Textbook of

Plumbing and Solar Water Heating System-II

Matric Tech Grade-X

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National Vocational & Technical Training Commission (NAVTTC)

Textbook of

Plumbing and Solar Water Heating System-II

Grade X

National Vocational and Technical Training Commission (NAVTTC),

ISLAMABAD

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PREFACE

This book has been written to meet the requirements to train the students of Matric Tech in plumbing specifically for solar water heating system. Matric Tech in plumbing and solar water heating system has been introduced for the first time in the history of Pakistan. This textbook is the first national effort to describe the topics related to solar water heating system in one book.

Energy prices are escalating day by day throughout the world specifically in Pakistan. The nature has gifted our country balanced seasons. There are sources of energies like sun, wind and other natural resources. The solar energy can be utilized for heating purposes along with production of electricity. The usage of solar energy for heating water in extreme winter season is of dire need. Through utilization of hot water for domestic and commercial needs can save the foreign reserves which otherwise are being used for purchase of petroleum products. The petroleum products are used to produce electrical energy which is used for heating along with other purposes.

A key attempt has been made to make the book interesting and useful. The chapters cover the basic details understandable to the students of secondary school level. All chapters include relevant solar water heating system's activities and assessment in form of MCQs, short questions and long questions.

Suggestion from the teachers/ instructors as well as students from the different institutions for the improvement of this book would be acknowledged and welcomed with thanks.

Executive Director
National Vocational and Technical Training Commission
H-9, Islamabad

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INTRODUCTION TO SOLAR WATER HEATING

After studying this unit, you will be able to:

- define solar water heating
- state purpose of solar water heating system
- describe importance of solar water heating system
- state the parts of solar water heating system.
- applications of solar water heating system
- describe benefits of solar water heating system
- describe disadvantages of solar water heating system

1.1 Basics of Solar Water Heating System

1.1.1. Introduction to Solar Water Heating.

Energy is used in many ways in the homes, including space heating and cooling, water heating, refrigeration, appliances, lighting, televisions, computers, stereos, and more. Solar energy which is energy from the sun can provide the energy needed for many of these uses. In fact, solar energy can provide all the energy needs in a home. However, systems designed to meet all energy loads in a home are larger and thus expensive.

The shallow water of a lake is usually warmer than the deep water. That's because sunlight can heat the lake bottom in the shallow areas which, in turn, heats the water. It's nature's way of solar water heating. The sun can be used in the same way to heat water used in buildings and swimming pools.

In a solar water-heating system, heat collection is the main objective, along with moving the heat from the collecting surface, transferring it to storage, and ultimately using it to heat the domestic hot water.

Solar water heating (SWH) is the process of converting sunlight into energy that can be used for domestic water heating. This heated water can be used for washing in the home, radiant floor heating, or to heat swimming pools.

Do you know?

Solar water heating is the process of converting sunlight into energy that can be used for domestic water heating

Solar water heating systems use a large number of different technologies and these technologies can be used almost anywhere in the world. Each of these systems include two main components - storage tanks and solar collectors. Additionally, there are two main types of solar water heating systems: active systems with circulating pumps and passive systems without pumps.

A solar water heater is a device that captures sunlight to heat water. It can be an economical way to generate hot water for your family (for shower and bath).

Do you know?

A solar water heater is a device that captures sunlight to heat water.

Active systems

These come in two forms. Direct circulation systems pump household water through collectors, which is then delivered to where needed in the house. They have automatic controllers that sense when sunlight is available. However, the systems are ineffective in temperatures below freezing.

Indirect circulation systems heat water by pumping it through a heat-transfer fluid that doesn't freeze. It's then sent through collectors and a heat exchanger. Operational in freezing temperature and in multiple heating applications, they're often more expensive than direct circulation systems.

Do you know?

Active system of SWH relies on pumps to move the liquid between the collector and storage tank.

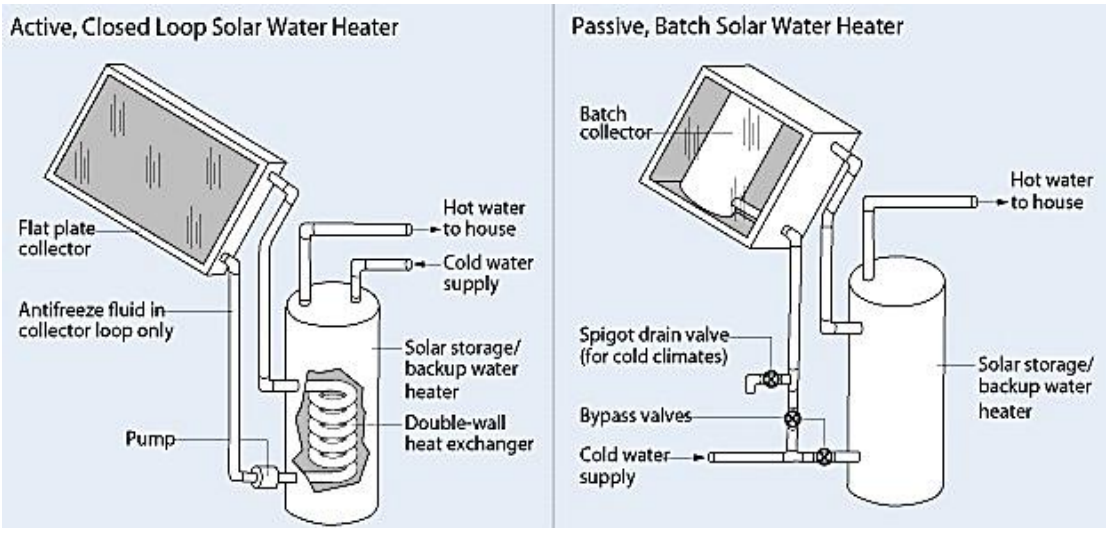
Passive systems

Two types are available here as well. An integral collector-storage passive system consists of a storage tank, solar collection unit, and pipes that pump cold water into the collector. It suits a home that needs hot water in the day and evening but also doesn't work as well in cold outside temperatures.

A thermo-syphon system works on the principle of warm water is rising and cold water sinking. Warm water in the collector rises into the storage tank, which is a reliable configuration. A downside is the weight of the storage tank, which can be a challenge for contractors working on the roof; the system is a more expensive option as well.

Do you know?

Passive system relies on gravity and tendency for water to naturally circulate as it is heated.



1.1.2. Purpose of Solar Water Heating.

Using the energy from the sun to heat water can save homeowners significant amount of money in the long run. If solar is used to replace all or part of the water heating in a home, there can be significant saving on the homes energy bill. This depends largely on how much the sun shines where the collector is located, and the price of energy.

The fact that energy used is reduced with the use of solar water heaters is also beneficial to the environment. Currently, most energy people use comes from burning a variety of fossil fuels.

This combustion of fossil fuel resources is associated with a wide array of environmental including climate change, acid rain, and global warming associated with carbon dioxide emissions. The use of solar water heating reduces energy use from these fossil fuel sources, benefiting the environment in the long run.

1.1.3. Importance of Solar Water Heating System.

It is said that that more solar energy hits the earth in an hour than is being utilized in an entire year. Sun is a free and abundant source of energy available on earth that can be taken advantage off by offsetting a solar water heating system at home. It is the best cost-effective and conventional way to harness the solar energy and protect a user from the rising fuel prices, whether it is gas or electricity. Installing a domestic solar water heating system not only provides clean energy to heat the water, safety from bathroom accidents using electrical water heaters, low maintenance costs, and save space as well as these are installed on rooftops.

With respect to the life cycle of solar water heating system, it is said that the energy spent on the manufacturing and installation of the device is recouped in approximately one year while the payback time of the system varies from a few months to three years. The cost of damage by pollutants to the solar water heating systems and environment is negligible as compared the devices using electricity, diesel or other kind of fuel. Thus, it is considered that the solar water heating systems and other deices based on solar energy offer significant protection to the rising fuel prices, environment and can be employed whenever and wherever possible to achieve a sustainable future.

1.1.4. Parts of Solar Water Heating System.

Most solar water-heating systems for buildings have two main parts:

i. Solar collector and
ii. Storage tank.

The most common collector is called a flat-plate collector. Mounted on the roof, it consists of a thin, flat, rectangular box with a transparent cover that faces the sun. Small tubes run through the box and carry the fluid — either water or other fluid, such as an antifreeze solution — to be heated. The tubes are attached to an absorber plate, which is painted black to absorb the heat. As heat builds up in the collector, it heats the fluid passing through the tubes.

The storage tank then holds the hot liquid. It can simply be a modified water heater, but it is usually larger and very well-insulated. Systems that use fluids other than water (usually a

propylene-glycol mixture) heat the water by passing it through a heat exchanger, which transfers the heat from the glycol mixture to the water being heated.

Solar water-heating systems can be either active or passive. Most common are active systems, which rely on pumps to move the liquid between the collector and the storage tank. Passive systems, on the other hand, rely on gravity and the tendency for water to naturally circulate as it is heated.

Do you know?

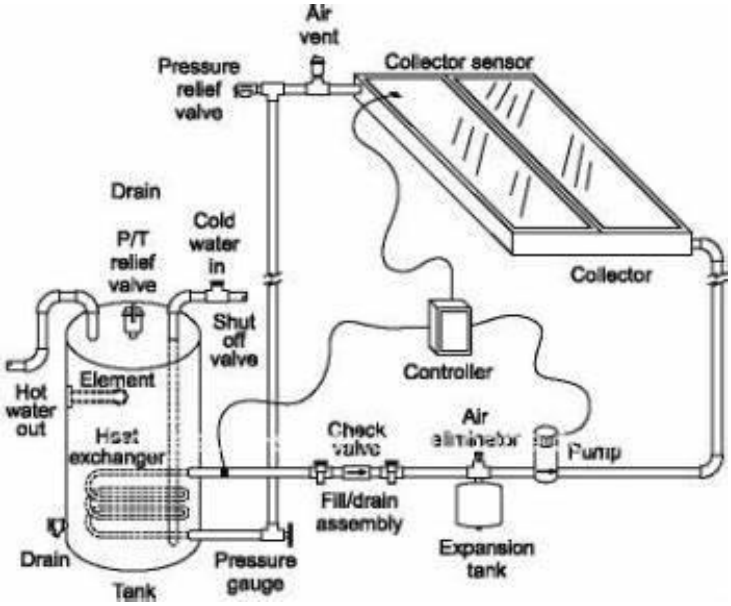
The storage tank holds the hot liquid and is simple a modifies water heater, but it is usually larger and very well-insulated.

Solar collectors are the key component of active solar-heating systems. Solar collectors gather the sun's energy, transform its radiation into heat, and then transfer that heat to water, solar fluid, or air. The solar thermal energy can be used in solar water-heating systems, solar pool heaters, and solar space-heating systems. There are several types of solar collectors:

- Flat-plate collectors
- Evacuated-tube collectors
- Integral collector-storage systems

Residential and commercial building applications that require temperatures below 200°F typically use flat-plate collectors, whereas those requiring temperatures higher than 200°F use evacuated-tube collectors.

In addition to solar collectors and storage tank, solar water heating system has following components:



i. Heat exchangers.
ii. Heat-transfer fluids.

iii. Centrifugal-type circulating pump.
iv. Sensors and controls.
v. Check valves.
vi. Expansion tank.
vii. Pressure relief valve.
viii. Pressure and Temperature Gauges.

1.1.5. Activity-1.1 Demonstrate Flow Diagram of Existing SWH.

The teacher/ instructor is required to demonstrate the students to prepare basic flow diagram of existing solar water heating system

1.1.6. Applications of Solar Water Heating System.

Water heating is one of the most cost-effective uses of solar energy. Every year several thousands of new solar water heaters are installed worldwide. Solar water heaters can be used for homes, hospitals, community centers, hotels, restaurants, dairy plants, swimming pools, canteens, hostels and industry etc.

Use of solar water heaters can curtail electricity or fuel bills considerably. Usage of solar water heater for any application where steam is produced using a boiler or steam generator can save 70-80% of electricity or fuel bills. A residence can save 70-80% on electricity or fuel bills by replacing conventional water heater with a solar water heating system.

- In domestic sector, hot water is used for bathing, washing of clothes & utensils etc. The requirement may, however, vary for the season of the year and number of family members. On an average 30 to 35 liters of water at 50 to 55º C. is consumed by an individual. Thus for a family of 4 members, a solar water heating system of 125 liters per day (LPD) is quite sufficient.
- In commercial & industrial sectors, where large quantity of water is required at fairly high temperature, "Water Heating Systems" are designed to meet the above requirement. Depending on the distribution pattern of hot water, the system could be either modular or a big capacity single tank system.

1.2 Merits and Demerits of Solar Water Heating System

1.2.1. Benefits of Solar Water Heating System.

A lot of energy is used in the home to heat water. It is possible to reduce energy use and the associated costs, by switching to a home solar water heating system. Such a system does not depend on fossil fuels and takes energy from the sun to heat stored water. It, therefore, saves money, which is a major advantage of solar heating systems. Energy from the sun doesn't cost anything, so no charge from electrical utilities is needed.

The advantages go beyond cost savings and the availability of power, which are also realized with solar electric systems. Here are a few unique benefits of home solar water heating products.

1. **Choice of size**: Proper sizing is essential, as homeowners must have enough storage to meet 90 to 100 percent of their hot water needs. Storage volume is also a consideration. A 50- to 60-gallon storage tank is fine for up to three people, an 80-gallon tank for up to four people, and a larger one for as many as six people.
2. **Less space**: Solar thermal panels are usually less space-intensive than photovoltaic panels. Fewer are required to heat water than in an array used to produce sufficient power for a home.
3. **High efficiency**: About 80 percent of the sun's radiation is turned into the heat energy needed to obtain hot water at home.
4. **Cost savings**: Solar Water Heaters are also commonly known as domestic solar hot water systems and have gained a lot of popularity recently. They are not just a cost effective but also an environmental friendly way to heat water for your domestic needs. As they use sun's heat to work so if you stay at a place which has good exposure to sunlight then a solar water heater will surely help in decreasing the electricity bill expenses. The cost of two or three panels is cheaper than larger domestic installations. It also saves on fuel bills for supplying gas heating systems.
5. **Low maintenance**: After installation, little maintenance is required, and a solar water heater can run for up to 20 years.
6. **Lower carbon footprint**: A home can be eco-friendlier. Any time you use fossil fuels like natural gas to heat up your water, greenhouse gases get released into the atmosphere. Even technologies powered by electricity cause pollution because that electricity is likely generated from fossil fuels. With a solar hot water system, you can be 100 percent sure you're using a zero-emissions renewable resource for your water heating needs.

1.1.7. Other advantages are:

- Solar Heaters help utilizing free natural resource such as sun light and thus helps in saving electricity costs.
- It requires basic fittings and a one-time investment and after that it is free for up-to 20 years.
- Day by day cost of solar equipment is decreasing and new and more efficient equipment is available in the market.
- It is a renewable and clean energy source.
- These systems are easy to install and require very little maintenance.
- These systems have long life hence gives value for your investment. A solar water heater can wok trouble free for up-to 20 years.
- Solar energy is kind of universal, decentralized and no -polluting energy.
- Solar energy is the energy of the sun, which reaches earth in the form of short wave radiation visible light and near ultraviolet light.

- Solar energy helps considerably in maintaining the ecological balance through the process of photosynthesis and greenhouse effect.
- Solar energy is bound to achieve great economic importance in future because of depletion trend of convention energy sources.

1.1.8. Activity-1.2 Group Discussion on benefits of SWH System.

The teacher/ instructor is required to involve students in group discussion regarding benefits of solar water heating system

1.2.2. Disadvantages of Solar Water Heating System.

1. **Location** of solar panels is of major importance in the generation of electricity. Areas which remains mostly cloudy and foggy will produce electricity but at a reduced rate and may require more panels to generate enough electricity for your home. Houses which are covered by trees, landscapes or other buildings may not be suitable enough to produce solar power.
2. **Pollution** can be another problem. Most of the photovoltaic panels are made up of silicon and other toxic metals like mercury, lead and cadmium. Pollution in the environment can also degrade the quality and efficiency of photovoltaic cells. New innovative technologies can overcome the worst of these effects.
3. **Inefficiency:** Since not all the light from the sun is absorbed by the solar panels therefore most solar panels have a 40% efficiency rate which means 60% of the sunlight gets wasted and is not harnessed.
4. **Also, heating is only provided in the daytime**. That does not mean hot water would not be available at night. An insulated storage tank can maintain water temperature so that the water heated during the day can be used during nighttime hours.
5. **Reliability:** Unlike other renewable source which can also be operated during night, solar panels prove to be useless during night which means you have to depend on the local utility grid to draw power in the night. Else you can buy solar batteries to store excess power which you can later utilize in the night.
6. **Installation area:** For home users, a solar energy installation may not require huge space but for big companies, a large area is required for the system to be efficient in providing a source of electricity.
7. **Maintenance** is one disadvantage, although most systems don't require a high degree of care. However, scaling occurs when there are minerals suspended in domestic water, which builds up as calcium deposits in the system. Adding water softeners or mild acidic substances such as vinegar can avoid scaling. It only must be done every three to five years, but this can vary depending on the water quality.
8. **Corrosion** is another concern. In open loop hydroid solar systems, oxygen can rust any iron or steel part. The plumbing components are more resistant if they're made of copper,

brass, bronze, stainless steel, plastic or rubber. Storage tanks should be lined with glass or plastic to resist corrosion as well.

9. **Active systems can overheat** if the size of the storage tank is not appropriate for the collector. The general rule is that for each square foot of collector, there should be 1.5 gallons of storage. With that in mind, such a disadvantage can be avoided.
10. **Cost can be another disadvantage**. Oftentimes a solar water heating system costs more in terms of purchasing and installation, compared to other types of water heaters. The savings come over the long run because water heating bills can be reduced by as much as 50 to 80 percent. Price hikes, fuel shortages, and other issues with utility-based heat are not a concern either.
11. Other disadvantages:
    i. Compared to photovoltaic panels, solar thermal panels only heat water.
    ii. Solar heaters require additional roof top space to install the solar heater.
    iii. The system does not function on cloudy, rainy, or foggy days.
    iv. Annual maintenance is recommended to check the pump and antifreeze.
    v. Installation requires the use of a new hot water cylinder.
    vi. Working of solar heaters depends up on abundance and availability of direct sun light.
    vii. It heats only in day time, however if the storage tank is well insulated, heated water can be stored and used even at night.

What I have learnt

- Solar energy is kind of universal, decentralized and no -polluting energy, which reaches earth in the form of short-wave radiation visible light and near ultraviolet light. It helps in maintaining the ecological balance through the process of photosynthesis and greenhouse effect.
- Solar water heating (SWH) is the process of converting sunlight into energy that can be used for domestic water heating.
- A solar water heater is a device that captures sunlight to heat water.
- The use of solar water heating reduces energy use from fossil fuel sources, benefiting the environment in the long run.
- There are two main types of solar water heating systems: active systems with circulating pumps and passive systems without pumps.
- Active systems rely on pumps to move the liquid between the collector and the storage tank.
- Passive systems rely on gravity and the tendency for water to naturally circulate as it is heated.
- Solar water heating system includes two main components - storage tanks and solar collectors.

- Solar collectors are the key component of active solar-heating systems which gather the sun's energy, transform its radiation into heat, and then transfer that heat to water, solar fluid, or air.
- Residential and commercial building applications that require temperatures below 200^{o}F typically use flat-plate collectors, whereas those requiring temperatures higher than 200^{o}F use evacuated-tube collectors.
- The storage tank holds the hot liquid and is simply a modified water heater, but it is usually larger and very well-insulated.
- In addition to solar collectors and storage tank, solar water heating system has following components:
  i. Heat exchangers.
  ii. Heat-transfer fluids.
  iii. Centrifugal-type circulating pump.
  iv. Sensors and controls.
  v. Check valves.
  vi. Expansion tank.
  vii. Pressure relief valve.
  viii. Pressure and Temperature Gauges.
- In domestic sector, hot water is used for bathing, washing of clothes & utensils etc. This requirement may, however, vary for the season of the year and number of family members.
- Advantages of solar water heater are:
  Choice of size, less space, High efficiency, Cost saving and Low maintenance.
- Disadvantages

i. Compared to photovoltaic panels, solar thermal panels only heat water.
ii. The system does not function on cloudy, rainy, or foggy days.
iii. Installation requires the use of a new hot water cylinder.
iv. Working of solar heaters depends up on abundance and availability of direct sun light.
v. It heats only in day time, however if the storage tank is well insulated, heated water can be stored and used even at night.

EXERCISE

Q-1. Tick (✓) the correct option for the following MCQs.

i- A solar water heater use solar energy to:

(A) Heat water (B) Generate steam
(C) Generate current to heat water (D) All of these

ii- Which of the following determines complexity and size of solar water heating system?

(A) Food (B) Solar radiation constant
(C) Chemicals (D) Changes in ambient temperature

iii- Which of the following is a conventional solar water system?

(A) Solar air collectors (B) Flat-plate collectors
(C) Parabolic dish collectors (D) None of these

iv- Which of the following metals are used to make pipes of low cost solar water heating system?

(A) Gold (B) Silver
(C) Copper (D) Polymer

v- Direct solar water heating systems offer _____

(A) Great overheating protection (B) No overheating protection
(C) Great freeze protection (D) None of these

vi- Which part of a house receives majority of solar radiation?

(A) Roof (B) Side walls
(C) Floors (D) Doors

vii- Which application is best suited for a solar water system?

(A) Food industry (B) Semi-conductor industry
(C) Liquid adsorption (D) Residential Applications

viii- Which of the following is/are applications of solar heating systems?

(A) Pasteurization and drying (B) Rainfall
(C) Wetting (D) Battery and capacitor technology

ix- Why back tube of solar water heater is surrounded by vaccum?

(A) To provide support (B) To cease leakage
(C) For Insulation (D) To enhance efficiency

x- The advantages of solar water heating is

(A) Cost saving (B) Less space required
(C) Low maintenance (D) All of these

Give short answer to the following questions.

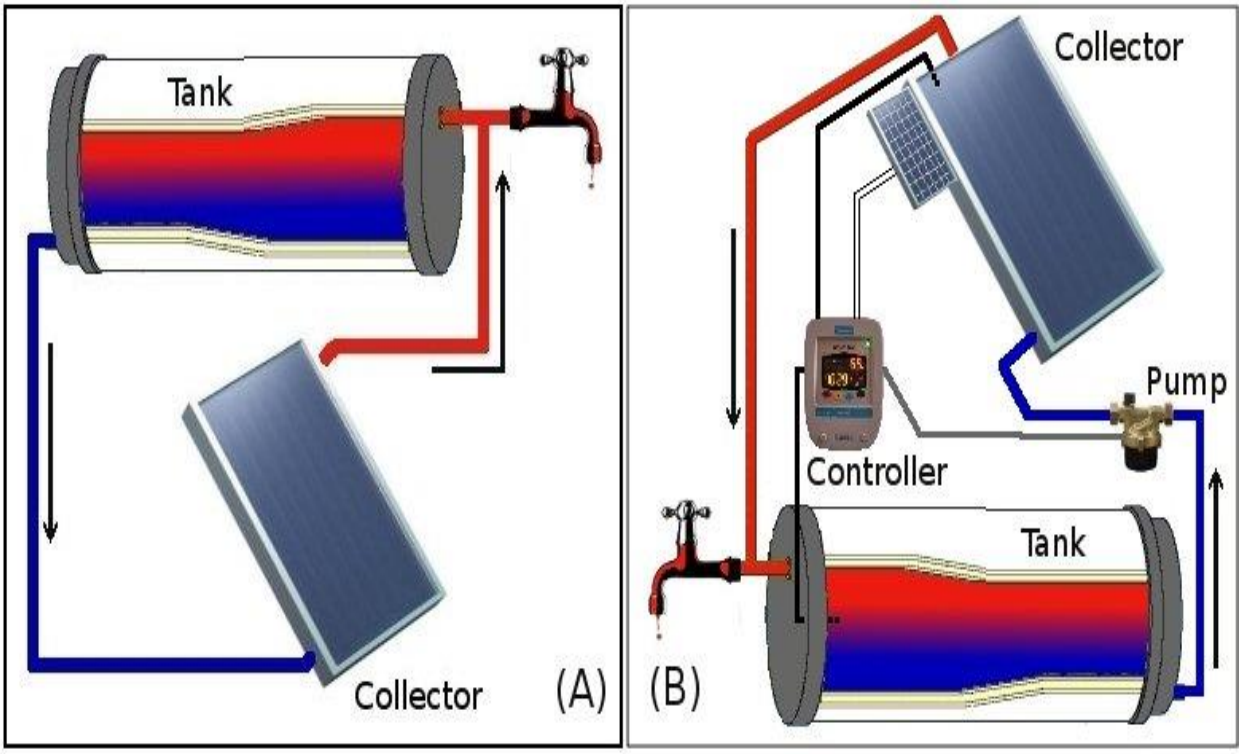
i- What is solar water heating system?
ii- State the purpose of solar water heating.
iii- Enlist the types of solar water heating system.
iv- Differentiate between active and passive solar water heating systems.
v- Differentiate between direct and indirect solar water heating systems.
vi- Write down the components of solar water heating system.
vii- Write down the advantages of solar water heating system.
viii- Enlist the disadvantages of solar water heating system.

Answer the following questions in detail.

i- Define solar water heating. Write down purpose of solar water heating.
ii- Briefly explain different parts of solar water heating system.
iii- Write down importance of solar water heating system.

CHAPTER -02

FUNDAMENTALS OF SOLAR WATER HEATING



After studying this unit, you will be able to:

- define light and heat energy.
- define solar thermal energy.
- describe basic function of domestic solar water heating.
- explain different types of solar water heating systems and their merits & demerits.
- analyse the water discharge level for domestic and commercial water heating systems.

2.1 Solar Thermal Energy

2.1.1. Introduction to Light and Heat Energy.

Solar power is the flow of energy from the sun. The primary forms of solar energy are heat and light. Sunlight and heat are transformed and absorbed by the environment in a multitude of ways. Some of these transformations result in renewable energy flows such as biomass, wind and waves.

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar radiation account for most of the available renewable energy on earth. Only a little fraction of the available solar energy is used.

Every day, the sun radiates an enormous amount of energy. This energy comes from within the sun itself. Like most stars, the sun is a big gas ball made mostly of hydrogen and helium. The sun produces energy in a process called nuclear fusion.

The high pressure and temperature in the sun's core cause hydrogen atoms to split apart. Four hydrogen nuclei combine or fuse, to form one helium atom, producing radiant energy in the process.

The sun radiates more energy in one second than the world has used since time began. Only a small portion of this energy strikes the earth, one part in two billion. This amount of energy is enough to meet the world's needs, if it could be harnessed.

About 15 percent of the radiant energy that reaches the earth is reflected back into space. Another 30 percent is used to evaporate water, which is lifted into the atmosphere and produces rainfall. The radiant energy is also absorbed by plants, landmasses and the oceans.

Oceans cover more than 70 percent of the earth's surface and most of the ocean's energy comes from the sun. Only the tides—caused by the gravitational energy of the moon—and the geothermal energy under the oceans are not solar powered. Ocean currents, waves and winds all are a result of the sun's radiant energy. Solar energy can also be used to produce electricity with photovoltaic.

Solar energy refers primarily to the use of solar radiation for practical ends. However, all renewable energies, other than geothermal and tidal, derive their energy from the sun.

Solar powered electrical generation relies on heat engines and photovoltaic. Solar energy's uses are limited only by human ingenuity. A partial list of solar applications includes space heating and cooling through solar architecture, potable water via, distillation and disinfection, day lighting, solar hot water, solar cooking and high temperature process heat for industrial purposes. To harvest the solar energy, the most common way is to use solar panels.

Solar technologies are broadly characterized as either passive or active depending on the way they capture, convert and distribute sunlight. Active solar techniques use photovoltaic panels, pumps, fans and solar thermal collectors to convert sunlight into useful outputs.

Passive solar techniques include selecting materials with favourable thermal properties, designing spaces that naturally circulate air and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side

technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies.

2.1.2 Solar Thermal Energy.

Solar energy is the main source of providing light and heat to the planet earth. Solar thermal energy is the energy collected from the sun and used to generate heat. This heat is usually concentrated using mirrors and used for heating water later.

The Earth receives 174 peta watts (PW) of solar radiation at the upper atmosphere. While traveling through the atmosphere 6% of the incoming solar radiation (insolation) is reflected and 16% is absorbed. Average atmospheric conditions (clouds, dust, pollutants) further reduce insolation by 20% through reflection and 3% through absorption. The absorption of solar energy by atmospheric convection (sensible heat transport) and by the evaporation and condensation of water vapor (latent heat transport) drive the winds and the water cycle.

Atmospheric conditions not only reduce the quantity of insolation reaching the Earth's surface but also affect the quality of insolation by diffusing approximately 20% of the incoming light and altering its spectrum. After passing through the Earth's atmosphere approximately half the insolation is in the visible electromagnetic spectrum with the other half mostly in the infrared and ultraviolet spectrum.

Solar energy has an enormous potential like all the different prototypes have shown, and the prediction about this type of technology show that the efficiency of these systems can be increased in a significant way.

Different techniques of active solar heating and solar thermal power generation are technically feasible and cost effective, and some commercially available plants can produce up to 350MW these systems are highly dependent on the local climate and energy needs; this is a big limitation because only in certain regions these systems can be efficient enough to be implemented.

The main obstacle for the development of these systems is the low price of fossil fuels, and their high availability, like coal and biomass.

The solar systems have a low environmental impact, and one of the most important benefits is that it doesn’t have emissions like CO_2 or other toxic gases or radioactive material, like the ones that are produced by the current systems used to produce energy.

The costs of these energy systems consist only of the construction and maintenance of the plant, the source of energy is free and in theory unlimited. The environmental impact of these systems is practically zero.

Some of the disadvantages are that these systems can only be installed in areas in which the solar radiation is longer during the days and during the year. They are also less efficient than the current energy systems

These systems can be a combination of solar energy generators and a conventional fossil fuel generator, this combination has the advantage that energy can be provided even if there is no solar energy available.

Applications of Solar Thermal Energy.

1. Domestic Water Heating
2. Domestic Space Heating
3. Solar Cooking
4. Crop Drying
5. Space Cooling
6. Day-Lighting

2.1.3. Basic Function of Domestic Solar Water Heating

A solar hot water heater's basic function is to expose water or a heat-exchanging liquid to the sun's rays, then circulate the warmed liquid back into your home for domestic use. The basic components of all solar water heaters are a storage tank and a collector to trap the sun's heat.

Collectors are a series of flat plates, tubes or tanks through which water or a heat transfer fluid passes and absorbs the sun's heat. From there, the fluid is circulated to either a water tank or heat exchange unit.

Solar water heaters are most commonly used as energy-saving devices to preheat water before entering a conventional water heater in the home. But some solar water heaters warm and store water without the use of a conventional tank, offering totally sun-powered hot water.

A solar water heater is a great alternative for producing hot water every day. Heating water with the help of solar energy is the best alternative way rather than using electricity or gas. A solar water heater consists of solar collectors, a tank and a circulating pump. In some solar water heaters, a backup is also included for the days when solar energy is not available at all and you require hot water. Solar collectors are installed to collect the sunlight. The tank is for storing the hot water and the circulating pump is used for carrying the solar energy from the collector to the tank, and a thermal regulator.

The basic function of a solar water heater is that it absorbs light with the help of collectors and then it is converted into heat energy. The circulating pump then passes the heat energy on to the water tank. This exchange is made possible with the help of the thermal regulator. This circulating pump is the reason why you don’t need electricity at all. It also prevents your water heater from overheating.

The collectors work best during the midday when the sky is most of the time cloudless and it should be made sure that the collectors are facing south. During the times when sunlight is insufficient, the water is preheated after which the back-up system takes over and brings the water to the needed hot temperature. This is why a solar water heater can be used to produce hot water without emitting any carbon dioxide. To properly know the working of a solar water heater, you should also know that their way of functioning differs due to the varying type of collectors and circulation systems.

Activity-2.1 Group Discussion regarding Functions of SWH.

The teacher/ instructor is required to involve students in group discussion regarding basic functions of solar water heating by making groups.

2.2 Types of Solar Water Heating Systems

2.2.1 Types of Solar Water Heating Systems.

Solar water heating (or SWH) is the process of converting sunlight into energy that can then be used for domestic water heating. This heated water can be used for washing in the home, radiant floor heating, or to heat swimming pools.

Solar water heating systems use a large number of different technologies and these technologies can be used almost anywhere in the world.

Generally speaking, solar water heating systems are composed of two main components: storage tanks and solar collectors. The collectors serve the purpose of collecting and retaining heat from the Sun. Once the collectors capture the energy from the Sun, this heat is transferred to a liquid known as the heat transfer fluid. If this fluid is water it takes the heat from the collector and moves the warm water for use or storage. However, if this fluid is not water, heat exchangers are used to transfer the heat from the heat exchange fluid to domestic water supply. Pumps are sometimes used in active heating systems to control what temperature the water gets to and how quickly it moves. There are two main types of solar water heating systems:

i. Active systems with circulating pumps and
ii. Passive systems without pumps.

i- Active Solar Water-Heating Systems

Active solar hot water systems employ a pump to circulate water or heat transfer fluid (HTF) between the collector and the storage tank. Like their passive counterparts, active solar water heating systems come as two types: direct active systems which pump water directly to the collector and back to the storage tank, while indirect active systems pump transfer fluid (HTF), the heat of which is transferred to the water in the storage tank. Because the pump should only operate when the fluid in the collector is hotter than the water in the storage tank, a controller is required to turn the pump on and off.

