

Solar Solutions

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Bristol's six principles of good solar hydronic design

Basic Combi-System Controls

In this series of articles, I have been making the case that the key ingredients for solar/hydronic design and installation can be divided into six categories, listed below, roughly in order of their importance.

1. RELIABILITY
2. EFFECTIVENESS
3. COMPATIBILITY
4. ELEGANCE
5. SERVICEABILITY
6. EFFICIENCY

The success of any solar hydronic home heating installation depends on the often-conflicting balance between any of these six principles. Finding the balance between them defines the art of solar heating design.

In previous columns I have introduced and explained some of the elemental concepts of hydronic solar home heating. Water tank heating, mass floor heating, thermostat control, glycol loops, combi-systems and flow centers have been discussed in earlier issues. These individual concepts are typically grouped together and installed in every Solar Hydronic Combi-system that we have built in the past five years or so. Of course, every solar home heating system was installed with the wiring and controls to make it work properly. Let's take a closer look at a Primary Check-Loop solar heating system and the controls that make it work. In this column I will discuss the Solar Combi-system we most commonly install and the Basic controls required for reliable operation. Please look online to review the previous columns in the *PE* and *Phc News* archives.

Primary Loop "Flow Center" Piping

In our region, the most typical Solar Hydronic Combi-system includes a (1) solar heat collector array, a (2) gas boiler backup, a (3) domestic water heater and a (4) radiant heated floor. I introduced this application in an earlier issue (spring 2009) as Combi-system 101, since I have installed these features so many times in home heating projects. This system includes only four items, two heat sources and two heat loads and so presents a relatively simple example for discussion.

The diagram seen in Figure 14-1 shows the configuration that has

become my basic standard piping arrangement for over a decade for Combi-system 101. There are a number of additional benefits when using this system in real-world installations. The primary loop is typically installed horizontally, hanging from the ceiling. The swing check valves must be installed horizontally or "flow upward," since they may not close properly if installed "flow downward."

For the purpose of this discussion, I will present the very simplest control system that will provide the homeowner with Reliable and Effective use of the solar heat available from this sample heating system. Keep in mind, that as a simple example, it does not include night cooling, baseboard heat, heat storage tanks for space heating or other relatively common options. Each additional option would require additional control components to be included in our wiring and control system. So to keep this article brief we will limit the discussion to the bare minimum heating system components using the bare minimum controls.

This type of system is typically installed with an economical number of collectors that are tilted to maximize winter space heating. With a limited number of collectors, all the solar heat can normally be delivered to the cool mass of the radiant heated floors, or stored in the domestic water heater. If the collector tilt is matched to the summer load properly, all the solar heat available can be controlled by storing it in the domestic hot water tank and any excess solar heat can be dissipated to the floor mass without overheating the rooms. When properly designed and installed, this version of the Solar Combi-system can be about as simple, economical and effective as any active solar home heating system can be. This is because most of the heating equipment (boiler, tank, radiant floors) had to be there anyway, even without the solar collectors.

Basic Control Requirements

A complete wiring diagram for the Combi-system 101 is shown in Figure 14-2. This diagram is adapted from the control boxes that we have deployed on many similar installations. It contains a 2-stage set-point control, a differential control, four relays (DPDT), a 2-stage room thermostat for each zone valve, a zone valve control box, and two pump control relay boxes. The models and brand names of the components are included for example only, and do not constitute an endorsement or recommendation.

There are certain controls for this heating system that are required, and then some that are optional. Here is a short list of the most important functions. All the "required" functions are included in the components shown on Figure 14-2.

Combi-System 101 — Solar Domestic Hot Water Tank Control (DHW)

Required Temperature Controls

- Low limit aquastat "AQ" (Usually comes with the hot water tank.)
- Solar heat storage ON (Provided by Tekmar 155 differential control.)
- Solar heat storage OFF (Provided by Tekmar 155 differential control.)
- High Limit OFF (Provided by Tekmar 155 dif-

