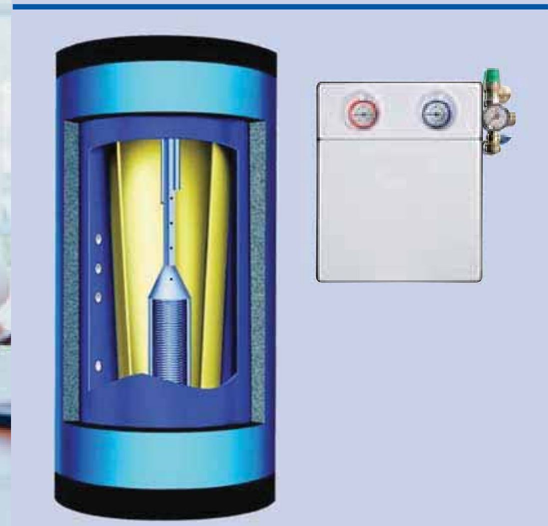
Applications Manual

Solar Technology for
DHW and Space Heating



Solar Collectors
DHW and Combi Tanks
Pump Stations
Controls & Accessories

Buderus
Bosch Group

Contents

1 Principles

1.1 Free solar energy

The sun radiates a tremendous amount of energy to the earth, enough to replace to replace all sources of natural resources including natural gas, oil and coal! The annual insolation level lies in North America between 2.0 kWh/m2/day (73,000 BTU/ft2/day) and 7 kWh/m2/day (250,000 BTU/ft2/day). The “insolation map” gives you an idea of the average insolation that can be expected in your region(□2/1).

A solar thermal heating system uses the energy of the sun to heat domestic hot water (DHW) and central space heating. Solar systems for DHW heating only are energy-saving and environmentally friendly. Combined solar heating systems for DHW and space heating are progressively becoming more popular. People are often unaware of the astounding proportion of heating that technically advanced solar heating systems can provide today.
A considerable portion of solar energy can be used for heat generation saving valuable fuel, and reducing emissions, thus lowering the burden on the environment and the earth’s climate.

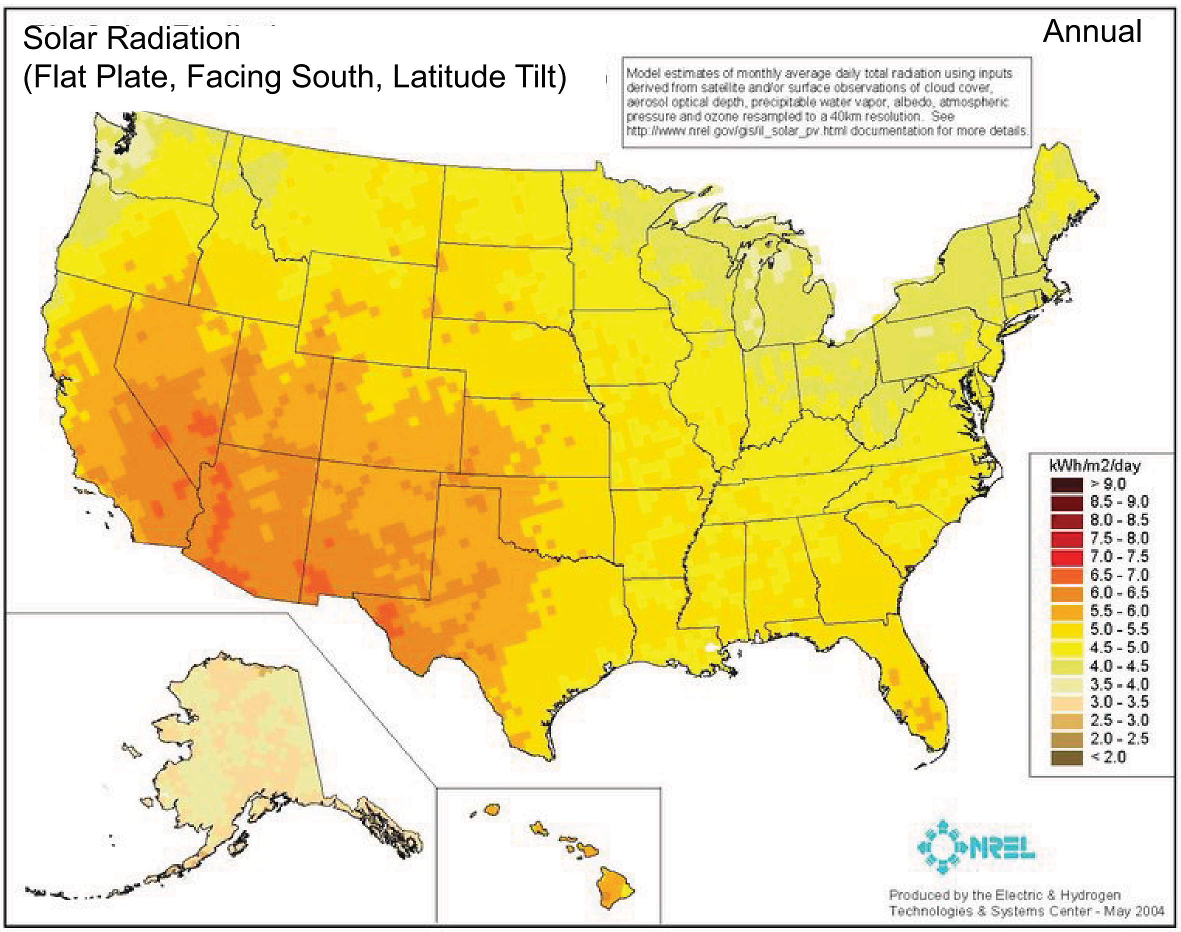


Fig. 1 Average insolation in North America

1.2 Energy supplied by solar collector systems in relation to the energy demand

Solar collector systems for DHW heating

DHW heating is the most prominent application for solar thermal systems. The regular demand for hot water all year round is a good match for solar energy. Almost 100% of the energy demand for DHW heating during the summer can be covered by a solar heating system (Fig. 2). Nevertheless, the back up heating system must still be able to cover the DHW demand independently of solar heating. Long periods of bad weather may occur during which the convenience of hot water still has to be assured.

Solar collector systems for DHW heating and central heating

Being environmentally conscious means thinking of solar collector systems not just for DHW heating but also for central heating. However, the solar heating system can only give off heat if the return temperature of the heating system is lower than the temperature of the solar collector. Large radiators with low system temperatures or radiant floor heating systems are therefore preferred.

With an appropriate design the solar heating system will cover up to 30% of the annual heating energy that is needed for DHW heating and central heating. Combined with a condensing boiler, the use of fossil fuels can be reduced even further.

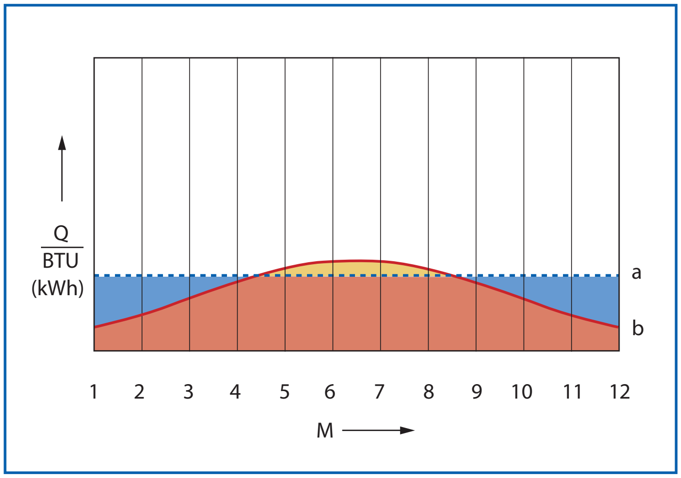


Fig. 2 Energy provided by a solar collector system in relation to annual energy demand for DHW heating.

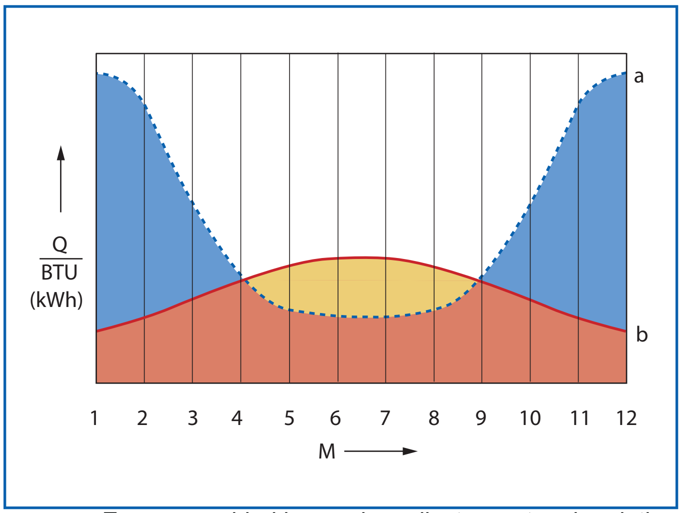


Fig. 3 Energy provided by a solar collector system in relation to the annual energy demand for DHW and central heating

Legend (Fig. 2 and Fig 3.)

a Energy demand

b Energy provided by the solar heating system

M Month

Q Heating energy

- Solar energy suplus (available for a swimming pool, for example)
- Utilized energy suplus (solar coverage)
- Energy demand that has not been covered (reheating)

2 Technical description of system components

2.1 Solar collectors

2.1.1 Logasol SKN3.0 flat-plate collector

Selected features and characteristics
- Favorable price/performance ratio
- Consistently high yield through robust, highly-selective black chromium coating
- Rapid collector connection without the need for tools
- Easy handling because of light weight of 90 lbs (42 kg)
- Long term stability of heat transfer fluid resulting from the strong characteristics of the fan absorber
- Energy-saving manufacture with recyclable materials

Component design and functions
The casing of the Logasol SKN3.0 solar collector consists of a lightweight and extremely strong fiber glass frame profile. The back panel is made from 24 gauge (0.6 mm) aluminium zinc-coated sheet metal. The collector is protected from the environment by the 1/8 inch (3.2 mm) thick single-pane tempered safety glass. The low-ferrous, structured cast glass is coated, highly transparent (92% light transmission) and has extremely good load-bearing capability.
The 2-3/16 inch (55 mm) thick mineral wool provides extremely good thermal insulation and high efficiency. It is heat resistant and non-outgassing.
The absorber consists of individual strips with a highly-selective black chromium coating. It is ultrasonically welded to the pipe fan in order to provide an extremely good heat transfer.
The Logasol SKN3.0 has four pipe connections for making simple, rapid hydraulic connections. The solar pipes are fitted using spring clips that require no tools. They are designed for temperatures up to 380°F (170°C) and pressures of up to 87 psi (6 bar) in conjunction with the collector.

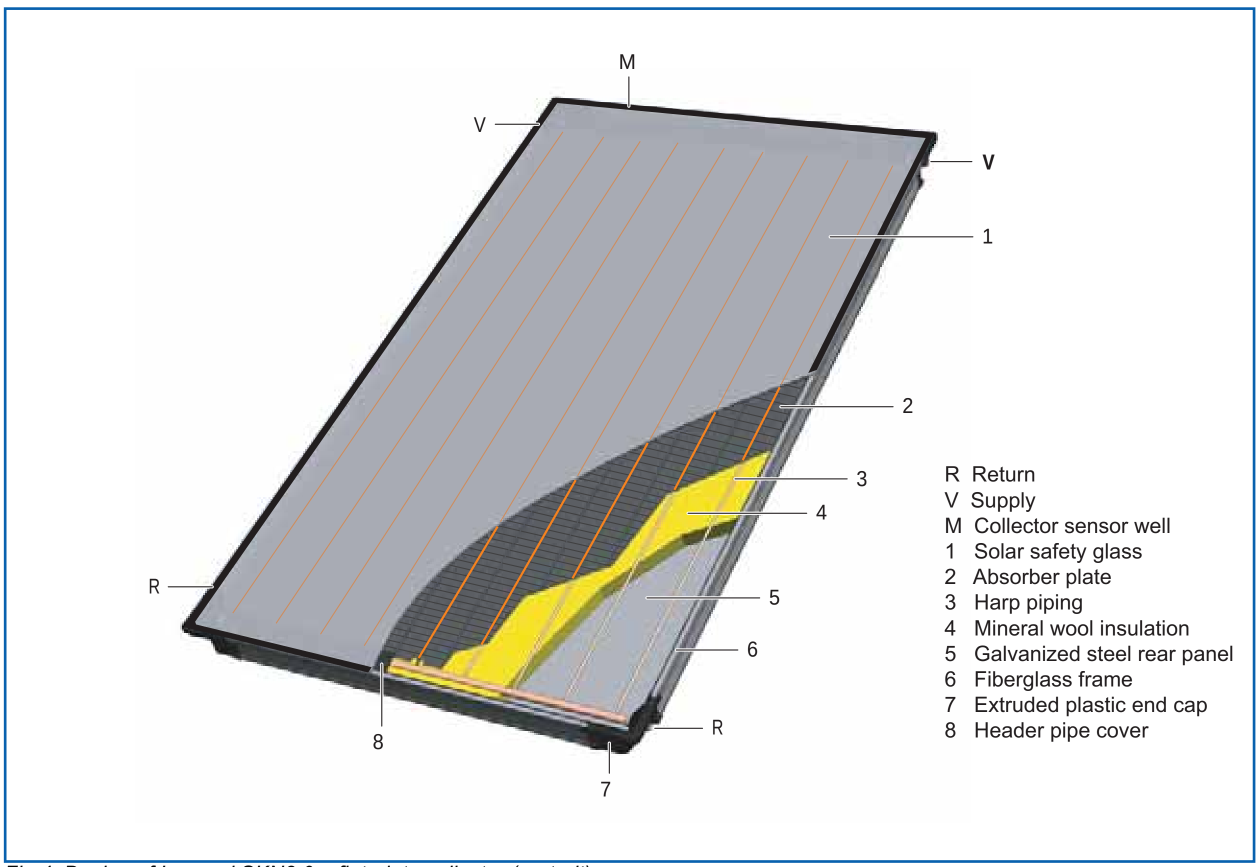


Fig.4 Design of Logasol SKN3.0-s flat-plate collector (portrait)

Dimensions and specification for Logasol SKN3.0 flat-plate collectors

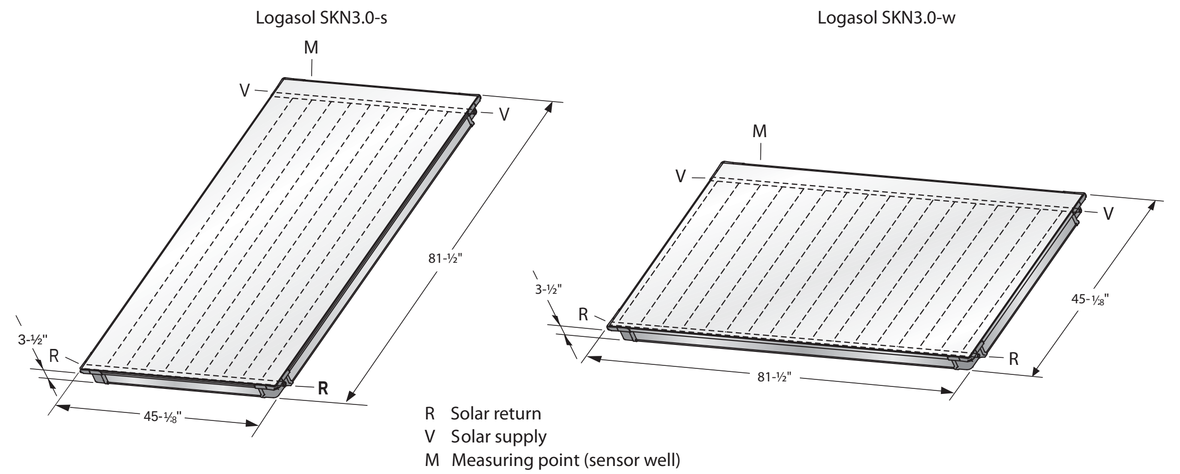


Fig. 5 Dimensions of Logasol SKN3.0-s (portrait) and SKN3.0-w (landscape) flat-plate collectors; dimensions in mm (inches)

SKN3.0 Flat Plate Collector Performance Data		
Collector type	**SKN3.0s (Portrait)**	**SKN3.0w (Landscape)**
Gross collector area (m2)	25.95' (2.41)	
Net aperture area (m2)	24.3' (2.25)	
Dry weight (kg)	90 lbs. (41)	92 lbs. (42)
Fluid content (L)	0.23 Gal (.86)	0.33 Gal (1.25)
Max. operating temperature (°C)	248°F (120)	
Stagnation temperature (°C)	370°F (188)	
Solar glass thickness (mm)	1/8" (3.2)	
Solar glass transmission	91.5%	
Coating	Highly selective black chrome	
Absorptivity	96% ± 2%	
Emissivity	12% ± 2%	
Absorber material / type	Copper with ultrasonic welding / harp	
Collector type / construction	Plug and socket connector / open vented	
Thermal insulation (mm)	2 1/6" mineral wool, high temp resistant and outgassing free	
Max. operation pressure (bar)	87 psi (6)	
Nominal flow rate (L/hr)	0.22 GPM (50)	
Efficiency η_0 (%)	85.1	
Effective heat transfer coefficient **k1 W/(m2 ≥ K1)** **k2 W/(m2 ≥ K2)**	3.6810 0.0173	
Thermal capacity c kJ(m2 · K)	4.82	
Irradiation angle correction factor **$IAM^{dir}_{T\alpha}$ (50°)** **$IAM^{dir}_{T\alpha}$**	0.95 0.90	
Collector yield (minimum yield verification)	> 525	
Max. # col/row opposite side connection	10	
Max. # col/row same side connection	0	
Y-intercept	0.723	

Fig. 6 Specification for Logasol SKN3.0 flat-plate collectors

2.1.2 Logasol SKS4.0 high performance flat-plate collector

Selected features and characteristics

- High performance flat-plate collector
- Hermetically sealed with inert gas filling between glass and absorber for increased performance in on both sunny and cloudy days
- No collector condensation
- Absorber coating protects against dust, moisture and airborne pollutants
- Optimized insulation of the glass cover
- Powerful full-area absorber with vacuum coating and double meander
- Array of up to 5 collectors with piping connected on one side, up to 10 collectors with piping connected diagonally
- Fastest hydraulic connection on the market - No tools required

Component design and functions

The Logasol SKS4.0 collector is encased in a lightweight and extremely strong fiber glass frame. The back panel is made from 24 gauge (0.6 mm) aluminium zinc-coated sheet metal. The collector is covered with 1/8 inch (3.2 mm) thick single-pane safety glass. The low-ferrous, slightly structured cast glass is highly transparent (92% light transmission).

The 2-3/16 inch (55 mm) thick mineral wool insulation provides extremely good thermal insulation and high efficiency. It is heat resistant and non-outgassing.

The effective copper surface absorber is provided with a highly selective vacuum coating. The double meander on the back is ultrasonically welded to the absorber for enhanced heat transfer.

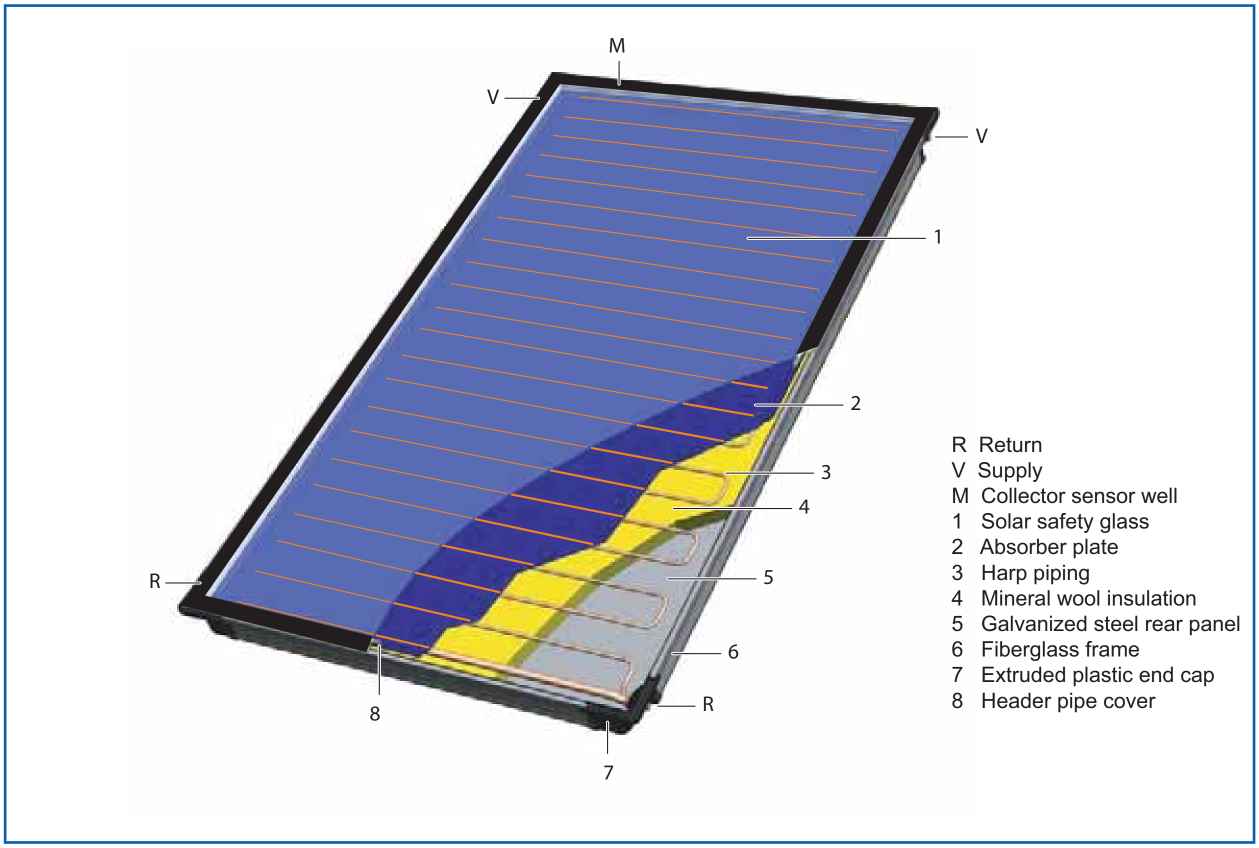


Fig. 7 Design of the Logasol SKN4.0-s flat-plate collector (portrait)

Inert gas filling
Between the tempered glass and the absorber plate (Fig.8) is a gap filled with an inert gas. This inert gas is reduces collector emissivity by inhibiting convective heat loss. To contain the inert gas within the collector, the tempered glass is hermetically sealed to the frame.

The hermetically sealed design provides the additional benefit of protecting the absorber coating from environmental influences such as moisture, dust and pollutants. This gives the collector a longer service life and consistently higher output.

Double meander absorber
Because the absorber is designed as a double meander, supply and return to the collectors can be easily connected on one side, for arrays of up to 5 collectors. This design provides the benefit of homogenous flow through the collectors of a large array as well. The double meander absorber piping makes the collector extremely efficient by creating turbulent flow over the entire flow rate range. The pressure drop is kept low by connecting two meanders in parallel. The collective return line of the collector is at the bottom so that the hot heat transfer fluid can escape from the collector in the event of stagnation.

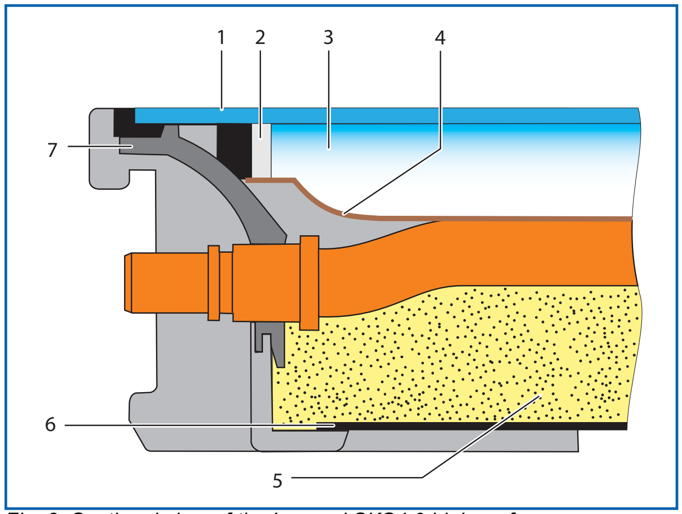


Fig. 8 Sectional view of the Logasol SKS4.0 high performance flat-plate collector with inert gas filling

Legend
Item 1: Solar safety glass
Item 2: Hermetically sealed composite frame
Item 3: Argon gas
Item 4: Copper absorber plate
Item 5: Mineral wool insulation
Item 6: Galvanized steel rear panel
Item 7: Absorber gasket

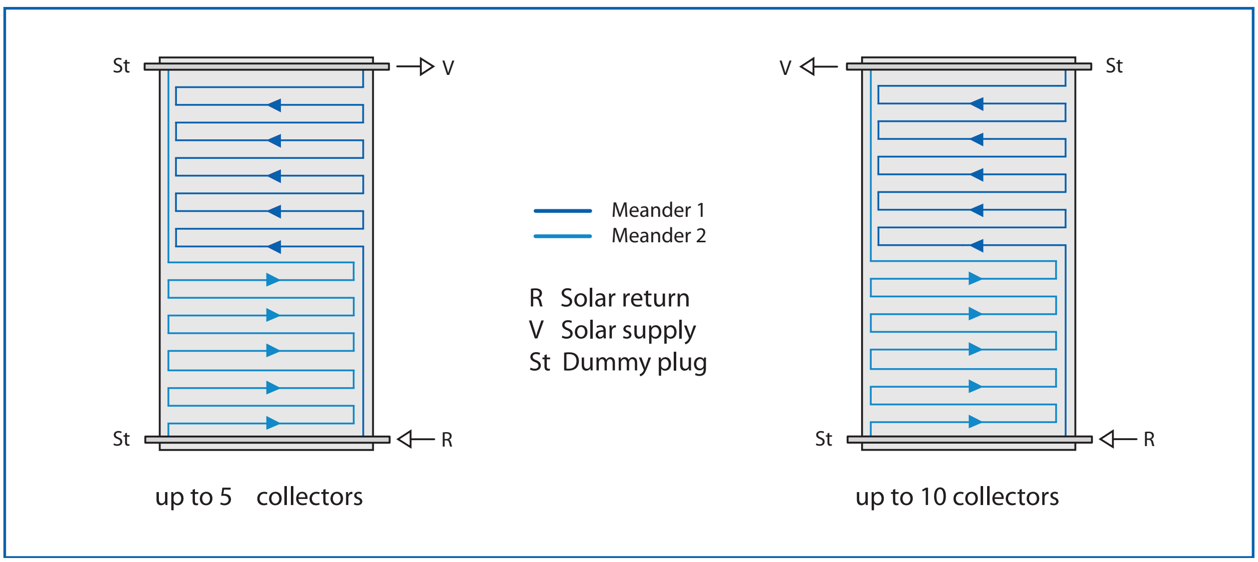


Fig. 9 Design and connection of the Logasol SKS4.0-s double meander absorber

Dimensions and specification for Logasol SKS4.0 high performance flat-plate collectors

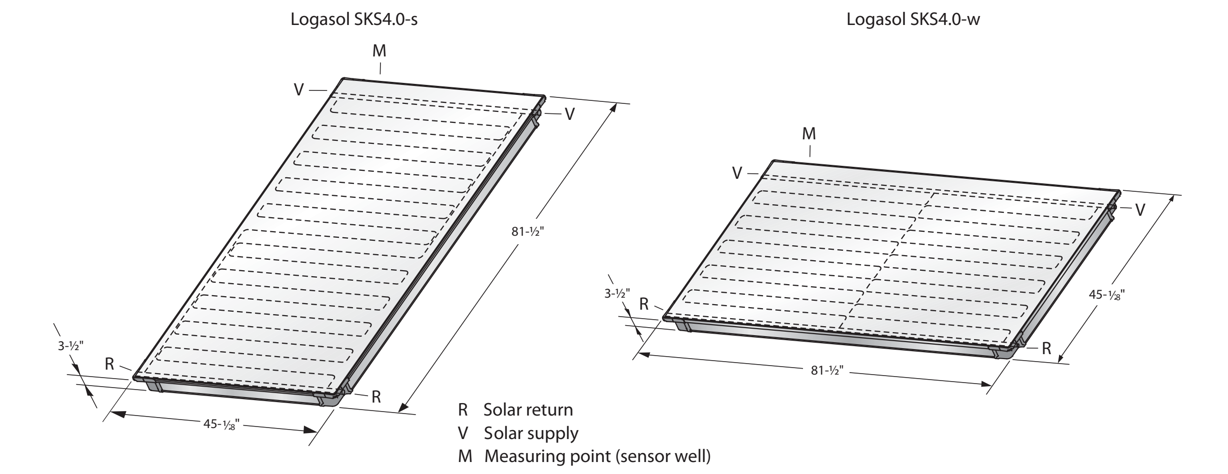


Fig. 10 Dimensions of Logasol SKS4.0-s (portrait) and SKS4.0-w (landscape) high performance flat-plate collectors; dimensions in inches

SKS4.0 Flat Plate Collector Performance Data		
Collector type	**SKS4.0s (Portrait)**	**SKS4.0w (Landscape)**
Gross collector area (m2)	25.95' (2.41)	
Net aperture area (m2)	22.5' (2.10)	
Dry weight (kg)	101 lbs. (46)	103 lbs. (47)
Fluid content (L)	0.39 Gal (1.47)	0.46 Gal (1.76)
Max. operating temperature (°C)	248°F (120)	
Stagnation temperature (°C)	400°F (204)	
Solar glass thickness (mm)	1/8" (3.2)	
Solar glass transmission	91.5%	
Coating	Highly selective PVD	
Absorptivity	95% ± 2%	
Emissivity	5% ± 2%	
Absorber material / type	Copper with ultrasonic welding / double meander	
Collector type / construction	Plug and socket connector / hermetically sealed argon gas	
Thermal insulation (mm)	2 1/6" mineral wool, high temp resistant and outgassing free	
Max. operation pressure (bar)	145 psi (10)	
Nominal flow rate (L/hr)	0.22 GPM (50)	
Efficiency η_0 (%)	85.1	
Effective heat transfer coefficient **k1 W/(m2 ≥ K1)** **k2 W/(m2 ≥ K2)**	4.0360 0.0108	
Thermal capacity c kJ(m2 · K)	4.82	
Irradiation angle correction factor **$IAMdir_{T\alpha}$ (50°)** **$IAMdir_{T\alpha}$**	0.95 0.90	
Collector yield (minimum yield verification)	> 525	
Max. # col/row opposite side connection	10	
Max. # col/row same side connection	5	
Y-intercept	0.715	

Fig. 11 Specification for Logasol SKS4.0 high performance flat-plate collectors

2.2 Logalux solar storage tank

2.2.1 Logalux SM dual coil storage tank for DHW heating

Selected features and characteristics

- Dual coil storage tank with two smooth tube indirect coils
- Buderus thermoglazing and dual magnesium anodes for corrosion protection
- Large clean-out cover
- Low heat loss due to high-grade thermal insulation
- CFC-free insulating jacket made from 2 inch (50 mm) thick rigid polyurethane foam (Logalux SM300) or 4 inch (100 mm) thick flexible polyurethane foam (Logalux SM400).

Design and function

The Logalux SM300 and SM400 dual coil storage tanks are designed for solar DHW heating with conventional reheating by a boiler.

The large size of the solar indirect coils inside the Logalux SM300 and SM400 dual coil storage tanks provide an extremely good heat transfer and therefore create a high temperature differential in the solar circuit between the supply and the return.

A second indirect coil is fitted into the upper part of the storage tank for additional heating from the boiler, to ensure hot water is available even during times of low solar energy.

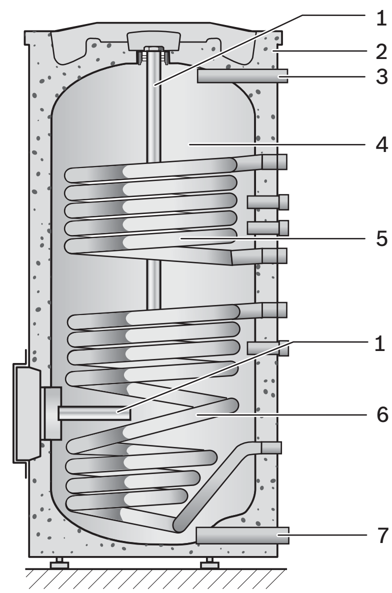


Fig. 12 Components of the Logalux SM300 and SM400 dual-coil storage tanks

Legend

1 Magnesium anode

2 Thermal insulation (rigid foam insulation for Logalux SM300, flexible foam insulation for SM400)

3 DHW outlet

4 Storage tank

5 Upper indirect coil for reheating with a conventional boiler

6 Solar indirect coil

7 Cold water inlet

Dimensions and specifications of Logalux SM dual-coil solar storage tank

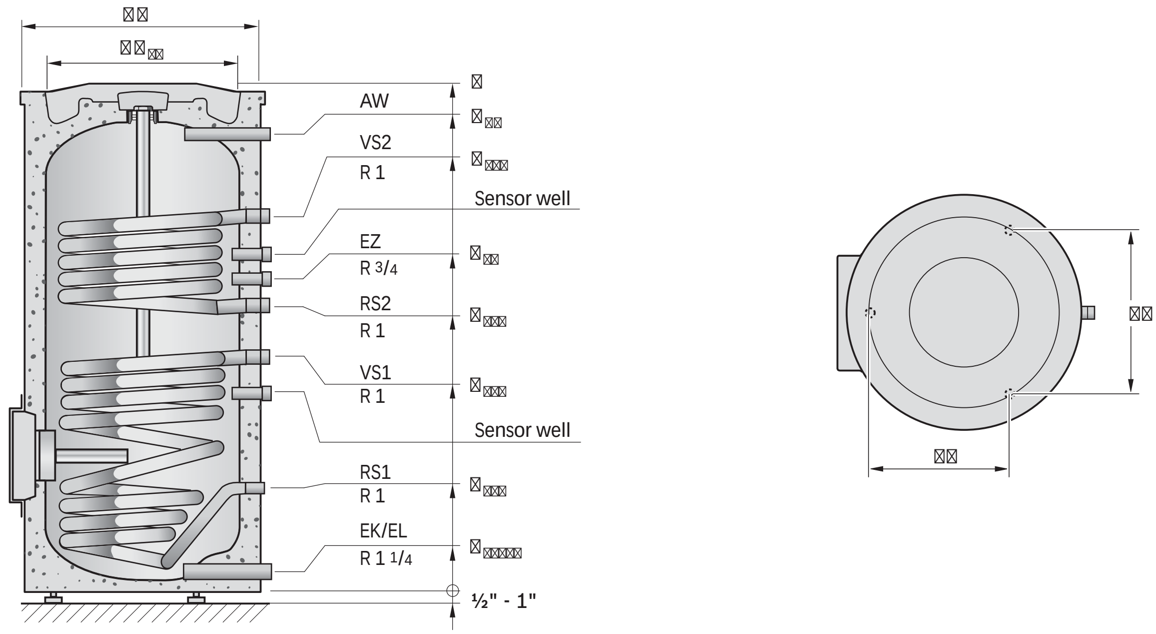


Fig. 13 Dimensions and connections of Logalux SM dual-coil storate tanks

Logalux dual-coil storage tank			**SM300**	**SM400**
Storage tank diameter	ØD	in (mm)	27" (686)	34" (864)
Height	H	in (mm)	57-⅔" (1465)	61" (1550)
Cold water inlet / drain	$H_{EK/EL}$	in (mm)	2-⅓" (60)	5-¾" (148)
Storage tank return on the solar side	H_{RS1}	in (mm)	11-⅔" (297)	12" (303)
Storage tank supply on the solar side	H_{VS1}	in (mm)	26-¾" (682)	27" (690)
Storage tank return	H_{RS2}	in (mm)	33-⅛" (842)	31" (790)
Storage tank supply	H_{VS2}	in (mm)	42-½" (1077)	43-½" (1103)
DHW circulation inlet	H_{EZ}	in (mm)	30" (762)	36" (912)
DHW outlet	ØAW H_{AW}	in in (mm)	1" 52-¼" (1326)	14 " 52-¾" (1343)
Distance between feet	A1 A2	in (mm) in (mm)	15-¾" (400) 16-½" (408)	19" (480) 16-½" (420)
Storage tank capacity total/standby		gal (l)	76-½ / 34-⅓ (290/≈130)	103 / 43-½ (390/≈165)
Content, solar indirect coil		gal (l)	2 (8)	2 1/2 (9.5)
Size of solar indirect coil		ft^2 (m^2)	13 (1.2)	14 (1.3)
Standby heat loss		BTU/day (kWh/24h)	7200 (2.1)	9600 (2.81)
Pressure drop @ 11 gpm (2,600 l/h)	upper coil lower coil	ft. of head (mbar) ft. of head (mbar)	7.5' (223) 1.7' (52)	8.4' (250) 1.7' (52)
Continuous output (upper indirect coil) with 176/113/60 °F[1]		BTU/hr [gal/hr] (kW [l/h])	120,000 [223] (35 (847))	120,000 [223] (35 (847))
Weight (net)		lbs (kg)	317 (144)	445 (202)
Max. operating pressure heating water/DHW		psi (bar)	360/145 (25/10)	
Max. operating temperat ure heating water/DHW		°F (°C)	320/203 (160/95)	

Fig. 14 Specification of the Logalux SM300 and SM400 dual-coil storage tanks

1) Heating water supply temperature/DHW outlet temperature/cold water inlet temperature

2.2.2 Selected features and characteristics of the Logalux PL750/2S thermosiphon combi storage tank

- Internal DHW storage tank, conical internal design, with Buderus thermoglazing and magnesium anode for corrosion protection
- Patented heating lance in the DHW inner tank stratifies the storage tank heating and runs across the entire height of the tank
- Solar indirect coil integrated in the heating lance
- Significantly improved solar efficiency because the solar heating system always heats the coldest medium first
- All connections on the heating side are at the side of the storage tank for easy installation in retrofit applications
- Solar connection and cold water inlet are at the bottom

Design and operation of the Logalux PL750/2S thermosiphon combi storage tank

The Logalux PL750/2S thermosiphon combi storage tank has a conical internal body (item 5) for DHW heating. There is a heating lance suspended in the DHW that runs along the entire height of the storage tank integrating the solar indirect coil (item 6 and item 8). The DHW storage tank is heated in accordance with the thermosiphon principle using this patented stratification system. Subject to the availability of adequate insolation, a significant temperature increase is reached in the DHW storage tank after only a short time. The DHW storage tank is within a thermal store (item 4) containing buffer water that is heated subject to the stratification in the internal DHW tank.

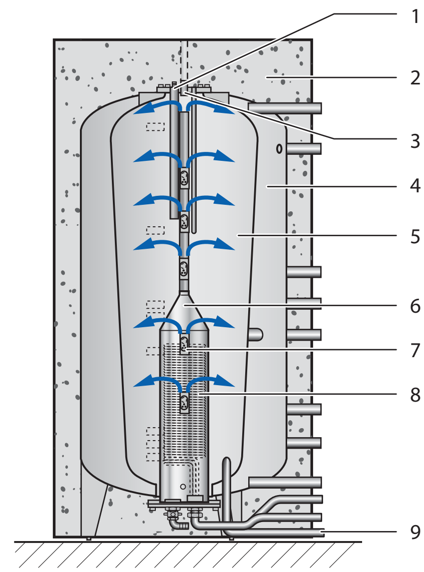


Fig. 15 Design of the Logalux PL750/2S thermosiphon combi storage tank

Legend

1 Magnesium anode

2 Thermal insulation

3 DHW outlet

4 Storage tank

5 Upper indirect coil for reheating by a conventional boiler

6 Heating lance

7 Gravity flap

8 Solar indirect coil

9 Cold water inlet

Cold water enters the lower section of the conical internal body, ensuring that the solar indirect coil and the heating lance are in the coldest water. The heating lance has an opening at the bottom that enables the cold drinking water to reach the solar indirect coil. Here the water is heated by the solar loop and rises upwards within the lance separated from the surrounding colder water.

There are outlets at different levels of the lance with buoyancy-controlled gravity flaps, through which the heated water reaches the layers with equal temperature levels in the storage tank (phase 1). After a delay during which the DHW water is heated, the heat is transferred to the buffer water in the outer body, heating the thermal store from top to bottom (phase 2). The solar system shuts down (phase 3) once the DHW storage tank and the thermal store are both fully heated. Drawing hot water gradually discharges the DHW storage tank from bottom to top. Cold drinking water replaces the DHW drawn inside the inner body. Because of the heat-up delay between the inner and outer bodies, the internal body which is now filled with colder supply water can absorb solar heat again, although the outer thermal store is still fully heated (phase 4). This makes the system considerably more efficient.

When the DHW storage tank is almost
completely drawn, both the solar indirect coil and the thermal store reheat the DHW storage tank (phase 5). If no solar yield is available (e.g. during bad weather), the thermal store can be reheated using a conventional boiler (phase 6). A heating return temperature controller combined with an SBH module is required for connecting to the heating system.

Legend (Fig. 16, 17, 18)
AW DHW outlet
EK Cold water inlet
RS1 Solar return
VS1 Solar supply
RS2 Boiler return
VS3 Boiler supply

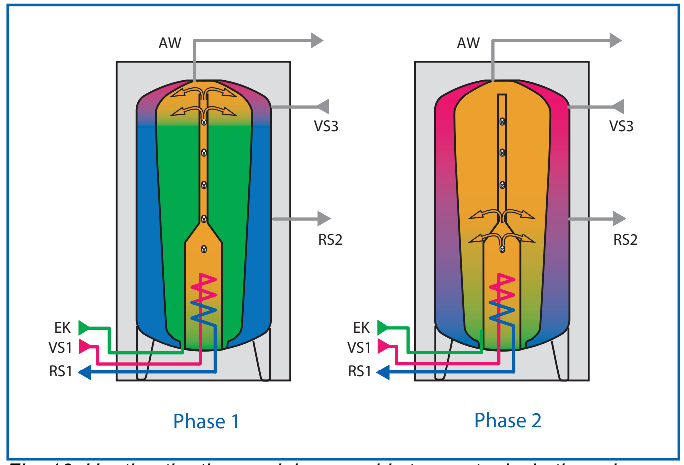


Fig. 16 Heating the thermosiphon combi storage tank via the solar indirect coil (1) and delayed thermal store heating (2)

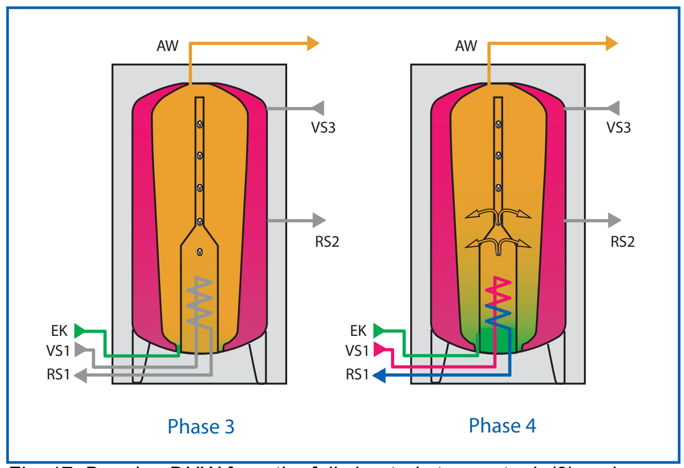


Fig. 17 Drawing DHW from the fully heated storage tank (3) and reheating the DHW storage tank (which is cold at the bottom) via the solar indirect coil in spite of having a full thermal store (4)

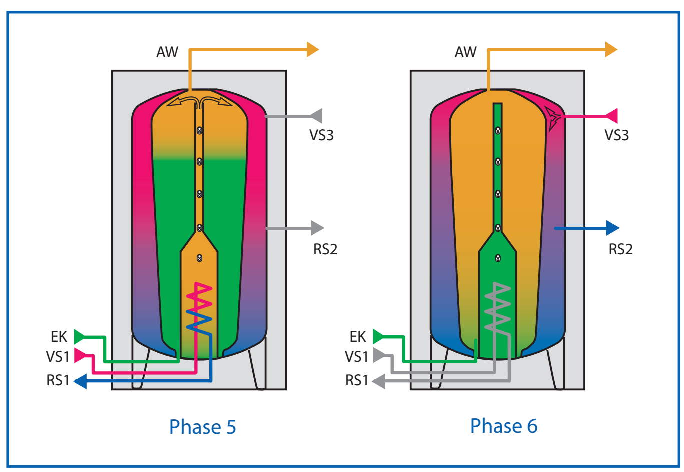


Fig. 18 Reheating the DHW storage tank via the solar indirect coil and the thermal store (5) and reheating via a conventional boiler in the event of insufficient solar yield (6)

Dimensions and specification of the Logalux PL750/2S thermosiphon combi storage tank

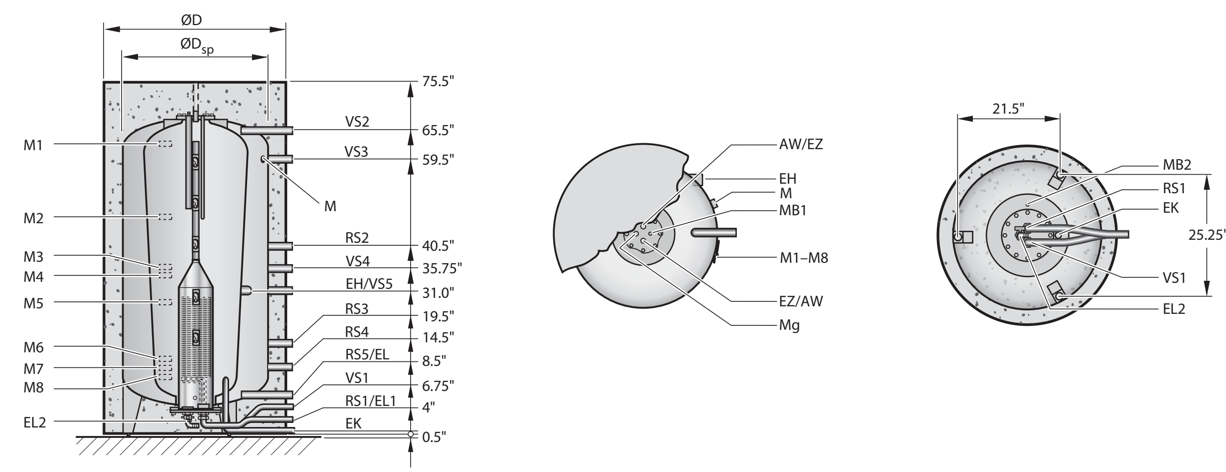


Fig. 19 Dimensions and connections of the Logalux PL750/2S thermosiphon combi storage tank

Logalux thermosiphon combi storage tank			**PL750/2S**
Storage tank diameter with/without insulation	ØD/ØD $_{Sp}$	in (mm)	40 "/32" (1000/800)
Cold water inlet	ØEK	in.	1"
Draining the heating system	ØEL	in.	14 "
Solar/DHW draining	ØEL1/ØEL2	in.	6 "
Storage tank return on the solar side	ØRS1	in.	6 "
Storage tank supply on the solar side	ØVS1	in.	6 "
Return, oil/gas fired/condensing boiler for DHW heating	ØRS2	in.	14 "
Supply, oil/gas fired/condensing boiler for DHW heating	ØVS3	in.	14 "
Return, oil/gas fired boiler	ØRS3	in.	14 "
Supply, oil/gas fired boiler	ØVS5	in.	14 "
Return, heating circuits	ØRS4	in.	14 "
Supply, heating circuits	ØVS4	in.	14 "
Return, solid fuel boiler	ØRS5	in.	14 "
Supply, solid fuel boiler	ØVS2	in.	14 "
DHW circulation inlet	ØEZ	in.	6 "
DHW outlet	ØAW	in.	6 "
Immersion heater	ØEH	in.	15 "
Capacity		gal (l)	200 (750)
Capacity, thermal store only		gal (l)	73 (275)
Capacity, DHW total/standby part		gal (l)	80/40 (300/150)
Content, solar indirect coil		gal (l)	0.33 (1.4)
Size of the solar indirect coil		ft^2 (m^2)	11 (1.0)
Standby heat loss		BTU/day (kWh/24h)	13,000 (3.7)
Performance factor	N_L		3.8
Continuous output at 176/113/50 °F (80/45/10 °C) [1]		BTU/hr [gal/hr] (kW [l/h])	96,000 [182] (28 [688])
Number of collectors			→ 52/1
Weight (net)		lbs (kg)	556 (252)
Max. operating pressure (solar indirect coil/heating water/DHW)		psi (bar)	116/44/145 (8/3/10)
Max. operating temperature (heating water/DHW)		°F (°C)	203/203 (95/95)

Fig. 20 Specification for the Logalux PL750/2S combi storage tank for DHW and central heating

1) Heating water supply temperature/DHW outlet temperature/cold water inlet temperature

2.3 Solar control unit

2.3.1 Selection tools

Selection and standard delivery of control unit
Various control units and function modules are available depending on the application area and the boiler control unit:

- Heat source with RC35 control unit:
  Solar function module SM10
- Heat source with Logamatic 2107 control unit:
  Solar function module FM244
- Heat source with Logamatic 4000 control unit:
  Solar function module FM443
- Heat source with third party control unit:
  TR0301U Solar Controller
  TR0603mc U Solar Controller

The standard delivery of a FM or SM module includes:

- One collector temperature sensor FSK
  (NTC 20 K, Ø1/4 inch (6 mm), 7 ft (2.5m) lead) and
- One collector temperature sensor FSS
  (NTC 10 K, Ø3/8 inch (9.7 mm), 9 ft (3.1m) lead)
- TR0301 includes 2 x 1K ohm PTC sensors

The standard delivery of a TR0301 U controller includes:

- 2 x PT1000 1K ohm sensors

The standard delivery of a TR0603mc U controller includes:

- 3 x PT100 1K ohm sensors

2.3.2 Control strategies

Temperature differential control

In “Automatic” mode the solar control unit monitors whether there is sufficient insolation to heat the solar storage tank. To do this, the control unit compares the collector temperature (FSK sensor) and the temperature in the lower area of the storage tank (FSS sensor). If there is adequate heat absorption by the collector, i.e. the set temperature differential between the collector and the storage tank is exceeded, the solar circuit pump starts and the storage tank is heated. After a long period of insolation with low DHW consumption, high storage tank temperatures are reached. The solar circuit control unit switches the solar circuit pump off when the maximum storage tank temperature has been reached.

