1. REFRIGERATION CONTROL & MONITORING MODULE

Underpinning knowledge for NVQ prepared by BARCAMM (The British Association of Refrigeration Control and Monitoring Manufacturers)[1]
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1.1 PRINCIPLES OF REFRIGERATION CONTROL

1.1.1 Evaporators

When the sensing element is in the space or in the product, the thermostat controls the space or product temperature directly. If the sensing element is on the evaporator, the thermostat controls the evaporator directly and the space is controlled indirectly. The most suitable method of control depends on the requirements of the application. Where close control of space and product is required then the sensing element should be in the space. Where off-cycle defrosting is required and where fluctuations in space temperature are not objectionable, indirect control is the best method. For complete defrosting the evaporator must be allowed to warm up to approx. 2-3°C during each off-cycle. When the control is on the evaporator then the cut-in can be set for 3°C

1.1.2 Central Compressor Packs

Larger refrigeration installations usually have a central plant configuration where a number of compressors are assembled with a common liquid receiver etc. The central system is designed to provide refrigerants to the cold rooms and cabinets from that central plant compressor pack at a requisite suction pressure / evaporating temperature . This pressure / temperature set point is dependent on the refrigerants used and the temperature set point of the cold rooms / cabinets relative to that pack. Information for the central system to enable the pressure to be controlled is provided by a ‘pressure transducer’ which converts pressure into an electrical signal which is then fed into the electronics control circuit. The central plant pack has a number of compressor which may also have stages on each compressor. The control system will need to have this information inserted via the Local Interface Unit i.e. number of compressors and number of stages per compressor. Other information could be the type of refrigerants in the system as this will have a bearing on the default parameters relative to the control set point. The control system will be overridden by a ‘safety chain’ which is normally provided for each separate compressor. This safety chain is dependent on oil flow, high and low pressure mechanical switches. Once the information is inserted the pack will automatically ‘sort’ the compressor, dependent on demand, stop /start inhibit times and equal run times.

Most system have a manual override / electronics fail facility which provides a selectable number of compressors being cycled permanently in this mode. An alarm is raised at the same instance but the override allows refrigerants to continue.

[1] BARCAMM is a section of the British Refrigeration Association (BRA)

1.1.3 Central Plant Condensers

Condenser control may be separate or integral to the pack control system. The method of control and setting remains the same. The condenser fans are cycled on/off dependent on the system discharge pressure set point.

Information for the condenser system to control this pressure is again provided by a pressure transducer as is the pack control. The control system will need to have discharge pressure information together with the number of fans running inserted via the H.H.U. for initial set up. Other information could be the type of refrigerants. The control system will automatically control about the set point and relative default parameters. The fans will cycle on and off, dependent on rise or fall of discharge.

1.2 EXPANSION VALVES AND PRESSURE REGULATORS

1.2.1 Expansion valve control

An expansion valve controls the amount of regrigerant allowed into the evaporator.
The controller drives an expansion valve to achieve some control objective which includes maintenance of some minimum superheat (to avoid liquid refrigerant being discharged into the suction line). Maintenance of superheat may be the only control objective, but in some cases the superheat may be allowed to rise above the minimum value to control case air temperature: if case temperature is too low, superheat is allowed to rise; evaporator is no longer fully utilised as a heat exchanger; air is no longer cooled so effectively; and case air temperature rises.

Usually superheat is deduced from temperature sensors mounted on the outside of the evaporator coil. It is essential that these be mounted in accordance with the controller manufacturer's instructions. Incorrect probe placement could yield a temprerature measurement which is incorrect be a value comparable to the minimum superheat which the controller is set to achieve.

In some cases the superheat demand is set into the controller as a single number, somewhere around 4 - 6 degrees. However the minimum safe superheat in general depends on the load on the evaporator. To achieve the best out of the evaporator some controllers require parameters which specify the details of this variation. Since there are various ways of describing these parameters it is necessary to consult manufacturer's literature.

When refrigerant starts to flow, the expansion valve must start at a position which will definitely not flood the evaparator, and gradually open until the the demanded superheat is achieved. If a solenoid valve is fitted then it should be controlled by the same device which operated on the expansion valve, so that the latter can know when to run this start-up program.

It may be necessary to set parameters which describe the dynamics of the case. These have to do with such things as how quickly the sensed superheat will change in response to a change in valve drive. There are various ways of specifying these parameters, and in any case they are difficult to deduce from resources available on site. If they are required then manufacturers instructions should be followed blindly.

1.2.2 Back pressure regulator control

A back pressure regulator valve sits between the output of the evaporator and the inlet to the compressors. The valve orifice can be adjusted between fully open and fully closed to allow a pressure drop to develop as refrigerant gas flows through it.
This allows the evaporating pressure to be greater than the suction pressure at the compressor. It may be used
a) to allow a high temperature case to be run on a system otherwisw designed for low temperature cases,
b) to allow the evaporating temperature in a case to be controlled to achieve some local objective. For instance case air temperature may be controlled by varying the evaporating temperature. This has the advantage of reducing the drying effect of an unnecessarily cold evaporator and so is sometimes used when case humidity has to be kept high.
Back pressure regulator control is not very efficient however. Since the refrigerant is a gas at this point there is a relatively large volume flow through the valve and so the pressure drop represents gives an energy dissipation.

A controller drives the valve to achieve the required control objective which may be the maintenance of evaporator pressure or may be case air temperature control.
If case temperature is too high, the valve open up, evaporating pressure drops, evaporating temperature drops, and air is coooled to a lower value.

It may be necessary to set parameters which describe the dynamics of the case. These have to do with such things as how quickly the sensed superheat will change in response to a change in valve drive. There are various ways of specifying these parameters, and in any case they are difficult to deduce from resources available on site. If they are required then manufacturers instructions should be followed blindly.

1.3 OPERATING PRINCIPLES OF SENSORS

1.3.1 Transducers

A Transducer is any device that is used to measure some physical item i.e. pressure, temperature or level. It produces some form of electrical output that is then fed into an electronic device that will use the measurement to control or monitor the process. For example a pressure transducer would be used on a pack for measuring the pressure on the pipework. That pressure would form the control input to a pack controller that would operate valves and control the pack operation. A thermistor would be used to measure temperature and it would feed into a case controller to keep the case at a steady temperature to keep the food fresh. These transducers come in many shapes and sizes and they connect to the equipment they are monitoring in differing ways.

1.3.2 Platinum resistance sensors

Platinum resistance sensors are are more commonly known as PT100s or PT1000s.. These have resistances of 100 and 1000 ohms respectively at, 0°C and their resistance increases at around 0.35 & 3.5 ohms / degree respectively. More accurate characteristics are published in BS1904
The sensors are moderately priced, can be used in a fairly wide range of temperatures, and because their characteristics depend on the basic properties on platinum, they are internationally available. The output signals are small however and require moderately accurate resistors to recover temperature information in centigrade

1.3.3 Thermistor

Thermistors are resistors whose resistance varies rapidly with temperature. Thermistors are made from semiconductors and in refrigeration normally take the form of a disk encapsulated in a metal or plastic housing. A typical thermistor might have a resistance change of about 4% per degree C. Thermistors are particularly suitable for measuring temperatures normally encountered in refrigeration.

Thermistor come in two types, PTC and NTC thermistor. PTC (positive Temperature Coefficient) thermistors are those whereby the resistance of the probe increase with temperature.

There is a type of PTC thermistor where the resistance changes quite abruptly from some 10s of ohms to 10,000s at some specified temperature. They are quite commonly used for thermal protection applications .

