Heat Pumps

What is a Heat Pump and How Does it Work?

Heat pumps are a proven technology that have been used around the world for decades to efficiently provide heating and cooling. In fact, it is likely that you interact with heat pump technology on a daily basis: refrigerators and air conditioners operate using the same principles and technology. This section presents the basics of how a heat pump works and introduces different system types.

Heat Pump Basic Concepts

A heat pump is an electrically-driven device that extracts heat from a low temperature place (a **source**) and delivers it to a higher temperature place (a **sink**).

To understand this process, think about a bicycle riding over a hill: No effort is required to go from the top of the hill to the bottom, as the bike and rider will move naturally from a high place to a lower one. However, going up the hill requires a lot more work, as the bike is moving against the natural direction of motion.

In a similar manner, heat naturally flows from places with higher temperature to locations with lower temperatures (e.g., in the winter, heat from inside the building is lost to the outside). A heat pump uses additional electrical energy to counter the natural flow of heat and *pumps* the energy available in a colder place to a warmer one.

A heat pump is fully reversible, meaning that it can both heat and cool. So how does a heat pump heat or cool? As energy is extracted from a **source**, the temperature of the source is reduced. Similarly, as energy is added to a **sink**, its temperature increases.

Sources and Sinks for Heat Pumps

- **Air-Source:** The heat pump draws heat from the outside air during the heating season and rejects heat outside during the summer cooling season.
  It may be surprising to know that even when outdoor temperatures are cold, a good deal of energy is still available that can be extracted and delivered to the building. This allows the heat pump to provide a good deal of heating, even during colder weather. For example, the heat content of air at -18°C equates to 85% of the heat contained at 21°C.

An Introduction to Heat Pump Efficiency

Furnaces and boilers provide space heating by adding heat to the air through the combustion of a fuel such as natural gas or heating oil. While efficiencies have continually improved, they remain below 100%, meaning that not all the available energy from combustion is used to heat the air.

Heat pumps operate on a different principle. The electricity input into the heat pump is used to *transfer* thermal energy between two locations. This allows the heat pump to operate more efficiently, with typical **energy efficiency ratio (EER)** well over 100%, i.e., *more* thermal energy is produced than the amount of electric energy used to pump it.

It is important to note that the energy efficiency ratio of the heat pump depends greatly on the temperatures of the **source** and **sink**. Just like a steeper hill requires more effort to climb on a bike, greater temperature differences between the source and sink of the heat pump require it to work harder and can reduce the energy efficiency ratio. Determining the right size of heat pump to maximize the **seasonal energy efficiency ratio (SEER)** is critical.

The major benefit of using an air-source heat pump is the high energy efficiency ratio it can provide in heating compared to typical systems like furnaces, boilers and electric heaters. At 8°C, the **coefficient of performance (COP)** of an air-source heat pump typically ranges between 2.0 and 5.4. This means, as an example, units with a COP of 5, have 5 **kilowatt hours (kWh)** of heat is transferred for every kWh of electricity supplied to the heat pump. As the outdoor air temperature drops, COPs are lower, as the heat pump must work across a greater temperature difference between the indoor and outdoor space. At –8°C, COPs can range from 1.1 to 3.7.

On a seasonal basis, the heating seasonal performance factor (HSPF) of market available units can vary from 7.1 to 13.2 (Region V). Actual savings are highly dependant on the location of your heat pump installation.

The higher energy efficiency ratio of the heat pump can translate into significant energy use reductions. Actual savings will depend on a number of factors, including your local climate, efficiency of your current system, size, and type of heat pump and the control strategy. Many online calculators are available to provide a quick estimation of how much energy savings you can expect for your particular application.

Efficiency Terminology

A variety of efficiency metrics are used in manufacturer catalogues, which can make understanding system performance somewhat confusing for a first-time buyer. Below is a breakdown of some commonly used efficiency terms:

Steady-State Metrics: These measures describe heat pump efficiency in a 'steady-state,' i.e., without real-life fluctuations in season and temperature. As such, their value can change significantly as source and sink temperatures, and other operational parameters, change. Steady state metrics include:

Coefficient of Performance (COP): The COP is a ratio between the rate at which the heat pump transfers thermal energy (in kW), and the amount of electrical power required to do the pumping (in kW). For example, if a heat pump used 1kW of electrical energy to transfer 3 kW of heat, the COP would be 3.

Energy Efficiency Ratio (EER): The EER is similar to the COP and describes the steady-state cooling efficiency of a heat pump. It is determined by dividing the cooling capacity of the heat pump in Btu/h by the electrical energy input in Watts (W) at a specific temperature. EER is strictly associated with describing the steady-state cooling efficiency, unlike COP which can be used to express the efficiency of a heat pump in heating as well as cooling.

Seasonal Performance Metrics: These measures are designed to give a better estimate of performance over a heating or cooling season, by incorporating "real life" variations in temperatures across the season.

Seasonal metrics include:

> **Heating Seasonal Performance Factor (HSPF):** HSPF is a ratio of how much energy the heat pump delivers to the building over the full heating season (in Btu), to the total energy (in Watthours) it uses over the same period.
>
> Weather data characteristics of long-term climate conditions are used to represent the heating season in calculating the HSPF. However, this calculation is typically limited to a single region, and may not fully represent true performance.
>
> **Seasonal Energy Efficiency Ratio (SEER):** SEER measures the cooling efficiency of the heat pump over the entire cooling season. It is determined by dividing the total cooling provided over the cooling season (in Btu) by the total energy used by the heat pump during that time (in Watt-hours). The SEER is based on a climate with an average summer temperature of 28°C.