The maximum storage tank temperature can be adjusted at the control unit.

If there is little insolation, the pump speed is reduced (FM433) to maintain a constant temperature differential. This allows the storage tank to be heated with low power consumption. The solar control unit does not switch the pump off until the temperature differential has dropped below the minimum temperature differential set point, and the speed of the circulation pump has been reduced to its minimum value by the solar control unit. If the storage tank temperature is below the DHW temperature set point convenience, a heating circuit control unit ensures the reheating

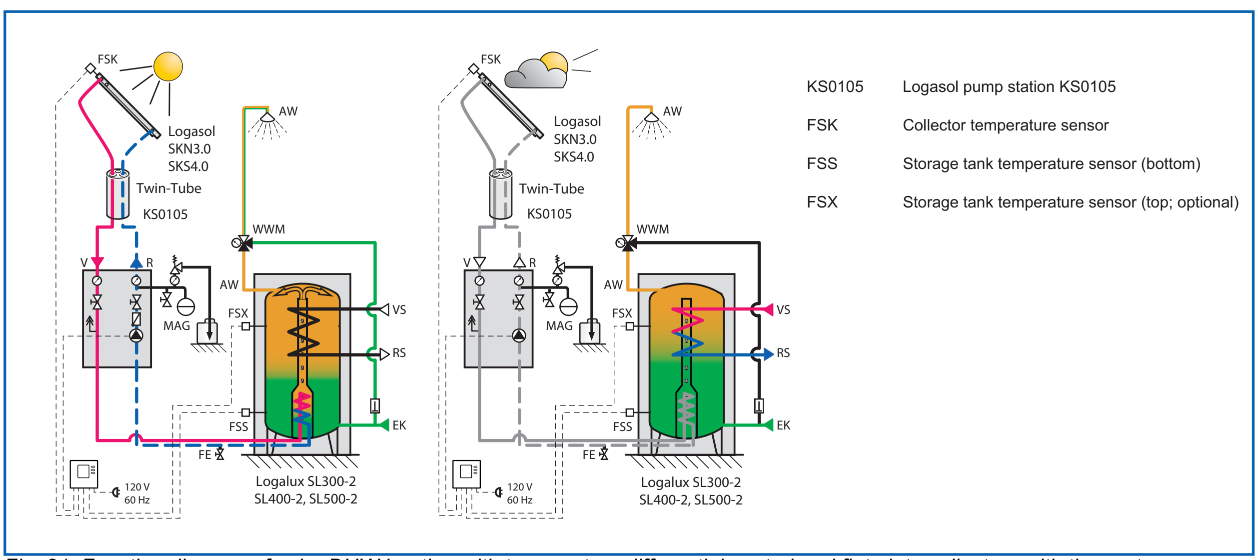


Fig. 21 Function diagram of solar DHW heating with temperature differential control and flat plate collectors with the system running (left) and conventional reheating if there is insufficient insolation (right)

Double-Match-Flow

Solar function module FM443 provides optimized heating of the thermosiphon storage tank using a special high-flow/low-flow strategy. The solar control unit monitors the storage tank heating status using a threshold sensor (FSX) located in the center of the storage tank. Depending on the heating status, the control unit switches to high-flow or low-flow operation, whichever is currently the best. This changeover feature is known as Double-Match-Flow.

Prioritized heating of the standby volume with low-flow operation

In low-flow operation the control unit attempts to achieve a temperature differential between the collector (FLK sensor) and the storage tank (FSS sensor). This is done by varying the flow rate via the solar circuit pump speed.

The standby volume of the thermosiphon storage tank is heated with priority using the resulting high flow temperature. Conventional storage tank reheating using the boiler is therefore lowered, thus further conserving fossil fuel.

Standard thermosiphon storage tank heating in high-flow operation

The solar control unit increases the speed of the solar circuit pump if the standby part of the storage tank has been heated up to 113 °F (45 °C) (FSX threshold sensor). The set temperature differential between the collector (FSK sensor) and the lower storage tank area (FSS sensor) is 27 °F (15 °C). The system is then operating with a lower flow temperature. In this operating mode, system efficiency is optimized during storage tank heating.

Subject to sufficient collector output being available, the control system reaches the set temperature differential and continues to heat the storage tank with optimum collector efficiency. If the set temperature differential can no longer be achieved, the control system uses the available solar heat at the slowest pump speed until the shut-off criterion is reached. The thermosiphon storage tank stores the heated water in the correct temperature layer (Fig. 24). If the temperature differential drops below 9 °F (5 °C), the control unit switches the solar circuit pump off.

Legend *(Fig. 22, 23, 24)*
Δφ Temperature differential between collector (FSK sensor) and lower storage tank area (FSS1 sensor)
R Solar return
V Solar flow

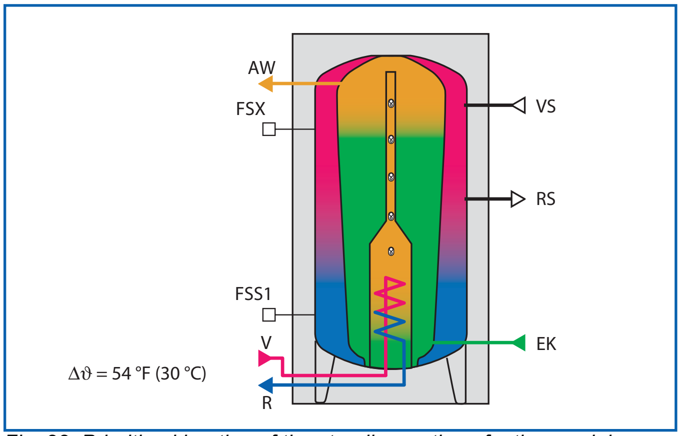


Fig. 22 Prioritized heating of the standby section of a thermosiphon storage tank with Δφ = 54 °F (30 °C) using a variable, slow pump speed in low-flow operation, until 113 °F (45 °C) is reached at the FSX threshold sensor

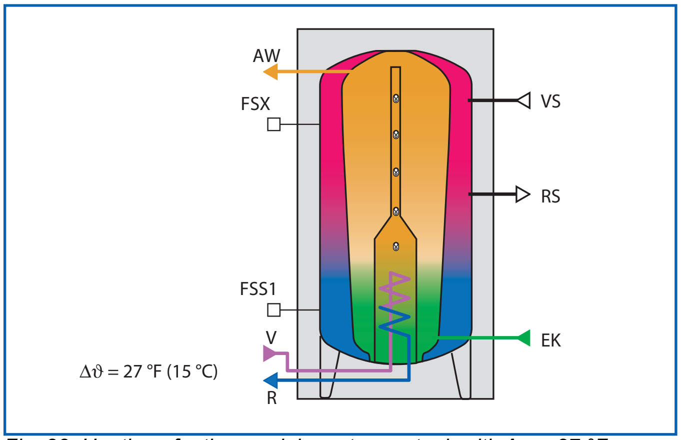


Fig. 23 Heating of a thermosiphon storage tank with Δφ = 27 °F (15 °C) with strong insolation using a fast pump speed in highflow operation

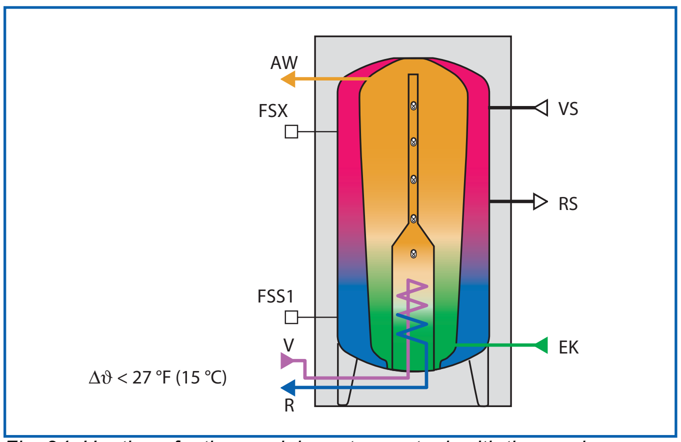


Fig. 24 Heating of a thermosiphon storage tank with the maximum possible flow temperature Δφ < 27 °F (15 °C) using the slowest pump speed with low insolation

Solar optimization function of function modules FM244 and FM443

With the solar optimization function, fossil fuel is conserved and solar yield is increased by integrating the solar control in the boiler control unit. The consumption of reheating (primary) energy for heating DHW is reduced by up to 10% compared to conventional solar control units. The number of burner starts is reduced by up to 24%.

With the solar optimization function the control unit captures the following:

● solar yield availability and whether
● the stored amount of heat is sufficient to provide DHW

.
The general objective of the control unit is to reduce the temporary DHW temperature as much as possible to prevent reheating by the boiler while maintaining user comfort.

The standby volume of the storage tank is designed to cover the DHW demand at a storage temperature of 140 °F (60 °C). If the lower region of the storage tank is preheated by solar energy, the boiler can heat the water to comfortable temperatures much more rapidly. Higher temperatures in the lower storage tank region therefore result in a reduction of the set reheating temperature, saving fossil fuels. The lowest acceptable DHW temperature can be set by the user using the “MINSOLAR” parameter within a range of 86 °F to 129 °F (30 °C to 54 °C).

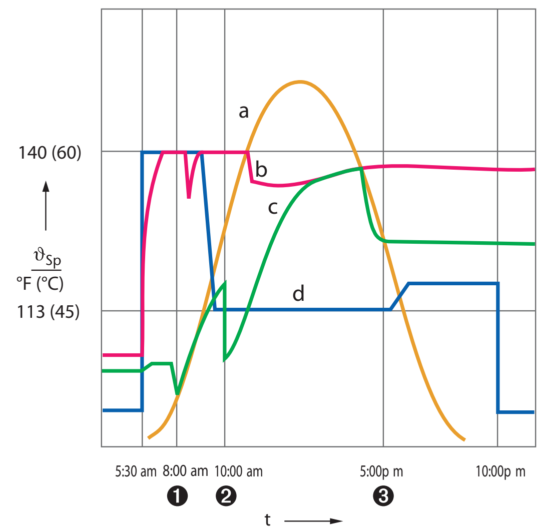


Fig. 25 “Solar yield optimization” control function

Legend

ϑ_{Sp} DHW temperature in the storage tank
t Time
a Insolation
b DHW temperature at the top of the storage tank
c DHW temperature at the bottom of the storage tank
d Set DHW temperature
❶ First draw (reheating)
❷ Second draw (adequate solar yield)
❷ Third draw (adequate storage tank temperature)

2.3.3 Solar control units and function modules

Logamatic 2107 control unit with solar function module FM244

Features and characteristics

● Combined boiler/solar control unit for low temperature boilers with low and moderate heating demand and solar DHW heating

● Up to 10% primary energy saving and up to 24% fewer burner starts compared to conventional solar control units by means of system integration in the Logamatic 2107 control unit (solar optimization function)

● Optional functionality of solar supplement for central heating in combination with the RW return temperature limiter

● Optional dual-storage tank systems (storage tanks connected in series) for DHW heating (requires additional components).

● Solar function module FM244 is integrated in control unit 2107

● Monitors solar pump run time hours

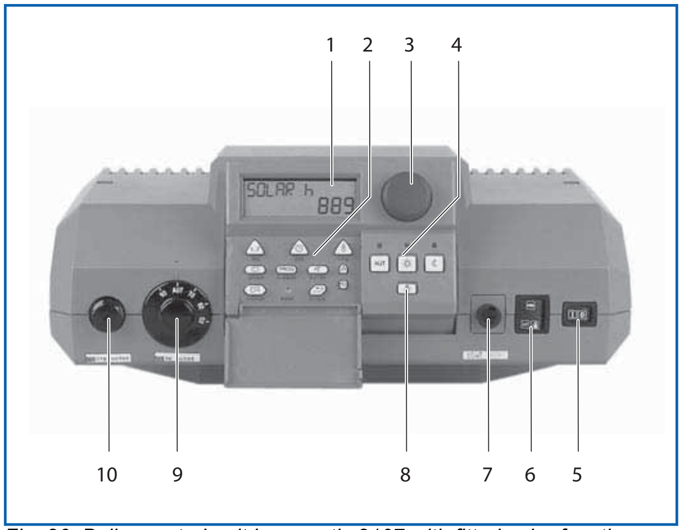


Fig. 26 Boiler control unit Logamatic 2107 with fitted solar-function module FM244

Legend
Components that can be used for solar operation (with solar function module FM244):
1 Digital display
2 User interface with cover
3 Dial
4 Operating mode buttons

Additional boiler control components:
5 Control unit ON/OFF switch
6 Burner control selector switch
7 Control unit power fuse
8 Flue gas test button (chimney sweep)
9 Boiler control manual aquastat
10 Boiler manual reset high limit

Logamatic 4000 control system with solar function module FM443

Features and characteristics

- For use with the Logamatic 4321 and 4323
- Solar function module FM433 enables the control of DHW heating or DHW and central heating combi systems in applications with a maximum of two solar consumers (storage tanks)
- Up to 10% primary energy saving and up to 24% fewer burner starts compared to conventional solar control units by means of system integration in the heating control unit (solar optimization function)
- Prioritized heating of the standby part of thermosiphon storage tanks and energy-optimized operation control using Double-Match-Flow (FSX sensor also used as threshold sensor)
- Required for solar heating systems for DHW heating with central heating because of the external heat detection function
- Entire system, including the solar control unit, can be operated from the living room using the MEC2 programming unit
- Stratification of dual-coil storage tanks
- Transfer of hot water in dual-storage tank systems for DHW heating
- Intelligent buffer management
- Statistics function
- Solar function module FM443 is integrated in the digital control unit of the Logamatic 4000 modular control system

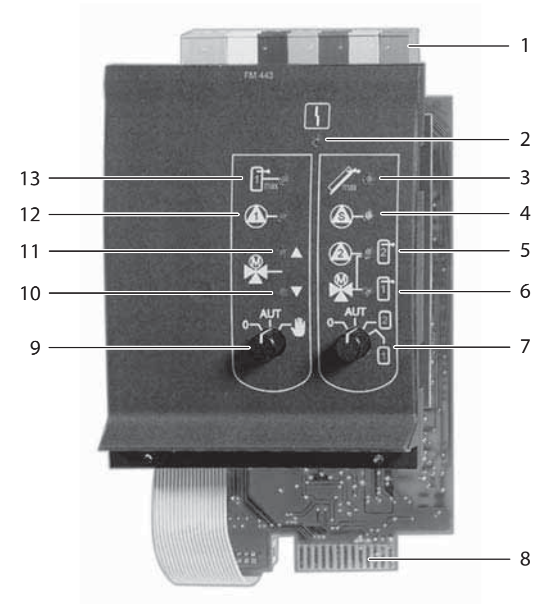


Fig. 27 Solar function module FM443

Legend

1 Connection plugs
2 LED indicator, module fault
3 LED maximum collector temperature
4 LED solar circuit pump 2 (secondary pump) running
5 LED solar circuit pump 2 running or three-way diverter valve in solar circuit 2 position
6 LED three-way diverter valve in solar circuit 1 position
7 Manual switch solar circuit selection
8 PCB
9 Manual switch, solar circuit function 1
10 LED three-way diverter valve in direction “Central heating via thermal store off” or “Pump off” (bypass operation)
11 LED three-way diverter valve in direction “Central heating via thermal store on” or “Pump running” (thermal store operation)
12 LED solar circuit pump 1 running
13 LED maximum temperature in storage tank 1

Disinfection

If the pump function is set to “Disinfection” with dual-coil solar storage tanks, the pump that is connected is used to heat up the solar pre-heating stage to 140 °F (60 °C) once every day, if needed, to provide disinfection in accordance with current law or for the disinfection of the solar pre-heating stage.

Transfer of hot water

If the pump function is set to “transfer”, with storage tanks connected in series, the connected pump is used to transfer the water from the solar storage tank to the storage tank that is heated via the boiler. As soon as the solar storage tank is hotter than the storage tank that is heated by the boiler, pump PUM is switched on and the water in the storage tanks is transferred.

This pump is also used to heat the solar storage tank, i. e. the solar pre-heating stage, to 140 °F (60 °C) once every day if needed or for the disinfection of the solar pre-heating stage.

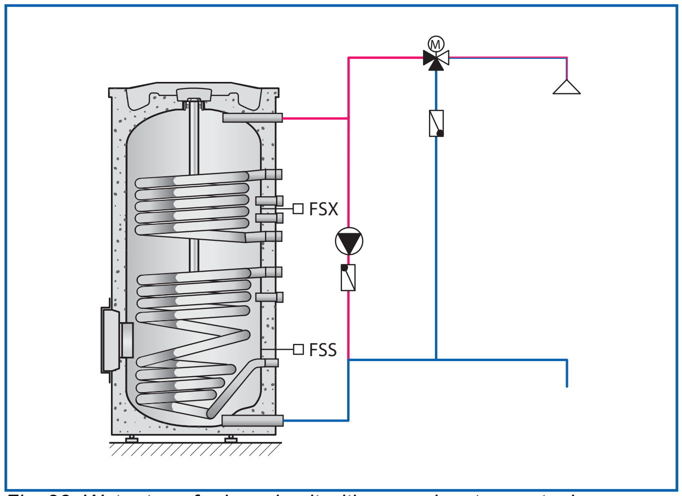


Fig. 28 Water transfer in a circuit with one solar storage tank

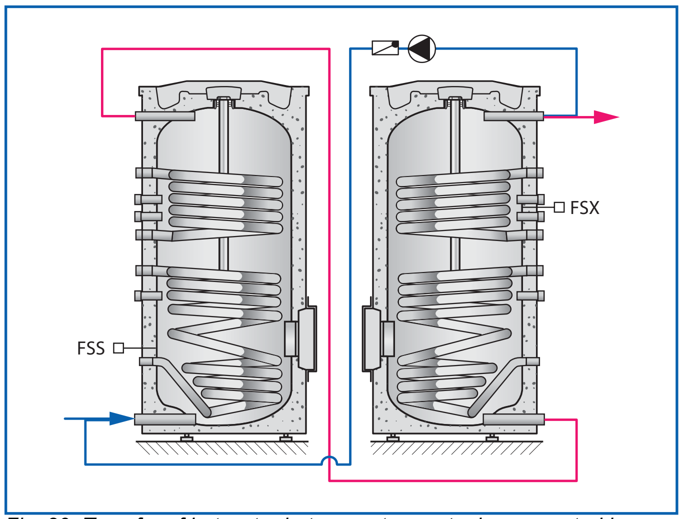


Fig. 29 Transfer of hot water between storage tanks connected in series

Legend
FSX Storage tank temperature sensor (top, optional)
FSX Storage tank temperature sensor (bottom)

2.3.4 Special functions

Central heating via buffer bypass circuit

A buffer bypass circuit provides a hydraulic connection between the solar buffer tank and the heating system return. If the temperature in the buffer tank is higher than the heating return temperature by an adjustable amount (∂_{On}), the three-way diverter valve opens in the direction of the buffer tank to preheat the return water that is flowing to the boiler. If the temperature differential between the buffer tank and the heating circuit return drops by an adjustable
amount (∂_{Off}), the three-way diverter valve switches in the direction of the boiler and stops buffer tank discharge.

Solar heating systems with two storage tanks

Two solar storage tanks (buffer tanks) can be heated using the FM443 solar heating function module in combination with the SBH module for systems of 10 collectors or less.

For Systems of more than 10 collectors a second KS pump station may be used as an alternative to the SBU module. Priority is given to the first consumer. If the temperature differential setting of 18 °F (10 K) is exceeded, the solar control unit switches on the supply pump in solar heating circuit 1 (high-flow/low-flow operation with thermosiphon storage tank). The solar control unit optionally changes over to an additional solar circuit pump or the second consumer via a three-way diverter valve, if:

- The first consumer has reached the maximum storage tank temperature or
- The temperature spread in solar circuit 1 is no longer adequate for heating the first consumer, in spite of using the slowest pump speed.

Heating of the second consumer is interrupted every 30 minutes to check the temperature rise in the collector. If the collector temperature increases by more than 2 °F (1 K) per minute, the check is repeated until:

- The temperature increase at the collector temperature sensor is less than 2 °F (1K) per minute, or
- The delta temperature spread in solar circuit 1 allows heating of the prioritized consumer again

The solar function module FM443 indicates which consumer is currently being heated. The following are required as accessories for a second consumer:

- SBU module: chang-over diverter valve.
- Alternative: an additional KS pump station
- Sensor kit for 2nd storage tank FSS: Storage tank temperature sensor FSS2 (NTC 10K, Ø9.7 mm, 10 ft. (3.1 m) lead)

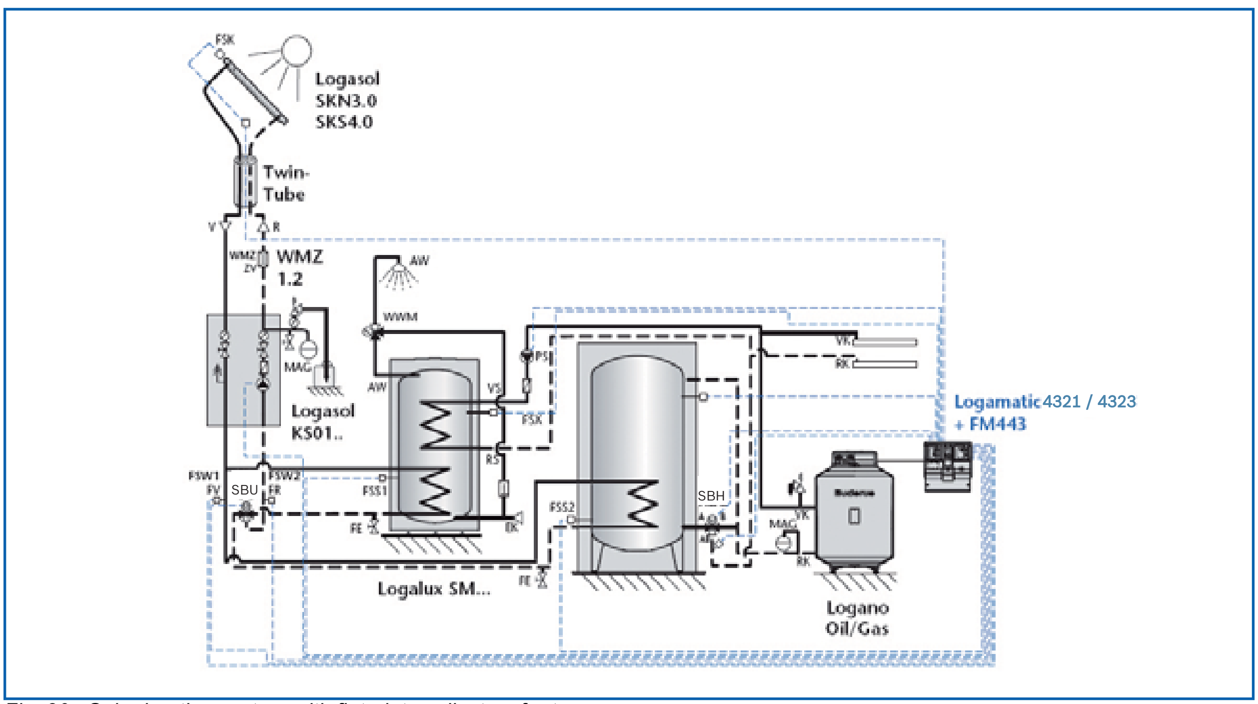


Fig. 30 Solar heating system with flat-plate collectors for two consumers with control via solar function module FM443

Storage tanks connected in series

When storage tanks are connected in series, the preheating storage tank is heated via the solar heating system. The solar heating function module FM443 is used to control the solar heating system.

When hot water is drawn, the water that has been preheated using solar energy enters the cold water inlet of the standby storage tank via the hot water outlet of the pre-heating storage tank and is reheated by the boiler, if needed (Fig. 31).

With high solar yield, the pre-heating storage tank can also achieve higher temperatures than the standby storage tank. To enable the use of the entire storage tank volume for solar heating, a pipe must be routed from the hot water outlet of the standby storage tank to the cold water inlet of the pre-heating storage tank. A pump is used to deliver the water in such cases. Code may require that the water in the pre-heating stages be heated to 140 °F (60 °C) once every day. The temperature in the standby storage tank should always be ≥ 140 °F (60 °C). The daily heating of the preheating stage can be carried out either in standard operation by solar heating or via conventional reheating.

In combination with the solar control unit, two additional storage tank sensors are needed at the top or bottom of the standby storage tank. Storage tanks with insulation that can be removed allow the sensor to be secured with straps. The FSX sensor is installed inside a well in the standby storage tank.

The control unit FM443 monitors the temperatures via the sensor in the pre-heating storage tank. If the required temperature of 140 °F (60 °C) is not achieved in the pre-heating storage tank using solar energy, circulation pump PUM between the hot water outlet of the standby storage tank and the cold water inlet of the pre-heating stage is started during a period when no hot water is drawn (preferably at night). The PUM pump remains on until the required temperature has been achieved at both sensors.

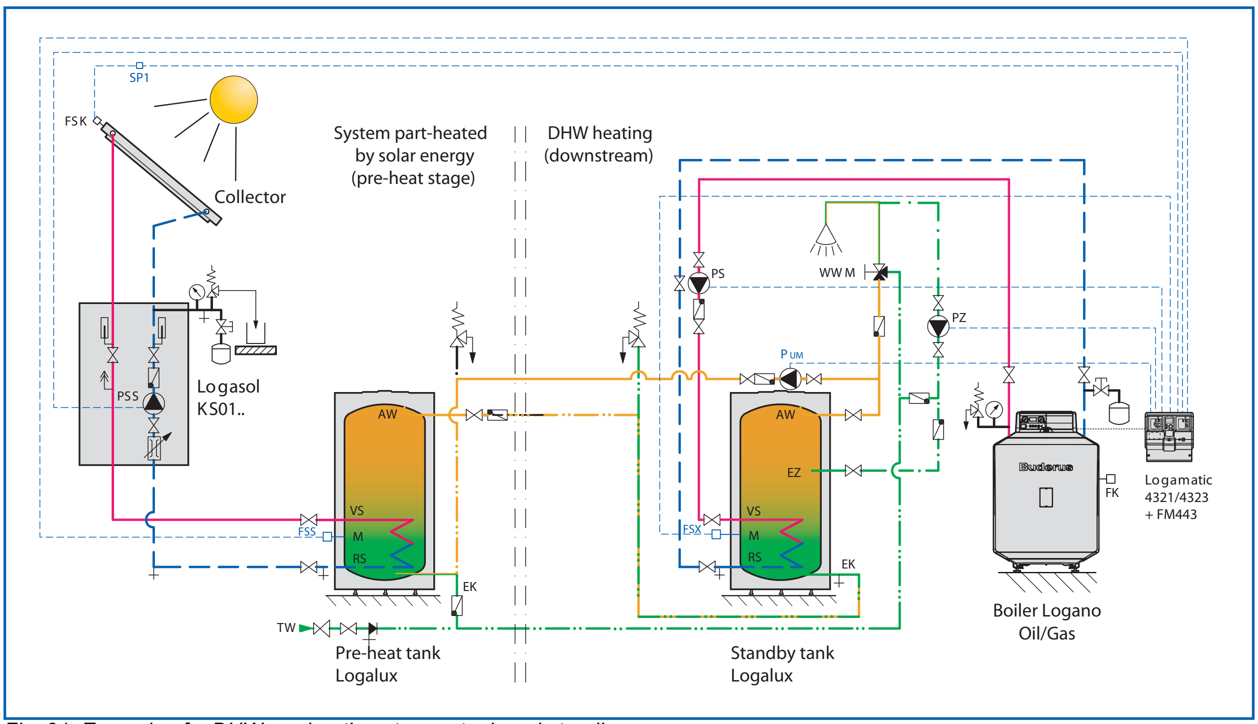


Fig. 31 Example of a DHW pre-heating storage tank and standby storage tank connected in series, control of storage tank water transfer and disinfection, controlled by an FM443

TR0301 U Differential Temperature Controller

Automatic Storage Tank Loading

The TR0301 U controller constantly compares the temperatures between the collector (T1) and the lower area of the storage tank (T2) via temperature sensors. Once the sun heats the collector and there is a temperature difference of 16 °F (9 °C) between the collector and the storage tank, the pump is switched on and the pump symbol shown rotating on the display. The pump transports the heat transfer fluid from the storage tank to the collectors. There it is heated by the sun and transported back to the storage tank, where the heat is transferred to the domestic water. If the temperature difference between collector and storage tank falls below 8 °F (4.5 °C), the pump is switched off. The sun symbol is no longer shown on the display.

Automatic Stagnation

If the lower area of the storage tank (T2) reaches the set maximum storage tank temperature (factory default 140 °F (60 °C)), charging is stopped. A temperature of 6 °F (4 °C) below the maximum storage tank temperature must first be reached before charging can resume.

Automatic Pump Protection

During periods of high insolation, the temperature (T1) of the heat transfer fluid can exceed 266 °F (130°C). In order to protect the pump from overheating, the system will resume operation as soon as the temperature drops below 261 °F (127 °C).

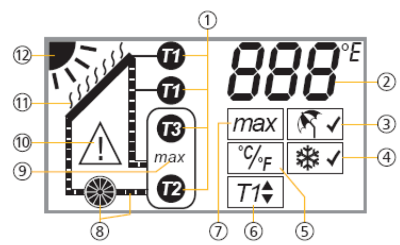
Vacation Function

The vacation function is used to cool down a completely heated storage tank via the collector. The storage tank can heat up too much if no DHW is drawn over an extended period of time (e.g. vacation). Discharging the solar system over night prevents the solar system idling in stagnation for extended periods.

Anti-freeze Function

If the anti-freeze function is activated, the controller switches the pump on as soon as the collector temperature falls below +41 °F (+5 °C). The heat transfer fluid is then pumped through the collector and the system is prevented from freezing. If the collector reaches a temperature of +45 °F (7 °C), the pump is switched off.

Fig. 32 Solar Controller TR0301U



Legend - Display

1 Temperature sensor symbols
2 Temperature and faults code display
3 Vacation function
4 Anti-freeze function
5 Select temperature Unit °C/°F
6 Evacuated tube collector function
7 Setting maximum storage tank temperature
8 Activated pump and fluid symbols indicate a system in operation
9 Indicates maximum storage tank temperature reached
1 Warning display if fault occurs
11 Indicates system stagnation
12 Shows sufficient heat for system operation

Features and characteristics

- *1 outlet 120 V / 60 Hz*
- *3 sensor inputs (Pt1000)*
- *Suitable for a standard solar system, or storage tank reloading*
- *Adjustable high limit for tank*
- *Freeze protection function*
- *Vacation overheat protection*

Steca TR 0603mc U Differential Temperature Controller

The Steca TR 0603mc U is designed exclusively for the North American market. The TR 0603mc U stores the system‘s operational data on a SD memory card, which can be used for data evaluation purposes.

The 40-programmed systems and numerous additional functions allow universal use of the controller. The large display panel shows the animated control circuits, which allows you to view the operating conditions of each system.

The TR 0603mc U has 6 inputs for recording temperature or pulse values, as well as an additional “Direct Sensor” input for combined temperature and flow rate measurement.

Pumps and switching valves are controlled by 3 outputs, some of which can be RPM controlled.

Fig. 33 Solar Controller TR0301U

Product Features

- Animated LCD display with backlight
- Heating return increase
- Freely programmable thermostat function
- Timer and holiday (storage recool) functions
- Heat quantity (pulse generator / Direct Sensor/ calculation)
- Circulation function
- Back-up heating function measured in kwh/BTU
- Solid fuel boiler back-up heating
- Tube collector function
- Anti-freeze function
- Interval function
- Rapid storage tank loading
- Reduction of system stagnation phases
- Anti-legionella function
- Fault diagnosis and fault reporting output
- Bypass switching
- Data logging on SD card
- Seasonal systems (loading of pool / storage tank according to the time of the year)
- Multilingual menu navigation

Technical Data	
Operating voltage	120 VAC, 60 Hz [optional 240 VAC, 60 Hz]
Max. own consumption	≤ 4 W
Inputs	6 5 x temperature recording (Pt1000), 1 x temperature recording or pulse
Additional input	1 x ”Direct Sensor“ (temperature/flow rate)
Outputs	3 1 x relay switched output, max. 0.5 HP (120 V~) 2 x triac output for speed control, max. 0.17 HP (120 V~)
Additional output	1 x (fault reporting output)
Line cord	7‘, 18 AWG rated at 221 °F
Number of pre-defined hydraulic schemes	40
Interfaces	SD card, RS232, RS485 (TPC 1)
Data logging	SD card
Permitted ambi-ent temperature	32 °F ... +113 °F (0 °C ... +45 °C)
Display	animated graphic LCD with backlighting
Protection class	IP 20/DIN 40050
Dimensions l x w x h	6.69 x 6.69 x 3.50 inch (170 x 170 x 89 mm)

2.4 Logasol KS pump stations

Features and characteristics

- The KS pump station module consists of all required components such as the solar circuit pump, the flow checks, the safety pressure relief valve, the pressure gauge, ball valves in the flow and return with integrated thermometer, a flow setter vavle and thermal protection.

- Four different output stages are available:

Max. recommended no. of collectors	Without integral control unit	With integrated air separator
5	Logasol KS0105	●
10	Logasol KS0110	●
20	Logasol KS0120	●
50	Logasol KS0150	●

Fig. 34 Selection of a suitable KS... pump station subject to the number of collectors

Configuration of the Logasol KS01.. pump station

The solar stations for collector arrays with up to 50 collectors are already equipped with an air separator.

The Fig. 34 shows the different versions and recommends the maximum number of collectors that can be operated with them. A pipework calculation is required to determine the correct output level.

The essential diaphragm expansion vessel (DEV) is not part of the standard delivery of the Logasol KS pump station. It must be sized for each individual case. The wall bracket cannot be used for DEV with a capacity of 9 to 13 gal (35 l to 50 l). The AAS/Solar connecting kit is not suitable for MAG with a capacity in excess of 13 gal (50 l) because the MAG connection is larger than ¾”.

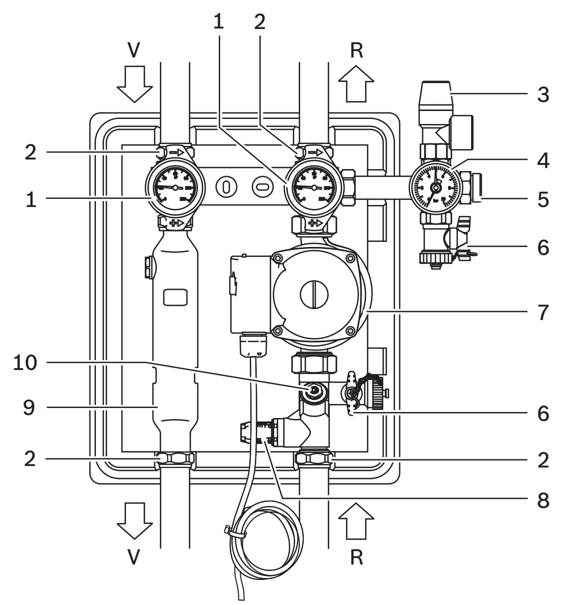


Fig. 35 Layout of the Logasol KS01 pump station

Legend

V Supply from collector to consumer
R Return from consumer to collector
1 Ball valve with thermometer and integrated gravity brake
Position 0° = gravity brake ready for operation, ball valve open
Position 45° = gravity brake manually open
Position 90° = ball valve closed
2 Compression ring fitting (all flow and return connections)
3 Safety relief valve
4 Pressure gauge
5 Connection for diaphragm expansion vessel (DEV and AAS/Solar not part of the standard delivery)
6 Fill & drain valve
7 Solar circuit pump
8 Flow volume indicator
9 Air separator
10 Regulating/shut-off valve

Dimensions and specification of Logasol KS... pump stations

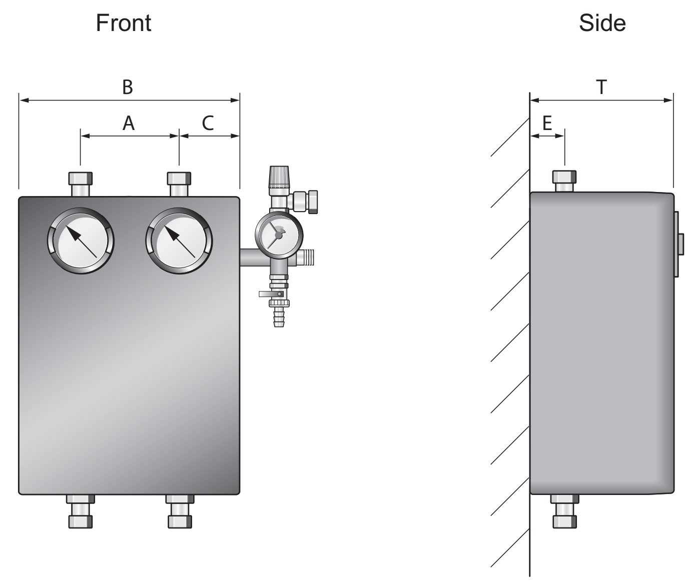


Fig. 36 Dimensions of the KS pump station

Logasol pump station			KS0105	KS0110	KS0120	KS0150
Number of consumers			1	1	1	1
Casing dimensions	Height H	in (mm)	14" (355)	14" (355)	14" (355)	14" (355)
	Width W	in (mm)	11-½" (290)	11-½" (290)	11-½" (290)	11-½" (290)
	Depth D	in (mm)	9-¼" (235)	9-¼" (235)	9-¼" (235)	9-¼" (235)
Detailed dimensions	A	in (mm)	5-⅛" (130)	5-⅛" (130)	5-⅛" (130)	5-⅛" (130)
	C	in (mm)	3-⅛" (80)	3-⅛" (80)	3-⅛" (80)	3-⅛" (80)
	E	in (mm)	2" (50)	2" (50)	2" (50)	2" (50)
Copper pipe connection size (clamping ring fitting)	Supply/ return		½" ID × 1	¾" ID × 1	1" ID × 1	1" ID × 1
Expansion vessel connection			6 "	6 "	6 "	6 "
Safety relief valve		psi (bar)	87psi (6)	87psi (6)	87psi (6)	87psi (6)
Circulation pump	Type		Grundfos Solar 15-58	Grundfos Solar 15-58	Grundfos UPS 25-99	Grundfos Solar 15-58
	Finished length	in (mm)	5-⅛" (130)	5-⅛" (130)	5-⅛" (130)	5-⅛" (130)
Electrical power supply		V AC	120	120	120	120
Frequency		Hz	60	60	60	60
Max. power consumption		W	60	125	195	125
Max. current load		A	0.25	0.54	0.85	0.54
Throughput limiter adjusting range		gpm (l/min)	⅛ - 1-½ (0.5–6)	½ - 4-¼ (2–16)	2 - 7 (8–26)	½ - 4-¼ (2–16)
Weight		lbs (kg)	16 (7.1)	16 (7.1)	21 (9.3)	16 (7.1)

Fig. 37 Specification and dimensions of the Logasol KS pump station

2.5 Solar pump station modules

Module SBU: change over unit

- Solar systems with two storage tanks and one solar pump station.
- Priority/first tank connect on the left side, second tank on the bottom.
- Overlap of the rear panel is needed for cooling of the solar pump station.

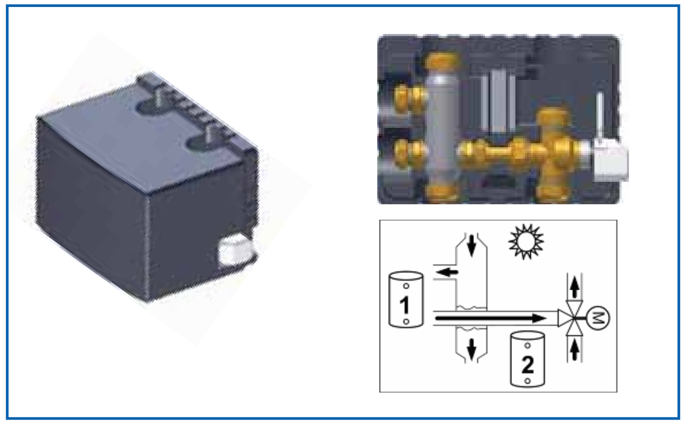


Fig. 38 SBU Module - change over unit

Module SBH: heating support unit

- Solar space heating with return flow increase.
- Horizontal or vertical mounting

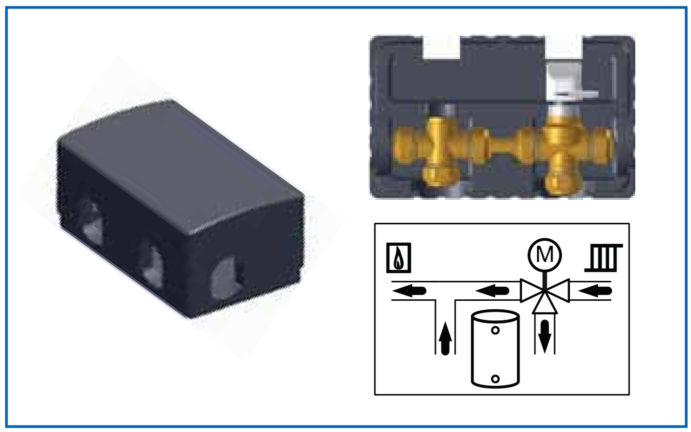


Fig. 39 SBH Module - heating support unit

Module SBT: system division unit

- Division solar fluid - heating water.
- Used with buffer tank without internal heat exchanger.
- Max. 8 collectors, 250 gallon tank

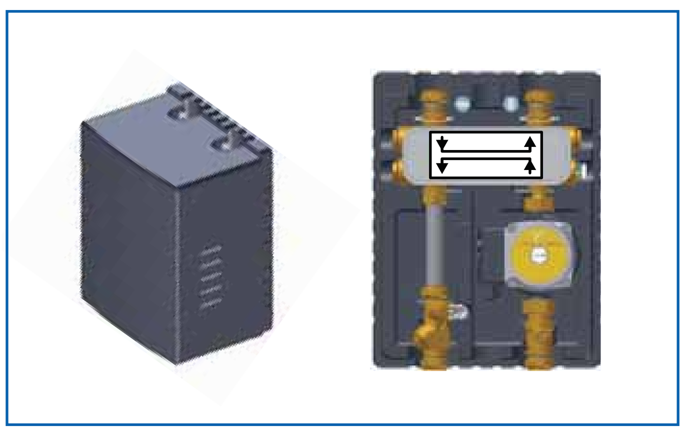


Fig. 40 SBT Module - system division unit

2.6 Other system components

2.6.1 Connection with Twin-Tube

Twin-Tube is a thermally insulated double tube for solar supply and return piping with UV protective jacket and integrated sensor lead. The connection kit contains suitable fittings for the various collector type to enable the Twin-Tube 1/2 and 3/4 inch fittings to be connected to the collector array, the pump station and
the storage tank. Space for a bending radius of at least 5 inches (125 mm) for routing the Twin-Tube 1/2 inch must be available on site (Fig. 41).

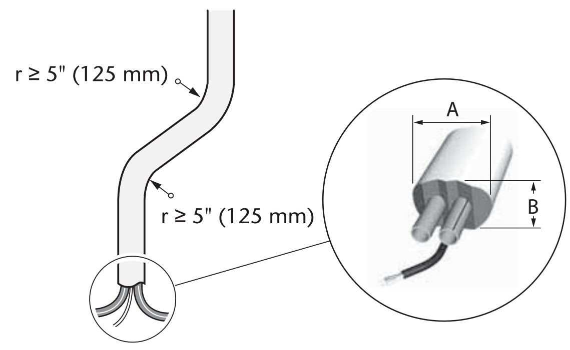


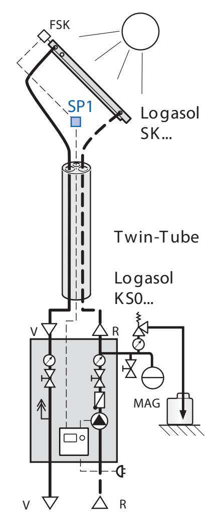
Fig. 41 Bending radius for Twin-Tube ½"

Twin-Tube			1/2 INCH	Stainless steel 1/2 INCH	Stainless steel 3/4 INCH
Dimensions (→ Fig.40)	A	inch (mm)	3" (73)		
	B	inch (mm)	2" (45)		
Pipe dimensions	Diameter		2 × ½" ID inch	2 × ½" ID inch	2 × ½" ID inch
	Length	ft.	50		
Insulating material			EPDM rubber	EPDM rubber	EPDM rubber
Insulation thickness		inch (mm)	⅔" (15)		
Temperature resistant up to		° F (°C)	374 (190)		
Protection film			PE, UV-resistant	PE, UV-resistant	PE, UV-resistant
Sensor lead			AWG18 (2 × 0.75 mm^2)	AWG18 (2 × 0.75 mm^2)	AWG18 (2 × 0.75 mm^2)

Fig. 42 Twin-Tube specification

2.6.2 Lightning protection for the control unit

The collector temperature sensor in the lead collector can be subject to overvoltage during a thunderstorm because of its exposed location on the roof. This overvoltage can damage the sensor and the controls. The overvoltage protection is not a lightning rod. It is designed for situations where lightning strikes in the vicinity of the solar collectors. Safety diodes limit this overvoltage to a level that will not damage the control unit. The junction box must be located within 10 ft. (3.5 m) of the FSK collector temperature sensor (Fig. 43).



