STUDY GUIDE FOR SOLAR WATER AND POOL HEATING SYSTEM INSTALLERS

AND

SAMPLE QUESTIONS WITH ANSWER KEY

Prepared for the

North American Board of Certified Energy Practitioners

By

The Florida Solar Energy Center

And

Energy Conservation Services

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TABLE OF CONTENTS

1. INTRODUCTION

This Study Guide presents some of the basic cognitive material that individuals who install and maintain Solar Thermal systems should know and understand. This information is intended primarily as a Study Guide to help individuals better prepare for the NABCEP solar thermal installer examination but does not provide all of the materials needed for completing the certification examination. Knowledge of the information presented, knowledge of pertinent sections of the International Plumbing Code and appropriate experience and qualifications are generally required of those applying for and completing the NABCEP certification process. Applicants and certificants are also reminded that local installation codes can differ from national codes and the information presented in this Guide.

This Guide is based on a task analysis for the Solar Thermal system installer, which includes the following eight major job/task areas when installing Solar Water Heating and Solar Pool Heating systems:

1.	Working Safely with Solar Thermal Systems	5%
2.	Identifying Systems and Their Components	8%
3.	Adapting a System Design	10%
4.	Conducting a Site Assessment	5%
5.	Installing Solar Collectors	10%
6.	Installing Water Heater and Storage Tanks	10%
7.	Installing Piping, Pipe Insulation and Connecting System Piping	10%
8.	Installing Mechanical/Plumbing Equipment and Other Components	10%
9.	Installing Electrical Control Systems	10%
10.	Installing Operation and Identification Tags and Labels	2%
11.	Performing a System Checkout	10%
12.	Maintaining and Troubleshooting a Solar Thermal System	10%

The percentage following each task area represents the approximate emphasis that each topic is given in this Guide, and is similar to what would be expected for a typical distribution of emphasis in training programs and on formal testing for certification and/or licensure in the trade.

How this Guide is used may depend upon how much the reader already knows about installing solar thermal systems. This Guide is organized in the following manner:

- Introduction
- Reference Resources
- Study Guide
- Sample Examination Questions
- Answer Key

The Guide is intended to provide an overview of each of the major content areas of the above task analysis. A set of practice questions that relate to each of the major content areas is then provided. The questions are organized according to each content area. The answers to the practice questions, along with related explanations, are given at the end of this Guide. The experienced installer may wish to try the questions first. Then, if any are missed, s/he can study the answer key to review the methods for solving the problems used by the technical experts who provided input to the authors of this Guide. Individuals that are new to these topics likely will benefit most from starting at the beginning of the material and working through to the end, answering questions after completing each section, but this Guide alone will neither ensure the applicant will meet the requirements for taking the exam nor provide enough code-related information to successfully complete the exam.

The sample examination questions span fundamental trade knowledge, codes and standards, and accepted industry practice in the relevant design, installation, and maintenance of solar thermal systems. Many questions are based on system installation scenarios, requiring the use of schematics, diagrams, and equipment specifications.

Guidelines for determining solutions to the questions may be found in the text of this Guide, or from the references listed below. The suggested reading materials are also listed to broaden resources for the applicant but have not been validated by legal entities or checked for accuracy by NABCEP.

In addition to the specific content areas listed above, knowledge and skills in the following content areas are required for successful completion of the examination:

- Reading and interpreting plans and specifications
- Reading and interpreting codes and standards
- Using basic mathematics and some trigonometry (addition, subtraction, multiplication, division, calculations of area and volume, fractions, decimals, percentages, calculating the sides of triangles, square roots, powers of numbers, and solving simple algebraic equations for unknown variables)

One does not need to understand algebra or calculus to be able to engage in safe work practices around solar thermal systems, but it is useful to better understand how solar thermal systems work, to understand how to calculate expected system performance, and to evaluate the results of the system operation.

2. REFERENCES AND RESOURCES

The following reference list identifies instruction and training materials, regulations, and codes and standards associated with the design and installation of solar thermal systems and are complementary to this Guide. Many of the sample questions come from these references, as does other content in this guide.

1. *Solar Water and Pool Heating Manual, Design and Installation & Repair and Maintenance*, January, 2006. Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922-5703. www.fsec.usc.edu

2. *2005 Code of Federal Regulations, Chapter 29 Part 1926 Safety and Health Regulations for Construction*. U.S. Department of Labor/OSHA, OSHA Publications, P.O. Box 37535, Washington, D.C. 20013-7535. http://www.osha.gov

3. *SRCC Document OG 300, Operating Guidelines and Minimum Standards for Certifying Solar Water Heating Systems*, May 2002, Solar Rating and Certification Corporation. http://www.solar-rating.org/

4. *The Copper Tube Handbook*, Copper Development Association, 260 Madison Avemue, New York, NY 10016. www.copper.org

5. *Residential Solar Water Heater with Heat Exchanger*. Provided by solar water heater manufacturers upon purchase of the unit. The manual may be downloaded from the NABCEP website at www.nabcep.org

6. *Uniform Plumbing Code,* 2006. International Association of Plumbing & Mechanical Officials, 5001 East Philadelphia Street, Ontario, CA 91761-2816. http://www.iapmo.org

Additional Reading Material:

1. *Solar Hot Water Systems Lessons Learned 1977 to Today*, 2004. Tom Lane, Energy Conservation Services, 6120 SW 13th Street, Gainesville, FL 32608 www.ecs-solar.com

2. *Roofing Construction and Estimating*, Daniel Atcheson, Cratftsman Book Co., 6058 Corte Del Cedro, P.O. Box 6500, Carlsbad, CA 92018 www.craftsman-book.com

3. 2005 National Electric Code, National Fire Protection Association. One Battery Park, Quincy, MA 02269. http://www.nfpa.org/nec

3. SOLAR THERMAL INSTALLER STUDY GUIDE

3.1 Working Safely with Solar Water and Pool Heating Systems

(Tasks 1.1 thru 1.8 of the NABCEP Task Analysis)

Working safely with solar thermal systems requires a fundamental understanding of plumbing systems coupled with common sense. The common sense aspects can be summed up with the following statements:

- If the workplace is cluttered, the possibility of tripping over something is significantly increased.
- If the workplace is a sloped roof with clutter, the possibility of falling off the roof is significantly increased.
- If tools are left lying out on a roof, the chance of them falling off the roof and injuring someone below is increased.
- If the workplace is a rooftop in bright sunshine, the chance of sunburn is increased, so a good layer of sunscreen is in order.