(Source: Above information extracted from Government of Canada website)

Hydropool Recommended Heat Pumps

Although there are plenty of heat pumps available that can be used for both hot tubs and swim spas, Hydropool is currently recommending two different heat pump units, one from Gecko Alliance and a second from Balboa Spa.

1. Gecko Alliance

For products manufactured with **Gecko Alliance** spa electronics, we recommend the **Gecko in.temp heat pump.**

- This heat pump is fully compatible with Hydropool's current Gecko spa pack with our current touchscreen control panel and **most** 2022 and later Hydropool products (see below).
- The in.temp heat pump is available through Gecko Direct in both Europe and North America.

For products that use our other, non-touchscreen control panels, we would recommend you use the **in.touch2 mobile app.** to control the heat pump. Or, if necessary, you can replace the current control panel with a **K330** from Gecko Direct (refer to the compatible panel list below). The Gecko in.temp heat pump is controlled by the spa's topside control panel and/or the in.touch2 app. as it does not have an independent control.

Information (in.temp Techbook) and compatibility (including alternate panel compatibility) can also be found on the following website:
https://www.geckointemp.com/.

Note:

If your spa pack is not a version 3 Gecko Spa Pack, we recommend that you upgrade your spa pack to version 3 and verify that the RS-485 module is installed. If you don't want to change the pack, use a third-party heat pump that has an HMI installed.
In this case, the heat pump will work independently and will be controlled by the HMI, or through a gecko product called an in.grid (not covered in this guidline)

Please fully review the in. temp' s product installation instructions located under the website's 'Docs' page before attempting installation.

2. Balboa Spa

For products that use **Balboa Spa electronics**, we recommend the **Balboa Clim8zone** heat pump.

This heat pump does come with its own control system, which can be used independently in the case of a non-compatible control panel or spa pack. The Balboa

heat pump will be compatible with Hydropool's Balboa spa pack and Balboa's SpaTouch 2/ SpaTouch 3 panels, which will allow the heat pump to be plugged into the spa pack and controlled by the topside touch screen early in 2023.

For products that use our non-touch screen TP600 topside: If you wish to control the heat pump off the swim spas topside panel you will need to add a compatible additional aux control panel, i.e., SpaTouch 3 mini (purchased through Balboa direct), or just use the Clim8zone's control panel.

Note: Information and compatibility can be found on the following website: https://www.balboawater.com/Clim8zone for the product's installation guide as well as below. Please fully review the Clim8zone product installation guide located on the website before attempting installation.

Gecko and Balboa

Both the Gecko Alliance and the Balboa Spa products, with a compatible control panel or app, will work in conjunction with:

- the product's current inline heater
- or it will allow you to use only the heat pump
- or it can work with both the inline heater and heat pump.
- both will allow you to control the water temperature and heat and cool your water as required.

Installation: Gecko System (in.temp)

With the exception of the Executive Trainer, when using the in.YE Version 3 spa pack the in.YE spa pack has an expansion connection on the circuit board which allows you to directly plug in the heat pump's connection cable directly into the in.YE's circuit board (see connection drawing below).

For products that use our non-touch screen topside, you can install the in.touch2 mobile app to control the in.temp, or you can replace the current topside and install a k330 or compatible topside (from Gecko Direct). A list of compatible topside keypads is below or can be found in the Techbook.

The power for the heat pump connects directly to the DI port or is connected directly to the circuit board (see drawing below). If the DI port is already used, and you do not want to plug directly into the circuit board, you may need an amp plug splitter cable, (Gecko part number 9920401369 / Hydropool part number 5520073).

Please review prior to installation: All connection instructions that are explained in this document or shown in the in.temp Techbook.

Note: This method requires modification for the Hydropool Executive Trainer, see below.

Gecko Installation: Hydropool's Executive Trainer Models

A custom control cord that replaces the cord that comes with the in.temp is required.

- This connection cord will need to be plugged into both pump VSP controllers as well as connected to the in.temp.
- This control cord and instructions (the wiring instructions are below) can be ordered from the Hydropool Parts Department (Hydropool part number 2025073).

Installation: Balboa Clim8zone System

Early in 2023, Hydropool will be using a compatible Balboa BP spa pack on all models. The heat pump's communications cable will plug into the circuit board's topside control ports, directly onto the circuit board. (In some cases, a splitter cable may be required if all the Data Bus ports are used. Balboa part number 25657 / Hydropool part number 2025043).

These spa packs will be identifiable with a heat pump-compatible mark. Although a compatible spa pack is not required for this heat pump as the Clim8zone has an independent control panel that controls its operation.

For power, the Clim8zone plugs directly into the AV power port (in some cases you may need a splitter cable; Balboa part number 22934 / Hydropool part number 5520073) for power. (Please see the Clim8zone installation guide). For Europe, there is a difference in electrical setup between 3 service and 1 service, please refer to the Clim8zone installation guide.

Note: Depending upon the installation, the Clim8zone should be installed with a flow restriction valve in front of the heat pump. If you are using a low amperage 2 - speed pump (Jacuzzi NA product) or a circulation pump you may require a Balboa flow control valve (Balboa part number 73003). For products with a standard 2-speed pump that has a low-speed amp draw of 3 or more (this includes EU products), you will need a different flow control valve (Balboa part number 73002). In general, any product utilizing both speeds of a 2-speed pump should always be plumbed with a 3 – 5 lb check valve to minimize flow losses that will occur when the pump is switched to high speed. Please refer to the drawing below.

