ALMUSTAQBAL UNIVERSITY
Iraq – Babylon

RENEWABLE ENERGY TECHNOLOGY

Sustainable Path For a Carbon Free Future

Refrigeration and Air conditioning Techniques Engineering Department

Subject : **Renewable Energy**
Grade: **4th Class**

Solar Space Heating and Cooling

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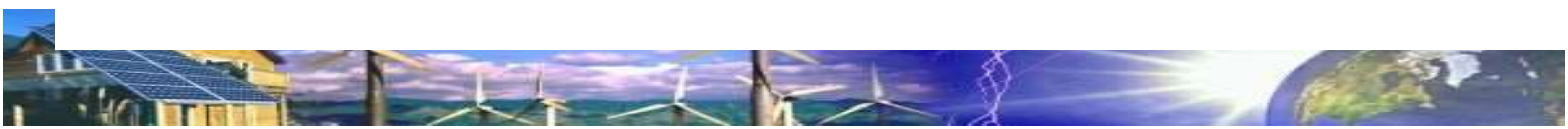
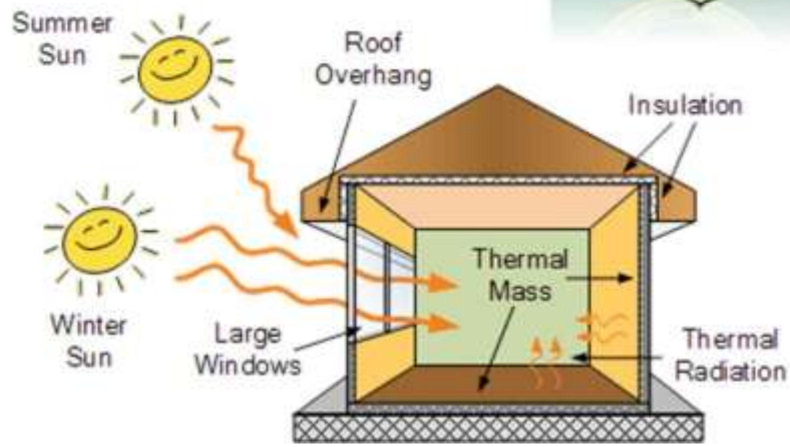


Solar Space Heating and Cooling

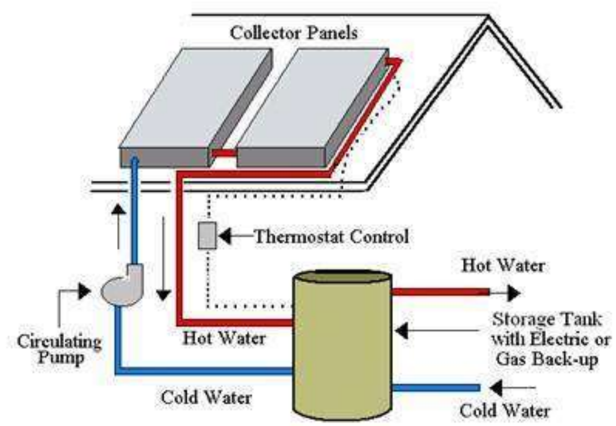
Solar Space Heating and Cooling

The two principal categories of building solar heating and cooling systems are:

1- **Passive system** is applied to buildings that include, as integral parts of the heating. building, elements that admit, absorb, store, and release solar energy and thus reduce the needs for auxiliary energy for comfort



2- **Active systems** are the ones that employ solar collectors, storage tank, pumps, heat exchangers, and controls to heat and cool the building



Active Solar Water Heating System

Solar Space Heating and Cooling

1- Thermal load estimation : three basic terms that are important in thermal load estimation are explained.

Heat gain

Heat gain is the rate at which energy is transferred to or generated within a space and consists of sensible and latent gain. Heat gains usually occur in the following forms:

1. **Solar radiation passing through glazing and other openings.**
2. **Heat conduction with convection and radiation from the inner surfaces into the space.**
3. **Sensible heat convection and radiation from internal objects.**
4. **Ventilation and infiltration.**
5. **Latent heat gains generated within the space.**

Thermal load

The thermal load is the rate at which energy must be added or removed from a space to maintain the temperature and humidity at the design values.

Heat extraction rate

The heat extraction rate is the rate at which energy is removed from the space by cooling and dehumidifying equipment.