There are the usual subtle hazards, as well. These include nicks, cuts, and burns from sharp or hot components. Gloves should be used when handling anything that might be sharp, hot, rough, or that might splinter. There is always the possibility of dropping tools or materials on either oneself, someone else, or on sensitive equipment or materials. Using torches for soldering and brazing create hazards for fire or severe burns. When a solar thermal system is being assembled or serviced, it presents the possibility of thermal burns from high temperature fluids or steam to personnel. Improperly installed systems may result in severe damage to the roof and/or contents of the home.

The surprise elements on the job site cannot be overlooked. There is nothing more disconcerting when trying to move to a new position on a roof, only to bump into someone who has quietly moved into the space that you had hoped to occupy. It can cause a loss of balance and result in a serious fall. When working in a potentially dangerous location, it is wise to keep a conversation going so workers know exactly where everyone is located.

3.1.1 OSHA Regulations

All Solar installers should be familiar with construction standards established by The Occupational Safety and Health Administration (OSHA), which are covered in Chapter 29 of the U.S. Code of Federal Regulations, Part 1926, Safety and Health Regulations for Construction. Part 1926 consists of 26 subparts, labeled from A to Z. All parts are important, but some parts, such as underwater construction, refer to situations that will not be encountered with typical solar installations. The OSHA rules most relevant to solar installations include

Subpart D – Occupational Health and Environmental Controls
Subpart E – Personal Protective and Life Saving Equipment
Subpart P – Tools, Hand, and Portable Power Tools
Subpart Q – Welding, Cutting, Brazing

Several especially pertinent issues relating to solar installations include the following:

- No construction worker will be required to perform work under conditions that are unsanitary, hazardous, or dangerous to his safety or health. 1926.10(a)
- The employer shall initiate and maintain a job site safety and health program. 1926.20(b)(1)
- The use of any machinery, tool, material, or equipment that is not in compliance with safety standards is prohibited. 1926.20(b)(3)
- Every employee shall be instructed in the recognition and avoidance of unsafe conditions. 1926.21(b)(2)
- Every employee shall be instructed in the safety and health regulations applicable to his/her work. 1926.21(b)(2)

Falls are the leading cause of workplace fatalities, with 150–200 workers killed each year and nearly 10,000 injured. Because nearly every solar system involves climbing on a ladder, onto a roof, or both, it is essential that solar installers be familiar with OSHA fall protection regulations. OSHA requires that fall protection must be provided where needed. Any work done at more than six (6) feet above ground level must be done with fall protection considerations. Fall protection systems may include safety net systems, warning line systems, covers, toe boards, safety harnesses, or lanyards.

In cases where no specific fall protection system is used, OSHA allows a safety monitoring system in which a person can oversee the operation provided that the person is

- Competent in recognition of fall hazards,
- Capable of warning other workers,
- Operating at the same level as the other workers where the other workers can be seen by the monitor,
- Close enough to the operations to communicate orally, and
- Having no other distracting duties.

Even when care is taken to ensure that no person falls, it is equally important to ensure that no tool or part is dropped. If the object is dropped from overhead, anyone below is subject to having the object fall on him or her. Furthermore, there may be scaffolds, lumber, or any number of other items on a job site capable of inflicting head or other bodily injury. For this reason, it is important to review Subpart E, where OSHA specifies foot protection, head protection, eye protection, face protection, and respiratory protection, in addition to fall protection practices.

3.1.2 Safety in Attics

Solar thermal installations in most cases involve working in attic spaces. Working in an attic generally will require wearing a breathing mask, eye protection, clothing that will protect skin from insulation, and will require knowledge of where it is safe to support the weight of a person without risk of falling through the ceiling. It will also involve planning the excursion into the attic to ensure that it will also be possible to get out of the attic. And adequate lighting will be needed in the confines of the attic. Before entering an attic, one should be sure to drink water for hydration if the attic is hot and if it is expected that the attic work will take more than 15 minutes.

It is essential when traversing an attic to support one's weight by stepping only on the ceiling joists or trusses. There may be 1x2" furring strips for holding rock lath or plaster board, but these will not support the full weight of a worker. They may be confused with joists or trusses when they are covered with insulation. The ceiling material itself will definitely not support the weight of a worker. In many cases, planking or boards may be placed above joists temporarily to support the weight of workers in attics, making it easier to work.

Care should be taken not to drop or lay heavy tools onto the ceiling material. It may crack the ceiling. Also, care should be exercised when climbing around wires, piping, air conditioning ductwork, and any other attic protrusions, such as recessed lighting fixtures. The recessed fixtures may be hot, and the other items are subject to damage if they are overstressed. Furthermore, wires, pipes, etc., present a tripping or choking hazard to the worker. Special care must be made to avoid crushing air conditioning ductwork or existing electrical wiring. Caution is essential where protruding roofing nails may catch on clothing or cause lacerations and punctures to the worker.

3.2 Identifying Systems and Their Components

(Tasks 2.1 thru 2.5 of the NABCEP Task Analysis)

Installers must be familiar with and able to identify all components of active direct systems. This includes collectors, storage and auxiliary tanks, control systems using either differential, photovoltaic (PV), or timers, AC or DC pumps, and the various other components that make up these systems. The installer must be able to identify, in all categories of systems, proper piping, insulation, mounting hardware, and flashing components.