The other type NTC (Negative Temperature Coefficient) the resistance of the sensor decreases with temperature. The thermistors are used by a controller to measure the temperature within the cases or coldroom. The exact temperature to resistance relationship will be dependent on the sensor type and will be important to the operation of the controller. There are no agreed standard characteristics - different manufacturers have different recipes.

Thermistors are inexpensive, robust and give relatively large signals which are easily measured. The temperature range over which they operate is often restricted compared to other sensing devices but quite suitable for most refrigeration control applications.

1.3.4 Characteristics of common types

See appendix

1.3.5 Thermocouples

Thermocouples are another type of temperature measuring device. They are cheap, small fast acting, suitable for a wide range of temperatures, and can be made to withstand harsh environments. The thermocouple senses temperature by measuring small voltage differences that occur when connecting dissimilar metals. This means that the signal output is small (typically 40uV per degree).

The thermocouple also as a result measures the temperature difference between the sensing element and the indicating device. A controller which uses thermocouples therefore needs an additional sensor to measure its own temperature.

Characteristics of different types of thermocouple are given in BS4937

1.3.6 Pressure Sensor

A pressure sensor or pressure transducer is often used with electronic controls. These devices produce an output signal that is proportional to pressure. The Transducer sensing element is usually formed of resistance elements that change resistance with pressure. This results in low voltage signals. Many transducers used in refrigeration include built in electronics for amplifying and calibrating the transducer. The outputs from these devices are typically 1 to 5 V, 1 to 6 V or 4-20 mA. The signal from the transducer is converted in the electronic control unit back to a pressure reading that is used as the measurement in say compressor control. The set point and differential (or dead band) along with time delays are used to control the compressor switching.

1.3.7 Sensor outputs

Some sensors such as the thermistors and thermocouples described above are passive devices and sensed information is presented in whatever way the physics of the sensor dictates. Other sensors may require some external power source and have some signal processing built in. There are some common ways of such sensors delivering their information . One such way is 4 - 20mA output in which 4mA represents the smallest sensible output from the transducer and 20mA represents its maximum output.. Such a transducer is intended to work with a low resistance load.

1.4 COMBINED SENSING AND OUTPUT DEVICES

Controls operate output devices (e.g. relays) in response to information from sensing devices (e.g. temperature sensors) in accordance with some program.

Sometimes the sensing element may be combined with the output device but more often they are separated with some electronics in between..

1.4.1 Thermostat

A thermostat will be found in all refrigeration plants used to maintain the required temperature in the evaporator chamber or cold room. In this application it is designed to switch on the plant when the temperature rises.

Thermostats have definite ‘cut-in’ and ‘cut-out’ points. E.g. the thermostat is adjusted to start the compressor when the temperature of the space or product rises to some pre-determined maximum (the Cut-in temperature) and to stop the compressor when the temperature is reduced to some predetermined minimum (the cut-out’ temperature). The difference between ‘cut-out’ and ‘cut-in’ is called the differential. In general the size of the differential depends upon the particular application and location of the temperature sensing element. If the element is on the product and thus controls it directly the differential is usually small 1 or 2°C. If the element controls the space temperature the differential is usually 3 or 4°C. In some cases the sensing element is clamped on to the evaporator and the space temperature is controlled indirectly thus the differential must be larger still in order to avoid short-cycling of the equipment, 7 or 10°C is usual. When the thermostat controls the space temperature directly the average space temperature is approximately the average of ‘cut-in’ and ‘cut-out’ temperatures. Thus to maintain an average space temperature of say 5°C the thermostat can be adjusted to cut-in at 7°C and cut-out at 3°C.

1.4.2 Dew Point Thermostat

This is an ordinary thermostat used to control humidity. When air is passed through washer sprays of refrigerated water, its moisture content is dependent upon the temperature of the water. A thermostat used to control the temperature of the washer water determines the absolute humidity, and consequently the dew point, of the air leaving the washer.

1.4.3 Pressure Stats

The operation and function of a pressure stat is the same as a thermostat except that the primary element senses pressure. Pressure stats, pressure switches are used both as control and safety devices.

1.4.4 Liquid Level

Liquid level can be measured in many ways. The most common are the float switch and the external sight glass or tube with a floating magnet. This magnet can be detected by a magnetic switch on the outside of the measurement tube. The advantage of the external tube is that the switch position can be adjusted from top to bottom of the tube where a standard float switch may have little or no adjustment. The liquid level devices are often used on the refrigerant liquid receiver to give early warning of refrigerant leakage.

The oil feed systems on compressor packs (racks) sometimes use float valves to control the oil level in the crank case of the compressor.

1.4.5 Low Pressure switch

This is connected to the suction side of the compressor. It will stop the compressor when the pressure falls to a pre-determined level and start it again when the pressure rises. it is used to prevent the compressor from pumping down to a very low evaporator pressure and to stop the machine in the even of refrigerant loss.

The low pressure control may also be used in conjunction with a thermostat expansion valve to maintain a temperature in the evaporator related to the pressure.
Used both as safety devices and as temperature controls. If low side pressure becomes excessively low, the control breaks the circuit and stops the compressor. When pressure returns to normal the circuit is again closed and the compressor runs. Some Low Pressure controls have lock-out devices and must be manually reset. Low pressure controls are most frequently used as temperature controls in commercial applications. Since the pressure at the suction inlet of the compressor is governed by the saturation temperature of the refrigerants in the evaporator, changes in evaporator temperature are reflected by changes in suction pressure. It will thus be seen that a control actuated by changes in pressure can control the space temperature indirectly by controlling the pressure in the evaporator. This case cut-in and cut-out pressures are the pressures corresponding to the cut-in and cut-out temperatures of the remote bulb thermostat.

EXAMPLE

Assume that cut-in and cut-out temperatures for a thermostat are +3°C (38°F and -6°C (20°F) respectively. If a low pressure control is used instead, cut-in pressure for the control will be 3.4 Bar A. (56 PSIA) and cut-out will be 2.5 Bar A (36 PSIA) using R12.

As the evaporator warm up during the 'off' cycle, pressure increases accordingly and when it reaches cut-in pressure the compressor starts. Soon after compressor start the temperature and pressure of the evaporator are reduced to approximately the design temperature are pressure and they remain at this condition throughout most of the running cycle. Near the end of this cycle the evaporate temperature and pressure are gradually reduced below design conditions and when the evaporator pressure is reduced to cut-out pressure setting of the L.C. it breaks the circuit and stops the compressor. Note that the vapour will undergo a drop in flowing through the suction line and the pressure at the inlet to the compressor is approximately 0.2 Bar less then the evaporator pressure. This is particularly so when the compressor is some distance from the evaporator and pressure drop must be allowed for when setting the control cut-out pressure. Cut in pressure is not affected since when the compressor is at rest there is no flow. Since the L.P.C. controls evaporator temperature rather than space temperature, it is ideal for applications requiring off-cycle defrosting.

1.4.6 High Pressure Switch

This control has an open bellows and is connected to the delivery side of the compressor. Its purpose is to stop the machine in the event of excessive discharge pressure. it must be fitted in systems with water cooled condensers where the risk of water failure is always a possibility. Used as a safety control, cycles the compressor 'off' in the event of pressure in the system becoming excessive. When the pressure returns to normal the H.P. control acts to close the circuit and re-start the compressor. Some types have lock-out devices which must be re-set manually before the compressor can be re-started. H.P. controls are desirable on all equipment but are essential on water cooled condensers. Since the condensing pressures of various refrigerants are different, the cut-out and cut in settings of the high pressure control depends on the refrigerant used.