The use of an electronically controlled pump has several advantages:

i. The storage tank can be situated lower than the collectors. In passive systems the storage tank must be located above the collector so that the thermo-siphon effect can transport water or HCF from collector to tank. The use of a pump allows the storage tank to be located lower than the collector since the circulation of water or HCF is enforced by the pump. A pumped system allows the storage tank to be located out of sight.

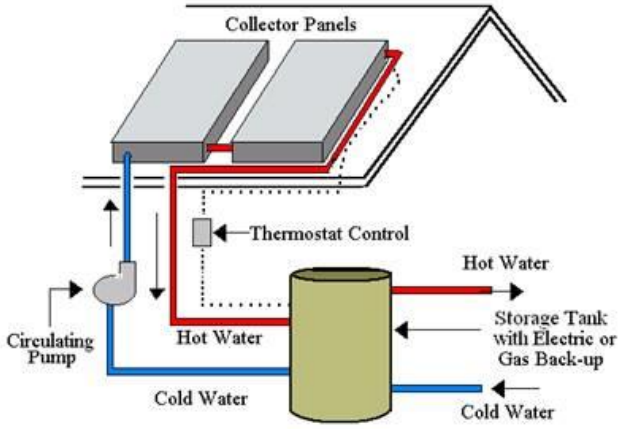
ii. Because of the fact that active systems allow freedom in the location of the storage tank, the tank can be located where heat loss from the tank is reduced, e.g., inside the roof of a house. This increases the efficiency of the solar water heating system.

iii. Reduces the risk of overheating. If no water from the solar hot water system is used (e.g., when water users are away), the water in the storage tank is likely to overheat. Several pump controllers avoid overheating by activating the pump at night. This pumps hot water or HTF from the storage tank through the collector (that is cold at night), thus cooling the water in the storage tank.

iv.

v. Reduces the risk of freezing. For direct active systems in cold weather, the pump controller can pump hot water from the water storage tank through the collector in order to prevent the water in the collector from freezing, thus avoiding damage to the system.

Active systems can tolerate higher water temperatures than would be the case in an equivalent passive system. Consequently, active systems are often more efficient than passive systems but are more complex, more expensive, more difficult to install and rely on electricity to run the pump and controller



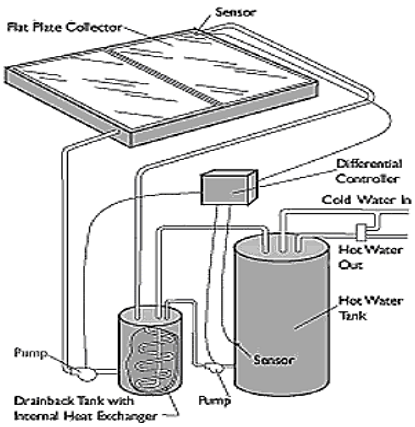
There are the three types of active solar water-heating systems:

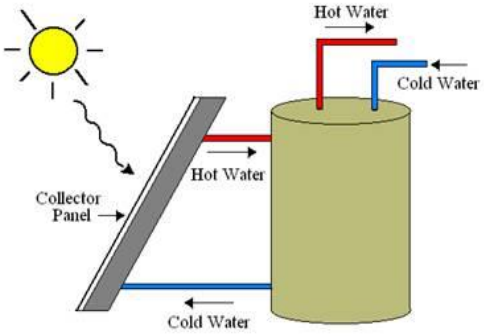
1. **Direct-circulation systems** (or **open systems**) use pumps to circulate water through the collectors. These systems are appropriate in areas that do not freeze for long periods and do not have hard or acidic water. These systems should not be used if they use recirculation freeze protection (circulating warm tank water during freeze conditions) because that requires electrical power for the protection to be effective.

2. **Indirect-circulation systems** (or **closed systems**) pump heat-transfer fluids, such as a mixture of glycol and water antifreeze, through collectors. Heat exchangers transfer the heat from the fluid to the potable water stored in the tanks. Some indirect systems have overheat protection, which protects the collector and the glycol fluid from becoming super-heated when the load is low and the intensity of incoming solar radiation is high.
3. **Drain back system**, is an indirect active system where heat transfer fluid circulates through the collector, being driven by a pump. However, the collector piping is not pressurized and includes an open drain back reservoir.

If the pump is switched off, all the heat transfer fluid drains into the drain back reservoir and none remains in the collector. Consequently, the collector cannot be damaged by freezing or overheating. This makes this type of system well-suited to colder climates

Drain back systems must be carefully installed to assure that the piping always slopes downward, so that the water will completely drain from the piping. This can be difficult to achieve in some circumstances. Drain back solar water-heating systems are a good choice for cold.





ii Passive Solar Water-Heating Systems

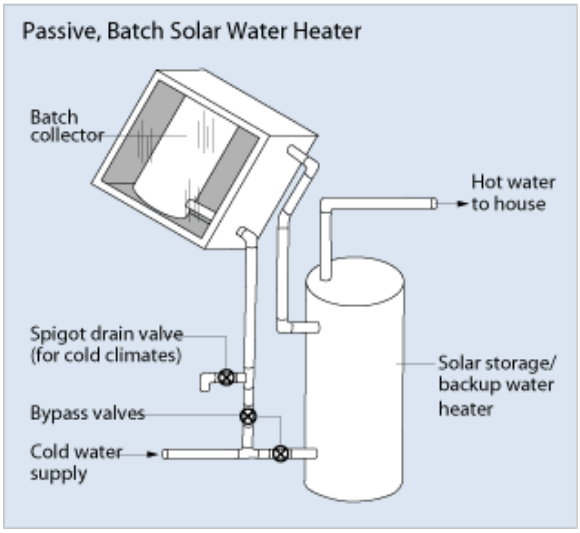
Passive solar water heating systems are typically less expensive than active systems, but they're usually not as efficient. Passive solar water heaters rely on gravity and the tendency for water to naturally circulate as it is heated. Because they contain no electrical components, passive systems are generally more reliable, easier to maintain, and possibly have a longer work life than active systems.

The two main types of passive water heating systems are:

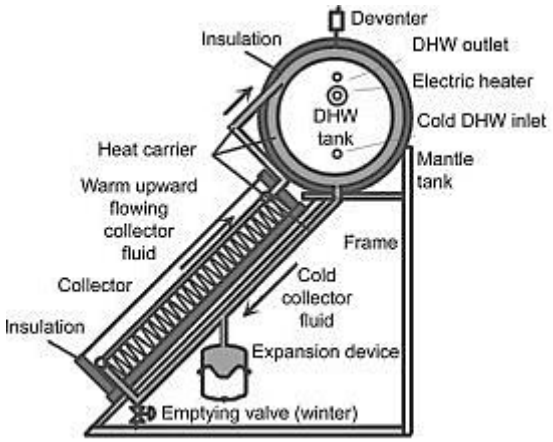
1. **Integral-Collector Storage (ICS) Systems or Batch Heaters** are special type of passive system where the tank acts as both storage and solar collector. Batch heaters are basically thin rectilinear tanks with glass in front of it facing the sun generally in or on house wall or roof.

   They are seldom pressurized and usually depend on gravity flow to deliver their water. They are simple, efficient and less costly than plate and tube collectors but are only suitable in moderate climates (where temperatures rarely go below freezing) with good sunshine.

   During the winter, they must be drained or protected from freezing. They are also good in households with significant daytime and evening hot-water needs; but they do not work well in households with predominantly morning draws because they lose most of the collected energy overnight.



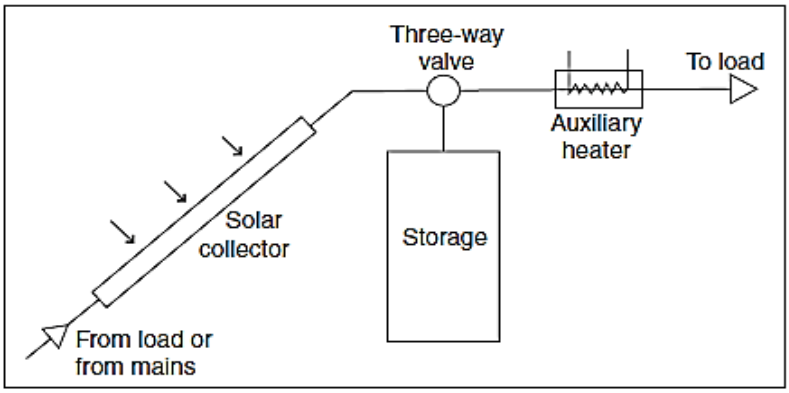
2. **Thermo-Syphon Systems or Convection Heat Storage Unit (CHS)** is a step up from the ICS and are an economical and reliable choice, especially in new homes. These are often plate type or evacuated tube collectors with built-in insulated tanks. The unit uses convection (movement of hot water upward) to move the water from collector to tank (located above the collector).



As water in the solar collector heats, it becomes lighter and rises naturally into the tank above. Meanwhile, the cooler water flows down the pipes to the bottom of the collector, enhancing the circulation. Neither pumps nor electricity are used to enforce circulation.

It is more efficient than an ICS as the collector heats a smaller amount of water that constantly rises back to the tank. It can be used in areas with less sunshine than the ICS, An CHS also known as a compact system or mono-bloc has a tank for the heated water and a solar collector mounted on the same chassis. Typically, these systems will function by natural convection or heat pipes to transfer the heat energy from the collector to the tank.

Direct ('open loop') passive systems use water from the main household water supply to circulate between the collector and the storage tank. When the water in the collector becomes warm, convection causes it to rise and flow towards the water storage tank. They are often not suitable for cold climates since, at night, the water in the collector can freeze and damage the panels.



Open-loop passive SWH system

Indirect ('closed loop') passive systems use a non-toxic antifreeze heat transfer fluid (HTF) in the collector. When this fluid is heated, convection causes it to flow to the tank where a passive heat exchanger transfers the heat of the HCF to the water in the tank.

The attraction of passive solar water heating systems lies in their simplicity. There are no mechanical or electrical parts that can break or that require regular supervision or maintenance. Consequently, the maintenance of a passive system is simple and cheap. The efficiency of a passive system is often somewhat lower than that of an active system and overheating is largely avoided by the inherent design of a passive system.

Solar water-heating systems almost always require a backup system for cloudy days and times of increased demand. Conventional storage water heaters usually provide backup and may already be part of the solar system package. A backup system may also be part of the solar collector, such as rooftop tanks with thermo-syphon systems. Since an integral-collector storage system already stores hot water in addition to collecting solar heat, it may be packaged with a demand (tank less or instantaneous) water heater for backup

Activity-2.2 Group Discussion regarding merits and demerits of Solar Water Heating systems

The teacher/ instructor is required to involve students in group discussion regarding merits and demerits of each SWH systems by making groups.

2.2.2 Water discharge level for Domestic and Commercial Solar Water Heating Systems.

Commercial solar water heaters are used in factories and commercial buildings whereas domestic water heaters are used in homes for small scale water requirements.

Domestic water heating system is called thermo-syphon system. For the commercial and industrial needs forced circular systems are installed which provide more water.

Water level means height of water or a place from where water is to be provided to the solar water heating system when necessary. Keeping in view the water supply system in Pakistan, if hot water line of solar water heating system is attached to the existing water lines, pressure and discharge will be reduced considerably.

In a two-storey building, directly 8mm below overhead water tank, water pressure is 0.8 bar. Flow of discharge is measured in litres per minute and discharge in hot water pipe in remote part of building should not be less than five litres per minute.

What I have learnt

- Solar power is the flow of energy from the sun. The primary forms of solar energy are heat and light. Sunlight and heat are transformed and absorbed by the environment in a multitude of ways.

- Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies.
- The About 15 percent of the radiant energy that reaches the earth is reflected back into space. Another 30 percent is used to evaporate water, which is lifted into the atmosphere and produces rainfall. The radiant energy is also absorbed by plants, landmasses and the oceans.
- Solar thermal energy is the energy collected from the sun and used to generate heat. This heat is usually concentrated using mirrors and used for heating water later.
- A solar hot water heater's basic function is to expose water or a heat-exchanging liquid to the sun's rays, then circulate the warmed liquid back into your home for domestic use.
- The basic components of all solar water heaters are a storage tank and a collector to trap the sun's heat.
- A solar water heater consists of solar collectors, a tank and a circulating pump. In some solar water heaters, a backup is also included for the days when solar energy is not available at all and you require hot water.
- Solar water heating is the process of converting sunlight into energy that can then be used for domestic water heating. This heated water can be used for washing in the home, radiant floor heating, or to heat swimming pools.
- Active solar hot water systems employ a pump to circulate water or heat transfer fluid (HTF) between the collector and the storage tank.
- Direct-circulation systems (or open systems) use pumps to circulate water through the collectors. These systems are appropriate in areas that do not freeze for long periods and do not have hard or acidic water.
- Indirect-circulation systems (or closed systems) pump heat-transfer fluids, such as a mixture of glycol and water antifreeze, through collectors. Heat exchangers transfer the heat from the fluid to the potable water stored in the tanks.
- Drain back system, is an indirect active system where heat transfer fluid circulates through the collector, being driven by a pump. If the pump is switched off, all the heat transfer fluid drains into the drain back reservoir and none remains in the collector
- Integral-Collector Storage (ICS) Systems or Batch Heaters are special type of passive system where the tank acts as both storage and solar collector. Batch heaters are basically thin rectilinear tanks with glass in front of it facing the sun generally in or on house wall or roof.
- Thermo-Syphon Systems or Convection Heat Storage Unit (CHS**)** is a step up from the ICS and are an economical and reliable choice, especially in new homes. These are often plate type or evacuated tube collectors with built-in insulated tanks. The unit uses convection (movement of hot water upward) to move the water from collector to tank (located above the collector).

EXERCISE

Q-1. Tick (✓) the correct option for the following MCQs.

i- Which of the following is an example of direct solar water heating system?

(A) Pressurized antifreeze system (B) Convection heat storage system

(C) Drain back system (D) All of these

ii. A transparent cover is used to maximize the transmission of the incident sunlight into the box in.

(A) Flat plate collector (B) Batch heaters

(C) Drain back system (D) All of these

iii. Drain back systems in solar water heating system are such systems that:

(A) Tracks the sun (B) Pumps excess transfer fluid

(C) Drains the transfer fluid (D) Reverses direction of flow of transfer fluid

iv. Which of the following is generally used as circulating fluid in tropical and sub-tropical climates?

(A) Water (B) A mixture of ethylene glycol and water

(C) Glycerol (D) A mixture of propylene glycol and water

v. Which of the following is generally used as circulating fluid in freezing climates?

(A) Water (B) Liquid nitrogen

(C) Liquid carbon dioxide (D) A mixture of propylene glycol and water

vi. Which of the following is a circulating fluid in evacuated flat-plate solar collectors?

(A) Water (B) Nitrogen

(C) Steam (D) Hydrogen

vii. Which of the following is not used in a passive solar heating/cooling system?

(A) Building walls (B) Building roofs

(C) Building floors (D) Air conditioners

viii. Which of the following is an example of passive solar technology?

(A) Photovoltaic (B) Active solar water heating systems

(C) Solar furnace (D) Solar thermo-mechanical systems

ix. The Earth receives solar radiation at the upper atmosphere.

(A) 184 peta watts (B) 174 peta watts

(C) 164 peta watts (D) 154 peta watts

x. Discharge in hot water pipe in remote part of building should not be less than

(A) 5 l/sec (B) 10 l/sec

(C) 15 l/sec (D) 20 l/sec

Give short answer to the following questions.

i- Define solar power.

ii- What is solar energy?

iii- What are common uses of solar energy?

iv- Define solar thermal energy.

v- Enlist some uses of solar thermal energy.

vi- Differentiate between direct and indirect active solar water heating system.

vii- Define direct-circulation system (or open system) of active solar water heating system.

viii- Define indirect-circulation system (or closed system) of active solar water heating system.

Answer the following questions in detail.

i- Define light and heat energy. How this energy is harnessed?

ii- Define solar thermal energy. Briefly explain some of its common uses.

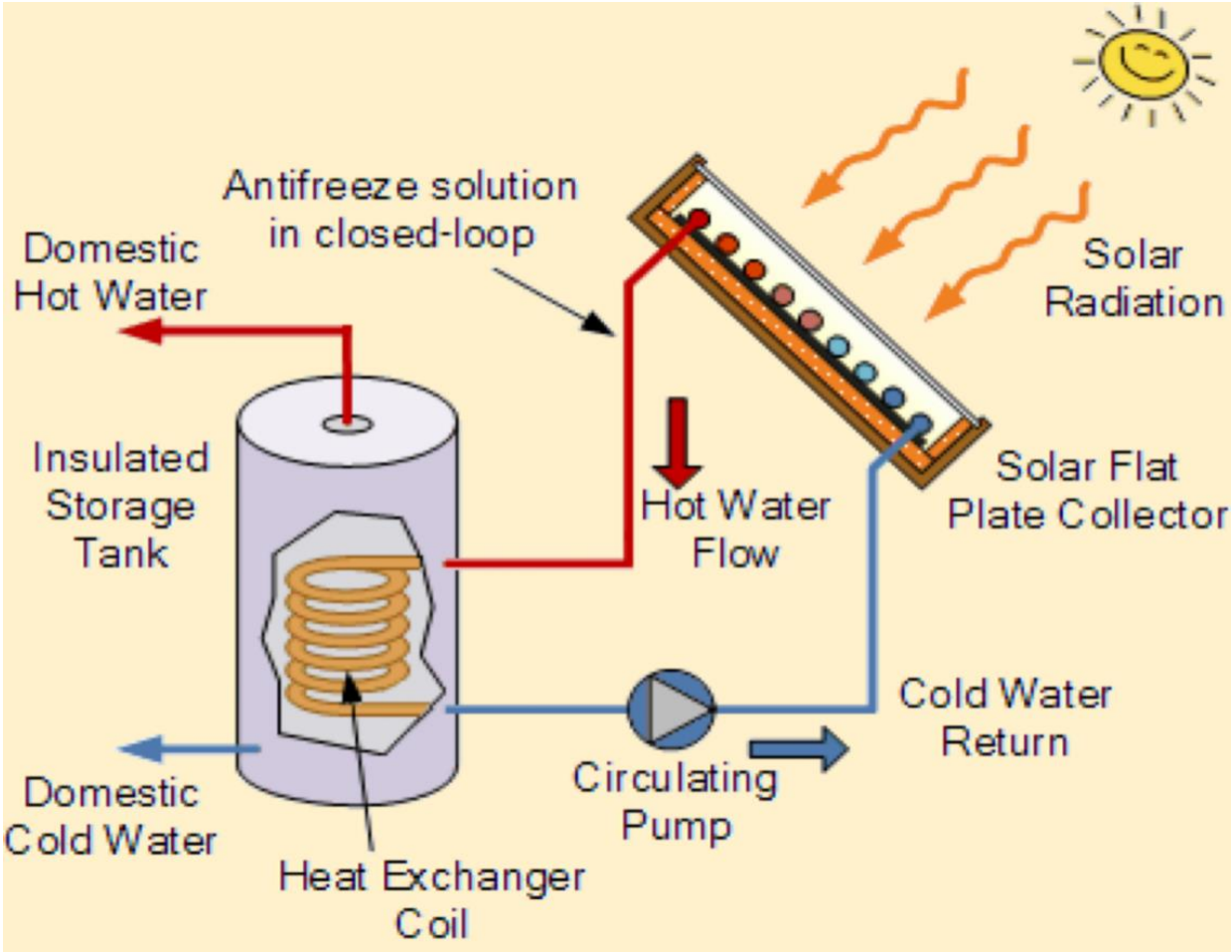
iii- Briefly explain active solar water heating system and its types.

iv- Briefly explain passive solar water heating system and its types.

v- What is water discharge level for domestic and commercial use?

CHAPTER - 03

COMPONENTS OF SOLAR WATER HEATING SYSTEM



After studying this unit, you will be able to:

- understanding the function and use of different parts of solar water heating system.
- importance of alternate electrical and gas arrangement.
- understand and identify types of collectors.
- know about the frame and storage tank of hot water.
- storage and expansion vessels.

3.1- Parts of Typical Solar Water Heating System

3.1.1- Functions and use of different parts of SWH system:

Following are the parts of a solar water heating system:

i. Solar collectors.
ii. Heat exchangers.
iii. Heat transfer fluids.
iv. Circulating pumps.
v. Sensors and controls.
vi. Storage tank.
vii. Check valve.
viii. Expansion tank/vessel.
ix. Pressure relief valve.
x. Pressure and temperature gauges.

i. Solar collectors:

Detail is given in section 3.2

ii. Heat exchangers:

Solar water-heating systems use heat exchangers to transfer solar energy absorbed in solar collectors to the liquid or air used to heat water or a space.

Heat exchangers can be made of steel, copper, bronze, stainless steel, aluminum, or cast iron. Solar heating systems usually use copper, because it is a good thermal conductor and has greater resistance to corrosion.

Do you know?

SWH system usually use copper because of its good thermal conductivity and greater resistance to corrosion.

Solar water-heating systems use two types of heat exchangers:

1. Liquid-to-liquid heat exchangers

Liquid-to-liquid heat exchangers use a heat-transfer fluid that circulates through the solar collector, absorbs heat, and then flows through a heat exchanger to transfer its heat to water in a storage tank. Heat-transfer fluids, such as antifreeze, protect the solar collector from freezing in cold weather. Liquid-to-liquid heat exchangers have either one or two barriers (single wall or double wall) between the heat-transfer fluid and the domestic water supply.

A **single-wall heat exchanger** is a pipe or tube surrounded by a fluid. Either the fluid passing through the tubing or the fluid surrounding the tubing can be the heat-transfer fluid, while the other fluid is the potable water.

Double-wall heat exchangers have two walls between the two fluids. Two walls are often used when the heat-transfer fluid is toxic, such as ethylene glycol. Double walls often are required as a safety measure in case of leaks, helping ensure that the antifreeze does not mix with the potable water supply. An example of a double-wall, liquid-to-liquid heat exchanger is the "wrap-around heat exchanger," in which a tube is wrapped around and bonded to the outside of a hot water tank. The tube must be adequately insulated to reduce heat losses. Some local codes require double-wall heat exchangers on solar water-heating systems.

While double-wall heat exchangers increase safety, they are less efficient because heat must transfer through two surfaces rather than one. To transfer the same amount of heat, a double-wall heat exchanger must be larger than a single-wall exchanger.

2. Air-to-liquid heat exchangers

Solar heating systems with air-heater collectors usually do not need a heat exchanger between the solar collector and the air distribution system. Some solar air-heating systems are designed to heat water if the space heating requirements are satisfied. These systems use air-to-liquid heat exchangers, which are similar to liquid-to-air heat exchangers.

Heat Exchanger Designs:

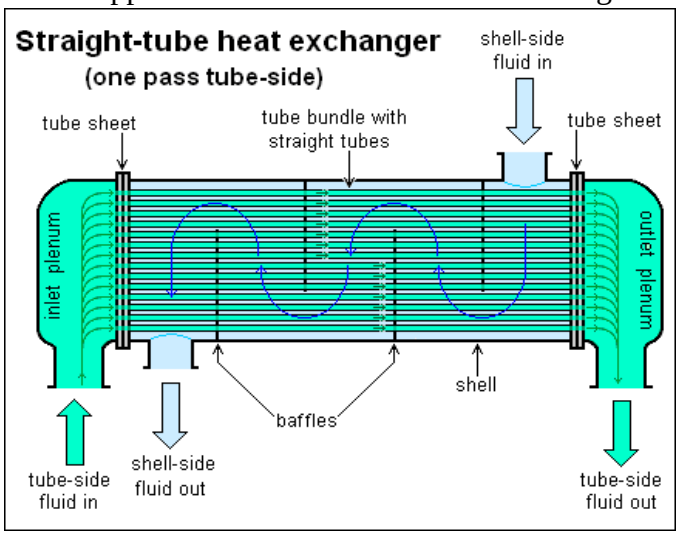
There are many heat exchanger designs. Here are some common ones:

1. Coil-in-tank heat exchanger

The heat exchanger is a coil of tubing in the storage tank. It can be a single tube (single-wall heat exchanger) or the thickness of two tubes (double-wall heat exchanger). A less efficient alternative is to place the coil on the outside of the collector tank with a cover of insulation.

2. Shell-and-tube heat exchanger

The heat exchanger is separate from (external to) the storage tank. It has two separate fluid loops inside a case or shell. The fluids flow in opposite directions to each other through the heat exchanger, maximizing heat transfer. In one loop, the fluid to be heated (such as potable water) circulates through the inner tubes. In the second loop, the heat-transfer fluid flows between the shell and the tubes of water. The tubes and shell should be made of the same material. When the collector or heat-transfer fluid is toxic, double-wall tubes are used, and a non-toxic intermediary transfer fluid is placed between the outer and inner walls of the tubes.



3. Tube-in-tube heat exchanger

In this very efficient design, the tubes of water and the heat-transfer fluid are in direct thermal contact with each other. The water and the heat-transfer fluid flow in opposite directions to each other. This type of heat exchanger has two loops similar to those described in the shell-and-tube heat exchanger.

Sizing

A heat exchanger must be sized correctly to be effective. There are many factors to consider for proper sizing, including the following:

- Type of heat exchanger
- Characteristics of the heat-transfer fluid (specific heat, viscosity, and density)
- Flow rate
- Inlet and outlet temperatures for each fluid.

Usually, manufacturers will supply heat transfer ratings for their heat exchangers (in Btu/hour) for various fluid temperatures and flow rates. Also, the size of a heat exchanger's surface area affects its speed and efficiency: a large surface area transfers heat faster and more efficiently.

Installation

For the best performance, always follow the manufacturer's installation recommendations for the heat exchanger. Be sure to choose a heat-transfer fluid that is compatible with the type of heat exchanger you will be using. If you want to build your own heat exchanger, be aware that using different metals in heat exchanger construction may cause corrosion. Also, because dissimilar metals have different thermal expansion and contraction characteristics, leaks or cracks may develop. Either of these conditions may reduce the life span of the heat exchanger.

iii. Heat Transfer Fluids

Heat-transfer fluids carry heat through solar collectors and a heat exchanger to the heat storage tanks in solar water heating systems. When selecting a heat-transfer fluid, you should consider the following criteria:

- Coefficient of expansion: the fractional change in length (or sometimes in volume, when specified) of a material for a unit change in temperature
- Viscosity: resistance of a liquid to sheer forces (and hence to flow)
- Thermal capacity: the ability of matter to store heat
- Freezing point: the temperature below which a liquid turns into a solid
- Boiling point: the temperature at which a liquid boils
- Flash point: the lowest temperature at which the vapor above a liquid can be ignited in air.

Do you know?

In cold climate SWH system requires fluids with low freezing points but fluids exposed to high temperature should have high boiling point.

For example, in a cold climate, solar water heating systems require fluids with low freezing points. Fluids exposed to high temperatures, as in a desert climate, should have a high boiling point. Viscosity and thermal capacity determine the amount of pumping energy required. A fluid with low viscosity and high specific heat is easier to pump, because it is less resistant to flow and transfers more heat. Other properties that help determine the effectiveness of a fluid are its corrosiveness and stability.

Types of Heat-transfer fluids

The following are some of the most commonly used heat-transfer fluids and their properties:

Air

Air will not freeze or boil, and is non-corrosive. However, it has a very low heat capacity, and tends to leak out of collectors, ducts, and dampers.

Water

Water is nontoxic and inexpensive. With a high specific heat, and a very low viscosity, it's easy to pump. Unfortunately, water has a relatively low boiling point and a high freezing point. It can also be corrosive if the pH (acidity/alkalinity level) is not maintained at a neutral level. Water with a high mineral content (i.e., "hard" water) can cause mineral deposits to form in collector tubing and system plumbing.

Glycol/Water mixtures

The most common fluid used in closed solar water heating systems is propylene glycol. Glycol/water mixtures have a 50/50 or 60/40 glycol-to-water ratio. Ethylene and propylene glycol are "antifreezes." Ethylene glycol is extremely toxic and should only be used in a double-walled, closed-loop system. You can use food-grade propylene glycol/water mixtures in a single-walled heat exchanger, as long as the mixture has been certified as nontoxic. Make sure that no toxic dyes or inhibitors have been added to it. Most glycols deteriorate at very high temperatures. The pH value, freezing point, and concentration of inhibitors should be checked annually to determine whether the mixture needs any adjustments or replacements to maintain its stability and effectiveness.

iv. Circulating Pumps

Centrifugal-type circulating pumps are most commonly used in solar water-heating systems. Centrifugal pumps generally have low power consumption and low maintenance and are highly reliable. The bodies are typically made with cast iron, bronze, or stainless steel. For closed loop systems lower cost, cast iron circulating pumps are adequate. For open-loop systems, circulating a replenishing supply of water, a bronze circulating pump is necessary. Stainless steel pumps are used in swimming pools and other applications where chemicals are present.

Once it is determined that the pump is to operate in a closed loop, open loop, or other particular environment, the solar system head and flow requirements are used to select the appropriate pump. Head is the pressure the pump must develop in order to create desired flow through the system. The overall pressure a pump must create is determined by the height the water must be lifted and the frictional resistance of the pipe.

Static head is pressure resulting from the vertical height and corresponding weight of the column of fluid in a system. The higher a pump must lift the fluid against gravity, the greater the static head it must develop. Dynamic head includes the frictional resistance of the fluid flowing through the pipe and fittings in the system. The pressure a pump must develop to overcome dynamic head varies with the size and length of the pipe, number of fittings and bends, and the flow rate and viscosity of the fluid.

Circulating pumps are typically categorized for low, medium, or high head applications. Low head applications have 3 to 10 feet (0.9-3 m) of head; medium head applications, 10 to 20 feet (3-6 m) of head; and high head applications, over 20 feet of head.

v. Sensors and Controls

The **differential controller** tells the pump when to turn on and off. The controller, via sensors connected to the collector and the storage tank, determines whether the collector outlet is sufficiently warmer than the bottom of the tank to turn the circulating pump on.

The sensors are located at the collector outlet, and at the bottom of the solar storage tank. These sensors are thermistors that change their resistance with temperature. The differential control compares the resistances of the two sensors. It turns the pump on when the collectors are warmer (usually $20^{o}F$) than the bottom of the solar storage tank to collect useful heat. The controller usually shuts the pump down when the temperature difference is 3 to $50^{o}F$.

vi. Storage Tank

A solar water-heating system is generally installed between the cold water coming into the home and the conventional water heater, and is used to pre-heat the water entering the conventional water heater. A **storage tank** is necessary to hold water heated by the solar water heating system. Adding another storage tank to hold solar heated water is not only more efficient than have just the conventional water heater, but the solar water storage tank acts as a means to keep the solar panels from overheating.

vii. Check Valve

A check valve permits fluid to flow in one direction only. It prevents heat loss at night by convective flow from the warm storage tank to the cool collectors. Check valves are either the "swing" type or the "spring" type. Swing-type check valves should be properly installed (i.e. not

vertically upside-down which allows them to hang open). A swing-type check valve should be used with pump powered directly from a PV module. Low sun conditions produce lower flow rates, which may not be strong enough to overcome a spring-type check valve. For systems using AC circulating pumps, spring-type check valves should be installed. The spring resists thermo syphon flow in either direction.

Do you know?

A check valve permits the fluid to flow in one direction only.

viii. Expansion Tank

An expansion tank allows the fluid in a closed-loop system to expand and contract depending on the temperature of the fluid. Without the expansion tank, the plumbing would easily burst when the fluid is heated. Diaphragm-type expansion tanks are constructed with an internal bladder and a pressurized air chamber. Heated fluid expands in the closed loop against the bladder and pressurized air chamber. As the fluid contracts while cooling, the air chamber maintains pressure in the closed loop.

The size of the expansion tank must be able to handle the expansion based on the volume, coefficient of expansion, and range of temperature fluctuation. The size and number of collectors, and the size and length of piping and fittings determine fluid volume. Diaphragm-type expansion tanks are readily found in most plumbing supply houses.

ix. Pressure Relief Valve

Every hydronic heating system must have protection against high pressures due to high temperatures. A pressure relief valve of 50 psi is usually adequate to protect closed-loop plumbing systems from excessive pressures. Temperature/pressure relief valves are not commonly used in the closed loop because high temperatures are common. Pressure-only relief valves are most commonly used. Pressure relief valves should have a vent tube that directs escaping fluid to a bucket or floor drain. Once one of these valves opens, it is wise to replace it, since they often do not fully reseat, scale or dirt particles may allow a slow leak.

Do you know?

A pressure relief valve of 50 psi is usually used to protect closed loop plumbing systems from excessive pressures.

x. Pressure and Temperature Gauges

A **pressure gauge** shows if the closed loop system is within an acceptable range of pressure. A typical system pressure is on the order of 10 to 15 psi. A pressure gauge is used as a diagnostic tool to monitor the state of the glycol charge. A loss of pressure indicates a leak in the system that needs to be located and repaired.

