Chapter 18

Refrigerators and Freezers

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ECRI Code	13-315	15-170	17-157	15-171	22065	15-145
Denomination	Refrigerators	Biological refrigerators	Laboratory refrigerators	Blood bank refrigerators	Freezer, laboratory, ultralow	Freezer, laboratory

REFRIGERATORS AND FREEZERS

Refrigerators and freezers are among the most important pieces of equipment in laboratories. They maintain a temperature controlled (refrigerated) environment for various fluids and substances. At lower temperatures, less chemical and biological activity is present so that fluids and substances are better preserved. To achieve this, the temperature of the refrigerated storage unit needs to be lower than ambient temperature. In the laboratory, different kinds of refrigerators and freezers are used. They can be grouped by temperature ranges:

- Conservation refrigerators in the range of 2 to 8 °C.
- Low temperature freezers in the range of –15 to –35 °C.
- Ultralow temperature freezers in the range of –60 to –86 °C.

A unit with appropriate functions must be selected depending on the activities carried out in the laboratory. For example: if it is necessary to conserve whole blood, it will be appropriate to use a Blood bank refrigerator which provides temperatures between 2 and 8 °C. On the other hand, if it is required to conserve a particular viral or microbial stock, an ultralow temperature freezer is required. Refrigerators and freezers are essential for conserving biological substances and reagents. This chapter deals with the operational and maintenance aspects of the conservation refrigerators and ultralow temperature freezers.

PHOTOGRAPH OF A REFRIGERATED STORAGE UNIT

Photo courtesy of Cole-Parmer Instrument Co.

PURPOSE OF REFRIGERATED STORAGE UNITS

Refrigerators and freezers are used for the conservation of blood and its derivatives, biological liquids and tissues, reagents, chemicals, and stocks. In general, the higher the temperature the more chemical and biological activity is present. By reducing temperature, one can control the effects on the composition and structure of substances to be preserved. In the laboratory, systems of refrigeration are used for conserving substances such as reagents and biological elements which would otherwise decompose or lose their properties. Refrigeration, as a technique offers conditions which renders possible the conservation of elements such as blood and its derivatives needed for diagnosis, surveillance and for providing health services. It is possible to achieve extremely low temperature ranges, such as those used for master stocks conservation (–86 °C) or temperatures within the range of 2 and 8 °C, which is sufficient for conserving reagents and diverse biological products.

OPERATION PRINCIPLES

Refrigerators and freezers function according to laws of physics regulating the energy transfer where temperature differences exist. From the second law of thermodynamics it is known that, if thermal energy needs to be transferred from a point with low temperature to another with high temperature, a mechanical task needs to be carried out. Modern refrigerators and freezers are thermal systems which function mainly using a cycle called *compression*, where refrigerant gas with special properties achieving heat transference is used. This chapter focuses on explaining how refrigerators and freezers using compression operate.

Refrigeration circuit

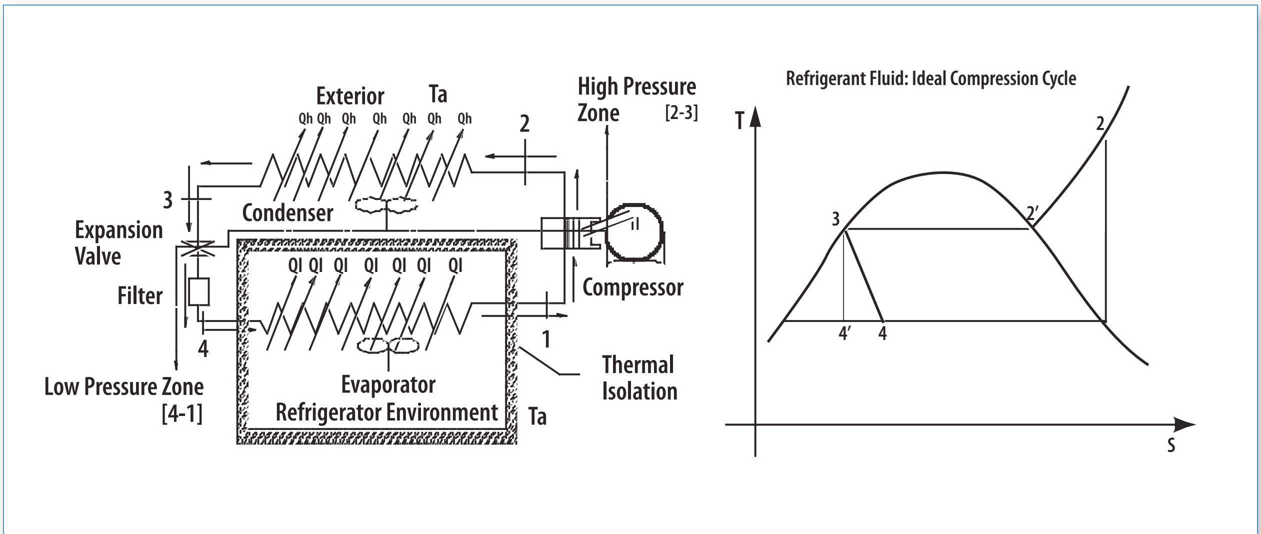
The basic circuit shown in Figure 56 demonstrates how a refrigerator functions. On the left side it is possible to distinguish the following components: evaporator, condenser, compressor, expansion valve, filter and interconnection tubing. Within each one of these components, refrigerant gas circulates.

