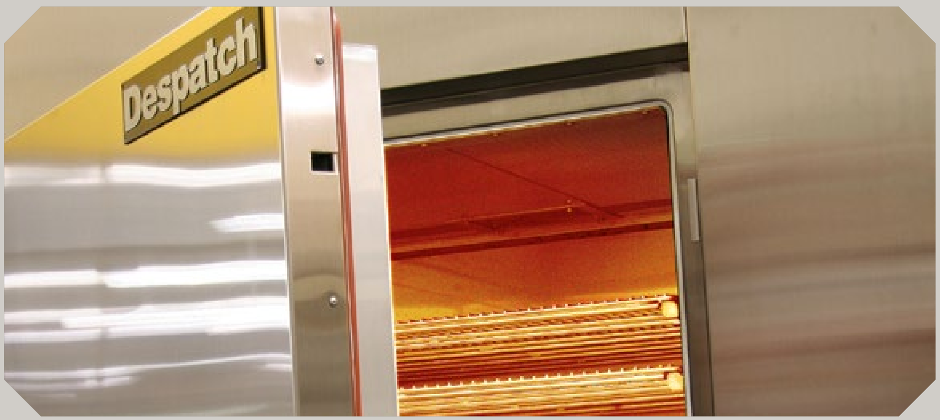
Despatch

Thermal Processing Technology

ITW EAE

ENGINEER'S GUIDE
TO EFFECTIVE HEAT PROCESSING



Engineer's Guide to Effective Heat Processing

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Glossary of Terms

- Backwelded Seams: A method of joining sheet metal panels by welding seams on the backside.
- Conduction: The transfer of heat through a material by passing it from molecule to molecule.
- Dry Bulb: Temperature of air as determined by a standard temperature sensor.
- Dwell Time: Refers to the amount of time that the product spends in the oven. While dwell time can refer to batch-type ovens, it is most often used with regard to continuous ovens where the product is conveyed into and out of the oven within specific time intervals.
- Exhaust Volume: The amount of air leaving an oven system, either passively or forced.
- Forced Exhaust: Process air removed from an oven by an exhaust fan.
- Load Configuration: The way in which the parts to be processed are situated in the oven.
- Lower Explosive Limit (LEL), Lower Flammable Limit (LFL): The point at which process air containing solvents becomes explosive/flammable.
- Purge Timer: A settable device that times the replacement of air in an oven with fresh air or an inert gas.
- Radiant Heat: A mode of heat transfer in which heat is transferred in a straight line from an emitting surface, without significantly heating the intervening space.
- Setpoint Temperature: An operator controlled variable. The desired temperature level of the oven selected as a numeric value on the control instrument.
- Soak: The amount of time that a part or component spends at a given processing temperature.
- Temperature Stratification: Variation in air temperature across a cross-section of air due to uneven mixing of the air.
- Temperature Uniformity: Variation measured in active work space or in airflow entering work area generally defined as "X" spread.
- Thermocouple: A temperature sensor made of two dissimilar metals welded at the measuring junction. A millivolt signal proportional to the temperature difference between hot and cold junctions is produced.
- Wet Bulb: Temperature of air as determined by a temperature sensor with a wet wick. The relationship between wet bulb and dry bulb temperature readings is a measure of the water vapor in the air.

About

This guide discusses general issues related to the selection of industrial equipment for heat processing. Since nearly all products manufactured today require heat application at some point in the process, this guide was created to provide a base knowledge of the complexity of issues related to selection of optimum equipment for any particular process.

This guide is just that – a guide only. Actual specification of equipment should be made only after consultation with Despatch engineers who can thoroughly analyze your process.

Process Description

Heat processing applications vary widely from industry to industry. Curing, drying, heat treating, sterilizing and bonding represent just a few of the many uses for ovens and furnaces. To some extent, all ovens and furnaces utilize the same basic principles of thermal transfer.

Selection of heat processing equipment is dependent on the type of application, but also on the specific needs of the products under manufacture. Described here are some of the general criteria you should consider and be aware of in order to succeed with your thermal application.

Basic Oven Considerations

Ovens generally are classified as heating equipment operating from ambient to 1000°F (538°C), while furnaces operate above 1000°F. Equipment may be designed for intermittent loadings (a batch at a time), or for a continuous flow of work using some form of conveyor. The source of heat is normally derived from combustion of fuel (gas, oil, etc.), electricity, hot water or from steam.