A pressure

Two **temperature gauges** in the closed loop and one in the water loop are optional, but valuable indicators of the system's function. One gauge on each side of the heat exchanger in the collector loop shows the temperature rise across the collectors and the temperature change across the heat exchanger. A temperature difference of 15 to 20ºF indicates effective system operation. One temperature gauge in the water loop between the exit of the heat exchanger and the entry to the storage tank will display the current temperature of solar heated water entering the storage tank. The temperature gauges should have a range of 0 to 240 or 300ºF. A hot summer day may produce water temperatures in the solar loop around 200ºF, although normally 180ºF is the maximum temperature attained.

Activity-3.1 Discussion about different parts of SWH system and their functions

The teacher/ instructor is required to involve the students in discussion about different parts of solar water heating and their functions.

Activity-3.2 Recognition of Different Parts of an Existing SWH System

The teacher/ instructor is required to involve the students in recognizing different parts of an existing solar water heating system

3.1.2- Importance of Alternate Electrical and Gas Arrangement

Residential solar thermal installations fall into two groups- passive (sometimes called 'compact') and active (sometimes called 'pumped') systems. Both typically include an auxiliary energy source (electric heating element or connection to a gas or fuel oil central heating system) that is activated when the water in the tank falls below a minimum temperature setting such as 55°C.

Hence, hot water is always available. The combination of solar water heating and using the back-up heat from a wood stove chimney to heat water can enable a hot water system to work all year round in cooler climates, without the supplemental heat requirement of a solar water heating system being met with fossil fuels or electricity.

When a solar water heating and hot-water central heating system are used in conjunction, solar heat will either be concentrated in a pre-heating tank that feeds into the tank heated by the central heating, or the solar heat exchanger will replace the lower heating element and the upper element will remain in place to provide for any heating that solar cannot provide. However, the primary need for central heating is at night and in winter when solar gain is lower.

Therefore, solar water heating for washing and bathing is often a better application than central heating because supply and demand are better matched. In many climates, a solar hot water system can provide up to 85% of domestic hot water energy. This can include domestic non-electric concentrating solar thermal systems.

This picture shows the 80-gallon storage tank on the left and the natural-gas fired conventional water heater with the add-on insulation blanket on the right.

For the summer months that can be satisfied with solar hot water alone, you can install a "bypass valve assembly" between the solar storage tank and the backup water heater. The solar bypass consists of three valves (or two 3-way valves), which will allow the house to be supplied with solar heated water directly. A tempering valve should be added when solar heated water is hotter than normally produced by thermostatically controlled conventional tank. The tempering valve is installed on the hot water line feeding the home. The desired maximum temperature of the water delivered to the tap can be adjusted. Hot water enters one side, cold water, if necessary, enters from the bottom and mixed water goes out to the home's hot water plumbing.

3.2 Solar Thermal Collector

3.2.1- Types of Solar Collectors:

A solar collector is a device that collects and/or concentrates solar radiation from the Sun. These devices are primarily used for active solar heating and allow for the heating of water for personal use. These collectors are generally mounted on the roof and must be very strong as they are exposed to a variety of different weather conditions.

Do you know?

Solar energy strikes the Earth's surface about 1,000 watts per square meter.

The use of these solar collectors provides an alternative for traditional domestic water heating using a water heater, potentially reducing energy costs over time. As well as in domestic settings, a large number of these collectors can be combined in an array and used to generate electricity in solar thermal power plants. The term solar collector is applied to solar hot water panels, but may also be used to denote more complex installations such as solar parabolic, solar trough and solar towers or simpler installations such as solar air heat.

The more complex collectors are generally used in solar power plants where solar heat is used to generate electricity by heating water to produce steam which drives a turbine connected to an electrical generator. The simpler collectors are typically used for supplemental space heating in residential and commercial buildings. A collector is a device for converting the energy in solar radiation into a more usable or storable form.

The energy in sunlight is in the form of electromagnetic radiation from the infrared (long) to the ultraviolet (short) wavelengths. The solar energy striking the Earth's surface depends on weather conditions, as well as location and orientation of the surface, but overall, it averages about 1,000 watts per square meter under clear skies with the surface directly perpendicular to the sun's rays.

Types of Solar Collectors:

There are many different types of solar collectors, but all of them are constructed with the same basic premise in mind. In general, there is some material that is used to collect and focus energy from the Sun and use it to heat water. The simplest of these devices uses a black material surrounding pipes that water flows through. The black material absorbs the solar radiation very well, and as the material heats up the water it surrounds. This is a very simple design, but collectors can get very complex. Absorber plates can be used if a high temperature increase isn't necessary, but generally devices that use reflective materials to focus sunlight result in a greater temperature increase.

Since solar energy is widely spread, there is a need to make it available in concentrated form for which solar collectors are required. A solar collector absorbs the incident solar radiation and converts it into useful heat energy which is used for heating a collector fluid such as water, oil or air. The surface of a solar collector is designed for high absorption and low emission. Solar collectors are of two types:

1. Non-concentrating and
2. Concentrating.

1- Non-Concentrating Type Solar Collectors:

In the non-concentrating type, the collector area (i.e., the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs the light.

Flat plate and evacuated tube solar collectors are used to collect heat for space heating or domestic hot water.

Flat plate collectors are used where temperatures below 100°C are required. These collectors could be of liquid heating or air heating types. The liquid heating collectors are often used for heating water whereas air heating collectors are used for drying of agricultural products, heating of green-houses etc.

Do you know?

Flat plate collectors are used where temperature below 100ºC is required.

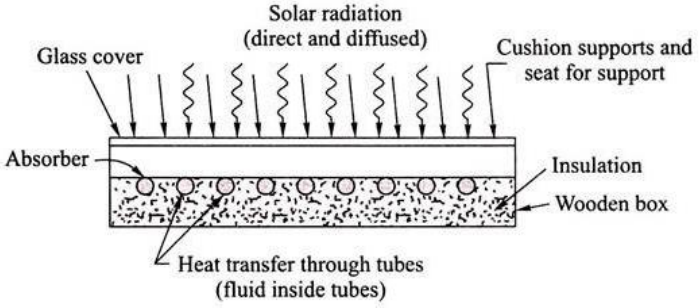
a. Flat Plate Collector

Flat plate collectors, developed by Hottel and Whillier in the 1950s, are the most common type. They Consist of:

i. A dark flat-plate absorber of solar energy,
ii. A transparent cover that allows solar energy to pass through but reduces heat losses,
iii. A heat-transport fluid (air, antifreeze or water) to remove heat from the absorber, and
iv. A heat insulating backing.

Flat plate collectors are non-concentrating-type collectors, which are convenient and effective, when temperature below 90°C is adequate for room heating or water heating.

They are made in rectangular panels of about 1.7- 2.9 m^2 area and relatively simple in construction and easy to install. Flat plate collectors absorb both direct and diffused solar radiations. They are effective even on cloudy days when there is no direct radiation. In a flat plate collector, a blackened sheet of metal is used to absorb all sunlight.

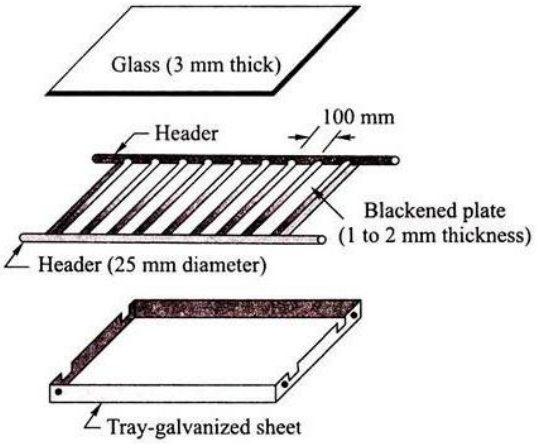


Flat plate collector

The metal sheet painted in black acts as a black body; the heat absorbed from the sunlight is transferred to another fluid such as air, water, etc. The metal sheet which acts as black body absorption plate should be in good thermal contact with the tubes holding water or any other fluid.

The thermal contact between the tubes and the plate is ensured by bonding tubes to the bottom of absorber plate as shown in Figure below. The bonding can be done by soldering or brazing by brass with thermal plate. Figure shows the complete assembly of a solar plate collector.

The heat received is transferred continuously to the fluid. The fluid becomes heated at some elevated temperature. In a flat plate collector, the conduction and convection losses can be reduced by placing the blackened sheet of metal in a closed insulated box having its top covered by a transparent glass sheet to allow solar radiations and get entrapped. The collector box supports all the components and provides weather protection. An exploded view of collector assembly is given in Figure below.



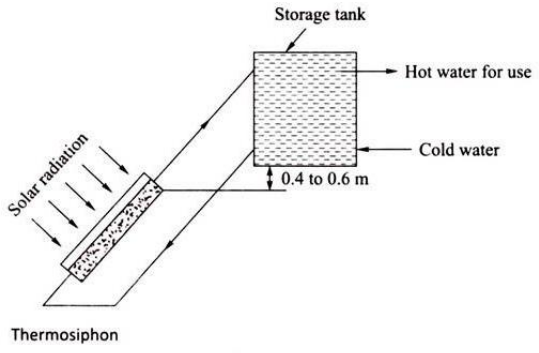
Components of a collector assembly

The glass sheet on top allows the transmission

of short wavelength radiations through it while blocking the long wave length radiations from the surface of blackened sheet.

Flat plate collectors are used for wide range of low-temperature applications such as cooking of food, water heating, room heating, grain drying, etc.

A conventional solar system involves solar collectors and separate thermal storage. Energy is transported from collectors to storage and subsequently from storage to the utilization unit and control device. The flow of energy is regulated by the systems incorporated in the unit. These are controlled by using pumps and/or blower to transport heat.



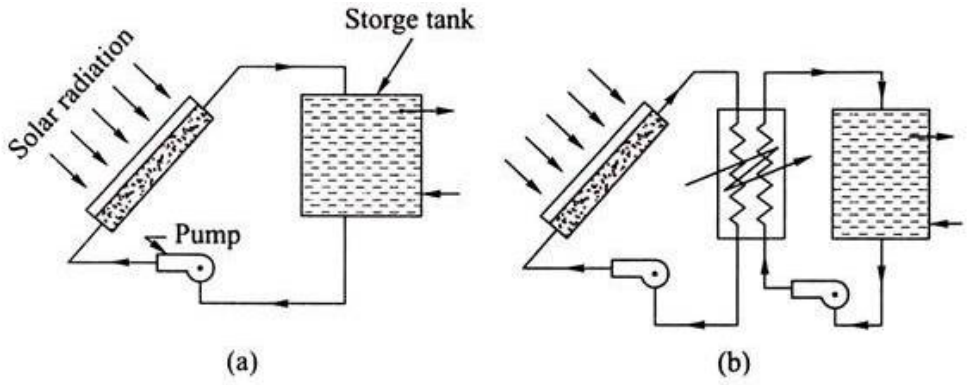
The heat transfer from collector plate to storage unit may be achieved by natural convection or thermo-siphon methods as shown in Figure.

Alternatively, it may be accomplished by the forced flow of fluid using an electrically operated pump as shown in Figures.

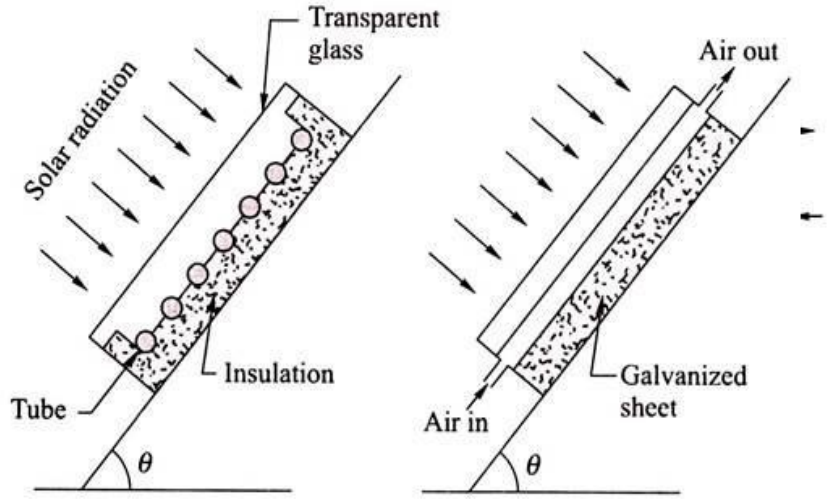
(a) Direct heating of storage tank [Figure (a)] and

(b) Indirect heating of storage tank [Figure (b)].

Figure (a) below shows the arrangement of a flat plate collector utilizing solar radiation for heating water/liquid flowing through the tubes. The tubes are brazed with the metal plate surface forming heat-absorbing surface. Similarly, Figure (b) shows the placement of collector for heating the air passing through the passage.

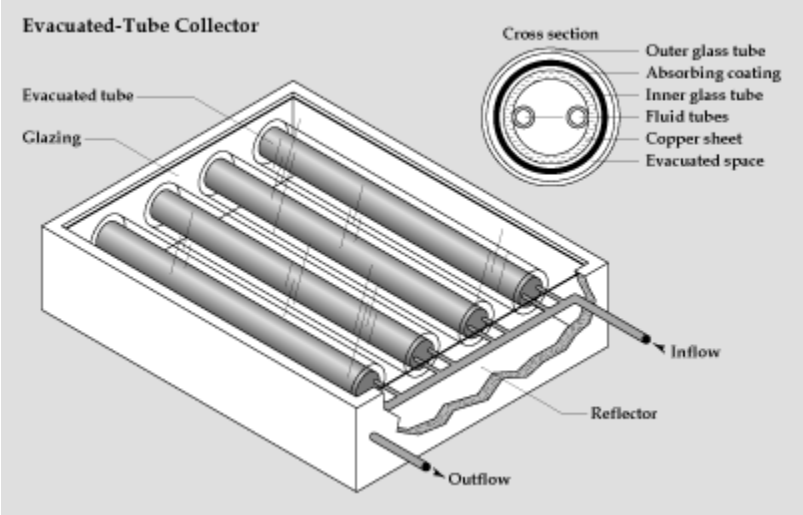


Forced circulation: (a) direct heating and (b) indirect heating



(a) Liquid heating and (b) air heating

b. Evacuated Tube Collectors



Evacuated tube solar collector

This type of solar collector uses a series of evacuated tubes to heat water for use. These tubes utilize a vacuum, or evacuated space, to capture the suns energy while minimizing the loss of heat to the surroundings. They have an inner metal tube which acts as the absorber plate, which is connected to a heat pipe to carry the heat collected from the Sun to the water. This heat pipe is essentially a pipe where the fluid contents are under a very particular pressure. At this pressure, the "hot" end of the pipe has boiling liquid in it while the "cold" end has condensing vapours. This allows for thermal energy to move more efficiently from one end of the pipe to the other. Once the heat from the Sun moves from the hot end of the heat pipe to the condensing end, the thermal energy is transported into the water being heated for use.

The heat from the hot end of the heat pipes is transferred to the transfer fluid (water or an antifreeze mix—typically propylene glycol) of a domestic hot water.

The vacuum that surrounds the outside of the tube greatly reduces convection and conduction heat loss to the outside, therefore achieving greater efficiency than flat-plate collectors, especially in colder conditions.

This advantage is largely lost in warmer climates, except in those cases where very hot water is desirable, for example commercial process water. The high temperatures that can occur may require special system design to avoid or mitigate overheating conditions.

2- Concentrating type Solar Collectors

Concentrating collectors use optical systems in the form of reflectors or refractor to concentrate the energy of solar direct radiation on the absorbing surface. The reflectors may be flat mirrors or in the shape of a parabolic trough or paraboloidal dish.

In spite of the methods of reducing heat losses, the maximum temperature at which a flat plate collector operates is quite low, about 100°C in summer and 40°C in winter. So, for higher temperature focusing or concentrating collectors are used. Such collectors are more effective but very costly.

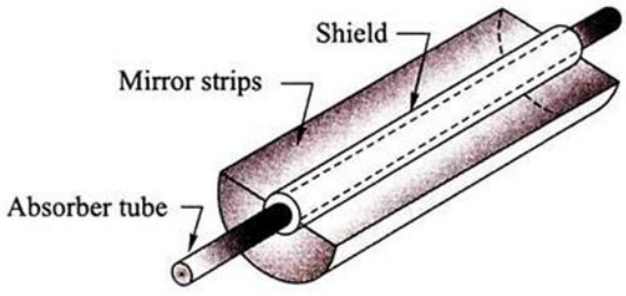
In focusing collectors, a parabolic or a Fresnel mirror is used. Sun rays are focused on the focal point of the mirror by reflection from its surface. A tube may be placed along the focal line of the mirror and a fluid circulated through it to absorb the heat. With these collectors, temperatures of 200- 300°C or above may be obtained. Some mechanism should be provided to track the sun seasonally.

The focusing collectors can have two arrangements:

a. Line Focus Collectors

These collectors, sometimes known as parabolic troughs, use highly reflective materials to collect and concentrate the heat energy from solar radiation. These collectors are composed of parabolic shaped reflective sections connected into a long trough.

A pipe that carries water is placed in the centre of this trough so that sunlight collected by the reflective material is focused onto the pipe, heating the contents. These are very high-powered collectors and are thus generally used to generate steam for solar thermal power plants and are not used in residential applications. These troughs can be

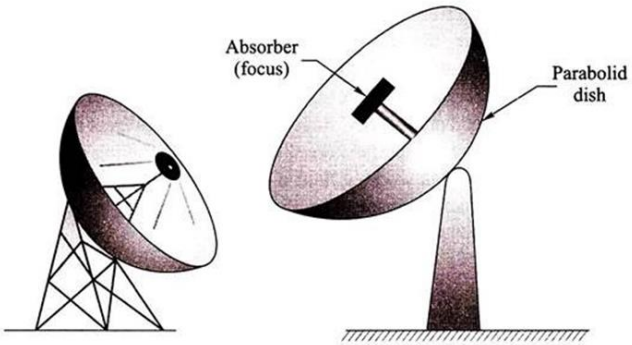


Cylindrical parabolic solar collector

extremely effective in generating heat from the Sun, particularly those that can pivot, tracking the Sun in the sky to ensure maximum sunlight collection.

b. Point Focus Collectors

These collectors are large parabolic dishes composed of some reflective material that focus the Sun's energy onto a single point. The heat from these collectors is generally used for driving Sterling engines. Although very effective at collecting sunlight, they must actively track the Sun across the sky to be of any value. These dishes can work alone or be combined into an array to gather even more energy from the Sun.



Point-focus solar collector paraboloid

Point focus collectors and similar apparatuses can also be utilized to concentrate solar energy for use with concentrated photovoltaic. In this case, instead of producing heat, the Sun's energy is converted directly into electricity with high efficiency photovoltaic cells designed specifically to harness concentrated solar energy.

Practical

Activity-3.3 Identification of different types of collectors

The teacher/ instructor is required to plan mock exercise on safety and health rules in case of fire, wearing of PPEs, report general provisions for health and safety in the campus.

Activity-3.4 Group discussion on functions of collectors

The teacher/ instructor is required to involve the students in discussion about different parts of solar water heating and their functions.

3.2.2- Frame and Storage Tank of Hot Water

A storage tank for storing hot water is an important part of solar water heating system. This tank is made with 0.5 to 0.8 mm thick stain less steel sheet. This thickness of steel sheet is only suitable for non-pressurized system. In case of pressurized system, a steel sheet of 3 mm thickness is used. Even this tank should not be given a pressure of 6 bar. To keep the water hot, tank is insulated externally which keep the water hot for 36 hours. Even then water reduces its temperature up to 6 to 8^{o}C in every 12 hours.

Frame is an important part of solar water heating system. During the installation of system, flat plates can be fitted at different angles. This frame is made up of 20 to22 gauge of metal sheet. Fitting of geezer is adjustable, which can be tightened with the help of nut and bolts. All the nut bolts are made of steel to prevent them from corrosion. A powder coating is also done on frame to prevent it from corrosion.

3.2.3- Storage and Expansion Vessel:

Storage vessel is a container in which more pressurized liquid is kept.

To control the thermal expansion in closed loop system or in case of not opening the safety valves, expansion vessel is very much important. Otherwise, pipe line can be damaged.

What I have learnt

- Solar water-heating systems use heat exchangers to transfer solar energy absorbed in solar collectors to the liquid or air used to heat water or a space.
- A single-wall heat exchanger is a pipe or tube surrounded by a fluid. Either the fluid passing through the tubing or the fluid surrounding the tubing can be the heat-transfer fluid, while the other fluid is the potable water.
- Double-wall heat exchangers have two walls between the two fluids. Two walls are often used when the heat-transfer fluid is toxic, such as ethylene glycol.
- Heat-transfer fluids carry heat through solar collectors and a heat exchanger to the heat storage tanks in solar water heating systems.
- In cold climates, solar water heating systems require fluids with low freezing points and Fluids exposed to high temperatures, as in a desert climate, should have a high boiling point.
- Static head is pressure resulting from the vertical height and corresponding weight of the column of fluid in a system where as dynamic head includes the frictional resistance of the fluid flowing through the pipe and fittings in the system.
- Centrifugal-type circulating pumps are most commonly used in solar water-heating systems. For closed loop systems lower cost, cast iron circulating pumps are adequate and for open-loop systems, circulating a replenishing supply of water, a bronze circulating pump is necessary.
- The differential controller via sensors connected to the collector and the storage tank, determines whether the collector outlet is sufficiently warmer than the bottom of the tank to turn the circulating pump on
- A check valve permits fluid to flow in one direction only. It prevents heat loss at night by convective flow from the warm storage tank to the cool collectors.
- An expansion tank allows the fluid in a closed-loop system to expand and contract depending on the temperature of the fluid.
- A pressure relief valve of 50 psi is usually adequate to protect closed-loop plumbing systems from excessive pressures.
- A pressure gauge is used as a diagnostic tool to monitor the state of the glycol charge.
- A solar collector is a device that collects and/or concentrates solar radiation from the Sun.
- The solar energy strikes the Earth's surface about 1,000 watts per square meter under clear skies with the surface directly perpendicular to the sun's rays.
- Solar collectors are of two types: non-concentrating and concentrating.
- In the non-concentrating type, the collector area (i.e., the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs the light.
- Flat plate collector consists of:
    i. A dark flat-plate absorber of solar energy,

ii. A transparent cover that allows solar energy to pass through but reduces heat losses,
iii. A heat-transport fluid (air, antifreeze or water) to remove heat from the absorber, and
iv. A heat insulating backing.

- Evacuated type of solar collector uses a series of evacuated tubes to heat water for use. These tubes utilize a vacuum, or evacuated space, to capture the suns energy while minimizing the loss of heat to the surroundings.

EXERCISE

Q-1. Tick (✓) the correct option for the following MCQs.

i- A solar collector is a system which collects:
(A) Heat by absorbing sunlight (B) Rainwater using sunlight
(C) Electricity by using sunlight (D) All of these

ii- Aperture area of a solar collector is roughly equal to _____
(A) Coolant area (B) Generator area
(C) Absorber area (D) System area

iii- It is the components of a flat plate collector?
(A) Flat Box (B) Transparent cover
(C) A circulating fluid (D) All of these

iv- Evacuated flat-plate solar collectors are a type of _____
(A) Concentrating collectors (B) Non-concentrating collectors
(C) Photovoltaic technology (D) Solar stills

v- An indirect solar water heating system transfer heat from the transfer fluid to the potable water by using.
(A) Electrical heater (B) Circulating potable water through collector
(C) Heat exchanger (D) Directly exposing the substance to sunlight

vi- How is water heated in a direct solar water heating system?
(A) Electrical heater (B) Circulating potable water through collector
(C) Heat exchanger (D) Directly exposing the substance to sunlight

vii- Which of the following are used as absorbers in evacuated-tube solar collectors?
(A) Carbon tubes (B) Wooden or metallic tubes
(C) Plastic or glass tubes (D) Metallic or glass tubes

viii- Which of the following is a problem with evacuated tubes?

(A) Under heating (B) Poor absorption of sunlight
(C) Over heating (D) Poor reception of sunlight

ix- _____ lose more heat to the environment than evacuated-tube solar collectors.

(A) Photovoltaic (B) Solar air conditioners
(C) Solar stills (D) Flat-plate collectors

x- Which of the following provides highest energy conversion efficiency in non-concentrating solar collectors?

(A) Flat plate collectors (B) Evacuated flat plate collectors
(C) Evacuated-tube collectors (D) Parabolic collectors

Give short answer to the following questions.

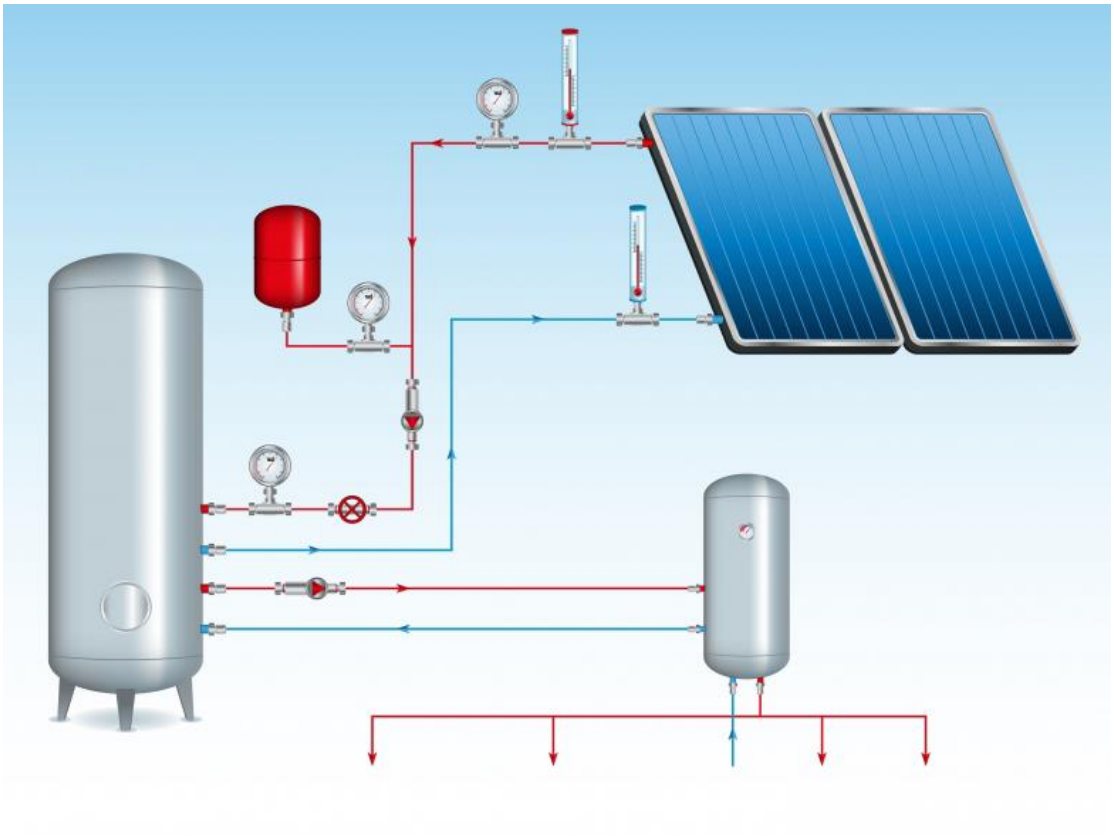
i- What is the function of heat exchanger?
ii- Differentiate between single walled and double walled heat exchanger.
iii- What is heat transfer fluid?
iv- Enlist different types of heat transfer fluids.
v- Differentiate between static and dynamic head.
vi- Why circulating pumps are used in SWH system?
vii- What is the main function of expansion tank in closed loop system?
viii- Why should a check valve be installed on a solar water-heating system?

Answer the following questions in detail.

i- Enlist the parts of SWH system. Explain any two of them.
ii- What type of sensors and controllers are used in SWH system?
iii- Write down a detailed note on flat plate solar collector.

CHAPTER -04

PLANNING FOR SOLAR WATER HEATING SYSTEM



After studying this unit, you will be able to:

- estimate the requirement of water.
- factors affecting efficiency of system.
- differentiate between domestic and commercial use.
- set the flow and exit of water.

4.1 Estimation of water Quantity

4.1.1- Estimate the requirements of water

Before you buy and install a solar water heating system, you need to first consider the characteristics of your site: available roof or land area, the solar resource, shading by trees or buildings, as well as the optimal orientation and tilt of your solar collector. The efficiency and design of a solar water heating system depends on how much of the sun's energy reaches your building site.

Solar water heating systems use both direct and diffuse solar radiation. Even if you don't live in a climate that's warm and sunny most of the time your site still might have an adequate solar resource. If your building site has un-shaded areas that generally face toward the equator it's a good candidate for solar water heating system. Your local solar system supplier or installer can perform a solar site analysis.

1- Customer site visit

Collating customer information is an important step in designing a SWH system. Time should be taken to conduct a detailed site survey as it can help make informed choices about the size, type, location and orientation of the SWH system.

The site survey should reveal at least the following:

- Number of residents, any special hot water needs
- Condition, slope and type of roof. Any shading issues and best direction for solar.
- Information on the existing plumbing and hot water tank, if any.
- Information on the local water pressure and quality and whether the residence has an elevated storage tank for mains water and/or a pressure pump.

Once the above has been completed by the system designer, it allows the designer to select which type of system is required: active or passive and whether a direct or indirect water heating system is best. Before selecting a system, it is necessary to consider a few key design points.

Some important considerations

A passive SWH system with direct water heating and tank connected to the collector to form a thermo-syphon loop is by far the most common and practical choice for residential applications. However, other considerations when selecting the type of system include:

- Is the roof strong enough to hold the weight of a water tank?
- If not, where is the most suitable place on the ground for a tank, given that the existing hot and cold-water plumbing must be connected?
- Is there a section of the roof that is positioned to make it possible for the collectors to have a suitable orientation to the sun?
- Are there nearby shading considerations that may require extra collectors to be used?

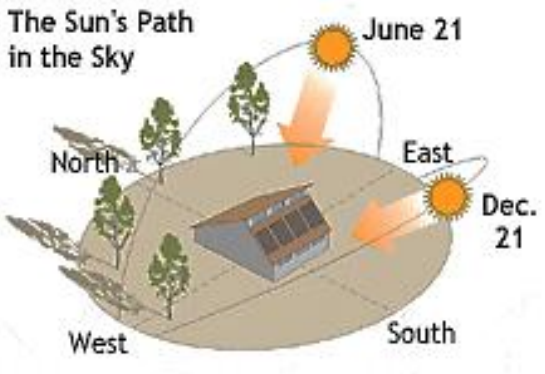
- Is the roof tilt suitable or will a tilted mounting frame be being required? (Minimum is 15° for a flat plate and 20° for evacuated tube collectors in a Passive (thermo-siphon) SWH).
- If not, consider a batch water system which does not require a minimum tilt; the batch water system contains a tilted black tank in an insulated box lined with reflective foil.
- Is there an existing tank that is old and needing replacement?
- If the tank is in a good condition, is it suitable for a solar retrofit to be considered?
- If the existing tank is suitable, are there extra hot water demands that requires that a larger system (and hence tank) should be installed?
- Does the quality of the local mains water (clean, suspended dirt, high mineral content, etc.) affect the choice of tank and collector material or would a propylene glycol based indirect heating system be more suitable?
- For commercial installations: where is the best location for tank(s) and collectors given the higher volumes of hot water required.
- Wind loading issues: these are very important to consider for the safe operation of the SWH system particularly in locations where cyclones/typhoons are likely. Solar water heaters high up on the roof can act as a wind sail and can potentially damage the roof. So, an edge zone of a 500 mm minimum should be maintained when installing the collectors on the roof. If the installation is in a very windy area (top of a hill) or subject to cyclones/typhoons, a structural engineering calculation should be undertaken. (At the very minimum, follow the manufacturer's instructions for high wind locations).

Do you know?

Minimum roof tilt is 15° for a flat plate and 20° for evacuated tube collectors in a Passive (thermo-siphon) SWH

2- Siting the Collectors and Determining Collector Tilt and Orientation

Knowing the site-specific solar resource is important in designing SWH systems. Site-specific solar resource data may be obtained from in-country meteorological departments. Sometimes the solar radiation data also provides adjusted values for different collector orientations. This is valuable information for estimating the yield for SWH systems where the collectors are installed on a specific slope, or for finding the optimal angle to position collectors at a certain time of the year. Knowing how much solar energy is received on an area enables a solar water heating system to be sized to either displace a set amount of energy, or to heat a predetermined amount of water. Solar collectors

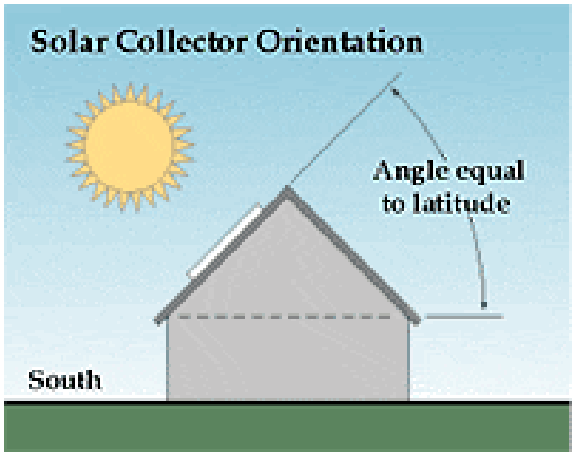


should be positioned to face the Sun over the course of each day to maximize the use of the available solar resource. Specific site constraints will affect the amount of solar resource that can be collected.