Cont……

Thermal load

The thermal load is the rate at which energy must be added or removed from a space to maintain the temperature and humidity at the design values. The cooling load differs from the heat gain mainly because the radiant energy from the inside surfaces, as well as
the direct solar radiation passing into a space through openings, is mostly absorbed in the space. This energy becomes part of the cooling load only when the room air receives the energy by convection and occurs when the various surfaces in the room attain higher
temperatures than the room air.

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Heat extraction rate

The heat extraction rate is the rate at which energy is removed from the space by cooling and dehumidifying equipment. This rate is equal to the cooling load when the space conditions are constant and the equipment is operating.

Since the operation of the control systems induces some fluctuation in the room temperature, the heat extraction rate fluctuates and this also causes fluctuations in the cooling load.

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Methods of thermal load estimation

- The heat balance method

- The transfer function method

▪Heat extraction rate and room temperature -

- Degree day method

▪- Building heat transfer

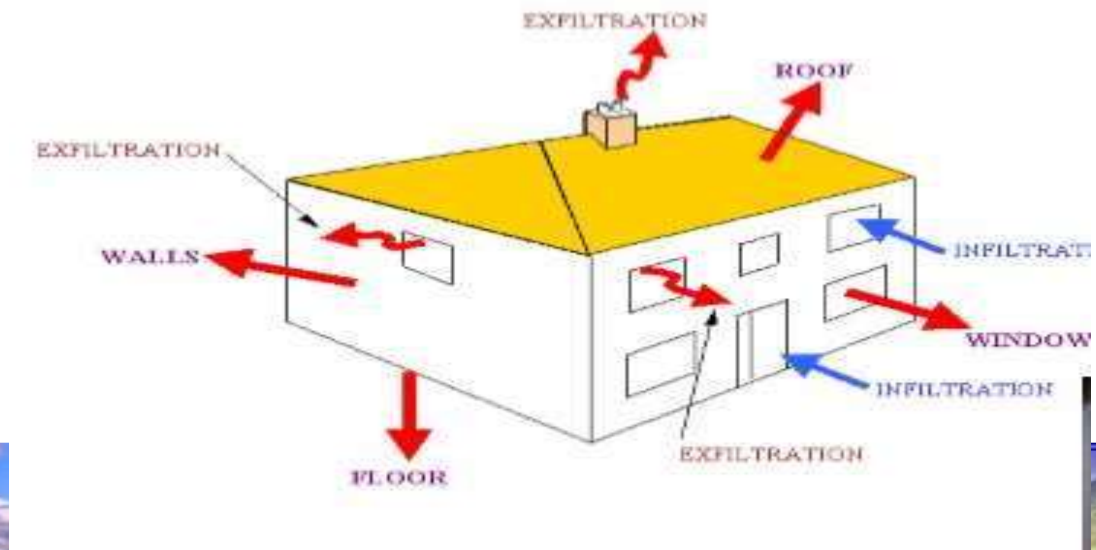
Cont……

1. Heating Load Estimation

Heating loads are due to heat losses by:

1)Conductive heat loss through envelope (walls, windows, doors, floors, roof, etc.).

2)Infiltration, exfiltration and ventilation air



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1.1 Conductive Heating Load

$$Q = UA\Delta t \qquad Q = \sum_{j=1}^{n} U_j A_j (t_i - t_o)$$

Q = heating load (W) (kcal/h)

A_j = area of each envelope element (m^2)

U = overall heat transfer coefficient (W/m^2K) ($kcal/m^2h$ ℃)

t_i = indoor design air temperature (K) (℃)

t_o = outdoor design air temperature (K) (℃)

Cont……

U-Factor (Overall Heat Transfer Coefficient)

