

SOLAR HEATING ACADEMY

Participant Guide



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SOLAR HEATING ACADEMY

Module 1: Introduction to Solar Heating

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Objectives

- ▶ Describe the expectations for careers in the Solar Heating industry
- ▶ Pass the Entry Level NABCEP Solar Heating Installer Exam
- ▶ Conduct a site analysis, including a load analysis
- ▶ Identify solar heating safety practices, standards, codes, and certifications



Objectives (continued)

- ▶ Identify systems for specific climates and applications
- ▶ Identify proper operation and installation methods
- ▶ Identify proper use of balance-of-system, components, and materials
- ▶ Identify common solar heating maintenance items

Introductions

Interview the person next to you for 3 minutes then switch

- Why he/she is taking the class
- Related work experience
- Expectations for the course

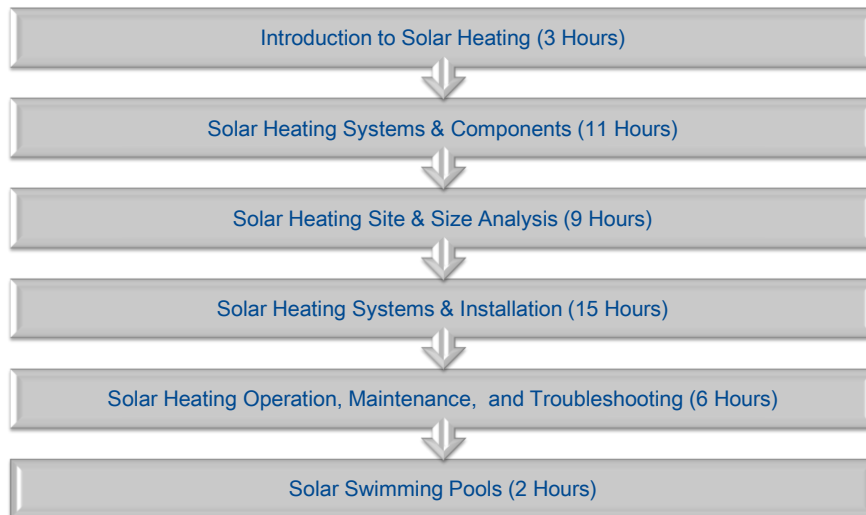
Introduce your partner to the class

Ground Rules

- ▶ Demonstrate respect for classmates/instructor
- ▶ Quiet cell phones, laptops etc.
- ▶ Participation encouraged
- ▶ No side bar conversations
- ▶ Put off-topic items in “Parking Lot”



Modules



Agenda

- ▶ Course Materials
- ▶ Career Path in Solar Heating
- ▶ History of Solar Heating
- ▶ Safety
- ▶ Questions

Course Materials

- ▶ Student Guide with Appendix
- ▶ Text
- ▶ Flash Drive
- ▶ Web Resources List

Career Path

► Entry Level Occupations

- Solar Installation Helper
- Mechanical Assembler

► Mid Level Occupations

- HVAC Technician with Solar Expertise
- Roofer with Solar Expertise

Interstate Renewable Energy Council, Inc. Solar Energy Education & Training: Best Practices – Solar Content Integration, IREC, May 2012. www.sitnusa.org



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Career Path (Continued)

► Mid Level Occupations

- Solar Thermal Installer (Residential/Small Commercial)
- Solar Thermal Technician (Commercial/Utility)
- Electrician with Solar Expertise
- Plumber with Solar Expertise

► Advanced Level Occupations

- Solar Installation Contractor

Interstate Renewable Energy Council, Inc. Solar Energy Education & Training: Best Practices – Solar Content Integration, IREC, May 2012. www.sitnusa.org



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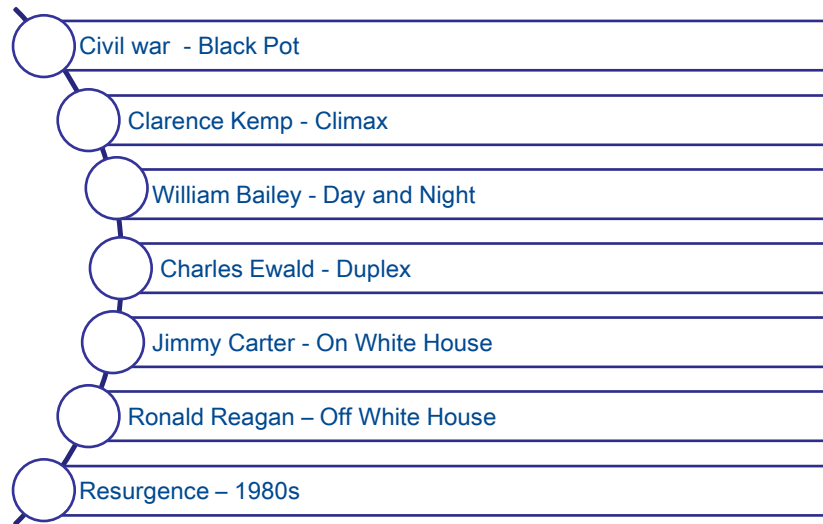
NABCEP Certification

- ▶ Voluntary
- ▶ National standards by which solar heating installers with skills and experience can distinguish themselves from their competition
- ▶ Target candidate is person responsible for the system installation

NABCEP Certification (continued)

- ▶ NABCEP Objectives
- ▶ NABCEP Exam Blueprint
- ▶ NABCEP Practice Exam

Brief History



Solar Resources

- ▶ Sunlight falling on the United States for what length of time transfers enough energy to power the nation for one year?
 - a. one half day
 - b. one week
 - c. one day
 - d. one month

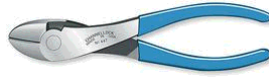
Safety Topics

- ▶ Eye Safety
- ▶ Hand Tool Safety
- ▶ Power Tool Safety
- ▶ Electric Tool Safety
- ▶ General Safety Precautions

Eye Safety

- ▶ How many work-related eye injuries are there each day?
- ▶ Which occupation has the highest eye injury rates?
- ▶ What are the eye hazards at a solar heating installation site?
- ▶ What is the best way to protect your eyes?

Hand, Power, and Electric Tools



Hand, Power, and Electric Tool Safety

- ▶ Hand tools are non-powered.
- ▶ Power tools are based on the power source they use - electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.
- ▶ Chief hazards of electric-powered tools are burns, slight shocks and electrocution

Tool Safety

- ▶ Divide into groups of 4
- ▶ Brainstorm
 - What precautions should you take when using hand tools?
 - What precautions should you take when using power tools?
 - What precautions should you take when using electric tools?
- ▶ Share with the class

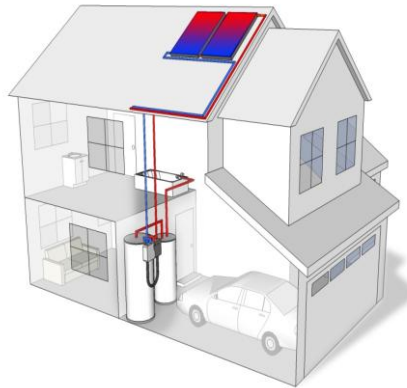
Next Steps

- ▶ Please ask questions if you have any
- ▶ Please review text and flash drive materials
- ▶ Thank you!



Agenda

- ▶ Course Materials
- ▶ System Classification
- ▶ System Components
- ▶ Controllers
- ▶ Other Devices
- ▶ Questions



Your Solar Heating Mantra

- ▶ All SH systems must control for:
- ▶ Over Heating
- ▶ Freezing
- ▶ Scaling

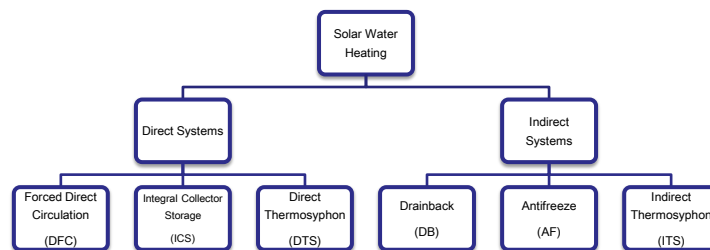
Remember this when studying, designing, installing, servicing and troubleshooting a Solar Heating System.



Course Materials

- ▶ Student Guide with Appendix
- ▶ NABCEP Installer Guide Chapter 4
- ▶ Flash Drive
- ▶ Web Resources List

Systems Classification



Active Direct and Indirect

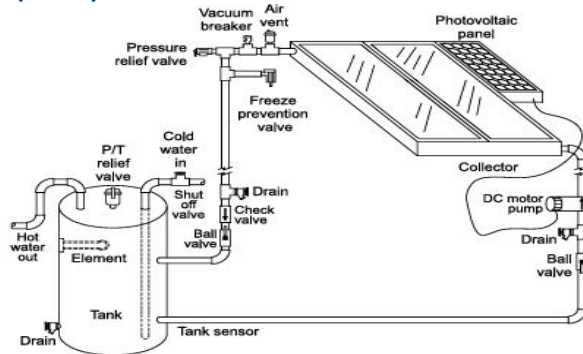
- ▶ Active = pumped
- ▶ Direct = source water (well, utility, village) flows into solar heating system and then into home.
- ▶ Indirect = source water and solar heating system heat transfer fluid are separated (often by heat exchange mechanism)

Active Direct

- ▶ Water storage
- ▶ Solar collector
- ▶ Controller, timer, or P-V pump regulation
- ▶ Pump or circulator

Active Direct

- ▶ Direct system with photovoltaic-powered pump



Active Indirect

- ▶ Water storage
- ▶ Solar Collector
- ▶ Controller, timer, or P-V pump regulation
- ▶ Pump or circulator
- ▶ Heat exchange mechanism
- ▶ Heat transfer fluids

Inactive/Passive Direct

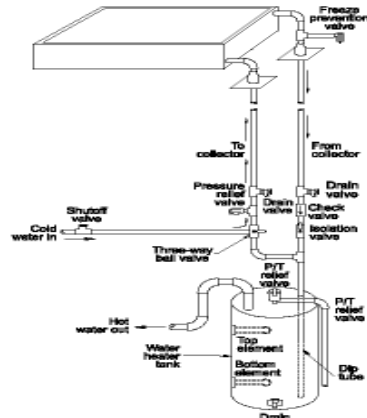
- ▶ Inactive/Passive = no pump
- ▶ Direct = source water (well, utility, village) flows into solar heating system and then into home.
- ▶ Include water storage and Solar Collector

Inactive/Passive Indirect

- ▶ Indirect = source water and SH system heat transfer fluid are separated (using heat exchange mechanism)
- ▶ Inactive Indirect systems include:
 - Water storage
 - Solar Collector
 - Heat exchange mechanism
 - Sometimes heat transfer fluids

Inactive Direct

► Integral collector storage system



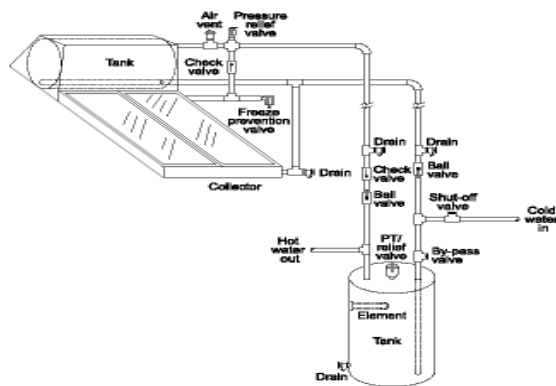
Permission to Use Granted - www.fsec.ucf.edu

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Inactive Direct

► Thermosiphon system



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Freeze Protection

- ▶ Mechanisms to prevent freeze damage to system components include:
 - Indirect Antifreeze (Heat Transfer Fluid) Circulation
 - Draining
 - Water Flow
 - Thermal Mass
 - Auxiliary Heater

Indirect Antifreeze Fluid Circulation

- ▶ Systems typically used in cold climates use a heat transfer fluid (propylene glycol)
- ▶ Some systems pressurized
- ▶ External heat exchanger
 - Heliodyne System (NABCEP page 41)
- ▶ Internal (in-tank) heat exchanger
 - Buderus System (NABCEP page 40)

Draining

- ▶ All water is removed from the collector and exposed piping.
- ▶ Water removed to conditioned space.
- ▶ System Examples:
 - Drain-down (NABCEP page 38)

Water Flow

- ▶ Freeze protection provided by moving warm water from storage through the collector.
- ▶ Recirculation and/or freeze protection valves.

Thermal Mass

- ▶ Freeze protection provided by a large amount of water in the system: collector(s), tank(s).
- ▶ Any system protected by thermal mass may eventually lose heat and freeze.

System Components

- ▶ Collectors
- ▶ Storage Tanks
- ▶ Pumps
- ▶ Piping
- ▶ Insulation

Collectors

- ▶ Low Temperature
 - Pool
- ▶ Medium Temperature
 - Flat Plate ¹
 - Evacuated Tube ²
 - Solar Air Heater
- ▶ High Temperature
 - Parabolic Trough
 - Dish Stirling
 - Central Tower
 - Fresnel Reflector

Low – Medium - High



Low Temperature

- ▶ Typically unglazed.
- ▶ Usually polypropylene.
- ▶ Types:
 - Black flat-plates
 - Black flexible mats
 - Black pipes

Low – Temperature

SHW TECHNOLOGY COLLECTORS

heliodyne
SOLAR HOT WATER

UNGLAZED COLLECTORS



Unglazed collectors are typically made of plastic tubes combined into an absorber and used for residential pool heating to extend the pool season

PRO

- Easy to install
- Inexpensive → Short Payback period

CON

- No insulation → Efficiency sensitive to wind and ambient temperature
- Low temperature range (75°F - 95°F)
- Aesthetics → May be considered visually unpleasing
- Low durability

EXCELLENCE BY DESIGN

Medium Temperature

- ▶ Applications:
 - Domestic Hot Water (DHW)
 - Space Heating
 - Indoor Pool Heating
 - Commercial Systems
- ▶ Flat Plate
 - Named for flat absorber plate
 - All flat absorber plates are enclosed
- ▶ Evacuated Tube
 - AKA: Vacuum Tube
 - Types: Twin-glass and Single-wall
- ▶ Air Collectors
 - Glazed
 - Unglazed, AKA “Transpired”

Florida page 2-1 thru 2-5
NABCEP pages 18 thru 25

Medium Temperature

**SHW TECHNOLOGY
COLLECTOR**

heliodyne
FLAT-PLATE COLLECTORS

FLAT PLATE COLLECTOR



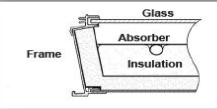
Consists of an insulated weather sealed metal box containing the absorber and closed with a transparent cover typically made of tempered glass.

