Electricity and New Energy
EDS® Solar Thermal

Introduction to Solar Thermal Energy

Courseware Sample

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Safety and Common Symbols

The following safety and common symbols may be used in this manual and on the equipment:

Symbol	Description
⚠ DANGER	**DANGER** indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.
⚠ WARNING	**WARNING** indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.
⚠ CAUTION	**CAUTION** indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.
CAUTION	**CAUTION** used without the *Caution, risk of danger* sign ⚠, indicates a hazard with a potentially hazardous situation which, if not avoided, may result in property damage.
	Caution, risk of electric shock
	Caution, hot surface
	Caution, risk of danger
	Caution, lifting hazard
	Caution, hand entanglement hazard
	Notice, non-ionizing radiation
	Direct current
	Alternating current
	Both direct and alternating current
	Three-phase alternating current

Safety and Common Symbols

Symbol	Description
	Earth (ground) terminal
	Protective conductor terminal
	Frame or chassis terminal
	Equipotentiality
	On (supply)
	Off (supply)
	Equipment protected throughout by double insulation or reinforced insulation
	In position of a bi-stable push control
	Out position of a bi-stable push control

Table of Contents

Preface

The EDS® Solar Thermal, Model 46121, is a modular program that covers the history, fundamentals, installation, operation, maintenance, and servicing of solar thermal energy systems.

From now on, the EDS® Solar Thermal will be referred to simply as the solar thermal training system.

The curriculum is divided into the following topics:

- Introduction to solar thermal energy
- Solar thermal energy systems
- Multi-loop systems

⚠ WARNING

The solar thermal training system should be operated under supervision at all time. Never let the system operate unattended.

⚠ WARNING

Be careful to prevent water from making contact with electrical components. Use a bucket and mop if some leakage occurs.

⚠ CAUTION

The surface of the work lights can become very hot. Whenever you manipulate them, take great care to avoid direct contact with the skin.

⚠ CAUTION

Be careful when rotating the solar collector. Improper use can lead to injuries.

CAUTION

The maximum operating temperature of the liquid inside the system is 50°C. If this temperature is reached, stop the system operation, turn the lights off, or cover the solar collector.

Preface

We invite readers of this manual to send us their tips, feedback, and suggestions for improving the book.

Please send these to did@de.festo.com.

The authors and Festo Didactic look forward to your comments.

About This Manual

The topics covered in this manual are presented in the form of Job Sheets. The Job Sheets include a description of the objectives, a list of equipment required, a list of safety procedures, and a list of steps required to attain the objectives.

The topics are introduced in an Information Job Sheet. However, to obtain detailed information about the covered topic, you should refer to your textbook or ask your instructor to guide your learning process.

Safety considerations

Safety symbols that may be used in this manual and on the equipment are listed in the Safety Symbols table at the beginning of the manual.

Safety procedures related to the tasks that you will be asked to perform are indicated in each exercise.

Make sure that you are wearing appropriate protective equipment when performing the tasks. You should never perform a task if you have any reason to think that a manipulation could be dangerous for you or your teammates.

Reference material

Refer to the textbook titled *Solar Water Heating* written by Bob Ramlow & Benjamin Nusz.

Appendices

The appendices included in the manual are:

Appendix A:	*Equipment Utilization Chart*, shows in which Job Sheet(s) the equipment is used.
Appendix B:	*Safety Procedures*, lists the basic safety procedures to be performed before you begin any of the Job Sheets in this manual.
Appendix C:	*Work Assessment Table*, provides a table allowing the instructor to assess the students' work in the exercises (Instructor Guide only).

Improvements

Equipment is constantly improved by manufacturers to maintain state-of-the-art quality. Therefore, you may discover some discrepancies between the instructions and/or graphics in the course and the actual equipment. To ensure correct setup and operation, always consult the latest equipment user guide.

To the Instructor

You will find in this Instructor Guide all the elements included in the Student Manual together with the answers to all questions, results of measurements, graphs, explanations, suggestions, and, in some cases, instructions to help you guide the students through their learning process. All the information that applies to you is placed between markers and appears in red.

Accuracy of measurements

The numerical results of the hands-on exercises may differ from one student to another. For this reason, the results and answers given in this manual should be considered as a guide. Students who correctly performed the exercises should expect to demonstrate the principles involved and make observations and measurements similar to those given as answers.

Instructions

- Before a student begins a job sheet, ensure that the equipment is in good condition and does not represent any risk when used.
- When a student has to complete a setup that is already partially mounted, ensure that the setup corresponds to the job description.
- This guide provides you with the answers to calculations, measurements, and review questions. Your evaluation, however, must relate to the quality of the accomplished work. Make sure that the objectives listed in the Work Assessment Table are met.
- When the jobs are performed in teams, ensure that each student has and installs a padlock when performing the lockout/tagout procedure.
- Make sure that the students understand the objectives of the job to do. They should have read the appropriate pages in their textbook.