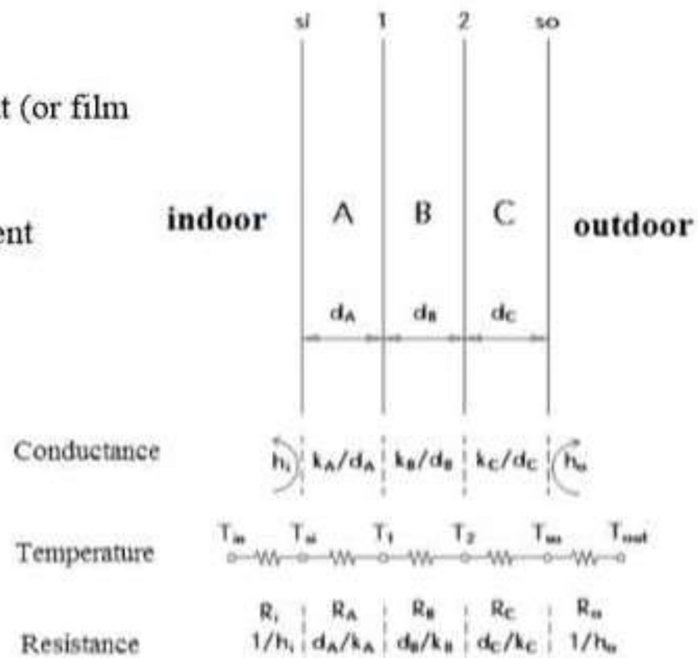
$$R_{tot} = \frac{1}{h_i} + \sum \frac{d_i}{k_i} + R_{air} + \frac{1}{h_o}$$ (m²K/W) (m²h°C/kcal)

Where,

h_i = indoor surface heat transfer coefficient (or film conductance) (kcal/m²h°C)

h_o = outdoor surface heat transfer coefficient (kcal/m²h°C)

$$U = \frac{1}{R_{tot}}$$ (W/m²K) (kcal/m²h°C)



2. Infiltration Heating Load

1) Sensible Heating Load

$$Q = 0.24 \times 1.2 \times CMH \times (t_i - t_o)$$

Where,

Q = heating load (W) (kcal/h)

0.24 = specific heat of dry air (kJ/kgK) (kcal/kg ℃)

1.2 = specific weight of air (kg/m³)

CMH = airflow (m³/h)

t_i = indoor air temperature (K) (℃)

t_o = outdoor air temperature (K) (℃)

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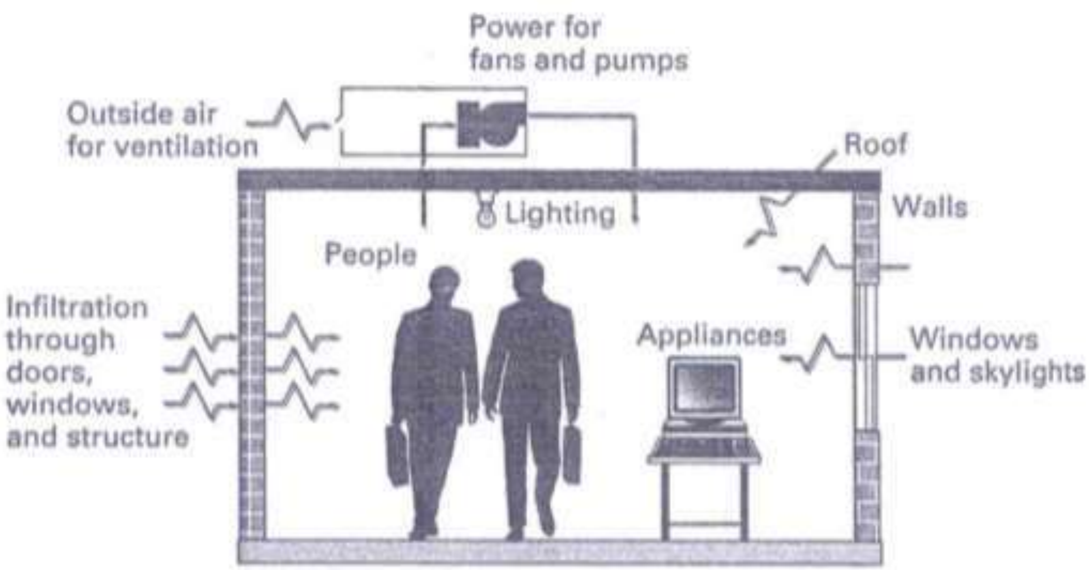
2. Cooling Load Estimation

Heat gains include conduction, solar effects, outdoor air loads, and internal heat loads.



Components of building cooling load

Heat Gain through Walls and Roofs (Opaque)

A simple temperature difference between indoor and outdoor air will not account for solar heat. The outside surface is much warmer than the surrounding air, due to the solar radiation effect.