The placement, orientation and inclination of the solar collectors at a site will be affected by:

i. Roof pitch and collector tilt angle

Solar collectors are best oriented such that the collector is perpendicular to the incoming sunlight. The altitude of the sun changes throughout the year and the altitude of the sun at any time on any given day can be calculated based on the latitude of the installation site. This means that solar collectors generally have the best annual output if they are placed at the same tilt angle as the latitude angle of the site and are oriented to face that tilt toward the equator. However, for aesthetic reasons and for ease of installation, the collectors are often installed flush/parallel to the roof as long as the roof tilt meets the minimum tilt angle required for the type of collector that is installed. Fortunately, for sites in the tropical islands, the reduction of solar input when not received at optimum tilt and orientation is not great and can be easily overcome by the use of a slightly larger collector area than would be needed if the orientation and tilt were optimal. Manufacturers will specify the range of tilt angles and orientations that are acceptable for the solar collectors, based on where they are installed. Typical specification is within ± 20° from latitude angle and within ± 45° from the direction facing the equator although in general they should not have a tilt less than 10° so rain will run off fast enough to keep the glazing clean. Note for sites with latitudes between 0° and 10° the collectors can face either north or south. The manufacturer will also require a minimum tilt angle for thermo-siphon SWH systems. This requirement must be adhered to in order for the system to function. Typically, this is 20° for evacuated tube heat pipe systems and 15° for passive flat plate thermo-siphon systems. Greater tilts may provide higher efficiency, particularly for evacuated heat pipe systems. The collector angle and orientation to be used is required in order to determine the amount of solar radiation received by the collectors at the installation site when installed in the proposed plane.



ii. Available installation space

The dimensions of unobstructed roof space that is facing within 45° east and west of the direction of the equator should be determined. The location of obstructions such as roof ventilation shafts, chimneys, etc. should also be noted, as well as any other areas that must be

avoided. When calculating the amount of available roof space, remember that a minimum edge zone of 500 mm should be kept clear when installing the collectors on the roof.

Do vou know?

when installing the collectors on the roof, keep clear a minimum edge zone of 500 mm

iii. Local shading

Solar collectors should be installed in a position that is shade-free for at least three hours both sides of solar noon, i.e. from around 9am to 3pm. This is the time of the day when the Sun is highest in the sky, throughout the year. This makes it possible to obtain the maximum production from the SWH system. Check for potential shading objects such as trees, other buildings, and boundary walls. The effectiveness of the collectors is greatly reduced when they are shaded.

iv. Determining Hot Water Requirements

The daily hot water requirement is a key parameter for system sizing. The best way to obtain this data is to install an inline water meter that logs the water usage for weeks or months. However, due to the time it takes to gather the data and the additional cost involved, this is not always practical. The average of 40-50 litres per person per day can be used as a rule of thumb. Actual hot water requirements may differ from these figures and should be confirmed with the customer.

Do you know?

The average hot water requirement of 40-50 litres per person per day can be used as a rule of thumb

Worked Example 1:

A family of 4 people lives in a house that has 3 bedrooms. Let's estimate the hot water demand per day for this family:

Step 1: Identify the building type. In this example it's a domestic residential house, so the daily hot water demand is assumed to be 40 L per person.

Step 2: Specify the number of persons. In this case it is 4

Step 3: Multiply values from step 1 and 2: 40 L (10.6 gal) of water per person x 4 persons = 160 L (42.4 gal) per day

v. Selecting the Tank and Determining the Collector Size

When selecting the storage tank for a solar water heating system, the designer needs to consider the tank material as well as the holding capacity of the storage tank. The tank material selected will be based partly on the water quality at the site and partly on customer budget.

Once the hot water requirement has been estimated, calculations are required to determine the size of the collectors and the tank, so that enough water will be heated and stored. The processes involved include:

- Calculating the required tank capacity in relation to the daily hot water demand.
- Matching the collector size to the storage tank size to meet the hot water requirements.
- Understanding that the collector size may have to be increased if a non-ideal location or shading exists.
- Assessing whether retrofitting SWH to an existing hot water tank is practical or whether a new tank must be installed.

vi. Estimating the Tank Capacity

For Solar Water Heating System, the storage water tank for solar water heating systems needs to be sized to cater for the hot water needs of the customer. As a general rule of thumb, size the storage tank to equal 1.5 times the daily hot water requirement of the building in Litres/Gallons per day. Then round that up to the nearest equal or larger tank size.

Worked Example 2:

A family of 4 people lives in a house which has 3 bedrooms. Estimate the capacity of the hot water storage tank (for one day).

Step 1: Use the rule of thumb of sizing 1.5 times the daily hot water storage demand to get the tank size. In worked example 1, the daily hot water requirement is 160 L per day. So, the tank capacity should be, = 160 x 1.5 = 240 L (63.4 gal)

Step 2: Rounding up the obtained value to a commonly available sized tank. We round the value obtained in Step 1 to 300L (80 gal) as this is a commonly available size. Some typical tank sizes available are 180L (50 gal), 300L (80 gal), 330L (90 gal), 440L (116 gal), 480L (130 gal), etc., however these sizes may vary from one manufacturer to another.

vii. Estimating the Collector Size for a Solar Water Heating system

Solar Collectors are the most important part of the SWH system as they capture the sun's energy and heat the water. The collectors heat the required daily volume of hot water during the sunlight hours and then store this in the well-insulated hot water storage tank. For an initial estimate of the size of the collectors, a simple rule of thumb is:

- 1 m² (10.8 ft^2) flat plate collector per 80 L (21.2 gal) of tank capacity or
- 10 evacuated tubes per 100 L (26.4 gal) of tank capacity.

Worked Example 3:

A family of 4 people lives in a house which has 3 bedrooms. Estimate the size of collector for daily hot water need for both flat and evacuated tube type solar collectors.

For Flat plate collectors:

Step 1: Use the tank value calculated in worked example 3 and utilizes the rule of thumb to obtain the area of the flat plate collectors. The tank size recommended was 300 L (80 gal) per day. So, the collector size would be, = 300 ÷ 80 = 3.75 m^2 (40.4 ft^2)

Step 2: Rounding up the obtained value to a commonly available size We round the value obtained in Step 1 to 4m^2 (43 ft^2) as 2m^2 (21.5 ft^2) collectors are commonly available. Therefore 2 x 2m^2 collectors can be used to satisfy this requirement.

For Evacuated tube collectors

Step 1: Use the tank value calculated in worked example 2 and utilizes the rule of thumb to obtain the area of the flat plate collectors. The tank size recommended was 300 L (80 gal) per day. So, the collector size should be, = (300 ÷ 100) x 10 = 30 tubes

Do you know?

For an initial estimate of the size of the collectors, a simple rule of thumb is10 evacuated tubes per 100 L (26.4 gal) of tank capacity

viii. Provision For Collector Size In A Non-Ideal Location Or If Shading Exists

The above sizing for collector and tank assumes that the solar collectors are facing the equator and are at an optimum tilt angle. However, in a real scenario, this probably will not be the case and there also may be some shading so that there is less than optimal exposure to sunlight. The best practices for sizing, as mentioned previously will likely change if:

- Roof does not face within 25° of the equator.
- Roof tilt angle is greater than 20°.
- Shading from surrounding trees or buildings is present.
- Locations have substantially more or less solar peak sun hours than assumed.

  For instance, on a roof tilted at 30° and facing west, or experiencing shading for half the day, it would be best practice to reassess the available solar resource and add extra collectors on the roof to compensate for the loss in the heat energy due to sub-optimal tilt/orientation.

ix. Finalizing Sizing and Selection

Based on tank size, collector size and type of system appropriate, a selection can be made from the range of system sizes and types available from manufacturers. Consideration should be given and the selection should be made based on efficiency, quality of products, reliability, warranty, etc. It is recommended that the customer/installer reviews and understands all specifications prior to the purchase and installation. A thorough market survey will help determine the higher quality and more reliable systems for installation.

Activity-2.1 Calculation of water requirements for different number of persons.

The teacher/ instructor is required to demonstrate the students about calculating the requirement of water for different number of persons.

4.1.2- Factors affecting efficiency of the system:

Solar power systems are considered a key tool in the energy supply for the present and future generations. Several factors have promoted the development of photovoltaic such as environmental concerns, incentives and tax deductions, a more performing and less expensive technology and the need to replace carbon fossil energy systems with renewables.

A solar cell or photovoltaic cell is a device that converts the sunlight into usable energy. The amount of sunlight that can be converted into electricity is referred to as solar cell efficiency. There are some factors that should be taken into consideration to guarantee the optimal efficiency of the solar panels.

i. **Temperature**

The temperature influences the efficiency of the photovoltaic cell due to the intrinsic characteristic of the semiconductor material. The efficiency of the solar panels increases when the temperature drops and decreases in high temperatures, as the voltage between the cells drops.

ii. **Solar Shadings**

Solar PV panels are very sensitive to solar shadings. Total or partial shading conditions have a significant impact rate on the capability of delivering energy and may result in lower output and power losses. Cells in a solar panel are usually connected in series to get a higher voltage and therefore an appropriate production of electricity.

But when shading occurs, this structure presents some limitations. In fact, when a single solar cell is shaded, the current of all the units in the string is determined by the unit that produces the least current. When a cell is shaded, the whole series is virtually shaded too. To prevent the loss of energy, the installation usually includes bypass diodes.

Bypass diodes are wired in parallel to the solar cells. When a solar cell is shaded, the bypass diode provides a current path that allows the string of connected solar cells to generate energy at a reduced voltage.

iii. **Orientation, Inclination, Latitude of the place and Climatic conditions**

The installation of the photovoltaic modules must take into account some factors to take full advantage of solar radiation: the orientation, the inclination, the latitude of the place, the climatic conditions. The correct consideration of these variants will help ensure that they produce maximum energy by being exposed to the greatest intensity of solar radiation for the longest period of time.

iv. **Operation and Monitoring**

O&M services help with the management of the implementation of certain processes to avoid or mitigate potential hazards and to guarantee the optimal return on investment.

Operations mainly consist of the remote monitoring and control of the PV conditions and performance. Monitoring software provides access to all data collected, which can be used for different purposes: defect detection, performance analysis, improvement, predictive maintenance, and security. A good monitoring system will provide information on the production, alarms, and analytical data, in a timely, efficient, and precise manner to detect any anomaly of the PV plant.

v. Maintenance/Cleanliness of Solar Panel Surface

Solar panels are very durable, main warranties last for 15-25 years. However, cleaning solar panels is important to maximize the amount of light available to turn into electrical power.

The cleanliness of the solar panel surface is directly connected to photoelectric power conversion. Due to polluted environment, rainfall, snow, dust, sandstorms are few factors can play a role in reducing the efficiency of solar module hence ensure cleaning frequency of the solar panels according to the local labour cost.

In most places, there`s more pollution in the winter; hence spring is the best time to do an annual cleaning. While once solar panels are cleaned once or twice a year, they will produce 3.5% and 5.1% more electricity compared to un-cleaned.

Activity-2.2 Discussion on factors affecting efficiency of system.

The teacher/ instructor is required the students to discuss the factors affecting efficiency of system..

4.2 Calculation of Thermal Requirements

4.2.1 Difference between Domestic and Commercial Use:

Commercial solar water heaters are used in factories and commercial buildings whereas domestic water heaters are used in homes for small scale water requirements.

Domestic water heating system is called thermo-syphon system. For the commercial and industrial needs forced circular systems are installed which provide more water.

There are several differences between residential and commercial solar panels that help to make understanding of the systems when one thinks to choose renewable

Commercial Solar Water Heater

energy for his home or business. These differences in solar energy systems determine the nature of commercial and residential solar panels in terms of purpose, efficiency, size, location, installation, and color.

Domestic Solar Water Heater

i. **Purpose:**

For domestic usage less quantity of water is required as compared to commercial usage where more water is required. Therefore, installation of solar water heater is done keeping in mind its usage for domestic or commercial purpose. One purpose of installation of solar water heating system is to make use of energy without any additional expenses.

ii. **Size:**

A large size of solar water heater is used for commercial solar water heating system whereas for domestic purpose a small size solar water heater is used. For installation of solar water heater in any building its size is selected according to need and drawing.

Size is the most important distinction that comes first when it comes to the difference between a commercial solar panel and a domestic solar panel. Commercial solar panels are greater than residential solar panels. The average size of a commercial solar panel is 78 inches by 39 inches and 96 cells, whereas the residential solar panel is 65 inches by 39 inches and 72 cells in its size. Many residents are installing commercial-sized solar panels for their houses as those produce more power. For this reason, it is wise to consider commercial-sized solar power panels for your home.

iii. **Installation:**

Installation of both commercial and residential solar panel systems is done the same way as roof-mounted with a bolted racking system. The commercial solar panels are usually easy to install because they are fixed on a flat roof with a non-penetrating ballasted mounting system.

Commercial solar power systems can use a mounting system that doesn't enter the roof; hence it is much simpler to set up. Residential solar systems for homes require the panels to lay flush against the shingles, which needs a much slower and more careful process for

installation. When commercial systems take up to a month to complete its installation process, while residential solar panels generally take one or two days to install.

iv. **Production and Efficiency**

The commercial solar panels are capable of producing more power than the smaller residential panels because they incorporate more cells and consider themselves as bigger than residential panels. And when it comes to efficiency, commercial solar panel (19.6%) is more efficient than residential solar panel (18.1%). However, solar panels for both the systems is almost the same, for example, we calculate the price of 5kw solar panels by the power they produce for a residence the same cost as a commercial system charges.

v. **Colour or Shade:**

The commercial solar panel systems are available in white color, while residential systems offered either in black or white shade. White-colored solar panels are the most commonly used solar products for both residential and commercial applications. Residential customers usually want black-colored panels on a black backing, and commercial customers generally prefer to use black panels on white backing.

vi. **More Options for Commercial Solar Systems**

There are several options for businesses as they have to get off the grid when they start researching solar panel systems. Companies can install solar panel systems on their roofs (solar rooftop), but they can also expand more creatively, for example, solar-panelled parking lots are another choice, as are ground installations in the surrounding land. However, residential solar systems usually don't have more options like commercial systems because the home size and neighbourhood restrictions often make roof installation the only option.

Activity-2.3 Discussion about thermal requirements of domestic and commercial use.

The teacher/ instructor is required the students to have group discussion about thermal requirements of domestic and commercial use.

4.2.2- Set the flow and exit of water:

Water level means height of water or a place from where water is to be provided to the solar water heating system when necessary. Keeping in view the water supply system in Pakistan, if hot water line of solar water heating system is attached to the existing water lines, pressure and discharge will be reduced considerably.

In a two-storey building, water pressure is 0.8 bar directly 8 mm below overhead water tank. Flow of discharge is measured in litres per minute and discharge in hot water pipe in remote part of building should not be less than five litres per minute.

Different types of valves are used in solar water heating system like solar safety valve, diaphragm safety valve, mixing valve and expansion vessel etc. All these valves and safety instrument are used according to the necessity and are fitted as per drawing.

Every solar water heating system has a safety valve which releases increased pressure created due to rising temperature and saves the system.

Activity-2.4 Analysis of water discharge level for domestic and commercial WH system.

The teacher/ instructor is required to demonstrate the students about analysis of water discharge level for domestic and commercial water heating system.

What I have learnt

- The efficiency and design of a solar water heating system depends on how much of the sun's energy reaches your building site
- A passive SWH system with direct water heating and tank connected to the collector to form a thermo-syphon loop is the most common and practical choice for residential applications.
- Minimum roof tilt suitable for mounting frame is 15° for a flat plate and 20° for evacuated tube collectors in a Passive (thermo-siphon) SWH.
- Solar collectors should be positioned to face the Sun over the course of each day to maximize the use of the available solar resource.
- Solar collectors should be installed in a position that is shade-free for at least three hours both sides of solar noon, i.e. from around 9am to 3pm.
- Solar collectors generally have the best annual output if they are placed at the same tilt angle as the latitude angle of the site and are oriented to face that tilt toward the equator.
- When calculating the amount of available roof space, remember that a minimum edge zone of 500 mm should be kept clear when installing the collectors on the roof.
- The average daily hot water requirement of 40-50 litres per person per day can be used as a rule of thumb.
- As a general rule of thumb, size the storage tank to equal 1.5 times the daily hot water requirement of the building in Litres/Gallons per day.
- For an initial estimate of the size of the collectors, a simple rule of thumb is:

  i- 1 m^2 (10.8 ft^2) flat plate collector per 80 L (21.2 gal) of tank capacity or

  ii- 10 evacuated tubes per 100 L (26.4 gal) of tank capacity.

- A solar cell or photovoltaic cell is a device that converts the sunlight into usable energy.
- The amount of sunlight that can be converted into electricity is referred to as solar cell efficiency
- When a single solar cell is shaded, the current of all the units in the string is determined by the unit that produces the least current therefore when a cell is shaded; the whole series is virtually shaded too.
- To prevent the loss of energy, the installation usually includes bypass diodes.
- Bypass diodes are wired in parallel to the solar cells. When a solar cell is shaded, the bypass diode provides a current path that allows the string of connected solar cells to generate energy at a reduced voltage.
- The installation of the photovoltaic modules must take into account some factors to take full advantage of solar radiation: the orientation, the inclination, the latitude of the place, the climatic conditions.
- The average size of a commercial solar panel is 78 inches by 39 inches and 96 cells, whereas the residential solar panel is 65 inches by 39 inches and 72 cells in its size.
- In a two-storey building, water pressure is 0.8 bar directly 8 mm below overhead water tank.
- Flow of discharge is measured in litres per minute and discharge in hot water pipe in remote part of building should not be less than five litters per minute.

EXERCISE

Q-1. Tick (✓) the correct option for the following MCQs.

i- The site survey for SWH installations should reveal the following:

(A) Number of residents (B) Information on the existing plumbing

(C) Slope and type of roof (D) All of these

ii- Minimum roof tilt suitable for mounting frame for flat plate collector is:

(A) 25^o (B) 20^o

(C) 15^o (D) 10^o

iii- For drainage of rain water quickly to keep the glazing clean, minimum tilt should not be less than:

(A) 20^o (B) 15^o

(C) 10^o (D) 5^o

iv- When installing the collectors on the roof, a minimum edge zoon should be kept:

(A) 600mm (B) 500mm
(C) 400mm (D) 300mm

v. As a rule of thumb water requirement per person per day is assumed for SWH system design.
(A) 10-20 litres (B) 20-30 litres
(C) 30-40 litres (D) 40-50 litres

vi- As a rule of thumb, for 100 litres for tank capacity number of evacuated tubes required:
(A) 5 (B) 10
(C) 15 (D) 20

vii- Number of cells in an average size commercial solar panel are:
(A) 108 (B) 96
(C) 72 (D) 48

viii- In a two-storey building, water pressure directly 8 mm below overhead water tank is:
(A) 0.6 bar (B) 0.7 bar
(C) 0.8 bar (D) 0.9 bar

ix- Which of the following fire extinguisher is used for firefighting for paper and wood?
For 1 m^2 (10.8 ft^2) flat plate collector, tank capacity require is:
(A) 90 litres (B) 85 litres
(C) 80 litres (D) 75 litres

x- The installation of the photovoltaic modules must take into account the following factors to take full advantage of solar radiation:
(A) Orientation (B) Latitude of the place
(C) Inclination (D) All of these

Give short answer to the following questions.

i- Which system is mostly used for SWH and why?
ii- What is the minimum tilt for mounting frame of collectors?
iii- What is edge zone?
iv- What should be minimum edge zoon on roof?
v- What is average daily hot water requirement?
vi- How size of tank is determined?
vii- How size of collector is determined?
viii- What factors should be considered during installation of the photovoltaic modules.

Answer the following questions in detail

i- What factors affect the placement, orientation and inclination of the solar collectors at a site?
ii- State the factors to be considered while selecting the type of system.
iii- Briefly explain the factors affecting efficiency of solar water heaters.

CHAPTER -05

INSTALLATION AND COMMISSIONING OF SOLAR WATER HEATING SYSTEM

After studying this unit, you will be able to:

- estimate materials required for plumbing works.
- estimate the materials required for solar system.
- state the tools required for installation.
- select place for installation of solar water heating system.
- state the stepwise procedure of water heating installing system.
- define auto controller.
- state the procedure of installing auto controller.
- state the instructions for first time running of solar water heating system.
- state the procedure of checking of solar water heating system.

5.1: Estimation Requirements

5.1.1- Estimate Materials required for Plumbing Works

Compact type evacuated tube collector (ETC) system does not require any piping between the collector and the hot water storage tank whereas flat plate collector (FPC) based direct system requires a flexible connection between the collector and the storage tank. Body separation type system (ETC and FPC both) require internal piping between the collector and the hot water storage tank. Since body separation type systems normally come with heat exchanger, piping needs to be insulated adequately to limit heat loss.

1- Materials for Cold water plumbing

i. PVC or GI pipe may be used up to the cold-water inlet of the system. Proper care should be taken so that there is no leakage at the joints. If GI pipe is used, the pipe should be painted externally to avoid galvanic corrosion.
ii. The connection of cold water supply to collectors should be either horizontal or continuously moving downwards to the collector.
iii. For thermo siphon system, height of the bottom of the cold water source (typically a storage tank) should be at least 7 feet or more, above the terrace level where solar water heating system shall be installed.
iv. Separate piping should be done from the cold water source (storage tank) to the hot water storage tank.
v. In the cold water line, a separate gate valve and a union have to be provided at a point near and below the solar hot water storage tank.
vi. Cold water air vent pipe is to be provided at the point from where the cold water pipe from the cold water source drops down.
vii. The top height of the air vent pipe provided at the drop down point should be at least 2 feet higher than the cold water source overflow outlet.
viii. If a separate cold water tank is provided for the solar water heater, the capacity of the cold water tank should be at least double the size of the solar water heating system.
ix. Cold water tank should be kept clean and covered.
x. It is recommended to use a non-return valve at the inlet of the cold water into the hot water storage tank.

2- Materials for Hot water plumbing

i. Hot water connection can be done with insulated GI or copper pipes. Special attention should be given to ensure that the plumbing does not get damaged due to thermal expansion and contraction
ii. Zigzag piping is likely to create air bubbles inside pipes, blocking the flow of water, resulting in system overheating and steam generation.
iii. The hot water pipe should be comparatively of smaller diameter and of shorter lengths. Smaller diameter and shorter lengths will reduce heat loss.
iv. Hot water air vent pipe should be at least 2 feet higher than the cold water air vent.

v. In the hot water delivery line, only one union has to be provided in the nearest point of the solar system.
vi. If the hot water line is taken via geyser, it should be connected to the outlet point of the geyser.

Keeping in view the above considerations, measure and calculate the lengths of pipes as well as all necessary installations.

Activity-5.1 Calculation of material required for plumbing woks of SWH system

The teacher/ instructor is required to demonstrate the students about calculating the materials required for plumbing works of SWH system.

5.1.2- Estimate Materials Required for Solar System

The main components of a Solar Water Heating (SWH) system are:

- Collectors (flat-plate type or evacuated-tube type).
- Mounting Structures for different types of surfaces (roofs, ground, etc.).
- Tanks (Stainless steel, Enamel lined, Galvanized iron) and Anodes.
- Backup water heater. (electric or LP Gas)
- Valve types (Non-return, Pressure Reducing, Isolation Gate, Thermo-siphon Restrictor, Temperature–pressure relief, Expansion Control, Thermostatic Mixing, Air bleed).
- Pipework and Insulation.
- Pumps and Controllers.

Activity-5.2 Calculation of material required for solar system of SWH system

The teacher/ instructor is required to demonstrate the students about calculating the material of solar system required for SWH system.

5.2: Tools, Equipment and Instruments for Installation

5.2.1- Tools required for Installation

Following tools are required for installation of solar water heater:

- Foam pads for roof installs
- Propane torch (for installs requiring brazing) & striker
- Flux & wire brushes
- Pipe reamer
- Voltage meter
- Solder box
- Paint brush
- Garden Hose

- Caulking gun
- Glycol pump w/ 5gl bucket
- Ladder(s) for roof installs
- Fall protection gear
- Tape measure
- String or chalk line
- Drill & screw gun w/ bits
- Wrenches in various sizes
- Channel Lock pliers
- Hammer
- Reciprocating saw w/ blades
- Cutter for PVC & copper pipe
- Pressure gauge
- Extension lead
- Flexible spanner

Personal protective equipment (PPE) is essential during every solar installation. Employers have to assess workplaces for hazards and make sure they provide workers with the necessary PPE for their safety. This can include:

- Hard hats
- Gloves
- Steel-toed shoes with rubber soles
- Eye protection, like glasses or goggles
- Vests
- Harnesses

Make sure employees know how to use the PPE, as well as how to maintain it so it is kept in safe and reliable condition. Workers should know the process to request replacement PPE if it's necessary.

Activity-5.3 identification and selection of tools and equipment for solar water heater installation

The teacher/ instructor is required to ask the students to identify and select the tools and equipment for solar water heater installation.

5.2.2- Selection of Place for Installation of Solar Water Heating System

Before the actual solar system installation can take place, a site survey must be done to answer questions such as:

- Can the roof support the dead load of the solar collectors and the live load of the installation crew?

- Is the roof properly oriented with enough un-shaded area and surface that does not need to be replaced in the near future?
- Can the roof work be done safely?
- Is there room in the building for the storage tank and associated hardware?
- Can the plumbing lines be installed between the storage tank and the collectors without a significant remodeling effort?

Solar water heaters can be installed easily in the houses which has concrete roofs. However in the houses which do not have concrete roofs following precautions should be kept in mind:

- Angle of solar heater plates should be 45^{o}
- During installation of solar heater on metal sheets, ensure that solar water heater is installed on beam of roof.
- In case of metal roof, it should be capable of supporting load of solar water heater.
- Wooden roof should also be capable of supporting load of solar water heater.
- Solar water heater should be installed with nut and bolts to make it safe during wind and rain.
- Metal sheets should be made water proof after making drill holes.

Activity-5.4 Selection of place for installing solar water heater in groups

The teacher/ instructor is required to make the groups of students and give them the task for selecting place for solar water heater installation.

5.3: Installation of Solar Water Heating System

5.3.1- Procedure of Solar Water Heating System

Following considerations should be kept in mind during the installation of a solar water heating (SWH) system:

i. Except in rare instances it will be inefficient to install a SWH system with no electrical or gas or other fuel backup. Many SWH systems (e.g., thermo siphon systems) have an integrated electrical heater in the integrated tank. Conversely, many active solar systems incorporate a conventional 'geyser'. But even in a tropical environment there are rainy and cloudy days when the insolation is low and the temperature of the water in the tank increases very little on account of solar heating.

Do you know?

Electrical or other backup ensures a reliable supply of hot water in SWH system

ii. The installation of a SWH system needs to be complemented with efficient insulation of all the water pipes connecting the collector and the water storage tank, as well as the storage tank (or 'geyser') and the most important warm water outlets.

iii. The installation of efficient lagging significantly reduces the heat loss from the hot water system. The installation of lagging on at least two meters of pipe on the cold water inlet of the storage tank reduces heat loss, as does the installation of a 'geyser blanket' around the storage tank (if inside a roof). In cold climates the installation of lagging and insulation is often performed even in the absence of a SWH system.

iv. If a photovoltaic (PV) panel is used to drive the pump in an active system, the installation of a controller is crucial. This prevents the pump from switching on early in the morning when there is light to drive the pump but while the collector is still cold. This causes the hot water in the storage tank to be cooled. Some modern pumps can operate even in fairly low light levels, causing unwanted circulation through the collector.

v. Usually a large SWH system is more efficient economically than a small system. This is because the price of a system is not linearly proportional to the size of the collector, so a square meter of collector is cheaper in a larger system. If this is the case, it pays to use a system that covers all or nearly all of the domestic hot water needs, and not only a small fraction of the needs. This facilitates more rapid cost recovery.

vi. Due to the modularity of an evacuated tube collector panel, this technology allows the adjustment of the collector size by removing some tubes or their heat pipes. Budgeting for a larger than required array of tubes therefore allows for the customization of collector size to the needs of a particular application, especially in warmer climates.

Installation Steps

While no two installations are exactly the same, these are the general steps that any contractor while installing a solar hot water system will likely follow. The six steps detailed below are meant to be an overview of the solar hot water installation process, and don't reflect the exact course of action every installer might take.

The basic steps to install a closed-loop solar water-heating system are:

1. Mount the solar collectors on the roof
2. Install the solar storage tank and heat exchanger next to conventional water heater
3. Install the piping and pump for the glycol loop
4. Install the water piping
5. Install the controls
6. Fill the system
7. Insulate the water and glycol lines

1. Mount the solar collectors on the roof

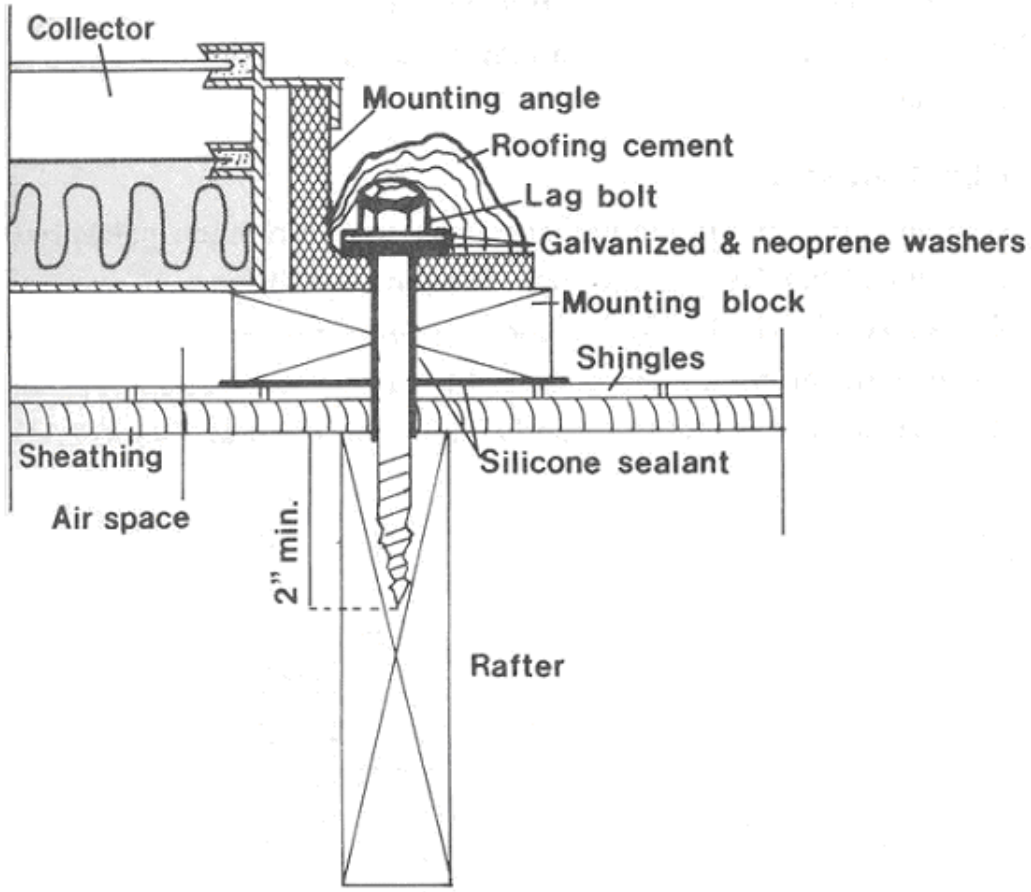
In most solar hot water installations, the first step is to put the solar collectors in place on the roof. Most solar hot water collectors are similar in shape to photovoltaic solar panels, and also will lie flat on the roof.

In order to properly mount the collectors, installer may need to remove portions of selected roof shingling and expose the flat tar paper that acts as protection between shingles and roof deck.

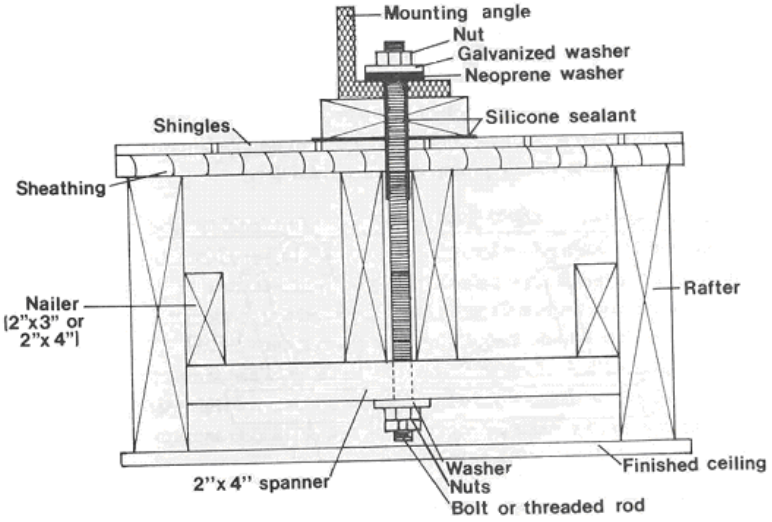
Once a suitable surface has been found or created, the collectors are maneuvered into place and screwed into the roof deck and underlying rafters directly.

While mounting collectors, make as few roof penetrations as possible. In some cases, the collectors can be mounted on a roof and the piping run through a vertical wall instead of through the roof. Seal all roof penetrations with silicone sealant. Different manufacturers will supply slightly different hardware for mounting the collectors on the roof. Follow the manufacturer's directions carefully.