Trainer Familiarization and Safety

The solar thermal training system provides a small-scale hot water supply, radiator, and floor heating system to teach students how solar radiant energy can be harnessed and converted to solar thermal energy in order to elevate air, water, and surface temperatures within a residential home or commercial business.

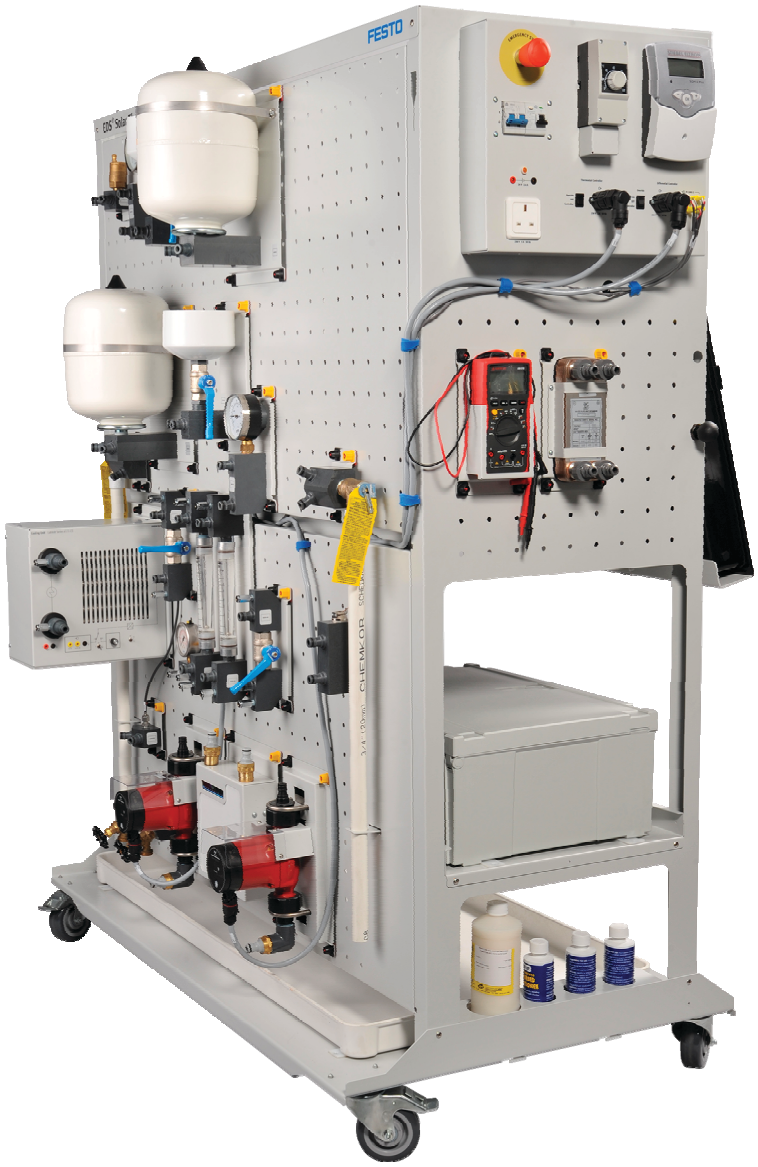

Figure 6. The solar thermal training system.

The training system can be configured to exchange and store thermal energy. It permits experimenting with open and closed loop heating systems. The main (primary) loop can collect the thermal energy, and a secondary loop can distribute and apply heat to a gas, liquid, or solid in order to dissipate the thermal energy.

In addition to miscellaneous plumbing fittings and fixtures, the following main system components are commonly found in heating systems and are required to complete the solar thermal energy training. The trainer also includes several safety devices and features, as described below.

Mobile workstation (training system frame and assembly)

The mobile workstation provides a place to mount and store all of the training system modules and materials. See Figure 6.

Solar collector (flat plate type)

The solar collector converts radiant energy (light) into thermal energy (heat) and transfers that energy to a fluid, commonly water or a water and antifreeze mixture. The polycarbonate frame is thermally insulated with 70 mm thick mineral wool insulation and contains an aluminum-copper absorber. The absorber has a highly selective vacuum coating with an absorption rating of 95%. Glazing is achieved by a solar glass (ESG) pane. Content volume is 0.60 L with an absorption area of 0.96 m^2. Its outer dimensions are 1200 mm x 800 mm.

Figure 7. Solar collector.

Collector inlet (with shutoff valve)

The collector inlet is the cold water input to the solar collector, which is often temperature monitored for efficiency calculations. The attached ball valve helps to ensure that hot water cannot spill out of the collector during system maintenance. The inlet is at the bottom of the solar collector.

Figure 8. Collector inlet.

Collector outlet

The collector outlet is the hot water output from the solar collector, which is often temperature monitored for efficiency calculations. The outlet is at the top of the solar collector. The top of the outlet is normally capped. However, for draindown and drainback systems, a vacuum breaker can be attached.