Conduction calculating use TETD(Total equivalent temperature difference)

TETD include solar effects as well as temperature difference TETD vary with the orientation, time of day, absorption property of the surface, and thermal mass of the building assembly

Cont……

$$Q = UA(\mathrm{TETD}) \qquad Q = \sum_{j=1}^{n} U_j A_j (\mathrm{TETD})$$

Where,

Q = cooling load (W) (kcal/h)

U = overall heat transfer coefficient (W) (kcal/m^{2}h℃)

A = area of each envelope element (m^2)

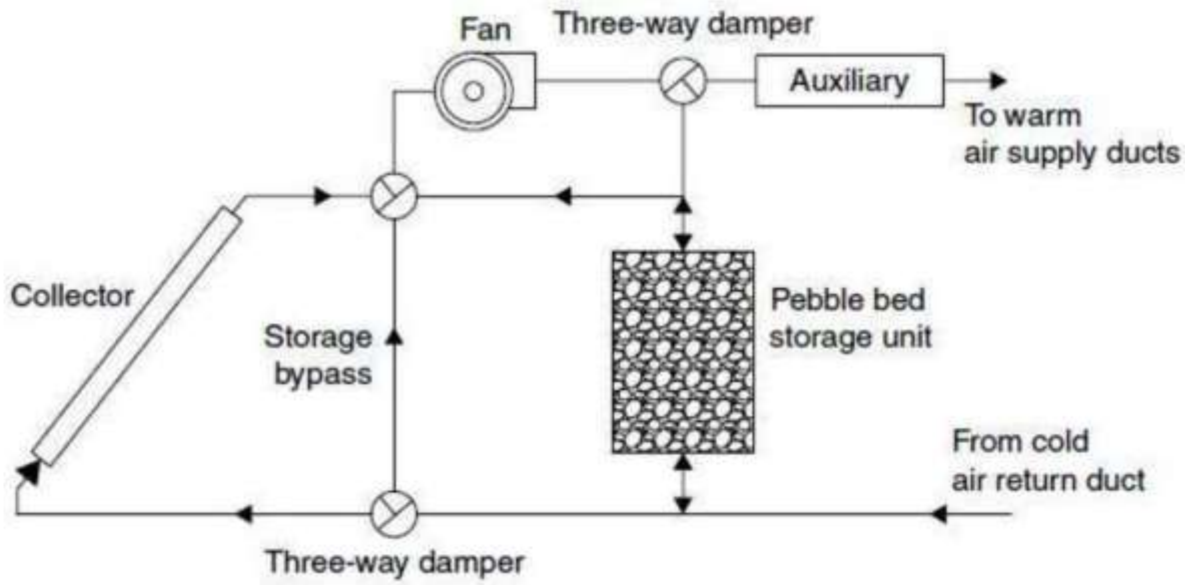
$TETD$ = total equivalent temperature difference(℃)

Solar Space Heating and Cooling

-3Air systems

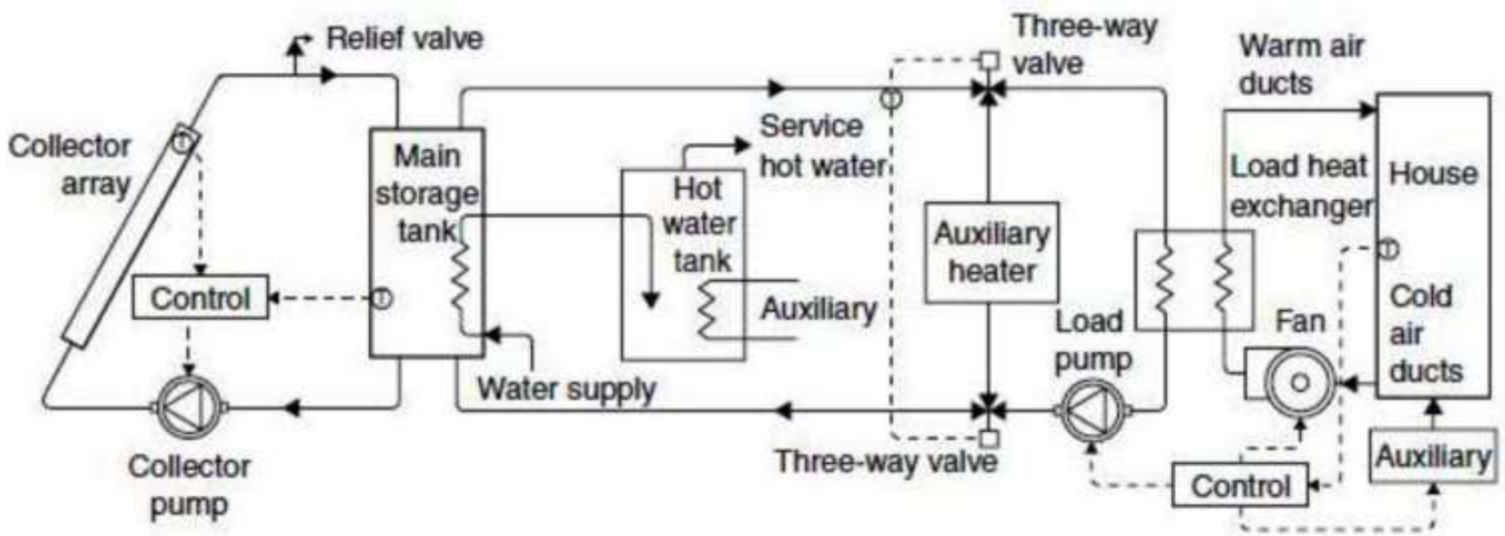
A schematic of a basic solar air heating system with a pebble bed storage unit and auxiliary heating source is shown in **Figure .1**