PRO

- Simple and proven technology
- Low maintenance
- Highly durability
- High Performance in Cold and Hot Climates
- Cost-effective (More energy per Dollar)
- Easy Installation

CON

- Relatively heavy to carry
- Limited temperature range of up to 220°F



Medium Temperature

- ▶ Applications
 - Domestic Hot Water (DHW)
 - Space Heating
 - Indoor Pool Heating
 - Commercial Systems
- ▶ Flat Plate
 - Named for flat absorber plate
 - All flat absorber plates are enclosed

Medium Temperature (continued)

- ▶ Evacuated Tube
 - AKA: Vacuum Tube
 - Types: Twin-glass and Single-wall
- ▶ Air Collectors
 - Glazed
 - Unglazed, AKA “Transpired”

Medium Temperature Collectors

- ▶ Focus of Course
 - Flat Plate Collectors
 - Domestic Hot Water (DHW)
 - Residential
- ▶ Also Reviewed in Course
 - Evacuated Tube
 - Swimming Pool

Medium Temperature

SHW TECHNOLOGY COLLECTOR

FLAT PLATE COLLECTOR



Consists of an insulated weather sealed metal box containing the absorber and closed with a transparent cover typically made of tempered glass.

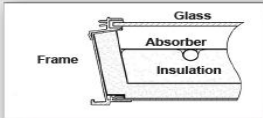
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SOLAR HOT WATER

PRO

- Simple and proven technology
- Low maintenance
- Highly durability
- High Performance in Cold and Hot Climates
- Cost-effective (More energy per Dollar)
- Easy Installation

CON

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- Limited temperature range of up to 220°F



High Temperature

- ▶ “Concentrating” Collectors
- ▶ Typically for Utility-scale Production of Electricity
- ▶ Common Types:
 - Parabolic Trough
 - Dish Stirling
 - Central Tower
 - Fresnel Reflector

High Temperature

SHW TECHNOLOGY COLLECTOR

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SOLAR HOT WATER

VACUUM TUBE COLLECTORS



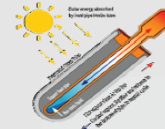
Double wall glass tube with vacuum in between or a glass tube with a top seal and a pumped vacuum containing an absorber. The vacuum efficiently insulate the absorber minimizing collector heat loss and sensitiveness to wind and ambient temperature

PRO

- Works well at high temperature ranges > 220°F
- Good for high temperature industrial applications

CON

- May be considered aesthetically displeasing
- Relatively higher maintenance
- Sensitive to loosing vacuum
- High installation complexity
- Relatively expensive
- Relatively fragile



High Temperature Collectors

- ▶ High Temperature Parabolic Trough
- ▶ High Temperature Dish Stirling
- ▶ High Temperature Central Tower
- ▶ High Temperature Fresnel Reflector

Flat Plate Collectors

- ▶ Commercially available since 1909
- ▶ Flat Plate Topics:
 - Construction
 - Absorbers
 - Selective Surface

Flat Plate Collector Construction

- ▶ Absorber enclosed inside glazed and insulated casing.
 - Usually extruded aluminum case
 - Hi-temp insulation
 - Low-iron and tempered glass
 - Certified SRCC OG-100 (collectors), OG-300 (systems)
 - System certification typically required for incentives, etc.
- ▶ Typical Collector Sizes
 - 4'x6', 4'x8', 4'x10'

Flat Plate Collector Absorber

- ▶ Absorbers (enclosed inside glazed and insulated casing)
 - Categorized by tubing configuration
 - Risers and headers
 - Single tube serpentine
 - Typically copper or aluminum
 - System certification typically required for incentives, etc.

Flat Plate Selective Surface

- ▶ Absorber finish/coating influences collector efficiency.
- ▶ Ideal: 100% of solar energy absorbed, “high absorbance”

Flat Plate Selective Surface

- ▶ Early finish: flat black paint (85% absorption)
 - Emmissivity or radiative loss
- ▶ “Selective Coatings” AKA “Selective Surface”
 - Proprietary names: “Black Chrome”, “Black Crystal”, “Sputtered Aluminum”, “Blue Sputtered”.
 - A climate determination.
 - (enclosed inside glazed and insulated casing)
 - Categorized by tubing configuration
 - Risers and headers
 - Single

Flat Plate Selective Surface

SHW TECHNOLOGY
COLLECTOR ABSORBER VARIOUS SURFACES

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SOLAR HOT WATER

BLACK PAINT

- Low cost solution
- Recommended for warm climates with high solar radiation

BLACK CHROME

- First generation selective surface
- Tough surface
- Recommended for cool climates

BLUE SPUTTERED

- State of the art technology
- Optimal heat absorption with minimal emission
- Suitable for all types of installations and regions
- Recommended for cool climates

$\epsilon = 0.25$
 $\alpha = 0.85$

$\epsilon = 0.12$
 $\alpha = 0.95$

$\epsilon = 0.05$
 $\alpha = 0.95$

α : Absorptivity → A measure of an object's ability to absorb incident energy
 ϵ : Emissivity → The ability of a material to hold or release heat

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Evacuated Tube Collectors

- ▶ Commercially available since 1970's
- ▶ Vacuum used as insulation/heat retention device
- ▶ Essentially Two Styles:
 - Twin-glass Evacuated Tube
 - Single-wall Evacuated Tube

Twin-glass Evacuated Tube

- ▶ Twin glass tubes fused together with vacuum.
- ▶ Absorber not in vacuum.
- ▶ Modular design (separate tubes)
- ▶ Essentially two absorber styles:
 - Flooded pipe
 - Heat pipe

Twin-glass Evacuated Tube

- ▶ “Vacuum tube” contains a glass envelope in which the absorber is within a vacuum.
- ▶ Heat pipe, is in ambient air – sealed usually with a rubber or plastic stopper similar to a thermos bottle.

Single-Wall Evacuated Tube

- ▶ Absorber inside vacuum.
- ▶ Essentially two absorber styles:
 - Flooded tube (not modular)
 - Heat pipe (modular)
- ▶ Absorber plates mechanically bonded to heat pipes.
- ▶ Heat pipes mechanically bonded to glass tube.

Collector Efficiency

- ▶ One way to demonstrate collector efficiency at various temperatures is the efficiency curve.
- ▶ See also chart in NABCEP, Page 24

Collector Performance

- ▶ SRCC Collector Certification (OG-100)
- ▶ SRCC Heating System Certification (OG-300)
- ▶ SRCC website: “Solar Facts – Collector Ratings: Performance Data”

Air Collectors

- ▶ Commonly used for space heating
- ▶ Common in New Mexico
- ▶ Two Styles:
 - Glazed
 - Unglazed
- ▶ Glazed: Heat circulated building air
- ▶ Unglazed: Preheat outside air for use in building ventilation system

Swimming Pool Collectors

- ▶ Some collectors are suitable for pool heating.
 - Low-temperature, flat-plate collectors are most common.
 - Design may call for medium-temperature collector.
 - Many different low-temp collector designs.
- ▶ High flow rates.
- ▶ Sizing affected by region/climate
- ▶ ROT (Rule of Thumb – One San Diego Company)
 - 75% of pool top surface area in collector area (on a pool where a cover is used) equals bumping the pool temp about 10 degrees

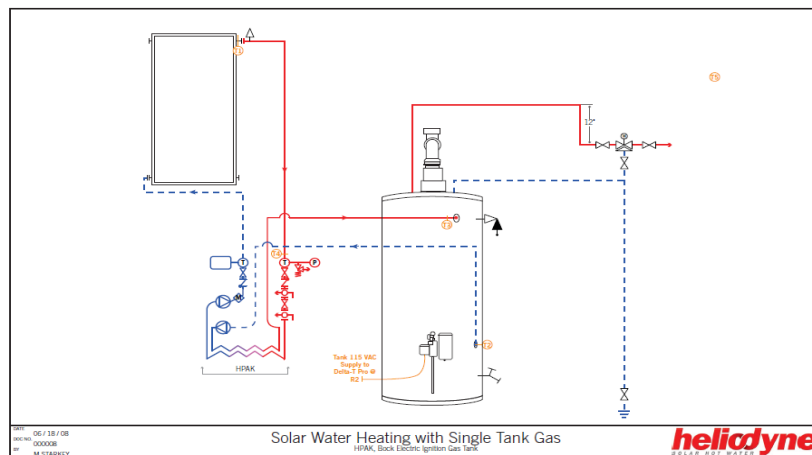
Storage Tanks (includes water heaters)

- ▶ Storage tanks hold water heated in the collector
 - Single tank system
 - Two/multiple tank system
- ▶ Tanks may be pressurized or unpressurized

Storage Tanks (includes water heaters)

- ▶ Tank type and size is a fundamental Solar Heating design consideration
 - Natural gas, propane fired
 - Electric element
 - Wood fired
 - 6 gal, 40 gal, 80 gal, 120 gal
 - “Tankless”

Single Tank Gas Water Heater System



Stratification

- ▶ Stratification refers to the temperature layering of water in SH tanks.
- ▶ Stratification is fundamental to a successful design & installation.
- ▶ Hot water for domestic use is plumbed out near the top of the tank.
- ▶ Good SH designs minimize “stirring” within a stratified tank. Dip Tubes

Dip Tubes

- ▶ Dip Tubes
 - Typically plastic tubes (pipes) inserted into the domestic hot water tank.
 - Maintain stratification within the tank.
 - Cold/supply line water plumbed to the top of the tank is carried inside via a dip tube to the bottom portion of the tank.
 - The hot water supply dip tube, if included, draws water from the top portion of the tank.

Anodes

- ▶ Protect buried/submerged metal structures from corrosion.
- ▶ Metal alloy with a more "active" voltage (more negative electrochemical potential) than the metal of the structure.
- ▶ Galvanic anode corrodes, so that the anode material is consumed in preference to the structure.
- ▶ Loss (or sacrifice) of the anode material gives rise to the alternative name of sacrificial anode.

Boiler Drains

- ▶ Ones found on newer domestic water heaters are typically a plastic, use-one-time design.
- ▶ A quality installation often includes the replacement of the plastic boiler drain with a brass fitting.

Anti-Scald, Mixing, & Tempering Valves

- ▶ Hot water at temperatures of ~120° F or better will cause burns if not severe and permanent damage.
- ▶ Allow SH water to enter a domestic system at 190°F and expect a lawsuit!

Mixing Valve

- ▶ Term, typically used generically, referring to a device that mixes water from two or more sources.

Tempering Valve

- ▶ Thermostatically controlled to mix hot and cold water sources and send water into the domestic hot water source at a set temperature.
- ▶ Less expensive than “Anti-scald Valves.”

Anti-Scald Valve

- ▶ Operate similarly to “Tempering Valves”
- ▶ They shut off the domestic hot water supply when they detect an interruption in the cold water supply source.

Pressure Temperature Release Valve

- ▶ Critical safety valve, typically supplied with a new hot water tank.
- ▶ Two types: “Pressure Relief Valve” and “Pressure-Temperature Relief Valve”
- ▶ Sensitive valves. Often wrongly opened by owners and installers to test or use as an air vent. Valves will not last long or work properly if manually opened.

Glass Lined

- ▶ Maximum temperature in glass-lined
 - The glass lining inside of a domestic hot water tank will typically begin to break-down at ~190° F or better.
 - Why is this important to a SH system designer/integrator?

Energy Cutoff Switch

- ▶ Gas water heater safety device that shuts off the gas supply to the unit if water temperature exceeds 190°F.
- ▶ Single-use switch and requires complete replacement of the entire thermostat if activated.

CAZ

- ▶ Combustion Appliance Zone
- ▶ Make up air for gas appliances

Storage Tanks



A. O. Smith Effex®

Easy Installation

Atmospheric design for direct retrofit

Energy Efficiency

Patented air assembly design allows for precise air-to-gas mixture in the combustion chamber which increases the efficiency to an unprecedented .70EF

Energy Star Compliant

Only atmospheric model to meet Phase II .67 EF requirement



Powered Anodes

Improved tank protection in all water conditions

LCD Display

User friendly control designed for easy interaction

Hot Surface Ignition

No standing pilot, prevents service issues



Condensing Residential Water Heaters

- Heater exchanger is a coil
- Glass inside the coil is different from glass on the water side
- Note condensate drain
- Vertex has same foot print as standard. 50 gal heater



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Rheem Heat Pump Water Heater



- Uniquely pumps water to the heat pump components
- 50 gallon tank
- EF = 2.0, FHR = 67 gallons
- Non-replaceable sacrificial anode
- MSRP = \$1495
- Assuming an installation cost of \$500 and annual savings of \$286, the payback is 7.0 years compared to standard electric resistance water heater.
 - With Federal tax credit, payback is 4.9 yrs.

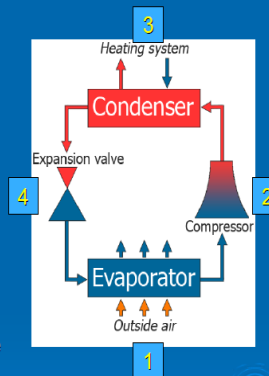
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HPWH Operation

1. A fan forces air through the evaporator (1). The liquid refrigerant evaporates and absorbs air heat from the ambient air.
2. The warm gaseous refrigerant is compressed (2) and the refrigerant becomes a hot liquid.
3. The refrigerant then passes through the condenser (3) and loses its heat to the water.
4. The cooler refrigerant goes through an expansion valve (4) where it returns to the gaseous state and the cycle starts over.