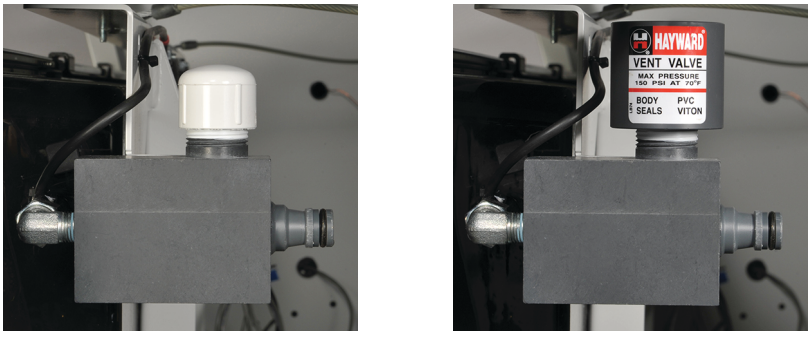

Figure 9. Collector outlet (with end cap or vacuum breaker).

Circulator pumps (2)

The circulator pumps are water pumps that are driven by an integrated electric motor and impeller assembly that must be controlled electronically. The maximum flow rate is 79.49 LPM (at 0 m) and the maximum head is at 5.80 m (with 0 LPM flow). The circulator pumps can work in the following modes:

- Mode I: Fixed to slow speed. In this mode, the pump runs at a constant speed, following a constant curve (the minimum curve) under all operating conditions.
- Mode II: Fixed to medium speed. In this mode, the pump runs at a constant speed, following a constant curve (the medium curve) under all operating conditions.
- Mode III: Fixed to high speed. In this mode, the pump runs at a constant speed, following a constant curve (the maximum curve) under all operating conditions.
- Constant pressure I: The duty point of the pump moves left and right along the lowest constant-pressure curve depending on the water demand in the system, keeping the head constant.
- Constant pressure II: The duty point of the pump moves left and right along the middle constant-pressure curve depending on the water demand in the system, keeping the head constant.
- Constant pressure III: The duty point of the pump moves left and right along the highest constant-pressure curve, depending on the water demand in the system, keeping the head constant.
- AUTO adapt: In this mode, the control of the pump performance is automatic, within the defined performance range. The pump performance is automatically adjusted to the system demands over time.

In the job sheets, “Mode III” is used, so that the pump works at maximum power.

Figure 10. Circulator pump.

Storage tank

The storage tank is a stainless-steel, thermally-insulated vessel that is used to hold thermal energy (heat) in a storage medium (water) for later use. It contains two internal heat exchangers (see below) and a temperature sensor. The tank includes a drain port with a shut-off valve and a return port, both of which are described in greater detail below. It can hold up to 51.10 L, but is usually only filled to about 37.85 L.

Figure 11. Storage tank.

Tank heat exchangers (2 coil types)

The tank heat exchangers are two coils of copper tubing that are located inside the storage tank (one on the top and one on the bottom) for transferring thermal energy (heat) between the transfer medium (collector water) and the storage medium (tank water).

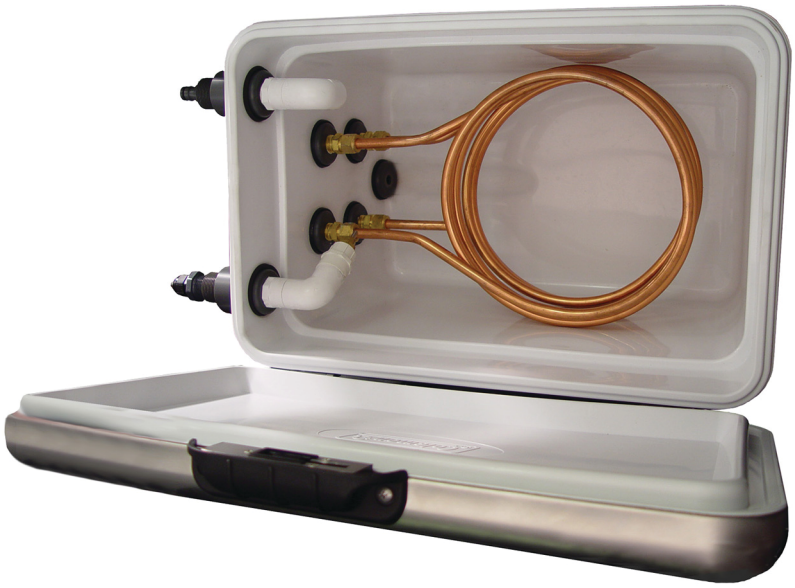

Figure 12. Tank heat exchangers.

Tank drain (with shutoff valve)

The tank drain is the cold water feed to the storage tank; however, it can also be used as a return point in the system. The attached ball valve helps to ensure that hot water cannot spill out of the tank during system maintenance. The drain is at the bottom of the storage tank.

Tank return

The tank return is the hot water supply from the storage tank; however, it can also be used as a feed point in the system. The return is at the top of the storage tank.

