Water Volume Calculation in
Hydronic Heating & Cooling Systems

Preface

There are several methods which can be used to calculate the volume of water in a hydronic heating or cooling systems. However, these methods are not always 100% accurate due to inaccurate or incomplete systems information and variations in measurement techniques. Consequently it is recommended that at least two methods are used to calculate water volume in the system to cross check and help finalise the amount to be quoted or sold.

Water V olume Calculation Methods

The methods below are described in more detail later; here you can see which methods are most applicable during the sales and installation process.

Domestic

Method	Indicative ROI	Quote	Installation/ Rollout
1 - Drawings and Specifications	Yes	Yes	Yes
2 - Site Survey	Yes	Yes	n/a
3 - Calculation based on Heat/Cooling load capacity	n/a	n/a	n/a
4 - Measure Drained Water (Meter)	n/a	n/a	Yes
5 - Measure Drained Water (Buckets)	n/a	n/a	Yes
6 - Number of Radiator Panels	Yes	Yes	n/a

Commercial

Method	Indicative ROI	Quote	Installation/ Rollout
1 - Drawings and Specifications	Yes	Yes	Yes
2 - Site Survey	Yes	Yes	n/a
3 - Heat/ Cooling Load Capacity (kW)	Yes	Yes	Yes
4 - Measure Drained Water (Meter)	n/a	n/a	Yes
5 - Measure Drained Water (Buckets)	n/a	n/a	n/a
6 - Number of Radiator Panels	n/a	n/a	n/a

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As can be seen some methods are only applicable at the time of installation. These methods will add time to the installation works, but will give the Installer a good indication that the correct amount of water has been drained, or indicate that there is more water in the system and it has not been fully drained. When water has been left in the system it can be further drained or alternatively a higher concentration of Hydromx can be installed to compensate and ensure the final solution is the optimum 50% (see DR0005 Instructions for Use).

1. Drawings and Specifications

Water volume calculations can be made by taking sizing information from the building mechanical project materials lists and project drawings, (see Appendix A for pipe work volume calculation).

Commercial buildings should have a mechanical project report and this report should include; Boiler/Chiller type and size, pipe type, length and diameters, main pump size and flow rates, fan coils, radiators, drainage points, air valves, pressure vessels etc. This information will enable a calculation of water volume in the system to be made.

Also, many buildings have AutoCAD or similar computer drawings. In these cases, pipe work water volume can be calculated with the help of these programs as well.

Accuracy rate 90%.

NOTE: Engineering variations may have altered the system and may not have been recorded on original drawings or kept in up to date manuals. Where drawings are re-issued following variations, care should be taken to ensure information is taken from the latest issued drawings.

2. Site Survey

Where drawings are not available a walk through survey can be done to provide the information to calculate volumes, (see Appendix A for pipe work volume calculation). Clearly this only applies for buildings of a size than can be surveyed without excessive expense.

The details of boilers, chillers, expansion vessel, pipe work and heat exchangers, etc. can be collected. Details of water volume sizing can be acquired from manuals, online specifications and by phone/email from manufacturers and distributors.

Accuracy rate 90%.

3. Heat/Cooling load capacity

This method calculates water volume in heating and cooling systems based on heat load capacity. This is ONLY valid for Commercial installations, as Domestic boilers can be significantly oversized for the property. With this method the thermal capacity (kW) of the boiler/chiller should be known.

Heating systems formula

kW x 0.014 = m^3 → m^3 less %20 = Estimated Water Volume in the system

By applying the kW x 0.014 = m^3 formula the maximum water volume of the boiler is calculated; then subtract 20% (typical heat engineering boiler sizing tolerance margin) to give the estimated water volume in the system.

In making this calculation it is very important to know the accurate kW heat capacity of the active boilers. For example there may be a primary boiler is the main feeder and a secondary/backup boiler. The calculation must use the kW of the heating needed for the building, and exclude backup and capacity tolerances.

NOTE: 20% is a typical boiler capacity tolerance margin, but this may vary. This exact boiler capacity tolerance may be available in the original Heat Engineering calculations.

EXAMPLES

Example1

The system has one 1400 kW boiler.

1400 kW x 0.014 = 19.6 m^3 → 19.6 m^3 - %20 = 15.68 m^3 estimated water volume in the system.

Example 2

The system has two boilers which are working together, (both are 1400 kW). In this situation the total kW (the working load)

of the boilers must be used in the formula

(1400 kW + 1400 kW) * 0.014 = 39.2 m^3 → 39.2 m^3 - %20 = 31.36 m^3 estimated water volume in the system.

NOTE: If there is more than one boiler in the system and it is uncertain whether the other boilers are back ups or not, a different method should be used to calculate the water volume.

Chiller systems formula

$$kW \times 0.014 \times 1.32 = m^3 \rightarrow m^3 - \%20 = \text{Water Volume in the system}$$

To use this formula it is essential to know which is the Primary chiller and which chiller is the secondary/back up. The maximum working load of PRIMARY feeders ONLY should be calculated. As with the Heating Systems Formula this formula also includes a tolerance factor of 20%.

EXAMPLES

Example 1

The system has one 488 kW chiller.

488 kW x 0.014 x 1.32 = 9 m^3 → 9m3 - %20 = 7.2 m^3 estimated water volume in the system.

