

## Installing Solar Water and Pool Heating Systems Objectives and Task Analysis for Solar Water and Pool Heating Systems Installation Contractor

### Introduction

This document presents a comprehensive task analysis for contractors installing solar water and pool heating systems on buildings.

It is important to note that these tasks are applicable to the installation contractor - not to the system designer. This task list assumes the installation contractor starts with an approved solar system design package, complete with major components, manufacturer installation manual, system schematics, and assembly and troubleshooting instructions. While the solar installation contractor may not design the system, in many cases they must be knowledgeable about many aspects of systems design, and may be required to adapt certain designs to fit a particular application or customer need.

For the purposes of developing training curricula, assessment mechanisms and certification criteria, specific tasks are classified as either cognitive or psychomotor skills. Cognitive skills are marked by the letter (C) in this document, and are skills that require knowledge processing, decision-making and computations. Psychomotor skills are marked by the letter (P), and are skills that require physical actions such as assembling, measuring, etc. Some tasks that are not as specific involve both cognitive and psychomotor skills, and are marked by the letters (C/P).

In addition, the tasks are also categorized according to their priority or importance using three levels; *Critical* items are considered high priority tasks and are expected competencies for all installers. These include items involving safety and other tasks with a high chance of error that could lead to system failure, destruction of components to which the system is attached, etc. *Very important* items are medium priority tasks, and are generally expected of all quality installers. *Important* items are considered low priority tasks, but are usually performed by all installers.

Fundamentally, these tasks assume that the installer begins with adequate documentation for the system design and equipment, including manuals for major components, electrical and mechanical drawings, and instructions. While these tasks have been developed based on conventional designs, equipment and practice used in the industry today, they do not seek to limit or restrict innovative equipment, designs or installation practice in any manner. As with any developing technology, it is fully expected that the skills required of the practitioner will develop and change over time, as new materials, techniques, codes and standards evolve.

**Prerequisites:** Each student will be expected to have basic plumbing, electrical, and roofing skills. (Specifically, knowledge of basic plumbing tasks such as soldering pipe joints, gluing pipe joints, sealing fittings, testing for plumbing leaks, etc. In regards to electrical, the installer should be familiar with basic electrical concepts and terms and with the operation of a multimeter. Also included is the ability to connect wiring, create weather sealed connections, etc. Regarding roofing knowledge, the installer should be familiar with basic roof materials, terminologies as well as flashing and sealing methods.)

### Primary Objective for Solar System Installation Contractor

Given basic instructions, manufacturer installation manual, major components specifications, schematics and drawings, the installer is required to install a solar water heating system that meet the performance and reliability needs of the customer, incorporates quality craftsmanship, and complies with all applicable codes and standards by:

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<b>1. Working Safely With Solar Hot Water and Pool Heating Systems</b>		
<b>Task/Skill</b>	<b><i>Skill Type</i></b>	<b><i>Priority/Importance</i></b>
<b>As part of safety considerations associated with installing and maintaining solar thermal systems, any solar thermal installer must be able to:</b>		
1.1 Maintain safe work habits and clean, orderly work area	Cognitive, Psychomotor	Critical
1.2 Demonstrate safe and proper use of required tools and equipment	Cognitive, Psychomotor	Critical
1.3 Demonstrate safe and accepted practices for personnel protection	Cognitive, Psychomotor	Critical
1.4 Demonstrate awareness of safety hazards and how to avoid them	Cognitive, Psychomotor	Critical
<b>The installer must be able to identify plumbing, electrical and other hazards associated with solar thermal installations, and implement preventive and remedial measures to ensure personnel safety:</b>		
1.5 Identify and implement appropriate codes and standards concerning installation, operation and maintenance of solar thermal systems and equipment	Cognitive, Psychomotor	Critical
1.6 Identify and implement appropriate codes and standards concerning worker safety and public safety	Cognitive, Psychomotor	Critical
1.7 Identify personnel safety hazards associated with solar thermal installations	Cognitive, Psychomotor	Critical
1.8 Identify environmental hazards associated with solar thermal installations through demonstrated awareness of pertinent Material Safety Data Sheets and other appropriate documents	Cognitive, Psychomotor	Critical
<b>2. Identifying Systems and Their Components</b>		
<b><i>Task/Skill:</i></b>	<b><i>Skill Type:</i></b>	<b><i>Priority/Importance:</i></b>
<b><i>Given the components required for an installation, the installer shall be able to identify the typical tools and components required for conducting the solar system installation. (This includes all components – collectors, pumps, controllers, sensors, heat exchangers, piping, valves, heat transfer fluids, etc.)</i></b>		

