Technical Note 2

An Introduction to Climatic Test Chambers

Introduction

This guide is an introduction to temperature or temperature and humidity (climatic) test chambers. It covers the type of chambers that are commonly available, their constituent parts, how they are used, and how to evaluate and specify a chamber for purchase.

Test chambers

The most common and widely used equipment to be found in environmental test laboratories are temperature and climatic chambers. They will provide the user with a defined test space within an insulated enclosure to contain the test item, and this will ensure the test will be controlled and repeatable. The other components that make up a climatic test chamber include a heat source, a means of cooling, a humidifier, a dehumidifier, an air circulation system and a control and measurement system. There may also be some other features such as data loggers, air dryers (to simulate particularly arid conditions) and different types of measurement and control systems, as well as means for introducing special gasses into the test space (for example to provide an inert atmosphere).

Test Space

This is usually defined by its volume or dimensions and can range from a compact design, that sits on a trolley or workbench and is used for small components or materials, up to a walk-in or drive-in facility that can accommodate extremely large assemblies, including fully trimmed vehicles and large aerospace components, or multiples of smaller items such as pharmaceuticals or packaging for long-term storage tests. Access is usually by way of a hinged door (or set of doors), often with a viewing window and in most cases internal lighting is provided to enable the user to observe a test in progress. Most chambers will also have sealable portholes in the side or the top for connection to external devices such as data loggers or mechanical test rigs.

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Air Circulation

A good circulation of air through the heat exchangers is vital to ensuring uniformity of the conditions inside the test space. This usually comprises an 'air-handling' channel to the rear of the test space (sometimes it can be in the side or on the top) where the heaters, cooling component and humidifier are located. Motorised impellers draw the air from the test space, condition it as desired and recirculate it. In some larger chambers, additional ducting might be required for optimal air distribution.

Heating

This is usually provided by electrical heating elements. Depending on the design, these can be bare wire elements (such as nichrome) or sheathed heaters. Temperature up to 180°C is feasible inside a climatic test chamber. If higher temperatures are required, then a test oven (up to +300°C) will be a better option. In special cases (where surface temperatures need to be controlled below a defined value) a coiled heat exchanger containing heated gas, water or oil might be used. The heater will be located inside the air-circulation channel.

Cooling System

In most cases a refrigeration system will provide the cooling. This comprises a cooling plant (sometimes called a condensing unit) that is mounted in a frame outside the test space and a heat exchanger (or evaporator) that is mounted inside the air handling channel. The chamber air is cooled by the evaporator as it is drawn through by the circulating impellers. A well-designed refrigeration system, using modern eco-friendly refrigerants, can provide cooling to approximately -70°C.

If lower temperatures are required or if extremely fast rates of change are needed, cryogenic gasses (liquid CO2 or liquid N2) can be expanded into the air circulation compartment via nozzles. Temperatures well below -100°C are achievable at ramp rates of 1K/second.

Humidification

There are several methods for generating humidity inside the test space. A steam generator, ultrasonic nebuliser or heated water bath are among the most common and chosen depending on the application. A steam generator is generally used for high temperature – high humidity testing and for large test volumes. A tank of water is brought to the boil and the steam is released into the test space. The disadvantage of this method is the steam adds heat energy and it can be more problematic to control at lower temperature and humidity conditions and particularly in small test space volumes. The ultrasonic nebuliser generates a vapour mist and is good for small test spaces and where close control is required. The heated water bath is a good all-round method for humidity generation. A water sump mounted just below the air handling channel is heated, causing water vapour to be released into the circulating air.

Dehumidification

The most common method of removing moisture is by way of a cooled coil or pipe inside the air circulation channel. Cooling is provided by the chamber's refrigeration system. Water vapour inside the test space condenses on this pipe and drains away, removing it from the circulating air.

Control and Measurement Systems

The controller manages all aspects of the chamber's heating, cooling, and humidity function. Modern controllers are likely to have a touch-screen user interface which, as well as allowing manual entry of temperature and humidity set points, can be programmed to follow a defined test programme. The controller should be able to display the temperature and humidity set points as well as the actual measured values within the chamber. Some controllers will show this in digital format as well as graphically.

Temperature control is managed by the controller, using feedback from a measurement sensor located in the chamber's delivered airflow. The temperature sensor is generally a PRT type as this provides good accuracy, optimum response time and is highly reliable.

