



UNIT 4

PERCENTAGES

Practical Maths for
Plumbing & Heating Students
and Apprentices



PERCENTAGE
BASICS



FIND PARTS
OF AMOUNTS



INCREASES &
DECREASES



PRACTICAL
CALCULATIONS



PLUMBING &
HEATING USES

PERCENTAGE BASICS

% means "per hundred"

KEY FORMULAE

- $Part = \frac{\%}{100} \times Whole$
- $\% = \frac{Part}{Whole} \times 100$
- $Whole = \frac{Part \times 100}{\%}$

EXAMPLES

- Find 20% of 150
 $= \frac{20 \times 150}{100} = 30$
- 15% increase on 80
Increase $= \frac{15 \times 80}{100} = 12$
New amount $= 80 + 12 = 92$
- 10% decrease on £250
Decrease $= \frac{10 \times 250}{100} = 25$
New amount $= 250 - 25 = £225$

PRACTICAL EXAMPLE

A heating system costs £1,200.
What is 25% VAT?

$$VAT = \frac{25 \times 1200}{100} = £300$$

$$Total\ cost = 1200 + 300 = £1,500$$



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Learning Outcomes

By the end of this guide, you will be able to:

- Understand what percentages are and how they relate to fractions and decimals
- Calculate percentages of quantities for plumbing and heating applications
- Apply percentages to pressure drop calculations
- Work with percentage error and tolerance
- Convert between percentages/fractions/decimals confidently
- Find percentage increase and decrease
- Calculate efficiency percentages for boilers/pumps/heating equipment
- Solve practical plumbing and heating problems using percentages

Introduction - Why Percentages Matter

Percentages are everywhere in plumbing and heating work. You will use them daily when:

- calculating pressure drop across pipework and fittings
- working with heat loss and energy savings
- assessing performance reductions and improvements
- calculating material wastage or allowances
- determining system efficiency for boilers/pumps/cylinders
- calculating percentage error in measurements
- working with tolerance specifications
- comparing output/demand/efficiency

This guide focuses on percentages - an essential mathematical skill that helps you ensure systems perform correctly and calculations are easy to compare.

What is a Percentage?

Definition

A percentage is a way of expressing a number as a fraction of 100. The word percent literally means per hundred.

Symbol: %

- 50% means 50 out of 100 or $50/100$ or 0.5
- 25% means 25 out of 100 or $25/100$ or 0.25
- 100% means 100 out of 100 or the whole amount

The Percentage Scale

0% = Nothing

50% = Half

100% = Everything or the whole amount

Greater than 100% = More than the original amount

Why Use Percentages?

Percentages make comparisons easier.

Instead of saying:

"pressure dropped by 0.09 bar out of 3.0 bar"

We say:

"pressure drop is 3%"

Instead of saying:

"boiler delivers 850 W out of 1000 W input"

We say:

"boiler is 85% efficient"

Percentages give us a standard way to compare different values regardless of their actual size.

The Relationship: Percentage, Fraction, Decimal

Understanding the Connection

Percentages, fractions, and decimals are three different ways of expressing the same thing - a part of a whole.

Example: Half of something can be written as:

Fraction: $\frac{1}{2}$

Decimal: 0.5

Percentage: 50%

Key relationship

$$\text{Percentage} = \text{Decimal} \times 100$$

$$\text{Decimal} = \text{Percentage} \div 100$$

Common Equivalents Table

| | | |
|------|-----------------|------|
| 1% | $\frac{1}{100}$ | 0.01 |
| 5% | $\frac{1}{20}$ | 0.05 |
| 10% | $\frac{1}{10}$ | 0.1 |
| 20% | $\frac{1}{5}$ | 0.2 |
| 25% | $\frac{1}{4}$ | 0.25 |
| 50% | $\frac{1}{2}$ | 0.5 |
| 75% | $\frac{3}{4}$ | 0.75 |
| 100% | $\frac{1}{1}$ | 1.0 |

