Sanitary hot water and space heating design guide

for HXHD high temperature hydrobox for VRV systems

VRV HT Basic control functions (HXHD* unit)

The VRV HT Hydroboxes can be used for *Space Heating applications* as well for *Sanitary Hot Water applications* or a combination of both. The use of below patterns depends on your application and needs. The purpose of the explanation given is to be able to judge which operation pattern fits your dedicated situation the best. Details on settings can be found in the Installation and operation manuals of the HXHD* units series.

Two basic control patterns exist for Hydrobox VRV HT to supply hot water intended for **space heating application**.

> - Leaving Water Temperature control (LWT control)
> - Thermostat control

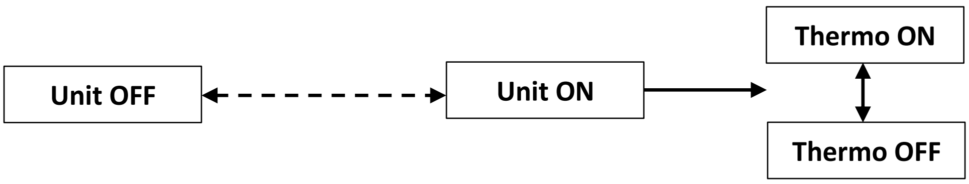
Several patterns for **Sanitary Hot Water (SHW) preparation** exist.

> - Automatic SHW storage operation
> - Manual SHW storage operation
> - Reheat SHW operation
> - Automatic SHW by Heat Recovery operation

A. Space Heating operation controls

Definitions

- Unit ON/OFF:
  When the unit is ON; the unit can operate if deemed necessary or not.
  When the unit is OFF; the unit cannot operate, even though if deemed necessary or not.
  → Unit ON/OFF is allowing the unit to operate or not
- Thermo ON/OFF
  The unit is in Thermo ON; the unit will be able to operate, when the unit is ON.
  The unit is in Thermo OFF; the unit will not operate, when the unit is ON
  → Thermo ON/OFF is the judge whether operation is required or not
  → Thermo ON/OFF can be judged in several ways



1.Leaving Water Temperature control (LWT control)

In this case the unit controls, based on its own water sensors (Leaving Water Temperature (LWT) and Return Water Temperature (RWT)), when a Thermo ON or OFF condition is established.
Primary setting to be executed in this case is setting the LWT_{set} (=Leaving Water Temperature setpoint). This is at the same time the main control parameter.

Judging a Thermo OFF condition.

The unit will control INV rps in order to always reach the requested LWT_{set}. In case the LWT is reached and load down of compressor is impossible (required capacity of heating emitter system is low, no heat is required anymore (auto feedback loop)), the water temperature will increase, eventually going over the LWT_{set}.
Based on how much the LWT is going over LWT_{set} and how long LWT is going over LWT_{set}, the unit will go to Thermo OFF condition. This decision is made by the unit itself, and is implicitly coming through an auto feedback loop from the heating emitters.

Judging a Thermo ON condition.

Once Unit is in Unit ON conditions, the unit will start intermittent pump operation (= pump sampling), to determine the water temperature in the system.
The unit will restart operation in case, when during pump sampling operation, the water temperature is below the LWT_{set}-X°C.
In this control there is no feedback to the unit apart from its own leaving and return water temperature sensors to determine Thermo ON or OFF.

2.Thermostat control

First of all it is important to know there are two types of Thermostat control are possible:

> Remote controller (=Remocon) room thermostat control (default available)
> External room thermostat control (available through option PCB)

The Thermostat control bases its control information primary on external information (a room temperature is most commonly used). It considers that the external input it receives from the judge device is valid and correct.

Heating operation

> In case of Remocon room thermostat control.
When Troom_air < Troom_set on remocon: Thermo ON
When Troom_air > Troom_set on remocon: Thermo OFF
(with 0,5°C hysteresis)
> In case of External room thermostat control.
When external device decides Thermo ON → Allow operation
When external device decides Thermo OFF → Stop operation
➔ It is always depending on an 'external' input (external judge).

During the time where the Thermo ON condition is established, and as such is received (from remocon or external device), the unit will keep operating = **<u>THERMOSTAT PRIORITY</u>**.

It means that during Thermo ON conditions, the unit will do all to regulate to the desired water temperature selected (=LWT_{set}): LWT control is active. When Thermo ON condition is existing: the unit INV will modulate to keep this LWT (if you request 65°C, you will get 65°C, not 35°C).

<u>However,</u> the stop condition, **in a limit scenario**, is different than under *normal* LWT control (discussed in previous section).
When Thermo ON condition is existing and the unit reached the LWT_{set}, and the INV *cannot* modulate any further load down, LWT will increase.
At that time the increase of LWT will not be stopped as long as the external device is not instructing a Thermo OFF (since the external device has priority (Thermostat priority)). In normal LWT control, the unit decides stop by himself. But now, it should obey to the external input.

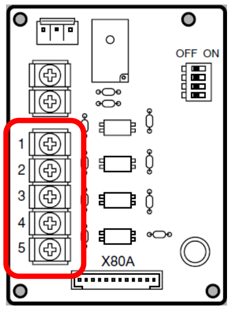
To cope with the idea that there should be "a" limit. It is possible to have, even in such a limit case, the unit stopped at LWT_{set} + 5°C by applying special field setting.

Normally, such special field setting is not required, since load balance is important in a hydraulic circuits and is executed correctly.
When working with thermostats (remocon or external) and there is an occasion where heat load is required (Thermo ON is decided by external device), but the heat pump system cannot release any heat (since load down is maximum and still LWT is increasing), is pointing to complete unbalance in the system or very bad decision of the external device.
→ Reconsidering of location of the Thermostat is required
→ Reconsideration of emitter system is required

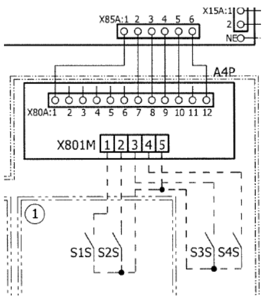
Related to Thermostat control with External thermostat control, 2 patterns are available. They are established depending on a field setting value. It is explained below.

First observe the input contacts. We name and define them.

PCB



Wiring Diagram (simple)



Option PCB EKRP1AHTA has 5 contact points and following closing options:

A] 1) – 5) → Thermostat input (S1S)
B] 2) – 5) → Option not available for HXHD* (S2S)
C] 3) – 5) → Multiple set point (see manual, only dedicated setup) (S3S)
D] 4) – 5) →Multiple set point (see manual, only dedicated setup) (S4S)

A]
1)-5) Open: Thermo OFF
1)-5) Closed: Thermo ON

B. Sanitary Hot Water (SHW) preparation

B.1 Automatic SHW storage operation

Typical patterns for domestic use of SHW include heating of the hot water tank 1 or 2 times a day till a certain set point.
This normally covers the SHW needs for a family in correspondence with the chosen SHW Tank volume.
To keep settings easy, there is an automatic SHW storage operation schedule timer which can be activated through field settings. When activated this foresees each day at your chosen time to heat up the SHW Tank till the Storage set point. Typically this would occur during night time and in the afternoon. Modifications are at will of programmed field settings.
The SHW operation of the system is stopped, and will NOT resume, when the SHW Tank set point has been reached.