Heat Transfer Methods: Advantages and Disadvantages

Heat can be transferred to the work by natural convection, forced convection or by radiant heat sources. Natural convection heating can be very fast, but may not be as uniform as forced convection. Both methods are flexible, easily controllable and can be directed for odd shapes. Radiant heat transfer is faster at higher temperatures and initially less expensive, but is not as flexible as convection and must be tailored specifically to the product.

In addition to different types of transfer, heating equipment may be designed to contain special atmospheres such as argon or nitrogen, or may incorporate special construction materials necessary for a specific application.

Types of Equipment

There are many issues that must be considered when selecting industrial equipment, including:

- the quantity of material to be processed
- the uniformity, size and shape of the products
- the temperature tolerance that is permissible
- whether the product or process lends itself to batch or continuous in-line processing

For processes which involve slurries of chemicals, or where the product size or output varies substantially, batch processing is a good approach. Processes such as paint finishing and some heat treating operations, where a large quantity of similar workpieces are processed, generally lend themselves well to continuous operation. Bench-mounted and cabinet-type ovens are most often used for laboratory applications.

Batch-Type Ovens

These ovens represent the largest category of ovens used to manufacture products Batch-type ovens can be classified as cabinet-style or truck-loaded type. The size can range from small bench top units to large industrial installations with thousands of cubic feet.

Bench-mounted or small cabinet-style ovens are most often used for laboratory applications such as sterilizing, curing, drying and other general laboratory activities. They range in capacity from 2 to 24 cubic feet. Typical temperature ranges are from 100°F to 650°F (38°C to 343°C). Usually, these ovens are used in lighter duty applications than are industrial production ovens.

LAC High Performance Oven

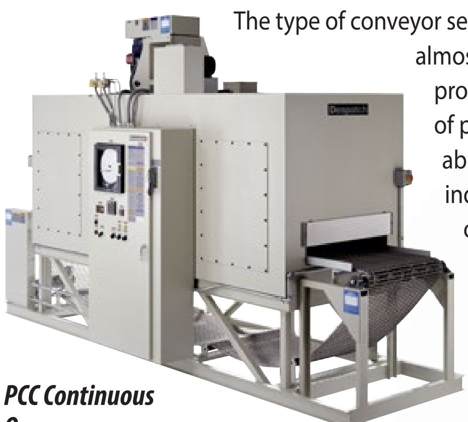
Ranging in size from 3 cubic feet interior volume and up, production-type ovens are used extensively for curing, baking, drying, finishing and annealing processes and an almost limitless number of other applications.

Continuous Ovens

These ovens include the entire spectrum of oven equipment operated on a continuous or indexing basis. These ovens have construction characteristics that generally are similar to batch ovens. The distinguishing characteristics of continuous ovens include such items as the means of conveyance, air distribution techniques and product loading methods.

Conveyorized ovens can be a component in a larger material handling system, including fully computerized systems. In some cases, these ovens can be automatically loaded and unloaded, reducing manual handling and labor costs.

The type of conveyor selected for a continuous application depends almost entirely on the type of products being processed and their configuration at the time of processing. Monorail conveyors are adaptable to a wide variety of workpieces, as many individual workpieces can be positioned on fixtures or racks suspended from the monorail.



PCC Continuous Oven

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:

A. 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. For example, the specific heat of steel is 0.125 BTU/lb x Fahrenheit degrees. For 1000 pounds of steel to reach 400°F (204°C) from 70°F (21.1°C) within 1 hour will require:

$$1{,}000 \text{ pounds} \times (4000F-700F) \times \frac{0.125 \text{ Btu}}{\text{lb} \times 0F} \div 1 \text{ hour} = 41{,}250 \text{ Btu/H}$$

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. In an oven where the exhaust rate during heat up is 50 Standard Cubic Feet Per Minute (SCFM), the heat required to heat the make-up air will be:

50 SCFM x (4000F-700F) x 1.1 Btu/H/SCFM 0F = 18,150 Btu/H

If the wall losses for the oven are 5500 Btu/H, the heater capacity will need to be at least:

41,250 + 18,150 + 5,500 = 64,900 Btu/H or 64,900 Btu/H ÷ 3,412 Btu/kW-Hr = 19 kW

B. 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.

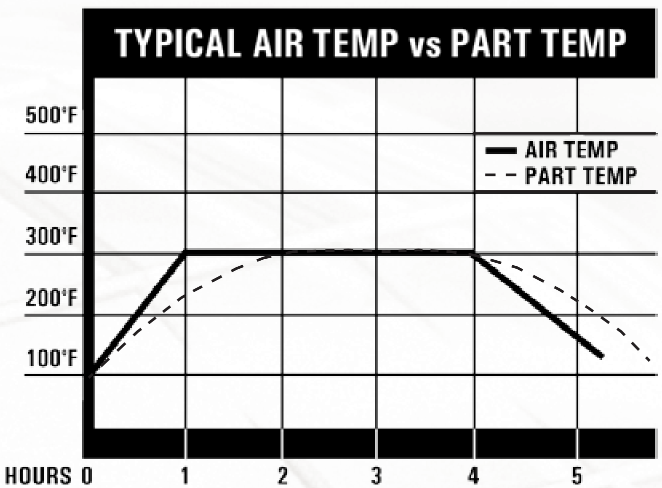
While heat absorption rates can be estimated for common materials based on charts and formulas, you should conduct actual tests if it is necessary to know the exact rate at which a product can absorb heat. Despatch Industries maintains an Innovation Center that conducts tests that can give you the necessary information. We also use the Innovation Center to improve process technologies, confirm expected results of equipment design, and conceptualize and test new heat processing methods.

C. Must the heat-up rate be at a controlled rate, or is it sufficient to allow the product to reach temperature as quickly as posisble, 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 (e.g., heat-up at 1 degree F per minute), a programmable, ramping controller is needed. Such a controller allows a specific, linear heat-up rate to be programmed.

Soak Times

Soak time refers to that time when the product has reached the desired process temperature for the desired length of time. 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.



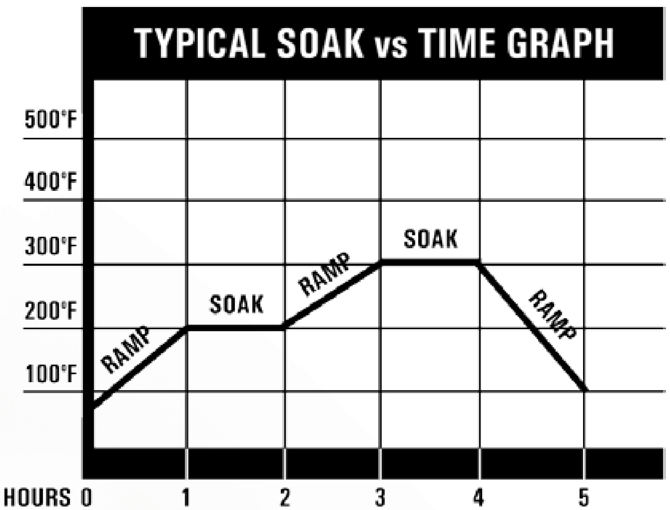
Cool-Down Times

Since cooling can be thought of as removal of heat, product considerations for cool-down rates are similar to those for heat-up rates. 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:

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

B. 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, however, 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.

Air-To-Air Heat Exchangers

These use a finned plate positioned between the oven air and a duct through which ambient air is drawn. By this means, heat is conducted through the plate and released to the ambient air. This type of exchanger is suitable for higher operating temperatures where the temperature difference between the oven air and ambient air is great enough for heat transfer to occur at a sufficient rate.

Air-To-Water Heat Exchangers

These are used at lower operating temperatures, typically 50°F (28°C) above ambient. With this type of exchanger, oven air passes over a finned, water-cooled coil. The cooling rate is controlled with a solenoid valve which regulates the flow of water into the coil. Remember, the coil size and flow should be designed to prevent water from boiling in the coil.

Temperature Uniformity

Oven temperature uniformity has different definitions depending on the type of oven and application in question. A basic definition is that temperature uniformity is the overall temperature variation in the oven workspace. Uniformity is generally stated as ±°F or ±°C at a given setpoint temperature. 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.

Wall Losses

In order to minimize wall losses, insulation thickness should vary depending on 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. The best uniformities are maintained when airflow is uniform and reaches all points in the oven. A purely horizontal or vertical airflow is most desirable to accomplish uniform airflow.

Also, the greater the air volume through an oven, the better the 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.

Uniformity is commonly tested with the use of a nine-point thermocouple survey. A thermocouple is placed in each corner of an 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.

Tests like these are done at the Despatch Innovation Center to assure the uniformity of Despatch ovens and furnaces.