On the right side of the figure is shown a graph of temperature [T] versus entropy [S], which demonstrates the functioning of an ideal[1] refrigeration cycle. The numbers on the basic diagram on the left show points of the adiabatic processes (compression [1-2] and choking [3-4]) and the processes involved in heat transference (in the evaporator – refrigerated environment [4-1], in the condenser [2-3] on the exterior). The complete cycle is described as the sequence of processes [1-2-3-4-1].

Evaporator. Contains a network of channels through which the refrigerant gas circulates. In the evaporator, a process of heat transference [Ql] occurs at a constant pressure. In order for the refrigeration process to occur, the environment to be refrigerated must be surrounded by a system of thermal isolation. This is to prevent thermal energy from entering the evaporator's zone of influence at the same rate as the refrigerant gas absorbs it. The refrigerant gas enters into a liquid phase in the evaporator by point [4] (ideal) or [4'] (real) and while it passes through the network of evaporator channels, it absorbs heat [Ql] and progressively transforms into vapour. When the refrigerant gas reaches point [1], it is under the form of vapour. It is then suctioned by the compressor through a tube or line.

[1] The real cycle differs from the ideal cycle by some irreversible processes not indicated in the graph for the sake of clarity and simplicity.

Figure 56. Refrigeration circuit



Compressor. Usually propelled by an electric motor, the compressor suctions the vaporized refrigerant from the evaporator (saturated) at low pressure and by means of a piston or set of pistons, exercises a process of reversible adiabatic compression on it (without heat transfer) between points [1-2]. Upon being discharged from the compressor, the vapour is hot as a result of the compression process and is delivered to the condenser in point [2].

Condenser. Similar device to the evaporator, which has a network of channels through which the refrigerant gas circulates. As the temperature of the refrigerant is higher than ambient temperature [Ta], a heat transference process [Qh] is produced from the refrigerant to the environment at constant pressure. To facilitate heat transference, the condenser tubes have thin fins which increase the transfer surface. As heat continues to be lost [Qh] as a result of the process of transference, the refrigerant returns to its liquid phase until it reaches point [3] as saturated liquid where it enters the expansion valve.

Expansion valve. Allowing the refrigerant to flow in a controlled manner, the valve exercises a resistance on the passage of the refrigerant to avoid any heat transference by an adiabatic process. As a result, the pressure in the valve is reduced in a drastic way in point [4]. A filter is generally installed at the exit of the expansion valve. Some manufacturers replace the expansion valve by a capillary tube which has an equivalent restrictive effect on the passage of the cooling fluid.

Filter. Retains humidity and impurities which may be present in the refrigerant. At the back of the filter, the system is connected again to the evaporator at point [4] and the cycle described is repeated.

Liquid collector. Sometimes placed by manufacturers before the refrigerant enters the compressor. Its purpose is to retain any portion of that fluid in liquid phase to guarantee that only vaporized refrigerant gas enters the compressor (not shown in the refrigeration diagram).