E Automatic all-metal air vent valve (accessory)
FSK Collector temperature sensor (standard delivery of the control unit)
KS01… Logasol KS… pump station with integral control unit
SK… Logasol SKN3.0 or SKS4.0 solar collector
SP1 Lightning protection

Fig. 43 Overvoltage protection for control unit (sample installation)

2.6.3 Heat transfer fluid - Tyfocor L

The solar heating system must be protected from freezing.

Heat transfer fluid L is a ready-made mixture consisting of 46% PP glycol and 54% water. This clear mixture is food-grade and biologically degradable.

Heat transfer fluid L protects the system from freezing and corrosion. As shown in Fig. 44, heat transfer fluid L provides frost protection down to an outside temperature of -35 °F (-37 °C). In systems with Logasol SKN3.0 and SKS4.0 collectors, heat transfer fluid L ensures a reliable operation at temperatures from -35 °F to +338 °F (-37 °C to +170 °C).

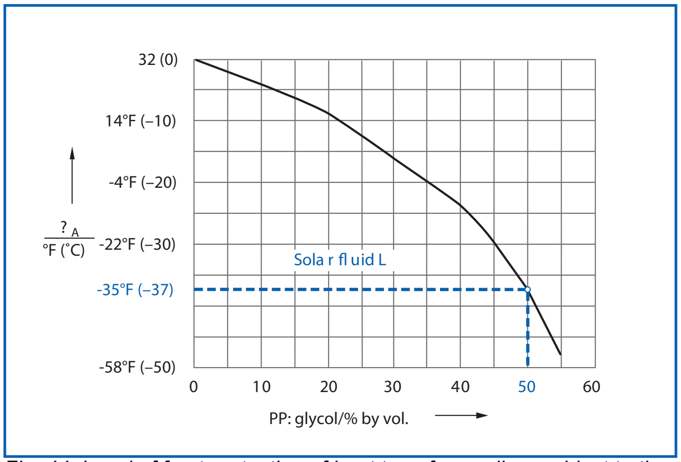


Fig. 44 Level of frost protection of heat transfer medium subject to the glycol:water mixture

Legend

∂A Outside temperature

Testing the heat transfer fluid

Heat transfer media based on mixtures of propylene glycol and water age during operation in solar heating systems. This decay can be identified by dark coloration or opaqueness. Long periods of overheating (>392 °F (200 °C)) result in a characteristic pungent burnt smell. The fluid becomes almost black because of the increase in solid decomposition products of the propylene glycol or the inhibitors that are no longer soluble.

The main influences are repeated overheating and over pressure. These factors are much influenced by the absorber geometry and system piping.

Favorable characteristics are obtained using fanshaped absorbers such as the ones used in the SKN3.0, and double meander absorbers with return line at the bottom such as the ones used in the SKS4.0.

However, the locations of the connecting pipes on the collector also influence the stagnation characteristics and therefore the ageing of the heat transfer fluid. It is therefore important to avoid running the flow and return lines over long distances with inclines at the collector array, since heat transfer fluid will run into the collector from these line sections in the event of stagnation and increase the vapor volume. Ageing is also accelerated by oxygen (air-borne systems) and impurities such as copper or iron shavings introduced in installation.

To check the heat transfer fluid on site, determine the pH value and the antifreeze value. Suitable pH indicator strips and a refractometer (frost protection) are included in the Buderus solar service kit.

Ready-mixed heat transfer fluid	pH value in the delivered condition	min. pH
Heat transfer fluid L 46/54	approx. 8	7

Fig. 45 pH limits for checking ready-mixed heat transfer fluid

2.6.4 Thermostatically controlled domestic hot water mixer

Anti-scald protection / tempering valve

If the maximum storage tank temperature is set higher than 122 °F (50 °C), take suitable measures to provide protection against scalding. The following options are available:

- Install a thermostatically controlled DHW mixing valve (tempering valve) downstream of the storage tank's DHW connection.

See Fig. 46 for system integration of a thermostatically controlled DHW mixing valve (tempering) and a recirculation pump.

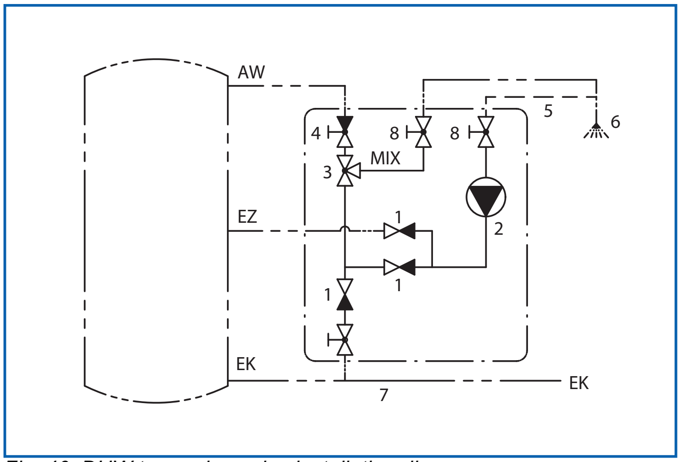


Fig. 46 DHW tempering valve installation diagram

Legend

AW DHW outlet
EK Cold water inlet
EZ DHW circulation inlet
MIX Mixed water
1 Check valve
2 DHW recirculation pump
3 Thermostatic mixing valve / tempering valve
4 Shut-off valve with check valve
5 DHW re-circulation line
6 Faucet, shower, etc.
7 Cold water supply
8 Shut-off valve

3 Sample Applications

3.1 Legend

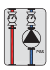
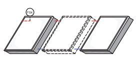
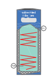
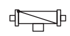
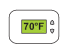
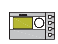
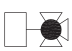
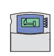
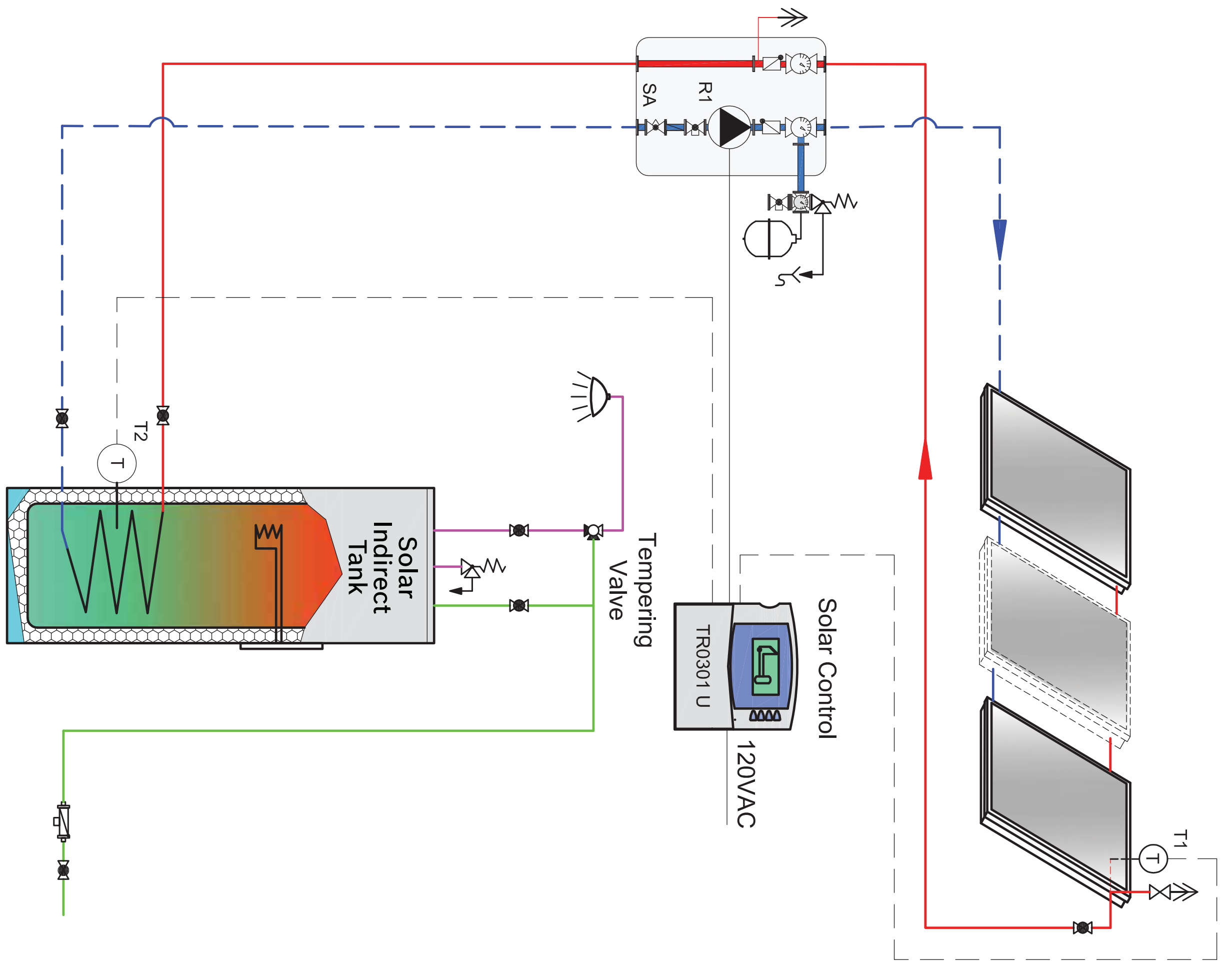
Component	Description	Component	Description
	High temperature zone		Expansion tank
	Solar pump station		Flow volume indicator
	Solar collector array		Indirect fired solar tank
	Line voltage connection (120V)		Feed line check and safety valve
	Air valve		Pump
	Sensor connection		Check valve
	Temperature sensor		Room thermostat
	Drain valve		Boiler controller
	Motorized mixing valve		Solar controller
	Two way shut off valve		Feed line
	Safety relief valve		Pressure gauge kit
	Return line		Indirect fired PL tank
	Supply line		

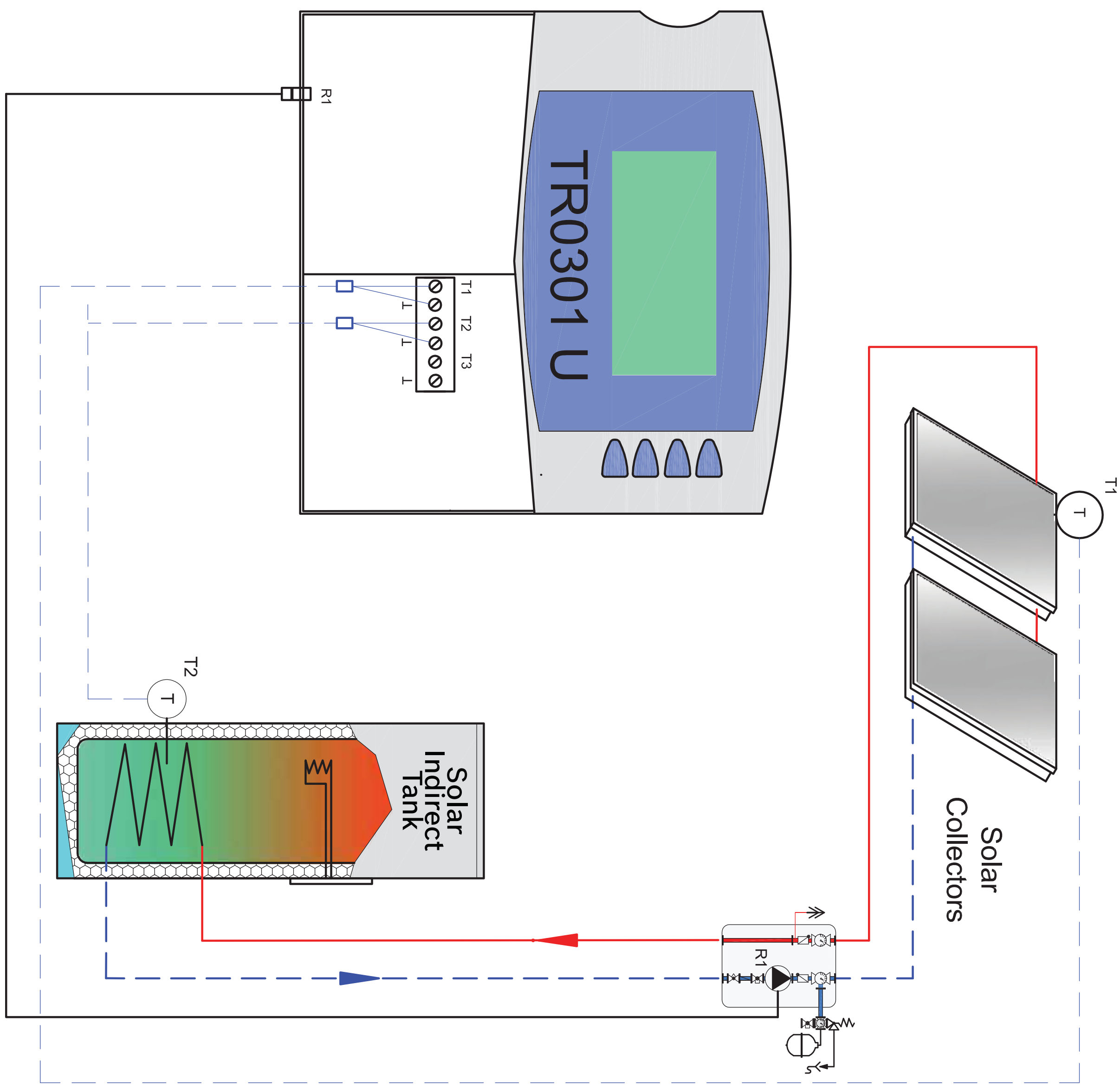
Fig. 47 Legend

3.2 Single coil tank applications

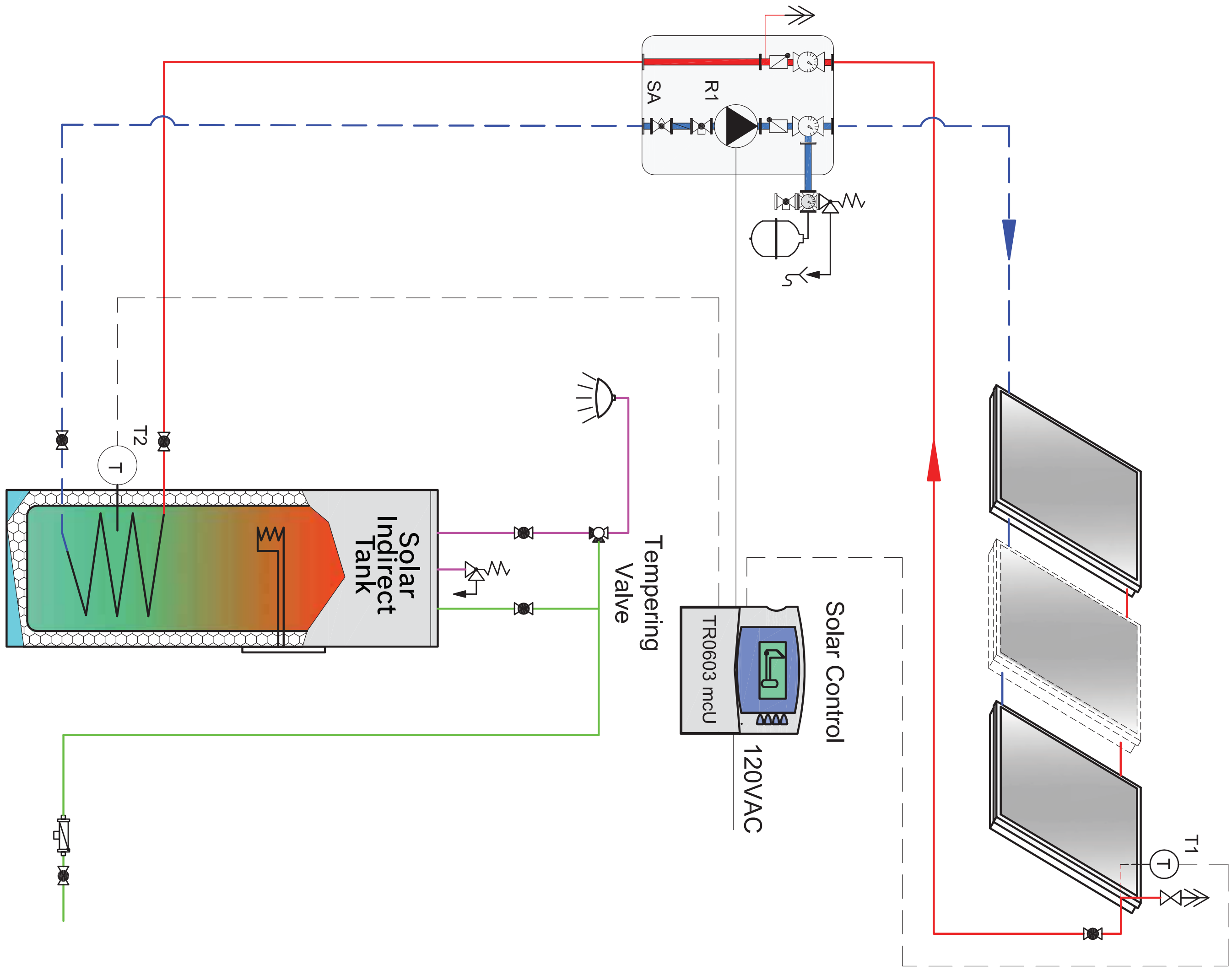
3.2.1 Piping diagram - Solar collectors, single coil tank with electric element and TR 0301U solar control



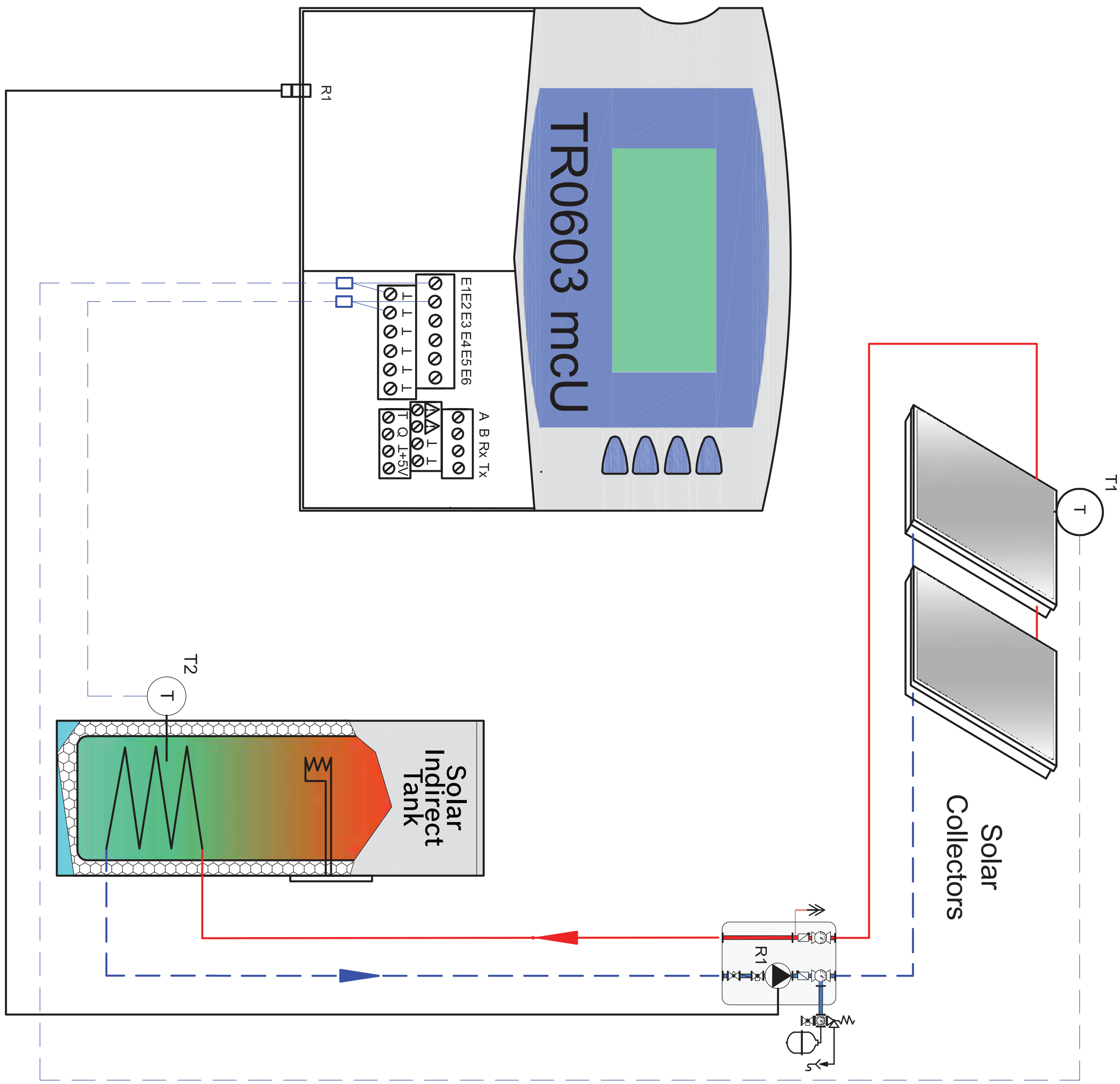
3.2.2 Wiring diagram - Solar collectors, single coil tank with electric element and TR 0301U solar control



3.2.3 Piping Diagram - Solar collectors, single coil tank with electric element and TR 0603mcU solar control

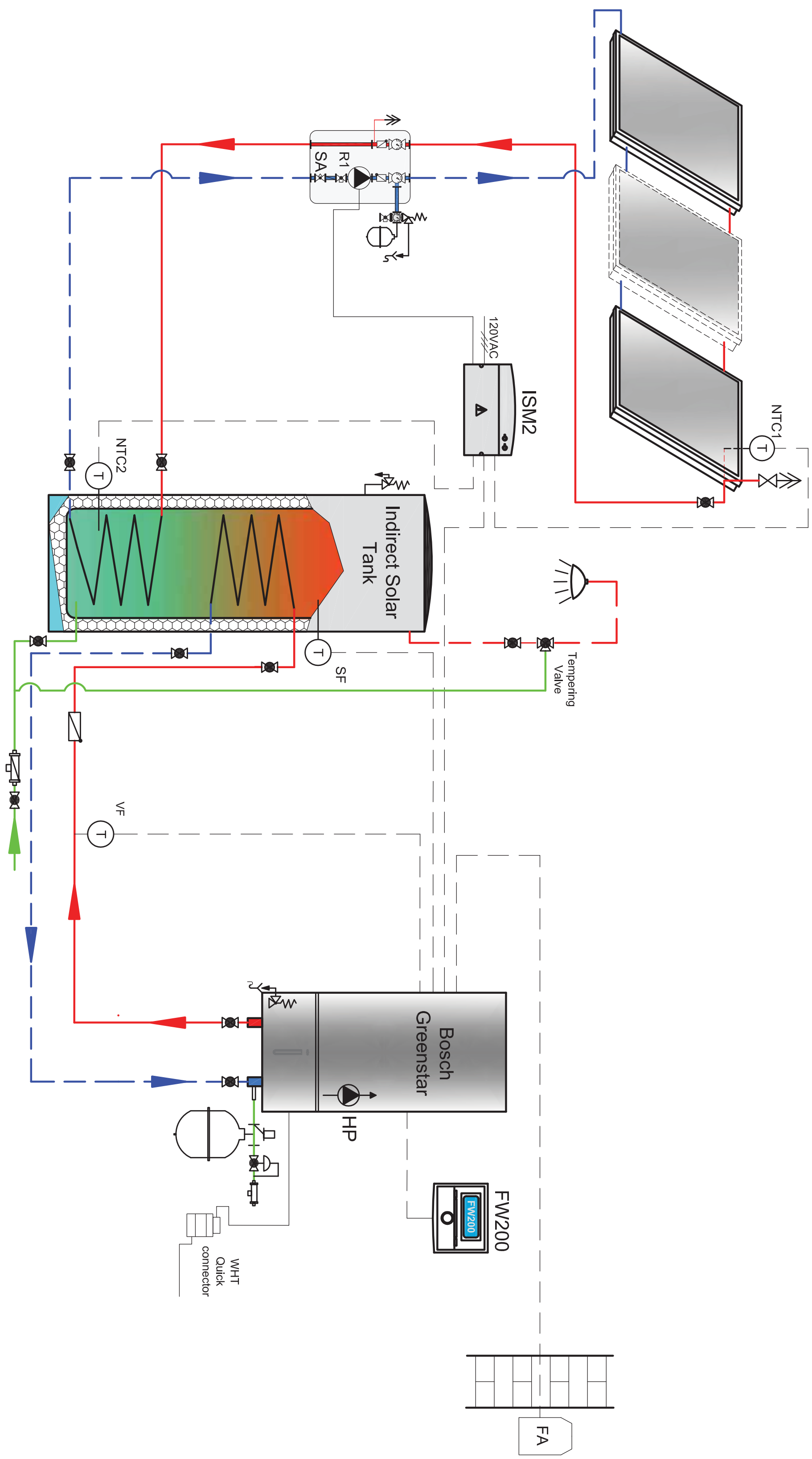


3.2.4 Wiring Diagram - Solar collectors, single coil tank with electric element and TR 0603mcU solar control

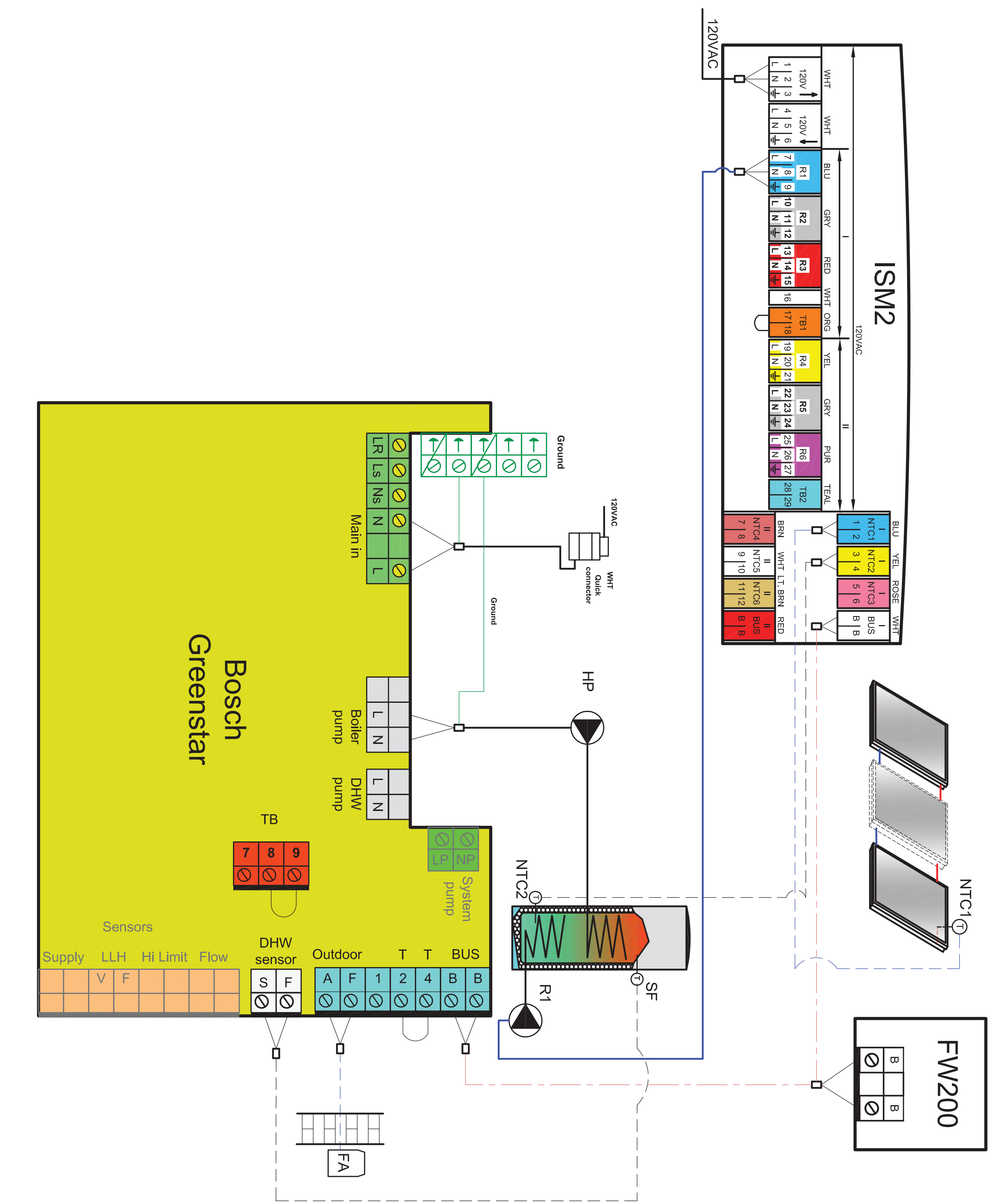


3.3 Dual coil tank applications

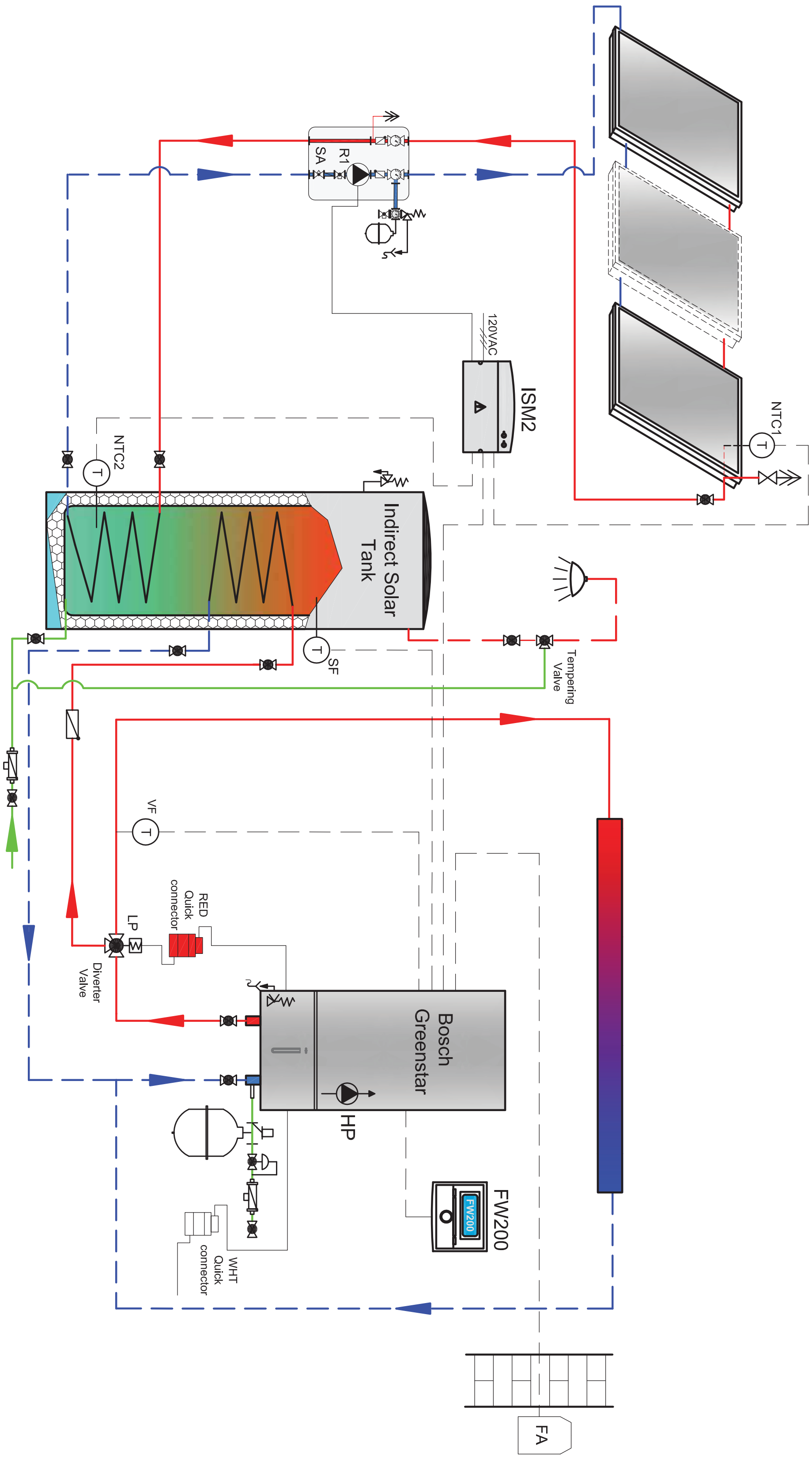
3.3.1 Piping diagram - Dual coil DHW tank, Greenstar boiler, ISM 2, FW200



3.3.2 Wiring diagram - Dual coil DHW tank, Greenstar boiler, ISM 2, FW200

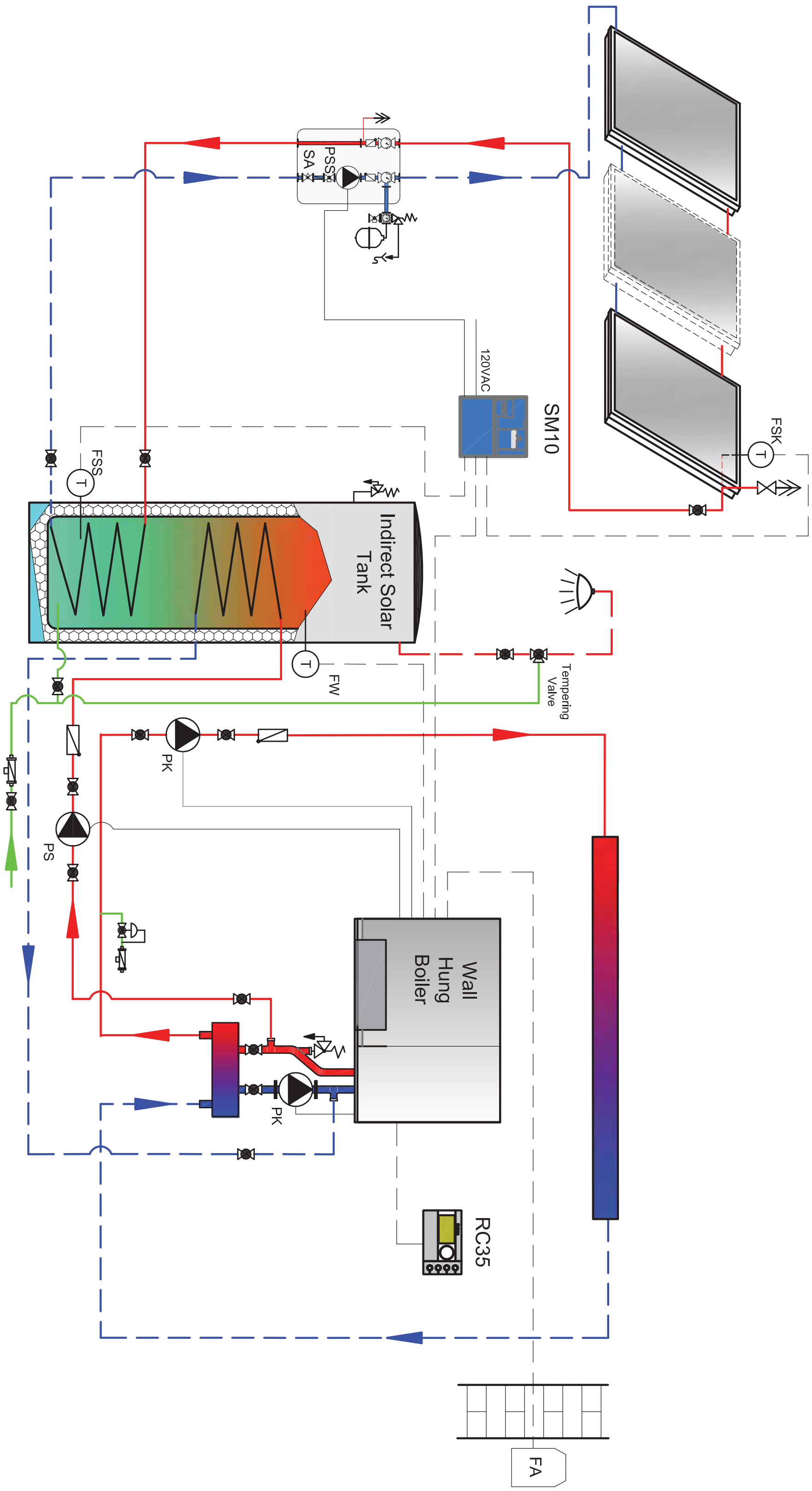


3.3.3 Piping diagram - Single heating zone, dual coil DHW solar tank, Greenstar boiler, ISM 2, FW200

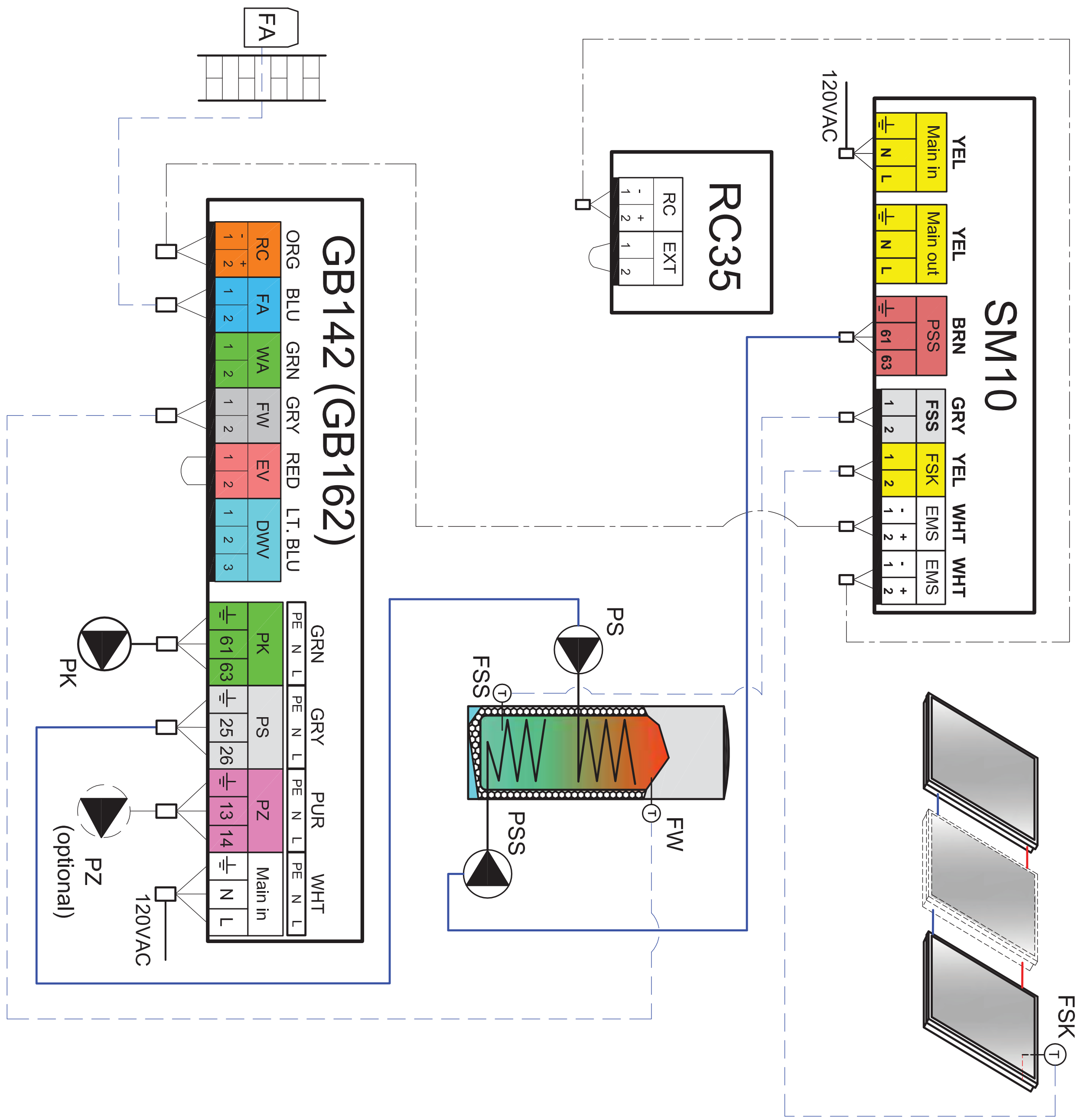


3.3.4 Wiring diagram - Single heating zone, dual coil DHW solar tank, Greenstar boiler, ISM 2, FW200

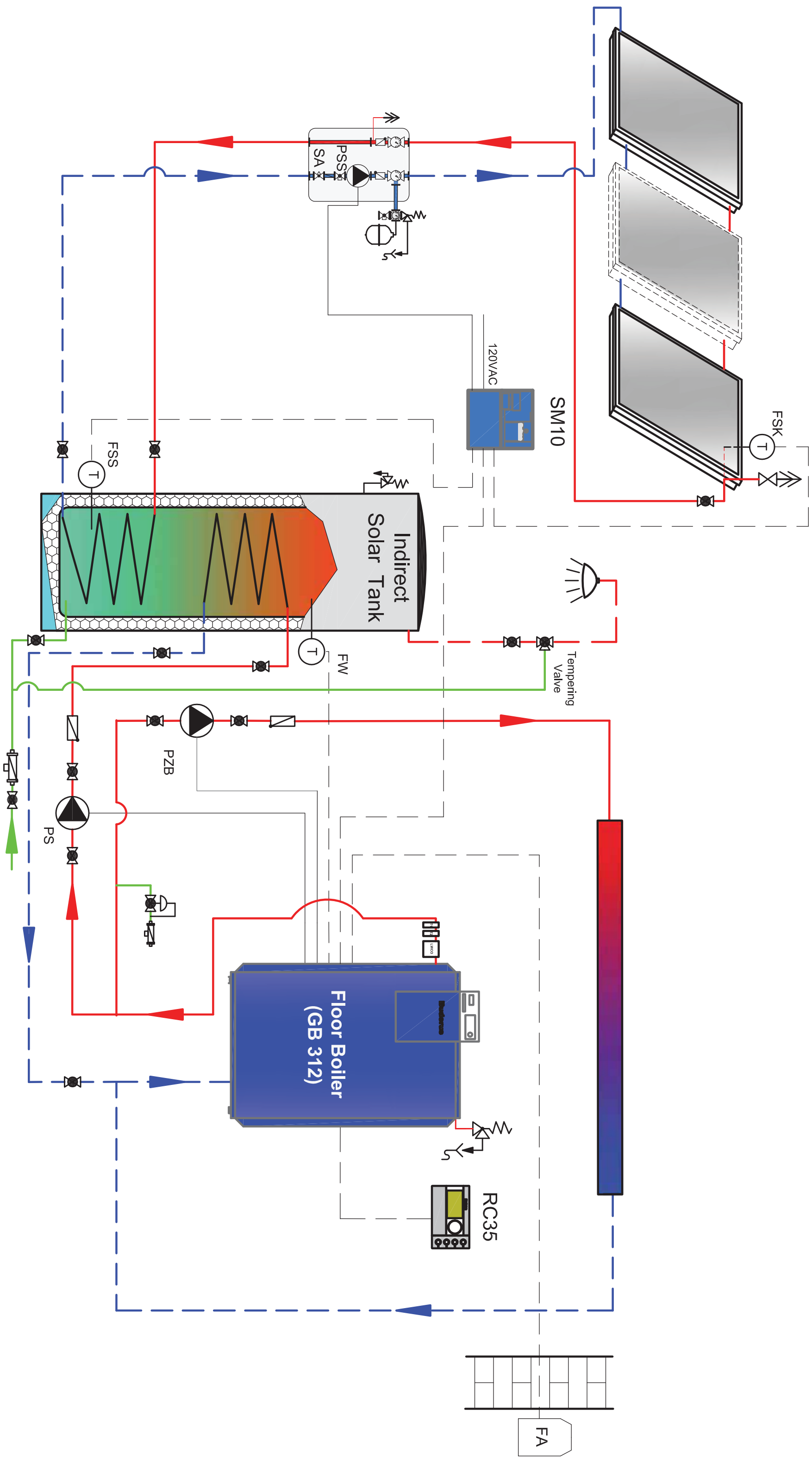
3.3.5 Piping diagram - Single heating zone with system pump, dual coil DHW tank, wall hung boiler, SM10, RC35



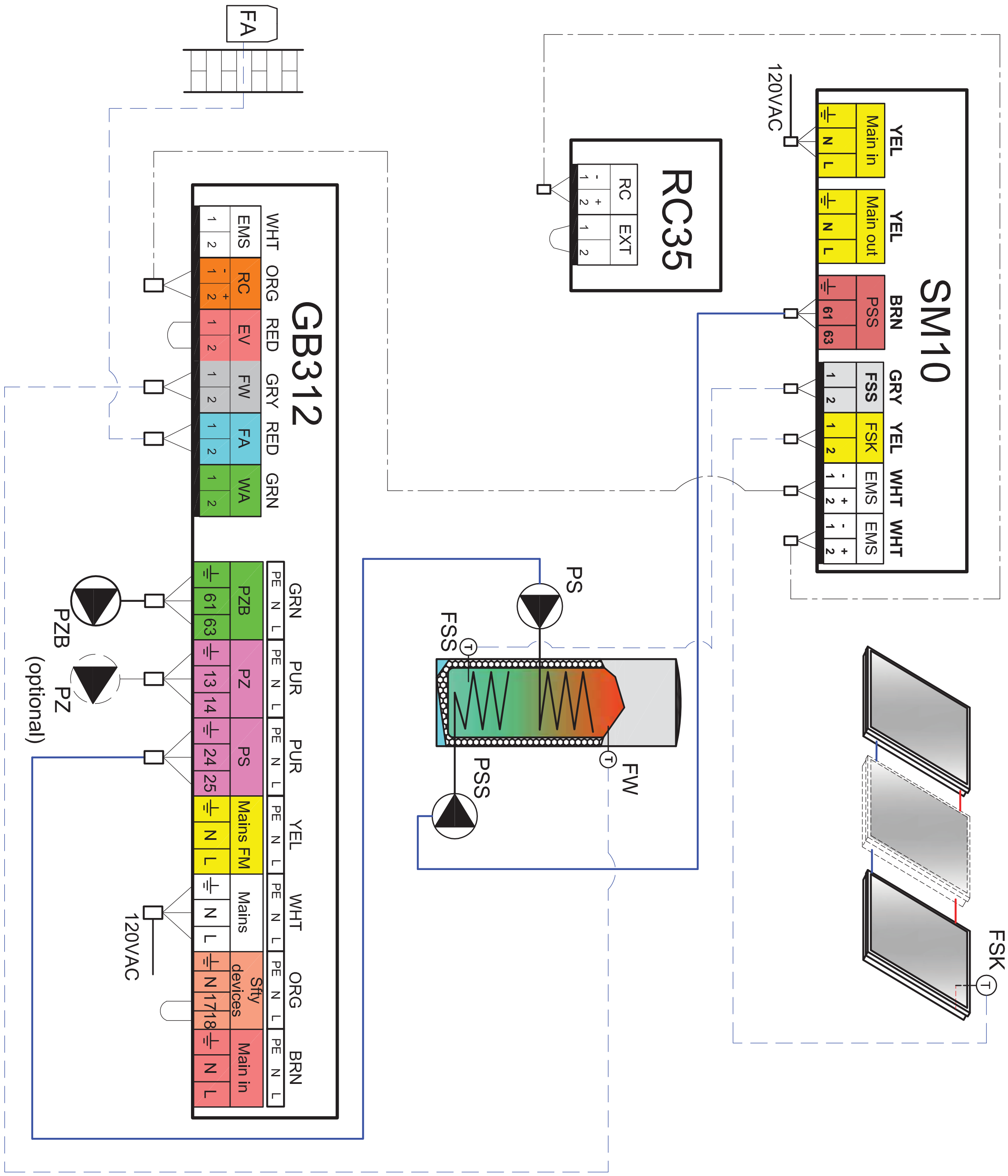
3.3.6 Wiring diagram - Single heating zone with system pump, dual coil DHW tank, wall hung boiler, SM10, RC35