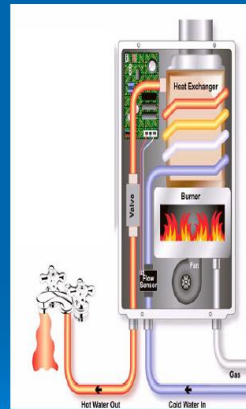


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Gas Tankless Water Heaters

Principle of Operation

- Flow is sensed
- Fan purges combustion chamber
- Burner is ignited and modulated to match measured flow rate
- Heat exchanger begins to heat water as it passes through
- When flow stops, burner is extinguished and combustion chamber is purged.
- Power supply is needed for the electronic controls and the fans

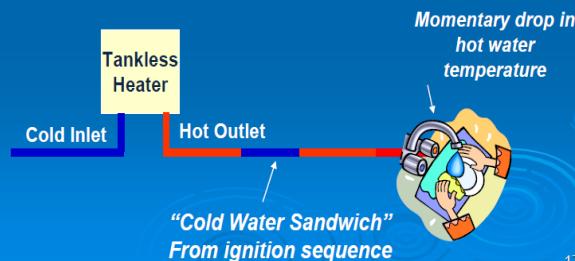


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Gas Tankless Water Heaters

“Cold Water Sandwich Effect”

- The introduction of cold water into the hot water line during frequent on/off operation
- Cold water flows through the water heater during the ignition sequence delay (~ 10 sec),
- Two causes:
 - Drop in flow rate below minimum firing rate
 - Intermittent use



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Electric Tankless Water Heaters

Older Technology

- Flow switch controls operation
 - Minimum and maximum flow rates
- Restricted flow - $\frac{3}{4}$ inch down to $\frac{3}{8}$ inch tubing
- Downward plumbing connections
- Elements:
 - Multiple, welded-in, non standard elements with different wattages.
 - Turn on combinations of elements to get the desired output temperature.
- Canisters contain relatively small volume of water
 - More difficult to absorb residual heat at the end of a draw
 - Cool down relatively quickly



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Navien



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Unique Electric Storage Water Heaters

➤ Marathon

- Manufactured by Water Heater Innovations (Rheem)
- Seamless blow-molded polybutene tank
- EF = 0.90-0.94
- Warrantee
 - Tank – as long as you own it.
 - Parts – 6 years



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A.O. Smith-Vertex



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American Water Heater-Polaris



207

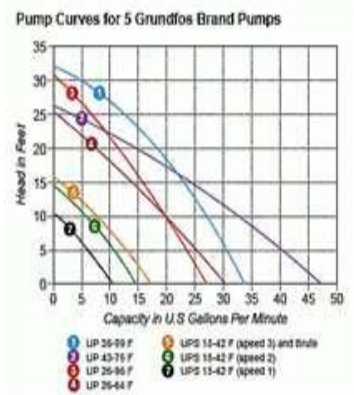
Pumps – Active Systems

- ▶ Internal heat exchanger use a “pump/circulator” to move the heat transfer fluid from the storage tank heat exchanger and through the collector.
- ▶ External heat exchanger use a “pump/circulator” to move the heat transfer fluid from the external heat exchanger and through the collector.
- ▶ May use a “pump circulator” to move domestic water through the external heat exchanger and storage tank.

Pumps (continued)

- ▶ Drainback systems typically require a high head pump to lift fluid to the collector.
- ▶ Active direct systems must have bronze or stainless housings and impellers.
- ▶ Indirect systems using heat transfer fluids may use a cast iron pump.
- ▶ Pumps may be AC or DC
- ▶ Pumps may be single or multiple speed.

Grundfos Curve Chart



Flow

- Describes the volume of liquid pumped within a given period of time.
- Physical size of a pump determines the flow, which can pass through it.
- Flow will always be an issue when you select a pump.

Head

- ▶ Meters or inches of water column.
- ▶ Indicates how high a given pressure can lift a column of liquid.
 - Knowledge about the relationship between flow and head and about the conversion between head and pressure will enable you to perform basic sizing of a pump for a specific application.

Cavitation

- ▶ Cavitation is undesirable in pumps, as it causes a great deal of noise, damage to components, vibration, and reduced efficiency.

Cool Collector

- ▶ A cool collector is an efficient collector
- ▶ System designers work from a one-to-three degree , up to ten-to-twenty degree temperature differential in fluid entering the collector(s) and exiting the collector(s).

Piping

- ▶ Path of fluid flow in the solar heating system.
 - Piping must be compatible with system temperatures, pressures, fluid pH, and other components.
 - Most SH systems use copper pipe.
 - Type L, K, or M is used, depending on application, “authority having jurisdiction (AHJ)”, and even local, common practice.
 - Some use stainless steel “line-set”
 - Line-sets are available in single tube or dual tube designs.
 - Line-sets are often pre-insulated
 - Many line-sets employ “O-ring” end-seals.

Copper Piping

- ▶ Typically in ten foot and twenty foot “sticks”.
 - Half-inch and three-quarter inch are common
 - Pipe diameter selection is determined by pump size, length of run (pipe friction), and component parts.
 - Type M is thin-walled, Type L is medium-walled and Type K is thick-walled.
 - Type L is good for home use.
 - Piping must be compatible with system temperatures, pressures, fluid pH, and other components.

Copper Piping (Continued)

- ▶ Most solar heating systems use copper pipe
- ▶ Type L, K, or M is used, depending on application, “authority having jurisdiction (AHJ)”, and even local, common practice.
- ▶ Some use stainless steel “line-set”
 - Line-sets are available in single tube or dual tube designs.
 - Line-sets are often pre-insulated
 - Many line-sets employ “O-ring” end-seals.

Type L Copper Pipe

- ▶ Thicker wall than type M copper pipe making it more durable.
- ▶ Type L is the preferred copper pipe in residential construction.
- ▶ Color coded blue, and has BLUE markings along the pipe.

PIPING (Line Set)

- ▶ FlowMaxx
- ▶ 65 Foot Twin Line set
- ▶ SunMaxx Solar
5/8" Pre Insulated Line Set, 80'

Insulation

- ▶ Most common pipe insulation used on SH systems is closed cell elastomeric foam.
- ▶ Do not use DIY home center polystyrene or polyethylene – these materials cannot handle the high temperatures of SH systems and disintegrate under ultraviolet rays.
- ▶ Exterior piping installations, and insulation, must be protected from ultraviolet light and critters.
- ▶ The installation of insulation is one of the final tasks of the integrator/installer – certainly AFTER pressure testing.

Controllers

- ▶ Controller = “brains” of the active SH system
- ▶ Types:
 - Differential
 - Photovoltaic
 - Timer

Controllers (Differential)

- ▶ Determine when to activate the pump to send fluid through the collector and back to the tank.
- ▶ Use two (or more) sensors – one at the hottest point of the solar loop (collector output) and the other at the coolest point (tank bottom).
- ▶ To operate, controllers are either preset or manually set to a temperature “differential”.

Controllers (Photovoltaic)

- ▶ Includes solar panels mounted next to the solar collector for power to the controller and DC pump.
- ▶ As the panel only generates electricity when the sun is up, the pump only circulates fluid through the SH system when sufficient energy is available.

Controllers (Timer)

- ▶ A Timer Controller is typically set to turn the pump on only during the brightest portion of the day.

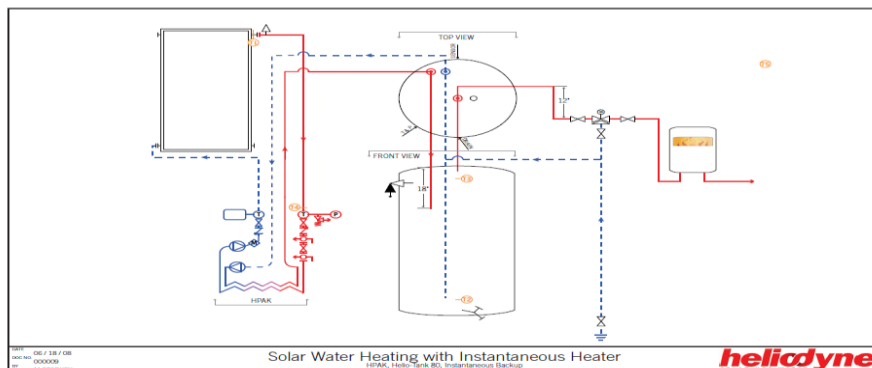
Other Devices

- ▶ “BOS” Balance of System -- typically denoting all components other than the solar thermal collectors. (e.g. controllers, tank, piping).
- ▶ Other components discussed here:
 - Heat Exchangers
 - Expansion tanks
 - Sensors
 - Valves, Gauges, Meters
 - Heat Transfer Fluids

Other Devices (continued)

- ▶ Heat Exchangers
 - Transfer heat from solar, heat-transfer fluid to domestic water
 - Used in indirect/closed-loop systems
- ▶ Heat Exchanger Types
 - External and Internal
 - Single-wall and Double-wall
 - Tube-in-Tube
 - Tube-in-Tube-in-Tube
 - Shell-in-tube
 - Flat-Plate

Other Devices (continued)



Other Devices

- ▶ External Heat Exchangers
 - plumbed into the system as a separate and distinct component,
 - plumbed around the exterior skin of a tank
- ▶ Internal Heat Exchangers
 - plumbed within another system component – usually a tank.
 - The efficiency debate is currently on the external exchanger's side

Heat Exchangers

- ▶ Counter-flow or Countercurrent Flow
 - Efficient SH heat exchangers take advantage of fluid counter-flow. (opposite directions).
 - Maximum amount of heat transfer that can be obtained is higher with countercurrent than concurrent (parallel) exchange because countercurrent maintains a slowly declining difference or gradient (temperature difference). In concurrent exchange the initial gradient is higher but falls off quickly, leading to wasted potential.

Heat Exchangers (continued)

- ▶ Single-wall and Double-wall
 - Heat exchangers may be constructed with one or two walls.
 - Double-wall heat exchangers often provide small passageways between the two walls for leak detection.
 - Some AHJ's/codes require double-walled heat exchangers.

Heat Exchangers (continued)

- ▶ Some argue double-walls are only necessary when using a propylene glycol solution.
- ▶ SH heat exchanger materials must be compatible with system components and fluids. Copper is the most commonly used material.
- ▶ SH heat exchangers are sized based on heat-transfer capabilities.

Heat Exchangers (continued)

- ▶ Shell-in-Tube
 - Available with single-wall or double-wall construction.
 - Used in technologies other than SH systems.

Heat Transfer Fluid

- ▶ Propylene Glycol most common
- ▶ NEVER Ethylene Glycol
- ▶ Mixed with water according to contract, geographical area, micro-climate, standard procedures.
- ▶ Sometimes requires import of quality water for mixing.
- ▶ Glycol, with additives, provides some level of protection against freezing and overheating.
- ▶ A glycol-water mix has less heat-transfer ability than pure water: the higher the percent of glycol the less efficient.

Expansion Tanks

- ▶ Water EXPANDS when it gets cold AND it EXPANDS when it gets hot!
- ▶ Water, unlike air, does NOT compress.
- ▶ Expanding water in a closed system must have somewhere to go – or it will damage the system.
- ▶ Contracting water (cooling cycle) will also pull a vacuum and damage a system without an expansion tank.

Expansion Tanks

- ▶ Diaphragm
 - Must be installed in an upright - vertical position
- ▶ Bladder (balloon-like)
 - May be installed in any position.
- ▶ Features of Both
 - Most pre-charged by manufacturer
 - Size dependent on fluid volume and potential for elevated temperatures
 - Some AHJ's require an expansion on the cold water (supply) side of the system.

Valves, Gauges, Meters

- ▶ Air Vent
- ▶ Pressure-Temperature Relief Valve
- ▶ Pressure Relief Valve
- ▶ Vacuum Breaker
- ▶ Isolation Valve
- ▶ Check Valve
- ▶ Freeze-Protection Valve
- ▶ Pressure Gauges
- ▶ Temperature Gauges
- ▶ Flow Meters

Air Vent

- ▶ Allows air in the system to escape.
- ▶ Prevents air locks.
- ▶ Must be positioned vertically.
- ▶ Commonly installed at “top” of system.
- ▶ Manually closed on indirect systems after initial and annual purge.

Pressure-Temperature Release Valve

- ▶ AKA: “P&T” and “T&P” valve
- ▶ Protects system from excessive pressures and temperatures.
- ▶ Always plumbed to tanks.
- ▶ Inside P&T valves must drain to outside (see local AHJ/code requirements).
- ▶ Not built to be opened and closed manually to purge system.

Pressure Release Valve

- ▶ Protects system from excessive pressures.
 - Must be installed where the collector loop can be isolated from the storage tank.
 - Usually installed at the collector.
 - Inside P&T valves must drain to outside (see local AHJ/code requirements).

Vacuum Breaker

- ▶ Admits atmospheric pressure into the system so it may drain.
- ▶ Typically located at collector outlet.

Isolation Valve

- ▶ Typically used to isolate subsystems:
example – servicing collectors.
- ▶ Ball valves typically preferred.

Check Valve

- ▶ Swing
- ▶ Spring
- ▶ Motorized
- ▶ Check valves allow fluid flow only in one direction.
- ▶ Used to prevent system thermo siphoning

Freeze Protection Valve

- ▶ Set to open at near-freezing temperatures.
 - Installed on collector return line above roof.
 - Warm water bleeds from collector through valve to protect system.
 - Legacy model: “Dole Valve”.
 - Requires companion check valve.

Pressure Gauges

- ▶ Used to monitor system pressure.
- ▶ May indicate leak.

Temperature Gauges

- ▶ Indicate fluid temperature at gauge location.
- ▶ Multiple gauges aid in system evaluation.

Flow Meters

- ▶ SH pumps are very quiet.
- ▶ Flow meters enable owner and service provider to determine flow rate and pump operation.
- ▶ Typically installed above the pump.

Thank you!

*It's been a pleasure working with you today as
we complete Solar Heating Module #2.*

WATER HEATER MANUFACTURING

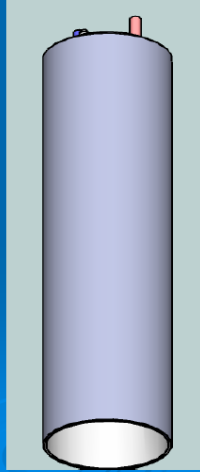
OPTIONAL SLIDE SEQUENCE

WATER HEATER MANUFACTURE AND RELATED TOPICS.