NOTE: If there is more than one chiller the maximum working load should be calculated as below and one other method should be used for verification.

Example 2

The system has three chillers of 500 kW, 300 kW and 300 kW respectively, which are working together as a main feeder.

(500 kW + 300 kW + 300 kW) x 0.014 x 1.32 = 20.328 m^3 → 20.3 m3 - %20 = 16.24 m^3

estimated water volume in the system

If the kW of the Boiler/ Chiller is unknown

If the main pump/pumps flow rate and the ΔT of the chiller/boiler (for example, chillers usually have 3 ˚C ΔT (input 10˚C, output 7˚C) are known the estimated kW of the system can be calculated using the formula:

$$kW = (m/h) * \Delta T/0.86$$

Secondary pumps are only for back up and should not be included in the calculation if they are not working together as main pumps.

EXAMPLE

The main pump of the system has 120 lt/h flow rate and if there is 3˚C ΔT.

120 lt/h x 3˚C / 0.86 = 418 KW

Water volume calculation based on heat load capacity generally gives the minimum amount of water. The accuracy of this method depends on the accuracy and completeness of the information provided by customer's technical team. It is strongly recommended that another method is also used to calculate the volume of water in the system.

Accuracy rate 80 - 90%. depending on the accuracy of the engineering calculations on the original construction drawings and the accurate tracking of any engineering variations.

4. Measure drained water (meter)

Providing there is a single connection point through which the whole system can be drained this is the easiest way to measure water volume in the system.

Whilst draining the system the water temperature should be the same as normal tap water. If the water is hotter it will be less dense and this may affect the accuracy of the measurement.

In larger systems this method can increase draining time and therefore several draining points may be required with a meter connected at each point.

Care should be taken to avoid the formation of bubbles while draining the system as this may give inaccurate results as the water meter will count bubbles as water.

Accuracy rate for smaller systems 90%.

Accuracy rate for large systems 70-80% as this assumes that the residual water left in larger systems is a greater proportion than smaller ones.

5. Measure drained water (bucket)

This method is the preferable method for small domestic type properties where drained water can be collected in a measuring bucket and the total water volume is summed from the number of buckets and measured amounts.

Accuracy rate 90% assumes 10% residual water is left in system.

6. Number of radiator panels x average number of litres per panel

This method is suitable as a method for indicative quotes for domestic scale properties and can be varied with experience of house types. Although this method does not always accurately allow for open vented header tanks, over sized expansion vessels, or low water capacity radiators/emitters, it is a good initial assessment.

EXAMPLE

This example assumes a typical 3/4 bedroom detached house would have installed 15mm copper pipes and steel radiators. For each radiator panel a figure of 7 litres per panel is used, which gives an average water volume for the entire system.

Therefore in a house with 6 single panel radiators and 5 double radiators (10 panels) the estimated volume of water in the system is 112 litres.

e.g. (6 single panels + 10 panels in double radiators) x 7 litres = 112 litres

Accuracy rate for domestic type systems 85%.

Appendix A - Pipe Volume Calculations

The following formulas and worked example show how to calculate the volume of pipe work, once an assessment of the length of pipe work and sizes has been made from a walk through survey or from drawings.

Pipe capacity calculation formula

$$V = \pi \times R1 \times R1 \times L \times 1000$$

Where:

V = volume in Litres

π = 3.14159

R1 = internal radius of pipe in meters

L = length in meters

1000 = number of litres in $1m^3$

^ DN = diameter nominal

EXAMPLES

<u>Example 1</u>

Calculation of 10 meters of 1" (DN ^ 25) pipe.

Using the figures in Table 1 R1 is calculated as:

R1 = Inner diameter/1000/2 → 26.9/1000/2 = 0.014

$V = \pi \times R1 \times R1 \times L \times 1000$ → 3.14 x 0.014 x 0.014 x 10 x 1000 = 6.15 litres

Example 2

Calculation of 3 meters of 1/2" (DN 15) pipe.

Using the figures in Table 1 R1 is calculated as:

R1 = Inner diameter/1000/2 → 15.7/1000/2 = 0.008

V = π x R1 x R1 x L x 1000 → 3.14 x 0.008 x 0.008 x 3 x 1000 = 0.6 litres

Table of nominal diameter and pipe diameters

Imperial Size	Metric Size	OUTER DIAMETER (mm)	PIPE THICKNESS (mm)	INNER DIAMETER (mm)
1/2"	DN 15	21.3	2.8	15.7
3/4"	DN 20	26.9	2.9	21.1
1"	DN 25	33.7	3.4	26.9
1 1/4"	DN 32	42.4	3.6	35.2
1 1/2"	DN 40	48.3	3.7	40.9
2"	DN 50	60.3	3.9	52.5
2 1/2"	DN 65	73.0	5.20	62.6
3"	DN 80	88.9	5.5	77.9
4"	DN 100	114.3	6	102.3
5"	DN 125	141.0	6.6	127.8
6"	DN 150	168.3	7.1	154.1
8"	DN 200	219.1	8.18	202.74
12"	DN 300	323	9.5	304.0
16"	DN 400	406	9.5	387.0
18"	DN 450	470	9.5	451.0

Table 1