 961736 Friction Factor 0.025450 Exit Velocity 21.68 m/sec Pressure 483.00 kpa a Entry Pressure 483.00 kpa a Entry Density 5.739275 kg/m ³ Exit Density 5.323385 kg/m ³ Exit Compressed 0.3553 m ³ /sec Standard Flow 0.3553 kg/m ³ Exit Density 5.323385 kg/m ³ Exit Compressed 0.3553 m ³ /sec Flow V Entry Compressed 0.3553 m ³ /sec Standard Flow 0.3553 m ³ /sec Flow V Entry Compressed 0.3553 m ³ /sec Flow V Entry Compressed 0.3553 m ³ /sec Exit Compressed 0.3553 m ³ /sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.000 bar Elevation Loss 0.000 bar | Nominal Size | 150 | mm |
| Elevation Change 0.00 m Fluid (20°C) Air Compressed@ 483.00 kpa a Density 5.739275 kg/m³ Viscosity 0.018000 Centipoise Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Compressed Flow 0.3553 m³/sec Pressure Loss 0.350 bar Friction Factor 0.025450 Entry Pressure Entry Pressure 483.00 kpa a Exit Velocity 21.68 m/sec Pressure 483.00 kpa a Entry Pressure 483.00 kpa a Exit Peressure 483.00 kpa a Exit Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow V Entry Compressed 0.3553 Flow V Standard Flow 6097.9707 Standard Flow 6.0353 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6.0350 bar Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Internal Diameter | 150.000 | mm |
| Fluid (20°C) Air Compressed@ 483.00 kpa a Density 5.739275 kg/m³ Viscosity 0.018000 Centipoise Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Compressed Flow 0.3553 m³/sec Pressure Loss 0.350 bar Flow Type Turbulent Entry Pressure 961736 Friction Factor 0.025450 Exit Velocity 21.68 m/sec Pressure 483.00 kpa a Exit Pressure 483.00 kpa a Exit Velocity 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow V Entry Compressed 0.3553 m³/sec Exit Cenpressure 0.3553 m³/sec Flow V Entry Compressed 0.3831 m³/sec Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Bar Standard Flow 6097.9707 SCMH Friction Loss 0.000 bar Bar Standard Flow 6097.9707 | Elevation Change | 0.00 | m |
| Compressed@<< | Fluid (20°C) | Air | |
| Density5.739275kg/m³Viscosity0.018000CentipoiseMass Flow2.0394kg/secStandard Flow6097.9707SCMHCompressed Flow0.3553m³/secPressure Loss0.350barFlow TypeTurbulentReynolds Number961736Friction Factor0.025450Entry Pressure483.00kg a aEntry Pressure448.00kg a aEntry Density5.739275kg/m³Exit Density5.323385kg/m³Flow✓Entry Compressed0.3553m³/secM³/secExit Compressed0.3831m³/secExit Compressed0.350barFlow✓Entry Compressed0.350barbarFriction Loss0.000barFlitings Loss0.000barElevation Loss0.000bar | Compressed@ | 483.00 | kpa a |
| Viscosity 0.018000 Centipoise Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Compressed Flow 0.3553 m³/sec Pressure Loss 0.350 bar Flow Type Turbulent Fiction Factor 0.025450 Exit Velocity 21.68 m/sec Pressure 483.00 kpa a Exit Pressure 448.00 kpa a Entry Pressure 483.03 kg/m³ Exit Density 5.739275 kg/m³ Exit Compressed 0.3553 m³/sec Flow ✓ Entry Density 5.323385 kg/m³ Exit Compressed 0.3831 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.300 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Density | 5.739275 | kg/m³ |
| Mass Flow2.0394kg/secStandard Flow6097.9707SC/MHCompressed Flow0.3553m³/secPressure Loss0.350barFlow TypeTurbulentReynolds Number961736Friction Factor0.025450Exit Velocity21.68Pressure483.00Entry Pressure483.00Entry Pressure448.00Entry Density5.739275Sit Density5.323385FlowEntry Compressed0.3553Mass Flow2.0394Kg/secStandard FlowFriction Loss0.000barLength171.252391m | Viscosity | 0.018000 | Centipoise |
| Standard Flow6097.9707SCMHCompressed Flow0.3553m³/secPressure Loss0.350barFlow TypeTurbulentReynolds Number961736Friction Factor0.025450Exit Velocity21.68Pressure483.00Entry Pressure483.00Entry Pressure448.00Entry Density5.739275Exit Density5.323385FlowEntry Compressed0.3553Mass Flow2.0394Kadard Flow6097.9707Friction Loss0.000barElevation Loss0.000bar | Mass Flow | 2.0394 | kg/sec |
| Compressed Flow 0.3553 m³/sec Pressure Loss 0.350 bar Flow Type Turbulent Finition Factor 0.025450 Friction Factor 0.025450 Finition Factor Finition Factor Pressure 21.68 m/sec Pressure 483.00 kpa a Exit Velocity 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow V Fitty Compressed 0.3553 Exit Compressed 0.3553 m³/sec Standard Flow 2.0394 kg/sec Standard Flow 0.000 bar Fittings Loss 0.000 bar | Standard Flow | 6097.9707 | SCMH |