Gas Water Heater Fabrication

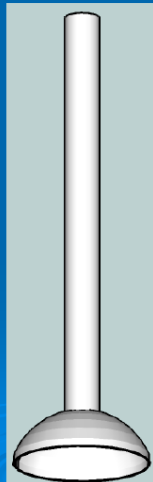
- All manufacturers use basically the same process.
- Tanks are welded and glassed
- Tank assemblies are put into the jackets and foamed in place
- Burners, T & P valve, etc. added
- Boxed and Shipped

Fabricate top head to tank shell assembly



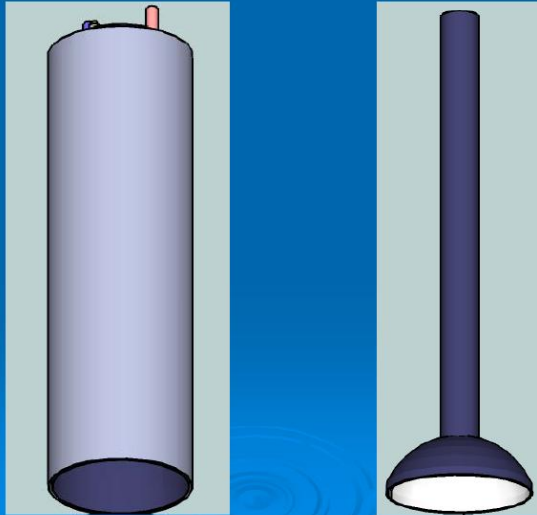
44

Fabricate the bottom head to flue assembly



45

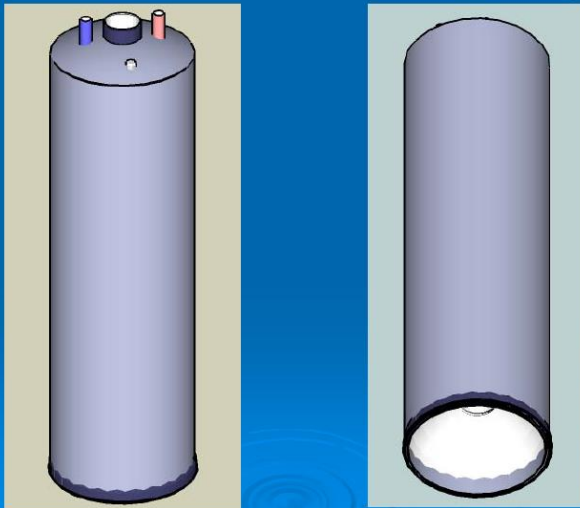
Glass the assemblies



46

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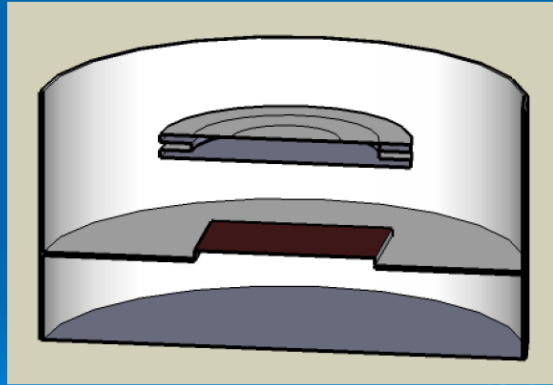
Make the tank assembly



47

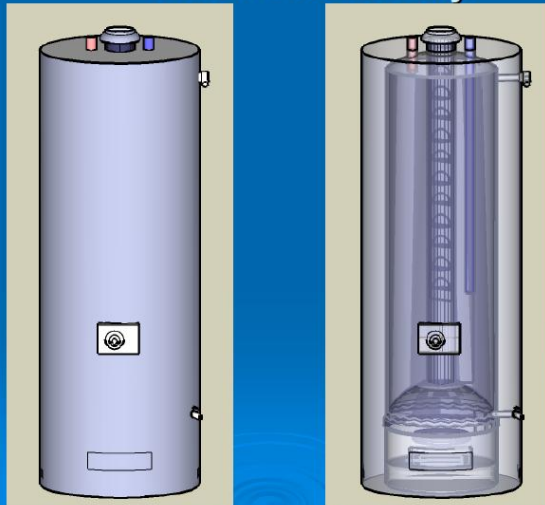
140

Fabricate skirt ring assembly



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Final Assembly



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Storage Water Heater Manufacturing



Steel coils received

50

Storage Water Heater Manufacturing



Steel coils processed through shot blaster

51

Storage Water Heater Manufacturing



Blasted coil proceeds through tank cut-off line

52



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Storage Water Heater Manufacturing



Top and bottom parts are formed

53



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Storage Water Heater Manufacturing



Tank shell and top/bottom parts are staged for fabrication

54

Storage Water Heater Manufacturing



Tank shell is roll formed and welded

55

Storage Water Heater Manufacturing



Threaded members for T&P valve, drain and thermostat opening are welded to tank shell

56

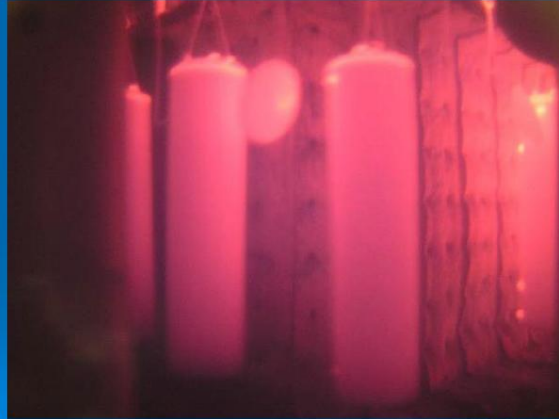
Storage Water Heater Manufacturing



Glass spraying prior to fusing in the furnace

57

Storage Water Heater Manufacturing



Tanks, flues and bottoms are fired in the furnace

58

Storage Water Heater Manufacturing



Tank bottom and flue assembly welded into tank

59

Storage Water Heater Manufacturing



All welds are tested for leaks

60



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Storage Water Heater Manufacturing



Jackets are rolled and formed

61



154

Storage Water Heater Manufacturing



Jackets and small parts are washed and painted

62

155



Storage Water Heater Manufacturing



Jackets and tops are placed on the tanks

63

156



Storage Water Heater Manufacturing



Foam is shot into unit between tank and jacket

64



157

Storage Water Heater Manufacturing



Boxed heaters move to Distribution Center

65



158

Storage Water Heater Manufacturing



Heaters positioned for delivery

66



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SOLAR HEATING ACADEMY

Module #3: Solar Heating Site and Size Analysis



Solar Heating Mantra

- ▶ All SH systems must control for
- ▶ Over Heating
- ▶ Freezing
- ▶ Scaling

Address all three whenever studying, designing, installing, servicing and troubleshooting a SH system.



Solar Site and Size Analysis

- ▶ NABCEP Installer Guide: Chapters 5 & 6
 - Pages 45, 56, 59, 60, and 61.
- ▶ Home Power Articles:
- ▶ Florida: 1-1 thru 1-13
 - Codes & Certifications
 - Site Assessment
 - SHW Primer
 - Simple SHW

Module #3 : Topics

- ▶ SH Applications & Technologies
- ▶ Solar Basics
- ▶ Applying the Basics
- ▶ Sizing a System
- ▶ Site Assessment
- ▶ Additional System Considerations



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SH Applications and Technologies

- ▶ Residential Applications
 - Domestic hot water – FOCUS OF THIS COURSE
 - Swimming Pool and Spa – Course short topic
 - Space Heating
 - Water purification – distillation
 - Air Conditioning
- ▶ Commercial Applications
 - Hotels, schools, apartments/condominiums, recreational areas, hospitals, nursing homes, restaurants, laundries, car washes, beverage manufacturing, cane sugar refining, canning facilities.



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SH Applications and Technologies

- ▶ Agricultural Applications
 - Crop drying, Green houses, Dairy processing, Meat processing, Food processing
- ▶ Space Heating
 - Radiant Heating
 - Fan-coil
- ▶ Radiant heating is commonly referred to as “HYDRONICS”

Domestic Hot Water

- ▶ Records of solar collectors in the United States dating back to before 1900.
- ▶ Black-painted tank mounted on a roof.
- ▶ 1896 Clarence Kemp of Baltimore created the first 'batch water heater' as they are known today.
- ▶ Flat-plate collectors for solar water heating were used in Florida and Southern California in the 1920s.
- ▶ Surge of interest in solar heating in North America after 1960.

SH Solar Basics

- ▶ Solar Basics:
 - Terms & Principles (go to Florida pages 1-3 thru1-7)
 - What do the terms mean? Why are they important to SH?

Applying the Basics

- ▶ Collecting & Converting Solar Energy
- ▶ Daily Variations
- ▶ Seasonal Variations
- ▶ Tilt Angle
- ▶ Heat Storage
- ▶ (Florida pages 1-7 thru1-13)
- ▶ (NABCEP Chapter 3)

Applying the Basics

- ▶ Infrared (IR) light
 - _ Electromagnetic radiation with longer wavelengths than those of visible light, and includes most of the thermal radiation emitted by objects (absorber, glass)
- ▶ Ultraviolet (UV) light
 - _ Electromagnetic radiation with a wavelength shorter than that of visible light but longer than X-rays.

Daily Variations

- ▶ Solar energy striking the Earth's surface averages about 1,000 watts per square meter under clear skies with the surface directly perpendicular to the sun's rays
- ▶ $1,000\text{W/m}^2$ as “one sun” or “S” = 317 BTU/ft².
- ▶ Greenhouse effect principle; solar radiation incident upon the transparent surface of the solar collector is transmitted through this surface. The inside of the solar collector is insulated and may be evacuated, the energy contained within the solar collect is trapped and thus heats the coolant contained within the tubes.

Seasonal Variations

► Solar Maps – NREL

- Solar maps provide monthly average daily total solar resource information on grid cells.
- Isolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal to equal to the latitude of the collector location.
- Typical practice for PV system installation, although other orientations are also used.

Tilt Angle

- The ROT with collector tilt is tilt to latitude (see previous slide).
 - Tilt may increase/decrease collector output.
 - Tilt collectors to align with a lower winter sun when doing an install on a winter ski cabin.
 - Tilt collectors to align with a higher summer sun when doing an install at a summer cabin.
 - A rare homeowner will choose to manually adjust collector tilt throughout the seasons to maximize collector output.

Heat Storage

- ▶ Water Heater Tank
- ▶ Solar Storage Tank
- ▶ Pressurized and Non-Pressurized
- ▶ Various Capacities: 40 gal, 80 gal, 119 gal

Water Use Analysis

- ▶ Range of water use analyses techniques:
 - An extensive, pencil-and-paper exercise (Florida Appendix 2),
 - On-line at agency web sites (e.g. Florida Solar Energy Center, Solar Distributor websites)

Water Use Analysis (continued)

- ▶ Estimate 20 gallons per person.
- ▶ Consider hot water use (e.g. shower) uses tempered (with cold) hot water.

System Type Selection

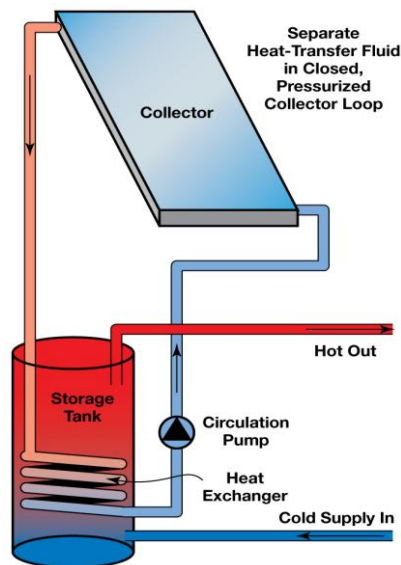


Image courtesy of NABCEP

System Type Selection (continued)

- ▶ These two extremes demonstrate the many variables that must be taken into account when selecting a specific SH system – the first example is primarily a geographical and temperature extremes decision, the second example requires changes in thinking and human behavior. All system selections must be carefully thought through.
- ▶ Remember your SH Mantra.

System Type Selection (continued)

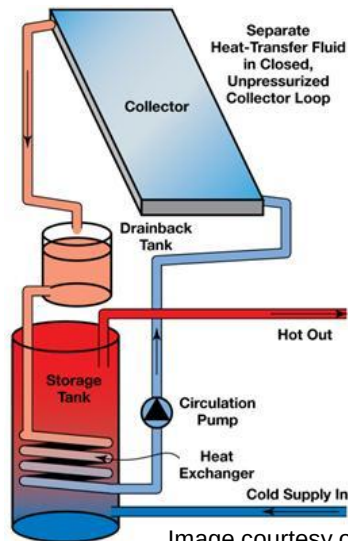


Image courtesy of NABCEP

System Type Selection

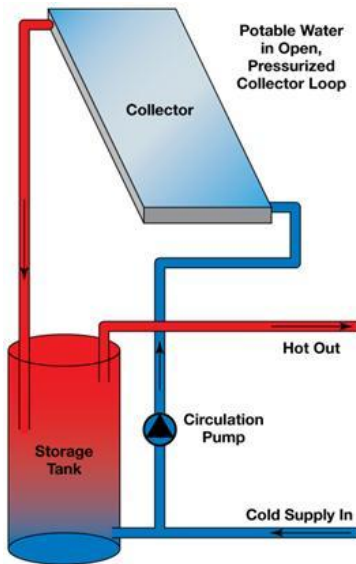


Image courtesy of NABCEP

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System Type Selection (continued)



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Sizing a System

- ▶ Rules of Thumb (ROTs)
 - Energy Conservation
 - Roof Load
 - Open or Closed Loop
 - Hot Water Demand
 - Collector Area

Sizing Software

- ▶ Online resources are available at agency web sites (e.g. Florida Solar Energy Center)
- ▶ Manufacturer's websites offer system-specific calculators

Shading Analysis

- ▶ It's like having a firm grip on the obvious – solar collectors must be in the sun!
- ▶ ROT – collectors face to the south.
 - To get maximum SH system performance, collectors must face the sun (south) at noon.