B.2 Manual SHW storage operation

When a customer wants to have an immediate SHW operation and heat up till the SHW storage set point, this can be activated by using 1x the Manual SHW storage operation.

B.3 Reheat SHW operation

Next to Storage operation for SHW, there is also possibility to operate SHW by reheat operation.
Reheat SHW operation can be combined with SHW storage operation. Reheat SHW operation is also possible to be used as only SHW operation method.
When reheat SHW operation is activated, the unit will make SHW till a certain SHW Tank set point. When the set point is achieved, the unit will stop operation. During consumption of SHW, the Tank temperature will drop. When a certain under limit (settable) is reached, the unit will automatically restart reheat SHW operation.
Like this, there is a guarantee that continuously the SHW Tank will be kept at a certain temperature. Limit settings and SHW Tank set point should be chosen wisely in function of consumption, installed total capacity and SHW Tank volume.

B.5 Commercial use of SHW operation (guidelines and suggestions)

The systems explained above are the default SHW operation modes. They reflect operation in the most simple way. A VRV HT Hydrobox connected to its own dedicated SHW Tank. A situation that practically rarely will exist in commercial applications.

In commercial applications, 3rd party tanks will make up majority of installations. Due to the nature of the application many variations will exist:

> Volume
> Heat exchanger size
> Several 3rd party tanks instead of one
> …

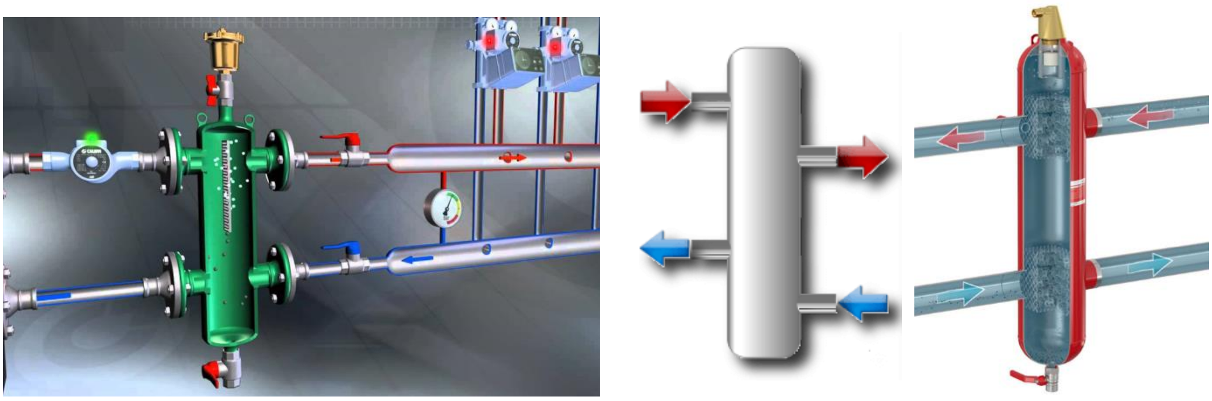
They will be fed by several VRV HT Hydroboxes rather than one single unit.

Following text will provide some good practice guidelines and possible control methods that can be used for commercial applications.

It is assumed good practices in hydraulic balancing are executed. The guidelines focus on the design and control side.

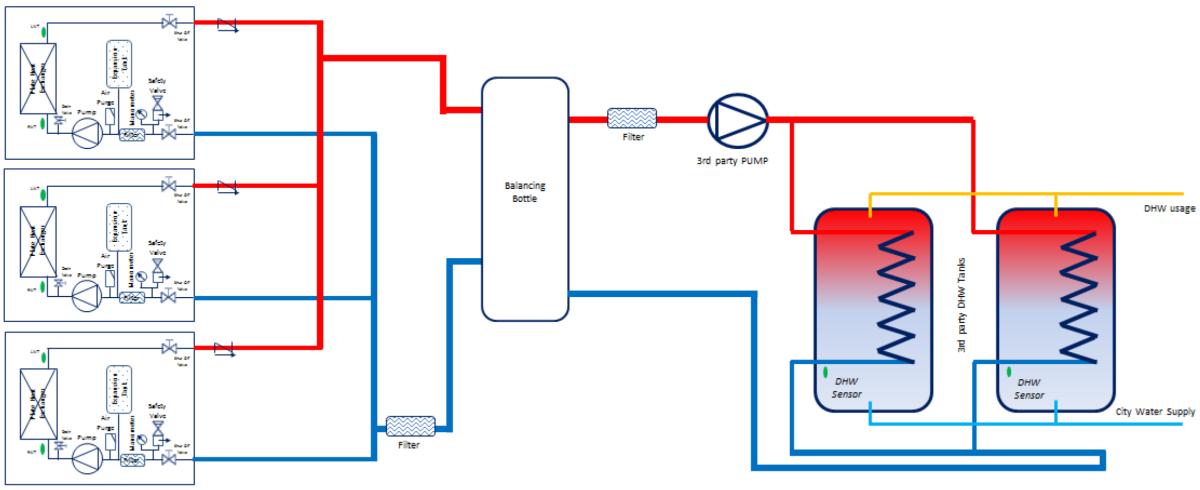
B.5.1 Hydraulic system (basic requirements)

It is advised to use a system which is capable of **full Hydraulic decoupling**. Such a system is using a hydraulic balance bottle (see below) and provides free pathway on hydraulic side, reducing the risk in case of single components failure.
Selection is explained in the next paragraphs.



Using a system that only uses the VRV HT hydrobox own pumps to maintain the flow in the system is not at all favourable. The pumps inside the Hydro modules can provide circulation for single circuits but are not to be used as supply pumps for the 3rd party hydraulic system. Doing so could lead to reduced performance or unwanted output of the system.

The flow towards the 3rd party SHW Tank(s) should be provided by an adequate 3rd party **field selected pump** that is capable of delivering enough ESP and flow for the dedicated 3rd party hydraulic part of the system. *Selection is explained in the next paragraphs.*



B.5.1.1 Sizing of the collectors in the primary circuit and sizing of the hydraulic decoupling bottle.

