TE6

Humidity Measurement Bench

User Guide

TecQuipment has taken care to make the contents of this manual accurate and up to date. However, if you find any errors, please let us know so we can rectify the problem.

TecQuipment supply a Packing Contents List (PCL) with the equipment. Carefully check the contents of the package(s) against the list. If any items are missing or damaged, contact TecQuipment or the local agent.

PS/DB/1011

TecQuipment

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Humidity Measurement Bench

User Guide

Introduction

Figure 1 The Humidity Measurement Bench (TE6)

Humidity (the moisture content of the air) affects both organic and non-organic processes. It affects how comfortable we feel, how quickly water evaporates from surfaces and can affect the shelf-life or storage time of dried food. It can also affect the speed of corrosion on metal surfaces. Humidity measurement is also a useful tool to help predict weather changes.

Pressure, temperature and air velocity (or wind speed) affect Humidity, so it is important to know the value of each when comparing readings. The Humidity Measurement Bench (TE6) includes different humidity and temperature measuring instruments and a blower with adjustable air valve to vary the air speed in a duct. The bench helps demonstrate the principles of Relative Humidity measurement and compares the accuracy of the different humidity measuring methods.

Description

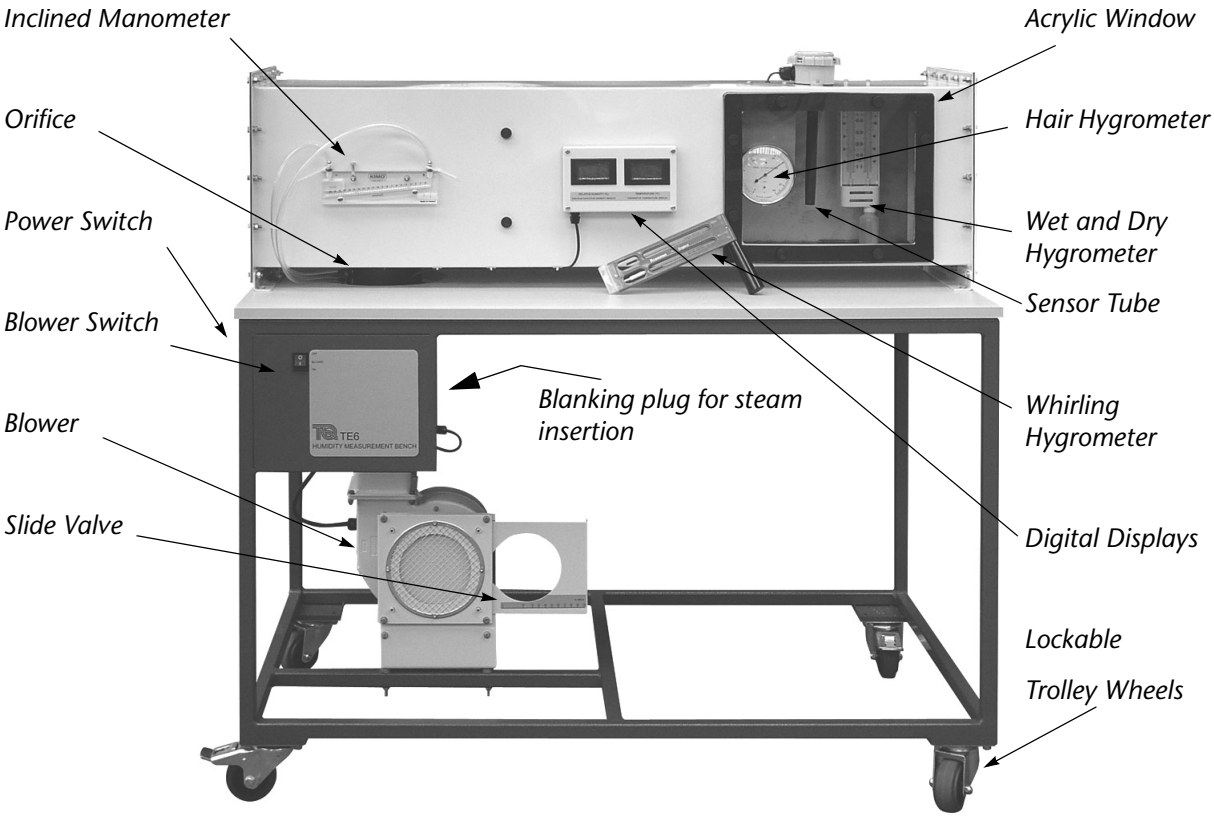

Figure 2 The Humidity Measurement Bench (TE6)

Humidity Bench

The Humidity Measurement Bench has three main parts; a mobile frame, a blower unit and a duct. The duct contains an air filter and the humidity measuring instruments. These are:

- A Hair Hygrometer
- A Wet and Dry Bulb Hygrometer
- A combined electronic Humidity and Temperature Sensor Unit
- An external (hand-held) Whirling Hygrometer

The blower unit forces ambient air over the instruments within the duct. If necessary, users can remove a blanking plug above the blower to inject low pressure steam (equipment not supplied) into the duct.

A calibrated slide valve to the front of the blower allows the user to adjust the air flow rate to the duct. An inclined manometer measures the pressure drop across an orifice to help measure the air flow rate. A removable transparent window gives users access to the instruments in the duct. A filter in the duct helps to reduce the chances of air-born dust or dirt entering the instruments.

Hair Hygrometer

The Hair Hygrometer uses actual hair, which is sensitive to moisture. The hair changes dimension as it becomes more moist. A mechanical linkage magnifies the dimensional change, and links to a pointer. The hair has a special coating to:

- speed up its reaction to differences in Relative Humidity (great differences can be registered within less than a minute).
- reduce the hysteresis of the hair to half that of untreated hair.
- ensure a constant and even degree of measuring accuracy throughout the scale, even in low temperatures.

Figure 3 Hair Hygrometer

The instrument is designed for vertical mounting and is typically used to monitor environments where a direct reading is required. It is not recommended for field use where airborne contaminants such as pollen, flying insects or floating debris could clog the hairs.

NOTE 

You must regenerate the Hair Hygrometer regularly (refer to its user instructions).

TecQuipment supply a spare unit with the equipment for you to use while you regenerate the first.

