Despatch

Thermal Processing Technology

ITW EAE

CHOOSING AN OVEN WHEN FAILURE IS NOT AN OPTION

WHAT TO LOOK FOR WHEN SELECTING AN OVEN FOR CRITICAL THERMAL PROCESSING APPLICATIONS

WHEN FAILURE IS NOT AN OPTION

For many thermal processing applications, the cost of failure is extremely high. **Poor thermal processing can result in scrapped parts, product failure after sale, and in some cases can risk lives.**

For these applications you need a high quality oven that can deliver the uniform and repeatable thermal processing required for critical components to operate flawlessly and ensure reliable product performance. Selecting an oven that delivers uniform temperature and invariable performance for as long as it is in service requires careful consideration. In addition you need to consider any special atmosphere and safety requirements for your process. This guide defines what you should look for when selecting an oven if failure is not an option.

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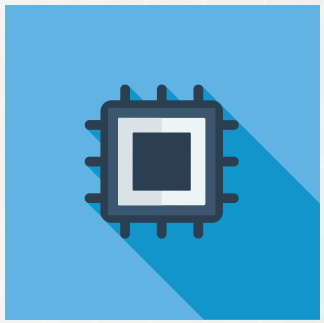
REPUTATION

Look for a manufacturer with a reputation and proven track record of high performance and durability. The best way to see if an oven will stand the test of time is to find a brand with ovens in the field that are still delivering high levels of performance and repeatability after 20 or more years of use. Despatch is still servicing ovens that it put in the field over 50 years ago. With proper maintenance these ovens are performing to the same specifications as when they were purchased.

APPLICATION EXPERIENCE

The best solution for your application is most often found from a company who has experience in your industry. The requirements for your application are more likely to already be built into the oven as a standard offering and you will have greater assurance that your concerns will be understood and addressed.




TEMPERATURE UNIFORMITY

The obvious advantage of tight oven uniformities is that all parts within the oven will be subject to the same temperature, therefore insuring consistent product quality. However, **the tighter the uniformity, the more costly the oven or furnace is to manufacture.**

Oven characteristics that affect uniformity are: wall losses (including through-metal); oven openings; air distribution and the volume of airflow; control accuracy and construction techniques.

UNIFORMITY FACTORS

Wall Losses

In order to minimize wall losses, insulation thickness needs to be suited for the maximum temperature and uniformity required. Through-metal loss should be kept to an absolute minimum by special panel and unitized construction.

Oven Openings

Be sure that oven openings for fresh air and exhaust are strategically located. The location helps to provide a positive pressure differential (in relation to the outside of the oven), so cool ambient air introduced into the oven through door seals is minimized. The fresh air opening should also be located so that the fresh air can mix thoroughly with the recirculated air.

Air Distribution

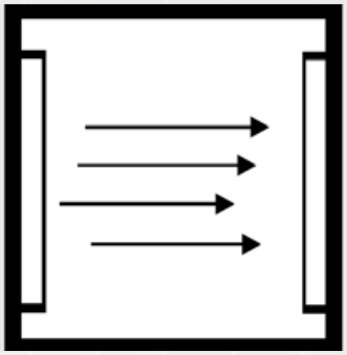
Similarly, the oven airstream should be designed so air passing through the heating elements is adequately mixed before entering the work chamber. If fresh air is insufficiently mixed with recirculated air, air layers at different temperatures, called air stratification, will affect oven uniformity. Air duct design, placement and geometry also contribute to uniformity.