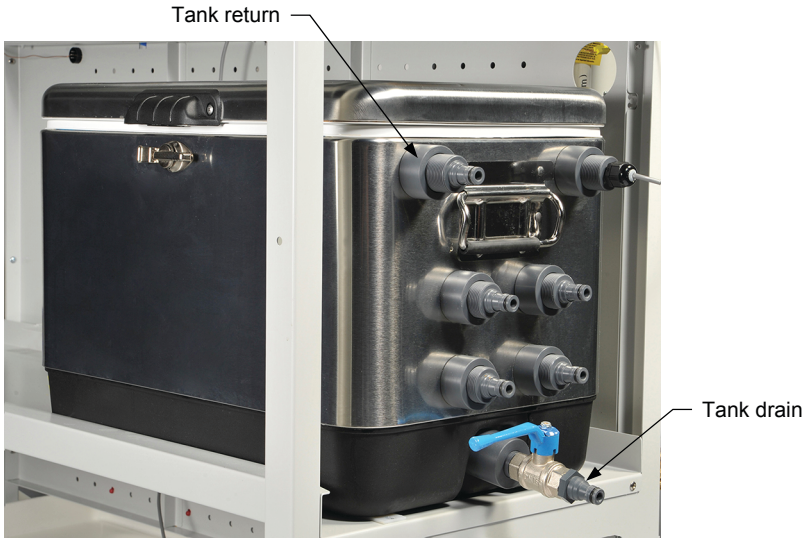

Figure 13. Tank drain and return.

Plate heat exchanger

The plate heat exchanger is an external device that is a copper, brazed-plate type of heat exchanger for transferring thermal energy (heat) through a fluid containment wall. It has a thermal transfer area of 0.12 m^2 and a volume of 0.11 L.

Figure 14. Plate heat exchanger.

Electrical panel

The electrical panel (Figure 15) includes an emergency switch, a circuit-breaker switch, a dc power source that connects to the radiator, an ac power outlet to which to the work lights connect, a thermostat controller, and a differential controller. Temperature sensors also connect to the electrical panel. The differential controller, the thermostat controller, and the temperature sensors are described below.

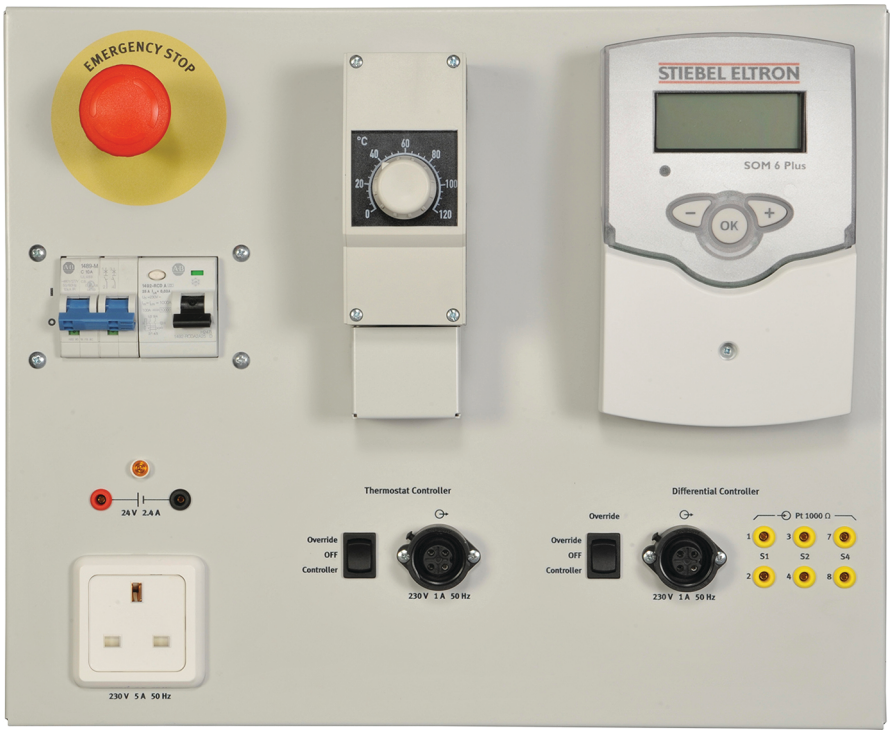

Figure 15. The electrical panel.

Differential controller

The differential controller is a digital device for controlling circulators (pumps and blowers) that uses a difference in two temperatures to determine operating set points for its circulator. The differential temperature range can be set between 1.1°C and 22.22°C. The default set points are 6.67°C to turn the pump on, and 4.45°C to turn the pump off. The differential controller uses several remotely located 1000 Ω (1 kΩ) platinum (Pt) resistance temperature detector (RTD) sensors. The two leftmost connectors (identified by numbers 1 and 2) are labelled “S1”, and are connected to the solar collector’s sensor. The two middle connectors (identified by numbers 3 and 4) are labelled “S2”, and are connected to the storage tank’s sensor. Finally, the two rightmost connectors (identified by numbers 7 and 8) are labelled “S4”, and are connected to the remote temperature sensor. The differential controller has a digital display and three push-button switches (“-”, “OK”, and “+”) to select various options. The controller and the pump are controlled by an override switch. When it is in the “Override” mode, the pump works independently from the controller settings. When the switch is in the “Off” mode, the pump is turned off. Finally, when the switch is in the “Controller” mode, the pump works according to the controller settings. A 4-pin connector is used to connect the controller to the pump. The differential controller is also called a temperature differential indicating controller (TDIC). It is rated for controlling an ac pump or relay.