General Installation:

Heat pump installations can vary depending upon:

- Location of the heat pump to the primary circulation pump providing water flow to the heat pump.
- If the product is using a 2-speed main pump as a circulation pump.
- If the product is using a dedicated smaller 24 hr circulation pump.

In most cases, you can use the current pump providing circulation which will provide enough waterflow to allow the heat pump to function properly. You will just need some minor plumbing modifications.

Note: Use the following information as a guide only as every installation differs.

Both Gecko and Balboa Heat Pumps
Amperage Draw

Either of the heat pumps that are discussed here will add approximately an additional 4 amps to 6 amps to your potential overall amp draw. It is important to do a quick calculation and ensure that the overall amperage draw of the entire product does not exceed the overall allowed product's amperage draw.

If it does, you must make sure that you only allow one item to be active at a time, either the heater or the heat pump they cannot be allowed to work in conjunction with each other or your breaker may shut down and need resetting. This setting can be done through both systems settings.

General Plumbing Guidelines:

Products with a dedicated 48 frame single speed circulation pump water flow system:

The location of the heat pump is critical in determining whether you can use this smaller low amperage pump or not. Typically, if you are pumping the water to an elevation greater than 3 ft (91 cm) higher or lower than the current position of the pump with a plumbing run of more than 10 ft (3 m) in distance, you may need to use a larger pump, or you may need to add a booster pump.

If you are on the same elevation, and you are pumping the water farther in one direction than 14 ft (4 m) from the spa's circulation pump to the heat pump, you may need to install a larger pump or a booster pump.

A larger pump, for example, would be a 2-speed pump wired to low speed only, replacing the circulation pump and running the circulation system. This pump should have a minimum amperage draw of at least 3 amps. This pump can be sized onsite depending upon the distance and the elevation that is required.

Note: The optimum flow rate required in the system is approximately 20 gpm (75 l/min). The pump would need to be sized to maintain this rate under all circumstances.

Guidelines to follow:

- The water flow to the heat pump should be plumbed on the pressure side of the spa's circulation system, directly after the circulation pump.
- Keep the plumbing runs as straight as possible and the number of 45 and 90-degree elbows to a minimum.
- For swim spas with a 48 frame circulation pump and a 2" wet end, use 2" pipe to travel to and from the heat pump (reduced to 1.5" at the entry and exit of the heat pump).
- For hot tub's with a 48-frame circulation pump and a 1.5" wet end, use 1.5" pipe, but for a hot tub with a standard 2 speed pump and a 2" wet end, use 2" pipe.
- Keep the heat pump as close to the product as possible, keeping the plumbing as short and as straight as possible.
- Locate the heat pump as per the required product clearance distances as stated in the product manuals.

How to Plumb a Heat Pump with a Circulation Pump System

Below are two simple concept drawings of how to plumb a heat pump in a circulation system using a circulation pump.

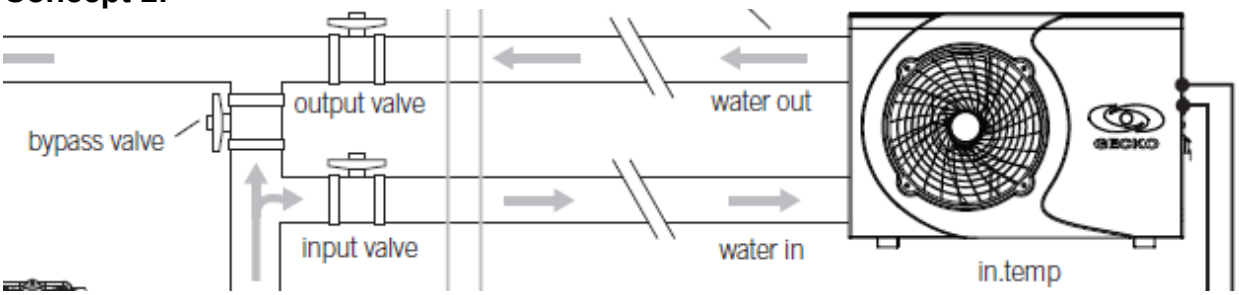
Either plumbing version can be plumbed when using a short plumbing run with a standard circulation pump.

If you are going to use the check valve concept, be sure to use at least a 3 lb check valve which will push most of the water to the heat pump and not through the bypass.