Processes Involving Flammable Solvents

When the material to be processed in an oven is combustible or contains flammable solvents, a special oven defined as "Class A" by the National Fire Protection Association (NFPA), Bulletin 86, is required. NFPA standards are used by OSHA and insurance underwriters to meet their requirements, as well.

As defined by the NFPA: A "Class A" oven must have a forced exhaust, a method to prove airflow, a purge timer and an explosion relief area.

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. The membrane design offers some unique advantages with easier oven loading/unloading.

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.

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

TFD Truck-In Oven

Material Handling

Products may be moved into and out of ovens by a wide variety of material handling equipment. This equipment can vary from simple manual systems to complex automated systems.

Trucks that are moved into and out of a walk-in oven area offer a straightforward approach to material handling. For a truck loaded oven, you need to consider how many products can be loaded on the truck, the weight of the loaded truck, number of trucks that will fit in the oven, and the length of the process time in the oven.

Belt type conveyors are another commonly used means of moving products through an oven. It is important to determine how your products will fit on the belt, i.e., how many parts per lineal foot of belt. The conveyor belt speed is determined by your production parts per hour. The oven length will depend on how long the product needs to be in the oven. Other considerations include the weight of your part and the total weight of the belt moving the parts.

> **Example:** Your parts are 3 inches in diameter and weigh 5 lbs. You want to produce 1000 parts per hour. You need to have the parts in a 450°F (232°C) oven for fourteen minutes. Allowing 1 inch between parts, you can load 12 parts per lineal foot on an 18 inch wide belt. 1000 parts per hour divided by 12 parts per lineal foot indicates your conveyor speed must be 83.33 feet per hour or 1.39 feet per minute. 1.39 feet per minute times fourteen minutes indicates 19.46 feet in the oven. Round this up to 25 feet oven length due to end loss effects.

Other common types of conveyor systems are: Monorail conveyors, Pusher conveyors, Powered roller conveyors, Drag chains, Walking-beam conveyors, Screw conveyors

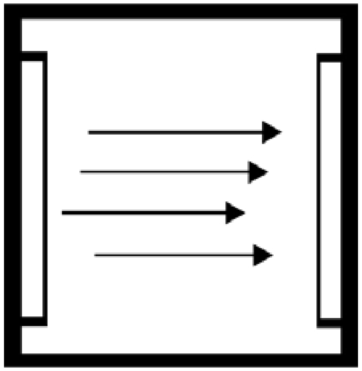
Overhead monorail conveyors can make turns inside an oven so the conveyor can make several passes in the oven. Monorail conveyors usually consist of the chain-in-a-tube type or the chain and trolley type. The chain and trolley type provides a heavier duty conveyor. When specifying a monorail system, the following should be considered: weight per part; number of parts per hook; hook or fixture weight; hook spacing; conveyor speed; and time needed in the oven.

Types of Airflow

When selecting an airflow pattern, the most important consideration is the load configuration. The main goal is to minimize obstructions to the airflow for more uniform heat distribution and to maximize the product surface area with which airflow will come into contact.

Horizontal Airflow

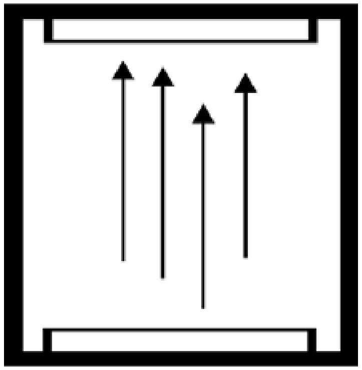
Supply on one side and return on the other, is most often used for a product that is tray or shelf loaded. The load is such that air can pass above and below.



Horizontal Airflow

Vertical Airflow

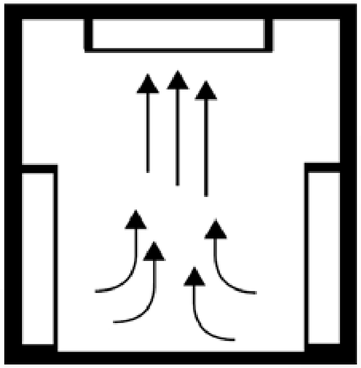
Supply at top or bottom and return opposite, is for products that allow air to pass vertically through or around. Products may be shelf loaded, suspended from stationary hooks or monorails, or placed on conveyor belts.



Vertical Airflow

Uniflow Airflow

Supply along both lower sides and return at the top, is a combination of vertical up and horizontal airflow and is best suited for larger products with an uneven shape. Products are usually truck loaded with this type airflow.

