



www.pipelflow.com

Pipe Flow Gas Pressure Drop For iOS

User Guide



Copyright Notice © 2022

All Rights Reserved

Daxesoft Ltd.

Distribution Limited to Authorized Persons Only.

Trade Secret Notice

Pipe Flow Software, PipeFlow.com, PipeFlow.co.uk and Daxesoft Ltd. names and logo and all related product and service names, design marks, logos, and slogans are either trademarks or registered trademarks of Daxesoft Ltd. All other product names and trademarks contained herein are the trademarks of their respective owners.

Printed in the United Kingdom – March 2022

Information in this document is subject to change without notice. The software described in this document is furnished under a license agreement. The software may be used only in accordance with the terms of the license agreement. It is against the law to copy the software on any medium except as specifically allowed in the license agreement. No part of this document may be reproduced or transmitted in any form or by any means electronic or mechanical, including photocopying, recording, or information recording and retrieval systems, for any purpose without the express written permission of Daxesoft Ltd.

Contents

1 Introduction	7
1.1 Pipe Flow Gas Pressure Drop Software Overview	7
1.2 Device Compatibility	8
1.3 Licensing Information	9
1.4 Contacting Pipe Flow Software	11
1.5 Additional Pipe Flow Software Programs	12
1.5.1 Mobile - iPhone and iPad	12
1.5.2 Desktop – Windows & MacOS	12
2 Interface and Menus	14
2.1 Main Menu	15
2.1.1 Help & User Guide Menu	16
2.1.2 Results Verification Menu	17
2.2 Calculation Panel	18
2.3 Results Panel	20
2.3.1 Results Menu Bar	22
2.4 Results Share Action Sheet	23
2.5 Expandable Sections	24
2.6 Notifications & Action Sheets	25
3 Settings	27
3.1 Pipe Flow Gas Pressure Drop	28
3.1.1 Rate on the App Store	29
3.1.2 Recommend Pipe Flow Gas Pressure Drop	29
3.1.3 Reset	30
3.2 Units	31
3.3 Results Decimals	32
3.4 General	33
3.5 Reports	34
4 File and Calculation Operations	35
4.1 Filename Extension	35
4.2 Saving a Calculation	35
4.3 Saved Files	36
4.3.1 Export / Backup all Files	37
4.4 Sharing a Calculation	37
4.5 Loading a Calculation	39
4.5.1 Load Calculation from Saved Files	39
4.5.2 Load Calculation from Shared File	39
4.5.3 Display Filename of Loaded Calculation	39
5 Pressure Drop Calculation	41

5.1 Gas Pressure Drop Calculation	42
6 Fluids Database	44
6.1 Adding Gases to the Fluid Database	45
7 Pipe Material & Diameters	48
7.1 Selecting a Pipe Material	49
7.2 Duplicating a Pipe Material	50
7.3 Adding a new Pipe Material	52
7.4 Selecting a Pipe Diameter	53
7.5 Adding a Pipe Diameter	54
8 Fittings & Valves	55
8.1 Adding a Fitting to the Pipe	55
8.2 Removing a Fitting from the Pipe	57
8.3 Adding a Fitting to the Database	58
9 Flow Rate Calculator / Helper	60
10 Calculations and Results	61
10.1 Automatic Checks and Updates	61
10.1.1 Fitting Sizes	61
10.2 Configuring the System Results	61
10.3 Creating a Report of the Results	62
10.4 PDF Report Example	63
11 Working with Compressible Fluids	65
11.1 Defining Gas Data	66
11.1.1 Gas Calculator Data	67
11.2 Using Compressible Flow Equations	68
12 Calculation Theory and Method of Solutions	70
12.1 Fluid Flow States	70
12.2 Fluid Viscosity	70
12.3 Reynolds Numbers	70
12.4 Friction Factors	71
12.5 Colebrook-White Formula	71
12.6 Friction Losses (Resistance to Flow)	72
12.7 Darcy-Weisbach Formula	72
12.8 Fitting Losses	73
12.8.1 'K' Factor Fitting Head Loss Calculation for Liquids	73
12.8.2 Equivalent Length Head Loss Calculation for Gases	73
12.8.3 Fittings Database	74
12.9 Compressible Gas Flow Equations	74

13 Glossary **75**

Table of Figures

Figure 1 License Software	9
Figure 2 Calculation Panel Interface	14
Figure 3 Results Panel Interface	14
Figure 4 Main Menu	15
Figure 5 Help & User Guide	16
Figure 6 Results Verification Menu	17
Figure 7 Calculation Panel	18
Figure 8 Results Panel	20
Figure 9 Results Menu Bar	22
Figure 10 Results Share Action Sheet	23
Figure 11 Expandable Sections	24
Figure 12 Temporary Notification	25
Figure 13 Temporary Notification with Additional Information	25
Figure 14 Notification with Action Sheet	26
Figure 15 Settings	27
Figure 16 Pipe Flow Gas Pressure Drop Menu	28
Figure 17 Reset	30
Figure 18 Units	31
Figure 19 Results Decimals	32
Figure 20 Settings General	33
Figure 21 Settings Reports	34
Figure 22 Save Dialog	35
Figure 23 Saved Files - All Calculations	36
Figure 24 Saved Files (Action Buttons)	36
Figure 25 Results Panel Share Action Sheet	37
Figure 26 Calculation Panel Share Action Sheet	37
Figure 27 Calculation Loaded Screen Title	39
Figure 28 Filename of Loaded Notification	40
Figure 29 Gas Pressure Drop Calculation	42
Figure 30 Gas Pressure Drop Results	43
Figure 31 Fluid Database - Gases	44
Figure 32 Fluids Database Action Sheet	45
Figure 33 Gas Data Calculator	46
Figure 34 Gas Data Calculator Save Action Sheet	47
Figure 35 Pipe Material Database	49
Figure 36 Pipe Material List Actions Menu	50
Figure 37 Material Database - Material Action Sheet	51
Figure 38 Add New Pipe Material	52
Figure 39 Pipe Diameter	53
Figure 40 Add Pipe Diameter	54
Figure 41 Fittings & Valves	55
Figure 42 Fitting Database	56
Figure 43 Remove Fitting from the Pipe	57
Figure 44 Create New Fitting	58
Figure 45 Choose Fitting Symbol	58
Figure 46 Flow Calculator	60
Figure 47 Fitting Sizes	61
Figure 48 PDF Report - Tabulated	63
Figure 49 PDF Report – Non-Tabulated	64
Figure 50 Compressible Flow Equations	68

1 Introduction

Pipe Flow Gas Pressure Drop is a software application developed for iOS that can perform calculations to find the pressure loss of a gas in a single pipe. With an intuitive and easy to use interface, it allows the user to quickly specify the known information, calculate the answer, view the comprehensive results, generate Excel or PDF reports, save and share the calculation.

The required calculation data can be entered manually, leveraging the wide range of metric and imperial units available or selected from the integrated fluid, material, pipe and fitting databases. The software is also backed up by an unrivalled support service that provides help to users when they need it.

1.1 Pipe Flow Gas Pressure Drop Software Overview

Pipeline systems range from single pipelines to very large complex networks with hundreds of interconnecting pipes. They may be simple, carrying water from one reservoir to another reservoir, or they may be complex with many interconnecting pipes that distribute fluid over a large area, or they could fall somewhere in-between such as a system that transfers a fluid from a supply container to a delivery point.

The Pipe Flow Gas Pressure Drop software is designed to calculate pressure loss for a single pipe. It is a useful tool for piping calculations that engineers often need to perform either at the office or out in the field.

Note: Our [*Pipe Flow Expert*](#) software can be used to model and calculate flow rates, pressure losses and pumping requirements within a complex pipe system.

The Pipe Flow Gas Pressure Drop calculation panel has a set of data input fields that enable the known information to be entered. This data includes:

- The internal size, roughness and length of the pipe.
- The elevation change between the start and end of the pipe.
- The type, quantity and position of fittings on the pipe.
- The type and characteristics of the gas in the pipe.
- The required flow rate of the gas in the pipe.

Once the known information has been specified for the required calculation, the results can be obtained by tapping Calculate. The results panel slides up and over the inputs panel to concisely display the calculated data which typically includes:

- Friction losses, fitting losses, elevation change gains / losses.
- Flow type, Reynolds number and Friction factor.
- Entry and exit pressures and densities.
- Entry and exit flow rates.
- Total pressures loss.

1.2 Device Compatibility

Requires iOS 11.0 or later.

Please see the Compatibility section of Pipe Flow Gas Pressure Drop in the App Store for a full list of compatible devices.

1.3 Licensing Information

Pipe Flow Gas Pressure Drop for iOS is a software package that is provided for use on Apple iOS devices.

Installation

When the software is installed from the App Store, it can be used in Trial Mode.

When in Trial Mode, calculations can be performed however the pipe diameter cannot be changed. In addition, Excel & PDF reports that were produced with a licensed version of the software cannot be viewed.

To enable the above functionality, the software must have a valid License.

To purchase a license, tap the **Buy** button **BUY** in the footer to display the **License Software** screen, then tap the **Buy Pipe Flow Gas Pressure Drop**.

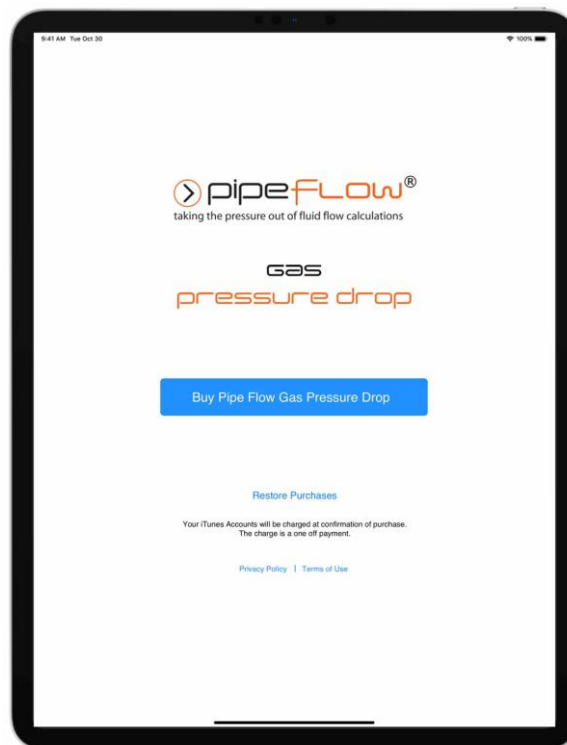


Figure 1 License Software


Purchasing a License

App purchases are entirely managed by Apple Inc. The license fee will be charged to your iTunes Account at confirmation of purchase. The license fee is a **one-time** cost that provides access to the software for its lifetime.

You require an internet connection when licensing the software. The software does not need an internet connection to operate.

Manage License

If you delete and re-install Pipe Flow Gas Pressure Drop, or install the App on a new device, Pipe Flow Gas Pressure Drop will return to trial mode.


To restore your license, launch Pipe Flow Gas Pressure Drop, tap the **Main Menu**  button and then In App Purchases > Restore Purchases.

Additional Devices

The Pipe Flow Gas Pressure Drop software can be downloaded to all your compatible Apple devices.

If you have purchased a license, then this license is valid on all compatible Apple devices that share the same Apple ID (or family sharing).

To enable a license on another device:

Launch Pipe Flow Gas Pressure Drop, tap the **Main Menu**  button and then In App Purchases > Restore Purchases.

Summary

- The Pipe Flow Gas Pressure Drop software can be downloaded and installed for a free trial.
- A license can be purchased via the Apple App Store In App Purchase that will enable use of the software for its lifetime.
- A user can be up and running with a licensed version of the software within a few minutes.
- Software support and maintenance, including technical assistance, help with modeling issues and free upgrades to new releases, are provided for free while you are running a licensed copy of the Pipe Flow Gas Pressure Drop software.

1.4 Contacting Pipe Flow Software

Email: support@pipeflow.com

Internet: www.pipeflow.com

UK Telephone: +44 (0)161 408 3569

USA Telephone: +1 650-276-3569
+1 650-276-FLOW

Pipe Flow Software, PipeFlow.com and PipeFlow.co.uk are trading names of Daxesoft Ltd, a U.K. Registered Company.

1.5 Additional Pipe Flow Software Programs

1.5.1 Mobile - iPhone and iPad

Single pipe liquid pressure drop and flow rate calculators:

- [Pipe Flow Liquid Pressure Drop](#)
- [Pipe Flow Liquid Flow Rate](#)
- [Pipe Flow Liquid Pipe Length](#)
- [Pipe Flow Liquid Pipe Diameter](#)

Single pipe gas pressure drop and flow rate calculators:

- [Pipe Flow Gas Pressure Drop](#) (This software program)
- [Pipe Flow Gas Flow Rate](#)
- [Pipe Flow Gas Pipe Length](#)
- [Pipe Flow Gas Pipe Diameter](#)

Pipe Flow GasRef – gas properties calculator

[Pipe Flow GasRef](#) can be used to calculate the density, z compressibility, viscosity, specific heat ration at different temperature and pressure conditions for a number of common gases.

1.5.2 Desktop – Windows & MacOS

Pipe Flow Expert - for designing piping and pumping systems (Windows)

Pipe Flow Expert can be used to model pipe systems with just a few pipes through to more complex systems with many hundreds of pipes, with multiple supply points, multiple discharge points, and multiple pumps running in series or in parallel.

For more information about Pipe Flow Expert, see:

www.pipeflow.com/pipe-flow-expert-software

Pipe Flow Wizard – Flow Rate and Pipe Pressure Drop Calculators (Windows & MacOS)

Pipe Flow Wizard software makes it easy to calculate pressure loss, flow rate, size a pipe diameter and calculate pipe length. It allows users to perf ‘What If?’ calculations on both liquids and gases flowing in a single length of pipe between a start and end elevation, when pipe fittings can be added to represent valves and bends.

For more information about Pipe Flow Wizard, see:

<https://www.pipeflow.com/pipe-flow-wizard-software>

Pipe Flow Advisor - for Channels and Tanks (Windows)

Pipe Flow Advisor may be used to estimate water flow rate from various shaped channels and tanks. It can calculate:

- Open Channel Flow
- Water Flow Rates
- Time taken to empty tanks
- Volume, Capacity, Weight and Expansion

For more information about Pipe Flow Advisor, see

www.pipeflow.com/pipe-flow-advisor-software

All desktop software program can be downloaded for a free trial by visiting:

www.pipeflow.com

Once you have installed a trial version of one of our software products it can be fully enabled and licensed by buying a license code from our web site. You can be up and running with a fully licensed program within just a couple of minutes.

2 Interface and Menus

This section details the different features of the Pipe Flow Gas Pressure Drop interface. For each feature, there is an explanation, a screen shot and a table providing descriptions for each element of the feature. The following sections provide instructions for using the Pipe Flow Gas Pressure Drop application.

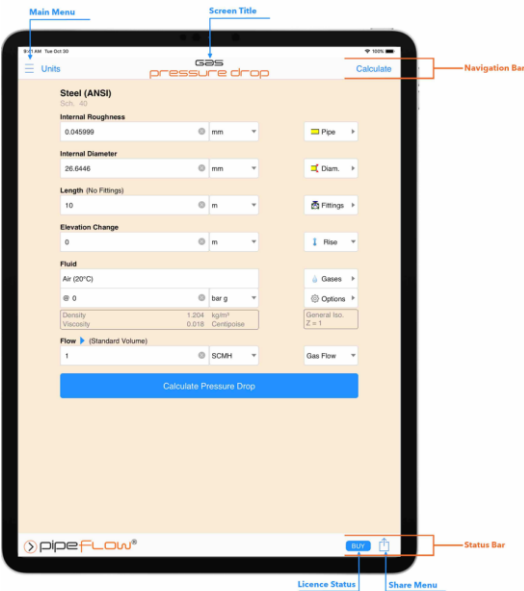


Figure 2 Calculation Panel Interface

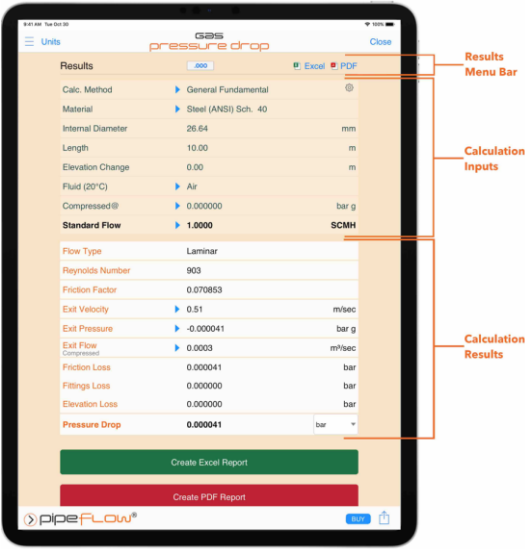



Figure 3 Results Panel Interface

2.1 Main Menu

Tap the **Main Menu**  button to display the Pipe Flow Gas Pressure Drop main menu.

The main menu has five different sections to help you navigate and work in Pipe Flow Gas Pressure Drop.

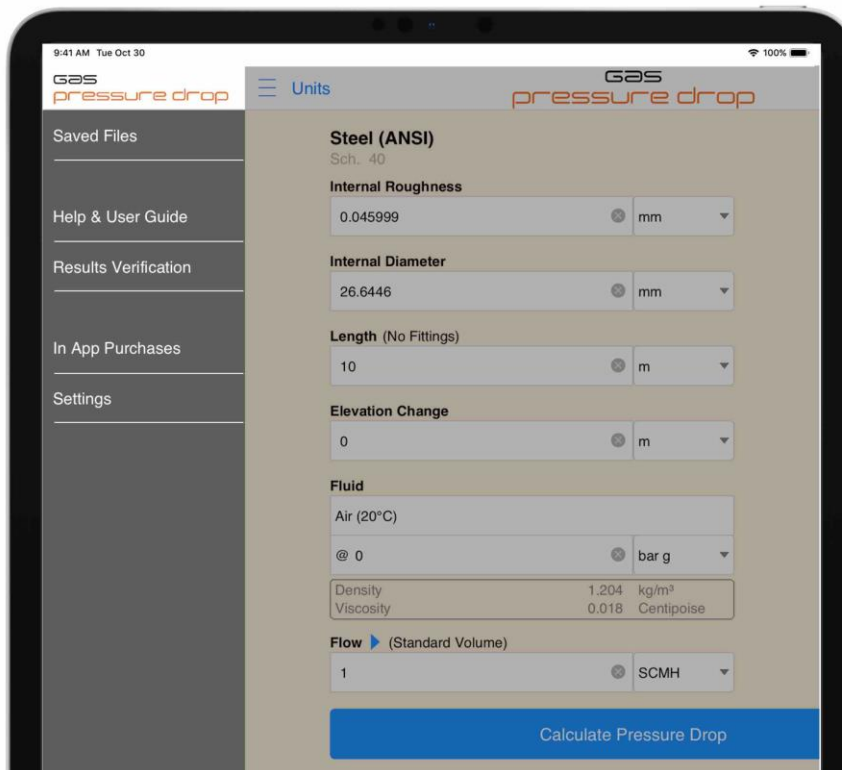


Figure 4 Main Menu

Menu Items	Description
Saved Files	Display the Saved Files screen. For more information, see: Saved Files .
Help & User Guide	Displays the Help & User Guide menu. For more information, see: Help & User Guide Menu .
Results Verification	Display the Results Verification menu. For more information, see Results Verification Menu .
In App Purchases	Display the In App Purchase or Purchase screen. For more information, see Licensing Information .
Settings	Display the Settings menu. For more information, see Settings .

