# Chapter 13

# Drying Oven

| | | | |
|---|---|---|---|
| GMDN Code | 21086 | | 21087 |
| ECRI Code | 21-086 | | 21-087 |
| Denomination | Oven, laboratory | | Oven, laboratory, forced-air |

The drying oven is used in the laboratory for drying and sterilizing glass and metal containers. Manufacturers have developed several types of drying oven for that purpose: some operate by natural convection or by forced convection, others by gravity convection. In general, the ovens operate between room temperature and 350 °C. They are also known as *hot air oven*, or *poupinel* or *pupinel*.

## PHOTOGRAPH OF DRYING OVEN

Photo courtesy of Cole-Parmer Instrument Co.

## PURPOSE OF THE OVEN

The drying oven is used for sterilizing or drying glassware and metal materials used for examinations or tests performed in the laboratory. Dry heat sterilization of clean material is conducted at 180 °C for two hours in the oven. Upon being heated by high temperature dry air, humidity is evaporated from glassware and thus the possibility of any remaining biological activity is eliminated.

## OPERATING PRINCIPLES

Generally, drying ovens have an internal and an external chamber. The internal chamber is made of aluminium or stainless steel material with very good heat transference properties. It has a set of shelves made of stainless steel grids so that air circulates freely around objects requiring drying or dry heat sterilization. It is isolated from the external chamber by insulating material which maintains high temperature conditions internally and delays the transference of heat to the exterior. The external chamber is made of steel laminate, covered with a protective film of electrostatic paint. Heat is generated through sets of electrical resistors transferring this thermal energy to the chamber. These resistors are located in the lower part of the oven and heat is transferred and distributed by natural or forced convection (in oven with internal ventilators).

The power (energy by a unit of time) dissipated by an electrical resistor can be calculated by means of the following equation:

$$P = I^2R$$

Where:
I = Intensity of the electric current in amps [A]
R = electrical resistance in ohms [Ω]

Given that the energy is neither created nor destroyed but transformed, it is possible to calculate the thermal energy equivalent to the resistive elements. In the case of a resistive wire, the quantity of heat [q] dissipated can be calculated by the following equation[1]:

$$I^2R = \dot{q}\pi r_0^2 L$$

Where:
R = resistance of resistive wire
I = intensity of the electrical current
$r_0$ = outer radius of the wire
L = length of the resistance wire
$\dot{q}$ = is the heat generated per unit volume

Resistance [R] can be calculated by the following equation:

$$R = \rho \frac{L}{A}$$

Where:
ρ = resistivity of the resistor's material
A = surface of the resistance wire

The oven has a metallic door with its own thermal insulation equipped with a similarly insulated handle to prevent burns on hands. The door is installed on the front part of the oven by a set of hinges which allow it to open at a 180° angle.

The modern oven is controlled by a module with a microprocessor. It allows selection of the equipment's operation parameters and its alarms; and the programming of cycles or thermal processes through which are controlled, not only the temperatures but also the way in which they need to vary in time through phases of heating/cooling (natural) or through stable temperatures maintained within certain time intervals. Ovens operate normally from room temperature up to 350 °C. Some models have limited ranges of operation. Older ovens simply have a set of resistors, whose operation is controlled by a thermostat.

The following table features the temperature/time relationship required for dry heat sterilization in drying ovens.

**Table of temperature/sterilization time by dry heat**

| Temperature °C | Time in minutes[2] |
|---|---|
| 180 | 30 |
| 170 | 60 |
| 160 | 120 |
| 150 | 150 |
| 140 | 180 |
| 121 | 360 |

## INSTALLATION REQUIREMENTS

In order to be used, the drying oven requires the following:

1. A large, strong, levelled work table.
2. Free space of at least 5 cm around the oven and enough space to place the material to be processed.
3. An electrical outlet with a ground pole of appropriate size for supplying electrical power to the oven. It must be in good condition and comply with the national or international electrical standards used in the laboratory and must not be more than 1 m away from the equipment. The typical voltage used is 110 V or 220 V/60 Hz.
4. Verifying that the electrical circuit has the necessary protection devices for guaranteeing an adequate electrical feed.