3.2.1 Freeze Protection

In addition to knowledge of active direct system components, applicants must be able to identify the freeze protection mechanisms incorporated in these systems as well as proper installation techniques and methods to ensure freeze protection. The type, function and proper location of all relevant valves used in active direct system designs, including check valves, temperature relief valves, isolation and drain valves, air vents, vacuum breakers, etc., must be identified. All back-up power systems must be identified.

3.2.2 Indirect Systems

Installers must be knowledgeable in the design, the components used and the installation requirements of indirect systems. While many of the same components used in the active direct systems are also used in the indirect systems, many are not. Applicants must be able to differentiate between direct and indirect systems as it applies to the various designs, components, and installation issues. Issues specific to indirect systems such as identifying whether the system is pressurized (closed-loop anti-freeze), or unpressurized (closed-loop drainback) must be understood. The type of heat exchanger used, or whether it be single wall, double wall, side arm, whether the circulation strategy is single or double pumped, thermosiphon, the type of heat transfer fluids used and the safety requirements of specific fluids must also be well understood. All active indirect component parts of the collection, control and storage systems must be identified. The use of back-up energy as a part of the system or as a pre-feed from solar must also be identified.

The installer must be able to identify the type of heat exchanger and heat transfer mechanism located between the collector and storage of a passive indirect system. In addition, the installer must know which ports are to be used in the thermosiphon tank for plumbing connections and the reason for the locations of the ports. The use of back-up power is also critical for this type of system with roof-mounted storage.

3.2.3 Direct Systems

Installer knowledge of passive direct systems includes the ability to identify the component parts of thermosiphon and ICS (Integrated Collection Storage) systems as well as being able to outline the differences between these types of systems. Identifying how back-up power will be used is critical for ICS systems and horizontal or vertical thermosiphon systems.

The knowledge base required of solar pool heating solar system installers include identifying the collectors and controls used for direct heating of swimming pools, and how back-up heaters are integrated into the system. Installers must also be aware of the plumbing methods used in integrating the solar system to the conventional pool system piping strategy.

The installer must have working knowledge of the types of piping used in the various solar water and pool heating systems, the reason why certain piping is used and how the pipe material and installation will affect system performance.

3.2.4 Valves

In regards to the various valves that are used in solar thermal systems, the installer must be acutely aware of the functions of each valve and why they are used in particular systems, be they water or pool heating. In addition, the installer must know the reason for locating the valves in specific locations in the system. The installer must also be cognizant of the type of valve used, be it a safety valve, valve used for filing, valve used for draining, etc., and the safety issues related to the valves' installation in the overall system.

3.2.5 Other Components

Although discussed later in this guide, it is critical that installers are knowledgeable in the ancillary components used in the installation of solar systems. Many of these items, even though considered "materials", are nevertheless critical components of a total system and must be well understood. These would include knowledge of the various types of pipe insulation, what type is suitable for certain applications, why different wall thicknesses are used, tank insulating blanket materials and the meaning of R-value. Installers must also be aware of the various flashing and sealing components and materials available, as well as the benefit of one flashing type versus another on specific roof type. Knowledge of all other components and materials used in the overall professional installation of a solar system is required.

3.3 Adapting a System Design

(Tasks 3.1 thru 3.9 of the NABCEP Task Analysis)

The solar installer is often required to make judgments and recommendations based on site considerations, including customer needs and other factors. Inevitably, the installer will be asked to advise on basic system type, location, and system layout and configuration. The solar system design package includes collectors, subsystem components and mounting hardware for the collectors.

Building on the site assessment and requirements of the owner, the installer must be able to determine the type of system, its components and location, system layout and configuration. These will include active direct and active indirect components, passive direct and indirect components.

The installer must be able to understand and interpret system schematics provided by the system manufacturer. The installer must know why a certain component is installed in a particular location in the system. For instance, not only must the installer understand why an air vent is used, but also how and where to install it in a manner that ensures proper operation.

A solar installer must know whether certain systems are feasible. For Example: A site requiring an indirect drainback system due to climatic freezing conditions requires an installer to know how a drainback system works and must ensure that the system layout, pipe runs, etc., will allow proper drainback. Experience with the reliability of systems, or the ease or difficulty of the installation of specific systems enable the installer to inform a potential system owner of the advantages and disadvantages associated with different system types. The experienced solar installer will be expected to be able to fully inform the owner of system operation and maintenance requirements. This allows the consumer to make a more intelligent choice of systems types for the intended application. After the system has been installed, it is essential that the system perform safely and reliably without damage to the consumer's property.

3.3.1 Components, Orientation and Layout of Solar Pool Systems

The installer must be able to determine the installation location, system layout and configuration for solar pool heating systems. This will include being able to understand and interpret system schematics provided by the system manufacturer. The installer must also know why a certain component is installed in a particular location in the system. For instance, not only must they understand why a vacuum breaker is used, but also how and where to install it in a manner that ensures intended operation.

3.3.2 Permits, Estimating Costs, Installation Sequence, Inspection of System

The installer must apply for all necessary permits required by local and state laws. The installer must comply with all local, state and national building codes, roofing codes, plumbing codes and national electrical codes. In additional, the installer must be aware of state and national solar system certification requirements. Once the manufacture's instruction manuals and equipment have been found to meet the above requirements, then the installer must be able to estimate the time, materials, and labor required for installation. The installer will be expected to determine the logical sequence to optimize use of time and materials.

The installer, using previous knowledge or reference materials must be able to estimate time, materials, tools and labor required for the proper installation of the solar water heating or pool heating system. In addition, the installer will also be capable of determining specific systems' installation sequences in order to optimize the installation time and use of required materials.

The installer must be able to inspect all systems components for damage prior to installation. Experienced installers must have knowledge of how to check all components at and before leaving the job site.

