
# Sanden SANCO$_2$

# Heat Pump Water Heater

# Technical Information

## August 2018


# SANDEN Technical Book

Advisory note:
Basic knowledge of hot water, refrigeration, electricity and thermodynamics is required to fully understand this material.

Thank you for your attention, the Sanden Technical team.

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## SANCO$_2$

SANCO$_2$ is a customized CO$_2$ Heat Pump Water Heater (HPWH) that Sanden has designed to meet the North American market needs.

It is based on the Eco Cute units, which is a widely accepted and commonly used water heater in Japan and were first introduced to the market in 2001.

An Eco Cute is a HPWH that uses carbon dioxide as a refrigerant. “Cute” translates to hot water in Japanese which is pronounced Kyuto.

Since 2011, Sanden has collaborated with local utility companies to conduct laboratory and field testing to ensure that the technology will transfer to the North American market without problems.

## Why CO$_2$?

Carbon dioxide is a unique refrigerant that does not contribute to global warming.

The Global Warming Potential (GWP) of carbon dioxide is 1, compared to the GWP of the typically used HPWH’s refrigerants such as R134a – GWP of 1,430 and R410a – GWP of 2,086.

CO$_2$ is used as the benchmark to measure Global Warming, so these numbers translate that 1lb of CO$_2$ released into the atmosphere will contribute 1lb of Global Warming Potential, 1lb of R134a will contribute 1,430lbs of Global Warming Potential for 100 years.

SANCO$_2$ utilizes a 22 oz. of CO$_2$ refrigerant which is charged and stored inside of a closed loop system with an operating pressure range of 600 psi to 1,600 psi.

Carbon dioxide rarely achieves its liquid state. After being compressed and heated, the CO$_2$ refrigerant becomes as dense as liquid, while still remaining as a gas (transcritical state), substantially increasing the transfer of heat between itself and the water, especially in low ambient conditions.

In addition to the refrigerant attributes mentioned above, carbon dioxide extracts heat even at very low temperatures. The unit operates down below -20°F without a back-up heating element, and will deliver a maximum water temperature of 160°F at those very low ambient temperatures.

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Think of it this way – the outside air will transfer heat to the $CO_2$ through an evaporator, the $CO_2$ is then heated through compression, the heat from $CO_2$ is transferred to the cold water through a double wall heat exchanger, and the hot water is pumped from the unit.

In the unlikely event of a refrigerant leak, the system can be recharged with $CO_2$ as would a normal HVAC system, however we recommend contacting Sanden Technical Support for information on this procedure.

## What advantages are there?

**Energy Efficiency**

- SANCO$_2$ is 4 x more efficient than traditional electric water heaters. It uses much less energy to heat water faster
- SANCO$_2$ is more efficient in field testing than integrated HPWH's

**High Performance**

- Greater first hour rating than all HPWH's:
- 83 Gallon tank – FHR 115 gallons
- 43 Gallon tank – FHR 71 gallons
- Temperature set-point between 130 and 175°F, delivering hotter water than all other residential electric water heaters
- Faster recovery after hot water draw, approximately 18 GPH delivered to the top of the tank

**Extended Operating Range**

- Hot water production down to -20°F and below
- No need for back up electric element in the storage tank

**Flexible Installation**

- Heat Pump is installed outside, so no energy stealing from the space or cold airflow issues to overcome
- Tank can be installed almost anywhere in the home, power is not required or a large space requirement around the tank
- Heat pump has an extremely small footprint and a low operating noise level making it suitable for installation almost anywhere

**High Quality with Low Maintenance**

- Long Life Stainless Steel Tank with a 15 year prorated warranty
- No anode rods to replace or air filters to clean

**Environmentally Friendly**

- Minimal impact on global warming

# Applications - Residential

**Sizing**
Sizing of the system to the home is **EXTREMELY IMPORTANT.**

**43 Gallon Tank:**
First hour delivery (UEFHR): 74 gallons. This tank size is suitable for families of 2 to 4 members.

**83 Gallon Tank:**
First hour delivery (UEFHR): 109 gallons. This tank size is suitable for families of 5+ or larger users of DHW.

**Heat Pump Outdoor Installation**
The outdoor unit can be installed in various locations including: directly outside of a home, a garage, basement, mechanical room, or a rooftop.

When mounting the unit, ensure no obstacles that can prevent air flow obstruct the unit.

If wall mounted installation is desired, the outdoor unit can be installed either high on a wall or low on a wall, but should be accessible in the event of maintenance. In areas with high snowfall, the unit must be installed above the anticipated snowline.

**Heat pump Indoor Installation**
To remove any ambient issues, locating the condenser inside of a building can be a viable alternative as long as the minimum 800 CFM (cubic feet per minute) ventilation requirements are met and can be maintained throughout use.

**Tank Installation**
The Storage tank must be installed upright.

Installation clearances are 2” around the tank, no airflow is required so closet installation is no problem.

No power is required for the tank, just water connections to the home and heat pump plus a control wire connection to the heat pump.

**Max Distance**
The distance between the heat pump and tank must be within the maximum limits of the system.

Gen3; GS3-45HPA; 50ft total length including 16ft vertical separation

Gen2; GUS-A45HPA; 25ft total length including 10ft vertical separation

# Applications - Multi-family Buildings

**Multiple Units in a Central system**
In most multi-residential applications, multiple heat pump units as well as tank units can be connected together to increase efficiency, hot water output, and recovery.

**Sizing**
When sizing for multi-residential applications, the following information is required to determine the number of heat pumps and tanks. Both the heat pump and tank unit are scalable depending on hot water usage.

- Number of apartments per building
- Number of apartments on each floor
- Number of bedrooms per apartment
- Number of bathrooms per apartment
- Number of kitchens per floor
- Number of laundry rooms per floor
- Expected number of residents per building
- Expected demography of residents (professional, family, senior)

**Installation**
As per residential applications, the heat pumps and tanks can be installed indoor and/or outdoor depending on a building design, location, and climate.

Installation location specifics must be as per the residential application.

**Important**
It is very important to install multiple heat pumps and tanks using a plumbing schematic developed in consultation with Sanden.

Detailed planning and a meticulous installation is required, especially with multiple units piped together so that the entire installed system will function as it is intended.

# Applications - Light Commercial

**Sizing**
The Sanden heat pump can be used for light commercial applications, such as schools, restaurants, farms and small businesses.

The following information is required for water heater sizing:
- Daily hot water usage
- Peak hot water usage and time
- Hot water usage type, for example Dish washing, Agricultural or hair dressing
- List of appliances that use hot water
- Number of appliances, bathrooms, shower rooms and kitchens that use hot water
- Delivered hot water temperature
- Expected hot water draw pattern

**Installation**
Like residential applications, heat pumps and tanks can be installed indoor and/or outdoor depending on a building design, location, and climate.

Installation location must be as per the residential application.

**Important**
It is very important to install multiple heat pumps and tanks using a plumbing schematic developed in consultation with Sanden.

Detailed planning and a meticulous installation is required, especially with multiple units piped together so that the entire installed system will function as it is intended.

# Applications – Combination Heating and DHW

**It is permitted to use the SANCO$_2$ system to provide some limited capacity heating (radiant, fan coil, etc.) in certain areas of North America, when combined with a minimum of 25 gallons per day usage of DHW.**

**It is NOT permitted to use the SANCO$_2$ system to provide heating as its only function.**

**Sizing**
Maximum heating capacity must be less than 8,000 BTU/h.
Minimum design ambient temperature must be above 27°F.
Tank size must be the 83 gallon tank.
DHW usage – minimum 25 gallons per day.

**Installation**
Like residential applications, the heat pumps and tanks can be installed indoor and/or outdoor depending on a building design, location, and climate.
Installation location specifics must be as per the residential application.

**Important**
Per your local code, potable and non-potable water may need to be separated. Check with your local code authority to determine if separation, and/or use of a double wall heat exchanger is required.

In applications requiring separation between potable and non-potable water, Sanden mandates the use of a Taco X-block system.

It is very important to install a combination system using the plumbing schematic developed by Sanden.