1.5 OPERATING PRICIPLES OF OUTPUT DEVICES

1.5.1 Relays & Contactors

Relays and contactors are similar devices. both being electrically operated switches . There are many different types of relays : small ones for PCB mounting; bigger ones that plug into sockets; and larger ones that clip into DIN terminal rails sililar to small contactors.

Contactors also come in various sizes depending on the load (current) the contactors are required to switch. Relays are available to switch loads from milliamps to tens of amps whereas contactors can switch up to hundreds of amps.

Both require a voltage applied to the coil to energise them and this causes the contacts to make or break quickly.

The number of contacts and how the contacts are wired are important and are usually part of the description of the part. A double pole relay has two sets of contacts, 3 pole and 4 pole relays have 3 and 4 sets of contacts and change over the contacts when energised. The larger DIN terminal rail mounted relays can have up to 8 poles with various numbers of normally open and normally closed contacts. Sometimes a two digit configuration part number is quoted indicating the number of normally open and normally closed contacts. E.g. “44” would indicate 4 normally open and 4 normally closed contacts.

Contactors have three poles for switching power (often one pole per phase) and quite often one or more auxiliary control contacts which can be normally open or normally closed depending on specification.

Checking the switching of a relay requires a volt meter and an idea of the type of voltages being switched. To check the operation of a relay or contactor the output from the contacts is measured in both energised and de-energised modes, in one position the feed voltage will appear on the output contacts and in the other position no feed voltage will appear. If a relay on a PCB fails then the only option is to replace the entire PCB unit. If a contactor fails then the contactor can be removed from the terminal rail and another equivalent should be put in its place. Always replace contactors or relays with the same type and ratings.

1.5.2 Solid state switches

1.5.2.1 Thyristor / SCR (Silicon Controlled Rectifier)

The thyristor can be regarded as a silicon rectifier (diode), that is controlled by its gate. It is a three terminal unidirectional device which can only conduct current from anode to cathode. Normally it acts as an open switch, but if its anode is positive to its cathode it can be made to switch on and act as a forward biased rectifier by applying a brief trigger current to its gate. The thyristor latches into the 'on' state until the cathode to anode current falls below a minimum holding level, at which point it reverts to an open switch state.

1.5.2.2 Triac

The triac is a bidirectional device which can conduct current in either direction between its two main terminals (MT1 and MT2), thus it can be used to directly switch or proportionally control AC power.

The triac can for most practical purposes, be regarded as a pair of thyristors wired in inverse parallel sharing a common gate terminal. The device action is such that it can be triggered by either positive or negative gate currents irrespective of the polarity of the MT2 current, it thus has four possible triggering modes or quadrants.

1.5.2.3 Solid State Relay

A solid state relay can be conisdered as a packaged triac device always including its neccessary triggering circuity and possibly including some or all of the following features.

a. Heatsinking to dissipate energy lost by device losses.
b. Zero cross circuitry to switch the device on and off only at the zero voltage point of the AC cycle. This reduces transients and noise when switching inductive loads.
c. Optical isolation to provide electrical isolation between input and output terminals.
d. Suppression components to protect the output device from transients, generated when switching reactive loads.

Solid state relays are often used in preference to relays in applications when high switching frequencies are a factor, thus eliminating contact life problems.

1.6 CONTINUOUSLY VARIABLE OUTPUTS

1.6.1 Analogue Outputs

Many control devices, such as process control valves or invertors for variable speed motors, require a control voltage or current input signal which is proportional to the required valve position (0 to 100%) or motor speed (0 to 4000 rpm). The input signal to the control device is often generated by using an Analog Output signal from an electronic controller.

Analogue Outputs can be either voltage or current signals which are varied in small increments to provide accurate, optimum speed or valve open positions dependent on plant operating conditions.

Microprocessor controllers normally use a Digital to Analogue converter chip to produce the required analogue output signal from a digital number. The resolution and accuracy of the Analogue Output is dependent on the number of bits in the digital number used to provide the digital to analogue conversion.
The minimum change of Analogue Output signal size is one digital bit.

Typical Digital to Analogue converter sizes for refrigeration process control are

8-bit (1 part in 256) 0.4% if 0-100%, 6 rpm if 0-4000rpm
or 10-bit (1 part in 1024) 0.1% if 0-100% 4 rpm if 0-4000rpm

Voltage signal ranges frequently used are 0-1Vdc, 0 to 5Vdc, 0 to 10Vdc.
Current signal ranges frequently used are 1 to 5ma, 4 to 20ma, 0 to 20ma.

For a typical Analogue Output voltage range of 0 to 10 Vdc for a process control valve opening 0 - 100%

0.0 Vdc would close the valve completely at 0% open
4.6 Vdc would nearly half open the valve at 46% open
10.0 Vdc would fully open the valve at 100% open

For a typical Analogue Output current range of 4 to 20 mA for a motor speed of 0 to 4000 rpm

0.0 ma would indicate that the control signal wire was disconnected
4.0 ma would stop the motor at 0 rpm
12.0 ma would run the motor at half speed of 2000 rpm
20.0 ma would run the motor at full speed of 4000 rpm

1.6.2 Pulse Width Modulation

Some control devices, such as electronic expansion control valves or heater elements, require a digital control signal which, relative to a periodic time for the device, is switched 'on' and then 'off' with a 'on' time duration which is proportional to the required valve position or power output (0-100%).

Control signals required to drive this type of device are called Pulse Width Modulated Outputs since the output position or power of the device is changed or modulated dependent on the width of the pulsed signal.

Due to the frequent switching requirements of Pulse Width Modulated Outputs, relay contacts wear out very quickly and therefore semiconductor solid state relays or triacs switches are normally used.

E.g. For an expansion valve with a period of 5 seconds

an output of 0 seconds during 5 seconds (permanently off) would close the valve at 0%
an output of 1.25 seconds during 5 seconds would open the valve to 25%
an output of 2.5 seconds during 5 seconds would open the valve to 50%
an output of 5.0 seconds during 5 seconds (permanently on) would fully open the valve at 100%

1.7 DEFROST STRATEGY

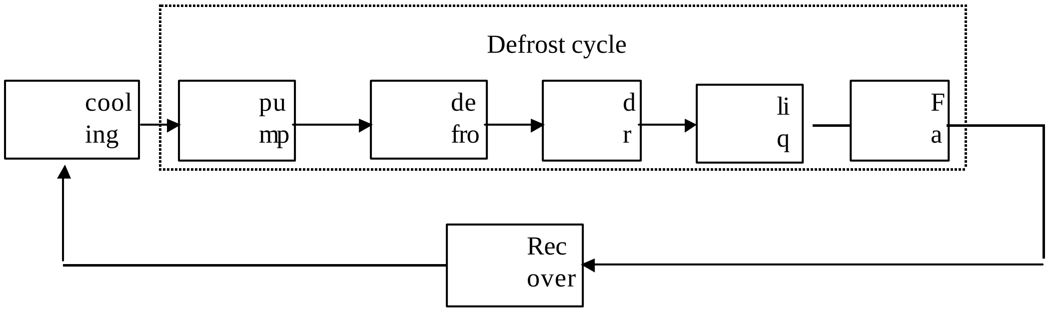
1.7.1 Pump Down Cycle

A commonly used method of cycling the condensing unit known as the 'pump down' cycle employs both a thermostat and a low pressure switch. In a pump down cycle, the space or evaporator temperature is controlled directly by the thermostat. However, instead of starting and stopping the compressor motor the thermostat opens and closes a solenoid valve in the liquid line usually near the refrigerant flow control (T.E.V.). As the temperature is reduced to cut-out temperature the thermostat breaks the circuits, de-energises the solenoid and stops the flow of liquid refrigerants to the evaporate. Continuing operation of the compressor reduces the pressure on the evaporator side of the solenoid valve and when the pressure is low pressure control the motor is switched off. When the temperature rises to thermostat cut-in temperature, the solenoid is again energised and permits liquid to flow to the evaporator. Since the evaporator temperature is now much higher the liquid is vaporised rapidly, pressure rises and actuates the low pressure control which starts the motor again.