Select an option from the menu or tap the Gas Pressure Drop logo to close the menu.

2.1.1 Help & User Guide Menu



Figure 5 Help & User Guide

Menu Items	Description
User Guide	Open the User Guide PDF document (this document).
View Website	Open the Pipe Flow website.
View Support	Open Pipe Flow Gas Pressure Drop's support pages on the web.
Email Support	Send an e-mail to our support team.

2.1.2 Results Verification Menu

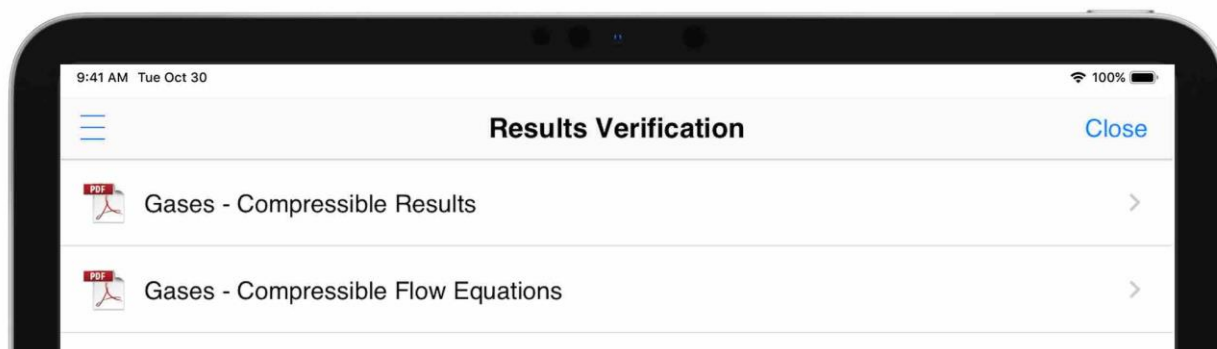


Figure 6 Results Verification Menu

Menu Items	Description
Gases – Compressible Results	Open the Compressible (Gases) Calculation Results Verification PDF document.
Gases – Compressible Flow Equations	Open the Compressible (Gases) Flow Equations & formula descriptions PDF.

2.2 Calculation Panel

The calculation panel allows you to enter known information for the required calculation

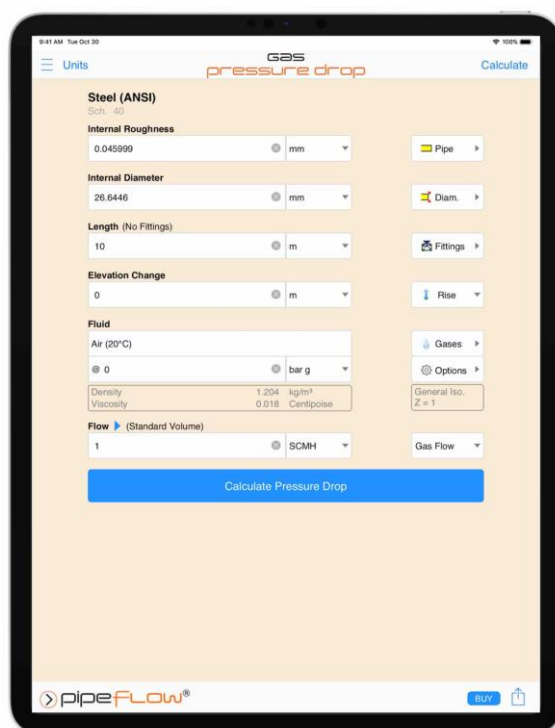






Figure 7 Calculation Panel

The **Material name**, **Schedule** and **Internal roughness** of the pipe can be specified by tapping the **Pipe**  button to open the **Pipe Material** screen from where a material can be selected from the database or a new material defined. For more information about working with pipe materials, see: [Pipe Material & Diameters](#).


The **Internal diameter** of the pipe can be specified by tapping the **Diam.**  button to open the **Pipe Diameter** screen from where a pipe size can be selected from the database or a new size defined. For more information about working with pipe diameters, see: [Pipe Material & Diameters](#).

Fittings can be added to the pipe by tapping the **Fittings**  button to open the **Fitting Screen** from where fittings can be selected, or new fittings defined. For more information about working with fittings, see: [Fittings & Valves](#).

The pipe's **Elevation** change can be specified by entering the difference in height from the start of the pipe to the end of the pipe in the **Elevation Change** field and specifying whether this is a rise or fall.

The **Gas** in the pipe can be specified by tapping the **Gases**  button to display the Fluid Database. For more information about working with fluids, see:

Fluids Database.

The **Flow** rate of the fluid can be specified by entering the value into the **Flow** field or tapping the expander  button to open the **Flow Rate Calculator**. For more information about entering a flow rate based on a velocity using the **Flow Rate Calculator**, see: [Flow Rate Calculator / Helper](#).

Tap the **Calculate** button to solve the calculation using the data supplied.

The **Results Panel** will slide up and over the calculation panel to display the results of the calculation. For more information about the Results Panel, see: [Results Panel](#).



Depending upon the amount of information in the calculation panel and/or the height of the program window, it may be necessary to scroll down to reveal further information.

2.3 Results Panel

When a calculation is solved, the **Results Panel** slides up and over the **Calculation Panel**.

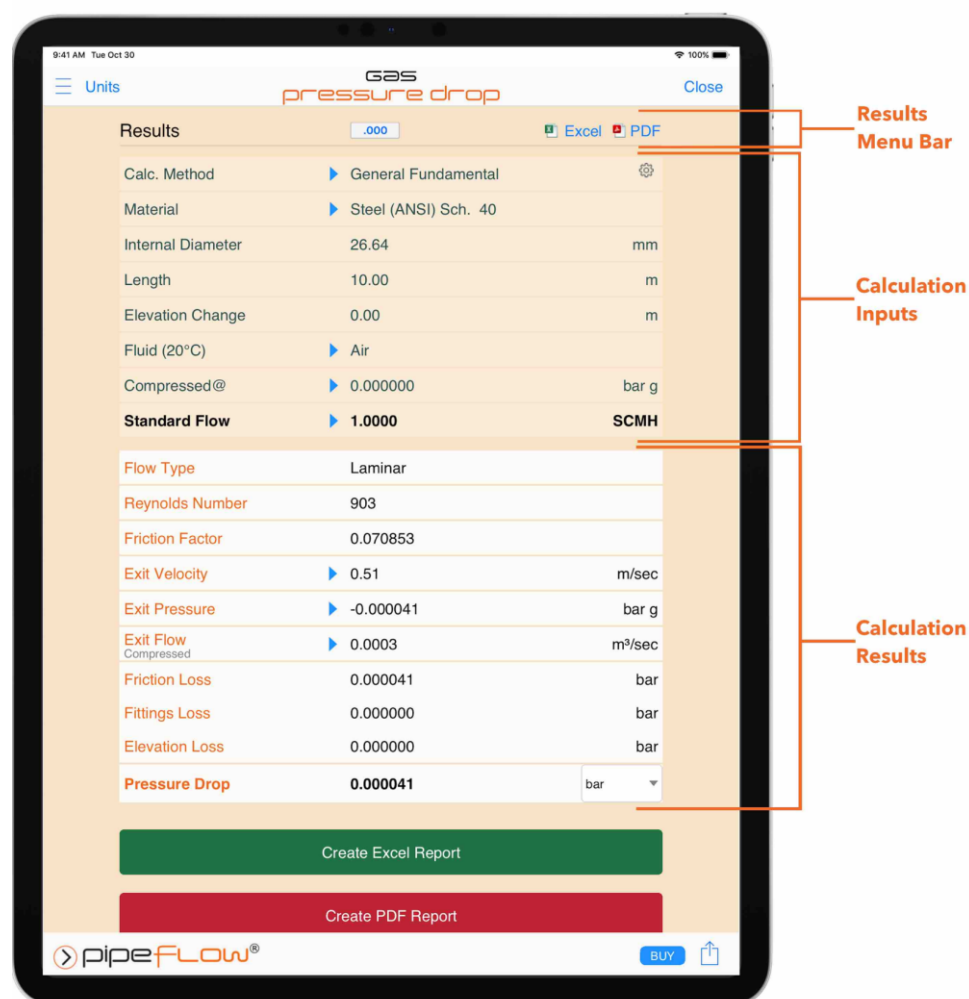



Figure 8 Results Panel

The results panel displays the data that was entered by the user at the top in the 'Calculation Inputs' section and displays the results beneath the inputs in the 'Calculation Results' section.

The display unit for each different item of data can be changed in Settings. In addition, for the main result the display unit can be changed by selecting the unit from the drop-down list. When the result panel is closed, and another calculation is performed, the result unit will be reset to the unit that is specified in settings for that attribute. For more information about setting units, see: [Units](#).

Tapping the expander  button for a result attribute will reveal further data associated with that attribute. For further information about expanders, see: [Expandable Sections](#).

2.3.1 Results Menu Bar

In the header of each result panel is the results menu bar.

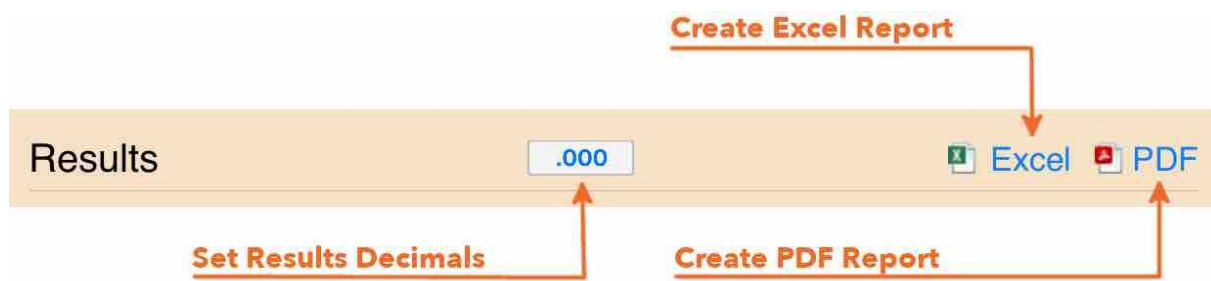





Figure 9 Results Menu Bar


The menu bar contains three buttons which provides quick access to:

Menu Items	Description
	Setting the decimals for the results. For more information about results decimals, see: Results Decimals .
	Creating and viewing an Excel Report. For more information about Excel Reports, see: Creating a Report of the Results .
	Creating and viewing a PDF Report. For more information about PDF Reports, see: Creating a Report of the Results .



Depending upon the amount of information in the result panel and/or the height of the program window, it may be necessary to scroll down to reveal further information.

2.4 Results Share Action Sheet

In the footer of each result panel is the status bar. Tap the **Share**  button to open the **Share Action Sheet**.

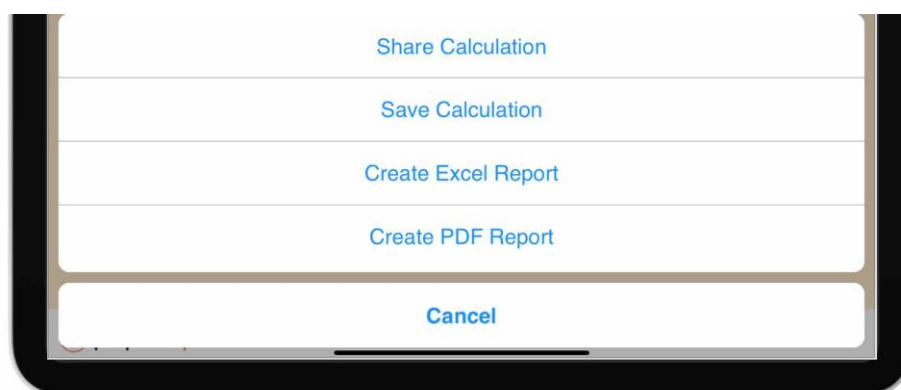



Figure 10 Results Share Action Sheet

Menu Items	Description
Share Calculation	Opens the iOS Share Action Sheet to allow the calculation to be exported from the device (e.g. via AirDrop, mail, DropBox etc.). For more information about sharing calculations, see: Sharing a Calculation .
Save Calculation	Saving the calculation to the local storage on the device. For more information, see Saved Files .
Create Excel Report	Create and view an Excel Report. For more information about Excel Reports, see: Creating a Report of the Results .
Create PDF Report	Create and view a PDF Report. For more information about PDF Reports, see: Creating a Report of the Results .
Cancel	Close the Share action sheet.

2.5 Expandable Sections

Pipe Flow Gas Pressure Drop uses expandable sections to allow the user to increase or reduce the information that is displayed.

Sections that can be expanded display the expander button  which when tapped will expand the section to reveal more information.

Tapping the expander button when the section is expanded will collapse the section.

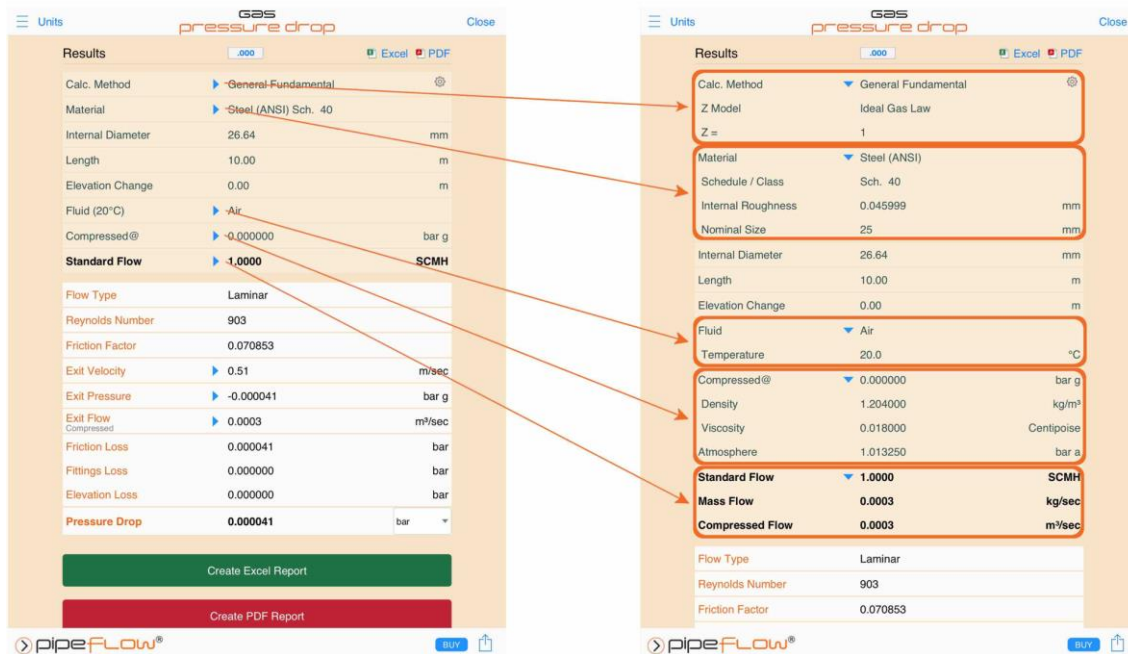


Figure 11 Expandable Sections

2.6 Notifications & Action Sheets

Messages that do not require user acknowledgement / interaction are displayed as a notification at the top of the screen.

These notifications are displayed for a short period of time.

To close a notification, tap or swipe up on the notification banner.

To prevent a notification from closing, press and hold on the notification banner.



Figure 12 Temporary Notification

Some notifications may also display a button in the bottom right corner (e.g. More Details, or Learn More), which when tapped will open an information panel providing additional information about the notification.



Figure 13 Temporary Notification with Additional Information

Action Sheets display at the bottom of the screen and allow the user to select certain options.

In some cases, action sheets are displayed in conjunction with a notification. When notifications appear with action sheets, the notification will remain on display and will be removed when an option on the action sheet has been selected – the notification cannot be removed by tapping or swiping.

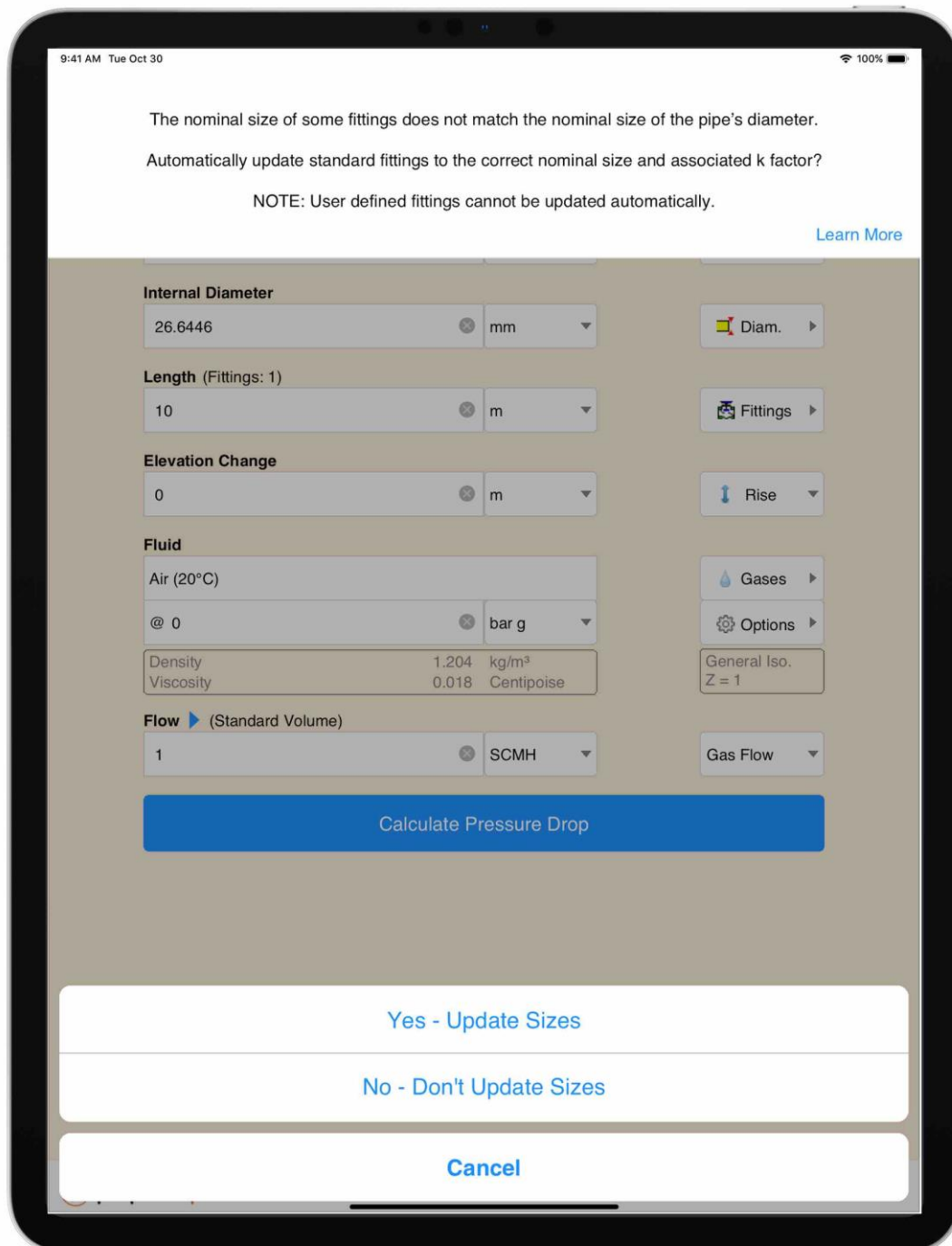



Figure 14 Notification with Action Sheet

3 Settings

Pipe Flow Gas Pressure Drop can be configured and set-up to suit the user's working preferences.