Thermostat controller

The thermostat controller is an electromechanical switch for controlling a circulator (pump or blower) that uses a temperature threshold to activate or deactivate the circulator. This controller uses a remote sensing bulb with a fluid-filled capillary tube to detect temperature levels and trigger the switch as needed. The temperature set point is adjustable from 0°C to 40°C with a rotating knob and is compensated for ambient temperature. An internal single-pole, double-throw (SPDT) switch breaks contact (opens the circuit) when the temperature rises to the manually adjusted set point, and makes contact (closes the circuit) when the temperature falls 3.34°C below the set point. A 4-pin connector is used to connect the controller to the pump. The controller and the pump are controlled by an override switch. When it is in the “Override” mode, the pump works independently from the controller settings. When the switch is in the “Off” mode, the pump is turned off. Finally, when the switch is in the “Controller” mode, the pump works according to the controller settings.

Temperature sensors (3 electrical devices and 1 mechanical device)

Also called temperature detectors, the temperature sensors are specifically intended for use with the controllers provided in the training system.

Figure 16. Temperature sensor (RTD).

Figure 17. Electrical remote temperature sensor.

Figure 18. Mechanical remote temperature sensor.

Expansion tanks (2)

The expansion tanks are vessels that contain a flexible diaphragm and a pressurized secondary fluid (air) that permits the safe thermal expansion and contraction of its primary fluid (water). This fluid separation allows changes in primary fluid volume to occur that are directly related to primary fluid temperature changes. Each tank has a capacity of 7.95 L (maximum usable volume) and a maximum water capacity of 4.16 L. At ambient pressure, each tank can contain 50 mL of water, resulting in an air-side pressure of 248.21 kPa. In a closed loop circuit, a rise in the water temperature causes the water volume to increase above 50 mL. The maximum working pressure of the water side is 1000 kPa.

Figure 19. Expansion tank.

Radiator (with magnetic surface thermometer)

The radiator contains a 15.2 cm^2 radiator core with a 1.06 m^2 heat exchanger area to transfer thermal energy from water to air, and allows manual control of its blower speed for changing the air flow rate. The maximum air flow rate is 3000 L/min. The dual blower consists of two electric motors with fan blades powered by a 24 V dc, 2.4 A power supply output. The power supply input is rated appropriately for the ac power mains. A magnetic surface thermometer can be placed between the blower vents (slightly above the center) to monitor output temperature. Its measurement range is from -17.8°C to 65.6°C.

Figure 20. Radiator (front view).

Figure 21. Radiator (rear view) with magnetic surface thermometer.

Radiant floor (hydronic type)

The radiant floor is a 412 cm^2 flooring that is constructed with copper tubing bonded to a ceramic tile 6.8 mm thick. It acts as a heat exchanger that permits the thermal energy from hot water to partially heat the top floor surface and partially radiate into the ambient air. It also provides some limited heat storage, and has a thermal mass volume of 280.8 m^3 dimensionally, or 526 g by weight. You can view the underside construction of this module through a window in the back.

Figure 22. Radiant floor.

Digital multimeter (DMM)

The digital multimeter is a hand-held meter that provides a convenient means to measure ac/dc voltage, ac/dc current, dc resistance, and circuit continuity.

Figure 23. Digital multimeter.

Thermometers (2)

The thermometers are analog meters that provide a quick indication of fluid temperature in degrees Celsius (°C) or Fahrenheit (°F). They use a coiled bimetallic strip to indicate the fluid temperature sensed in a brass immersion well. These devices also help to ensure that system fluid temperature ratings are not exceeded. Their measurement range is from 0°C to 121.1°C.

⚠ CAUTION

Never allow any of the system operating temperatures to exceed 50°C.

Figure 24. Thermometer.

Rotameters (2)

Also called flow meters, the rotameters measure the flow rate of a fluid as the material pushes on a floating indicator. These devices also help to ensure that system fluid flow rates are normal and passageways are not excessively restricted or blocked, which could dramatically raise fluid pressure. Each meter is calibrated in both gallons per minute (GPM) and liters per minute (LPM). The clear, tapered tube permits visual inspection of the internal fluid to see trapped air bubbles, dirt, and debris within a system loop. Their measurement range is from 0.76 to 7.6 LPM.

Figure 25. Rotameter.

Pressure gauge

The pressure gauge is an analog device that measures the pressure of a fluid as the material unrolls its internal bourdon tube to indicate a calibrated value in either kilopascals (kPa) or pounds per square inch (psi). This device also helps to ensure that system fluid pressure ratings are not exceeded. Its measurement range is from 0 to 103.4 kPa.

Figure 26. Pressure gauge.