1.7.2 Defrost Control

Under normal running conditions where an evaporator is running at negative temperatures (below 0°C) water from the atmosphere condenses onto the cold evaporator and freezes causing a steady build up of ice on the evaporator. Ice is a good thermal insulator, so any build up of ice will cause the evaporator to become less efficient. The ice will also block the fins of the evaporator so that air flow and thus, the heat exchanging efficiency of the evaporator will als o be reduced. Defrost is the name applied to the action of heating the evaporator either by hot gas (internally) or electric heaters (externally) to melt the ice and allow it to run off the evaporator. To ensure that a system runs as efficiently as possible, regular defrosts are needed to keep the evaporator clear of ice. The frequency (time between defrosts) that is required will depends u pon the system design and operating conditions. For supermarket cases 4 to 6 hours is normal whilst larger rooms may be 6 to 8 hours between defrost.

A typical defrost cycle comprises



1.7.2.1 Pump Down

In this context pump-down refers to a state preceding defrost where a refrigerant is sucked out of the evaporator prior to any defrost heating. Generally it lasts for a fixed time (if it exists at all). In a more general context pump down refers to any condition in which refrigerant is sucked out of the evaporator while refrigerant inlets are block off. (e.g. see "pump down cycle").

1.7.2.2 Defrost

When "defrost" is used to refer to a controller state it only includes the active part of the defrost cycle.

(a) If there is heating involved in defrosting and the heating is not cycled on & off then "defrost" comprises only the period where the heating is enabled

(b) If heating is involved but the heater may be cycled on & off:"defrost" comprises the condition in which heating is possible if suitable temperatures obtain.

(c) If no heating is involved:- "defrost" comprises the period where refrigeration is are switched off to allow the ice to melt.

In all cases the defrost state <u>excludes</u> drain down; liquid hold off; fan delay; Recovery.

Defrost generally lasts until some temperature is achieved or until some time conditions are met.

1.7.2.3 Drain Down

This is state after defrost where neither heating nor refrigeration is enabled. Often fans are held off also. It generally lasts for a set time

1.7.2.4 Liquid hold off

This is a state after defrost where refrigeration is kept off until nearby cases are also ready for refrigeration to resume.

1.7.2.5 Fan delay

This is a state after defrost where refrigeration is enabled but fans are held off. It generally lasts for a certain time, or until a temperature is low enough to suggest that water will have frozen on the evaporator.

1.7.2.6 Recovery

After the defrost cycle is complete and all attempts to refrigerate are resumed, there is often a period during which high temperature alarms are suppressed and temperature displays may be inhibited. This state is known as "recovery". It generally lasts for a set time or until temperature conditions suggest that satisfactory refrigeration has been achieved

1.7.3 Defrost Initiation

Defrost is most often initiated by time. The timing may be done within the controller or by an external clock. The defrosts may take place regularly, or be set to some pattern to suit changing circumstances throughout the day. Regular defrosts may or may not be synchronised to time of day. In non-integral cabinets defrost is generally initiated in the pack rather than in the controller in the case.

There are several schemes for initiating defrost on demand, where an attempt is made by the control system to deduce the need for defrosting from some sensing technique..

1.7.4 Defrost Termination

Once a defrost has been started, then a decision has to be made how long to defrost for.

1.7.4.1 Time Termination

The simplest method is to stop the defrosts after a set time. In this option a timer is set running at the start of defrost and when the timer runs out the defrost stops. The time can be set by trial and error, but has to be set sufficiently long to allow for the worst case. Although this is the simplest method of defrost termination. It is not very efficient as extra energy is used when the conditions are not at there worst.

1.7.4.2 Temperature Termination

A more efficient method is to use a temperature sensor or stat positioned so as the signal when sufficient ice has been cleared from the evaporator. If the evaporator fans are left running during a defrost (supermarket cases) then this temperature sensor can be placed in the air flow leaving the evaporator (AIR OFF).

1.7.5 Methods of frost removal

1.7.5.1 Off cycle defrost

The evaporator is switched off for a period of time to allow it to defrost. This method of defrost is only suitable for evaporators that normal operate around 0 degrees celcius where the frost does not form into ice between defrosts.

1.7.5.2 Electric Defrost

Electric heating coils are inserted between the finned tubes of the evaporator. These are usually operated by a timer which stops the refrigeration (by shutting off the liquid refrigerant supply and stopping the compressor when the evaporator has been emptied) and then switching on the currents to the heaters. After a pre-set period the heaters are switched off and refrigeration re-commenced. Faults on this system usually occur on the timing mechanism.

1.7.5.3 Hot Gas Defrosting

Hot gas from the compressor discharge is re-routed directly into the evaporator, after shutting off the liquid refrigerant feed to the expansion valve. This method gives a rapid defrost but can only be employed on large multiple systems so that the compressor still has a work load from other units. The liquid feed must be shut off before opening the hot gas connecting valve. This may be done manually or automatically using solenoid control valves.

1.7.5.4 Saturated gas defrosting

Gas from the top of the receiver is re-routed into the evaporator, after shutting off the liquid refrigerant feed to the expansion valve. This method can only be employed on large multiple systems so that the compressor still has a work load from other units. Saturated gas and hot gas defrosting systems require similar control.

1.7.5.5 Reverse cycle defrosting

This method reverses the role of the evaporator and condenser by switching over high and low pressure systems. Solenoid valves are usually employed to control the changeover, together with an additional constant pressure expansion valve to feed the condenser. The hot gas discharge from the compressor enters the evaporator causing it to defrost.

1.8 CONTROL SETTINGS

1.8.1 Determination of Control Set Point

The function of the control set point is to provide a datum point about which the control system will react to achieve that set point. (e.g. a typical temperature set point for a refrigerated display cabinet merchandising ice cream should be maintained). Determine of the set point for a control system is dependent upon the equipment's function. In the example used above relative to a refrigerated display cabinet, this was shown for an ice cream cabinet. Food producers will recommend at what temperature their products should be merchandised. To enable this fact cabinet manufacturers will design their cabinets to mechanise the product at a suitable range to temperatures. The control system is designed to enable these various temperatures to be enabled by the input of a set point.

1.8.2 Determination Of Alarm Set Points

Alarm set points are used to provide information and alert appropriate personnel that the system is not maintained within requirements. These set points are usually pre-determined within the control system and act, in conjunction with the control set point, but again may be 'fined tuned' to meet special requirements.

1.8.3 Parameters

To enable the control system to function certain information is required. This is the parameters to which the control system is instructed to function. These parameters are always relevant to the equipment being controlled e.g. a high temperature refrigerated cabinet requires different parameters to a low temperature cabinet, similarly high and low temperature compressor packs. The control systems manufacturer supplies recommended parameters appropriate to the equipment to be controlled. In some cases these may be set up by the use of bit switch settings. These settings are normally known as "default parameters".