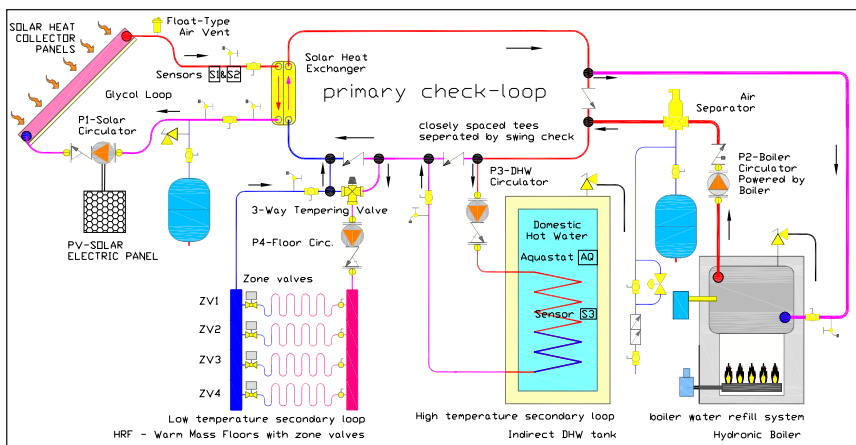


Figure 14-1

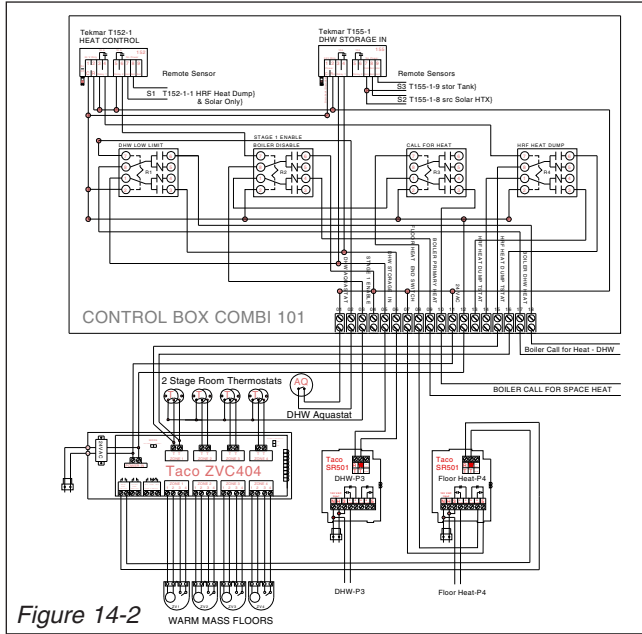


Figure 14-2

ferential control.)

- Safety High Limit (P & T valve shown on the DHW tank in Fig. 14-1.)

Optional Temperature Controls for DHW

- Low limit aquastat priority (Requires another relay control.)

- Solar heat source low limit (ON delay requires another temp. control.)
- AC solar circulator instead of PV (Requires another differential control.)

Combi-System 101 – Solar Heated Warm Mass Floor Zone Control

Required Room Temperature Control (Provided by 2 Stage Room Thermostats)

- Auxiliary low limit “Stage 2” Heat ON (Backup or Auxiliary ON)
- Minimum comfort temperature “Stage 2” Heat Off (Auxiliary OFF)
- Solar Heat Banking Allowed — “Stage 1” Solar Room Heat ON
- Maximum comfort temperature “Stage 1” Solar Room Heat OFF

Required Solar Collector Temperature Control

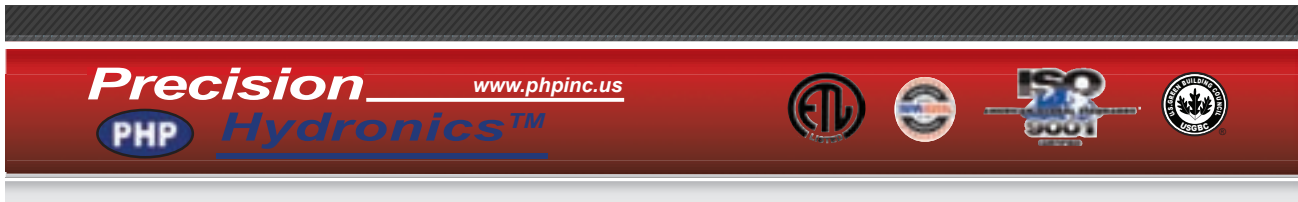
(Provided by Tekmar 152, 2 Stage Set-Point Thermostat)

- “Solar Priority” low limit (Solar Only ON, Boiler OFF, Heat Banking ON)
- “Heat Dissipation” high limit (a.k.a. Solar heat dump, Overheat protection)

Features and Functions of the 101 Basic Controls

The 101 control system allows the warm floors and the DHW tank to warm up more when it is sunny and less when it is not sunny, all within a comfort range that is programmable using the 2 Stage thermostats and Tekmar controls shown in Figure 14-2. As long as the floors and water tank are even a few degrees warmer than the boiler control set points, the boiler will not fire. This delay and pre-

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vention of boiler operation is where the solar savings comes from.

