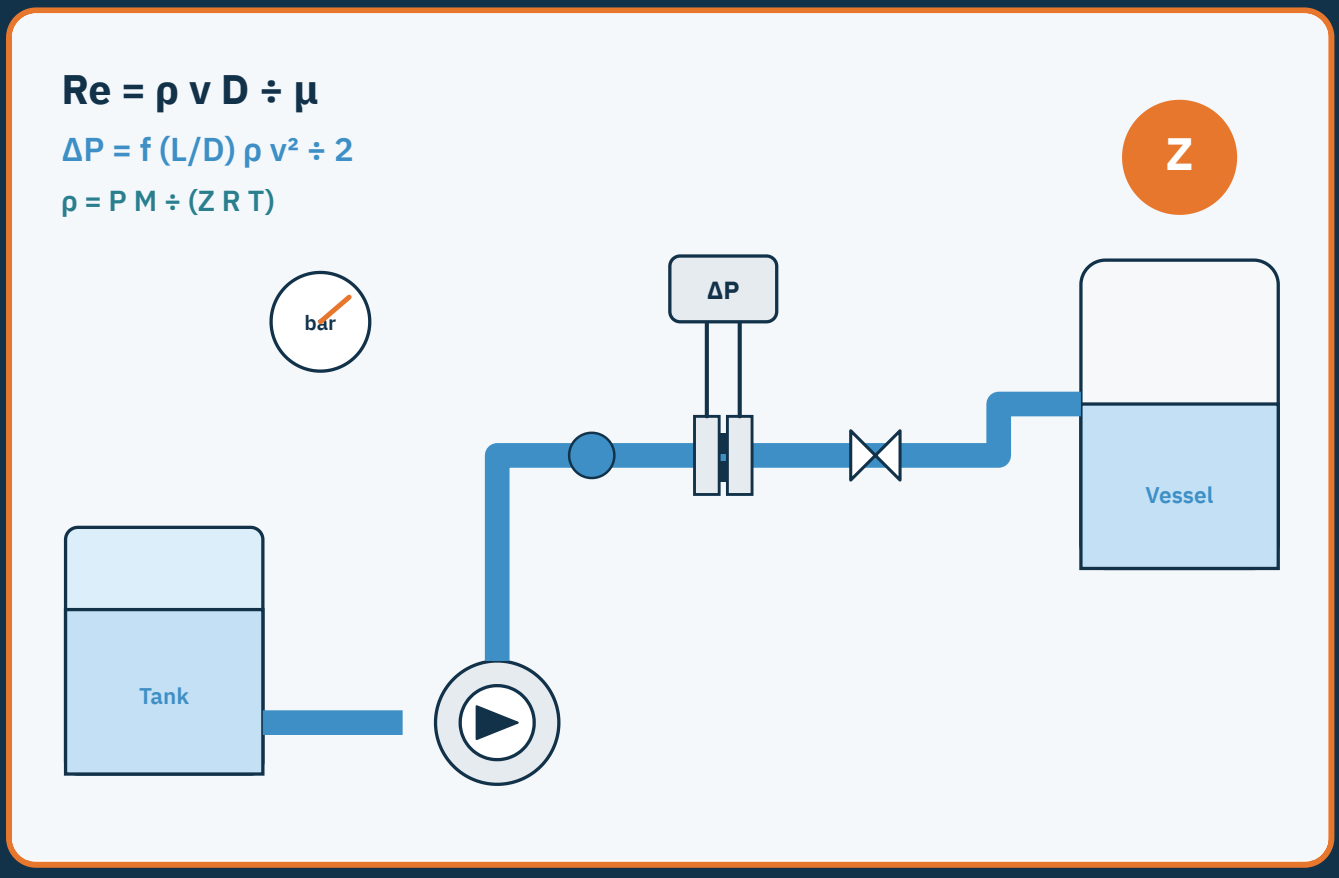
PlantCalcKit

Piping, Flow and Fluid Properties Made Simple

A field guide to fluid properties, pipe flow, flow measurement and vessels

Density · Viscosity · Vapour pressure · Gas Z factor · Reynolds number · Pressure drop · Fittings · Line sizing · Gas and steam lines · Orifice plates · Restriction orifices · Tank volume · Purging and tracing · Water hammer · Wall thickness



FREE SAMPLER — Chapters 1 to 3

Edition 1.0 · November 2026

PlantCalcKit

Piping, Flow and Fluid Properties Made Simple
A field guide to fluid properties, pipe flow, flow measurement and vessels
Edition 1.0 · November 2026 — free sampler (Chapters 1 to 3)

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Written in our own words from published engineering sources, listed in Appendix G with their editions. All diagrams, picture pages and charts are original PlantCalcKit artwork; charts are computed from the worked examples. No equipment maker, chemical supplier or brand is named or recommended.

Site P and all its equipment are made up. Every example value is generic; costs and prices are illustrative.

This guide is for training and engineering estimates. It does not replace your equipment maker's instructions, the published codes and standards, or your plant's approved procedures and safety rules. Where a method follows a code or standard, the calculation is aligned with the publicly documented method; no result in this book claims to meet a code. Pipe wall thickness, surge, restriction orifices, tank venting and nitrogen blanketing are safety-critical: the book teaches understanding and checking, and the responsible engineer decides.