Wet and Dry Bulb Hygrometer

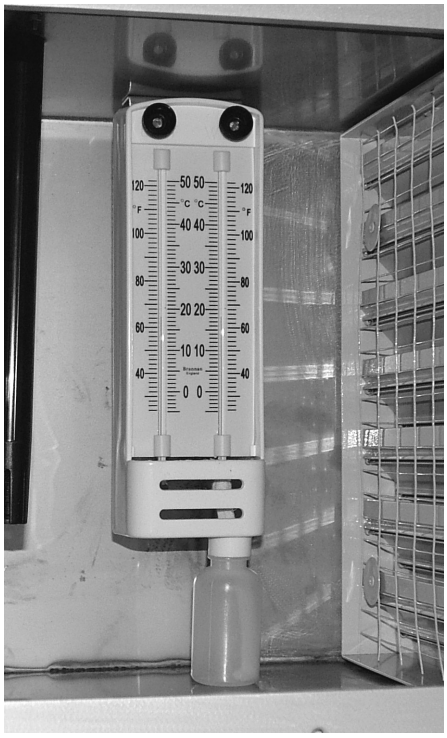

Figure 4 The Wet and Dry Bulb Hygrometer

The Wet and Dry Bulb Hygrometer is designed for vertical mounting in environments where a constant measurement of Relative Humidity [RH] is required, such as:

- computer rooms
- grain stores
- office environments
- factories

This instrument has two thermometers. One has a ‘wick’, wetted by a small reservoir of water.

The amount of moisture present in the air affects the amount of evaporation from the wick and therefore changes the temperature of the wet bulb. High humidity means less evaporation and smaller temperature differences between thermometer readings.

You use the charts supplied with the instrument to find the relative humidity from the difference in temperatures.

Whirling Hygrometer

The Whirling Hygrometer is a type of sling Psychrometer and is basically a portable form of the Wet and Dry Bulb Hygrometer. As with the Wet and Dry Hygrometer, the unit measures percentage Relative Humidity by providing contrasting wet and dry bulb temperatures that can be compared using Psychrometric Tables.

Evaporation on the wet bulb results in a lower temperature in exactly the same way as in the Wet and Dry Bulb Hygrometer. The difference between the two instruments is that the Whirling Hygrometer is manually whirled by the operator to achieve a movement of air.

Sensor Unit

The sensor unit held in the duct housing (Figure 5) has two current output sensors contained in a special enclosure suitable for duct-mounted installations:

- Thin Film Capacitive Humidity Sensor *Relative Humidity (%)*
- Thermistor Temperature Sensor *Temperature (°C)*

The Relative Humidity Sensor part uses a thin film Bulk Polymer capacitive sensor for use in air conditioning systems, process control and monitoring in laboratories, plantrooms or outside.

The Temperature Sensor part uses a NTC (negative temperature coefficient) thermistor. Its electrical resistance decreases as temperature increases.

The sensor unit gives a direct output to the display unit mounted on the front panel (Figure 5). Both displays are calibrated and should not need adjustment.

In standard installations, the output from the sensors would control air flow, coolers and heaters in air conditioning, cooling or heating systems.

The sensor unit includes electronic circuits to compensate for the characteristics of the sensing elements, to minimise errors.

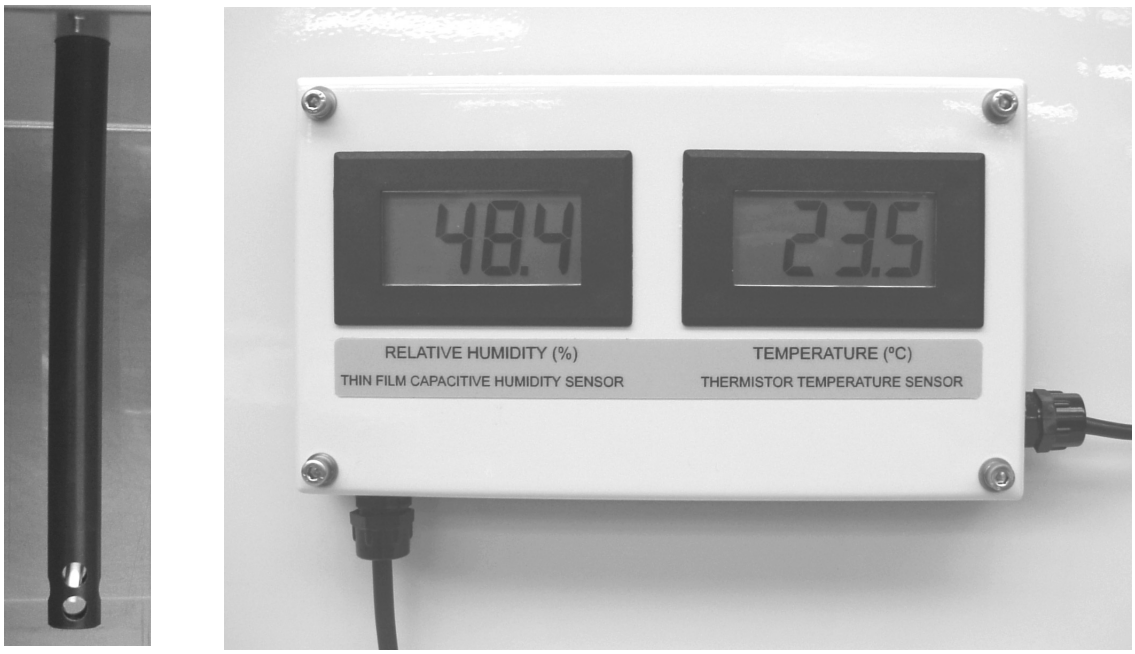

Figure 5 Sensor Unit and Display

Technical Details

Part	Details
Dimensions and Weight	1200 mm wide x 700 mm front to back x 1270 mm high and 95 kg
Electrical Supply	110 VAC 60 Hz or 230 VAC 50 Hz determined by order.
Fuse	20 mm T4 A (110 VAC) or T2 A (230 VAC)
Duct cross section	0.3 m x 0.3 m
Orifice Plate Area	6.4×10^{-3} m^2
Orifice Inlet Area	7.8×10^{-3} m^2
Orifice coefficient of discharge	0.62
Operating temperature range	+5°C to +40°C (Hair Hygrometer = –30°C to +60°C)
Operating relative humidity range	**Ambient***:* 80% at ≤ +31°C, decreasing linearly to 50% at +40°C **In Duct:** Maximum 100% RH and up to +50°C
Electronic Relative Humidity Sensor (capacitive)	Range 10% to 90% RH with accuracy ± 3% RH.
Electronic Temperature Sensor (thermistor)	Range -20°C to +50°C

Noise Levels

In normal use, the bench emits sound levels lower than 70 dB(A).