2.1 Identify components specific to an active direct solar system (For example, this would include: collector, tank, pump, controller, sensors, isolation and drain valves, pressure and temperature relief valves, air vent, piping, insulation, flashing, etc. This would apply to the components relevant to each specific type of system.	Cognitive	Very Important
2.2 Identify components specific to an active indirect solar system	Cognitive	Very Important
2.3 Identify components specific to a passive direct solar system	Cognitive	Very Important
2.4 Identify components specific to a passive indirect solar system	Cognitive	Very Important
2.5 Identify components specific to a swimming pool heating solar system	Cognitive	Very Important

<b>3. Adapting a System Design</b>		
<b><i>Task/Skill:</i></b>	<b><i>Skill Type:</i></b>	<b><i>Priority/Importance:</i></b>
<b><i>Given a solar system design package - including collectors and subsystem components and building on the site assessment, the installer shall be able to:</i></b>		
3.1 Determine active direct system components' location and system layout and configuration	Cognitive	Very Important
3.2 Determine active indirect system components' location and system layout and configuration	Cognitive	Very Important
3.3 Determine passive direct system components' location and system layout and configuration	Cognitive	Very Important
3.4 Determine passive indirect system components' location and system layout and configuration	Cognitive	Very Important
3.5 Determine solar pool system components' location and system layout and configuration	Cognitive	Very Important
3.6 Apply for building permits	Cognitive	Important
3.7 Estimate time, materials, tools and labor required for installation	Cognitive	Very Important
3.8 Determine installation sequence to optimize use of time and materials	Cognitive	Important

3.9	Inspect all provided system components for damage prior to installation	Cognitive, Psychomotor	<i>Important</i>
<b>4. Conducting a site assessment</b>			
<b><i>Task/Skill:</i></b>		<b><i>Skill Type:</i></b>	<b><i>Priority/ Importance:</i></b>
<i>Given a selected site, the solar installer shall be able to:</i>			
4.1	Determine the required installation area, orientation, and tilt for proposed collector installation	Cognitive	Very Important
4.2	Establish whether there is suitable installation area with unobstructed solar access for installing collector	Cognitive	Very Important
4.3	Determine the extent of current and future shading for any proposed collector location using typical sun path calculators or similar methods	Cognitive, Psychomotor	Very Important
4.4	Assure structural integrity and suitability of collector site. Determine soil conditions and integrity for footing design and pipe path. (Local codes or site conditions might then require involving an engineer).	Cognitive	Critical
4.5	Determine suitable location for installing all subsystem components (This includes piping, water heater, valves, and ancillary equipment required for complete system installation.)	Cognitive	Very Important
4.6	Practice all personnel safety requirements	Psychomotor	Critical
4.7	Identify any other constraints and options for the installation related to local and state code requirements	Cognitive	Very Important
4.8	Verify that system to be installed is appropriate for the building and climate	Cognitive	Very Important
4.9	Verify with the homeowner the proposed location of the collector and other major components	Cognitive	Very Important
<b>5. Installing Solar Collectors</b>			
<b><i>Task/Skill:</i></b>		<b><i>Skill Type:</i></b>	<b><i>Priority/ Importance:</i></b>