Particular importance must be given to the location of the heating system return water pipe from the X-block to the tank, lower return water temperatures should return to the bottom of the tank.

Detailed planning and a meticulous installation is required, especially with multiple units piped together so that the entire installed system will function as it is intended.

# Unit Operation

As hot water is drawn from the top of the tank for showers etc., cold water enters the bottom of the tank from the City or Well cold water supply feed.

The incoming cold water and stored hot water do not fully mix inside the tank (unlike other water heaters), this helps maintain a higher average tank temperature and is called stratification.

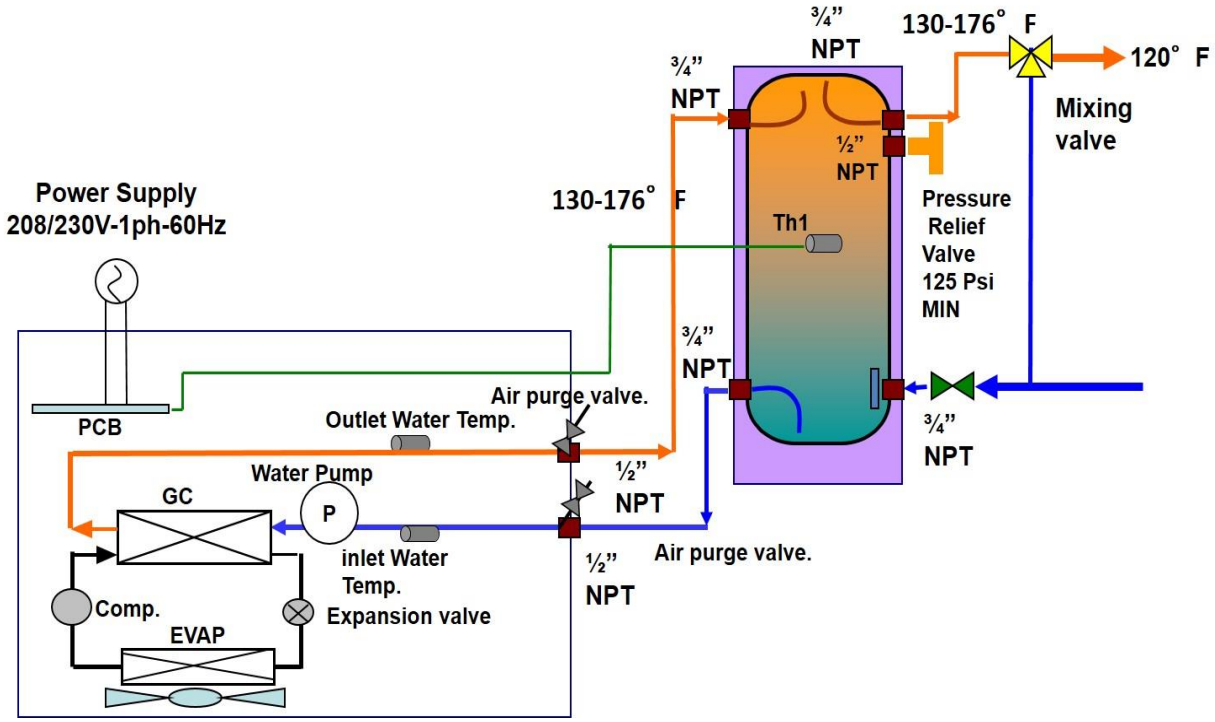
As more hot water is drawn from the tank, the volume of cold water increases, however the tank still remains stratified. When the tank temperature sensor measures the water temperature below 113°F, the heat pump control will start the unit.

The variable speed pump pulls the cold water into the heat pump, and using the heat from the ambient air the water is heated to the user selected water temperature set-point and the returned to the top of the tank.

Heating continues until the water entering the heat pump heat exchanger is 122°F, at which point the heat pump will cycle off and the tank is now completely full of hot water.

The $SANCO_2$ unit will produce hot water at temperatures between 130°F and 176°F depending on set-point chosen.

Therefore, it is mandatory to install the supplied Honeywell AM101 mixing valve and set the delivered water temperature to the home at the customer's requirement.



# Hot Water Recovery

The SANCO₂ system capacity is rated at a minimum of 4.5Kw (15,400 Btu/h) at all ambient temperatures above 5°F.

Below 5°F, total capacity is reduced, the amount of reduction will depend on the outdoor temperature.

Above 5°F, the Hot water recovery for a Sanden system is equivalent to any 4.5Kw electric water heater, however depending on user set-point selected and incoming water temperature this recovery rate can alter.

| Gallons per Minute (GPM) | | | | | | |
|---|---|---|---|---|---|---|
| | Incoming Water Temperature | | | | | |
| Heat Pump Set Point | 40 | 45 | 50 | 55 | 60 | 65 |
| 130 | 0.34 | 0.36 | 0.39 | 0.41 | 0.44 | 0.47 |
| 140 | 0.31 | 0.32 | 0.34 | 0.36 | 0.39 | 0.41 |
| 150 | 0.28 | 0.29 | 0.31 | 0.32 | 0.34 | 0.36 |
| 160 | 0.26 | 0.27 | 0.28 | 0.29 | 0.31 | 0.32 |
| 165 | 0.25 | 0.26 | 0.27 | 0.28 | 0.29 | 0.31 |
| 175 | 0.23 | 0.24 | 0.25 | 0.26 | 0.27 | 0.28 |
| | | | | | | |
| Gallons per Hour (GPH) | | | | | | |
| | Incoming Water Temperature °F | | | | | |
| Heat Pump Set Point °F | 40 | 45 | 50 | 55 | 60 | 65 |
| 130 | 20.5 | 21.7 | 23.1 | 24.6 | 26.4 | 28.4 |
| 140 | 18.5 | 19.5 | 20.5 | 21.7 | 23.1 | 24.6 |
| 150 | 16.8 | 17.6 | 18.5 | 19.5 | 20.5 | 21.7 |
| 160 | 15.4 | 16.1 | 16.8 | 17.6 | 18.5 | 19.5 |
| 165 | 14.8 | 15.4 | 16.1 | 16.8 | 17.6 | 18.5 |
| 175 | 13.7 | 14.2 | 14.8 | 15.4 | 16.1 | 16.8 |

This table shows the recovery flow for a single heat pump unit.

The flow rate given is the flow from the heat pump to the tank, not flow into the home/appliance. The recovery rate is the same for an 83 or 43 gallon tank.

In multiple heat pump systems, simply multiply the GPH by the number of heat pumps to calculate system recovery flow.

Cont.

Sanden recommends that the heat pump set-point should be at a minimum of 150°F for the combination of maximum hot water production and system efficiency.

This setting will increase the total delivered recovery of the tank as the hot water from the tank will be mixed with cold water to provide the lower delivered water temperature to the home, to prevent scalding and potential injury.

The ratio of hot water and cold water used can be calculated using this formula which was developed by ASPE.

**Heat pump set-point and average tank temperature 150°F**

| Incoming Cold Water Temp | 130°F Mixed Delivered Water Temp | 125°F Mixed Delivered Water Temp | 120°F Mixed Delivered Water Temp | 115°F Mixed Delivered Water Temp | 110°F Mixed Delivered Water Temp |
|---|---|---|---|---|---|
| 40°F | 0.82 | 0.77 | 0.73 | 0.68 | 0.64 |
| 45°F | 0.81 | 0.76 | 0.71 | 0.67 | 0.62 |
| 50°F | 0.80 | 0.75 | 0.7 | 0.65 | 0.6 |
| 55°F | 0.79 | 0.74 | 0.68 | 0.63 | 0.58 |
| 60°F | 0.78 | 0.72 | 0.67 | 0.61 | 0.56 |

For example:
A 3 GPM hot water flow into the home with the mixing valve set for a temperature of 120°F, and a cold incoming water temperature of 50°F will need 2.1 GPM of tank water and 0.9 GPM of cold water.

This reduction in water usage from the tank results in greater hot water production from the tank and increased recovery rate of the DHW system when viewed as a whole.