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PART A — FLUID PROPERTIES

1 Why piping and fluid properties matter 7
2 Density and specific gravity 13
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GUIDE

How to use this book

This book explains piping, flow and fluid properties in plain words: what density, viscosity and vapour pressure are, how pressure is lost in pipe, how to size a line, how an orifice plate works, how to find the volume in a tank, how nitrogen blanketing and heat tracing are sized, and what water hammer and wall thickness mean. You do not need to be an expert. If you can read a gauge and use a calculator, you can follow every example.

Who it is for

- **Plant operators** who want to know what the numbers on the gauges mean.
- **Young engineers** who must size a line, check a meter or write a report.
- **Senior engineers** who want a quick refresher or a training text for their team.

How the book is built

Part	What you learn	Chapters
A	Fluid properties: density, viscosity, vapour pressure, heat, gases	1 to 6
B	Flow in pipes: Reynolds number, friction, fittings, sizing, gas and steam lines, pumps	7 to 12
C	Measuring and restricting flow: orifice plates and restriction orifices	13 to 14
D	Vessels and tanks: volume, residence time, nitrogen and heat tracing	15 to 17
E	Surge, wall thickness and units	18 to 19

Each chapter is short and stands alone. At the back you will find a glossary, an FAQ, units and conversions, a formula sheet, printable checklists, answers to all exercises and quizzes, and the list of sources.

The boxes you will see

- **Field check**: a table of what you might see on the plant, what it may mean, and what to check first.
- **Engineer's calculation corner**: a worked example with every step and number, using Site P's equipment.
- **Watch out**: a common mistake or a safety point.
- **Try it**: a short exercise; answers are in Appendix F.
- **Free tools**: QR codes to the free online calculator and the matching Excel toolkit for the chapter.
- **Quick quiz**: five questions to check you have the main ideas; answers are in Appendix F.
- **Picture pages**: a cutaway or parts drawing with numbered parts and a table that says what each part does.

Suggested reading paths

- **Operator**: read Chapters 1, 7, 9, 12, 15 and 17 first, and use the Field check tables.
- **Young engineer**: read in order from Chapter 1 to 12, then the chapter your current job needs; work every Try it exercise.
- **Senior engineer**: skim the Engineer's calculation corners, check the Sources appendix for editions, and use the chapters as training material.

Site P and the numbers

All examples follow one made-up plant, Site P (Chapter 1). Where a matching PlantCalcKit toolkit or free calculator has an example case, the book's example uses the same inputs, so you can open the tool and see the same calculation. Every number in the worked examples was computed with a script, not typed by hand, and the script also recomputes the toolkit examples as a check. Costs and prices are illustrative only.

Units

SI units come first, with US customary units in brackets where it helps. Pressures are marked "bar g" (gauge) or "bar a" (absolute). Appendix C has the conversions.

Limits of this book

This book teaches you to understand and check piping calculations. It is not a design code and not a signed-off design calculation. Pipe wall thickness, surge, relief, restriction orifices in safety service, nitrogen blanketing and venting, and tank venting are safety-critical: use the book to understand what the engineer is checking, then follow the current code, your company's standards and the advice of the responsible engineer. Where a method follows a published standard, the calculation is aligned with the publicly documented method; that is not a claim that any result meets the standard. The sources and their editions are listed in Appendix G, and the book names no equipment maker, supplier or brand.

Related books

Long gas pipelines and two-phase flow get only a short treatment here. For them see *Water Treatment, Utilities and Energy Made Simple*. For relief valves, control valves and flare headers, see *Safety Valves, Control Valves and Flare Made Simple*. For pumps in detail, see *Pumps Made Simple*.

FREE TOOLS

Free calculators and Excel toolkits

Every chapter has a Free tools box with QR codes: a free online calculator (two in some chapters) for a quick check, and the matching PlantCalcKit Excel toolkit, which carries out the full calculation of the chapter's worked example with the same numbers. The toolkits show every formula, check every input and print a report. Shop pages are information pages; nothing is bought by scanning a code. The Physical Properties Kit (below) bundles the Gas, Liquid and Fluid Properties calculators that Chapters 2 to 6 refer to.

All free calculators
plantcalckit.com/tools/

All Excel toolkits
plantcalckit.com/shop/

Physical Properties Kit (USD 89)
plantcalckit.com/shop/physical-properties-kit/

Ch.	Chapter	Free calculator	Excel toolkit (does the chapter's calculation)
1	Why piping and fluid properties matter	Pipe pressure drop and sizing /tools/pipe-pressure-drop/	Pipe Sizing and Pressure Drop USD 29 /shop/pipe-sizing-and-pressure-drop-excel/
2	Density and specific gravity	Gas density and Z factor /tools/gas-density-z-factor/	Fluid Properties Calculator USD 29 /shop/fluid-properties-calculator-excel/
3	Viscosity	Reynolds number and line velocity /tools/reynolds-number/	Liquid Properties Calculator USD 49 /shop/liquid-properties-calculator-excel/

PART A

Fluid properties

Density, viscosity, vapour pressure, heat and gases

CHAPTER 1

Why piping and fluid properties matter

Every plant is a set of vessels joined by pipe. The pipe has to carry the right amount of fluid, at a pressure the next machine can use, without wearing out, shaking itself loose or costing a fortune in pump power. Three questions sit behind almost every piping job: how much flows, what is the fluid, and how much pressure is lost on the way. This chapter shows how the three fit together and introduces the line we follow through the whole book.