Locate the rafters to which you will be attaching the collectors. You may be able to do this with a stud finder, or you may have to go inside the attic space and drill a small hole next to a rafter to locate it. Drill the hole, and then run a small wire out of the hole to help locate it on the outside. Remember to seal the hole with silicone sealant.

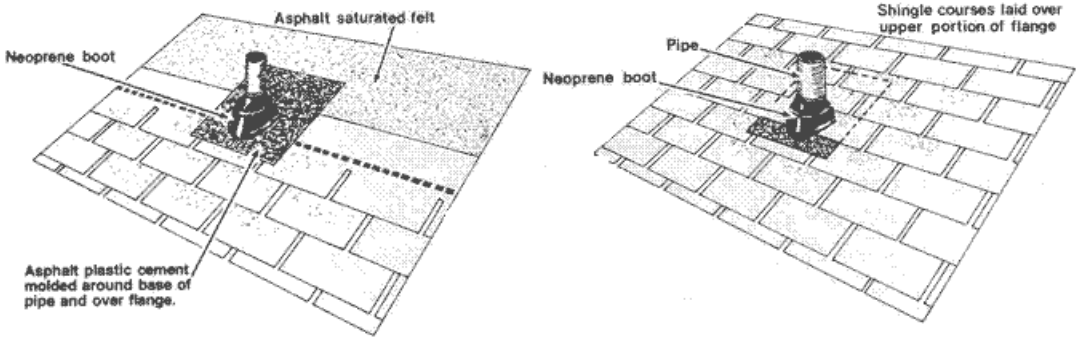


Rafters are usually 16 inches or 24 inches center to center. If you cannot attach the collector mounting hardware to the rafter itself, you must install a spanner block between the rafters and mount the collector hardware to the sleeper. Do not rely on the roof sheathing to support the solar collectors. Be sure that the collector mounting hardware is securely attached to the framing members.



Use the manufacturer's recommended flashing around piping going through the roof, or use pipe flashing. Install the flashing with roof sealant to be sure it will not leak.

ROOF- AND GROUND-MOUNTING PROCEDURES



If you are using sweated copper plumbing fittings, protect the roof from the torch with a flame-resistant mat.

Remember to install an air vent at the top of the collector.

Locating the Collectors on Roof & Marking Roof Penetrations:

Step 1

Begin by outlining with chalk or a marking pen where the collectors are to be mounted on the roof. Collectors should ideally be mounted at least 12 inches down from the roof peak. This will keep them away from potential up-lifting wind conditions, and keep the manifold away from the roof cap and any ridge vents.

Step 2

Once the collector has been positions, use a chalk line to snap a horizontal line where the bottom of the collectors will go, along the tube rack. Along this line, you will next mark where the rafters underneath intersect and where you will sink your fasteners to secure the frame to the roof.

Step 3

Mark off along chalk line where the rafters intersect. Usually, rafters are spaced 16" or 12" apart, on center.

Step 4

For each collector, choose the intersections that match up with where your collectors will be mounted. The collector frame is designed to match up to rafters that are either 16" or 24" on center.

Step 5

Now that the roof penetration points have been marked, screw the frame along with the rubber pads into the rafters, using 3/8" x 3 1/2" stainless steel lag screws.

Step 6

Attach the manifold to the now assembled frame.

Step 7

Make the appropriate roof penetrations, and flash the appropriate collars in place. Now that the manifold is in place, you can determine where your piping will go. Many times, the piping is installed through the roof. If this is the case, go ahead and make the appropriately sized roof penetration, using a standard hole saw.

Step 8

The next step is routing the lines. When using copper pipe, the piping must be insulated after it has been installed.

Activity-5.5 Marking of layout for SWH system

The teacher/ instructor is required to demonstrate the students about drawing and marking of SWH system on the place selected.

Activity-5.6 Installation of SWH system

The teacher/ instructor is required to demonstrate the students about installation of SWH system in the layout marked.

2. Install the solar storage tank and heat exchanger next to conventional water heater

Next, your collector needs a storage tank where they can send their heated antifreeze transfer fluid.

Place the solar storage tank near the conventional water heater. If the heat exchanger is internal to the storage tank, make sure that the glycol loop connections to the heat exchanger and the cold and hot water connections are accessible. If the heat exchanger is external to the storage tank, it is likely that it is supported by the plumbing. Install unions at the storage tank and heat exchanger connections so that the piping will not have to be cut if the tank or heat exchanger is to be replaced in future. For this purpose, follow the steps given below:

Step 1

Position the storage tank in place. If you are using a storage tank that has electrical backup, ensure that the tank will be located near an appropriate electrical supply for the backup element. Even if there is no electrical outlet, ensure there is at least a 120 volt outlet available nearby.

Step 2

Remove the components from the Solar Pump Station. This is done by sliding the spring clips out.

Step 3

Now that the components have been removed, mount the bracket and then the Pump Station to a nearby wall.

Step 4

The pump station components can now be re-assembled to the bracket. Begin by installing the rear foam cover over the brackets. Then push the two pump station assemblies onto their respective pins on the mounting bracket.

Step 5

Now that the solar pump station has been mounted onto the wall or onto the solar storage tank, the connections can be made.

3. Install the piping and pump for the glycol loop

In order to connect collectors to the heat exchanger and storage tanks, installer will run flexible piping from roof to new storage tank or tanks. Antifreeze fluid leaves from one pipe on the side of the collector and runs down to the heat exchanger. An additional line will be installed to connect the end of the heat exchanger back up to rooftop so that fluid can be cycled. If there are multiple collectors, additional pipes will be installed to connect them. Installing these antifreeze piping paths requires access to roof, which will almost always mean cutting a couple of holes in

the roof deck – one for the piping that brings antifreeze down, and one for the piping that sends it back to the collectors.
These holes don't need to be larger than the pipe diameter, and can be easily covered with insulating material and replacement shingles as the installation is being finalized.

The pump should be installed at the lowest part of the glycol loop. The pump outlet is plumbed to the piping leading to the solar collectors on the roof. A check valve must be installed at the outlet of the pump so that when the pump is turned off, the glycol will not flow backwards around the loop. An expansion tank must be installed, and a pressure gauge should be installed to monitor the pressure in the glycol loop. A pressure relief valve must be installed in the glycol loop. The outlet from the pressure relief valve should be piped to a drain. This pressure relief valve should be a boiler relief valve, and the operating pressure should be no more than 30 psi. Optional Equipment:

- A ball valve or circuit setter may be installed to control the flow in the loop
- A flow meter also may be installed in the glycol loop
- Thermometers on the inlet and outlet of the heat exchanger will help to monitor system performance

4. Install the water piping

Plumb the cold water energy in the house to the inlet of the solar storage tank, and the outlet of the solar storage tank to the inlet of the conventional water heater. Install valves and unions on the inlets and outlets of the tanks. If the heat exchanger is external to the solar storage tank, you may choose to use a natural convection loop between the heat exchanger and the solar storage tank, or you may install a pump to force water through the heat exchanger and tank. If you choose to use natural convection, you should use a large pipe—at least 1-1/4" copper—to get adequate flow through the heat exchanger. If you choose to install a pump to force water through the heat exchanger, you can use 3/4-inch copper pipe.

5. Install the controls

The differential controller must be installed to sense the temperature difference between the water at the bottom of the solar storage tank and the glycol at the top of the solar collectors. The sensors can be attached to the pipes with hose clamps.
Two temperature sensors have to be connected with wiring and installed along hot water system. One sensor should be connected to the collectors, and one to the base of the storage tank. These devices will connect to the central control system and provide guidance on when to circulate antifreeze fluid. For example, if the temperature at the collectors is lower than the temperature in the tank, there's no reason to circulate fluid – in fact, doing so will cool the water.

A central control system also needs to be installed and connected to the home electricity supply. This device will act as the "brains" of new solar hot water installation, facilitating pumping of antifreeze based on the data it receives from the temperature sensors.

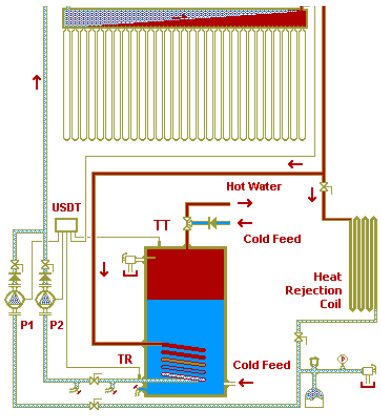
There are some optional additions to this part of the system that, while adding additional costs, will add convenience and possibly safety to the system. Optional equipment includes:

- Bypass valve
- Tempering valve
- High-temperature radiator loop

Bypass valve: Run a pipe between the water pipe entering and the water pipe leaving the conventional water heater. Install a valve in this pipe (bypass valve). When this valve is closed and the valves on the inlet and outlet of the conventional water heater are open, water will flow from the solar storage tank to the conventional water heater (normal operation). If the valves on the water pipe entering and the water pipe leaving the conventional water heater are closed and the bypass valve is open, water will flow from the solar storage tank past the conventional water heater. This bypass mode can be used in the summertime when water temperatures are high, and the conventional water heater can be shut off completely.

Tempering valve: To avoid scalding temperatures from the solar storage tank, a tempering valve may be installed after the conventional water heater. The tempering valve adds cold water to the hot water to control the temperature so that there is no risk of scalding.

High-temperature radiator loop: A radiator, pump, and controls may be installed on the system to dump the energy in case the glycol loop gets too hot. This addition to the system can protect the system from overheating if there is no hot water used for several days in the summertime.



An example of a heat rejection loop using a radiator.

Operation

- The solar collector heats the solar storage tank through the bottom coil in the tank.
- Heat rejection loop removes excessive heat when tank temperature (TT) exceeds its design limit.

6. Fill the system

Check the glycol loop for leaks by filling the glycol loop with water. The circulation pump will probably be too small to fill the system, so you will need a fill pump that can provide enough pressure to lift the water (and glycol) up to the top of the solar collectors. A drill pump has successfully been used to fill solar water-heating systems. To test the system for leaks, being sure that there is no air in the glycol loop, overpressure the glycol loop to twice the operating pressure (30 PSI maximum, and less than the pressure relief valve rating) and let the system stand for eight hours. If the pressure in the loop has dropped, you have a leak that must be found and repaired. If the pressure holds, fill the system with a 50-percent propylene glycol 50-percent water mixture and pressurize the loop to no more than 15 PSI.

7. Insulate the water and glycol lines

Once all of the pieces are in place, the last step in any solar hot water job is to insulate each part. Any energy lost along the piping systems or within the storage tank itself is lost savings, so it is vital to insulate system properly.

After the system has been checked for leaks, carefully insulate all of the glycol and water lines. Water piping can be insulated with standard foam pipe insulation. Glycol piping and external heat exchangers should be insulated with fiberglass pipe insulation. Duct tape can be used on the joints of the water piping insulation, and use the joint tape that comes with fiberglass piping insulation. Insulation exposed to sunlight can be protected by a foil wrap, or UV resistant paint. Fiberglass insulation used outside should be protected with PVC insulation covers.

Install the system according to the diagram and keep in mind following general precautions/ instructions:

- The collectors should be installed as close in proximity as possible to the storage tank.
- The collectors should be mounted in an area with a full solar window.
- The collectors should be mounted with a minimum of 1 ½’ air gap above the roof sheeting.
- The collectors and pipe runs must be at slope at least 4″ in 10 feet to allow a complete drainage.
- The collectors should be mounted in parallel positioning.
- The collectors mounting bolts should penetrate the roof rafters, or use a wood block under the sheeting.
- All roof penetrations should be sealed.
- Install collector array piping in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length.

- Install a freeze protection valve on the return line according to the diagram (optional).
- An air vent should be installed vertically on the highest point of the system.
- An air vent cup must remain loose for proper operation. The Air vent should be insulated
- The collector sensor should be mounted near the collector outlet.
- For best protection the freeze sensor should be mounted on the absorber in the center of the collector's array.
- Sensor wires should not be exposed to direct sunlight.
- Wire nuts connecting the sensors should be filled with silicon to prevent any moisture from penetration the sensor.
- Use ¾" copper pipe for total runs of over 50 ft. Use ½" or ¾" for runs less than 50 ft.
- Use soft copper tubing as possible to minimize flow restrictions.
- All pipe runs should be insulated.
- All exterior pipe insulation should be protected from UV radiation and moisture. (Paint with exterior latex)
- Set the storage tank indoors close in proximity to 110V electrical outlets. Secure tank in event of an earthquake.
- Install a shut-off valve for the solar system so that the cold water supply is not interrupted.
- Install a T&P Relief Valve. The drain line should be discharged to the outdoors no higher than 6″ above grade.
- Install the pump on the collectors feed line with the arrow pointing to the direction of flow. (To collectors)
- Install a thermo-syphon prevention check valve on the collectors return line.
- Install the tank sensor on the threaded stud located behind the cover plate of the bottom portion of the tank.
- Mount the automatic controller on the tank or next to the 110V outlet.
- Install the controller according to the installation instructions provided with the controller.
- Follow the tank manufacturer's instructions for high voltage connection of the electrical element and element timer.
- Attach the warning and instructions labels provided with the system.

5.3.2- Auto Controller

The auto controller is a differential temperature thermostat designed specifically to regulate a solar system operation. Its basic function is to monitor collector and storage temperatures and to automatically turn a small circulator ON or OFF at the appropriate temperature differentials. The controller can also provide additional functions, such as: system freeze protection (drain down / drain back or re-circulation), storage tank high temperature limit and positive OFF when the collector is below 80°F.

Auto controllers are used to automatically on-of the solar water heaters. Auto controller controls the following things:

i. On or off the filling motor according to level of water.
ii. Displays temperature of water constantly.
iii. Automatically on or off electric rod according to temperature.
iv. On or off the inlet auto magnetic valve.

When solar water heater is mounted on the roof of a home and level of water in water tank is below the level of solar water heater tank, a 0.25 HP motor is installed. Connections of this motor are made through auto controller, so that in case of less water motor can start automatically.

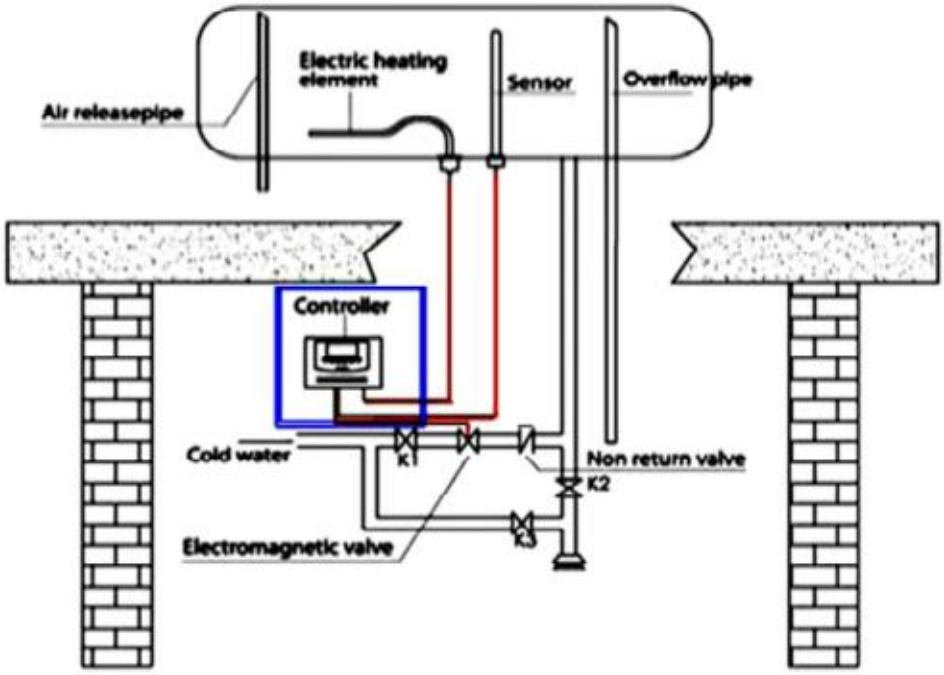
There is another sensor with the auto controller of the geezer, which is inserted in water tank. This sensor takes care of temperature and level of water. It makes the electric rod on and starts the motor of water when necessary. It also displays the temperature of water.

5.3.3- Procedure for Installing Auto Controller

A sensor is attached to the solar water heater tank. It is either attached to the water inlet pipe of the tank or inside of the air vent pipe fixed at the top of solar water heater tank. A tee pipe is attached at the top of air vent pipe. One side of the tee serves as air vent where as controller is fixed in the room below so that temperature of the water can be adjusted and displayed.

- Two wires form the sensor came into the controller which takes care of water level and temperature.
- Two wires runs from controller to water inlet magnetic valve. When water level is low, sensor gives signal to this auto valve which opens and water enters into the water tank. When water rises to the required level, controller automatically closes the valve and supply of water stops.
- Two wires runs from controller to motor which automatically on or off the motor when necessary.
- Also two wires runs from controller to electric rod, which automatically on the rod in case of low temperature.

To avoid any error follow the instructions given in the manual of controller during installation.



Activity-5.7 Installation of auto controller of SWH system

The teacher/ instructor is required to demonstrate the students about the installation of auto controller of SWH system.

5.3.4- Instructions for first time running of SWH System:

i. At this point all electrical power to the system is off, the cold-water supply valve is off, the collector isolation valves are off and the storage tank is empty. The air vent on top of the collectors is not installed so the collectors can be flushed.
ii. Ensure that there is no mechanical weight on solar water heating system.
iii. Whether valves, safety valve and air vent are working properly.
iv. Whether vacuum is present in the tube. If the colour of lower part of tube is silver instead of white, then vacuum did not exist when tube is broken and tube has to be replaced.
v. Ensure that the temperature of the tubes is not raised much due to working in sunlight.
vi. Fill the tank by turning on the main valve and allowing the air to flush out of the tank.
vii. After filling the water check the leakage of solar water heater and all pipes.
viii. Turn on the isolation valves to fill the collectors. (You can flush the impurities like loose solder; flax, joint compound ext. from the collectors threw the air vent thread connector).
ix. After the collectors have been flushed, install the air vent and pressurize the system, the automatic air vent will bleed remaining air out of the collectors if its plug is loosened. (The system must be free of air for the pump to circulate water).
x. Once the system has been filled, follow the controller's instructions for fine-tuning. Plug in the pump cord into the controller. Plug in the controller to the 110V outlet and set the controller switch to automatic operation.

xi. The system should begin functioning if the sun is shining. Within a few second the collectors return line will be very hot. Within a minute or two the return line should cool to about 10°F to 15°F higher than the feed line.
xii. Set the electrical element timer so it does not compete with the sun.
xiii. Check whether the minimum discharge of water in all hot water pipes is 5 liters/minute.
xiv. Turn on the electric rod and check its efficiency.
xv. Turn off the alternate (Electric rod) heater and check whether solar water heater is working in sun light. At noon in clear weather solar water heater raises the temperature of water up to 7-8^{o}C with solar radiation.
xvi. Check whether hot water is coming in all taps which are connected to solar water heater.

Activity-5.8 Test run of SWH system

The teacher/ instructor is required to demonstrate the students about test run of SWH system

5.3.5- Procedure of Checking of Solar Water Heating System:

To check whether solar water heater is working in sun light properly or not, follow the following steps:

i. Turn off the electric rod.
ii. Open the hot water tape to remove all the water present in solar water heater and fresh water is filled in.
iii. If weather is clear solar water heater will raise the temperature of water up to 7-8^{o}C with solar radiation.

Activity-5.9 Checking of whole SWH system

The teacher/ instructor is required to demonstrate the students about checking the whole SWH system.

Activity-5.10 Uninstalling and reinstalling of SWH system

The teacher/ instructor is required to demonstrate the students about uninstalling and reinstalling of SWH system.

What I have learnt

- Personal protective equipment (PPE) is essential during every solar installation. Employers have to assess workplaces for hazards and make sure they provide workers with the necessary PPE for their safety
- While no two installations are exactly the same, these are the general steps that any contractor installing a solar hot water system will likely follow.
- The basic steps to install a closed-loop solar water-heating system are:
    i. Mount the solar collectors on the roof

ii. Install the solar storage tank and heat exchanger next to conventional water heater
iii. Install the piping and pump for the glycol loop
iv. Install the water piping
v. Install the controls
vi. Fill the system
vii. Insulate the water and glycol lines

- If you cannot attach the collector mounting hardware to the rafter itself, you must install a spanner block between the rafters and mount the collector hardware to the sleeper.
- Install unions at the storage tank and heat exchanger connections so that the piping will not have to be cut if the tank or heat exchanger is to be replaced in future.
- Minimum discharge of water in all hot water pipes should not less than is 5 liters/minute.
- If the colour of lower part of tube is silver instead of white, then vacuum did not exist when tube is broken and tube has to be replaced.
- The auto controller is a differential temperature thermostat designed specifically to regulate a solar system operation.
- Its basic function is to monitor collector and storage temperatures and to automatically turn a small circulator ON or OFF at the appropriate temperature differentials.
- The controller can also provide additional functions, such as: system freeze protection (drain down / drain back or re-circulation), storage tank high temperature limit and positive OFF when the collector is below 80°F.
- Install unions at the storage tank and heat exchanger connections so that the piping will not have to be cut if the tank or heat exchanger is to be replaced in future.
- An air vent should be installed vertically on the highest point of the system.
- After the system has been checked for leaks, carefully insulate all of the glycol and water lines.
- An expansion tank must be installed, and a pressure gauge should be installed to monitor the pressure in the glycol loop.

EXERCISE

Q-1 Tick (✓) the correct option for the following MCQs.

i- The top height of the air vent pipe provided at the drop-down point should be higher than the cold-water source overflow outlet by

(A) 2 feet (B) 3 feet
(C) 4 feet (D) 5 feet

ii- Houses which do not have concrete roofs, angle of solar heater plates should be

(A) 15^o (B)25^o
(C) 30^o (D) 45^o

iii- For total runs of over 50 ft, use copper pipe of size:

(A) ¼” (B) ½”
(C) ¾” (D) Any one of these

iv- In clear weather solar water heater raises the temperature of water with solar radiation up to:

(A) 5-6^{o}C (B) 7-8^{o}C
(C) 9-10^{o}C (D) 12-15^{o}C

v- Minimum discharge of water in all hot water pipes should not be less than:

(A) 4 liters/minute. (B) 5 liters/minute.
(C) 6 liters/minute. (D) 8 liters/minute.

vi- The auto-controller also provide positive OFF when the collector is below:

(A) 80°F (B) 90°F
(C) 110°F (D) 120°F

vii- The collectors should be mounted above the roof sheeting with a minimum air gap of:

(A) 1 ¼’ (B) 1 ½’
(C) 2 ½’ (D) 2 ¼’

viii- To add convenience and possibly safety to the system, optional equipment includes:

(A) Bye pass valve (B) high-temp. Radiator valve
(C) Temperature valve (D) All of these

ix- A flexible connection is provided between the collector and the storage tank in SWH system using:

(A) Flat plate collector (B) Evacuated glass collector
(C) Line focus collector (D) All of these

x- The collectors should be installed as close in proximity as possible to:

(A) Storage tank (B) Expansion tank
(C) P&T valve (D) None of these

Give short answer to the following questions.

i- Enlist few tools required for installing SW heater.

ii- Enlist the basic steps to install a closed-loop solar water-heating system.

iii- How vacuum in the glass tube is checked?

iv- Define direct solar water heating system.

v- Define auto controller.

vi- What is the basic function of auto controller?

vii- What should be minimum discharge in hot water pipes?

viii- Where air vent is installed?

Answer the following questions in detail.

i- Briefly explain the installation steps for installing SW heater.

ii- Write down importance of personal protective equipment.

iii- Write down the instructions for first time running of SWH System.

CHAPTER -06

HEALTH AND SAFETY FOR SOLAR WATER HEATING SYSTEM

After studying this unit you will be able to:

- learn safety concept of solar water heating systems.
- learn importance of safety for a solar water heater.
- learn about handling of glass parts and safety of electric and electronic parts.
- learn about function and importance of pressure relief valve and temperature relief device.
- learn about preventing scaling and corrosion.
- learn about periodic inspection.
- describe hazards associated with solar water heating installation and maintenance.
- learn about freezing phenomena in a solar water heater.
- learn about over heating of SWH.
- learn about use of antifreeze solution.

6.1 Introduction of Safety for Solar Water Heating System

6.1.1- Safety Concept of Solar Water Heating Systems

Following safety guidelines should be adhered to during installation of solar water heating system:

i. The installation of the solar thermal system in it's entirety shall conform to all federal, state, and local regulations, codes, ordinances, and standards governing solar water heating systems and installations, and the contractor shall adhere to sound building safety and trade practices. Special consideration must be given to building code requirements for the penetration of structural members and fire rated assemblies.

ii. The installer shall have proper safety equipment when working with elevated surfaces, hot water, heating systems, electrical systems, or any other systems that could pose a danger to himself or anyone around him, and he shall take necessary precautions to ensure a safe work environment.

iii. The homeowner, business owner, or other appropriate person(s) and the installer shall confirm the location of all components – roof mounted or otherwise – in advance of the installation.

iv. The solar panels must be located in a structurally sound area of the roof that will be un-shaded for the majority of the day all year round. Adjacent trees, buildings, and any other obstacles should be checked for winter shading.

v. Before the installation begins, the installer shall inspect the condition of the roof and any other surfaces pertaining to the solar hot water system, and notify the owner or other appropriate person(s) of any existing damage or any repairs that may be needed.

6.1.2- Importance of Safety for a Solar Water Heater

Safety is the most important consideration while installing the system. Using personal protective equipment is often essential, but it is generally the last line of defense after engineering controls, work practices, and administrative controls. Solar energy employers must assess their workplace to determine if hazards are present that require the use of protective equipment.

Solar energy workers can be exposed to many hazards that may require the use of safety glasses, hard hats, gloves, respirators, or other personal protective equipment used to protect against injuries and illnesses. Workers exposed to potential electrical hazards must be provided with appropriate electrical protective equipment, and workers must use them. Electrical protective equipment must be maintained in a safe and reliable condition. They must be periodically inspected or tested.

Below are the recommended safety tips during solar water heater installation:

- Wear proper safety dress and tie with safety rope during assembly.
- Take extra care while working on roofs. (Specially taking care of loose tiles or electrical cables)
- Avoid working on inclined wet roof during rainy days.

6.1.3- Handling of Glass Parts and Safety of Electric and Electronic Parts

At the installation site, begin by opening the crate or pallet your solar collectors were shipped in. Remove the individual components, open each box, and familiarize yourself with the contents. It is advised to label the various boxes and organize them to make it easy to find specific components during the installation. Locate and open the box containing the evacuated tubes with the heat pipes & fins installed. Check to ensure that all of the evacuated tubes are intact, and the bottom of each tube is silver.

If a tube has a white or clear bottom, the tube has been damaged and has lost it's vacuum, and must subsequently be replaced. To do this, simply remove the heat pipe and fins from the damaged tube and insert them into the replacement tube.

If a glass cracks or breaks it must be replaced immediately. The collector front has to be covered until the broken glass is replaced. Water or humidity will damage the insulation. Before new glass is fitted, clean the plate with a dry rag. Glass can easily be replaced on collectors already installed, provided the site is easily accessible.

It is advisable to always handle the evacuated tubes wearing gloves to avoid leaving finger prints on the tubes. The oil from your hands will attract dirt, and can leave noticeable marks on the glass.

Do not fully remove nor expose the tubes to sunlight until you are ready to install them (after the loop has been completed, charged, and pressure tested). When the tube is exposed to sunlight, the tip of the heat pipe will become extremely hot, and can cause serious skin burns. The outer glass surface will not become hot.

Do you know?

Never touch the inside of n evacuated tube, nor the heated pipe tip after exposure to sunlight. This results in serious burns.

After the collectors have been unpacked, the blackened collector plate has to be cleaned as follows:

- Clean off dust and dirt with a dry rag.
- Remove all traces of oil or dirt with clean, dry rag.
- Clean the glass of dust and dirt.

Activity-6.1 Handling of glass parts of SW heater

The teacher/ instructor is required to demonstrate the students about handling of glass parts of SW heater.

Activity-6.2 Safety of electric and electronic parts of SWH system

The teacher/ instructor is required to demonstrate the students about safety of electric and electronic parts of the SWH system.

6.2 Introduction and Importance of Pressure Relief Valve and Temperature Relief Device:

Every hydronic heating system must have protection against high pressures due to high temperatures. A pressure relief valve of 50 psi is usually adequate to protect closed-loop plumbing systems from excessive pressures. Temperature/pressure relief valves are not commonly used in the closed loop because high temperatures are common. Pressure-only relief valves are most commonly used. Pressure relief valves should have a vent tube that directs escaping fluid to a bucket or floor drain. Once one of these valves opens, it is wise to replace it, since they often do not fully reseat, scale or dirt particles may allow a slow leak.

Do you know?

A pressure relief valve of 50 psi is usually used to protect closed loop plumbing systems from excessive pressures.

6.2.1: Temperature Pressure Relief Valve (T&P Valve)

A temperature pressure relief valve is a valve that's located somewhere near the top of your water heater. The valve has a lever that can be lifted up or down and a discharge pipe that runs from the valve straight down to the bottom of your water heater.

The purpose of the temperature pressure relief valve is to release water, and in turn lower the pressure inside the tank, in the event that the temperature or pressure gets too high in your water heater. Without a temperature pressure relief valve, your water heater would run the risk of exploding if the temperature or pressure got higher than the tank was designed to handle.

6.2.2: Maintain Temperature Pressure Relief Valve

Because the temperature pressure relief valve plays such an important role for your water heater, it's important to ensure that it's working properly. There are two main ways to do this:

1. **Check for water leaks.**

If you notice a water leak from your temperature pressure relief valve or the discharge pipe that's attached to it, the valve is likely working improperly and might need to be replaced. Be sure to contact a contractor like Cabrillo to have the valve inspected and repaired.

2. **Test the valve annually.**

Once a year, lift the lever on the temperature pressure relief valve and make sure water comes out of the discharge pipe. Be aware that the water in the tank is hot, so you should clear the area around it and allow the water to discharge safely. If water comes out of the pipe, your valve is working properly and you can check it again next year.

The TP relief valve controls and limits the temperature and pressure of the hot water contained in a solar domestic water storage heater and prevents it from being able to reach temperatures of over 100°C, with

the formation of steam. On reaching the settings, the valve discharges a sufficient amount of water into the atmosphere so that the temperature and pressure return within the system's operating limits.

6.2.3: Operating Principle:

The valve opens the outlet on reaching the settings for: -

Temperature: the thermostat compound inside the temperature sensor

i. Submerged in the hot water storage heater, expands as the temperature increases. This expansion causes a thrust pin to move and act on the obturator
ii. Opening the valve. The valve is set to open at temperatures of over 90°C.

Pressure: the obturator, opposed by a set spring, raises on reaching the pressure setting and opens the outlet completely. The pressure setting is chosen according to the maximum permissible pressure in the system. As the temperature and pressure decrease, the opposite action occurs with the valve subsequently reclosing within the set tolerances.

Pressure and Temperature Gauges

A **pressure gauge** shows if the closed loop system is within an acceptable range of pressure. A typical system pressure is on the order of 10 to 15 psi. A pressure gauge is used as a diagnostic tool to monitor the state of the glycol charge. A loss of pressure indicates a leak in the system that needs to be located and repaired.

A pressure

Two **temperature gauges** in the closed loop and one in the water loop are optional, but valuable indicators of the system's function. One gauge on each side of the heat exchanger in the collector loop shows the temperature rise across the collectors and the temperature change across the heat exchanger. A temperature difference of 15 to 20°F indicates effective system operation. One temperature gauge in the water loop between the exit of the heat exchanger and the entry to the storage tank will display the current temperature of solar heated water entering the storage tank. The temperature gauges should have a range of 0 to 240 or 300°F. A hot summer day may produce water temperatures in the solar loop around 200°F, although normally 180°F is the maximum temperature attained.

Activity-6.3 P&T relief valves in SWH system

The teacher/ instructor is required to demonstrate the students about pressure re;ief valve and temperature relief device in SWH system.

Activity-6.4 Working of PRV and Temperature relief device in SWH system

The teacher/ instructor is required to demonstrate the students about working of PRV and temperature relief device in SWH system.

6.3: Maintenance and Safety Considerations

6.3.1- Preventing Scaling and Corrosion

Two major factors affecting the performance of properly sited and installed solar water heating systems include scaling (in liquid or hydronic-based systems) and corrosion (in hydronic and air systems). Hydronic refers to heating systems which involve circulating hot water or steam.

i. Scaling

Domestic water that is high in mineral content (or "hard water") may cause the build-up or scaling of mineral (calcium) deposits on heat transfer surfaces. Scale build-up reduces system performance in a number of ways. If system uses water as the heat-transfer fluid, scaling can occur in the collector, distribution piping, and heat exchanger. In systems that use other types of heat-transfer fluids (such as propylene glycol, scaling can occur on the surface of the heat exchanger in contact with potable water that transfers heat from the solar collector to the domestic water. Scaling may also cause valve and pump failures on the potable water loop.

Scaling can be avoided by using water softeners or by circulating a mild acidic solution (such as vinegar) through the collector or domestic hot water loop every 3–5 years, or as necessary depending on water conditions. It is necessary to carefully clean heat exchanger surfaces. A "wrap-around" external heat exchanger is an alternative to a heat exchanger located inside a storage tank.