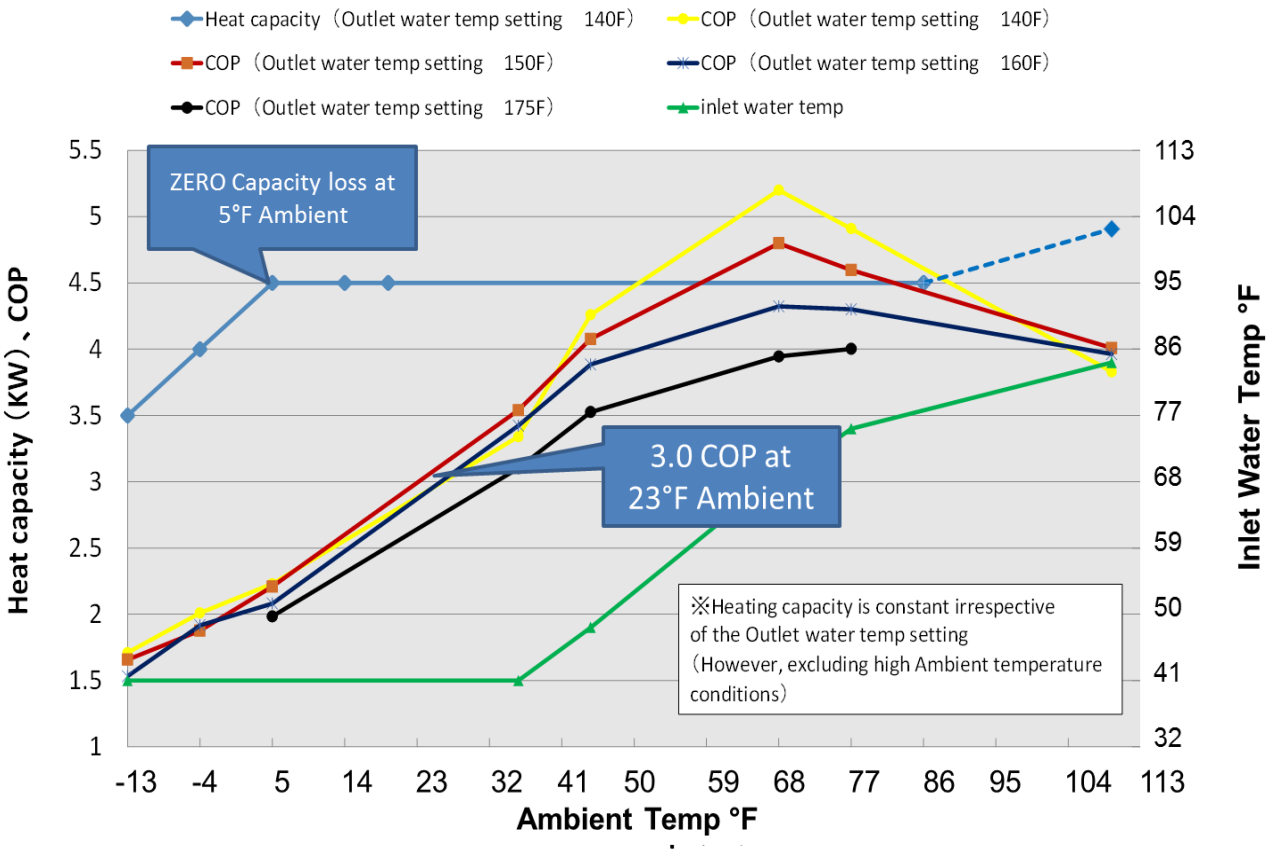
Contact Customer Service or Technical Support for the Water fractions at the various other temperatures of hot water supplied by the SANCO$_2$ Heat Pump.

## Efficiency, Capacity vs Ambient

Unit efficiency is affected by delivered water temperature and outdoor ambient
Unit capacity is ONLY affected by outdoor ambient.

Annual efficiency can be approximated using the system Coefficient of Performance at the various ambient temperatures.

Coefficient of Performance (COP) is calculated by dividing capacity by power input.




**SANCO₂ can always make 160 DegF Hot Water (depending on set point) at all Outside Air temps**

As can be seen, at 5°F ambient the system COP over 2.0, which rises to over 4.0 at 67°F ambient.

# Pre-Installation Check List

**1. Unit application sizing and plumbing planning**
Refer to this manual for information on the sizing and requirements/limitations for the specific application required.
If in doubt, call technical support for advice.

**2. Electrical Requirements**
The outdoor unit should be fed with mains power from the breaker and local disconnect (per NEC code). Wire sizing should be calculated based on Minimum Circuit Ampacity and wire length.

The unit has a 16ft thermistor cable as standard, use a 16-2 AWG shielded wire to extend the thermistor cable from the heat pump unit to the tank.

Ensure the breaker size and voltage is correct for the system.
Sanden units do not have start components for the compressor, and therefore they rely on the correct power and amperage supply to start:

| Unit | Power Supply | Breaker Size |
|---|---|---|
| GS3-45HPA-US | 208/230V-1Ph-60Hz | 15 Amps |
| GUS-A45HPA | 208/230V-1Ph-60Hz | 15 Amps |

Voltage tolerance is 187V to 253V.

**3. Pipe Length and Sizes**
Ensure that the maximum piping lengths are observed or the system will not operate correctly and will likely experience premature failure of its components.

Do not upsize or alter the piping length from those published as Sanden cannot guarantee operation with incorrectly installed pipe.

For a GS3-A45HPA unit the pipe length should not extend more than 50 feet in length with 16 feet in height or elevation, with a maximum of 6 bends in each pipe run between the tank and heat pump unit.

Water supply to the tank, and from the tank to the building MUST be a minimum of ¾" and should be either copper or PEX piping, depending on local code requirements

The piping size between the heat pump and tank unit MUST be ½" diameter and should be either copper or PEX piping.

Cont.

ALL piping external to the building or in an unconditioned space **MUST** have a minimum ¾" thick closed cell insulation with all joints taped, ensuring none of the system piping is exposed.

**4. Water Quality**
Water with high concentrations of chloride that exceed 0.1 ounces per gallon (200mg/litre) can cause corrosion and subsequent failures, and thus the warranty will be no longer valid for the heat pump unit and tank unit.

No warranty coverage is given on the heat pump unit and tank unit where the PH is less than 6.0.

Supply water with a PH less than 6.0 may be treated to raise the PH and it is recommended that an analysis of the supply water be conducted before connecting the heat pump unit to the system.

Changing, or alternating, from one water supply to another can have a detrimental effect on the operation and/or life expectation of the water tank, PR valve, water heating circulation and the heat exchanger in the system and should be tested to ensure it meets the warranty requirements in the installation manual.

**5. Tank Unit Positioning**
If installing the tank unit indoors or in an enclosed space, leave at least 2" of clearance around the back and sides of the tank.

Sanden tanks have all of the connections on the sides of the tank, not the top of the tank like the majority of the North American water heaters.

Ensure adequate clearance for the connections and piping to the tank and the piping for the supplied Mixing Valve is maintained.

**6. Outdoor Unit Positioning**
Ensure that a minimum distance of 6" behind the unit and 12" in front of the unit is maintained, otherwise, the condenser airflow could be affected. Ensure adequate access for service and setting panel operation is provided.

Access to the unit can be obtained by removing the top cover and front cover of the condensing unit and all valve and electrical connections are on the RHS of the outdoor unit when looking at the condenser fan.

Sanden recommends a minimum of 18" separation when stacking the units vertically and 24" for RHS service access.

**7. Error Codes**
Errors occur typically because the system has either: Too little flow of water from the tank to the heat pump, incorrect voltage to the system, and/or has not been purged of air in the water on start up.

# Installation Tips

**Condensate**
As the unit is taking heat from the outside air, the coil on the unit will be colder than the ambient temperature. Depending on the humidity level of the outside air, the unit will produce condensate. Volume of condensate will depend on the current humidity level.

It is very important that this condensate be drained away from the outdoor unit and the outdoor unit be raised a minimum of 4" from the ground.

**In areas where winter design temperature is below 32°F, Sanden recommends NOT installing the drain hose connector and drain hose.**

This is particularly important in areas exposed to freezing weather as the melted condensate from defrost could create a slip and fall hazard.