| Pressure Loss 0.350 bar Flow Type Turbulent Reynolds Number 961736 Friction Factor 0.025450 Image: Comparison of the sector of the s | Compressed Flow | 0.3553 | m³/sec |
| Flow Type Turbulent Reynolds Number 961736 Friction Factor 0.025450 Exit Velocity 21.68 m/sec Pressure 483.00 kpa a Entry Pressure 483.00 kpa a Entry Pressure 448.00 kpa a Entry Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow ▼ Entry Compressed 0.3553 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.300 bar bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar Standard Flow 5000 bar | Pressure Loss | 0.350 | bar |
| Reynolds Number 961736 Friction Factor 0.025450 Exit Velocity 21.68 m/sec Pressure 21.68 m/sec Entry Pressure 483.00 kpa a Exit Pressure 448.00 kpa a Entry Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow ✓ Entry Compressed 0.3553 m³/sec Exit Compressed 0.3831 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Frittings Loss 0.000 bar Elevation Loss 0.000 bar | Flow Type | Turbulent | |
| Friction Factor 0.025450 Exit Velocity 21.68 m/sec Pressure 483.00 kpa a Entry Pressure 448.00 kpa a Exit Pressure 448.00 kpa a Entry Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow Entry Compressed 0.3553 m³/sec Exit Compressed 0.3831 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.300 bar Elevation Loss 0.000 bar | Reynolds Number | 961736 | |
| Exit Velocity 21.68 m/sec Pressure 483.00 kpa a Entry Pressure 483.00 kpa a Exit Pressure 448.00 kpa a Entry Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Flow Entry Compressed 0.3553 m³/sec Exit Compressed 0.3831 m³/sec Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Friction Factor | 0.025450 | |
| Pressure Pressure A83.00 kpa a Exit Pressure 448.00 kpa a Entry Density 5.739275 kg/m³ Exit Density 5.323385 kg/m³ Exit Compressed 0.3553 m³/sec Standard Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.000 bar Elevation Loss 0.000 bar Length 171.252391 m <lim< li=""> M <lim< li=""> <lim< li=""></lim<></lim<></lim<> | Exit Velocity | 21.68 | m/sec |
| Entry Pressure483.00kpa aExit Pressure448.00kpa aExit Pressure448.00kpa aEntry Density5.739275kg/m³Exit Density5.323385kg/m³FlowEntry Compressed0.3553m³/secExit Compressed0.3831m³/secMass Flow2.0394kg/secStandard Flow6097.9707SCMHFriction Loss0.000barElevation Loss0.000barLength171.252391m | Pressure | · | |
| Exit Pressure448.00kpa aEntry Density5.739275kg/m³Exit Density5.323385kg/m³FlowImage: State of the state o | Entry Pressure | 483.00 | kpa a |
| Entry Density5.739275kg/m³Exit Density5.323385kg/m³FlowImage: State of the st | Exit Pressure | 448.00 | kpa a |
| Exit Density 5.323385 kg/m ³ Flow Image: Compressed 0.3553 m ³ /sec Exit Compressed 0.3831 m ³ /sec Exit Compressed 0.3831 m ³ /sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Entry Density | 5.739275 | kg/m³ |
| Flow m³/sec Entry Compressed 0.3553 m³/sec Exit Compressed 0.3831 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Exit Density | 5.323385 | kg/m³ |
| Entry Compressed 0.3553 m³/sec Exit Compressed 0.3831 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Flow | • | |
| Exit Compressed 0.3831 m³/sec Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Entry Compressed | 0.3553 | m³/sec |
| Mass Flow 2.0394 kg/sec Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar | Exit Compressed | 0.3831 | m³/sec |
| Standard Flow 6097.9707 SCMH Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar Length 171.252391 m < | Mass Flow | 2.0394 | kg/sec |
| Friction Loss 0.350 bar Fittings Loss 0.000 bar Elevation Loss 0.000 bar Length 171.252391 m | Standard Flow | 6097.9707 | SCMH |
| Fittings Loss 0.000 bar Elevation Loss 0.000 bar Length 171.252391 m | Friction Loss | 0.350 | bar |
| Elevation Loss 0.000 bar Length 171.252391 m ~ | Fittings Loss | 0.000 | bar |
| Length 171.252391 m ~ | Elevation Loss | 0.000 | bar |
| _ | Length | 171.252391 | m ~ |