Thermal insulation. Set of materials with the property of slowing heat transference. Its function consists of preventing thermal energy from the environment to reach the refrigeration area at the same rate as the system extracts the internal thermal energy. All refrigeration equipment has adequate thermal isolation for this purpose. Among the most commonly used insulation materials are polyurethane foam and glass wool. Similarly, it is customary to manufacture interior surfaces in materials such as ABS plastic.

Service valves. Valves used for loading the refrigeration circuit with refrigerant gas. By means of these valves, the draining and filling systems are connected so that the refrigerated storage unit operates according to specifications established by the manufacturer. Only the manufacturer and specialized technical personnel have access to these valves (not indicated in the refrigeration diagram).

Thermal protector. This is a protective device which is activated and disconnects the compressor in case overloads affecting the bobbins in the compressor's field occur (It pertains to the electrical system and is not indicated in the refrigeration system's diagram).

Note: The evaporator, as well as the condenser are made of materials with good thermal conduction properties such as aluminium [Al] and copper [Cu]. To improve heat transference, ventilation systems which induce forced convection processes have been incorporated. To attain the different temperatures (refrigeration) required in laboratories or in the industry, manufacturers have developed diverse designs and refrigerants for the targeted results.

INSTALLATION REQUIREMENTS

For their functioning refrigerators and freezers require the following precautions:

1. An electrical connection with a ground pole appropriate to the voltage and frequency of the equipment. In general depending on their capacity, refrigerators and freezers can be obtained in versions with 115 V, 60 Hz and 220-240 V, 50 Hz. Electrical connections complying with international and national electric standards used in the laboratory must be anticipated.
2. If more than one unit installed depend on the same electrical circuit, it must be verified that the capacity (electrical power) and safety devices are adequate for supplying the amount of power required by these units.
3. Directly connect the unit to the electrical outlet. Never connect a unit to an overloaded electrical outlet or one with voltage deficiencies. Avoid the use of electrical extensions. The electrical outlet must not be more than 2 m from the unit.
4. Install the unit on a levelled surface, leaving free space around the equipment. Refrigerators and freezers have a levelling system at their base which allows them to adjust to small differences in level of the floor. It is customary to leave a free space of 15 cm at the sides and at the back of the unit to facilitate ventilation of the condenser.
5. Avoid installing the unit under direct sunlight or near a heat source such as radiators or heaters. Remember that the greater the difference in temperature is between the environment and the condenser, the more efficient will the heat transference be.

REFRIGERATOR CONTROL CIRCUIT

The scheme in Figure 57 is a typical control circuit installed in refrigerators and freezers. Its purpose is to give an idea of how their diverse subsystems are interrelated. The control circuit of each model varies according to the characteristics incorporated by the manufacturer.

The following are featured as central components:

1. The main switch. It energizes the refrigerator.
2. The door switch. It turns on the light when the door is opened.
3. The compressor.
4. The evaporator's ventilators.
5. The defrosting subsystem. The switch, resistors, temporizer (5, 5', 5", 5"', 5"").
6. The resistor subsystem for defrosting or maintaining the equipment's components free from ice.
7. The thermostat.