Defrosting of the outdoor coil occurs to remove frost buildup on the coil, the unit will calculate when to defrost based on operating conditions.

The unit is supplied with a 5/8" drain hose connector for a hose to drain away the condensate (this can be found in the base of the heat pump packaging).

**Tank Connections**
All tank connections are ¾", this is designed to allow flexibility in the tank installation due to site conditions.
For the heat pump piping, 2 x ¾" to ½" reducers are required.

**Multiple heat pump systems**
For systems with multiple heat pumps attached to a single tank, every heat pump requires its own individual thermistor.

The thermistor should be securely fitted in the thermistor well and secured with silicon or thermal paste.

If using several thermistors, push the first thermistor(s) as deep into the well as it will possibly go, then follow up by inserting additional thermistor(s).

Only one thermistor can go through the terminal block on the tank, with the other thermistors wired directly to the other heat pump units' thermistor wire.

**Existing Tanks**
Sanden tanks have been developed to maximize performance and efficiency.
For correct unit operation, it is important that the heat pump receives cold water, therefore we do not permit existing water heaters or tanks to be used.

# Freeze Protection

The basic design for a Sanden system requires piping potable water to the heat pump.

Eco Cute systems are designed to be able to lift water temperatures over 100°F quickly and efficiently, having a heat exchanger in the storage tank and a closed loop type system will significantly reduce performance and efficiency.

This results in water being potentially exposed to freezing outdoor temperatures, so strategies are set up both in installation and the unit control system to minimize the potential of a freeze-up.

1. **Minimal Water Piping Outdoors** – Plan your job site and unit location to penetrate into the building adjacent to the heat pump
   Use ¾" minimum thick Closed Cell insulation on the external piping
   Tape joints and ensure that none of the system piping is exposed

2. **Control Logic** – Two stages of freeze protection built into the control logic.

   Stage 1; Unit measures Inlet water temperature or outlet water temperature below 39°F (4°C), with an outside air temperature less than 30°F (-1°C)

   Stage 2; If the outside air temperature is at or below the temperatures in the table below, freeze protection will be triggered based on timing, not inlet & outlet water temperatures.

   Timing starts once the compressor has cycled off in normal operation, unless power is lost to the unit, in which case the timing will restart at zero when power is restored.

| Outside Air Temperature | Interval time |
|---|---|
| LESS THAN -16 DegC (3 DegF) | 1 Hour |
| BETWEEN -12 DegC (10 DegF) & -16 DegC (3 DegF) | 3 Hours |
| BETWEEN -1 DegC (30 DegF) & -12 DegC (10 DegF) | 4 Hours |

   When the freeze protection cycle starts initially the water pump will operate, then the compressor will start 3 minutes later.
   Water will be heated to the set-point temperature and the compressor will continue to operate until the return water to the heat exchanger reaches 122°F.

   Once the compressor stops the timing will begin again and based on the ambient temperature freeze protection will begin again after the appropriate time period has passed.

Cont.

3. **Trace Heat** - To protect the piping between the tank and heat pump, we require that trace heat be installed in applications where the winter design ambient is below 30°F.

   Self-regulating trace heat at 6W per foot is recommended.
   Sanden recommends our official Heat trace cable accessory : Part # FG2-6L
   6ft length of trace heat cable, with connection for 208/230V Power.

   This length is designed to install on both the hot and cold water pipes attached to the unit and connected to the mains voltage wiring for the unit.

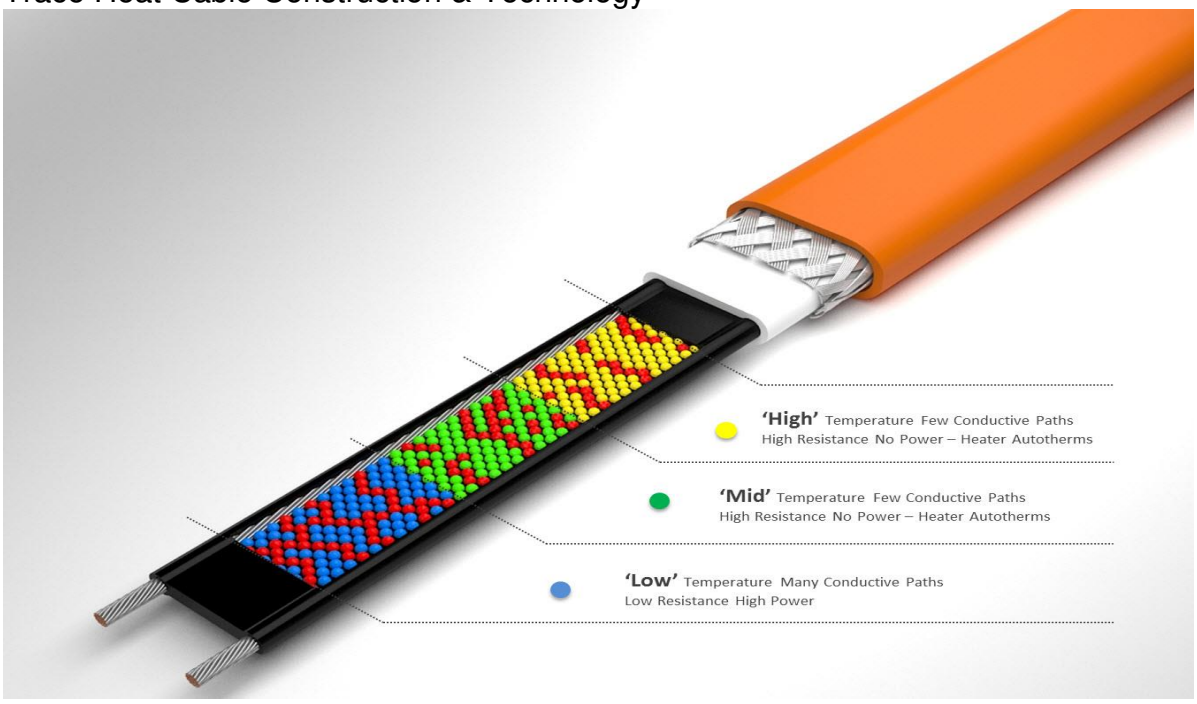
   The Sanden trace heat cable selected will regulate based on the exact temperature down to the inch that the cable senses.

   Sanden recommends that the trace heat cabling start at the top connection set, then wrap around the hot water supply piping (under the insulation) and cross over to the cold water inlet piping inside the building (minimizes the length of cable exposed to the air, then finish at the bottom connection set.

   Follow the instructions provided in the trace heat kit for detailed information on the cable instruction.

   Field testing has shown that when correctly installed, self-regulating trace heat will use less than 0.3% of the total energy consumed by the Sanden unit.