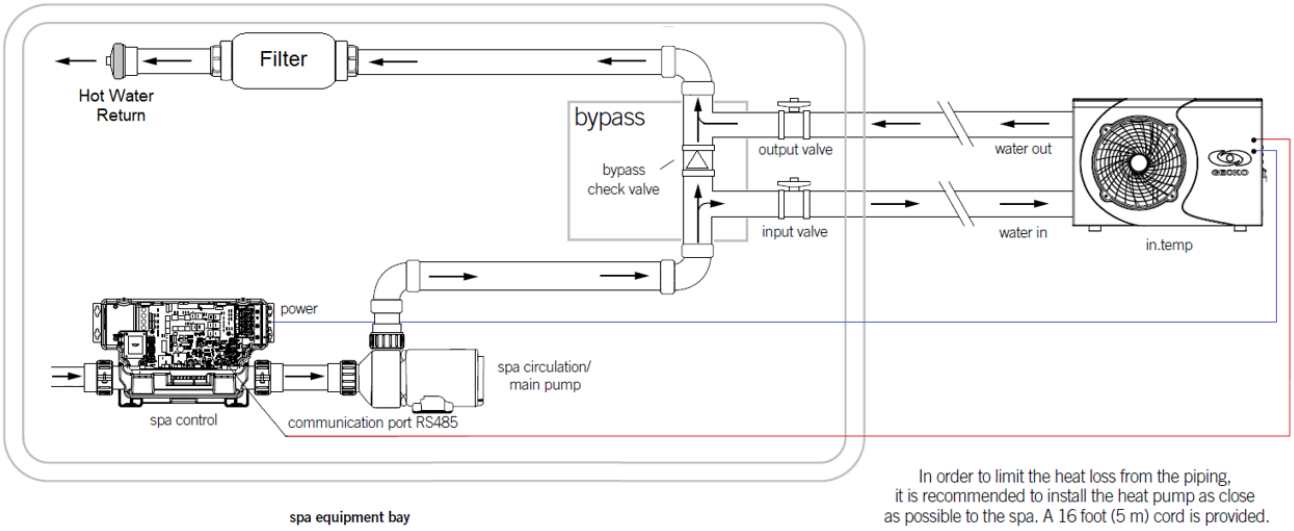
With very short plumbing runs, it is best to use Concept 2 (below) which will allow the bypass check valve to open when required.

With medium distance or long pumping runs, it can be best to use Concept 1 (below) with no check valve as the resistance in the plumbing lines may cause the check valve to open prematurely, while will not allowing proper water flow to the heat pump. Keep your plumbing run as short as possible as not only will this maintain a consistent water flow, but it will also help reduce heat loss through the heat pump piping.

Concept 1:



Concept 2:



2-Speed Pump Water Flow System:

You first must determine if your product is using a low amperage 2-speed pump or a regular 2-speed pump. Low amperage 2 speed pumps on low speed generally use around 1 amp of power and pump around the same amount of water as a circulation pump under low pressure. If you are using a low amperage 2 speed pump the same basic distance rules apply as a circulation pump.

Low amperage 2-Speed Pump vs Standard 2-Speed Pump

Typically, if you are pumping the water to an elevation greater than 3 ft (91 cm) higher or lower than the current position of the pump with a run of more than 10 ft (3 m), you may need to replace the low amperage pump with a standard 2-speed pump (which on low speed uses around 3 amp's) or add a booster pump.

If you are on the same elevation and you are pumping the water farther (in one direction) then 14 ft (4 m) from the pump to the heat pump you may need to use a larger pump (which on low speed uses around 3 amps) or a booster pump.

A larger pump, for example, would be a standard 2-speed pump, with a minimum low-speed amperage draw of at least 3 amps. This pump would need to be sized onsite depending on the distance and the elevation that is required.

Note: The flow rate required in the system should be designed for approximately 20 gpm (75 l/min), and the pump would need to be sized to maintain this rate under all circumstances.

The water flow to the heat pump should be on the pressure side of the spa's circulation system, directly after the 2-speed pump.

Guidelines to follow:

- Keep the plumbing runs as straight as possible and the number of 45 and 90-degree elbows to a minimum.
- For hot tubs and swim spas with a 2" wet end use 2" pipe to travel to and from the heat pump (reduced to 1.5" at the entry and exit of the heat pump).
- Keep the heat pump as close to the product as possible, keeping the plumbing as short as possible.
- Plumb this piping system to the heat pump on the pressure side directly after the 2-speed pump.
- Take into consideration the required product clearance as stated in the product manuals. Below is a concept drawing of how to plumb in a heat pump in a system with a 2-speed pump.

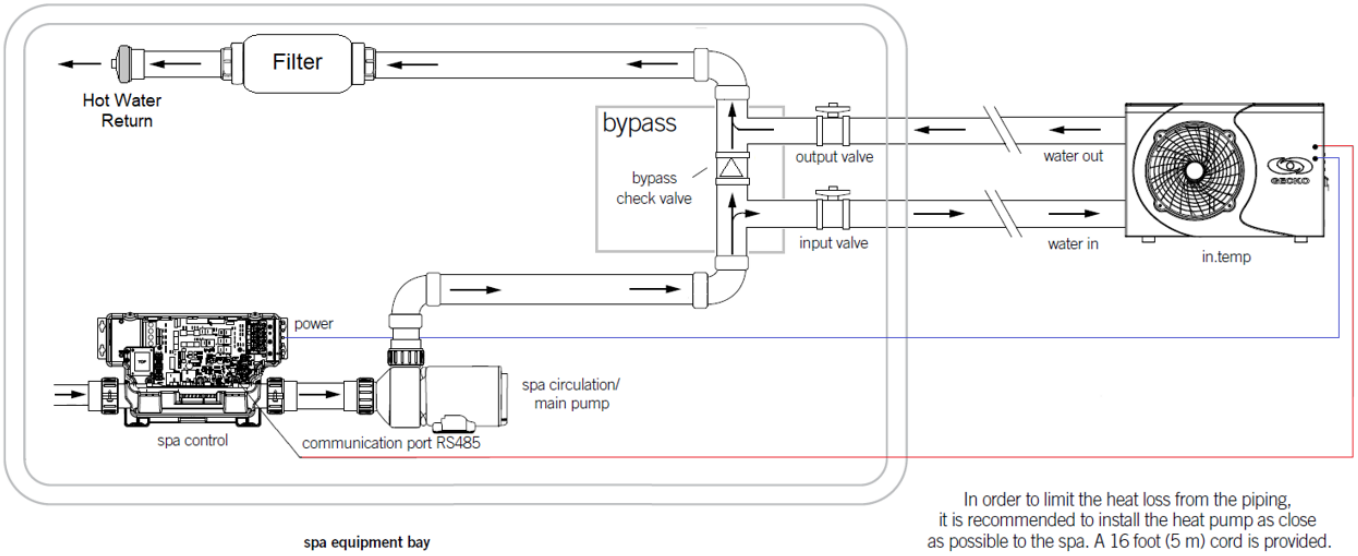
Important: A product requiring a 2-speed pump should **always** be plumbed with a check valve to minimize flow losses that will occur when the pump is switched to high speed.

