IP7/2 - PLANT.ROOM.POSITION.AND.SIZE

From page 30

DISTRIBUTION

There are a number of services which may require distribution throughout a building. These include; hot and chilled water, potable water, electrical power and lighting, control cabling, conditioned air, communications cables and fire systems cabling. Taking heating as an example hot water is generated in the plantroom by the boilers. It must then be distributed to the heat emitters in each room. Finally, water which has had its heat removed must be returned to the plantroom for re heating. It can be seen that vertical runs of pipe are required to carry heated water to each floor. Horizontal runs of pipe are required to distribute the hot water to each heat emitter. In domestic buildings vertical pipes are surface mounted and boxed in for cover. Horizontal runs are made between joists and under the floorboards. In commercial buildings vertical service shafts are required. Horizontal distribution usually takes place under a raised floor system or above a suspended ceiling.

Ducting is the most difficult system to accommodate since it has a much larger cross sectional area than water pipes. This is especially so close to the air handling unit where the ducting must carry all the conditioned air for each space. The cross sectional area reduces the further away from the air handling unit you are as the conditioned air is progressively divided off into successive spaces.

Service runs should preferably be linear. This provides economy of installation and operation. A change of direction in ductiong or pipework requires additional components and fabrication. Bends and junctions offer greater resistence to fluid flow. As a result a larger and therefore greater energy consuming pump or fan would be required.

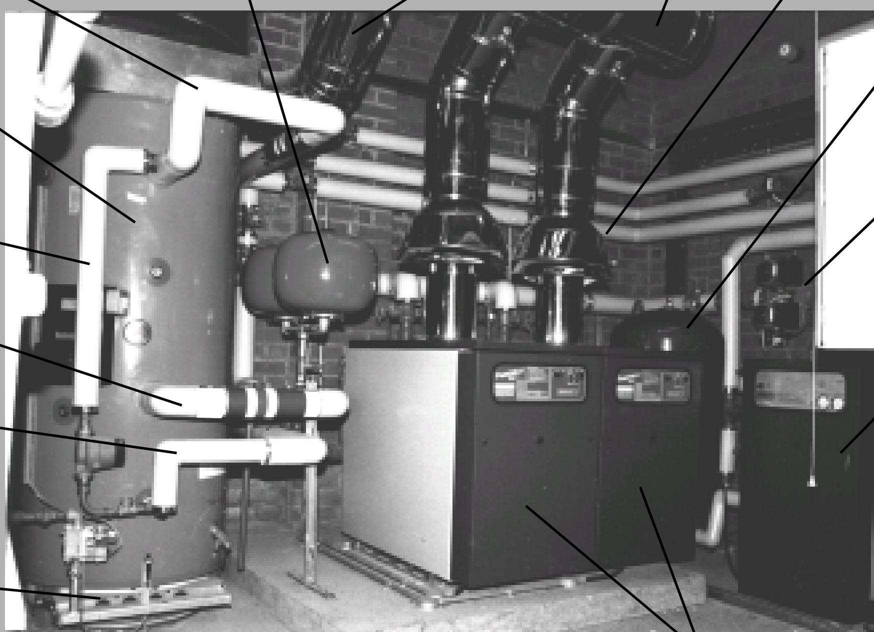

Figure IP7. Some of the components found in a typical heating plantroom photo: ***Hamworthy Heating Ltd.***

1.6 Controls

Controls are required to ensure that the heating system operates safely, efficiently and provides comfort for the building occupants. Figure 1.27 shows a typical arrangement of controls for a domestic central heating system. It is comprised of the following components.

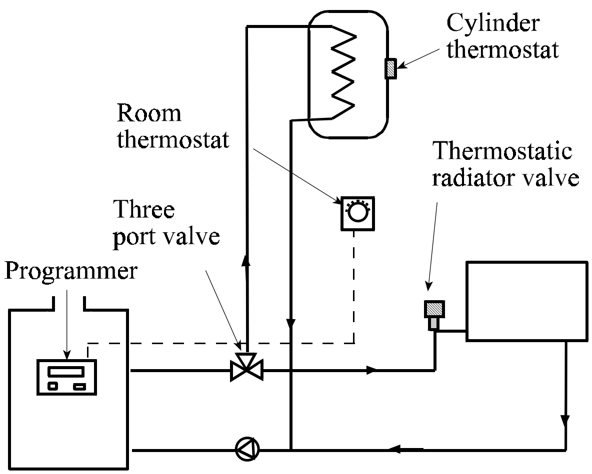

Figure 1.27 Domestic heating controls

Room Thermostat. Is a device which controls room temperatures. Control is made in relation to a preferred temperature setting made on the thermostat by the occupant. The thermostat is in fact a switch opened and closed as the room temperature rises above or falls below the temperature setting respectively.

The thermostat should be positioned in a representative room such as the living room at standing chest height away from sources of heat such as direct sunlight. This means it will accurately sense the air temperature experienced by an occupant in the room. When the thermostat switch is closed, current can flow through it. This is interpreted by the boiler as a call for heat. The boiler will fire, the pump will run and the three way valve will direct hot water to the radiators. When the room temperature rises above the preferred temperature setting, changes within the thermostat either electronically sensed or due to the differential expansion of metal in a bi metallic strip cause the thermostat switch to open. As a result the control current will stop and the boiler and the pump will switch off. It can be seen therefore that room temperatures are controlled by stopping and starting the flow of heat into the room as required.

Programmer. This is a time switch that determines the times within which the heating will respond to a call for heat from the room thermostat. The start and stop times between which the heating will be allowed to operate are entered into the programmer. For example, heating may be required from 07:00 to 08:30 in the morning then 17:00 to 23:30 in the evening. Modern microprocessor controlled programmers allow multiple daily heating periods and the ability to programme each day of the week with a different heating programme. An example is that the first "on" period at the weekend may start at 8:00 and end at 12:00 to reflect the fact that the occupant is not in work on that day.

Cylinder thermostat. This is a temperature controlled switch similar to the room thermostat. The difference is that it is clamped on to the indirect cylinder and therefore senses and controls the temperature of the dhw. When the switch is closed and therefore calling for heat, the three way valve will be instructed to divert boiler flow through the calorifier in the cylinder. This will cause the temperature of the water in the cylinder to rise. When the temperature reaches the setting on the thermostat the switch will open. The three way valve will then direct the flow away from the cylinder and back to the heating circuit.

Thermostatic Radiator Valve (TRV). This is a valve (section 1.7) fitted to the inlet of the radiator. Gas in the TRV head (figure 1.28) expands with temperature and pushes a gate downwards blocking the inlet flow. This will restrict or even stop the flow of heat into the radiator. The heat output will then be reduced

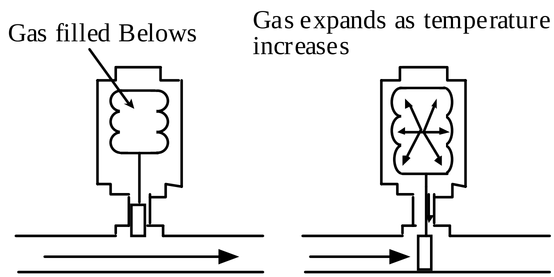

Figure 1.28 Thermostatic radiator valve

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Heating controller

Modulating control valve

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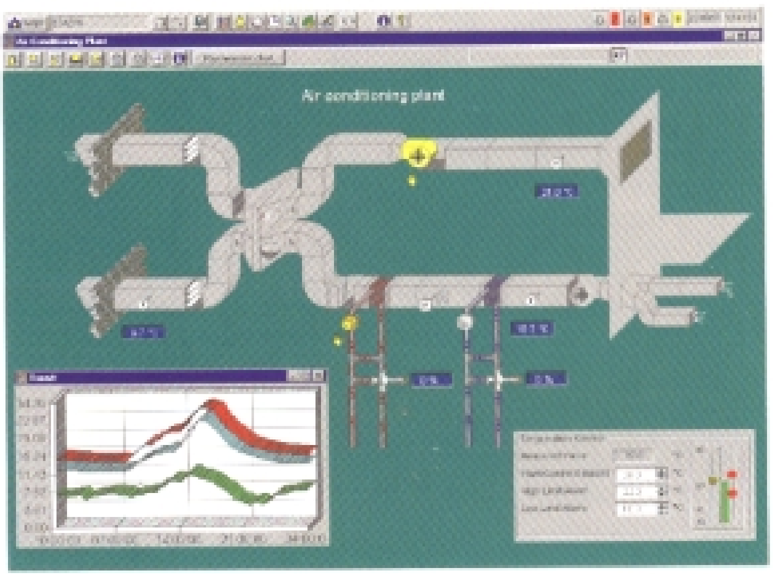

Building management system graphic diagram

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causing the room to begin to cool. As it does so the gas in the TRV head will contract and the valve will open up once more. TRV's allow room by room control of temperatures to be achieved. They are particularly useful in south facing rooms and rooms subject to casual heat gains, giving an extra layer of control beyond the single room thermostat.