3.4 Conducting a Site Assessment

(Tasks 4.1 through 4.9 of the NABCEP Task Analysis)

The site assessment involves determining the proper installation location of the collector and also determining the proper orientation and tilt for that specific location. For example: The installer will determine whether the location of the collector will be shaded, especially between the hours of 9:00 a.m. and 3:00 p.m. solar time. Since shading may significantly reduce the output of the thermal collectors, the installer must be familiar with conducting a solar site shading analysis in order to determine a site's proper solar access. An installer must be able to use a solar pathfinder or solar site selector or similar device to estimate the amount and impact of shading at a given location.

The installer must be able to determine the long term effect of vegetative growth and how this will impact the system. The installer must also be able to identify other potential shading obstructions such as chimneys, parapets, etc., and determine their impact on system performance.

Installer must have knowledge in determining the proper installation area, orientation and tilt for the proposed collector installation. The installer must be able to calculate and inform the consumer of the effects of facing a collector tilted at various angles in relation to the sited latitude as well as the effects of being oriented east or west of due south The installer must be knowledgeable in regards to these calculations as well as the source reference for such.

Equally critical is to determine how collectors mounted one in front of the other are spaced to prevent shading. This requires using formulas in the references calculate situations such as the following: Based on your latitude at 10:00 a.m. on December 21st, and the pitch angle of the roof, the tilt angle of the collector, the raised length of the collector, and the standoff or strut length of the rear mounting hardware, determine how far the front mounts of each row of collectors must be spaced apart south to north to prevent the collectors from shading each other.

The installer must have the knowledge and proficiency to determine the structural integrity and the suitability of the collector mounting location. For example, the installer must determine if the roof is suitable for mounting the collector and the type of mounting hardware required for various types of roofs. If a ground mount is required, then the installer must determine the soil conditions and the integrity of the footing design and pipe path.

Familiarity with local and national codes is required on the part of the installer. Local codes or site conditions might require involving an engineer or using commercially approved mounting racks. Specific site conditions from cold, dry mountains to hurricane loading wind forces to humid seacoast environments must be determined when choosing the mounting materials and structure. The installer must have a knowledge of the type of installations required in these specific conditions as well as the materials to use. In many cases this will be a coordinated effort between the installer and the collector/system manufacturer.

Installers must be able to determine the suitable location for all subsystem components, i.e., piping, storage or auxiliary heater, valves and ancillary equipment required for the complete installation.

The installer must be knowledgeable in determining all personal and personnel safety requirements including the proper insurance to carry to do the job safely. The installer must be familiar with all local and state code requirements.

As stated above, it is critical that the system to be installed is appropriate for the specific geographical location and local climatic conditions. The installer must also be knowledgeable in the structural requirements or restrictions of the particular building. Following this, the installer must determine and from that determination make professional system installation judgments regarding the impact of hard or acidic water, freeze potential, local temperatures and water pressures, etc. For example: Almost all hot water systems will be required to withstand temperatures of 240 F for brief periods after stagnation and constant temperatures of 180 F at up to 150 p.s.i. in the entire circulation loop. Thermal collectors and exterior collector components must be capable of withstanding over 360 F during collector stagnation. The installer must be able to make installation decisions based on this type of knowledge.

The installer must verify with the homeowner the proposed location of the collectors and other major components. The installer should be able to explain to the homeowner, in a manner understandable by the layperson, the reasons necessary for the location and system components and layout. The homeowner must be able to verify this communication with the installer.

3.5 Installing Solar Collectors

(Tasks 5.1 through 5.13 of the NABCEP Task Analysis)

The installer has to be able to safely and securely install the collector and components on a variety of given roofs of various types (tile, asphalt shingle, metal, built-up gravel, etc.) and of varying pitch.

This will include identifying the manufacture's mounting design and mounting hardware and knowledge of what materials the installer must acquire to secure the collectors to the structure.

The installer must be familiar with and able to use methods for roof mounting and penetration and sealant methods acceptable to the National Roofing Association. This will require identifying proper collector mounting methods, roof flashing, and wind loading requirements suitable for various roof types and as importantly, various collector types.

The installer must be able to access the weight requirements of the structural load on the roof. For systems that have their water storage systems on the roof due to extra weight (typically ICS or thermosiphon systems), the installer must be familiar with the manufacturer's requirements for adding roof support as required for the specific roof type.

An installer must be able to identify the location for roof or wall attachments. The installer must be able to make penetration and structural attachments that safely and securely hold the collectors on the roof or wall without compromising the structure's foundation or building envelope. This will require the ability to evaluate the suitability of the selected mounting structural attachments not only to comply with applicable codes, both structural and wind loading, but also to meet the manufacturer's requirements for supporting the collectors. This may substantially require exceeding local and/or state requirements.

The installer must show proficiency in installing multi-collector arrays to assure equal flow through multi collectors at the proper flow rates as required by the manufacturer and/or good hydronic flow design.

It is especially important when attaching the mounting hardware and piping penetrations through the roof that these penetrations are sealed with weatherproof materials selected for the site. Knowledge of the type and installation method of these materials is required on the part of the installer. All flashing and sealants must comply with local site requirements and the National Roofing Association and Waterproofing Manual.

Thermal water heating collectors and especially passive water storage systems can be quite heavy. Installers must be familiar with proper OSHA methods specified to lift heavy items such as collectors and/or storage systems to the installation areas to prevent damage to the installer and system materials.

The installer must know how to secure collector mounting brackets and if necessary the struts to the collector and/or storage systems. Securing the collector to the collector's mounting system must not only meet the manufacturer's requirements, but additional support may be required by local codes and/or wind loading requirements.The installer must be able to adapt these requirements to the collector manufacturer's approved mounting hardware.