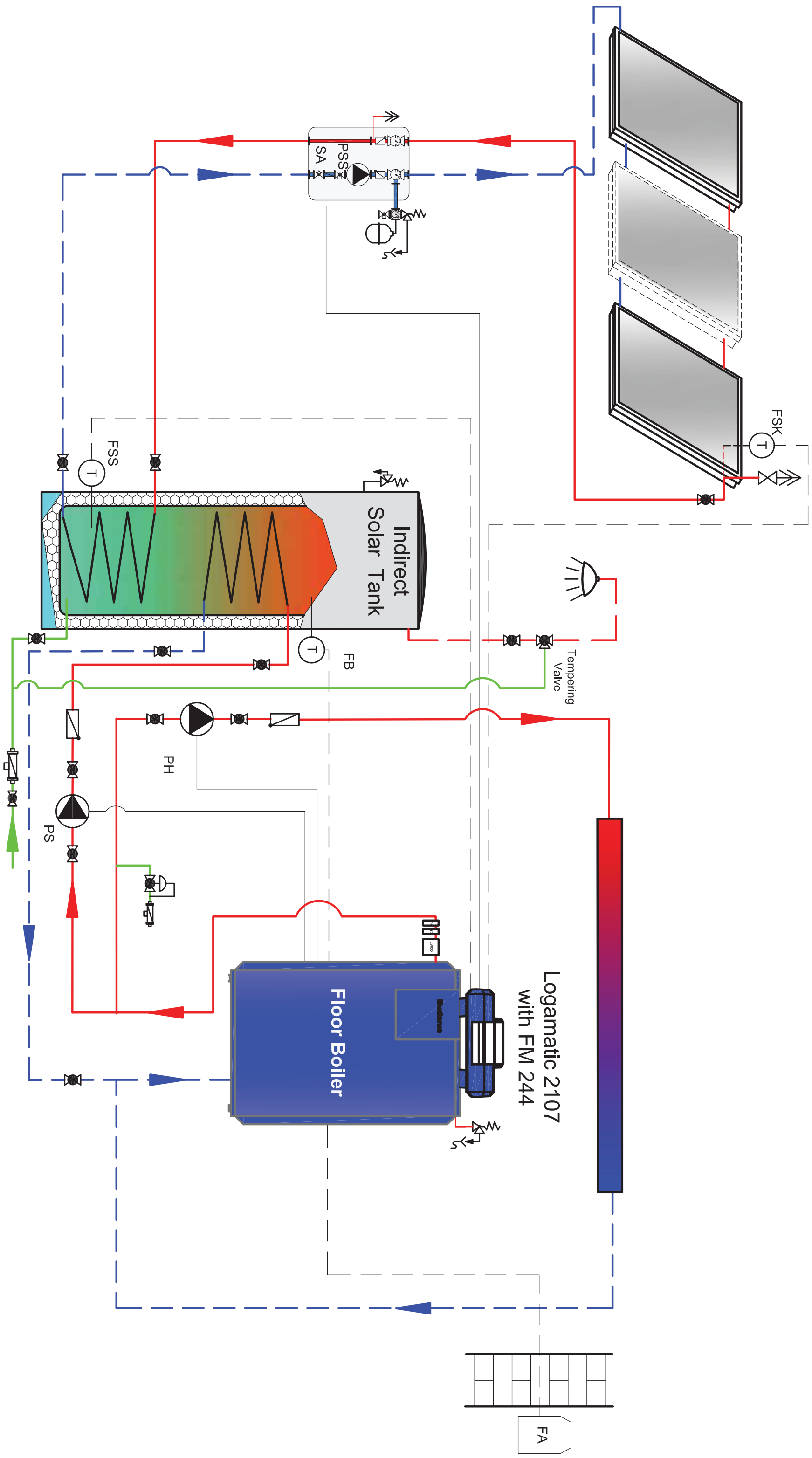
3.3.7 Piping diagram - Single heating zone, dual coil DHW-solar tank, floor standing boiler, SM10, RC35



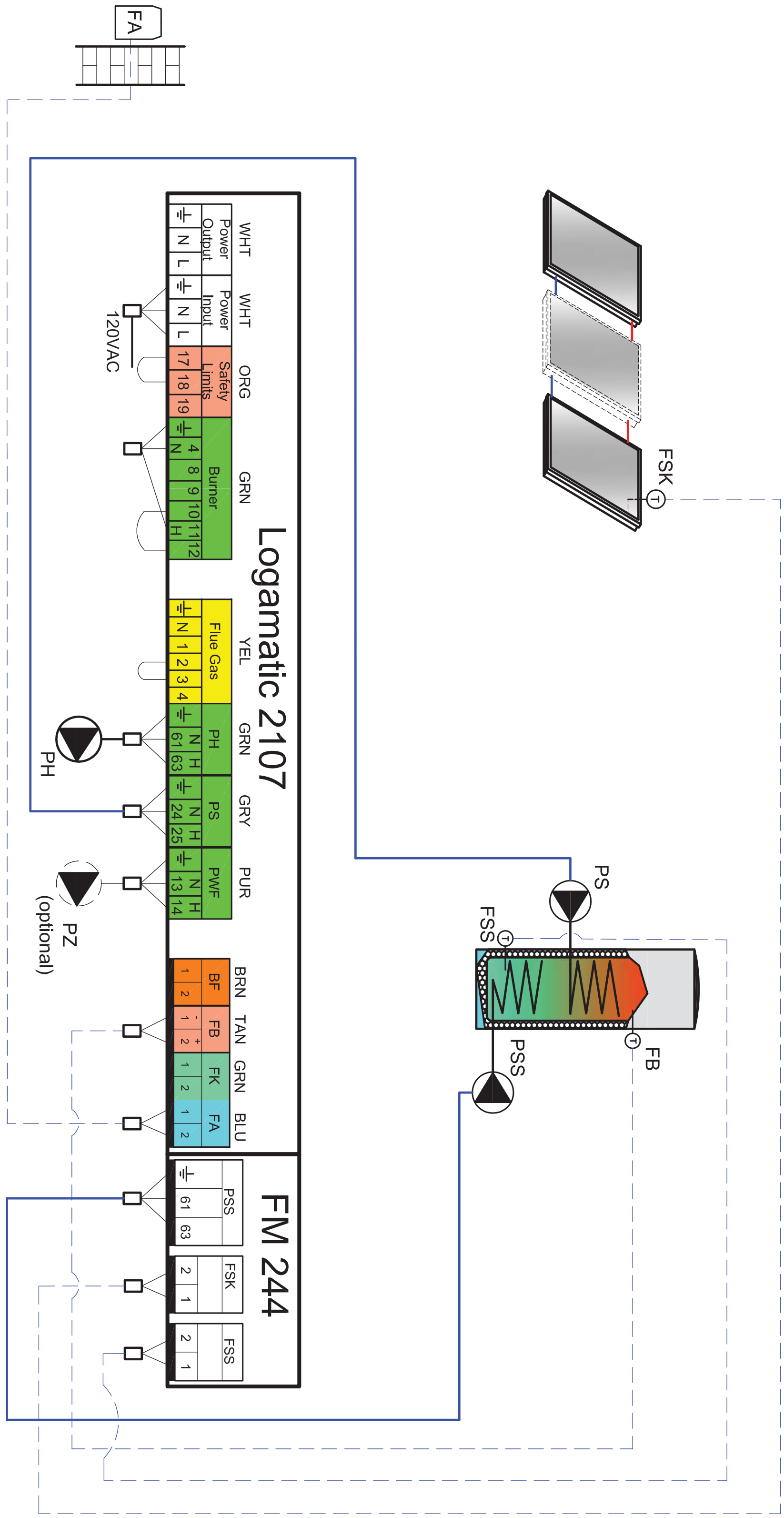
3.3.7 Wiring diagram - Single heating zone, dual coil DHW-solar tank, floor standing boiler, SM10, RC35



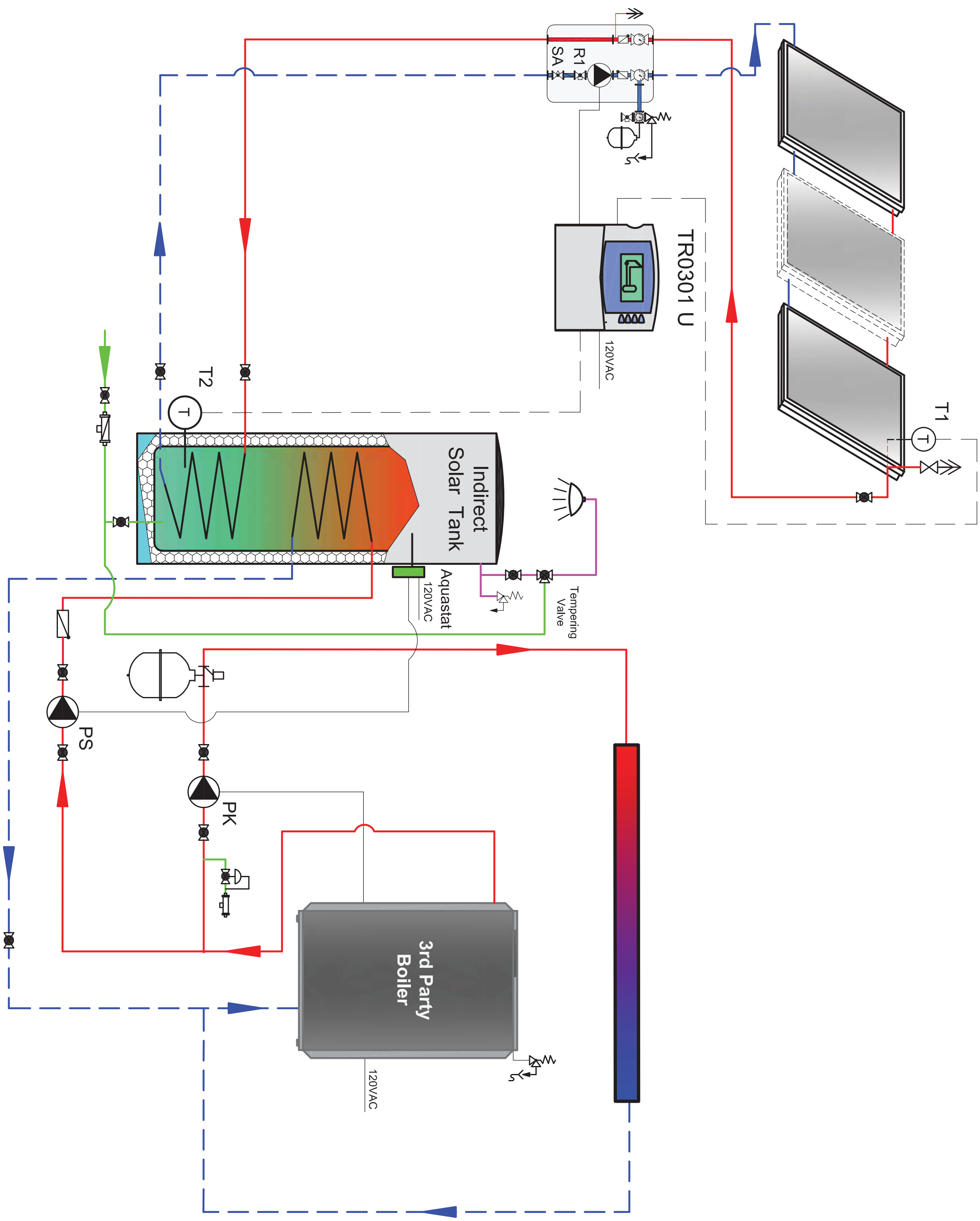
3.3.8 Piping diagram - Single heating zone with system pump, dual coil DHW-solar tank, floor standing boiler, 2107 with FM244 card



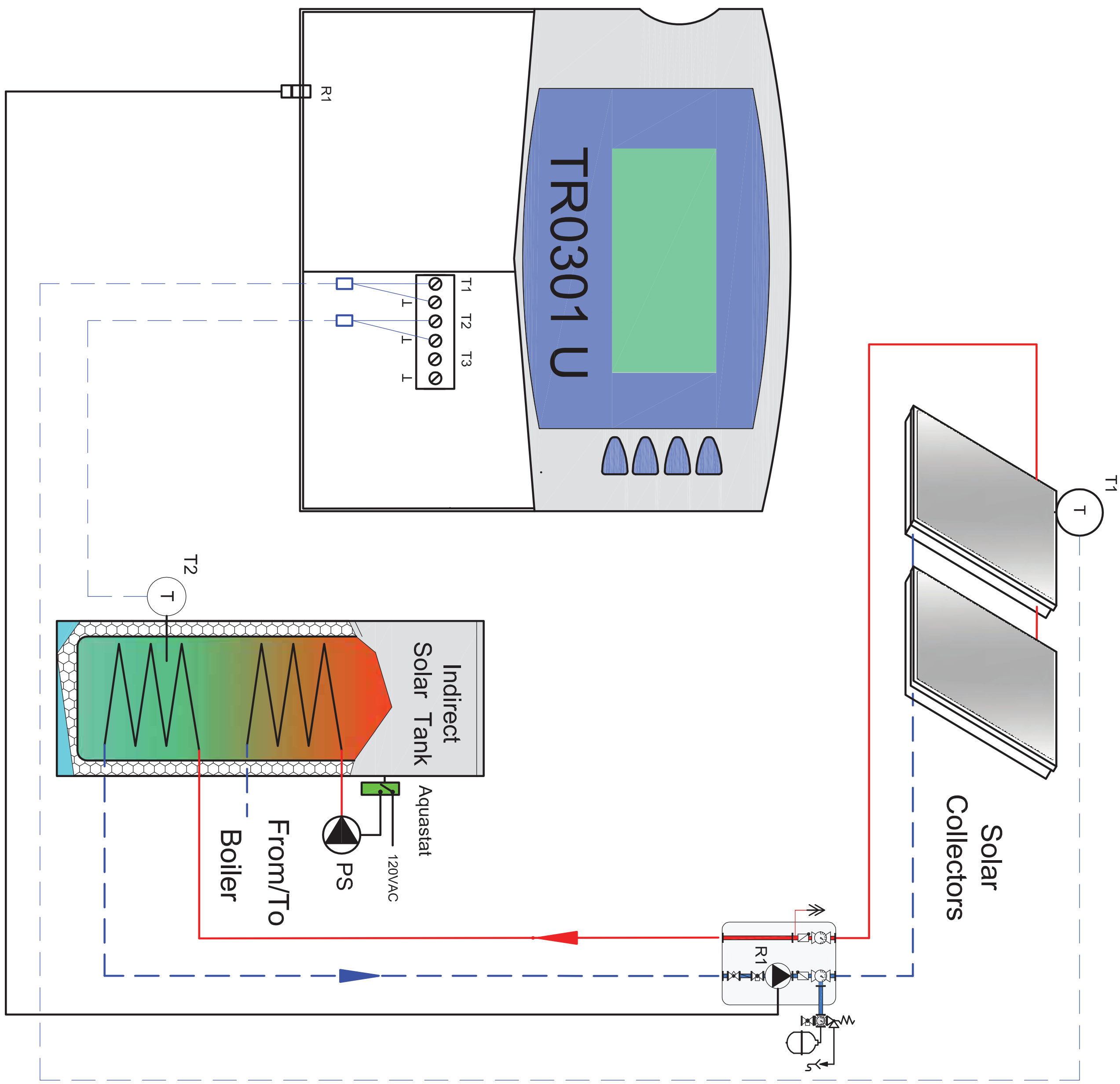
3.3.8 Wiring diagram - Single heating zone with system pump, dual coil DHW-solar tank, floor standing boiler, 2107 with FM244 card



3.3.9 Piping diagram - Single heating zone with system pump, dual coil DHW tank, floor standing commercial boiler, TR 0301U solar control

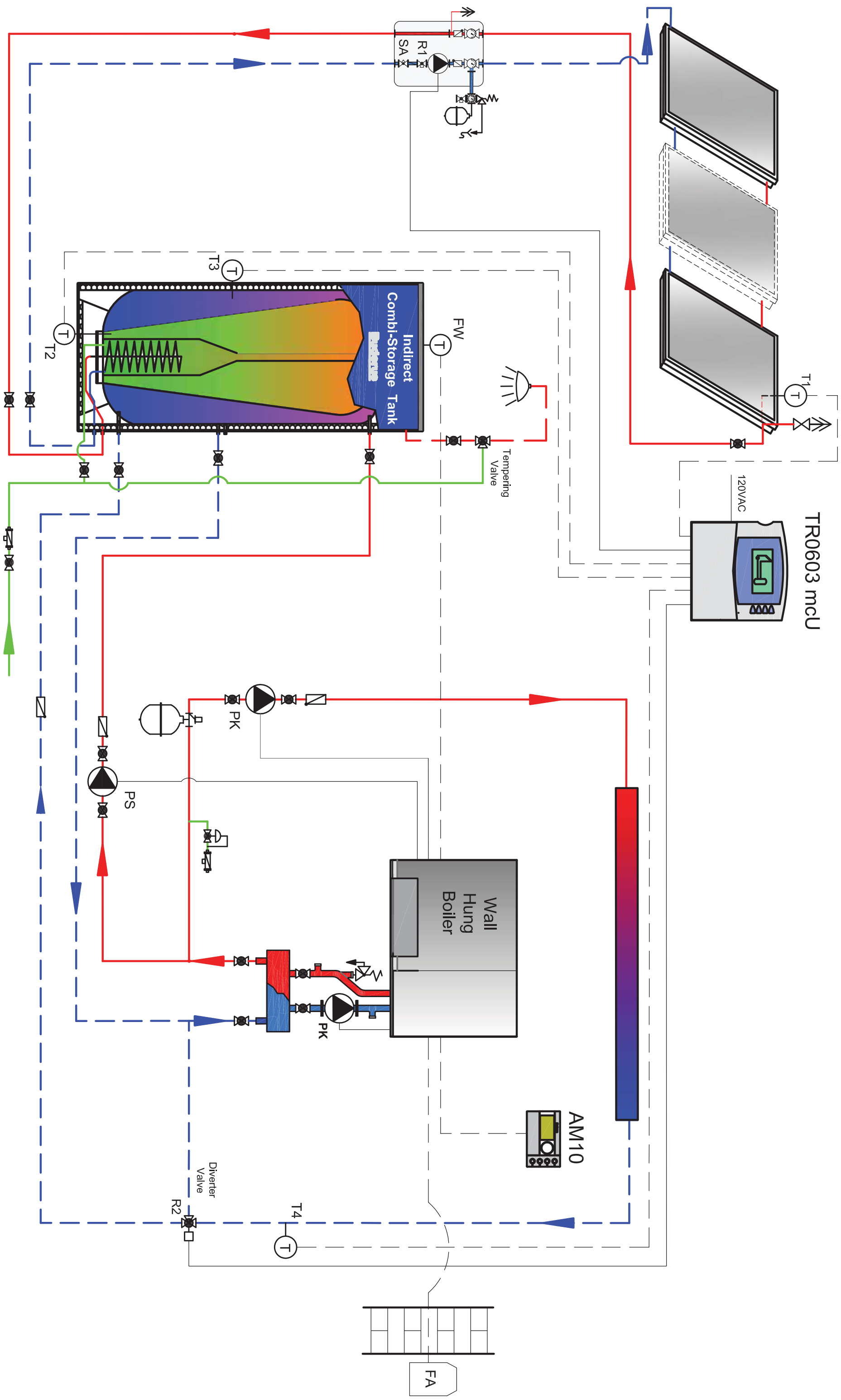


3.3.9 Wiring diagram - Single heating zone with system pump, dual coil DHW tank, floor standing commercial boiler, TR 0301U solar control

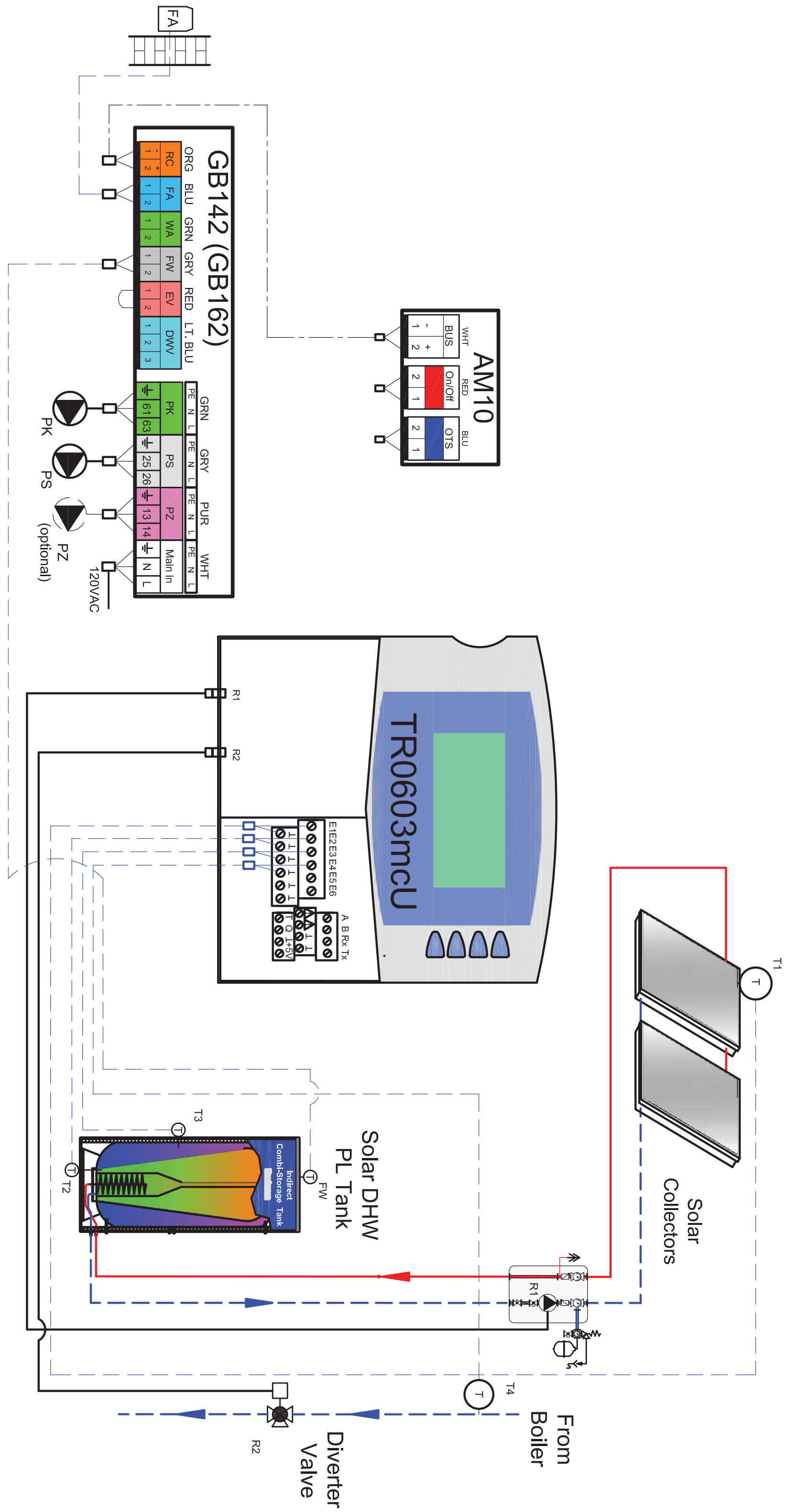


3.4 PL750 tank applications

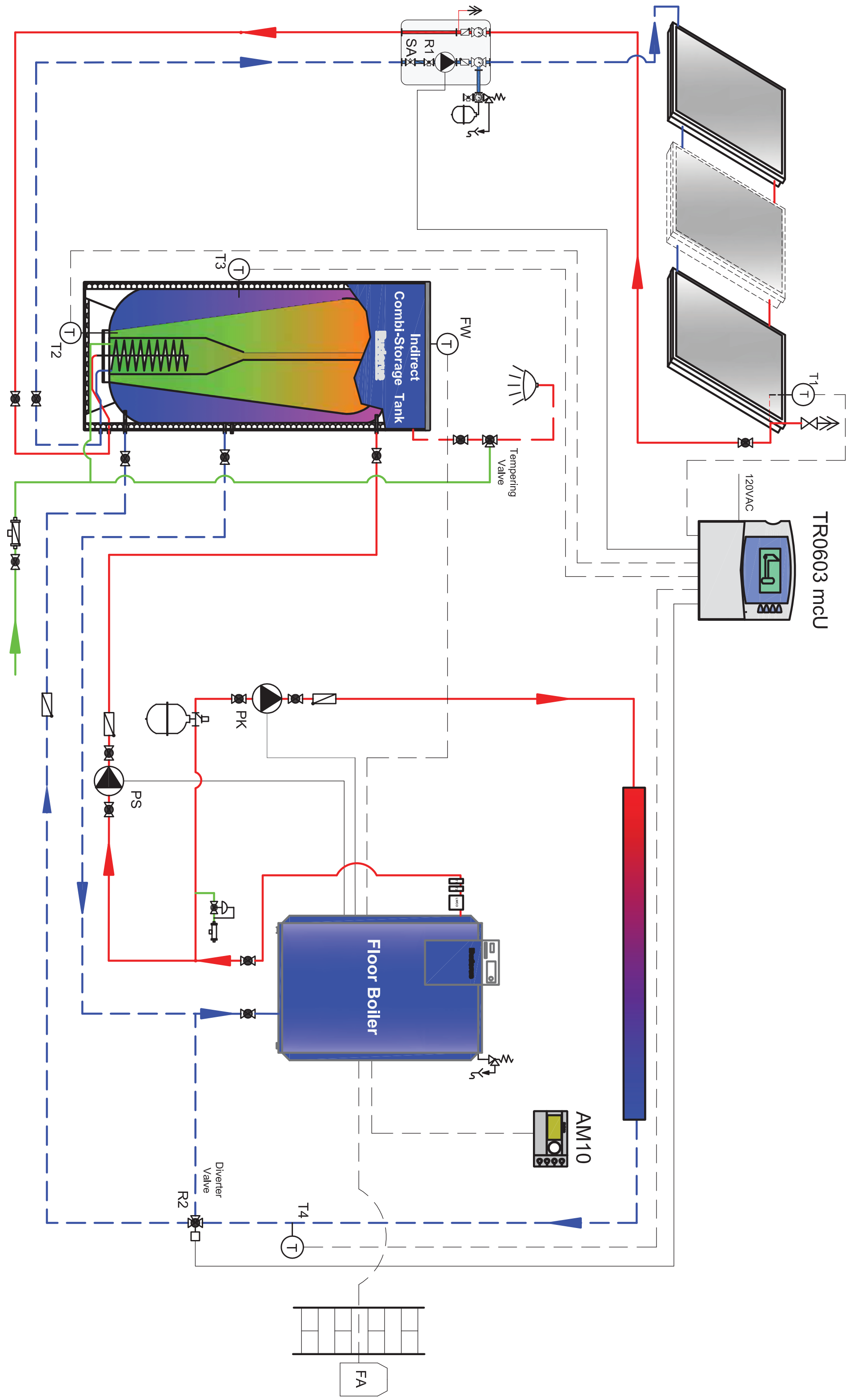
3.4.1 Piping diagram - Single heating zone with system pump, wall hung boiler, combi tank, AM10, TR 0603mcU solar control



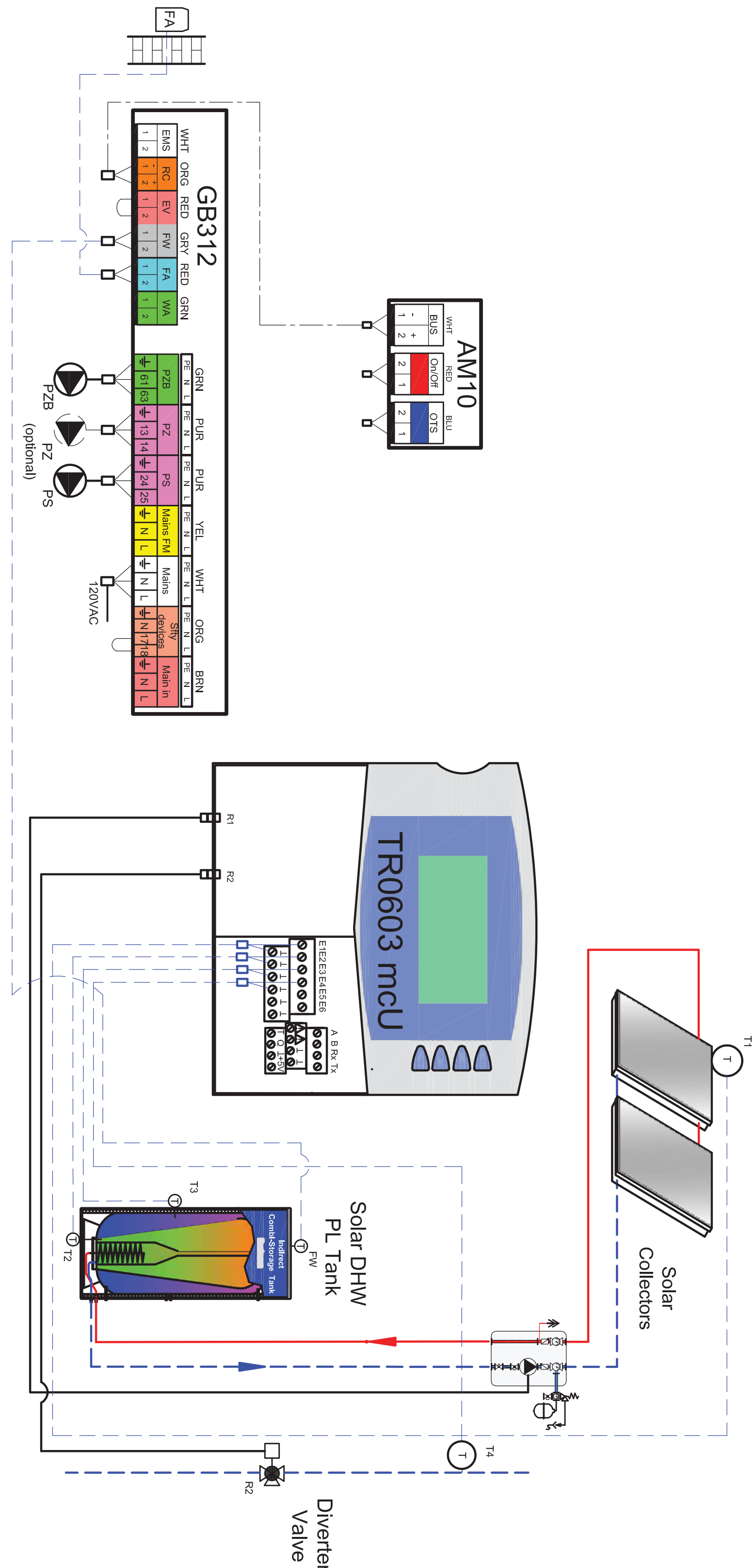
3.4.1 Wiring diagram - Single heating zone with system pump, wall hung boiler, combi tank, AM10, TR 0603mcU solar control



3.4.2 Piping diagram - Single heating zone with system pump, wall hung boiler, combi tank, AM10, TR 0603mcU solar control

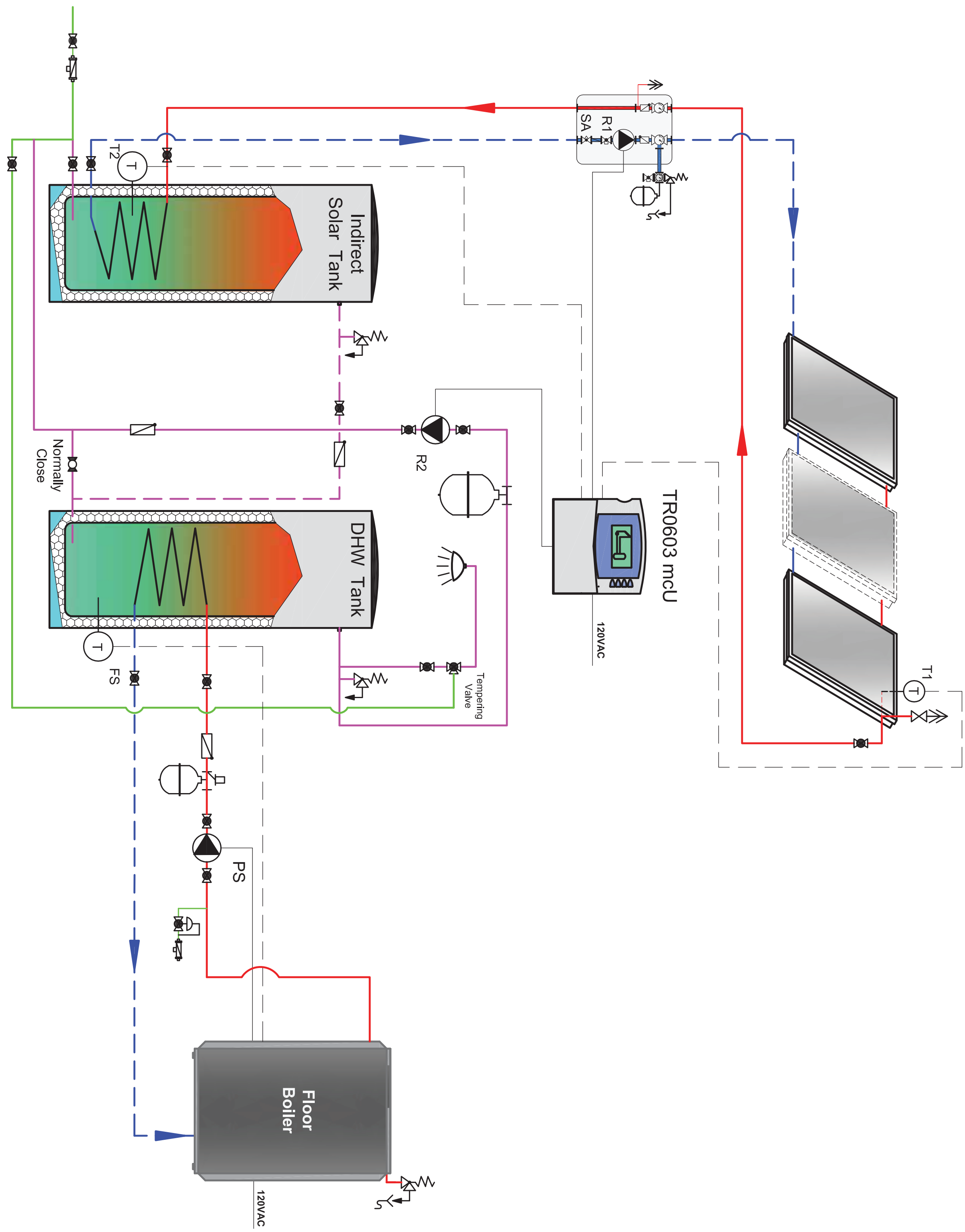


3.4.3 Wiring diagram - Single heating zone with system pump, wall hung boiler, combi tank, AM10, TR 0603mcU solar control

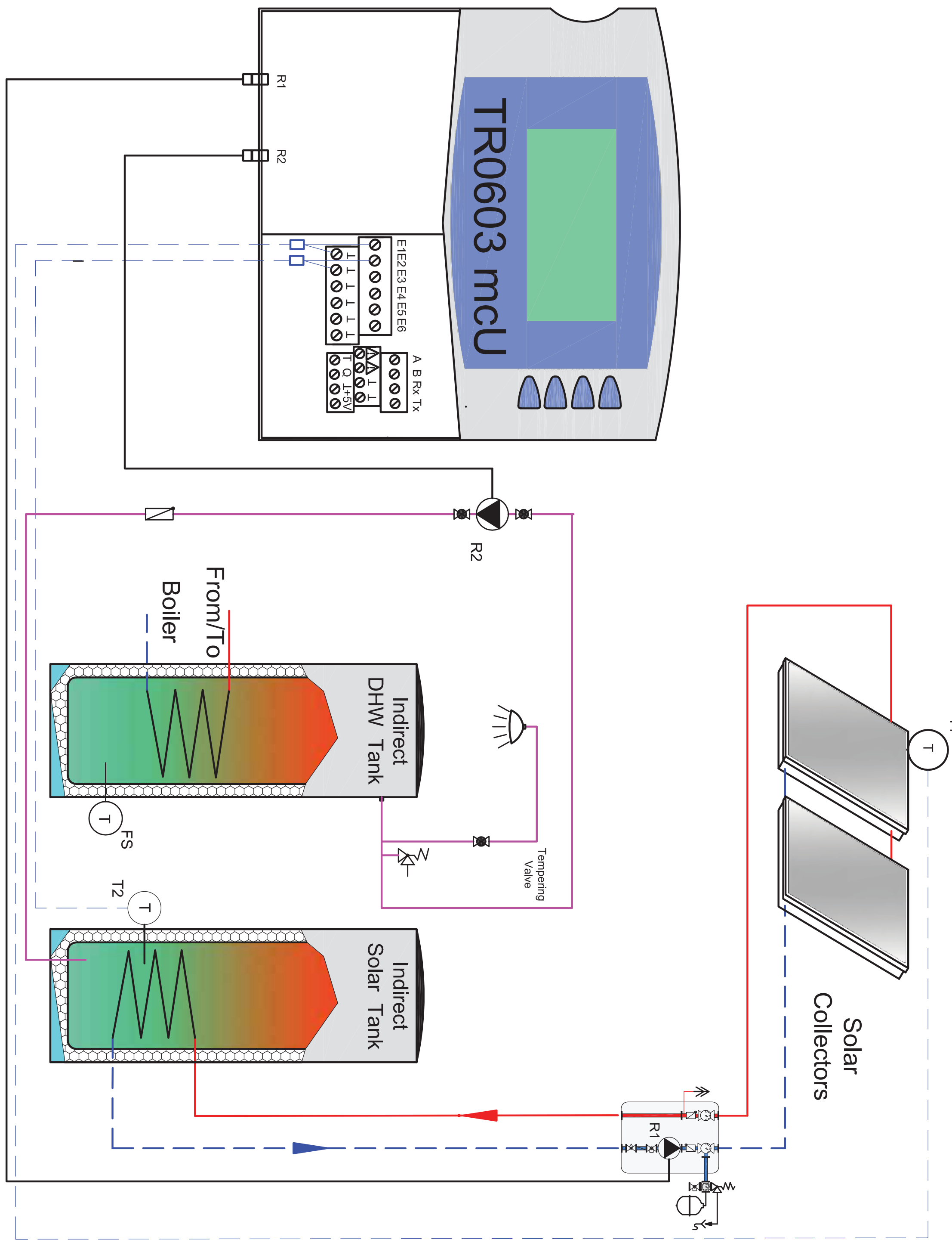


3.5 Commercial applications

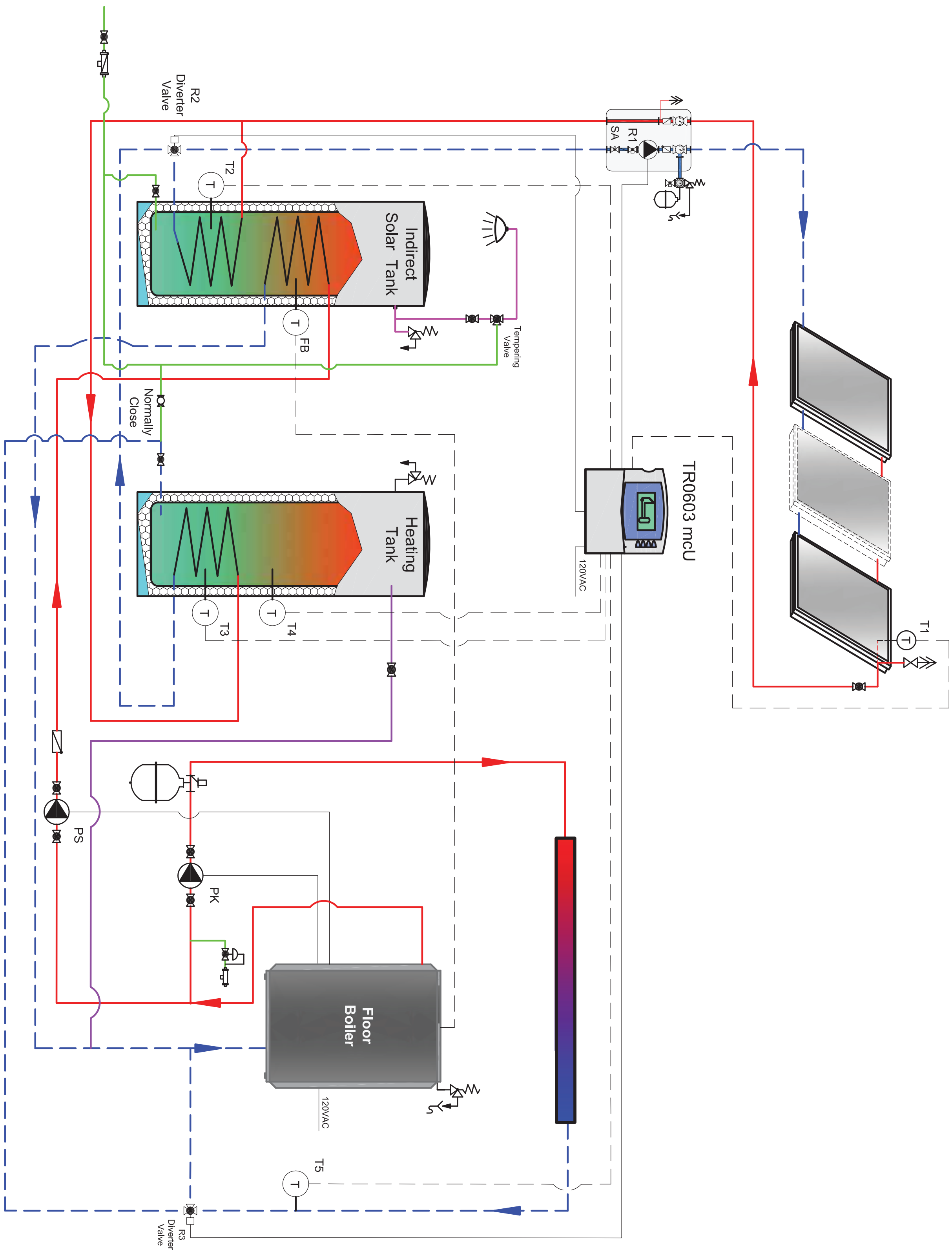
3.5.1 Piping diagram - Two DHW tanks, floor standing boiler, TR 0603mcU solar control



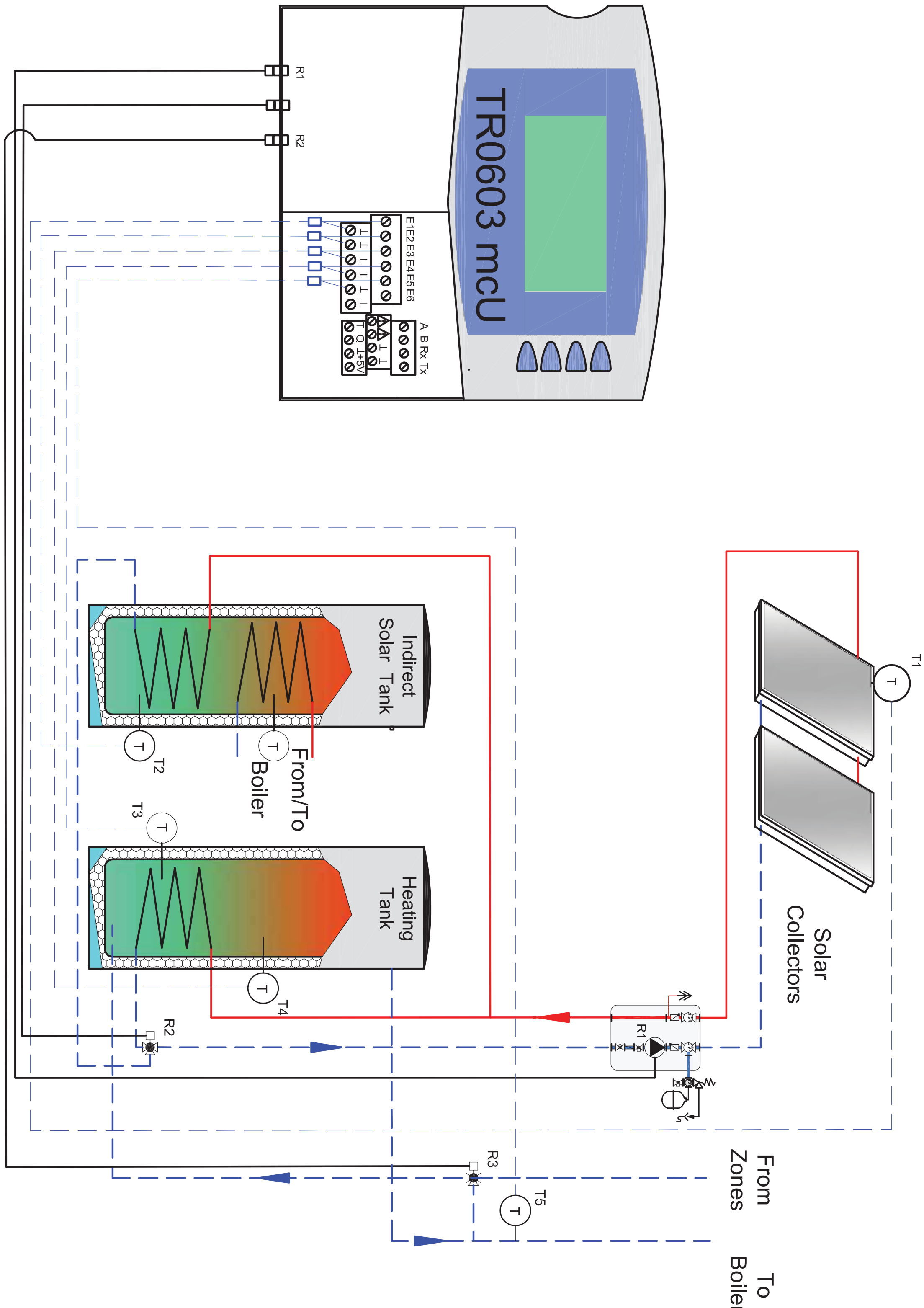
3.5.1 Wiring diagram - Two DHW tanks, floor standing boiler, TR 0603mcU solar control