## OVEN OPERATION

A series of precautions must be taken into account for the correct operation of the oven. Among the most important are the following:

1. Do not use flammable or explosive materials in the oven.
2. Avoid spills of acid solutions or corrosive vapours inside the oven to prevent corrosion of the surfaces and interior shelves.
3. Use personal protection elements (insulated gloves, safety glasses and tongs for placing or removing substances or materials inside the drying oven).

### Operation routine

In general, the following procedure is performed:

1. Activate the main switch, pressing the button usually identified by the symbol [I].
2. Press the key identified as *Program*.

[1] This example of heat transference equation is for a wire-type resistor of circular shape. For other shapes, different equations must be used.
[2] Time is counted from the moment that the corresponding temperature is reached.

3. Select the operational temperature by pressing the key marked by the sign (+) until the selected temperature appears on the screen. The oven will start the heating process until reaching the selected temperature.
4. For programmable ovens, instructions must be followed as defined by the manufacturer for setting additional parameters such as time, types of warming and alarms.

## OVEN CONTROLS

A diagram of controls regulating modern drying ovens is shown in Figure 37. It is possible to identify the following elements:

1. The main switch.
2. Screens for controlling the current and selected temperatures.
3. The parameter selection button (menu).
4. The button for programming operation cycles.
5. Buttons for increasing and decreasing the temperatures.

Each manufacturer supplies detailed instructions to operate these controls. In general, they are located on the lower part of the oven and are cooled by a ventilator which circulates ambient air inside the assembly space where other electronic components are installed.

### Electric circuit

Figure 38 shows the basic electrical circuit of the drying oven. The following elements are outlined:

1. ***Main switch.*** It energizes or turns off the oven.
2. ***Control.*** It controls the oven's functions (temperature, time, type of heating and cooling, selected operation modes such as preheating, sterilization, dehydration, preparation, drying and even baking).
3. ***Resistors.*** Heating elements transforming electrical energy into thermal energy.
4. ***Indicator systems.*** Devices complementing the general control. These indicate if the oven is ON and in operation.

**Figure 37.** Electronic control of the oven

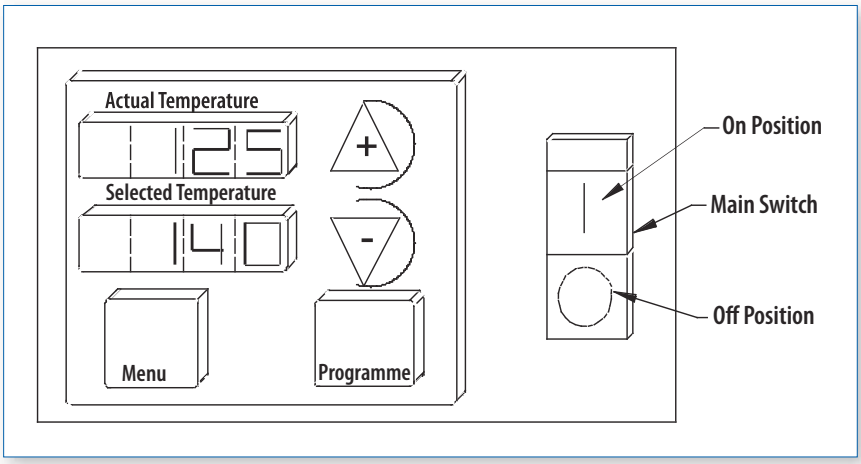
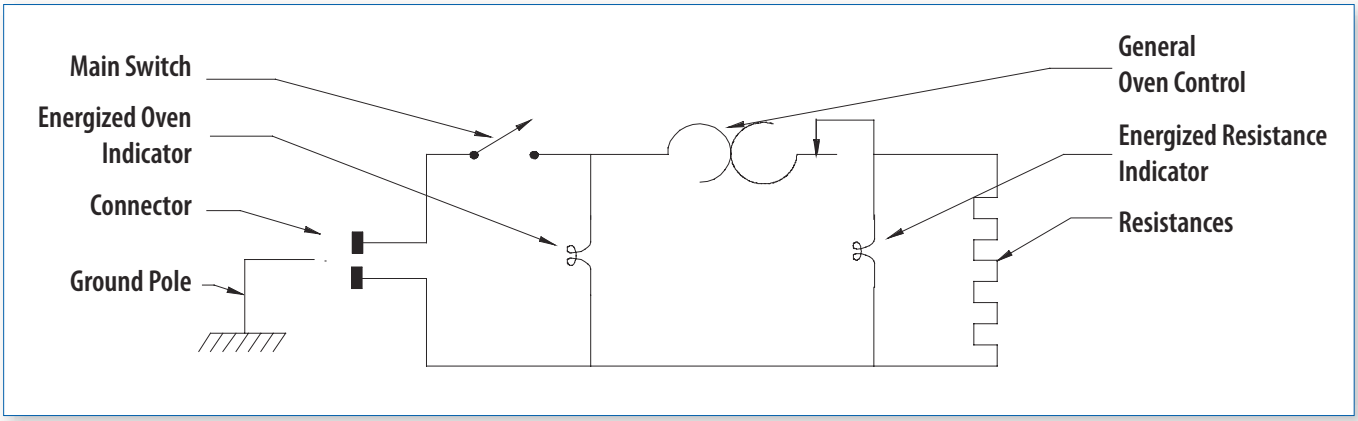