CONTROLS FOR COMMERCIAL BUILDINGS

Large buildings cannot be controlled effectively using domestic control systems. The components must be scaled up and certain refinements made to provide adequate control. The difficulties encountered in heating control in large buildings arise due to their; thermal sluggishness, different heat loads/gains and differences in hours of usage of spaces. Both time and temperature control require consideration.

Optimum start controller. Time control in domestic buildings is adequately carried out using the fixed on/off time controller described previously. This is because even on cold days the time taken for the majority of domestic buildings to warm up to comfortable temperatures is unlikely to be more than thirty minutes. This period when the building is warming up to the occupancy temperature setting is known as the pre heat period. In large buildings the pre heat period will be considerably longer due to the thermal inertia of the structure of the building and the heating system itself. The pre-heat period is also variable. It is longer in winter than in spring and autumn because the building cools more during the night. This means a fixed start and stop time would be wasteful. This is illustrated in figure 1.29. It can be seen that on a cold night the heating must come on at 1.0 a.m. to heat the building up to adequate levels by the start of occupancy at 8.00 am. If this fixed on time is retained on a mild night then the building is raised to the occupancy temperature at 5:30 am. This is two and a half hours prior to occupancy and so is wasteful.

To overcome this problem an optimum start controller is used. This is a device into which the operator inputs the times of the beginning and end of occupancy, say 8.00 am and 5.00 pm. The optimum start controller then monitors inside and outside temperatures, combines this with a knowledge of the thermal inertia of the building and as a result determines at which time to activate the heating in the morning to achieve the desired internal temperatures by the start of occupancy. In the above example the optimum start controller would delay the onset of heating until 3:30 am. Thereby saving two and a half hours of heating which for a large building represents a significant saving in fuel costs.

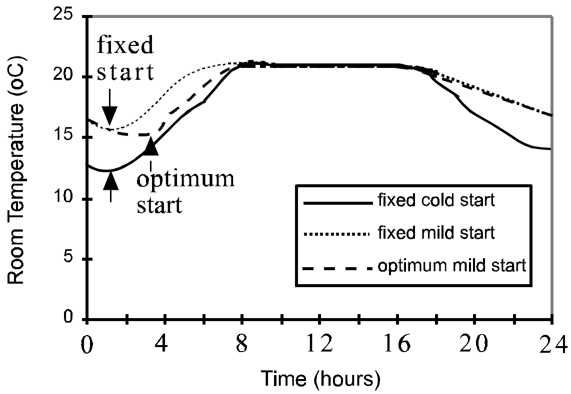

Figure 1.29 Graph of room temperature against time of day showing the benefits of optimum starting

The most difficult parameter to determine for the effective operation of the device is the thermal inertia of the building. Initial estimates of this may need to be modified during the commissioning stage to achieve accurate performance. Some devices monitor their own performance and carry out this adjustment automatically. They are known as self learning optimisers.

Compensated temperature control. Temperature control is achieved in domestic buildings by simply switching on and off the flow of heat to the radiators. When the desired room temperature is achieved the boiler will be switched off and after a short run on period, to dissipate residual heat, so will the pump. This is not practical in large buildings because of the thermal inertia of the large volume of water circulating in the heating system. Swings in temperature about the set point would be too great as the water in the heating system was alternately heated and cooled. Instead, large buildings do not switch on and off the flow of heat to the building but modulate it up or down as the demand for heating goes up or down. This process is achieved using a compensated flow circuit.

Compensated flow circuits vary the boiler flow tem-


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perature in response to changes in outside air temperature.

Figure 1.30 illustrates the principle. The graph is known as a compensated flow curve. Moving from right to left on the graph, it can be seen that as the outside temperature increases the temperature of the boiler flow is progressively decreased. At 16ºC outside air temperature the boiler flow temperature is equal to ambient conditions. In effect the heating is switched off . This temperature is known as the outside air cut off temperature. At this temperature no mechanical heating is required since 6ºC worth of heating can be achieved from casual gains in the building from passive solar energy, body heat, lighting and appliances.

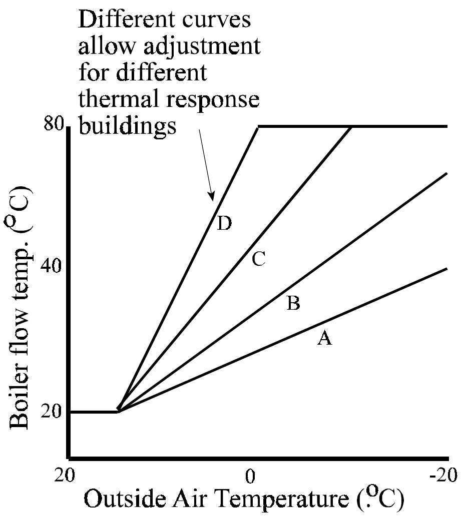

Figure 1.30 Compensation curves

The adjustment in flow temperatures is achieved using a variable temperature (VT) heating circuit. How this is achieved is illustrated in figure 1.31 and IP8. The boiler produces hot water for the constant temperature (CT) circuit at 80ºC. Using a three way valve a proportion of this hot water is allowed to pass into the heating circuit. When the demand for heat is high such as on a cold day more hot water will be allowed into the heating circuit. On a mild day less heated water would be allowed into the heating circuit. The radiator temperatures will therefore be hotter on a cold day than a mild one

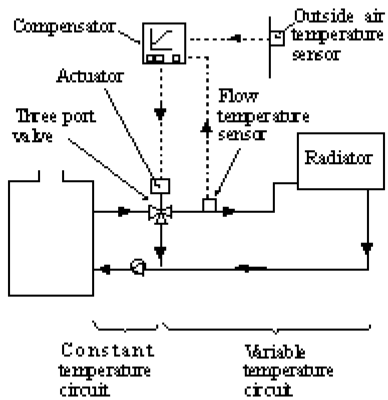

Figure 1.31 Variable temperature flow circuit

ZONING

In large buildings some spaces may need heating and some may not. Differing heating demands within the same building occur for two primary reasons, these are; differences in heat gains and differences in occupancy patterns (hours of use).

For example, south facing rooms will experience solar gains and the heating effect may be sufficient to remove the need for mechanical heating. In this situation the heating to the south side of the building should be shut off. Heating will still be required in north facing rooms. It can be seen then that the building can be split along an east/west axis into two zones one facing north and the other facing south. Further zones can be identified such as those subject to other heat gains. For example, rooms with high occupancy levels or where extensive use of computers is being made.

Individual room by room control of the south side of a building can be achieved using thermostatic radiator valves. An alternative method of zoning, which is more appropriate to larger buildings, is to install separate pumps and flow and return pipe work to supply each zone. A motorised valve, zone temperature sensors and

an appropriate control system are required to control the flow of heat into each zone. As a result there is a capital cost associated with zoning a building. However, these additional costs will be recouped over time in the value of energy savings made. There are also additional benefits to zoning a building such as greater degree of temperature control leading to improved thermal comfort and greater productivity of staff.