Note: Memorising common equivalents saves time in calculations

Converting Between Forms

Percentage to Decimal

Method: divide by 100 or move decimal point 2 places left

$$50\% = 50 \div 100 = 0.5$$

$$3\% = 3 \div 100 = 0.03$$

$$125\% = 125 \div 100 = 1.25$$

$$0.5\% = 0.5 \div 100 = 0.005$$

Decimal to Percentage

Method: multiply by 100 or move decimal point 2 places right then add % sign

$$0.85 = 0.85 \times 100 = 85\%$$

$$0.03 = 0.03 \times 100 = 3\%$$

$$1.5 = 1.5 \times 100 = 150\%$$

$$0.005 = 0.005 \times 100 = 0.5\%$$

Percentage to Fraction

Method: write as fraction over 100 then simplify

$$50\% = 50/100 = 1/2$$

$$25\% = 25/100 = 1/4$$

$$80\% = 80/100 = 4/5$$

$$3\% = 3/100$$

Fraction to Percentage

Method: divide top by bottom, multiply by 100, then add % sign

$$1/4 = 1 \div 4 = 0.25 = 25\%$$

$$3/5 = 3 \div 5 = 0.6 = 60\%$$

$$7/8 = 7 \div 8 = 0.875 = 87.5\%$$

Finding a Percentage of a Quantity

The Basic Method

To find a percentage of a number:

Convert percentage to decimal

Multiply number by decimal

Formula:

$$\text{Result} = \text{Number} \times (\text{Percentage} \div 100)$$

Examples

Example 1:

Find 30% of 200 litres = $200 \times 0.3 = 60$ litres

Example 2:

Find 5% of 400 litres = $400 \times 0.05 = 20$ litres

Example 3:

Find 3% of 3.0 bar = $3.0 \times 0.03 = 0.09$ bar

Example 4:

Find 125% of 80 litres = $80 \times 1.25 = 100$ litres

Quick Mental Methods

Finding 10%: divide by 10

- 10% of 500 = 50

Finding 5%: find 10% then halve it

- 5% of 500 = 25

Finding 1%: divide by 100

- 1% of 500 = 5

Finding 50%: divide by 2

- 50% of 500 = 250

Build from these:

$$15\% = 10\% + 5\%$$

$$30\% = 3 \times 10\%$$

$$20\% = 2 \times 10\%$$

Finding What Percentage One Number is of Another

The Method

To find what percentage one number is of another:

$$\text{Percentage} = (\text{Part} \div \text{Whole}) \times 100$$

Remember the Formula

$$\text{What percentage is X of Y?} = (X \div Y) \times 100$$

The part goes on top, the whole goes on the bottom

Example 1

A boiler delivers 850 W out of 1000 W input. What is efficiency percentage?

$$= (850 \div 1000) \times 100 = 85\% \text{ efficient}$$

Example 2

A system has pressure drop of 0.09 bar from 3.0 bar supply. What percentage is this?

$$= (0.09 \div 3.0) \times 100 = 3\%$$

Example 3

A heat pump delivers 4.8 kW output from 5 kW input. What is efficiency?

$$= (4.8 \div 5) \times 100 = 96\% \text{ efficient}$$

Example 4

A measured volume is 0.25 m³ out of total storage capacity of 0.533 m³. What percentage is filled?

$$= (0.25 \div 0.533) \times 100 = 46.9\%$$

Percentage Increase and Decrease

Percentage Increase

When a value increases, we can express the increase as a percentage of the original value.

Formula: Percentage Increase = $(\text{Increase} \div \text{Original}) \times 100$

Example 1: Flow rate increases from 10 l/min to 12 l/min.

Step 1: Find increase = $12 - 10 = 2$ l/min

Step 2: Calculate percentage = $(2 \div 10) \times 100 = 20\%$ increase

Example 2: A boiler cost increases from £50 to £65.

Increase = $65 - 50 = 15$

$(15 \div 50) \times 100 = 30\%$ increase

Percentage Decrease

When a value decreases, we express the decrease as a percentage of the original value.