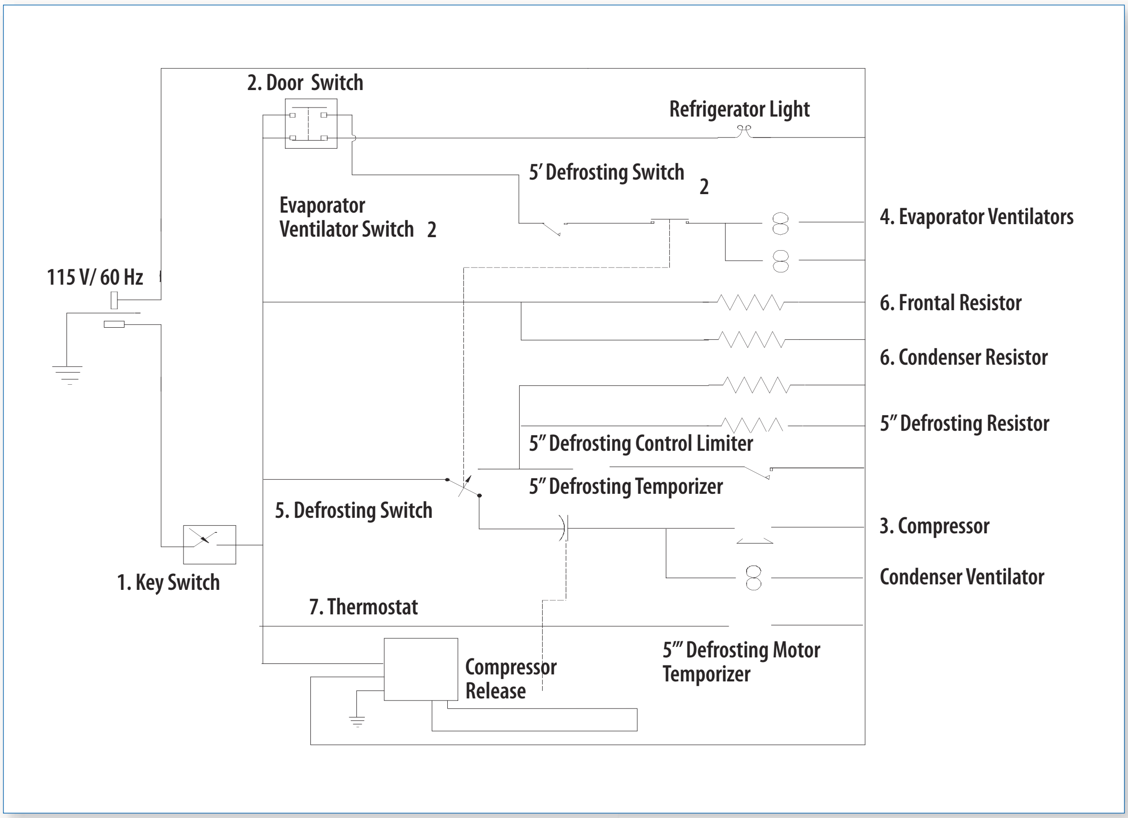
REFRIGERATOR OPERATION

Conservation refrigerators

The operation of conservation refrigerators is generally very simple. Each manufacturer gives basic recommendations. Some of these are highlighted below.

1. Connect the refrigerator's electrical feed cable to an electrical outlet equipped with a ground pole and the capacity to supply voltage at the required power.
2. Activate the on switch. Some manufacturers place key switches on refrigerators. Wait for the refrigerator to reach the operating temperature before storing any product. The manufacturers adjust the temperature of refrigerators at approximately 4 °C.
3. Select the temperature at which the alarm must be activated. Follow the instructions provided by the manufacturer.
4. Load the refrigerator according to the capacity established by the manufacturer.

Figure 57. Control circuit of the refrigerator



5. Distribute the load homogeneously inside the refrigerator. The temperature uniformity depends on the free circulation of air within the refrigerator.
6. Avoid opening the door for long periods of time in order to prevent thermal energy and humidity (from the air) from entering into the refrigerated environment. This forms ice and increases the working temperature of the refrigeration system. Open only for placing or removing stored elements.

Conservation refrigerator controls

A diagram of a recently developed control for conservation refrigerators (e.g. a Blood bank refrigerator) is shown in Figure 58.

The following controls can be seen in the diagram:

1. A main switch, activated by a key
2. Open door, low battery and abnormal technical condition indicators
3. Buttons for adjusting parameters
4. Display screen

REFRIGERATOR ROUTINE MAINTENANCE

Refrigerators are generally not very demanding from a maintenance perspective, although demanding with regards to the quality of the electrical feed systems. If connected to good quality electrical circuits and good ventilation flows around the unit, they can function for years without specialized technical service. The refrigeration circuit is sealed during manufacturing and does not have components requiring routine maintenance. The most common maintenance routines are described next. Consult WHO's *Manual on management, maintenance and use of cold chain equipment, 2005*, for care and preventive maintenance schedules specific to Blood bank refrigerators, plasma freezers and walk-in refrigerators and freezers used in the blood cold chain.