Assembly and Installation

The terms **left**, **right, front** and **rear** of the apparatus refer to the operators' position, facing the unit.

NOTE 

- *A wax coating may have been applied to parts of this apparatus to prevent corrosion during transport. Remove the wax coating by using paraffin or white spirit, applied with either a soft brush or a cloth.*
- *Follow any regulations that affect the installation, operation and maintenance of this apparatus in the country where it is to be used.*

Preparation

Use the equipment in a clean laboratory or classroom type area on solid, level ground.

CAUTION 

This equipment uses sensitive scientific equipment. Use it only in normal atmospheric conditions. Never try use it to measure non-standard conditions, for example, where smoke or gases are present.

*Do **not** operate the equipment in a dirty or dusty environment, or where insects could enter the equipment. Dust, dirt and insects will clog the air filter and may damage the instruments.*

Do not use the equipment in places of high vibration.

WARNING 

Never use this equipment outdoors in an unsheltered area, or in any position where it could become wet.

Set Up Procedure

Humidity Bench

1. Unlock and relock the trolley wheels (Figure 6) when moving the bench.

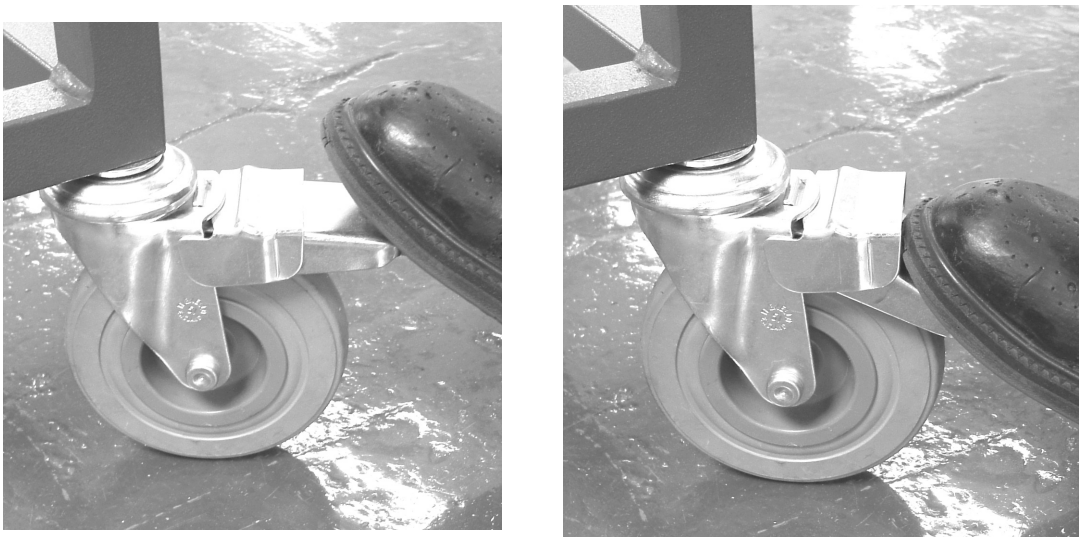

Figure 6 Wheel Locking Mechanism

Inclined Manometer

2. Check that the bubble in the integral spirit level is in the centre (Figure 7).

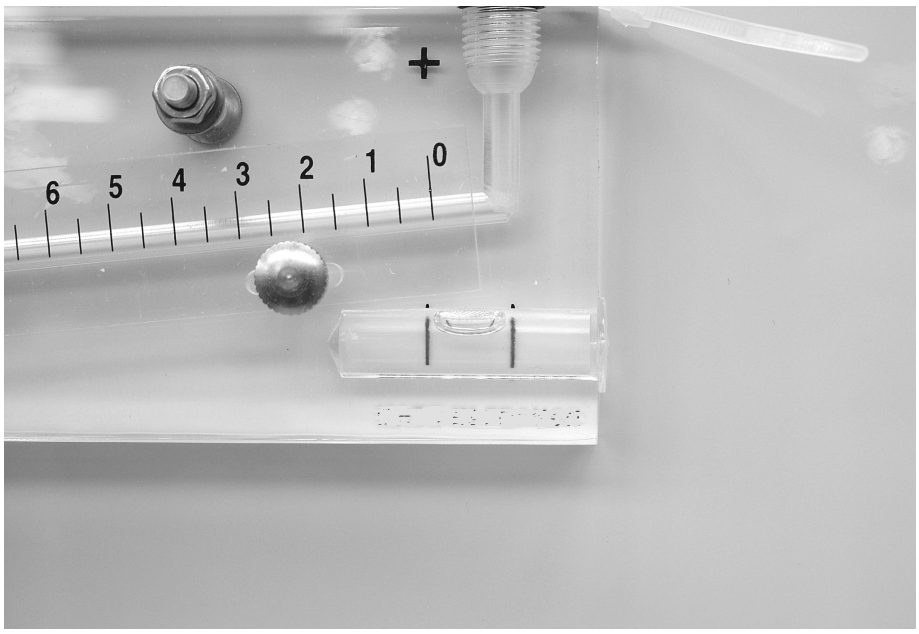

Figure 7 Manometer Integral Spirit Level

NOTE *The manometer must be horizontal before you take any readings.*

3. If the manometer is not horizontal, either move the apparatus to a more level floor or adjust the level screw until the manometer becomes level (look at the bubble in the manometer spirit level).