Separate heating circuits can also be used to cater for differential occupancy of spaces within a building. One example is in the case of a school which holds night classes. Rather than heat the whole school for this event the school should be zoned and heating can then be supplied to the night school block only.

If the use of parts of buildings are being charged for separately heat meters can be fitted to each heating zone pipe work. These meters monitor how much heat is being taken by the zone from the central boiler plant. Knowledge of this allows accurate costing of out of hours use of spaces to be made

BUILDING ENERGY MANAGEMENT SYSTEMS (BEMS)

All of the control functions discussed previously including boiler step control, optimisation, compensation and zoning can be carried out using a building energy management system (BEMS). A BEMS is a computer based heating, ventilation and air conditioning control system which offers a great deal of flexibility in the way it is set up and operated. It also offers the possibility of close interaction between the operator and the building services systems. The main components of a BEMS are shown in figure 1.32 and are described below.

Outstations are small computers. Unlike dedicated hard wired controllers which only control the functions for which they have been purchased outstations are flexible in what they can do. The outstation can be programmed to perform any or all of the above control functions. The outstation receives information about what is happening to the heating system and the building from sensors. The programme which decides what this information means and what to do as a consequence is called a control strategy. A simple example is if the room temperatures are below the required temperature setting known as the set point. Temperature sensors will signal this to the outstation. Using the logic contained in the control strategy the outstation will send signals to actuators to make the boiler fire and pumps operate to supply heat to the room. The control strategy refers to other rules before carrying this out for example heating will only be supplied if the time is within the occupancy or pre heat period.

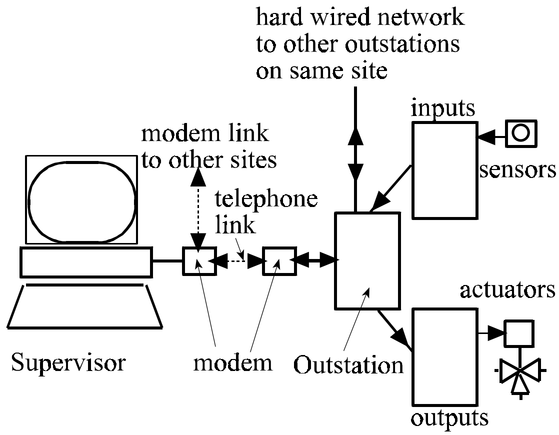

Figure 1.32 Building energy management system components

Sensors are the input devices for the outstation. They are transducers which convert a physical state into an electrical signal. There are two main types; analogue sensors and digital sensors. Analogue sensors return a varying signal to the outstation. For example, a signal in the range 0 to 5 volts from a temperature sensor can be set to represent the temperature range 0 to 25°C.

A digital signal can only take one of two values for example 0 volts or 5 volts. Such a signal can be sent from a switch to represent it being opened or closed. So for example if a boiler was firing a 5V signal would be returned if it had failed then a 0V signal would be returned.

Actuators like sensors can be either analogue or digital. They are devices which turn electrical signals into physical actions using motors or solenoids. An example of an analogue actuator is one which sets the position of a motorised valve. The electrical signal to it may vary between 0 and 5V this corresponds to the fully

shut and fully open positions. Hence a signal of 2.5V would cause the valve to be half open.

A digital signal can be used to open or close a solenoid. For example changing the signal to a pump from 0 to 5V causes a pump to operate returning the signal to 0V causes it to stop.

The supervisor allows human operators to interface with the system. It is a standard personal computer which is loaded with the necessary software to interact with the outstations. The supervisor can be used to programme the outstation with its control strategy. Once this is achieved it is possible to visualise on screen all of the information available to the outstation. So for example room temperatures, the status of boilers, pumps and other equipment such as the position of valves or dampers can all be displayed. This information id displayed graphically so that their interpretation is easily understood with only a small amount of training.

The system constantly upgrades the information it presents and also stores data at the outstation for later inspection. For example, room temperatures over the last 24 hours can be displayed graphically. This is a most useful tool for diagnosing faults and commissioning the heating system following installation. The supervisor is also used to set variables. One example is the inputting of room temperature set points.

Buildings fitted with a BEMS have been found to have low energy consumptions. There are a number of reasons for this. The first is the accuracy of control that can be achieved. The second is the ability of the system to signal heating system faults which may otherwise go undetected causing excessive energy usage. Finally, monitoring and management of energy consumptions is also facilitated by fitting sensors on to the utility meters. This allows logging of energy consumptions which can then be used to prepare reports and note excessive consumptions.

One supervisor can be used to control the operation of many outstations. The supervisor will be located in the office of the energy or building manager. It can communicate with various outstations using the telephone system and network cabling on site. This communication is not limited to outstations and other BEMS systems. It is also possible to communicate with other control systems in buildings. For example it is possible to integrate BEMS systems with security systems. So for example access to spaces using key cards can be monitored. When it is known that all people have left a space the heating can be turned off or turned down to a set back position. Communication can also occur between BEMS and fire systems. Ventilation systems which would cause spread of smoke can be closed by dampers in the event of fire being detected and smoke clearance fans can be turned on.

1.7 Valves

Valves have a role in the commissioning, operation and maintenance of wet indirect heating systems. In commissioning, valves are used to balance the flow of water around the distribution and heat emitter network, in operation, valves are used to direct and control the extent of heat output and finally, in maintenance, valves are used to isolate failed sections of pipework and components for repair. These roles are achieved using the way that valves modify the flow of water in pipes. There are many different types of valve. The following section describes the three valve functions associated with flow modification and gives an example of a specific valve type used to carry out each one. These valves are illustrated in figure 1.33.

- The first function is to stop the flow of water completely. These valves, also referred to as isolating valves, are fitted on both sides of components such as pumps. The valve, when closed, stops the flow of water so that the pump can be removed for repair without having to drain down the entire system.

One type of isolation valve is the globe valve. Water normally flows through a gap in the valve body. Turning a threaded rod by hand or by a motorised actuator causes a plug on the end of the rod to block the gap in the valve body stopping the flow.

- The second function is to regulate the flow of water between full flow and no flow. If the water is heated the amount of heat delivered to a heat emitter can be varied by varying the flow of water. Thermostatic radiator valves (section 1.6) work in this way.

One type of flow regulating valve is the butterfly valve.

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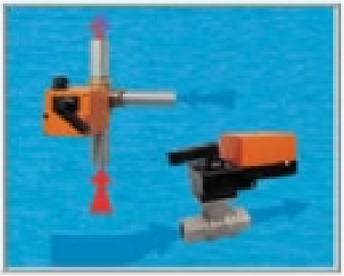
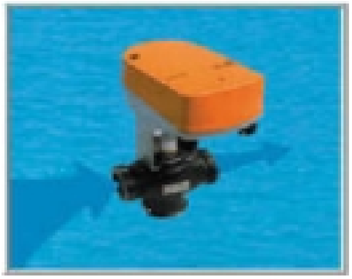


Mixing actuators and motorized ball valves for HVAC water circuits



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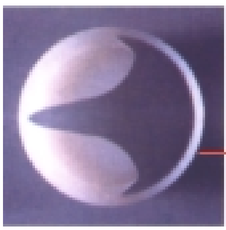

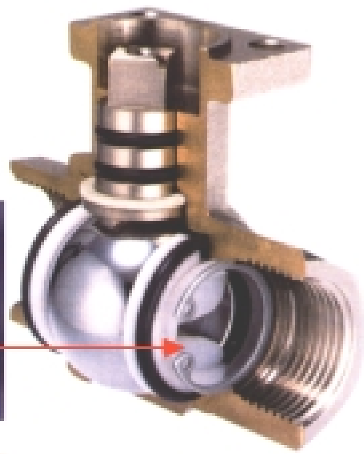

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This valve has an internal disk whose diameter is the same size as the bore of the valve. When the disk is positioned across the valve flow is stopped, when the disk is in line with the bore full flow is achieved. The position of the disk is determined by a rod connected to the disk centre pivot and extending out of the valve. Rotation of the rod determines the alignment of the disk and hence rate of flow of water.