To make sure the Hydroboxes get the same water flow individually, it is required to maintain the speed inside the **collector** below 0,9-0,8m/s. This implies a minimum diameter to be used for the collector: d(m).
It is can be calculated as follows:

d(m) = Sqrt ((4 * V (m^3/h))) / (Pi() * v(m/s)))

In this case

v (m/s) = 0,9m/s; ΔT = 5K

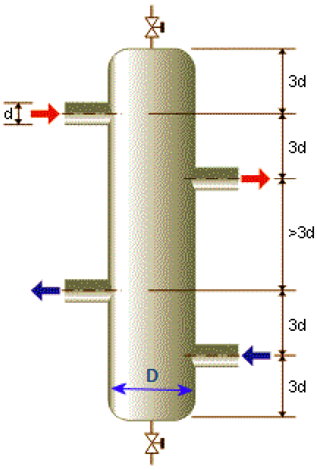
Q (kW) the required capacity of the system (determination see further on)
Q (kW) = m*c*ΔT = m (kg/s) * 4,186(kJ/kg/K) * ΔT(K)
= ρ (kg/m^3) * V (m^3/s) * 4,186(kJ/kg/K) * ΔT(K)
→ V (m^3/s) = Q (kW) / (ρ (kg/m^3) * 4,186(kJ/kg/K) * ΔT(K))

Simplified in common used terms:
d (mm) = Sqrt (354 * Q (m^3/h) / v (m/s))

The speed in the hydraulic decoupling bottle should be kept below 0,1m/s, this in order to keep the hydraulic resistance of the decoupling bottle low enough not to impact the hydraulic system.
The diameter of the hydraulic decupling bottle can be calculated in the analogue way as above
→ **D (m)**.

Alternative, rule of thumb, is to keep the diameter: **D > 3*d** (when using single inlet and outlet)**.** When using multiple outlet: **D > (n+2)*d**

Appropriate dimensions are indicative linked to the rule of thumb.

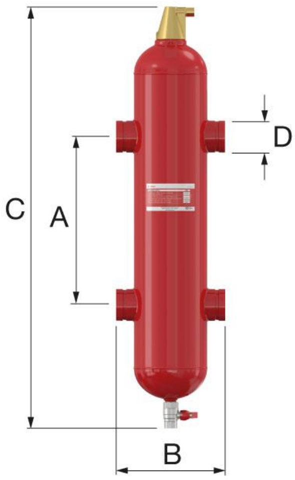


Main benefit

* Hydraulic independence of the system, even when some units are not working.
* Pumps won't work against each other. Each system can operate without blocked water flow.

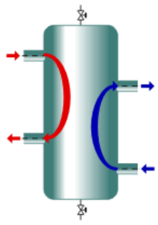
Optional benefits of using a hydraulic decoupling bottle:

* Dirt can be captured and evacuated easily (most types have a valve at the bottom).
* Air can be easily purged (most types have an air purge at the top).



!Heads Up!

- Many types of hydraulic decoupling bottles are existing. Pay attention short circuit is to be avoided (→ This risk is existing when the diameter D becomes very big; D >>> 3*d)



- Do keep in mind to use hot water connections to the bottle on top and cold water connections at the bottom.
- Use a filter in the secondary circuit as well as in the primary circuit. One with the possibility to remove metal particles (magnetic type) will protect the pumps of the Hydroboxes the best.
- The minimum water flow which is required for each Hydrobox (diameter of first pipes and ESP available by the Hydrobox).
- Consider the total water volume of the system. When the total water volume is bigger than the sum of the maximum water volumes each individual Hydrobox can cope, an additional expansion vessel might be required!
- The minimum water volume/Hydrobox is 20l.
- Installation of multiple Hydroboxes implies the use of a non-return valve in the leaving water temperature line of the single Hydroboxes used.

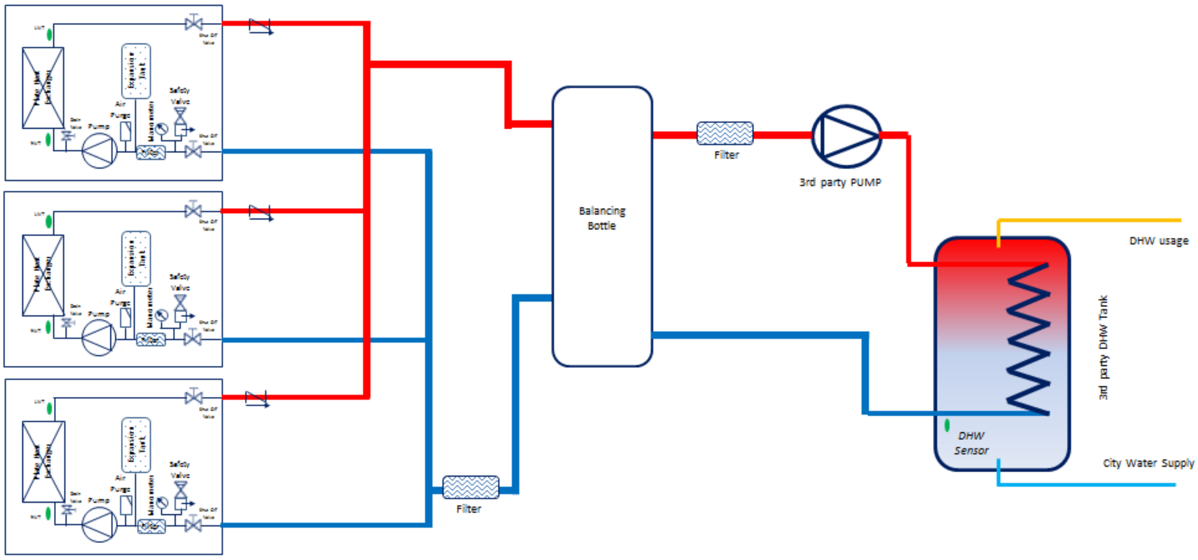
B.5.1.2 Sizing of the secondary circuit. Checking your Secondary hydraulic system

The secondary side, or consumer side if you wish, will consist out of

- Tank(s)
- Pump(s)
- Piping
- Control valve
- Filters
- Re-circulation piping
- Auxiliary equipment
- Etc…

We will provide two examples. A system having one big 3rd party SHW Tank and a system containing on secondary side several SHW Tanks to be fed. This to help avoiding pitfalls when designing.

Single SHW Tank setup in secondary side



Selection is limited to the piping size and the selection of the 3rd party pump.

* Piping: make selection according to the pressure drop expected. This depends largely on the actual layout of the system and the number of bends existing. Make sure to keep speed inside the pipes lower than the speed limits specified by the manufacturer to avoid breakdown or quick corrosion.

* Pump: make selection according to the expected ESP required and the flow required.