**Figure 38.** Electric circuit of the oven



## QUALITY CONTROL

Quality control of drying ovens is slightly demanding since sterilization by dry heat has temperature and time as critical parameters. Generally, spores of *Bacillus subtilis* (Niger variety) are used as biological indicators. These must be incubated for several hours after the sterilization process. The initial spore load of the biological indicator ranges between $5 \times 10^5$ and $1 \times 10^6$. The effectiveness of the cycle depends on the diffusion of heat, its amount available and the amount lost. Its microbicidal action is affected by the presence of organic material or filth on the article. Sterilization by dry heat must be limited to materials which cannot be sterilized in autoclaves.

## ROUTINE MAINTENANCE

The maintenance required by a drying oven is simple and no complex routine maintenance is necessary. General maintenance routines to carry as necessary are described next. The procedures vary depending on the type of oven and designs from different manufacturers.

**Warning:** Before carrying out any maintenance routine on the oven, verify that it is at room temperature and disconnected from the electrical feed outlet.

### Access to electronic components

**Frequency: Whenever necessary**

The oven's electronic components are usually located in its lower part. In order to be able to check them, proceed as follows:

1. Disconnect the oven from the electrical feed outlet.
2. Move the oven forward until the front part of the base is aligned with the edge of the working space.
3. Place two wedges of approximately 3 cm in thickness below each front support. This will elevate the front part of the oven and facilitate the inspection of electronic elements once the lower cover is removed.
4. Remove the screws securing the lower cover and lift it. Next, check the electronic control components. In general, the following elements are located in this compartment.
   a) The programmable control panel
   b) A safety release
   c) The main switch and circuit breaker (combined)
5. Replace the cover once checking has been completed.

### Changing of the heating resistors

**Frequency: Whenever necessary**

The procedure explained next must be performed by personnel with a good knowledge of electricity.

1. Disconnect the oven from the electrical feed outlet.
2. Remove the thermometer from the upper part of the chamber.
3. Open the door and remove the shelves.
4. Disconnect the thermometer's probe.
5. Remove the screws that secure the lower panel.
6. Remove the lower panel.
7. Remove the screws that secure the resistor's electrical feed cables and disconnect the terminals fastening these to the resistors.
8. Remove the screws that secure the resistors as well as the external resistors.
9. Install new resistors with the same characteristics as the originals.
10. Reinstall the parts and reconnect the electrical components.

### Changing the cooling ventilator

**Frequency: Whenever necessary**

To change the cooling ventilator (generally located in the lower part), these procedures must be followed:

1. Proceed as explained for opening the electronic compartment.
2. Disconnect the ventilator's electrical feed terminals.
3. Undo the screws that secure the ventilator.
4. Install a ventilator with the same specifications as the original; connect the wires feeding the ventilator to the terminals.
5. Replace the protective cover.

### Changing of the door gasket

**Frequency: Whenever necessary**

The door's gasket is usually made of silicone.