The settings screen is opened by tapping the **Main Menu**  button and then **Settings**.

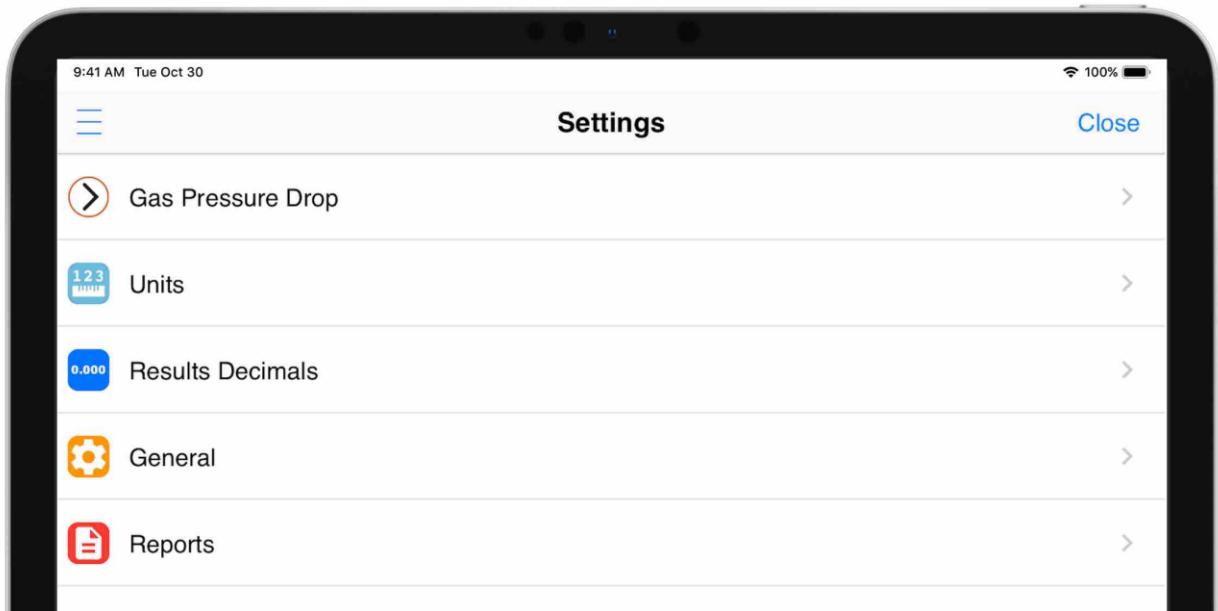




Figure 15 Settings

Menu Items	Description
Pipe Flow Gas Pressure Drop	Open the Pipe Flow Gas Pressure Drop screen. For more information, see: Gas Pressure Drop Calculation .
Units	Open the Units screen. For more information, see: Units .
Results Decimals	Open the Results Decimals screen. For more information, see: Results Decimals .
General	Open the General menu. For more information, see: General .
Reports	Open the Reports screen. For more information, see: Reports .

3.1 Pipe Flow Gas Pressure Drop

The **Pipe Flow Gas Pressure Drop** screen is displayed by tapping the **Main Menu**  button, **Settings** and then the **Pipe Flow Gas Pressure Drop**  menu item.

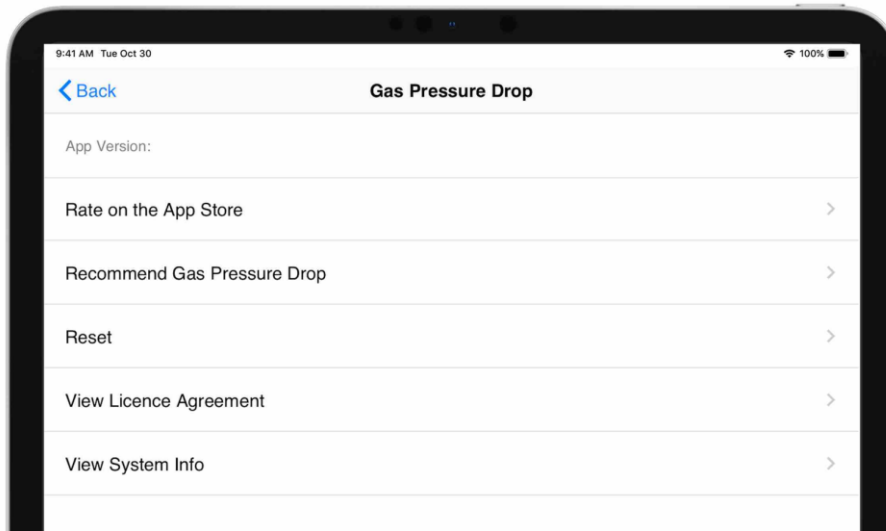




Figure 16 Pipe Flow Gas Pressure Drop Menu



Menu Items	Description
App Version	Displays the Pipe Flow Gas Pressure Drop version number.
Rate on the App Store	Open the Apple App Store so that you can provide a rating / review of Pipe Flow Gas Pressure Drop. For more information, see: Rate on the App Store .
Recommend Pipe Flow Gas Pressure Drop	Easily send a Pipe Flow Gas Pressure Drop recommendation e-mail to a friend or colleague. For more information, see: Recommend Pipe Flow Gas Pressure Drop .
Reset	Open the Reset screen. For more information, see: Reset .
View License Agreement	Displays the Pipe Flow Gas Pressure Drop license agreement.
View System Info	Displays information about the version of Pipe Flow Gas Pressure Drop and your device.

3.1.1 Rate on the App Store

To provide a rating and/or review of Pipe Flow Gas Pressure Drop on the Apple App Store, tap the **Main Menu**  button, **Settings > Pipe Flow Gas Pressure Drop**  and then the **Rate on the App Store** menu item.

The App Store application on your device will be launched and the Pipe Flow Gas Pressure Drop App display from where you can leave a review / rating.



3.1.2 Recommend Pipe Flow Gas Pressure Drop

To easily recommend Pipe Flow Gas Pressure Drop to a friend or colleague, tap the **Main Menu**  button, **Settings > Pipe Flow Gas Pressure Drop**  and then the **Recommend Pipe Flow Gas Pressure Drop** menu item.

The Mail application on your device will be launched and new Email prepared containing some default text and a link to download the Pipe Flow Gas Pressure Drop.

Enter the email addresses of the people you wish to send the recommendation to and edit the body text as needed, then tap Send.

3.1.3 Reset

The **Reset** screen is displayed by tapping the **Main Menu**  button, **Settings** > **Pipe Flow Gas Pressure Drop**  and then the **Reset** menu item.

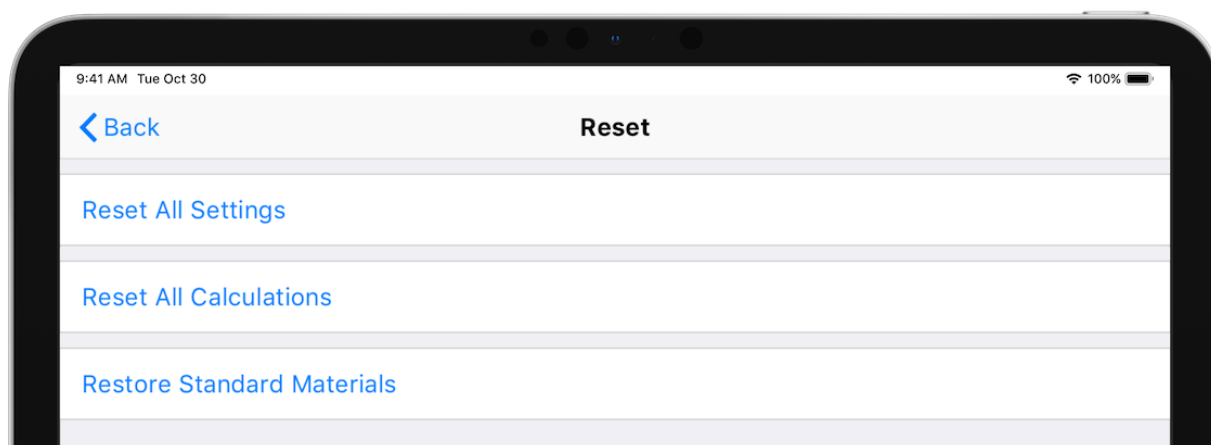




Figure 17 Reset

Option	Description
Reset All Settings	Reset all settings values to defaults.
Reset All Calculations	Reset all calculation values to defaults.
Restore Standard Material	Restore standard materials that have been deleted.

3.2 Units

The **Units** screen is displayed by tapping the **Main Menu**  button, **Settings** and then **Units**  menu item.

It can also be displayed by tapping the **Units** button in the **Navigation Bar** from any calculation.

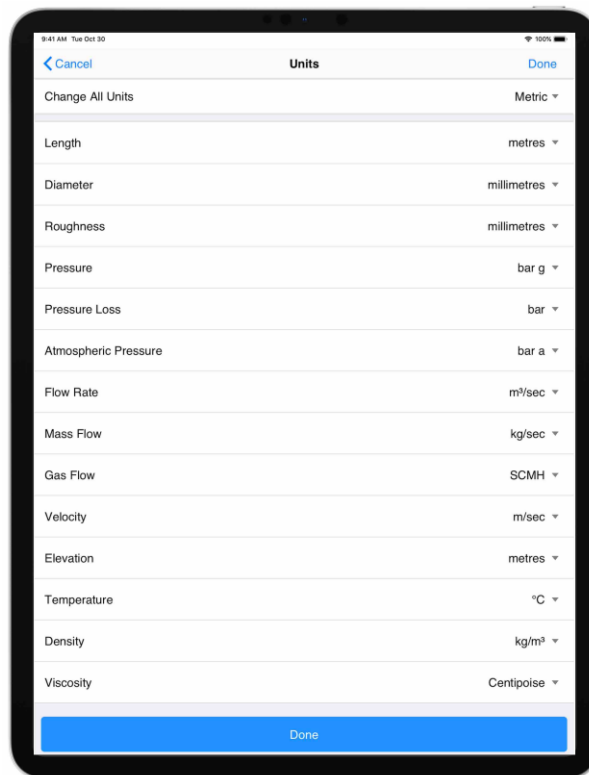





Figure 18 Units


Units for each of the calculations can be specified by:

1. Selecting the required unit for each of the attributes, OR
Selecting Imperial / Metric to change all units for that calculation.
2. Tap Done.

 Scroll down to reveal more units if not all units are displayed.

3.3 Results Decimals

The **Results Decimals** screen is displayed by tapping the **Main Menu**  button, **Settings** and then **Results Decimals**  menu item.

It can also be displayed by tapping on the  **Results Decimals** button in the **Results Menu Bar** from any calculation. For more information, see: [Results Menu Bar](#).

The number of post decimal digits for each attribute can be specified individually, or all attributes can be set to the same number of post decimals by selecting a value from the **Set All Decimals** drop down.

The number of post decimal digits can be reset to their default values by tapping **Reset to Defaults**.

All results data displayed on the Results Panel and in the Excel / PDF reports will be displayed to the number of post decimals specified.

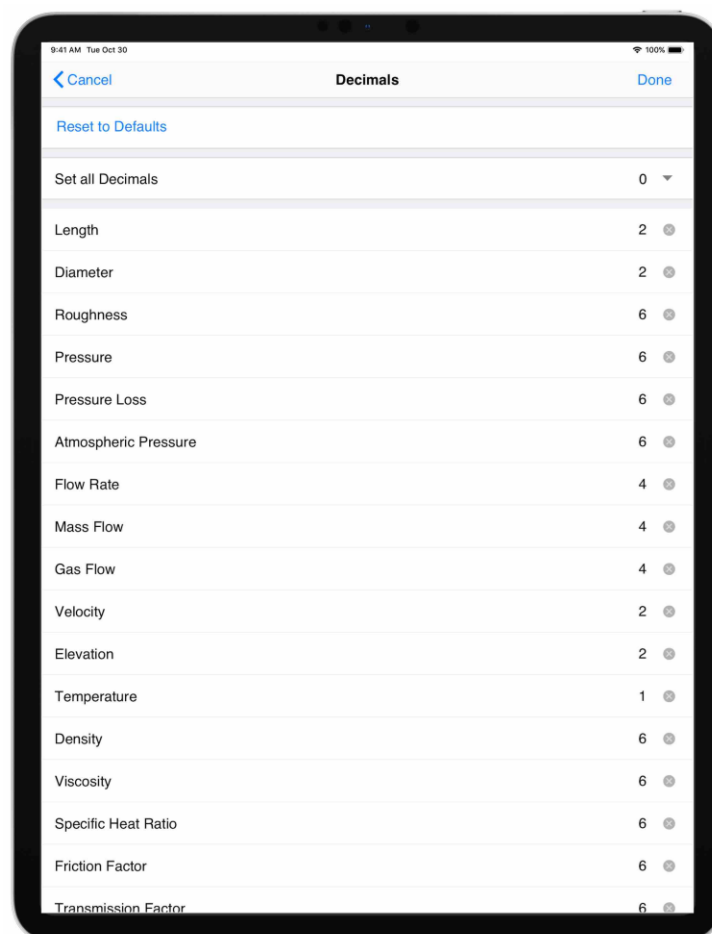




Figure 19 Results Decimals

 Scroll down to reveal more attributes.

3.4 General

The **General** screen is displayed by tapping the **Main Menu**  button, **Settings** and then **General**  menu item.

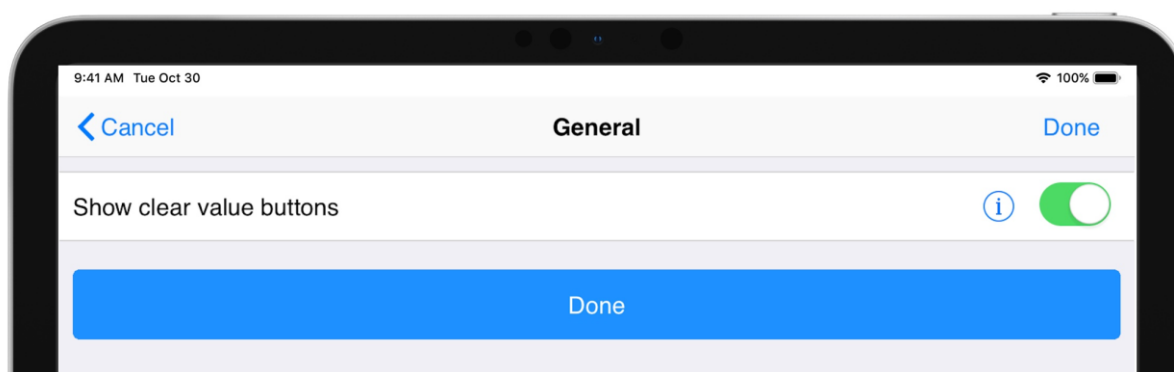





Figure 20 Settings General

Option	Description
Show clear value buttons	When checked, edit boxes contain a clear value  button that when tapped will erase the contents of the edit box.

3.5 Reports

The **Reports** screen is displayed by tapping the **Main Menu**  button, **Settings** and then **Reports**  menu item.

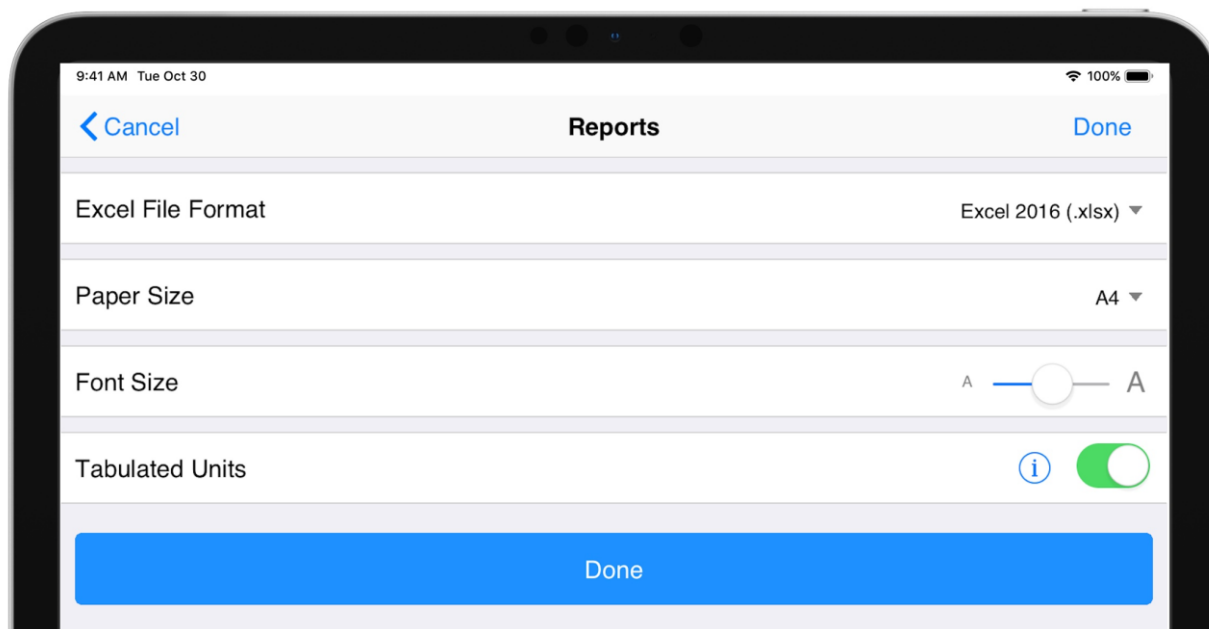


Figure 21 Settings Reports

Option	Description
Excel File Format	Configure the version of Excel that will be used.
Font Size	Configure the font size to use for the report.
Paper Size	Configure the paper size to use for the report.
Tabulated Units	When enabled, units will be displayed in their own column. When un-checked, units will be displayed next to their value in the same column. For examples of tabulated and non-tabulated reports, see: PDF Report Example .