Pressure relief valves (2)

Also called safety relief valves, the pressure relief valves open at a safely rated fluid pressure level. They also help to ensure that system fluid pressure ratings are not exceeded. The training system can operate safely without pressure relief valves, but these devices were included to demonstrate the normal safety precautions necessary in an actual system installation.

The temperature and pressure (T&P) relief valves used in the training system are rated for 99°C and 1060 kPa maximum. However, the circulator pumps typically can only deliver about 5% of this pressure rating. T&P relief valves are commonly used on conventional hot-water heaters.

Discharge lines (2)

The discharge lines are tubes or pipes that safely redirect fluid as it is expelled from a relief valve.

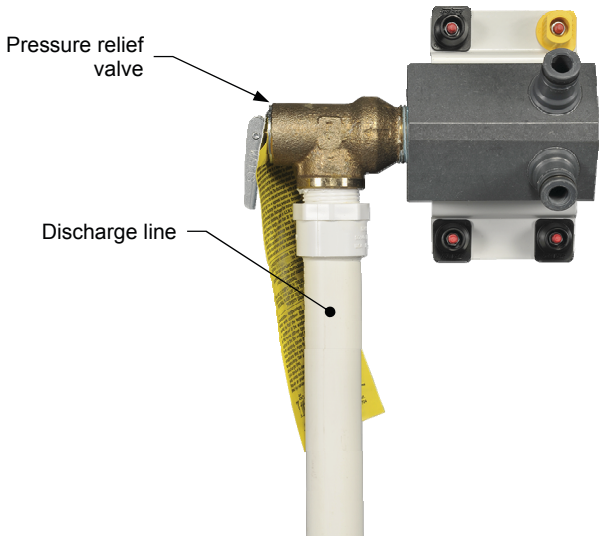

Figure 27. Discharge line and pressure relief valve.

Shutoff valves (2)

The shutoff valves are manually operated devices for controlling fluid flow in an on or off fashion. These devices can also help to ensure that a system component is safely isolated from other parts of the system when necessary.

Figure 28. Shutoff valve.

Check valve (swing gate type)

Also called a flow check valve or non-return valve, the check valve is an automatic device for controlling fluid flow in only one direction, as indicated on the device.

This device also helps to ensure that system fluid travels in only one direction to maintain safe operating conditions. It should not be positioned pointing in a downward direction. Check valves are often used in solar loops to prevent thermosiphoning.

Drain valves (2)

The drain valves are two boiler drain valves that are part of the check valve assembly, and can be used to fill, drain, or purge the system.

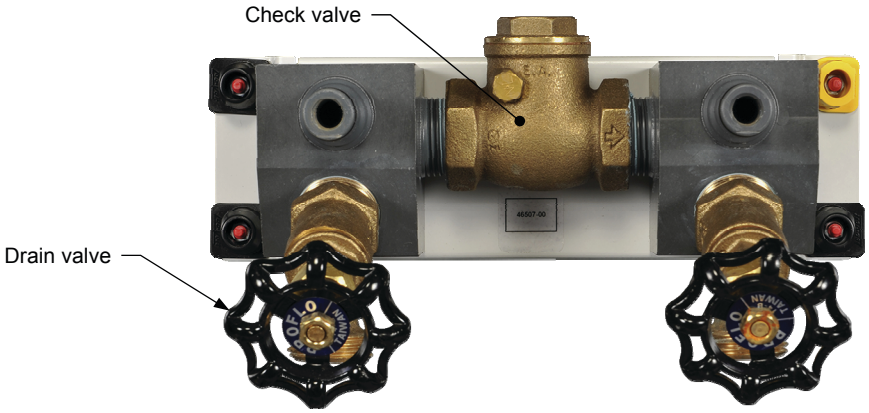

Figure 29. Check valve assembly.

Fill bowls (2)

Also called manual air vents, or manual fluid feeders, the fill bowls consist of a funnel and ball valve that (when open) permit trapped air bubbles to escape from a liquid system, and also allow liquid to be added to the system to replace the air. These devices also help to ensure that other system components operate efficiently and do not overheat. There is a pitcher that comes with the system, which can be used to fill the fill bowl with water.

Figure 30. Fill bowl.

Automatic air vent (float type with valve)

The automatic air vent is an automatically operated valve that permits trapped air to bleed from a liquid-based system. This device also helps to ensure that other system components operate efficiently and do not overheat. The manually adjusted valve on top of the air vent can be closed, so that no air can escape.

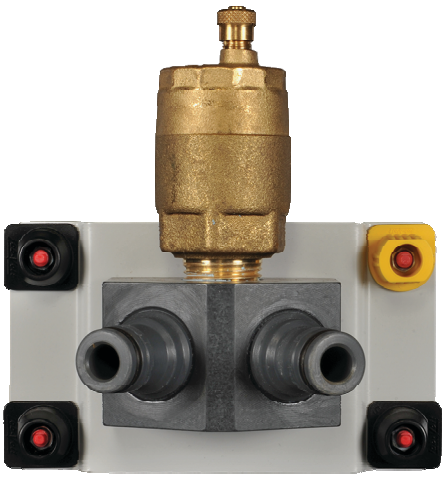

Figure 31. Automatic air vent.