Formula: Percentage Decrease = $(\text{Decrease} \div \text{Original}) \times 100$

Example 1: Pressure drops from 3.0 bar to 2.91 bar.

Decrease = $3.0 - 2.91 = 0.09$ bar

$(0.09 \div 3.0) \times 100 = 3\%$ decrease

Example 2: Power consumption reduces from 5000 W to 4250 W.

Decrease = $5000 - 4250 = 750$ W

$(750 \div 5000) \times 100 = 15\%$ decrease

Calculating New Values After Percentage Change

To increase by a percentage:

New value = $\text{Original} \times (1 + \text{Percentage} \div 100)$

Example: Increase 400 litres by 10%

$= 400 \times 1.1 = 440$ litres

To decrease by a percentage:

New value = $\text{Original} \times (1 - \text{Percentage} \div 100)$

Example: Decrease 3.0 bar by 3%

$= 3.0 \times 0.97 = 2.91$ bar

Practical Pressure Drop Example

Given information

- Pipe run length: 50 m
- Pressure loss: 0.18 bar per 10 m
- Supply pressure: 3.0 bar
- Design limit: 5%

Step 1: Calculate actual pressure drop

50 m = 5 sections of 10 m
 $0.18 \times 5 = 0.9$ bar

Step 2: Calculate as percentage

$(0.9 \div 3.0) \times 100 = 30\%$

Step 3: Check against limit

30% > 5% - **Not acceptable**

Solution

Use a design with lower pressure loss

Pressure Drop Calculations

Pressure Drop Limits

In practical plumbing and heating work, pressure drop is often checked as a percentage of available supply pressure or design pressure so that system performance remains acceptable.

For 3.0 bar supply:

3% of 3.0 bar = 0.09 bar

5% of 3.0 bar = 0.15 bar

For 4.0 bar supply:

3% of 4.0 bar = 0.12 bar

5% of 4.0 bar = 0.20 bar

Finding Maximum Permitted Pressure Drop

For 3.0 bar supply:

3% limit = $3.0 \times 0.03 = 0.09$ bar

5% limit = $3.0 \times 0.05 = 0.15$ bar

For 4.0 bar supply:

3% limit = $4.0 \times 0.03 = 0.12$ bar

5% limit = $4.0 \times 0.05 = 0.20$ bar

Calculating Pressure Drop as a Percentage

Formula: Percentage pressure drop = $(\text{Actual pressure drop} \div \text{Supply pressure}) \times 100$

Example 1: System has 0.06 bar drop from 3.0 bar supply. Is this acceptable against 3% design limit?

= $(0.06 \div 3.0) \times 100 = 2\%$ - Acceptable under 3%

Example 2: Heating circuit has 0.18 bar drop from 3.0 bar supply. Is this acceptable against 5% design limit?

= $(0.18 \div 3.0) \times 100 = 6\%$ - Not acceptable over 5%

Example 3: Boosted supply has 0.18 bar drop from 4.0 bar supply. Check if acceptable against 5% design limit

= $(0.18 \div 4.0) \times 100 = 4.5\%$ - Acceptable under 5%

Efficiency Calculations Using Percentages

What is Efficiency?

Efficiency measures how well a device converts input energy or power into useful output, always expressed as a percentage.

Formula: Efficiency (%) = (Output Power ÷ Input Power) × 100

Efficiency can never exceed 100%

Boiler Efficiency

Example 1:

A boiler has 1000 W input and 850 W useful output.

Calculate efficiency = $(850 \div 1000) \times 100 = 85\%$ efficient.

This means 85% of input energy becomes useful output and 15% is lost.

Example 2:

A boiler outputs 2.2 kW with 90% efficiency. What is input power?

Input = $2.2 \div 0.9 = 2.44$ kW input required

Pump Efficiency

Pumps are not 100% efficient, so some energy is lost as heat, friction, and noise.

Example:

A pump has 5 kW input and 4.8 kW useful output.