Booster Pumps

A booster pump can be used as an option instead of adding a larger pump or for very long plumbing runs, in conjunction with the circulating pump. It should be used for long plumbing runs and major changes in elevation.
This pump, in most cases, should be located on the return (water out) line of the plumbing after the heat pump and with a splitter cable so it using the same power system that powers the product's circulating pump.

A booster pump can be a variety of different pumps from a small circulation pump to a larger 2-speed pump (on low speed) and must be sized into to maintain the minimum flow rate.

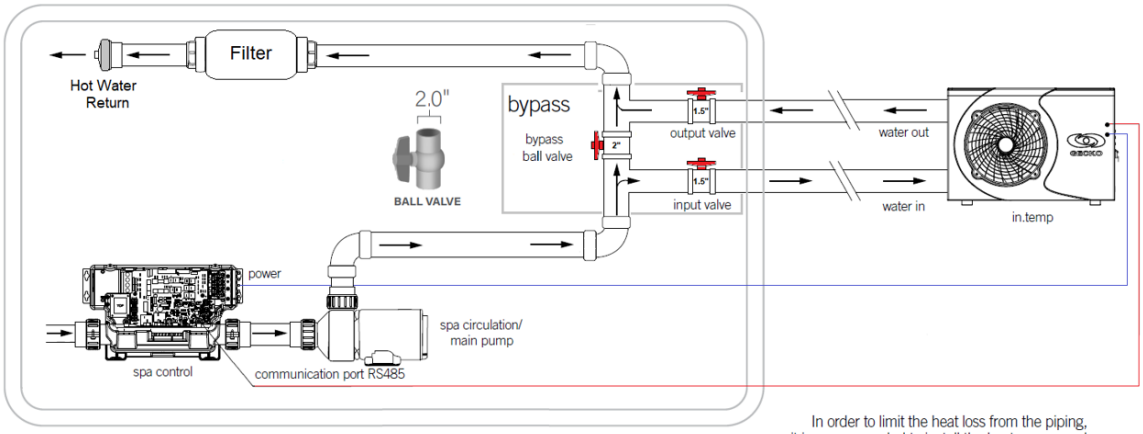
Gecko In.temp Concept:



Or

Plumbing System

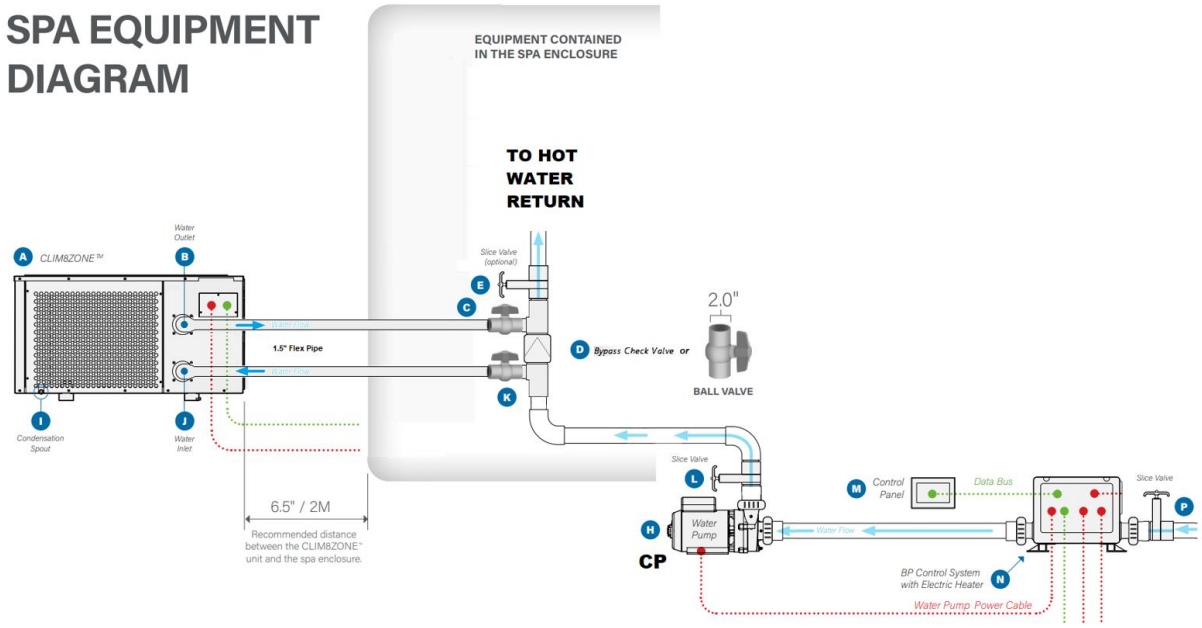
A bypass, consisting of three valves, must be installed to adjust water flow to the in.temp and to isolate the apparatus for maintenance purpose. For a more stable flow in the heat exchanger, it is recommended to install the in.temp on the pressure side of the main pump.



spa equipment bay

In order to limit the heat loss from the piping, it is recommended to install the heat pump as close as possible to the spa. A 16 foot (5 m) cord is provided.