Dual work light

The dual work light contains two 500 W lamps for a total of 1 kW (2 lamps) that are powered by the AC mains. These two lamps are intended to be directed at the solar collector with their light evenly distributed to simulate radiant energy from the sun.

Figure 32. Dual work light.

Tubing kit (assortment of 30.48 cm, 60.96 cm, 91.44 cm, and 182.88 cm lengths)

The tubing kit is an assortment of pre-fabricated vinyl interconnection hoses that are included with the trainer and feature special one-way valves at each end to help prevent accidental system draining. The hoses are kept inside a white case, as shown on Figure 34.

Figure 33. Hoses (from tubing kit).

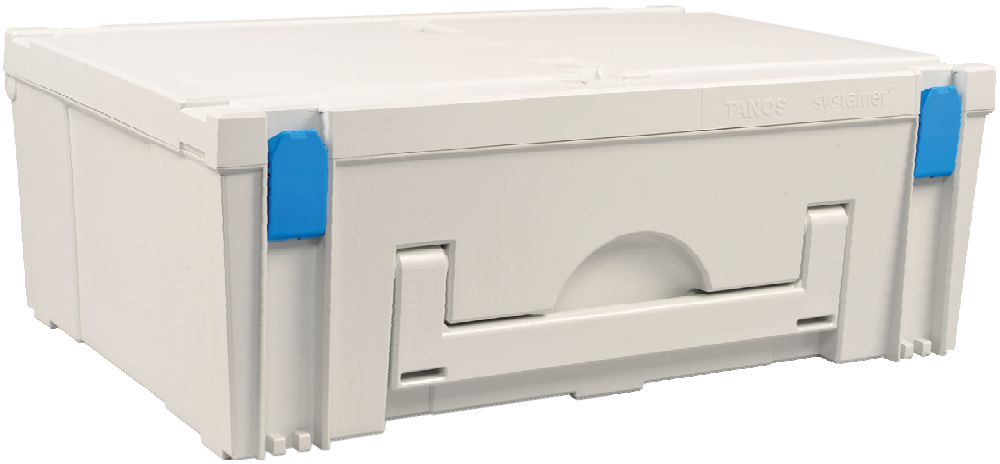

Figure 34. Case containing the hoses.

Other useful tools and materials that may be needed, include the following:

Shop vac: to remove water from drip pan.

Bucket and mop: these handy items can be helpful to clean up minor water spills in order to avoid water damage to the work area and to help prevent accidental slipping.

Towels: cloth towels or a roll of paper towels can be used to dry hands and equipment surfaces.

Basic tools and equipment

Some common hand tools and equipment (see Table 2) are typically required when working with solar thermal energy systems. A vast range of tools may be needed while installing or troubleshooting a particular system. These basic items can help with both electrical and mechanical aspects of the job and when working with the electrical wires, water pipes, and air ducts.

Table 2. Common hand tools and equipment used with solar thermal energy systems.

Wiring	
Digital multimeter (DMM)	Screwdriver set (flat and Phillips blade types) with insulated handles
Assorted pliers (standard and needle nose types) with insulated handles	Wire cutters/strippers/crimpers with insulated handles
Allen hex wrenches (set of various sizes)	Socket wrench or combination wrench set
Soldering station (and accessories, including solder)	Utility knife (and blades)
Rubber gloves	Fish tape
Flashlight	
Plumbing and ducting	
Level	Caulking gun
Hammer	Electric drill (and bits)
Pipe wrenches (assorted sizes)	Adjustable (Crescent) wrench
Propane or acetylene torch (and accessories, including solder and flux)	Wire brush
Hacksaw	Wood saw
Pipe cutter	Duct crimper
Locking pliers	Tin snips
Pop riveter	Insulation stapler
Tape measure	Steel rule
Square	Crowbar
Reciprocating saw (and blades)	Small hand brake (for bending sheet metal)
Safety glasses	Work gloves
Hard hat	Respirator
Ear protection	First aid kit
Outdoors	
Sun protection (sun screen)	Work boots (and/or roof boots)
Rope/cable	Ladders (self-supporting and extension types)
Body harness (and lanyard)	Roof jacks (with planks)
Saw horses (two)	Work lights

In addition to insulated copper wire, pipes, and ducting, some other basic materials that may be needed for a system installation include: marking crayon, chalk line, caulking/sealant, nails, screws, rivets, wire nuts, electrical tape, duct tape, Teflon tape and/or pipe dope, PVC cleaner/adhesive, sandpaper or emery cloth, steel-wool, rags, insulation, paint, flashing, plumber's strap, hardware cloth, roof cement, extension cords, electrical conduit and junction boxes, and an assortment of pipe/duct fittings.

Basic safety practices

As with any electrical and/or mechanical equipment, there are inherent dangers. Alternative energy systems can involve devices in motion (turbines and motors), high voltages (inverter output and utility grid), and other hazards (scalding hot water). Serious injuries can occur if the following basic safety recommendations are not followed correctly.