4 File and Calculation Operations

4.1 Filename Extension

The filename extension for the Gas Pressure Drop calculation is .pfgdp

4.2 Saving a Calculation

When on the results panel of a calculation, tap **Save Calculation** to display the filename dialog. It is not necessary to add a file extension. The filename will be pre-populated with a default filename, alternatively this can be cleared / overtyped with your own filename.

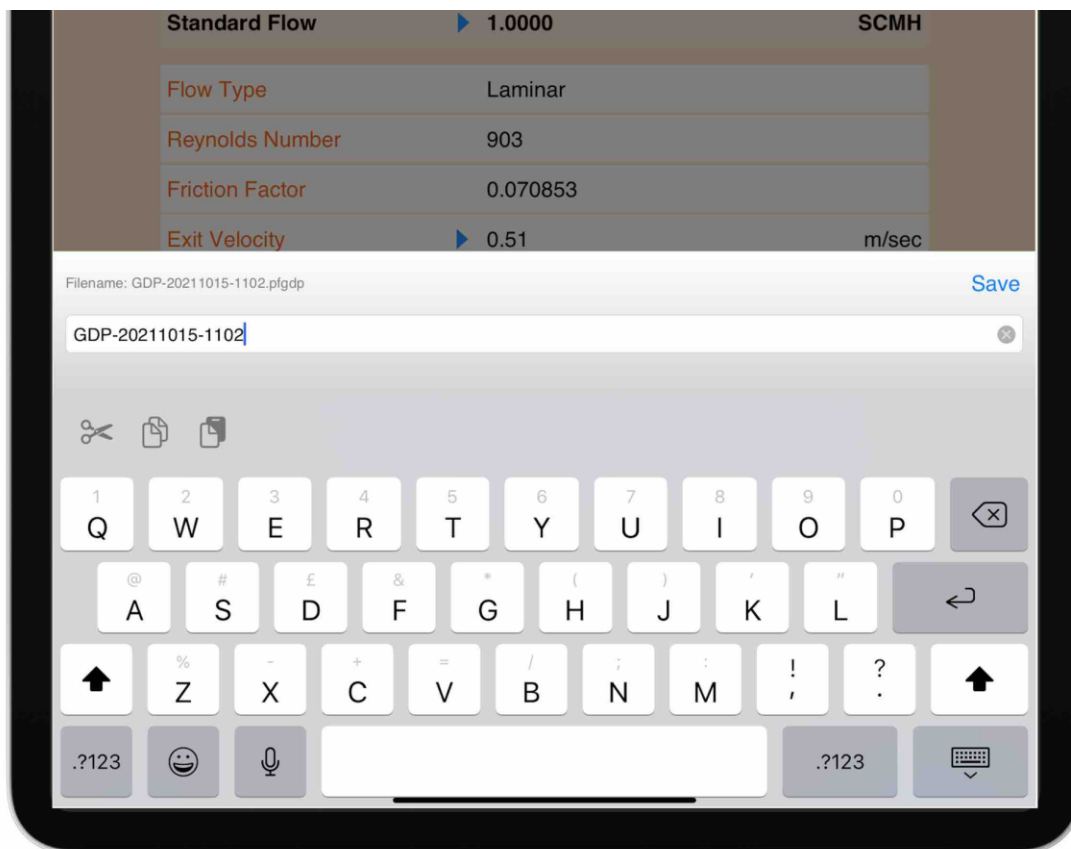


Figure 22 Save Dialog

Saved calculations are stored on your device and can be accessed by tapping **Saved Files** on the **Main Menu**.

4.3 Saved Files

The **Saved Files** screen displays all calculations that have been saved to your device. The file list can be sorted date ascending or descending.

Tap on a row in the list to load the calculation.

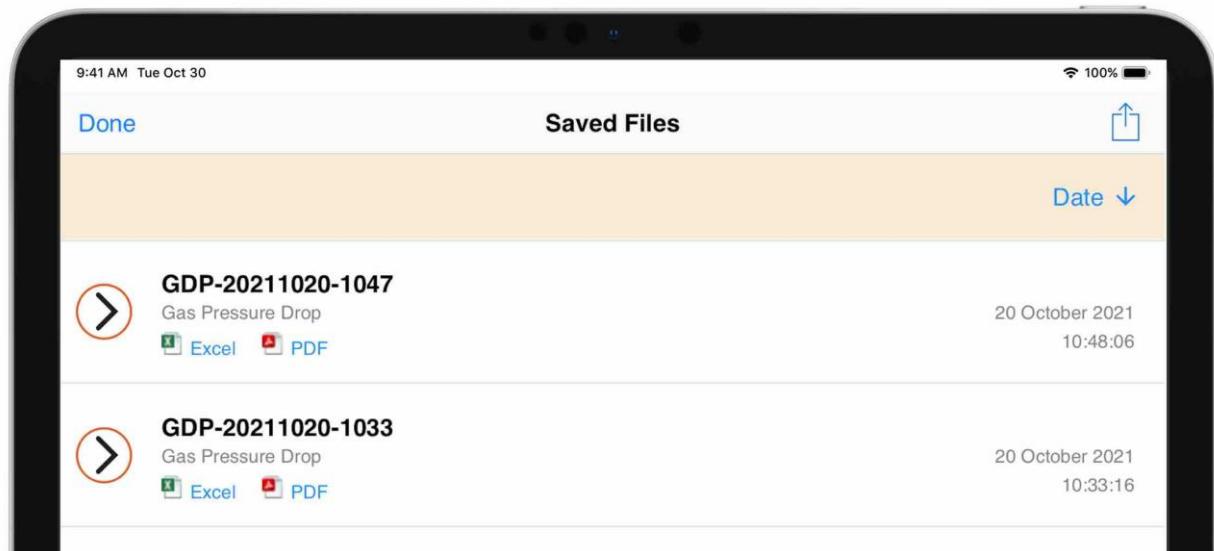


Figure 23 Saved Files - All Calculations

Tap the **Excel** or **PDF** buttons to create and view a calculation report directly from the **Saved Files** screen.

Swipe right to left, on a row in the list, to display the additional action buttons for the saved file.

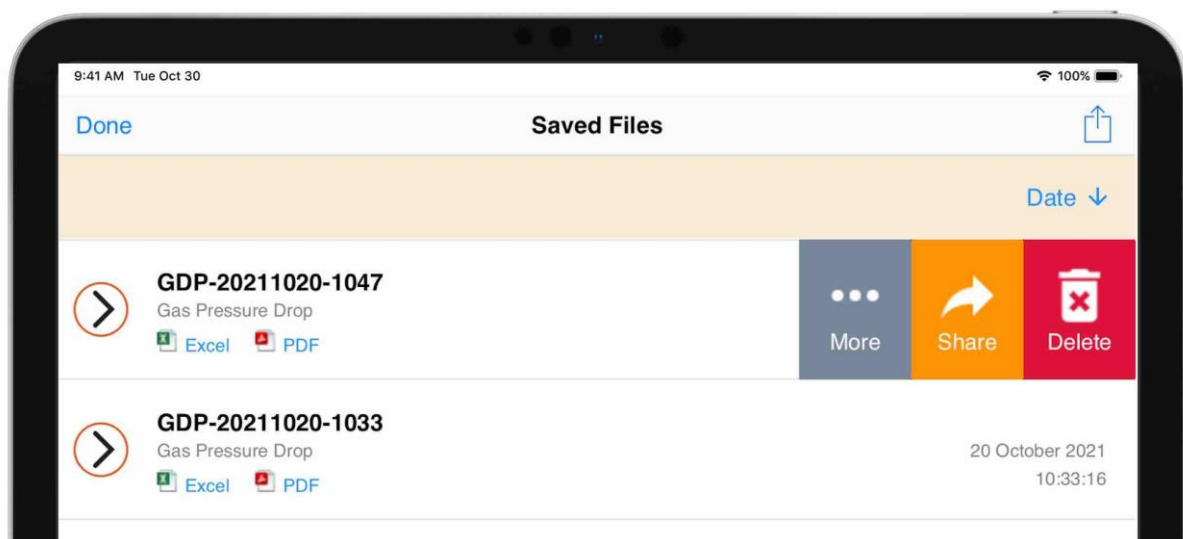



Figure 24 Saved Files (Action Buttons)


Action Button	Description
More	Displays the more action sheet with options to create an Excel or PDF report.
Share	Displays the iOS Share Action Sheet so that the calculation can be shared with other Pipe Flow Gas Pressure Drop users (on any device).
Delete	Delete the selected file from your device. A confirmation dialog will be displayed to confirm the file deletion. Once deleted, the file cannot be recovered.

4.3.1 Export / Backup all Files

To export / backup all calculation files on your device, tap the  button to display the **Share Action** sheet and tap **Export all Calculations**. Pipe Flow Gas Pressure Drop will create a compressed folder (zip) containing all the calculation files and then display the **iOS Share Action** sheet from where you can select how to share the zip file. For example, you can select to send the zip file via e-mail or use a third-party cloud service such as Drop Box.

4.4 Sharing a Calculation

The calculation data can be shared with other Pipe Flow Gas Pressure Drop users (on any device).

To share a calculation, tap the **Share**  button to display the associated action sheet. This will be either the Results Panel Share Action Sheet (depending upon the current panel shown) or the Calculation Panel Share Action Sheet.

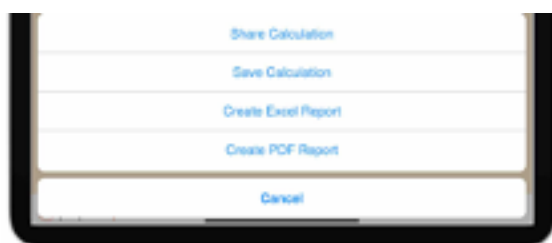


Figure 25 Results Panel Share Action Sheet

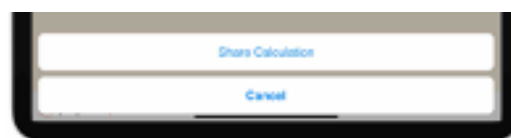


Figure 26 Calculation Panel Share Action Sheet

Tap **Share Calculation** to show the **iOS Share Action Sheet**.

Tap the required method of sharing the calculation.




The options / applications available on the iOS Share Sheet will depend upon the applications installed on the device and how the share sheet is configured.

4.5 Loading a Calculation

Calculations that have been saved on your device, or that have been shared with you (e.g. via email) can be opened in Pipe Flow Gas Pressure Drop.

4.5.1 Load Calculation from Saved Files


The Saved Files screen is displayed by tapping the **Main Menu**  button, then **Saved Files**. For more information, see: [Saved Files](#).

Tap the required calculation in the list to load it from your device.

4.5.2 Load Calculation from Shared File

A calculation that has been shared (e.g. via email) can be opened in Pipe Flow Gas Pressure Drop.

1. Open the e-mail that contains the Pipe Flow Gas Pressure Drop attachment. For more information on the type of files Pipe Flow Gas Pressure Drop uses see: [Filename Extension](#).
2. Tap the attachment to open the **iOS Share Sheet**.
3. Tap Copy to Pressure Drop

 If the **Copy to Pressure Drop** option is not immediately available, it may be necessary to swipe the applications to the left.

4.5.3 Display Filename of Loaded Calculation

When a calculation has been loaded from a file, a blue information icon appears next to the app title.



Figure 27 Calculation Loaded Screen Title

Tapping the app title or the blue information icon will display the name of the loaded file in a temporary notification.

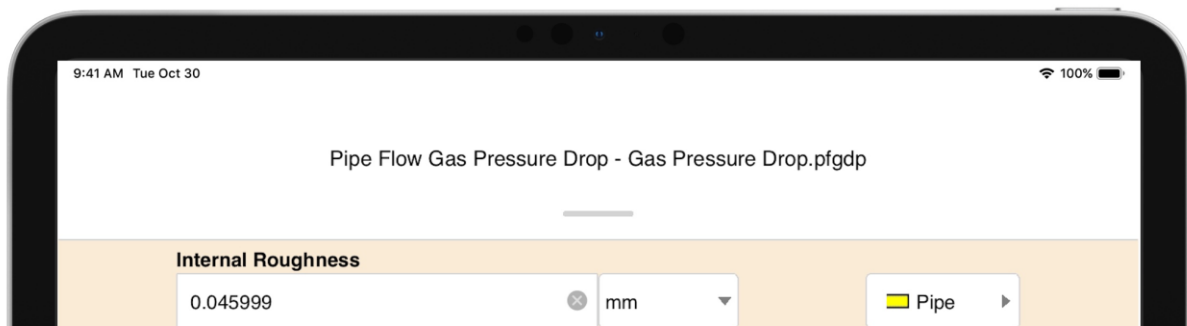


Figure 28 Filename of Loaded Notification

5 Pressure Drop Calculation

The **Pressure Drop** through the pipe can be calculated when the following values are known:

- Pipe internal roughness
- Pipe internal diameter
- Pipe length
- Pipe elevation change
- Fittings
- Flow rate

For more information about working with gases, see: [Working with Compressible Fluids](#).

For more information about the theory and formulas used to calculate the flow rate, see: [Calculation Theory and Method of Solutions](#).

5.1 Gas Pressure Drop Calculation

The pressure drop for a gas in a pipe can be calculated as follows:

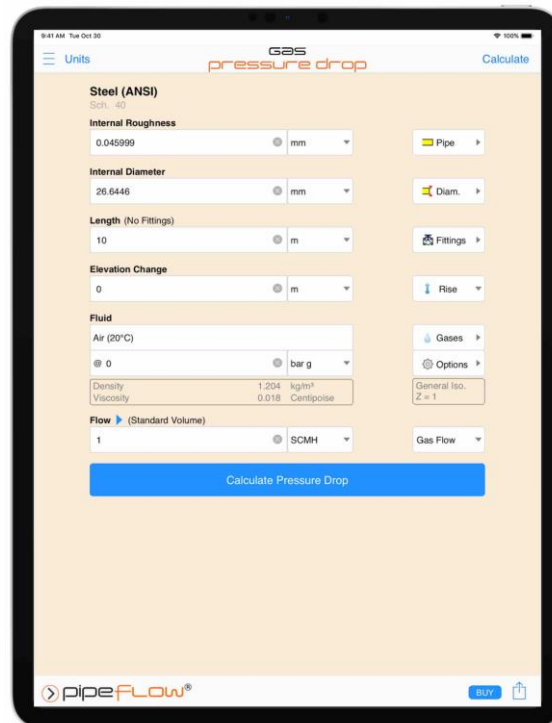



Figure 29 Gas Pressure Drop Calculation

1. Select or define the **Material** and **Internal Roughness** of the pipe. For more information about working with pipe materials, see: [Pipe Material & Diameters](#).
2. Select or define the **Internal Diameter** of the pipe. For more information about working with pipe diameters, see: [Pipe Material & Diameters](#).
3. Set the **Length** and **Elevation Change** of the pipe.
4. Add **Fittings** to the pipe if required. For more information about working with fittings, see: [Fittings & Valves](#).
5. Select the **Gas** in the pipe. For more information about working with fluids, see: [Fluids Database](#).
6. Enter the **Pressure** of the fluid at the start of the pipe.
7. Enter the **Flow Rate** of the fluid in the pipe. For more information about setting a flow rate based on a velocity, see: [Flow Rate Calculator / Helper](#).
8. Tap **Calculate Pressure Drop** and the **Results** panel will slide up.

 The internal diameter will be reset to 1.049" (26.64 mm) if running the trial version of Pipe Flow Gas Pressure Drop.

The **Gas Pressure Drop Results Panel** displays the calculation input data and the results of the **Pressure Drop** calculation. For more information about the Results Panel, see: [Results Panel](#).

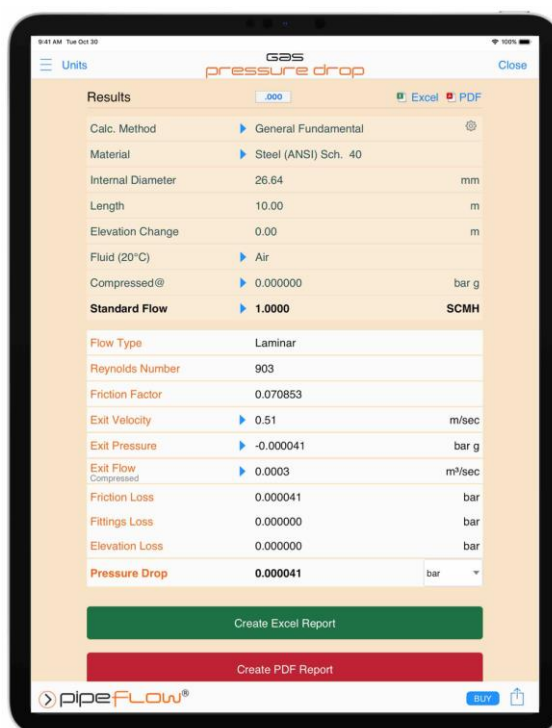





Figure 30 Gas Pressure Drop Results

The pressure loss unit can be changed as required. To change the pressure loss unit for all subsequent calculations, the pressure loss unit can be specified in Settings > Units. For more information about setting units, see: [Units](#)

To generate and view an Excel or PDF Report of the results, tap the Excel  button or PDF  button. For more information about generating reports, see: [Creating a Report of the Results](#).

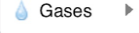
To change the number of decimals the results are displayed to, tap the **.000**  button in the **Results Menu Bar**. For more information, see: [Results Menu Bar](#).

To close the **Results Panel**, tap the **Close** button in the **Navigation Bar** or the **Close Results**  button at the bottom.

6 Fluids Database

The Pipe Flow Gas Pressure Drop software includes a fluid database. The Fluid Properties list displays all the fluids available in the gases database. When you are selecting a gas to be used for a calculation, you can select an existing gas, or enter your own gas data. Once entered, new gas data will be displayed in the list of fluids and can then be used just the same as the standard gas data.