· The third function is to direct the flow of water down one of two alternative outlet pipes connected to the valve. For example a three port valve has one inlet and two outlets. Flow entering the inlet can be directed down either of the outlets or shared between them. One example of the use of this is in domestic heating system control. Hot water from the boiler can be diverted either to the heating circuit, dhw cylinder or shared between the two depending on which thermostats are calling for heat.

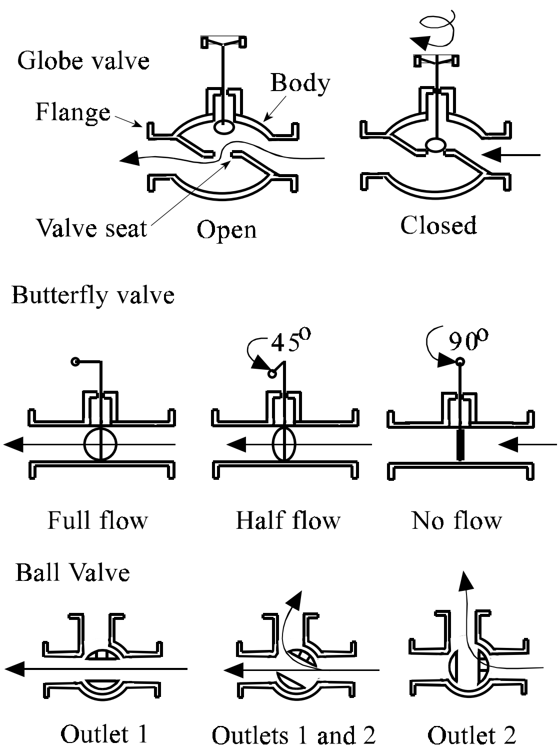


Figure 1.33 Functions and types of valve

An example of a flow diverting valve is the ball valve. The valve body has three ports. Situated at the centre of these in the bore is a ball. This ball has a hole bored through it. Water normally passes through inlet to outlet 1 through the hole in the ball. However, rotation of the ball at first shares flow with outlet 2 then diverts it wholly to outlet 2.

A mixing valve is a three port valve working in the opposite sense. It has two inlets and one outlet. Inlet 1 carries hot water, inlet 2 carries cold water. Variable positioning of the ball will mix the two flows to give a constant temperature at the outlet ranging between the two flow temperatures.

The build quality of valves is an important issue. For example globe valves must seat positively if they are to stop flow. Control valves must be constructed to close tolerances because when they begin to close the pressure increases and there is a tendency for water to seep past the valve. This will result in energy wastage and poor control. This is particularly important when valves carry out more than one of the functions described above. For example globe valves can act as a flow regulation and an isolation valve (page 42).

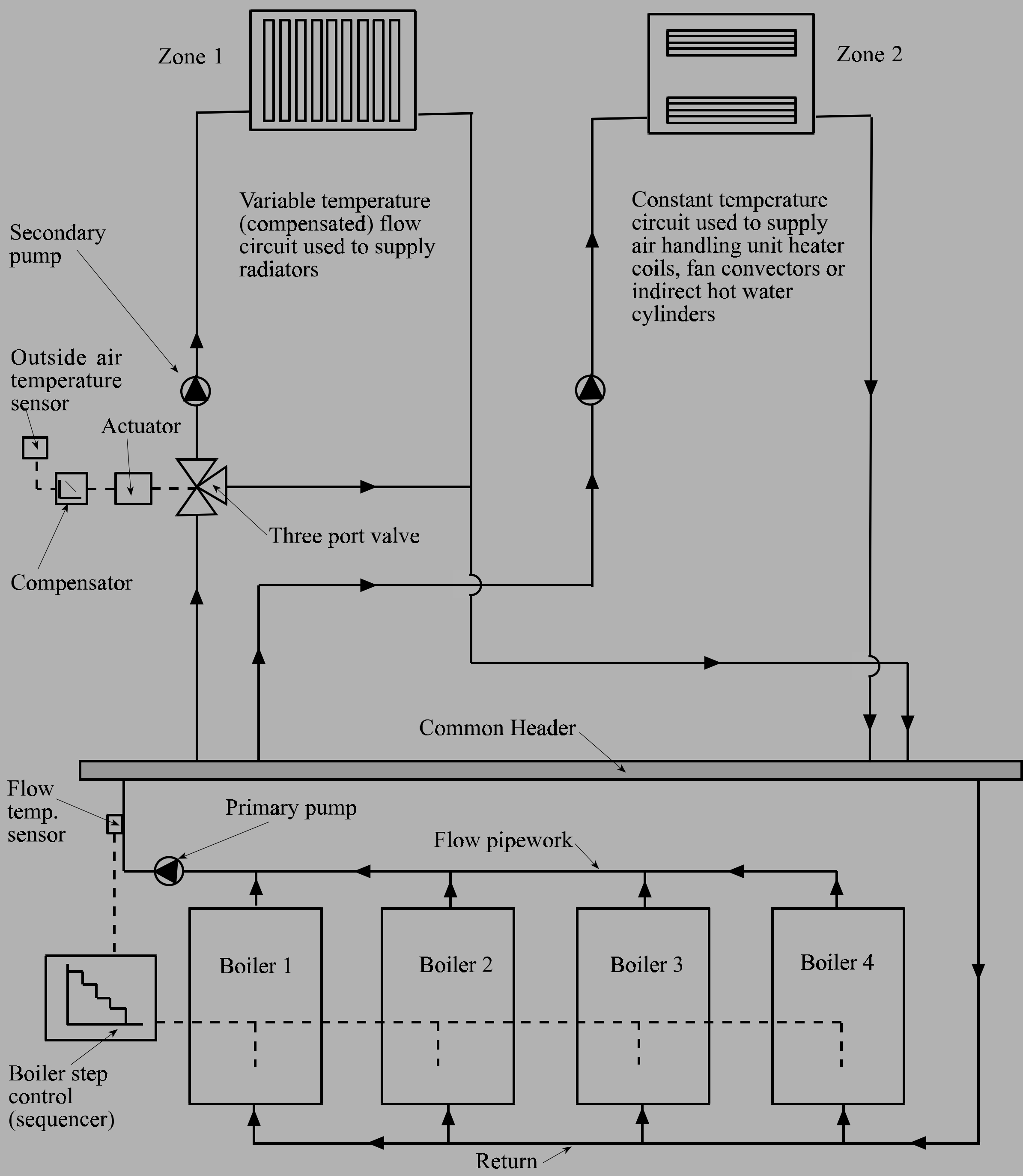
The setting of valves can be adjusted manually as is the case with most isolation valves. However they can also be set using a motorised actuator which is the case for valves associated with control. The position of the butterfly or ball within the valve is usually indicated by a visual marker outside the valve. This enables maintenance workers visiting the plantroom to assess its current position and check that the position changes in response to a control signal.

1.8 Feed and Expansion

Indirect heating systems using water as the heat transfer medium must have some means of replenishing minor water losses and accommodating the expansion that occurs as water is heated. Domestic systems use a feed and expansion tank. In commercial systems the pipe work is sealed and a pressurisation unit is used to satisfy the requirements for feed and expansion.

Feed and Expansion (FE) Tank is usually sited in the loft so that it is higher than the heating system it serves. Water from the mains fills the tank to a pre set level determined by the ball valve (figure 1.34). If water is

IP8-SCHEMATIC-TWO.ZONE.MULTIPLE.BOILER.SYSTEM



Reproduced with permission from **Hamworthy Heating Ltd.** from their publication 'Energy Efficient Multiple Boiler Systems' lost from the heating system it is replenished from the FE tank via the feed water pipe. The expansion pipe is connected to the heating system pipe work and terminates in FE tank (figure 1.1, page5). If the heating controls should fail the temperature of the boiler flow could rise causing the water in the system to expand. If the system were sealed the resulting pressure rise would damage the system. However this does not occur since the additional water volume can escape through the expansion pipe. Excess water in the FE tank will be safely discharged outside via the overflow pipe.