<b>Given roofs of various types (tile, asphalt shingle, built-up gravel, etc.) and of varying pitch, the installer shall be able to:</b>			
5.1	Identify specific manufacturer's mounting design and materials	<i>Cognitive</i>	<i>Important</i>
5.2	Identify acceptable National Roofing Contractor's Association roof mounting and penetration methods	<i>Cognitive</i>	<i>Very Important</i>
5.3	Identify different collector mounting methods suitable for roof types or other installation areas	Cognitive	Very Important
5.4	Identify different system (in the case of ICS and thermosiphon systems, due to extra weight and components) mounting methods suitable for roof type	Cognitive	Very Important
5.5	Identify locations for roof/ wall, foundation penetrations, and structural attachments	Cognitive	Critical
5.6	Evaluate the suitability of selected mounting structural attachments and compliance with applicable local codes	Cognitive	Very Important
5.7	Determine multi-collector piping strategy	Cognitive	Very Important
5.8	Install collector mounting device to installation area	Psychomotor	Very Important
5.9	Weather seal roof penetrations and other structural devices with flashings and sealants	Psychomotor	Critical
5.10	Lift collectors to installation area	Psychomotor	Very Important
5.11	Attach mounting bracket and struts (if required) to collector	Cognitive	Very Important
5.12	Secure collector to collector mounting device	Psychomotor	Very Important
5.13	Connect collector to piping	Psychomotor	Very Important
<b>6. Installing Water Heater and Storage Tanks</b>			
<i>Task/Skill:</i>		<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>Given a water heater and/or storage tank to be installed and the system design, the installer shall be able to:</i>			

6.1	Prepare the environment for tank installation (water and power source)	Cognitive	Critical
6.2	Determine by inspection that the new water heater and/or storage tank and required subcomponents are damage free	Cognitive	Very Important
6.3	Determine tank ports to be used for plumbing lines	Cognitive	Very Important
6.4	Determine dip tube strategy	Cognitive	Very Important
6.5	Determine plumbing retrofit method to be used if conventional water heater tank (electric or gas) is used	Cognitive	Very Important
6.6	Install drain pan per local codes	Psychomotor	Very Important
6.7	Remove the old conventional water heater tank, if required	Psychomotor	Important
6.8	Install dip tubes	Psychomotor	Critical
6.9	Install port fittings if required	Psychomotor	Very Important
6.10	Install tank valves (drain, pressure temperature relief, etc.)	Psychomotor	Very Important
6.11	Connect plumbing and valves between solar tank and conventional auxiliary tank (if required)	Psychomotor	Critical
6.12	Connect water heater and/or storage tank to water source	Psychomotor	Very Important
6.13	Fill tank with water	Psychomotor	Very Important
6.14	Connect the water heater and/or storage tank to power source	Psychomotor	Very Important
6.15	Determine that water heater and storage tanks are installed per manufacturers' recommendations and code	Cognitive	Very Important
6.16	Determine that installed tank and fittings have no leaks	Cognitive	Very Important
6.17	Install exterior tank insulation blanket if required	Psychomotor	Important

6.18	Install thermosiphon solar tank	Psychomotor	Critical
<b>7. Installing Piping , Pipe Insulation and Connecting System Piping</b>			
<b>Task/Skill:</b>		<b>Skill Type:</b>	<b>Priority/ Importance:</b>
<b>Given copper pipe, fittings, a pipe cutter, acetylene torch, solder, wire brush, sand cloth, and flux, the installer shall be able to (for solar water heating system):</b>			
7.1	Determine the extent of, and make allowances for expansion of pipe and its effect on hangers and the integrity of the pipe	Cognitive	Very Important
7.2	Determine type, length, and diameter of copper piping required	Cognitive	Very Important
7.3	Cut copper pipe to desired length	Psychomotor	Important
7.4	Solder copper piping connections	Psychomotor	Very Important
7.5	Test soldering fittings for leaks	Cognitive, Psychomotor	Very Important
<b>Given plastic pipe, fittings, pipe cutter, plastic pipe cleaner and glue, the installer shall be able to (for solar pool heating system):</b>			
7.6	Determine type, length, and diameter of plastic piping required	Cognitive	Very Important
7.7	Cut plastic pipe to desired length	Psychomotor	Important
7.8	Glue plastic piping connections	Psychomotor	Very Important
7.9	Test glued fittings for leaks	Cognitive, Psychomotor	Very Important
<b>Given a run of piping insulation, a cutting tool, and adhesive material, the installer shall be able to:</b>			
7.10	Determine type, diameter, and length of insulation required	Cognitive	Important
7.11	Cut insulation and install over piping and plumbing fittings	Psychomotor	Important