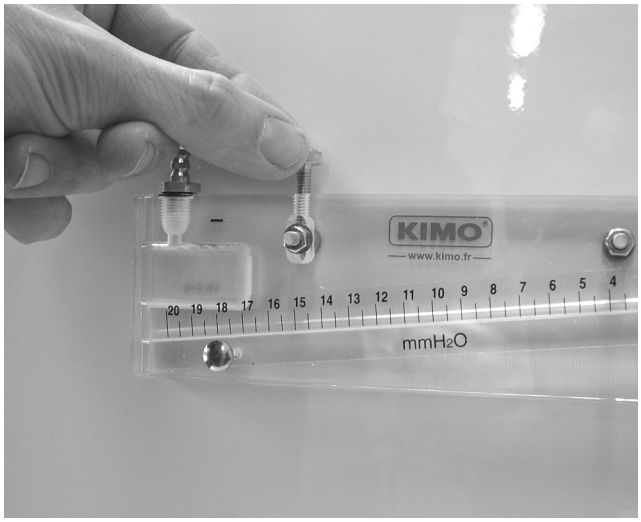

Figure 8 Adjusting the Manometer Incline

4. Add the fluid supplied to fill the small reservoir in the manometer.

WARNING ***Do not spill, splash or ingest the manometer fluid. Refer to the safety datasheet supplied for details.***

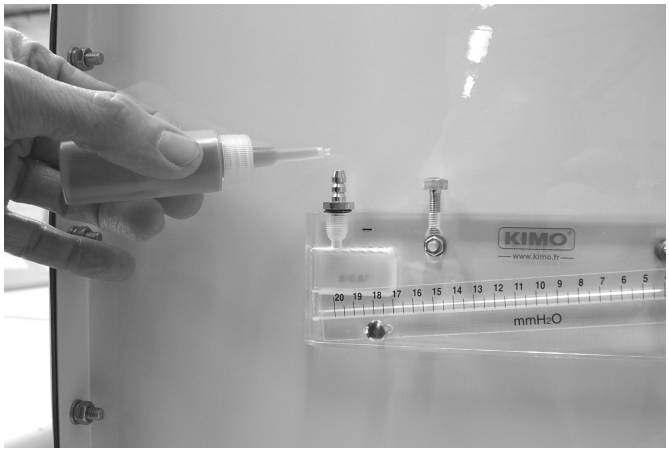

Figure 9 Fill the Manometer Reservoir

5. Fit the pipes to the manometer and tighten the plastic ty-wraps. The pipe from the upstream orifice tapping (nearest to fan) connects to the left-hand port of the manometer. The pipe from the downstream orifice tapping connects to the right-hand port of the manometer.

Hair Hygrometer

NOTE  *For best results, check that you have a regenerated Hair Hygrometer before you start your tests.*

6. Check condition and accuracy of the Hair Hygrometers:

   - A quick method of checking accuracy is to compare the readings of the two Hair Hygrometers under identical conditions.
   - Alternatively, test each instrument's accuracy by comparing its measurements with a fundamental reference instrument such as the Whirling Hygrometer. Refer to the manufacturers instructions if you need to adjust the Hair Hygrometer to match the reference instrument.

7. If in doubt, regenerate each Hair Hygrometer as shown in the manufacturers instructions.

8. Unscrew the fixings and remove the acrylic window to gain access to the instrument duct.

Figure 10 Opening the Acrylic Window

9. Slot one of the hair hygrometers onto the support bracket to the left of the sensor unit, ensuring that the metal clasp is securely fitted over the support pin. Return the spare hygrometer to its box.

Wet and Dry Hygrometer

1. Unscrew the Wet and Dry Hygrometer and take it out of the apparatus. Unscrew and fill its bulb with cold water. See Figure 11.

Figure 11 Unscrew the Wet and Dry Hygrometer, then Fill its Bulb with Cold Water

2. Carefully screw the bulb back into position, making sure the string (wick) fits inside, then refit the Hygrometer unit back into the apparatus.

3. Dry any spillages and refit the acrylic window.

NOTE *For best results, use de-ionized water.*

Whirling Hygrometer

1. Remove the Compact Whirling Hygrometer from its box. It has a 'wet' bulb, covered with material and a 'dry' bulb without material.

2. Keep the 'dry' bulb dry while you use clean water to thoroughly wet the 'wet' bulb.

CAUTION *Keep water away from the dry bulb.*
Never use hot water as this may damage the thermometer.
For best results, use de-ionized water.

3. Allow the instrument to settle for a few minutes before use.

NOTE *The 'wetting' should allow the instrument to work for at least an hour.*

Electrical Connection

Use the cable supplied with the equipment to connect it to an electrical supply.

WARNING  ***Connect the apparatus to the supply through a switch, circuit breaker or plug and socket. The apparatus must be connected to earth.***

These are the colours of each individual conductor:

GREEN AND YELLOW:	**EARTH E OR** ⏚
BROWN:	**LIVE or L1 or Hot 1**
BLUE:	**NEUTRAL**

Theory

Notation

Symbol	Details	Units
A_O	Orifice Plate Area	m^2
A_I	Orifice Inlet Area	m^2
A_D	Duct Area	m^2
C_d	Orifice Coefficient of Discharge	-
Q	Volume flow	$m^3.s^{-1}$ or $L.s^{-1}$ where shown
m_a and m_v and m_{sat}	Mass of dry air, mass of water vapour and mass of saturated air	kg
h	Head (manometer reading)	m H_2O
ρ_{H2O}	Water density	1000 $kg.m^{-3}$
ρ_{air}	Air density	$kg.m^3$
g	Acceleration due to gravity	9.81 $m.s^{-2}$
v	Air velocity	$m.s^{-1}$

Conversions

Volume and Volume Flow

$$1\ m^3 = 1000\ L$$

$$1\ m^3.s^{-1} = 1000\ L.s^{-1}$$

Psychrometry and Humidity

Psychrometry is the study of mixtures of air and water vapour. Normally, science experiments assume that air is made mainly of nitrogen and oxygen, but it also contains water vapour (moisture).

The amount of moisture present in air (humidity) affects not only the environment in which we live but also a large number of industrial processes that rely on moisture, or the absence of moisture, in order to function correctly. Local weather or industrial conditions such as rain or steam affect humidity, so it can vary widely from one location to another.

In environmental processes such as air-conditioning, humidity control is related to human comfort and is therefore highly subjective.

In industrial processes, the moisture control may be far more critical since it may be related to storage of foodstuffs such as grain, or to the germination of seeds.

In each of these areas there are a number of different techniques used for the measurement and control of humidity. Each area of industry tends to use different units to define the amount of moisture present in the atmosphere.