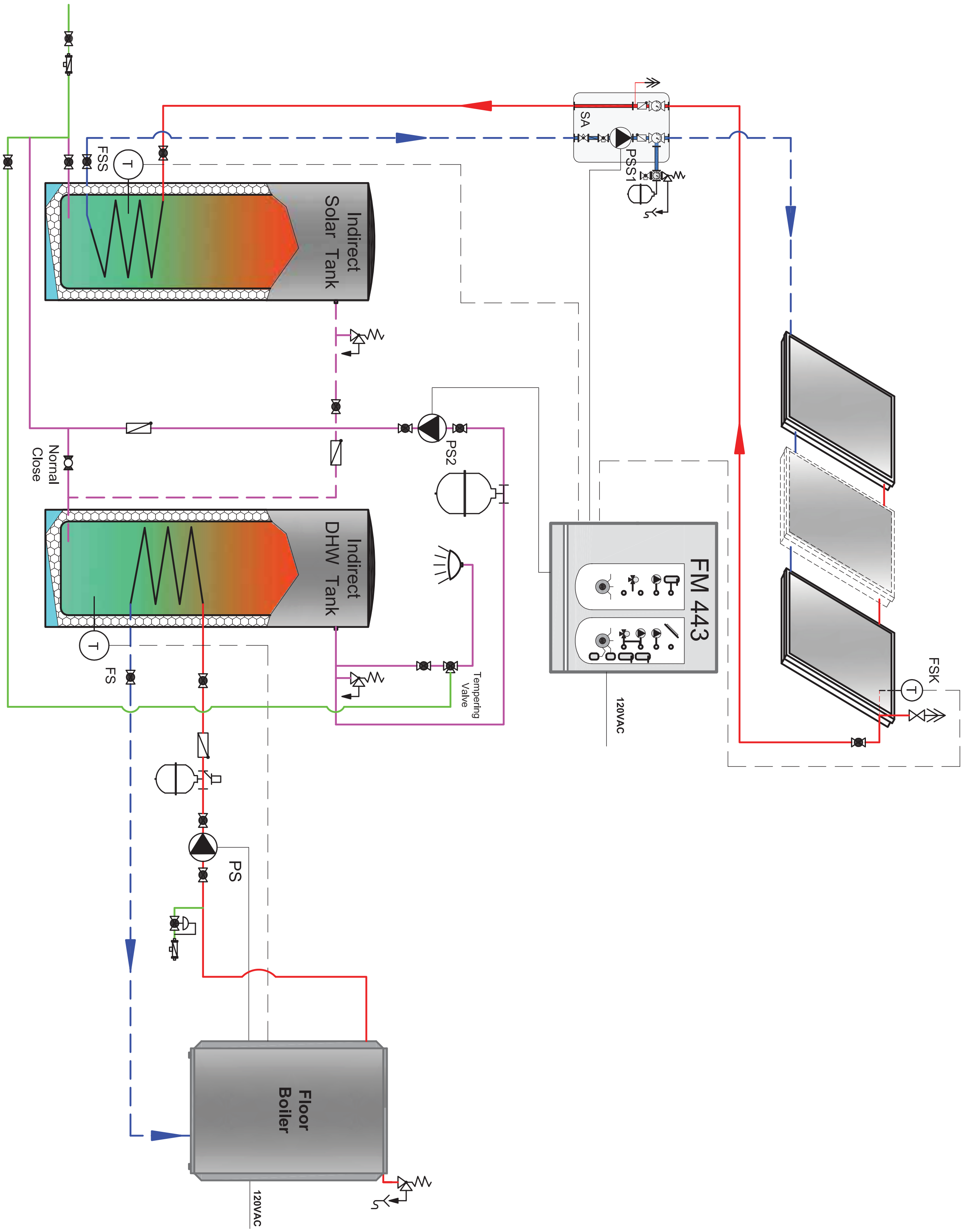
3.5.2 Piping diagram - Single heating zone with system pump, two DHW tanks, floor standing boiler, TR 0603mcU solar control



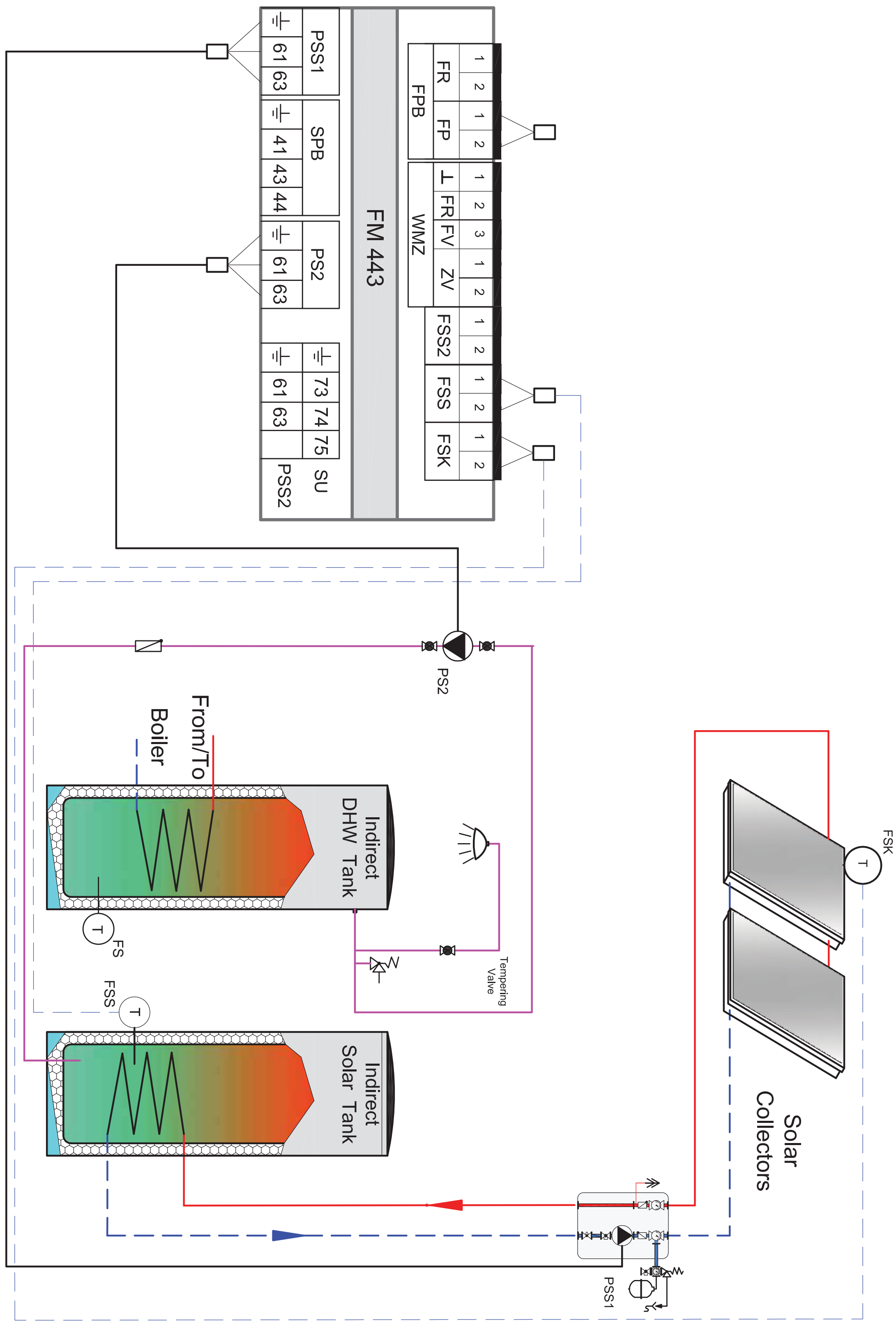
3.5.2 Wiring diagram - Single heating zone with system pump, two DHW tanks, floor standing boiler, TR 0603mcU solar control



3.5.3 Piping diagram - Single heating zone with system pump, two DHW tanks, floor standing boiler, FM443

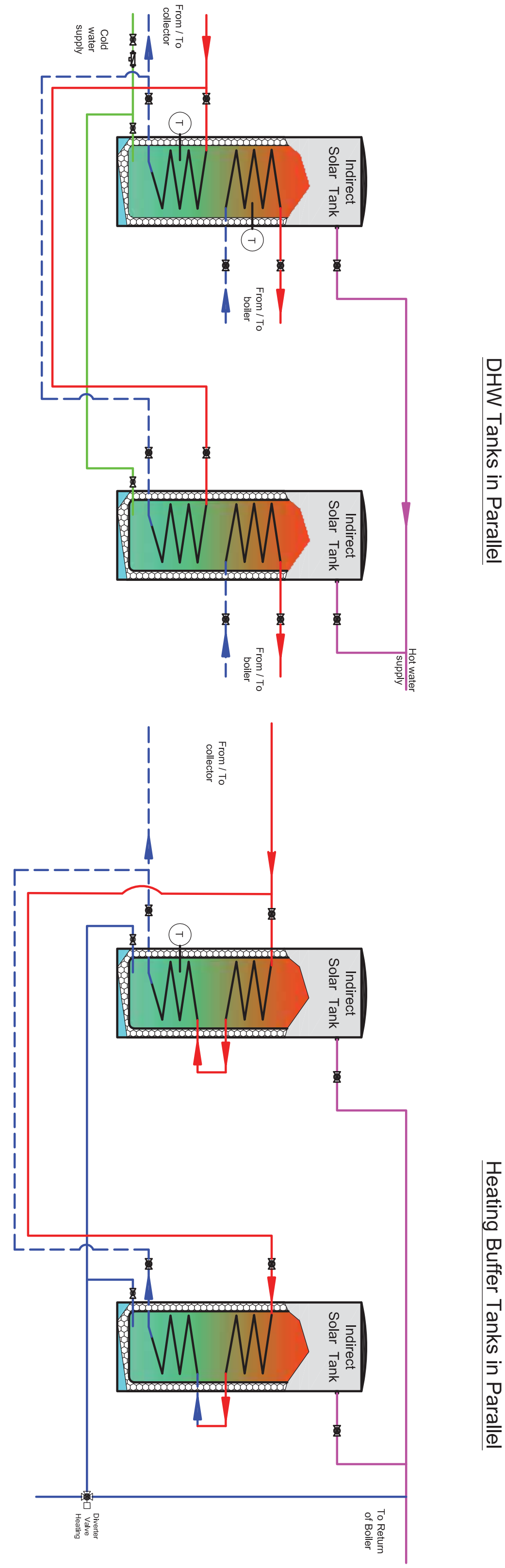


3.5.3 Wiring diagram - Single heating zone with system pump, two DHW tanks, floor standing boiler, FM443

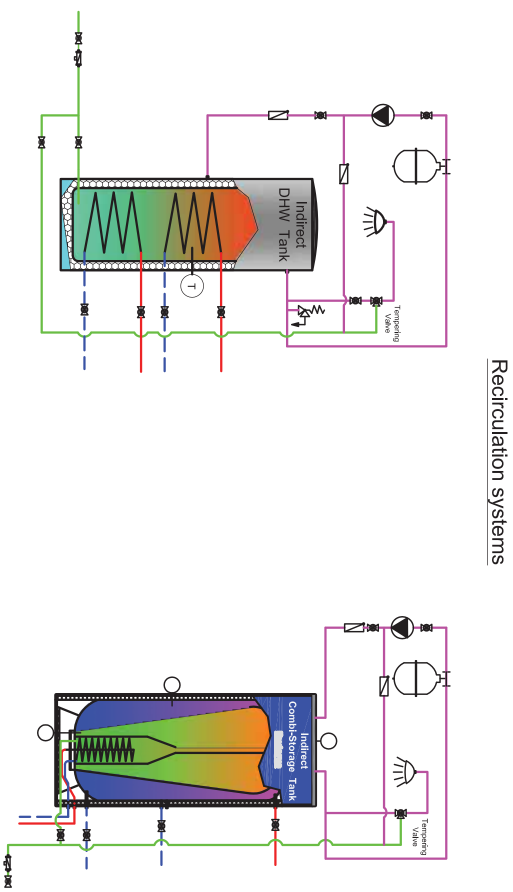


3.6 Piping - parallel tank applications

3.6.1 Piping diagram - DHW tanks piped in parallel, , buffer tanks piped in parallel, DHW recirculation system



Note: All parallel piping circuits shown must be balanced in order to guarantee equal flow thru all circuits. Properly sized reverse-return piping may be used for applications comprised of only two parallel circuits. Applications with more than two parallel circuits must use some type of mechanical device to properly balance the flow rate thru each individual parallel circuit (i.e. autoflow or circuit setter).



4 Sizing

4.1 Sizing principles

4.1.1 Solar DHW heating

Solar heating systems are most frequently used for DHW heating. Check each case individually as to whether it is possible to upgrade an existing heating system with a solar heating system. The conventional heat source must be able to provide the hot water in a building independently of the solar heating system. There is also an appropriate comfort requirement that must be reliably covered during periods of bad weather.

Coverage of 50% to 60% is generally desirable for DHW heating systems for single family homes and two-family homes. Sizing for less than 50% is also relevant if the available consumption values are unreliable. A coverage of less than 50% is generally appropriate in multifamily buildings.

4.1.2 Domestic hot water (DHW) heating and central heating

Solar heating systems can also be designed as combination systems for DHW heating and central heating. Solar swimming pool water heating, combined with DHW heating and central heating is also possible.

Since the system is operated at low temperatures during the spring and fall, the type of heat distribution only plays a minor part in the efficiency of the system. A solar heating system for providing central heating can be realized in combination with an underfloor radiant heating system and with radiators.

The desired coverage for DHW heating systems combined with central heating is between 15% and 35% of the total annual heating demand for DHW and central heating. The achievable coverage is largely dependent on the building's heating demand.

The Logasol SKS4.0 high-performance flat-plate collector is particularly recommended as solar collectors for systems with central heating because of their high efficiency and dynamic response behavior.

4.1.3 Sizing with computer simulation

It is advisable to size the solar heating system using computer simulation:

- With six collectors or more, or
- If there is a significant difference from the calculation conditions in the sizing diagrams

Correct sizing essentially depends on the accuracy of the information concerning the actual DHW demand.
The following values are important:

- Daily DHW demand
- Daily profile, DHW demand
- Weekly profile, DHW demand
- Seasonal influence on the DHW demand (e. g. camp site)
- Set DHW temperature
- Existing DHW heating equipment (if an existing system is being extended)
- Recirculation losses
- Location
- Orientation
- Slope

The GetSolar simulation program is extremely practical for calculating solar heating systems. Simulation programs require consumption values as well as the size of the collector array and the storage tank. Consumption information should always be obtained, since values taken from literature are of little use.

The collector array and the solar heating storage tank must therefore be pre-sized for the computer simulation. The required output result is obtained in stages.

The GetSolar program stores results such as temperatures, energy levels, efficiencies and coverage in a file. This information can be displayed on screen in many different ways and can be printed out for further analysis.

4.2 Sizing the collector array and solar heating storage tank

4.2.1 Systems for DHW heating in single family homes and two-family homes

Number of collectors

Empirical values from single family homes and two family homes can be used when a small solar heating system for DHW heating is being sized. The following factors influence the optimum sizing of the collector array, the storage tank and the pumping station for solar collector systems for DHW heating:

- Location
- Roof slope (collector angle of inclination)
- Roof orientation (south-facing collector)
- DHW consumption profile

Take the draw-off temperature in accordance with the existing or intended sanitary equipment into consideration. The typical number of occupants and the average consumption per person per day are essential for a reasonably accurate estimation. Information about particular draw-off habits and comfort requirements are ideal.

Calculation principles

Figures 48 to 54 are based on a sample calculation with the following system parameters:

- Logasol SKS4.0 high-performance flat-plate collectors, Logasol SKN3.0 flat-plate collectors
- Logasol SKN3.0: Logalux SM300 dual-coil storage tank (for more than three collectors: Logalux SM400)
- South-facing roof orientation (correction factor , page 44)
- Roof incline 45° (correction factor , page 44)
- Location Albany, NY
- Draw temperature 113 °F

Determining the number of collectors in accordance with Fig. 48, 49 or 54 results in a solar coverage of approx. 60%

Example

- Household with four occupants and a DHW demand of 50 gallons per day
- Solar heating system for DHW heating

According to Fig. 48, curve b, two Logasol SKS4.0 high-performance flat-plate collectors are required.

Logasol SKS4.0

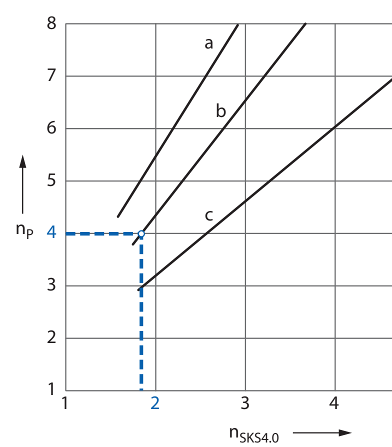


Fig. 48 Diagram for an approximate determination of the number of Logasol SKS4.0 collectors for DHW heating (example highlighted, observe calculation principles!)

Legend

$n_{SKS4.0}$ Number of collectors
n_P Number of occupants

DHW demand curves:
a Low (< 10 gallons per person per day)
b Average (13 gallons per person per day)
c High (20 gallons per person per day)

Logasol SKN3.0

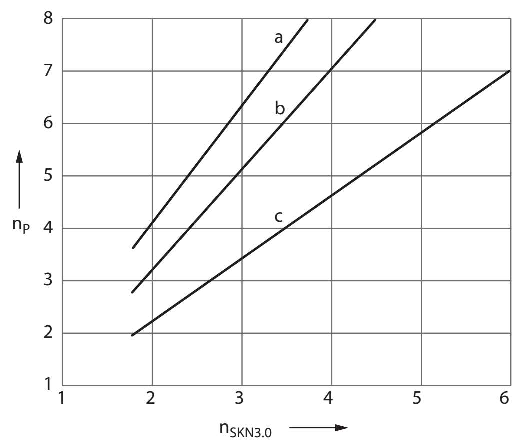


Fig. 49 Diagram for an approximate determination of the number of Logasol SKN3.0 collectors for DHW heating (observe calculation principles!)

Legend

$n_{SKN3.0}$ Number of collectors

n_P Number of occupants

DHW demand curves:

a Low (< 10 gallons per person per day)

b Average (13 gallons per person per day)

c High (20 gallons per person per day)

Influence of collector orientation and inclination on solar yield

Optimum angle of inclination for collectors

Use of solar heat for	Optimum angle of inclination of collectors
DHW	30° – 45°
Domestic hot water + central heating	45° – 53°
Domestic hot water + swimming pool water	30° – 45°
Domestic hot water + central heating + swimming pool water	45° – 53°

Fig. 50 Angle of inclination of collectors subject to the use of solar heating system

The optimum angle of inclination depends on the use of the solar heating system. The shallower angles of inclination for DHW and swimming pool water heating take into account the higher position of the sun in the summer. The steeper angles of inclination for central heating are designed for the lower sun position in spring and fall.

Collector orientation according to the points on the compass

Orientation in accordance with the points on the compass and the angles of inclination of the solar collectors have an influence on the thermal energy that is supplied by a collector array. For maximum solar yield align the collectors at an angle of inclination close to angle of latitude of the site, and within 10° East or West of due South.
If the collector array is mounted on a steep roof or a wall, the orientation of the collector array is identical to that of the roof or wall. If the collector array orientation deviates to the east or west, the rays of the sun will no longer strike the absorber area in the most effective way. This will reduce the performance of the collector array.
According to Fig. 51, there is a correction factor for every collector array deviation from the southern point of the compass, subject to the angle of inclination. The collector area that was determined under ideal conditions must be multiplied by this factor to achieve the same energy yield as is achieved with direct southern orientation.

Correction factors for solar collectors Logasol SKN3.0 and SKS4.0 for DHW heating

Angle of Inclination	Correction factors for collector orientation deviation from south												
	Deviation to the west by						South	Deviation to the east by					
	90°	75°	60°	45°	30°	15°	0°	-15°	-30°	-45°	-60°	-75°	-90°
Lat + 20°	1.26	1.19	1.13	1.09	1.06	1.05	1.05	1.06	1.09	1.13	1.19	1.26	1.34
Lat + 15°	1.24	1.17	1.12	1.08	1.05	1.03	1.03	1.05	1.07	1.12	1.17	1.24	1.32
Lat + 10°	1.23	1.16	1.10	1.06	1.03	1.02	1.01	1.04	1.06	1.10	1.16	1.22	1.30
Lat + 5°	1.21	1.15	1.09	1.05	1.02	1.01	1.00	1.02	1.04	1.08	1.14	1.20	1.28
Latitude	1.20	1.14	1.09	1.05	1.02	1.01	1.00	1.02	1.04	1.08	1.13	1.19	1.26
Lat - 5 °	1.20	1.14	1.09	1.05	1.02	1.01	1.01	1.02	1.04	1.08	1.12	1.18	1.25
Lat - 10°	1.19	1.14	1.09	1.06	1.03	1.02	1.01	1.03	1.05	1.08	1.13	1.18	1.24
Lat - 15°	1.19	1.14	1.10	1.07	1.04	1.03	1.03	1.04	1.06	1.09	1.13	1.17	1.22

Correction ranges: 1.00–1.05 1.06–1.10 1.11–1.15 1.16–1.20 1.21–1.25 > 1.25

Fig. 51 Correction factors with south deviation of Logasol SKN3.0 and SKS4.0 solar collectors for different angles of inclination

The correction factors only apply to DHW heating and not for central heating.

Example

- *Parameters*
  - *Household with four occupants with DHW demand of 50 gallons per day*
  - *Location: Albany, NY (approx. 40° Latitude)*
  - *Angle of inclination 25° with rooftop installation of Logasol SKS4.0 solar collectors*
  - *Deviation to the west by 60°*

- *Measure*
  - *1.8 Logasol SKS4.0 collectors (Fig. 62)*
  - *40° Latitude - 15° = 25° roof inclination*
  - *Correction factor 1.10 (Fig. 65)*
  - *The calculation results in: 1.8 × 1.10 = 2.0*

To achieve the same energy yield as with direct southerly orientation, allow for 2 Logasol SKS4.0 solar collectors.

Storage tank selection

A suitable ratio between collector output (size of collector array) and storage tank capacity (storage tank volume) is required to make a solar heating system operate efficiently. The size of the collector array is limited subject to the storage tank capacity (Fig. 52).

A dual-coil solar storage tank has a solar heat exchanger and a heat exchanger for reheating by a boiler. In this concept the upper part of the storage tank acts as the standby part.
Note: when replacing an old indirect tank with a new dual coil tank please check to be sure the recovery rating when using the upper coil only matches the application need.
Two-storage tank systems are only worthwhile for greater DHW demands than can be covered by a dualcoil storage tank. In such systems, a single coil storage tank for accepting the solar heat is installed upstream of a conventional storage tank.

The conventional storage tank must be sized to cover all DHW demands. The solar storage tank can therefore be somewhat smaller. This concept can also be used for retrofitting a solar heating system in a conventional system. However, the use of a dual-coil storage tank should always be considered for energy and financial reasons.

Rule of thumb
A storage tank volume of twice the daily demand has proven to be adequate. Table 45/1 shows standard values for selecting the DHW storage tank subject to the DHW demand per day for the relevant number of occupants. A storage tank temperature of 140 °F (60 °C) and a draw-off temperature 113 °F (45 °C) have been assumed. In a multi-storage tank system the stored volume of DHW should be able to cover twice the daily demand with a draw-off level of 85%.

DHW storage tank	Recommended daily DHW demand in gallons	Recommended number of occupants with a DHW demand per person per day of			Capacity	Rec. no.[1] Collectors SKN3.0 or SKS4.0
Logalux	with storage tank temperature of 140 °F (60 °C) and draw-off temperature of 113 °F (45 °C)	10 gallons Low	13 gallons Average	20 gallons High	gallons	
SM300	up to 53/66	approx. 5–6	approx. 4-5	approx. 3	77	2–3
SM400	up to 66/80	approx. 6-8	approx. 5-6	approx. 3-4	103	3–4

Fig. 52 Standard values for selecting the DHW storage tank
1) Determining the number of collectors, page 45

4.2.2 Systems for DHW heating and central heating in single family homes and two-family homes

Number of collectors

The sizing of the collector array for a solar heating system for DHW heating and central heating backup is directly dependent on the heating demand of the building and the required solar coverage. Only partial coverage is generally achieved during the heating season.

Figures 53 to 55 assume an average DHW demand for a 4-person household to be 13 gallons per person per day for DHW heating.

Calculation principles

Figures 53 to 55 are based on a sample calculation with the following system parameters:

- Logasol SKS4.0 high-performance flat-plate collectors, Logasol SKN3.0 flat-plate collectors
- Logasol SKS4.0: Thermosiphon combi storage tank PL750/2S
- Household with four occupants with a DHW demand of 53 gallons per day
- Roof orientation towards south
- Roof pitch 45°
- Location Albany, NY
- Low temperature heating supply with ∂v = 104 °F (40 °C), return □R = 86 °F (30 °C)

Example

- Household with four occupants with a DHW demand of 53 gallons per day
- Solar heating system for DHW heating and underfloor radiant heating
- Heating demand 28,000 BTU/hr (8kW)
- Required coverage 25%

According to Figure 53, curve c, six Logasol SKS4.0 high-performance flat-plate collectors are required.

Logasol SKS4.0

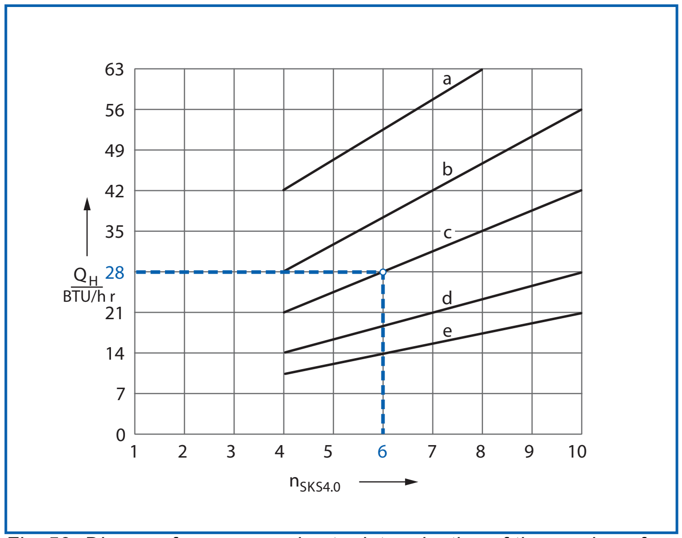


Fig. 53 Diagram for an approximate determination of the number of Logasol SKS4.0 collectors for DHW heating and central heating (example highlighted, observe calculation principles!)

Legend

$n_{SKS4.0}$ Number of collectors
Q_H Building heating demand

Curves for coverage of total annual heating demand for DHW heating and central heating

a Coverage of approx. 15 %
b Coverage of approx. 20 %
c Coverage of approx. 25 %
d Coverage of approx. 30 %
e Coverage of approx. 35 %

Logasol SKN3.0

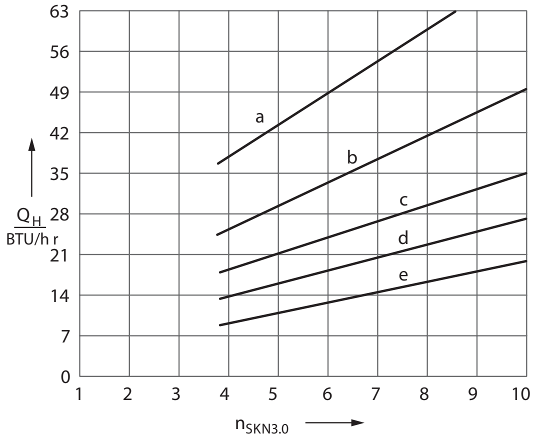


Fig. 54 Diagram for an approximate determination of the number of Logasol SKN3.0 collectors for DHW heating and central heating (observe calculation principles!)

Legend

$n_{SKN3.0}$ *Number of collectors*
Q_H *Building heating demand*

Curves for coverage of total annual heating demand for DHW heating and central heating

- *a Coverage of approx. 15 %*
- *b Coverage of approx. 20 %*
- *c Coverage of approx. 25 %*
- *d Coverage of approx. 30 %*
- *e Coverage of approx. 35 %*

Storage tank selection

Solar heating systems for DHW heating and central heating should be operated using a combination storage tank if possible. When a storage tank is being selected ensure that the DHW standby part corresponds to the user's usage pattern. Besides providing an adequate supply of DHW, a solar heating system for DHW heating and central heating must also take the building heating demand into consideration.

Fig. 55 shows standard values for selecting the combi storage tank subject to the DHW demand per day for the relevant number of occupants, and the recommended number of collectors. A storage tank volume of at least 26 gallons must be available per flat-plate collector to minimize stagnation times. The total coverage can be sized in accordance with Figures 55 to 63. A detailed result can be obtained by simulation using a suitable simulation software

DHW storage tank **Logalux**	Recommended daily DHW demand in gallons at a storage tank temperature of 140 °F (60 °C) and draw-off temperature of 113 °F (45 °C)	Recommended number of occupants	Capacity DHW/total gallons	Recommended number[1)] of collectors SKN3.0 or SKS4.0
PL750/2S	**up to 66/92**	**approx. 3-9**	**80/200**	**4–8**

Fig. 55 Standard values for selecting the combi storage tank
1) Determining the number of collectors, page 45

Alternatively it is possible to install a two-storage tank system instead of a combi storage tank. This would be particularly advisable if an additional DHW demand or buffer water demand arises due to an additional consumer. The number of collectors must be adapted to the demand of the additional consumer in this case (e.g. swimming pool or thermal store).

DHW storage tank **Logalux**	Recommended daily DHW demand in gallons at a storage tank temperature of 140 °F and draw-off temperature of 113 °F	Recommended number of occupants with DHW demand per person per day of			Storage tank capacity gallons	Rec. number[1)] of collectors SKN3.0 or SKS4.0
		10 gallons Low	13 gallons Average	20 gallons High		
SM300	up to 53/66	approx. 5-6	approx. 4-5	approx. 3	77	2–3
SM400	**up to 66/80**	**approx. 6-8**	**approx. 5-6**	**approx. 3-4**	**103**	**3–4**

Fig. 56 Standard values for selecting the DHW storage tank for a two-storage tank system
1) Determining the number of collectors, page 45

4.2.3 Multifamily buildings with 3 to 5 residential units

Dual-coil storage tank in large systems

For small single family homes the pre-heating stage (the part of the storage tank volume that is heated by the solar heating system) and the standby part (conventionally heated storage tank volume) can be combined in a dual-coil storage tank. For rapid DHW delivery to the individual flats, a connecting line with recirculation pump is recommended between the DHW outlet and the cold water inlet. The pump is controlled via the FM443 solar function module. This means that a coverage of approx. 30% can be achieved for a system with a Logalux storage tank with 4 or 5 collectors and a DHW demand of 26 gallons at 140 °F (60 °C) per residential unit.

When sizing the storage tank ensure that the DHW demand can also be covered without solar yield via conventional reheating.

Daily heating/disinfection control

Disinfection can only be achieved if the same parameters as for multifamily buildings with up to 30 residential units are met.

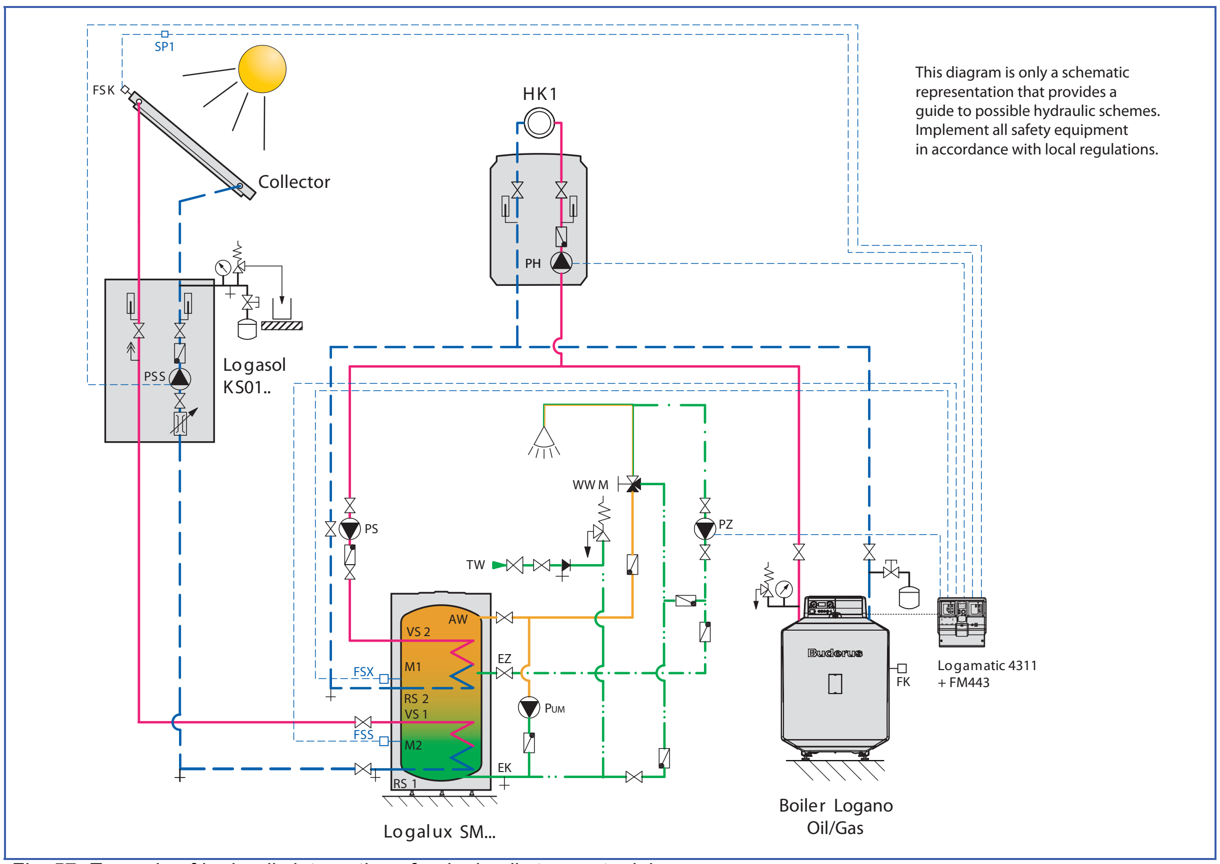


Fig. 57 Example of hydraulic integration of a dual-coil storage tank in large systems for multifamily buildings of 3 to 5 residential units; control of storage tank water transfer and disinfection using solar function module FM443

4.2.4 Multifamily housing with up to 30 residential units

Two-storage tank system with pre-heating stage

In systems with uniform consumption or lesser coverage requirements of approx. 20% to 30%, systems with pre-heating stages filled with DHW can be a financially interesting solution.

Systems with DHW storage tanks are suitable for retrofitting, since the pre-heating stage and the standby part have separate storage tanks. The preheating stage and the standby storage tank can be sized separately. The set temperature for the standby storage tank is at least 140 °F (60 °C). Solar heating must be enabled up to 167 °F (75 °C) so that the solar heating system can utilize the entire storage tank volume. The solar function module FM443 switches pump PUM ON for a water transfer between the two storage tanks if the pre-heating storage tank is hotter than the standby storage tank. This means that both storage tanks are heated above the set temperature, and the heat loss due to DHW circulation can also be covered by solar energy.

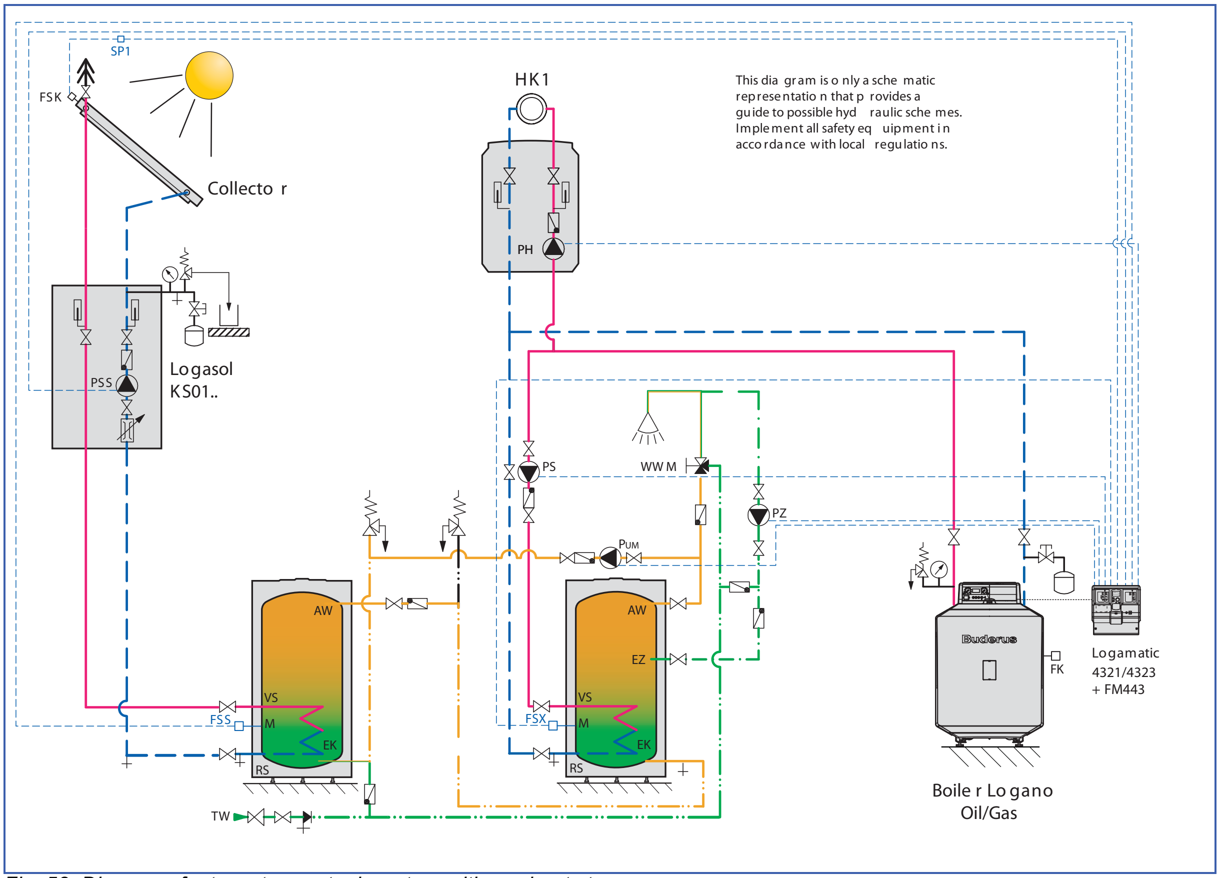


Fig. 58 Diagram of a two-storage tank system with pre-heat storage tank and standby storage tank filled with DHW; storage tank water transfer and disinfection by solar function module FM443

Daily heating/disinfection control

Follow local codes and regulation for disinfection and prevention of Legionnaires’ disease outbreak.

Collector area sizing

Apply a daily consumption of approx. 1.8 - 2.0 gallons of DHW at 140 °F (60 °C) per ft² of collector area for sizing the collector area in properties with a uniform consumption profile, such as in multifamily buildings.

By way of simplification, the following formula can be used taking the specified marginal conditions into consideration:

$$n_{SKS4.0} = 0.6 \cdot n_{WE}$$

$$n_{SKN3.0} = 0.7 \cdot n_{WE}$$

Fig. 59 Formulae for the required number of Logasol SKS4.0, SKN3.0 solar collectors in relation to the number of residential units (observe marginal conditions!)

Calculating sizes

nSKS4.0 *Number of Logasol SKS4.0 solar collectors*
nSKN3.0 *Number of Logasol SKN3.0 solar collectors*
nWE *Number of residential units*

Marginal conditions for formula (Fig. 59)

- *Re-circulation cost: 340 BTU/hr per unit (100W/unit) Old building: 480 BTU/hr per unit (140W/unit)*
- *Pre-heat storage tank temperature max. 167 °F (75 °C), water transfer enabled*
- *26 gal per unit at 140 °F (100 l/unit at 60 °C)*

Storage tank volume sizing

The DHW storage tanks connected in series must be equipped with a water transfer system. Ensure that daily heating takes place, and also a transfer of hotter water from the pre-heat storage tank to the standby storage tank. The storage tank volume for the solar heating system then consists of the volume of the preheat storage tank plus the volume of the standby storage tank.

Sensor positions are critical for storage tank selection. A storage tank with removable flexible foam insulation makes it possible to attach additional contact sensors using straps.

Pre-heat storage tank

The minimum pre-heat storage tank volume should be approx. 5 gallons/ft² of collector area:

$$V_{VWS,min} = A_K \cdot 5 \text{ gallons/ft}^2$$

Fig. 60 Formula for minimum pre-heat storage tank volume in relation to the collector area

Calculating parameters (Fig. 60)

AK Collector area in ft²

VVWS,min Minimum pre-heat storage tank volume in gallons

An increase in the specific storage tank volume increases the system's robustness to buffer fluctuations in demand.

A pre-heat storage tank needs two additional sensors at 20% and 80% of the storage tank height.

The maximum number of collectors for the pre-heat storage tank refers to a maximum storage tank temperature of 167 °F (75 °C) and solar heating system coverage of 25% to 30%. Simulations must be used to verify that stagnation is unlikely to occur, as during stagnation available solar energy is no longer utilized. This is particularly important for properties with limited summer use (e.g. schools).

Standby storage tank

The standby storage tank is only heated by a lower temperature differential (maximum temperature minus reheat temperature) compared to the pre-heat storage tank, but this tank provides about one third of the necessary storage tank capacity because of its larger volume. The heating of the standby storage tank also enables integration of solar for coverage of the heat loss resulting from the DHW re-circulation.

The standby storage tank is sized in accordance with conventional heat demand without taking the preheat storage tank volume that is heated using solar energy into consideration. However, the specific total storage tank volume should be approx. 1.2 gallons/ft² of collector area:

$$\frac{V_{BS} + V_{VWS}}{A_K} \geq 1.2 \text{ gallons/ft}^2$$

Fig. 61 Formula for minimum total storage tank volume of pre-heat stage and standby part per square foot of collector area

Calculating parameters (Fig. 61)

AK Collector area in ft²

VBS Standby storage tank volume in gallons

VVWS Pre-heat storage tank volume in gallons

4.3 Swimming pool water heating systems

The weather conditions and the swimming pool heat loss into the ground have a considerable influence on sizing. For that reason, sizing a solar heating system for heating swimming pool water can only ever be approximate. Basically, the sizing has to be oriented to the area of the pool. The water cannot be guaranteed to be at a certain temperature over several months.

If the solar swimming pool water heating system is combined with DHW heating, we recommend the use of a Logalux SM... dual-mode solar heating storage tank with a large solar indirect coil and limited storage tank heating up to 140 °F.

Standard values for indoor swimming pools with covers.

Conditions for standard indoor swimming pool values:

- Pool basin covered when not in used (insulation)
- Set pool water temperature 75 °F

If the required set water temperature is higher than 75 °F, the number of required collectors increases by the correction factor in Fig. 62.

Standard values for outdoor swimming pools

The standard values only apply if the swimming pool is insulated and embedded in the ground in a dry condition. First insulate the pool if the swimming pool is at the level of groundwater without insulation. Then carry out a heat demand calculation.

Covered outdoor swimming pool (or indoor swimming pool without insulation)
A ratio of 1:2 applies as standard value. This means that the area of a collector array with Logasol SKN or SKS must be half the size of the pool surface area.

Outdoor swimming pool without insulation
In this case the standard value ratio is 1:1. This means that the area of a collector array comprising Logasol SKN or SKS must be the same size as the pool surface. If the solar heating system is intended for an outdoor swimming pool, DHW heating and/or central heating backup, add the required collector areas for the swimming pool water and DHW. Do not add the collector areas for central heating. The solar heating system heats the outdoor swimming pool in summer and central heating in winter. DHW is heated all year round.

Range	Reference size	Sizing with solar collectors	
		SKN3.0	SKS4.0
Pool surface	Pool surface in ft^2	1 collector for every 50ft^2	1 collector for every 70ft^2
Correction factor for pool water temperature	Deviation above 75 °F pool water temperature	1.3 additional collectors For every +1 °F above a pool water temp. of 75 °F	1 additional collector

Figure 62 Calculating the number of collectors for swimming pool water heating

Example
- Parameters
  - – Indoor swimming pool, covered
  - – Pool surface 350 ft²
  - – Pool water temperature 75 °F
- Wanted
  - – Number of Logasol SKS4.0 solar collectors for solar swimming pool water heating
- Read off (Fig. 62)
  - – 5 Logasol SKS4.0 solar collectors for pool area of 350 ft²
  - – 1 Logasol SKS4.0 solar collector as correction for +1 °C above 25 °F pool water temperature

Six Logasol SKS4.0 solar collectors are required for solar swimming pool water heating.

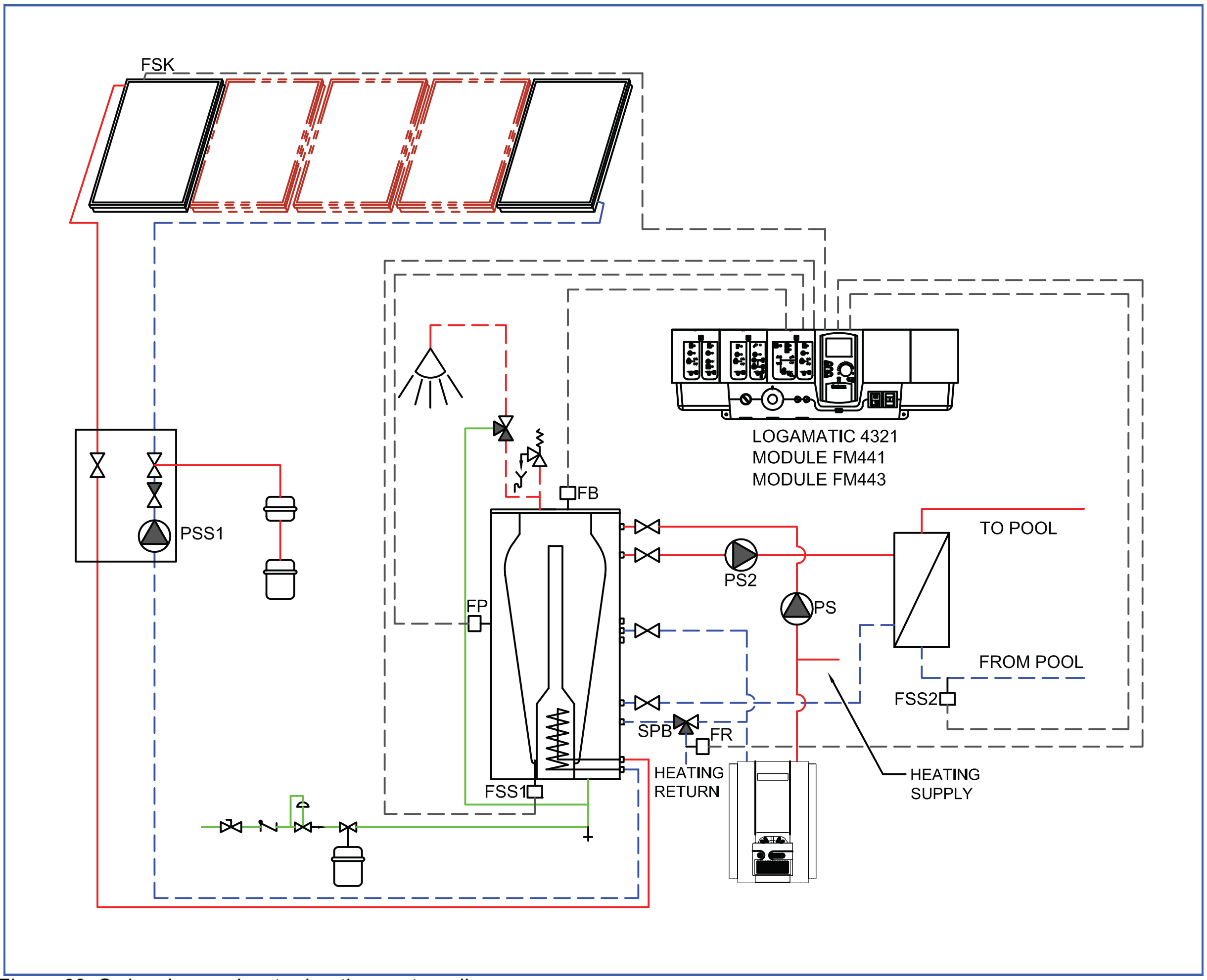


Figure 63 Swimming pool water heating system diagram

4.4 Space requirements for solar collectors

4.4.1 Space requirement with rooftop installation and roof integration

Logasol solar collectors can be installed on roofs with a pitch of 25° to 65° and offer two installation options. Installation on corrugated sheet and standing seam metal roofs are limited to roof pitches between 5° and 65°.