Auxiliary Backup Only

When there is no solar heat, the hydronic boiler operates the same way a conventional heating system works. The DHW aquastat "AQ" keeps the hot water tank up to shower temperature, and the Stage 2 switch in each room thermostat keeps the rooms at a minimum comfort level using the boiler.

Solar Preheat

During partly sunny weather, the solar collector pump will run on Photovoltaic power. This will circulate warm glycol through the heat exchanger on the primary loop. If water is circulating around the primary loop, it is preheated by the solar heat exchanger before reaching the boiler. The boiler provides the final temperature boost. The internal aquastat that controls the boiler temperature can be set to the lowest required temperature to give priority to solar heat.

Solar Only

When the solar glycol loop temperature exceeds the low-limit settings in the Tekmar controls, the boiler is shut off, and both water heating and floor heating will continue using solar heat only. The floors will continue to heat up until the room thermostats reach the Stage 1 high limit. The DHW tank will continue to heat up until it reaches the high limit setting in the Tekmar solar water tank control. If all the solar heating loads are at their high-limit, the heat dissipation control keeps the collector from overheating by using cool fluid from the floor to maintain a safe collector temperature. If the sun sets or cloudy weather causes the solar loop to cool off below the solar low limit, the

solar-only functions will stop, and the boiler will be allowed to take over.

Common optional control functions

All of the following options have been designed and installed on local Combi solar heating systems in our area. Each requires some additional thought and explanation to wire it properly into an integrated control box. All of these options have been successfully installed many times using the flow center piping as shown in Figure 1, along with temperature controls and relays added to the Basic 101 system. This approach allows piping modules and control modules to be added together with a minimum of redesign.

- Wireless 2-Stage Room Thermostats for difficult retrofits.
- Programmable 2 Stage thermostat set points, differentials and deadbands.
- Larger heat storage tanks with storage in and storage out controls.
- Baseboard zones (do not require 2 Stage room stats).
- Pool or Spa solar heating (Similar to a low temp. solar water tank.)
- Solar only switch for room heat, DHW, or whole house heat.
- Night tank cooling through the solar panels.
- Night floor cooling through the solar panels.
- Solar heat dissipation using pools, ice melt zones or other controlled heat sinks.
- Additional collector cooling 'fins' or panels.
- Web interactive t'stats that can be operated from any remote computer.
- Data logging and BTU meters for recording solar heat and energy flow.

Flow Center Control Systems are evolving

If there is one thing you may have gathered from this article, it is that there are a lot of control decisions to be made by a Solar Combi control system. Some of the control decisions are conditional or multi-layered, and the architecture of the components and the wiring can be complicated. I have often wished for a single control box that allowed all of these control decisions to be easily modified and installed.

In the past year I decided to stop waiting for a better solar home control, and develop one locally. So, with two other partners, we have formed a new company Solar Logic LLC which is developing a "Control Center" for the Flow Center Combi. This control box is known as the Solar Logic Integrated Controller (SLIC) and our first prototypes are in operation in our solar home heating laboratory. This control system is capable of implementing all the Basic functions along with all the optional features mentioned above. Web access will be a standard feature of the SLIC control box and we are operating the prototypes entirely by remote control. While we continue to build control boxes full of relays at the present time, I believe those days are numbered. ■

Bristol Stickney, partner and technical director at Cedar Mountain Solar Systems in Santa Fe, N.M., has been designing, manufacturing, engineering, repairing and installing solar hydronic heating systems for more than 30 years. He holds a Bachelor of Science in Mechanical Engineering and is a licensed mechanical contractor in New Mexico. He is the chief technical officer for SolarLogic LLC and is involved in training programs for solar heating professionals (visit www.cedarmountainsolar.com for more training information.)

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