To define the fluid and fluid properties for the currently selected calculation:

1. Tap the **Gases**  button on the calculation panel to display the gases in the Fluids Database.

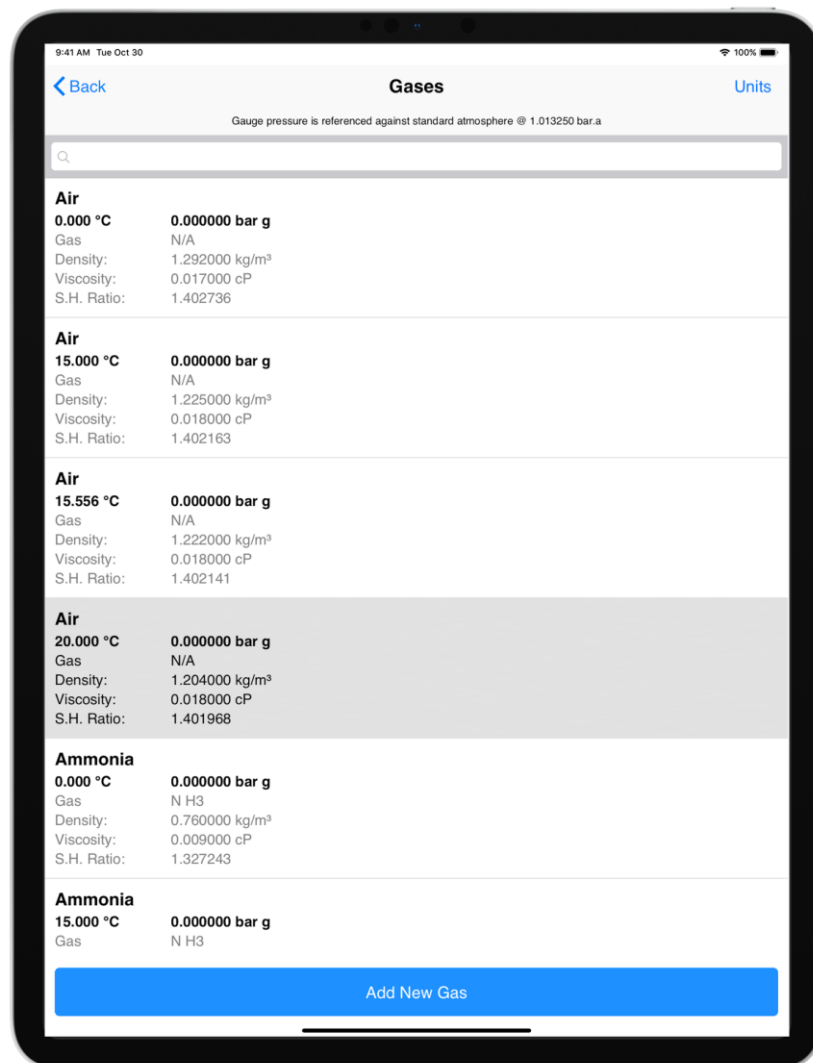


Figure 31 Fluid Database - Gases

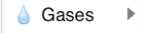
2. Select the gas contained in the pipe from the **Fluid Database** list. The name of the gas is displayed in the calculation next to the gases button.

6.1 Adding Gases to the Fluid Database

If the gas you are using does not exist in the Pipe Flow Gas Pressure Drop fluid database, you can quickly add the gas to the database by tapping the Add Gas button on the Fluid Database screen.

NOTE: Be sure to enter the value for the gases properties in the units displayed in the column header. For example, if you are using imperial units, °F for Fahrenheit is displayed under Temperature in the Temperature column. The temperature value in this case should be entered in degrees Fahrenheit.

To add a new gas to the fluid database:

1. Tap the **Gases**  button on the calculation panel to display the Fluids Database Action Sheet.
2. Select **Gases** from the action sheet to display the list of standard gases.
3. Tap Add New Fluid and then select Use Gas Calculator or Use Own Data.

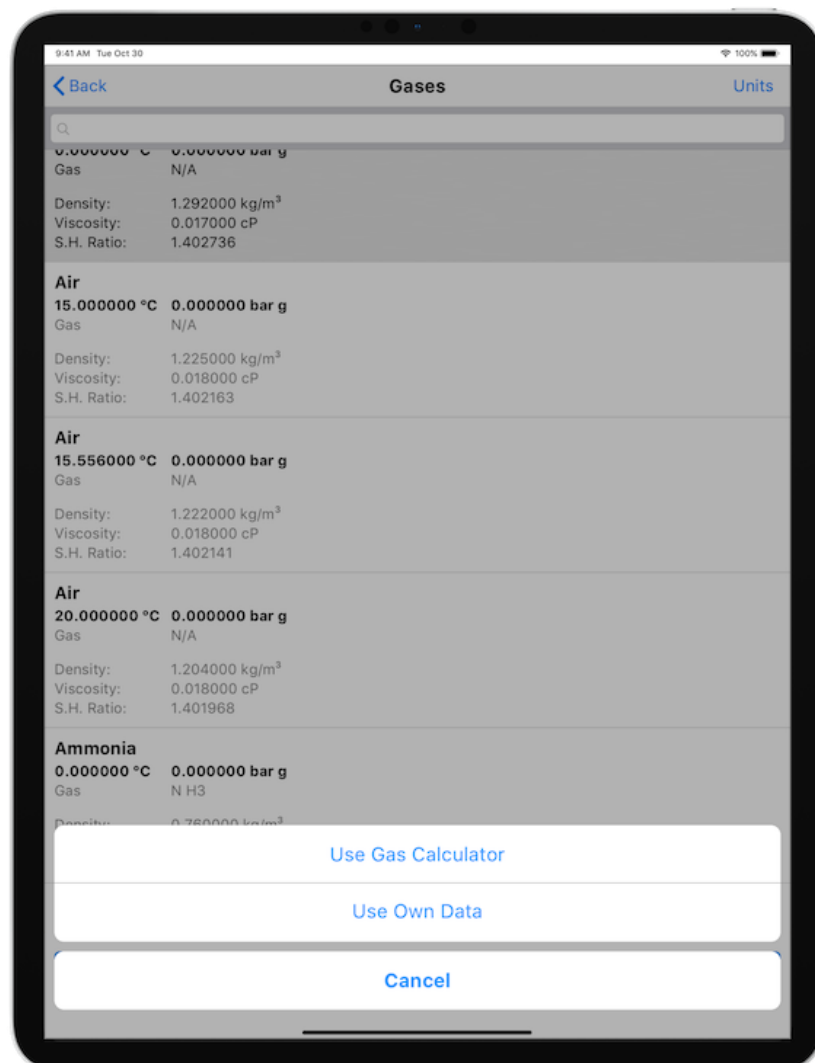


Figure 32 Fluids Database Action Sheet

Tap the **Use Gas Calculation** menu item to display the **Gas Data Calculator**.

The screenshot shows the 'Gas Data Calculator' interface. At the top, there are 'Cancel' and 'Save...' buttons. The main area contains several rows of data:

- Gas:** Air (selected from a dropdown)
- Temperature:** 20 °C
- Pressure:** 0 bar g. A note below states: 'Gauge pressure is referenced against standard atmosphere @ 1.013250 bar.a'
- Density (from Ideal Gas Law):** 1.203847 kg/m³
- Compressibility Factor Z=:** 0.9996
- Real Density:** 1.204295 kg/m³
- Use Real Density:** A toggle switch is currently turned off.
- Viscosity:** 0.018206 Centipoise
- Specific Heat Ratio:** 1.401968

 At the bottom of the input section, there is a blue 'Save...' button.

Figure 33 Gas Data Calculator

4. Choose a Gas from the drop-down listing.
5. Enter the temperature of the gas.
6. Enter the pressure condition.
7. Tap **Calculate Gas Data**.
8. The density, viscosity and specific heat ratio for the gas are displayed.
9. Tap **Save...** to display the Save action sheet.



The Gas Data Calculator will not generate fluid data if running the trial version of Pipe Flow Gas Pressure

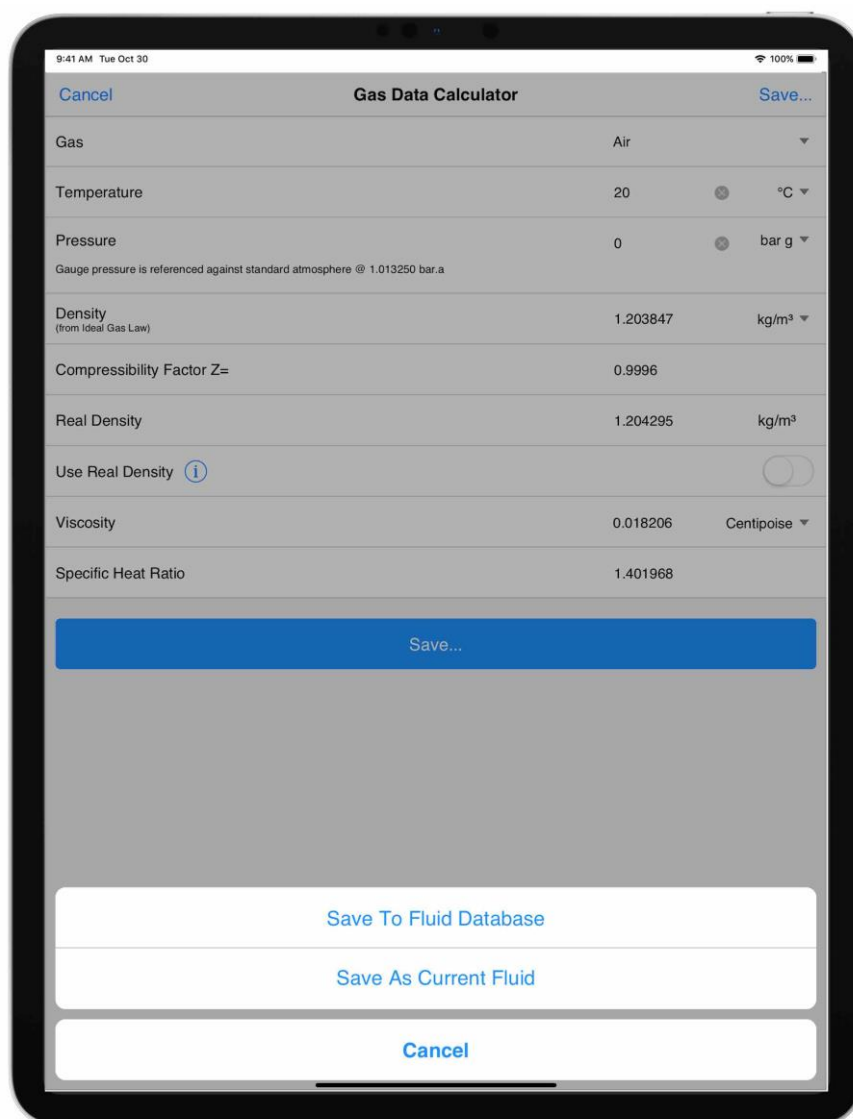


Figure 34 Gas Data Calculator Save Action Sheet

Tap **Save To Fluid Database** to save the new fluid data to the database.

Tap **Save As Current Fluid** to use the defined fluid in the calculation without saving it to the database.


7 Pipe Material & Diameters

Pipe Flow Gas Pressure Drop includes a database of common pipe materials for which a range of pipe characteristics (internal roughness, nominal size and internal diameter) are defined.

If the pipe you are using does not exist in the database, then its characteristics can be entered manually and optionally added to the database.

7.1 Selecting a Pipe Material

To select a pipe material:

1. Tap the on the **Pipe**  button on the calculation panel to open the **Pipe Material** screen.

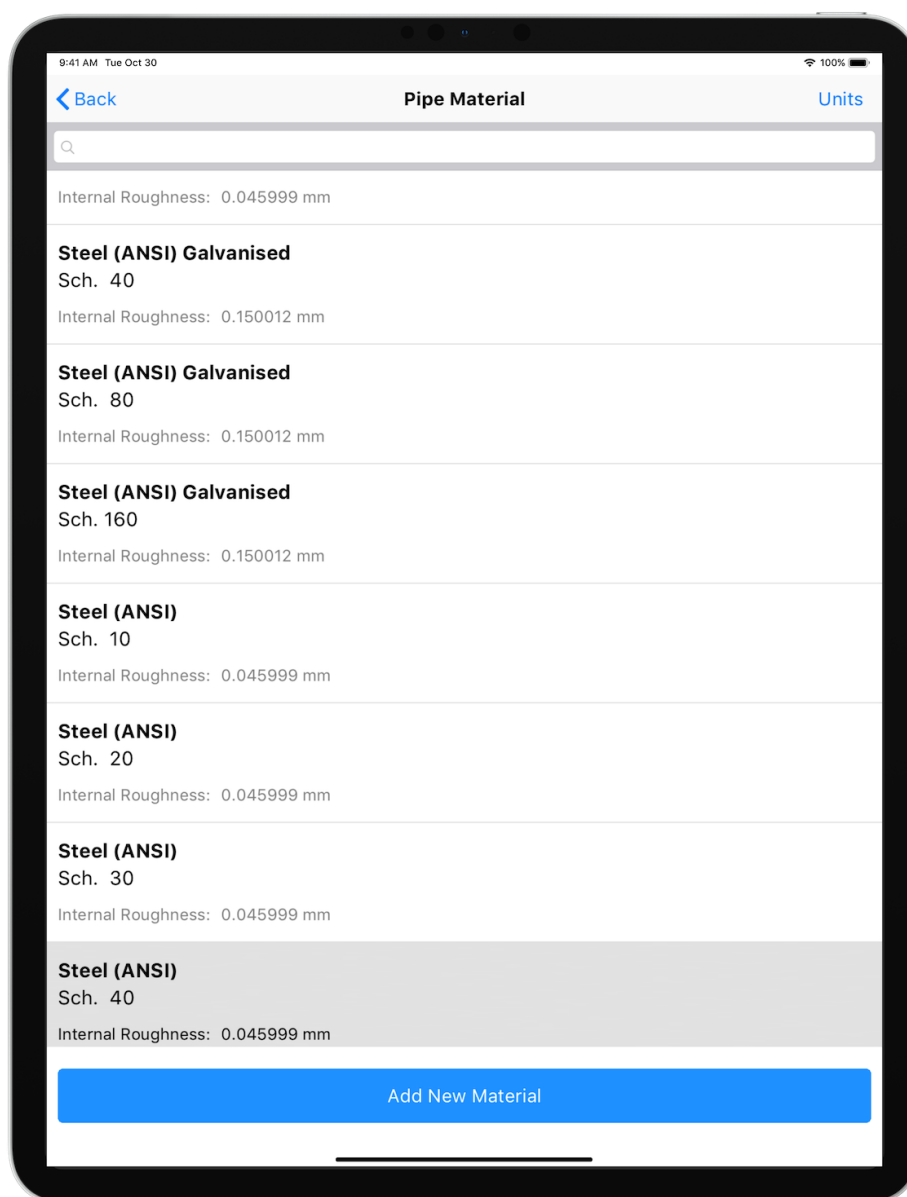



Figure 35 Pipe Material Database

Tap the required Material in the Material Database list.

7.2 Duplicating a Pipe Material

To select a pipe material:

1. Tap the on the **Pipe**  button on the calculation panel to open the **Pipe Material** screen.
2. Swipe right to left on a material in the material database list to display the actions menu.