A good example is the Control Set Point described earlier. Although recommended by the control system manufacturer it is determined by a combination of manufacturers, system designers, food merchandising regulations and special applications recommendations, together with behaviour of the system once commissioned. Control Set Point values are pertinent to the environment they are controlling e.g. temperature in the case of refrigerated cabinets and cold rooms, suction pressure in the use of compressors etc. The control system usually has the ability to "fine tune" parameters such as the control set point for special applications if required.

Typical parameters for a cabinet/cold room would be:-

Unit Number
Control Set Point
Alarm Set Points
Defrost Times

Defrost Termination (temperature & time)
Temperature Display Weighting etc.

Typical parameters for a control system compressor pack and/or condenser would be:-

Control Set point
Alarm Set Point
Refrigerant Type
Start/Stop Times etc.

Individual manufacturers may have parameters which are specific to their equipment and these should be referred to in the manufacturer's literature.

1.9 PARAMETER ENTRY

The parameter entry system is the means whereby the control is configured to suit a particular case. Typical parameters might be
Temperature set point
Differential
Details of times for defrost initiation
Type of defrost
Times and temperatures governing the various stages in the defrost cycle
Alarm temperatures
Controller name (see serial communications)
Some parameters may be adjustable by the user, some by the service engineer and some may be factory set

Often the parameter entry system may use the data display system to show the parameter values as they are being adjusted. Sometimes a special programming device is needed.

Adjusting screws on the controller
Push buttons on the controller or its local display
Buttons or keyboard on remote data display unit
Portable plug-in programming device.

1.9.1 Hardware

Default settings have been established and implemented by the majority of the control systems manufacturers to provide a range of control settings (Parameters) relative to the set point. These are enables 'informing' the control system via 'bit switches' or 'links' or rotary adjustors positioned on the control module. Instruction for these are control system manufacturers dependent and will be found in their literature.

1.9.2 Local User Interface or Setup Unit

To enable the set point to be entered or 'fine tuned' locally to that unit some equipment will have the facility to plug in a steup unit which will only operate with the respective manufacturers controllers. Having connected the set up unit the operator is able to view and reset the set point, again relative control and alarm parameters will be readjusted automatically. The set up unit also enables the operator to change any individual parameters (within range restricted limits) for fine tuning purposes.

This on-site user interface might be in the form of a computer which has a monitor attached to display system activity and also allows protected access to the system for alteration of set points and parameters. The functions that are available on the L.I.U. plus others are generally available at the user interface. The user interface will sometimes display what function has been changed previously and by what operator, (identified by protected access password or similar) or by the L.I.U. This ensures the engineer has some historical knowledge of changes before more are implemented.

The on-site computer not only provides access but also data storage facilities for historical data.

1.10 COMMUNICATIONS NETWORK

When putting a system together it is becoming more and more common to use data collection from the individual controllers for alarm and monitor purposes. This data comes back from the controllers via a communications network. The controllers are connected via a wiring scheme that returns data to a network controller. There are usually two levels to this protocol, firstly there is the hardware level and this defines what type of wiring and the physical way of connecting the controller and monitoring units together. The other is a software protocol that ensures that temperatures returned are read as temperatures and that pressures are read as pressures. Generally speaking the communications are via a “Belden” type twin and earth cable using RS485 hardware interface protocols. There are other protocols being used but this is the main one. Data transmission speeds will vary dependent on different control manufacturers. How the controllers and monitoring units actually communicate should not matter to the installers since this should be sorted out by the supplier. If the communications fails then the cable needs to be checked and the wiring to the controllers also will need checking to make sure that they have been connected in accordance with the manufacturer’s instructions.

1.10.1 Network Controller

The network controller communicates to any equipment (e.g. cabinet/cold room controllers, compressor controllers etc.) within the system which is connected via the communication network. It collects data for items such as alarm handling, historical data etc. It is accessed via the local or remote user interface. Its function is to record and store any parameter changes that are made to any controller on the system and to ensure that alarms are genuine before passing on to the appropriate destination.

The network controller in most instances will function without the local user interface for control and monitoring purposes but will only hold a minimum of historical data. This is usually passed on to the local user interface which has sufficient memory to store requisite data which may be used for longer term analysis.

1.10.2 Remote User Interface

Most systems may be accessed from a remote location via a modem and the telephone network (in future some of the emerging network systems such as Internet). Remote access will provide the same on-site facilities as the local user interface. Some installations will not have an on-site computer but have a connection point available for a portable computer for local access with integral modem, which may also be used for remote access e.g. from the engineer’s home during stand by duties etc.

1.10.3 Distance Communications Systems

Distance Communications systems include such things as wide area networking dial up communications systems and radio links. Some stores have wide area networking whereby the alarm and monitoring panels can connected to the store mainframes at head office. This means that head office can check the condition of the case and packs within any store in their local computers. If a modem is being used then the panel needs to have a phone socket and a main supply point for the modem, the modem then being connected to the monitoring panel as per the suppliers instructions. In-store wide area networks require the networking connections as required by both the supplier and the store to be wired as per instructions supplied.

1.10.4 Modems

As systems and technology have developed the rate of data transmission (baud rate) has increased and continues to do so. This means there are a variety of baud rates for modems to deal with. When the modem is connected to the on-site system it has to communicate with an appropriate outstation/outstations. It is therefore essential to ensure that the modem is set up to be able to exchange data as required, To do this the manufacturer will usually recommend a selection of suitable modems for the task also to be compatible with any outstation modem it has to communicate with. Modems are now quite versatile and can be set up to meet most requirements by following the modem manufacturer's handbook. In some cases it may require the control system manufacturer to configure the system for the appropriate modem.

1.11 DATA DISPLAY

Data displays allow the viewing of data obtained from controller within the store. This may be a monitoring panel that is connected to all the controllers in the store via a serial communications network or it may be a display on a single controller.

A remote monitoring panel would normally be a signal point containing a computer of some type connected to the controllers (both case and pack) via a serial communications network. This system would be different from manufacturer to manufacture and so the instruction and connection details would need to be obtained from the appropriate companies.

When fault finding the first thing to check is that power is getting to the unit and that it is being powered up. If temperatures are not getting back to the system then check the cabling between the Data Display System and the case or pack controller.

1.11.1 Computers

Most on-site systems will have a computer as an access terminal to the rest of the system and to the wide area network via a communication link such as a modem. The computer is configured with the control system manufacturer's software installed on the computer's hard disc. Data such as alarm logs, temperature readings etc. are also stored on the hard disc. The system manufacturer's software is usually written to ensure that the user always has a route back to the beginning in case of confusion. In the case of computer faults these should always be reported to the supplier of the control system for clarification or rectification. The computer usually has a floppy disc drive installed, this is for either collecting data from the hard disc or updating the software by transferring data from a floppy disc to the hard disc. Manufacturers will supply a floppy disc with the appropriate instructions of how to "load" the software onto the hard disc, similarly for extracting data the disc must be formatted before use. It is essential that only software approved by the manufacturer is loaded onto the system. Games or other non-approved software should not be loaded via the floppy disc as this could corrupt the software rendering the system faulty.

1.12 INSTALLATION AND TESTING OF SENSORS

Sensors should always be fitted to the manufacturer instructions.
A pressure transducer may be fitted in the pipe that it is monitoring a temperature transducer would be fitted on or in the appropriate pipework. When changing transducers always remove the power from them and the equipment they feed before starting and always fit the same type and value of transducer as that being taken off.