AIR FLOW

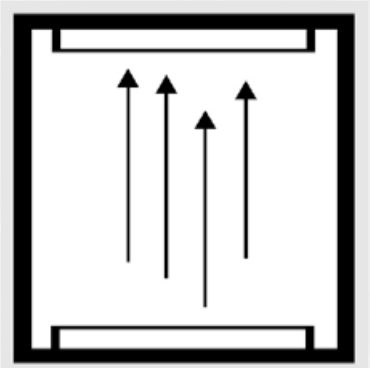
The most important factors determining temperature uniformity are the type of airflow and the volume of air being moved. Airflow needs to uniformly reach all points in the oven. **Your product and how it is loaded will determine what type of airflow will provide uniform distribution of heat to all parts of the load.** For instance, if your product is to be loaded on a solid tray, horizontal airflow is the best option. Consider how parts can be spaced with each type of airflow to ensure optimal airflow through or around all parts of the load.

Greater air volume through an oven leads to better uniformity. A fan and motor combination must be sized to take into account the amount of static pressure drop through the oven in order to meet the desired uniformity.

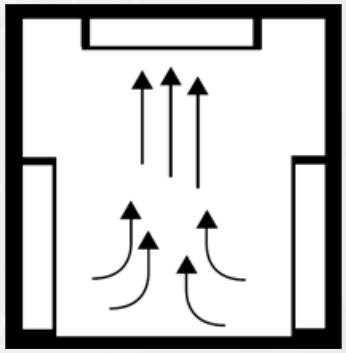
Uniformities at low temperatures (typically, 150°F or 66°C) are the easiest to obtain due to minimal wall losses. They require minimal amounts of airflow and a simple body construction. As temperatures increase, wall losses increase. Uniformities are harder to achieve, requiring higher airflow fans and motors, enhanced insulating characteristics and more stringent airflow distribution.



Horizontal



Vertical (up or down)



Uniflow

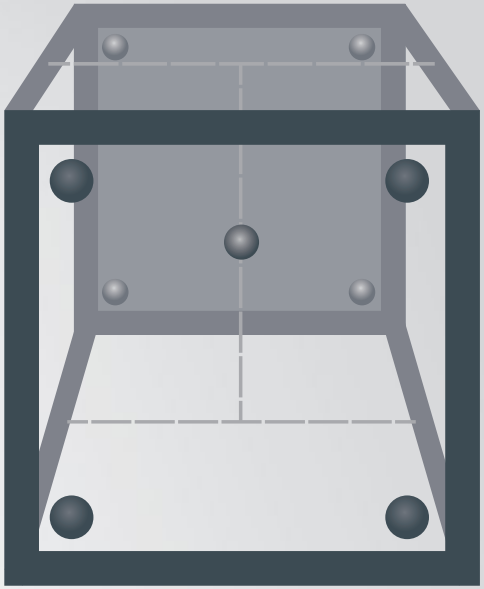
Uniflow is a combination of vertical up and horizontal airflow typically used in walk-in and truck-loading ovens. Ideal for large products with an uneven shape.

VERIFICATION OF TEMPERATURE UNIFORMITY

To confirm that the oven is delivering the temperature uniformity required for your process, it should be tested with the use of a nine-point thermocouple survey. A thermocouple is placed in each corner of the empty oven, at least 3 inches from any surface, with one thermocouple in the center. Temperature readings are taken for all nine thermocouples after the oven has stabilized at setpoint temperature.

If at all possible, work with a test facility to confirm expected results from the oven for your specific application. Many companies have used the Despatch Innovation Center for testing and process development before making a purchase commitment. By utilizing the expert technical information and process solutions provided by Despatch, you may be able to actually improve process technologies already in place.

NINE-POINT UNIFORMITY TEST



Before implementing a critical thermal processing step you need to confirm that the oven you are using is delivering the temperature uniformity required for your process.

A nine point uniformity test that measures temperature in every corner as well as the center of the oven will ensure that the temperature throughout the oven remains relatively constant.

ATMOSPHERE REQUIREMENTS

Your application may require a clean process oven to prevent particulate contamination of sensitive products. In that case the oven will need special construction and components, such as a HEPA filter or other special air filtration system, stainless steel for cleaning and continuous back welding to prevent migration of particles into the oven.