It is also possible to bypass the collector and storage unit when there is no sunshine and the storage tank is completely depleted and use the auxiliary alone to provide the required heat



Solar Space Heating and Cooling

4- Water systems Many varieties of systems can be used for both solar space heating and domestic hot water production



A schematic diagram of a solar heating and hot water system is shown in **Figure 2**. Control of the solar heating system is based on two thermostats: the collector storage temperature differential and the room temperature. The collector operates with a differential thermostat.

Solar Space Heating and Cooling

5- Location of auxiliary heater

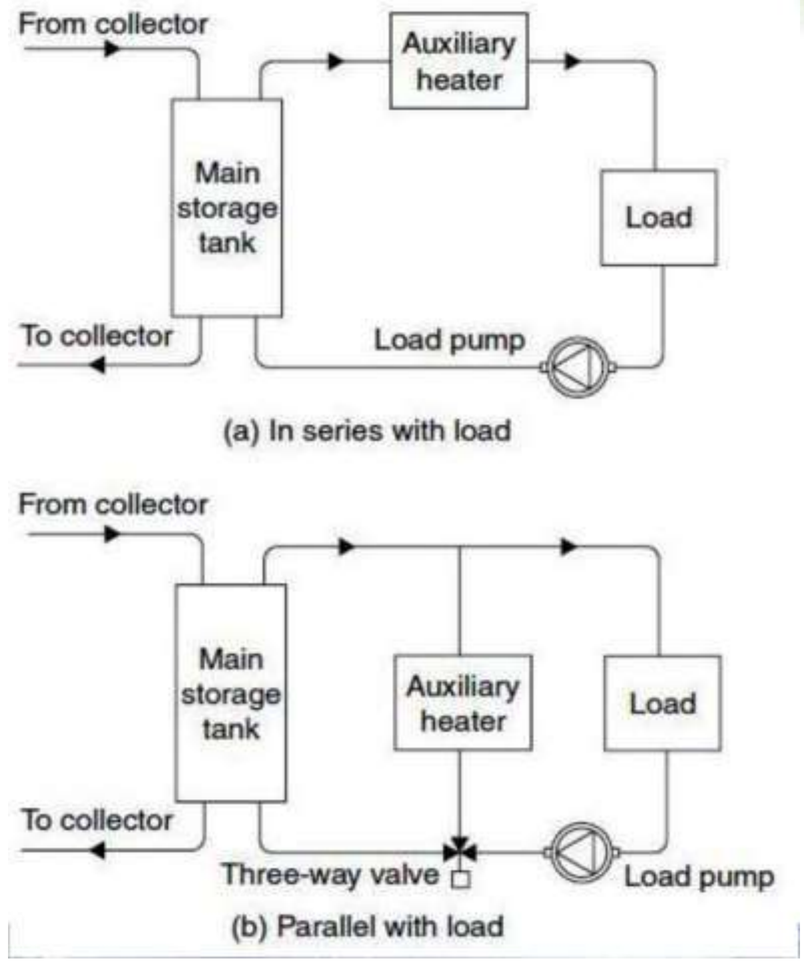


Figure 3 Auxiliary energy supply in water-based systems.

4.1.5 Heat pump systems

Active solar energy systems can also be combined with heat pumps for domestic water heating or space heating. In residential heating, the solar energy system can be used in parallel with a heat pump, which supplies auxiliary energy when the sun is not available. Additionally, for domestic water systems requiring high water temperatures, a heat pump can be placed in series with the solar storage tank.