Shading Analysis (continued)

- ▶ The YMCA Method
- ▶ “Solar Pathfinder”
- ▶ “Solmetric Sun Eye”
- ▶ “Google Earth”

Site Assessment

- ▶ System installation obstacles
- ▶ Site access barriers/difficulties

Site Assessment (continued)

- ▶ Access to the cellar, where you must install a new tank, is lined with canned fruit (glass Mason jars).
- ▶ You think of it, it can and has happened
- ▶ A site assessment walk through is a first step when you arrive on a new installation job – don't even get the ladder off of the truck!

Solar Pathfinder

- ▶ The Chrome Dome siting/shading tool (similar to Pathfinder) is described in Florida, Appendix 1, and the Pathfinder is briefly discussed in NABCEP, pages 60-61.
- ▶ We will work with Pathfinders in class.
- ▶ The Solar Pathfinder web site includes documentation (operation manual) and instructional videos.

Domestic Hot Water: Additional System Considerations

- ▶ System Safety
 - Equipment Failure - Tank
 - Myth Buster's exploding tank!
 - TV showed what happens when temperature is allowed to get too high in a storage water heater.
 - They did not point out that they had over- ridden three (3) separate safety features.
 - 1 Thermostat
 - 2 ECO (Energy Cut Off)
 - 3 T & P valve

Domestic Hot Water: Additional System Considerations (continued)

- ▶ Water heater/storage tank seismic bracing?
- ▶ T/P valve installed properly?
- ▶ Set on 18" high stand in a garage?
- ▶ Anti-scald/tempering valve installed?
- ▶ Expansion tank installed?
- ▶ Not installed in bathroom?

Domestic Hot Water: Additional System Considerations (continued)

- ▶ CAZ – Combustion Appliance Zone
 - Gas water heaters – vent pressure of two Pascal's
 - Potential for spillage of gas water heater flue gases into the home.
 - Fumes harmful and even deadly

Domestic Hot Water: Additional System Considerations

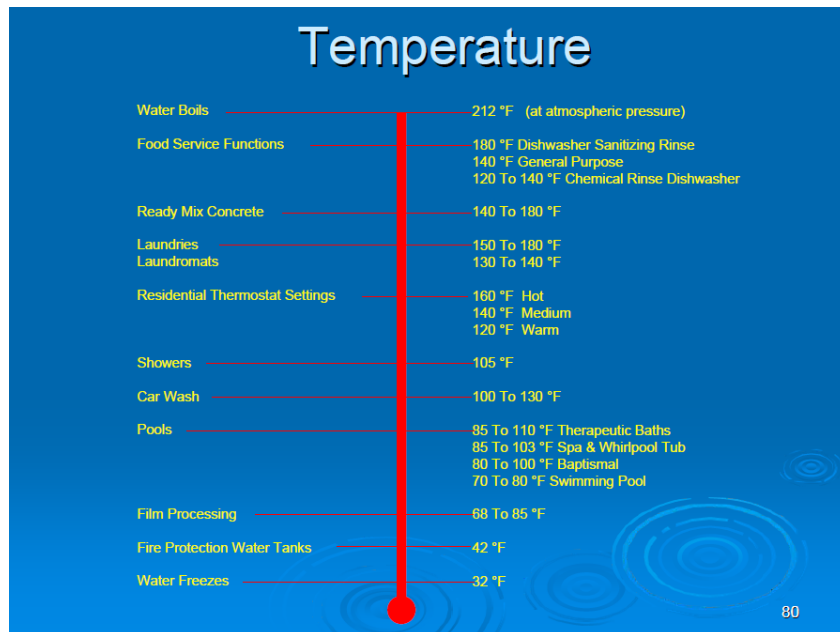
► Exposure Time

Celsius Temperature	Fahrenheit Temperature	2 nd Degree Burn No Irreversible Damage	3 rd Degree Burn Full Thickness Injury
45°	113°	2 hours	3 hours
47°	116.6°	20 minutes	45 minutes
48°	118.4°	15 minutes	20 minutes
*49°	*120°	8 minutes	10 minutes
51°	124°	2 minutes	4.2 minutes
55°	131°	17 seconds	30 seconds
60°	140°	3 seconds	5 seconds

*Activation temperature = 120° max (response time is less than 5 seconds)



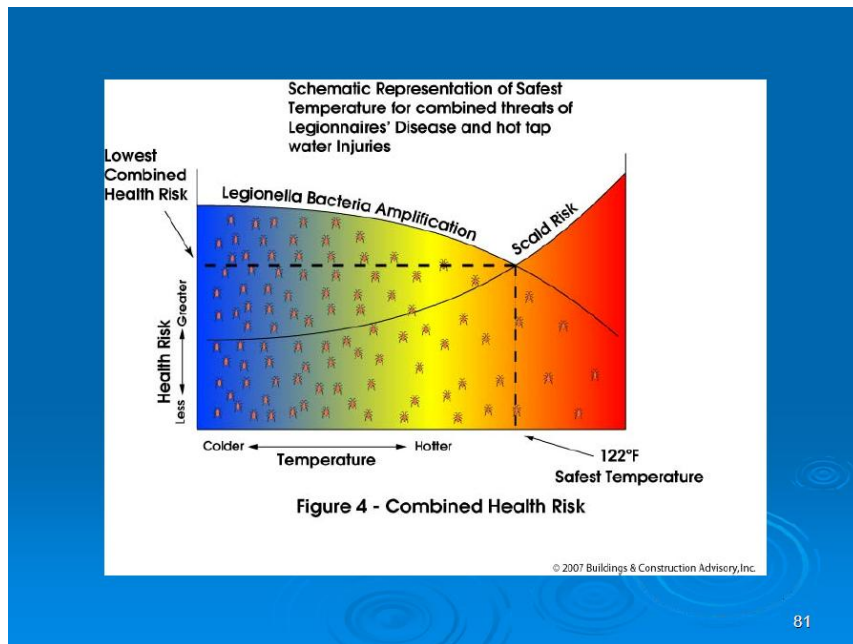
191



whoover@wi.rr.com



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Valves, Gauges, Meters

- Air Vent
 - Allows air in the system to escape.
 - Prevents air locks.
 - Must be positioned vertically.
 - Commonly installed at “top” of system.
 - Manually closed on indirect systems after initial and annual purge.

Valves, Gauges, Meters

- ▶ Pressure-Temperature Release Valve
 - AKA: “P&T” and “T&P” valve
 - Protects system from excessive pressures and temperatures.
 - Always plumbed to tanks.
 - Inside P&T valves must drain to outside (see local AHJ/code requirements).
 - Not built to be opened and closed manually to purge system.

Valves, Gauges, Meters

- ▶ Pressure Release Valve
 - Protects system from excessive pressures.
 - Must be installed where the collector loop can be isolated from the storage tank.
 - Usually installed at the collector.
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Valves, Gauges, Meters

- ▶ Vacuum Breaker
 - Admits atmospheric pressure into the system so it may drain.
 - Typically located at collector outlet.

Valves, Gauges, Meters

- ▶ Isolation Valve
 - Typically used to isolate subsystems: example – servicing collectors.
 - Ball valves typically preferred.

Valves, Gauges, Meters

► Check Valve

- Swing
- Spring
- Motorized

Check valves allow fluid flow only in one direction.

Used to prevent system thermosiphoning

(Ex: Cool water in nighttime roof-mounted collector pulled by gravity into storage tank pushing heated water into the cool collector).

Valves, Gauges, Meters

► Freeze Protection Valve

- Set to open at near-freezing temperatures.
- Installed on collector return line above roof.
- Warm water bleeds from collector through valve to protect system.
- Legacy model: “Dole Valve.”
- Requires companion check valve.

Valves, Gauges, Meters

- ▶ Pressure Gauges
 - Used to monitor system pressure.
 - May indicate leak.
- ▶ Temperature Gauges
 - Indicate fluid temperature at gauge location.
 - Multiple gauges aid in system evaluation.

Valves, Gauges, Meters

- ▶ SH pumps are very quiet.
- ▶ Flow meters enable owner and service provider to determine flow rate and pump operation.
- ▶ Typically installed above the pump.

Materials

- ▶ Metals: Copper, brass, cast iron, steel, stainless steel
- ▶ Rubber: O-rings, washers
- ▶ Solder: Non-lead only

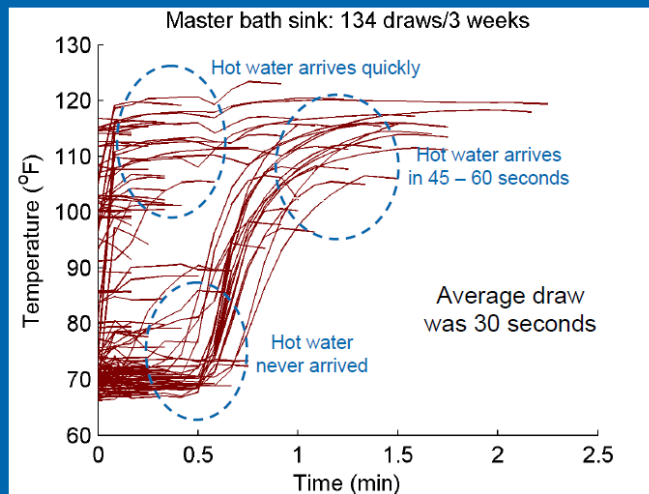
Materials (continued)

- ▶ Plastics: Pex, PVC, CPVC, Insulation

Hot Water Economics

- ▶ Energy and Hot Water Use
 - _ Hot water and household energy use
 - _ Hot water flow rate distribution
 - _ Time and temperature at the master bathroom

Time and Temperature at the Master Bath Sink



Source: National Renewable Energy Laboratory

Human Motivations

- ▶ “Heck No’s” (anti-utility)
- ▶ “Fixed Income” (worried about rising energy bills)
- ▶ “Greenies” (go green, environmentalists)
- ▶ “Hippies”, “Off-gridders” (independence)
- ▶ “Look at Me’s” (social/political reasons)
- ▶ “Tax Breaks” (incentives, write-offs)
- ▶ Other motivations?

Thank you!

*It's been a pleasure working with you today as
we complete Solar Heating Module #3.*

Instructor ID #:

Class ID #:



SOLAR HEATING ACADEMY

Module 4: Solar Heating Systems and Installation



FIRST: Your SH Mantra (Yes, Again!)

- ▶ All SH systems must control for:
- ▶ Over Heating
- ▶ Freezing
- ▶ Scaling

Address all three whenever studying, designing, installing, servicing and troubleshooting a SH system.



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MODULE #4 : TOPICS

SH Systems and Installation

- ▶ SH Installation Safety
- ▶ Codes and Licenses
- ▶ Collector Mounting
- ▶ Component Installation
- ▶ System Installation Checkout and Start-up Procedures



[Diablo Valley College SH Class "On Roof"](#)



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SH Systems and Installation

- ▶ NABCEP Installer Guide:
 - Chapters 7, 8 & 9
- ▶ Florida: 3-2 thru 3-35
- ▶ Home Power Articles:
 - Installation Basics
 - SHW Mounting



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SH Systems and Installation: Topics

- ▶ SH Installation Safety
 - Fall Protection
 - Ladder Safety
 - Selection and Use of Personal Protection Equipment (PPE)

SH Installation Safety Fall Protection

- ▶ See NABCEP pages 48-49.
- ▶ Falls and deaths are a reality in solar installations.
- ▶ See OSHA web site and links.
http://www.osha.gov/dep/greenjobs/solar_falls.html
- ▶ See fall protection short:
<http://www.youtube.com/watch?v=JWRiB9fbOdo>
- ▶ **YOU SHOULD ALL TAKE AN OSHA 10 CLASS!**

Falls in Construction

Falls are the leading cause of deaths in the construction industry.

Most fatalities occur when employees fall from open-sided floors and through floor openings.

Falls from as little as 4 to 6 feet can cause serious lost-time accidents and sometimes death.

Open-sided floors and platforms 6 feet or more in height must be guarded.

Fall Protection Options



Personal Fall Arrest System (PFAS)



Safety Net



Guardrails

Personal Fall Arrest Systems

- ▶ You must be trained how to properly use PFAS.
- ▶ PFAS = anchorage, lifeline and body harness.

Safety Line Anchorages

- ▶ Must be independent of any platform anchorage and capable of supporting at least 5,000 pounds per worker.

Safety Nets

- ▶ Place as close as possible, but no more than 30 feet below where employees work.

Roofs

If you work on roofs and can fall more than 6 feet, you must be protected.

Fall Protection

► QUIZ (Quickly write down answers)

- 1. Fall protection equipment does not include which of the following?
 - Guard rails
 - Safety nets
 - Personal fall arrest system
 - Safety glasses
- 2. Wall opening barriers must support at least
 - 200 pounds
 - 300 pounds
 - 500 pounds
 - 1000 pounds
- 3. To be safe, an anchor point has to support how much weight per person?
 - 1000 pounds
 - 3000 pounds
 - 5000 pounds

Fall Protection

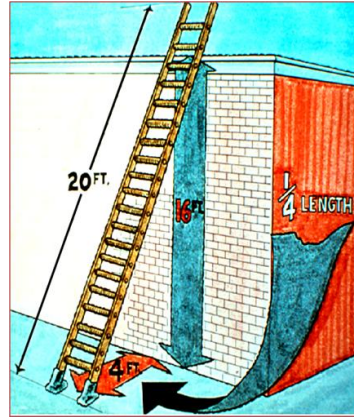
► ANSWERS

- 1. Fall protection equipment does not include which of the following?
 - Guard rails
 - Safety nets
 - Personal fall arrest system
 - **Safety glasses**
- 2. Wall opening barriers must support at least
 - **1910.23(e)(9)**
 - Wall opening barriers (rails, rollers, picket fences, and half doors) shall be of such construction and mounting that, when in place at the opening, the barrier is capable of withstanding a load of at least 200 pounds applied in any direction (except upward) at any point on the top rail or corresponding member.
- 3. To be safe, an anchor point has to support how much weight per person?
 - (6) Dee-rings and snap-hooks shall be capable of sustaining a minimum tensile load of 5,000 pounds (22.2 kN).
 - (3) Lanyards and vertical lifelines which tie-off one employee shall have a minimum breaking strength of 5,000 pounds (22.2 kN)

Ladder Angle

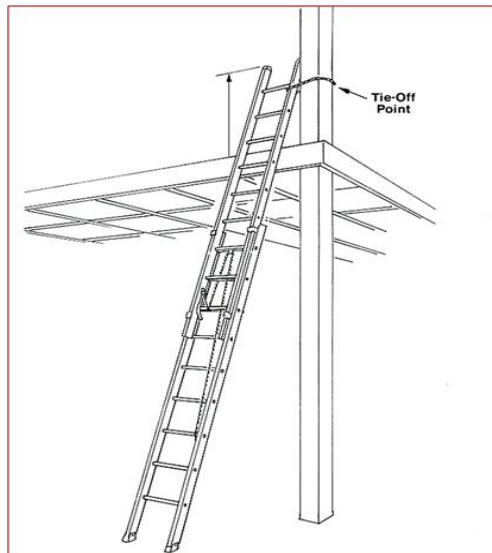
Non-self-supporting ladders (that lean against a wall or other support):

Position at an angle where the horizontal distance from the top support to the foot of the ladder is $\frac{1}{4}$ the working length of the ladder.