The installer must have the capabilities and material knowledge to properly connect the collector to the system piping transport loop. The collector and/or collectors must be attached to the piping following acceptable plumbing practices listed in the references. The piping for solar hot water and space heating systems must be insulated. The insulation, sensors and other components must be protected from UV light and other normal yearly weather conditions at the site. The installer must understand how to weather and ultra violet ray proof the insulation and what insulation is appropriate for the manufacturer's design requirements. The pipe attachments to the collectors must be suitable to the collector materials and be able to prevent corrosion and withstand expansion and contraction cycles due to heat and pressure. The installer must have full knowledge of these procedures.

3.6 Installing Water Heaters and Storage Tanks

(Task analysis 6.1 through 6.18 of the NABCEP Task Analysis)

The installer must be familiar with the materials and steps required in installing storage and auxiliary water tanks. The installer has to prepare the environment for the tank installation for space requirements (i.e. storage vessel fit) and allow for pressurized water to connect to the potable plumbing system. The power source for the solar control system must often be located near the storage system.

The installer must be able to determine the back-up power requirements for the solar storage and/or auxiliary water heater in the event of inclement weather (i.e. 240 volt A/C power supply for electric or natural or LP gas backup) Before installation, the new solar water heater and/or storage tank and subcomponents must be inspected to determine that they are damage free.

Before the tank is installed, the tank and ports to be used for the plumbing lines (i.e. hot in, cold out, solar in, solar out) and pressure relief valves should be inspected. Especially important is the dip tube strategy or the location of the suction side of storage to the collectors, and the discharge from the collectors to the storage. Must be familiar with dip tubes with integrated check valves and how it may affect the operation of the solar system. The discharge and suction parts should be designed to not break up stratification of the thermal water layers in storage. Familiarity with all the tank subcomponents is critical on the part of the installer, as improper installation would greatly affect the performance of the installed system.

The installer must be capable of retrofitting conventional water heaters as solar water heaters and of determining how backup gas or electric water heaters can be used.

Installers must be familiar with local codes that may require drain pans for solar and/or back-up water heaters. Preparations should be made to prevent damage to the drip pan when installing the solar water heater.

The installer will be required to install and/or modify dip tubes. Installers must be familiar with and install all solar storage tank fittings with compatible non-corrosive fittings and pipe, and all cut-off, drain, and pressure temperature relief valves in accordance with national and local plumbing codes. In addition, the installer will be familiar with the plumbing and valve strategy between solar and auxiliary tanks.

The installer will be required to test the storage tank and plumbing lines with air pressure as per local codes and fill storage tank with water. The installer must be capable of connecting the back up or power source to the solar storage tank.

The water heater and storage tank are to be installed as per the manufacturer's requirements and local codes. The storage tank and fittings must be checked for material compatibility before the system is installed, and for leaks once the system is pressurized. The installer must be capable of insulating the storage tank especially if the storage is located in non-conditioned space.

Thermosiphon tanks and ICS (Integrated Collector Storage) collectors located on the roof require special mounting structures to secure the storage vessel. Many thermosyphon storage tanks have electrical back-up systems. All appropriate national electrical codes must be followed for procuring exterior power to the back-up element. Roofing requirements as they apply to national roofing codes for electrical lines must be followed.

The consumer should be informed about how to use a timer or electrical cut-off device for the back-up power to horizontal thermosiphon tanks. Savings will be significantly reduced if power to the electrical back up on horizontal thermosiphon systems is not coordinated with consumer demand.

3.7 Installing Pipe, Pipe Insulation and Connecting System Piping

(Task Skills 7.1 through 7.26 of the NABCEP Task Analysis)

Given copper pipe, pipefittings, pipe cutter, acetylene torch, solder, wire brush, sand cloth and flux, the installer must have the knowledge skills and be able to perform the following tasks as per the referenced Copper Tubing Manual.

The installer must be able to determine the extent of and make allowances for piping expansion, its effects on hangers and the integrity of the pipe required for pressurized open loop systems, closed loop systems and un-pressurized closed loop systems.

The installer must determine the type, length, and diameter of the copper piping requires. The installer must make allowances for the expansion and contraction cycle loops on large collector arrays.

The installer must be able to properly cut the copper pipe to the desired length and prepare the pipe and fittings for soldering or brazing or other pipe connecting technologies (pro-press). Once soldered and/or brazed and assembled, the installer must be capable of testing all fittings and connections for leaks.

3.7.1 Installing Piping and Connecting System Pipe

Given plastic schedule 40 PVC or Schedule 40 ABS solid core pipe, fittings, plastic pipe cleaner, and glue, the installer must be able to install a solar pool heating system.
The installer shall determine the type, length, and diameter required for the proper flow rate and pressure.

The installer must know how to cut plastic pipe to the desired length, clean and prepare the pipe and fittings for the appropriate glue. The installer has to know how to test the glue fittings for both suction and discharge leaks.

3.7.2 Installing Insulation

The installer has to determine the appropriate exterior and interior insulation for the type of collectors and system being installed. The installer must know how to apply the insulation to the piping system. This involves also knowing what valves, and/or components should not be insulated

The installer must know how to cut insulation and install the insulation over pipe and pipefittings. Insulation ends are mitered and taped or glued as appropriate.
It is critical that the installer select ultraviolet and weather protection as well as protection from vermin and animals for the insulation.

3.7.3 Connecting the System Piping

The installer must have knowledge of the proper tools, sealants and specific flashings required for various types of roofs. It is important to determine where the pipe, flashing, and sensor or control wire will be installed.

The installer should have the tools required to make roof penetration properly, as well as know how to to install pipe and sensor wire, flashing, and to seal the roof against leaks.

3.7.4 Installing Piping Runs

In various locations in accordance with the system design, the installer must determine the strategy and system requirements to determine the slope to avoid traps on horizontal pipe runs and understand the significance of this action. Vents drain lines, and/or other devices may be required to be attached on horizontal pipe runs. This may be required to eliminate air to prevent restricting flow of the heat transfer fluid in pressurized systems.

Installers must show knowledge in the proper pipe hangers and supports to use on piping and must be familiar with the proper methods of attaching insulation to piping and pipe supports.

