

The *vapour resistance* of a material is a measure of the material's reluctance to let water vapour pass through. The vapour resistance takes into account the material's thickness, so can only be quoted for a particular thickness of material. It is usually measured in MNs/g ("Mega-Newton seconds per gram"). If the quantity is measured in MNs/gm (notice the small "m" at the end) then it's actually a *vapour resistivity* and should be dealt with as explained on the next page.

The μ -value ("mu-value") of a material is also known as its "water vapour resistance factor". It is a measure of the material's *relative* reluctance to let water vapour pass through, and is measured in comparison to the properties of air. The μ -value is a property of the bulk material and needs to be multiplied by the material's thickness when used in a particular construction. Because the μ -value is a relative quantity, it is just expressed as a number (it has no units).

To convert a vapour resistance (MNs/g) to a μ -value

1. Multiply by 0.2 gm/MNs
(this is a typical value in the UK for the vapour permeability of still air, and converts the vapour resistance to the "equivalent air layer thickness")
2. Divide by thickness in metres
(this gives the μ -value)

Example:

For a material with:

vapour resistance = 10,000 MN.s/g and thickness = 100 mm

We have:

$$\mu\text{-value} = 10,000 \text{ MN.s/g} \times 0.2 \text{ g.m/MN.s} \div 0.1 \text{ m} = 20,000$$

To convert a μ -value to a vapour resistance (MNs/g)

1. Multiply by thickness in metres
(this gives the "equivalent air layer thickness" in m)
2. Divide by 0.2 g.m/MN.s
(this is a typical value in the UK for the vapour permeability of still air)

Example:

For a material with:

μ -value = 4000 and thickness = 3 mm

We have:

$$\text{vapour resistance} = 4000 \times 0.003 \text{ m} \div 0.2 \text{ g.m/MN.s} = 60 \text{ MN.s/g}$$

Equivalent air layer thickness (s_d)

You might see the reluctance of a material to let water vapour pass through expressed as an "equivalent air layer thickness", which is usually represented as s_d . As its name suggests, the equivalent air layer thickness is measured in metres. Like vapour resistance, it can only be quoted for a particular thickness of a material.

The equivalent air layer thickness was used as an intermediate step in the conversions given on the previous page. So, if you want to convert between an equivalent air layer thickness and a μ -value, you can just use the relevant step from the earlier conversions (the one dividing or multiplying by the thickness of the material):

To convert an equivalent air layer thickness to a μ -value

Divide by thickness in metres

Example:

For a material with:

$$s_d = 2,000\text{m} \text{ and thickness} = 100 \text{ mm}$$

We have:

$$\mu\text{-value} = 2,000 \text{ m} \div 0.1 \text{ m} = 20,000$$

(Remember that...

s_d is the symbol for *equivalent air layer thickness*

... and that μ -values have no units.)

To convert a μ -value to an equivalent air layer thickness

Multiply by thickness in metres

Example:

For a material with:

$$\mu\text{-value} = 4000 \text{ and thickness} = 3 \text{ mm}$$

We have:

$$s_d = 4000 \times 0.003 = 12 \text{ m}$$

Vapour resistivity

You might also see the *vapour resistivity* of a material quoted. This is similar to the *vapour resistance*, but is a property of the bulk material and is usually measured in MNs/gm (“Mega-Newton seconds per gram-metre”).

Because vapour resistivity and μ -value are both properties of the bulk material, there is no need to consider the thickness of the material when converting between them. Again, you just need to use the relevant step from the conversions on the first page:

To convert a vapour resistivity (MNs/gm) to a μ -value

Multiply by 0.2 gm/MNs
(this is a typical value in the UK for the vapour permeability of still air)

Example:

For a material with:
vapour resistivity = 1,000 MNs/gm

We have:
 μ -value = 1,000 MNs/gm \times 0.2 gm/MNs = 200

To convert a μ -value to a vapour resistivity (MNs/gm)

Divide by 0.2 gm/MNs
(this is a typical value in the UK for the vapour permeability of still air)

Example:

For a material with:
 μ -value = 400

We have:
vapour resistivity = 400 \div 0.2 gm/MNs = 2,000 MNs/gm

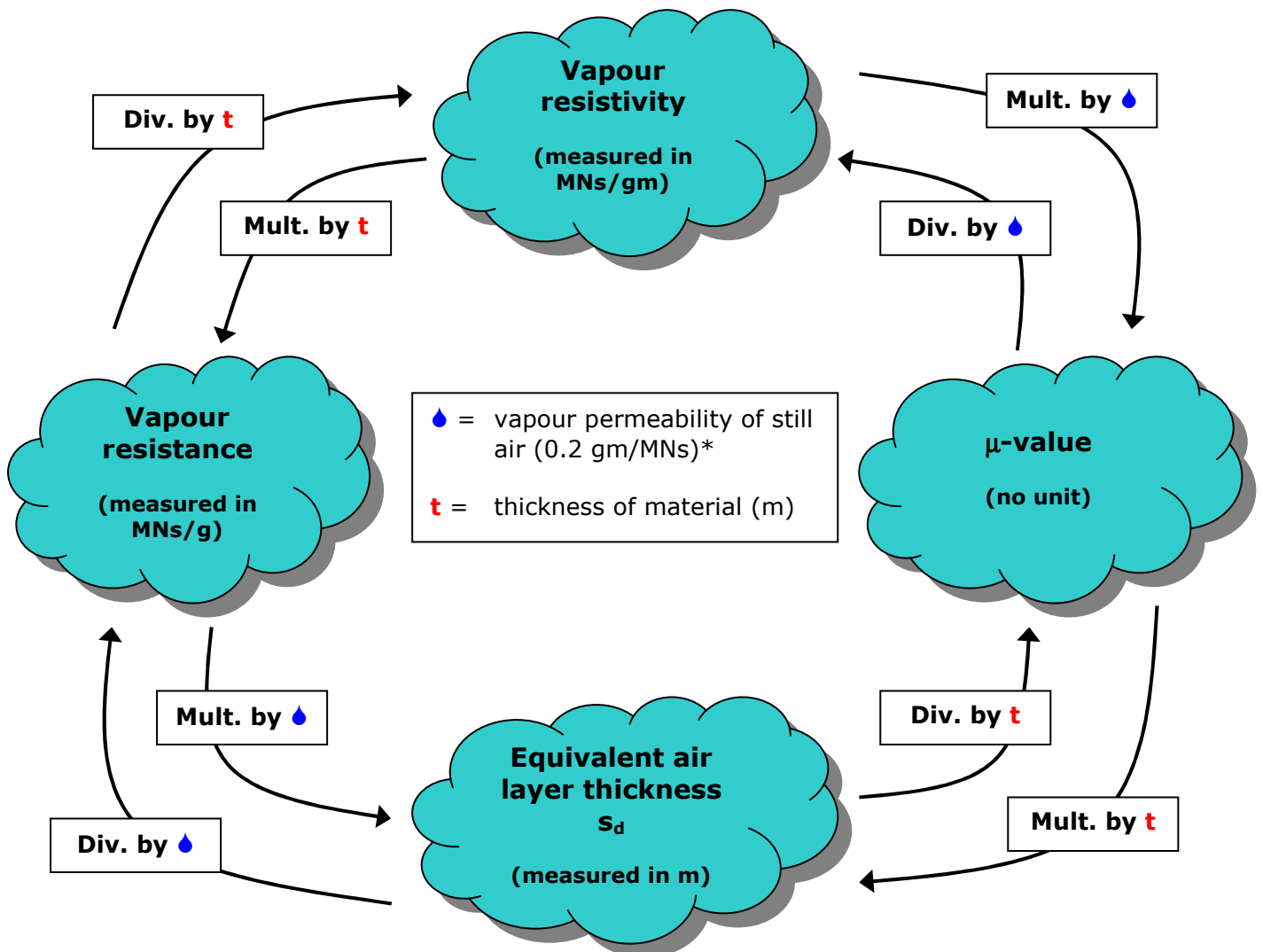
Tying it all together

The previous three pages have discussed several related quantities, and it can be tricky keeping them straight in your mind.