Calculate efficiency = $(4.8 \div 5) \times 100 = 96\%$ efficient

Power loss: $5 \text{ kW} - 4.8 \text{ kW} = 0.2 \text{ kW}$ lost

Input Power from Output and Efficiency

Example:

A heating device delivers 60 W useful output with 85% efficiency.

Calculate input power = $60 \div 0.85 = 70.6$ W input required

Power wasted: $70.6 \text{ W} - 60 \text{ W} = 10.6 \text{ W}$

Percentage Error and Tolerance

Measurement Accuracy

No measurement is perfect. Percentage error tells us how accurate a measurement is.

Formula: Percentage Error = $(|Measured - Actual| \div |Actual|) \times 100$

Examples

Example 1:

You measure pressure as 2.28 bar. Actual pressure is 2.30 bar. Find percentage error:

$$= (|2.28 - 2.30| \div 2.30) \times 100 = (0.02 \div 2.30) \times 100 = 0.87\% \text{ error}$$

Example 2:

A fitting is measured as 103 mm. Its stated size is 100 mm. Find percentage error:

$$= (|103 - 100| \div 100) \times 100 = 3\% \text{ error}$$

Component Tolerance

Many components have a tolerance - the acceptable variation from stated value, expressed as a percentage.

Example: A 100 mm component with $\pm 5\%$ tolerance

$$\text{Minimum value: } 100 \times 0.95 = 95 \text{ mm}$$

$$\text{Maximum value: } 100 \times 1.05 = 105 \text{ mm}$$

Acceptable range: 95 mm to 105 mm

Test Instrument Accuracy

Test instruments often have specified accuracy, expressed as a percentage.

Example: A pressure gauge has $\pm 2\%$ accuracy. You measure 2.40 bar. What is the possible range?

$$\text{Error margin: } 2.40 \times 0.02 = 0.048 \text{ bar}$$

Range: Minimum $2.40 - 0.048 = 2.352$ bar, Maximum $2.40 + 0.048 = 2.448$ bar

Worked Examples - Complete Calculations

Example 1: Pressure Drop Check

Question: A 30 m pipe run has 0.075 bar pressure drop from 3.0 bar supply. Is the pressure drop acceptable against a 5% limit?

Solution:

Step 1: Calculate percentage = $(0.075 \div 3.0) \times 100 = 2.5\%$

Step 2: Check against limit - $2.5\% < 5\%$ - Acceptable

Answer: Yes, 2.5% is acceptable

Example 3: Finding Required Pressure Performance

Question: A system must operate with maximum 5% pressure drop from 3.0 bar. A design gives 0.21 bar drop. Is this acceptable?

Solution:

Step 1: Calculate maximum permitted drop = $3.0 \times 0.05 = 0.15$ bar

Step 2: Compare - $0.21 \text{ bar} > 0.15 \text{ bar}$ - Not acceptable

Answer: No, the drop is too high

Example 2: Boiler Efficiency Calculation

Question: A boiler takes 1.334 kW input and outputs 1.2 kW. Calculate the efficiency.

Solution:

$(1.2 \div 1.334) \times 100 = 89.96\%$

Answer: 90% efficient rounded

Example 4: Percentage Increase in Load

Question: A heating load increases from 8 kW to 10 kW. What is the percentage increase?

Solution:

Step 1: Find increase = $10 - 8 = 2$ kW

Step 2: Calculate percentage = $(2 \div 8) \times 100 = 25\%$

Answer: 25% increase in load

Quick Reference Guide - Essential Formulas

Conversion

- Percentage to decimal: divide by 100
- Decimal to percentage: multiply by 100

Finding percentages

- Percentage of a number: $\text{Number} \times (\text{Percentage} \div 100)$
- What % is X of Y?: $(X \div Y) \times 100$
- Percentage increase: $(\text{Increase} \div \text{Original}) \times 100$
- Percentage decrease: $(\text{Decrease} \div \text{Original}) \times 100$