Specific Humidity (ω) or 'Moisture Content'

This is the mass of water present in each unit mass of air, or moisture content, found from the ratio:

$$\omega = \frac{m_v}{m_a}$$

It is dimensionless (kg/kg) and varies from $\omega = 0$ (dry air) to $\omega = \infty$ (pure water vapour). In normal atmospheric tests, its value can never reach zero, as even the driest air has a small amount of moisture.

Relative Humidity (ϕ) or RH or 'Percentage Saturation'

This is the more common measurement of humidity, often called the RH value or Percentage Saturation. It is the mass of water vapour in the air divided by the maximum mass of water which could be present in the air at the given temperature and pressure.

$$\phi = \frac{m_v}{m_{sat}}$$

Like specific humidity it is dimensionless (kg/kg), but usually expressed as percentage, so must be multiplied by 100. Fully saturated air has a specific humidity of 100%. Dry air has a specific humidity of 0%. As with specific humidity, dry air is not possible in normal atmospheric conditions.

Measuring Humidity

There are two basic methods for measuring relative humidity:

Method Type 1

This method cools a portion of air until a physical condition caused by the air's water vapour content is observed and then to record the temperature at which this condition occurs. These temperatures may be specified as ***Dew Point***, ***Frost Point***, or ***Wet Bulb*** temperatures.

The temperatures can be considered primary measurements since the only calibration required is related to the temperature sensor. These instruments include the wet and dry and whirling hygrometers. You use them with a 'Psychrometric Chart' to find the relative or specific humidity.

Figure 12 shows a typical Psychrometric Chart for a pressure of 1013 mbar. It shows an example where the dry bulb has a temperature of 30 °C, and the wet bulb has a temperature of 22°C. They meet on a relative humidity curve of 50% or specific humidity line of 0.014.

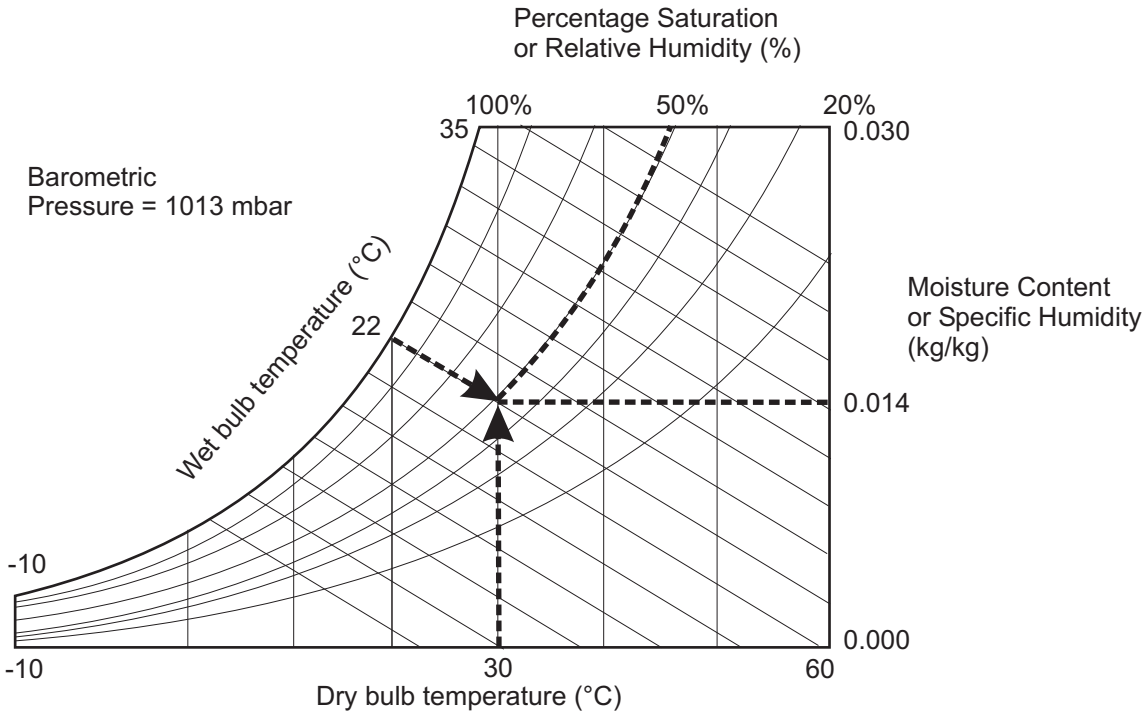

Figure 12 A Typical Psychrometric Chart

Method Type 2

With the second approach, a material is allowed to equilibriate with the air sample, then a particular moisture-dependent property of the material such as resistance, capacitance or change of physical dimension is measured. These instruments include the electronic sensor unit and the hair hygrometer.

Evaporative Cooling

The wet and dry bulb hygrometers use this method. Air passes over a wet material that surrounds a temperature sensor or thermometer bulb. The air will generally have a lower water content (moisture or humidity) than the wet material. Energy transfer will take place as the air loses energy vaporizing the water from the material and takes the water away as added vapour. The temperature of the sensor or bulb becomes lower in relation to the dryness of the air that passes over it.

Pressure, Temperature and Humidity

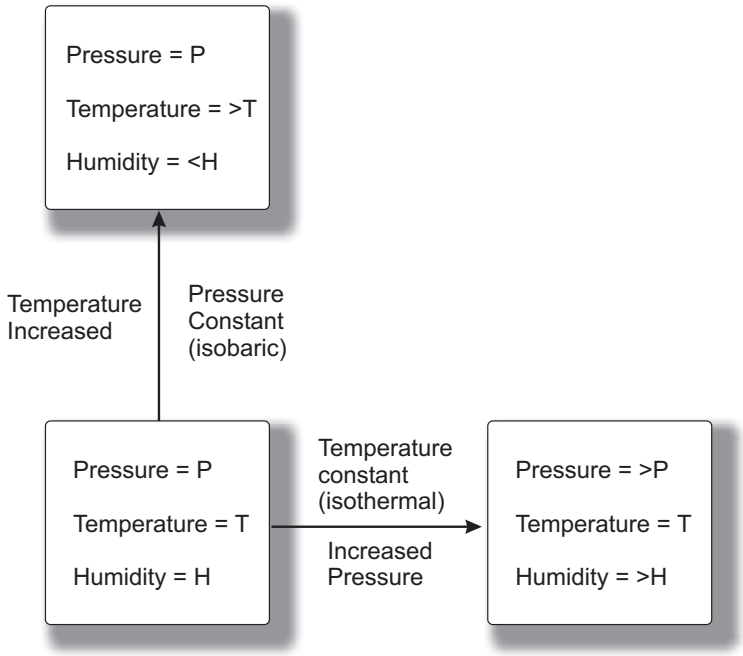

Figure 13 Pressure Temperature and Humidity

As shown in Figure 13, pressure and temperature affect humidity. Under constant pressure (isobaric) conditions, increasing temperature decreases relative humidity. Under constant temperature (isothermal) conditions, increasing pressure increases relative humidity.