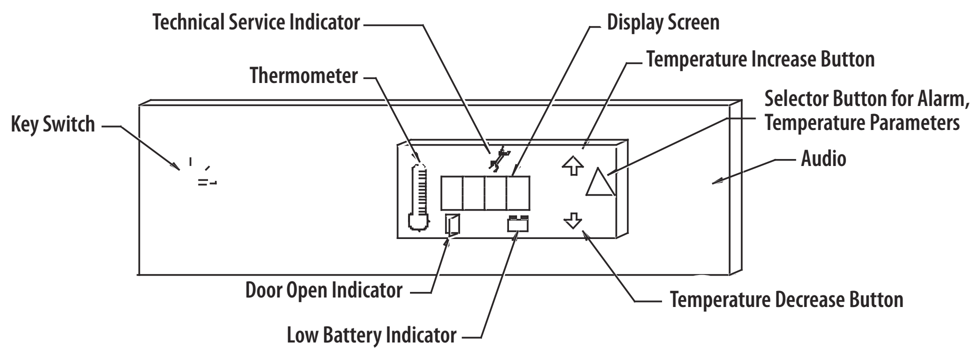
Cleaning the interior

Frequency: Every quarter

1. Verify that the refrigerator's inner shelves are clean. These are generally made of rust proof metallic mesh. Before cleaning, any material which can interfere must be removed from the refrigerator. Move the empty shelves towards the front. Dampen a piece of cloth with a mild detergent and apply by rubbing surfaces gently. Dry and place in their original position.
2. If the refrigerator has drawers, cleaning is done the same way. Empty the drawers and dismount from the adjustment devices. Remove them from the refrigerator.
3. Once the shelves and drawers are dismounted, clean the interior walls of the refrigerator, using a mild detergent. Dry before mounting the internal accessories.
4. Apply a mild detergent with a damp piece of cloth to the drawers. Rub carefully. Dry the drawers and put them back on their mounts in the refrigerator.

Warning: Avoid using steel wool or other abrasive materials for cleaning the shelves and drawers. Avoid using gasoline, naphtha or thinners, as these damage the plastic, the packing or the paint on the surfaces.

Figure 58. Blood bank refrigerator controls



Cleaning of the condenser

Frequency: Every six months

1. Disconnect the electrical feed cable.
2. Verify the position of the condenser. Manufacturers usually place it at the lower back of the equipment. In some refrigerators, it is installed on the top part.
3. Remove the condenser's protective grids and the protective filter (not all manufacturers provide a filter).
4. Remove the dust and grime deposited on the surface of the condenser. Use an aspirator equipped with a suction brush. Run it over the entire surface of the condenser to remove grime or accumulated dust. Verify that the tubes' surfaces as well as those of the heat conducting wings are clean. Vacuum the filter as well (if present).
5. Replace the cover.
6. Connect the refrigerator to the electrical connection.

Warning: If the condenser is not clean, this will interfere with the heat transference process and the refrigerator could "heat" or function at temperatures different than selected.

The door gasket verification

Frequency: Quarterly

The door gasket is a component which must stay in a good condition for the unit to work correctly. To verify its condition, one must proceed according to the following steps:

1. Open the door.
2. Insert a strip of paper of about 5 cm in width between the door gasket and the edge of the refrigerator's body where the gasket is housed.
3. Close the door.
4. Pull the paper gently from the exterior. The paper must put up resistance when being moved outwards. If the paper can be moved without resistance, the gasket must be substituted. Perform this procedure on 10 cm of gasket at a time around the entire gasket housing.

Warning: A door gasket in bad condition produces various problems in the functioning of cooling units:

1. It allows humidity to enter which condenses and freezes inside the evaporator.
2. It increases the time needed by the compressor for maintaining the selected temperature.
3. It affects the storage temperature.
4. It increases the operational costs.

Defrosting

Frequency: Every six months

Many modern freezers have automatic cycles for defrosting the evaporator in order to avoid frost accumulation. Normally, these cycles are done with a set of electrical resistors which rapidly eliminate the frost present. Some models do not have defrosting cycles and the process is done manually on a scheduled basis. The following are the recommended procedures for defrosting.

1. Verify that the thickness of the frost is more than 8 mm.
2. Remove the contents of the compartments.
3. Disconnect the freezer.
4. Leave the door open.
5. Remove the water while it is accumulating in the compartments. Use a sponge or a piece of absorbent cloth.
6. Place a towel to avoid the melting ice from wetting the front and interior part of the refrigerator.

Warning: Never use sharp elements to remove ice or frost from the evaporator. Such an action can perforate the wall of the evaporator and allow the refrigerant gas to escape causing a serious defect which can only be repaired by a specialist.