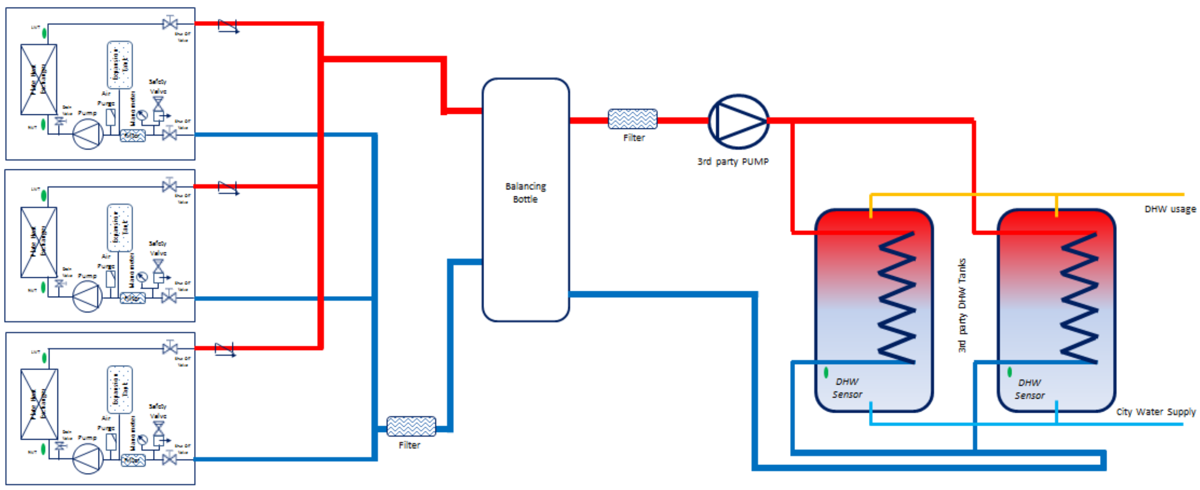
The ESP of the pump should cover the losses in the piping circuit, filter, auxiliary valves and the heat exchanger of the SHW Tank.

At the working point to overcome this pressure loss, the pump should still be able to provide adequate flow towards the heat exchanger of the 3rd party SHW Tank.

In case you consider the ΔT between the EW and the LW to be 5-10K you are on the safe side for calculating the water flow required on the secondary side:

$$Q(kW) = F(l/min)/60 * 4{,}186(kJ/kg/K) * 10(K) \rightarrow \mathbf{F(l/min)}$$

Multiple SHW Tank setup in secondary side



Selection is limited to the piping size, layout of the piping and the selection of the 3rd party pump.

* Piping: see above.

+

Since now the *piping layout* will be a little more complex and we still want to deliver the same amount of capacity to each of the 3rd party SHW Tanks, we have to consider how to connect the piping. The piping should obey to Tichelmann principle. → Shortest supply gets the longest return.

Each line can have the same hydraulic resistance in that case.

* Pump: see above.

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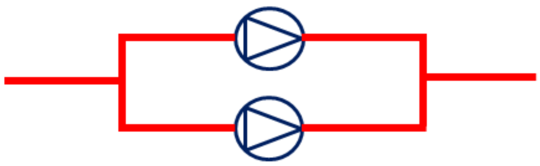
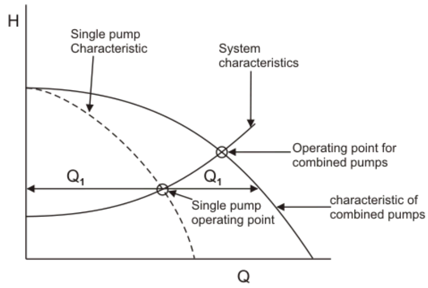
It might be convenient to use several pumps, to overcome the static height (due to pressure drops in the system) or to have a redundant system.

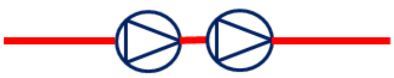
In that case, keep in mind.

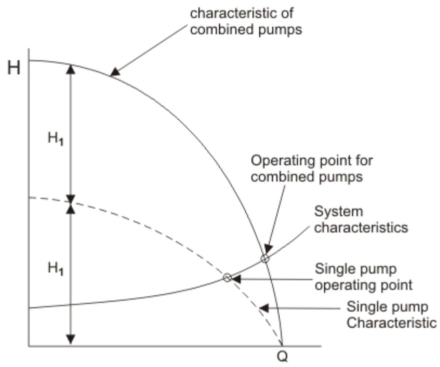
> Parallel placement of pumps: will not increase the static height, will increase the flowrate.





> Serial placement of pumps: will not increase the flowrate, will increase the static height.





Balancing the secondary and primary side

General rule is that the secondary flow should always be lower than the flow in the primary circuit. This to avoid the secondary side supply flow to have a lower temperature than the primary supply flow (energetic loss from system point of view).

The native ΔT on the primary side is 10K for the cascade side. Depending on the operation mode this can vary (drop when working in other modes; example: SHW mode). It depends on the forced water temperature due to the water mass that needs to be heated up.

Quick calculation (assume nominal):

> 22,4kW = F(l/min)/60 * 4,186kJ/kg/K * 10K → F = 32,1 (l/min) on primary side.

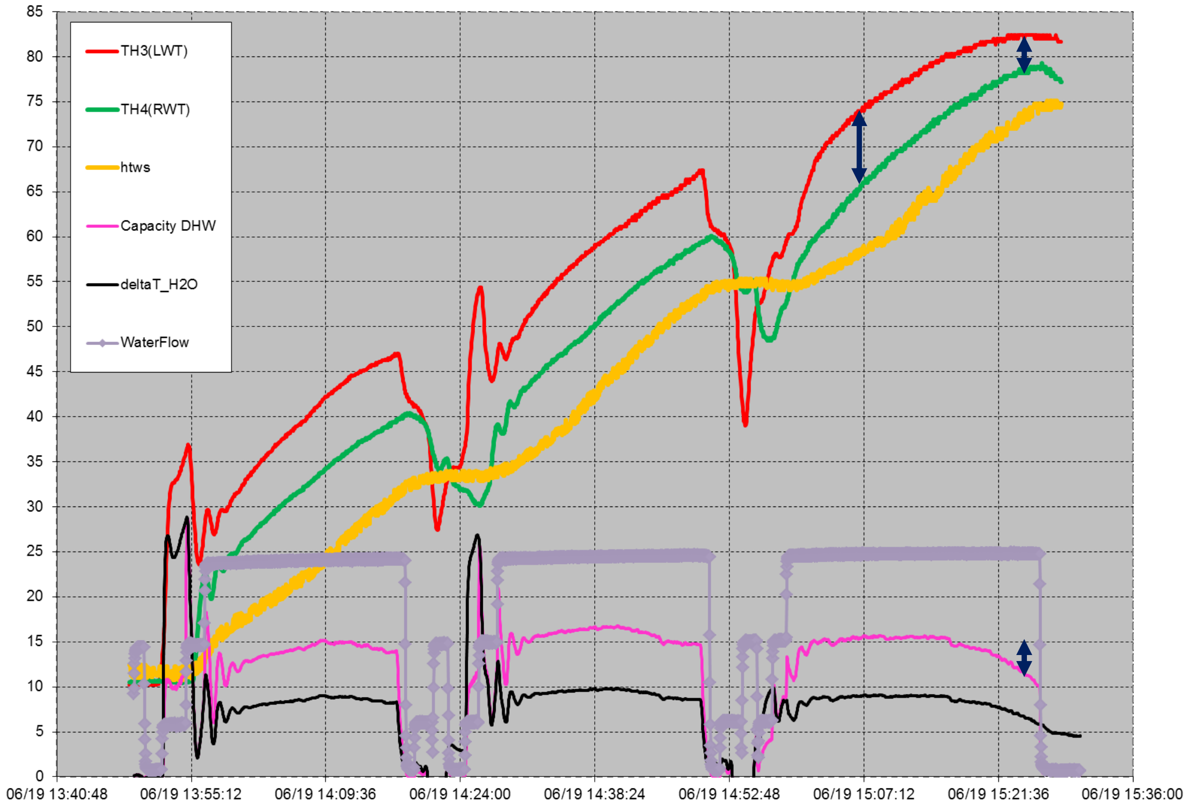
> 5 x HXHD = 5*32,1 = 160,5 l/min @ 112kW on primary side. Regime 80/70.