Using this knowledge, weather predictors can use measurements of pressure and humidity (see Figure 14) to help predict weather changes, but they must be used with other factors such as cloud conditions and wind speed for accuracy.

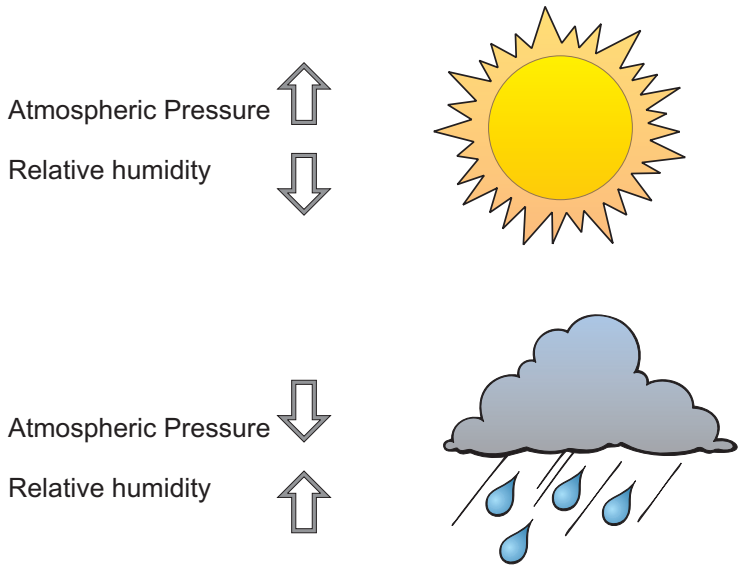

Figure 14 Predicting the Weather

Air Density

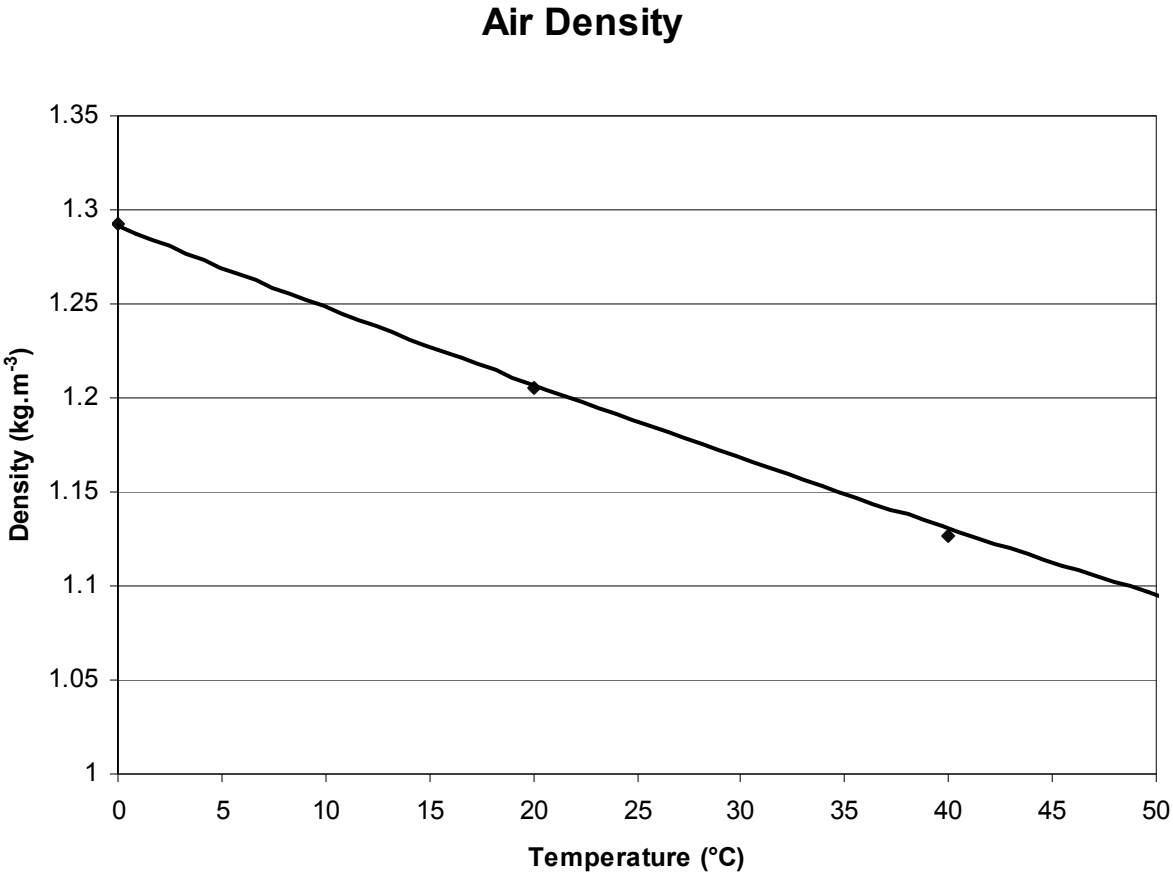

Figure 15 Air Density

Air density changes slightly with temperature. It becomes less dense as temperature increases. Figure 15 shows the relationship.

