Remote

control

An insight into the development of the new breed of remote conditioner chambers

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Automotive and electrical components that need be thermal-cycled come in many shapes and sizes, as do test chambers. But one size definitely does not fit all. Just try to force your half-buck fixture into your 8ft^3 chamber or explain to management why a walk-in chamber is being used to test four airbag modules. While the ideal situation is to have a dedicated environmental chamber designed specifically to test a component, this setup is not always economically or physically feasible. Flexibility is the reason many customers build an insulated enclosure, or hood, around their test article and use a Remote Conditioner (RC) to condition the Device Under Test (DUT). In this way a single environmental chamber can supply conditioned air to hoods built around various size components or processes. For increased flexibility, RC chambers also provide an internal test that allows an RC to be used as a dual-purpose test chamber – it can be used as a remote conditioner or stand alone temperature/humidity chamber.

There are many different types of automotive and electronic remote conditioning applications. Brake dynamometer testing is an application where hoods and remote conditioners have been used for research and development testing on brake systems for items such as squeaks, stopping power, etc. Testing protocol requires the brake assembly to be cold-soaked prior to testing on the dynamometer. Rather than building a dedicated brake-dynamometer chamber, an insulated hood can be built around the wheel-brake assembly mounted on the dynamometer. Conditioned air from a RC chamber located approximately ten feet away is circulated through the hood and across the brake assembly prior to dynamic testing.

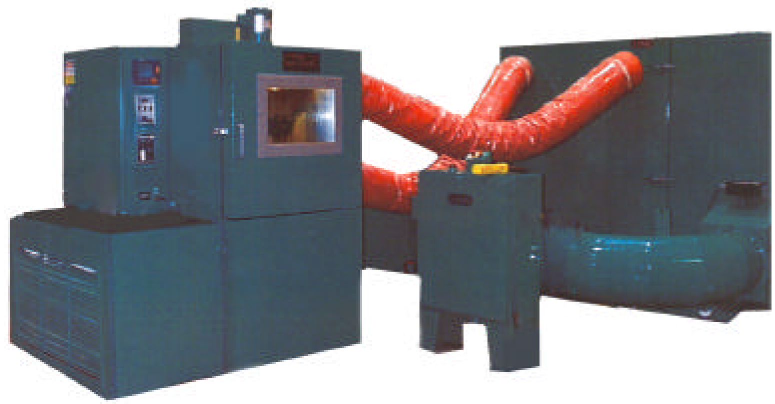
There are a number of pitfalls that must be avoided to successfully select and use a RC chamber and hood. A little research followed by judicious questioning of potential suppliers can avoid disappointment in unit performance further down the line.

Air temperature in the chamber does not equal the air temperature of the hood. A RC chamber uses a blower to provide airflow to the hood and some manufacturers will quote the temperature in the chamber as the supply air temperature. However, this temperature is upstream of the blower and there will be a temperature rise of several degrees across the blower due to the work input by the blower motor.

Table 1: Typical blower static performance

Motor Horsepower	Static (in H20)	CFM
1	1”	460
1	1.75”	300
3	1”	1100
3	2”	1040
3	3”	980
3	4”	800

For instance, a 22.6 m^3/min (800 CFM) blower with a 3HP motor has a temperature rise of 5ºC across the blower, and as a result, a system with –40ºC at the inlet only delivers –35ºC at the blower outlet. Once you have discovered, chamber temperature can be lowered to compensate, but since the refrigeration capacity of the system decreases as the temperature is lowered, the system capacity required at the lower set point temperature may not be available. Heat picked up in the hoses between the RC and the hood will also raise the air temperature entering the hood. When ordering an RC it is essential to specify a



Remote conditioners are used to condition devices under test

“local/remote” temperature sensor switch in order to allow measuring the air temperature either inside the RC chamber (local) or the air temperature in the hood (remote).