Dampness, freezing and thawing can be damaging to any extensions of sensor leads within the refrigerated space. Cable jointing methods which are suitable for more benign environments may not be adequate, and cable extensions within the refrigerated space are best avoided unless jointing methods specifically designed for the purpose are used..

1.12.1 Platinum resistance sensors

Joint resistance and lead resistance cannot be assumed negligible in any extensions to the sensor cabling.

There are measuring techniques which involve three or four wire connections to the sensor to reduce the effect which lead resistances may have on the measurement.. These must be continued in any extensions cables

1.12.2 Thermistor

Fitting the wrong thermistor type will result in the wrong temperatures being measured and the operation of both the case controller and alarm panel will be compromised. When changing sensors, exactly the same type should be used to replace the faulty one.

Thermistors can be checked by measuring their resistance using a multimeter switched to resistance measuring. The sensor should first be disconnected from its connector block at the controller. The resistance measured is then compared against the resistance / temperature table for this type of sensor. If the probe is open or short circuit or it has a significantly incorrect value then it should be discarded and a new sensor fitted.

1.12.3 Thermocouples

Probe fitment should always be as per the case manufacturer instructions. There are various different types of thermocouple. The cable and connectors joining the thermocouple to the instrument are special in nature and must be of the correct type and polarisation for the thermocouple being used. It is not recommended that the leads to a thermocouple are extended, however if this is done joints MUST be made using the correct connectors maintaining cable AND connector polarity

Thermocouples can only be checked by connecting them correctly to an instrument with the appropriate thermocouple input and correct connector. The thermocouple must be disconnected from the controller or monitoring device and reconnected to the instrument. If it has a significantly incorrect value then it should be discarded and a new sensor fitted.

1.12.4 Pressure Sensor

Pressure sensors are fragile mechanical devices. It is essential that they are installed according to the manufacturers instructions. They can easily be damaged by overpressure, overtemperature, physical abuse and sometimes underpressure. In particular care should be taken during pressure testing. The pressures that can permanently damage a transducer are often in the order of 100% overpressure. Suction pressure tranducers that are meant to measure pressure around 0 psi gauge are often at risk and should be removed or isolated during testing. Overpressure will often cause a permanent offset in the output reading.

Test a 4-20 mA transducer by disconnecting the wiring at one transducer output terminal and connecting a dc ammeter between the terminal and the disconnected wire. If the ammeter does not read the expected value, the fault may be in the transducer but it may also be a break in the wiring between the transducer and its load. To check this connect the ammeter directly across the transducer output terminals with at least one of the output terminals otherwise disconnected. The ammeter should then give the expected reading from a working, properly installed transducer.

1.13 INSTALLATION AND TESTING OF OUTPUTS DEVICES

1.14 INSTRUMENTATION

1.14.1 Voltmeter

Portable voltmeters often take the form of a general purpuse multimeter which will also measure current and resistance. The commonest application is in checking whether mains or auxiliary supplies are present at the various pieces of equipment within the refrigeration system.
Select AC volts or DC volts as appropriate (AC for mains voltages) and a suitable range. Some meters will be destroyed if asked to measure a voltage greater than the selected range.

Voltages in a circuit are measured from one point to another. It is essential to be sure that both points are suitable for the information required. E.g . if you believe that some equipment should be running but it is not, check that the voltage between its live and neutral terminals is indeed at the expected value (around 230 or 240V for UK mains) before condemning the equipment. Measuring voltages should be done with extreme care since there are voltages within store environment that can kill.

Modern voltmeters have a very high source impedance and so can indicate voltages even if there is only a small amount of power available from the circuit being measured. This can give misleading results. E.g. switch connected to L, with no load connected, but with suppression components across it . Voltmeter between live feed and N will read 240V whether switch is closed or not.

1.14.2 Ammeter

Current flows through conductors so in order to measure it with a standard type of ammeter it is necessary to break into the circuit. That is the cable is cut and each raw end connected to to an ammeter terminal. Thus the meter becomes part of the circuit. When the power is reapplied to the cable the current can be read from the meter.

Ammeters of this type are often incorporated into multimeters.

It is essential to switch off power before connecting the ammeter into the circuit.

Select AC or DC and an appropriate current range. Some multimeters have terminals exclusively for current measurement.

Once the reading is complete do not leave a multimeter in the current range lest it is inadvertently used to measure voltage.

There is an alternative type of ammeter which clips around the conductor carrying the current to be measured. Many of these are only suitable for AC current measurement. It is physically possible to clip this ammeter around more than one conductor at a time and measure the total current in all of them.

1.14.3 Ohmmeter

An ohmmeter is almost always a part of a general purpose multimeter. It is useful for checking thermistor probes; integrity of wiring; integrity of multi-meter's own leads.

Make sure that the meter's battery is healthy by shorting the leads.

1.15 PLANT LOG SHEETS AND DOCUMENTATION

Before attending site it is essential that all efforts are made to establish exactly what equipment is installed and that manufacturers technical literature is available to the Engineer.

When entering customer's premises, the Engineer(s) will follow the security procedures by the customer's specification.

If required a permit to work shall be obtained.

In the absence of a customer instruction, the Engineer(s) at the time of arrival shall report to a member of the customer(s) staff or someone of authority.

Prior to leaving the customer's premises, the Engineer(s) will ensure that the equipment is operating in a safe condition, that the alarm panel is displaying "no faults" and inform the customer of the requirements and our intentions.

Prior to leaving the customer's premises, the Engineer(s) shall complete the company Service Report and any other relevant documentation specified by the customer. If a site long is available a resume of work carried out should be recorded to assist subsequent visits.

The Engineer(s) will endeavour to notify the customer(s) representative of the situation prevailing and obtain a signature on the Service Report from an authoritative source. A copy of the Service Report shall be, where required, provided to the customer.

1.16 DEFECT REPORTING

Any defects should be recorded and defective items returned to the manufacturer with a completed Returns from site clearly stating the suspected fault.

1.17 EMC REQUIREMENTS

1.17.1 Definition

The abbreviation EMC stands for Electromagnetic Compatibility and means the capability of an electric/electronic apparatus to function faultlessly in common surroundings under mutual influence.

Compatibility is ensured when the apparatus is satisfactorily *immune* to electromagnetic impacts from the surrounding of the apparatus as well as when the *emission* of the apparatus is so low that other systems, e.g. radio transmissions, are not disturbed.

After January 1st., 1996 all apparatus with independent functions must be CE-certified according to the Electromagnetic Compatibility Directive 89/336/EEC. This certification means that the manufacturer/importer guarantees that his products meet certain minimum demands on immunity and emission under the condition that the manufacturers' installation instructions are followed.

1.17.2 Noise sources

To understand what EMC noise really is, some typical noise sources are listed up below, the main noise sources can be divided into continuous sources and transient sources. The characteristic of continuous sources is generation of a permanent disturbance throughout a long timeperiod whereas transient sources typically are disturbances of very short duration.

1.17.3 Continuous sources

Low-frequency fields (magnetic or electric) typically occur near power stations, under high-voltage cables, near power-supply cables, around network transformers inside the appliance, close to neon tubes, etc.

The field strengths typically drop between 2nd and 3rd power index in proportion to the source distance.

High-frequency electromagnetic fields are typically caused by radio transmitters and ISM devices (which use high-frequency field rates for warming up, etc. ISM devices are: certain medical equipment, industrial welding appartus, etc.)

As the purpose of these devices is radiation/utilization of high-frequency fields in order to obtain a certain function, even very high field strengths can be expected in the close surrounding of the devices.