Knowledge of the type and methods of attaching proper roof standoffs between the roof and piping is required on the part of the installer.

Although not a frequent occurrence in conventional residential solar water heating system installations, installers must be familiar with proper under ground mounting installation methods.

3.8 Installing Mechanical/Plumbing Equipment and Other Components

(Tasks 8.1 through 8.7 of the NABCEP Task Analysis)

The proper location and purpose of a specific system's components is critical to the successful solar installation. The installer must know how to identify and install all of the component parts of the system. The installer must know how the components work and where they are located in the system to function properly.

For example, installers must be familiar with these common system requirements. Air vents in both open loop and closed-loop direct systems must be rated for the proper pressure and located properly to prevent air locking in the system, which can in turn restrict pump flow.

3.8.1 Locating, Installing Plumbing Valves and Monitoring Components

Check valves must be properly located in these systems to stop reverse flow thermosiphoning from storage to collector. Some systems can lose more heat than they gain if the check valves are not installed correctly. Flow meters and/or temperature gauges/sensors must be properly installed to correctly monitor the system. Temperature and/or pressure relief valves must be properly located to protect the system. Freeze protection valves must be properly located and installed to prevent freeze damage to the collector and piping. Drainback closed-loop system reservoirs must be properly located to assure proper draining and filling of the system. The installer must be capable of following the manufactures instructions for the location of all the components.

The above are only examples of the knowledge that the installer must have to properly determine the type of components as well as their function and proper location in the solar system. This includes expansion tank sizing, bladder compatibility with the heat transfer fluid and temperature ratings of the materials. In addition, the installer must be familiar with the system manufacturer's schematic that indicates what and where these components are to be installed in the system. Therefore, the ability to properly interpret schematics is critical.

3.8.2 Proper Location and Plumbing of Indirect System Heat Exchanger.

The installer must be able to identify the location of the heat exchanger integral to the system or the external location of an external heat exchange system. The installer must be able to identify the proper suction and discharge ports through the heat exchanger to and from the collectors. The installer must also be able to identify the proper piping and flow from storage through an external heat exchanger and the discharge cycle back to storage. The installer must know how to monitor the temperature from the collector to storage and from storage to the collector and also to identify if the heat exchanger and/or pumping system is working correctly.

The installer must also be able to monitor the temperature at the flow from storage to the external heat exchanger and the temperature back to storage to determine if the system is working correctly. The installer must be able to choose the proper heat transfer rate based on the manufacturers design, public safety, local codes, and local low temperatures for record freezes and the pumping requirements for the system. The installer must know the physical and chemical characteristics of the heat transfer fluids based on the type of collectors being used in relation to the temperature and pressure that the solar system will be operating at.

As had been repeated numerous times in this study guide, the installer must be familiar with and follow the specific system manufacturer's installation manual and schematics. In many cases these systems their manuals and schematics have been approved by a state or national certification agency which provides a level of comfort for the installers using these systems. At the point of installation, it is the installer's responsibility to install the system based on the installer's professional solar installation experience and also follow any specific guidelines and schematics provided by the system manufacturer and local codes.

3.8.3 Pump Location and Function

The installer must be capable of determining the appropriate AC or DC pump for the system. The installer must be capable of installing the pump in the system according to the manufacturers' specifications for how the pump should be correctly installed, and where the system design is appropriate for the pump's location.

Although a design issue, the installer should be familiar with a given AC or DC pump and PV module's capability of creating the proper head and flow rate for the system. When pumping from storage or a water tank through the collectors or an external heat exchanger, the pump must create adequate flow rates according to the collector manufacturer's specifications or for the effective removal of heat from a heat exchanger, but not break up the stratification in the storage tank.

The installer must be capable of understanding why the system designer has chosen the PV module that matches the DC pump for the correct starting and stopping times of approximately .2 sun or 200 watts per square meter at 80 Btus per square foot of collector area. The installer should also understand why the designer has to select the proper PV module and DC pump to assure adequate flow and heat transfer under full sun conditions for the collector area and given pressure drop through the system.

3.9 Installing an Electrical Control System

(Task Skills 9.1 through 9.9 of the NABCEP Task Analysis)

The installer must be capable of installing the controller, in the event a differential or timer controller is used, as a part of the subsystem near the pump and storage components. The installer must know the proper sensor wire type and size used with a differential controller. The installer must be able to determine the proper location for the sensor at the collector, how to attach the sensor at the collector and how to properly wire the sensor to the differential controller. The installer must also know how to protect and insulate the collector sensor. It is critical that collector sensors be attached securely at the proper location at the collector to function properly. Freeze sensors, if used, must be situated correctly to assure proper recirculation flow through all of the collectors during freeze conditions.

Storage sensors must be securely mounted on the storage system and adequately insulated. The contractor must be able to test the collector and storage sensor to verify that they are at the correct temperature reading. The installer must be capable of programming or making selections on the controller. The installer must know how and when to activate the controller freeze recirculation if and when necessary. The installer must know why and when the high limit control feature for storage should be set for a chosen system design and how to program the high limit switch.

The installer must know how to set a minimum starting temperature for the controller or to add additional control sensors with a minimum starting point to the system. This may be required in extremely cold climates with low ground water temperatures.

The installer must know how to test the controller and sensors to see that they are functioning correctly. The installer must be familiar with basic voltmeters and also be familiar with differential controller manufacturer's controller testing apparatus.

The installer must know the type of electrical wiring to use in connecting specific PV to DC pumps. The proper size and type of wire must be chosen by the installer to carry the correct current from the PV module with no more than 5% voltage loss from the PV module.

The installer must be able to add a cut off toggle type switch between the DC pump and the wiring from the PV module. The installer must know how and when (time of day) to test the PV module for adequate voltage and amperage for the DC pump.

The installer must know, for both sensor and PV module wire, what type wire is suitable for ultra-violet ray, temperature, and the weather extremes that exterior wire will be exposed to.