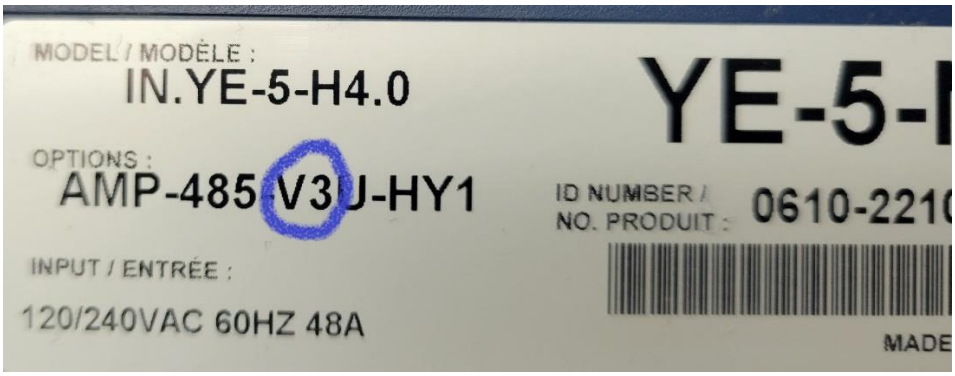
Balboa Clim8zone Concept:



System Connections: Gecko In.temp

You must be using a recent version 3 spa pack that is compatible with the in.temp.

NOTE: *if replacing a YT12 (either for model 970T or a swim spa), you must order the following*
NA – ye6 (7505095) (+ ye0 for swim spa – 7505096),
EU – ye5-V3 (7510050) (+ B-EXT-1R-CE (7510052) for 970T) (+ye0 for swim spa - 7510048)
EITHER pack must be complete with the software version **646V16**.



Please refer to the most recent version of the in.temp Techbook found on Gecko's website.

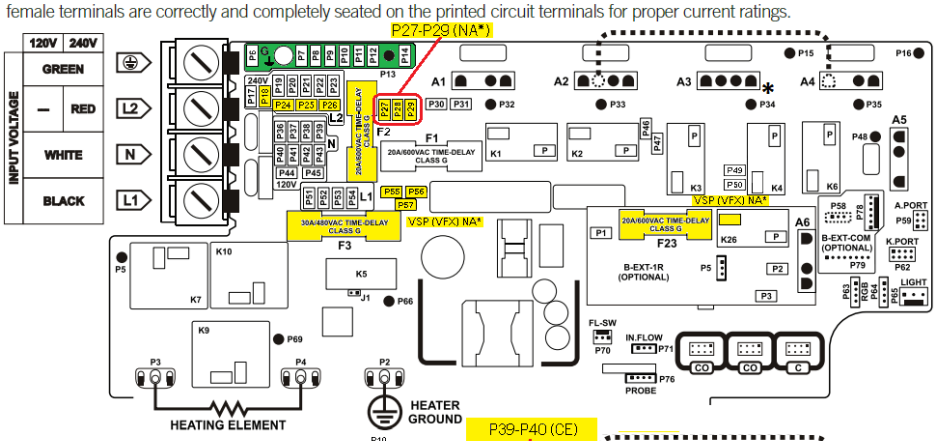
Note: The in. temp power cable connectors are female quick spade, ease to connect directly to the pack PCB as shown in the wiring diagram below.
If you are using a separate power source for the in. temp, that is not connected to the spa pack, you must go into the heat pump programming and set the in. temp to Zero Amperes so the pack will not try to manage the current.

System connection (With Blower/ No Blower)

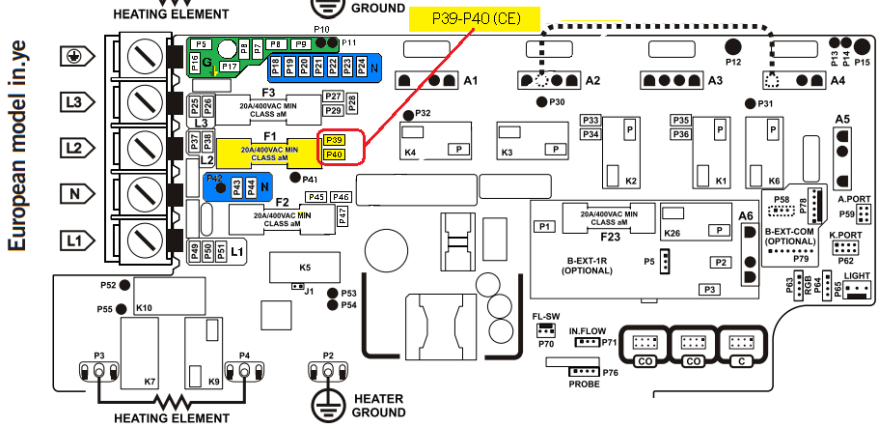
The communication cable provided with the heat pump must be connected to the RS485 communication port of the spa control.

The power cable connects to the spa control using 6,35mm (0,250") quick connect female terminals. Ensure that all female terminals are correctly and completely seated on the printed circuit terminals for proper current ratings.