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For humidity, the chamber is fitted with a second PRT covered by a piece of wet gauze (wet cloth or wet sock) which is fed from a small water tank. The heat from the chamber causes the moisture in the gauze to evaporate which cools the humidity sensor. This brings about a difference in temperature between temperature and humidity sensors. The controller measures this difference and displays it as a percentage of relative humidity (%RH). [reference: Psychrometric Principle]. The higher the amount of water vapour (humidity) in the chamber air, the less moisture will evaporate from the gauze brining the temperature sensor and humidity sensor closer in temperature.

The temperature sensor is also known as the dry sensor or dry bulb, and the humidity sensor is called the wet sensor or wet bulb.

Sometimes a capacitive (solid state) sensor will be used to measure %RH directly. This is mostly used in applications requiring lower humidity conditions and has some advantage over the psychrometric method as there is no need to provide a water supply to the wet bulb.

Climatic chamber applications

There are two main uses for a temperature chamber or a temperature – humidity (climatic) chamber.

- **Simulation** – where the conditions in which the test product or material is to be manufactured, transported, stored, and used are reproduced for the purpose of validity and compliance. Data from these tests can provide a manufacturer with confidence in a product's fitness for purpose and determine such matters as shelf-life, service-life, and warranties.
- **Stimulation** – where the application of temperature and humidity is designed to stress or artificially age a product or material to expose any design, manufacturing, or general product weaknesses. The aim is to uncover latent defects and the results fed back to improve product design, quality, and robustness.

Considerations for the purchaser

There are many standard industrial tests (or norms) that have been conceived and developed over time and usually a chamber will be procured with a particular test, or set of tests, in mind. The purchaser will determine the size of the test space that is required; this might depend on the dimensions of the test load. Some thought will have to go into how the test item (or items) will be placed in the chamber to spread the load around the test space. This is to provide optimal airflow and not block the delivered and returned air vents. The chamber should not be overloaded, and good practice is to maintain a chamber volume to test load volume of not less than 4:1.

Refrigeration System

Test Space Control Sensors

Touch-screen Control Panel

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Consider how the test item(s) will be loaded and unloaded. This may be straightforward in the case of a compact or mid-size chamber but for larger test loads, will there need to be available access for any mechanical handling equipment such as pallet trucks, fork-lifts, or hoists. Will the chamber require any shelves (how many?) or racks to accommodate the test load? Will there be any requirement to interface with the test load? This might be an electrical connection for power or to collect data during a test or there may need to be a connection with an external mechanical rig. In this case decide what access portholes will be needed in terms of quantity, size, and location. Consider if the test rig must sit inside the chamber (and be able to withstand the conditions) or if it needs to be entirely or partially outside the chamber.

The purchaser must also consider the range of temperature and humidity specified in the test to ensure specific temperature – humidity control points are within the capability of the chamber. They must check that the 'climatic range' of the chamber complies with the test standard that is being followed. Particular attention should be given to low temperature – low humidity and high temperature – high humidity requirements that might be at the extremes of a test chamber's operating range.

Sometimes fast temperature rates of change are required, and the purchaser will need to check that the proposed chamber has the capability of meeting these specifications. It may be equally important to have the means to control the rate of change in cases where it would be undesirable to over-stress a test item.

For humidity tests, ensure that the water tank has sufficient capacity and there is a means of topping it up or check that it is possible to connect to an external water supply. In a well-sealed chamber, steady-state humidity tests will use up very little water once the set points have been reached, however, humidity cycling will use much higher quantities and in these circumstances a connection to an external water source is advisable.

Some standards call for extremely long test durations, some for many days or weeks. Before purchasing a chamber for extended test programmes, make sure your prospective supplier is aware of this as certain design parameters may need to be considered.

The controller is an important consideration. Ensure that it can be programmed to carry out the full test cycle including any repeats and for the specified duration. The user interface is also worth looking at; is the display clear and uncluttered and is it straightforward and intuitive to programme and operate?

Other useful features (or options) might include one or more of the following:

- Temperature limiters which will protect the test item as well as the chamber
- Alarm and diagnostic indicators in the event of a malfunction
- A paperless chart recorder
- Air dryers (to quickly achieve or maintain low-humidity conditions)
- Boost cooling devices
- Air (or gas) purge systems
- Gas detection and alarm
- Fire suppression
- Password protection to prevent unauthorised access to the control system
- Door interlock to prevent access to the test space while the chamber is running
- Bespoke designs to interface with mechanical systems or test rigs
- Remote control software
- Emergency stop in remote control room
- Customised test racks
- Customised access doors and portholes
- Explosion proof (including ATEX) chambers

For further information contact:

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