Mobile communication equipment constitute an increasing problem, particularly because of their very mobility which implies the possibility of getting extremely close to other electronic equipment. The field strength typically decrease proportionally to the source distance.

Several of the above mentioned sources generate field strengths (noise) which indeed exceed many times the limits set for CE-marked devices. This means that even a CE-marked device can cause EMC problems in special servere environments.

1.17.4 Transient sources

Transient fields can be caused by e.g. lightning strikes. Lightning currents measure rates from 2 to 200 kA. As the rise time of a lightning-current is extremely short, very high voltage rates can be induced in electric installations even if the lightning does not directly hit the installation.

Another type of transient noise source is ESD (ElectroStatic Discharge) which arises on the friction of certain material. The lower the rate of humidity the higher static charge will be stored (up to several kV). If a person walks over a synthetic carpet he will be charged. When he gets close to equipment, which have a current path to earth, the resulting sparking can have a damaging effect on sensitive electronics. This factor must be taken into account when for example an EPROM in a controller is to be exchanged. The use of arm bracelets to protect against discharge to earth is highly recommended.

A third very frequently appearing type of transient noise is burst transients, typically arising on power lines when inductive loads, as for example motors, transformers, contractors, etc., are switched off. Burst transients are extremely fast transients with an amplitude rate of up to several kV

Finally, it must be mentioned that disturbance in a micro processor circuit can be caused by supply voltage variations or voltage drop out, even if it is only for a fraction of a second.

1.18 METHODS OF NOISE TRANSMISSION

1.18.1 Ways of noise transmission to receiver

To protect against EMC problems it is essential to know how noise is transmitted to electrical equipment, which generally happens in four different ways:

Galvanic transmission where noise is directly conducted via the wires (mains or signal lines)

Capacitive transmission where electrical fields induce noise signals in the equipment

Inductive transmission where magnetic fields induce noise signals in the equipment

Electromagnetic transmission where electromagnetic fields induce noise signals in the equipment.

1.18.2 Galvanic transmission

Transient problems (caused by in and out cutting of motors, speed controller etc.) mostly arise when sensitive electronics are connected to a main supply cables which are also connected to some noisy, energy-consuming equipment (motors, switches etc.), or when sensitive electronics are connected to same earthing line as the noisy equipment. In such cases the noise is directly transmitted to the electronics. Measures against this type of transmission are the following:

Avoid the connection of the controller's mains supply to the same main phase as used for the noisy equipment's power supply. Use a separate phase.

Ensure efficient earth. The normal grounding in an installation is mostly a safe grounding not suited for EMC earth.

Low impedance to earth with as short as possible ground cables must be ensured. These cables are not to be used in connection with other equipment.

1.18.3 Capacitive transmission

If two cables are closely located, there will always be a certain amount of hidden capacity around the cables. As noise frequencies often contain very high frequencies, coupling between the two cables will arise. Measures against such couplings are as follows:

Never place sensitive low-voltage cables in same cable box as high-voltage cables with noise properties. Keep distance!

Use of screened cables protects the electronics from direct influence of electrical noise. It, however, must be ensured that the connection between screen and ground is correctly carried out according to the manufacturer's instructions.

In cases where the noise comes directly via the main supply cables, the installation of an extra network filter in the power supply input of the sensitive equipment can be recommended.

1.18.4 Inductive transmission

Noise around two closely placed cables can be inductively transmitted (magnetic field). A magnetic field always arises when a cable has electrical properties. The higher the current rate the greater the magnetic field.

This magnetic field is able to induce noise signals in a cable near-by if it constitutes a current loop (coil). The rate of the induced noise signal is proportional to the area of the current loop. The following measures against inductive transmission are the following:

Never place sensitive low-voltage cables in same cable box as high-voltage cables with noise properties. Keep distance!

Use twisted pair cables to greatly reduce the induced noise as the noise voltage in every other twist is in the opposite direction so that they neutralise each other.

In cases where the noise comes directly via the main supply cables, the installation of an extra network filter in the power supply input of the sensitive equipment can be recommended.

1.18.5 Electromagnetic transmission

Many types of noise have extreme high-frequency properties. At high frequencies cables and components will start to act as aerials able to send out electromagnetic noise and to receive electromagnetic noise as well. The noise is transmitted in the form of radio waves through the air. Measures against this type of noise transmission are as follows:

Use of screened cables. This will ensure that the noise only being transmitted to the screen, and not the signal lines, on condition that the screen is correctly connected to frame/earth of the apparatus.

In special cases it can be recommended to place the sensitive equipment in a metal box (a Faraday box).

1.18.6 Conclusion

Always keep a minimum distance of 0.5 m between cables with noise properties and signal cables.

When earthing is used, low earth impedance must be ensured.

The use of screened cables can reduce problems in noisy environments.

The use of extra filtering (e.g. power supply filter) can reduce problems in noisy environments.

1.19 CABLING

1.19.1 CABLE INSTALLATION REQUIREMENTS

When installing electronic controllers into equipment it is essential that the following requirements are observed.

1.19.2 CABLE SEGREGATION

Connections are divided in to two groups

power/control

signal

It is essential that the cable connections to these groups be segregated. For full information about which connection is which see the relevant wiring diagram.

1.19.2.1 SIGNAL CABLES

Low voltage signals should be run in multicore cable to minimise EMC problems and to avoid any confusion with power cables during installation or subsequently. Signal cables should have a minimum insulation voltage of 250 Vac. Signal cables should be flexible with a minimum of 7 strands. Telephone cable should not be used. Flexible cables connected to screw connectors should be bootlace ferruled with the correct ferrule using an appropriate crimp tool. Signal cables should be identified if possible. Signal cables are separated in to 2 groups, common ground and RS485 communication cables. Common ground cables must obey the above rules totally. RS485 communication cables are more tolerant of problems so some relaxation may be allowed. No signal cable should be run in trunking with power cables.

1.19.2.2 POWER AND CONTROL CABLES

All electronic controllers which drive electrical equipment have specified rations. For full details see appropriate manuals. All outputs should be suppression. This is usually done by the use of a resistor/capacitor network connected from the load to the neutral. It is essential that the relays are wired correctly according to the controller manufacturers instructions. When suppressors are internally connected to neutral it is essential that line (L) Neutral (N) polarity is observed on all power connections. If this polarity is not observed data corruption or controller mal-operation may occur.

1.19.3 HIGH VOLTAGE TESTING

No electronic controllers should be connected in circuit during high voltage “Flash” testing.

1.19.4 CABLE INSTALLATION WITHIN ENCLOSURES

Within the enclosure separation must occur with a minimum of 150 mm between parallel runs of power and signal cables. These must not be run in common trunking.

1.19.5 EXTERNAL CABLE TO CONTROL EQUIPMENT (SITE WIRING)

A minimum spacing of 350 mm must be maintained between parallel runs of power and signal cables. These must not be run in common trunking.

Where separation of 350 mm is not possible the signal cable should be screened and run in conduit or separate section steel trunking.

1.19.6 ELECTRICAL INTERFERENCE SUPPRESSION

1.19.6.1 PRINCIPLE

Electronic controllers need suppressors to suppress electrical interference that is generated by relays, solenoids and contractors when power to such devices is removed. Many manufacturers provide built in suppression. The suppressor provides a path for the stored energy in the coil and thus prevents high voltage and sparks which generate the interference.