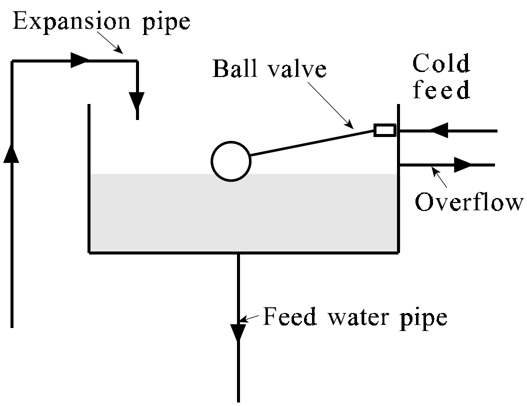


Figure 1.34 Feed and Expansion tank

Pressurisation unit. The pipe work in heating systems incorporating a pressurisation unit has no openings to the outside air. It is sealed. A pressure sensor is fitted into the system as shown in figure 1.35. If the pressure falls too low a pump is operated that feeds mains water into the pipe work. When the boiler fires pressure in the system will increase due to the expansion of water. This increased water volume is accommodated in the expansion tank. The tank is partially filled with nitrogen which is compressed by the incoming water. If, due to a boiler control fault, the pressure increase is too great then an interlock between the pressurisation unit and boilers will switch the boilers off until the cause of the fault can be corrected. Excess pressure is released by allowing water to escape through the pressure release valve. Continuous filling of the system by the pump would signal a leak in the system.

As well as keeping system water levels maintained the pressurisation unit can also pressurise the water in the system. The benefit of this is that the boiler flow temperatures can be increased above 100°C without it boiling. This means that the same volume of water will carry more energy to the heat emitters. In a large building this will result in smaller pipe diameters which are easier to accommodate within service runs. The temperature ranges encountered are;

- Low temperature hot water (LTHW)
  70 - 100 °C
- Medium temperature hot water (MTHW)
  100 - 120 °C
- High temperature hot water (HTHW)
  120 - 150 °C

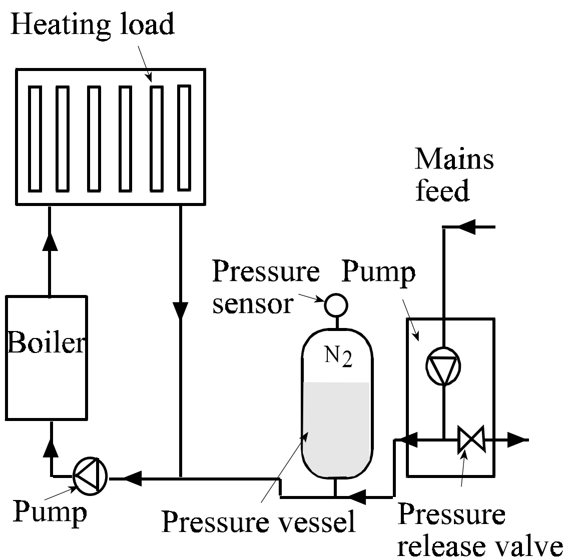


Figure 1.35Pressurisation unit

The high temperatures can be used to provide heat for certain industrial processes such as drying. However care should be taken with positioning heat emitters which will have very hot surfaces and would burn anyone touching them.

2.0 Indirect Warm Air Heating

Air can be used as a heat transfer medium in the same way that water is used to carry heat. The warm air is

NOTES

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delivered to the space to be heated in ducts rather than pipes. Air has a much lower heat carrying capacity than water and so ducts need to be bigger in cross sectional area than a water pipe to carry the same amount of heat. The space required for these ducts must be allowed for in the structure of the building.

There are three benefits of warm air heating. The first is that ventilation can be supplied to a room along with the heat. The second is that the time taken to warm up rooms to comfort temperatures is less than that taken by a wet system and finally the room warm air outlet terminals take up much less wall space than a radiator. Figure 2.0 shows the main components of a domestic indirect warm air heating system.

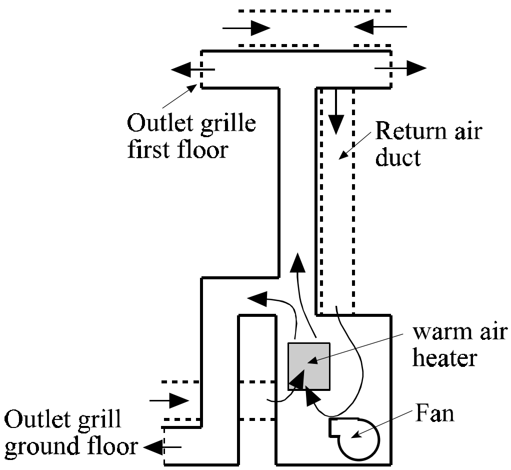


Figure 2.0 Domestic warm air heating system

A centrifugal fan is used to pass air over a surface which is heated by a gas burner. This air is then delivered to the various rooms using ducts. The vertical ducts are sited centrally in the building to achieve economy of duct lengths and ease of accommodating them. Short horizontal runs deliver the air to each room. The outlet grilles should be directed towards external walls to counteract the cold down draughts which occur at windows. Air typically returns to the heater via the stairwell and halls. Gaps are usually created in doors to allow the free passage of return air. Air can also return to the heater via ducting as is shown in the diagram. Return inlet grilles should not be sited in toilets or bathrooms due to the risk of re circulating moisture and odours throughout the building. Fresh air enters via infiltration routes into the building.

COMMERCIAL SYSTEMS

Indirect warm air heating systems for large buildings share many of the characteristics of air conditioning systems which are discussed in detail in section 7.0 Figure 2.1 shows a typical warm air heating system. Outside air is drawn into the air handling unit using a centrifugal fan. It is filtered and heated before leaving the unit to be delivered to each room using ducting. The outlet diffusers may be sited under the window sill to counteract perimeter heat losses. Dampers are fitted to control the flow of warm air out of the unit. The return air outlet is positioned to give a good flow of air across the room, possibly within a suspended ceiling. The return fan is smaller than the supply fan so that the rooms become slightly pressurised. This helps to prevent the ingress of draughts into the building.

An advantage of warm air systems is that in summer the heater coil can be turned off and free cooling obtained by bringing in fresh outside air. By pass ducting will be required to avoid any heat recovery devices to ensure that the incoming cool air is not preheated by the outgoing stale air.

If the exhaust air quality is good then the majority of it will be re circulated back into the inlet. The remainder of the air supply will be fresh air. In this way some of the energy used to heat the air will be recovered. If the air quality is poor then 100% fresh air will be used. To avoid wasting energy heat should be recovered and used to pre heat the supply air (section 4.4).

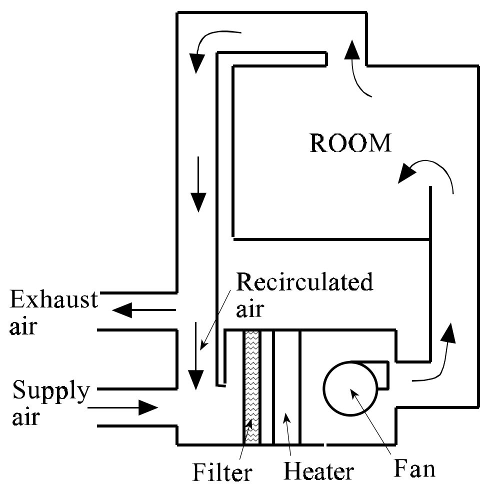


Figure 2.1 Commercial warm air heating system

IP9 - HEAT.TRANSFER.MECHANISMS

Heat naturally flows from a body at a high temperature to bodies at a lower temperature. It is as if the universe is trying to balance out the temperature of all the objects contained within it. In the far future it can be predicted that everything will have the same temperature and heat transfer will stop. Until that day we can use heat transfer mechanisms to make our heating systems work.Heat moves by three mechanisms; conduction, convection and radiation.