At the planning stage, the amount of space required beneath the roof must be taken into consideration as well as the area required on top of the roof.

On ceramic tile roofs dimensions A and B represent the area requirement for the selected number and layout of collectors (Fig. 64). With roof integration they include the area required for the collectors and their connection kits. These dimensions must be considered to be the minimum requirements.

Dimension C represents at least two rows of tiles up to the roof ridge. If the tiles are laid in concrete there is a risk of damaging the roof cover at the roof ridge.

Dimension D represents the roof overhang, including the gable end thickness. The adjacent 20 inches space from the collector array is required beneath the roof, depending on the type of connection (right or left).

Allow 20 inches to the right and/or left of the collector array for the connection lines (beneath the roof!).

Allow 12 inches beneath the collector array (beneath the roof!) for routing the return connection line.

- Route the return line with a rise to the automatic air vent valve if the system is not filled using a filling station.

Allow 16 inches above the collector array (beneath the roof!) for routing the flow header (rising) and the automatic air vent if the system is not filled using a filling station.

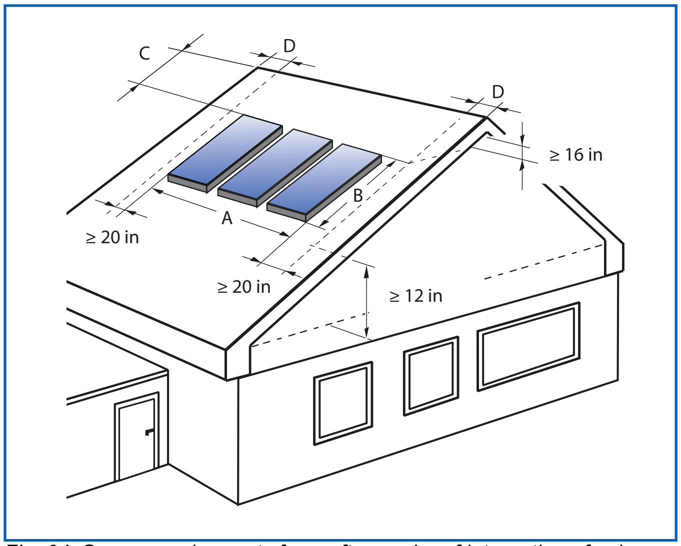
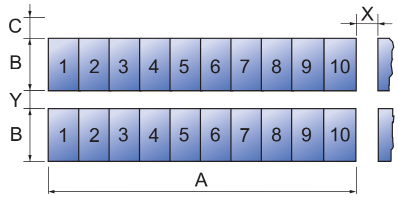


Fig. 64 Space requirements for rooftop and roof integration of solar collectors (explanation in the text body); dimensions in inches

Area required for solar collector rooftop installation



A Width of collector row
B Height of collector row
C Distance from roof ridge
X Distance between collectors rows side by side
Y Distance between collectors rows above each other

Fig. 65 Area required for collector arrays for rooftop installation

Dimensions			Collector array dimensions for Logasol flat-plate collectors SKN3.0 and SKS4.0 at rooftop installation	
			portrait	landscape
A	for 1 collector	in	45-¼"	81-½"
	for 2 collectors	in	91-⅜"	164-3/16"
	for 3 collectors	in	137-7/16"	246-½"
	for 4 collectors	in	183-½"	329-⅛"
	for 5 collectors	in	229-½"	411-⅜"
	for 6 collectors	in	278"	494"
	for 7 collectors	in	321-⅝"	576-⅜"
	for 8 collectors	in	367-11/16"	659"
	for 9 collectors	in	413-¾"	741-5/16"
	for 10 collectors	in	459-⅞"	824"
B		in	81-½"	45-¼"
C		in	12" or 2 rows of tiles	12" or 2 rows of tiles
X		in	8"	8"
Y			subject to roof construction (batten spacing)	subject to roof construction (batten spacing)

Fig. 66 Collector array dimensions with Logasol flat-plate collectors for rooftop installation

4.4.2 Space required for flat roof installation

Flat roof installation is possible with portrait and landscape Logasol SKS4.0 or SKN3.0 collectors. The area required for the collectors corresponds to the installation area for the flat roof supports used plus a space for pipework routing. This space should be at least 20 in to the left and right of the array. Maintain a minimum distance of 39 in from the roof edge.

In locations with snowfall, consider that snow will slide off the collectors and may accumulate at their base. In areas with large amounts of snowfall consider measures for snow removal to minimize service interruptions.

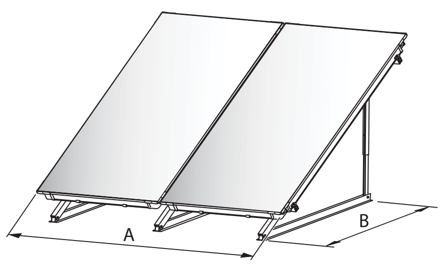


Fig. 67 Flat roof stand installation dimensions on the example of Logasol SKN3.0-s and SKS4.0-s portrait flat-plate collectors (dimension A - Fig. 66 and dimension B - Fig. 67)

Number of collectors	Collector row dimensions for Logasol SKN3.0 and SKS4.0	
	portrait	landscape
	A in	A in
2	92-⅛"	164-½"
3	138-3/16"	247-¼"
4	184-¼"	330"
5	230-5/16"	412-⅝"
6	276-⅜"	495-¼"
7	322-7/16"	578"
8	368-½"	660-⅝"
9	414-½"	743-5/16"
10	460-⅝"	826"

Fig. 68 Collector row dimensions when using flat roof supports

Angle of inclination	Collector row dimensions for Logasol SKN3.0 and SKS4.0	
	portrait	landscape
	B in	B in
25°	72- 7/16"	41-¾"
30°	68-⅞"	40-3/16"
35°	66-⅛"	37-3/16
40°	62-3/16"	35-13/16"
45°	58-¼"	33-7/16"
50°	58-¼"	33-7/16"
55°	58-¼"	33-7/16"
60°	58-¼"	33-7/16"

Fig. 69 Collector row dimensions when using flat roof supports

Minimum row spacing

If several rows of collectors are installed behind each other, they must be a minimum distance apart to minimize shading on the collectors behind. Standard values that apply to standard sizing apply to this minimum spacing (Fig. 70).

$$X = L \cdot \left(\frac{\sin \gamma}{\tan \varepsilon} + \cos \gamma \right)$$

Fig. 70 Formula for minimum row spacing for flat roof installation

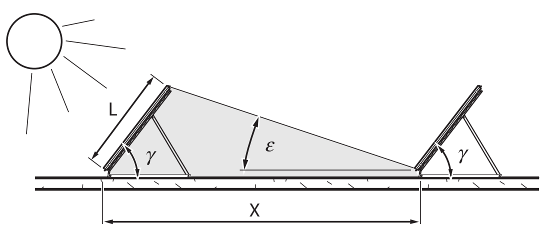


Fig. 71 Calculation parameter display (Fig. 84)

Calculation parameters *(Fig. 81, 82)*

X Free minimum spacing between collector rows (standard values Fig. 85)
L Length of solar collectors
γ Collector angle of inclination relative to the horizontal (standard values Fig. 85)
ε Minimum solar altitude relative to the horizontal without shading

Angle of inclination[1)]	Free minimum space X between collector rows for Logasol SKN3.0 and SKS4.0	
	portrait	landscape
γ	in	in
25° [2)]	186-⅝	103-½
30° [3)]	204	113
35°	219-11/16	121-11/16
40°	233-13/16	129-½
45°	246- 7/16	136-¼
50°	256-11/16	142-⅛
55°	265-⅜	146-⅞
60°	271-⅝	150-⅜

Fig. 72 The values for minimum collector spacing depend on latitude of the location. These values are valid for 12/21 with the sun at its shallowest angle, for Calgary, Alberta, and locations of similar latitude. South of Calgary less spacing is needed, North of Calgary more spacing.

1) Only these angles of inclination are approved by the manufacturer. The use of different positions could damage the system.
2) Adjustable by trimming the telescopic strut
3) Adjustable by trimming the telescopic strut with landscape collectors

4.4.3 Space requirements for wall mounting

Logasol flat-plate collectors

Wall mounting is only suitable for Logasol SKN3.0-w and SKS4.0-w landscape flat-plate collectors, and is only approved for an installation height of up to 65 ft above ground. The wall must have adequate loadbearing capacity!

The space requirement on the wall for the collector rows depends on the number of collectors. In addition to the width of the collector array, allow at least 20 inches to the left and right (dimension A , Fig. 73) for routing the pipework. The space between the collector row and the edge of the wall must be at least 3ft. (1.0m).

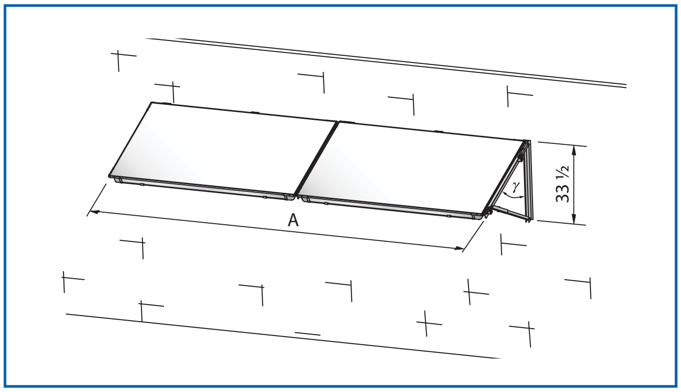


Fig. 73 Installation dimensions of wall mounting kits for Logasol SKN3.0-w and SKS4.0-w landscape flat-plate collectors; dimensions in inches (dimension A Fig. 83)

Number of collectors	Collector row dimensions for Logasol SKN3.0-w and SKS4.0-w landscape A in
2	164-⅛"
3	246-½"
4	329-⅛"
5	411-⅜"
6	494"
7	576-⅜"
8	659"
9	741-⅜"
10	824"

Fig. 74 Collector row dimensions when using wall mounting supports

Minimum row spacing

The wall mounting kit is particularly suitable for buildings with non-ideal roof orientation, or where shading of windows and doors is desired. This allows taking advantage of the sun while creating an architectural feature.

Collectors can be mounted to provide ideal shade for windows and keep rooms nice and cool. In winter, when the sun ‘s path is lower, solar gain can provide an additional source of energy.

Several rows of collectors arranged above of each other must be kept at least 145 inches apart to prevent the collectors from casting shadows on each other (Fig. 75).

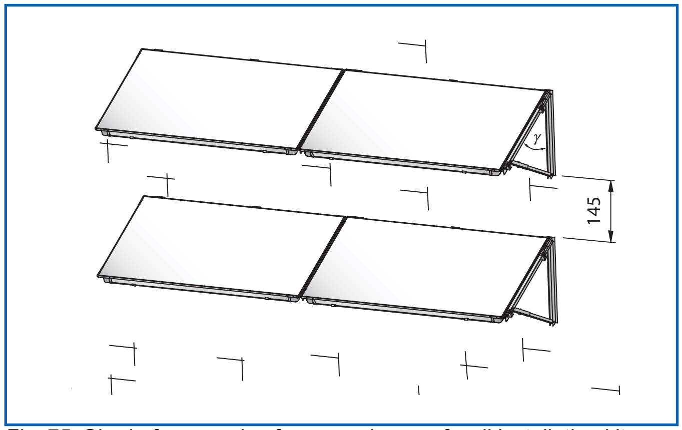


Fig. 75 Shade-free spacing for several rows of wall installation kits for landscape flat-plate collectors arranged above each other. Logasol SKN3.0-w and SKS4.0-w; dimensions in inches

Snow and ice accumulating on the collectors may give way and slide off suddenly. Take provisions that the installation does not pose a risk to property and personal injury from falling snow and ice.

4.5 Hydraulic system engineering

4.5.1 Hydraulic circuit

Collector array

A collector array must consist of the same type of collectors and have the same orientation (all portrait or all landscape). This is necessary, since the flow distribution would otherwise not be uniform. A maximum of ten Logasol SKN3.0 or SKS4.0 flat-plate collectors may be installed in a row and hydraulically connected in parallel if the supply and return connections are on alternate sides. If the connections are all on the same side, a maximum of five Logasol SKS4.0 flat-plate collectors can be installed in a row.

In small systems it is preferable to connect collectors in series. Connecting the collectors in parallel is better in larger systems. This allows a more uniform volume flow distribution of the entire array.

<table>
<tr><th colspan="2">Connection in series</th><th colspan="2">Connection in parallel</th></tr>
<tr><th>Row(s)</th><th>Max. number of collectors per row</th><th>Row(s)</th><th>Max. number of collectors per row</th></tr>
<tr><td>1</td><td>10</td><td>1</td><td rowspan="7">With alternate connections max. 10 collectors per row or with connections on same side max. 5 SKS4.0 per row</td></tr>
<tr><td>2</td><td>5</td><td>2</td></tr>
<tr><td>3</td><td>3</td><td>3</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">More than three rows connected in series not permitted!</td><td>4</td></tr>
<tr><td>...</td></tr>
<tr><td>...</td></tr>
<tr><td>n</td></tr>
</table>

Fig. 76 Collector array layout options

Connection in series

The hydraulic connection of collector rows in series is accomplished quickly because of the simple connection design. Connection in series is the preferred way to achieve a uniform volume flow distribution. If there are several arrays (rows) in a system, the number of collectors per row may not differ by more than one.

The maximum number of flat-plate collectors connected in series is limited to 10 collectors and 3 rows (Fig. 76).

Allow for a higher pressure drop if Logasol SKS4.0 collectors are connected in series (Fig. 84). The hydraulic connection is shown in the following diagram with the example of a rooftop installation. Additional automatic air vent valves may be required if such valves cannot be installed above the top row (i.e. flat roof installation). As an alternative to the use of automatic air vent valves, the system can also be operated using an air separator (integrated into the Logasol KS01... pump station) provided the system is filled using a high pressure and high volume filling station.

Examples of connections in series

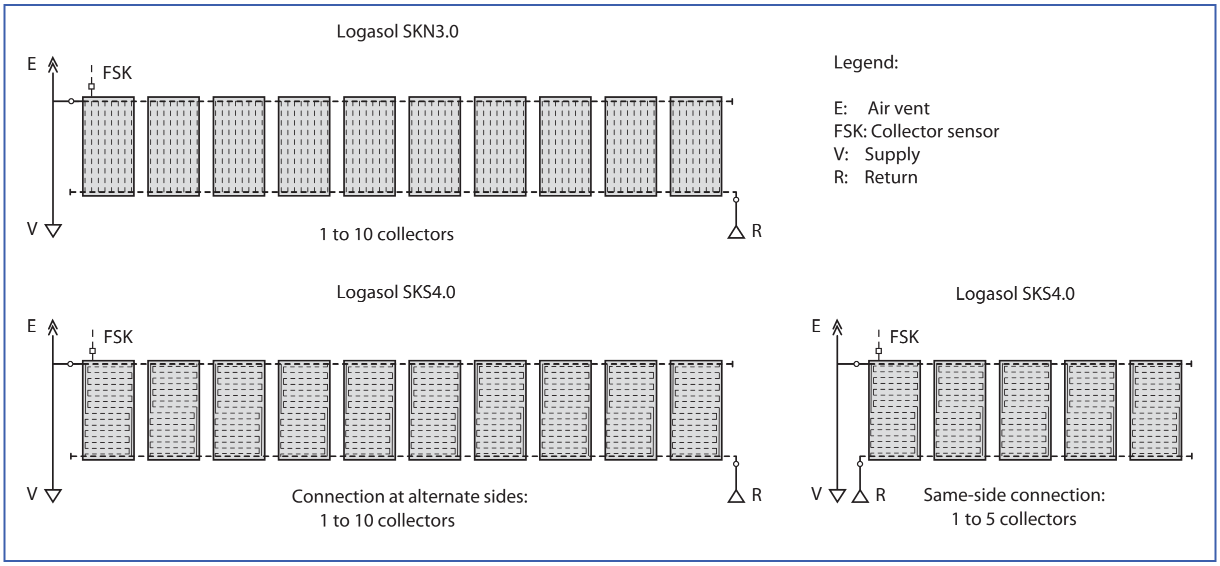


Fig. 77 Layout of a row of collectors

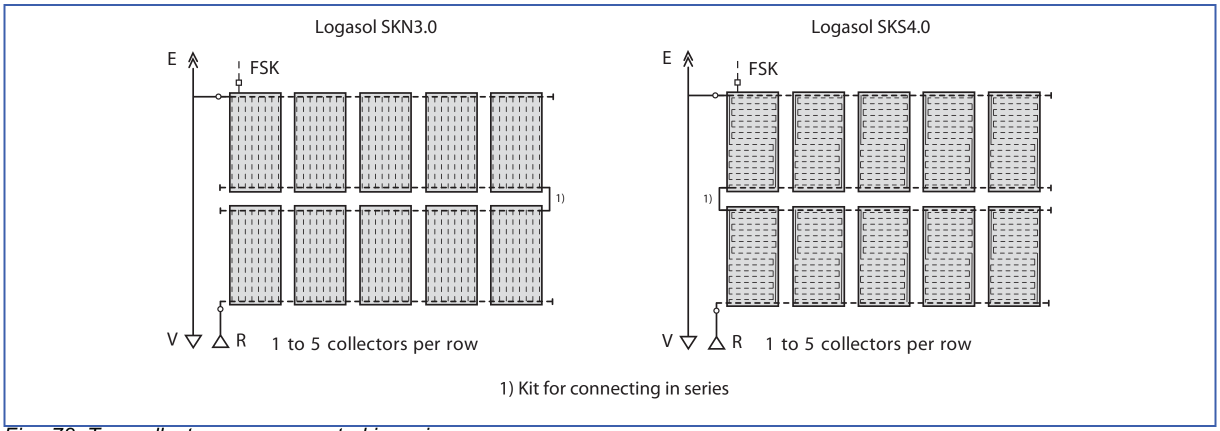


Fig. 78 Two collector rows connected in series

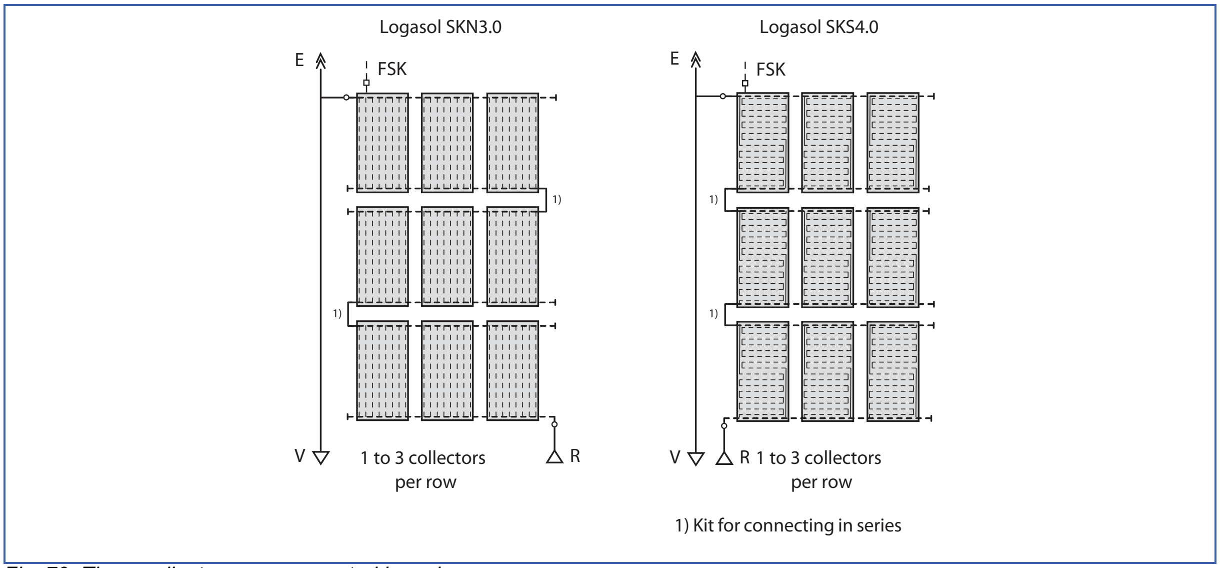


Fig. 79 Three collector rows connected in series

Connection in parallel

Connect the collector rows in parallel if more than 10 flat-plate collectors are used. Rows connected in parallel must consist of the same number of collectors and must be hydraulically connected in reverse-return (sum of supply and return pipe length equal for all rows). Ensure that the pipe diameters are identical. Perform hydraulic balancing if this is not possible. Reverse-return piping is necessary in the return to minimize heat losses. Collector arrays that are installed side by side can be arranged in a mirror image so that both arrays can be connected with a riser in the center.

Ensure that only collectors of one type are used, since portrait and landscape collectors have different pressure drops.

Each row requires a separate automatic air vent valve. As an alternative to the use of automatic air vent valves, the system can also be operated using an air integrated into the Logasol KS01... pump station, provided the system is filled using a high volume and high pressure filling station. In this case, a shut-off valve is required for each row.

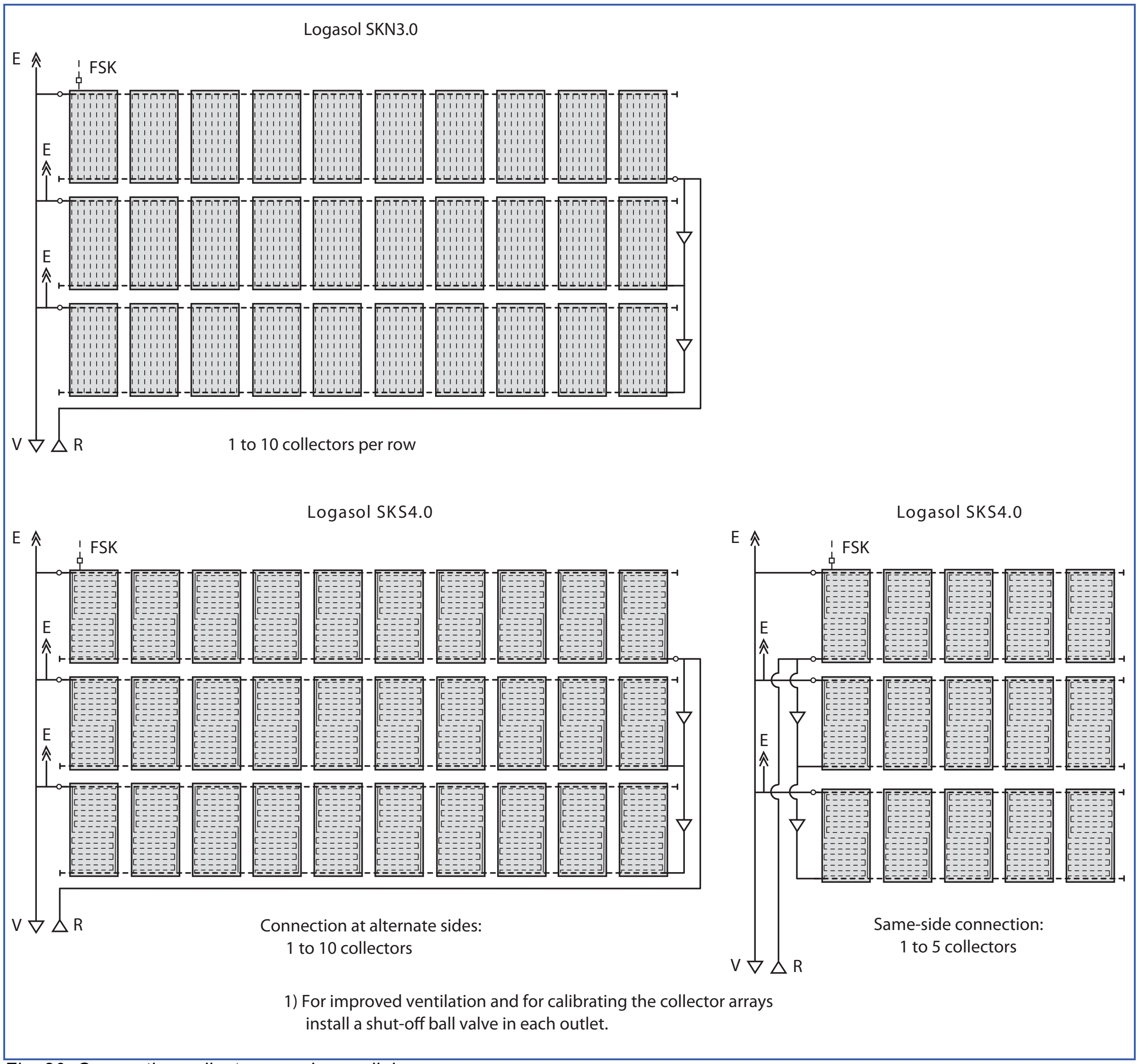


Fig. 80 Connecting collector rows in parallel

Combined connection in series and in parallel

Connecting more than three collectors above or behind each other can only be done by using a combination of connections in series and in parallel. This is done by connecting the bottom two (1 + 2) and the top two (3 + 4) collectors in series (Fig. 81).

Then connect rows 1 + 2 to rows 3 + 4 in parallel. Here too, observe the location of the automatic air vent valve.

- The maximum permitted number of collectors per row is 5.
- Take the pressure drop of the collector array into consideration when selecting the pump station.

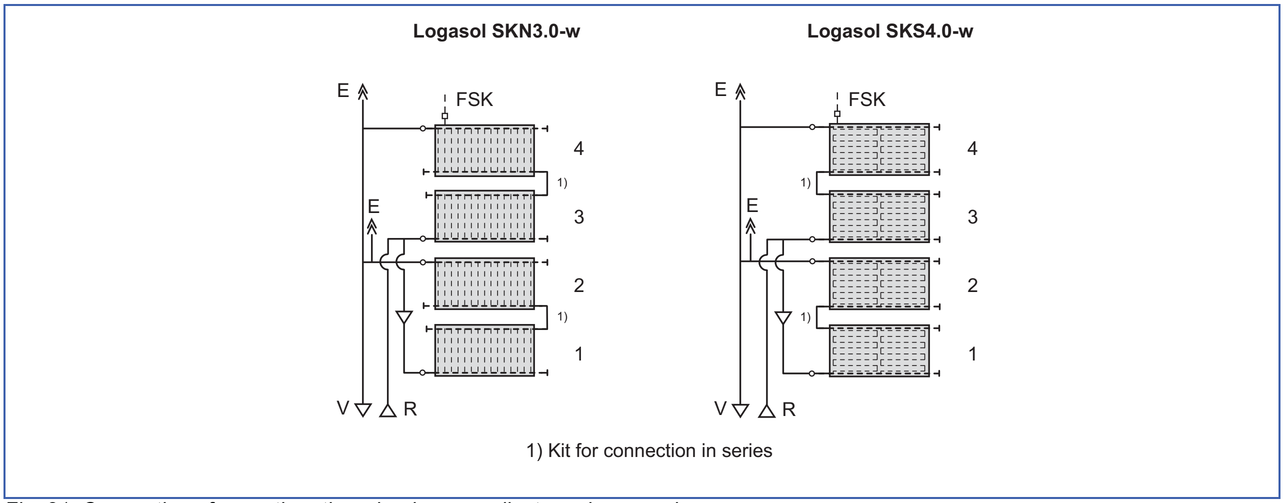


Fig. 81 Connection of more than three landscape collectors above each other

Collector array with dormer

The following hydraulic schemes represent one option for solving the challenge posed by dormers. These hydraulic schemes generally equate to two rows of collectors connected in series. Observe the maximum number of collectors that can be used in rows of collectors in series. As an alternative to the use of automatic air vent valves, the system can also be operated using an air separator integrated into the Logasol KS01... pump station, provided the system is filled using a high volume and high pressure filling station.

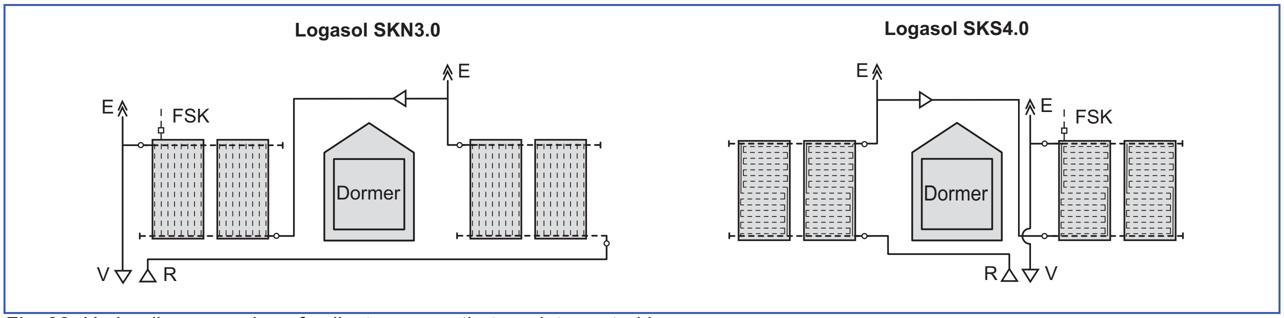


Fig. 82 Hydraulic connection of collector arrays that are interrupted by a dormer

4.5.2 Flow rate in the collector array for flat-plate collectors

The nominal flow rate for engineering small and medium-sized systems is 0.22 gpm (50l/h) per collector, resulting in a total system flow rate per formula (Fig. 83).

A flow rate 10% to 15% lower (at full pump speed) does not usually lead to significant yield reductions. However, avoid higher flow rates to minimize the amount of power required by the solar circuit pump.

$$\dot{V}_A = \dot{V}_{K,\,Nom} \cdot n_k = 0.22\text{gpm} \cdot n_k$$

Fig. 83 Formula for total system flow rate

Calculating sizes

V_A Total system flow rate in gpm
$V_{K,Nom}$ Nominal flow rate of collector in gpm
n_K Number of collectors

4.5.3 Pressure drop calculation in collector array for flat-plate collectors

Collector row pressure drop

The pressure drop of a collector row increases with the number of collectors. The pressure drop for a row including accessories, subject to the number of collectors per row, can be found in the figure below.

The pressure drop values for the Logasol SKS4.0 and SKN3.0 collectors for a solar fluid mixture consisting of 50% glycol and 50% water at a mean temperature of 122 °F (50 °C) are specified below.

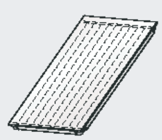
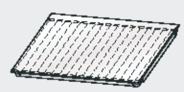
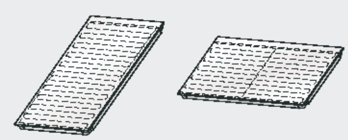
Number of collectors	Pressure drop for a row consisting of n collectors								
	Logasol SKN3.0						Logasol SKS4.0		
	portrait			landscape			portrait and landscape		
									
	at a flow rate per collector (nominal flow rate 0.22 gpm)								
	0.22 gpm	0.44 gpm[1)]	0.66 gpm[2)]	0.22 gpm	0.44 gpm	0.66 gpm	0.22 gpm	0.44 gpm	0.66 gpm
n	in H_2O	in H_2O	in H_2O	in H_2O	in H_2O	in H_2O	in H_2O	in H_2O	in H_2O
1	0.44	1.89	4.09	0.16	0.68	1.72	12	28.5	52.59
2	0.60	2.6	5.23	0.76	2.77	5.78	12.45	29.3	53.39
3	0.84	5.42	10.56	2.25	7.27	14	12.85	32.92	61.43
4	2.6	8.87	–	3.73	11.92	–	15.66	38.54	–
5	4.45	13.85	–	5.94	18.79	–	17.66	46.17	–
6	6.1	–	–	8.55	–	–	19.67	–	–
7	8.43	–	–	11.6	–	–	24.48	–	–
8	11.2	–	–	15	–	–	29.30	–	–
9	14.4	–	–	19	–	–	34.93	–	–
10	18	–	–	23.52	–	–	40.55	–	–

Fig. 84 Pressure drop values for collector rows with Logasol SKN3.0 or SKS4.0 including AAV and connection kit; pressure drop values apply to solar fluid L at an average temperature of 122°F (50°C)
1) Flow rate per collector, connected in two rows
2) Flow rate per collector, connected in three rows
— Not permitted

Rows of collectors connected in series

The pressure drop of the array results from the total of all pipework drop values and the pressure drop for each row of collectors. The pressure drop of rows of collectors connected in series is cumulative.

$$\Delta p_{\text{Array}} = \Delta p_{\text{Row}} \cdot n_{\text{Row}}$$

Fig. 85 Formula for pressure drop of a collector array with rows of collectors connected in series

As far as Fig. 82 is concerned, take into consideration that the actual flow rate is calculated from the individual collectors connected in series, the number of rows, and the nominal collector flow rate (0.22 gpm):

$$V_{\text{K}} = V_{\text{K,Nom}} \cdot n_{\text{Row}} = 0.22\ \text{gpm} \cdot n_{\text{Row}}$$

Fig. 86 Formula for flow rate through a collector with rows of collectors connected in series

Calculation parameters *(Fig. 85, 86)*

Δp_{Array} *Pressure drop for collector array in in.W.C.*
Δp_{Row} *Pressure drop for one collector row in in.W.C.*
n_{Row} *Number of collector rows*
V_K *Flow rate through the individual collectors in gpm*
$V_{K,Nom}$ *Nominal flow rate of collector in gpm*

Example

- Parameters
  - Connection in series of 2 collector rows, each with 5 Logasol SKN3.0-s solar collectors
- Wanted
  - Pressure drop of collector system
- Calculation
  - Flow rate through one collector:
    VK = VK,Nom · nRow
    VK = 0.22 gpm· nRow = 0.22 gpm · 2 = 0.44 gpm
    – Read from Fig. 84:
    13.85 in H2O per collector row
    – Pressure drop of array:
    ΔpArray = ΔpRow · nRow = 13.85 in H2O · 2 = 27.2 in H2O

The pressure drop of the collector array is 27.2 in H2O.

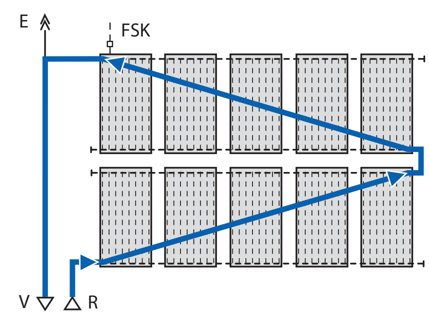


Fig. 87 Connection in series of two Logasol SKN3.0 collector rows

Collector rows connected in parallel

The pressure drop for the array results from the total of the pipework pressure drop values up to a collector row and the pressure drop of an individual collector row.

$$\Delta p_{\text{Array}} = \Delta p_{\text{Row}}$$

Fig. 88 Formula for the pressure drop of a collector array with rows of collectors connected in parallel

Unlike the situation when connecting in series, the actual flow rate via the individual collectors corresponds to the nominal collector flow rate of 0.22 gpm (50 l/h).

$$V_{\text{K}} = V_{\text{K,Nom}}$$

Fig. 89 Formula for the flow rate through a collector with rows of collectors connected in parallel

Calculation parameters *(Fig. 88, 89)*

Δp_{Array}	*Pressure drop for collector array in W.C.*
Δp_{Row}	*Pressure drop for one collector row in W.C.*
V_K	*Flow rate through the individual collectors in gpm*
$V_{K,Nom}$	*Nominal flow rate of collector in gpm*

Example

- Parameters
  - Connection in parallel of 2 collector rows, each with 5 Logasol SKN3.0-s solar collectors
- Wanted
  - Pressure drop of overall collector array
- Calculation
  - Flow rate through one collector: VK = VK,Nom = 0.22 gpm
  - Read from Fig. 82: 4.45 in H2O per collector row
  - Pressure drop of array: ΔpArray = ΔpRow = 4.45 in H2O

The pressure drop of the collector array is 4.45 in H2O

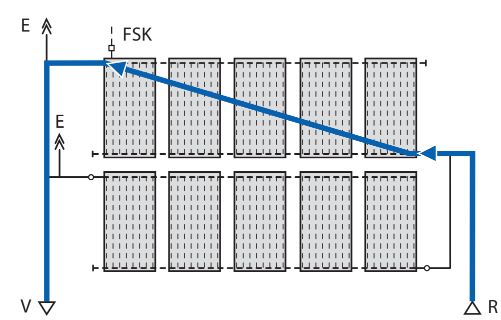


Fig. 90 Two Logasol SKN3.0 collector rows connected in parallel using reverse-return piping

Combined connection in series and in parallel

Figure 91 shows an example of a combination of connections in series and in parallel. In each case, the top and bottom rows of collectors are connected in series to form a sub-array, meaning that only the pressure drop values of the sub-array collector rows connected in series will cumulate.

$$\Delta p_{\text{Array}} = \Delta p_{\text{Sub-array}} = \Delta p_{\text{Row}} \cdot n_{\text{Row}}$$

Fig. 91 Formula for the pressure drop of a collector array consisting of a combination of collector rows connected in series and parallel

For this, take into consideration that the actual flow rate is calculated via the individual collectors connected in series from the number of collector rows connected in series and the nominal flow rate per collector of 0.22 gpm (50 l/h):

$$V_{\text{K}} = V_{\text{K,Nom}} \cdot n_{\text{Row}} = 0.22 \text{ gpm} \cdot n_{\text{Row}}$$

Fig. 92 Formula for the pressure drop through a collector array consisting of a combination of collector rows connected in series and in parallel

Calculation parameters *(Fig. 91, 92)*

Δp_{Array} Pressure drop for collector array in W.C.
$\Delta p_{sub\text{-}array}$ Pressure drop of the collector sub-array consisting of collector rows connected in series in W.C.
Δp_{Row} Pressure drop for one collector row in W.C.
V_K Flow rate through the individual collectors in gpm
$V_{K,Nom}$ Nominal flow rate of collector in gpm

Example

- Parameters
  – Connection in parallel of 2 sub-arrays consisting of 2 rows of collectors, each of which consists of 5 Logasol SKN3.0 solar collectors.
- Wanted
  – Pressure drop of collector system
- Calculation

– Flow rate through one collector:
VK = VK,Nom · nRow
VK = 0.22 gpm· nRow = 0.22 gpm · 2 = 0.44 gpm
– Read-off from Fig. 82:
13.85 in H2O per collector row
– Pressure drop of (sub-)array:
ΔpArray = ΔpSub-array = ΔpRow · nRow
ΔpArray = 13.85 in H2O · 2 = 27.2 in W.C.

The pressure drop of the collector array is 27.2 in H2O.

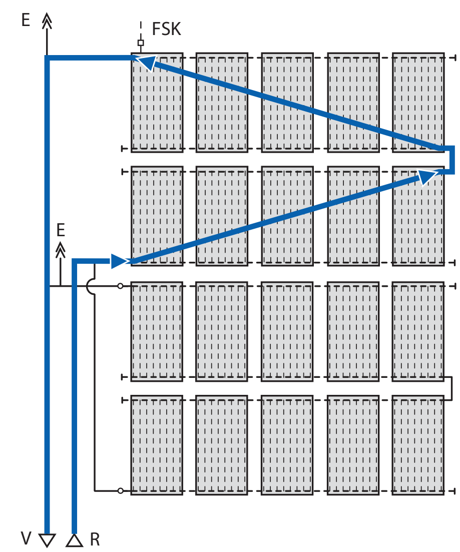


Fig. 93 Combination of connections in series and in parallel in a collector array consisting of Logasol SKN3.0 solar collectors

4.5.4 Pressure drop of pipework in the solar circuit

Calculating the pipework

The flow velocity in the pipework should be in excess of 1.3 ft/sec to allow air remaining in the heat transfer medium to be transported to the next air separator. Flow noise can occur from velocities of 3 ft/sec and higher. Take individual resistance values (caused by bends, for example) into consideration in the pressure drop calculation by adding 30% to 50% to the pressure drop of the straight pipework.

Number of collectors	Flow rate	Flow velocity v and pressure drop R in copper pipes with pipe dimensions of					
		1/2 inch		3/4 inch		1 inch	
		v	R	v	R	v	R
	gpm	ft/s	in H_2O/ft	ft/s	in H_2O/ft	ft/s	in H_2O/ft
2	**0.44**	0.69	0.11	–	–	–	–
3	**0.66**	1	0.17	–	–	–	–
4	**0.88**	1.38	0.42	–	–	–	–
5	**1.1**	1.7	0.61	–	–	–	–
6	**1.32**	2	0.85	–	–	–	–
7	**1.54**	2.39	1.12	1	0.14	–	–
8	**1.76**	2.75	1.42	1.15	0.17	–	–
9	**1.98**	3.1	1.72	1.31	0.22	–	–
10	**2.1**	–	–	1.44	0.26	–	–
12	**2.64**	–	–	1.73	0.36	1.12	0.12
14	**3.08**	–	–	2.03	0.48	1.31	0.16
16	**3.52**	–	–	2.33	0.60	1.48	0.20
18	**3.96**	–	–	2.62	0.78	1.67	0.25
20	**4.4**	–	–	2.88	0.89	1.87	0.31
22	**4.84**	–	–	3.18	1.06	2.03	0.36
24	**5.28**	–	–	–	–	2.23	0.42
26	**5.72**	–	–	–	–	2.43	0.49
28	**6.16**	–	–	–	–	2.59	0.55
30	**6.60**	–	–	–	–	2.79	0.63

Fig. 94 Flow velocity and pressure drop per ft of straight copper pipe for a 50/50 glycol:water mixture at 122 °F (50 °C)

4.5.5 Pressure drop of the selected solar storage tank

The pressure drop of the solar storage tank depends on the number of collectors and the flow rate. The indirect coils of the solar storage tank have various pressure drop characteristics because of their differing dimensions. Use Fig. 95 to estimate the pressure drop. The pressure drop in the table applies to a 50/50 glycol:water mixture at a temperature of 122 °F (50 °C).

Number of collectors	Flow rate	Press drop in solar indirect coils of the Logalux storage tank	
		SM300 SM400	PL750/2S
	gpm	in H_2O	in H_2O
2	0.44	< 4	< 4
3	0.66	< 4	< 4
4	0.88	< 4	4.4
5	1.1	< 4	6
6	1.32	–	8.8
7	1.54	–	16
8	1.76	–	17.7
9	1.98	–	–
10	2.2	–	–
12	2.64	–	–
14	3.08	–	–
16	3.52	–	–

Fig. 95 Pressure drop values of solar storage tanks for a 50/50 glycol: water mixture at 122 °F (50 °C).

4.4.6 Selecting the Logasol KS... pump station

The selection of the suitable pump station can be approximately determined through the number of collectors. The pressure drop (residual head) and the flow rate in the collector circuit are required for finalizing the selection. Take the following pressure drop values into consideration:

- Pressure drop in the collector array
- Pipework pressure drop
- Pressure drop in the solar storage tank
- Additional pressure drop due to heat meter, valves or other fittings

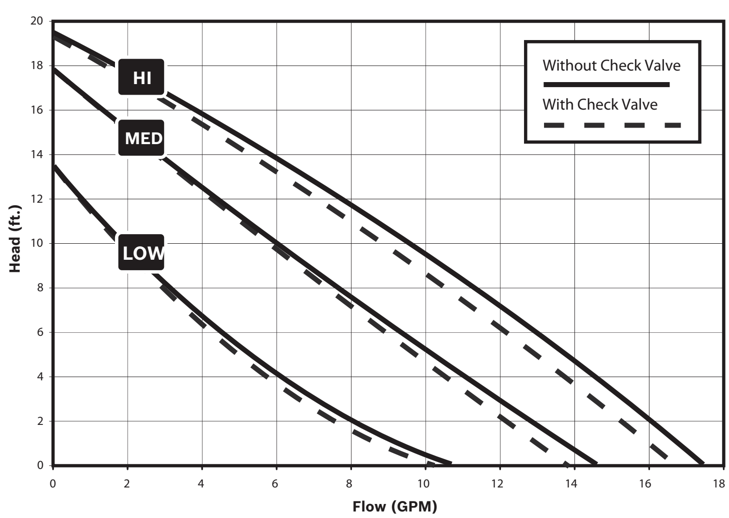


Fig. 96 Pressure ranges of the KS105 & 110 pump stations

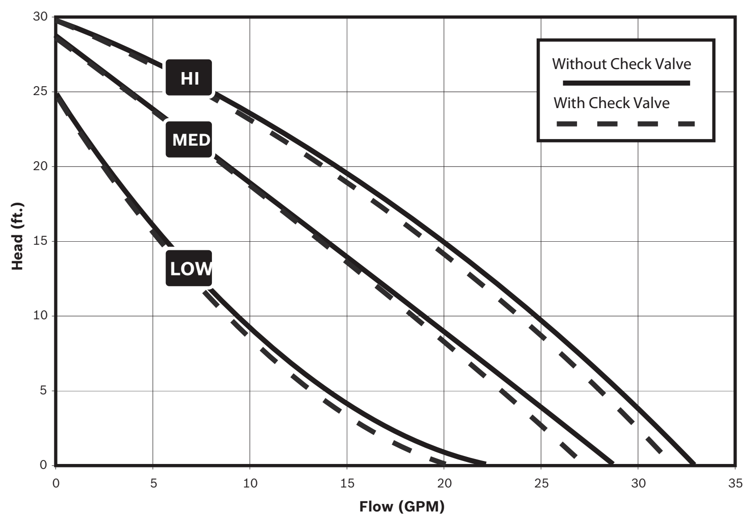


Fig. 97 Pressure ranges of the KS120 pump station

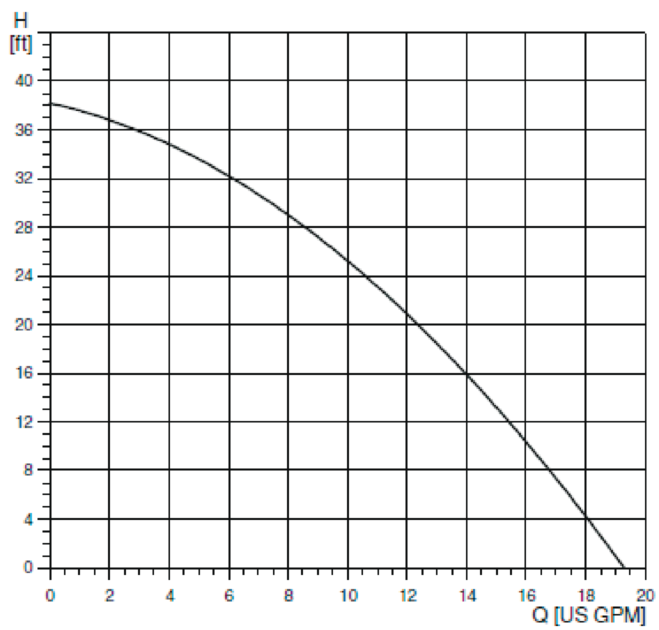


Fig. 98 Pressure ranges of the KS150 pump station

4.6 Sizing of the diaphragm expansion vessel (DEV)

4.6.1 System volume calculation

The volume of a solar heating system with the Logasol KS... pump station is significant for sizing the expansion vessel and determination of the volume of solar fluid.