Ladder Rail Extension

- ▶ When using a portable ladder for access to an upper landing surface, the side rails must extend at least 3 feet above the upper landing surface.



Near Energized Electrical Equipment

- ▶ If using ladders where the employee or the ladder could contact exposed energized electrical equipment, they must have nonconductive side rails such as wood or fiberglass.

Overhead Power Lines

- ▶ Stay at least 10 feet away.
- ▶ Post warning signs.
- ▶ Assume that lines are energized.
- ▶ Use wood or fiberglass ladders, not metal.
- ▶ Power line workers need special training and PPE.

Ladder Safety

► QUIZ (Quickly write down answers)

- 1. If using a straight ladder to reach a roof, how many rungs should extend beyond the roof edge for proper support?
 - One
 - Two
 - Three
 - Four
- 2. What is the correct relationship between a ladder's distance away from the wall versus its "working length"?
 - 3 to 1
 - 4 to 1
 - 5 to 1
- 3. When climbing a ladder, how many "contact points" (hands – feet) should be touching the ladder at all times?
 - Two
 - Three
 - Four



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Ladder Safety

► ANSWERS

- 1. If using a straight ladder to reach a roof, how many rungs should extend beyond the roof edge for proper support?
 - One
 - Two
 - **Three**
 - Four
- 2. What is the correct relationship between a ladder's distance away from the wall versus its "working length"?
 - 3 to 1
 - **4 to 1**
 - 5 to 1
- 3. When climbing a ladder, how many "contact points" (hands – feet) should be touching the ladder at all times?
 - Two
 - **Three**
 - Four



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Personal Protection Equipment Responsibilities

Employer

Assess workplace for hazards.
Provide personal protective equipment (PPE).
Determine when to use.
Provide PPE training for employees and instruction in proper use.

Employee

Use PPE in accordance with training received and other instructions.
Inspect daily and maintain in a clean and reliable condition.

Examples of PPE

Body Part Protection Equipment

Eye	Safety Glasses, Goggles
Face	Face Shields
Head	Hard Hats
Feet	Safety Shoes
Hands and arms	Gloves
Bodies	Vests
Hearing	Earplugs, Earmuffs

Eye Protection for Employees Who Wear Eyeglasses

Ordinary glasses do not provide the required protection. Proper choices include:

Prescription glasses with side shields and protective lenses

Goggles that fit comfortably over corrective glasses without disturbing the glasses

Goggles that incorporate corrective lenses mounted behind protective lenses



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Safety Shoes

Impact-resistant toes and heat-resistant soles protect against hot surfaces common in roofing and paving

Some have metal insoles to protect against puncture wounds

May be electrically conductive for use in explosive atmospheres, or nonconductive to protect from workplace electrical hazards



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Selecting the Right Hard Hat

Class A

General service (building construction, shipbuilding, lumbering)

Good impact protection but limited voltage protection

Class B

Electrical/utility work

Protects against falling objects and high-voltage shock and burns

Class C

Designed for comfort, offers limited protection

Protects against bumps from fixed objects, but does not protect against falling objects or electrical shock



233

Hand Protection

Gloves

Solar thermal installers/integrators must deal everyday with at least two realities:

- ▶ **HEAT:** Collectors are usually framed in aluminum – leave them in the sun for just a bit on a hot summer day and they’re too toasty to pick up bare-handed. Tools and ladders and other equipment can also get “warm” in the summer – too hot to grab.
- ▶ **SHARP EDGES:** Aluminum collector frames are notorious for sharp corners and often razor sharp corner burrs. Deburring copper pipe has a way of gouging out a bare hand too.

It’s a good idea to show up on the job with at least one pair of sturdy work gloves.



234

Dangers of Electrical Shock

Currents above 10 mA* can paralyze or “freeze” muscles.

Currents more than 75 mA can cause a rapid, ineffective heartbeat -- death will occur in a few minutes unless a defibrillator is used.

75 mA is not much current – a small power drill uses 30 times as much.

* mA = milliampere = 1/1,000 of an ampere



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Shock Severity

Severity of the shock depends on:

Path of current through the body

Amount of current flowing through the body (amps)

Duration of the shocking current through the body

LOW VOLTAGE DOES NOT MEAN LOW HAZARD



236

Selection and Use of Personal Protection Equipment (PPE)

► QUIZ (Quickly write down answers)

- 1. The employer is not responsible to:
 - A. Assess workplace for hazards
 - B. Provide personal protective equipment (PPE)
 - C. Determine when to use PPE
 - D. Inspect daily and maintain in a clean and reliable condition
- 2. If you wear prescription glasses you must wear:
 - A. Prescription glasses with side shields and protective lenses
 - B. Goggles that fit comfortably over corrective glasses without disturbing the glasses
 - C. Goggles that incorporate corrective lenses mounted behind protective lenses
 - D. All of the above
- 3. Currents above ____? ____ can paralyze or “freeze” muscles.
 - A. 10 mA
 - B. 25 mA
 - C. 75 mA



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Selection and Use of Personal Protection Equipment (PPE)

► ANSWERS

- 1. The employer is not responsible to:
 - A. Assess workplace for hazards
 - B. Provide personal protective equipment (PPE)
 - C. Determine when to use PPE
 - D. Inspect daily and maintain in a clean and reliable condition
- 2. If you wear prescription glasses you must wear:
 - A. Prescription glasses with side shields and protective lenses
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 - D. All of the above
- 3. Currents above ____? ____ can paralyze or “freeze” muscles.
 - A. 10 mA
 - B. 25 mA
 - C. 75 mA



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New Mexico and Licenses



The state of New Mexico uses the **Uniform Codes** published by IAPMO, including the **Uniform Solar Energy Code**.

Codes and Licenses

► New Mexico SOLAR HEATING Codes

- The state of New Mexico uses the **Uniform Codes** published by IAPMO, including the **Uniform Solar Energy Code**.
- The International Association of Plumbing and Mechanical Officials (IAPMO) works with government and industry to implement comprehensive plumbing and mechanical systems around the world. There are many IAPMO codes and standards that pertain to photovoltaic installations, including:
[Uniform Solar Energy Code](#)
[IAPMO IGC 086-2002 - PASSIVE SOLAR WATER HEATERS](#)
[IAPMO IGC 190-2003 - AIR BASE SOLAR THERMAL COLLECTOR](#)

Codes and Licenses – Cont.

- ▶ The *Uniform Plumbing Code*® (UPC) sections in this code are taken from the 2009 edition of the *Uniform Plumbing Code*.
- ▶ The *Uniform Mechanical Code*® (UMC) sections in this code are taken from the 2009 edition of the *Uniform Mechanical Code*.
- ▶ An American National Standard *IAPMO/ANSI USEC 1-2009*

Codes and Licenses

- ▶ **New Mexico SH Codes**
- ▶ The advantages of a *Uniform Solar Energy Code*®, acceptable in various jurisdictions as a means of promoting the public's health, safety and welfare, has long been recognized.
- ▶ The “Solar Heating Notes” that follow provide code examples important to the SH installer.

Solar Heating Notes: Selections from the 2009 *Uniform Solar Energy Code*®.

► Chapters

- 1 Administration
- 2 Definitions
- 3 General Regulations
- 4 Piping
- 5 Joints and Connections
- 6 Thermal Storage
- 7 Collectors
- 8 Thermal Insulation
- 9 Duct Work
- 10 Electrical
- 11 Material Standards

Solar Heating Notes: Selections from the 2009 *Uniform Solar Energy Code*®.

- 1 Administration
 - 101.5 Applications to Existing Solar System
 - 103.0 Permits and Inspections
 - 103.2.1 Need permit for install, alteration, repair, replacement [UPC:103.2.1]
 - 103.1.2.1 No permit req'd given no system changes [UPC:103.1.2.2]

Solar Heating Notes: Selections from the 2009 *Uniform Solar Energy Code®*.

- ▶ 1 Administration (cont)
- ▶ 103.2 Application for Permit
- ▶ 103.2.1 Use AHJ form – all include:
- ▶ 103.2.1.1 Scope of Work, Site, Use or Occupancy, Data (Plans), Signature, Other Info [UPC:103.2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6]

Solar Heating Notes: Selections from the 2009 *Uniform Solar Energy Code®*.

- ▶ 1 Administration (cont)
- ▶ 103.2.2 Plans and specs [UPC:103.2.2]
- ▶ 103.2.3 Drawn to scale [UPC:103.2.3]
- ▶ 103.3.4 Expiration 180 days [UPC:103.3.4]
- ▶ 103.4.1 Fees [UPC:103.4.1]
- ▶ 103.5.3 Testing [UPC:103.5.3]

Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 2 Definitions
- ▶ (Very nice list of terms)



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 3 General Regulations
- ▶ 310.0 Installation
- ▶ 310.1 Accessible Locations [UPC:311.6]
- ▶ 310.2 Direction of flow [UPC:311.7]
- ▶ 316.0 Testing (plastic not tested with air)
- ▶ 316.2.1 Open Loop Systems – water pressure not less than max rated or 50 psi air (test durations not less than fifteen (15) minutes)
- ▶ 316.2.3 Closed Loop Systems – tested at one and one-half (1-1/2) times max designated operating pressure (test durations not less than fifteen (15) minutes)



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ **3 General Regulations (cont)**
- ▶ 316.3 Storage Tanks
- ▶ 316.3.1 Pressure Type. Tested as prescribed in 316.2.3
- ▶ 316.3.2 Non Pressure Type. Tested with water for period of twenty-four (24) hours



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ **3 General Regulations (cont)**
- ▶ 319.0 Safety Requirements
- ▶ 319.4 Water temperature. ...water @ 140°F shall be equipped ... tempering valve or temperature-limiting device to limit ... to a maximum of 140°F or less.
- ▶ 319.5 Spark or Flame. Solar equipment ... glow, spark, or flame ... in a residential garage.. not less than eighteen (18) inches above the floor level unless ... vapor ignition resistant.



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 4 Piping
- ▶ 401.0 Unlawful Connections
- ▶ 401.1 General. No installation of solar piping, ..., shall be made ...will be possible for used, unclean, polluted, or contaminated water, ...to enter any portion of the potable water system ... by reason of back-siphonage, by suction, ...



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 4 Piping (cont)
- ▶ 402.0 Identification of a Potable and Nonpotable Water System [UPC:601.2]
- ▶ 402.1 Potable Water (**LABEL**) Green background, white lettering [UPC:601.2.1]



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 4 Piping (cont)
- ▶ 402.2 Nonpotable Water (**LABEL**) Yellow background, block lettering, uppercase “CAUTION: NONPOTABLE WATER, DO NOT DRINK”.
- ▶ Labeled every twenty (20) feet, at least once per room
- ▶ Each outlet labeled
- ▶ Visible from floor level
- ▶ Direction of normal flow indicated.



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 4 Piping (cont)
- ▶ 406.1.1 Copper tube, Type L, not less
- ▶ Exception: Type M, above ground, in or on building, or underground outside of structure [UPC:604.2]
- ▶ 406.5.2 Water Heater Connections. PEX tubing shall not be installed within the first eighteen (18) inches of piping connected to a water heater. [UPC:604.13.2]
- ▶ 406.8 Flexible Corrugated Connectors. Limited to twenty-four (24) inches in length. [UPC:604.12]



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 4 Piping (cont)
- ▶ 407.2 Control Valve. A control valve shall be installed immediately ahead of each water-supplied solar system.
- ▶ 407.4 Closed Loop Systems. ...valves used to charge/drain system shall be of loose key type, ... outlets capped or ... handles removed when ... operational.
- ▶ 409.0 Automatic Air Vents. Install at high point.

Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 4 Piping (cont)
- ▶ 410.0 Vacuum Relief Valves.
- ▶ 410.1 Installation. Install at high point: drain down and drain back.
- ▶ 412.0 Check Valves. Install ... system design would allow reverse thermosiphoning ... into the collector array.
- ▶ 413.0 Flow Directions. Systems shall have flow directions indicated on system components and piping or ... a diagrammatic representation of the ..., permanently affixed ... ready visible location. **(LABEL)**

Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 5 Joints and Connections
- ▶ 502.0 Types of Joints
- ▶ 502.1 Threaded Joints. Pipe joint material applied to male threads. Conventional pipe thread compounds, putty, linseed-oil-based products, unknown lubricants and sealants – not on plastic. [UPC:316.1.1]
- ▶ 502.2 No lead solder [UPC:316.1.3]

Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 5 Joints and Connections (cont)
- ▶ 502.6 Solvent Cement Plastic Pipe Joints. Plastic ...
- ▶ ABS pipe and fittings shall be cleaned and then joined with solvent cement(s).
- ▶ CPVC pipe and fittings shall be cleaned and then joined with listed primer(s) and solvent cement(s).
- ▶ Exception:
- ▶ PVC pipe and fittings shall be cleaned and then joined with listed primer(s) and solvent cement(s). [UPC:316.1.6]

Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ **5 Joints and Connections (cont)**
- ▶ **503.0 Special Joints**
- ▶ **503.4 Unions.** Installed not more than 12 inches from equipment (tank, regulating equipment, and similar) that facilitates removal/replacement. [UPC:609.5]

Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ **6 Thermal Storage**
- ▶ **602.0 Expansion Tanks**
- ▶ **602.1** Need for expansion tank on hot water system.
...secured to support twice the weight of a full tank – no strain on connecting pipes.
- ▶ **603.0 Test Pressure for Tanks Used in Solar Systems.**
Test pressure = 2 times working pressure, but not less than 300 psi.

Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ **7 Collectors**
- ▶ 701.2 Mounting. ...Maintain roof integrity, water integrity, roof surface.
- ▶ 701.4 Construction. “Panels” constructed to prevent interior condensation, outgassing.
- ▶ 701.5 Glass. Tempered glass.
- ▶ 701.7 Stagnation Condition. Capable of withstanding stagnation.



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ **7 Collectors (cont)**
- ▶ 704.0 Fire Safety Requirements
- ▶ 704.1... Collectors functioning as building components must comply with Building Code.
- ▶ 704.2 Above or On the Roof. Shall not reduce required fire-resistance/retardance of roof covering materials.
- ▶ Exceptions:
- ▶ One- and two-family dwellings.
- ▶ Mounted on buildings less than three stories providing...



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 7 Collectors (cont)
- ▶ 705.0 Collector Installation
- ▶ 705.2 Safety. Allow workspace access on roof next to installed collectors..
- ▶ 705.3 Waterproofing. Joints, bolts, supports, sealed.



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 8 Thermal Insulation
- ▶ 802.0 Piping
- ▶ 802.1 Required. Pipe and fittings insulated suitable for continuous operation at 220°F.
- ▶ 802.3 Installation. Exposed insulation shall be protected.



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Solar Heating Notes:

Selections from the 2009 *Uniform Solar Energy Code*®.

- ▶ 9 Duct Work
- ▶ 901.0 Solar system ducting installed as per Uniform Mechanical Code.

Codes and Licenses

- ▶ **New Mexico Licenses**
 - Any one engaged in construction related contracting in New Mexico must be licensed. The activities that are considered to be contracting in New Mexico are defined in the Construction Industries Licensing Act, NMSA 1978, [Section 60-13-3](#).

Codes and Licenses

- 14.6.6.9 GENERAL CONSTRUCTION
- B. License Classifications.
- (2) Residential and commercial building.
- (a) GB-2. Residential.
- (b) GB-98. General building.
- 14.6.6.10 ELECTRICAL
- B. License classifications.
- (1) Residential and commercial.
- (a) EE-98. Residential and commercial ...
- (b) ER-1. Residential electrical wiring.

Codes and Licenses

- 14.6.6.11 MECHANICAL AND PLUMBING
- B. License classifications.
- (1) Residential and commercial.
- (a) MM-1. Plumbing.
- (c) MM-3. Heating, ventilation & air conditioning (HVAC).
- (e) MM-98 Mechanical.
- C. Journeyman classifications.
- (1) JP. Journeyman plumber.
- (2) JPF. Journeyman pipe fitter.
- (5) JR. Journeyman refrigeration.

Collector Positioning

- ▶ Generally roof-mounted or ground-mounted in a fixed position.
- ▶ Few “side-mounted” on wall.
- ▶ Site characteristics critical in collector positioning/orientation.
- ▶ Collector positioning may be season-specific:
 - Winter lodge
 - Summer cabin

Collector Positioning

- ▶ Ideally a collector should be positioned:
 - to face true south (north of equator), and
 - with a tilt angle at latitude.
- ▶ Given site considerations:
 - a collector may face within **30° to 45°** either east or west of true south
 - Consider your **Solar Window**
 - optimum tilt angles = site latitude **plus or minus 15°**
 - Albuquerque: Latitude: N 35° 11' 12.6845", or 35°N

Collector Positioning

- ▶ Performance versus Aesthetics
 - Aesthetic considerations vary in intensity with the client and system location.
 - The mounted collector should not detract from building's overall appearance/attractiveness.



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Collector Positioning

Roof Mounted Collectors

- ▶ Roof mounted collectors should:
 - shed water/rain and plant detritus,
 - Prevent puddling around roof penetrations.
 - limit collector-to-storage pipe runs to <100 feet.
- ▶ Pictured:
 - Getting it WRONG

Old School & Wrong



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Collector Positioning

► Wind Loading

- Withstand wind-loads of 146 miles per hour.
- Many collector racking systems tested to 180 MPH.
- Thermal expansion and contraction may loosen improperly installed fasteners.



Collector Positioning

► Rack Mounting

- Distances between rows calculated to minimize or eliminate shading.
- ROT: Between-row separation = 2.5 times row height.
- Or: $d = h + \tan \theta$

Collector Positioning

- ▶ Standoff Mounting
 - Very common racking
 - Easily matches roof slope
 - Usually faster install time than racking.
 - May be used to set collectors at angle different from roof slope.
 - Allows for drainage (rain) and debris (leaves) flow.
 - Huge variety of mounts.

Collector Positioning

- ▶ Direct Mounting
 - Collectors may be mounted directly on the roof surface.
 - Waterproof flashing is built up around the collector.

Collector Positioning

► Integral Mounting

- Collector mounting incorporated in to roof structure.
- Collector(s) serve as finished roof surface.
- Typically installed during new roof construction.
- Not your common installation.

Collector Positioning

► Ground Mounting

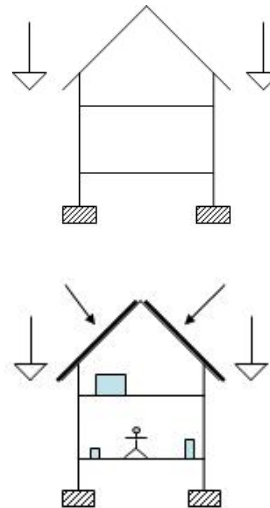
- Ground mounting is often a good alternative to roof mounting.
- Local codes and AHJ requirements must be followed for a ground mount.
- A popular elevated ground mount design provides shaded automobile parking (think Albuquerque's Sunport).

Roof Work Considerations

- ▶ “Illegal”?
- ▶ “Legal”?
 - Safety
 - Roof damage
 - OSHA regulations
 - Lifting collectors on to roof

Roof Work Considerations

- ▶ Roof Loading
 - “Dead Load” static forces that are relatively constant for an extended time.
 - “Live Load” usually unstable or moving loads.
 - TOP DIAGRAM: Dead Load
 - BOT. DIAGRAM: Live Load



Roof Work Considerations

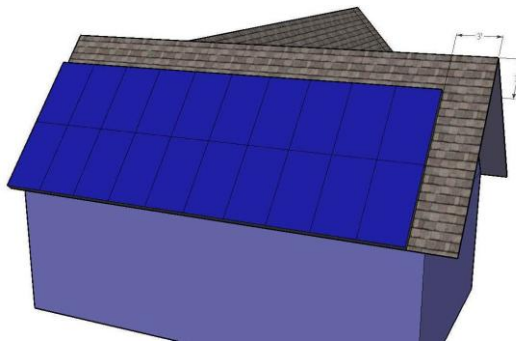
► Roof Condition

- Extreme roof conditions and related concerns include dry rot, structural defects, “sway-back” and older roofing materials.
- Shingles out of alignment will look even worse next to a straight-edge collector.

Roof Work Considerations

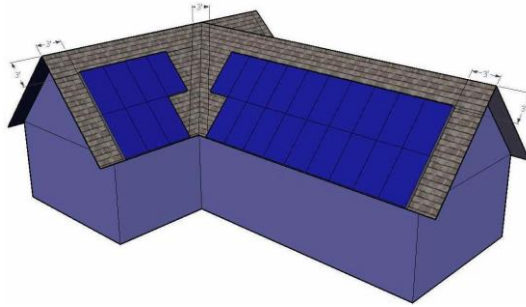
Cross-Gable Roof

Single and multiple collector array installations should consider fire fighter and maintenance access.



Roof Work Considerations

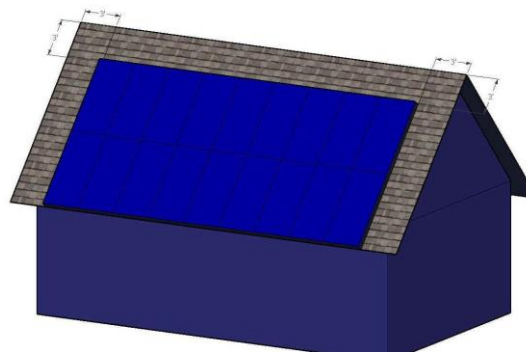
Cross-Gable Roof With Valley



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Roof Work Considerations

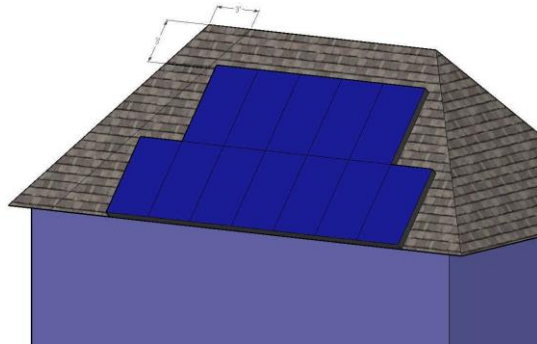
Full Gable Roof



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Roof Work Considerations

Full Hip
Roof



Roof Work Considerations

► Roof Damage

- Your objective is NOT to install a solar collector on a roof, your job is to install a collector safely and with no damage to the roof.

Site Preparation

- ▶ On The Roof
 - Collector roof mounts are ANCHORED to roof rafters or trusses – NOT roof sheathing!

On the Roof

Images of "J" bolts.
Required in NM by some
AHJ's



http://www.alibaba.com/product-free/121264764/J_bolt_J_Head_Bolt.html

Site Preparation

- ▶ In The Basement/Cellar/Garage
 - Where is the system pump station to be located?
 - Where is the existing water heater and water connections?
 - Is the existing water tank in good working order?
 - What else?

Site Preparation

- ▶ Inside/Outside
 - INSIDE: Where does my pipe run?
 - Roof penetrations?
 - Through the attic?
 - Through a chase?
 - Inside a wall?
 - What else?
 - OUTSIDE: Where does my pipe run?
 - Through the eaves or around the eaves?
 - Roof penetrations?
 - Other?

Roof Penetration

- ▶ Pipe flashing
 - Flashing is placed around solar collector pipes which protrude from the roof of a building to deflect water away from seams or joints.
- ▶ Collector mount flashing
 - Largely dependent on manufacturer's specifications and recommendations.
- ▶ Working with asphalt shingles
 - Two valuable tools:
 - Flat bar
 - Roofing bar

Bracket Mounting and Sealing

- **“Brackets”, AKA “feet”, “legs”, “boots”, etc., attach the collector to underlying rafters or trusses.**
- **Bracket installation varies by manufacturer.**

Bracket Mounting and Sealing

– Many Players:

- Distributers
- Manufacturers
- Suppliers
- Contractors

Heliodyne
SunEarth
Alternative Energies
Thermomax
FAFCO
Apricus
Buderus
Solar Heat Exchange
Aurora
Quick Mount PV
Fast Jack
S-5!™ Clamps
Unirac
MORE.....

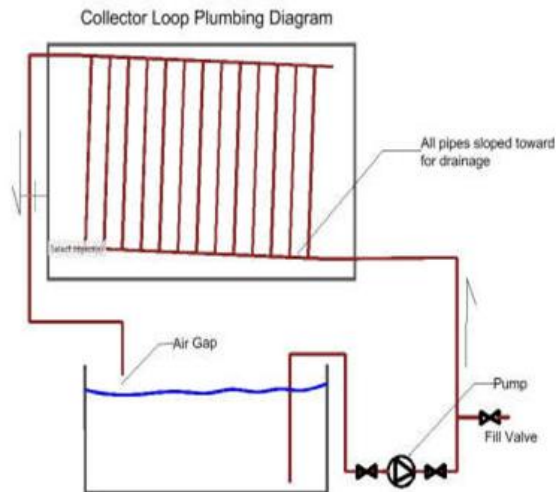


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Collector Attachment

Drainback collectors must be sloped on the roof to ensure that they “drain back”.

To what angle should the collector be mounted ?



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Roof Piping and Penetrations

How do you fix this problem quickly and at little cost?



295

PIPING

Type L
Type M
Type K

Type K copper pipe is commercial grade and is usually not used in residential plumbing. Type K is color coded with green markings.

Type L copper is color coded with blue markings.



- **Type M** copper pipe and tubing can be used in residential plumbing, and often is, because it is less expensive but also lower quality. Type M copper pipe has a shorter useful life than type L copper piping. Type M is color coded with **RED** markings along the pipe.



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VALVES, GAUGES, METERS

► Air Vent

- Allows air in the system to escape.
- Prevents air locks.
- Must be positioned vertically.
- Commonly installed at “top” of system.
- Manually closed on indirect systems after initial and annual purge.

► Vacuum Breaker

- Admits atmospheric pressure into the system so it may drain.
- Typically located at collector outlet.

VALVES, GAUGES, METERS

► Freeze Protection Valve

- Set to open at near-freezing temperatures.
- Installed on collector return line above roof.
- Warm water bleeds from collector through valve to protect system.
- Legacy model: “Dole Valve”.
- Requires companion check valve.

► Check Valve

- Swing, Spring, Motorized
- Check valves allow fluid flow only in one direction.
Used to prevent system thermosiphoning

Piping Collector Arrays

1. Collectors may be mounted in series.
2. Collectors may be mounted in parallel.
3. Collectors are limited in the number that may be linked together in series or in parallel.

Piping Collector Arrays

1. Collectors must be insulated.
2. Elastomeric insulation rated for 230° F on solar plumbing.
3. R-Value requirements may vary with system.
4. NEVER use polyethylene foam insulation.
5. Insulation must be protected from weather, UV, and critter damage.
6. Some components must NOT be insulated.

