# Humidity: RH and other humidity measures

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Humidity in greenhouses is controlled for various reasons. One is avoiding too high humidity to avoid fungal infection, and another reason is to regulate the transpiration. These two aspects require a different approach, for which often different units are used. Most growers work with relative humidity expressed in %. Control computers may use other units, such as absolute humidity in $g/m^3$, or vapour deficit also in $g/m^3$, or VPD expressed in kPa. This article explains the meaning of these units, and how to convert from one unit to another.

**Absolute and Relative humidity**

A good indication of air humidity would be the **absolute humidity** in $g/m^3$, but horticulturist usually work with **relative humidity (RH)** in percents. RH of 100 % means extremely humid conditions and for instance 50 % indicates very dry air conditions. RH is a handy measure and growers are used to it, but RH is not always appropriate. The disadvantage is that RH does not say anything about the amount of water in the air.

Some examples may illustrate this, and it can be seen form the table. If we would use a steamer to bring water vapour into the air, we would see that moisture is absorbed until the maximum water content (or 'saturation') is reached. If the steaming continues we would see condensation appear. Cold air can hold much less water than warm air, so cold air is easily saturated. Air of 10 °C can hold 9.4 gram of water vapour per $m^3$ at maximum; air of 20 °C can hold 17.3 $g/m^3$; and air of 30 °C can hold 30.4 $g/m^3$ at maximum.

Relative humidity is the percentage of maximum water content at a given temperature. If air of 20 °C holds 13 $g/m^3$ (instead of 17.3) the air has a relative humidity of 75 % (because 13 is 75 % of 17.5). In contrast air of 30 °C with the same absolute humidity of 13 $g/m^3$ has a relative humidity of only 43 %.

If air temperature goes down, while the absolute humidity (in $g/m^3$) remains equal, the relative humidity goes up. This continues until saturation is reached. Then we see condensation occur on cold glass and even on leaves when they are cold.

**RH control**

Spores of Botrytis and other fungal diseases are waiting for condensation on the leaves ('wet leaves') to start growing, so growers would like to avoid wet leaves. Unfortunately measuring condensation is not easy, and therefore RH can be used to indicate the risk of condensation.

In theory, RH below 100 % means that there is no condensation. When the sensors via the computer tell it is 20 °C and 95 % RH, it means it is 20 °C at the sensor, and absolute air humidity is 16.5 $g/m^3$ (see table). The absolute humidity is the same on all places in the greenhouse. However, the temperature is not very even. It can be a few degrees lower on many places in the greenhouse and higher on other places. Therefore the relative humidity is different on different places. Because cooler air can hold a lower amount of water, the relative humidity is higher on cooler spots. Hence condensation may occur on the plants here. So in reality, if RH of around 95 % is measured, there will be condensation happening on many cooler spots, most likely also on plant leaves. Thus we need a safety margins when RH is used to indicate the risk of condensation and fungal infection. Let's say when RH above 90 % is measured, the control should aim at reducing the humidity. If it is known that the temperature in the greenhouses is very uneven, it is safer to say that RH above 85% indicates a risk of fungal diseases.

### Vapour Pressure (VP) and Vapour Pressure Deficit (VPD)

Vapour pressure (VP) is not used as much as Vapour Pressure Deficit (VPD), but we start with explaining VP first. VP is the pressure caused by a gas or a vapour. All gases in the air together make up the air pressure. Vapour pressure of water normally ranges from 10 to 50 mbar (millibar) or in other units, from 1 to 5 kPa (kilo-Pascal). At each temperature there is a maximum vapour pressure of water. If more water was added, while the temperature remained the same, we would see condensation of water (as described for relative humidity).
This brings us to Vapour Pressure Deficit (VPD). Deficit is a lack of water. VPD is the difference between the actual and the maximum vapour pressure. For water, VPD is normally in the range 0.1 kPa (very humid) to 3 kPa (very dry air), or 1 to 30 mbar. Note that a low VPD means a low lack of water, in other words a high air humidity. Similarly, a high VPD means a low air humidity. The higher the VPD (lack of water vapour) the stronger the drying effect on plants, so the stronger the driving force on transpiration.

### Conversion of units

Above the units for air humidity that are most important in horticulture were explained. These are Relative humidity (RH), absolute humidity (ABS) and Vapour Pressure Deficit (VPD). There is no easy conversion from one to another unit. For instance at 20 °C, 80% RH equals 13.87 $g/m^3$ absolute humidity, and 0.47 kPa VPD. Conversion can be done by formulas (preferably in a computer) or by using a table. The table below shows the conversion from one unit into other units, at various prevailing temperatures.

### Table for conversion of units

*RH = relative humidity (%). ABS = absolute humidity ($g/m^3$). VPD = Vapour Pressure Deficit (kPa). 1 kPa (kilo-Pascal) = 10 mbar (10 millibar). kPa and mbar are units for VP and VPD.*

| | at 10 °C | | at 15 °C | | at 20 °C | | at 25 °C | | at 30 °C | |
|---|---|---|---|---|---|---|---|---|---|---|
| **RH %** | **ABS $g/m^3$** | **VPD kPa** | **ABS $g/m^3$** | **VPD kPa** | **ABS $g/m^3$** | **VPD kPa** | **ABS $g/m^3$** | **VPD kPa** | **ABS $g/m^3$** | **VPD kPa** |
| **100** | 9.42 | 0.00 | 12.86 | 0.00 | 17.33 | 0.00 | 23.09 | 0.00 | 30.43 | 0.00 |
| **95** | 8.94 | 0.06 | 12.21 | 0.09 | 16.47 | 0.12 | 21.94 | 0.16 | 28.91 | 0.21 |
| **90** | 8.47 | 0.12 | 11.57 | 0.17 | 15.60 | 0.23 | 20.79 | 0.32 | 27.39 | 0.42 |
| **85** | 8.00 | 0.18 | 10.93 | 0.26 | 14.73 | 0.35 | 19.63 | 0.48 | 25.87 | 0.64 |
| **80** | 7.53 | 0.25 | 10.28 | 0.34 | 13.87 | 0.47 | 18.84 | 0.63 | 24.34 | 0.85 |
| **75** | 7.06 | 0.31 | 9.64 | 0.43 | 13.00 | 0.59 | 17.32 | 0.79 | 22.82 | 1.06 |
| **70** | 6.59 | 0.37 | 9.00 | 0.51 | 12.13 | 0.70 | 16.17 | 0.95 | 21.30 | 1.27 |
| **60** | 5.65 | 0.49 | 7.71 | 0.68 | 10.40 | 0.94 | 13.86 | 1.27 | 18.26 | 1.70 |
| **50** | 4.71 | 0.61 | 6.43 | 0.85 | 8.67 | 1.17 | 11.55 | 1.59 | 15.22 | 2.12 |
| **40** | 3.77 | 0.74 | 5.14 | 1.02 | 6.93 | 1.41 | 9.24 | 1.90 | 12.17 | 2.55 |
| **30** | 2.82 | 0.86 | 3.86 | 1.20 | 5.20 | 1.64 | 6.93 | 2.22 | 9.13 | 2.97 |