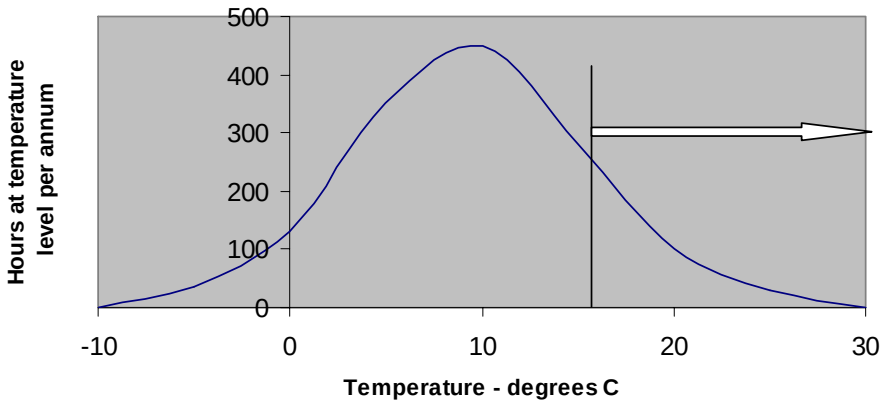
Preparation Material

Introduction

Internal conditions in buildings require governing and control to take account of the needs of the structure and the personnel working within. Any building, which contains personnel, whatever their activities and duties, will either need heating or cooling.

The Designer and Energy Manager should be aware of the variance in heating demands brought about by annual climate variations which place demand on installed heating and cooling plant.

Variations in UK outdoor temperatures



The graph demonstrates the conditions that prevail in the UK where the hours below freezing are relatively low (<7%) and the time above an external temperature norm of 16 degrees C is larger (20%). Once the ambient temperature rises above 16 degrees C it is normal to consider switching off heating systems and appliances however it is human nature to use heat providing resources to a higher level – sometimes to the point where the heating conflicts with the cooling plant installed, especially if thermostats have been adjusted incorrectly.

Heat Transfer

Heating, whether supplied artificially or by nature, reaches the user in one of three ways: Convection, Conduction and Radiation. All three types of transfer, when produced by heating equipment are very effective but sometimes use completely different methodologies dependent on the application. Quite often the heating of a space can employ all three approaches.

Conduction

Conduction is where thermal energy (heat) is transferred through a solid material partially as a result of molecular collision as a result of the flow of electrons which is induced by a temperature differential. Usually the denser the material the better is its ability to conduct heat. Less dense materials such as gases are not conductors. This is why metals are a good conductor of heat. In a boiler the heat from the combustion of fuel is contained in metal tubes surrounded by water. Because they are made of metal quick heat transfer takes place across the tube wall by conduction to heat up the water.

Convection

Convection current heat transfer is caused by fluid movement and the difference in density in that material. If heated air or liquid rises it is said to be experiencing Natural Convection. If a fan or pump is used to accentuate or even create the flow then that is known as Forced Convection.

Natural convection is experienced when heat rises in the air from heaters or heat sources and creates stratification where the higher levels are warmer than the lower. Eventually the heated air will cool and start to drop whilst warm air rises to replace it – this loop is known as a convection current and is best demonstrated when watching a glider as it rises on ‘thermals’ (ground heated air) to greater heights.

Radiation

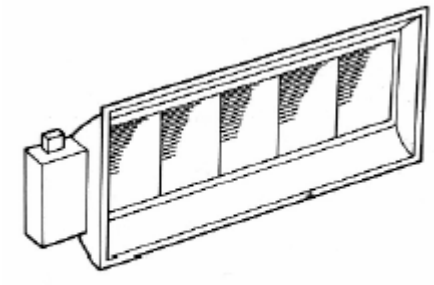
The final mode of heat transfer is by Radiation which is present in the form of electromagnetic waves and is in contrast to convection and conduction as it requires no medium. The heat felt from an open fire or from the Sun, 150 million kilometres away, is radiated energy.