TROUBLESHOOTING TABLE		
PROBLEM	**PROBABLE CAUSE**	**SOLUTION**
The unit is not functioning.	Blown fuse.	Check fuse.
	The equipment is disconnected.	Verify the unit's connection.
	There is no or low electricity in the feed circuit.	Test the electrical connection.
		Verify the main switch (breaker).
The freezer is functioning continuously but is not cooling.	The thermostat is adjusted too high.	Confirm the adjustment of the thermostat.
		Adjust the thermostat to a lower temperature.
	The unit contains excessive frost.	Defrost the unit.
The unit is showing fluctuations in temperature.	The temperature control is not calibrated.	Calibrate the operational temperature according to the procedure defined by the manufacturer.
	The condenser is dirty.	Clean the condenser according to the procedure cited in the maintenance routines.
The unit shows a high temperature.	The door is open.	Verify that the door is well adjusted and closed.
	Poor door seal.	Level cabinet and adjust door seal or replace gasket.
	There is a defect in the electrical feed.	Confirm that the electrical connection functions correctly.
	A warm load (liquids or solids) was placed inside the unit.	Wait for the unit to cool the load.
	The compressor is not functioning.	Verify the functioning of the compressor.
		Test to see if one of the alarms is on.
	The compressor is functioning but there is no ice in the evaporator.	Verify if the evaporator's ventilators are functioning.
	The compressor is functioning, but there is no ice in the evaporator and the evaporator's ventilators are functioning well.	A complete verification of the refrigeration system is required. Call in the specialized service technician.
	Low refrigerant gas level.	Call in the specialized service technician.
Upon operating the unit, noises similar to clicking sounds can be heard.	The compressor's thermal protector has been disconnected.	Verify that the feed voltage is correct.
Noisy operation.	Floor not stable or cabinet not levelled.	Move to an adequate floor area or adjust casters as appropriate.
	Drip tray vibrating.	Adjust tray or cushion it.
	The cooling fan hitting cover or compressor is loose.	Call in the specialized service technician.
The compressor runs continuously.	Not enough air circulation around the unit.	Move the unit to provide with sufficient clearance. Relocate if necessary.
	Faulty thermostat.	Call in the specialized service technician.
	Poor door seal.	Check seals and adjust.
	Room too warm.	Ventilate the room appropriately.
	The door is being opened too often or is not closed.	Restrict door opening or close door.
	The light switch is defective.	Check if light goes out after the door is shut.

OPERATION OF ULTRALOW FREEZERS

Ultralow temperature freezers

Operation of ultralow temperature freezers implies following a procedure recommended by their manufacturers to achieve the conditions stipulated for the equipment. The recommendations common to any ultralow freezer are highlighted next:

1. Connect the unit to an electrical outlet with a ground pole exclusively dedicated to the unit. This outlet must be in good working condition and appropriate for the electrical power required for the unit. It must also be in compliance with the national and international electrical standards. The voltage must not vary by more than +10 % or –5 % from the voltage specification on the equipment. There are units which require power of approximately 12 kW. It is then essential to have an electrical connection which is of a suitable size for such loads.
2. Select a location which has a firm and levelled floor (in all directions). It should be well ventilated and away from direct sunlight or heat sources. Some manufacturers stipulate that suitable ambient temperature is between 10 °C and 32 °C. The free space at the sides and back must be at least 15 cm. The door must open freely at an angle of 90°. Normally, manufacturers include additional devices at its base on the support wheels for levelling the unit.

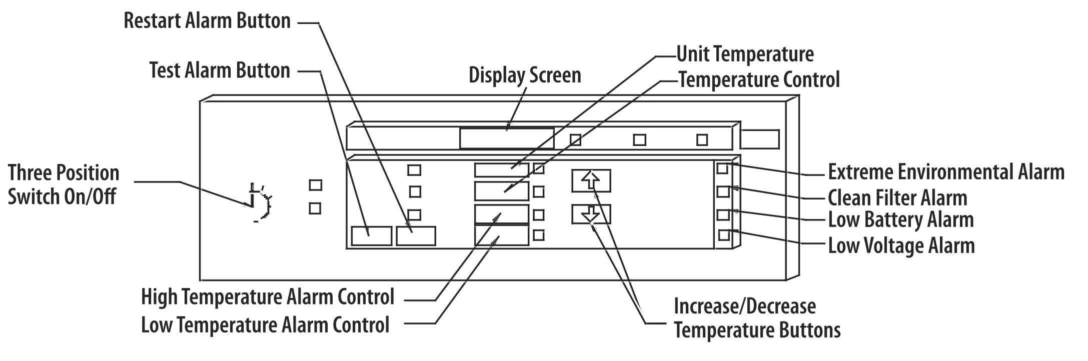
TURNING THE UNIT ON

In order to understand the freezer's operational procedures, a diagram of a control panel similar to those used in such units is presented. The diagram in Figure 59 is generic: differences in the controls used by the various manufacturers will certainly be encountered. Included next are recommendations common to all refrigerators.