> So on secondary side:
Assume ΔT = 5K → Flow = 160,5*2 = 320l/min
Energy balance at that time: hydraulic balance bottle out, and as such the feed side of SHW Tank heat exchanger, = 75°C.
Steady state condition reaching 75°C tank temperature is not possible (only possible over long period of time and very good SHW Tank heat exchanger: practically, not possible).
However, ΔT over SHW Tank water and feed water will decrease due to increasing tank temperature (physical fact). The capacity that can be rejected by the SHW Tank heat exchanger will reduce when the SHW Tank temperature is increasing. ΔT over the SHW Tank heat exchanger will decrease ((10 →) 5 → 2,5 or lower). As such the balance temperature of water going into the SHW Tanks heat exchanger will increase 77,5°C. Like this new balance will be possible and SHW temperature of 75°C will be possible to reach. This due to the fact that a full release of capacity to the SHW Tank heat exchanger is not possible at any condition. This situation is independent from the primary heat source (gas boiler, heat pump, oil burner, etc. combined to a storage SHW Tank).

Remark: secondary return temperature during heat up is depending on the SHW Tank heat exchanger size. When the size is big, the return temperature can be lower. This does not cause an immediate issue to reaching the final tank temperature. Since anyhow the tank temperature will increase and finally the ΔT between the Tank temperature and the supply water will decrease, allowing the exit temperature of the tank to increase (you end up in explanation above).

Even when secondary flow would be same as primary flow, this causes no problem. Same phenomenon will occur as explained. Basically in this case there in no negative impact towards energetic loss since in that case the feed water will have the same temperature from the beginning as the water supplied by the heat pump.

→ The secondary side does not need to have a lower ΔT than the primary circuit to achieve the required maximum SHW Tank set point.



B.5.2 Checking your SHW Tank Size and capability (Sizing the system)

Most important consideration items are:

- How much SHW at which temperature do I need?
  What is conventional?
- How often do I want to make SHW (related to consumption pattern)?
  Consumption patterns?
- How much space do I have available to put a (new?) SHW Tank?
  Resulting in Volume restrictions
- What are my current SHW Tank specifications?
  How do I read them?
- Will I use and auxiliary system to make SHW or only use heat pump technology?
  f=(required renewable need)
- Etc.

We help to find the relation between these parameters.

First we have to consider. VRV HT Hydro modules are available in 2 sizes: 14kW and 22,4kW. Since we are discussing large scale SHW production, we will focus number and examples using the largest capacity Hydrobox: HXHD200.
This, without any doubt, is the most favourable in terms of installation space required and installation cost.

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B.5.2.1 How much SHW at which temperature do I need?

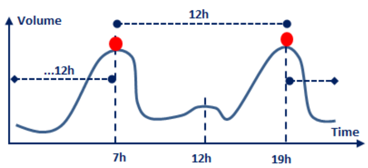
!Legal Heads Up!
Check your local and national regulations.
You might have to obey to recirculation requirements and ant-legionella measures.

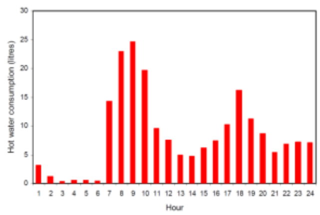
> Recirculation of consumer SHW flow is subject to the installation and the 3rd party SHW Tanks which are used on site.
> Legionella measures involve heating up the tank over a certain water temperature for a given time. The VRV HT Hydroboxes have a Legionella function built in. It is up to you to check this is sufficient for the installation involved (installer responsibility to obey national and local legislation).

<u>Know your application</u>
In general for Hotels. The average size (expressed in number of beds) for 3 to 5 star hotels is about 60~190beds, which is rather high spread. We will focus to higher end Hotels and consider an example with 125beds.

Category	Average size of hotel in terms of rooms	beds
1-star	24.6	56.2
2-stars	23.1	44.6
3-stars	32.4	60.5
4-stars	72.3	130.6
5-stars	105.8	187.7
other basic categories	20.4	44.6
not classified	15.0	31.5
Weighted average	**27.0**	**52.3**

Typical consumption patterns





Typical required SHW volume @ 60°C per bed can be found in various literature:

Example for 4 star hotels

> EN15316-3-1:2007 = **132** l/bed @ 60°C
> Spain (CTE HE4) = 70 l/bed @ 60°C
> Germany (X) = 7kWh/bed/day ~ EN-10% ~ 115 (l/bed/day)

Information and guides are varying. It is due to fact whether you include laundry services of not.
In the example we assume 132l/bed @ 60°C.

B.5.2.2 Consideration factors, how they are linked?

Following additional considerations need to be made and well considered for every system or system modification:

- Take a **safety factor**.
  We take in the example 10% on the required water quantity @ 60°C. Which is on the high side.
  Another safety factor could be take a safety of 10% towards capacity installed. Etc.
- A heat pump can never fulfil a sudden peak demand. A **SHW Tank volume** is required. In many cases a larger volume compared to the one needed when using a gas or oil burner. It is a matter of capacity and investment.
  So a trade of between Capacity installed and Total SHW Tank volume is required.
  (It is also an economical trade off)
  Since regulations are pointing to a **percentage** of obligatory **renewable** based SHW production (R(%)), one can consider a certain other percentage will be made in conventional way. This makes the hydraulic system more complex (see further).
- **Reheat time** is to be considered, eg., 7 hours. It is mainly linked to your consumption pattern.
  The shorter the reheat time, the larger the SHW Tank volume which is required or the bigger the *installed capacity* needs to be.
- Tapping pattern: full tapping of 50% of the daily requirement happens **on peak moment**s.
  It suggests what is your **minimum SHW Tank volume**

B.5.2.3 Determining required SHW Tank Volume and installed Capacity

To cover a certain demand **W** of SHW for a Hotel or appliance @T_1, the required SHW Tank volume is considered to be **W”** @T_2:

W (l) = Water required during a day
= # beds * (132*(1+10%)) @60°C
= 18150l (→ # beds; for easiness of calculation = 125 beds)

This *volume of water can be reduced* by using a higher SHW Tank set point (T_{set}).
Recalculation is done according to following formula (“equivalent volume”):

$$(60 - T_{mains}) / (T_{set} - T_{mains}) * W = W'$$

→ T_{mains} depends on your region and varies with the season. It is assumes 10°C.
→ T_{set} = 65°C
→ W’ (l) = 16500l

R (%) = Renewable% required for SHW making by Heat Pump
→ R = 100%

→ P = 2 ; the assumed reheat cycles over 24h period (see above)
→ **W" (l)** = W' (l) / P = W1 (l) + W2 (l) = **8250l**

W1 (l) = W*(R) = 8250l = Required volume of water to be heated from 10°C to 65°C to cover the needs by 100% renewables (= Heat Pump in this case)

W2 (l) = W*(1-R) = 0l

To heat up this SHW Tank volume within the reheat time gives you the required Heat Pump capacity part C (kW):

C (kW) = W1 (l) * 4,186 (kJ/kg/K) * (T_{set} - T_{main}) (K) / Time (s) / η_{tank}
= 8250 * 4,186 * (65-10) / 7*3600 / 0,90 = 84kW

The number of required Hydroboxes is clear:

N (#) = C (kW) / 22,4 (kW) = 3,75

To cover the renewable energy part of required daily SHW need (assumed 100% renewable vs 0% conventional), when using a SHW Tank with a volume of 8250l and a required reheat time of 7hours, will require 4 HXHD200 VRV HT Hydrobox units.

B.5.2.4 Understanding SHW Tank Heat Exchanger specifications

Rule of thumb to determine the required surface of the SHW Tank heat exchanger.

➔ About 0,1 m²/kW surface is required.
In the example from above this gives as requirement of the SHW Tank heat exchanger surface: 84kW * 0,1 m²/kW = 8,4m²

Checking existing SHW Tank specs or translate the information into usable form.

Specifications of SHW Tanks are expressed in **X**kW **@ (Y-Z) @ A°C**
Interpretation is as follows.
The SHW Tank heat exchanger coil can transfer **X**kW capacity if the supply entering water of the heat exchanger coil is **Y**°C and the supply leaving water from the heat exchanger temperature is **Z**°C and the water temperature in the tank is **A**°C.
Example:
50kW @ (80-60) @ 20°C
The SHW Tank heat exchanger coil can transfer **50**kW capacity if the supply entering water of the heat exchanger coil is **80**°C and the supply leaving water from the heat exchanger temperature is **60**°C and the water temperature in the tank is **20**°C.

The SHW Tank Heat exchanger capacity can also be expressed per K → kW/K.
In such case the basic idea is that the SHW Tank heat exchanger capacity should be bigger that the connected Heat Pump capacity:

SHW Tank heat exchanger capacity per K ≥ (Capacity connected to the tank)/($(T_{in}+T_{out})/2 - T_{tank}$)

For T_{tank}, you have to make an assumption, based on data available, when the tank temperature is not provided directly.

<u>Example:</u>
50kW @ (80-60) @ 20°C → SHW Tank heat exchanger capacity per K = 50/((80+60)/2 – 20) = 1kW/K.
Practically, it means that maximum 1kW/K * 10K = 10kW Heat Pump capacity can be transferred to that SHW Tank heat exchanger coil.

In reverse way, you can also calculate what should be the specs of the SHW Tank heat exchanger if you want to transfer some given Heat Pump capacity. This in order to be sure that your Heat Pump capacity will be absorbed!

<u>Example:</u>
Your Heat Pump delivers 85kW with water ΔT = 10K → 8,5kW/K is min requirement for your tank. Now we have to translate this into the specs of the tank.
→ 8,5 * ((80+60)/2-20) = 425kW
Concluding:
If you have a Heat Pump that can deliver 85kW with a ΔT=10K and you want to use this 85kW to heat up your SHW Tank, your SHW Tank should have specifications of 425kW @ (80-60) @ 20°C.
In case the spec is lower, the Heat Pump will not be able to transfer the full 85kW to the SHW Tank.
Considering the rule of thumb, you would need a SHW Tank heat exchanger surface of at least 85kW * $0{,}1m^2/kW = 8{,}5m^2$.

<u>Example from literature:</u>

Storage Tank Type	Article No	Material Group	Ø D (mm)	Height (mm)	Weight kg	Inclination Height mm	Heating Surface top/buttom m2
AH 300/1	7772310	60	700	1294	139	1393	3.2
AH 400/1	7772410	60	700	1591	170	1672	5.0
AH 500/1	7772510	60	700	1921	222	1990	6.2
AH 750/1	7782200	60	990	2050	263	1972 (2173)	7.0
AH 1000/1	7782900	60	1090	2083	335	2010 (2226)	9.2

Performance Table		300/1	300/2	400/1	400/2	500/1	500/2	750/1	750/2	1000/1	1000/2
Water volume - upper coil	litres	-	20.4	-	27.2	-	36.3	-	39.6	-	42.7
Water volume - lower coil	litres	24	9.1	35	11.3	45	13.6	49	15.6	64	21.5
Max pressure coil	bar	16	16	16	16	16	16	16	16	16	16
Max temperature coil	°C	110	110	110	110	110	110	110	110	110	110
Heating capacity - upper coil	kW	-	46	-	64	-	88	-	110	-	132
Continuous flow ΔT 35°C	l/h	-	1319	-	1835	-	2323	-	3153	-	3784
Performance ΔT 35°C	l/10min	-	671	-	907	-	1172	-	1653	-	2134
Performance ΔT 35°C	l/1st hour	-	1705	-	2349	-	3166	-	4119	-	5071
Heating time ΔT 35°C	min	-	16	-	15	-	14	-	17	-	19
Heating capacity - lower coil	kW	68	33	106	40	131	46	152	60	203	82
Continuous flow ΔT 35°C	l/h	1949	946	3039	1147	3755	1319	4557	1720	5819	2351
Performance ΔT 35°C	l/10min	776	609	1108	792	1377	971	1853	1414	2473	1895
Performance ΔT 35°C	l/1st hour	2335	1332	3553	1661	4399	1962	5323	2685	7106	3638
Heating time ΔT 35°C	min	11	22	9	25	9	27	12	31	12	30

Calculation with T = 10°C Cold Water, Hot Water T = 45°C, storage tank T = 60°C, heating ΔT 80 /60°C

Consider the 1000l tank. Stated coil surface is about 9,2m².
By rule of thumb we know this tank can cope with input Heat Pump capacity of about: 9,2m²/0,1m²/kW = 92kW.
Based on the data 203kW is mentioned. Let us see what the detailed information is saying and whether a conclusion can be made.