7.12	Miter insulation ends, where appropriate	Psychomotor	Important
7.13	Glue and seal insulation joints, as required	Psychomotor	Important
7.14	Select ultraviolet radiation protective method	Cognitive	Very Important
7.15	Protect insulation from ultraviolet degradation	Psychomotor	Very Important
<b><i>Given a standard tool set, sealant, and copper pipe or tubing, the installer shall be able to:</i></b>			
7.16	Determine type of pipe flashing to use for specific roof type	Cognitive	Critical
7.17	Determine the area where pipe flashing will be installed	Cognitive	Very Important
7.18	Make roof penetrations	Psychomotor	Very Important
7.19	Install pipe flashing and sealant	Psychomotor	Critical
<b><i>Given a standard tool set, a pipe cutter, solder and soldering equipment (solar water heating), pipe cleaner and glue (solar pool heating systems), pipe and fittings, the installer shall be able to</i></b>			
7.20	Determine slope strategy of piping to avoid traps on horizontal runs	Cognitive	Critical
7.21	Slope piping to avoid traps in horizontal pipe runs	Psychomotor	Critical
7.22	Attach pipe hangers and supports	Psychomotor	Very Important
7.23	Install stand-off hangers beneath piping on roof if needed	Psychomotor	Very Important
7.24	Connect all system piping to water heater tank, collector, valves, pumps, etc.	Psychomotor	Very Important
7.25	Determine under-ground piping method	Cognitive	Important
7.26	Install under-ground piping	Cognitive	Important
<b>8. Installing Mechanical/Plumbing Equipment and Other Components</b>			

<b>Task/Skill:</b>	<b>Skill Type:</b>	<b>Priority/ Importance:</b>
<b><i>Given system valves and monitoring components and the system installation manual, manufacturers' product directions, piping, fittings, and a standard tool set, the installer shall be able to:</i></b>		
8.1 Determine system plumbing, valves and other components required  (This includes the following: valves, air vent, check, drain, auto drain down, expansion tanks, flow control, isolation, diverting, solenoid, mixing, anti-scald, pressure relief, temperature pressure relief, vacuum relief, balancing, freeze, etc. as well as the following monitoring components; flow meter, temperature gauge, pressure gauge, etc.)	Cognitive	Very Important
8.2 Determine location of plumbing valves and other components	Cognitive	Very Important
8.3 Install system plumbing valves and monitoring system components as specified in component manufacturer's or solar manufacturer's installation manual and schematic	Psychomotor	Very Important
<b><i>Given a heat exchanger and installation manual, manufacturer's directions, piping, solder and soldering equipment, fittings, and a standard tool set, the installer shall be able to:</i></b>		
8.4 Determine the heat exchanger location	Cognitive	Important
8.5 Install heat exchanger and heat exchanger fluids as specified in manufacturers installation manuals and schematics	Psychomotor	Important
<b><i>Given a circulating pump and manufacturer's directions, pipe, fittings, solder and soldering equipment, electrical supplies, teflon tape and a standard tool kit and other plumbing materials, the installer shall be able to:</i></b>		
8.6 Determine pump location	Cognitive	Very Important
8.7 Install the pump according to the manufacturer's installation manual	Psychomotor	Very Important
<b>9. Installing Electrical Control Systems</b>		
<b>Task/Skill:</b>	<b>Skill Type:</b>	<b>Priority/ Importance:</b>
<b><i>Given a system controller, manufacturer's directions, and a standard tool set, the installer shall be able to:</i></b>		
9.1 Determine the location of the controller	Cognitive	Important
9.2 Install differential controller and sensors	Psychomotor	Very Important