The following formula applies to the filling volume of the solar system with a Logasol KS... pump station:

$$V_A = V_K \cdot n_K + V_{WT} + V_{KS} + V_R$$

Fig. 99 Formula for filling volume of solar heating systems with a Logasol KS... pump station

Calculating sizes

V_A System filling volume
V_K Volume of one collector (Fig. 101)
n_K Number of collectors
V_{WT} Solar indirect coil volume (Fig. 102)
V_{KS} Volume of a Logasol KS… pump station (approx. 1/4 gal (1 l))
V_R Pipework volume (Fig. 100)

Pipework volume

Pipe dimension Ø × wall thickness in	Specific line volume gal / ft
1/2"	.012
3/4"	.017
1"	.025

Fig. 100 Specific filling volume of selected pipework

Solar collector volume

Solar collectors Type		Version	Collector content gallons (liters)
Flat-plate collector	SKN3.0	portrait	0.23 (0.86)
		landscape	0.33 (1.25)
High-perf. flat-plate collector	SKS4.0	portrait	0.38 (1.43)
		landscape	0.46 (1.76)

Fig. 101 Filling volume of Logasol solar collectors

Solar indirect coil volume

Solar storage tank Scope	Type	Brand / model	Indirect coil content in gallons
DHW heating	dual-coil	Logalux SM300	2.11
		Logalux SM400	2.50
	single-coil with electric back-up	Sol-Ret 80 gal.	2.20
		Sol-Ret 120 gal.	2.60
DHW heating and central heating	combi storage tank	Logalux PL750/2S	0.36
Solar preheat	single coil	SST150-40	1.60
		SST250-65	1.90
		SST300-80	2.10
		SST450-119	3.20

Fig. 102 Filling volume of solar indirect coils in Logalux storage tanks

4.6.2 Diaphragm expansion vessel for solar heating systems with flat-plate collectors

Calculation principles

Precharge
Adjust the precharge of the diaphragm expansion vessel (DEV) prior to filling the solar heating system. The required system precharge is calculated using the following formula:

$$p_V = 0.4455 \cdot h_{stat} + 10.3\text{psi}$$

Fig. 103 Formula for inlet pressure of a diaphragm expansion vessel

Calculation parameters *(Fig. 103) and picture legend (Fig. 104)*
p_V *DEV inlet pressure in bar*
h_{stat} *Static height in ft between center of DEV and highest point of system*

The minimum precharge is 17.4 psi (1.2 bar).

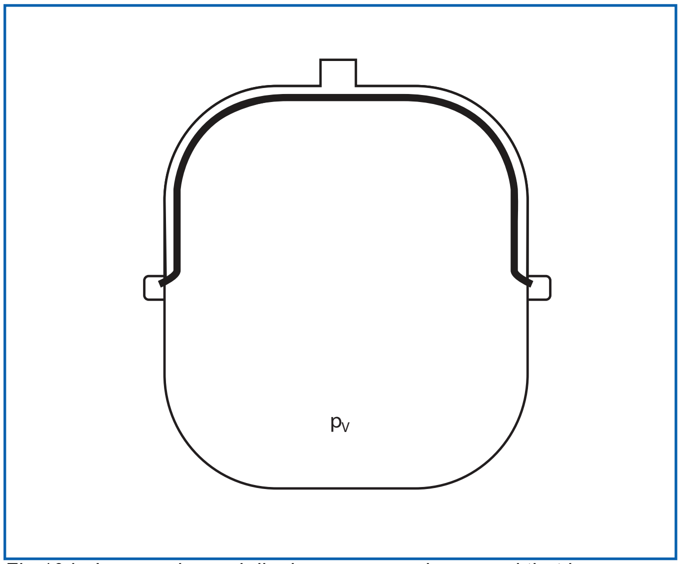


Fig.104 In a precharged diaphragm expansion vessel that is disconnected from the system the membrane will fill the entire space.

Filling pressure
The expansion vessel creates an equilibrium between the fluid pressure and the gas pressure. The equilibrium (V_V, Fig. 106) is set with the system cold and monitored via the pressure gauge after bleeding the air from the system. The system pressure should be dialed in at 5 psi above the DEV preset pressure. A controlled evaporation temperature of 250 °F (120 °C) is therefore reached in the event of stagnation.

The filling pressure is calculated using the following formula:

$$p_0 = p_V + 5\text{psi}$$

Fig. 105 Formula for filling pressure of a diaphragm expansion vessel

Calculation parameters *(Fig. 105) and picture legend (Fig. 106)*
p_0 *DEV filling pressure in psi*
p_V *DEV precharge pressure in psi*
V_V *Membrane*

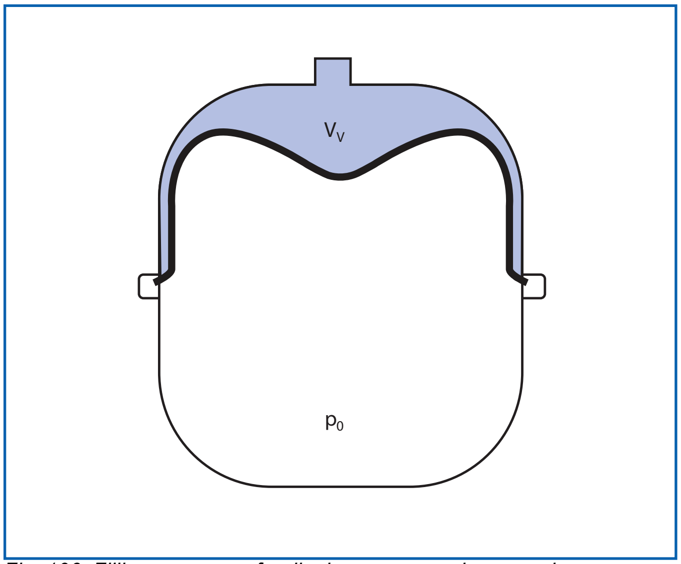


Fig. 106 Filling pressure of a diaphragm expansion vessel

A deviation from the optimum precharge pressure or filling pressure always leads to a reduction in available volume. This can cause system malfunctions, like early stagnation, or fluid spills from the relief valve.

Operating pressure

At the maximum collector temperature, the filling gas is compressed to the final system pressure by taking up additional expansion volume (Ve, Fig. 108).

The final pressure of the solar heating system and therefore the pressure rating and the required size of the DEV are determined by the safety valve response pressure. The final pressure is determined using the following formula:

$$p_e \leq p_{SV} - 3\,\text{psi} \quad \text{for} \quad p_{SV} < 44\,\text{psi}$$

$$p_e \leq 0.9 \cdot p_{SV} \quad \text{for} \quad p_{SV} > 44\,\text{psi}$$

Fig. 107 Formulas for final pressure of a diaphragm expansion vessel subject to the safety valve response pressure

Calculation parameters *(Fig. 107) and picture legend (Fig. 108)*

p_e DEV final pressure in psi
p_{SV} Safety valve response pressure in psi
V_e Expansion volume
V_V Hydraulic seal

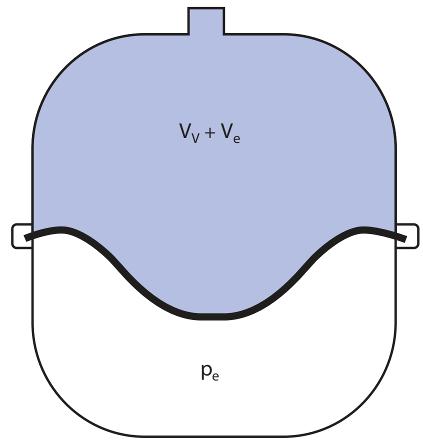


Fig. 108 Final pressure of a diaphragm expansion vessel

Intrinsic safety of a solar heating system

A solar heating system is considered to be intrinsically safe if the DEV can absorb the volume change as a result of solar fluid evaporation in the collector and the connecting lines (stagnation). If a solar heating system is not intrinsically safe, the safety valve responds during stagnation. Then the solar heating system has to be re-started. A DEV is sized on the basis of the following assumptions and formula:

$$V_{n,\,min} = (V_A \cdot n + V_D) \cdot \frac{(p_e + 14.5)}{(p_e - p_0)}$$

Fig. 109 Formula for minimum DEV volume

$$V_D = n_K \cdot V_K$$

Fig. 110 Formula for the evaporation volume

Calculation parameters *(Fig. 109 and Fig. 110)*

$V_{n,min}$ Minimum D volume in gallons
V_A System filling volume in gallons
n Expansion coefficient (= 7.3 % with Δ∂ = 100 K)
V_D Evaporation volume in gallons
p_e DEV outlet pressure in psi
p_0 DEV filling pressure in psi
n_K Number of collectors
V_K Volume of one collector

Nomograph for the graphical determination of the diaphragm expansion vessel for solar heating systems with flat-plate collectors

The size of the diaphragm expansion vessel in systems with a 87 psi (6 bar) safety valve can be determined graphically subject to the system configuration using the nomograph (Fig. 111). The nomograph is based on the above assumptions.

Sizing example

- Specified solar heating system with
  - 4 Logasol SKS4.0-s collectors and Logalux SM400 thermosiphon storage tanks
  - 36 ft (12 m) single pipe length between collector array and storage tank
  - Pipe dimension 1/2 inch
  - Static height between DEV and the highest point of system = 33 ft (10 m)
- Wanted
  - Required expansion vessel

The graphical determination of the diaphragm expansion vessel is described in the nomograph on following pages.

Item	Calculation principles and initial values	Required operation
1	The single pipe between the storage tank and the collector array is 36 ft (12 m) in length.	Trace the "Single pipe length" axis at 36 ft (12 m) horizontally to the left of the "Pipe dimensions" sub-diagram.
2	The pipe diameter used is 1/2 inch.	From the intersection with line 1/2 inch continue vertically upward into the "DHW storage tank" sub-diagram.
3	A Logalux SM400 DHW storage tank is specified for this system.	At the intersection with the "Logalux SM400 curve, turn right and go horizontally to part 2 of the nomograph into the "Collector filling volume" sub-diagram.
4	The system is operated using 4 Logasol SKS4.0-s collectors. The filling volume V_K of the collector array is 1-1/3 gal (5.7 liters) [1].	Draw an additional line parallel to the existing lines for a filling volume of 1-1/3 gal (5.7 liters) in the "Collector array filling volume" sub-diagram. Go vertically down into the "static height" sub-diagram from the intersection point with the new line.
5	The static height between the highest point in the system (automatic air vent valve) and the expansion vessel is 30 ft.	At the intersection with line 33, go horizontally left and read off the minimum nominal volume of th e expansion vessel (12 liters). Result: Allow for a DEV with 10 gallons (DEV 10, white field).

Fig. 111 Description of operations for the example of expansion vessel sizing with nomograph (Fig. 110and Fig. 111)

1) See Fig. 101 for collector fluid volume

Nomograph for sizing the diaphragm expansion vessel for solar heating systems with flat-plate collectors (part 1)

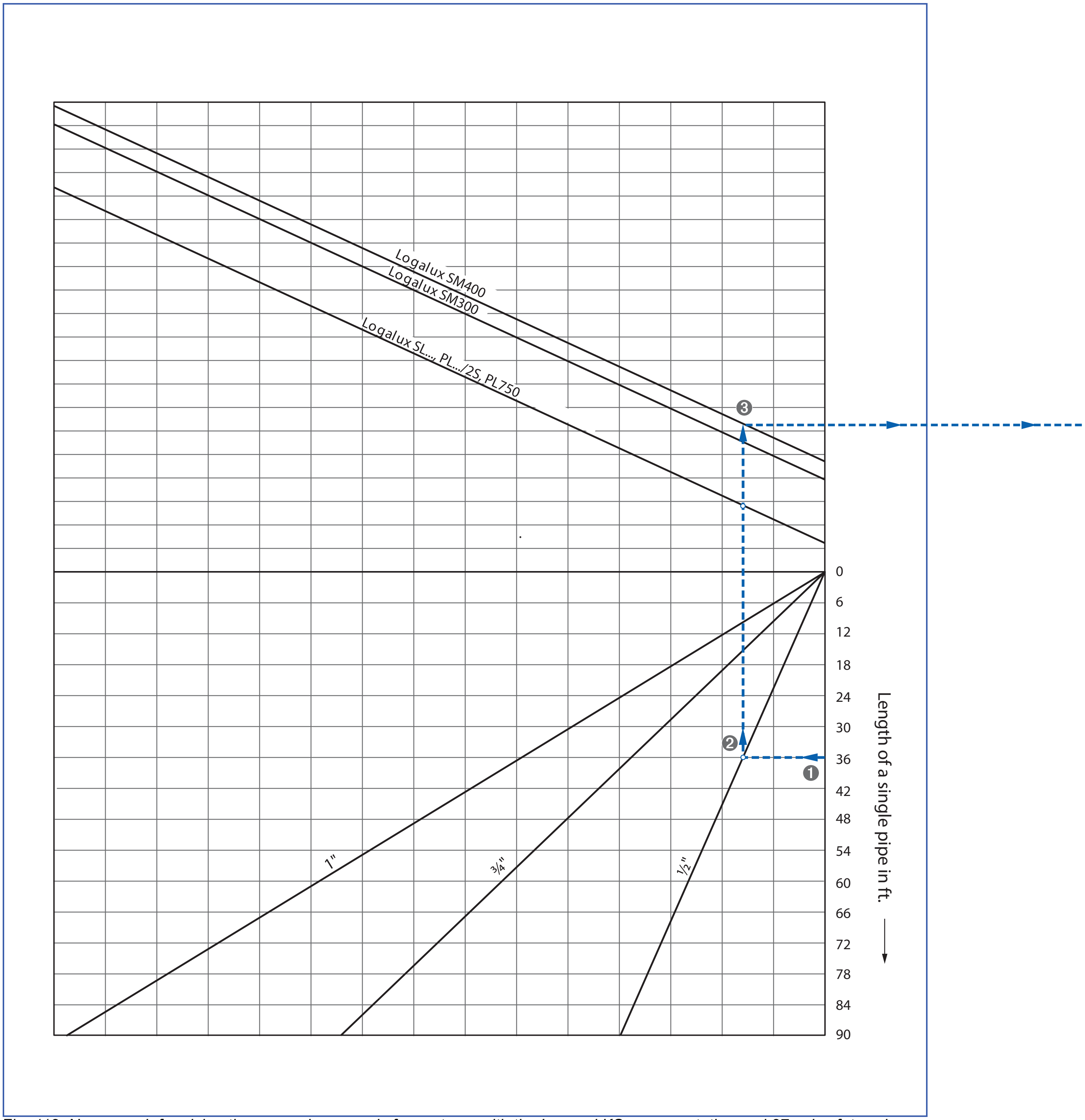


Fig. 112 Nomograph for sizing the expansion vessels for systems with the Logasol KS... pump station and 87 psi safety valve (part 2 , Fig. 123) with sizing example highlighted in blue (description - page 89)

Nomograph for sizing the diaphragm expansion vessel for solar heating systems with flat-plate collectors (part 2)

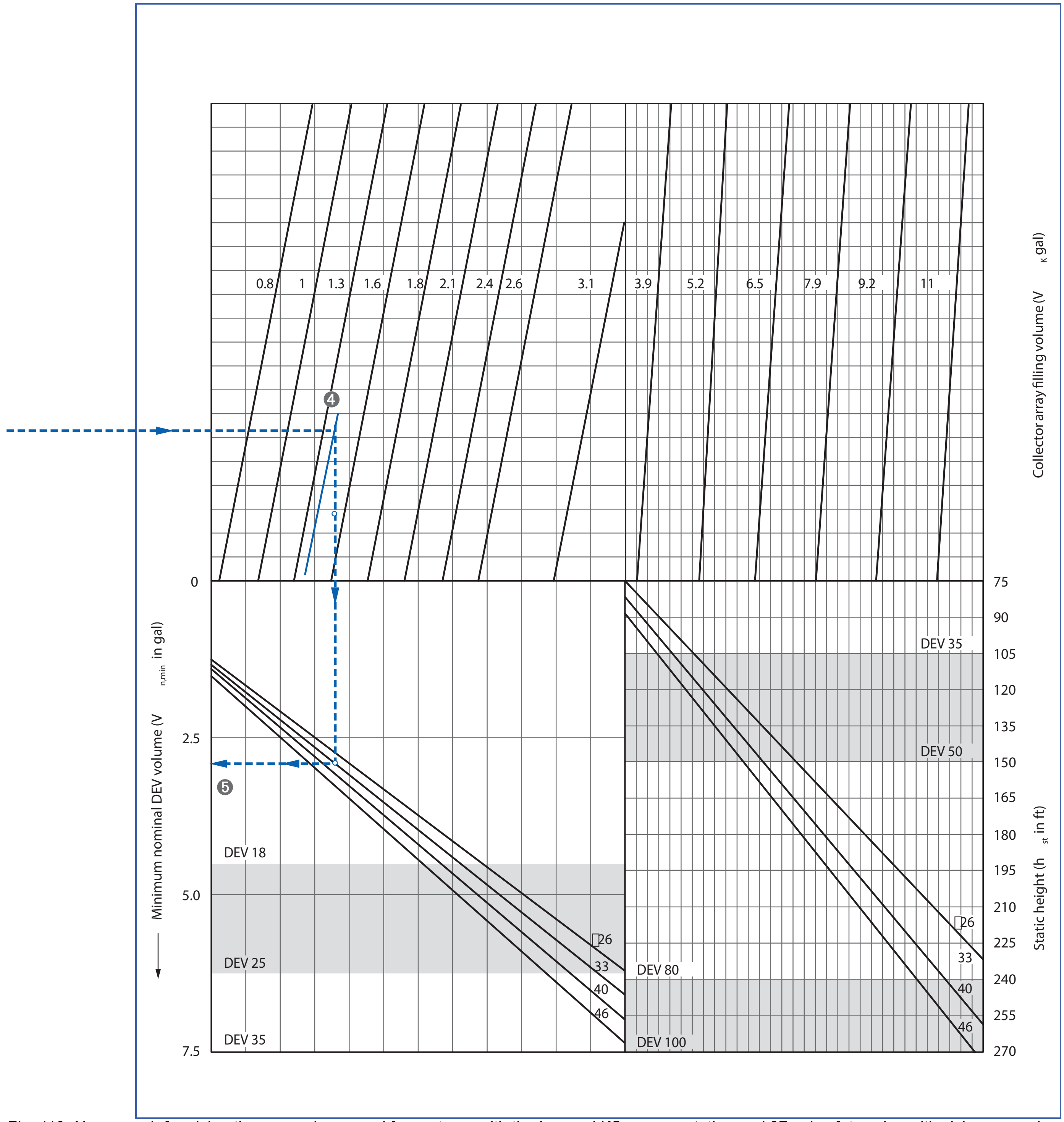


Fig. 113 Nomograph for sizing the expansion vessel for systems with the Logasol KS... pump station and 87 psi safety valve with sizing example highlighted in blue (description - page 89)

5 Design/engineering information regarding the installation

5.1 Pipework, thermal insulation and collector temperature sensor extension cable

Glycol and temperature-resistant sealing

All components of a solar heating system (including flexible seals for valve seats, diaphragms in expansion vessels etc.) must be made from glycol-resistant materials and carefully sealed, since water:glycol mixtures have a greater tendency to leak than pure water. Aramide fiber seals have proven to be effective. Graphited cord is suitable for sealing glands. Hemp seals must also be coated with temperature-resistant and glycol-resistant thread paste. Nissen products “Neo Fermit universal” or “Fermitol” can be used as thread paste (observe the manufacturer’s instructions).

The solar hose ferrules on the Logasol SKN3.0 collectors and the connectors of the Logasol SKS4.0 collectors provide an easy and reliable seal for collector connections. Connecting kits for 1/2 inch Twin-Tube are available for providing a reliable connection to the special Twin-Tube double tube.

Pipework routing

All connections in the solar circuit must be brazed. Alternatively, press fittings can be used, provided that they are suitable for use with a water:glycol mixture and respectively high temperatures of up to 400 °F (205 °C). All pipework must be routed with a rise towards the collector array or the air vent valve, if installed. Heat expansion must be taken into consideration when the pipework is being routed. The pipes must be routed with provisions for expansion (bends, sliding clamps, compensators) to prevent damage and leaks. Plastic pipework, PEX, or galvanized comoponents are not suitable for solar systems.

Thermal insulation

Connection lines may be routed in unused fl ues, air ducts and wall cavities (in new buildings). Open ducts must be properly sealed to prevent heat loss caused by rising air (convection). Follow building codes when penetrating floors.

The thermal insulation of the connection lines must be designed for the operating temperature of the solar system. Therefore use appropriate high temperature-resistant insulating materials such as insulating hoses made from EPDM rubber. Thermal insulation exposed to the elements on the roof must be UV, weather and temperature resistant. Figure 74/1 shows standard values for the insulating thickness on pipework in solar systems. Mineral wool is not suitable for outdoor applications because it absorbs water and then fails to provide thermal insulation.

Pipe diameter **inches**	Twin-Tube (double tube) insulation thickness1) inches	Aeroflex SSH pipe diameter × insulation thickness inches	Aeroflex HT pipe diameter × insulation thickness inches	Mineral wool insulation thickness (indoor application only) inches
1/2	½"	–	½ x 1"	¾"
5/8	–	⅝ x 1"	⅝ x 1"	¾"
3/4	½"	1 x 1"	1 x 1"	¾"
1	–	1 x 1"	1 x 1"	¾"
1-1/4	–	1-¼ x 1-½"	1 x 1-½"	1-3/16"
1-1/2	–	1-½ x 1-½"	1-½ x 1-½"	1-3/16"

Fig. 114 Thickness of thermal insulation for solar heating system connection lines

1) Requirements according to the Energy Saving Order (EnEV) [Germany[

Collector temperature sensor extension lead

When routing the pipework, also route a two-core lead (up to 164 ft length 2 × 18 AWG) for the collector temperature sensor alongside. An appropriate lead is provided in the insulation of the Buderus Twin-Tube. Provide a shield for the collector temperature sensor extension lead, if it is routed next to a 120 V cable. Install the FSK collector temperature sensor in the sensor well of the top supply header of the Logasol SKN3.0 and SKS4.0 collectors.

5.2 Air vent valve

5.2.1 Automatic air vent valve

Unless a high volume and high pressure filling station with air separator is being used, solar heating systems with flat-plate collectors are vented via quick-acting air vent valves at the highest point of the system. After filling has been completed, this valve must be closed to prevent evaporated solar fluid from escaping from the system in the event of stagnation.

Provide an air vent valve at the highest point of the system (detail E Fig. 115) and, for every change of direction, with a new rise (e.g. in dormers). If there are several rows of collectors, provide an air vent valve for each row (Fig. 116), unless the system can be vented above the top row (Fig. 117). Use only automatic all-metal air vent valve in the form of an air valves.

Never use air vent valves with plastic floats in solar heating systems because of the high temperatures that occur. If there is insufficient room for an automatic allmetal air vent valve with an upstream ball valve, install a manual air vent valve.

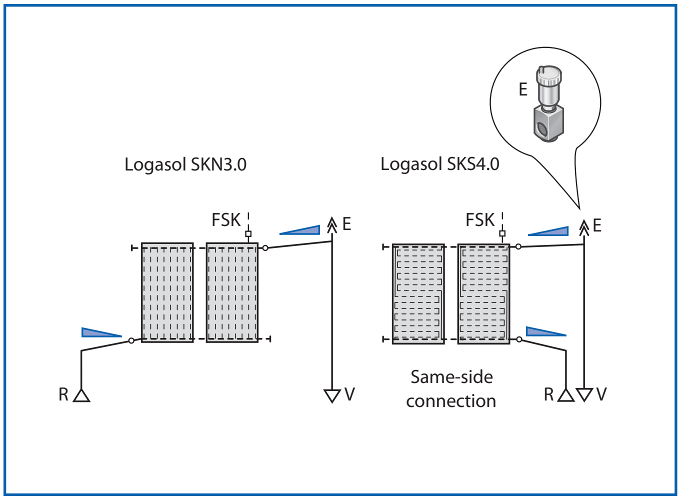


Fig. 115 Hydraulic diagram with air vent valve at the highest point of system

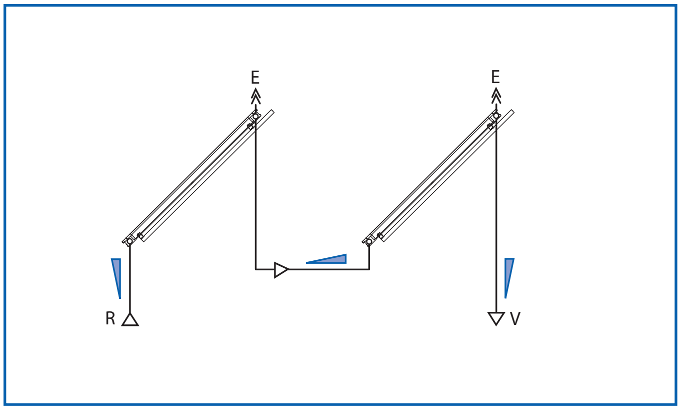


Fig. 116 Hydraulic diagram with air vent valve for each collector row on the example of flat installation (connected in series)

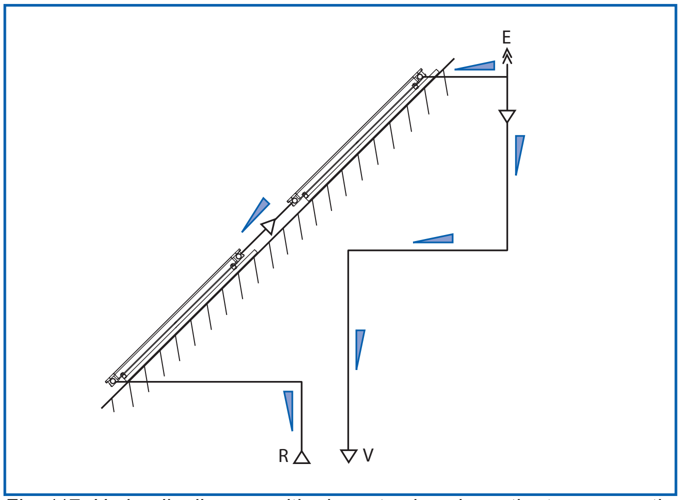


Fig. 117 Hydraulic diagram with air vent valve above the top row on the example of rooftop installation (connection in series)

5.2.2 Filling station and air separator

The quickest and most efficient way to fill Buderus solar systems is by using the Zuwa Unistar 2000-A filling station (Fig. 118), resulting in most air being pushed out of the system during the filling procedure. An air vent valve on the roof is not needed in this case. Instead, a central air separator is part of the Logasol KS01 2-line pump station. (Fig. 119). This separates the residual micro-bubbles out of the medium during operation.

Benefits of the system are:

- Reduced installation effort because no air vent valves are needed on the roof
- Easy and quick commissioning, i.e. filling and ventilation in one step.
- Efficiently vented system
- Low-maintenance operation

If the collector array consists of several rows connected in parallel, provide each individual row with a shut-off valve in the supply pipe. Each row is filled and vented individually during the filling procedure.

Fig. 118 Zuwa Unistar 2000-A filling station

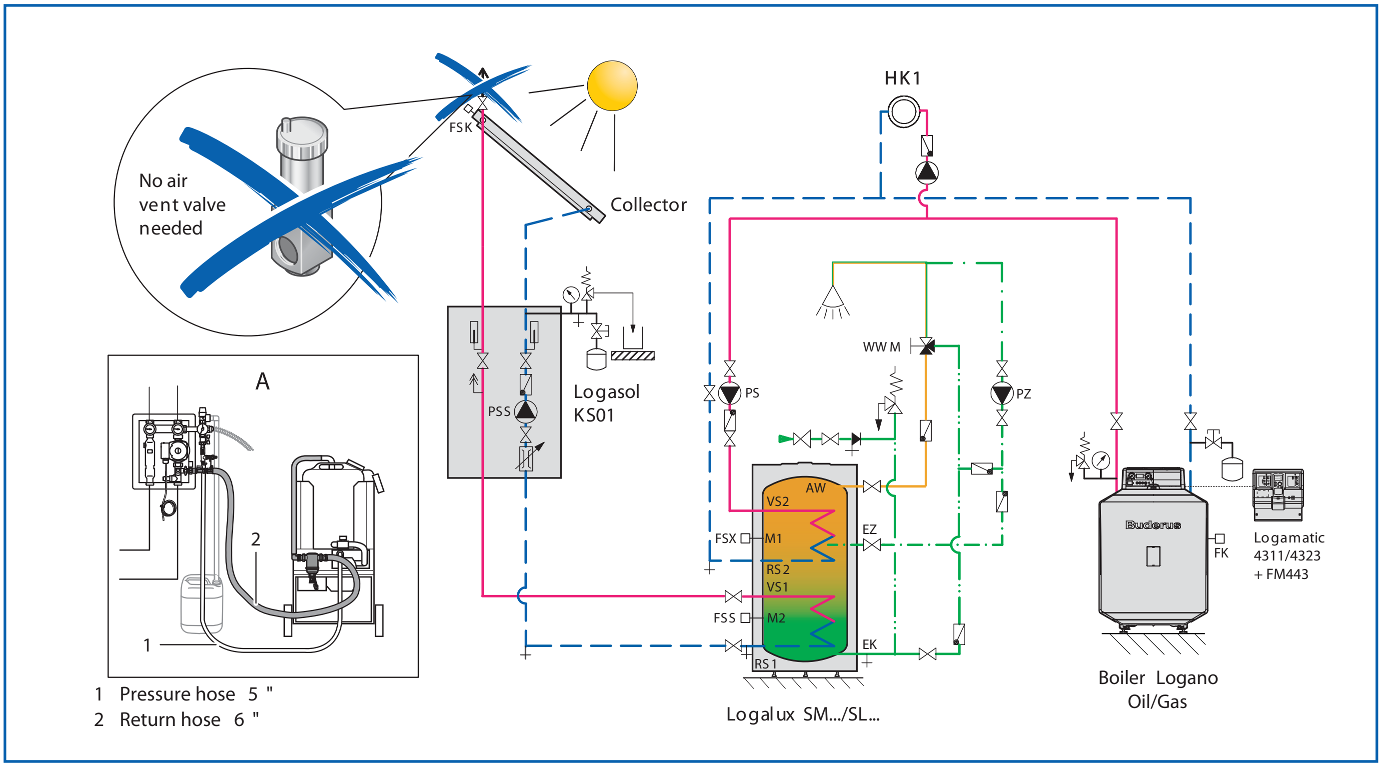


Fig. 119 System design; detail A: Filling procedure with pump

5.3 Information regarding the different flat-plate collector installation systems

5.3.1 Permissible standard snow loads and building heights

The following table contains the permissible standard snow loads and building heights for the different installation options. Take advantage of below information during the planning phase of solar thermal project.

	Rooftop installation Portrait/landscape	Flat roof installation Portrait/landscape	Wall mounting 45–60 Landscape
Roof cover/wall	Tiles, plain tiles, slate, shingle, corrugated sheets, sheet steel, bitumen	–	load-bearing
Permissible roof pitch	25°–65°, 5°–65° (corrugated sheets, sheet steel roof)	0° (with slightly sloping roofs of up to 25°, protection from sliding off or on-site fixing)	–
Permissible building heights (wind loads) of up to 65 ft- at wind speeds of up to 80 mph	Without accessories	Without accessories (observe securing flat roof supports!)	Without accessories
Permissible building heights (wind loads) of up to 300 ft - at wind speeds of up to 94 mph	Only portrait collectors with rooftop installation kit	With flat roof support kit (observe flat roof support fixing!)	Not permissible
Standard snow loads 0 - 42 lbs/ft²	Without accessories	Without accessories	Without accessories
Standard snow loads > 42 lbs/ft²	Only portrait collectors with rooftop installation kit up to 65 lbs/ft²	Without flat roof support kit up to 79 lbs/ft²	Not permissible

Fig. 120 Permissible standard snow loads and building heights

5.3.2 Selection aid for hydraulic connection accessories

Provide suitable hydraulic connection accessories subject to the number of collectors and their hydraulic connections.

For further details regarding the various assembly systems, see the relevant “Hydraulic connection” section in the following sub-chapters.

Single-row collector array

Number of collectors	Number of rows	Connection kit	Air vent valve kit[1)]
1 to 10	**1**	1	1

Fig. 121 Hydraulic connection accessories for a single-row collector array
1) The air vent valve kit is not needed if the system is filled with a “Filling station”

Connecting two collector rows in parallel

Number of collectors	Number of rows	Connection kit	Air vent valve kit[1)]
2 to 20	**2**	2	2

Fig. 122 Hydraulic connection accessories for connecting two collector rows in parallel
1) The air vent valve kit is not needed if the system is filled with a “Filling station”. Also provide a shut-off valve in the flow of each row if the collectors are connected in parallel.

Several collector rows connected in series

Number of collectors	Number of rows	Number of collectors per row	Connection kit	Air vent valve kit[1)]	Series connection kit
2	2	1	1	1	1
3	2	2 1	1	1	1
	3	1	1	1	2
4	2	2	1	1	1
5	2	3 2	1	1	1
6	2	3	1	1	1
	3	2	1	1	2
7	2	4 3	1	1	1
8	2	4	1	1	1
9	2	5 4	1	1	1
	3	3	1	1	2
10	2	5	1	1	1

Fig. 123 Hydraulic connection accessories for connecting several collector rows in series

1) The air vent valve kit is not needed if the system is filled with a "Filling station" (page 81). Additional air vent valve kits are required unless the system can be vented above the top row (e.g. with flat roof installation).

5.3.3 Rooftop installation of flat-plate collectors

Rooftop installation

The collectors are secured at the same angle as the pitched roof using the rooftop installation kit. The roof skin retains its sealing properties.

The rooftop installation kit for Logasol SKN3.0 and SKS4.0 flat-plate collectors consists of a standard kit for the first collector in a row and an extension kit for each additional collector in the same row (Fig. 124). Use the rooftop installation extension kit only in conjunction with a standard kit. In place of the single-side collector tensioner (item. 1 Fig. 124) the extension kit contains so-called double-sided collector tensioners (item 5 Fig. 124) and connectors for defining the correct spacing and securing two adjacent Logasol SKN3.0 or SKS4.0 flat-plate collectors.

Roof connections for different roof covers

The profile rails and collector tensioners of the various rooftop installation kits are identical for all roof connections. The various installation kits for tile and plain tile, slate and shingle cover as well as for corrugated sheet and sheet steel roofs only differ with regard to the type of roof hook (Fig. 124) or special attachment materials used (Fig. 125).

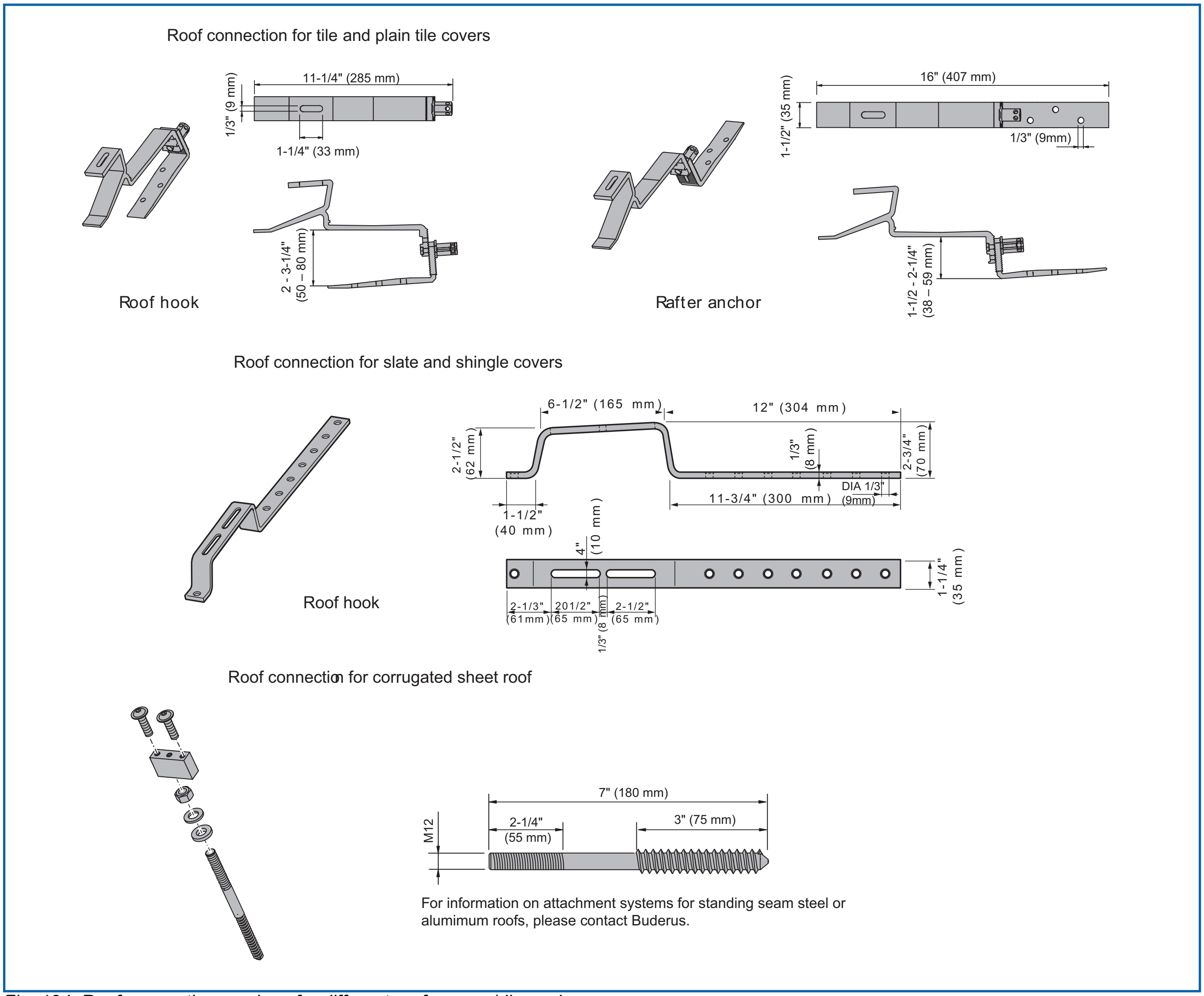


Fig. 124 Roof connection versions for different roof covers (dimensions in inches (mm))

Roof connection for tiled roofs

Fig. 125 shows an example for a rooftop installation on a tile roof. On roofs with simple battens, the roof jacks are fastened to the sheathing (Fig. 127). This is done by turning the lower part of the roof jack over. If additional height compensation is needed, the lower section of the roof jack can be shimmed up. On roofs with counter battens, the roof jacks (Fig. 124 and 125) are hooked over the existing roof battens (Fig. 126) and fastened to the profile rails.

When considering installation on a tile roof, check whether the dimensions specified in Fig. 125, detail A can be met. Use the roof jacks supplied, if they

- fit into the valley of the roof tile and
- extend over the roof tile plus roof batten.

The tile cover should not exceed 5 inches. Where necessary, include a roofing contractor in the planning and installation process. Care must be taken that the hooks are only mounted on parts of the roof that are capable of providing the necessary support under all foreseeable conditions.

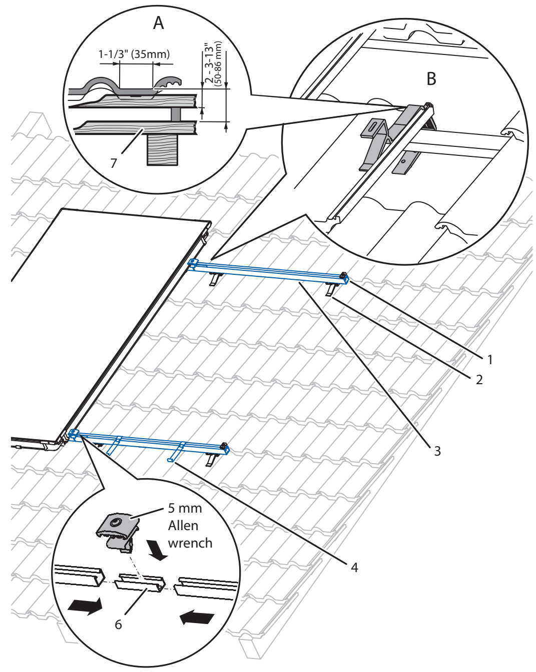


Fig. 125 Rooftop installation standard kit and extension kit (highlighted in blue) for one Logasol SKN3.0 or SKS4.0 flat-plate collector (detail A: dimensions in inches (mm))

Legend *(Fig. 125)*
1 Single-sided collector tensioner (only in the standard kit)
2 Roof jack, adjustable
3 Profile rail
4 Collector hook (2x per collector)
5 Double-sided collector clamp (only in the extension kit)
6 Connector (only in the extension kit)
7 Sheathing

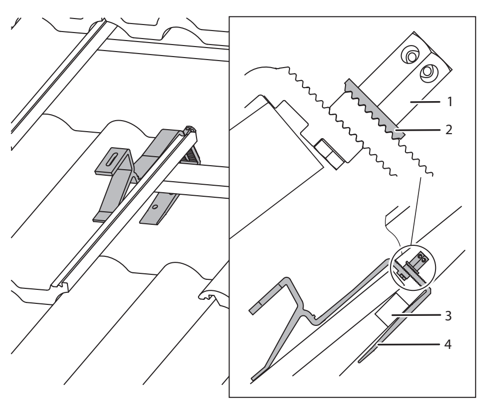


Fig. 126 Installed roof jack

Legend *(Fig. 126)*
1 Hex nut
2 Serrated washer
3 Roof batten
4 Roof jack, lower part

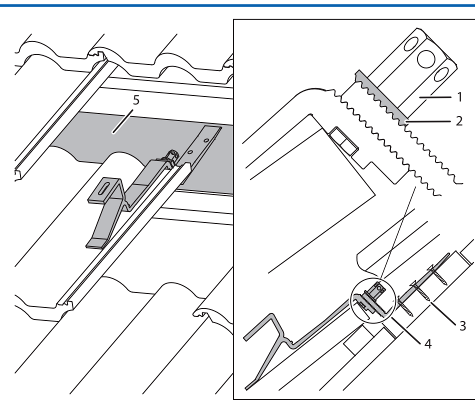


Fig. 127 Roof jack fastened to the sheeting

Legend *(Fig. 127)*
1 Hexagon nut
2 Serrated washer
3 Wood screws
4 Roof jack, lower part
5 Sheathing

Plain tile roof connection

Fig. 128 shows attaching the roof jack (item 2) to a plain tile roof. Trim and attach the plain tiles on site.

The horizontal profile rails are fastened to the roof jack the same way as with regular tiles (Fig. 125).

Consult a roofing contractor for rooftop installation on plain tiles, if needed.

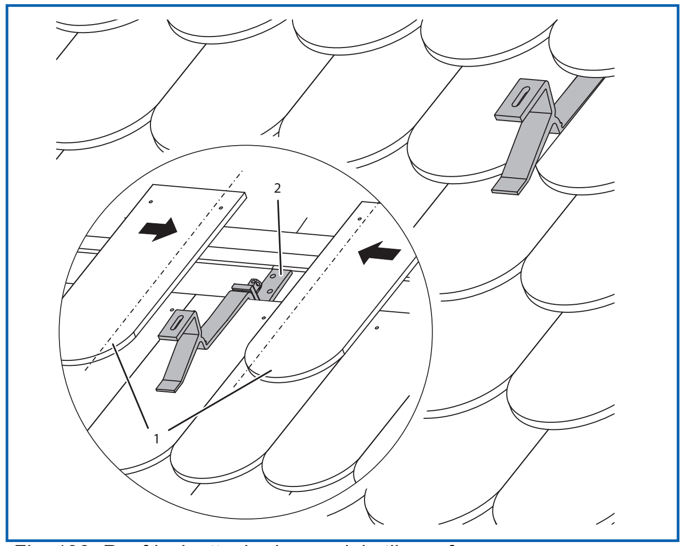


Fig. 128 Roof jack attached on a plain tile roof

Legend *(Fig. 128)*
1 Plain tiles (cut along the dotted line)
2 Roof hook, lower part fastened to sheathing

Roof connection with slate or shingle

Roof jack installations on slate or shingle roofs should be carried out by a roofing contractor. Fig. 129 shows an example of an installation of the roof jacks (item 5 Fig. 129) on a slate or shingle roof. Gaskets, caulking and flashing to be provided on site. The horizontal profile rails are to be fastened to the roof jacks in the same way as on a tile roof (Fig. 125).

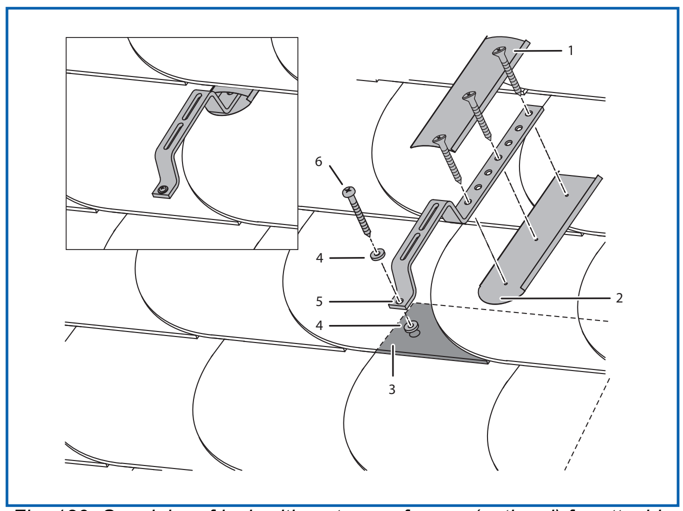


Fig. 129 Special roof jack with waterproof cover (optional) for attaching a rooftop installation kit for flat-plate collectors to a slate or shingle roof

Legend *(Fig. 129)*
1 Flashing top (on site)
2 Flashing bottom (on site)
3 Overlapping shingle or slate
4 Gasket or caulking (on site)
5 Roof jack
6 Screw (provided)

Roof connection in situations with added insulation on rafters

Fig. 130 shows a scenario with insulation on rafters using the roof hooks. In order to establish an adequate base to attach the roof hooks to, the roofing contractor secures wooden boards with a minimum cross-section of 1 x 8 inches to the rafters. The force generated by the roof hook must be transferred by this board to the loadbearing rafters. With an assumed maximum snow load of 42 lbs/ft² (without accessories) or 65 lbs/ft² (with accessories), the design must be able to safely bear the following loads:

- Force parallel to the roof surface: Fsx = 180 lbf
- Force perpendicular to the roof surface: Fsy = 400 lbf

The horizontal profile rails must be fastened to the special roof jacks in the same way as they are with a tile roof (Fig. 123)
.