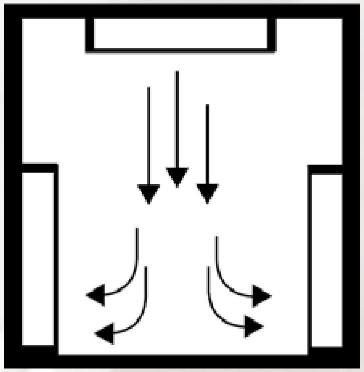


Uniflow Airflow

Reverse Uniflow

Supply at the top and return at the bottom sides, is an airflow pattern that is basically the reverse of uniflow. It is often used for large loads requiring vertical airflow.

In addition, standard ovens often come with adjustable louvers to assist with airflow around various product loads or configurations. For velocity sensitive products, fans can be supplied with variable speed drives or velocity dampers to control airflow in these situations.



Reverse Airflow

Oven Loading Openings

The type of oven loading opening is quite important in order to get the right equipment to do the job. For example, standard reach-in front load models are well suited for products which can be loaded onto a shelf. These generally accommodate light weight or easy-to-handle parts. Walk-in front load units are used in truck load type applications or for large, heavy or hard to handle parts. Top loading units with openings located on top of the oven are required for overhead loading situations.

All ovens can be provided with manual or powered (pneumatic/electric) doors. Generally, powered doors are overhead lift type. Some applications are better suited for drawers instead of doors. A drawer can be sized closer to the actual part size to help limit heat loss during loading operations. You should consider drawer ovens when the process time is long but frequent access is required, e.g., if the parts are to be soaked at a specified temperature, or if the process involves multiple small batches, or if the application has parts with different start and stop times.

Drawers come in light duty cabinet styles to large heavy duty styles supported with a track and trolley system. Powered drawers can also be supplied.

LNB oven
with truck loading system

Heating/Cooling Systems

Energy consumption is quite a significant factor when specifying heat processing equipment and is likely to remain a central consideration in the buying decision for the foreseeable future. Generally, gas heating is the least expensive and electric heat the most expensive, despite the fact that electric heat may be up to 100% efficient. Direct fired gas heating is more efficient than indirect gas fired, but efficiency for both is highly dependent on oven temperature and ventilation air requirements. In addition, indirect gas provides a much cleaner chamber environment. However, below 150°F (66°C), gas heating is not recommended due to control difficulties. You should also know that electric heaters generally provide better temperature uniformities.

Down to 100°F (37.8°C) cooling rates are easily obtained with a properly sized exhaust fan. If you have time constraints or have an inert atmosphere oven, you may need to look at air-to-air or air-to-water heat exchangers to obtain lower temperatures and faster cooling rates.

LCC/LCD Stackable Ovens

Atmosphere Type

Thermal process ovens utilize different atmospheres in order to satisfy certain processing criteria. For example, inert atmosphere ovens are generally utilized when a process requires a low oxygen concentration in the oven due to oxidation of the test parts at elevated temperatures. The inert gas is injected into a sealed chamber, pressurizing the oven and replacing the oxygen. 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.

Humidity may be added to an oven to achieve controlled moisture removal rates and to speed curing of certain compounds. The addition of moisture into the oven to maintain humidity is accomplished in two ways. Either water is boiled in a steam generator and directly injected as steam into the oven or water is sprayed through atomizers into the oven to maintain a specified humidity level. Ovens built to maintain high humidity levels must be constructed with a stainless steel interior and have continuously backwelded seams to prevent rusting and migration of moisture into the insulation. (Backwelded seams refer to a technique whereby inside seams are welded on the insulation side of the wall.)

The relative humidity inside an oven is often determined by comparing "the wet bulb temperature and the dry bulb temperature." Dry bulb temperature is obtained by reading a temperature sensor placed inside the oven. Wet bulb temperature is obtained when a moisture laden sock is placed over the temperature sensor and the temperature measured Relative humidity, then, can be measured by two temperature readings: the higher the wet bulb temperature in relation to the dry bulb, the higher the relative humidity.

Accurate wet bulb temperatures can be difficult to achieve, especially at high dry bulb temperature and low humidity. To achieve greater accuracies, use a solid state, electronic humidity transducer. These sensors provide accurate humidity readings over a wide range of temperatures and humidities.

Nitrogen Atmosphere

Design Considerations for Ovens in Hazardous Areas

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.

Since there are several classifications requiring different design features, you should check on the specific classification of the area. The NFPA is the source for this information.