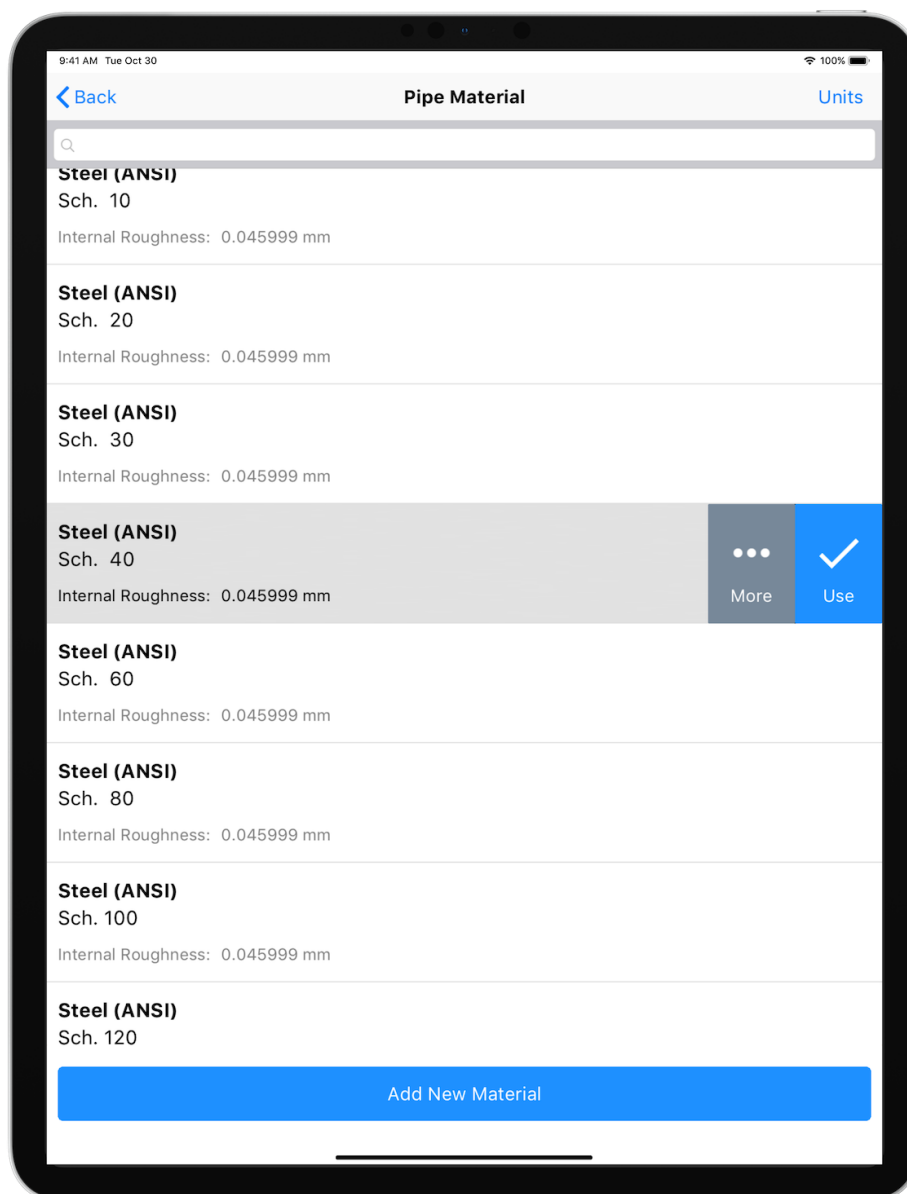


Figure 36 Pipe Material List Actions Menu

3. Tap the **More...** button to display the **Material Action Sheet**.

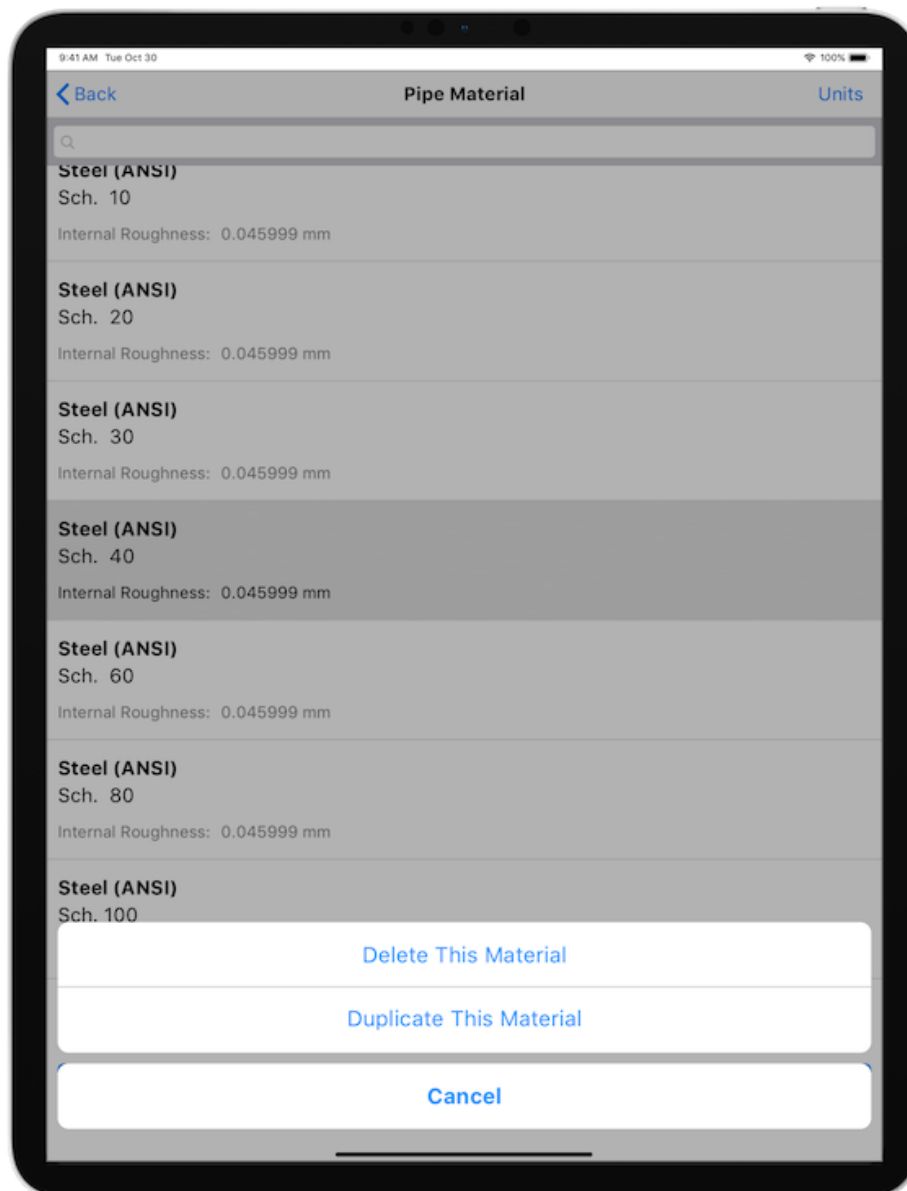




Figure 37 Material Database - Material Action Sheet

Tap the **Duplicate This Material** button to display the **Add New Material** screen with the field values pre-populated with the material to be duplicated.

4. Edit the **Name** field.
5. Edit the **Schedule / Class** field.
6. Edit the **Internal Roughness** field.
7. Tap the **Save Material** button to add the new material to the material database.

7.3 Adding a new Pipe Material

To select a pipe material:

1. Tap the on the **Pipe**  button on the calculation panel to open the **Pipe Material** screen.
2. Tap the **Add New Material**  button.

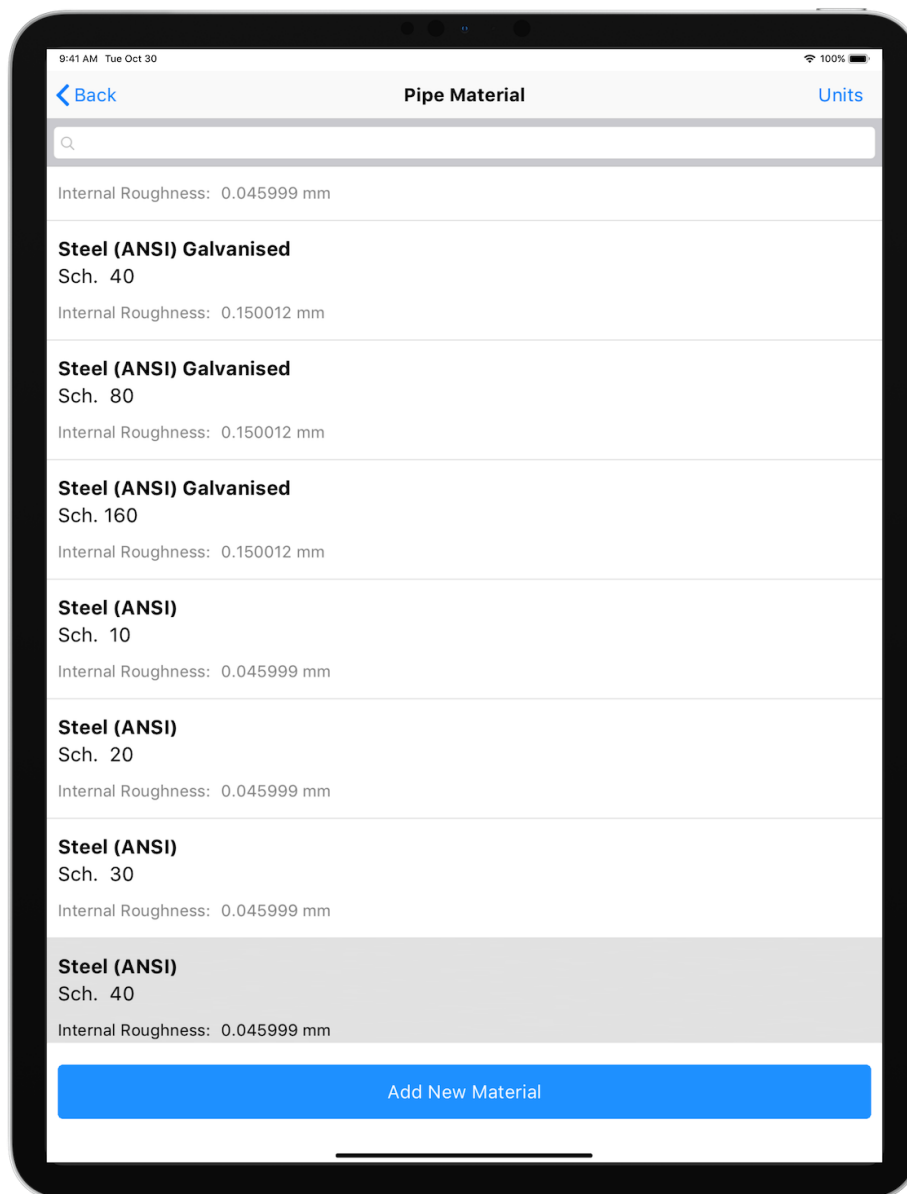



Figure 38 Add New Pipe Material

3. Enter the **Name**, **Schedule / Class**, and **Internal Roughness** values.
4. Tap the **Save Material** button to save the new material to the database.

7.4 Selecting a Pipe Diameter

To select a pipe diameter:

1. Tap the **Diam.**  button on the calculation panel to open the **Pipe Diameter** screen.

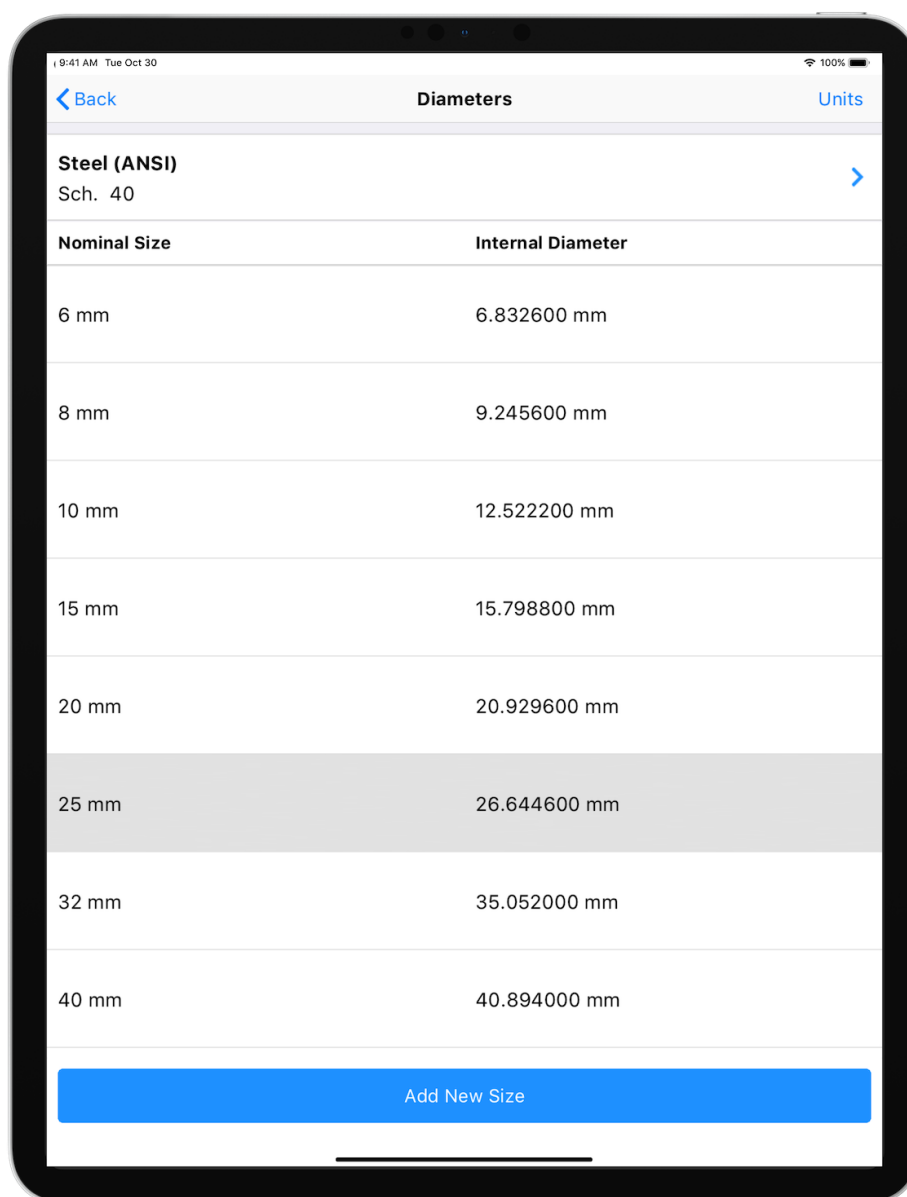
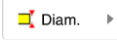



Figure 39 Pipe Diameter

2. If required, change the pipe material by tapping the currently selected material above the list of pipe diameters.
3. Tap the required **Diameter** in the **Pipe Diameter** database list.

7.5 Adding a Pipe Diameter

To add a new pipe diameter:

1. Tap the **Diam.**  button on the calculation panel to open the **Pipe Diameter** screen.
2. Tap the **Add New Size**  button.

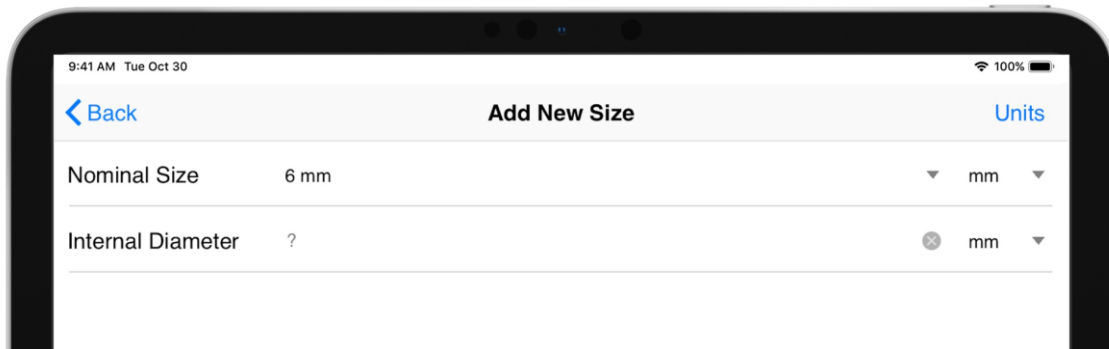



Figure 40 Add Pipe Diameter

3. Specify the **Nominal Size** and **Internal Diameter** values.
4. Tap the **Save Size**  button.
Note: Pipe Flow Gas Pressure Drop will verify that the Nominal Size value and Internal Diameter value are equivalent, and if not, will prevent the new pipe diameter from being saved.

8 Fittings & Valves

Up to five different fitting types can be added to a pipe. Multiple fittings of each type can be specified, and each fitting type can be selected to be at the start or end of the pipe.

Fittings can be selected from the Pipe Flow Gas Pressure Drop Fitting database, or user fittings can be created using an appropriate K value.

8.1 Adding a Fitting to the Pipe

To add fittings to a pipe:

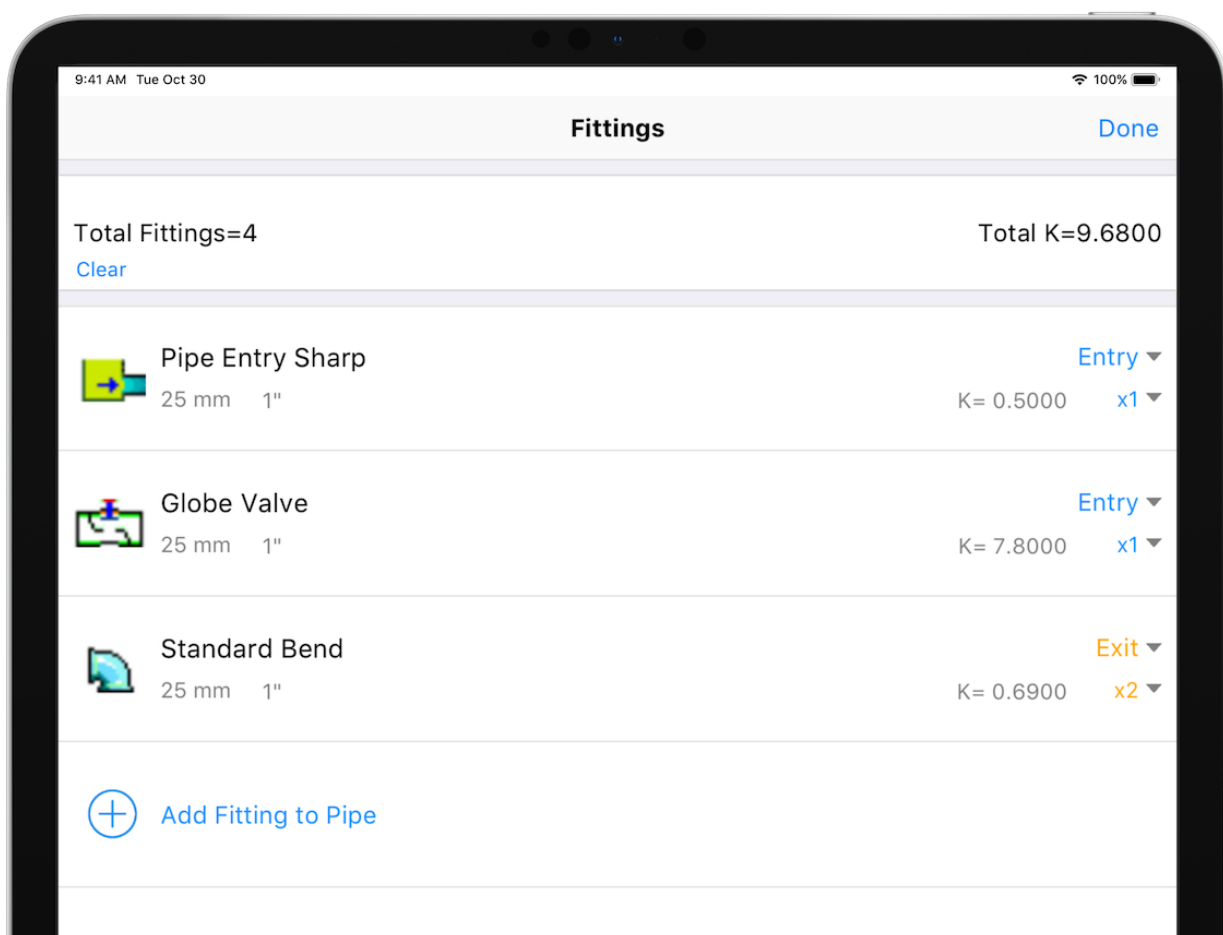



Figure 41 Fittings & Valves

1. Tap the **Fittings**  button on the calculation panel to open the **Fittings** screen.
2. The fittings on the pipe will be shown.
3. Tap the **Add Fitting to Pipe** button to display the **Fitting Database**.