Keeping in mind:
SHW Tank heat exchanger capacity per K ≥ (Capacity connected to the tank)/($(T_{in}+T_{out})/2$ - T_{tank})

> $T_{tank\ storage}$ = 60°C
> $T_{hot\ water}$ = 45°C
→ Since it is not clear which data is used, we assume tank temperature to be lowest of these 2. This means the Capacity/K will be lower, but safer for calculation.
> T_{in} = 80°C
> T_{out} = 60°C
> 203 kW / ((80+60)/2 K – 45 K) = 8,12 kW/K
➔ It means 8,12 kW/K * 10 K = 81 kW can be supplied to inlet/outlet
This is in line with the rule of thumb we firstly checked. Although, it is lower. This is due to our safe assumption.

In case we would assume the tank temperature to be effectively 60°C, we can assume 20kW/K; which largely overshoots the rule of thumb and would indicate we can connect easily 200kW to this SHW Tank. This is quite unlikely.

In case we would assume the tank temperature is between 60 and 45°C, we can assume 11,6kW/K. This lies very closely to the value of the rule of thumb.

<u>Other example</u>
Specifications of Supplier:

Cylinder capacity:								
Total available capacity	l	93	123	161	191	216	246	292
Heat exchanger power (80-60 °C / 10-40 °C)	kW	31.9	31.9	31.9	31.9	39.4	39.4	39.4
Heat exchanger surface	m²	0.657	0.657	0.657	0.657	0.845	0.845	0.845

We take 300l tank.

1) Data based: 39,4 kW / ((80+60)/2 K – (40+10)/2 K) = 0,876kW/K
→ So if our Heat Pump is providing with ΔT=10K → 8,76kW we can connect to this coil. Our maximum Heat Pump capacity output should be not more than 8,76kW

2) Based on rule of thumb (reverse use): 0,845m² / 0,1 m²/kW = 8,45kW

Again Tank temperature is unclear. We used the average between indicated 10-40 condition.

Other example

Specification of Supplier:

Technical specifications	Duo HLS-E							
	120	150	200	300	400	500	750	1000
Heating surface area of the coil [m²]	0.57	0.66	0.91	1.32	1.59	1.59	2.25	2.25
Rated power output 85/65 °C coil [kW]	16.9	20.5	30.1	45.7	52.9	52.9	76.1	76.1
Rated power output 90/70 °C coil [kW]	21.2	25.7	37.3	56.3	65.4	65.4	93.9	93.9

* Hot leg temperature: 85 °C. Heating water throughput as per rated output 85/65 °C. Cold water temperature: 10 °C.
n/a = not applicable.

We take 1000l tank.

1) Data based: 76,1 kW / ((85+65)/2 K – (65+10)/2 K) = 2,09 kW/K
→ So if our Heat Pump is providing with ΔT=10K → 20,0kW we can connect to this coil. Our maximum Heat Pump capacity output should be not more than 20,9kW

1”) Data based: 93,9 kW / ((90+70)/2 K – (70+10)/2 K) = 2,34 kW/K

2) Based on rule of thumb (reverse use): 2,25m² / 0,1 m²/kW = 22,5kW
→ Or if we would like to release 22,5kW to that coil we need minimum surface of 22,5kW / 0,1kW/m² = 2,25m²
Both approached lead to almost same conclusion. Specific data is more accurate. Rule of Thumb is on safe side.

Assumption here is as done before: assume the tank temperature between 10°C and the maximum tank temperature, assumed as high as the return water temperature from the coil connection.

<u>Other example</u>

Specification of Supplier:

Performance Data			
Feature		**Unit of Measure**	**Series Y 500**
Continuous withdrawal of hot domestic water 15°C - 45°C			
Water heater power	Input temperature 80°C	kW	101
Withdrawal of hot domestic water		l/h	2892
Flow of primary circuit		m3/h	3.8
Water heater power	Input temperature 70°C	kW	91
Withdrawal of hot domestic water		l/h	2615
Flow of primary circuit		m3/h	3.3
Water heater power	Input temperature 60°C	kW	54.5
Withdrawal of hot domestic water		l/h	1560
Flow of primary circuit		m3/h	4.0
Water heater power	Input temperature 50°C	kW	37
Withdrawal of hot domestic water		l/h	1063
Flow of primary circuit		m3/h	4.2
Pressure loss			
Coil		m²	5.7

500l Tank

1”) Data based: 101kW / ((80+60)/2 K – (60+45)/2 K) = 5,77 kW/K →→ 58kW

2) Based on rule of thumb (reverse use): 5,7m² / 0,1 m²/kW = 57kW

This is assuming regular regime 80/60 and tank temperature average of 60/45

B.5.3 Using several VRV HT Hydroboxes to supply a big SHW Tank Hydraulic schemes

See before

B.5.4 Using several VRV HT Hydroboxes to supply a big SHW Tank Controls

In order to use HXHD200 solely to produce SHW, we have foreseen some additional operation patterns next to the regular one explained in the beginning of this document.

The patterns explained here have the advantage there is no need to use a 3way valve at any time (since it is considered, the units will not be used for space heating) and special control is available which can be used depending on several field situations.
The units, depending on the pattern, will use its own sensors on determining the situation of the SHW Tank which is connected or will use a thermistor to know the situation of the SHW Tank.

Daikin tanks are equipped with the correct 3way valve and the correct thermistor to control normal SHW making and switch over from Space Heating to Sanitary Hot Water making.
Since this this thermistor is not the existing on a 3rd party SHW Tank, we will provide the part N° (available through service network as a spare part) of the Daikin thermistor in case required: 125002145. When control is wanted based upon feedback of a Tank thermistor, it is advised to use this part.

!Heads Up!

- Avoid connecting 3rd party sensors or thermistors, their resistance characteristic is different and will provide bad feedback resulting in unwanted operation.
- These Patterns and settings are NOT available for HXHD125, they are **only available for HXHD200**.

We will discuss Patterns: A, B, C and D. An overview of functionality you can find below.

		Pattern "A"	Pattern "B"	Pattern "C"	Pattern "D"
System Specifics	DHW Tank type	Daikin	3rd Party	3rd Party	3rd Party
	DHW judge parameter: Thermistor	Daikin Tank thermistor	Daikin Tank thermistor	External input (switch) Controlled by 3rd party control	None
	Daikin Part Number	125002145	125002145	-	-
System Control	Required Field Settings	[5-04] = 1 [7-01] = 1 [6-00] = 1	[5-04] = 1 [7-01] = 1 [6-00] = 1	[5-04] = 1 [7-01] = 1 [6-01] = 1	None
	Control Method	**Floating Leaving Water Temperature Control** The Hydro unit will decide the target Leaving Water Temperture from the Daikin Tank thermistor information. The target Storage/Reheat temperatures are obtained from the field settings of the hydro module.		**Fixed Leaving Water Temperature Control** You can select the required water temperature the unit will provide to the heat exchanger of the 3rd Party DHW Tank heat exchanger coil by selecting on the remote controller of the hydro module.	
	Availabe functions on remote controller	**DHW related features** • Scheduled Storage • Manual Storage • Reheat operation • Legionella function		**Space heating functions to use for DHW** • ON/OFF • LWT setpoint selection • Scheduled LWT	
	Remark1	*Hydro module operates with fixed pump rpm (about 4000rpm)*			
	Remark2	*Normal space heating functions are not available for use*		*Differential of the LWT control is selectable by field settings* ***Thermo ON:*** *RWT < LWT$_{set}$ - [A-02]* *[A-02] = (3~15°C); default = 10°C* ***Thermo OFF:*** *LWT > LWT$_{set}$ + [F-00]* *[F-00] = (3~15°C); default = 5°C*	

The activation of the special SHW Only operation modes is done by changing field setting. These field settings need to be applied when you want to operate your HXHD200 heat pump to make SHW by operation pattern A, B, C or D.