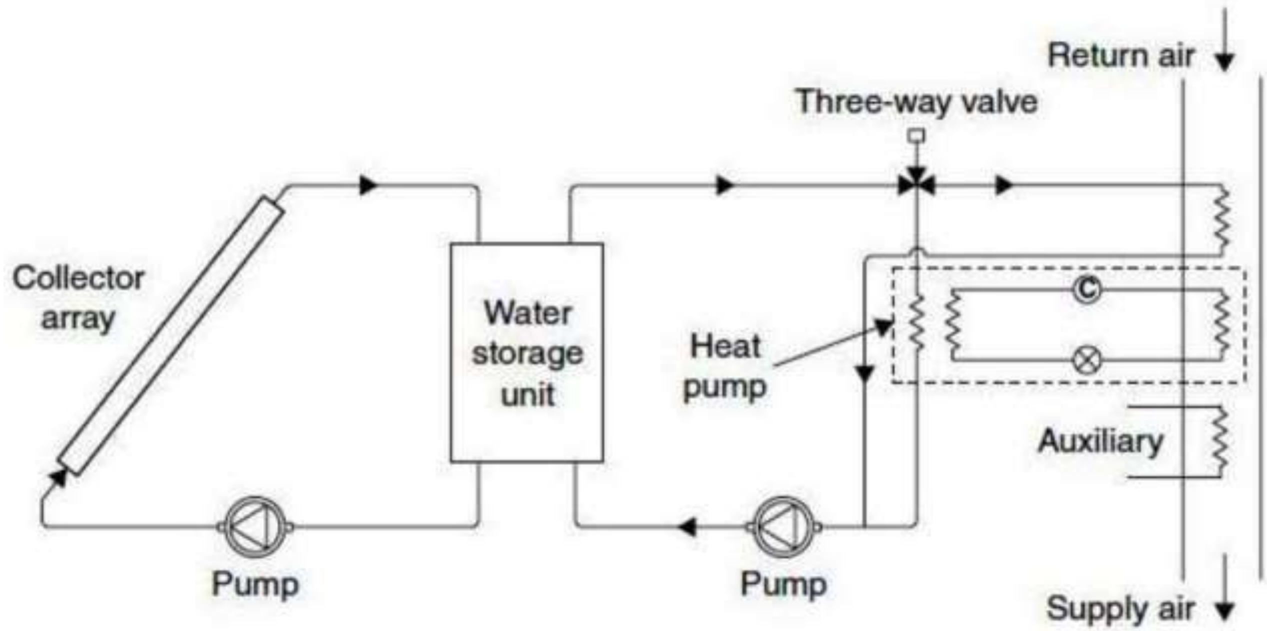


Figure 4 Schematic diagram of a domestic water-to-air heat pump system (series arrangement).

Practical considerations

Installation of large collector arrays presents specific piping problems.

1. Pipes, Supports, and Insulation

The material of a solar energy system piping may be copper, galvanized steel, stainless steel, or plastic. All pipes are suitable for normal solar system operation except plastic piping, which is used only for low temperature systems, such as swimming pool heating.

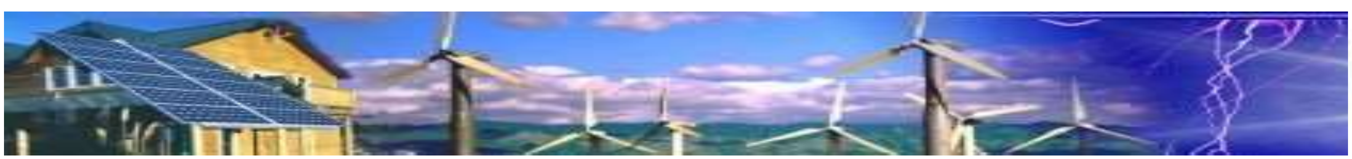
2- Pumps

For solar energy systems, centrifugal pumps and circulators are used. Circulators are suitable for small domestic-size systems. Construction materials for solar system pumps depend on the particular application and fluid used in the circuit.

3 Valves

Using too many valves, however, should be avoided to reduce cost and pressure drop. The various types of valves required in these systems are isolation valves, balancing valves, relief valves, check valves, pressure reducing valves, air vents, and drain valves. These are described briefly here.

1.Isolation valves. Isolation or shutoff valves are usually gate of quarterturn ball valves.