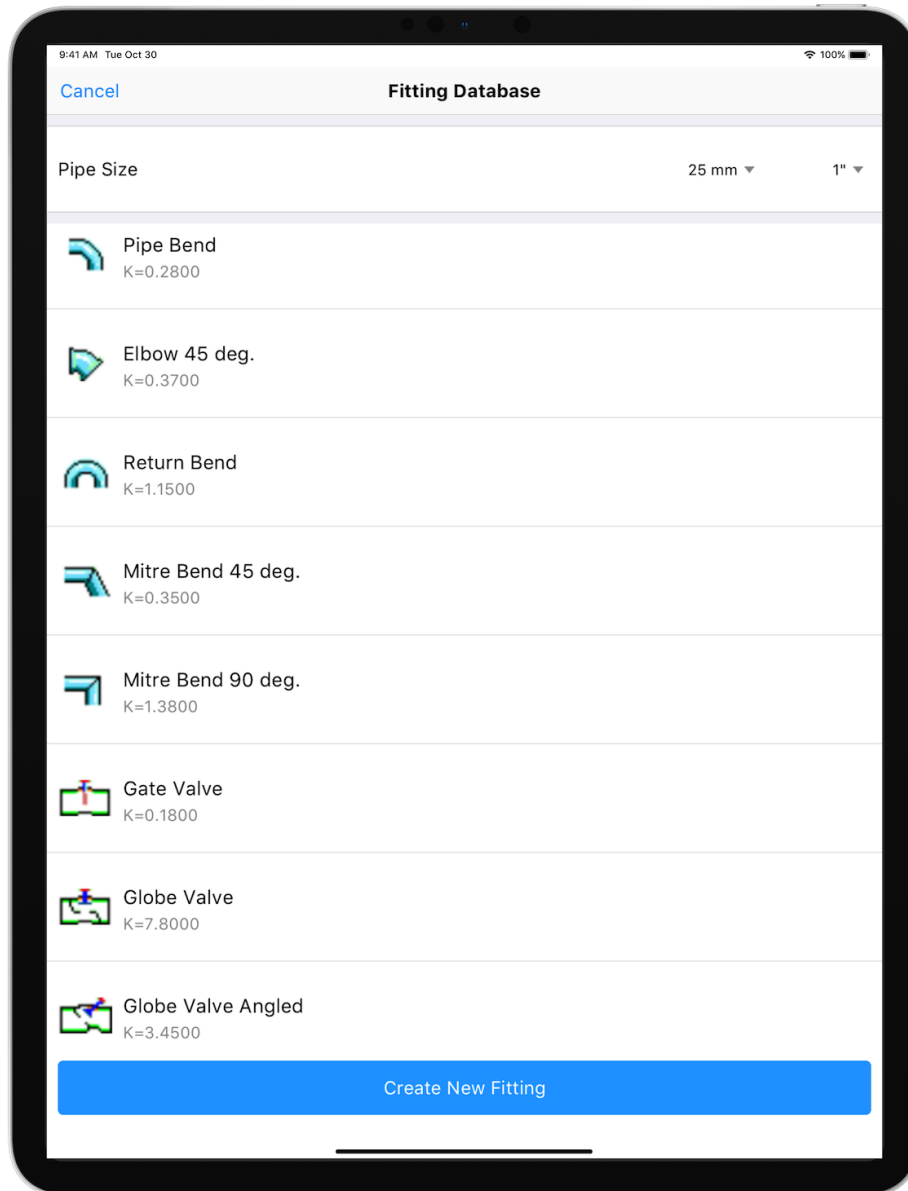


Figure 42 Fitting Database

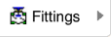
A list of available fittings will be shown for the current pipe size.

4. If required, change the nominal size by selecting from the metric or imperial drop-down list, to display the available fittings and their associated K value for a different size.
5. If the fitting is not in the **Fitting Database** list, tap the **Create Fitting** button to add the new fitting to the list. For more information about adding a fitting to the database, see: Adding a Fitting to the Pipe.
6. Tap on a fitting from the list to add it to the fittings on the pipe.

7. The selected fitting is displayed in **Fittings** screen.
8. Select the position of the fitting on the pipe to be either Entry or Exit and select the quantity of each fitting from the Qty drop down list.
9. To add additional fittings to the pipe, repeat Steps 3 – 8.
10. Tap **Done** to add the chosen fittings to the pipe, and to close the **Fittings** screen.

8.2 Removing a Fitting from the Pipe

To remove fittings from a pipe:

1. Tap the **Fittings**  button on the calculation panel to open the **Fittings** screen.
2. Swipe right to left on the fitting to be removed and tap **Remove**, or set the quantity for the fitting to be removed to zero.

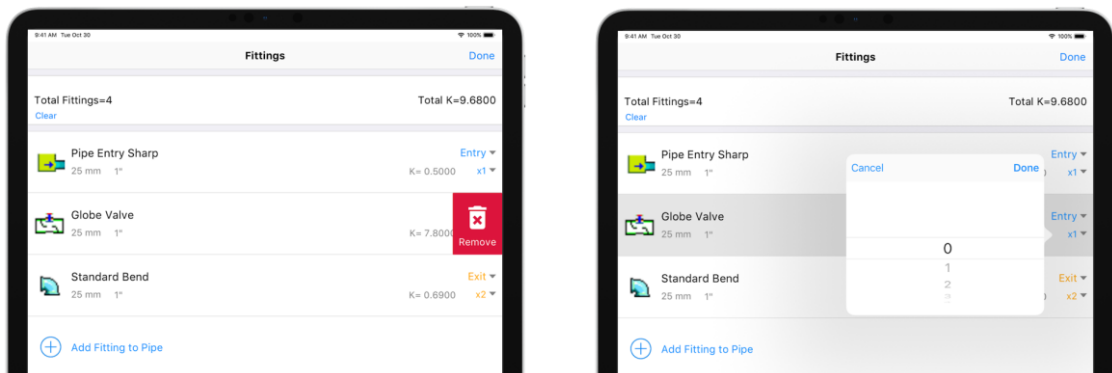
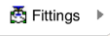


Figure 43 Remove Fitting from the Pipe

3. Tap **Done** to update the pipe with the chosen fittings, and to close the **Fittings** screen.

8.3 Adding a Fitting to the Database

To add a fitting to the database:

1. Tap the **Fittings**  button on the calculation panel to open the **Fittings** screen.
2. Tap the **Create New Fitting** button to open the **Create New Fitting** screen.

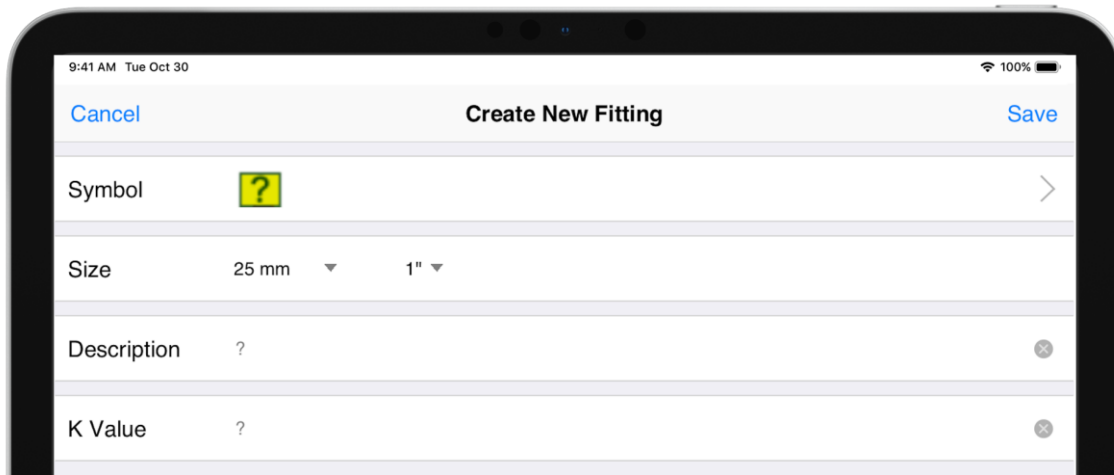


Figure 44 Create New Fitting

3. To change the symbol representing the fitting, tap the **Change** button to open the **Choose Symbol** screen.

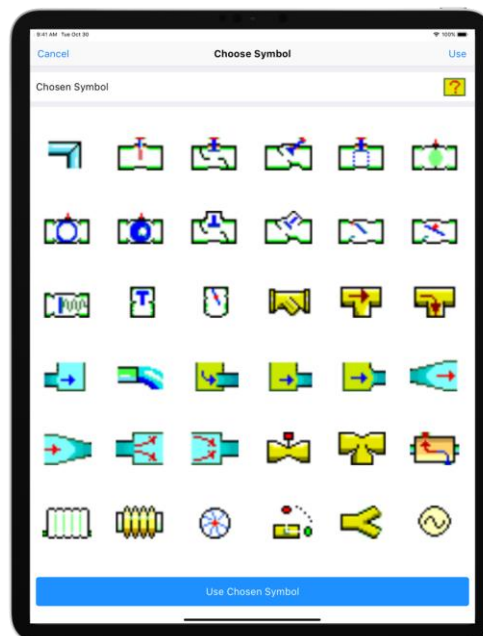


Figure 45 Choose Fitting Symbol

4. Select the symbol you want to represent the fitting.

1. Tap **Use Chosen Symbol** to add the symbol to the **Symbol** field and close the **Choose Symbol** screen.
2. Select the fitting's metric size from the **Metric** list or select the fitting's imperial size from the **Imperial** list.
3. You only need to select the metric or imperial fitting size. The Pipe Flow Gas Pressure Drop software automatically populates the other size for you. For example, if you select 32mm from the **Metric** list, the imperial equivalent, 1-1/4", automatically appears in the **Imperial** field.
4. Enter a description of the fitting in the **Description** field.
5. Enter the K value for the fitting in the **K Value** field.
6. Tap the **Save Fitting** to add the fitting to the **Fitting Database** list.

 Scroll down to reveal additional symbols.

9 Flow Rate Calculator / Helper

Pipe Flow Gas Pressure Drop incorporates a Flow Rate Calculator which uses the current internal diameter and a fluid velocity to calculate a flow rate.


To open the **Flow Rate Calculator**:

1. Tap the Flow  expander button:



Figure 46 Flow Calculator

2. Enter the required **Velocity**.
3. As you enter the **Velocity**, Pipe Flow Gas Pressure Drop automatically calculates the **Flow Rate** and displays it beneath the velocity.
4. Tap **OK** to apply the calculated flow rate and close the **Flow Rate Calculator**.

 Whilst the **Flow Rate Calculator** is open, no other operations can be performed in the calculation panel.

10 Calculations and Results

Once you have entered the required input data to a Calculation Panel, you can calculate the results for by tapping the **Calculate** button. If the input data is valid, the Results Panel slides up and over the Calculation Panel to concisely display the calculated data.

The values in the results panel can be scrolled up and down as needed, and where applicable, a result value can be expanded to reveal additional information related to that attribute. For more information about expanding attributes, see: Expandable Sections.

10.1 Automatic Checks and Updates

Before a calculation is solved, the software performs some automatic checking of the input data and allows users to accept various recommended updates to the make the calculation data consistent.

10.1.1 Fitting Sizes

Fitting sizes will be checked and matched to the nominal pipe size.



Figure 47 Fitting Sizes

If the nominal pipe size does not match some of the fitting sizes associated with the pipe, then the option to update the fittings sizes should normally be accepted. This will update the fitting sizes and the fitting 'K' values so that the correct data for the given pipe size is used, such that the pressure losses will be appropriately calculated.



Pipe Flow Gas Pressure Drop cannot automatically update fitting sizes for user defined fittings.

10.2 Configuring the System Results

Once a calculation has been solved, the calculated results are displayed in the Results Panel. The options selected in the Results Decimals and Units sections of Settings determine how the results values are displayed.

10.3 Creating a Report of the Results

When a calculation has been solved and the **Results Panel** displayed, an Excel or PDF report can be created.

To create an Excel Report, tap the **Excel** button. The report will be generated using the defined Reports settings and the Pipe Flow Gas Pressure Drop software will attempt to open it using **Microsoft Excel** (or compatible software) that is installed on your computer.

To create a PDF Report, tap the **PDF** button. The report will be generated using the defined Reports settings and Pipe Flow Gas Pressure Drop will attempt to open it using **Adobe Acrobat** (or compatible software) that is installed on your computer.

The options selected in the Results Decimals, Units and Reports sections of Settings determine how the results values are displayed.

10.4 PDF Report Example

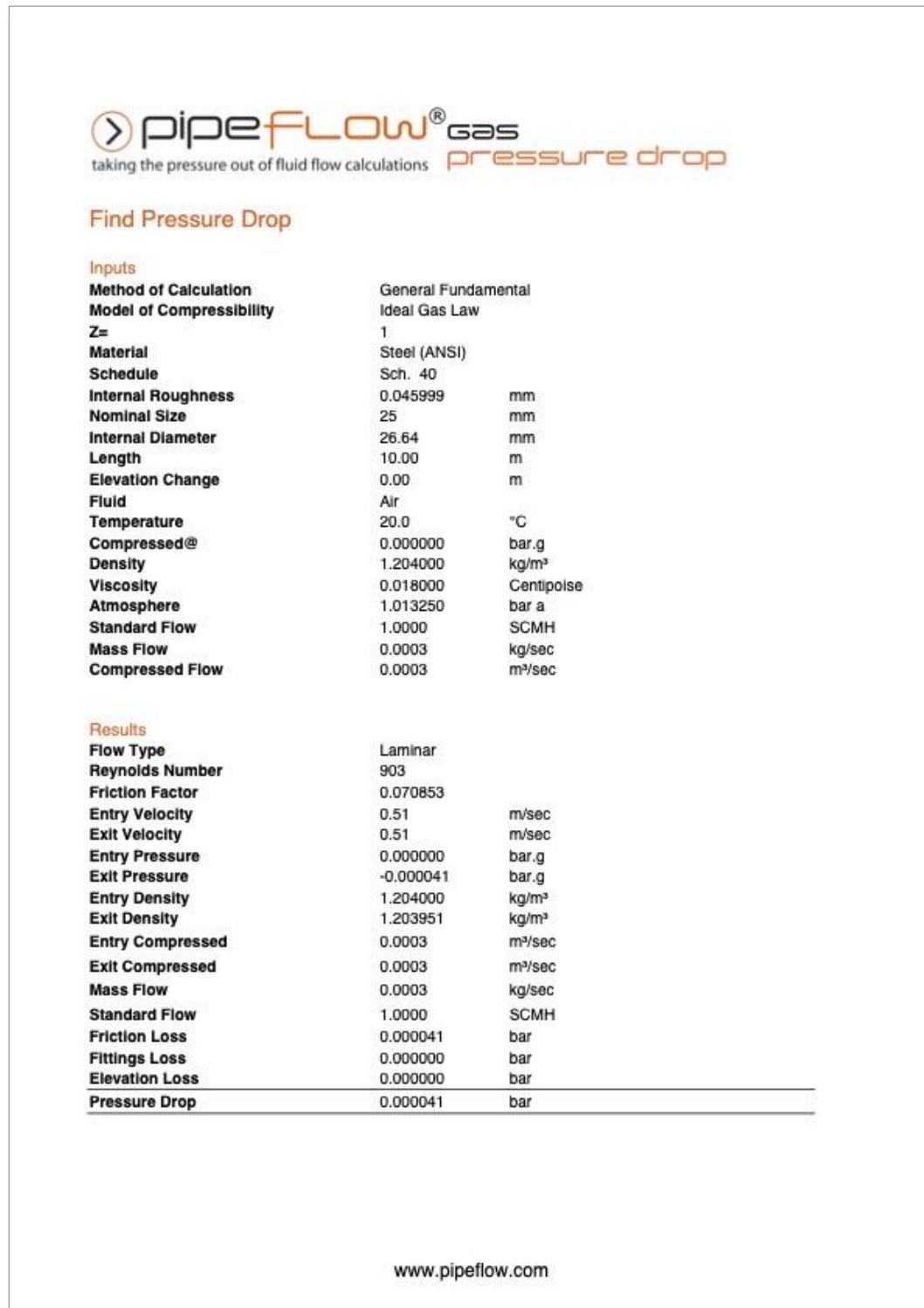


Figure 48 PDF Report - Tabulated

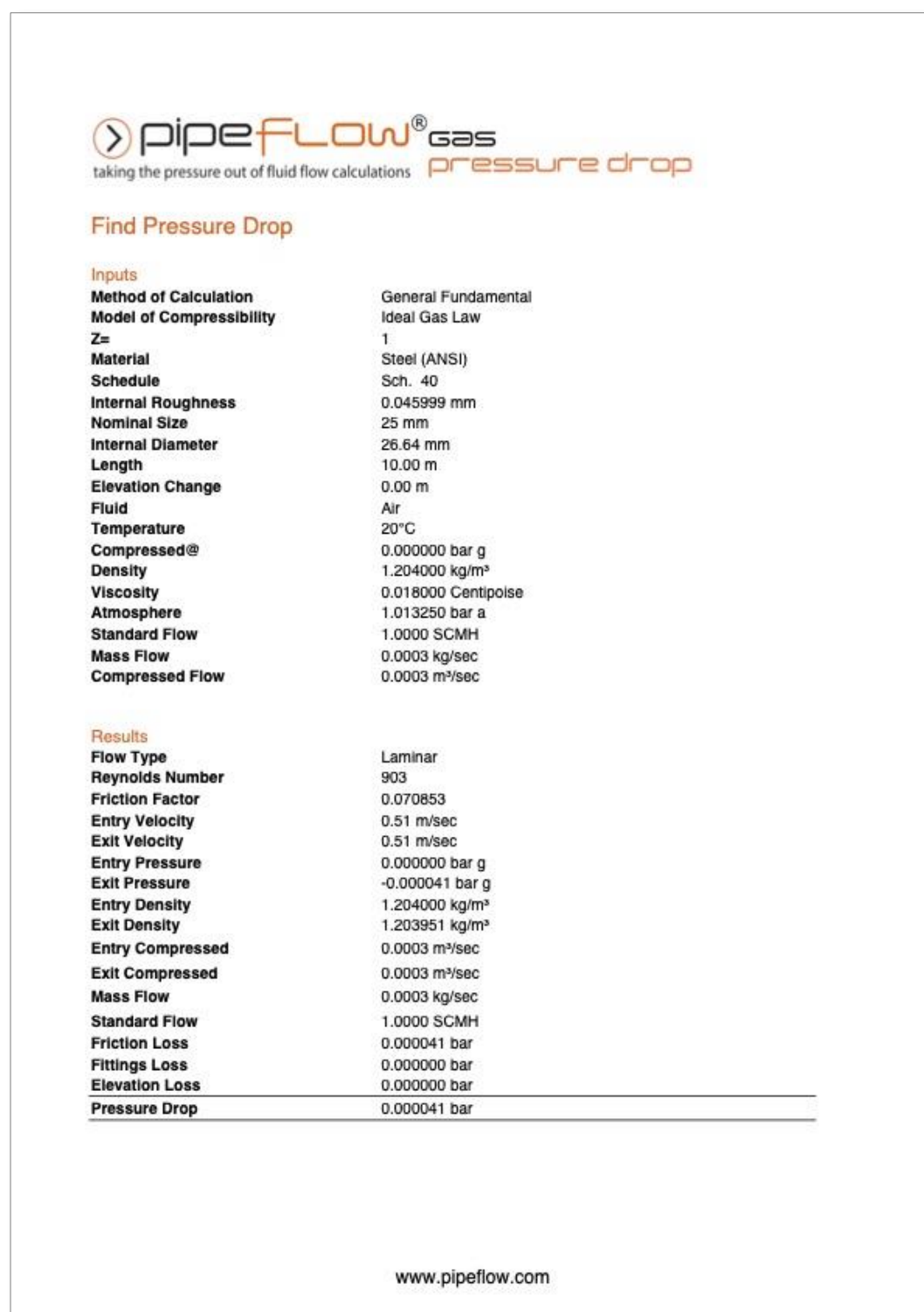


Figure 49 PDF Report – Non-Tabulated

11 Working with Compressible Fluids

The Pipe Flow Gas Pressure Drop software contains a Compressible Isothermal Flow Calculation Engine.