Activity-6.5 Scaling of corrosion tubes in SWH system

The teacher/ instructor is required to demonstrate the students about practice of old scaling of corrosion tubes in SWH system.

ii. Corrosion

Most well-designed solar systems experience minimal corrosion. When they do, it is usually galvanic corrosion, an electrolytic process caused by two dissimilar metals coming into contact with each other. One metal has a stronger positive electrical charge and pulls electrons from the other, causing one of the metals to corrode. The piping connection from the copper pipe to the steel tank should thus be a “bi-metallic” type of connector that uses a plastic sleeve to separate the dis-similar metals. The heat-transfer fluid in some solar energy systems can also provide a bridge over which this exchange of electrons occurs.

Oxygen entering into an open loop hydronic solar system will cause rust in any iron or steel component. Such systems should have copper, bronze, brass, stainless steel, plastic, rubber components in the plumbing loop, and plastic or glass lined storage tanks.

Activity-6.6 Insulation practice on pipes and wires of SWH system

The teacher/ instructor is required to demonstrate the students about insulation practice on pipes and wires of SWH system.

6.3.2- Periodic Inspection

Solar energy systems require periodic inspections and routine maintenance to keep them operating efficiently. Also, from time to time, components may need repair or replacement. Steps to prevent scaling, corrosion, and freezing should also be taken.

You might be able to handle some of the inspections and maintenance tasks on your own, but others may require a qualified technician. Work that requires going up ladders, walking on roofs, soldering or hot work, or cutting back tree limbs should be performed by a professional service for safety reasons. Ask for a cost estimate in writing before having any work done. For systems with extensive damage, it may be more cost effective to replace, shut off, or remove the solar system than to have it repaired.

Periodic Inspection List

Here are some suggested inspections of solar system components. Also read your owner's manual for a suggested maintenance schedule and keep track of previous maintenance activities in order to manage preventative maintenance intervals and better track elusive problems

i. Collector shading

Check visually for shading of the collectors during the day (mid-morning, noon, and mid-afternoon) on an annual basis. Shading can greatly affect the performance of solar collectors. Vegetation growth over time or new nearby construction may produce shading that wasn't there when the collectors were installed.

ii. Collector soiling

Dusty or soiled collectors will perform poorly. Periodic cleaning may be necessary in areas with specific sources of soiling such as birds or dust from plowing and if rain is not sufficient to rinse them off.

iii. Collector glazing and seals

Look for cracks in the collector glazing, and check to see if seals are in good condition. Plastic glazing, if excessively yellowed, may need to be replaced.

iv. Plumbing, ductwork, and wiring connections

Look for fluid leaks at pipe connections. Check duct connections and seals. Ducts should be sealed with a mastic compound. All wiring connections should be tight.

v. Piping, duct, and wiring insulation

Check that all valves are in the proper operating position. Look for damage or degradation of insulation covering pipes, ducts, and wiring. Cover the pipe insulation with protective plastic or aluminium wrapping and replace if necessary. Protect wiring in conduits

vi. Roof penetrations

Maintain flashing and sealant around roof penetrations as needed. Watch for any signs of water leakage on the underside of the roof (if visible).

vii. Support structures

Check all nuts and bolts attaching the collectors to any support structures for tightness. Watch for corrosion on steel parts- and clean and paint if necessary.

viii. Pressure relief valve (on liquid solar heating collectors)

Actuate the lever to make sure the valve is not stuck open or closed.

ix. Dampers (in solar air heating systems)

If possible, make sure the dampers open and close properly and are in the proper position.

x. Pumps or blowers

Verify that pumps or blowers (fans) are operating. Listen to see if they come on when the sun is shining on the collectors after mid-morning. If you can't hear a pump or blower operating, then either the controller has malfunctioned or the pump or blower has. The problem is often the starting capacitor, which can be replaced without replacing the pump or motor.

xi. Controls

Solar water heating controls consist of a temperature sensor on the solar collector outlet, another at the bottom of the solar storage tank, and a circuit (delta-T controller) to start the pump when the collector is hotter than the tank and stop the pump if it's not. If the pump is running at night, it could be that the collector sensor is short circuited or the tank sensor open circuited. If the pump is not running during the day the reverse could be the case and the resistance of these sensors should be compared to reference value to determine which one has failed. A common problem is temperature sensors simply falling off the surface they are intended to measure- ensure that they are fastened with a lug or stainless-steel clamp.

xii. Heat transfer fluids

The propylene glycol antifreeze solutions in liquid (hydronic) solar heating collectors need to be replaced periodically. The pH (acidity) and freeze point of the fluid can be measured with hand-held instruments and replaced if out of specification. It's a task best left to a qualified technician. If water with a high mineral content (i.e., hard water) is circulated directly in the collectors, mineral build-up in the piping may need to be removed by adding a de-scaling or mild acidic solution to the water every few years.

xiii. Storage systems

Check storage tanks, etc., for cracks, leaks, rust, or other signs of corrosion. Steel storage tanks have a "sacrificial anode" which corrodes before the tank does and should be replaced at an interval recommended by the supplier. It is a good idea to flush storage tanks periodically to remove sediment.

6.3.3- Hazards Associated with Solar Water Heating Installation and Maintenance:

Installation Hazards and Controls

Workers in the solar energy industry are potentially exposed to a variety of serious hazards, such as arc flashes (which include arc flash burn and blast hazards), electric shock, falls, and thermal burn hazards that can cause injury and death. While solar energy is a growing industry, the

hazards are not unique and OSHA has many standards that cover them. Some hazards that workers in the solar industry may face are:

- Falls
- Lockout/Tagout
- Crane and Hoist Safety
- Electrical
- Heat/Cold Stress

i. Solar Energy: Falls

Workers, who install and/or maintain solar panels often work on roofs, use ladders and scaffolding, are in proximity of ledges and sunroofs, and are exposed to fall hazards. As more solar panels are installed on the surface of a roof, the walking area which may once have been available may no longer be available to workers. This may force workers to squeeze by or walk very close to skylights and/or roof hatches. To protect workers from these potential fall hazards through skylights, roof edges and roof hatches, employers must make sure that skylights are guarded or that workers near skylights use personal fall protection.

Construction workers involved in the installation of solar panels exposed to fall distances of 6 feet or more must be protected from falls by using one of the following methods:

- Guardrail Systems
- Safety Net Systems
- Personal fall arrest systems

Solar panels should be lifted safely to the rooftops. Workers should never be allowed to climb ladders while carrying solar panels. Lifting equipment, such as ladder hoists, swing hoists, or truck-mounted cranes/conveyors, should be used wherever possible.

Maintenance work on solar panels is generally considered to fall under OSHA's general industry standards. Such workers when exposed to fall hazards of 4 feet or more must be protected by a standard railing. If such a railing is not possible then the workers must be protected by a fall protection device such as a personal fall arrest system or a safety net.

ii. Solar Energy: Lock out/Tag out

"Lock out/Tag out (LOTO)" refers to specific practices and procedures to safeguard employees from the unexpected energization or start-up of machinery and equipment, or the release of hazardous energy during service or maintenance activities.

Solar energy equipment can generate electrical energy and may be connected to electrical circuits. Workers may be exposed to electrical hazards from solar panels and from electrical circuits. While installing or servicing solar panels, employers should assure that workers cover the solar panels, in addition to protecting workers from electrical circuits.

The following are some of the significant requirements of a Lock out/Tag out procedure required under a Lock out/Tag out program.

- Only authorized employees may lock out or tag out machines or equipment.

- Lockout devices (locks) and tag out devices (tags) shall not be used for any other purposes and must be used only for controlling energy.
- All energy sources to equipment must be identified and isolated.
- The stored or residual energy must be safely discharged or relieved.
- Lock and tag must remain on the machine until the work is completed.
- Only the authorized employee who placed the lock and tag must remove his/her lock or tag.

iii. Solar Energy: Crane and Hoist Safety

Cranes can be used during the installation and maintenance of solar panels. Fatalities and serious injuries can occur if cranes are not inspected and used properly. Many fatalities can occur when the crane boom, load line or load contacts power lines and shorts electricity to ground. Other incidents happen when workers are struck by the load, are caught inside the swing radius or fail to assemble/disassemble the crane properly.

- Cranes are to be operated only by qualified and trained personnel.
- Be sure that the crane is on a firm/stable surface and level.
- Fully extend outriggers and barricade accessible areas inside the crane's swing radius.
- Watch for overhead electric power lines and maintain at least a 10-foot safe working clearance from the lines.
- Inspect all rigging prior to use; do not wrap hoist lines around the load.
- Do not exceed the load chart capacity while making lifts.
- Raise load a few inches, hold, verify capacity/balance, and test brake system before delivering load.
- Do not move loads over workers.
- Be sure to follow signals and manufacturer instructions while operating cranes.

iv. Solar Energy: Electrical

Solar energy workers are exposed to potential electrical hazards present in their work environment, which makes them more vulnerable to the danger of electrocution and arc flash hazards. Workers may be exposed to electric shocks and burns when hooking up the solar panels to an electric circuit. Since solar panels generate electricity, employers in the solar energy sector may be covered by the Electric power generation, transmission, and distribution standards and, therefore, may be required to implement the safe work practices.

Workers must pay attention to overhead power lines and stay at least 10 feet away from them because they carry extremely high voltage. Fatal electrocution is the main hazard, but burns and falls from elevations can occur while installing solar panels. Another hazard is from using tools and equipment that can contact power lines

v. Solar Energy: Heat/Cold Stress

Solar energy workers often work in very hot weather where hazards include dehydration, heat exhaustion, heat stroke, and death. Employers should monitor employees and workers should be trained to identify and report early symptoms of any heat-related illness. Workers may also be exposed to extreme cold weather conditions and should be protected from such conditions.

Heat stroke occurs when the body's system of temperature regulation fails and body temperature becomes abnormally high. Some of the signs and symptoms of heat stroke are:

- Confusion
- Loss of consciousness
- Convulsions
- Lack of sweating (usually) hot, dry skin, and
- Very high body temperature

If a worker shows signs of possible heat stroke, medical treatment should be obtained immediately. While waiting for medical help, the worker should be:

- Placed in a shady area and the outer clothing should be removed.
- The worker's skin should be wetted and air movement around the worker should be increased
- Fluids should be replaced as soon as possible.

Heat exhaustion: The signs and symptoms of heat exhaustion are:

- Headache
- Nausea
- Vertigo
- Weakness
- Thirst and
- Giddiness.

Workers suffering from heat exhaustion should be removed from the hot environment and given fluid replacement. They should also be encouraged to get adequate rest.

Maintenance Hazards

Freezing and overheating are the biggest hazards, so it is important to understand how your system addresses those possibilities.

i. If your system uses a heat transfer fluid (usually food–grade glycol), you will need to check the pH balancer once in a while. Glycol that has been overheated can become acidic and eventually can cause pin holes in the copper coils. Pin holes and pressurized glycol are not a good combination, so have your installer show you how to check your system every year or two. Solar water heater collectors are much more tolerant of partial and moving shadows than solar electric systems, but an annual hose down in dirty environments is a good idea.

ii. The hot water from your solar water heater system will be sent through your water heater, which may not even turn on if the solar water is hot enough. During the summer, solar water may be hotter than is safe for the home, and an anti-scald valve (required by code) will be installed to mix super-hot water with cold water before being sent to the home’s faucets.

Other safety equipment includes: pressure and temperature release valves, and thermal expansion tanks to protect the home and safety of the occupants.

6.4: Freezing and Overheating Hazards:

6.4.1- Freezing Phenomena in a Solar Water Heater:

Solar water heating systems, which use liquids as heat-transfer fluids, need protection from freezing in climates where temperatures fall below 42ºF (6ºC).

Don't rely on a collector's and the piping's (collector loop's) insulation to keep them from freezing. The main purpose of the insulation is to reduce heat loss and increase performance. For protecting the collector and piping from damage due to freezing temperatures, you basically have two options:

- Use an antifreeze solution as the heat-transfer fluid.
- Drain the collector(s) and piping (collector loop), either manually or automatically, when there's a chance the temperature might drop below the liquid's freezing point.

6.4.2- Over-heating of SWH system:

Overheating occurs when there is little hot water use in the home but the sun continues to heat the water. The controller will turn the pump off when the solar storage tank hits an upper limit (default 180°F but often set lower to prevent scaling). The collector will continue to heat up, which most systems can tolerate, but can lead to discharge of fluid out a pressure relief valve and premature degradation of the heat transfer fluid. Draining the fluid back into a drain-back tank can avoid this damage to the fluid caused by overheating. Some systems include a solenoid valve that will open to drain some water from the tank if overheated.

How to solve the problem of overheating of solar collector?

Solar collectors may overheat in hot summer or when they are not in use. The main reason for overheating is that since the sun rises, solar collectors automatically absorb heat. But when the absorbed heat is not used up in time, the heat will accumulate, and the temperature will rise, leading to overheating and causing damage to the system.

1. The solar controller has high temperature protection function

When the temperature of the water tank reaches the set value (the default setting is 60℃), the circulating pump immediately stops working, and the solar collector stops heating the water tank so as to protect the system from high temperature.

2. Configure PT valve (Pressure Temperature Valve) on the water tank

When the pressure of the water tank reaches 6 bar (or the temperature reaches 95°C), the PT valve will automatically open the drain to release the pressure and reduce the temperature, so as to avoid excessive pressure in the water tank and damage the water tank or shorten the life of the water tank.

3. Equipped with expansion tank in the circulation pipeline

The expansion tank can effectively adjust the pipeline pressure and protect the workstation and pipeline from damage. The model of the expansion tank is selected according to the operating conditions of the entire system configuration, and has a sufficient safety factor, which can effectively adjust the pipeline pressure under extreme conditions.

If multiple solar collectors are installed, there is too much heat remaining; or if they are used in winter and not used in summer or the system is idle for a long time following two solutions make system more secure :

1. The solar controller has a high-temperature bypass function, which can dissipate excess heat through the radiator. It is needed to increase the cost of the three-way solenoid valve and radiator, as well as the cost of power consumption for pump operation, so as to avoid overheating the system.
2. In the season of overheating, cover the solar collector with cloth.

Activity-6.7 Practice of heat control device for preventing overheating in SWH system

The teacher/ instructor is required to demonstrate the students about testing of heat control device for preventing overheating of SWH system.

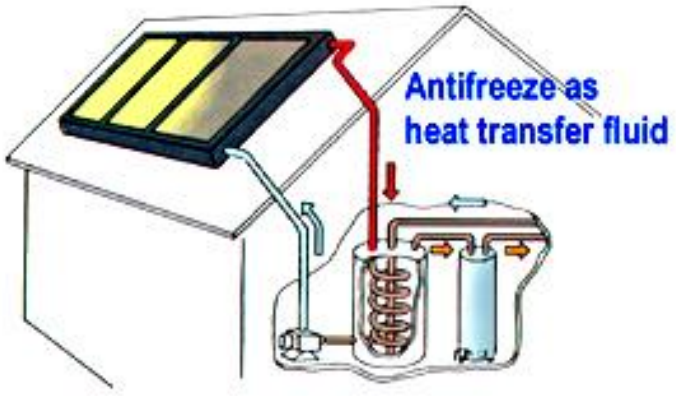
6.4.3- Use of Antifreeze Solution:

The greatest danger to a solar water heating system is freezing. Even when the air temperature at night is well above 32°F, idle fluid in the collector can freeze, because it radiates heat up to a cold, dark sky. Freezing can be prevented by using antifreeze solution instead of water as the heat transfer fluid. It circulates in a "closed loop" and transfers heat to the storage tank in a heat-exchanging coil. It is important to use Propylene Glycol rather than Ethylene Glycol because if the exchanger leaks, Ethylene Glycol can be poisonous.

Do you know?

Always use Propylene Glycol rather than Ethylene Glycol because if the exchanger leaks, Ethylene Glycol can be poisonous.

Solar water heating systems that use an antifreeze solution as a heat-transfer fluid have effective freeze protection as long as the proper antifreeze concentration is maintained.



Antifreeze fluids degrade over time and normally should be changed every 3–5 years. Since these systems are pressurized, it is not practical for the average homeowner to check the condition of the antifreeze solution. If you own this type of system, have a solar heating professional check it periodically.

Activity-6.8 Practice on antifreeze solution and its testing on low temperature in SWH system

The teacher/ instructor is required to demonstrate the students about practicing on antifreeze solution and its testing on low temperature in SWH system.

What I have learnt

i- Health and safety mean to provide an environment at work place to ensure the health and safety of workers.

ii- The work can be made safe simply by changing the behaviour of employees by poster campaigns and accident prevention training.

iii- All the peoples should be given the highest level of protection against risks to their health and safety that is reasonably practicable in the circumstances.

iv- If a tube has a white or clear bottom, the tube has been damaged and has lost its vacuum, and must subsequently be replaced.

v- Workers exposed to potential electrical hazards must be provided with appropriate electrical protective equipment, and workers must use them.

vi- Every hydronic heating system must have protection against high pressures due to high temperatures. A pressure relief valve of 50 psi is usually adequate to protect closed-loop plumbing systems from excessive pressures.

vii- The purpose of the temperature pressure relief valve is to release water, and in turn lower the pressure inside the tank, in the event that the temperature or pressure gets too high in your water heater.

viii- Solar water heating systems, which use liquids as heat-transfer fluids, need protection from freezing in climates where temperatures fall below 42ºF (6ºC).

ix- Overheating occurs when there is little hot water use in the home but the sun continues to heat the water. The controller will turn the pump off when the solar storage tank hits an upper limit (default 180ºF but often set lower to prevent scaling).

x- Draining the fluid back into a drain-back tank can avoid this damage to the fluid caused by overheating.

xi- Solar water heating systems that use an antifreeze solution as a heat-transfer fluid have effective freeze protection as long as the proper antifreeze concentration is maintained. Antifreeze fluids degrade over time and normally should be changed every 3–5 years.

xii- A pressure gauge is used as a diagnostic tool to monitor the state of the glycol charge. A loss of pressure indicates a leak in the system that needs to be located and repaired.

xiii- Scaling can be avoided by using water softeners or by circulating a mild acidic solution (such as vinegar) through the collector or domestic hot water loop every 3–5 years, or as necessary depending on water conditions.

xiv- Oxygen entering into an open loop hydronic solar system will cause rust in any iron or steel component.

EXERCISE

Q-1. Tick (✓) the correct option for the following MCQs.

i- Antifreeze solutions (antifreeze agents with water) are used as coolants in freezing climates to:

(A) Increase boiling point of water (B) Decrease boiling point of water

(C) Increase freezing point of water (D) Decrease freezing point of water

ii. Upper limit in solar storage tank is often set lower than default temperature of 180ºC to prevent:

(A) Scaling (B) Corrosion

(C) Freezing (D) All of these

iii- The equipment should be examined/ tested at least:

Workers must be protected by a standard railing when exposed to fall hazards of ------ or more.

(A) 4 feet (B) 6 feet

(C) 8 feet (D) 10 feet

iv- Antifreeze fluids degrade over time and normally should be changed after every

(A) 1–2 years (B) 2–3 years

(C) 3–5 years (D) After 5 years

v- Solar water heating systems, which use liquids as heat-transfer fluids, need protection from freezing in climates where temperatures fall below:

(A) 42ºF (6ºC) (B) 46ºF (8ºC)

(C) 50ºF (10ºC) (D) 54ºF (12ºC)

vi- Liquid used as antifreeze solution on solar water heater is:

(A) Water (B) Ethylene Glycol

(C) Propylene Glycol (D) None of these

vii. PT valve will automatically open the drain to release the pressure and reduce the temperature, when the pressure of the water tank reaches: 6 bar

(A) 4 bar (B) 6 bar

(C) 8 bar (D) 10 bar

Give short answer to the following questions.

i- How the blackened collector plate is cleaned after unpacking collector.

ii- What is a temperature pressure relief valve?

iii- Define temperature gauge.

iv- How corrosion is removed in SWH system?

v- What is preventive maintenance?

vi- Define collector soiling.

vii- Enlist some installation hazards.

viii- What are maintenance hazards?

Answer the following questions in detail.

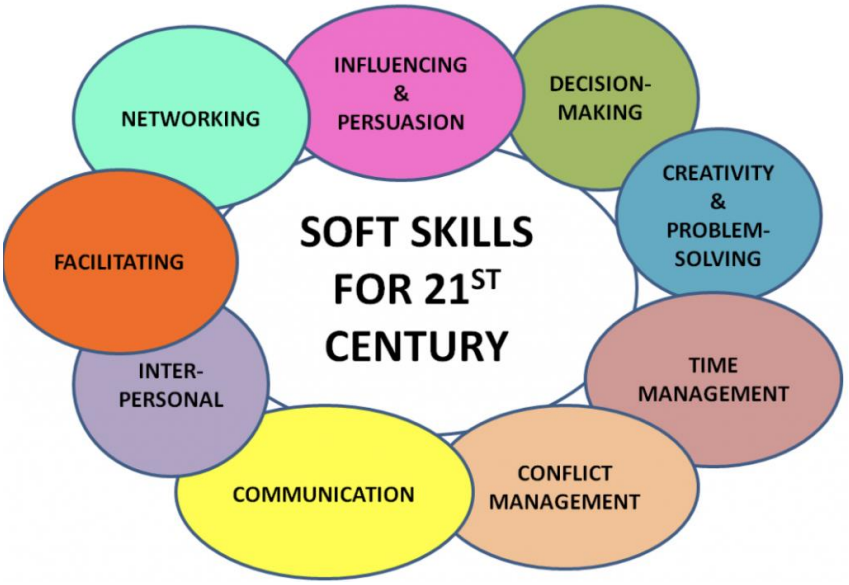
i- Explain scaling and corrosion in SWH system.

ii- What are some of preventive maintenance activities in SWH system?

iii- Briefly explain installation and maintenance hazards in SWH system.

CHAPTER -07

SOFT SKILLS



After studying this chapter students will be able to:

- know the basic soft skills.
- understand the importance of soft skills in daily life.
- apply soft skills for academic and professional success.
- learn the personal and professional aspects of life.
- understand the importance of self-image.
- develop self-confidence.
- know model of communication.
- realize importance of active listening and responding.
- understand effective communication.
- identify obstacles in communication.
- know the importance of teamwork in a professional environment.
- understand the concept of teamwork and leadership.
- know the concept of better time management.
- observe time management in daily life
- understand professional and personal time management.
- understand guidelines of attention to details.
- understand the advantages of attention to detail in work and studies.
- give attention to details to perform their tasks in an effective manner.
- learn the concepts of attitude and behaviour.
- understand the impact of positive and negative attitude in daily life.

7.1: Introduction to Soft Skills

7.1.1- Basics of Soft Skills

A skill refers to an area of expertise or an ability to do something well within a defined amount of time, energy, or both. It is the power to use one's knowledge and competencies effectively in execution or performance.

There are broadly two types of skills that are

- Hard skills and
- Soft skills.

Hard skills

Hard skills are those that are measurable and can be taught. In day-to-day parlance, hard skills are also known as technical skills.

Examples

Some common examples of hard skills would include industry-specific knowledge or certification, computer skills, bookkeeping, coding ability, analytical skills, presentation skills, and so on.

People generally acquire hard skills through education, practice, and repeating a type of work, i.e., performing everyday tasks over and over again.

1. Soft skills

On the opposite hand, soft skills are interpersonal skills. They refer to a personality trait or a habit. Unlike hard or technical skills, which are more about the knowledge that an individual has, these skills are about behavioral aspects of a person. They are mostly self-developed and do not require any training.

Examples

Common examples of soft skills include communication, leadership, negotiation, problem-solving, critical thinking, teamwork, and so on.

Although hard skills are important and relevant in specific businesses and industries, soft skills are required in all of them and an imperative requirement sought after by all organizations and a must-have in every individual.

Do you know?

"Soft Skills" are your human, personal and social skills; they directly refer to your emotional intelligence.

Common types of soft skills

The most common skills that are mostly required in all organizations are as follows.

- **Communication–** is a skill that is most important in a professional set-up. It refers to the ability to speak effectively to others in different situations. This skill includes confidence, active listening, clarity, empathy, and patience.
- **Teamwork–** people have to achieve a common organization's goal and objective in every workplace. This requires teamwork. It is a soft skill to ensure that people can work well together with minimal workplace conflict. It is also about the team leader's ability to resolve any conflict by using this skill of teamwork.
- **Problem-solving–** is a skill to resolve issues quickly and efficiently. Problem-solving is a subset of effective teamwork. This skill refers to an ability to find a long-term solution to a problem in the organization's best interest and that of people's interest
- **Critical thinking–** is a quality to think rationally and logically. This skill is imperative for problem-solving and decision-making.
- **Negotiation–** is an important skill. Negotiations happen at every workplace, among co-workers, different departments, between organization and clients, and in many other types of interactions. Negotiation skill is the quality of bringing two or more parties to a compromise. It includes abilities like those of communication and persuasion.
- **Leadership–** this skill is a determinant to assess the individual's capability to work independently and with the teams. Leadership is a mix of all of the above soft skills and hence reflecting this skill in the trait opens up the doors of success and vertical movement of a person in an organization.

The workplace is ever-changing. Different skills or a combination of these are required to be put into practice from time to time to function effectively at work. The list of soft skills is long, and there are many other skills that employers demand these days. These include time management, work ethic, adaptability and flexibility, work ethic, integrity, just to name a few more.

7.1.2- Importance of Soft Skills in Daily Life

Soft skills are indispensable and are key skills that every individual must possess. Lack of these skills can limit the potential of a person. However, having soft skills improve one's ability to work with others and to have a positive impact on furthering one's career or even positively influencing one's personal life by improving ways of interacting with others.

Soft skills cannot be learned through training and are more challenging to develop.

They are more about the character, relationships, and personality of a person. The world is changing fast. With the onset of artificial intelligence in almost every field of work, machines are replacing and automating tasks that humans once performed.

However, there is no substitute for soft skills. Hence, these become a differentiator for a job seeker to fit himself in the fast-changing job market landscape and meet the hiring requirements of any organization. So, human-centric skills are becoming essential due to this change. From an

organization's perspective, hiring employees with advanced soft skills can significantly impact their working capability.

Why are soft skills important in the workplace?

- The modern workplace is interpersonal.

Collaborations are an integral component of any workplace. Skills such as listening and writing ensure that there is a smooth flow of ideas without any conflicts. This creates a productive and healthy work environment.

- Soft skills set you apart.

Good communication and negotiation skills can help you gain an edge over other candidates. Hard skills can be learnt in a limited time but these skills are harder and take longer to develop, since they depend more on your nature rather than knowledge level. Having these skills can help you deal with challenges in the workplace.

- Soft skills complement hard skills.

Technical skills aren't enough to bring out your best in a job. All careers require soft skills to utilize technical expertise at the right time and place. For example, if an executive is trying to close a deal with a customer, they will need sales knowledge along with excellent communication skills.

- Future workplaces will depend more on these skills.

With advancements in technology, many technical jobs are beginning to be outsourced to automation and artificial intelligence (AI). This will result in more jobs relying on soft skills to be the key differentiators in a workplace.

7.1.3- Application of Soft Skills for Academic & Professional Success

Academic and career success requires soft skills as well as "book-smarts." Soft skills are defined as "a collection of abilities, behaviours, and attitudes that increase your effectiveness." Successful students demonstrate soft skills such as commitment, effective communication, problem solving, accountability, and time management.

Employers also place a high value on soft skills. Despite the importance of soft skills, employers commonly report them lacking in new hires. Two important points are common. First, soft skills are valued in the workplace. Secondly, many recent graduates are better prepared for the technical aspects of their jobs than for the "softer" aspects.

Students can enhance academic performance now and equip themselves for future academic and career success by sharpening their leadership and soft skills. Soft skills are presented within a framework of **R**eadiness, **R**elationships, and **R**esults. In this Readiness prepares you to handle whatever comes your way. If you are not ready to take advantage of opportunities or handle occasional setbacks, you will not make much progress in your education and career. To be ready, you must know yourself, be positive, commit to life balance and lifelong learning, and keep things in the proper context.

1. Know Yourself

We each have skills, abilities, and perspectives that allow us to make unique contributions. The better you recognize your strengths and your unique ability to make a difference, the readier you will be to leverage your opportunities.

Take some time to determine your strengths. Find a book or online resource to help. Contact your advisor to identify resources at your school. As you develop an understanding of your strengths, leverage them! If you have strengths in communication, write for your school's blog, start your own blog, or enter a public speaking competition.

2. Be Positive

Attitude is a critically important component of Readiness. Your attitude has a great influence on your relationships, productivity, and happiness. Conversely, the wrong attitude can damage your relationships and undermine your skills. Remember that you can control your attitude even when you can't control your circumstances.

Furthermore, a positive attitude will help you overcome the setbacks and struggles you will encounter. When you come up short, learn from the experience, and move on. Believe you will succeed and that you can move past setbacks.

3. Commit to Life Balance and Lifelong Learning

Readiness requires a commitment to life balance and lifelong learning. Life balance is achieved when you spend quality time in each of the important areas of your life. Long-term success and happiness will be difficult to achieve if your life is out of balance.

Keep track of your time over the next 20-30 days. Are you investing time in the most important aspects in your life? Are you investing time now in activities that contribute positively to your future? If not, reflect on your current activities and make the needed changes.

Look for opportunities to learn throughout your life. You are preparing to address issues and work in a career that will continuously evolve. Continuously enhance your leadership and soft skills, as well as your technical/hard skills, to stay competitive. Step up to a leadership position in a student organization, lead a volunteer project in your community, and complete an internship or two in college to enhance your skills.

4. Keep Things in the Proper Context

Readiness requires you to keep things in context to prevent you from getting so caught up in what you are doing that you lose sight of your overall goals. If you lose sight, you can burn out and want to give up. Keep focused on your big goals while working on the small, and occasionally tedious, steps needed to reach your goal.

Students who lose sight of their educational goals can become disillusioned and unmotivated. If you find yourself struggling, remember that your classes, tests, and assignments are necessary steps in your education journey. Keep your focus on your educational goals, and don't get discouraged.

Maintaining the proper context also contributes to your positive attitude and keeps you motivated after a loss or setback. Don't lose sight of the big picture of your life when you come up short, and don't let a setback derail your overall progress.

Readiness focuses on you. In the next article, we will discuss Relationships, which focus on your ability to build productive connections and work effectively with family, friends, and team mates. By applying what you learned in Readiness, you will be more effective in your Relationships.

Activity-7.1 Group discussion and model presentation on soft skills

The teacher/ instructor is required to make the groups of students to have group discussion about soft skills and make model presentation on them.

7.2 Personal and Professional Aspect of life

7.2.1- Personal and Professional Aspect of life

Personal life is a course or state of an individual's life, especially when viewed as the sum of persinal choices contributing to one's personal identity. People iidentified with the social role in their community and engaged in activities based on necessary rather than on personal choice.
Professional life is a career in industrial or commercial or professional activities.
Following principles can be applied equally to both personal and professional endeavours.

Principle 1: The Art of Pursuit

Effective pursuit is about observation, assessment, and calibration.
Any good pursuit begins with doing your homework. You must know your goals and standards before you can hope to live up to them. For example, if you see a company you want to work for, learn as much as you possibly can about the company's history, current status, and future goals. This knowledge will give you credibility as you engage with the company and its network.

Principle 2: The Impact of Energy

Confidence is the closest thing in this world to magic.
The human brain is amazing. Its complexity and magnificence is unquestioned in science and religion alike; it synthesizes complex information and seemingly unseen cues to make dozens of decisions each instant without any awareness from us. These unconscious interpretations made by one human brain, in turn, become unconscious signals which impact the awareness and brains of others around them, setting off profound but nearly invisible domino reactions in every human exchange.

Principle 3: The Wisdom of Surrender.

Never use the good to chase the bad.
Take time to re-evaluate every so often, not only on how you are making progress on achieving your goal, but also whether your goal is worth the long-term investment.
During the first few weeks and months of any new engagement, the first months of a new job, a new client, or a budding romance, it's critical to stay aware of your larger-scale needs and goals.

Principle 4: Be the Driver of your Success.

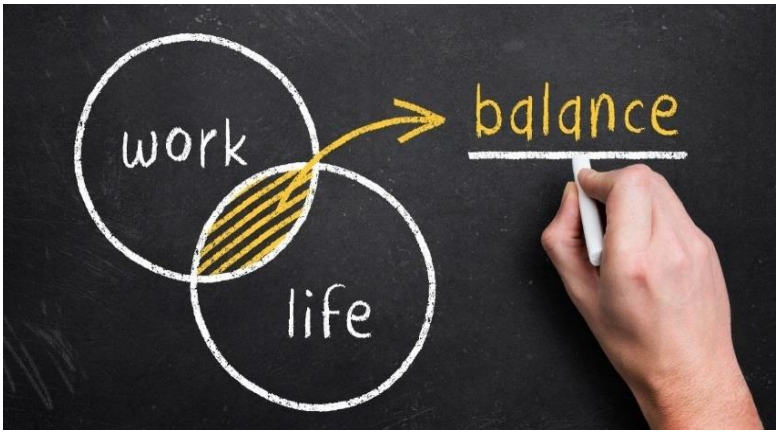
To achieve success in personal and work relationships, define what success is. Then, bend the world to match that definition.
Set measurable, transparent, and, more importantly, agreed-upon goals for the relationship. You must be able to define and articulate what happiness or success would be, so that all parties are

moving toward a common place. Any relationship without clear, on-going communication from each party is doomed to never achieving it. It is crucial to express to one another and understand one another's expectations, needs, and definitions of success in the relationship.