Procedures

1. Connect the electrical feed cable to the electrical supply outlet.
2. Turn the key to the on position. The screen must be illuminated indicating the temperature of the cabinet. A light transmitting diode display will indicate that the unit is energized. This action will start the compressor, ventilators of the evaporator and the condenser.
3. Select the unit's operational temperature. In general, various buttons are activated simultaneously; the button corresponding to the temperature control and those to adjust the temperature. Once the desired temperature is selected, the controls are released. The screen will show the operational temperature selected. Wait a suitable time for the unit to reach the selected temperature.
4. Select the limit temperatures which will activate the alarms. These temperatures do not generally differ by more than 10 % from the operational temperature. In general, the alarms are adjusted when the unit has reached a temperature near its operational point. The procedure consists of activating the alarms' control and selecting higher and lower temperature limits so that the alarm is activated if these are exceeded. The manufacturer's recommended procedure must be followed. Usually, the control has a button which allows the alarms to be deactivated and also the option to test their functioning.
5. Ultralow temperature units have another series of alarms which warn the operators regarding the occurrence of events which can affect the adequate functioning of the unit. Among these are the following:
   - A flaw in the electric feed.
   - Low voltage.
   - Excessive room temperature.
   - The lower temperature limit is exceeded.

Figure 59. Ultralow freezer temperature control



ROUTINE MAINTENANCE

The maintenance routines of the ultralow temperature freezers are focused on the following elements described below. Consult WHO's *Manual on management, maintenance and use of cold chain equipment, 2005*, for care and preventive maintenance schedules specific to plasma freezers and walk-in freezers used in the blood cold chain.

Cleaning of the condenser

Frequency: Every six months

1. Remove the protective grid.
2. Remove and clean the filter. If too obstructed, substitute by a new one with the same characteristics as the original.
3. Verify the functioning of the ventilator.
4. Vacuum the condenser and its diffusive fins.
5. Reinstall the protective grid and the filter.

Warning: A dirty condenser prevents normal heat transference causing the unit to warm up or exceed the selected temperature limits.

Integrity of the door gasket

Frequency: Recommended quarterly

It is recommended that periodically, the integrity of the door gasket be verified. It must remain in good condition and not display cracks, punctures or tears.

Defrosting

Frequency: Recommended every six months

Whenever it is necessary to defrost the unit, it must be conducted in the following manner:

1. Transfer the products kept frozen to another unit with the same operational characteristics.
2. Turn off the unit and allow its interior to reach room temperature.
3. Remove the ice and water accumulated inside the unit.
4. If strange odours emanate, wash the inside of the unit with sodium bicarbonate and warm water.
5. Clean the exterior with a mild detergent, dry and then apply a protective wax if appropriate.

Warning: Never use sharp elements for removing ice or frost from the evaporator. Such an action can perforate the wall of the evaporator allowing the refrigerant gas to escape, dangerous for the operator and causing a serious damage which can only be repaired by a specialized repair shop.

Maintenance of the alarm system battery

Frequency: Approximately every two to three years

The alarm system battery must be changed once worn out. To substitute it, proceed as described next:

1. Remove the front cover. In general, the battery (batteries) is (are) located immediately behind the front cover.
2. Disconnect the connection terminals.
3. Remove the worn out battery.
4. Install a battery with the same characteristics as the original.
5. Connect the terminals.
6. Replace the cover.