Practical considerations

3.2- Balancing valves. Balancing or flow-regulating valves are used in multi row installations to balance the flow in the various rows and ensure that all rows received the required quantity of flow.

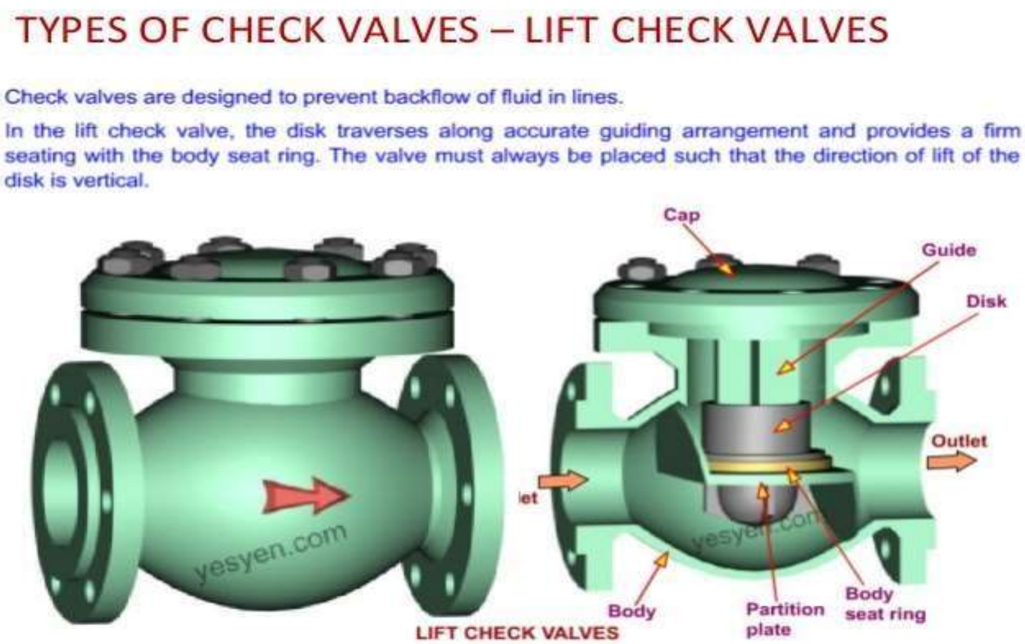
3.3- Relief valves. Pressure safety or relief valves are designed to allow esca of water or heat transfer fluid from the system when the maximum working pressure of the system is reached.

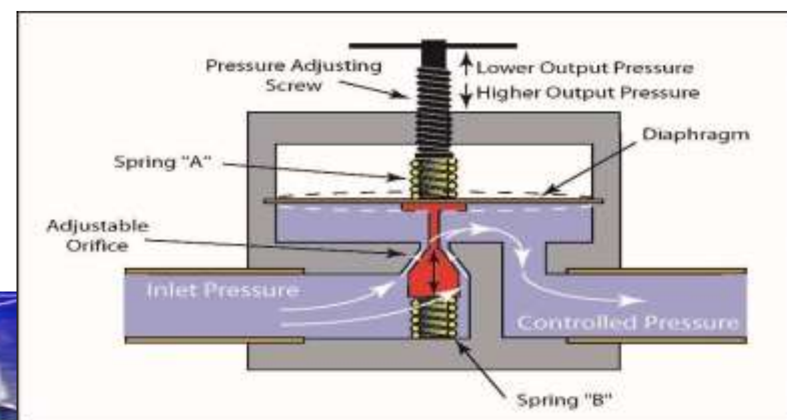
3.4- Check valves. Check valves are designed to allow flow to pass in only one direction. In doing so, flow reversal is avoided

BALANCING VALVE WITH FLOW METER, FOR SOLAR THERMAL SYSTEMS

Pressure Relief Valve

3.5- Pressure-reducing valves. Pressure-reducing valves are used to reduce the pressure of make-up city water to protect the system from overpressure.





Practical considerations

3.6- Automatic air vents. Automatic air vents are special valves used to allow air to escape from the system during fill-up

3.7- Drain valves. Drain valves are used in drain-down systems. These are electromechanical devices, also called solenoid valves, that keep the valve closed as long as power is connected to the valve (normally open valves).

4- Instrumentation

Instrumentation used in solar energy systems varies from very simple temperature and pressure indicators, energy meters, and visual monitors to data collection and storage systems.

Do You Have Any Questions?