Inert atmosphere ovens provide nitrogen or argon gas, which some processes require to prevent product oxidation at elevated temperatures. **With proper construction, special atmospheric ovens such as argon or nitrogen injected ovens can be built to control the oxygen level below 50 parts per million (PPM).** Construction techniques like high integrity welds, special fabrication methods and special motor shaft seals are examples of such construction.

The National Fire Protection Association (NFPA) requires specially designed "Class A" ovens for direct, gas-fired equipment, or for processing products involving flammable solvents, volatiles or combustible materials. **A "Class A" oven must have a forced exhaust, a method to prove airflow, a purge timer and an explosion relief area.**

DESPATCH TIP

Despatch recommends the use of an airflow switch with the forced exhaust to prove airflow.

The forced exhaust is sized to keep the flammable solvent vapor concentrations below the lower explosive limit (LEL) in the oven chamber. The purge timer operates in conjunction with the forced exhaust to purge the oven of volatiles before the heaters are allowed to energize. The purge time is based upon the volume of the oven, as the oven air must be changed four times before the heater may be energized.

The airflow switch is used to prove exhaust airflow. With no airflow, the heating system shuts down via the airflow switch. The explosion relief area is typically incorporated into the oven by means of an explosion relief panel/door or explosion relief membrane.

SAFETY ISSUES

Safety is of great concern when considering oven design alternatives. Fires, explosions, bodily injury or even death may result from improper operation. **Most ovens are designed for a specific process and should never be used for another process or with different parameters.**

Special design features are required when the oven and/or controls will be located in an area classified as hazardous. This classification refers specifically to an explosion hazard from the possible ignition of dust, vapors or gas in the area external to the oven, and is not limited just to volatiles within the oven chamber.

If the area is classified as hazardous, some of the design considerations are:

- Spark resistant fans
- Suitably rated motors.
- Sealed interconnecting wiring and junction boxes.
- A source of make-up air from outside the hazardous area.
- Either remote control enclosure or enclosures rated for the specific type of hazardous area.

Other standards and codes associated with industrial ovens include UL, C-UL, CE, SEMI, IRI, FM, IEEE and GMP (Good Manufacturing Practices).

CLASS A WARNING

Class A ovens are rated for a maximum solvent handling capacity, generally stated in gallons per hour of a given solvent at a given operating temperature. Solvent handling ratings must never be exceeded because an explosion may result.

OVEN CONSTRUCTION

When considering if the oven construction is suitable for the temperature range of the oven and the environment in which it will operate, look for these standards: a mild steel exterior finished in a scratch resistant paint, sufficient insulation to minimize heat loss, and a door system with sufficient thermal expansion and structural integrity to avoid warping.

Construction may be particularly important when a corrosive material is to be processed through the oven or when possible contamination of the work load can occur. **You will need a stainless steel interior whenever high degrees of cleanliness, clean ability and resistance to corrosion are required.** This type of interior includes stainless steel material throughout the air stream portion of the oven and in the heat chamber itself.

Aluminized steel interiors provide a thin layer of aluminum fused to a steel surface. This surface resists corrosion from moisture and other sources by forming a thin oxide coating on the aluminum to protect the underlying steel.

Mild steel interiors with corrosion resistant aluminum/silicone paint are acceptable for drying above 212°F (100°C) and for general non-corrosive heating/curing operations.

Several process-specific factors need to be taken into account in regard to oven construction. **Maximum temperature of the oven and size of the work chamber will affect the construction methods used.** The number and type of expansion joints used will be affected by these as well. Fan size will depend on process needs and your oven may require special door seals and breaker strips to get the uniformity desired. Surface temperature specifications may require special construction techniques and load support design will depend on the type and weight of the load.

Be sure to specify vertical lift doors (with pneumatic locking cylinders) for larger oven openings. They are more convenient to use and easier to seal.