1.1 Three questions behind every pipe

How much? Flow can be given as a mass flow (kg/h), a volume flow (m^3/h) or, for gas, a "normal" volume (Nm^3/h). The three are linked by density. Plants mix them all day, so the first skill is to move from one to the other without error.

What fluid? Density, viscosity, vapour pressure, specific heat and, for gases, the compressibility factor Z decide how the fluid behaves in the pipe. Part A (Chapters 2 to 6) takes these properties one at a time.

How much pressure is lost? Friction, fittings, height and speed changes use up pressure. Part B (Chapters 7 to 12) turns that into a calculation you can repeat on any line.

Parts C to E then use the same ideas for flow meters and restriction orifices (Chapters 13 and 14), vessels and tanks (Chapters 15 to 17), surge and wall thickness (Chapter 18) and unit conversions (Chapter 19).

1.2 Site P and the line L-1001

All examples in this book come from one made-up plant, Site P, and the equipment tags are generic. The main character is **L-1001**, a 6-inch line (NPS 6, Schedule 40, inside diameter 154.08 mm) that carries cooling water at 30 °C over 100 m. The inlet pressure is 5 bar g (6.01325 bar a). The flow is 100,000 kg/h. The line has two 90° elbows, two open gate valves, one swing check valve, a sharp entrance and an exit into a tank.

Figure 1.1 shows where the equipment of later chapters sits. Each tag appears again where its calculation is done.

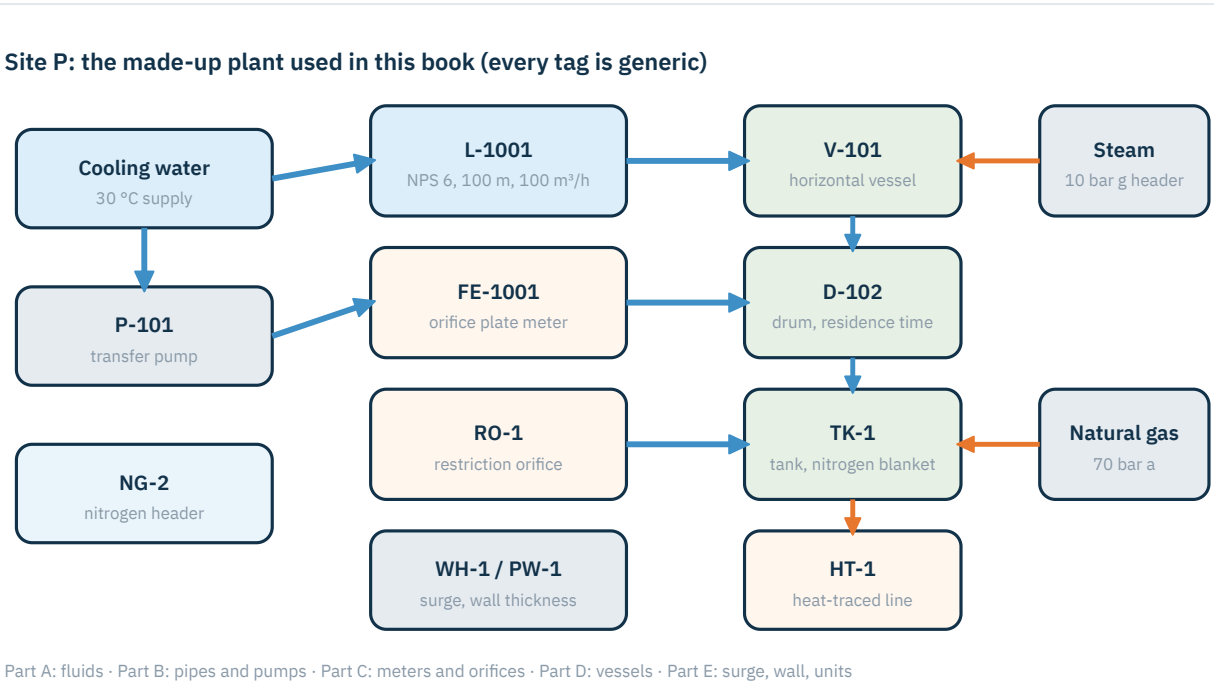


Figure 1.1 — Site P: the made-up plant used in this book. Every tag is generic, and every number comes from a calculation you can repeat.

The numbers of L-1001 are the sample case of the PlantCalcKit *Pipe Sizing and Pressure Drop* Excel toolkit. We recomputed them in Python to check them. They are:

Item	Value
Water density at 30 °C	995.140 kg/m³
Dynamic viscosity	0.8072 mPa·s
Volume flow	100.49 m³/h
Velocity	1.50 m/s
Reynolds number	284,368
Darcy friction factor	0.01704
Straight-pipe loss, 100 m	12.332 kPa
Fittings loss (K = 5.34)	5.955 kPa
Total loss	18.286 kPa
Outlet pressure	5.8304 bar a

By the end of Chapter 10 you will be able to reproduce every row by hand.