In a gas system, as pressure loss occurs along a pipe, the gas density will decrease, and the volume of the gas will expand. As the volume of gas increases, the velocity of the gas in the pipe will increase. Although the volume of gas and velocity in the pipe changes, the mass flow (weight of flow) in the pipe will remain constant.

Gas flow rates are therefore often referred to in terms of mass flow (weight of flow) or standard volume (which is the volume of gas at standard conditions, normally atmospheric pressure and some common temperature reference, since this standard volume also defines a constant mass flow).

Pipe Flow Gas Pressure Drop provides a choice of standard volume units for gas flow rate which include:

- SCCM (Standard Cubic Centimetres per Minute),
- SLM (Standard Litres per Minute),
- SCMH (Standard Cubic Meters per Hour)
- MMSCMH (Million Standard Cubic Meters per Hour)
- MMSCMD (Million Standard Cubic Meters per Day)
- SCFM (Standard Cubic Feet per Minute)
- SCFH (Standard Cubic Feet per Hour)
- SCFD (Standard Cubic Feet per Day)
- MMSCFH (Million Standard Cubic Feet per Hour)
- MMSCFD (Million Standard Cubic Feet per Day)

Each of the standard volume units for gas flow relate to the gas at a standard condition, however there are several slightly different standard reference conditions that are used worldwide depending on country and location. Pipe Flow Gas Pressure Drop provides a choice of standard reference conditions to be used when referring to the standard volume flow rate of gas and these include:

- 0°C, 100.000 kPa.a
- 0°C, 101.325 kPa.a
- 15°C, 101.325 kPa.a
- 20°C, 101.325 kPa.a
- 25°C, 101.225 kPa.a
- 60°F, 14.696 psi.a
- 68°F, 14.696 psi.a

Mass flow can also be used to refer to an amount of gas flow and the units for mass flow include:

- kg/sec
- kg/min
- kg/hour
- lb/sec
- lb/min
- lb/hour

11.1 Defining Gas Data

The calculations incorporate use of the Ideal Gas Law and if required a custom Compressibility Factor or use of the CNGA Compressibility Factor (that is calculated based on the pressures at the start and end of the pipe).

The Compressible Flow Calculation Engine will automatically take account of pressure changes within the pipe and will automatically adjust the density properties of the gas as appropriate when performing the gas flow rate, pressure loss, diameter size, and pipe length calculations. The equations used in the calculations currently assume isothermal flow where there is no change in temperature.

The Pipe Flow Gas Pressure Drop software will automatically account for changes in pressure and gas density within the pipe, however the original fluid properties must be defined for the operating temperature within the pipe (although the density may have been specified for a different pressure condition).

Normally the gas properties should be defined for the atmospheric pressure condition (0 bar.g or 0 psi.g) and the software will then automatically calculate the gas density at the start pressure condition prior to performing the appropriate calculation.

If the start pressure is a high pressure, and the real gas density at this condition varies from the ideal gas law prediction, then a compressibility factor other than 1.0 can be specified. This will be applied when calculating the gas density at the start pressure condition prior to performing the appropriate calculation.

11.1.1 Gas Calculator Data

The gas calculator helper within the Fluid Database can calculate and display the compressibility factor of certain gases at different temperature and pressure conditions, and it will show the real density of the gas at the specified condition.

The user should choose to either:

1. Define the gas properties at a condition on the ideal gas law line (normally say 0 bar.g) and then specify on the Options screen an appropriate compressibility factor for the pressure condition at the start of pipe.

OR

2. Define the gas properties at the start pressure condition using the real gas density at this pressure (if it differs from the predicted ideal gas law density at this condition) and then specify the compressibility ' $Z=1.0$ '.

This ensures that the calculation proceeds to use the correct real gas density at the start pressure condition.

i.e.

- a) If the gas properties are specified on the ideal gas law line then the predicted gas density at the start pressure condition will then be adjusted according to the compressibility factor that has been specified, in order to end up with the real gas density at the start condition.

OR

- b) If the gas properties are defined at a high-pressure condition, specifying the real gas density, then a compressibility factor of ' $Z=1.0$ ' should be used. The calculated density at the start pressure condition will then be derived from the real gas density (at the high-pressure condition) by applying the ideal gas law equation. This will normally give a good result in terms of predicting the real gas density at the start of the pipe, provided that the defined high-pressure condition and the start pressure are not too different.

This means that the gas properties should generally be specified on the ideal gas law line and a compressibility factor can be specified as appropriate, or if the real gas density is specified for the gas at a high-pressure condition at the start of the pipe then the compressibility factor should be set to 1.0.

11.2 Using Compressible Flow Equations

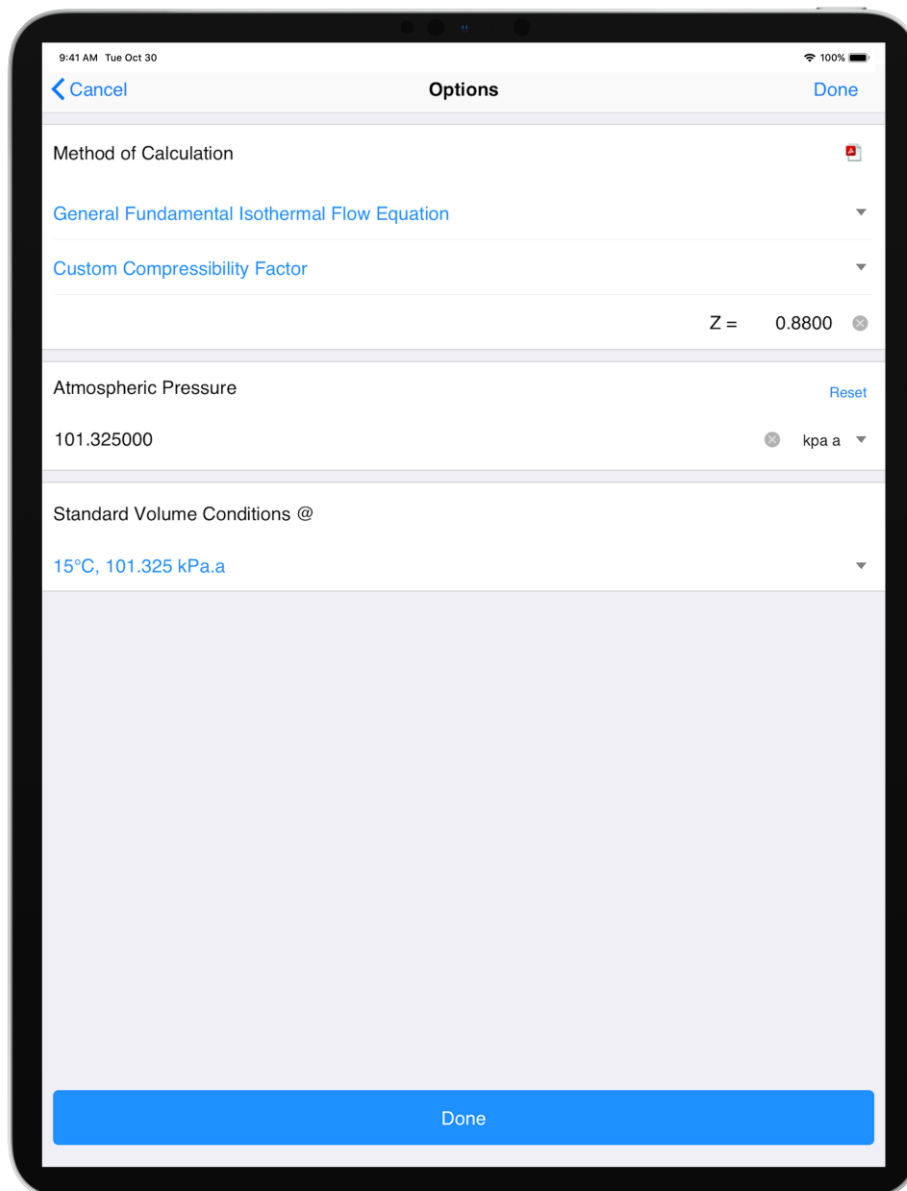


Figure 50 Compressible Flow Equations


There are a number of different equations that can be used to calculate flow rate and pressure loss in a compressible gas system and the type of design and user preference often determines which equation is used to calculate the results.

The Pipe Flow Gas Pressure Drop software allows for the selection of a specific compressible isothermal flow equation from a list that includes:

- General Fundamental Isothermal Flow Equation
- Complete Isothermal Flow Equation
- AGA Isothermal Flow Equation
- Weymouth Isothermal Flow Equation

- Panhandle A Isothermal Flow Equation
- Panhandle B Isothermal Flow Equation
- IGT Isothermal Flow Equation

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 Pressure Drop software provides such a friction factor by calculating this using the Colebrook-White equation.

The preferred method of calculation can be selected from by tapping the **Options**  button on the calculation panel.

12 Calculation Theory and Method of Solutions

12.1 Fluid Flow States

Fluids in motion are subjected to various resistance forces, which are due to friction. Friction may occur between the fluid and the pipe work, but friction also occurs within the fluid as sliding between adjacent layers of the fluid takes place.

The friction within the fluid is due to the fluid's viscosity. When fluids have a high viscosity, the speed of the flow tends to be low, and resistance to flow becomes almost totally dependent on the viscosity of the fluid. The condition is known as 'Laminar flow'.

Fluids which have a low viscosity are usually moving at higher velocities. The flow characteristics change, small eddy currents occur within the flow stream, and the friction between the pipe work and the fluid becomes a factor to be considered. This type of flow is known as 'Turbulent flow'.

12.2 Fluid Viscosity

A fluid viscosity can be described by its Dynamic viscosity (sometimes called Absolute viscosity), or it's Kinematic viscosity. These two expressions of viscosity are not the same but are linked via the fluid density.

Kinematic viscosity = Dynamic viscosity / fluid density

Dynamic Viscosity

Water @ 20°C has a viscosity of $1.00 \times 10^{-3} \text{ Pa} \cdot \text{s}$ or 1.00 Centipoise

Water @ 70°F has a viscosity of $2.04 \times 10^{-5} \text{ lbf} \cdot \text{s/ft}^2$

Kinematic Viscosity

Water @ 20°C has a viscosity of $1.004 \times 10^{-6} \text{ m}^2/\text{s}$ or 1.004000 Centistokes

Water @ 70°F has a viscosity of $10.5900 \times 10^{-6} \text{ ft}^2/\text{s}$

Pipe Flow Gas Pressure Drop has a database of viscosities and densities for common fluids.

12.3 Reynolds Numbers

Reynolds numbers (Re) describe the relationship between a fluid's velocity, the internal pipe diameter and the fluid's Kinematic viscosity.

Reynolds number = Fluid velocity x Internal pipe diameter / Kinematic viscosity

Note: Kinematic viscosity (not Dynamic viscosity) must be used to calculate Reynolds numbers. It is generally accepted that the 'changeover' point between laminar flow and turbulent flow, in a circular pipe, occurs when the Reynolds number (Re) is approximately 2100.

i.e. Laminar flow occurs when the Re is less than 2100. Turbulent flow occurs when the Re is greater than 4000. Between the Laminar and Turbulent flow conditions the flow may be neither wholly laminar nor wholly turbulent. In this transition region there is no exact equation to calculate the friction factor and therefore only an approximate friction factor can be used by way of appropriate interpolation.

12.4 Friction Factors

Many formulas have been developed to model the flow of liquids. The Hazen-Williams formula has been a popular method of estimating the head loss in piping systems for (particularly prior to the availability of today's modern computers), however, this empirical formula will only give reasonable accuracy if the fluid is water at 60°F or similar and it cannot be used with gases.

The Colebrook-White formula may be used with confidence to calculate an accurate friction factor applicable to the turbulent flow of fluids. The Colebrook-White formula is applicable over a whole range of fluid densities and viscosities, provided that the fluid flow is turbulent i.e. it work with all fluids and not only water.

The Colebrook-White friction factor is used in the Darcy-Weisbach equation when calculating friction loss for non-compressible flow (liquids). The Colebrook-White friction factor is also used with some compressible gas flow equations such as the General Fundamental Flow equation.

12.5 Colebrook-White Formula

The Colebrook-White formula:

$$1/\sqrt{f} = 1.14 - 2 \log_{10} [e/D + 9.35/(Re \times \sqrt{f})]$$

f = friction factor

e = internal roughness of pipe

D = internal diameter of pipe

Re = Reynolds number

Friction factors for turbulent flow calculated by Pipe Flow Gas Pressure Drop are based on the Colebrook-White formula.

The friction factor for Laminar flow is calculated from $f = 64/Re$

12.6 Friction Losses (Resistance to Flow)

Friction losses for incompressible flow (liquids) can be accurately calculated using the Darcy-Weisbach equation, and within specific criteria it can also be used for calculations with gases, however for has calculations within Pipe Flow application the friction losses are calculated using specific compressible flow equations as defined in the separate PDF document named 'Compressible Flow Equations'. This PDF is available from the 'Results Verification' menu inside the software.

12.7 Darcy-Weisbach Formula

For non-compressible fluids (liquids), fluid head resistance can be calculated by using the Darcy-Weisbach formula.

$$h_{\text{fluid}} = f (L/D) \times (v^2/2g)$$

f = friction factor

L = length of pipe work

D = inner diameter of pipe work

v = velocity of fluid

g = acceleration due to gravity

This formula can be used for compressible (gas) calculations provided that the gas density at the start of the pipe is used to determine the fluid velocity, and provided that the pressure drop in the pipe is less than ten percent of the absolute pressure at the start condition.

For compressible (gas) calculations where the pressure drop is more than ten percent, but less than forty percent of the absolute pressure at the start of the pipe, the equation gives reasonable results provided that the gas density at the average pressure condition in the pipe is used to calculate the average velocity of the gas.

The Pipe Flow Gas Pressure Drop software however, does not allow use of the Darcy-Weisbach equation for compressible gas calculations since it uses the more accurate specialist compressible gas flow equations, which provide more accurate results, and which are not limited to working with pressure drops of up to a certain percentage of the initial start pressure.

12.8 Fitting Losses

The fluid head resistance through various pipe work fittings can be calculated if the 'K' factor of the fitting is known. Many manufacturers of pipe work fittings and valves publish 'K' factors for their products.

12.8.1 'K' Factor Fitting Head Loss Calculation for Liquids

For non-compressible (liquid) systems, fluid head loss through fittings and valves can be calculated from the following equation:

$$h_{\text{fluid}} = 'K' \times v^2 / 2g$$

'K' = manufacturer's published 'K' factor for the fitting

v = velocity of fluid

g = acceleration due to gravity

12.8.2 Equivalent Length Head Loss Calculation for Gases

For compressible gas flow calculations, the Pipe Flow Gas Pressure Drop software converts the 'K' factor of the fitting to an equivalent length of pipe, which will result in the same friction loss. This is done automatically during the calculation.

A 'K' factor can be converted to an equivalent length of pipe when the diameter of the pipe is known.

$$\text{Equivalent length} = (K \text{ factor} \times \text{Diameter}) / \text{Friction factor}$$

The Pipe Flow Gas Pressure Drop software allows fittings to be placed at both the start and the end of the pipe, and with compressible flow, when pressure loss occurs along the pipe, the gas will 'expand' (become less dense), hence it's velocity will increase, to maintain the same mass flow rate.

The 'K' factor method for calculating head loss across a fitting requires that the density of the fluid entering the fitting is known, since the result is a head loss that is relative to this density, and with a compressible gas flow calculation, where there are fittings at the start and end of the pipe, the density of the gas is different at these points. In addition, the starting pressure of a gas flow calculation affects the overall friction loss results (for the same flow rate) and therefore technically if there are fittings at the start of the pipe then the loss through these must be accounted for and the pressure immediately after the fittings would then need to be used as the start pressure for the friction loss calculation.

Using the equivalent length method for compressible gas flow calculations simplifies the problem. Once the overall loss through the pipe has been calculated (including the additional equivalent length for the fittings) then the amount of loss through the

fittings at the start and the end of the pipe can be apportioned appropriately to break out the results in to the fittings losses and the pipe friction loss.

12.8.3 Fittings Database

Pipe Flow Gas Pressure Drop has a database of valve and fittings 'K' factors and calculation helpers for:

- gradual enlargements
- gradual contractions
- sudden enlargements
- sudden contractions
- rounded entrances
- long pipe bends

In systems where pipe lengths are relatively long, the effect of the fitting losses for bends may be minor (in comparison to the long pipe friction losses) and in these cases, fitting losses are sometimes ignored during initial assessment of the system.

If a partially open valve is part of the design, the effect of the valve should always be considered as the valve loss may be large.

12.9 Compressible Gas Flow Equations

Friction loss for a compressible fluid, such as a gas, needs to account for the change in density, as the gas moves along the pipe and loss of pressure occurs. When using the compressible flow calculation engine Pipe Flow Gas Pressure Drop can be set to use one of the following compressible flow equations:

- General Fundamental Isothermal Flow Equation
- Complete Isothermal Flow Equation
- AGA Isothermal Flow Equation
- Weymouth Isothermal Flow Equation
- Panhandle A Isothermal Flow Equation
- Panhandle B Isothermal Flow Equation
- IGT Isothermal Flow Equation

The formula for each of the above equations is detailed in a separate PDF document named 'Compressible Flow Equations'. This PDF is available from the 'Results Verification' menu inside the Pipe Flow Gas Pressure Drop software.

13 Glossary

Term	Description
Absolute Pressure	Pressure measured with respect to zero pressure.
Atmosphere	A standard atmospheric pressure of 1.01325 bar a or 14.696 psi a.
Centipoise	Absolute viscosity of a fluid expressed in $\text{Pa} \cdot \text{s} \times 10^{-3}$
Centistokes	Kinematic viscosity of a fluid expressed in $\text{m}^2/\text{s} \times 10^{-6}$
Colebrook-White equation	An equation used to calculate accurate friction factors from the internal diameter and internal roughness of a pipe and the Reynolds number for the flow conditions.
Darcy-Weisbach equation	An equation used to calculate the frictional head loss due to fluid flow from the friction factor, the length and diameter of the pipe, the velocity of the fluid and the gravitational constant.
Friction Factor	A factor to be used in the Darcy-Weisbach equation. Either calculated from the Colebrook-White equation or ready from the Moody diagram.
Entry Pressure	The pressure at the start of the pipe.
Exit Pressure	The pressure at the end of the pipe.
Fixed Pressure Loss	A static pressure loss which is independent of the flow rate.
K Value	Coefficient of frictional loss through a valve or pipe fitting.
Moody Diagram	A graphical representation of the relationship between Reynolds number, relative roughness and Friction factor.
Pressure Loss	The friction loss due to fluid flow expressed in a relative fluid head or a non-relative unit of pressure.
Reynolds Number	A dimensionless number derived from the fluid velocity, the internal diameter of the pipe and the Kinematic viscosity of the fluid.

Viscosity

A measure of a fluid's resistance to flow.
