Calculation for Airfix Vessels for Mains Water Systems

Basic concepts for the calculation of an expansion vessel in a mains water system

The following concepts are important in selecting the right vessel:

- **System water capacity**
  The total capacity of the boiler system.

- **Increase in water volume (in %)**
  The table below shows data on the water volume increase in percentage points when the temperature of the water increases by between 10 °C and 70 °C.

Increase in temperature	Increase in volume
10 - 40 °C	0.75%
10 - 50 °C	1.18%
10 - 60 °C	1.68%
10 - 70 °C	2.25%

- **Expansion volume**
  The expansion volume is determined in the following way: expansion volume = capacity x increase in volume at the maximum temperature.

- **Fill level**
  The pressure of the water supply when cold must be 0.2 bar above the initial pressure of the expansion vessel; otherwise, as the vessel cooled down the total water capacity would not be pushed out of the expansion vessel. That is why there must always be a residual amount of water in the vessel at the lowest operating pressure. This is called the fill level.

- **Initial pressure of the vessel**
  This must be 0.2 bar under the pressure of the water supplied when cold.

- **Residual factor**
  1 - fill level:
  This determines the residual factor of the expansion vessel.

- **Output**
  This is an expression of the ratio between gross and net vessel capacity.

$$\text{I} \quad \frac{\text{Cold water supply pressure - Initial pressure}}{\text{Cold water supply pressure}} = \text{fill level}$$

This means that the residual factor of the vessel can be determined.

Residual factor = 1 - fill level.

The end pressure must be 10% lower than the set pressure of the safety valve.

The output is calculated using the formula below:

$$\text{II} \quad \frac{\text{End pressure - Cold water supply pressure}}{\text{End pressure}} \times \text{residual factor} = \text{output}$$

Note: pressure in bar absolute

The maximum permissible output for the Airfix D-E/D-E-B vessels is 60% (0.60), while for the A and D vessels it is 63% (0.63).

- **End pressure**
  This is the maximum permissible pressure of the system at the vessel itself. The end pressure is equal to 90% of the set pressure of the Prescor boiler valve or the Prescor inlet assembly if it is mounted at the same level as the vessel.

- **Gross vessel capacity**
  The gross capacity of the vessel is determined in the following way:

$$\text{gross capacity of the vessel} = \frac{\text{expansion volume}}{\text{output}}$$

Example calculation of expansion vessels for mains-water systems

Data
- water capacity of the boiler $\quad$ = 150 litres
- maximum water temperature $\quad$ = 70 °C
- cold water supply pressure $\quad$ = 4 bar
- safety valve set pressure $\quad$ = 8 bar
- vessel initial pressure (4 - 0.2) = 3.8 bar
- end pressure (mean) $\quad$ = 7.2 bar

Initial vessel pressure $\quad$ = **Cold water supply pressure - 0.2 bar = 3.8**
End pressure (mean) $\quad$ = **Set pressure of safety valve x 90% = 7.2 bar.**

Calculation
Increase in volume: at 70 °C is 2.25% = 150 x 2.25 % = 3.4 litres

$$\text{Fill level:} \quad \frac{(\text{cold water supply pressure - initial pressure})}{(\text{cold water supply pressure})} = \frac{(4.0 + 1.0) - (3.8 + 1.0)}{(4.0 + 1.0)} = 0.04$$

Residual factor: 1 - fill level= 1 - 0.04 = 0.96

$$\text{Output:} \quad \frac{(\text{end pressure - cold water supply pressure})}{(\text{end pressure})} \times \text{residual factor} = \frac{(7.2 + 1.0) - (4.0 + 1.0)}{(7.2 + 1.0)} \times 0.96 = 0.375$$

Required gross capacity of expansion vessel: 3.4 / 0.375 = 9.1 litres

Airfix expansion vessel to select: $\quad$ Airfix A 12/4.0
$\qquad$ (adjust initial pressure locally to 3.8 bar).

Calculation for Airfix Vessels for Mains Water Systems

Basic concepts for the calculation of an expansion vessel in a mains water system

The following concepts are important in selecting the right vessel:

- **System water capacity**
  The total capacity of the boiler system.

- **Increase in water volume (in %)**
  The table below shows data on the water volume increase in percentage points when the temperature of the water increases by between 10 °C and 70 °C.

Increase in temperature	Increase in volume
10 - 40 °C	0.75%
10 - 50 °C	1.18%
10 - 60 °C	1.68%
10 - 70 °C	2.25%

- **Expansion volume**
  The expansion volume is determined in the following way: expansion volume = capacity x increase in volume at the maximum temperature.

- **Fill level**
  The pressure of the water supply when cold must be 0.2 bar above the initial pressure of the expansion vessel; otherwise, as the vessel cooled down the total water capacity would not be pushed out of the expansion vessel. That is why there must always be a residual amount of water in the vessel at the lowest operating pressure. This is called the fill level.

- **Initial pressure of the vessel**
  This must be 0.2 bar under the pressure of the water supplied when cold.

- **Residual factor**
  1 - fill level:
  This determines the residual factor of the expansion vessel.

- **Output**
  This is an expression of the ratio between gross and net vessel capacity.

$$I \; \frac{\text{Cold water supply pressure - Initial pressure}}{\text{Cold water supply pressure}} = \text{fill level}$$

This means that the residual factor of the vessel can be determined.

Residual factor = 1 - fill level.

The end pressure must be 10% lower than the set pressure of the safety valve.

The output is calculated using the formula below:

$$II \; \frac{\text{End pressure - Cold water supply pressure}}{\text{End pressure}} \times \text{residual factor} = \text{output}$$

Note: pressure in bar absolute

The maximum permissible output for the Airfix D-E/D-E-B vessels is 60% (0.60), while for the A and D vessels it is 63% (0.63).

- **End pressure**
  This is the maximum permissible pressure of the system at the vessel itself. The end pressure is equal to 90% of the set pressure of the Prescor boiler valve or the Prescor inlet assembly if it is mounted at the same level as the vessel.

- **Gross vessel capacity**
  The gross capacity of the vessel is determined in the following way:

$$\text{gross capacity of the vessel} = \frac{\text{expansion volume}}{\text{output}}$$

Example calculation of expansion vessels for mains-water systems

Data

- water capacity of the boiler = 150 litres
- maximum water temperature = 70 °C
- cold water supply pressure = 4 bar
- safety valve set pressure = 8 bar
- vessel initial pressure (4 - 0.2) = 3.8 bar
- end pressure (mean) = 7.2 bar

Initial vessel pressure = **Cold water supply pressure - 0.2 bar = 3.8**
End pressure (mean) = **Set pressure of safety valve x 90% = 7.2 bar.**

Calculation

Increase in volume: at 70 °C is 2.25% = 150 x 2.25 % = 3.4 litres

$$\text{Fill level:} \frac{(\text{cold water supply pressure - initial pressure})}{(\text{cold water supply pressure})} = \frac{(4.0 + 1.0) - (3.8 + 1.0)}{(4.0 + 1.0)} = 0.04$$

Residual factor: 1 - fill level= 1 - 0.04 = 0.96

$$\text{Output:} \frac{(\text{end pressure - cold water supply pressure})}{(\text{end pressure})} \text{ x residual factor} = \frac{(7.2 + 1.0) - (4.0 + 1.0)}{(7.2 + 1.0)} \text{ x } 0.96 = 0.375$$

Required gross capacity of expansion vessel: 3.4 / 0.375 = 9.1 litres

Airfix expansion vessel to select: Airfix A 12/4.0
(adjust initial pressure locally to 3.8 bar).