1.3 From mass flow to volume flow

The water in L-1001 is 100,000 kg/h. Divide by the density: 100,000 ÷ 995.140 = 100.5 m³/h. The same mass of methane at atmospheric pressure takes up 152,161 m³/h — 1,514 times more room, because gas is so much lighter. This is why gas lines are bigger than water lines and why gas pressure drop needs more care (Chapter 11).

ENGINEER'S CALCULATION CORNER **Worked example: how much water, how fast?**

1. Mass flow $\dot{m}$ = 100,000 kg/h = 100,000 ÷ 3,600 = 27.78 kg/s.
2. Volume flow $Q = \dot{m} \div \rho$ = 27.78 ÷ 995.140 = 0.02791 m³/s = **100.49 m³/h**.
3. Flow area $A = \pi/4 \times D^2$ = π/4 × 0.15408² = 186.46 cm².
4. Velocity $v = Q \div A$ = 0.02791 ÷ 0.018646 = **1.50 m/s**.

A velocity of 1.5 m/s is a comfortable value for water in a plant line (Chapter 10).

1.4 Units and conventions

SI units come first with US customary units in brackets where it helps: 100.49 m³/h is 440 US gpm at 100 m³/h. Pressure is **bar g** (gauge, above the atmosphere) or **bar a** (absolute, above a perfect vacuum); the two differ by about 1.013 bar at sea level. Temperature is in °C, but all gas equations use kelvin (K = °C + 273.15). Appendix C lists conversions.

1.5 What this book can and cannot do

This book teaches you to understand and check piping calculations. It does not replace the design codes, your company's design practice or a signed-off calculation by the responsible engineer. Pipe wall thickness, relief and surge work are safety-critical; Chapters 14 and 18 explain the ideas, and the limits box in each chapter says where the book stops. Where a method follows a published standard, the calculation is aligned with the publicly documented method; nothing in this book claims that a result meets a code.

1.6 A five-step routine for any piping question

Every worked example in this book follows the same routine, and you can use it on any line in your own plant:

1. **Write down the case**: fluid, flow with its basis (mass, volume or normal volume), temperature and pressure at the point you care about.
2. **Find the fluid properties at those conditions**: density, viscosity, vapour pressure and, for gas, Z (Part A).
3. **Compute the velocity and the Reynolds number** (Chapter 7). They tell you the regime and the first impression of whether the line is sensible.
4. **Add up the losses**: friction in the straight pipe, then fittings and valves, then height and equipment (Chapters 8 and 9).
5. **Compare with what you can measure**: gauges, a meter, the pump curve. If the two disagree, write down which assumption you doubt most and test it.

The routine is short on purpose. A calculation that cannot be written in five lines is usually hiding an assumption.

FIELD CHECK **Field check: first look at a line**

What you see	What it may mean	First thing to check
Pump discharge pressure higher than usual	Line partly blocked, valve closed, or fluid thicker than usual	Valve positions; fluid temperature
Pressure at the far end too low	Pressure drop larger than assumed	Flow rate; roughness; closed valves
Noise or vibration in a line	Velocity too high, cavitation or two-phase flow	Velocity; vapour pressure at the pump suction
Different flow in two meters	Density or temperature differs from the meter's assumption	Meter conditions (Chapter 13)

Watch out — mixing flow units

A volume flow means nothing without its conditions. 100 m³/h of gas at 70 bar a is very different from 100 m³/h at atmospheric pressure. Always write the pressure and temperature next to a gas volume.