Humidity Pitfalls: Relative Humidity (RH) is not an absolute measure of the moisture in the air, but as the name suggests, a measure of the moisture in the air relative to a given temperature. Keeping the moisture level constant, but changing the air temperature results in a change in the RH reading - a fact that becomes very relevant when trying to obtain high humidity levels in a hood when using an RC. For a given amount of moisture in the air, raising the temperature of the air will cause the RH level to drop. The upper limit on humidity inside any environmental chamber is typically 95% RH, which is the maximum inlet condition to the RC blower. At the lower temperature and humidity limit of 4ºC and 95% RH, a 5ºC temperature rise across the blower would provide an air supply of 9ºC. While the absolute measure of grams of water per kilogram of air would not change when the air temperature rose, RH would fall to 67% RH. Unlike the temperature-only example given earlier, chamber temperature cannot be lowered to compensate for the RH because of the physical limitations of humidity control. Thus, although the RC chamber interior could be rated at 95% RH and 4ºC, the true maximum RH at the outlet of the blower is only 67% with a minimum corresponding temperature of 9ºC. Any additional temperature rise and/or condensation in the connecting hoses will lower the RH of the air entering the hood even further, but this problem can be overcome by adding humidity either downstream of the blower or directly into the hood. In the same way as the temperature sensor, a remote humidity sensor is required in order to measure the conditions of the supply air entering the hood, and not just the local humidity inside the RC.

Another contributor to humidity control is the construction of the hood and the load contained within the hood. A bare concrete floor will condense a large amount of water, as will a DUT that is a large, dense mass, but such conditions will make achieving high humidity in the hood a slow process. Dehumidification, when going from a high humidity condition to a low humidity condition, can be a problem if the hood construction traps condensation. As the RC system lowers the humidity level in the supply air, any water collected in depressions on the floor or equipment will evaporate, maintaining a high humidity level high until virtually all water is gone. If the hood is equipped with an anechoic liner, moisture can be trapped in or behind the foam panels, requiring days to dry out. To avoid these problems, the hood design must use adequate insulation (including the floor) to minimize condensation and provide a means to remove any accumulated condensation. Any anechoic liner that is used in the interior of the hood must have a vapor-tight surface. Well-sealed doors and openings will prevent the vapor pressure caused by high humidity from forcing its way into or out of the hood.

Airflow Considerations: The capacity of the RC is a function of the airflow and air temperature delivered to the hood and cannot be determined solely by the horsepower of the compressors. The DUT will emit heat based upon the temperature difference between in temperature between the DUT and the air temperature, but how quickly it gives up its heat is a function of the air velocity over the part. However, material and geometry limit how quickly heat can be removed from the DUT. An object with a large surface area and high thermal conductivity will give up its heat readily, while a dense object with limited surface area and low thermal conductivity will require much longer to obtain heat from its interior, no matter how high the air velocity.

The need for air velocity over the DUT will affect the design of the hood and the placement of the air supply relative to the location of DUT. The amount of air available from the RC blower is inversely proportional to the pressure drop of the connecting hoses and hood. To minimize pressure drop, keep the hose length and number of bends to a minimum and specify hoses large enough to keep the air velocity as low as possible in the hose.

Hood Construction: The best-designed RC in the world will give poor performance if it is connected to a leaky or poorly constructed hood. The cooling load on the RC is the sum of the "dead" load and "live" load. Dead loads are those items that must be cooled down, but do not contain a regenerating source of heat. In our brake dynamometer example, the dead load consisted of the wheel-brake and dynamometer assembly, the hood walls, ceiling and floor. A heat source that regenerates heat is called a "live" load. In the brake dynamometer, the live load consists of the brake horsepower applied during operation, heat leak through the walls of the hood, and any air infiltration. When providing a hood, areas to pay particular attention to include: adequate insulation; adequate inlet and outlet sizes; and minimum leakage around openings. A minimum of 100mm (4in) is recommended for fiberglass insulation for testing at –40ºC, as this thickness will minimize heat leakage through the walls and the potential for condensation on external surfaces. Any doors, ports or other openings must be sealed in order to prevent infiltration of room air and resist the vapor-pressure present when running high humidity inside the hood.

In order to size a RC correctly, the manufacturer will need significant details about the hood being used, including construction materials, the amount of insulation, and the total dead and live load of the DUT. Alternatively, the manufacturer could provide the hood. By giving the manufacturer adequate information on the application and closely reviewing the manufacturer's quote for the aforementioned pitfalls, the RC will provide flexibility unmatched by any single-purpose chamber.■