Principle 5: You Get What You Give.

In a highly interconnected world, the foundation you build today will define your success tomorrow.

Look for ways to provide value to everyone you can on a daily basis. These actions, if consistent become behaviours which are highly desirable and never go unnoticed forever. People who create value for others accumulate goodwill and respectability. That goodwill and respectability translates to introductions, which build your network over time. Your network, in turn, opens the door for introductions and opportunities for you to pursue.



7.2.2- Importance of self-image:

Self-image is the personal view, or mental picture, that we have of ourselves. Self-image is an "internal dictionary" that describes the characteristics of the self, including such things as intelligent, beautiful, ugly, talented, selfish, and kind. These characteristics form a collective representation of our assets (strengths) and liabilities (weaknesses) as we see them.

How is self-image developed?

Self-image is a product of learning. Early childhood influences, such as parents and caregivers, have a major influence on our self-image. They are mirrors reflecting back to us an image of ourselves. Our experiences with others such as teachers, friends, and family add to the image in the mirror. Relationships reinforce what we think and feel about ourselves.

The image we see in the mirror may be a real or distorted view of who we really are. Based on this view, we develop either a positive or a negative self-image. The strengths and weaknesses we have adopted affect how we act today. We continually take in information and evaluate ourselves in several areas, such as physical appearance (How do I look?), performance (How am I doing?), and relationships (How important am I?).

With a positive self-image, we recognize and own our assets and potentials while being realistic about our liabilities and limitations. With a negative self-image, we focus on our faults and weaknesses, distorting failure and imperfections.

Self-image is important because how we think about ourselves affects how we feel about ourselves and how we interact with others and the world around us. A positive self-image can

boost our physical, mental, social, emotional, and spiritual well-being. On the other hand, a negative self-image can decrease our satisfaction and ability to function in these areas.

How can we create a positive self-image?

Self-image is not permanently fixed. Part of our self-image is dynamic and changing. We can learn to develop a healthier and more accurate view of ourselves, thus challenging the distortions in the mirror. Self-image change occurs over a lifetime. A healthy self-image starts with learning to accept and love ourselves. It also means being accepted and loved by others.

7.2.3- Development of Self-Confidence

Self-confidence is an attitude about your skills and abilities. It means you accept and trust yourself and have a sense of control in your life. You know your strengths and weakness well, and have a positive view of yourself. You set realistic expectations and goals, communicate assertively, and can handle criticism.

On the other hand, low self-confidence might make you feel full of self-doubt, be passive or submissive, or have difficulty trusting others. You may feel inferior, unloved, or be sensitive to criticism. Feeling confident in yourself might depend on the situation. For instance, you can feel very confident in some areas, such as academics, but lack confidence in others, like relationships. Having high or low self-confidence is rarely related to your actual abilities, and mostly based on your perceptions. Perceptions are the way your think about yourself and these thoughts can be flawed.

Low self-confidence might stem from different experiences, such as growing up in an unsupportive and critical environment, being separated from your friends or family for the first time, judging you too harshly, or being afraid of failure. People with low self-confidence often have errors in their thinking.

Self-esteem is a fairly stable trait that doesn’t change much in individuals—unless they put in some dedicated effort to improve it. It can generally be defined as our beliefs in our own inherent value, worth, and how deserving we are of love, happiness, success, and other good things in life. By contrast, self-confidence does not take into consideration any beliefs about the worthiness or overall value; rather, it focuses on the ability to succeed and beliefs about one’s likelihood of succeeding.

How to Increase Your Self-Confidence

- Recognize and emphasize your strengths. Reward and praise yourself for your efforts and progress.
- When you stumble on an obstacle, treat yourself with kindness and compassion. Don't dwell on failure.
- Set realistic and achievable goals. Do not expect perfection; it is impossible to be perfect in every aspect of life.
- Slow down when you are feeling intense emotions and think logically about the situation.
- Challenge making assumptions about yourself, people and situations.
- Recognize that past negative life experiences do not dictate your future.

- Express your feelings, beliefs and needs directly and respectfully
- Learn to say no to unreasonable requests.

Activity-7.2 Role play to enhance self-awareness, self-confidence and self-image

The teacher/ instructor is required to involve the students in role playing to enhance self-awareness, self-confidence and self-image.

7.7 Interpersonal and Communication Skills

7.3.1- Communication Model

Human beings communicate. So do animals, birds and even insects. We have examples of such communication in the chirping of birds, their warning calls at the approach of danger; apes cries expressing anger, pleasure, fear; honey bee communication, such as the queen bee‘s figure 8 type dance inside the hive to teach the rest of the bees about the direction and distance of the nectar; a dog‘s response to the ringing of the doorbell at different times.

However, the special qualities specific to human beings separate the human world from the animal kingdom. That is why human communication differs from animal communication.

For our purpose of study, we will restrict ourselves to human communication and the technical means used. A good starting point is recognition of the fact that man is a social animal who prefers to live in society. He is, in fact, born with the capacity to communicate – he simply cannot isolate himself. He feels the need all the time to express himself and share his ideas with others. And this attempt, we see even in the case of an infant who communicates his needs by cooing, crying, smiling etc. Man‘s very survival depends on communication. This is because, as a member of society, a human being is dependent on others and has to take help from others.

The Word ‘Communication’: Its Origin and Meaning:

The English word ‘communication comes from the Latin word, ***‘Communicare*** which means ***to impart or participate or to transmit***. The word ‘Communicare is derived from the root ‘Communis which means ***to make common or to share***.

So, communication is

i) the activity or process of sharing or exchanging ideas, feelings, information, experience between two or more persons;
ii) an act or instance of transmitting;
iii) the information actually communicated by some means.

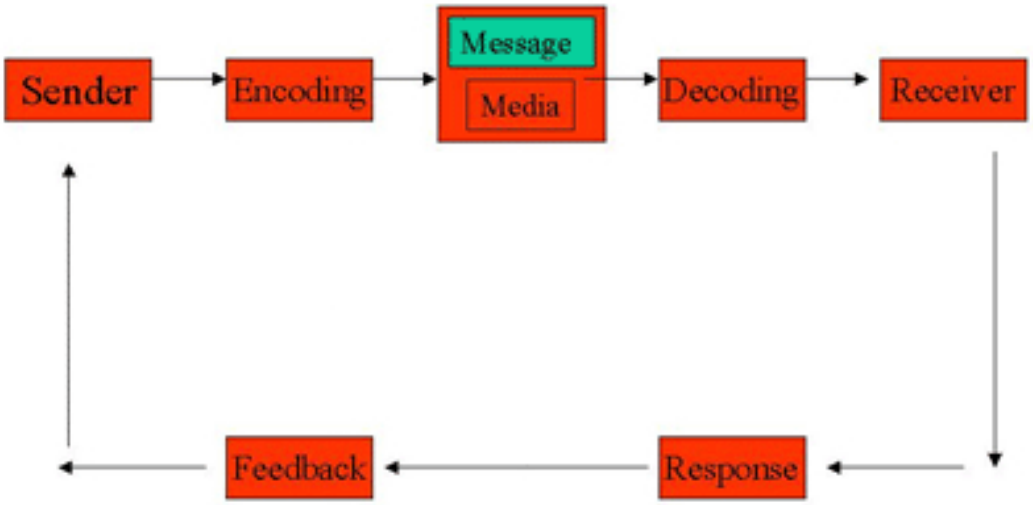
Communication occurs all the time. In fact, it is an ongoing activity. For example,

- interaction between the members of a family, friends, relatives;
- communication through letters, telegrams, telephone;
- stopping one’s vehicle at the red signal and starting it at the green signal;
- response given to the ringing of the bell by the students in a school.

It is clear, then that communication may be either verbal or nonverbal.

Communication is a process of exchanging verbal and non-verbal messages. It is a continuous process. Pre-requisite of communication is a message. This message must be conveyed through

some medium to the recipient. It is essential that this message must be understood by the recipient in same terms as intended by the sender. He must respond within a time frame. Thus, communication is a two-way process and is incomplete without feedback from the recipient to the sender on how well the message is understood by him.



Communication Process

The main components of communication process are as follows:

1. **Context -** Communication is affected by the context in which it takes place. This context may be physical, social, chronological or cultural. Every communication proceeds with context. The sender chooses the message to communicate within a context.
2. **Sender / Encoder -** Sender / Encoder is a person who sends the message. A sender makes use of symbols (words or graphic or visual aids) to convey the message and produce the required response. For instance - a training manager conducting training for new batch of employees. Sender may be an individual or a group or an organization. The views, background, approach, skills, competencies, and knowledge of the sender have a great impact on the message. The verbal and non-verbal symbols chosen are essential in ascertaining interpretation of the message by the recipient in the same terms as intended by the sender.
3. **Message -** Message is a key idea that the sender wants to communicate. It is a sign that elicits the response of recipient. Communication process begins with deciding about the message to be conveyed. It must be ensured that the main objective of the message is clear.
4. **Medium -** Medium is a means used to exchange / transmit the message. The sender must choose an appropriate medium for transmitting the message else the message might not be conveyed to the desired recipients. The choice of appropriate medium of communication is essential for making the message effective and correctly interpreted by the recipient. This choice of communication medium varies depending upon the features of communication. For instance - Written medium is chosen when a message has to be

conveyed to a small group of people, while an oral medium is chosen when spontaneous feedback is required from the recipient as misunderstandings are cleared then and there.

5. **Recipient / Decoder -** Recipient / Decoder is a person for whom the message is intended / aimed / targeted. The degree to which the decoder understands the message is dependent upon various factors such as knowledge of recipient, their responsiveness to the message, and the reliance of encoder on decoder.
6. **Feedback -** Feedback is the main component of communication process as it permits the sender to analyse the efficacy of the message. It helps the sender in confirming the correct interpretation of message by the decoder. Feedback may be verbal (through words) or non-verbal (in form of smiles, sighs, etc.). It may take written form also in form of memos, reports, etc.

7.3.2- Importance of Active Listening and Responding

Listening is the ability to accurately receive and interpret messages in the communication process. Listening is key to all effective communication, without the ability to listen effectively messages are easily misunderstood – communication breaks down and the sender of the message can easily become frustrated or irritated.

Did you know, people spend between 70%-80% of their day engaged in some form of communication, and about 45% is spent in listening compared to 30% speaking, 16% reading and 9% writing? But the question is, do they actively listen?

'Active listening' is the term first coined by psychologists, Carl Rogers and Richard Farson in 1957 in a paper of the same title.

They write;

'Active listening is an important way to bring about changes in people. They indicate how clinical and research evidence clearly shows it as one of the most effective agents for individual personality change and group development. And also how active listening brings changes in peoples' attitudes toward themselves and others; shaping their basic values and personal philosophy'.

The Importance of Active Listening in the Workplace

1. Building Trust

You and your employees are happy when you meet each other's respective goals. For an employer, it is the organizational success and for the employees, it is the tasks and objectives they are assigned to complete. It is, therefore, very vital to have trust in each other for a healthy work experience.

We are aware of the fact that to build trust; we must tick the following:

- To lend an ear.
- To be honest and supportive.
- To be non-judgmental.
- To have healthy communication.

To tick these points, one must have an understanding, which can be developed by active listening. This will help align your words and actions and help build trust.
Encourage the speaker, ask questions, and be considerate.

2. Productivity

Active listening has countless benefits when it comes to employee productivity.
When higher management does not hear the employees' views and ideas, it fuels employees' resentment and lowers productivity. Proper feedback and actively considering the employees' views and ideas are vital for a healthy workplace and performance. Having said that, it is also important to assure that the internal communication is solid, only then they can develop a culture of mutual trust and understanding. It is always a two-way process.

3. Resolves Conflicts

Conflicts and mishaps are inevitable in any workplace. The reasons for this can vary from a minor misunderstanding or a major debacle.
Misunderstandings, different viewpoints, or a lack of recognition often create conflicts in the workplace. There is nothing good communication cannot resolve. Here when I say 'good communication', I mean active listening.
Often, we fail to understand or respect other's views because we never see things from their perspectives. Our sense of self-righteousness also interferes here. Active listening helps in recognizing other's perspectives and feelings and helps us appreciate them. This not only helps in resolving conflicts but also helps foster a culture of respect.

4. Strong Work Relationship

It is important to form a healthy work relationships in the workplace for healthy work experience. A study conducted by Faye Doell in 2003 showed that there are two types of listening: 'listening to understand' and 'listening to respond.'
People who listen to understand form better relationships and are more empathetic in their approach. The same holds for work relationships. The more members in a workplace follow this approach, the better work relationships they form.

5. Self-Empowerment

Self-empowerment helps you build your confidence and let go of your agendas. When you practice active listening and understand what is beneficial for you in the workplace, you expand your perspective in that direction and empower yourself. You become more aware of your work environment, and you communicate with your peers and members of the organization with much ease and confidence.

6. Acceptance

Every company has its own company culture and each member adds value to it. The root of this culture starts with acceptance. Yes! Acceptance of its values and vision by all its members.
For an organization to succeed, both its employers and employees must be aligned with the common goal. Therefore, they need to accept each other for their respective parts and actively listen to each other while carrying out their work duties.

And also, in the onboarding process of new employees, management must listen to their feedback and views on different aspects of the organization. This minimizes confusion and gives a sense of acceptance to them. Active listening can, therefore, be a great morale booster.

7.3.3- Effective Communication:

In today's competitive world, a good writing must engage a reader. Whether it is a proposal or a resume, the reader must feel involved in the write-up.

Read on to get tips on how to write better while applying for a job or for a business....

1. **Start with something interesting:** In today's market scenario where several resumes are lying at the desk, why does a particular resume gets picked than the others in the lot? Thinking... It is because the resume has a cover letter / introductory note that make it saleable. A summary of a candidate's profile is always better than a simply stated one line objective which merely talks about a candidate's aspiration and does not tell about his / her profile summary.
2. **Add a personal touch:** While writing to potential clients for business, ensure that the content is customized as per the client's profile and requirement. This helps creating a special bond with the reader.
3. **Give examples and not just adjectives:** A candidate must mention a relevant example to demonstrate or justify the adjectives included in the resume. For instance, if he / she talks about his strength in area of team management, he / she should mention an example on how well a team was handled. Avoid giving micro level details, however, mention about achievements / recognitions.
4. **Leverage numbers:** A candidate must back-up achievements / adjectives stated with numbers. Same goes for the corporate looking for business. Numbers form a strong base for generating commitment. A percentage movement showing improvement in performance or scores always catches attention of the readers.
5. **Avoid jargons:** If a candidate is applying in a completely different industry than the one, he has worked before in, he should avoid / not use jargons which are not relevant to the new industry. Jargons tend to confuse people and there is a possibility of the message being lost. In case a jargon is to be used, the expanded form should also be mentioned. For instance, a jargon EMS should be written in a statement as "Employee Measurement System [EMS]".
6. **Do not misrepresent data:** Write with integrity. Whether it is numbers or years of experience or sales volume - all facts stated should be true.
7. **Communication Skills:** Ensure that the document is error free - no spelling or grammatical mistake. Always proof read the document / proposal or get it read by a friend / colleague.
8. **Follow-up:** Most of the times a candidate submits a resume or a proposal to a prospective client and does not follow-up. Remember, there are several other resumes and proposals which are lying at the desk. A candidate needs to ensure that a prompt follow-up [read "not too much"] should be done.

7.3.4- Obstacles in Communication

Communication is a process beginning with a sender who encodes the message and passes it through some channel to the receiver who decodes the message. Communication is fruitful if and only if the messages sent by the sender are interpreted with same meaning by the receiver. If any kind of disturbance blocks any step of communication, the message will be destroyed. Due to such disturbances, managers in an organization face severe problems. Thus, the managers must locate such barriers and take steps to get rid of them.

There are several barriers that affect the flow of communication in an organization. These barriers interrupt the flow of communication from the sender to the receiver, thus making communication ineffective. It is essential for managers to overcome these barriers. The main barriers of communication are summarized below.

Following are the main communication barriers:

1. **Perceptual and Language Differences:** Perception is generally how each individual interprets the world around him. All generally want to receive messages which are significant to them. But any message which is against their values is not accepted. A same event may be taken differently by different individuals. For example: A person is on leave for a month due to personal reasons (family member being critical). The HR Manager might be in confusion whether to retain that employee or not, the immediate manager might think of replacement because his team's productivity is being hampered, the family members might take him as an emotional support.

The linguistic differences also lead to communication breakdown. Same word may mean different to different individuals. For example: consider a word "value".

   a. What is the **value** of this Laptop?
   b. I **value** our relation?
   c. What is the **value** of learning technical skills?

"**Value**" means different in different sentences. Communication breakdown occurs if there is wrong perception by the receiver.

2. **Information Overload:** Managers are surrounded with a pool of information. It is essential to control this information flow else the information is likely to be misinterpreted or forgotten or overlooked. As a result, communication is less effective.
3. **Inattention:** At times we just not listen, but only hear. For example, a traveller may pay attention to one "NO PARKING" sign, but if such sign is put all over the city, he no longer listens to it. Thus, repetitive messages should be ignored for effective communication. Similarly, if a superior is engrossed in his paper work and his subordinate explains him his problem, the superior may not get what he is saying and it leads to disappointment of subordinate.
4. **Time Pressures:** Often in organization the targets have to be achieved within a specified time period, the failure of which has adverse consequences. In a haste to meet deadlines, the formal channels of communication are shortened, or messages are partially given, i.e., not

completely transferred. Thus, sufficient time should be given for effective communication.

5. **Distraction/Noise:** Communication is also affected a lot by noise to distractions. Physical distractions are also there such as, poor lightning, uncomfortable sitting, unhygienic room also affects communication in a meeting. Similarly, use of loud speakers interferes with communication.
6. **Emotions:** Emotional state at a particular point of time also affects communication. If the receiver feels that communicator is angry, he interprets that the information being sent is very bad. While he takes it differently if the communicator is happy and jovial (in that case the message is interpreted to be good and interesting).
7. **Complexity in Organizational Structure:** Greater the hierarchy in an organization (i.e., more the number of managerial levels), more is the chances of communication getting destroyed. Only the people at the top level can see the overall picture while the people at low level just have knowledge about their own area and a little knowledge about other areas.
8. **Poor retention:** Human memory cannot function beyond a limit. One cannot always retain what is being told specially if he is not interested or not attentive. This leads to communication breakdown.

There is a lot of communication barriers faced these days by all. The message intended by the sender is not understood by the receiver in the same terms and sense and thus communication breakdown occurs. It is essential to deal and cope up with these communication barriers so as to ensure smooth and effective communication.

As, in the previous section we have discussed the major barriers of communication. Let's talk about **how to overcome these barriers of communication**.

1. **Eliminating differences in perception:** The organization should ensure that it is recruiting right individuals on the job. It's the responsibility of the interviewer to ensure that the interviewee has command over the written and spoken language. There should be proper Induction program so that the policies of the company are clear to all the employees. There should be proper trainings conducted for required employees (for eg: Voice and Accent training).
2. **Use of Simple Language:** Use of simple and clear words should be emphasized. Use of ambiguous words and jargons should be avoided.
3. **Reduction and elimination of noise levels:** Noise is the main communication barrier which must be overcome on priority basis. It is essential to identify the source of noise and then eliminate that source.
4. **Active Listening:** Listen attentively and carefully. There is a difference between "listening" and "hearing". Active listening means hearing with proper understanding of the message that is heard. By asking questions the speaker can ensure whether his/her message is understood or not by the receiver in the same terms as intended by the speaker.
5. **Emotional State:** During communication one should make effective use of body language. He/she should not show their emotions while communication as the receiver might

misinterpret the message being delivered. For example, if the conveyer of the message is in a bad mood, then the receiver might think that the information being delivered is not good.

6. **Simple Organizational Structure:** The organizational structure should not be complex. The number of hierarchical levels should be optimum. There should be a ideal span of control within the organization. Simpler the organizational structure, more effective will be the communication.
7. **Avoid Information Overload:** The managers should know how to prioritize their work. They should not overload themselves with the work. They should spend quality time with their subordinates and should listen to their problems and feedbacks actively.
8. **Give Constructive Feedback:** Avoid giving negative feedback. The contents of the feedback might be negative, but it should be delivered constructively. Constructive feedback will lead to effective communication between the superior and subordinate.
9. **Proper Media Selection:** The managers should properly select the medium of communication. Simple messages should be conveyed orally, like: face to face interaction or meetings. Use of written means of communication should be encouraged for delivering complex messages. For significant messages reminders can be given by using written means of communication such as : Memos, Notices etc.
10. **Flexibility in meeting the targets:** For effective communication in an organization the managers should ensure that the individuals are meeting their targets timely without skipping the formal channels of communication. There should not be much pressure on employees to meet their targets.

Activity-7.3 Role play

The teacher/ instructor is required to demonstrate the students about group exercise through listening audio or video documentaries.

Activity-7.4 Dialogue

The teacher/ instructor is required to demonstrate the students about dialogue among students to reflect verbal and non-verbal communication

7.4 Team Work and Leadership

7.4.1-Importance of Team Work in Professional Environment

Teamwork, at its simplest, is the process of collaborating and working together in a group to achieve a common goal. When a group of people works cooperatively, they're combining each of their personal strengths to enhance their overall performance of the team.

In the process, they're creating a positive atmosphere of encouraging and motivating each other. Good teamwork brings forth a variety of viewpoints, experiences, and skills.

However, teamwork is much more than achieving common goals. It's also about skills that are essential to your personal and professional lives. Teamwork skills are qualities that allow you to work effectively with others. You're better equipped for collaborative assignments like projects and meetings.

At various points in life, one is required to work alongside others. It may be school teachers assigning group projects or managers putting several employees in charge of one assignment.

Teamwork will follow wherever you go. Learning about teamwork importance is therefore vital. Deeper work relationships lead to new and lasting opportunities. Efficient teamwork can help you strengthen your resume and that'll lead to well-rounded personal development.

7.4.2- Concept of Team Work and Leadership

Teamwork

Teams are a form of a group normally dedicated to production or problem solving. Teams can often achieve higher levels of performance than individuals because of the combined energies and talents of the members.

Collaboration can produce motivation and creativity that may not be present in single-contractor projects. Individuals also have a sense of belonging to the group, and the range of views and diversity can energize the process, helping address creative blocks and stalemates. By involving members of the team in decision-making, and calling upon each member's area of contribution, teams can produce positive results.

Teamwork is not without its challenges. The work itself may prove a challenge as members juggle competing assignments and personal commitments. The work may also be compromised if team members are expected to conform and pressured to go along with a procedure, plan, or product that they themselves have not developed. Groupthink, or the tendency to accept the group's ideas and actions in spite of individual concerns, can also compromise the process and reduce efficiency. Personalities and competition can play a role in a team's failure to produce.

We can recognize that people want to belong to a successful team, and celebrating incremental gain can focus the attention on the project and its goals. Members will be more willing to express thoughts and opinions, and follow through with actions, when they perceive that they are an important part of the team. By failing to include all the team members, valuable insights may be lost in the rush to judgment or production. Making time for planning, and giving each member time to study, reflect, and contribute can allow them to gain valuable insights from each other, and may make them more likely to contribute information that challenges the status quo.

Unconventional or "devil's advocate" thinking may prove insightful and serve to challenge the process in a positive way, improving the production of the team. Respect for divergent views can encourage open discussion.

John Thill and Courtland Bovee (2002) provide a valuable list to consider when setting up a team as follows:

- Select team members wisely
- Select a responsible leader
- Promote cooperation
- Clarify goals
- Elicit commitment
- Clarify responsibilities
- Instill prompt action
- Apply technology
- Ensure technological compatibility
- Provide prompt feedback

Group dynamics involve the interactions and processes of a team and influence the degree to which members feel a part of the goal and mission. A team with a strong identity can prove to be a powerful force, but it requires time and commitment. A team that exerts too much control over individual members can run the risk of reducing creative interactions and encourage tunnel vision. A team that exerts too little control, with attention to process and areas of specific responsibility, may not be productive. The balance between motivation and encouragement, and control and influence, is challenging as team members represent diverse viewpoints and approaches to the problem. A skilled business communicator creates a positive team by first selecting members based on their areas of skill and expertise, but attention to their style of communication is also warranted. Individuals that typically work alone or tend to be introverted may need additional encouragement to participate. Extroverts may need to be encouraged to listen to others and not dominate the conversation.

Leadership

Leadership is one of the most studied aspects of group communication. Scholars in business, communication, psychology, and many other fields have written extensively about the qualities of leaders, theories of leadership, and how to build leadership skills. It's important to point out that although a group may have only one official leader, other group members play important leadership roles. Making this distinction also helps us differentiate between leaders and leadership (Hargie, 2011). The leader is a group role that is associated with a high-status position and may be formally or informally recognized by group members. Leadership is a complex of beliefs, communication patterns, and behaviours that influence the functioning of a group and move a group toward the completion of its task. A person in the role of leader may provide no or poor leadership. Likewise, a person who is not recognized as a "leader" in title can provide excellent leadership.

Activity-7.5 Organization of a party

The teacher/ instructor is required to the students about organizing a welcome party/ birthday party and/ or a national event.

7.5 Time Management

7.5.1- Concept of better Time Management

It is rightly said "Time and Tide wait for none". An individual should understand the value of time for him to succeed in all aspects of life. People who waste time are the ones who fail to create an identity of their own.

What is Time Management?

- Time Management refers to managing time effectively so that the right time is allocated to the right activity.
- Effective time management allows individuals to assign specific time slots to activities as per their importance.
- Time Management refers to making the best use of time as time is always limited.

Ask yourself which activity is more important and how much time should be allocated to the same? Know which work should be done earlier and which can be done a little later.

Time Management plays a very important role not only in organizations but also in our personal lives.

Time Management includes:

i. Effective Planning
ii. Setting goals and objectives
iii. Setting deadlines
iv. Delegation of responsibilities
v. Prioritizing activities as per their importance
vi. Spending the right time on the right activity

➢ Effective Planning

Plan your day well in advance. Prepare a To Do List or a "TASK PLAN". Jot down the important activities that need to be done in a single day against the time that should be allocated to each activity. High Priority work should come on top followed by those which do not need much of your importance at the moment. Complete pending tasks one by one. Do not begin fresh work unless you have finished your previous task. Tick the ones you have already completed. Ensure you finish the tasks within the stipulated time frame.

➢ Setting Goals and Objectives

Working without goals and targets in an organization would be similar to a situation where the captain of the ship loses his way in the sea. Yes, you would be lost. Set targets for yourself and make sure they are realistic ones and achievable.

➢ Setting Deadlines

Set deadlines for yourself and strive hard to complete tasks ahead of the deadlines. Do not wait for your superiors to ask you every time. Learn to take ownership of work. One person who can

best set the deadlines is you yourself. Ask yourself how much time needs to be devoted to a particular task and for how many days. Use a planner to mark the important dates against the set deadlines.

- Delegation of Responsibilities

Learn to say "NO" at workplace. Don't do everything on your own. There are other people as well. One should not accept something which he knows is difficult for him. The roles and responsibilities must be delegated as per interest and specialization of employees for them to finish tasks within deadlines. A person who does not have knowledge about something needs more time than someone who knows the work well.

- **Prioritizing Tasks**

Prioritize the tasks as per their importance and urgency. Know the difference between important and urgent work. Identify which tasks should be done within a day, which all should be done within a month and so on. Tasks which are most important should be done earlier.

- **Spending the right time on right activity**

Develop the habit of doing the right thing at the right time. Work done at the wrong time is not of much use. Don't waste a complete day on something which can be done in an hour or so. Also keep some time separate for your personal calls or checking updates on Facebook or Twitter. After all human being is not a machine.

For Effective Time Management one needs to be:

Organized - Avoid keeping stacks of file and heaps of paper at your workstation. Throw what all you don't need. Put important documents in folders. Keep the files in their respective drawers with labels on top of each file. It saves time which goes on unnecessary searching.

Don't misuse time - Do not kill time by loitering or gossiping around. Concentrate on your work and finish assignments on time. Remember your organization is not paying you for playing games on computer or peeping into other's cubicles. First complete your work and then do whatever you feel like doing. Don't wait till the last moment.

Be Focused - One needs to be focused for effective time management.

Develop the habit of using planners, organizers, table top calendars for better time management. Set reminders on phones or your personal computers

Benefits of Time Management

Time Management refers to making the best possible use of available time.

Managing time well enables an individual to do the right thing at the right time.

Time Management plays a pivotal role in one's personal as well as professional life.

- Time Management makes an individual punctual and disciplined. One learns to work when it is actually required as a result of effective time management. To make the judicious use of time, individuals should prepare a "TASK PLAN" or a "TO DO" List at the start of the day to jot down activities which need to be done in a particular day as per their importance and urgency against the specific time slots assigned to each activity. A Task Plan gives individuals a sense of direction at the workplace. An individual knows how his day looks like and eventually works accordingly leading to an increased output.

- One becomes more organized as a result of effective Time Management. Keeping the things at their proper places minimizes the time which goes on unnecessary searching of documents, important files, folders, stationery items and so on. For better time management, individuals keep their workstations, study zones, cubicles, meeting areas clean and organized. People learn to manage things well as a result of Time Management.
- Effective Time Management boosts an individual's morale and makes him confident. As a result of Time Management, individuals accomplish tasks within the stipulated time frame, making them popular in their organization as well as amongst their peers. People who understand the value of time are the ones who manage to stand apart from the crowd. Individuals who finish off work on time are looked up to by others and are always the centre of attention everywhere.
- Individuals who stick to a time plan are the ones who realize their goals and objectives within the shortest possible time span. Managing time effectively helps employees to meet targets way ahead of deadlines and finish off task just when it is required.
- Effective Time Management helps an employee to reach the pinnacle of success quickly and stay firm at the top for a longer duration. An employee who works just for the sake of working fails to create an impression and is never taken seriously at work. Effective time management plays a pivotal role in increasing an individual's productivity. Output increases substantially when people manage their time well.
- Better Time Management helps in better planning and eventually better forecasting. Individuals learn to plan things well and know where exactly they stand five years from now.
- Research says that individuals who accomplish tasks on time are less prone to stress and anxiety. Remember there is no point in wasting time and cribbing later. Finish off pending work on time and then you would have ample time for your friends, relatives and family members.
- Time Management enables an individual to prioritize tasks and activities at workplace. It is foolish to stay overburdened. Do not accept anything and everything that comes your way.
- Time Management helps an individual to adopt a planned approach in life.

7.5.2- Time Management in Daily Life

Time Management is nothing but managing time well and doing the right thing at the right time. It is essential for individuals to allocate specific time slots to tasks as per their importance and urgency.

Time Management plays a pivotal role not only in organizations but also in an individual's personal life. Students aspiring for management courses or for that matter any professional course need to value time to reach the pinnacle of success and stay firmly entrenched at the top.

Let us go through some Time Management tips for Students:

- Set a goal for yourself. Know what you want to achieve in life. Take a pen and paper and write down where you want to see yourself five years from now. Setting an objective for yourself gives you a sense of direction.
- Organize your study space. Arrange books and study material properly at their respective places. Stationery items must not be scattered on the table.
- Plan your studies. Understand what all subjects are important and need to be done first. Go through your syllabus carefully. Find out the weightage of each subject and prepare a Task plan accordingly. Jot down what all subjects you think should be covered in a single day against specific time slots. Make sure you cover important topics first and then come to relatively easier ones. Beginning your day with something which is not that important is a sheer waste of time.
- Tick off subjects you have already completed. Give yourself a pat on your back. Remember self-motivation is one of the greatest tools for success.
- Avoid munching while studying. Prefer fruits, salads rather than calorie laden burgers, wafers, pizza etc. They make you feel sleepy and also add to your weight.
- Do a SWOT Analysis of yourself. There is no harm in writing your weaknesses. Understand in which all areas you need to work hard. Ignoring difficult subjects is of no use. You have to do them anyways. Assign extra time to critical subjects. Be logical.
- Remove all sources of distractions from your study zone. Prefer not to keep magazines, comics, novels, CDs, video games in your study room. Studying and watching television simultaneously is nothing but a waste of time.
- Do include some time for relaxation as well. No individual can study continuously at a stretch. One needs time to relax and unwind.
- Assign some time for revision as well. Revision is essential and it makes you perfect.
- Do not go for long calls during study time. One needs to set his /her priorities. Understand what is more important for you? Remember you will have ample time to catch up with all your friends once you clear your entrance exams and get into one of your dream business schools.
- Make sure your study space is well lit and ventilated. Dark corners make you feel sleepy and one finds it difficult to concentrate in studies and eventually wastes half of his/her time.
- It is essential to choose the right time for studies. MBA preparation is no joke and requires focus, concentration and planning. Prefer studying in the morning hours with less or no disturbance

7.5.3- Professional and Personal Time management

Time Management refers to making the best possible use of time and doing the right thing at the right time.

Managing time well plays a pivotal role in finishing off tasks within the stipulated time frame and also increases productivity of an individual.

Employees must learn to manage time well at the workplace to achieve targets ahead of deadline and make a mark of their own. One who understands the value of time is never overburdened and enjoys each and every moment to the fullest.

Why Time Management is Important in Corporates?