While this job covers some basic safety steps, it is not intended to replace a complete industrial safety training program.

Whenever installing, operating, servicing, or maintaining equipment, local and national building, fire and electrical codes must be followed to ensure a safe system and environment.

Equipment manufacturers normally supply manuals (or other documentation) with installation recommendations that should be followed to ensure safe operation. Recommended safe practices for specific equipment during service or maintenance are usually provided by the manufacturers, as well.

While servicing or maintaining machines and equipment, it is vitally important for you to stay alert and be aware of any potential conditions that may cause physical injury, such as slipping, tripping, or electrical shock. The proper use of tools is also vitally important for safety. For example, a knife blade should never be used as a replacement for a screwdriver.

While performing work, you can keep the equipment, yourself, other people, and your environment protected by applying some of the simple safety measures that are outlined here. Safety is a primary objective to being successful on the job. You should strive to continually develop safe work habits.

Clothing and personal protective equipment

Wearing appropriate clothes and protective equipment is essential to limit the risk of injury, but it is also important to bear in mind that protective equipment is not a substitute for good work practices.

- Always make sure that the clothes you are wearing cannot get caught in rotating equipment. Ties, jewelry, watches, and loose clothing must be avoided. If you are wearing a jacket with long sleeves, always roll the sleeves up.
- Always wear safety glasses and protective shoes. Remember that many injuries result from wearing improper or poorly fitting protective equipment.
- When wearing gloves to perform a task, always make sure that the gloves cannot get caught in rotating equipment.
- If your hair is long, tie it out of the way before using rotating equipment.

Working environment

Installation and maintenance operations require a safe working environment.

- Keep the working environment clean, orderly, and free of debris and other obstructions such as tools and loose parts.
- Floors should be clean and free of oil to ensure good footing and balance.
- Always keep hazardous machines and equipment properly guarded when in operation.

Trainer Familiarization and Safety

OBJECTIVE

In this job, you will become familiar with the solar thermal training system and the associated hardware that is required to properly install a solar thermal energy system. You will also apply some basic safety practices before beginning and while performing the work.

PROCEDURE

Equipment required

Refer to the Equipment Utilization Chart in Appendix A to obtain the list of equipment required for this job.

Safety procedures

Before proceeding with this job, complete the following checklist.

- ❑ You are wearing safety glasses.
- ❑ You are wearing safety shoes.
- ❑ You are not wearing anything that might get caught such as a tie, jewelry, or loose clothes.
- ❑ If your hair is long, tie it out of the way.
- ❑ The working area is clean and free of oil.
- ❑ The floor is not wet.
- ❑ Your sleeves are rolled up.
- ❑ The wheels of the system are locked in place.

System components

1. Locate and inspect the following items on the trainer. Check off each item in the list below as you complete this step for each component in the training system.
   - ❑ Mobile workstation (trainer frame and assembly)
   - ❑ Solar collector
   - ❑ Circulator pumps (2)
   - ❑ Storage tank (with 2 heat exchangers)
   - ❑ Plate heat exchanger
   - ❑ Differential controller (with 3 sensors)

- ❑ Thermostat controller (with 1 sensor)
- ❑ Expansion tanks (2)
- ❑ Radiator (with magnetic surface thermometer)
- ❑ Radiant floor
- ❑ Digital multimeter (DMM)
- ❑ Thermometers (2)
- ❑ Rotameters (2)
- ❑ Pressure gauge
- ❑ Pressure relief valves (2)
- ❑ Discharge lines (2)
- ❑ Shutoff valves (2)
- ❑ Check valve assembly (with 2 drain valves)
- ❑ Fill bowls (2)
- ❑ Automatic air vent
- ❑ Collector inlet (with shutoff valve)
- ❑ Collector outlet
- ❑ Tank drain (with shutoff valve)
- ❑ Tank return
- ❑ Electrical panel
- ❑ Dual work light
- ❑ Tubing kit (assortment of 30.48 cm, 60.96 cm, 91.44 cm, and 182.88 cm lengths)
- ❑ Water can
- ❑ Bucket and mop

2. Practice installing modules onto the work surface using the twist lock.

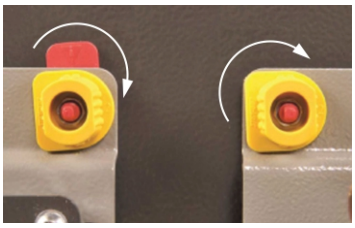

Figure 35. Twist lock.

3. List at least two modules that you tried to install and lock.

Answers vary.

4. Were you able to install and lock the modules successfully?

❑ Yes ❑ No

Yes

5. If you are having trouble locking any of the modules, ask your instructor for assistance.

6. Practice connecting a hose between two different modules while making sure that each hose connector is seated and locked securely.

7. Were you able to connect a hose properly?

❑ Yes ❑ No

Yes

8. If you are having trouble connecting any of the hoses, ask your instructor for assistance.

9. Ask the instructor to check your work.

Name: _____ Date: _____

Instructor's approval: _____