9.3	Install photovoltaic module controller and pump	Psychomotor	Very Important
9.4	Install a timer controller	Psychomotor	Very Important
9.5	Install control wiring	Psychomotor	Very Important
9.6	Select ultraviolet radiation protective method for external wiring	Cognitive	Very Important
9.7	Protect external wiring from ultraviolet degradation	Psychomotor	Very Important
9.8	Test operation of controller	Cognitive	Very Important
<b><i>Given flashing, sensor wires, sealant and a standard tool set, the installer shall be able to:</i></b>			
9.9	Determine type of flashing to use for specific roof type	Cognitive	Critical
9.10	Determine the area where wire flashing will be installed	Cognitive	Very Important
9.11	Make roof penetrations	Psychomotor	Very Important
9.12	Install wire flashing and sealant	Psychomotor	Very Important
9.13	Install control wiring	Psychomotor	Very Important

<b>10. Installing operation and identification tags and labels</b>			
<b><i>Task/Skill:</i></b>	<b><i>Skill Type:</i></b>	<b><i>Priority/Importance:</i></b>	
<b><i>After completing the installation of the solar system equipment and prior to operating the system, the installer shall be able to:</i></b>			
10.1	Determine components that require identification tag and/or label	Cognitive	Very Important
10.2	Install identification tags and/or label	Psychomotor	Very Important

<b>11. Performing a System Checkout</b>		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>After completing the installation of the solar system equipment and prior to operating the system, the installer shall be able to:</i>		
11.1 Identify any deficiencies in materials, workmanship, function or appearance by visually inspecting entire installation	Cognitive, Psychomotor	Very Important
11.2 Determine that the system mechanical installation has structural integrity and is weather sealed	Cognitive, Psychomotor	Very Important
11.3 Determine that the system plumbing installation is correctly installed	Cognitive, Psychomotor	Very Important
11.4 Determine that the electrical installation is correctly installed	Cognitive, Psychomotor	Very Important
11.5 Verify system start-up and shut-down functionality	Cognitive, Psychomotor	Critical
11.6 Verify overall system operation and functionality	Cognitive, Psychomotor	Critical
<i>Given an installed system, the installer shall be able to:</i>		
11.7 Demonstrate to the owner operation and functionality of system	Psychomotor	Important
11.8 Demonstrate to the owner start-up and shut-down procedures for system	Psychomotor	Very Important
11.9 Demonstrate to owner simple maintenance and diagnostic procedures	Psychomotor	Important
11.10 Identify for owner all markings and labels for system service and owner interaction	Cognitive	Important
11.11 Identify for owner safety issues associated with operation and maintenance of system	Cognitive	Very Important
11.12 Complete and transfer documentation package to system owner/operators	Cognitive	Very Important
11.13 Review system/component warranties and requirements with owner	Cognitive	Important

<b>12. Maintaining and Troubleshooting a Solar Thermal System</b>		
<i>Task/Skill:</i>	<i>Skill Type:</i>	<i>Priority/Importance:</i>
<i>As part of honoring system/component warranties or through service contract, the installer shall be able to:</i>		
12.1 Demonstrate proficiency in using tools and materials required for maintenance and troubleshooting	Cognitive, Psychomotor	Very Important
12.2 Interpret installation manual, wiring diagrams, drawings, and other specifications to plan maintenance or repair work	Cognitive	Very Important
12.3 Determine evaluation points for system monitoring, maintenance and troubleshooting (i.e., sensor calibration, heat exchanger fluid integrity, pump operation)	Cognitive, Psychomotor	Very Important
12.4 Identify cause of problems based on evaluation results	Cognitive	Very Important
12.5 Determine what repairs or system modifications are needed to restore the system to its baseline operating conditions	Cognitive	Very Important
12.6 Perform any identified repairs or modifications to restore system to manufacturer's or operator's specifications	Cognitive, Psychomotor	Very Important