TROUBLESHOOTING TABLE		
PROBLEM	**PROBABLE CAUSE**	**SOLUTION**
The low voltage indicator is on.	There is inadequate voltage in the electrical feed outlet.	Verify the feed voltage. Test the connection and its protective systems.
The dirty filter indicator is on.	Verify the cleanliness of the filter.	Clean the condenser's protection filter. If it is saturated with grime, substitute it for another with the same characteristics as the original.
The low battery indicator is on.	The battery is worn out.	Substitute with a battery of same specifications as the original.
The unit is not functioning.	The equipment is disconnected.	Connect the equipment to the electrical feed outlet.
	The fuse is burnt out.	Substitute with a fuse of same characteristics as the original.
The unit functions in a continuous manner.	The operating temperature selected is very low.	Increase the temperature selected.
The unit functions in a continuous manner without getting cold.	The condenser is dirty.	Clean the condenser.
	There is inadequate ventilation.	Verify and correct the ventilation.
	There is an ice build-up affecting the insulation.	Defrost the unit. Call in the specialized service technician if the problem is not resolved.
Rapid frost accumulation on the evaporator.	Leaking door gasket.	Adjust door hinges. Call in the specialized service technician if the problem persists.
The door on the freezer compartment is shut frozen.	Faulty door seal heater.	Call in the specialized service technician.
Noisy operation.	Floor not firm or cabinet not level.	Move to sound floor area or adjust casters as appropriate.
	Drip tray vibrating.	Adjust tray or cushion it.
	The cooling fan hitting cover or compressor is loose.	Call in the specialized service technician.
The compressor runs continuously.	Not enough air circulation around the unit.	Move the unit to provide with sufficient clearance. Relocate if necessary.
	Faulty thermostat.	Call in the specialized service technician.
	Poor door seal.	Check seals and adjust.
	Room too warm.	Ventilate the room appropriately.
	The door is being opened too often or is not closed.	Restrict door opening or close door.
	The light switch is defective.	Check if light goes out after the door is shut.
Other additional maintenance procedures require specialized tools and instrumentation.		

BASIC DEFINITIONS

Adiabatic process. A process in which there is no transference of heat. This implies $\Delta Q= 0$.

BTU. This is a unit for determining the heat transference in the English System. BTU is the acronym for the *British Thermal Unit*. One BTU is the quantity of heat that must be transferred for increasing the temperature of one pound of water from 63 °F to 64 °F.

Calorie. This is a quantity of heat which must be transferred to a gram of water to raise the temperature by 1 °C. This definition applies when under normal conditions (atmospheric pressure equal to 760 mm Hg, gravity acceleration equal to 9.81 m/s^2); the temperature of a gram of water is increased from 14.5 to 15.5 °C.

Entropy. Measure of a system's energy that is unavailable for work, or of the degree of a system's disorder. The reversible differential changes of entropy are expressed by means of the following equation:

$$dS = \frac{dQ}{T}$$

Where:
dQ: heat absorbed from a reserve at temperature T during an infinitesimal reversible change of the state.
T: temperature of the reserve.
The following equation must be carried out for any reversible cycle change.

$$\Delta S = \int dS = \frac{dQ}{T} = 0$$

If the cycle is irreversible, it must be:

$$\Delta S = \int \frac{dQ}{T} < 0$$

Heat. This is a form of transferred energy over the limit of a system at a given temperature, to another one at a lower temperature by virtue of the temperature difference between the two systems. When a system of great mass [M] is placed in contact with another of small mass [m'] at a different temperature, the resulting final temperature is close to the initial temperature of the greater mass system. It is therefore said that a quantity of heat ΔQ has been transferred from the system of higher temperature to the system of lower temperature. The heat quantity ΔQ is proportional to the change in temperature ΔT. The proportion constant [C], called the system's caloric capacity, allows the following relationship $\Delta Q=C\Delta T$ to be established, from which it is inferred that one of the consequences of the change in temperature in a system is the transference of heat.

Latent heat. The quantity of thermal energy required for a change in phase to occur in a substance, for example: from liquid phase to vapour phase.

Refrigerant gas. A substance (i.e. coolant) used as a medium in the processes of heat absorption.

Specific heat. The quantity of heat required to increase the unit of mass by one degree.

Sensitive heat. The quantity of energy required for increasing the temperature of the refrigerant gas upon absorbing heat. For example: the quantity of heat required for raising the temperature from 15 to 20 °C or from 30 to 40 °C.

Thermal system. A device which operates in a thermodynamic cycle and carries out a certain positive quantity of work as a result of the transference of heat between a body at high temperature to a body at low temperature.