All of the universe would really like to be one temperature. To achieve this, heat flows from high to low temperature objects..... Until this final temperature is met we can use the effect to make our heating systems work!

CONDUCTION

This is the transfer of heat through solid materials. This mode of heat transfer is often descibed by imagining that the atoms of a material vibrate. The hotter the material the greater are these vibrations. Conduction is explained by the transfer of these vibrations from one atom to the next, moving from the warm end of the material to the colder end. An example of conduction in buildings is the loss of heat through the building fabric from the warm interior to the cooler outside. Conduction of heat is also used in calorifiers and plate heat exchangers. Close contact is required between the hot and cold fluids to ensure good heat transfer is made.

CONVECTION

This is the transfer of heat within liquids. Here we can consider both air and water to be a type of liquid. Using the concept of vibrating atoms introduced above. It follows that the atoms in warm air will be more widely spaced due to their increased vibrational amplitude than those in cool air. As a result the warm air will be less dense, and so will float in the cooler air causing it to rise. When the warm air becomes cooled once more it will have the same density as the rest of the room air and convection will stop. Convection currents carry heat away from radiators and convector heaters. Convection also causes stratification of temperatures in tall spaces (see page 51). Downward convection currents occur when cold air is present in a space. This is a particular problem along the perimeter of highly glazed buildings. Downward cold convection currents from the windows can produce uncomfortable draughts. Which must be countered by a perimeter heating system (see page 23).

RADIATION

Any warm object will radiate heat to another object at a temperature lower than itself. This heat is in the form if infra red radiation which does not require gaseous or solid material for its transfer. When an object absorbs infra red radiation its temperature will be increased. Infra red radiation is the warmth we feel from the sun. It is also used as the heat transfer mechanism by radiant heaters. Thermal radiation is a similar form of energy to light. As a consequence just as light can be guided and directed using reflectors so can thermal radiation.

MASS TRANSFER

An additional mode of heat transfer used in buildings is that of mass transfer. In this a fluid such as air, water or steam is used as a heat transfer medium. By moving the air or water from one place to another the energy held by it is also transferred. Following the mass transfer the occupants in the room are heated by one of the above three mechanisms.

3.0 Direct Heating Systems

Direct heaters, which were introduced in section 1.0 give out their heat by a combination of convection and radiation directly into the space they are heating (see IP9). Common domestic gas fires are one type of direct room heater which aim to encourage both forms of heat output. However, for purposes of discussion in this book direct heaters will be grouped in to two main categories; those which give out most of their heat by radiation and those which give out most of their heat by convection.

This section will consider common types of domestic and industrial convector and radiant heaters and will conclude by looking at direct water heaters

3.1 Convector Heaters

Convector heaters give out their heat using the natural buoyancy of warm air. Room air comes into contact with a hot surface. When warmed this air becomes less dense and so rises out of the heater to warm the room. Some devices use fans to increase airflow across the heated surface. This increases heat output and reduces the time taken to heat the room.

DOMESTIC HEATERS

Gas Convector Heaters. These heaters are room sealed combustion devices. The combustion air is taken from outside the building via a balanced flue rather than from the room itself (figure 3.1). As a consequence heaters are usually installed on outside walls. Heaters can be installed on internal walls using longer lengths of flue and exhausting the flue gasses using a fan. To avoid the complexity associated with electrical wiring, basic models are fitted with a piezoelectric spark ignition. Temperature control is achieved manually using a variable burner setting. The only connections required by the heater therefore is a gas supply. To improve the level of control some models incorporate a room thermostat and a time switch the operation of which requires connection to an electrical supply.

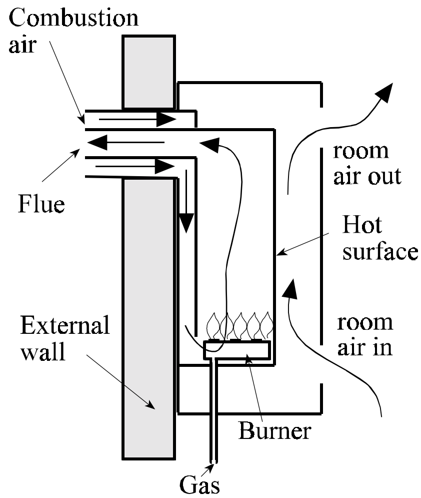


Figure 3.1 Gas convector heater

Electric storage heaters. This type of heater comprises of a metal casing which is filled with dense blocks (fig

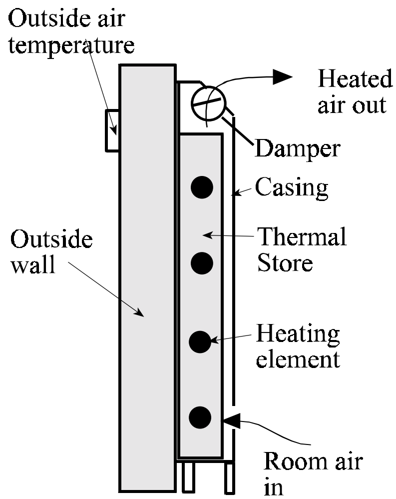
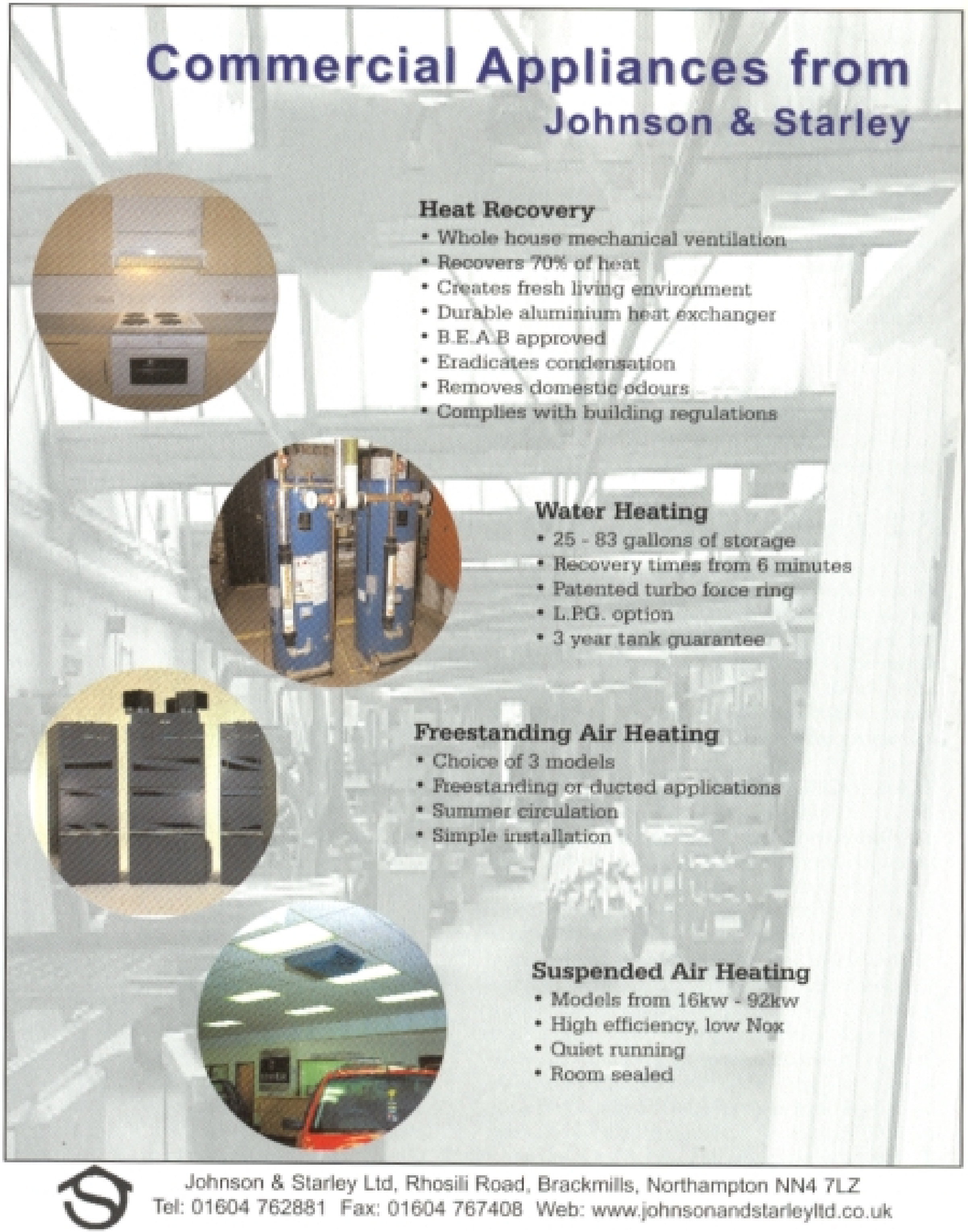