Trace Heat Cable Construction & Technology



## 4. Power Outage

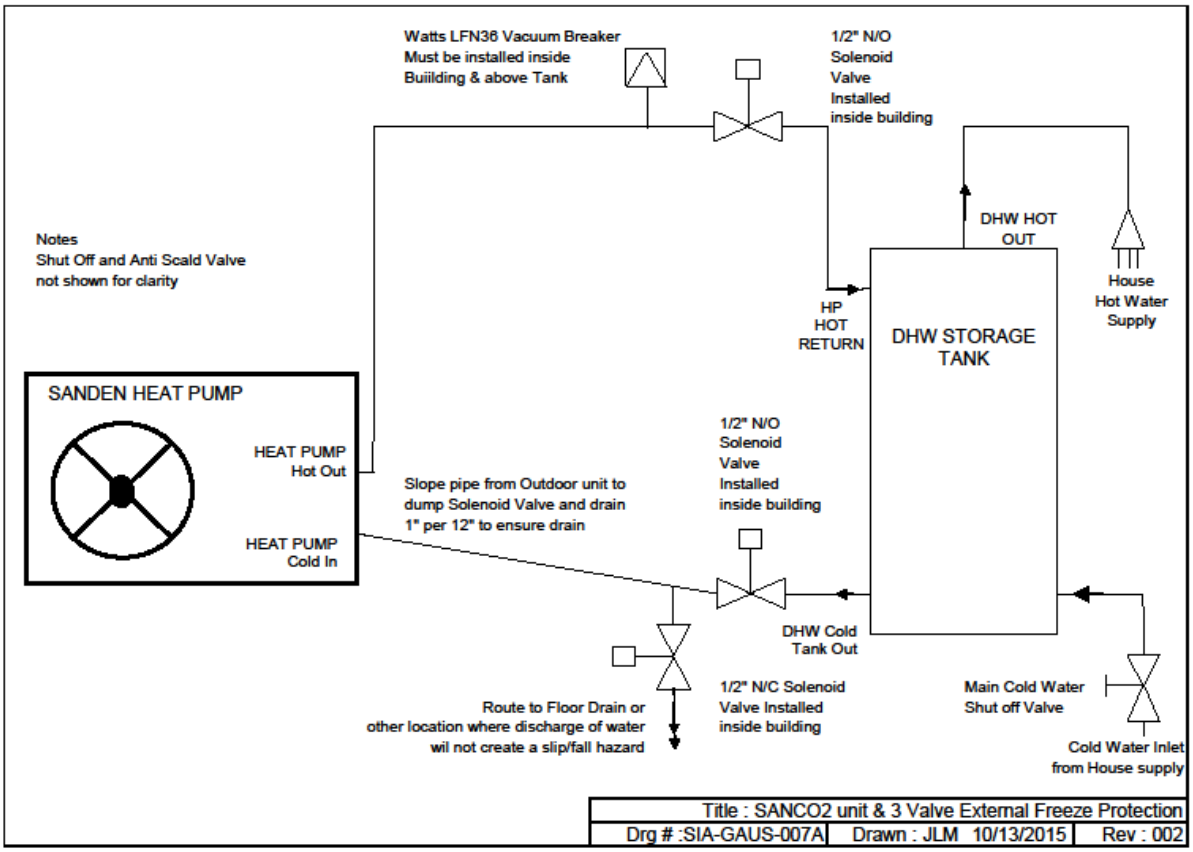
If the mains power is cut to the system for whatever reason, it is acceptable to run the unit using a generator. The unit will require approx. 2.5kw at -20°F.

However, without backup power there is a risk of the 0.6 gallons of water contained in the outdoor unit and the approximate maximum of 1 gallon of water in the interconnect piping may freeze.

Sanden has conducted tests where the unit has been left without power for 24 hours in a 25°F ambient and no freezing was reported.

The water in the outdoor unit and piping can be drained manually using the air bleed screws, however the tank will need to be isolated before draining.

An automatic system based on a drain back philosophy is available using three solenoid valves and a vacuum breaker to both isolate the tank and to drain down the outdoor unit and piping on power being cut.



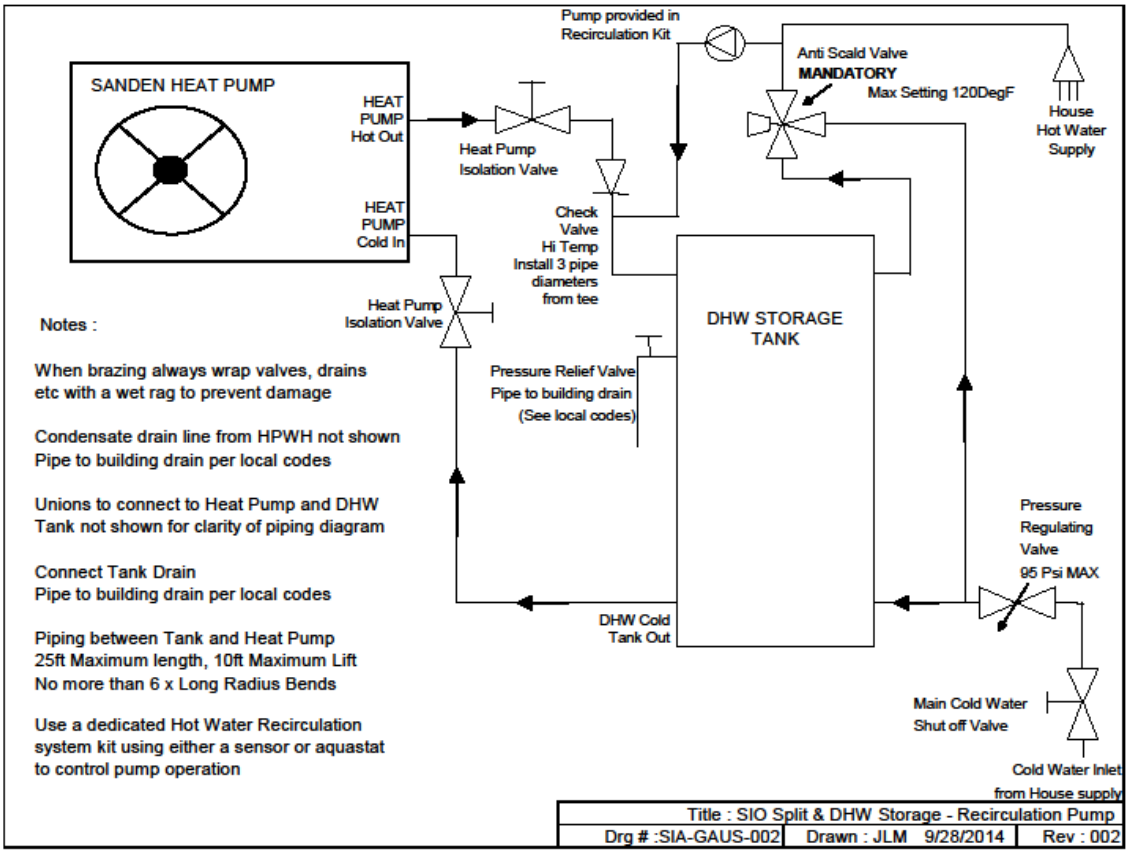
# Recirculation

These types of systems are often used to ensure hot water is available at the furthest fixture from the storage tank.

Multiple types of recirculation systems are available commercially.
Sanden only permits the use of systems that use either a sensor or an aquastat to control the pump. Timer systems are not permitted.

The recirculation system should only operate to clear the plug of cold water from the piping, typically this plug is less than 2 gallons in a residential application.
For commercial recirculation applications – please contact Technical Support.

| Pipe Size | Water Volume per Foot of pipe | Water Volume per 50ft of pipe |
|---|---|---|
| ½" | 0.01 | 0.5 |
| ¾" | 0.02 | 1.2 |
| 1" | 0.04 | 2.1 |



# Heat Pump Control Modes

**Setting Panel Location**
The setting panel is located under the top cover and the display can be viewed through the window above the water fitting side of the heat pump and is used to navigate and select between the modes listed above

**Time Setting**
As part of the water heating cycle logic refers to the current time, it is necessary to set the clock on the controller before starting to use the product.

**Commissioning Mode**
Press both Up/Down arrows to enter commissioning mode. Scroll through using Up arrow. Press the Enter key to select an option mode from the five modes described below.

**Heat Setting Mode**
Set the heating mode to either ON (unit runs) or OFF (unit cannot operate).

**Temperature Setting Mode**
The water temperature settings available are 130°F, 140°F, 150°F, 160°F, 165°F and 175°F (55°C, 60°C, 65°C, 70°C, 75°C and 80°C)

**Block Out Time Setting**
This mode is used to set a single block out time that prevents the heat pump unit operation within that chosen time period.

**Error History**
This records all errors that have occurred on the system and can be used for troubleshooting after an error code has been cleared by cycling the power to the unit.

**Parameter Display**
This displays all of the values currently measured by the unit's temperature sensors and can be used for troubleshooting and general unit performance questions.