North American model in.ye



European model in.ye



in.ye-v3 control system

The connection must be done according to the following tables:

NA* Model		
L	Black	P27, P28, P29 tab (F2)
N	White	Any Line 2 (L2) tab
G	Green	Any Ground (G) tab

L2 (P18, P24, P25, P26)
G (P6, P7, P8, P9, P10, P11, P12, P14)

L Black K26 tab (F23) VSP (VFX) or
L Black P55-P57 (F3) VSP (VFX)

CE Model		
L	Brown	Line 2 P39, P40 tab (F1)
N	Blue	Any Neutral (N) tab
G	Green/Yellow	Any Ground (G) tab

N (P18-P24, P43, P44)
G (P5-P9, P16, P17)

List of compatible keypads with in.temp

For more information on the compatible keypads for your in.temp refer to the corresponding Techbook.

in.k330 main keypad
Color LCD display, 5 keys

in.k500 main keypad
Color LCD display, 7 keys

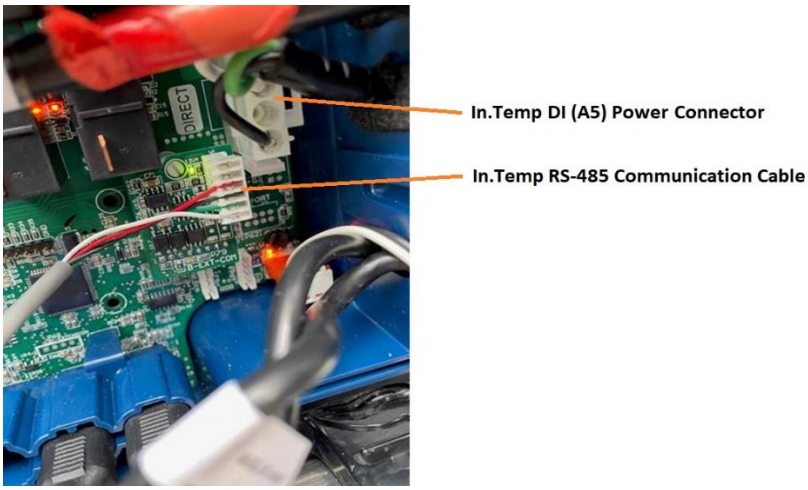
in.k800 main keypad
Color LCD display, 10 keys

in.k1001 main keypad
in.k1001+ main keypad
Color LCD capacitive touchscreen display

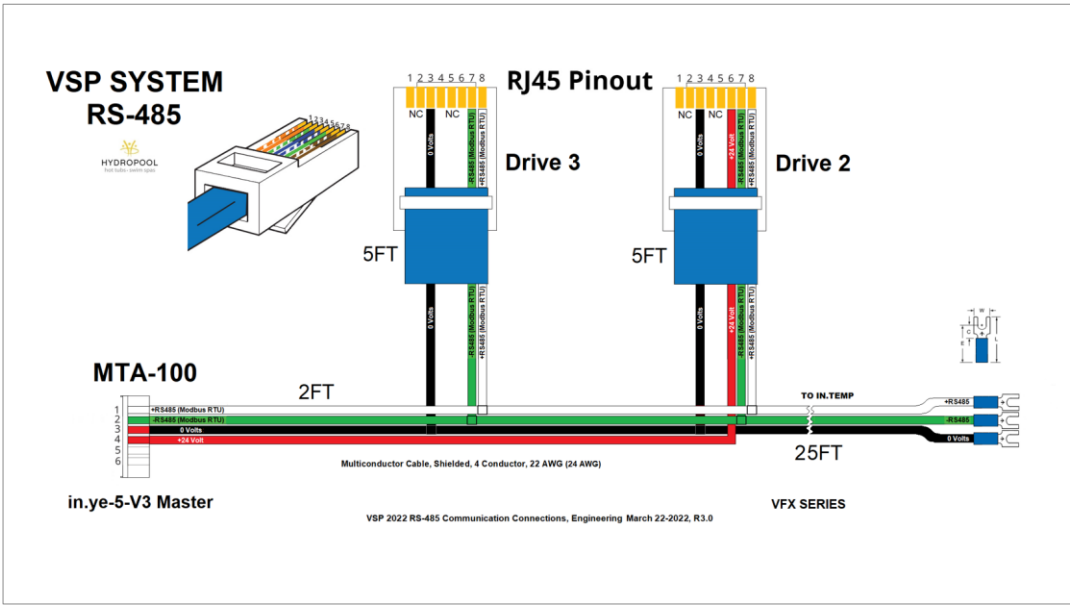
in.k1000 main keypad
in.k1000+ main keypad
Color LCD capacitive touchscreen display

The in.temp is also supported by the in.touch2 mobile app. So even if your spa is not equipped with any of the keypads above, you can still control your in.temp via the mobile app.

Gecko Control Connector Location on Circuit Board



Hydropool EX Trainer Additional Required Wire Harness (Hydropool part number 2025073). To connect the drives/spa pack and in.temp



In.temp Connection for Wire Harness

VFX System

Connections **RS-485 V3.0 Communication Cable**

Terminal box

The terminal box is located behind the terminal cover and allows access to the communication and power connections.