Electrical Requirements

When specifying an industrial oven, it is essential to know what electrical power is available at the installation site. Electrical utilities vary widely throughout the U.S. and the world. You will need to know the voltage, phasing and the frequency, e.g., 480 volt, 3 phase, 60 hertz.

Use the following formula to convert kW to amp draw for a 3 phase system:
for a 51kW heater at 480/3/60: $\frac{51{,}000\ \text{W}}{480\text{V}} \div \sqrt{3} = 61.4$ amps

Most ovens can be designed to operate on any electrical supply, but if multiple supplies are available, consider the following:

A. Electrical motors are an important part on most ovens. You should be aware that motors will operate more smoothly and quietly and will last longer with three phase power.

B. For electrically heated ovens, the lower the voltage, the higher the current requirements. As current increases, oven components and installation expenses increase, as well. Therefore, with the exception of smaller laboratory ovens, higher, three phase voltages should be selected whenever possible.

Also, though oven electrical wiring must conform to the National Electric Code, local codes and inspectors may require special construction or inspections by a testing laboratory or a UL listing. You should determine this early enough to incorporate local requirements before the equipment is specified.

Process Control and Monitoring

Meaningful process measurement and control is dependent upon three primary factors:

Sensor Accuracy; Controller Performance; System Dynamics

Sensor Accuracy

There are many types of temperature sensors, such as, but not limited to:

- thermistors
- thermocouples
- resistance temperature detectors (RTD's)
- optical pyrometers
- thermostatic (bimetallic) switches

Because thermocouples are the most-often used, only these will be considered in this discussion. Thermocouples come in several types. Each type has its own characteristics. Process and temperature criteria are used in selecting the proper thermocouple for a given application. The chart below lists a general application (operating) range. These are nominal and not range limits.

Type	Alloy	Operating Range	T/C Range	Std Limits of Error
T	Copper/Constantan	Low (to 550°F)	-328 to 750°F	±0.75%
J	Iron/Constantan	Medium (to 900°F)	-346 to 1400°F	±0.75%
K	Chromel/Alumel	High (to 1800°F)	-328 to 2500°F	±0.75%

Thermocouple performance is affected by:

- location, orientation
- wiring (distance, connectors, gauge, tolerances, noise)
- thermocouple construction (exposed, enclosed, wells, sheath material, gauge, etc.)
- process parameters (flow rate ... etc.)
- age (shifts due to aging)

Accuracy can be improved by using thermocouples with special tolerances and tested certification. Using the chart example, 1000°F X ±0.75% = ±7.5°F. The accuracy of the thermocouple would fall within this range, but without calibration the actual amount of error would be unknown. (Note: these error limits relate to absolute readings, not repeatability. Repeatability is normally much better than the error limits.)

Controller Performance

Modern digital temperature controllers with built-in PID tuning parameters offer seemingly precise indication and control. Three considerations are input accuracy, tuning, and output accuracy.

A. Input accuracy: The statement of controller accuracy must be carefully assessed. It may be stated as 0.2%, for example. On some controllers, this is 0.2% of the reading. On others, it is 0.2% of the selected thermocouple range. Thus, 0.2% could be either 0.2% x 1000°F = 2°F, ± 1 digit to allow for rounding in the controller, or 0.2% x 1746°F (span of type J range) = 3.49°F, ± 1 digit. This error must be added to the thermocouple error.

B. Tuning: 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.

C. Output accuracy: Output accuracy is generally less accurate than the input. For example, a 4 to 20 ma output may have a 12-bit resolution (4096) which means that the smallest increment of change in the output current is (20 minus 4) ÷ 4096, or 0.0039 ma per increment. This is generally adequate for most applications. If the final control device does not respond, the controller will automatically increment the output until the change is large enough to activate the final control device.

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

The controller and the final control device must be matched. If the final control device is a valve or other type of actuator it must have the input resolution and control capability to provide minute changes as required by the control.

A precision sensor input to a high-performance, accurately-tuned controller coupled to a sloppy control device will not provide good temperature control.

Programmable logic controllers (PLC) used for machine logic control now offer powerful and accurate control capabilities equivalent to the best discrete controllers. Most of the better PLCs offer 15-bit input accuracy (0.05%) and floating point PID algorithms. Coupled with PC-based data collection software, sophisticated control systems can be implemented to track processes and parts (using bar codes or other equipment) and perform logic functions based on the measured process variables.