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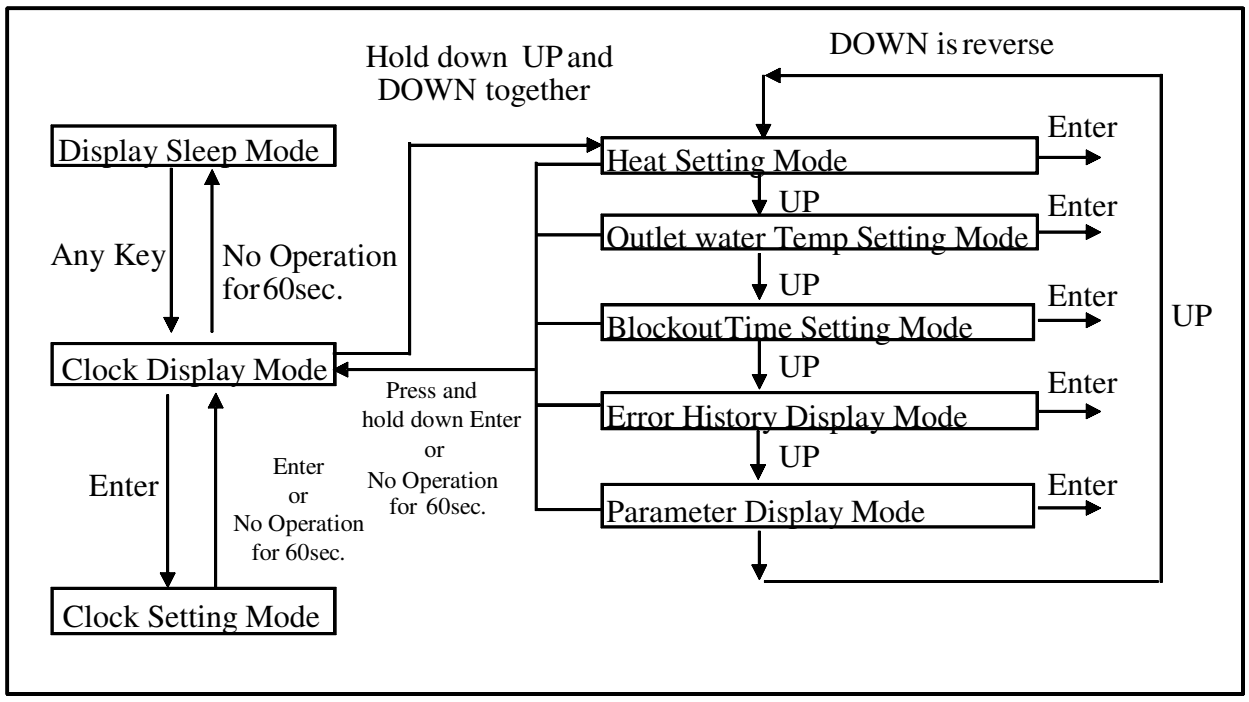
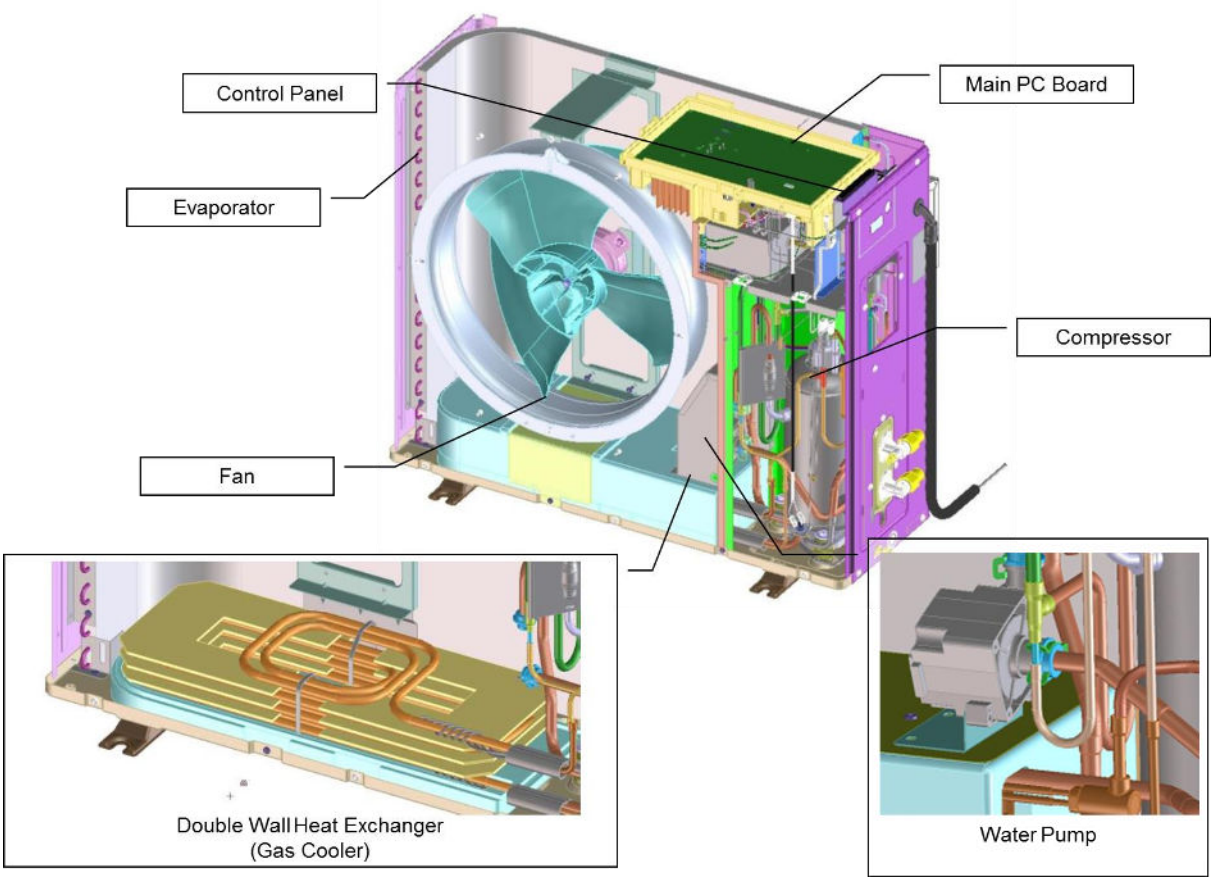



**Parameters**
In the parameter mode, the system will display control values used by the unit.

When a temperature value is displayed, it will show as °C x 10 for example 0580 = 58°C or when converted 136°F. To convert use this formula; °F = (°C x 1.8) +32

| Parameter | What is being measured |
|---|---|
| 00 | Tank Temperature : Shown as °C multiplied by 10 |
| 01 | Compressor Operating Time (Defrost & Freeze Protection) : Hour |
| 02 | Compressor Starting Frequency : Hz |
| 03 | Control Software Rev # |
| 04 | HP Outlet Water Temperature : Shown as °C multiplied by 10 |
| 05 | HP Inlet Water Temperature : Shown as °C multiplied by 10 |
| 06 | Discharge Line Temperature : Shown as °C multiplied by 10 |
| 07 | Ambient Temperature : Shown as °C multiplied by 10 |
| 08 | Compressor Operating Frequency : Hz |
| 09 | Fan Motor Speed : RPM |
| 10 | Pump Rotational Speed : RPM |

# Inside the Heat Pump




**Variable Speed Fan**
The fan speed is based on the ambient temperature for maximum capacity & efficiency.

**Water Pump**
Water flow is controlled by a variable speed water pump located inside the heat pump, the flow rate is varied to maintain the set-point supply temperature.

**PCB**
The PCB constantly monitors and adjusts the operation of the heat pump to maintain capacity, efficiency and reliability

**Setting/Operation Panel**
Used to navigate through each setting for the heat pump unit.

# Error Codes

**Outdoor Unit Self Diagnosis**
The outdoor unit has a built-in self-diagnostic system that will register 82 different faults based on the sensors and control logic of the outdoor unit.

The setting panel on the unit will display the numerical value of the error code with a red light. All of the error codes are listed in the Installation and Owners Manuals provided with the unit- and cause the heat pump to shut down simultaneously.

**Inadequate Flow**
Restricted water flow to and from the heat pump will ultimately result in an error code.

If this issue arises, make sure the pipe size is correct, the pipe length/lift is inside the maximum, check the heat pump piping for blockage or kinking, look for freezing if in a cold climate, ensure all water shut off valves are open, and ensure water is supplied to the system from the building.