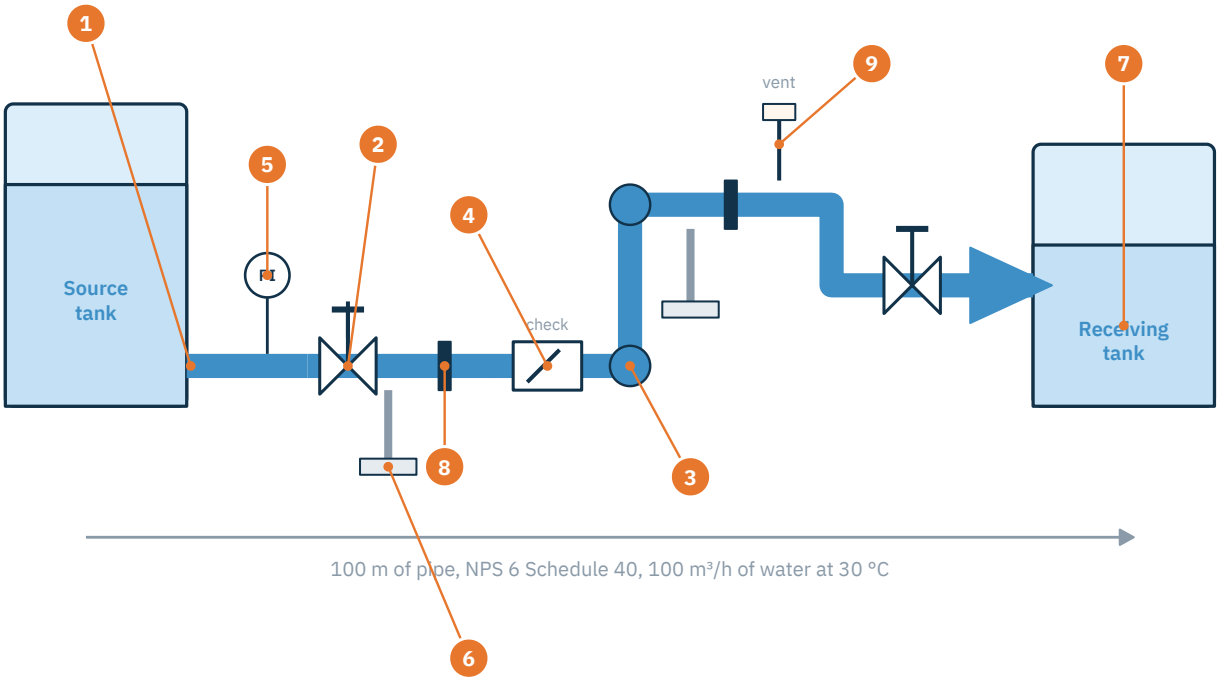
TRY IT

A transfer pump moves 25,000 kg/h of water at a density of 995 kg/m³ through a pipe of 100 mm inside diameter. What are the volume flow in m³/h and the velocity in m/s? (Answers in Appendix F.)

PICTURE PAGE 1

A pumped line and its fittings

Line L-1001: a typical pumped water line, from tank to tank



Line L-1001 with its seven loss items: two elbows, two gate valves, one check valve, entrance and exit. Generic arrangement.

No.	Part	What it does
1	**Source tank and entrance**	A sharp entrance from a tank costs K = 0.5 (Chapter 9).
2	**Gate valve (two in the line)**	Isolation only; K = 0.17 when fully open, much more when part-closed.
3	**Standard 90° elbow (two)**	K = 0.75 each; long-radius elbows cost K = 0.45.
4	**Swing check valve**	Stops back-flow; K = 2.0 and the largest single fitting loss in L-1001.
5	**Pressure gauge**	Read both ends of a line to find its real pressure drop.
6	**Pipe support**	Carries the weight of the water-filled pipe.
7	**Exit into the receiving tank**	All the velocity head is lost: K = 1.0.
8	**Flange pair**	Allows the line to be opened; gasket must not protrude into the bore.
9	**Vent at the high point**	Lets trapped air out; air pockets raise pressure drop and cause noise.

FREE TOOLS **Do this chapter's calculation**

Free calculator
Pipe pressure drop and sizing calculator
plantcalckit.com/tools/pipe-pressure-drop/

Excel toolkit: Pipe Sizing and Pressure Drop (USD 29)
plantcalckit.com/shop/pipe-sizing-and-pressure-drop-excel/
Topics: Any fluid · Pipe and friction · 27 fittings and valves · Gas and steam lines · Size table · Flow for an allowed drop

QUICK QUIZ

1. Name the three questions behind every piping calculation.
2. Why is a gas volume useless without a pressure and a temperature?
3. What is the difference between bar g and bar a?
4. In L-1001, what is the velocity and what is the total pressure loss?
5. Which part of the book deals with orifice plates and restriction orifices?

CHAPTER 2

Density and specific gravity

Density is mass per unit volume. It turns kilograms into cubic metres, sets the weight of a liquid column, and appears in almost every flow equation. For water it changes little with temperature; for gas it changes with everything. This chapter shows how to find density for liquids, gases and oils, and how large the errors are when you simply use one number.

2.1 Liquids: density changes slowly

Water at 20 °C has a density of 998.2 kg/m³. The values from the IAPWS-95 formulation (computed with the CoolProp library) are:

Temperature	Density (kg/m³)
4 °C	1,000.0
20 °C	998.2
30 °C	995.6
60 °C	983.2
80 °C	971.8
90 °C	965.3

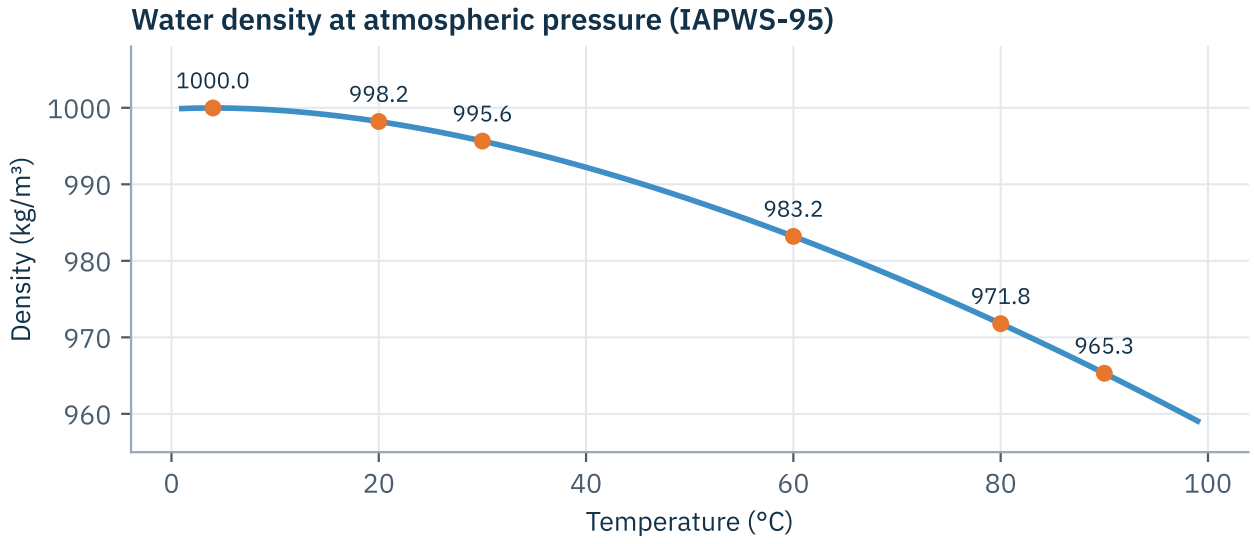


Figure 2.1 — Density of water at atmospheric pressure from 0 to 100 °C (IAPWS-95). The maximum is near 4 °C.