> [5-04] = 0 → **1**
> [7-01] = 0 → **1**

Depending on the Pattern chosen, additional settings apply. They are each time indicated in explanation below and the overview above.

Pattern A
Same as for normal SHW making as explained in beginning of this document.
SHW Tank thermistor feedback to the heat pump system is existing.

Assumption: use with Daikin SHW Tank

Difference to normal SHW as explained in the beginning of this document:

- Not possible to operate Space Heating functions.
- All SHW functions as explained before are possible

Additional setting required: **YES**

- [6-00] = 0 → 1
- [6-01] = 0

Additional Equipment required: **NO**

Pump operation of the VRV HT Hydrobox: fixed to maximum rpm.

Pattern A is assumed not to be used, since 3rd party SHW Tanks are considered for commercial applications not Daikin Tanks (= smaller capacity and SHW Tank heat exchanger surface).

The next patterns: B, C and D are considered interesting for use in commercial applications.

Pattern B
Same as for normal SHW making as explained in beginning of this document.
SHW Tank thermistor feedback to the heat pump system is existing.

Assumption: SHW only usage with a 3rd party SHW Tank.

Difference to normal SHW as explained in the beginning of this document:

- Not possible to operate Space Heating functions at all.
- Possibility to change feed water temperature target of the unit depending on 3rd Party SHW Tank needs.
  [F-03] field setting = 10°C (default value: eg. used in case of Daikin SHW Tank).
  (can be varied between 5~25°C)
  This setting sets the temperature of the water which send to the tank as function of the SHW Tank temperature: $LWT_{set} = T_{tank} + [F\text{-}03]$

The lower the value of [F-03], the better for the performance of the heat pump system (since the water temperature is lower). This also implies that the driving force (ΔT between T_{tank} and Water temperature going through the SHW Tank heat exchanger) is smaller and it will take more time to heat up the tank. In case of small know SHW Tank heat exchanger surface, this might lead to capacity problems when the driving ΔT becomes too small!

> All SHW functions as explained before are possible

Additional setting required: **YES**

> [6-00] = 0 → 1
> [6-01] = 0

Additional Equipment required: **NO** (except for Daikin Tank Thermistor)

Pump operation of the VRV HT Hydrobox: fixed to maximum rpm.

Pattern C

This patterns is particular and has no specific reference to the original controls existing for SHW operation. This pattern makes it possible to have operation of SHW based on the availability of an external input signal. When the external input is present, the unit will operate and maintain the target leaving water temperature (LWT_{set}). The leaving water temperature is the feed water going to the hydraulic balance bottle.
There is no feedback from a SHW Tank thermistor in this pattern, so the decision for a Thermo OFF/ON condition has to be made by the unit.
The leaving water temperature setpoint (LWT_{set}) is set on the remote controller directly (same as setting LWT on remocon during normal space heating operation under leaving water control). Of course this setting value should be higher than the required SHW Tank temperature. The LWT_{set} also depends on the 3rd party SHW Tank heat exchanger characteristics (see before).
When you selected the LWT_{set}, the unit will operate to achieve and maintain it. When the external input is not present, the VRV HT Hydrobox unit will not operate.

In case the unit is operating (external input is present) and the LWT_{set} is reached and surpassed with a certain value, the unit will go into Thermo OFF situation (cf this also happens in normal space heating leaving water control). When the system is in Thermo OFF and the water temperature sensor of the unit is sensing a water temperature that is below LWT_{set} – (certain value), the unit will restart operation (Thermo ON is decided).

There is no setting required of any SHW parameters as mentioned in the Installation and Operation manual. Since these settings only apply for typical normal SHW operation. The pattern C does not follow normal SHW operation.

Functions available:

- Remocon ON/OFF for Unit ON/OFF instruction
- LWT_{set} on remote controller (fixed)
- LWT_{set} Schedule timer

Assumption: SHW only usage with a 3rd party SHW Tank.

Additional setting required: **YES**

- [6-00] = 0
- [6-01] = 0 → 1

Additional Equipment required: **YES**

- PCB EKRP1AHTA: The external input is expected on the contacts 1)-5)
  (This PCB and input is expected on every HXHD200!)

Pump operation of the VRV HT Hydrobox: fixed to maximum rpm.

Decision parameters Thermo ON/OFF:

> Thermo OFF: LWT > LWT_{set} + [F-00]
([F-00] = 5°C is default value; range is from 3~15°C)
LWT > 85°C is limit stop anyhow.

> Thermo ON: RWT < LWT_{set} – [A-02]
([A-02] = 10°C is default value; range is from 3~15°C)

Pattern D

This patterns is particular and has no specific reference to the original controls existing for SHW operation. The patterns makes it possible to have operation of SHW based on solely the use of the heat pump system's water temperature sensors. There is no external input from a mother system (such as BMS) possible. As such, this operation is a downgrade version of pattern C (same operation but no external instruction).

Functions available:

> Remocon ON/OFF for Unit ON/OFF instruction
> LWT_{set} on remote controller (fixed)
> LWT_{set} Schedule timer

Assumption: SHW only usage with a 3rd party SHW Tank.

Additional setting required: **NO**

> [6-00] = 0
> [6-01] = 0

Additional Equipment required: **NO**

> None, since no external input is expected

Pump operation of the VRV HT Hydrobox: fixed to maximum rpm.

Decision parameters Thermo ON/OFF:

> Thermo OFF: LWT > LWT_{set} + [F-00]
([F-00] = 5°C is default value; range is from 3~15°C)
LWT > 85°C is limit stop anyhow.

> Thermo ON: LWT < LWT_{set} – [A-02]
([A-02] = 10°C is default value; range is from 3~15°C)

Conclusion on Pattern A, B, C and D

Pattern B is the most interesting and flexible one from features point of view.
In this case normal SHW functions remain available (storage operation, reheat operation, legionella operation, etc.).

Pattern C and D cannot use these features since there is no feedback from the system (apart from operation status in pattern C: external input).