

# **Vacuum Oven Drying: Selection, Operation and Best Practices**

White Paper



## **Introduction**

Drying is a critical step in many laboratory and industrial workflows, particularly where heat-sensitive, volatile, or oxidation-prone materials are involved. Vacuum ovens offer a controlled environment that enables efficient drying at lower temperatures by reducing atmospheric pressure. Modern laboratory vacuum ovens, such as those in the Gallenkamp range, are designed to deliver reliable temperature control, stable vacuum performance, and robust construction for routine laboratory use.

This white paper provides a practical overview of when to use a vacuum oven instead of heating ovens, how to select the appropriate oven and vacuum pump, and best practices for operation, monitoring, maintenance, and troubleshooting.

## **Comparison of Vacuum Ovens and Convection Laboratory Ovens**

The choice between a vacuum oven and a convection laboratory oven is primarily determined by material sensitivity, solvent characteristics, and required process temperature. Convection laboratory ovens operate at atmospheric pressure and utilise forced or natural airflow to transfer heat, making them well suited for routine laboratory processes such as drying glassware, curing coatings, and thermal conditioning of materials that are stable in the presence of oxygen and elevated temperatures.

Vacuum ovens are typically selected when processing requirements call for reduced thermal stress or controlled solvent removal. By operating under reduced pressure, vacuum ovens lower solvent boiling points, enabling effective drying at lower temperatures. This supports applications involving heat-sensitive or oxygen-sensitive materials, including pharmaceutical development, polymer processing, battery materials, and other advanced material systems where oxidation or thermal degradation may affect performance.

From an operational perspective, convection ovens provide uniform heating through convective airflow and are commonly used for general-purpose or higher-throughput laboratory applications. Vacuum ovens rely primarily on conduction from heated shelves and radiation, with process outcomes influenced by loading configuration and shelf contact between samples and shelves. This operating mode supports controlled low-temperature drying and solvent removal under reduced oxygen conditions. As a result, vacuum ovens are typically employed when reduced thermal exposure and controlled atmospheric conditions are required.

Selection Criteria	Vacuum Oven	Convection oven
Operating Pressure	Reduced pressure (vacuum)	Atmospheric pressure
Primary Heat Transfer	Conduction and radiation	Convection (forced or gravity air)
Recommended Temperature Range	Low to moderate	Moderate to high
Solvent Removal Requirements	Suitable for efficient removal of volatile or high-boiling solvents	Suitable for materials with minimal or non-critical solvent content
Material Sensitivity	Appropriate for heat-sensitive or oxygen-sensitive materials. Reduced oxygen environment.	Appropriate for thermally robust, oxidation-tolerant materials. Ambient oxygen unless inert purge is used.
Drying Uniformity Considerations	Influenced by shelf contact and loading configuration	Driven by airflow uniformity
Applications	Low-temperature drying, solvent removal, moisture reduction in sensitive materials	General drying, curing, baking, annealing

## Choosing the Right Oven Capacity and Vacuum Pump

Selecting the correct vacuum oven configuration is essential for achieving consistent, efficient performance aligned with application requirements.

### Oven Capacity

When choosing an oven size, consider:

- The physical dimensions and number of samples to be dried
- Airflow and spacing requirements for uniform drying
- Potential future increases in throughput

Laboratory vacuum ovens are typically available in a range of chamber sizes to suit different workloads. Choosing a capacity that balances current needs with flexibility for future applications can help maximise long-term value.

## **Vacuum Pump Selection**

The vacuum pump must be compatible with the oven volume and application. Key considerations include:

- Ultimate vacuum level required
- Pumping speed relative to chamber volume
- Chemical compatibility with solvents being removed
- Oil-sealed vs dry pump technologies

Many vacuum ovens, including Gallenkamp vacuum ovens, are designed to integrate easily with a wide range of commonly used laboratory vacuum pumps, allowing users to select a pumping solution that best matches their process requirements.

## **Best Practices for Vacuum Oven Operation**

Best practices for vacuum oven use ensure consistent, efficient, and safe drying. Proper control and monitoring of temperature and vacuum, along with appropriate loading practices, improve results, protect samples, and extend equipment life.



## Monitoring Vacuum Levels and Temperature

Accurate monitoring is essential for process control and reproducibility.

- Ensure vacuum gauges are calibrated and appropriate for the operating range
- Use independent temperature monitoring where critical
- Record vacuum and temperature profiles for validated processes
- Be aware of temperature gradients within the chamber, particularly at higher loads

Well-designed vacuum ovens incorporate intuitive controls and clear displays to support routine monitoring. Consistent, stable control of both temperature and vacuum helps improve reproducibility and confidence in drying results.

## **Troubleshooting Uneven Drying**

Uneven or incomplete drying can compromise product quality and process efficiency. Identifying the root cause promptly is essential to restore consistent performance and prevent recurrence. The following factors are commonly associated with uneven drying conditions:

- Overloading or poor sample placement
- Insufficient vacuum level or pump performance
- Temperature non-uniformity within the chamber
- Leaks in door seals or vacuum connections

Corrective actions may include redistributing samples, checking vacuum integrity, verifying setpoints, or reducing batch size

## **Cleaning, Maintenance, and Calibration**

In addition to routine cleaning and inspections, formal calibration activities help ensure ongoing measurement accuracy and reliable long-term performance.

### **Cleaning**

- Clean the chamber regularly to remove residues and prevent contamination
- Use cleaning agents compatible with chamber materials
- Allow the oven to fully dry after wet cleaning before operation

### **Preventive Maintenance**

- Inspect door seals and gaskets for wear or damage
- Check vacuum lines and fittings for leaks
- Service vacuum pumps according to manufacturer recommendations

### **Calibration and Maintenance Schedule**

A structured calibration and maintenance program is essential to ensure accurate measurements, reliable system performance, and ongoing compliance with operational requirements. Regular calibration and proactive maintenance help minimize downtime, extend equipment life, and allow potential issues to be identified and addressed before they impact operations.

- Calibrate temperature sensors and vacuum gauges at defined intervals
- Maintain records of calibration, servicing, and repairs
- Review performance trends to identify potential issues early

## **Conclusion**

Vacuum ovens are a versatile and essential tool for applications requiring controlled, low-temperature drying. By understanding when to use a vacuum oven, selecting the appropriate equipment, and following best practices for operation and maintenance, users can achieve reliable, reproducible results while maximising equipment lifespan.

Established laboratory oven manufacturers, such as Gallenkamp, design vacuum ovens with an emphasis on durability, control accuracy, and ease of maintenance, supporting consistent performance in routine laboratory environments. Implementing routine monitoring and preventive maintenance further ensures long-term reliability and process confidence.



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## **ABOUT GALLENKAMP**

Scientific Digital Imaging's acquisition of Gallenkamp in September 2018 marked a significant milestone in the field of Life Science Equipment. Today, Gallenkamp products are sold under their own brand name, separate from Sanyo Gallenkamp, and are distributed globally by our company. Whether you're seeking information or assistance, we're here to help you find local dealers and answer any questions you may have. Contact us today to learn more about our products and services.



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