Between 20 and 80 °C the density falls by 2.7 %. A 100 m³ tank of water heated from 20 to 80 °C grows to 102.72 m³: 2.72 m³ must go somewhere, which is why closed hot-water systems need an expansion vessel.

Pressure has a very small effect on liquids. At 100 bar the density of water at 20 °C is 1,002.7 kg/m³, only 0.45 % higher. For piping work you can treat liquid density as depending on temperature alone.

2.2 Specific gravity and API gravity

Specific gravity (SG) is the density of the liquid divided by the density of water at a reference temperature. Oil people often quote **API gravity**:

°API = 141.5 ÷ SG − 131.5 (at 60 °F)

For an oil of SG 0.85, the API gravity is 35.0. Always note the reference temperature of an SG: an SG at 15 °C is not the SG at 60 °C.

2.3 Gases: density depends on pressure and temperature

For an ideal gas, **ρ = P M ÷ (R T)**, with P absolute pressure in Pa, M molar mass in kg/mol, R = 8.314 J/(mol·K) and T in K. A real gas needs the compressibility factor Z (Chapter 6): **ρ = P M ÷ (Z R T)**.

Methane (M = 0.016043 kg/mol) at 25 °C and 1.01325 bar a has an ideal density of 0.6557 kg/m³. The Gas Properties kit gives 0.6572 kg/m³, which is +0.22 % higher, because Z is a little below 1 (0.99775). The difference is small at atmospheric pressure and large at high pressure.

ENGINEER'S CALCULATION CORNER **Worked example: density of air at 5 bar g and 35 °C**

1. Absolute pressure: 5 + 1.01325 = 6.01325 bar a = 601,325 Pa.
2. T = 35 + 273.15 = 308.15 K; M for air = 0.02896 kg/mol.
3. ρ = P M ÷ (R T) = 601,325 × 0.02896 ÷ (8.314 × 308.15) = **6.80 kg/m³**.

Check: air at atmospheric conditions and 15 °C is about 1.2 kg/m³; six times the pressure gives about six times the density.

2.4 Which density to use

Situation	Use	Why
Water line, temperature known	Table or toolkit value at line temperature	Changes 1 % per 20 K or so
Oil or chemical	Value at line temperature from the supplier's data	Small tables cover few temperatures
Gas at line pressure	ρ = P M ÷ (Z R T)	Needs P, T, composition
Mass flow from a volume meter	Density at the meter's conditions	Meters measure volume

2.5 Mixtures: one number is not always enough

A stream is often a mixture, such as water with glycol, or a blend of two oils. For liquids that mix without a large volume change, the specific volumes (the inverse of the densities) add by mass fraction: **1 ÷ ρ_mix = Σ (w_i ÷ ρ_i)**. For a 50:50 mass blend of a liquid of 1,000 kg/m³ and one of 800 kg/m³, 1 ÷ ρ = 0.5 ÷ 1,000 + 0.5 ÷ 800, so the blend has a density of **888.9 kg/m³**. Note that this is lower than the simple average of 900 kg/m³. Some mixtures shrink or swell on mixing; for those, use measured data or the mixture models in a property toolkit (the Liquid Properties and Gas Properties calculators handle mixtures of up to 12 components).

FIELD CHECK **Field check: density**

What you see	What it may mean	First thing to check
Tank level rises as the contents heat up	Thermal expansion	Size of the expansion margin
DP level reading wrong after a product change	Density differs from the transmitter set-up	Calibrated density (Chapter 15)
Gas flow reads high after a pressure rise	Meter uses fixed density	Compensation settings

Watch out — density in the wrong units

Always check whether a density is in kg/m³, g/cm³ or lb/ft³. 1 g/cm³ = 1,000 kg/m³ = 62.43 lb/ft³. A factor of 1,000 turns a sensible answer into an absurd one.

TRY IT

Water in a 50 m³ vessel is heated from 20 °C to 60 °C. By how many cubic metres does the volume grow? Then find the density of air at 5 bar g and 35 °C if you ignore Z. (Answers in Appendix F.)

FREE TOOLS **Do this chapter's calculation**

Free calculator
Gas density and Z factor calculator
plantcalckit.com/tools/gas-density-z-factor/

Excel toolkit: Fluid Properties Calculator (USD 29)
plantcalckit.com/shop/fluid-properties-calculator-excel/
Topics: About 165 fluids · Everything for heat transfer · Accurate enthalpy · Property table · Clear limits · Same library as the heat exchanger tools

QUICK QUIZ

1. At which temperature is water densest?
2. Why does pressure hardly matter for liquid density?
3. Write the density equation for a real gas.
4. A liquid has SG 0.85. What is its density in kg/m³ (water 1,000 kg/m³)?
5. Why must the reference temperature be stated with a specific gravity?