- Every organization works on deadlines. Time Management helps individuals to finish work within the assigned time and stay stress free and relaxed throughout the day. Time Management helps you plan specific time slots for all your day to day tasks at workplace.
- Time Management helps an individual to prioritize things. It is important for an employee to understand what is important and urgent at the moment. Staying overburdened at work leads to frustration and eventually one loses interest in work. You can't do anything and everything. Pick up all that is important and urgent at the start of the day and finish it off first before starting with something which can be done a little later. Know what is important for you. Allocate specific time slots to activities as per their relevance and make sure you stick to the same.
- Effective Time Management makes you a favourite amongst your superiors, clients as well as fellow workers. Do not keep work pending from your end. Finish off tasks as and when required. Ignoring critical issues is pointless. You have to do it in any case. Discuss with your co-workers or immediate reporting boss and find out a solution. Keeping a check on your time helps you, complete task just when it is needed.
- Managing time well helps an employee to plan his career path effectively. Doing things on time helps you reach the top of your career within the shortest possible time frame. Employees who just work for the sake of doing work and do not pay attention to deadlines are never taken seriously at the workplace. They are the ones who always crib and complain of excessive work load.
- Time Management makes you an organized individual. One needs to keep things at their respective places. Avoid keeping heaps of paper and stacks of files on your desk. Not only it gives a cluttered look to your workstation but also wastes half of your time in searching important documents, files, folders and so on. Individuals should prefer writing on notepads instead of loose papers.
- Effective Time Management helps an individual to identify the time wasters at the workplace. It is foolish to waste time on unproductive things which yield no results. No one expects you to work at a stretch for the whole day. Assign some time in your daily schedule to check updates on social networking sites or calling up your friends but do know where to draw the line. Your office does not pay you for gossiping and loitering around.
- Time Management makes an individual disciplined and punctual. One gets in the habit of reaching work on time as a result of effective time management.

How to Practice Effective Time Management at Workplace

Time Management refers to assigning specific time slots to activities as per their importance and urgency in order to make the best possible use of time.

In a layman's language Time Management is nothing but to manage time well and doing things when they actually need to be done. Every organization works on deadlines. An individual constantly needs to be on his toes to finish off assignments within stipulated time frame. It is essential for employees to understand the value of time for them to do well and make a mark of their own at the workplace.

How to practice effective time management in organization?

- Know your targets well. Do not hesitate to speak to your Boss if targets are unrealistic and unachievable within the allocated time slot. It is always better to discuss things at the initial stages than cutting a sorry figure later on. Accept tasks only when you are confident.
- There is absolutely no harm in discussing work with your fellow workers. You can't do almost everything on your own. Distribute work amongst your team members. It is foolish to over burden yourself. One must share his work load with others to finish assignments within the stipulated time frame. Know your capabilities.
- Organize yourself. Be very careful about your files, important documents, visiting cards, folders etc. Keep them at their proper places so that you do not waste half of your time in searching them.
- Be loyal to your organization. Do not work only when your superiors are around. Remember you are getting paid for your hard work. Concentrate on your own work rather than loitering and gossiping around. Do not waste time by playing games on computer or finding out what your fellow worker is up to.
- It is absolutely okay to call up family members or friends once in a while but make sure you do not end up in long phone calls while at work. Phone calls and messages are one of the biggest distractions at work.
- Plan your things well in advance. Do not work just for the sake of working. The first thing an employee should do in the morning is to jot down what all tasks he need to do in a single day against the time slot assigned to each task. Preparing a Task Plan right at the start of the day always helps and provides you a sense of direction at work. A "TO DO" List suggests you way forward. Tick off completed assignments. Make sure you finish tasks within the assigned deadlines.
- Keep a notepad and pen handy. Avoid writing on loose papers. You will never find them when you actually need something. Prefer using an organizer as it helps you plan your work better.
- Eat only during lunch hours. Eating while working not only makes you feel sleepy but also breaks continuity.
- Be punctual. Avoid taking frequent leaves from work unless it is an emergency. Make it a habit to reach office on time.
- Do not keep things pending at your end. Escalate matters immediately which need approval of higher authorities. Do not keep ignoring things. They would create problems for you sooner or later.

Activity-7.6 Arrangement of outdoor tour

The teacher/ instructor is required to demonstrate the students for arranging an outdoor tour to a nearest venue observing time management.

Activity-7.7 Scheduling tasks

The teacher/ instructor is required to demonstrate the students about scheduling their daily task in a report form.

7.6 - Attention to Details

7.6.1- Guidelines for Attention to Details

Attention to detail is the ability you have to efficiently and accurately allocate your cognitive abilities to focus on a specific task or number of tasks. It is a necessary skill to improve your productivity and efficiency, and one that employers look for.

Attention to detail is the ability to accomplish/complete a task while demonstrating a through concern for all the areas involved, no matter how small. This means monitoring and checking work or information, while organizing time and resources efficiently. It includes the ability to bring together different elements in order to achieve results or accomplish tasks. This means ensuring information is complete and accurate; and following up with others (on own work or that of others) to ensure that commitments have been fulfilled.

We all know that attention to detail is important because it helps prevent mistakes and makes success in the workplace easier.

Below are some examples of attention to detail skills.

- **Proofreading and editing skills.** This is one of the most common areas where you can discuss your attention to detail. Skills like proofreading or editing work require the individual to hone in on things like writing style, correct syntax and tenses, fact-checking, and adjusting grammatical errors.
- Expertise with numbers and number programs. Mathematical work is a skill that necessitates meticulous attention to detail. It requires high observations, quick mental computations and logic, organization, and clear thinking.

This area also includes programs such as Excel that highlight your expertise and attention to detail as it pertains to formulas or charts.

- Design work. Strong attention to detail is not just for the left-brained. Attention to detail can be found in abundance in creative work as well.

Work in graphic design or any creative work that requires a high refinement of craftsmanship can easily showcase your attention to detail accomplishments, not to mention the great patience necessary to complete a project.

- Time management. Paying close attention to detail is not just about getting work done accurately. It also involves budgeting your time appropriately so that you can meet deadlines and work efficiently.

Those who make daily to-do lists, religiously maintain their schedules, and track their own workflows are naturally paying close attention to detail.

- Organization. Sure, having a decluttered desk devoid of distractions is part of what we mean when we say "organization." But the other part of this is having an organized mind. Prioritizing tasks based on importance and urgency is a sign of a mind that pays close attention to the details and knows the value of each individual task.
- Observation. People who are attentive to details are constant observers. They learn both from their own experiences and those they interact with and are constantly looking for ways to improve things. Being mentally present all of the time will help your ability to notice details that might otherwise go unnoticed.
- Analytical skills. Being able to analyze a situation and solve problems effectively requires adept attention to detail. Identifying all of the moving parts of a project and synthesizing all of that information into a workable plan shows that you're not only attentive, but also able to put that attention to productive use.

How to improve your attention to detail

Not sure if you have the experience you need to ensure you're paying enough attention to the details? It's not a problem. This skill can be improved over time and you can start today, at your current job, and even in your day-to-day life.

- **Improve organization.** You can't pay attention to detail without being organized. Ensure your calendar is up to date and that you have a good process for taking notes and setting reminders so you won't forget.
- **Create lists.** It will be very rare for any professional to only have one thing to work on at a time. That's why it's so imperative to create lists and work against them. Keep a pen and paper nearby or use a digital version of a notebook, like Notepad.
- **Get into a routine.** Routines will help you dedicate a specific amount of time to a given task so that you can balance your day well and ensure everything on your list gets done. This will help you make sure you stay focused.
- **Quality over quantity.** While quantity may be important in some cases, quality is always king. Maintaining an appropriate workload will allow you to produce quality work that you are proud of and give you the time and space to focus on the small details.
- **Exercise your brain.** Your brain is an amazing thing and can be trained to work in a variety of different ways. A good way to make sure you're paying attention to detail is to play games that help train your brain's focus. Logic games like Chess are all great for boosting your cognitive capabilities.
- **Practice meditation.** Meditation has been proven to improve both your physical and mental health. Those who meditate regularly not only increase their ability to concentrate, but it also boosts your attention to detail and level of accuracy when completing projects.

7.6.2- Advantages of Attention to Details in Work and Studies

Attention to detail refers to a person's behavioural propensity towards thoroughness, accuracy, and consistency when accomplishing tasks. For example, when drafting documents, employees with exceptional attention to detail will do their best to avoid spelling errors, avoid internal inconsistencies, and relay all important details that the document requires. Not only does this ensure that employees work to a high standard, it also minimizes the amount of supervision that employees require, as employers can have confidence in their workforce's ability to avoid errors.

The antithesis of attention to detail is carelessness, which implies a lack of appreciation or interest in the finer details. When someone cares little for the details, they will likely rush through their work, spending little time and effort to ensure accuracy or precision in their deliverables. Naturally, employees that are careless will require extra supervision, and their work will need to be thoroughly checked by multiple colleagues, supervisors, or managers before completion. As a result, attention to detail is a common core competency, and hiring managers often seek candidates that express excellent attention to detail.

Why attention to detail matters

Attention to detail is essential to performance in any role where errors can be costly to the employing organization. For example, if a finance administrator accidentally lists the wrong figure on a large invoice, this could result in tangible financial losses for the organization and may cause significant embarrassment in front of a supplier or customer.

In more senior roles, a lack of attention to detail could result in poorly written contracts, policies, and procedures, which leaves the organization vulnerable to legal challenges. Ensuring that relevant staff show excellent attention to detail minimizes the risk of errors, and reduces the amount of checking, revising, and supervision that staff require.

Do you always read the instructions, avoid grammatical errors like the plague, and think no detail is too small? Then you already have a basic understanding of what it means to pay attention to detail. But there are still strategies you can use to improve your attention to detail skills and become detail-oriented if you aren't already.

Paying strong attention to detail will make you a more effective employee and can also help you in your personal life. Additionally, being detail-oriented will increase your productivity and lead to fewer errors in your work. Working on the attention to detail skills listed below will help you improve your overall eye for detail.

Attention to Detail Explained

Being detail-oriented means you are easily able to allocate cognitive resources to achieve thoroughness in your tasks. It is a necessary skill to improve your productivity and efficiency, and one that employers and companies look for.

There are four skills you should improve if you want to have a keen eye for detail: organization, time management, observation, and active listening. Let's explore these skills in more detail below.

i- Organization

Organization includes using your physical and mental energy efficiently. This starts with keeping your workspace clean. A clean and organized area reflects a clean and organized mind. It will ensure maximum productivity and keep you on track with your tasks.

ii- Time Management

Time management means dividing your time efficiently. Managing time also ensures that you are setting goals and achieving them within your designated time allotment.

iii- Observation

Observation merely concerns the act of noticing things, including small details, which will help you to gather information better. This skill will also improve your ability to interact with others.

iv- Active Listening

Active listening means paying attention to the person you are interacting with and being able to respond appropriately. To actively listen, you must carefully consider the words and body language of the person you are speaking with.

7.6.3- Attention to Details for Performing Tasks in an Effective Manner

You may think attention-to-detail is an ability you are just born with – but, in fact, attention-to-detail skills can be learnt by applying some simple techniques.

Employers value employees with good attention-to-detail because they can be trusted to turn in high-quality and consistent work. But attention-to-detail is not just about checking your work. Good attention-to-detail also means you will spot important information when preparing for tasks or evaluating a work situation. To become a civil engineer, you should ensure plans to meet safety regulations, match the specification and do not miss out important details.

Attention to detail refers to a person's behavioural propensity towards thoroughness, accuracy, and consistency when accomplishing tasks. For example, when drafting documents, employees with exceptional attention to detail will do their best to avoid spelling errors, avoid internal inconsistencies, and relay all important details that the document requires. Not only does this ensure that employees work to a high standard, it also minimises the amount of supervision that employees require, as employers can have confidence in their workforce's ability to avoid errors.

The antithesis of attention to detail is carelessness, which implies a lack of appreciation or interest in the finer details. When someone cares little for the details, they will likely rush through their work, spending little time and effort to ensure accuracy or precision in their deliverables. Naturally, employees that are careless will require extra supervision, and their work will need to be thoroughly checked by multiple colleagues, supervisors, or managers before completion. As a result, attention to detail is a common core competency, and hiring managers often seek candidates that express excellent attention to detail. Once you've snagged your dream job, attention to detail should not become an afterthought. Stay away from sloppy work and

ensure you take care and attention to detail as you settle into your new role. Here are some ways to ensure you maintain attention to small details.

- **Show up.** Be sure when you show up to meetings or simply for your workday that you are truly present. By being invested in your meetings, colleagues, and projects, you will be able to produce high-quality work.

Participate in conference calls and in team meetings to ensure your voice is heard, but also to capture all of the ideas and details you may need once the meeting is over. Active listening and note-taking is a great way to show your team and your managers that you are invested in your work.

- **Eliminate distractions.** It's sometimes difficult to concentrate when you have emails piling in or your phone is ringing off the hook. Because we live in a world where emails and phone calls are constantly at our fingertips, this can feel impossible.

If you are able, set aside certain times of the day to take phone calls, meetings, or look at your email. This will minimize distractions when you sit down to actually do a project so that you can give it your undivided attention.

- **Take care of yourself.** Take breaks as often as you can. If you can get outside, ensure you get a breath of fresh air or some sunshine on your face. Stand up, walk around, and have a conversation with a colleague.

Make sure that you eat breakfast and lunch and sign off and on to work at an appropriate hour. Avoid checking your email or taking phone calls when you are on a break. Work breaks are essential for brain health and they will allow you to maintain your focus and improve attention to detail on projects for the entirety of the workday.

- **Don't multitask.** It might seem to be the opposite of productive, but in fact, multitasking diminishes your attention to detail. It's impossible to pay keen attention to detail if you are thinking about something else while you are supposed to be working on a certain project.

Your accuracy and attention to detail will suffer if you work on multiple things at once, such as attending a meeting and trying to complete a project or a presentation. Ensure you are attentive to the task at hand, then move on to the next thing.

Activity-7.8 Attention to detail

The teacher/ instructor is required to demonstrate the students about applying five methods of attention to detail practically.

Activity-7.9 Attention to detail

The teacher/ instructor is required to demonstrate the students about enhancing through different exercises attention to detail skill.

7.7 Attitude and Behaviour and Custom Care

7.7.1- Concepts of Attitude and Behaviour

Attitude is defined as a more or less stable set of predispositions of opinion, interest or purpose involving expectancy of a certain kind of experience and readiness with an appropriate response.

An attitude describes persons' enduring favourable or unfavourable cognitive evaluations, feelings, and action tendencies toward some object or idea. People have attitudes regarding almost everything such as religion, politics, cloth, music, food etc.

Attitude can be defined as learnt predispositions to respond to an object or class of objects in a consistently favourable or un-favourable way.

In simple words, an "attitude" is an individual's way of looking or an individual's point of view at something.

To be more specific, an "attitude" may be defined as the mental state of an individual, which prepares him to react or make him behave in a particular pre-determined way. It is actually an acquired feeling.

Attitude is the mixture of beliefs and feelings that people have about situations, specific ideas or other people.

7.7.2- Impact of Positive and Negative Attitude in Daily Life

Attitude defines who you are and how you behave. Do you have a Positive Attitude and a Negative Attitude? What's the difference between a positive attitude and a negative attitude?

Positive Attitude:

Individuals who have a positive attitude will pay attention to the good rather than bad in people, situations, and events.

A simple example of a positive attitude; when you are having a very bad run of luck but still say "Good Morning" rather than "What's so good about this morning."

Well, Good news; you have a positive attitude.

Negative Attitude:

People with a negative attitude ignore the good and pay attention to the bad in people, situations, events, etc.

For example, when a guy has so much power, wealth, and influence with great luck; but still complains and goes on a rant; that person has a negative attitude.

Differences between Positive and Negative Attitudes:

Let's take a look in the real world; what differentiates a positive attitude from a negative attitude and how to identify them.

Positive Attitude	Negative Attitude
Individuals who have a positive attitude will pay attention to the good rather than bad in people, situations, events, etc.	People with a negative attitude ignore the good and pay attention to the bad in people, situations, events, etc.
Positive attitudes are rewarded, and it means the individual is encouraged to do the same thing in the future.	Negative attitudes are punished to discourage the same action in the future.
If we think positive thoughts, we will surely experience joy, love, gratitude, peace, and hope.	If we think negative thoughts, we will have negative feelings such as anger,

	disappointment, irritation, envy, etc.
Having a "positive attitude" means a person believes everything happens for the best in the end.	A person with a "negatives attitude" tends to believe their best days are in the past, and there is nothing to "look forward to" and considers it a waste of time and energy.
It is an optimistic approach for a person to achieve good results.	It is a pessimistic mindset of a person who is not capable of handling critical issues.
It can achieve long-term goals easily and in time.	It can achieve some initial goals but not the long-term goals
It is a process of solving problems.	It is a process of looking for problems.
A person with a positive attitude pays attention to the virtues of others.	A person with a negative attitude pays attention to other people's shortcomings.
These persons always see opportunities.	These persons see only limitations.

How to deal with negative attitudes and feelings

Not everyone is going to be positive all the time. That's an unrealistic idea. But even when people are down and at their most negative, there are things one can do to deal with those emotions and actions around the office to keep them from impacting others. Even if it's just one co-worker causing an issue, take matters into your own hands for your own happiness at work.

1. Choose who you associate with carefully.

If you find yourself surrounded by negative co-workers, try to switch cubicles or teams within the same department. Make conscious decisions with your space and your time at work that will result in surrounding yourself with co-workers with positive attitudes.

2. Be encouraging.

Encourage everyone. No one wake up in the morning wanting to do a bad job at work, therefore give some consideration and empathy to others.

3. Ask questions and don't assume.

No matter the positive or negative attitudes at work, it's important to be mindful in the workplace, rather than letting yourself be consumed by a negative attitude, question why that person might be coming across in that way. Don't take it personally, and do your best to build a barrier against negative comments or behaviors.

Activity-7.10 Customer care and positive attitude

The teacher/ instructor is required to demonstrate the students to practically apply the principles of customer care and positive attitude through different scenarios.

Activity-7.11 Role play

The teacher/ instructor is required to demonstrate the students about role playing to deal with problematic and angry persons.

What I have learnt

- A skill refers to an area of expertise or an ability to do something well within a defined amount of time, energy, or both. It is the power to use one's knowledge and competencies effectively in execution or performance.
- Hard skills are those that are measurable and can be taught. In day-to-day parlance, hard skills are also known as technical skills.
- Soft skills are interpersonal skills. They refer to a personality trait or a habit. "Soft Skills" are your human, personal and social skills; they directly refer to your emotional intelligence.
- Communication– is a skill that is most important in a professional set-up. It refers to the ability to speak effectively to others in different situations. This skill includes confidence, active listening, clarity, empathy, and patience.
- Teamwork– people have to achieve a common organization's goal and objective in every workplace. This requires teamwork. It is a soft skill to ensure that people can work well together with minimal workplace conflict. It is also about the team leader's ability to resolve any conflict by using this skill of teamwork.
- Problem-solving– is a skill to resolve issues quickly and efficiently. Problem-solving is a subset of effective teamwork. This skill refers to an ability to find a long-term solution to a problem in the organization's best interest and that of people's interest
- Critical thinking– is a quality to think rationally and logically. This skill is imperative for problem-solving and decision-making.
- Negotiation– is an important skill. Negotiations happen at every workplace, among co-workers, different departments, between organization and clients, and in many other types of interactions. Negotiation skill is the quality of bringing two or more parties to a compromise. It includes abilities like those of communication and persuasion.
- Leadership– this skill is a determinant to assess the individual's capability to work independently and with the teams. Leadership is a mix of all of the above soft skills and hence reflecting this skill in the trait opens up the doors of success and vertical movement of a person in an organization.
- Personal life is a course or state of an individual's life, especially when viewed as the sum of personal choices contributing to one's personal identity.
- Professional life is a career in industrial or commercial or professional activities.
- Sender / Encoder - Sender / Encoder is a person who sends the message. A sender makes use of symbols (words or graphic or visual aids) to convey the message and produce the required response.
- Message - Message is a key idea that the sender wants to communicate. It is a sign that elicits the response of recipient.
- Medium - Medium is a means used to exchange / transmit the message. The sender must choose an appropriate medium for transmitting the message else the message might not be conveyed to the desired recipients.

- Recipient / Decoder - Recipient / Decoder is a person for whom the message is intended / aimed / targeted. The degree to which the decoder understands the message is dependent upon various factors such as knowledge of recipient, their responsiveness to the message, and the reliance of encoder on decoder.
- Feedback - Feedback is the main component of communication process as it permits the sender to analyze the efficacy of the message. It helps the sender in confirming the correct interpretation of message by the decoder. Feedback may be verbal (through words) or non-verbal (in form of smiles, sighs, etc.). It may take written form also in form of memos, reports, etc.
- Listening is the ability to accurately receive and interpret messages in the communication process. Listening is key to all effective communication, without the ability to listen effectively messages are easily misunderstood – communication breaks down and the sender of the message can easily become frustrated or irritated.
- Organization includes using your physical and mental energy efficiently. This starts with keeping your workspace clean. A clean and organized area reflects a clean and organized mind. It will ensure maximum productivity and keep you on track with your tasks.
- Time management means dividing your time efficiently. Managing time also ensures that you are setting goals and achieving them within your designated time allotment.
- Observation merely concerns the act of noticing things, including small details, which will help you to gather information better. This skill will also improve your ability to interact with others.
- Active listening means paying attention to the person you are interacting with and being able to respond appropriately. To actively listen, you must carefully consider the words and body language of the person you are speaking with.
- Attitude is defined as a more or less stable set of predispositions of opinion, interest or purpose involving expectancy of a certain kind of experience and readiness with an appropriate response.

EXERCISE

Q-1. Tick (✓) the correct option for the following MCQs.

i- Communication is the part of -------- skills.

(A) Soft (B) Hard
(C) Rough (D) Short

ii- It is defined as the process by which meanings are perceived and understanding is reached among human beings.

(A) Communication (B) Message
(C) Statement (D) Language

iii- Pick out the different one:

(A)Chain (B) Time
(C) Bangle (D) Bracelet

iv- Count the number of Vowels in "WHAT YOU THINK YOU BECOME "

(A) 7 (B) 6

(C) 9 (D) 8

v- Organizations use ___ communication to announce Information and provide instructions to subordinates by superiors.

(A) Oral (B) Written

(C) Verbal (D) Non-verbal

vi- The experience of feeling competent to cope with basic challenges in life and being worthy of happiness:

(A) Arrogance (B) Self-efficacy

(C) Self-esteem (D) Wishful thinking

vii. Self-confidence is affected by comparing ourselves to others, or social comparison:

(A) Positively (B) Negatively

(C) Neutrally (D) None of above

viii. Which of following is/are suggested time management technique(s)?

(A) Clean up and get organized (B) Concentrate on one task at a time

(C) Make good use of technology (D) All of these

ix. Which of following is/are likely to be considered as "time tasks"?

(A) Procrastination (B) Indecisiveness

(C) Schmoozing (D) All of these

x. An attitude can be inferred from a person's:

(A) Cognition (B) Affect

(C) Behaviour (D) All of these

Q-2 Give answer to the following questions.

i- State the importance of soft skills in daily life.

ii- What do you mean by self-confidence?

iii- State the importance of active listening.

iv- What are the benefits of paying attention to detail?

v- State the importance of teamwork in a professional environment.

vi- State the importance of time management in daily life

vii- State the guidelines of attention to details

viii- State the advantages of attention to detail in work.

Q.3 Answer the following questions in detail.

i- Explain the importance of soft shills. How soft skills are applied for academic and professional success

ii- Define communication. Explain the major obstacles in effective communication.

iii- Define teamwork. Explain the importance of teamwork in a professional environment.

GLOSSARY

Active Solar heating System

Active systems rely on pumps to move the liquid between the collector and the storage tank.

Active Solar hot water System

Active solar hot water systems employ a pump to circulate water or heat transfer fluid (HTF) between the collector and the storage tank.

Auto Collector

The auto controller is a differential temperature thermostat designed specifically to regulate a solar system operation. Its basic function is to monitor collector and storage temperatures and to automatically turn a small circulator ON or OFF at the appropriate temperature differentials.

Centrifugal Pump

Centrifugal-type circulating pumps are most commonly used in solar water-heating systems. For closed loop systems lower cost, cast iron circulating pumps are adequate and for open-loop systems, circulating a replenishing supply of water, a bronze circulating pump is necessary.

Check Valve

A check valve permits fluid to flow in one direction only. It prevents heat loss at night by convective flow from the warm storage tank to the cool collectors.

Concentrating Type solar collector

Evacuated type of solar collector uses a series of evacuated tubes to heat water for use. These tubes utilize a vacuum, or evacuated space, to capture the suns energy while minimizing the loss of heat to the surroundings.

Direct Circulation systems

Direct-circulation systems (or open systems) use pumps to circulate water through the collectors. These systems are appropriate in areas that do not freeze for long periods and do not have hard or acidic water.

Double wall heat exchanger

Double-wall heat exchangers have two walls between the two fluids. Two walls are often used when the heat-transfer fluid is toxic, such as ethylene glycol.

Drain back system

Drain back system, is an indirect active system where heat transfer fluid circulates through the collector, being driven by a pump. If the pump is switched off, all the heat transfer fluid drains into the drain back reservoir and none remains in the collector

Expansion Tank

An expansion tank allows the fluid in a closed-loop system to expand and contract depending on the temperature of the fluid.

Heat Transfer fluids

Heat-transfer fluids carry heat through solar collectors and a heat exchanger to the heat storage tanks in solar water heating systems.

Indirect circulation system

Indirect-circulation systems (or closed systems) pump heat-transfer fluids, such as a mixture of glycol and water antifreeze, through collectors. Heat exchangers transfer the heat from the fluid to the potable water stored in the tanks.

Internal Collector Storage System

Integral-Collector Storage (ICS) Systems or Batch Heaters are special type of passive system where the tank acts as both storage and solar collector. Batch heaters are basically thin rectilinear tanks with glass in front of it facing the sun generally in or on house wall or roof.

Non-concentrating Type solar collector

In the non-concentrating type, the collector area (i.e., the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs the light.

Passive Solar heating System

Passive systems rely on gravity and the tendency for water to naturally circulate as it is heated.

Pressure Gauge

A pressure gauge is used as a diagnostic tool to monitor the state of the glycol charge.

Pressure Relief Valve

A pressure relief valve of 50 psi is usually adequate to protect closed-loop plumbing systems from excessive pressures.

Single wall heat exchanger

A single-wall heat exchanger is a pipe or tube surrounded by a fluid. Either the fluid passing through the tubing or the fluid surrounding the tubing can be the heat-transfer fluid, while the other fluid is the potable water.

Solar Cell

A solar cell or photovoltaic cell is a device that converts the sunlight into usable energy.

Solar Collector

Solar collectors are the key component of active solar-heating systems which gather the sun's energy, transform its radiation into heat, and then transfer that heat to water, solar fluid, or air.

Solar Energy

Solar energy is kind of universal, decentralized and no -polluting energy, which reaches earth in the form of short-wave radiation visible light and near ultraviolet light. It helps in maintaining the ecological balance through the process of photosynthesis and greenhouse effect.

Solar heater storage tank

The storage tank holds the hot liquid and is simply a modified water heater, but it is usually larger and very well-insulated.

Solar Power

Solar power is the flow of energy from the sun. The primary forms of solar energy are heat and light. Sunlight and heat are transformed and absorbed by the environment in a multitude of ways.

Solar Thermal Energy

Solar thermal energy is the energy collected from the sun and used to generate heat. This heat is usually concentrated using mirrors and used for heating water later.

Solar water heater

A solar water heater is a device that captures sunlight to heat water.

Solar water heater

A solar water heater consists of solar collectors, a tank and a circulating pump. In some solar water heaters, a backup is also included for the days when solar energy is not available at all and you require hot water.

Solar water heating

Solar water heating (SWH) is the process of converting sunlight into energy that can be used for domestic water heating.

Solar water heating

Solar water heating is the process of converting sunlight into energy that can then be used for domestic water heating. This heated water can be used for washing in the home, radiant floor heating, or to heat swimming pools.

Solar water heating systems

Solar water-heating systems use heat exchangers to transfer solar energy absorbed in solar collectors to the liquid or air used to heat water or a space.

Static Head

Static head is pressure resulting from the vertical height and corresponding weight of the column of fluid in a system where as dynamic head includes the frictional resistance of the fluid flowing through the pipe and fittings in the system.

Thermo-Siphon Systems

Thermo-Syphon Systems or Convection Heat Storage Unit (CHS**)** is a step up from the ICS and are an economical and reliable choice, especially in new homes. These are often plate type or evacuated tube collectors with built-in insulated tanks. The unit uses convection (movement of hot water upward) to move the water from collector to tank (located above the collector).

Active Listening

Active listening means paying attention to the person you are interacting with and being able to respond appropriately. To actively listen, you must carefully consider the words and body language of the person you are speaking with.

Attitude

Attitude is defined as a more or less stable set of predispositions of opinion, interest or purpose involving expectancy of a certain kind of experience and readiness with an appropriate response.

Communication– is a skill that is most important in a professional set-up. It refers to the ability to speak effectively to others in different situations. This skill includes confidence, active listening, clarity, empathy, and patience.

Critical thinking– is a quality to think rationally and logically. This skill is imperative for problem-solving and decision-making.

Feedback - Feedback is the main component of communication process as it permits the sender to analyze the efficacy of the message. It helps the sender in confirming the correct interpretation of message by the decoder. Feedback may be verbal (through words) or non-verbal (in form of smiles, sighs, etc.). It may take written form also in form of memos, reports, etc.

Hard skills are those that are measurable and can be taught. In day-to-day parlance, hard skills are also known as technical skills.

Leadership– this skill is a determinant to assess the individual's capability to work independently and with the teams. Leadership is a mix of all of the above soft skills and hence reflecting this skill in the trait opens up the doors of success and vertical movement of a person in an organization.

Listening

Listening is the ability to accurately receive and interpret messages in the communication process. Listening is key to all effective communication, without the ability to listen effectively messages are easily misunderstood – communication breaks down and the sender of the message can easily become frustrated or irritated.

Medium - Medium is a means used to exchange / transmit the message. The sender must choose an appropriate medium for transmitting the message else the message might not be conveyed to the desired recipients.

Message - Message is a key idea that the sender wants to communicate. It is a sign that elicits the response of recipient.

Negotiation– is an important skill. Negotiations happen at every workplace, among co-workers, different departments, between organization and clients, and in many other types of interactions. Negotiation skill is the quality of bringing two or more parties to a compromise. It includes abilities like those of communication and persuasion.

Observation

Observation merely concerns the act of noticing things, including small details, which will help you to gather information better. This skill will also improve your ability to interact with others.

Organization includes using your physical and mental energy efficiently. This starts with keeping your workspace clean. A clean and organized area reflects a clean and organized mind. It will ensure maximum productivity and keep you on track with your tasks.

Personal Life

Personal life is a course or state of an individual's life, especially when viewed as the sum of persinal choices contributing to one's personal identity.

Problem-solving– is a skill to resolve issues quickly and efficiently. Problem-solving is a subset of effective teamwork. This skill refers to an ability to find a long-term solution to a problem in the organization's best interest and that of people's interest

Professional Life

Professional life is a career in industrial or commercial or professional activities.

Recipient / Decoder - Recipient / Decoder is a person for whom the message is intended / aimed / targeted. The degree to which the decoder understands the message is dependent upon various factors such as knowledge of recipient, their responsiveness to the message, and the reliance of encoder on decoder.

Sender / Encoder - Sender / Encoder is a person who sends the message. A sender makes use of symbols (words or graphic or visual aids) to convey the message and produce the required response.

Skill

A skill refers to an area of expertise or an ability to do something well within a defined amount of time, energy, or both. It is the power to use one's knowledge and competencies effectively in execution or performance.

Soft Skills

Soft skills are interpersonal skills. They refer to a personality trait or a habit. "Soft Skills" are your human, personal and social skills; they directly refer to your emotional intelligence.

Teamwork– people have to achieve a common organization's goal and objective in every workplace. This requires teamwork. It is a soft skill to ensure that people can work well together with minimal workplace conflict. It is also about the team leader's ability to resolve any conflict by using this skill of teamwork.

Time Management

Time management means dividing your time efficiently. Managing time also ensures that you are setting goals and achieving them within your designated time allotment.

Answers to the Multiple-choice Questions

Book-2, Grade X

Chapter No. 1

1	A	2	D	3	B	4	C	5	B
6	A	7	D	8	A	9	C	10	D

Chapter No. 2

1	B	2	A	3	C	4	A	5	D
6	C	7	D	8	C	9	D	10	A

Chapter No. 3

1	A	2	C	3	D	4	B	5	C
6	B	7	D	8	C	9	D	10	B

Chapter No. 4

1	D	2	C	3	C	4	B	5	D
6	B	7	B	8	C	9	D	10	D

Chapter No. 5

1	A	2	D	3	C	4	B	5	B
6	A	7	B	8	D	9	A	10	

Chapter No. 6

1	D	2	A	3	A	4	C	5	A
6	C	7	B	8		9		10	

Chapter No. 7

1	A	2	A	3	B	4	C	5	B
6	C	7	A	8	D	9	D	10	D

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قومی ترانہ

پاک سَر زمین شاد باد! کشورِ حسین شاد باد!
تو نِشانِ عزمِ عالی شان ارضِ پاکستان
مرکزِ یقین شاد باد!

پاک سر زمین کا نِظام قُوّتِ اُخوّتِ عوام
قوم ، مُلک ، سلطنت پائندہ تابندہ باد!
شاد باد منزلِ مُراد!

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