The PC-based Supervisory Computer and Data Acquisition Systems (SCADA) and operator interfaces offer graphical process representations, data collection, and process control tools. The data can be exported to spreadsheets or other analysis tools, printed in any format, or archived on any media. It also allows networking and process monitoring from remote supervisory computers. On some systems, computers now drive all control functions without the use of PLC's.

System Dynamics

The physical construction or dynamics of the controlled oven or furnace system has enormous impact on the performance of the control system. A carefully-chosen highly-accurate control system cannot compensate for a poorly designed oven system.

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. Nothing can be done to improve the performance short of improving the mechanical characteristics of the system, which may not always be possible.

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.

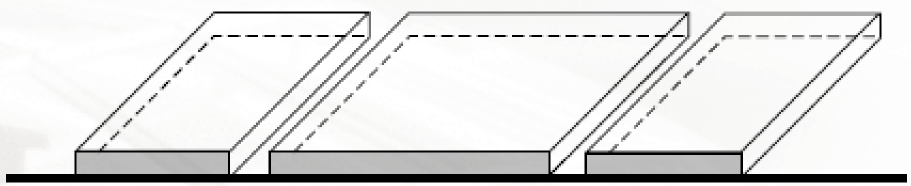
Floors

A wide variety of floor types are available. You'll need to consider what's best for your application. Many ovens have a metal panel floor for surface mounting as a standard feature. Others can be recessed into the existing factory floor, or surface mounted with insulating cement. Still others may be reinforced panel type floors, floors covered with steel plate or floors with embedded channel tracks. Floors incorporating exposed insulating cement are not recommended when the process is dust-sensitive. NFPA 86, Section 2-1.5 requires insulated floors for temperatures over 300°F (149°C). However, Despatch recommends insulated floors for temperatures over 200°F (93°C).

Special floors like calcium silicate insulating board provide the required insulating properties while saving on installation by eliminating the need for pouring an insulating cement floor.

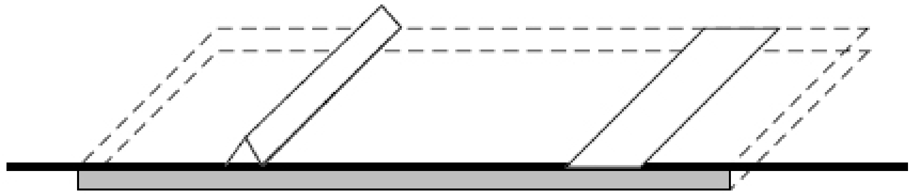
Truck loaded ovens use an insulated floor with recessed channel tracks or rails to guide the truck into position. The weight of the truck and load is actually supported by the factory floor. Oven floors without recessed tracks, such as a panel floor, can be used for loads that are forklift loaded. However, this floor type requires reinforcing based on the load configuration.

Floor Configurations

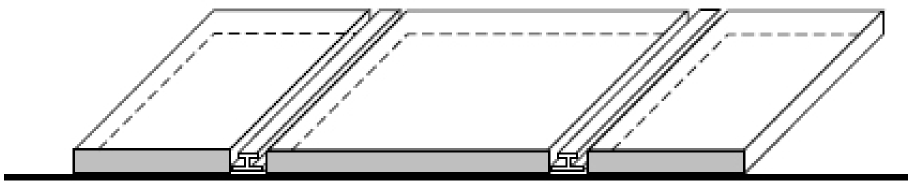


Surface mounted, metal panel or insulating cement

Recess mounted, insulating cement and 1/4" steel plate



Recess mounted, insulating cement and 1/4" steel plate with V grove track on plate



Recess mounted, with rails recessed in insulating cement

Oven Construction

Generally, a well constructed oven will be of a type 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, easily readable controls, 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, cleanability 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.

