



The Critical Role of Calibrations and Preventative Maintenance in Environmental Test Chambers

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Introduction



Environmental test chambers from Associated Environmental Systems (AES) are vital tools for product reliability testing, R&D, and quality assurance. Their core function is to subject products to precise, repeatable conditions of temperature and humidity. The integrity of the test data is directly dependent on the accuracy of the chamber's control and measurement systems.

This white paper outlines the essential requirements for routine calibration of measurement and control instruments, and the necessity of preventative maintenance (PM) to ensure the long-term reliability and performance of AES environmental chambers. Neglecting either can lead to non-compliant test results, costly downtime, and premature equipment failure.

What is a Calibration?

Calibration is the process of comparing a device's measurement against a known standard and adjusting the device to eliminate or minimize any difference. For an environmental chamber, this primarily concerns the temperature and humidity sensors (e.g., thermocouples and RTDs for temperature, or capacitance sensors for humidity).

System vs. Controller Calibration

Controller Calibration

This verifies the accuracy of the chamber's control hardware (e.g., the Watlow controller) itself. It involves providing the controller with a known, calibrated electrical input (voltage, current, resistance) corresponding to a specific temperature or humidity, and verifying that the controller displays the correct reading within the manufacturer's specification.

System Calibration

This is the more common and critical procedure. It validates the accuracy of the entire system—the control unit, the sensor, and the chamber environment as a whole. A separate, traceable, calibrated reference instrument is placed inside the chamber, and its reading is compared to the chamber's setpoint and indicated temperature/humidity. If a deviation (offset) is found to be outside of the chamber's tolerance, the chamber controller's offset parameter is adjusted to ensure the indicated reading accurately reflects the true environment inside the chamber working space.

How Does AES Handle Embedded Sensor Calibrations?

It may not be possible to readily perform this comparison near the system sensor if the sensor is embedded within a cooling coil, a heater, or the chamber wall. In this case, the system sensor is measuring the component's temperature, not the air temperature in the working volume.

- If the chamber's indicated temperature (from the system sensor) differs significantly from the reference sensor's reading in the working volume, the chamber is outside of its accuracy specification.
- To correct this, you can use the controller's calibration offset parameter to adjust the reading indicated by the controller, allowing the controller to display a temperature that more accurately reflects the working volume temperature rather than the internal component temperature.

Determining Required Accuracy

The required accuracy for an AES environmental chamber depends critically on the test standard (e.g., MIL-STD, ASTM) or the customer’s internal process specification.

AES environmental chambers are engineered and manufactured to inherently hold a tight stability specification, typically around $\pm 1\%$. This reflects the high-performance capability of the control system, sensors, and conditioning unit to maintain a constant condition over time.

However, the final tolerances for temperature and humidity testing must be catered to the customer’s specific process requirements. While the chamber might be capable of sustaining a stability and uniformity of $\pm 1^{\circ}\text{C}$, the required system accuracy and uniformity for a given test (e.g., pharmaceutical, aerospace, or automotive) may demand:

- A much tighter absolute temperature tolerance (e.g., $\pm 0.5^{\circ}\text{C}$) is achievable upon request.
- Multi-point uniformity checks across the working volume to ensure all test articles are exposed to the same conditions.

A qualified calibration technician ensures the chamber’s readings are within this specification to guarantee compliant and reproducible test results.

The Necessity of Preventative Maintenance (PM)

While calibration addresses accuracy, preventative maintenance addresses reliability and longevity. Environmental chambers are complex systems incorporating mechanical, electrical, and fluid components that operate under extreme stress. Regular PM minimizes the risk of catastrophic failures and extends the life of the unit.

SYSTEM COMPONENTS	PM FOCUS	CONSEQUENCES OF FAILURE
Refrigeration System	Analysis of compressor current draw, verification of refrigerant pressures, leak detection procedures, and cleaning of coils.	Complete loss of low-temperature capability, potential for compressor burnout, and system contamination.
Air Circulation System	Inspection and cleaning of squirrel cage blower wheels and motor bearings, and verification of belt condition (if applicable).	Suboptimal temperature uniformity, localized thermal gradients, and potential overheating of test specimens.
Humidification System	Cleaning and descaling of the boiler unit, and comprehensive inspection of water level sensors and heating elements.	Inaccurate humidity regulation, excessive chamber moisture, and failure of heating elements.
Heating System	Measurement of heating element resistance and verification of safety limit circuit functionality.	Over-temperature excursions, potential damage to test samples, and total heating system failure.
Electrical Components	Inspection of contactors, relays, wiring insulation, and verification of terminal block torque specifications.	Intermittent operational performance, heightened fire hazard, and electrical system faults.
Gaskets and Seals	Detailed inspection of door gaskets and cable port plugs for evidence of damage and wear.	Refrigerant leakage, diminished temperature control efficiency, and elevated power consumption.

Conclusion

A standard preventative maintenance (PM) schedule is typically annual (every 12 months); however, the ideal interval should be adjusted based on the chamber's usage intensity, operating range, and compliance requirements:

PM Interval = f (Usage Intensity, Operating Range, Compliance Requirements)

Maintaining consistent documentation of PM activities builds a comprehensive equipment history, enabling faster troubleshooting and providing critical records for quality audits and regulatory compliance.

Preventative maintenance and calibration are not interchangeable—they are two complementary components of a single strategy designed to maximize environmental test chamber uptime and data integrity. Calibration confirms the chamber is performing within specification, while preventative maintenance ensures the system remains reliable, safe, and fully operational over time.



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