Figure 3.2 Electric Storage Heater

ure 3.2). The blocks have a high specific heat capacity (see IP6). This means they can store large amounts of heat for each degree of temperature through which they are heated. The blocks are heated by electrical heating elements which run through them. Charging with heat usually takes place overnight to take advantage of cheaper night-time electricity tariffs. The amount of heat given out by the storage heater in the day de-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pends on how much heat is stored by it overnight this, in turn, depends on the time over which the heating elements are operated. Charging time can be set manually using a dial on the heater graduated in hours or it can be carried out automatically. Automatic control requires a controller which monitors outside air temperatures. If the air temperature is low, indicating that more heating will be required the next day, then the heating current will be allowed to flow for longer.

Heat output is by convection currents passing across the casing and through the heater. If the room becomes sufficiently warm further heat output can be restricted by closing a damper to block the internal convection path. Fanned storage heaters are available. These utilise well insulated casings to minimise heat losses. Heat output is via forced circulation of air through the unit. These storage heaters give a better degree of control but utilise additional electricity to operate the fan.

COMMERCIAL WARM AIR HEATERS

Direct heaters used in commercial or industrial buildings are bigger in scale than domestic heaters so that they can satisfy the increased heating demand of the large spaces that are used by industry. They are usually less decorative but are more robust. They are often mounted at high level to free up floor space which is more economically used as production area.

Floor standing cabinet heaters. Figure 3.3 shows a diagram of a floor standing cabinet heater. Air is drawn from the space by a fan and is passed over a surface heated by a gas burner. The hot air is then directed back into the room via cowls. Adjustable vanes within the cowls allow further variations to be made to the direction of the warm air jet. Combustion air for the burner is drawn into the heater from the adjacent space or it may be taken from outside using ducting. The times within which the heater can operate is controlled using an optimiser as described in section 1.6 (page 35). The space temperature is controlled using a thermostat which monitors the temperature of the air entering the heater. If the temperature is above set point the burner is switched off or modulated down.

It is not advisable to use warm air heaters when the space to be heated is draughty. This is because comfort is achieved by contact with the warm air. If this warm air is regularly removed from the space for example by opening loading bay doors then comfort will not be achieved and energy will be wasted. Care should also be taken where the space to be heated is tall. This is because warm air rises and hence stratification will take place.

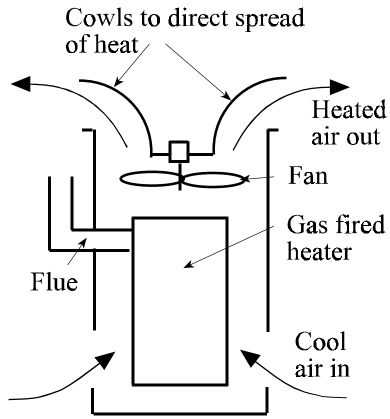

Figure 3.3 Cabinet heater

Stratification is the creation of a temperature gradient which increases between the floor and roof. The temperature adjacent to the roof in a 4m high space may be as high as 30°C. At low level, in the zone occupied by people, the temperature is 21°C. The high air temperature next to the roof is unnecessary for comfort and will increase heat losses through the roof.

The problem of stratification can be avoided using de stratification fans (figure3.4).

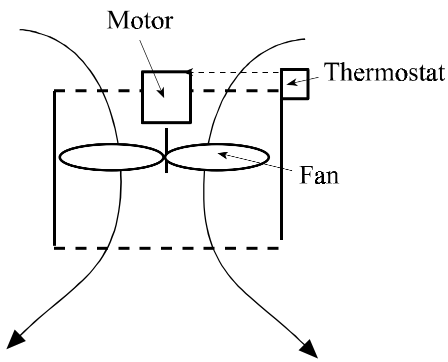

Figure 3.4 De-stratification fan

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These are fans mounted at high level in the space. An inbuilt thermostat monitors the air temperature next to the fan. If the temperature rises above a threshold temperature setting such as 27°C then the fan operates pushing the warm air back down into the occupied space.

Unit heaters. Unit heaters are a smaller version of cabinet heaters which are mounted at high level in a space (figure 3.5). Air flows through the heater, driven by a fan. It is heated as it passes through a series of venturi shaped plates made hot by a gas burner. Adjustable vanes on the warm air outlet directs the heat down into the occupied space. One of the benefits of this type of heater is that they do not occupy any floor space. Another benefit is that they help to avoid stratification by taking in air at high level and directing it down towards the occupied space.

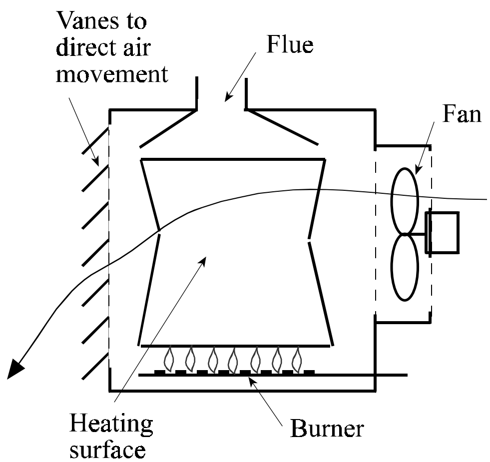

Figure 3.5 Unit heater

Heating and Ventilation. The warm air heaters described above use re-circulated room air as the medium for heating. However, fresh air can be supplied to the heater using a length of ducting so that heating and ventilation can be provided to the space at the same time.

Figure 3.6 shows, using a roof mounted unit heater as an example, that three modes of operation are possible by varying the position of dampers in the heater.

- Recirculation. If the room air quality is good, 100% recirculated air can be used. The high level input would de-stratify the space. If ventilation is required during occupancy 100% recirculation can still be used during the pre occupancy period to shorten the building warm up time.

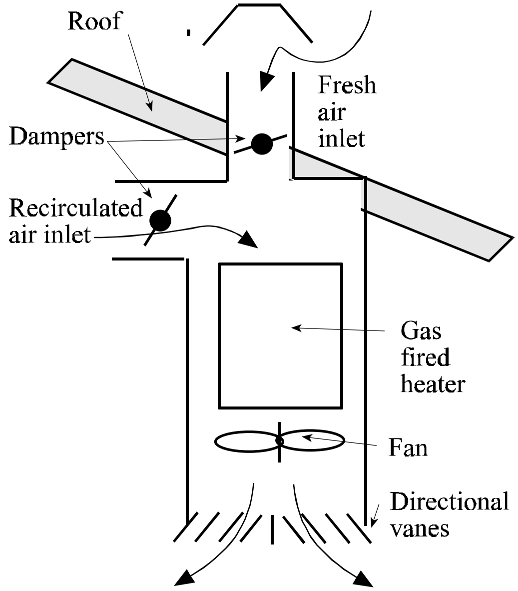

Figure 3.6 Ventilation unit heater

- Ventilation. If the room air quality deteriorates then a mix of fresh and recirculated air can be used. The proportions in this mix can be determined using room air quality sensors fitted into the inlet duct of the heater. Poor air quality would result in greater proportions of fresh air being used.