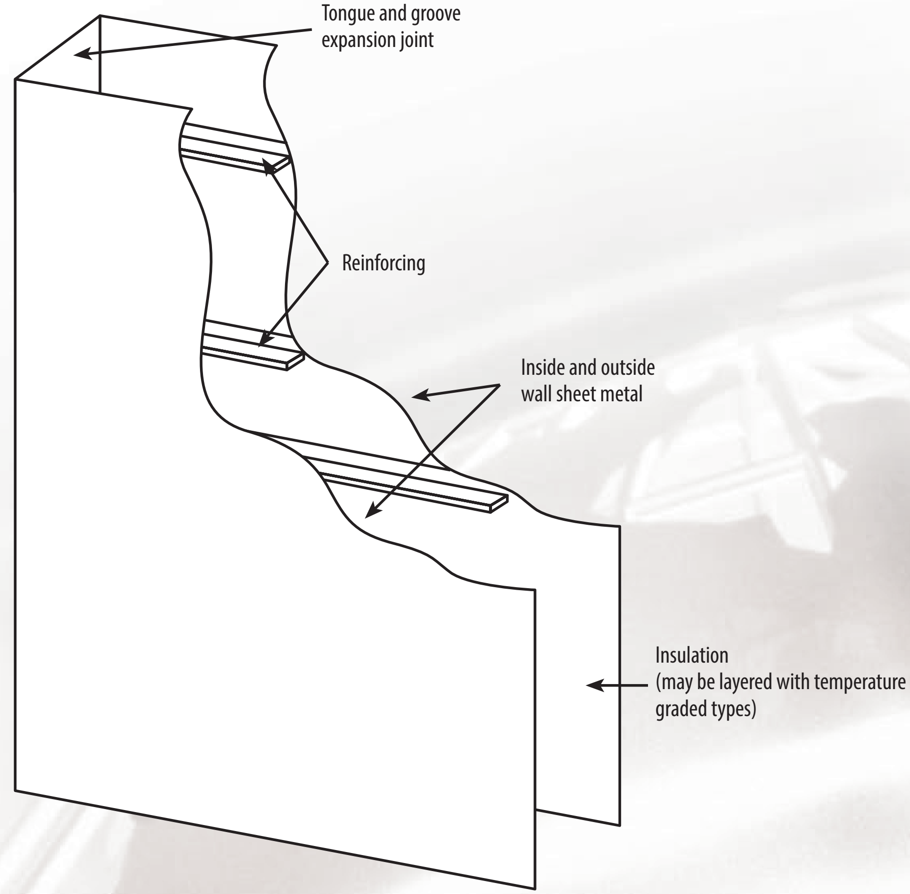
Mild steel interiors with corrosion resistant aluminum/silicone paint are acceptable for drying above 212°F (100°C) and for general non-corrosive heating/curing operations.

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. Number and type of expansion joints used will be affected by these as well. As indicated in the discussion under uniformity, 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. Recirculating High Efficiency Particulate Air Filters (HEPA filters) can be combined with the proper oven and process design to allow state-of-the-art particle control, typically much better than Class 100 particle levels. 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 fiber glass 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.



Sectional view of oven wall

Facility Considerations

Several facility considerations are critical to the successful installation of your processing oven. Be sure the power supply is correct for the application and that it is conveniently located. The same holds true for water drains, air and water supplies (volume and pressure). Check to see if there are any facility restrictions at the location and be certain that there is proper access clearance to bring an oven into the facility.

Testing and Proving Your Process Before an Equipment Purchase is Made

If at all possible, work with Despatch test facilities to help confirm expected results. Many ovens are unique pieces of equipment for a specific job. It may not be enough that a manufacturer has built many ovens. It may be necessary to prove that a specific oven design will work before it is built.

Further, Despatch may be able to actually improve process technologies already in place. The conceptualizing and testing of new heat processing methods is a sign of innovation and capability in the industry. If possible, visit vendor facilities to determine their level of commitment in the area of innovation.

Most of the Fortune 100 Industrial Companies have used the Despatch Innovation Center for testing and process development before making a purchase commitment. You and any of your colleagues are welcome to utilize the same expert technical information and process solutions provided here. To get immediate engineering help selecting the most cost-effective heat process solution for your application, call an experienced engineer or product specialist at Despatch.

If you find this guide helpful, or if you have suggestions or questions, please contact us. If you would like a general catalog and a Despatch capabilities brochure, go to our website or write to us. Our worldwide offices contact information can be found on the back of this guide.

Insurance Requirements

FM (Factory Mutual) or IRI (Industrial Risk Insurers) are the standard underwriters for factory equipment. If you need equipment to meet specific insurance requirements, it is important to determine this early in the buying cycle. Many manufacturers of ovens provide equipment that will meet FM or IRI requirements and approval is fairly straightforward. Also, oven manufacturers can submit the forms and drawings and obtain the approval for you.

Safety Issues

Safety is of great concern when considering oven design alternatives. Fires, explosions, bodily injury or even death may result from improper operation. Therefore, most ovens are designed for a specific process and should never be used for another process or with different parameters. For other safety issues, see the discussions on Class A ovens and ovens in hazardous areas.

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