Inert atmosphere ovens require special construction techniques for expansion because interiors need to be continuously welded. HEPA filters combined with the proper oven and process design provide operation at ISO Class 5 (Class 100) or better within the oven chamber. Experience and reputation are particularly important if you are interested in one of these clean process ovens.

Door seal design is determined by maximum temperature, required atmospheric conditions within the process chamber, size of the opening and door style. Lower temperature ovens often use two point silicone seals. Higher temperature ovens use a combination of fiberglass or ceramic and silicone. In addition, the seals can be water cooled if necessary. Clean process ovens use silicone HEPA seals to 500°F and ceramic gaskets up to 750°F.

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OVEN QUALITY

Proper Oven Construction:

- Improves temperature uniformity and performance
- Reduces heat loss and energy expenses
- Simplifies cleaning and service

Oven Interior Considerations:

- Stainless steel provides corrosion resistance and cleans easily.
- Aluminized and mild steel are less expensive, but offer less protection against corrosion, rust and contamination.
- Shelves should feature a sturdy, non-tip design, and allow for proper airflow and easy product loading/unloading.

Look for Applicable Standards

- U.L. & C-UL listed oven, U.L. & C-UL listed control panel (available as an option) and CE conformance are
  listings that are a sign of quality.

HEAT-UP/SOAK/COOL-DOWN TIMES

Heat-up, soak, and cool-down times are critical elements to consider for selecting the correct equipment. There are three basic questions to ask:

1. Does the oven have sufficient heating capacity to bring the product to the desired temperature within the specified cycle time?

The answer to this question depends on the mass and specific heat of the product. This is the energy required just to heat the product. The heating capacity of the oven will need to be greater, due to heat losses through the oven walls, through exhausted air and through heating of the oven mass itself.

2. Can the product absorb heat at a rate sufficient to reach temperature within the specified time frame?

The product may not be able to reach the desired temperature in the desired time frame, even though the heating capacity of the oven is sufficient. The rate at which a product can absorb heat is dependent on the thermal conductivity of the material, the size and shape of the product, and the velocity and direction at which the convected air impinges the surface of the product.

3. Must the heat-up rate be at a controlled rate, or is it sufficient to allow the product to reach temperature as quickly as possible, given the oven's heating capacity?

If the process does not require that the heat-up rate be controlled, a standard setpoint controller may be used to control oven temperature. The oven load will reach temperature as quickly as the product and oven heating capacities will allow, but will not necessarily be linear. If a controlled heat-up is required, a programmable, ramping controller is needed.

Soak Times

A programmable controller can be programmed to remain at temperature for a specified period of time, then cool-down to complete the cycle. For many applications, the soak cycle begins once the time specified for the heat-up cycle has been completed. **When more precise control is necessary and it is important that the soak time does not begin until the product has reached temperature, a Guaranteed Soak option can be utilized.** In this method, the controller does not start timing the soak cycle until a thermocouple embedded on the product, or in the airstream, senses that the setpoint temperature has been reached.