1. Turn off the oven and open the door.
2. Loosen the safety devices that keep the gasket in place.
3. Remove the gasket using a screwdriver for disengaging it from the retention guide. Avoid using excessive force which can distort the housing.
4. Install the replacement gasket starting from the upper part. Next, move the rest of the gasket towards the sides, securing it with the assembly elements which fasten it to the door. Finish the procedures on the lower part of the door in the same fashion.

### Changing of the thermocouple

**Frequency: Whenever necessary**

1. Open the electronic control compartment.
2. Remove the thermocouple's connecting cables from their connection points on the control card.
3. Loosen the thermocouple assembly from the upper part of the oven. Move it towards the front part until a free length of at least 15 cm of connector cable is left exposed.
4. Cut the cable from the thermocouple to remove its wrapping.
5. Secure the cut ends of the defective thermocouple with the cables from the replacement. Use tape to prevent these from becoming loose.

6. Gently pull the defective thermocouple outside of the electronic compartment while keeping the electric wiring attached to use as a guide during its replacement
7. Disconnect the wires of the old thermocouple and place those of the new thermocouple into their respective connection terminals. Check that the original polarity is maintained.
8. Reassemble the protective cover.

### Changing of the door hinges

**Frequency: Whenever necessary**

To change the door hinges, proceed as explained next:

1. Open the door and lift it from the hinges.
2. Remove the assembly screws of the defective hinges.
3. Remove the defective hinge(s).
4. Put the new hinge(s) in place and tighten with the assembly screws.
5. Reinstall the door.

**TROUBLESHOOTING TABLE**

| PROBLEM | PROBABLE CAUSE | SOLUTION |
|---|---|---|
| There is no power to the oven. | The oven is not connected. | Connect the oven to the electrical outlet. |
| | The main switch is off. | Activate the start switch. |
| | The circuit breaker is defective. | Change the circuit breaker. |
| | The control card is defective. | Substitute the control card. |
| | The connector cable is defective. | Check/repair connector cables. |
| Erratic elevated temperature. | The thermocouple is defective. | Substitute the thermocouple. |
| | The control is defective. | Substitute the control. |
| The oven shows heating errors. | A temperature lower than that selected. | Change the temperature selection. Wait until it reaches the selected temperature. |
| | The thermocouple is defective. | Substitute the thermocouple. |
| | The heating resistor is defective. | Substitute the heating resistor. |
| | The relay is defective. | Substitute the relay. |
| | The control is defective. | Replace the control. |
| The screen displays the message "open". | The thermocouple circuit is open. | Verify the thermocouple connection or substitute the thermocouple. |

## BASIC DEFINITIONS

**Circuit breaker.** An electrical control device which allows a piece of equipment or a device to be ON or OFF. It is also called a switch.

**Electric Thermocouple.** A device used for accurate measurement of temperature. It consists of wirings of two different metals joined together at one end, producing a small voltage proportional to the difference in temperature between the two ends. This phenomenon is known as the "Seebeck effect" in honour of its discoverer, the German physician Thomas Seebeck.

**Heat.** A form of energy transferred from one system at a given temperature to another at a lower temperature by means of the difference in temperature between the two. When a system of great mass [M] is put in contact with another of small mass [m'] at a different temperature, the resulting temperature is close to the initial one of the greater mass system. It is said, then, that a quantity of heat ΔQ has been transferred from the system of higher temperature to that of lower temperature. The quantity of heat ΔQ is proportional to the change in temperature ΔT. The proportion constant [C] or heat capacity of the system, allows the following relationship to be established: $\Delta Q = C\Delta T$, which infers that one of the consequences of the change in temperature in a system is heat transference.

**Resistance.** Opposition that a material or electrical circuit imposes to the flow of electric current. It is the property of a circuit that transforms electrical energy into heat as it opposes the flow of current. The resistance [R], *of a body of uniform section such as a wire, is directly proportional to the length [l] and inversely proportional to the sectional area [a]. The resistance is calculated by the following equation:*

$$R = k \times \frac{l}{a}$$

Where:
k = constant that depends on the units employed
l = Length of the conductor
a = sectional area of the conductor

The ohm (Ω) is the common unit of electrical resistance; one ohm is equal to one volt per ampere.

**Thermostat.** A device which regulates the temperature of a system. It usually operates by expansion of one of its components which mechanically activates another element, for example a switch which controls a particular function.