All heating systems, whether industrial, commercial or domestic, use one of these approaches or sometimes a combination of all three. A domestic or office central heating radiator is a perfect example in that water is heated in a boiler and circulated to the unit. The heat from the hot water conducts through the metal body to the outside where it radiates heat to the surrounding air which rises and circulates around the space by conduction.

Heating equipment

Heating can be supplied to spaces either by the direct combustion of fuel or by using secondary mediums such as steam, thermal fluid or electricity.

Primary heating from fossil fuels and other combustibles can be provided by an open fire or under control through gas fired ceramic plaque heaters.



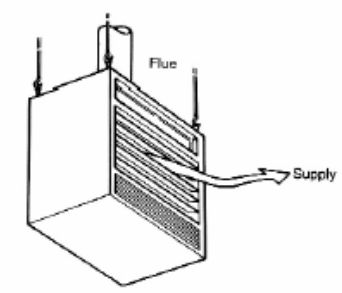
Gas-fired radiant plaque heater

These principally rely on radiated heat from the combustion surface.

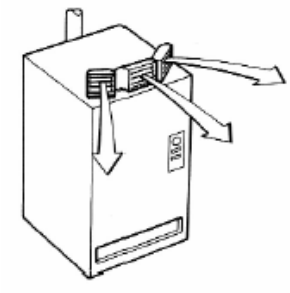
Secondary heating can come from some of the following sources:

- Hot water circulating through pipes or emitters such as radiators sometimes with fan assistance to blow cold air across the heated surface (as in Air Handling units)
- Steam or thermal fluid circulating through pipe work and other heat exchangers
- Electricity heating resistance wire which generates rising warm air currents sometimes with fan assistance
- Electrically heated oil filled panels which act like hot water radiators
- Electric radiant plaques – Infra red heaters
- Radiant tubes where gas is combusted inside and heat radiates from the black outer surface of the tube