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 | Арр |
|----------------|----------------|---------|
| Length (miles) | 112.31 | 111.996 |

| Results 🖭 🖺 🛛 | | × |
|--------------------|---------------------|--------------------|
| Calc. Method 📃 🤜 | General Fundamen | tal 🔅 |
| Z Model | Custom Compressi | bility Factor |
| Z = | 0.85 | |
| Material 🔍 | Steel (ANSI) | |
| Schedule / Class | Sch. 40 | |
| Internal Roughness | 0.001000 | inch |
| Nominal Size | 32 | inch |
| Internal Diameter | 29.000 | inch |
| Elevation Change | 0.00 | ft |
| Fluid (80°F) | Natural Gas (SG = (| 0.60) |
| Compressed@ | 1400.00 | psi g |
| Density | 4.998059 | lb/ft ³ |
| Viscosity | 0.012000 | Centipoise |
| Atmosphere | 14.700000 | psi a |
| Standard Flow 🔻 | 900.0000 | MMSCFD |
| Mass Flow | 477.4007 | lb/sec |
| Compressed Flow | 95.5172 | ft³/sec |
| Pressure Loss | 800.000 | psi |
| Flow Type | Turbulent | |
| Reynolds Number | 31192199 | |
| Friction Factor | 0.010015 | |
| Exit Velocity | 47.92 | ft/sec |
| Pressure 🔍 | · | |
| Entry Pressure | 1400.00 | psi g |
| Exit Pressure | 600.00 | psi g |
| Entry Density | 4.998059 | lb/ft ³ |
| Exit Density | 2.171702 | lb/ft ³ |
| Flow | | |
| Entry Compressed | 95.5172 | ft³/sec |
| Exit Compressed | 219.8279 | ft³/sec |
| Mass Flow | 477.4007 | lb/sec |
| Standard Flow | 900.0000 | MMSCFD |
| Friction Loss | 800.000 | psi |
| Fittings Loss | 0.000 | psi |
| Elevation Loss | 0.000 | psi |
| Length | 591666.649089 | ft 🗸 |

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 | Арр |
|-------------|----------------|-------|
| Length (ft) | 100 | 99.66 |

| Results 😐 😫 🛛 | | × |
|--|---------------------|--------------------|
| Calc. Method 📃 🤜 | General Fundamental | ŝ |
| Z Model | Ideal Gas Law | |
| Z = | 1 | |
| Material 🔻 | Steel (ANSI) | |
| Schedule / Class | Sch. 40 | |
| Internal Roughness | 0.001811 | inch |
| Nominal Size | 5 | inch |
| Internal Diameter | 5.047 | inch |
| Elevation Change | 0.00 | ft |
| Fluid (60°F) | Air | |
| Compressed@ | 100.00 | psi g |
| Density | 0.595577 | lb/ft ³ |
| Viscosity | 0.017988 | Centipoise |
| Atmosphere | 14.695949 | psi a |
| Standard Flow | 1300.0000 | SCFM |
| Mass Flow | 1.6534 | lb/sec |
| Compressed Flow | 2.7761 | ft³/sec |
| Pressure Loss | 0.103 | psi |
| Flow Type | Turbulent | |
| Reynolds Number | 414100 | |
| Friction Factor | 0.016921 | |
| Exit Velocity | 20.00 | ft/sec |
| Exit Pressure | 99.90 | psi g |
| Flow | , | |
| Entry Compressed | 2.7761 | ft³/sec |
| Exit Compressed | 2.7786 | ft³/sec |
| Mass Flow | 1.6534 | lb/sec |
| Standard Flow | 1300.0000 | SCFM |
| | 0.103 | psi |
| Friction Loss | | psi |
| Friction Loss Fittings Loss | 0.000 | |
| Friction Loss Fittings Loss Elevation Loss | 0.000 | psi |

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