**System Communication**
A system control error show up occasionally on a heat pump unit.

For a communication/system control error - Error Code 40 to 82 – perform the following checks:

- Check that all wire connections are firmly attached to the PCB.
- Check the unit for proper voltage at various points.

**Clearing Errors**
To clear an error code after it has been corrected, turn off power to the unit and wait 3 minutes before restarting.

The error code will now be accessible in the Error History mode.

**The following error codes apply to heat pump model GS3-45HPA-US only:**

| Error Code | Error Explanation |
|---|---|
| E000 | No error code reported |
| E001 | HP Water Outlet Over Temperature 1 |
| E002 | HP Water Outlet Over Temperature 2 |
| E003 | HP Outlet Temp thermistor detection error |
| E004 | HP Discharge Over Temperature 1 |
| E005 | HP Discharge Over Temperature 2 |
| E006 | HP Discharge Temperature Thermistor detection error |
| E007 | High Pressure Error |
| E008 | High Ambient Temperature Defrost Drive error |
| E009 | HP Defrost thermistor detection error |
| E011 | HP Inlet Temp thermistor wire break or reading value = -22°F |
| E012 | HP Outlet Temp thermistor wire break or reading value = -22°F |
| E013 | HP Discharge temp thermistor wire break or reading value = -24°F |
| E014 | HP Defrost thermistor wire break or reading value = -58°F |
| E015 | HP Ambient Temp thermistor wire break or reading value = -58°F |
| E016 | Tank thermistor wire break or reading value = -22°F |
| E021 | HP Inlet Temp thermistor wire break or reading value = 212°F |
| E022 | HP Outlet Temp thermistor short circuit or reading value = 302°F |
| E023 | HP Discharge thermistor short circuit or reading value = 302°F |
| E024 | HP Defrost Temp thermistor short circuit or reading value = 212°F |
| E025 | HP Ambient Temp thermistor wire break or reading value = 212°F |
| E026 | Tank thermistor short circuit or reading value = 248°F |
| E031 | Fan Motor Locked |
| E032 | Fan Motor Revolution error |
| E034 | Water Pump locked |

| Error Code | Error Explanation |
|---|---|
| E041 | INV Compressor Start error |
| E042 | INV Communication error |
| E050 | INV Transient Over Current error at Converter |
| E051 | INV Transient Over Current error at Inverter |
| E052 | INV Transient Over Current Software error at Inverter |
| E053 | INV Transient Over Current Software error at Converter |
| E054 | INV Temperature Sensor error |
| E055 | INV Heatsink Temperature error |
| E056 | INV Overload Detection error |
| E057 | INV Power Supply Low Voltage error |
| E058 | INV Power Supply Over Voltage error |
| E059 | INV Inverter Current Detection error |
| E060 | INV Transient Power Cutoff Detection error |
| E061 | INV Transient Power Cut off Detection error 1 |
| E062 | INV Transient Power Cut off Detection error 2 |
| E063 | INV Control Circuit Board Power Supply error |
| E064 | INV Transient Voltage Drop Detection error |
| E065 | INV Motor Operation Detection error |
| E066 | INV Converter Current Detection error |
| E080 | Outlet Water Temperature Rise error |
| E081 | Compressor Overload Protection |
| E082 | Compressor Low Current Protection |

**Error Code Explanation**

| Code | Error | Corrective Action |
|---|---|---|
| E001 | HP water outlet over temperature 1 Temp Sensor reading 187°F | 1. Check the heat pump piping for blockage/debris<br>2. Check piping size, length, kink, excessive number of bends |
| E002 | HP water outlet over temperature 2 | 3. Check outdoor piping is not sitting in the sun without insulation and preheating the water<br>4. Check for frozen pipes<br>5. Ensure mains water supply is ON<br>6. Ensure all shut off valves are open<br>7. Check the water circulation pump is running, replace the pump if not<br>8. Make sure each unit has its own separate tank thermistor. |

| Code | Error | Corrective Action |
|---|---|---|
| E003 | HP outlet temperature thermistor detection error reading < 86°F when compressor has been running for 30 minutes | 1. Check if the thermistor is out of the mounting pocket on the water outlet pipe |
| E004 | HP discharge over temperature 1 Temp sensor reading of 266°F | 1. Check & replace the discharge temp thermistor<br>2. Reconnect the expansion valve PCB connector, check to ensure connection<br>3. Replace the expansion valve (together with PCB), or the entire heat pump unit<br>4. Refrigerant flow blocked – replace unit |
| E005 | HP discharge temperature Thermistor detection error 2 | |
| E006 | HP Discharge temperature thermistor detection error reading < 113°F when compressor has been running for 30 minutes | 1. Check if the thermistor is out of the mounting pocket on the water outlet pipe<br>2. Check if the Expansion Valve Coil or wiring has become disconnected or not connected properly<br>3. Check resistance on Expansion Valve Coil, should be 46Ω across wires<br>4. Refrigerant Leak – Check for signs of oil, replace HP |
| E007 | High Pressure Switch Open Refrigerant Pressure > 2000 Psig | 1.Check wiring on the High Pressure switch – check switch continuity<br>2.Check piping for blockage and/or freeze up preventing flow in or out of the unit<br>3.Ensure all isolation valves are open & tank is completely filled<br>4.Check water pump for operation (parameters) ensure power wiring is connected to PCB<br>5.Check all the air is bled from the heat pump<br>6.Check if inlet or outlet temp, discharge sensor have fallen out of their wells<br>7.Check Expansion Valve Coil power connection and Coil Resistance |

| | | |
|---|---|---|
| E008 | High Ambient Defrost Drive – Unit is trying to defrost in an Ambient Temperature > 68°F | 1. Check if the Evaporator air flow is blocked or recirculating<br>2. Check Evaporator Coil for dirt and debris<br>3. Check Ambient Temperature sensor resistance/connection<br>4. Check Defrost Temperature resistance /connection |
| E009 | HP Defrost Thermistor detection error not sensing 37°F or less with at least 30 minutes of compressor operation | 1. Check if the Defrost thermistor has fallen out of its well on the Evaporator coil<br>2. Check Resistance and Connection of the Defrost thermistor |
| E011 | HP Inlet Temp thermistor wire break or reading value = -22°F | |
| E012 | HP Outlet Temp thermistor wire break or reading value = -22°F | |
| E013 | HP Discharge temp thermistor wire break or reading value = -24°F | |
| E014 | HP Defrost thermistor wire break or reading value = -58°F | |
| E015 | HP Ambient Temp thermistor wire break or reading value = -58°F | |
| E016 | Tank thermistor wire break or reading value = -22°F | |
| E021 | HP Inlet Temp thermistor wire break or reading value = 212°F | |
| E022 | HP Outlet Temp thermistor short circuit or reading value = 302°F | |
| E023 | HP Discharge thermistor short circuit or reading value = 302°F | |
| E024 | HP Defrost Temp thermistor short circuit or reading value = 212°F | |
| E025 | HP Ambient Temp thermistor wire break or reading value = 212°F | |
| E026 | Tank thermistor short circuit or reading value = 248°F | |

- These codes are all based on the 5 temperature sensors on the unit and tank sensor not giving a value back to the outdoor PCB.

- All these sensors are resistance based, so they can be checked with a multimeter and the resistance reading checked vs ambient, water temperature and the parameter value in the PCB.

- Apart from the tank thermistor, all other thermistors are provided in a single assembly.