Airflow Measurement

On the equipment, the orifice plate and the manometer allow you to measure the airflow using Bernoulli's Equation. The manometer measures the pressure drop from the inlet to the outlet of the orifice in terms of water height. Bernoulli's equation uses this value and the orifice and air details to find the volume air flow.

$$Q = \frac{C_d A_0 (2\rho_{H2O} g h)^{\frac{1}{2}}}{\{\rho_{air}[1-(A_0/A_I)^2]\}^{\frac{1}{2}}}$$

A typical calculation from a manometer reading of 14 mm H_2O (0.014 m H_2O) with an air temperature of around 15°C gives:

$$Q = \frac{0.62 \times 6.4 \times 10^{-3}(2 \times 1000 \times 9.81 \times 14 \times 10^{-3})^{\frac{1}{2}}}{\{1.225(1 - 0.673)\}^{\frac{1}{2}}}$$

Q = 0.105 $m^3.s^{-1}$ or 105 $L.s^{-1}$

NOTE  *You can assume that water density remains stable at 1000 kg.m^{-3} for the temperatures you work with.*

Mean Air Velocity

This is the mean air velocity in the duct. It is the ratio of the volume air flow to the area of the duct.

A typical calculation would give:

$$v = \frac{Q}{A_D} = \frac{0.105}{0.3^2} = 1.16 \text{ m.s}^{-1}$$

Normal Operation

Important Notes

Allow Time to Stabilize

Allow the equipment to stabilize in its test area for at least two hours before you use it for tests.

After turning on the fan, wait at least two minutes for all sensors to stabilize before taking any readings.

Average Your Readings

For best results, take several readings and 'average' them.

Water Reservoir

Before and during use, check the hygrometer water reservoir has enough water (refer to the installation section).

Using the Whirling Hygrometer

CAUTION 

Treat the Whirling Hygrometer with care; avoid dropping the instrument or smashing it into objects during operation, or you will break it.

1. Ensure that the wet and dry bulbs are indicating the same temperature (ambient temperature).
2. Dampen the wick (refer to installation section).
3. With the blower operating to force air through the duct, stand next to the duct exit louvre and hold the Whirling Hygrometer about 30 cm away from the grille to avoid collision during operation.
4. Set the Whirling Hygrometer at right angles, grip the handle firmly in one hand and rotate in small circular movements (Figure 16).

NOTE 

The Whirling Hygrometer may differ from that shown in the picture.

Figure 16 Operating the Whirling Hygrometer - Note: Actual Product may Vary

5. Whirl the instrument rapidly for 15 to 20 seconds, or alternatively, at about 2 or 3 revolutions per second for between 1 and 1½ minutes.

6. After stopping, read and record the wet bulb temperature immediately, as it will tend to rise quickly after you stop. Then read and record the dry bulb temperature.

7. Refer to the instructions supplied with the hygrometer to determine the humidity.

Adjusting Air Flow

To change the air flow through the duct, alter the position of the slide valve at the front of the blower unit. This will either enlarge or reduce the inlet aperture in front of the blower fan.

Experiments

1. Humidity at Different Air Flow Rates

1. Create a blank test sheet, similar to Table 1.
2. Note your local barometric pressure and ambient temperature for reference (barometer not supplied).
3. In steps, adjust the air valve to give a range of air flow rates from minimum to maximum.
4. At each step, wait for readings to stabilize and record all instrument readings**.**

2. Humidity under Different Conditions

Repeat experiment 1, but do it when local conditions have changed, for example:

- At different times of day or night.
- At different ambient temperatures.
- Under different weather conditions.
- At different locations.

This should help show the pressure, temperature and humidity relationship.

3. Humidity and Low Pressure Steam

(Optional Feature)

The TE6 Humidity Measurement Bench has an inlet port just above the fan to allow the injection of low pressure steam into the air flow to artificially add humid air to the duct. TecQuipment do not supply a steam generator.

Valve Position	Manometer *(Differential Pressure)* mm H_2o	Air Flow Rate $L.s^{-1}$	Instrument	Reading 1	Reading 2	Temperature Reading °c	Mean Velocity $m.s^{-1}$	Relative Humidity % Rh
1			Wet & Dry Bulb Hygrometer					
1			Hair Hygrometer					
1			Whirling Hygrometer					
1			% Relative Humidity Sensor					
1			Temperature Sensor					
2			Wet & Dry Bulb Hygrometer					
2			Hair Hygrometer					
2			Whirling Hygrometer					
2			% Relative Humidity Sensor					
2			Temperature Sensor					
3			Wet & Dry Bulb Hygrometer					
3			Hair Hygrometer					
3			Whirling Hygrometer					
3			% Relative Humidity Sensor					
3			Temperature Sensor					

Table 1 Blank Test Sheet

Results Analysis

Calculate the air flow rate and mean velocity for each position of the air valve.

Compare the affect of air flow rate on the temperature and humidity sensors.

Compare the values from each instrument and with the manufacturer's accuracy data (if supplied).

Comment on which instrument you think is best suited to particular measurement locations and control environments. Hint-think about maintenance and construction.

What does the equipment show you about getting the most accurate results?

Typical Test Results

INSTRUMENT	READING 1	READING 2	TEMPERATURE	% RH
Wet & Dry Bulb Hygrometer	20°C dry bulb	16.5°C wet bulb	20°C	68
Hair Hygrometer	70 %	n/a	n/a	70
Whirling Hygrometer	20°C dry bulb	16.5°C wet bulb	20°C	68
Humidity Sensor	n/a	68%	n/a	69.8
Temperature Sensor	19.2°C	n/a	19.2°C	n/a

Table 2 Typical Results of Full Flow Test

BAROMETER	1012 mbar
AMBIENT TEMPERATURE	20°C
MANOMETER	137 Pa
AIR FLOW RATE	105 $L.s^{-1}$
MEAN VELOCITY	1.2 $m.s^{-1}$

Different air flow rates should not affect temperature, but may slightly affect the humidity readings. Low airflow rates may give a false high humidity reading. The wet bulb hygrometers need some airflow to work correctly (manufacturers recommend a nominal airflow of around 1 to 2 $m.s^{-1}$). For this reason, humidity measurements can only be correct for a given range of air flow.

It is sometimes difficult to measure and compare relative humidity with high accuracy as it can vary by 10% to 20% RH over a few centimetres, for two main reasons:

1. Different sensor response times; one sensor type may react more quickly than another type. For this reason, you must allow a few minutes for conditions to stabilize before taking readings.

2. Slight temperature differences between measurement points. Particularly with the hygrometer instruments. Note from the theory that temperature affects humidity reading. If the local temperature at one sensor is slightly different to that at another, they will give different values of humidity.