The installer must know how to adequately attach relief strain to prevent the wire from being pulled out of the sensor or off the PV module. The installer must also be aware of materials adjacent to the wiring that could cause wire chaffing, destruction of wiring capabilities and therefore lead to system performance failure.

The installer must be capable of firmly securing and attaching the PV module to the collector or close proximity. The PV module should be attached in the same plane as the solar thermal collector so that it acts as both the controller and power source for the DC pump. The installation must be knowledgeable in the site selection principles as discussed previously in the collector siting section and how these are related to the PV module siting. Avoidance of shading on PV modules is even more critical. The PV module must not be shaded when the collectors are unshaded and oriented so that the pump will start when the collectors are receiving approximately .2 suns or 80 Btus per square foot.

The installer must know how to install a timer controller switch and when a timer controller is suitable. Time controllers are used on some open loop direct systems instead of differential controllers or PV module/DC pump control combinations. The pumping and flow in and out of storage strategy must be properly designed for timer controlled systems to operate properly.

There are some pool, spa and/or space heating systems that also activate power for a pump from storage through a heat exchanger or hydronic heating system based on control strategy during the 9:00 a.m. to 3:00 p.m. solar collection period. Installers must be familiar with these.

3.10 Installing Operation and Identification Tags and Labels

(Task Skills 10.1 through 10.2 of the NABCEP Task Analysis)

As stated previously, installers must be knowledgeable in identifying the types, functions and locations of various valves and ancillary equipment used in a solar system. The installer must be able to identify the various system components that require identification tags and/or labels. The tags and labels provide information on the identification and purpose of various components and at times system operation information. The labels and tags also define the types of fluids used in the system. The installer must be able to install in a secure manner these various tags/labels.

It should be noted that the national solar thermal certification program requires that tags/labels be affixed to various valves and components in certified systems. The manufacturer of these certified systems have been required to provide these tags/labels along with the system manuals. In those cases, the installers will have a description of the tags/labels as well as instructions as to which components (valves, discharge points, etc.) they are to be affixed. The installer should thus be knowledgeable in the manufacture's installation manual, the tags/labels provided, the location of these tags/labels, and also the types of fluids used in the systems.

In addition, national codes also require that certain tags/labels be affixed to locations in the system where discharge of fluids may occur. These tags/labels must identify the fluids that are being used in the system.

3.11 Performing a System Checkout

(Task Skills 11.1 through 11.13 of NABCEP Task Analysis)

The installer must be able to provide the owner with a basic understanding of how the system functions to collect solar energy from the thermal collectors and the current system operations that puts solar energy in storage. The installer will explain the basic function of the subsystem pumps and controls. The installer will explain, as applicable, all system monitoring devices (i.e. thermometers, pressure gauges, flow meters, site glass, etc.) that the consumer must be aware of to assure the system is functioning properly.

The installer must be able to demonstrate to the owner that the system is operating properly. The installer must be able to explain to the owner in simple terms the start up and shut down procedures for the system.

The installer will verify that the consumer is aware of any and all normal maintenance that is required. The installer will verify that the consumer can contact the correct service department if any problems arise or normal maintenance is required. The installer must verify that the consumer understands how to diagnose that the system is operating as advertised under average daily solar conditions. The installer will identify to the owner all markings and labels on the system and service date reminders. The installer will identify for the owner all safety issues associated with the system operation and maintenance. The owner will verify why certain handles or valves have been removed from systems to prevent access by unauthorized personnel or children.

The installer will go over all system warranties with the owner /operator and explain what the owner's responsibilities and rights are under the warranty. The installer will provide the owner all the component and manufacturer's documentation and manuals. The installer will review the component warranties and requirements with the owner/operator to verify that they understand the component warranties and requirements. If a permit inspection is required then the installer will verify that the owner/operator is aware of the building department's final approval procedure. The installer needs to verify that the pressure gauges on closed loop systems and the water level indicators on closed loop or drainback systems are critical for the owner/operator to watch for the first weeks of system operation.

The installer must make note of any critical issues the owner must be aware of by the manufacturer. The owner must be informed of what action to take and who to contact if any issues with the system arise.

3.12 Maintaining and Troubleshooting A Solar Thermal System

(Task Skills 12.1 through 12.6 of the NABCEP Task Analysis)

3.12.1 Use of Proper Tools for Maintenance and Interpreting Wiring Digrams

The installer must demonstrate an understanding of and proficiency in using the tools and materials required for maintenance and troubleshooting solar thermal systems. The installer must know how to use a digital voltage meter to check the accuracy of sensors versus temperature ohm resistance charts. The installer must be able to confirm conductivity in the wiring between sensors and controllers and between DC pumps and PV modules. The installer must know how and when to check for the proper amperage from a PV module and how to check for voltage. The installer must be familiar with and able to use a DC power supply to check a DC pump's ability to start properly and run at the proper flow rate.

The installer must know how to check the various differential controller functions. The installer must know how to test all high limit and freeze control circuitry of differential controllers. The installer must know how, with or without thermometers, to test for adequate flow during peak solar hours under normal solar conditions.

The installer must be able to use manufacturer and solar industry troubleshooting guides to determine problems such as; a system may not be heating the water sufficiently, there is no hot water in the morning, system is too noisy, there is a fluid leak, or there is too high a backup in use, etc. The installer must be capable of interpreting the manufacturers manual, wiring diagrams, installation schematics, and component specifications to determine how to evaluate the performance of the system. The installer must know what evaluation points should be monitored for troubleshooting and maintenance. The installer must know when and under what conditions to change a heat exchange or heat transfer fluid.