Collector-to-Storage Piping Installation

- ▶ Designing a copper tube water system is a matter of determining the minimum tube size for each part of the total system by balancing the interrelationships of six primary design considerations.
- ▶ Design and sizing must always conform to applicable codes.

Collector-to-Storage Piping Installation

- ▶ Drawn tempered tube requires support for horizontal lines at about 8-foot intervals for sizes of 1-inch and smaller, and at about 10-foot intervals for larger sizes.
- ▶ Vertical lines are usually supported at every story or at about 10-foot intervals

Storage Tank Installation

- ▶ Typical residential solar storage tanks come in common sizes up to 119 gallons.
- ▶ Residential systems are commonly two-tank systems, but designs do vary widely.

Storage Tank Installation

- ▶ STRATIFICATION is a critical process regarding solar storage tanks.
- ▶ Water is a convenient heat storage medium, because it has a high specific heat capacity.

Pump Installation

- ▶ Solar heating “pumps” or “circulators”.
- ▶ Indirect systems commonly have two pumps, one for the closed collector loop, the other for the domestic water supply.
- ▶ Drainback systems often use variable speed pumps.
- ▶ Pumps are made from various materials and the system design will dictate which pump may be used.
- ▶ Cavitation over time will ruin a pump.

Pump Installation

- ▶ **You need to understand how to access technical information on-line in order to understand component performance parameters.**
 - Cut sheets
 - Performance curves/charts

Controls and Sensor Installation

► Differential Controller

- Common choice
 - Others:
 - Timer Controller
 - Aquastat
 - Photovoltaic Controller

Controls and Sensor Installation

- Differential controllers determine when to activate the pump to send fluid through the collector and back to the tank.
- Differential controllers use two (or more) sensors – one at the hottest point of the solar loop (collector output) and the other at the coolest point (tank bottom).
- To operate, controllers are either preset or manually set to a temperature “differential”.

Controls and Sensor Installation

Electricity Basics: Thermistors

A thermistor is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors.

Thermistors are widely used as temperature sensors in SH systems.



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Controls and Sensor Installation

- ▶ Timer Controller
- ▶ Aquastat
 - high limit temperature and a low limit



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Controls and Sensor Installation

► Photovoltaic Controller

- Paired with P-V panel and DC pump
- Circulation Pump runs when the sun shines

SH Systems and Installation: Topics

► System Installation, Checkout and Start-up Procedures

- Pressure Testing
- Flushing the System
- Testing the Pump and Controls
- Cleanup
- Instructing the Homeowner

Pressure Testing

- ▶ Testing with compressed air is a good initial test – especially with pipe runs in the attic, walls, etc.
- ▶ Typically accomplished by monitoring a pressure gauge over a specified amount of time.
- ▶ A drop in pressure over time and you start looking for a leak.
- ▶ A final pressure test is accomplished with water.

Flushing the System

- ▶ Flush the collector loop first.
- ▶ Flush the storage tank loop next.
- ▶ Flush with water – then think about adding your expensive solar fluid to the system.
- ▶ Ensure that your solar fluid (e.g.: glycol) is compatible with your system.
- ▶ Remember – if you are working in a confined space, such as a basement, things are bound to get wet. Locate drains, hoses, buckets, rags, mops, etc., before pressure testing and flushing your system.
- ▶ Save for drainback collector loops, you must ensure that you are purging all air from your systems.

- ▶ Florida pages: 3-28 & 3-29
- ▶ VIEW: Heliodyne Installation DVD

OTHER DEVICES (BOS)

► Heat Transfer Fluid

- Propylene Glycol most common
- NEVER Ethylene Glycol
- A glycol-water mix has less heat-transfer ability than pure water: the higher the percent of glycol the less efficient.

Testing the Pump and Controls

- Check pump function.
 - If variable speed is it set properly?
 - Flow meter confirmation?
- Run differential controller through manufacturer's test steps.
- Check sensors with multimeter.

Controls and Sensor Installation

- ▶ **Multimeter**
 - Test for Voltage
 - Test for Continuity
 - Test for Resistance

Controls and Sensor Installation

- ▶ Insulation
- ▶ Closed cell elastomeric foam.
 - “Armaflex”, “Rubatex”
 - NO DIY home center polystyrene or polyethylene.
- ▶ Exterior piping protection.
 - Coatings, Shieldings
- ▶ Insulation AFTER pressure testing.
- ▶ System labeling!

Cleanup

► Cleanup time!

- One very important aspect of the job often overlooked.

Instructing the Homeowner

- Careful instruction minimizes unpaid callbacks!
- Careful instruction includes leaving a colorful and tabbed system information binder – ablaze with your company logo and contact information.

Thank you!

*It's been a pleasure working with you today as
we complete Solar Heating Module #4.*

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SOLAR HEATING ACADEMY

MODULE #5: SH OPERATION, MAINTENANCE AND TROUBLESHOOTING



FIRST: Your SH Mantra (Yes, Again!)

All SH systems must control for:

1. Over Heating
2. Freezing
3. Scaling

Address all three whenever studying, designing, installing, servicing and troubleshooting a SH system.



SH Operation, Maintenance, and Troubleshooting

- ▶ NABCEP Installer Guide:
 - Chapter 10
- ▶ Florida: 4-1 thru 4-28
- ▶ Home Power Articles:
 - Overcoming Overheating
 - Troubleshooting Part 1

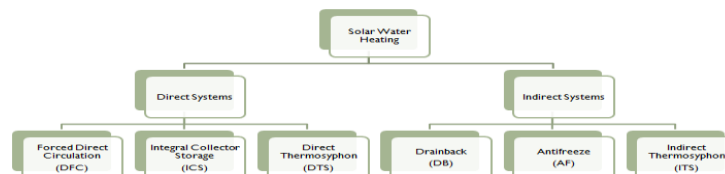
MODULE #5 : TOPICS

SH Operation, Maintenance, and Troubleshooting

- ▶ Problem Assessment and System Checkout
 - Problem Assessment
 - The Initial Service Call
 - Common Problems
 - Other Potential Problems
 - System Checkout
- ▶ Troubleshooting Checklist

Problem Assessment

- ▶ Problem assessment skills are tied to your understanding of system components, system types and system applications.



Problem Assessment

- ▶ Experienced SH professionals believe that
 - (1) properly chosen SH design,
 - (2) based on an evaluation of client needs,
 - (3) properly installed by a competent installer using good/high quality and tested products, (4) should last for decades with only periodic maintenance.

The Initial Service Call

- ▶ **CONTACT INFO**
- ▶ Date, time, name of caller, caller's cell number
- ▶ Client's name, client's spouse's name, address, address zip code, home phone, cell phone, work phone
- ▶ ☐ SH system your outfit installed? ☐ Another company installed? If other, name? (*checklist*)
- ▶ SH system site address (*may be different than home*), address zip code
- ▶ **SYSTEM INFO**
- ▶ System type: ☐ Drainback, ☐ Closed Loop Glycol ... (*checklist*)
- ▶ System siting: ☐ Roof mount (*how many stories/high – how long a ladder will you need to take?*), ☐ Ground mount ... (*checklist*)
- ▶ **What Else?**

The Initial Service Call

► SYSTEM ACCESS

- Can you get to all system components?

► CALL TYPE

- ☐ Service Maintenance
 - ☐ Annual maintenance, ☐ Seven year glycol replacement
- ☐ Problem Call
 - ☐ No hot water, ☐ Insufficient hot water

► PROMISED RESPONSE

► TIME AND MILEAGE

► More...



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The Initial Service Call

► CLIENT COMMUNICATION

- It is critical that someone communicates with the client at the end of the work day to be sure that she/he understands the process of work and details regarding the work.
- Be clear with your boss WHO it is that communicates with the client.

► SWEEP AND CLEAN OUT THE DOOR



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The Initial Service Call

▶ SERVICE CALL REPORT

- ▶ Itemized list of parts, part costs (especially if you had to pay out-of-pocket), initial findings, troubleshooting activities, solution taken to remedy problem, ... what else?

Running the Call

▶ ARRIVING ON SITE

- ▶ Make contact with the owner/caller
- ▶ Eyeball the problem.
 - A simple toolkit will help in this process:
 - Strong-beam flashlight
 - Troubleshooting mirror (automotive type on telescoping rod)
 - Pad, pencil
 - Digital camera
 - What else?

Running the Call

▶ ON-SITE ANALYSIS AND TESTING

- ▶ Your initial conversation with the client will direct your thinking towards related problem-solution scenarios.
 - “The system is leaking down the outside wall next to our new driveway” (yes, where someone just hit it with a vehicle).

System Checkout

▶ ON-SITE ANALYSIS AND TESTING

- ▶ As we continue our walk through of NABCEP’s and Florida’s troubleshooting “routines”, consider that they are very detailed and not designed to be pursued page-by-page.
- ▶ **Florida “Checklist”**

Thank you!

*It's been a pleasure working with you today as
we complete Solar Heating Module #5.*

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SOLAR HEATING ACADEMY

MODULE #6: SOLAR SWIMMING POOLS



FIRST: Your SH Mantra (Yes, Again!)

All SH systems must control for:

1. Over Heating
2. Freezing
3. Scaling

Address all three whenever studying, designing, installing, servicing and troubleshooting a SH system.



Solar Swimming Pools

- ▶ NABCEP Installer Guide: Chapters 4,8
- ▶ Florida: 5-1 thru 5-33

MODULE #6 : TOPICS

Solar Swimming Pools

- ▶ Pool System Components, Installation and Operation
- ▶ This module focuses only on the majority of residential pools – outdoor pools with unglazed collectors.

Heat Loss Mechanisms

- ▶ 70% of swimming pool heat loss is due to **EVAPORATION** from the pool surface.
- ▶ **CONVECTIVE** loss up to 20%.
- ▶ **RADIATIVE** heat loss about 10%.
- ▶ **CONDUCTIVE** heat loss is very minimal.

Passive Pool Heating

- ▶ The least expensive way to heat your pool.
 - Locate the pool in a sunny area.
 - Locate the pool in an area away from the wind – or build windbreaks.
 - Use a pool cover when the pool is not in use.

Pool Covers

- ▶ Pool covers are effective in reducing heat loss by reducing evaporation.
- ▶ Two traditional covers:
 - Opaque
 - Woven safety covers used at commercial pools.
 - Transparent
 - Reduce evaporation with benefit of acting like solar collector.

Active Pool Heating

- Basics: The primary purpose behind installing a residential solar swimming pool system is to provide the occupants with two extra and pleasant swimming months in the year
- SH solar pools are generally simple and inexpensive in comparison to domestic SH systems, and they typically operate at high efficiencies.
- “Heat Loss”, “Pool Cover”, and “Passive Pool” resolutions all go hand-in-hand with SH swimming pool systems.



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Active Pool Heating

- Economics: Solar swimming pools save money.
- Solar heated swimming pools may be indoor or outdoor.
- Low-temperature, outdoor solar pool systems have no heat exchanger, and the pool is the “storage tank”.



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Collector Installation

- ▶ Many types of collectors are suitable for pool heating.
- ▶ Low-temperature, unglazed collectors are most common.
- ▶ Many different low-temp collector designs.
- ▶ High flow rates.
- ▶ Sizing affected by regional climate.
- ▶ ROT (Rule of Thumb)
 - 75% of pool top surface area in collector area (on a pool where a cover is used) equals bumping the pool temp about 10 degrees (San Diego)

Collector Installation

- ▶ Collector installation is fairly straight-forward.
 - The roof layout is done according to the roof plan drawn by the system designer.
 - Most unglazed pool collectors will be mounted, similar to drainback collectors, with a slight pitch

Collector Installation

- Roof load is not typically a design consideration.
- Roof penetrations are also not typically a huge concern as most/all of the piping runs are usually outside of the dwelling envelope.
- Unglazed pool collectors often come in a kit, including connectors, clamps, straps, and even stainless lag bolts.

Collector Installation

- ▶ Collector installation...
- ▶ Your SH contractor should provide installation guidelines for the specific SH system products you are to install.
- ▶ CONSIDERATIONS...
 - **Roof Orientation:** Unglazed pool collectors, just like glazed collectors, want to face South.
 - **Arrays :** The usual solar pool collector array is one continuous row.

Collector Installation

- Pool Pump:** Existing pool pumps at many installations, specifically on one-story high roof mount systems, are often adequate.
- Systems may be designed for flow rates in the range of 4 or 5 gallons per minute. A typical one horsepower pump may be sufficient.

Collector Installation

- Piping
 - White PVC or CPVC pipe is often found on SH pool installations. A client may prefer black pipe as believing it looks better on their roof. Often white pipe is painted to match. Check your plan.
 - Plumb your system to plan. Consider flow rate through multiple collectors: see Florida, page 5-27.

Collector Installation

- PVC or CPVC or ? (check local codes, AHJ).
- 1-1/2" and 2" pipe is common.
- Under-sizing pipe leads to a reduced flow rate.
- Runs should be as short as possible.
- Slope-Drain like drainback systems.



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Collector Installation

- ▶ Diverter Valve
 - Used for diverting, shutting-off, or mixing applications.
- ▶ Ball Valve
 - Used to cut off, isolate and regulate system flow.
- ▶ Check Valve
 - Why do we use check valves in a pool system?
- ▶ Solar Pinch Valve
 - One potential flow controller.
- ▶ Solar Pool Flow Meter
- ▶ Solar Pool Thermometer



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Activating the System

- ▶ **FIRST purge.** Dirt, small plastic chips, it must all be flushed out.
- ▶ **SECOND pressure test.** Testing at twice the operating pressure is recommended.

Activating the System

- ▶ **THIRD** check all **automatic controls** for proper function.
- ▶ **FOURTH** check **flow rate** against specs.
- ▶ **FIFTH** (done on a sunny day) check for **temperature rise**.

Activating the System

- ▶ **LAST walk** the pool owner through the entire operation of his/her new solar pool heater.
 - During this owner walk-through you provide the all-important **binder or folder** containing system instructions, diagrams, etc.

- ▶ **HAPPY SWIMMING**

Thank you!

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we complete Solar Heating Module #6.*

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