The electronic devices are best suited for places that are normally difficult to get to, as they do not need regular maintenance like the hygrometers and their display can be a good distance away from their sensors. They can easily connect to other electrical measurement and heating systems for full automatic control of environments.

The hygrometers need regular attention (adding water or regenerating the hair) for accurate results, but do not need an electrical supply. They are fundamental and reliable instruments, giving accurate results but they rely on human measurement, which can add extra errors.

The whirling hygrometer is very portable and produces accurate results determined by how carefully you use it.

Dust and dirt do not affect the wet bulb hygrometers as much as they can affect the hair hygrometer or the capacitive sensor instrument.

You should note from the tests that for best accuracy, you must use Relative Humidity and Temperature instruments in a stable environment, where conditions change slowly.

Useful Textbooks

Mechanical Engineering Thermodynamics : A Laboratory Course, M.A.Plint and L. Boswirth, Charles Griffin & Company Ltd, ISBN 0-85264-276-8.

Maintenance, Spare Parts and Customer Care

Maintenance

General

Regularly check all parts of the equipment for damage, renew if necessary.

When not in use, store the equipment in a dry, dust-free area, preferably covered with a plastic sheet.

If the equipment becomes dirty, wipe the surfaces with a damp, clean cloth. Do not use abrasive cleaners.

Regularly check all fixings and fastenings for tightness; adjust where necessary.

NOTE  *Renew faulty or damaged parts with an equivalent item of the same type or rating.*

Hair Hygrometer

Refer to the manufacturers instructions about regenerating and cleaning the hair hygrometers, as they may dry out in normal laboratory use.

Air Filter

Periodically inspect the air filter. If it is clogged, renew with a clean filter. To do this:

1. Undo the nuts securing the end plate (Figure 17) using a spanner (not supplied).
2. Carefully remove the end plate and retain the nuts and bolts in a safe place.

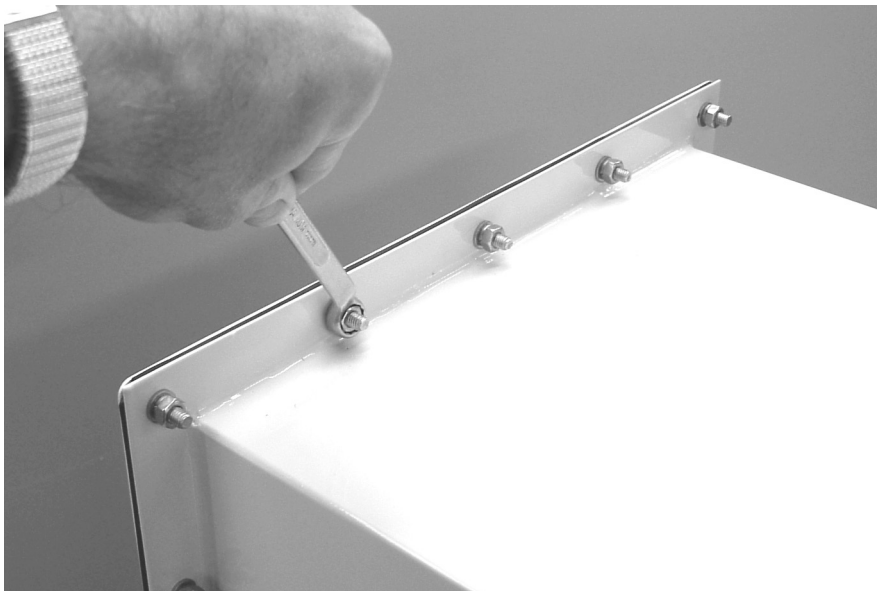

Figure 17 Detaching the End Plate

3. Release the filter support brackets by twisting the four knurled nuts (Figure 18), two of which are located at the front and two at the rear of the instrumentation duct. Retain the knurled nuts in a safe place.

Figure 18 Releasing the Air Filter Support Brackets

4. Slide out the two support brackets from the instrument duct.
5. Pull out the used filter from the duct housing.
6. Wipe out the interior of the duct housing to remove any accumulated dust or debris.
7. Slide a clean Air Filter into the duct housing until it rests against the stop bracket.

NOTE

- *Do not remove the outer casing of the air filter.*
- *Ensure the filter vanes are vertical.*
- *Check that the red flow arrow on the edge of the filter points towards the instruments.*

Figure 19 Air Filter

8. Make sure the support brackets hold the air filter correctly against the duct wall.
9. Align the screw holes and secure the filter support brackets in position with the knurled nuts.
10. Refit the end panel and secure with the fixings.

Electrical

WARNING  ***A qualified person must carry out electrical maintenance.***

Ensure the following procedures are followed.

- Assume the apparatus is energised until it is known to be isolated from the electrical supply.
- Use insulated tools where there are possible electrical hazards.
- Confirm that the apparatus earth circuit is complete.
- Identify the cause of a blown fuse or tripped circuit breaker before renewing or resetting.

To change a fuse

- Isolate the apparatus from the electrical supply.
- Renew the fuse.
- Reconnect the apparatus to the electrical supply and switch on.
- If the apparatus fails again, contact TecQuipment Ltd or your agent for advice.

NOTE  *Renew faulty or damaged parts with an equivalent item of the same type or rating.*

The main fuse is at the IEC inlet. Use a small flat-bladed screwdriver to open the fuse holder.

Spare Parts

Check the Packing Contents List to see what spare parts we send with the apparatus.

If you need technical help or spares, please contact your local TecQuipment agent, or contact TecQuipment direct.

When you ask for spares, please tell us:

- Your name
- The full name and address of your college, company or institution
- Your email address
- The TecQuipment product name and product reference
- The TecQuipment part number (if you know it)
- The serial number
- The year it was bought (if you know it)

Please give us as much detail as possible about the parts you need and check the details carefully before you contact us.

If the product is out of warranty, TecQuipment will let you know the price of the spare parts.

Customer Care

We hope you like our products and manuals. If you have any questions, please contact our Customer Care department:

Telephone: +44 115 954 0155

Fax: +44 115 973 1520

Email: **customer.care@tecquipment.com**

For information about all TecQuipment products visit: **www.tecquipment.com**