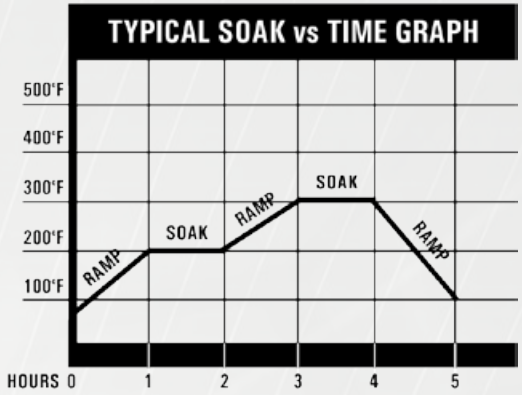
Cool-Down Times

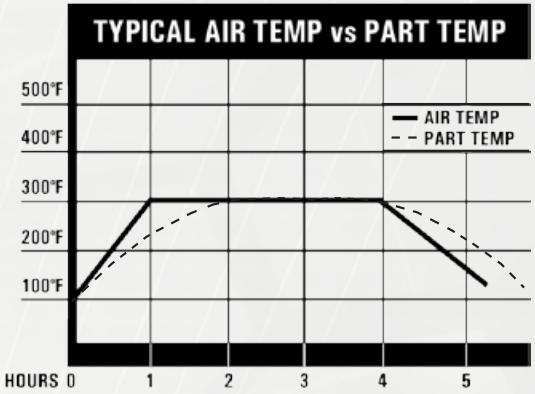
Typically, oven cool-down is achieved by exhausting heated air from the oven. A corresponding flow of cooler, ambient air will enter the oven to replace the warm exhausted air. If the cool-down rate requires no control, the only need is to size the exhaust fan large enough to remove the necessary amount of heat in the required time.

If the cool-down rate is to be controlled by exhausting oven air, it can be accomplished in two ways:

1. Exhaust dampers are opened to the maximum position, and the heaters supply enough heat to keep the temperature from dropping too rapidly.

2. Modulating dampers can be controlled by the programmable controller. The dampers will modulate in order to maintain a controlled cooling rate. Consider that the initial investment cost of this option is greater, but operating costs will be lower due to a more energy efficient system.





With an inert atmosphere oven, cooling by means of exhausting oven air is not usually a viable method, as oxygen is introduced into the oven. Air-to-air or air-to-water heat exchangers are effective in removing heat from the oven in these applications.

PROCESS CONTROL AND MONITORING

Controllers play a key role in overall oven performance. Meaningful process measurement and control is dependent upon three primary factors; sensor accuracy, controller performance, and system dynamics.

Sensor Accuracy

Thermocouple performance is affected by location and orientation, wiring (distance, connectors, gauge, tolerances, noise), thermocouple construction (exposed, enclosed, wells, sheath material, gauge, etc.), process parameters such as flow rate, and degradation due to aging. **Accuracy can be improved by using thermocouples with special tolerances and tested certification.**

Controller Performance

Controller performance is determined by input accuracy, tuning, and output accuracy.

Controller tuning can introduce error. If the PID settings are not well adjusted, the process will begin a natural deviation at some frequency. This deviation may be rapid or slow, of low magnitude or high. It may be offset either above or below the setpoint, or oscillate around it.

Output accuracy has significant impact on the control of the process. If the final control device unable to control in small enough increments, the controller will be forced to under- and then over-compensate, producing choppy control performance.

DESPATCH PROTOCOL 3

The Despatch Protocol 3™ controller can function either as a programmable ramp/soak controller or as a single setpoint controller. A Modbus 485 serial communications port allows data communication between the oven controller and a PC. Ethernet connection is available as an option.

With Protocol Manager software, the user may interface with up to 32 ovens from a single PC. This powerful tool provides data logging of critical operating information, recipe management and remote monitoring capability.

System Dynamics

The physical construction of the oven has an enormous impact on the performance of the control system. **A carefully-chosen highly-accurate control system cannot compensate for a poorly designed oven.** If the airflow supply is non-uniform, or cool air leaks exist in the process chamber, or the control point is improperly selected, or the heat source is incorrectly sized, the best control system in the world will not produce satisfactory results.

On the other hand, a system with good dynamics and an inadequate control system is an excellent candidate for improved performance. The controls may be upgraded to provide a first-rate piece of equipment. Despatch can provide properly designed equipment, and the level of control sophistication to meet your process requirements.

Despatch uses microprocessor-based, digital proportioning controllers. Precise temperature control is achieved with a thermocouple sensor and solid state heater controls.

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Rest assured that when you call our product specialists, you will be speaking with experienced, knowledgeable personnel, fully capable of assisting you with any equipment questions you may have. Our network of Certified Service Representatives is spread out across the globe to provide technical support and service to Despatch customers worldwide.

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WHEN FAILURE IS NOT AN OPTION

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