## GS3-45HPA & GUS-A45HPA Thermistor Values

### Inlet Water Temperature Thermistor, Outlet Water Temperature Thermistor

| Temp (°F) | 14 | 32 | 50 | 68 | 86 | 104 | 122 | 140 | 158 | 176 | 194 | 212 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°C) | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Resistance (kΩ) | 37.5 | 23.7 | 15.5 | 10.3 | 7.0 | 4.9 | 3.5 | 2.5 | 1.9 | 1.4 | 1.1 | 0.8 |

### Ambient Temperature Thermistor

| Temp (°F) | 14 | 32 | 50 | 68 | 86 | 104 | 122 | 140 | 158 | 176 | 194 | 212 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°C) | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Resistance (kΩ) | 12.00 | 7.20 | 4.45 | 2.83 | 1.85 | 1.24 | 0.84 | 0.59 | 0.42 | 0.31 | 0.23 | 0.17 |

### Defrost Temperature Thermistor

| Temp (°F) | 14 | 32 | 50 | 68 | 86 | 104 | 122 | 140 | 158 | 176 | 194 | 212 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°C) | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Resistance (kΩ) | 9.39 | 6.00 | 3.94 | 2.64 | 1.82 | 1.27 | 0.91 | 0.66 | 0.49 | 0.37 | 0.28 | 0.22 |

### Discharge Temperature Thermistor

| Temp (°F) | 14 | 32 | 50 | 68 | 86 | 104 | 122 | 140 | 158 | 176 | 194 | 212 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°C) | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Resistance (kΩ) | 276.0 | 162.0 | 98.3 | 61.5 | 39.5 | 26.1 | 17.6 | 12.1 | 8.5 | 6.1 | 4.5 | 3.3 |

### Tank Temperature Thermistor

| Temp (°F) | 14 | 32 | 50 | 68 | 86 | 104 | 122 | 140 | 158 | 176 | 194 | 212 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp (°C) | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Resistance (kΩ) | 54.6 | 32.4 | 19.9 | 12.5 | 8.1 | 5.3 | 3.6 | 2.5 | 1.8 | 1.3 | 0.9 | 0.7 |

| Code | Error | Corrective Action |
|---|---|---|
| E031 | Fan motor locked | 1. Reconnect the connector, check if it is off the PCB<br>2. Check motor will spin, if not replace the fan motor<br>3. Check to make sure that nothing is stopping<br>4. Check fan is not being affected by winds – install a baffle if needed<br>5. Check parameters to see motor speed |
| E032 | Fan motor revolution error | |
| E034 | Water circulation pump locked or circulating below 150 RPM | 1. Check the heat pump piping for debris or valves being closed<br>2. Confirm that the connector for the water circulation pump is connected to the PCB correctly<br>3. Replace the water circulation pump |
| E041 ~ E066 | System control error – Solution – Replacement PCB or possibly Replacement Unit | Replace the PCB<br>- These are the eccentric error codes that are seen with inverter drive units – such as IPM Overcurrent.<br>Always perform the 3 system checks:<br><br>Incoming voltage must be 187V to 253V – 1 Ph.<br>Check power wiring at the terminals for loose wires.<br>Check wiring to the compressor from PCB.<br>Check compressor resistance.<br>RED-WHT WHT-BLU BLU-RED<br>0.802 0.802 0.802 |
| E080 | Outlet Water Temperature Rise, unit is not hitting set point water & water pump is running continuously | 1.Check power wiring voltage may be down causing reduced operation<br>2.Check piping for blockage and/or freeze up preventing flow in or out of the unit<br>3.Ensure all isolation valves are open & tank is completely filled<br>4.Check water pump for operation (parameters) ensure power wiring is connected to PCB<br>5.Check all the air is bled from the heat pump<br>6.Check if inlet or outlet temp, discharge sensor have fallen out of their wells<br>7.Check Expansion Valve Coil power connection and Coil Resistance should be 46Ω |

| | | |
|---|---|---|
| E081 | Compressor Overload Protection, high load and high current draw on the compressor | 1.Check power wiring, voltage may be down causing high current draw, make sure power does not get cut off in operation<br>2.Check piping for blockage and/or freeze up preventing flow in or out of the unit<br>3.Ensure all isolation valves are open & tank is completely filled<br>4.Check compressor wiring is connected to PCB<br>5.Check all the air is bled from the heat pump<br>6.Check if inlet or outlet temp, discharge sensor have fallen out of their wells<br>7.Check Expansion Valve Coil power connection and Coil Resistance should be 46Ω |
| E082 | Compressor Low Current Protection, low load and low current draw on the compressor | 1.Check power wiring, voltage may be high causing low current draw, make sure power does not get cut off during operation<br>2.Check piping for blockage and/or freeze up preventing flow in or out of the unit<br>3.Ensure all isolation valves are open & tank is completely filled<br>4.Check compressor wiring is connected to PCB<br>5.Check all the air is bled from the heat pump<br>6.Check if inlet or outlet temp, discharge sensor have fallen out of their wells<br>7.Check Expansion Valve Coil power connection and Coil Resistance should be 46Ω |

# Maintenance

Split systems are very easy to maintain, in reality they are not very different to the maintenance on a Central A/C or heat pump system, and can be placed on a similar maintenance schedule.

**1. Heat Pump**
If the heat pump unit is installed outdoors, it will be exposed to the elements.

Remove the top and side covers of the unit and check the evaporator for any dirt or debris.

On the Gen2 unit, there is a filter on the cold water inlet connection – periodically, it needs to be removed and the filter cleaned.

Check for leaks of any kind from pipes and tears in insulation.

To clean the unit, simply blow away the debris with an air hose or spray the unit down with a water hose, coil cleaning solutions can be used without problem.

**2. System**
Draw water from the tank via a faucet: check the delivered mixed temperature vs customer requirement. Adjust the mixing valve if needed.

Draw water from the tank to start the heat pump. Check the unit parameter mode to check delivered water temperature vs set-point.

Check error history. Note any recent or new error codes

If drain down freeze protection system is installed, cycle the power to check valve operation – restart system and ensure unit operation.

**3. Tank**
Open the pressure relief valve to prevent sticking, ensure water is discharged.

Check the thermistor connection in to the thermistor well and the wiring connection to the terminals (both sides of the terminal).

# Warranty Information

The Sanden warranty is 10 years on the heat pump refrigeration circuit, 10 years on all other parts, 15 years (prorated after 10 years) on the tank, and 3 years on labor costs.

Warranty support first starts with the distributing company.
Initially, they should be able to provide information on the correct application, shipping and handling procedures for the product and general installation advice.

Always check the product packaging prior to leaving the distributor, note any damage and return the product to the distributor if necessary – DO NOT install damaged units and attempt to claim as a warranty.

Should a problem occur with the product, the distributor will be the first point of contact in the warranty process. A warranty claim can be filed either online or a request for a form can be sent to *info@sandenwaterheater.com*.

Following proper procedures will expedite warranties.

A warranty claim form should be filled out completely and will be reviewed by a Sanden Technical Support employee. After review, the claim will be processed and filed. If it is not filled out correctly, additional time may be required to complete the information required.

*If* a claim is determined to be valid, Sanden may contact the contractor or technician to review the installation. When approved, warranty parts will be expedited at Sanden's expense.

Please complete the information on the warranty claim form as completely as possible before submitting to expedite the warranty process.

Heat pump serial numbers are CCXXXXX- The entire serial number is requested when completing a claim.

On the tank unit, the serial number is located underneath the pressure relief valve and is SWLXXXX.

Once warranty repair is complete, unless specifically requested that the part be returned to Sanden the failed component can be field scrapped.

# Glossary

**Uniform Energy Factor**
A water heater's energy efficiency is determined by the energy factor (UEF), which is based on the amount of hot water produced per unit of energy consumed over a typical day. The higher the energy factor, the more efficient the water heater.

**Uniform Energy First Hour Rating**
First Hour Rating is a calculated amount used to explain the performance abilities of a water heater within the first hour of use when recovered to the thermostat setting. In other words, when determining the first hour rating, you will start with a fully heated tank of water.

| Tank Unit | UEF | First Hour Rating |
|---|---|---|
| SAN-83SSAQA/GAUS-315 | 3.34 | 109 Gallons |
| GAUS-160/SAN-43SSAQA | 3.00 | 74 Gallons |

# Notes

Manual Notes

Thank you for reading this manual, we hope it has been informative.

Please note that all Sanden units are subject to continuous improvement and specifications can change without notice.

Always check the information supplied with the unit before installation.

All sizing guides contained in this manual are suggestions only, based on our experience and knowledge, please perform an accurate DHW load analysis prior to selecting and installing your Sanden HPWH system.

We hope you enjoy the hot water produced from your Sanden SANCO$_2$ unit.

John, Maho & David