Here's a summary of the quantities discussed...

| Name | Symbol | Units | A property of |
|--|--------------------|-----------|---------------------|
| Vapour resistance | (no common symbol) | MNs/g | specified thickness |
| Vapour resistivity | (no common symbol) | MNs/gm | bulk material |
| Equivalent air thickness layer | S_d | m | specified thickness |
| Water vapour resistance factor ("μ-value") | μ | (no unit) | bulk material |

... and the relationships between them...



*This value of 0.2gm/MNs is used by convention in the UK. Outside the UK, local values for atmospheric temperature and pressure can be used to calculate the vapour permeability of still air from basic principles.

Tip: these conversions become easier to understand if you look at the units of measurement involved in each case.

What about perms?

An associated unit is the "perm". This is a measure of permeance, or water vapour transmission. Like vapour resistance, it is a measure associated with a given thickness of material.

To be able to use this measurement in the BuildDesk U software, you need to use a multiplication factor to convert it to relevant SI units; then you must reciprocate the result. (Reciprocating is necessary because the perm is a measure of how *easy* it is for water vapour to pass through a material, not how *difficult* it is.) The multiplication factor will depend on whether the measurement being converted is a US perm or a metric perm. The multiplication factors are shown in the table below. On some product data sheets you might see an SI equivalent to the perm, so this is included in the table.

| | Units | Multiplication factor to convert to g/(MNs) |
|----------------------|---|--|
| US perm | grains/(ft ² ·h·inHg) | 0.0572 |
| Metric perm | g/(m ² ·24h·mmHg) | 0.0968 |
| SI equivalent | ng s ⁻¹ m ⁻² Pa ⁻¹ | 0.001 |

After converting to g/(MNs), the result must be reciprocated to give vapour resistance in MNs/g.

Converting this result to other useful measurements (such as μ -value) can be done using the procedures summarised on the previous page.

Worked example...

A 50mm thick sample of material has a water vapour transmittance of **1.2** US perms.

Convert to g/(MNs)...

$$1.2 \times 0.0572 = \mathbf{0.06864} \text{ g/(MNs) .}$$

Reciprocate...

$$1/\mathbf{0.06864} = \mathbf{14.57} \text{ MNs/g}$$

So, this 50mm sample has a vapour resistance of = **14.57** MNs/g .

Multiply by the vapour permeability of air to give the equivalent air layer thickness...

$$S_d = \mathbf{14.57} \times 0.2 = \mathbf{2.92} \text{ m .}$$

The value of 0.2 is used by convention in the UK.
(See the note on the previous page.)

Divide by material thickness to give the μ -value...

$$\mu\text{-value} = \mathbf{2.92} \div 0.05 = 58.27 \text{ .}$$

In the BuildDesk software

When entering a material's reluctance to let water vapour pass through, you have to enter the value as a μ -value.

When creating or editing a material, you are presented with a form where you specify the material's properties. The relevant part of the form is shown below:

| Physical value | Source |
|-------------------------------|------------|
| λ 0.77 W/(mK) | BRE BR 443 |
| μ -min 45 | CIBSE |
| μ -max 70 | |
| ρ 1700 kg/m ³ | CIBSE |
| c_p 0.8 kJ/(kg K) | CIBSE |

You can see that the BuildDesk software actually asks for two μ -values, a minimum value and a maximum value. If you know that a particular material behaves differently under different conditions (the μ -value varies with air humidity, for example) you can specify the required range of μ -values in the two fields.

Usually, however, only one μ -value will be available for a particular material. In this case, just enter the same value in both the μ -min and μ -max fields.

What do you do if you don't know a material's μ -value? A good place to start is BS EN 12524 ("*Building materials and products - Hygrothermal properties - Tabulated design values*") which provides μ -values for many standard materials. These materials and their μ -values are provided in a standard catalog in the BuildDesk software.