Signal	220 V~240 V, 50 Hz			12V		RS-485	
Terminal ID	L	N	⏚	+	-	B	A
Wire color	Brown	Blue	Green/ Yellow	Red	Black	Green	White

Power cable (CE) Communication cable

Signal	240 V ± 5%, 60 Hz			12V		RS-485	
Terminal ID	L	N	⏚	+	-	B	A
Wire color	Black	White	Green	Red	Black	Green	White

Power cable (NA*) Communication cable

VSP Drive Connection (shown with EX Trainer wire harness Hydropool part number 2025073)

System Connections: Balboa Clim8zone System

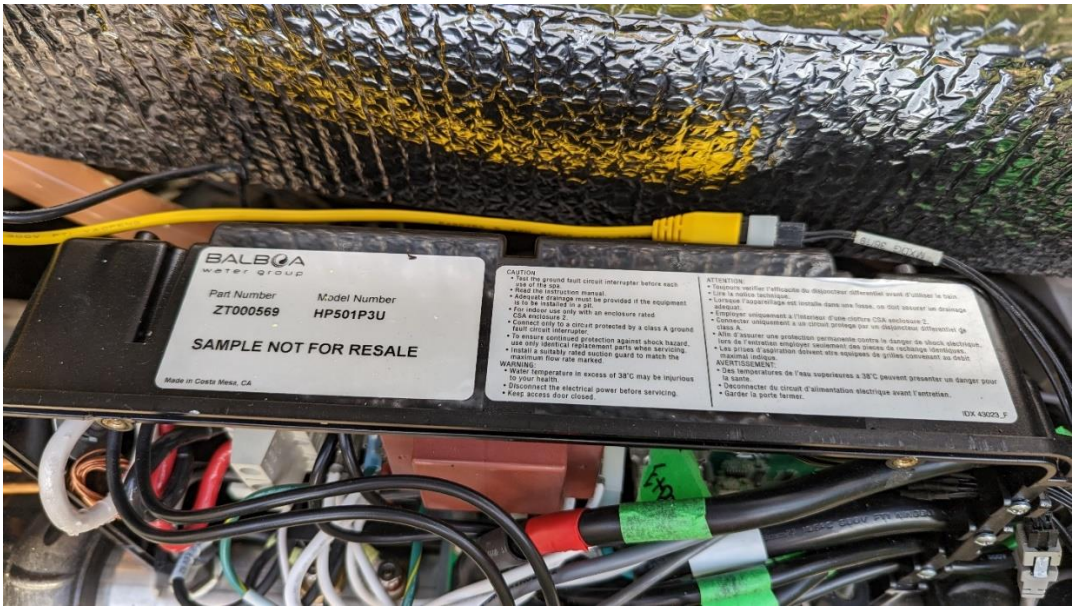
Compatible Control Panels

For standard compatible control panels and a complete list of compatible equipment packs, please see the Clim8zone installation instructions.

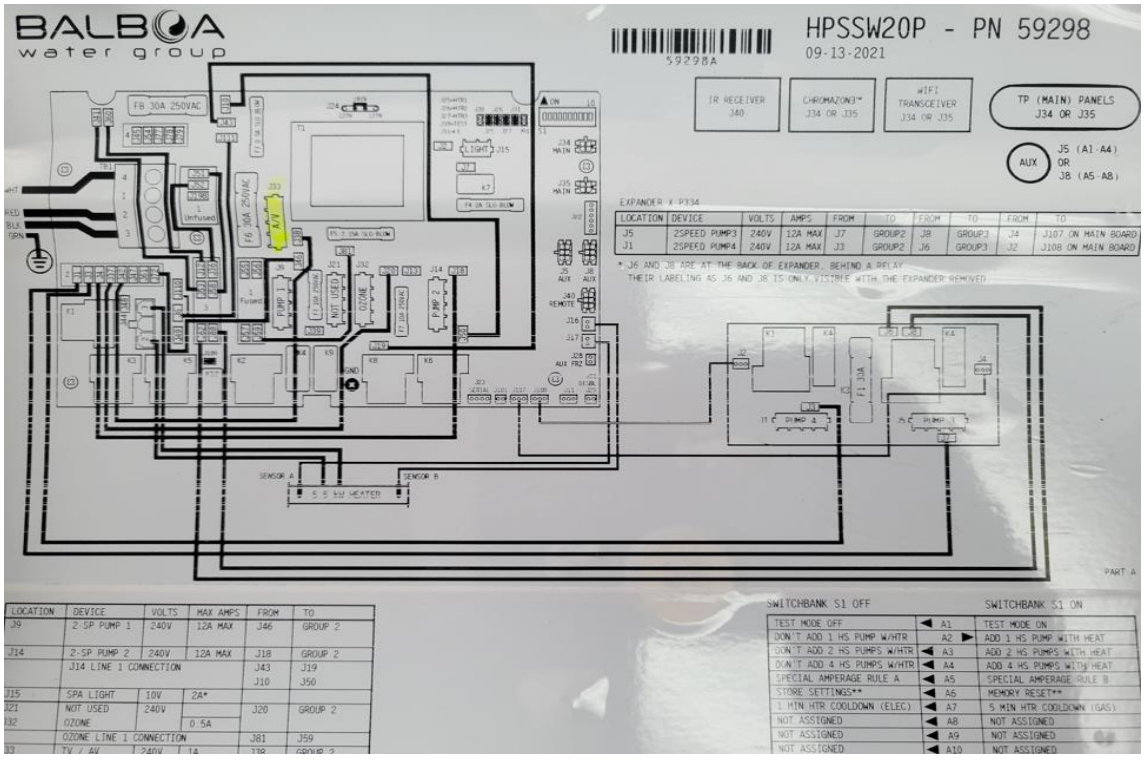
Hydropool's current Jacuzzi touch screen panels are compatible, while our spa packs are compatible in early 2023.

Note: As this heat pump has independent controls it is not required to have a compatible spa pack as the Clim8zone can operate independently.

Control Connector plugged into Splitter Cable



3. AV Connection Port Highlighted in Yellow on a standard Swim Spa Pack



The AV connection port is marked with a yellow dot in the picture below