CHAPTER 3

Viscosity

Viscosity is a fluid's resistance to flowing. Honey is thick, water is thin, and the same oil is thin when hot and thick when cold. Viscosity decides whether flow is smooth or turbulent (Chapter 7) and how much pressure friction takes (Chapter 8). It is the property that changes most with temperature, so it deserves care.

3.1 Two kinds of viscosity

Dynamic viscosity μ is the force needed to shear the fluid. Its SI unit is the pascal-second (Pa·s); plants use the millipascal-second, mPa·s, which equals the centipoise (cP).

Kinematic viscosity $\nu = \mu \div \rho$ is the dynamic viscosity divided by density. Its SI unit is m²/s; plants use the centistokes, cSt, where 1 cSt = 10^{-6} m²/s = 1 mm²/s.

Water at 20 °C has μ = 1.002 mPa·s; that is nearly exactly 1 cP, which is why 1 cP is the unit people remember. At 30 °C, the kinematic viscosity is 0.801 cSt.

3.2 Liquids: viscosity falls fast when heated

Temperature	Water viscosity (mPa·s)
5 °C	1.518
20 °C	1.002
30 °C	0.797
60 °C	0.466
80 °C	0.354

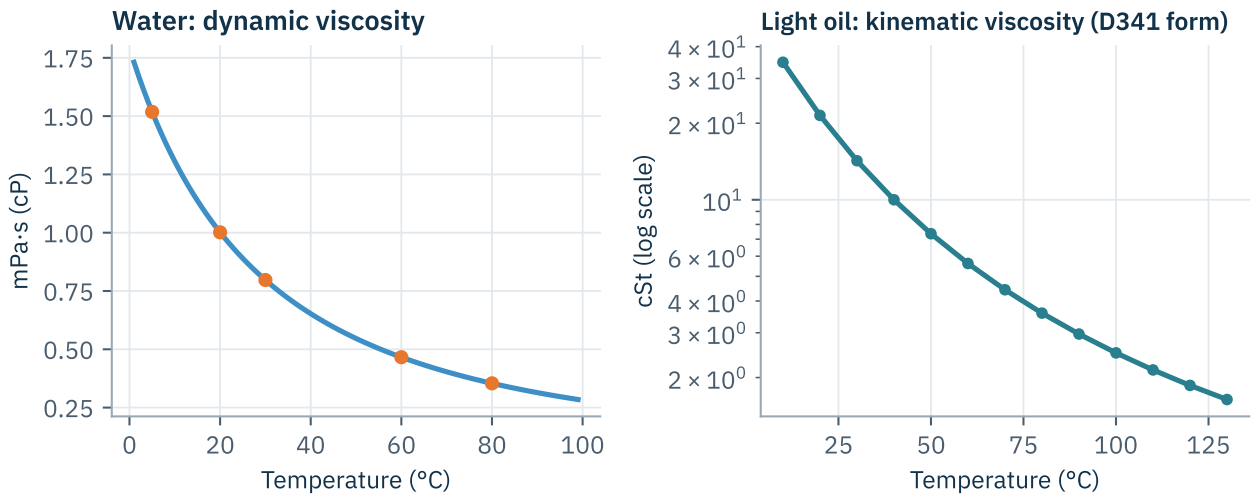


Figure 3.1 — Viscosity of water (left) and of a light oil (right) against temperature. Both fall quickly as the liquid warms; the oil changes by much more.

From 20 to 80 °C, the viscosity of water falls to about a third. For oils the change is far larger. A commonly used way to estimate an oil's viscosity at another temperature from two known values is the Walther equation in the form published as ASTM D341: $\log_{10}\log_{10}(v + 0.7)$ is a straight line against $\log_{10} T$. For an oil of 10 cSt at 40 °C and 2.5 cSt at 100 °C, the method gives 21.5 cSt at 20 °C, 5.6 cSt at 60 °C and 3.6 cSt at 80 °C.

An oil of 100 mPa·s and SG 0.85 has a kinematic viscosity of 117.6 cSt.

3.3 Gases: viscosity rises with temperature

Gases behave the opposite way. Methane at 0 °C has μ = 10.39 μPa·s and at 400 °C 21.24 μPa·s. At 25 °C the value is 11.20 μPa·s. The Gas Properties kit table (11 temperatures from 0 to 400 °C) differs from the reference equation of state by at most 0.18 %. Gas viscosity is about 50 to 100 times smaller than water's, yet gas flow is still turbulent because its density is low and its speed is high.

3.4 What viscosity does to your calculation

Re = ρ v D ÷ μ. A 1.3 % higher viscosity gives a 1.3 % lower Reynolds number, which changes the friction factor very little for turbulent flow. In L-1001 the toolkit's property library gives a viscosity +1.3 % different from the IAPWS-95 value, and the total pressure loss changes by only −0.16 %. For laminar flow of oil, by contrast, pressure drop is directly proportional to viscosity, so a 10 % viscosity error is a 10 % pressure-drop error (Chapter 7).