1.19.6.2 OUTPUTS

Where devices are driven directly by the controller, the built in suppression is adequate. Problems arise where the output is indirectly driving the device via a relay or contractor and are therefore unsuppressed. Where these indirectly driven devices are controlled by equipment mounted in the same enclosure as the electronic controller then extra suppression is required. This should be applied across each device.

1.19.6.3 SUPPRESSORS

For ac loads, suppressors should be series resistor - capacitor type.

1.20 ENERGY ABSORPTION DEVICES

1.20.1 Suppressors

When a 230 / 110 / 24 VAC voltage is switched via a relay contact to an inductive load such as a relay, contactor or solenoid valve coil, high voltage spikes are often generated during the period of contact release and to a lesser extent during contact closure. The level and frequency of these voltage spikes can be many times greater than the supply voltage and can cause damage or corruption of microprocessor based electronic control circuits.

This energy or noise can be significantly reduced by connecting the appropriate sized Suppressor Network across the inductive load. The Suppressor Network, comprising a Capacitor and a Resistor in series, makes the combined impedence of the load less inductive and therefore reduces the size of the voltage noise spike generated when the AC voltage is applied or released. Suppressor Networks are often built into the PCB relay contact output circuits of microprocessor controllers or can be purchased complete with short terminal wires for fitting directly across the load to be suppressed. To operate efficiently, an optimum size Suppressor is required for the supply voltage and load rating.

1.20.2 Varistors

Voltage spikes, often generated by closing and opening switch contacts supplying an AC voltage to an inductive load, may be clipped at a preset voltage level by connecting a Varistor across the load, thus preventing damage and noise problems on the electronic control circuits.

A Varistor is a special type of semiconductor resistance which dramatically changes its impedence at a certain preset voltage level. It protects against high transient voltage spikes by changing its impedence from a high standby impedence to a very low conducting value when the applied voltage goes above the preset level for the Varistor, thus clamping to this voltage level.

Varistors are often used in conjunction with Suppressors on relay contacts used to switch relays, contactors or solenoid valves coils.

1.21 IEE REGULATIONS

1.21.1 SOCKET OUTLETS

Candidates should be aware of the requirements of the IEE Wiring Regulations Extracts Section 553.

1.21.2 SAFETY

Candidates should be aware of the regulations of the IEE Wiring Regulations See chapter 13 IEE Wiring Regulations 1991

Section	130-01
	130-02

1.21.3 SUPPLY CABLES

Chapter 52 of the IEE Wiring Regulations
The candidates should be aware of the implications of these regulations even though they are not designing or installing the wiring.

1.21.4 FUSING & CIRCUIT PROTECTION

Candidates should be aware of the requirements of the IEE Wiring Regulations. See chapter 13 IEE Wiring Regulations 1991 16th edition.

Section	130-03
	130-04

1.21.5 ISOLATORS

Candidates should be aware of the requirements of the IEE Regulations. See IEE Wiring Regulations 1991

Chapter 13 Section	130-05
	130-06

and chapter 46

1.21.6 OVER CURRENT & FAULT CURRENT

The rules for over current and fault current protection are set out in the IEE Wiring Regulations chapter 43. The candidates should be aware of the differences between overload and fault current protection and the different requirements of the regulations. They should understand the principles of fault current reduction by the distribution system.

1.22 ELECTRICAL HAZARDS

1.23 RISK ASSESSMENT

BRA PUBLICATIONS

E1-E7 INCLUSIVE PLUS SIMPLE GUIDE TO ELECTRICAL SAFETY

SIMPLE GUIDE TO ELECTRICAL SAFETY

Set out below are some simple to follow rules for electrical safety which should be applied at all times.

The watchword for safety should always be:

"When in doubt - don't!".

Never operate any equipment unless you are familiar with its operation

Always follow the manufacturers handbook or Company instructions when handling Equipment.

Never cover ventilation openings in equipment - it may cause the equipment to overhead or cause a fire

Never cover over, tape up, or prevent easy access to plug tops fitted into sockets or to isolator switches fitted onto or mounted adjacent to items of equipment

These are the means of switching off for safety in an emergency.

Never enter any area that you are not permitted to enter, especially areas temporarily marked with "limit of safe working" signs.

Never use any electrical equipment that is damaged.

Always attach a label to show that the equipment has been withdrawn from service

Never use any electrical equipment for any other than that for which it is intended.

Never carry any permitted maintenance operations unless the electrical supply has been isolated and the means of isolation secured.

Never carry any permitted maintenance operations unless you are fully familiar with the equipment and operations to be carried out and, where necessary, have received appropriate training.

Never operate any item of switchgear unless you are fully aware of the parts of the distribution that it controls and the consequences of operating that switchgear.

Never immerse electrical equipment in water or use equipment that has been immersed or splashed with water unless it is designed for use with water.

Always ensure that equipment contaminated by water is withdrawn from service.

Never remove covers from equipment unless required for permitted maintenance.

Covers are provided for safety

Always ensure that the electrical supply has been isolated and secured before removing covers.

Always check equipment before use to make sure that it is not damaged and that maintenance work is not being carried out.

Never defeat safety switches provided on equipment.

Always withdraw plug tops when equipment is not being used - unless it is of the maintained type.

Isolated equipment cannot cause a fire or become a safety hazard.

Always switch off socket outlets before removing plug tops.

Always ensure that damaged equipment is repaired or replaced promptly, especially when it receives infrequent use.

It may be forgotten and not be available when required again.

Always take special care when carrying out permitted maintenance on batteries.

These store electrical energy and can inflict burns if mishandled.

Follow the maintenance guides.

Always use the proper tools for permitted maintenance operations. The wrong tools may slip and cause injury.,

Always use the correct materials or components when carrying out permitted maintenance operations.

Alternatives may work but can impair equipment performance and affect safety.

2. SYSTEMATIC FAULT FINDING

A systematic approach to fault finding is a skill in its own right. There are several key points that should be considered.

1. Has the system worked before? i.e. are you looking for a manufacturing or design fault or has something gone wrong or broken.
2. Most faults are simple faults. Only when all the simple things have been eliminated should one start looking obscure problems. E.g. check the power is on, the leads are plugged in correctly (fully home), the fuses etc
3. Most faults occur one at a time, it is unusual to get compound faults unless they have been caused by a common external event.
4. Before 'diving in' ask the staff if there were any unusual events or occurrences leading up to the fault.
5. Check with the alarm/datalogging system before starting to find the fault to see if there is any useful history prior to the fault.
6. Has this fault happened before?
7. Are there visible signs of damage, wear and tear etc?
8. Do not get overpowered by the complexity of the system, try to break it down into individual elements that can be understood and isolated.
9. When working with an electronic controller measure the inputs and outputs with a suitable meter e.g. if a liquid valve is not energised check the volts going into and out of the controller.

10. Remember that electronic controls are often no more than sophisticated thermostats and relays. E.g. if there are volts coming out of the relay output for the liquid valve but there is no refrigeration it is not the controllers fault.
11. Electronics does NOT change the fundamentals of refrigeration. It may make it more efficient or more accurate, it will give you more information but the principles and the mechanics are still the same.
12. You cannot get more refrigeration by turning down the setpoint. If the output is energised look elsewhere.
13. If in doubt swap the electronic controller with one that is working.
14. Make comprehensive notes in a note book on all your actions WHILE you are doing them. This will help reporting the fault, help organise your thoughts and help when phoning someone for advice if you cannot solve the problem. It will also help next time you come across the same fault, it is suprising how quickly you forget what EXACTLY happened.
15. When reporting or recording information on a computer screen write down the exact words not what you think says. This helps enormously when asking for help over the telephone.