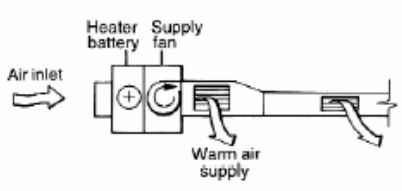
Convective heating systems



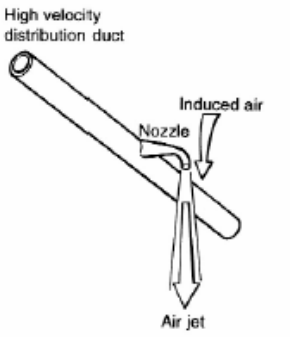
High-level unit heater



Floor-standing warm air heater

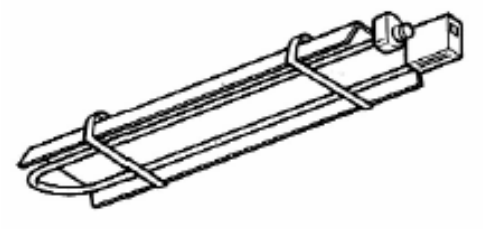


Ducted warm air system

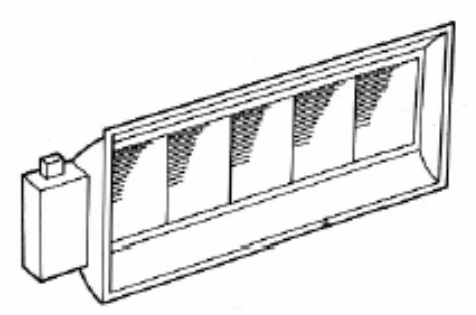


Warm air jet/induced jet system

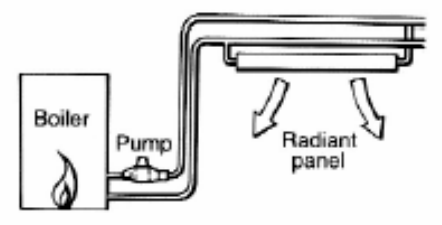
Radiant heating systems



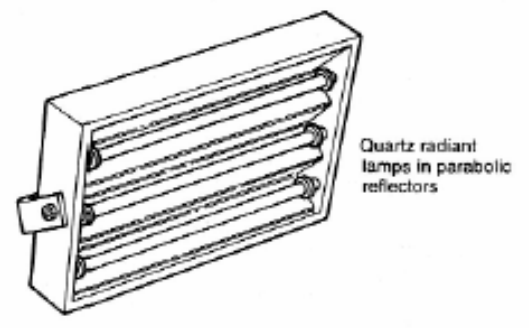
Gas-fired overhead radiant tube heater



Gas-fired radiant plaque heater



Radiant panels served by boiler



Electric radiant heater

Each method has advantages and disadvantages.

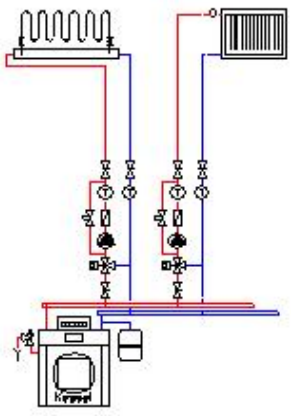
Using convection and heated air approaches in a factory or large space needs some time to elapse before the whole volume of the air is heated to the specified level. On a cold winter morning this will necessitate pre heating for some time. Thermostatic control is achieved by monitoring the space air temperature at a strategic location. The system is effective at maintaining air temperatures as long as no large volumes of outside air are allowed to enter

to chill the heated volume. If cold air does enter then it dilutes the heating effect and more energy must be consumed to reheat the space. This is a typical problem in an office when someone opens a window because it is too warm or else a factory roller shutter door is opened to allow vehicular access.

Pure radiant heating has some considerable advantages in that the heaters only heat the people and the objects that the emitter is aimed at. Space heating using radiant heaters can be turned on shortly before occupancy and will immediately give the impression of warmth similar to that perceived from the sun or an open fire. The operation of the heaters cannot be managed with air sensing thermostats as the rise in air temperature only comes from infra red heat being absorbed by people, machines, equipment and the building material being radiated back into the space. Radiant heat thermostats are usually matt black coloured sensors, mounted at shoulder level which sense the radiant energy being produced and absorbed.

Heating Efficiency

The efficiency or effectiveness of any heating installation will depend on a number of aspects of the heat generation and its application. In primary heating the direct combustion will produce radiant heat and create a degree of warmed air however some thermal energy will be lost in the exhausting of combustion products to atmosphere.



In secondary heating methods the conversion to thermal energy is managed in the heat exchanger, for instance a boiler, where the combustion is tuned to the conversion process so that the outcome product – hot water, steam or thermal fluid - is as absorbent as possible of all the energy in the original fuel. A modern condensing boiler will abstract over 90% of the energy initially present in the gas or oil fuel that has been combusted. That heat can then be transferred via insulated pipe work to where it is required for application.

Older boiler plant used to less efficient with a conversion efficiency of between 75 and 80% so over 1/5th of the energy present was lost in the conversion process. If the plant is not well maintained then that conversion efficiency can fall further to the point where half of the energy in the fuel is wasted which means twice as much will be required to heat the space.

Heating systems can become extremely expensive to run when the fuel conversion is not efficient or the heat is lost because of open doors and windows. Insulation of distribution systems is also essential as long pipe runs carrying hot liquids can cool them before they ever reach the point of use.

It is therefore critical that the design of the heating installation considers a number of factors:

- Where is the heat required?
- What is the coldest likely situation for which heat is needed?
- What fuels are available?
- Can we use solar energy?
- Would heat pumps be effective?
- Will we use primary or secondary processes?
- Will we heat the air or use radiant systems?
- What level of control is required?
- How will the heat be distributed?
- Can the heating system be zoned so that we don't heat empty spaces?
- Are there likely to be any conflicts with Air Conditioning systems?
- What maintenance is required to maintain efficient operations?
- How do we monitor heating effectiveness?
- What are degree days?

These and many other associated points and questions will be discussed and clarified in the practical part of this module.