ENGINEER'S CALCULATION CORNER **Worked example: kinematic viscosity of an oil**

1. Dynamic viscosity μ = 100 mPa·s = 0.100 Pa·s.
2. Density ρ = 850 kg/m³.
3. $v = \mu \div \rho = 0.100 \div 850 = 1.176 \times 10^{-4}$ m²/s = **117.6 cSt**.

3.5 Where viscosity data comes from

Good viscosity data are a measurement or a reliable table, not a guess. The usual sources are the supplier's data sheet (look for the temperature the value is given at), a laboratory measurement, and a property library for common fluids. Three habits avoid most trouble:

- Write the **temperature** next to every viscosity. A value without a temperature is not a value.
- When you have two values at different temperatures, interpolate with a method made for the purpose (the Walther form above for oils), never with a straight line. A straight line through two points on a viscosity curve can be wrong by a factor of two.
- Do not **extrapolate** far outside the temperature range of the data. Near the pour point, oils stop behaving like simple liquids.

Mixtures do not average linearly either. A blend of a thick and a thin oil is thinner than the mass-weighted average of the two viscosities suggests, so a blend needs a measurement or a proper blending rule.

FIELD CHECK **Field check: viscosity**

What you see	What it may mean	First thing to check
Pump amps rise on a cold morning	Thicker oil, more friction	Temperature of the fluid
A line that worked in summer fails in winter	Viscosity rose, Re fell	Heat tracing (Chapter 17)
Flow meter reads wrong with a heavier product	Viscosity outside the meter's calibration	Meter range; Reynolds number

Watch out — cSt and cP are not the same

Centipoise (cP) is dynamic viscosity; centistokes (cSt) is kinematic. They are equal only for a fluid of density 1,000 kg/m³ (SG 1.0). Divide cP by the SG to get cSt.

TRY IT

A fluid has a dynamic viscosity of 20 mPa·s and a density of 850 kg/m³. What is its kinematic viscosity in cSt? A second fluid of 25 cP has SG 0.9; what is its viscosity in cSt? For the oil of this chapter, what is the ratio of v at 80 °C to v at 40 °C? (Answers in Appendix F.)

FREE TOOLS **Do this chapter's calculation**

Free calculator
Reynolds number and line velocity calculator
plantcalckit.com/tools/reynolds-number/

Excel toolkit: Liquid Properties Calculator (USD 49)
plantcalckit.com/shop/liquid-properties-calculator-excel/
Topics: 543 chemicals, A to Z · Pressure corrections · All the liquid properties · Liquid mixtures · Your own data · Heating values and hazards

QUICK QUIZ

1. What is the SI unit of dynamic viscosity? What is the common plant unit?
2. How does the viscosity of a liquid change when it is heated? Of a gas?
3. How do you convert cP to cSt?
4. Which viscosity does the Reynolds number use directly?
5. Why does a viscosity error matter more in laminar than in turbulent flow?

APPENDIX G

Sources

Every chapter was written in our own words from the published references below. No text, tables or figures were copied; all diagrams and charts are original PlantCalcKit artwork, and the charts were computed from the worked examples. Where a method follows a code or standard, the calculation is aligned with the publicly documented method; that is not a claim that any result meets the code. Book citations give title, edition and chapter or section; method names (Darcy, Colebrook, Joukowsky and so on) are the usual names of published equations.

Edition caveat. Standards and handbooks are revised. Where a source below gives an edition, that is the edition we used or that the equation was checked against. Where it says "edition not confirmed", the equation is standard but we could not check the page against the book, and you should confirm it in the edition your project uses before relying on it. Codes and standards (ISO 5167-2, ASME B31.3, API Standard 2000) must always be applied in the edition your project or regulator requires.

General (all chapters)

- *Perry's Chemical Engineers' Handbook* (Perry, Green and Maloney, eds), 7th ed., 1997 — section 6 (fluid and particle dynamics, including friction factors, fittings, compressible flow and water hammer), section 10 (transport and storage of fluids, including flow measurement, pipe wall thickness, tank volumes). This is the main text we checked page by page; later editions renumber the pages.
- IAPWS-95 formulation for the thermodynamic properties of ordinary water (Wagner and Pruss, *Journal of Physical and Chemical Reference Data* 31, 2002) and the CoolProp property library (Bell, Wronski, Quoilin and Lemort, *Industrial and Engineering Chemistry Research* 53, 2014) — all property values.
- NIST Special Publication 811, *Guide for the Use of the International System of Units* — unit conversions.

Chapter 1 — Why piping and fluid properties matter

- Perry's 7th ed., section 6 — general flow relations.
- The PlantCalcKit *Pipe Sizing and Pressure Drop* toolkit sample report — the L-1001 example case.

Chapter 2 — Density and specific gravity

- IAPWS-95 (as above) for water density.
- The API gravity relation is the standard API definition, °API = 141.5 ÷ SG − 131.5 at 60 °F; the gas law is the standard form.
- Reference equation of state for methane in CoolProp; the Gas Properties toolkit sample report for the methane example.

Chapter 3 — Viscosity

- ASTM D341, *Standard Practice for Viscosity-Temperature Charts for Liquid Petroleum Products* (edition not confirmed) — the Walther form used for the oil example.
- IAPWS-95 and the CoolProp viscosity correlations for water and methane; Gas Properties toolkit sample table for the methane check.

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