- Full fresh air. If 100% fresh air is to be used for extended periods it would be economical to add an extract duct to the heater to enable the incoming and outgoing airstreams to pass through an air to air plate heat exchanger (see section 4.4). This would save energy by pre-heating the incoming airstream using energy contained in the exhaust airstream. In summer the use of 100% fresh air can also provide free cooling by switching off the heater and bringing in outside air if it is cooler than the space temperature.

3.2 Radiant Heaters

All hot surfaces radiate heat to objects cooler than

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themselves (see IP9). When a person is near a heated surface this radiant heat is felt as warmth. The essential element of a radiant heater is, therefore, an exposed heated surface. The human body is very sensitive to radiant heat and feelings of warmth are readily experienced in its presence (see IP5). As a result it is possible to feel comfortably warm in draughty spaces such as warehouses or workshops if a source of radiant heat is present, even if the air temperature is low.

Radiant heaters have a low thermal capacity. This means they will heat up quickly giving a quick response time, creating comfort shortly after being switched on. The heating effect is principally by radiation but eventually the radiant heat absorbed by people and objects will be re-emitted by convection. This will result in a gradual increase in room air temperatures

Radiant heat is a form of electromagnetic radiation. This is the same form of energy as light but at a different wavelength. Because of this it behaves like light. It can be reflected to where it is needed but also blocked by objects in its path. This latter point means that people can be shadowed from its warming effects. One example is the shading of customers by the tall shelves in a DIY store. To solve this problem radiant heaters are usually sited over the aisles where customers circulate. Since the heaters do not rely on warm air for their heating effect standard thermostats which detect room air temperature cannot be used to control them. Control is achieved using a black bulb thermostat. This is an electronic or bimetallic strip thermostat built into a black plastic hemisphere. The hemisphere absorbs the radiant heat which in turn warms the air trapped inside the globe. It is this enclosed warm air that the thermostat senses to provide control over the heaters.

There are two main types of direct radiant heater these are plaque heaters and radiant tube heaters.

Plaque heaters. Are comprised of a flat surface (figure 3.7) heated either by an electrical element or a gas burner. The surface of the heater is warmed until it radiates heat. Some units become red hot. This high surface temperature means that they must be fixed at high level, usually above three metres in height, so that the occupants of the building cannot be burned. Lower temperature plaque heaters are available which have much lower mounting heights. Plaque heaters are most often used to give spot heating to a particular location. This could, for example, be a workstation sited in the middle of a warehouse. Comfort can be achieved without heating the entire space.

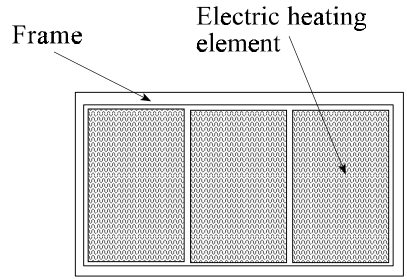

Figure 3.7 Radiant plaque heater

Radiant tube heaters are composed of a gas burner connected to a steel tube (figure 3.8). The burner directs the flames it produces along the inside of the tube. As a result the tube becomes hot and starts to emit radiant heat. Sometimes the tube is formed into a U shape doubling the surface area for heat output. A reflector above the tube directs the heat downwards. Radiant tube heaters, as with all heat emitters, have a limited area of influence. To heat a large space evenly an array of radiant tube heaters must be used arranged in a similar way to luminaires used to light a space.

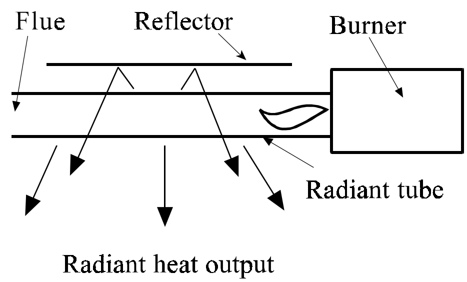

Figure 3.8 Radiant tube heater

Energy issues. Radiant heaters can result in significant savings in energy when used appropriately. The three situations when this occurs are;

Tall buildings - where excessive stratification would occur with warm air heating.

Spot heating - For example heating a manned workstation in the middle of a warehouse. Comfort can

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be achieved without heating the entire space.

Draughty buildings - High air change rates make warm air heating impractical and wasteful.

3.3 Direct Water Heating

The heaters in a direct heating system are dedicated to providing space heating. Because of this some form of direct water heater is also required. In addition, it is more economical and energy efficient to separate water heating from the indirect space heating system by providing hot water from a direct fired water heater. This avoids the low efficiency of indirect systems when firing at low loads to provide hot water only.

Direct water heating in domestic buildings takes one of two principle forms these are storage systems and instantaneous systems.

Storage systems. An example of a storage system is the use of an electric immersion heater to heat the water in a dhw cylinder. The immersion heater is a sealed element through which electricity is passed causing it to heat up. The immersion heater is fitted into the storage cylinder to make direct contact with the stored water. A typical domestic immersion heater would have a power rating of 3 kW.

The immersion heater has an in built thermostat to control the domestic hot water temperature. This switches the current on or off, as required, to maintain the pre set temperature, typically 60-65°C. The duration of operation of the heater can be controlled manually using a switch or automatically using a time switch.

Instantaneous water heaters warm the water as it is drawn from the tap so that it only heats the amount of water that is required. Gas fired water heaters are constructed like small boilers with a burner and heat exchanger. The water input to the heat exchanger is from the mains. Output is to the taps. Turning on the hot tap causes a pressure drop in the pipe work which, after a short delay, signals the burner to fire. Electrically heated units are also available. Electrical heaters like the gas heaters can supply all the taps in a small building. Small units can supply individual sinks, their small physical size means they can be fitted into the hot water pipe work under the sink. Their use in this way at the point of use avoids heat losses that occur from long pipe runs.

COMMERCIAL SYSTEMS

In large buildings the distance between the source of hot water and the taps is large. This can result in excessive heat losses from the pipe work as the water runs from the source of heat to the taps. One way of avoiding this is to decentralise the hot water system and to provide sources of hot water throughout the site corresponding to demand. Small storage or instantaneous heaters can be used as described above. For larger demands direct fired water heaters should be used. These devices are cylindrical in shape containing a small volume of stored water (figure 3.9). The gas burner is sited at the bottom of the unit. The heat exchanger and flue run up through the centre of the stored water volume and so excellent thermal contact is made between the source of heat and the water. Any heat losses from the flue also pass into the water. The exterior of the tank is well insulated to avoid standing heat losses. The volume of water stored is large enough to satisfy peak demands but small enough to reduce to acceptable levels, the standing losses that occur overnight as the stored volume of water cools down. As a consequence of this and the other features described above direct fired water heaters operate at an efficiency of approximately 90%.

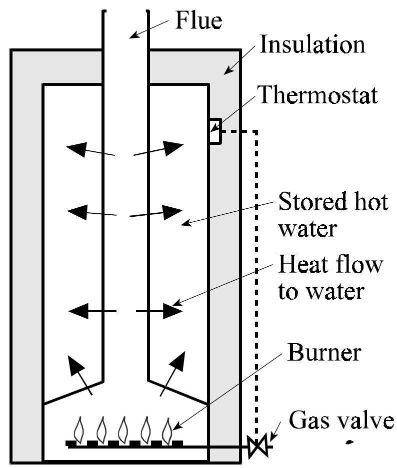

Figure 3.9 Direct fired gas water heater