Plumbing and heating applications

- Efficiency: $(\text{Output} \div \text{Input}) \times 100$
- Pressure drop %: $(\text{Drop} \div \text{Supply}) \times 100$
- Fill %: $(\text{Stored volume} \div \text{Total volume}) \times 100$
- Percentage error: $(|\text{Measured} - \text{Actual}| \div |\text{Actual}|) \times 100$

Quick Percentage Values for 3.0 bar Supply

- 1% = 0.03 bar
- 2% = 0.06 bar
- 3% = 0.09 bar
- 4% = 0.12 bar
- 5% = 0.15 bar
- 10% = 0.30 bar

Common Plumbing and Heating Percentages

| | |
|-----------------------|----------------------------|
| Boiler efficiency: | 80-95% |
| Pump efficiency: | 70-95% |
| Pressure drop checks: | 3-5% examples |
| Tolerance checks: | ±1% to ±10% |
| Diversity factor: | 40-80% depending on system |

Real-World Applications

Application 1: Appliance Upgrade Savings

Scenario: Replace 100 × 60 W older fittings with 10 W low-energy fittings.

Old system: Power 100 × 60 W = 6 kW, Running 10 hours/day, Energy per day: 60 kWh, Cost at £0.25/kWh: £15/day.

New system: Power 100 × 10 W = 1 kW, Running 10 hours/day, Energy per day: 10 kWh, Cost: £2.50/day.

Savings: £15 - £2.50 = £12.50/day

Percentage reduction: $(12.50 \div 15) \times 100 = 83.3\%$ reduction

Application 2: Diversity in a Property

Scenario: Building with Cooker 10 kW, Shower 9 kW, Sockets and equipment 8 kW, Lighting 2 kW

Total connected load: 29 kW.

With 40% diversity factor: $29 \times 0.4 = 11.6$ kW.

This represents a 60% reduction in expected simultaneous demand.

Application 3: Pressure Drop in Long Pipe Run

Scenario: Outbuilding 80 m from main supply, Supply pressure 3.0 bar, Design limit 5%

Pipe option A gives 0.24 bar drop, Pipe option B gives 0.13 bar drop.

Option A: $(0.24 \div 3.0) \times 100 = 8\%$ - Too much drop.

Option B: $(0.13 \div 3.0) \times 100 = 4.33\%$ - Acceptable.

Option B is required.

Common Mistakes to Avoid

1. Forgetting to convert percentage to decimal

Wrong: 5% of 200 = 5×200

Correct: 5% of 200 = 0.05×200

3. Using wrong original value for percentage change

Wrong: Increase from 10 to 15 - divide by 15

Correct: Divide by the original 10

5. Mixing up percentage increase and final value

Wrong: 20% increase on 100 = 20

Correct: 20% increase on 100 = 120

7. Efficiency over 100%

Wrong: Output greater than input with no explanation

Correct: Efficiency cannot exceed 100%

2. Wrong order in 'what percentage' questions

Wrong: What % is 50 of 200? = $200 \div 50$

Correct: What % is 50 of 200? = $50 \div 200 = 25\%$

4. Forgetting to multiply by 100 for percentage

Wrong: $0.85 = 0.85\%$

Correct: $0.85 = 85\%$

6. Ignoring units

Wrong: Mixing litres, m³, W and kW in same step

Correct: Convert units before calculating

8. Rounding too early

Wrong: Rounding every step

Correct: Keep accuracy until final answer

End of Unit 4

Percentages in Plumbing and Heating

Mastering percentages is essential for competent plumbing and heating work. These skills enable you to check pressure drops against design limits, calculate system and equipment efficiency, assess measurement accuracy and component tolerance, apply diversity factors correctly, compare performance and running costs, make informed decisions on energy efficiency, and verify system performance clearly.

Remember:

Percentages are parts per hundred

Always check which value is the whole in a calculation

Convert percentages to decimals before multiplying

Multiply by 100 when converting a decimal answer to a percentage

Efficiency can never exceed 100%

Keep units consistent