3.12.2 Identifying Problems Based on Evaluation of System

The installer has to know how to identify the problems based on evaluating the entire system. The installer must be able to determine how to correct the problems, to determine what cause or causes resulted in the problem. The evaluation by the installer should include knowledge on how and what action to take to mitigate the problem from occurring again in the future. The installer must sign off on what the problem was, what caused the problem, and what actions or repairs were performed on the system to make the system operational again and provide information on any and all recommendations for system upgrades, as well as service or maintenance in the future that will prevent the problem from reoccurring. Any repairs or maintenance required to restore the system to functional operation require identification of those components under warranty, which must be reported to the manufacturer or system assembler.

The installer must be capable of making the consumer/operator aware of any repairs required to restore the system and also to provide any recommendations for system modifications or maintenance requiring the consumer/operator's full and complete understanding and agreement on actions taken by the installer to fulfill recommendations and maintenance requirements. The installer needs to be able to make sure that the owner/operator receives a complete service and/or maintenance report including but not limited to date of service, parts used, and time and types of repairs. The installer must include copies of all service calls, maintenance logs and repairs in individual owner service folders.

4. SAMPLE QUESTIONS

1. All of the following are characteristic of a good heat transfer fluid except one.

   a. High density and high surface tension
   b. High dissolved solid contents
   c. Chemically inert and non-corrosive
   d. Low viscosity

2. The most common type of pump used as a circulator for solar hot water systems is:

   a. Diaphragm
   b. Reciprocating
   c. Centrifugal
   d. Piston

3. An expansion tank should be installed facing down on the feed side before the pump for all but one of the following.

   a. To keep the expansion tank cooler
   b. To keep air bubbles from being trapped in the expansion tank
   c. To help the pump operate better
   d. To keep air inside the expansion tank in case the air bladder leaks

4. When using a DC pump with a PV module which of the following is correct.

   a. The voltage and amperage must be able to start flow at 0.2 suns or 80 BTU per square feet
   b. The PV module and DC pump must have adequate or full flow at 1 sun for the collector area of at least 0.02 gallons per minute per square feet of collector area
   c. The piping must be sized correctly to prevent too much pressure drop due to friction
   d. The voltage of the PV module must not exceed the voltage of the DC pump motor by 5 volts DC

5. The most efficient double pumped heat exchanger design is
   a. Parallel flow
   b. Mix flow
   c. Counter flow
   d. Immersed coil

6. If the temperature going into the pool filter is 80 degrees F.-which of the following return temperatures from the pool collectors is more efficient?

A. 83F.
B. 90F.
C. 88F.
D. 101F.

7. Over 90% of all heat lost from an in-ground pool occurs from the following?

A. Evaporation
B. Radiation
C. Convection
D. All of the above.

8. The best way to get maximum pool temperature increase after reaching a 15 to 16 degree increase in pool temperature is

A. Add another solar pool collector
B. Add a pool blanket
C. Add a windbreak around pool
D. Increase the pump and filter size

9. Which of these factors reduce the quantity of solar energy received on the earth=s surface?

a) volcanic eruptions
b) local storms
c) smoke and dust
d) all of the above

10. The total energy received by a fixed surface during a given period of time depends on:

a) orientation and tilt
b) weather conditions
c) time of day and season
d) all of the above

11. The best slope of a collector for winter energy collection in Florida is:

a) mounting at an angle equal to the latitude
b) latitude minus 15 degrees
c) latitude plus 15 degrees
d) none of the above

12. An Integral Collector Storage system is considered a:

a) active direct system
b) active indirect system
c) passive direct system
d) passive indirect system

13. The most common heat transfer solutions used in indirect systems include:

a) ethylene glycol
b) peanut oil
c) propylene glycol
d) a and c

14. Which component is considered the "brains" of a solar system?

a) pump
b) motorized check valve
c) sensor
d) controller

15. Which of the following are common freeze protection methods?

a) draindown
b) drainback
c) recirculation
d) all of the above

16. The purpose of a ball valve is to:

a) prevent thermosiphon losses
b) isolate parts of the solar system
c) prevent vacuum locks
d) safely limit excessive pressures

17. Drain valves are used to:

a) drain the collector loop
b) fill and drain indirect systems
c) drain the water heater
d) all of the above

18. A high-temperature (collector) sensor on a flat plate collector should be placed:

a) on the inlet pipe of the solar collector
b) in the airspace between the collector absorber and the transparent cover
c) against the absorber plate
d) all of the above

19. Which of the following agencies provide certification of solar collectors and systems?

a) Solar Rating & Certification Corporation
b) Florida Energy Office
c) North Carolina Solar Energy Center
d) ASHRAE

20. The following should be conducted after a system has been installed:

a) provide the homeowner with instruction regarding system operation
b) provide the homeowner with a system operation manual
c) provide the homeowner with a warranty document
d) all of the above

21. Which of these is a toxic solar collector fluid?

a) distilled water
b) ethylene glycol
c) propylene glycol
d) synthetic oil

22. Which one is required for a heat exchanger using a toxic fluid to heat domestic hot water?

a) single wall construction
b) double wall, vented construction
c) copper flashing
d) none of the above

23. At a minimum, what should glycol-based solar fluids be checked for?

a) pH
b) pressure
c) dissolved copper
d) nitrates

24. Air vents should be mounted:

a) 90^0 straight up
b) 90^0 straight down
c) diagonally at 45^0
d) horizontally at 90^0

5. ANSWER KEY AND EXPLANATIONS

Note: Explanations provided where they assist in comprehension of the concept.

1) **B.** High dissolved or any solid contents are not desirable in heat transfer fluids..

2) **C.**

3) **D.**

4) **D.** The voltage of the PV module can exceed the voltage of the DC pump motor by more than 5 volts DC.

5) **C.**

6) **A.**

7) **D.**

8) **B.**

9) **D.**

10) **D.**

11) **C.** This is for anywhere not just Florida.

12) **C.**

13) **C.**

14) **D.**

15) **D.**

16) **B.**

17) **D.**

18) **A.**

19) **A.**

20) **D.**

21) **B.**

22) **B.**

23) **A.**

24) **A.**