Legend *(Fig. 130)*
1 *Roof tile*
2 *Roof jack*
3 *Insulation on rafters*
4 *Rafter*
5 *Adequate screw for load (provided on site)*
6 *Board (at least 1 x 8 inches)*
Fsx *Load parallel to the roof surface*
Fsy *Load perpendicular to the roof surface*

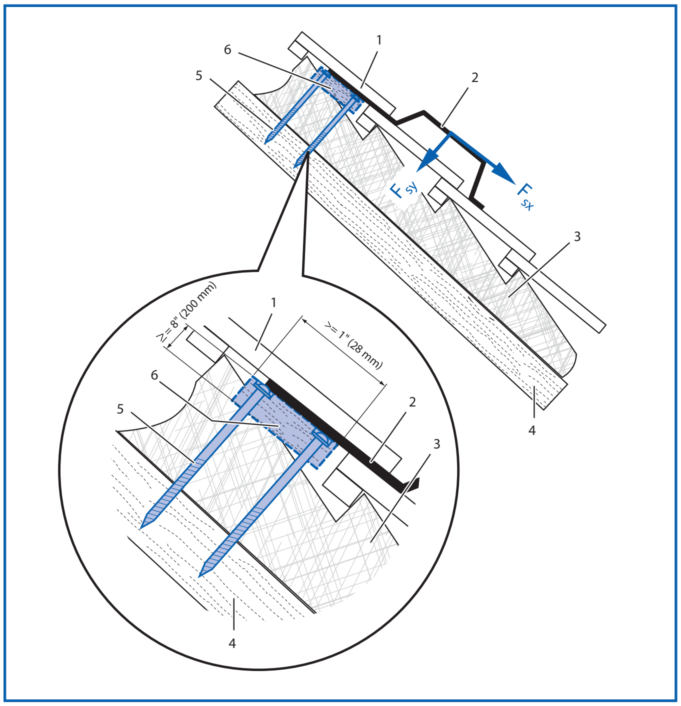


Fig. 130 Example of on-site attachment of additional boards on top of insulation on rafters. Design may vary based on conditions. Useof a roofing contractor highly recommended.

Attachment on corrugated sheet roofs

Installation on a corrugated sheet roof is only possible if the headless screws can be fastened at least 1-1/2 inches into a structural element with adequate load-bearing capacity (Fig. 131).

The corrugated sheet roof connection kit contains headless screws including retaining brackets and gaskets that are used instead of the roof jacks in the rooftop installation kit.

Fig. 131 shows how the profile rails are attached to the retaining brackets of the screws.

Legend *(Fig. 131)*
1 *M8 × 16 Allen screws*
2 *Profile rail*
3 *Retaining bracket*
4 *Hex nut*
5 *Gasket*

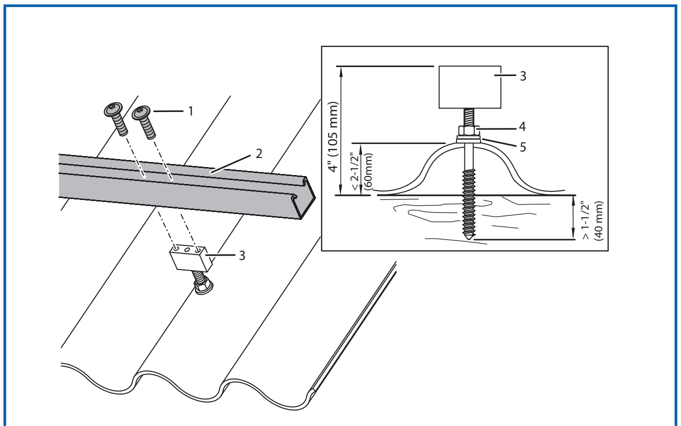


Fig. 131 Example of profile rail attachment with rooftop installation on a corrugated sheet roof. Use of a roofing contractor is highly recommended.

Installation on standing seam steel or aluminum roofs

Contact Buderus for special attachment clamps for standing seam metal roofs. http://www.buderussolar.com/
Connection on flat seam metal roofs Fig. 132 shows a mounting option for metal roofs without standing seams. It is recommended to consult a roofing contractor.
Secure a sleeve similar to the one shown in Fig. 132 to the roof on site and use appropriate measures to waterproof the penetration. Choose the number of sleeves per collector based on their load rating, but at least four. Sleeves can also be soldered or brazed to the roof. The M12 × 180 screws are fastened to the substructure (rafter or load-bearing beam, at least 2 x 2 inches) through the sleeve.

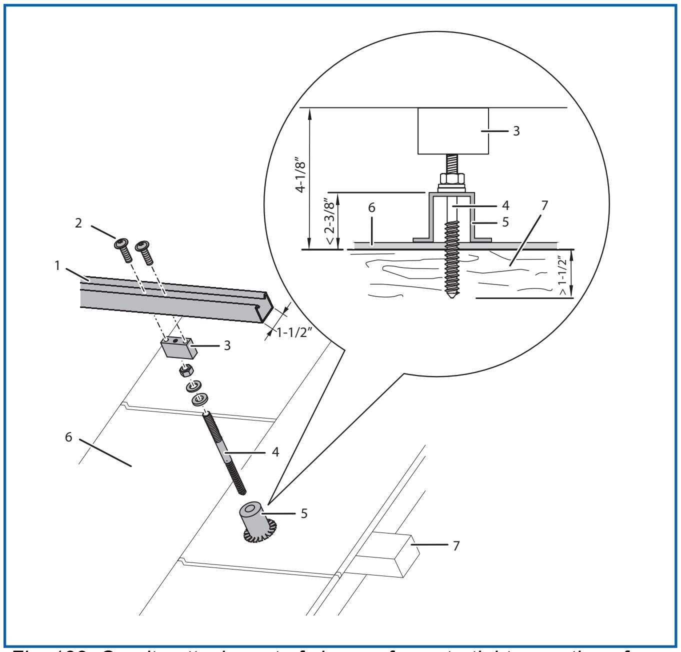


Fig. 132 On-site attachment of sleeves for watertight mounting of screws for installation on sheet metal roofs (dimensions in inches)

Legend *(Fig. 132)*
1 Profile rail
2 M8 × 16 Allen screws
3 Retaining bracket
4 M12 screw
5 Sleeve
6 Sheet metal roof
7 Load bearing sub-structure (minimum 2 x 2 inches)

Consult a roofing contractor to ensure a weather proof installation and avoid water damage to the building.

Snow load profile/additional rail

Install a snow guard and an additional rail (accessories) on buildings between 65 ft and 328 ft in height and in regions with snow loads of 42 lbs/ft² to 65 lbs/ft² . These provide better distribution of the higher loads on the roof.

Fig. 133 shows the installation of a snow guard and an additional rail on the example of tile cover. Both accessories can also be fitted to installation systems for other roof types.

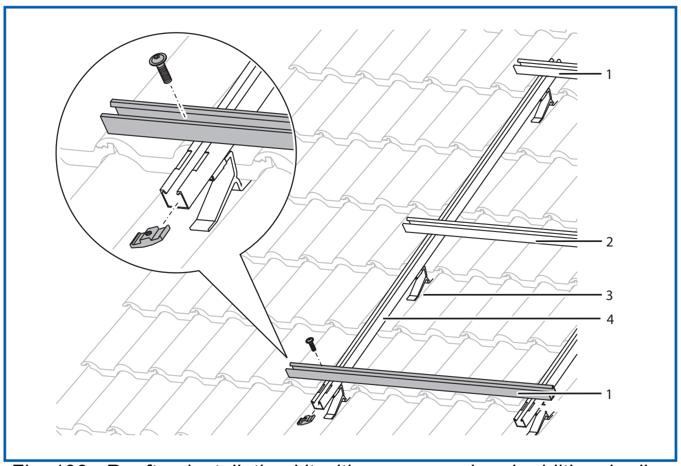


Fig. 133 Rooftop installation kit with snow guard and additional rail

Legend *(Fig. 133)*
1 Profile rails types (rooftop installation kit)
2 Additional rails (including collector tensioner)
3 Additional roof connection (snow guard standard delivery)
4 Vertical profile rails (snow guard standard delivery)

Hydraulic connections

The rooftop connection kits are used to make the hydraulic collector connections (Fig. 134 and 135).

It is recommended to penetrate the roof close to the collector connection, and avoid long pipe runs above the roof.

For asphalt shingle roofs use standard plumber's rubber pipe flashing.

It is recommended to consult a roofing contractor for specifics and to avoid water damage to the building.

Roof outlets are required for supply and return, since the collector connections are above roof level. On tile roofs a "ventilation tile" (Fig. 136) can be used as a roof outlet for the supply and return lines. If the site allows, and an air vent is needed (-> 6.2), mount the air vent in the attic. Ensure still that it marks the highest point of all piping, and is mounted perfectly vertical to ensure proper operation of the internal float. The supply line is routed through the roofing skin with an incline to the air vent valve, if required, via the upper ventilation tile. The lead from the collector temperature sensor also runs through this tile. Route the return line to the pump station. A plumber's rubber pipe flashing or ventilation tile can be used for this if the return line runs in the attic (Fig. 136). An additional air vent valve is not usually required, in spite of the change of direction at the penetration.

Involve a roofing contractor in the planning to prevent damage to the building.

Legend *(Fig. 134)*
1 Connecting line 39 inches
2 Dummy plug
3 Spring clips
4 Hose coupling with R 3/4 inch connection or 5/8 inch locking ring

Legend *(Fig. 135)*
1 39 inch connection line with R 3/4 inch connection or 5/8 inch locking ring at the system side, insulated
2 Dummy plug
3 Clip

Legend *(Fig. 136)*
1 Supply line
2 Return line
3 Sensor lead
4 Ventilation tile
5 Air vent valve

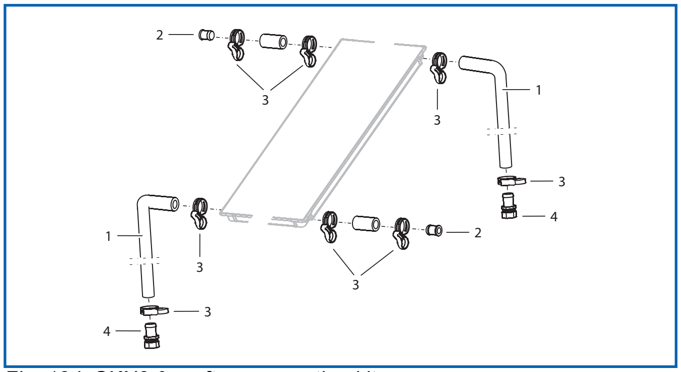


Fig. 134 SKN3.0 rooftop connection kit

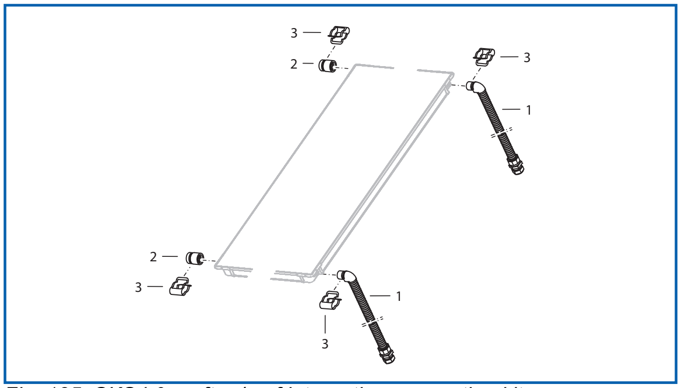


Fig. 135 SKS4.0 rooftop/roof integration connection kit

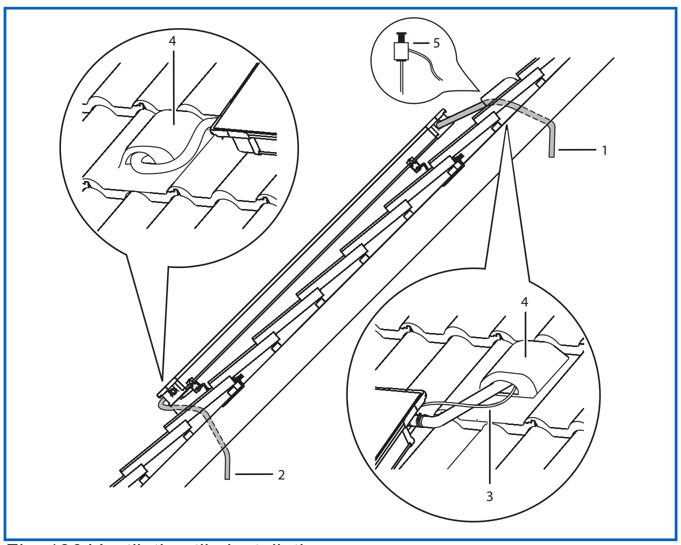


Fig. 136 Ventilation tile installation

Static requirements

The rooftop installation kit is exclusively designed for the secure mounting of solar collectors. Never attach other rooftop equipment such as antennae to the collectors or collector mounting kits.

The roof and the substructure must have an adequate load-bearing capacity. A load of about 100 lbs can be expected for each Logasol SKN3.0 or SKS4.0 flat-plate collector. Also take the specific regional loads resulting from wind, snow and other factors into account. The values in Fig. 120 are standard snow loads and building heights for rooftop installation.

Rooftop installation system component selection aid

Include appropriate connection materials in the design based on the number of collectors and their hydraulic connections.

		Total number of collectors	2		3			4		5		6			7		8		9			10	
		Number of rows	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
		Number of collectors per row	2	1	3	2 1	1	4	2	5	3 2	6	3	2	7	4 3	8	4	9	5 4	3	10	5
SKN3.0-s and SKS4.0-s	Standard kit[1]	Tiles Plain tiles Slate and asphalt shingle Corrugated sheet Sheet metal roof	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Extension kit[1]	Tiles Plain tiles Slate and asphalt shingle Corrugated sheet sheet metal roof	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
	Additional kit Standard kit[2]	Tiles Plain tiles Slate and asphalt shingle Corrugated sheet Sheet metal roof	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Additional kit Extension kit[2]	Tiles Plain tiles Slate and asphalt shingle Corrugated sheet Sheet metal roof	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
SKN3.0-w and SKS4.0-w	Standard kit[1]	Tiles Plain tiles Slate and asphalt shingle Corrugated sheet Sheet metal roof	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Extension kit[1]	Tiles Plain tiles Slate and asphalt shingle Corrugated sheet Sheet metal roof	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8

Fig. 137 Installation materials for rooftop installation system
1) Consisting of installation kit and roof connection
2) Consisting of snow guard and additional horizontal rail, required for snow loads of 42 lbs/ft² to 65 lbs/ft² or building heights of 65 ft to 328 ft

5.3.4 Flat roof installation

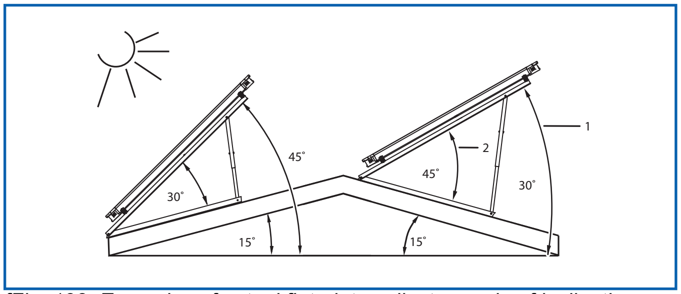
Flat roof installation is intended for level roof surfaces, or where the collectors are to be positioned at an angle steeper than the pitch of the roof (Fig. 138).

The flat roof installation kit for Logasol SKN3.0 and SKS4.0 flat-plate collectors consists of a standard kit for the first collector in a row and an extension kit for each additional collector in the same row (Fig. 139). Accessories are required for buildings more than 65 ft high, or with snow loads of > 42 lbs/ft2.

The angle of inclination of the flat roof support can be adjusted in steps of 5° as follows:

- Portrait flat roof support: 30° to 60° (25° by trimming the telescopic rail)
- Landscape flat roof support: 35° to 60° (25° or 30° by trimming the telescopic rail)

The flat roof supports can be installed to the roof by means of weighting (ballast) or by attaching them to the roof structure.



fFig. 138 Examples of actual flat-plate collector angle of inclination when using flat roof supports on a flat roof with a shallow pitch (< 25°)
Item 1: pitch; item 2: collector angle of inclination

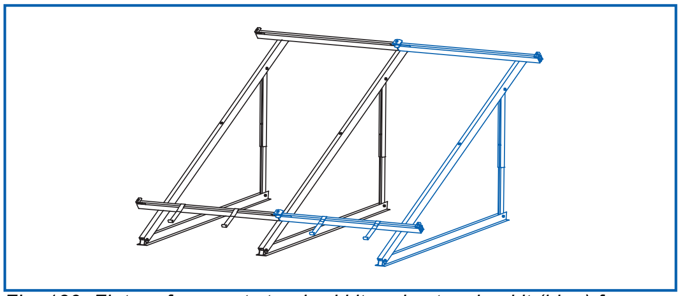


Fig. 139 Flat roof support standard kit and extension kit (blue) for one SKN3.0-s or SKS4.0-s flat collector

On-site mounting

The flat roof supports can by mounted onto on-site substructures consisting of I-beams, for example (Fig. 140). For this, predrilled holes are in the bottom profile rails of the flat roof supports. The on-site substructure must be designed such that the wind force acting upon the collectors can be absorbed.

The support spacing dimensions can be found in figures 141 to 143. The positions of the holes for attaching the flat roof supports to the on-site substructure can be found in figure 140.

For buildings more than 65 ft in height or with snow loads of 42 lbs/ft² to lbs/ft² to 79 lbs/ft², each standard kit for portrait collectors must be fitted with an additional rail (standard kit addition) and each extension kit must be fitted with an additional rail and an additional support (extension kit addition). With landscape collectors, fit all installation kits with an additional rail (standard kit and extension kit addition).

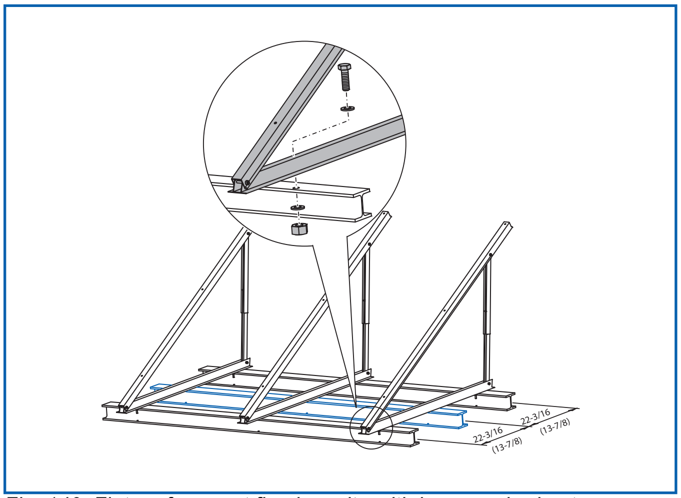


Fig. 140 Flat roof support fixed on site with base anchoring to a substructure consisting of I-beams supports (dimensions in inches); value in brackets for landscape version; center contact surface (blue) only required for buildings above 65 ft in height.

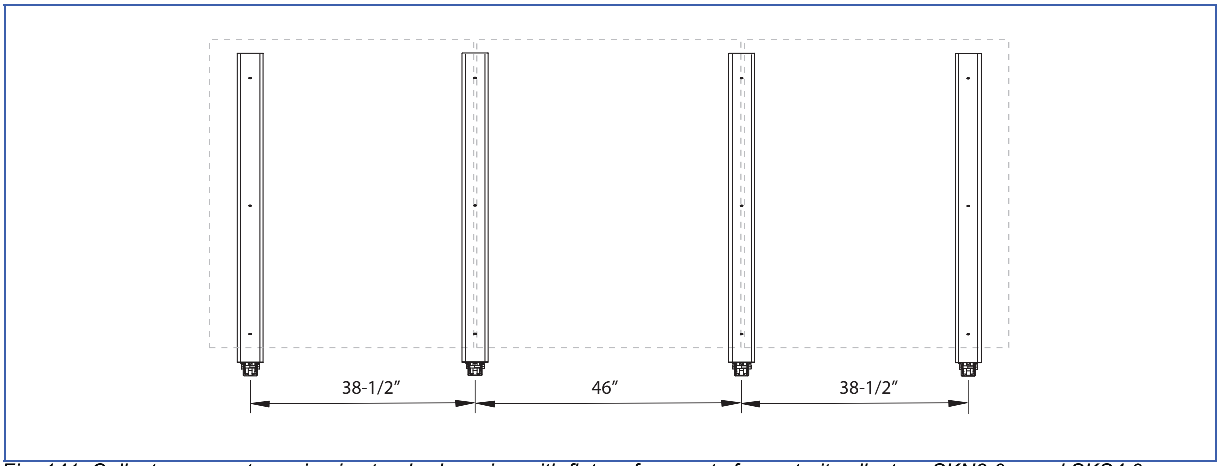


Fig. 141 Collector support spacing in standard version with flat roof supports for portrait collectors SKN3.0-s and SKS4.0-s (dimensions in inches)

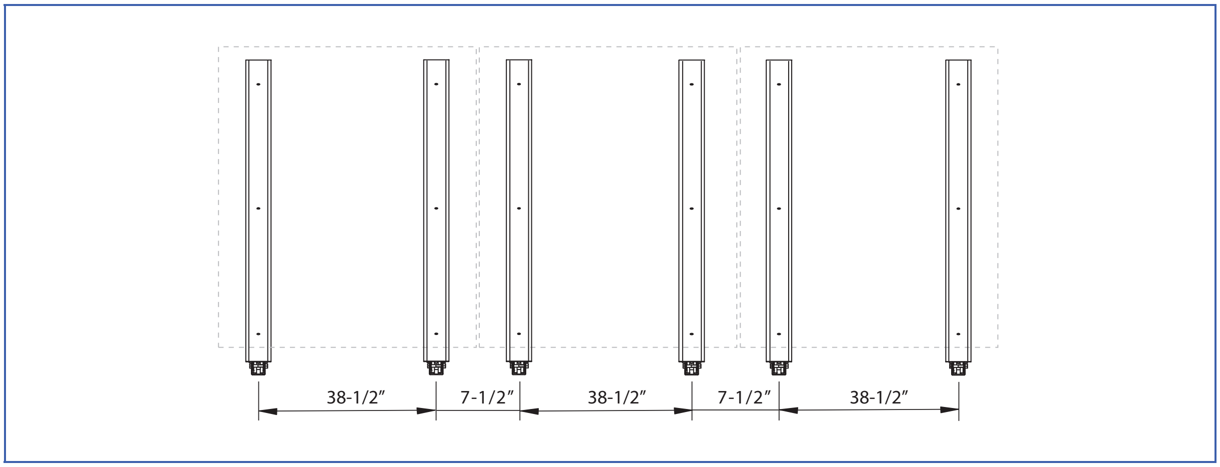


Fig. 142 Collector support spacing in standard version when using additional supports with flat roof supports for portrait collectors SKN3.0-s and SKS4.0-s (dimensions in inches)

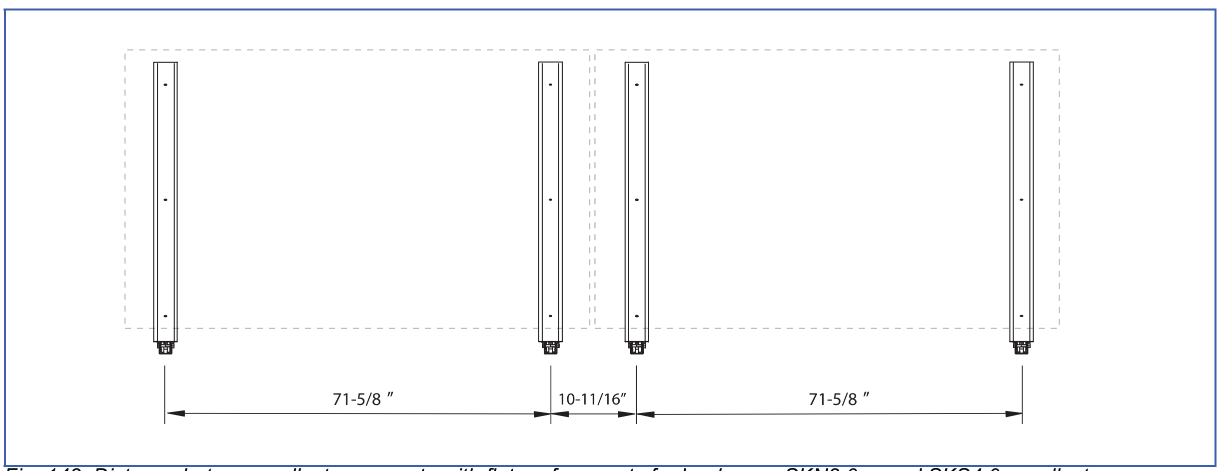


Fig. 143 Distance between collector supports with flat roof supports for landscape SKN3.0-w and SKS4.0-w collectors (dimensions in inches)

Securing by means of ballast trays

Four ballast trays are required for each flat roof support when the collectors are weighed down (dimensions: 37-3/8” x 13-3/4” x 2”) - these are hooked into the flat roof support (Fig. 144). They are filled with concrete bricks, gravel or the like. See Fig. 137 for the required ballast weight (maximum 700 lbs with gravel filling) subject to the height of the building.

With a building up to 65 ft high and snow loads of up to 42 lbs/ft², one additional support is required for the 4th, 7th and 10th collector in a row when ballast trays are used in conjunction with portrait collectors. The installation kit includes one additional support when landscape collectors are used. The additional supports are required for hooking in the trays.

For buildings higher than 65 ft or with snow loads of 42 lbs/ft² to 79 lbs/ft², each standard kit must include an additional rail (standard kit addition) and each extension kit for portrait collectors must include an additional support and an additional rail (extension kit addition). With landscape collectors, all installation kits must be equipped with an additional rail (standard kit and extension kit addition).

Erect the entire structure on protective building mats to protect the roof membrane.

Ensure that the roof and building can support the weight of the collectors and ballast.

Hydraulic connections

The flat roof connection kits are used to make the hydraulic collector connections during flat roof installation (Fig. 145 and 146). Route the supply line parallel to the collector to prevent damage to the connection due to the movement of the collector in the wind (Fig. 147).

Static requirements
Follow Fig. 120 snow loads and building heights.

Legend *(Fig. 145)*
1 *Bracket with R 3/4 inch connection on the system-side or 5/8 inch locking ring*
2 *Stop washer*
3 *Nut G1*
4 *Dummy plug*
5 *Spring clips*

Legend *(Fig. 146)*
1 *Bracket with R 3/4 inch connection on the system side or 5/8 inch locking ring*
2 *Dummy plug*
3 *Clip*

Legend *(Fig. 147)*
1 *Pipe clamp (on site)*
2 *M8 thread to attach hose clamp for routing pipe alongside the collector*
3 *Bracket (connection kit standard delivery)*
4 *Supply line*

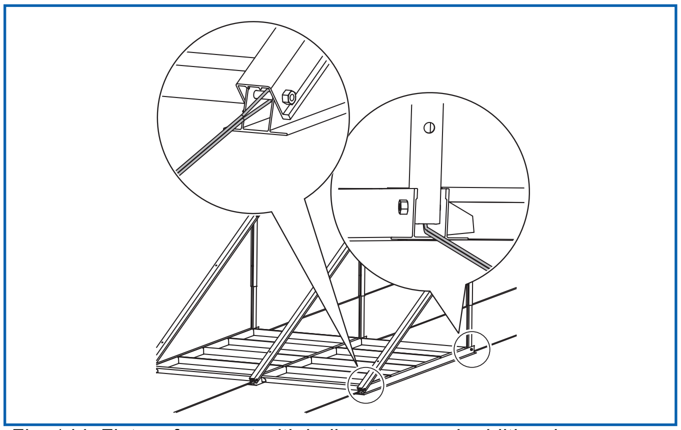


Fig. 144 Flat roof support with ballast trays and additional guy ropes

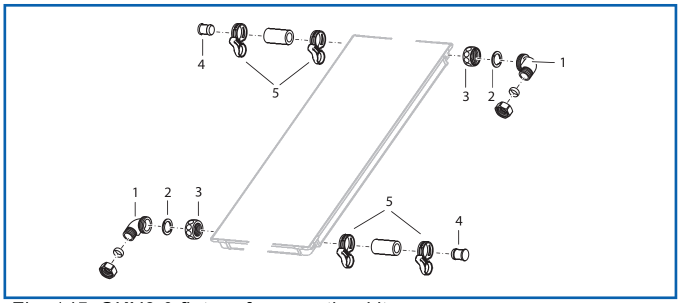


Fig. 145 SKN3.0 flat roof connection kit

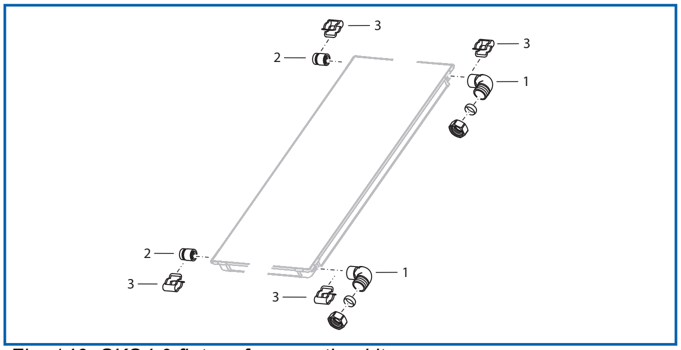


Fig. 146 SKS4.0 flat roof connection kit

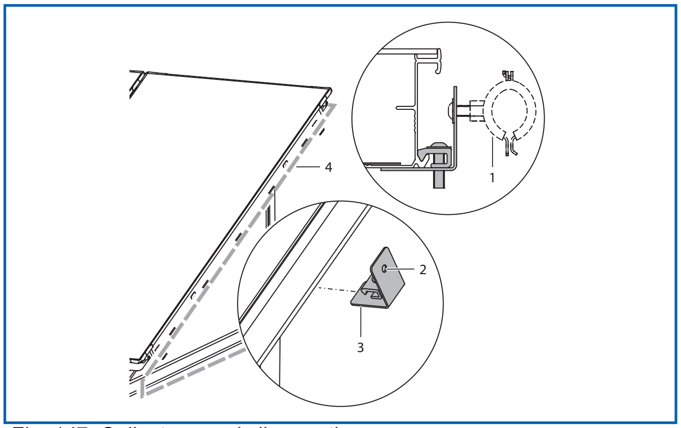


Fig. 147 Collector supply line routing

Flat roof support weights

To determine the roof loads, the following weights for flat roof installation kits, use the:

- Standard kit, portrait: 27 lbs
- Standard kit, landscape: 19 lbs
- Extension kit, portrait: 16 lbs
- Extension kit, landscape: 19 lbs

Flat roof support fixing (collector stabilisation)

Below is for reference only. Required support varies from site to site and should be verified by a professional engineering firm.

Building height	**Wind velocity**	Base anchoring	Ballast	Guy rope	
				Protection against tilting	Protection against slippage
		Number and type of screws[1]	Weight (e.g. concrete bricks)	Weight (e.g. concrete bricks)	Max. tensile strength per rope
ft	**mph**		lbs	lbs	lbf
0-25	**60**	2x M8/8.8	595	400	360
25-65	**80**	2x M8/8.8	990	700	560
65-300	**90**	3x M8/8.8	[2]	990	740

Fig. 148 Options for securing flat roof supports for each collector to prevent tilting and sliding as a result of wind; version for Logasol SKN3.0 and SKS4.0 flat-plate collectors

1) Per collector support
2) Not permitted

Flat roof installation system, component selection aid

Consider appropriate attachment materials in the design based on the number of collectors and their hydraulic connections.

	Total number of collectors	2		3			4		5		6			7		8		9			10	
	Number of rows	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Number of collectors per row	2	1	3	2 1	1	4	2	5	3 2	6	3	2	7	4 3	8	4	9	5 4	3	10	5
Installation kits with ballast tray[1]																						
SKN3.0-s and SKS4.0-s	**Standard kit**	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Extension kit	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
	Additional support[2]	–	–	–	–	–	1	–	1	–	1	–	–	2	1	2	2	2	2	–	3	2
	Standard kit addition[3]	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Addition to extension kit[3]	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
SKN3.0-w and SKS4.0-w	**Standard kit**	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Extension kit	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
	Standard kit addition[3]	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Addition to extension kit[3]	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
Installation kits for on-site attachment																						
SKN3.0-s and SKS4.0-s	**Standard kit**	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Extension kit	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
	Standard kit addition[3]	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Addition to extension kit[3]	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
SKN3.0-w and SKS4.0-w	**Standard kit**	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Extension kit	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8
	Standard kit addition[3]	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Addition to extension kit[3]	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8

Fig. 149 Fixing materials for the flat roof installation system

1) The standard installation and extension kits contain one set of ballast troughs each
2) Not required if the additional extension kit is selected
3) Required in addition to the standard and extension kit with snow loads in excess of 42 lbs/ft² or building height exceeding 65 ft

5.3.5 Wall installation

Wall installation is only suitable for landscape Logasol SKN3.0-w and SKS4.0-w flat plate collectors, and is only designed for walls up to an installation height of 65 ft.

Wall mounting requires horizontal flat roof supports. The first collector in the row is installed using a wall support standard kit. Every additional collector in the same row is installed using a wall support extension kit. These kits include three supports (Fig. 151). The pitch of the collectors on the wall may only be set to between 45° and 60° relative to the horizontal (Fig. 150).

On-site attachment

Secure the collector supports on site to structural elements of a wall capable of bearing the load of the collector array in addition to possible snow and wind loads using a minimum of three bolts per support.

Static requirements

The values in Fig. 120 are the permissible standard snow loads and building heights.

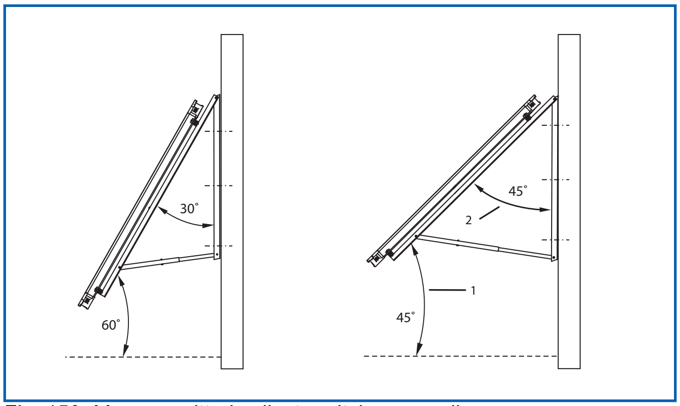


Fig. 150 Max. permitted collector pitch on a wall
1: pitch (absolute angle relative to the horizontal)
2: collector angle of inclination

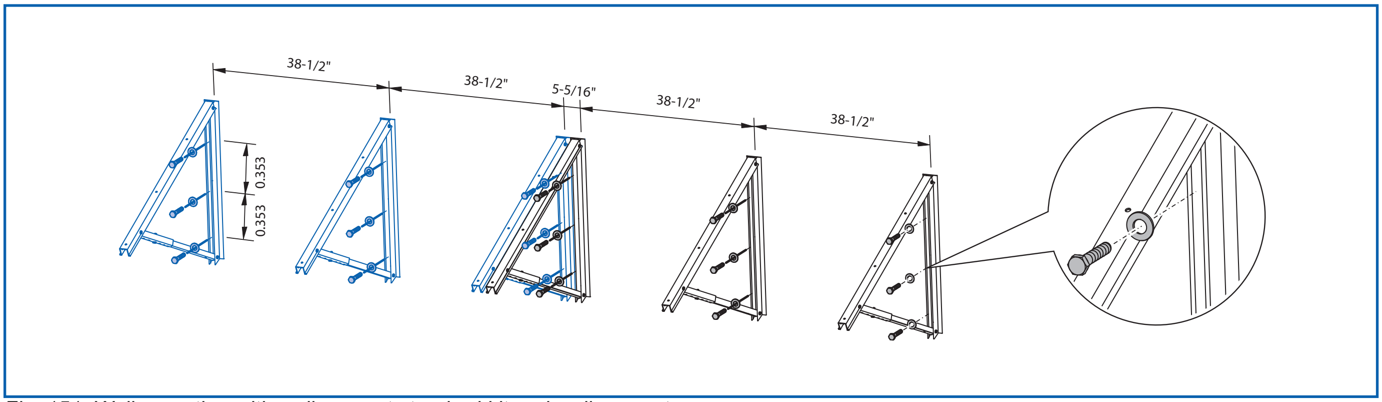


Fig. 151 Wall mounting with wall support standard kit and wall support extension kit (blue); dimensions in inches

Snow and ice accumulating on the collectors may give way and slide off suddenly. Take provisions that the installation does not pose a risk to property and personal injury from falling snow and ice.

Component selection aid for wall mounting system for Logasol SKN3.0-w and SKS4.0-w

	Total number of collectors	2		3			4		5		6			7		8		9			10	
	Number of rows	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Number of collectors per row	2	1	3	2 1	1	4	2	5	3 2	6	3	2	7	4 3	8	4	9	5 4	3	10	5
Installation kits																						
SKN3.0-w and SKS4.0-w	**Standard kit for wall mounting**	1	2	1	2	3	1	2	1	2	1	2	3	1	2	1	2	1	2	3	1	2
	Extension kit for wall mounting	1	–	2	1	–	3	2	4	3	5	4	3	6	5	7	6	8	7	6	9	8

Fig. 152 Fixing materials for wall mounting system for Logasol SKN3.0-w and SKS4.0-w

5.3.6 Estimated installation times

Use of contractors

At least two installers are needed when installing solar collectors. Most installations require penetrating the roof membrane for mounting the collector array and feeding the pipes into the building envelope. Source experienced contractors (roofers, plumbers) to ensure professional and satisfactory results and avoid water damage to the building. Buderus provides training in the installation of solar systems. Information on the training facilities and schedule can be obtained from your local Buderus sales representative or the Buderus Solar web site.

Kits are available for any installation option, including accessories and installation instructions. Read the installation instruction for the chosen installation option carefully before work commences.

Collector installation times

The times suggested in table Fig.153 apply to the installation of a typical system in a single row performed by experienced professionals. Times for personal safety measures, transporting the collectors and modifications to the roof (adapting and cutting roof tiles) are not taken into consideration. These times should be estimated in consultation with a roofing contractor.

The time calculation for planning a solar collector system is based on practical experience. These depend on the on-site situation. The actual installation times on site may therefore vary considerably from the times quoted in Fig. 153.

Installation option and scope	**Estimated installation times**	
	of 2 SKN3.0/SKS4.0 collectors	**for each additional collector**
Rooftop installation	1.0 h per installer	0.3 h per installer
Roof integration	3.0 h per installer	1.0 h per installer
Flat roof installation with ballast trays	1.5 h per installer	0.5 h per installer
Flat roof installation on substructures	1.5 h per installer	0.5 h per installer
Wall mounting 45°	2.5 h per installer	1.5 h per installer

Fig. 153 Installation times with two installers for collectors in small systems (up to 8 collectors) on roofs with an angle of inclination of ≤ 45°, excluding handling time, effort in conjunction with safety precautions and the creation of on-site substructures

5.4 Lightning protection and grounding of solar heating systems

Requirements for lighting protection

Lightning protection is defined in the national and local building regulations. In the absence of such regulations for the building in question, it is the building owner's responsibility to decide after consulting with professionals if a lightning protection system should be installed.

Take into account that the collector array may be adding height to the building, and that the metal rails may increase the likelihood of a lightning strike.

Lightning protection is typically required for buildings that

- measure more than 65 ft in height
- are significantly higher than the surrounding buildings or landscape
- In all other buildings a lightning protection system is advisable.

In buildings open to the public (schools, government, office buildings, etc.) the lightning protection requirements should be discussed with an expert and/or the building operator. This discussion should take place in the planning phase of the solar heating system.

Since solar heating systems are typically not significantly higher than the roof ridge the probability of a direct lightning strike for a residential building, is the same with or without a solar heating system.

Grounding of the solar heating system

Irrespectively of whether a lightning protection system is present, the supply and return of a solar heating system must always be grounded with a copper cable (minimum AWG 9) to the building's grounding rod.

If a lightning protection system is present, determine whether the collector array and the piping are protected by this system. If in question, consult, a specialist electrical contractor.

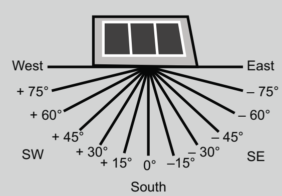
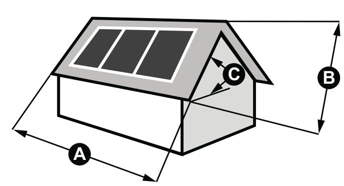
6 Regulations and Directives

Solar Thermal Site Survey

Buderus
Bosch Group

Project Information	
Project Name	
Contact Person / Information	Name: Tel.: Fax: Email:
Project Location	

System Information				
System Type (Check all that apply)	☐ DHW	☐ Space Heating	☐ Pool	
Application Type	☐ Residential Home	☐ Apartment	☐ Dormitory	☐ School
	☐ Hotel/Motel/Inn	☐ Office Building	☐ Restaurant	☐ Hospital
	☐ Prison	☐ Fire Station	☐ Industrial	☐ Other:_______________
Application Details (# of rooms, total occupants, etc.)				

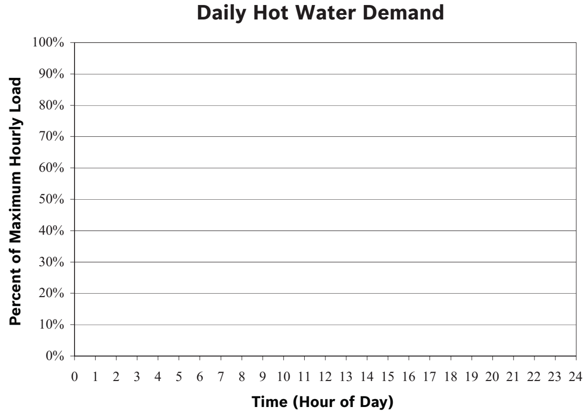
Installation Information					
Installation Mounting Type		☐ Flat Roof	☐ Wall Mounted	☐ Sloped Roof	☐ On Wall
Which Roof Type?		☐ Tile	☐ Shingle	☐ Slate	☐ Metal
		☐ Other:_____________________			
Load Conditions		☐ Wind Load	☐ Snow Load	☐ Ice Load	
Deviation from South		______(Degrees)			
Available Roof Space	A	______(Ft)			
Available Roof Space	B	______(Ft)			
Roof Pitch	C	______(Degrees)			
Shading?		☐ Yes	☐ No	_____% Shading	
Recirculation Loop?		☐ Yes	☐ No	_____Length (Ft)	
Line Set Run (One-way from collector to solar storage tank)		______(Ft)			
Building Type		☐ New Construction	☐ Retrofit		
- If Retrofit, Current Equipment in Use		Back-up Heat Source Type__________________		Output_________________(kbtu/hr)	
		Storage Tanks			
Fuel Type / Cost		☐ Gas $_____per Therm	☐ Oil $_____per Gal.	☐ Electric $_____per kW	☐ LPG $_____per Gal.

Solar Thermal Site Survey

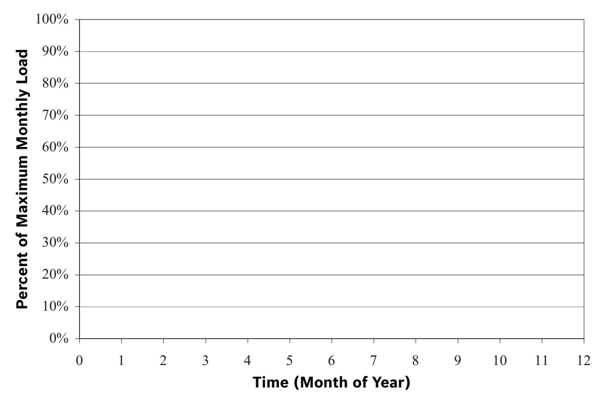
Buderus
Bosch Group

Domestic Hot Water Information		
DHW Load	_____(Gallons per day)	
Operational Pro⊠les		
Hot Water Supply Temperature	(°F)	Comments:
Maximum Water Storage Capacity	(Gallons)	
Cold Water Inlet Temperature	(°F)	
Back-Up Heat Source Type		
Back-Up Heat Source Output	(kbtu/hr)	
Fuel Type / Consumption		

Daily Hot Water Demand



Annual Hot Water Demand



To enter electronically, click on graph where applicable. Enter the hourly (monthly) DHW load as a percentage of the maximum hourly (monthly) value of a day (year).
E.g., the hour of the day with the highest load would be set at 100%, and the hour of the day with half the value as the maximum load would be set at 50%"

Space Heating Information		
Heat Loss	(kbtu/hr)	
Heated Area	(ft²)	
Type Of Heating	☐ Radiators ☐ Baseboard ☐ In-Floor Heating ☐ Other:____________________	
Heating Loop Temperatures	HT	Supply: ___________(°F) Return: ___________(°F)
	LT	Supply: ___________(°F) Return: ___________(°F)
Back-Up Heat Source Type	______________ ☐ Same as DHW	
Back-Up Heat Source Output	(kbtu/hr)	
Fuel Type / Consumption		
Comments:		

Pool Heating Information		
Pool Type	☐ Indoor	☐ Outdoor
Pool Dimensions		(ft)
Average Pool Depth		(ft)
Swim Season		(Jan - Dec)
Desired Pool Temperature		(°F)
Back-Up Heat Source Type	____________	☐ Same as DHW
Back-Up Heat Source Output		(kbtu/hr)
Pool Cover	☐ Yes	☐ No
Fuel Type / Consumption		
Comments:		

Solar Thermal Site Survey

Buderus
Bosch Group

Diagram / Schematic

Signature:

Please provide your name and date below as recognition that the information contained in this document is complete and accurate to the best of your knowledge. This information will be used in the calculations related to the design; inaccurate calculations will affect the design results provided. Please note that the design results do not replace a detailed system design. By using this system, you acknowledge and agree that the designer, installer and/or building owner is responsible for the system design, function and validation. Bosch Thermotechnology Corp. is not responsible for the system design, function or performance of the system installed. Bosch Thermotechnology Corp. is not responsible for errors due to false or unreliable data submitted by the authorizing representative.

Authorized Representative:

Printed Name: ______________________________ Date: ______________________________

List of abbreviations

Abb.	Description
AK	Cold water outlet (buffer system)
AV	Shut-off valve
AW/AB	DHW outlet
E	Air vent valve
EH	Immersion heater
EK	Cold water inlet
EL	Drain
EW	DHW inlet (primary system)
EZ	DHW circulation inlet
FA	Outside temperature sensor
FE	Fill & drain valve
FK	Boiler water temperature sensor
FR	Return temperature sensor
FSK	Collector temperature sensor
FP	Thermal store temperature sensor
FPO	Thermal store temperature sensor, top
FPU	Thermal store temperature sensor, bottom
FSB	Swimming pool water temperature sensor
FSS1	Storage tank temperature sensor (1st consumer)
FSS2	Storage tank temperature sensor (2nd consumer)
FSW1	Heat meter temperature sensor supply
FSW2	Heat meter temperature sensor return
FSX FSX1 FSX2 FSX3	Storage tank temperature sensor or threshold sensor for thermosiphon storage tank for High-Flow-/ Low-Flow operation with solar function module FM443 or SM10 (Storage tank connection set AS1, AS16 or DHW temperature sensor FB or FW)
FV	Supply temperature sensor
HK	Heating circuit

Abb.	Description
M	Measuring point (e.g. storage tank), motor (e.g. actuator)
MB	Domestic hot water measuring point
MAG	Diaphragm expansion vessel
PH	Heating circuit pump
PS	Storage tank primary pump
PSB	Swimming pool water pump
PSS	Solar circuit pump
PUM	Stratification pump
PWT	Heat exchanger pump
PZ	DHW circulation pump
R	Return; solar return
RK	Boiler return
RS	Storage tank return
RSB	Swimming pool control unit
RW	Return temperature limiter
SA	Line regulating and shut-off valve
SH	Heating circuit actuator
SMF	Dirt filter
SP1	Overvoltage protection
SU	Diverter valve
SV	Safety valve
SWT	Swimming pool water heat exchanger
TW	Drinking water/DHW
TWE	Domestic hot water heating
ÜV	Overflow valve
V	Return; solar return
VK	Boiler supply
VS	Storage tank return
Heat source	Residential unit
WT	Heat exchanger
WWM	Thermostatically controlled DHW mixer

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