Ring-main water heating systems

Grant Bourke

IMPORTANT

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If you find any apparent error or omission, please email Rinnai: info@rinnai.co.nz

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Please note that the sketches in this document illustrate concepts. They are not complete hydraulic specifications. Good trade practice will ensure all major components are fitted with isolation valves and unions to allow for removal, maintenance and replacement; as far as possible without draining the system. Installations must incorporate all building code requirements including pressure and temperature relief, seismic restraint, safe trays, etc.

While the information in this booklet may be applicable to other brands of water heaters, please check with your water heater supplier. Rinnai accepts no responsibility for issues arising with water heaters of other manufacturers installed in accordance with this guide.

To make this a practical guide for New Zealand plumbers, some brands and models of components are illustrated and discussed. These are known to be readily available and well-supported in the New Zealand market at time of publication. There will be many other products available that are entirely suitable for the plumbing systems described. This guide should not be read as an endorsement of any brand over another. At time of publication there are no commercial arrangements between Rinnai and any other brand mentioned for promotion of their products. Some brands illustrated compete with Rinnai in other product categories.

All components need to be certified for use in potable water heating systems. This usually means Watermarked or AS4020 certified, but other standards are listed in G12/AS1 and AS/NZS3500.

Ring main system components share many functions with hydronic heating systems. Care should be taken to ensure the model of component used is suitable for potable water. Suppliers often have similar looking components for domestic hot water and heating.

The heating system component versions without potable certification are often cheaper but not suitable to use in potable water systems.

Contents

List of Figures 4
Abbreviations 4
Definitions 4
Symbols 5
Introduction 6
Ring Main Types 7
High temperature ring-main 8
Low temperature ring-main 10
Pipe sizing 12
General pipe layout 13
Pressure relief 15
Multiple loop ring-main systems 20
Circulating pumps 22
UV sterilisers 26
Energy efficiency 29
Ring-mains with different Rinnai water heater technologies 32
- Ring-main re-heating cylinders 33
- Electric (resistance element) or gas storage 34
- Electric heat pump water heaters 37
- Gas continuous flow 40
- Rinnai INFINITY® NB56 gas continuous flow 42
- Solar and Wetback 45

List of Figures

Figure 1: Mixing valve set in recessed hatch 8

Figure 2: Small high-temperature ring-main system 9

Figure 3: Small low-temperature ring-main system 11

Figure 4: Air bleeding from ring-main system 14

Figure 5: Expansion vessel installation 19

Figure 6:Thermal balancing of multiple loop ring-main system 20

Figure 7: Caleffi 116 themostatic flow regulating valve 20

Figure 8: Flow balancing of multiple loop ring-main system........ 21

Figure 9: Stad balancing valve with Pete’s plugs and Caleffi balancing valve with flow meter ... 21

Figure 10: Grundfos single-stage circulators: left-to-right: bodies in stainless steel, bronze and cast iron: easily identifiable by the escutcheon colour 22

Figure 11: UVGuard ARM1 amalgam lamp model........ 27

Figure 12: UVS system components 28

Figure 13: DHW plant insulation of the highest standard 29

Figure 14: Grundfos Comfort T, Comfort TDT, Comfort TA pumps........ 30

Figure 15: Rinnai heat pump water heater range 32

Figure 16: Rinnai 30 & 57 litre electric cylinders often used as ring-main re-heaters 33

Figure 17: part of the Rinnai indoor-outdoor electric water heater range 34

Figure 18: Storage water heater with high temperature ring-main 35

Figure 19: Storage water heater with low temperature ring-main........ 36

Figure 20: Heat pump with high temperature ring main 38

Figure 21: Heat pump with low temperature ring main 39

Figure 22: Wetback or solar cylinder with high temperature ring-main 46

Figure 23: Wetback or solar cylinder with low temperature ring-main 47

Abbreviations

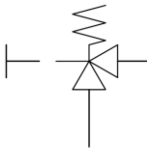
DCW	Domestic cold water supply
DHWF	Domestic hot water flow (supply)
DHWR	Domestic hot water return
UVS	Ultraviolet sterilizer, suitable and sized for hot water duty

Definitions

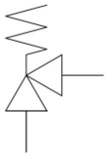
Sanitary fixture for personal hygiene	showers, baths, hand-basins and bidets

Symbols

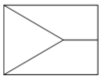
Symbols of system sketches are generally those used by the AS/NZS 3500 series of standards



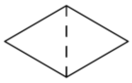
Temperature and pressure relief valve (TPR)



Pressure relief valve / Expansion control valve (ECV)



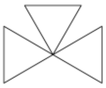
Pressure reducing valve (PRV)



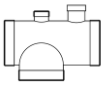
Strainer

Isolation valve

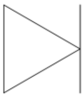
Swivel



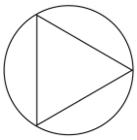
Mixing Valve



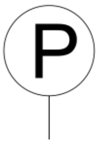
Jrgumat 4 port mixing valve



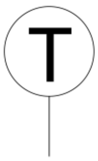
Non return valve



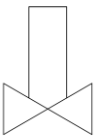
Pump (direction of flow indicated)



Pressure gauge



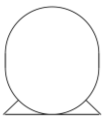
Temperature gauge



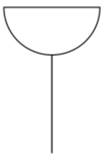
Thermal balancing valve

Flow/pressure balancing valve

Automatic air release valve (AAV)



Expansion vessel



Pete’s plug

Introduction

One of the common questions consumers ask is "how can I reduce the delay for hot water at a tap?"

Well-designed and installed ring-main systems can provide near-instant hot water at fixtures.

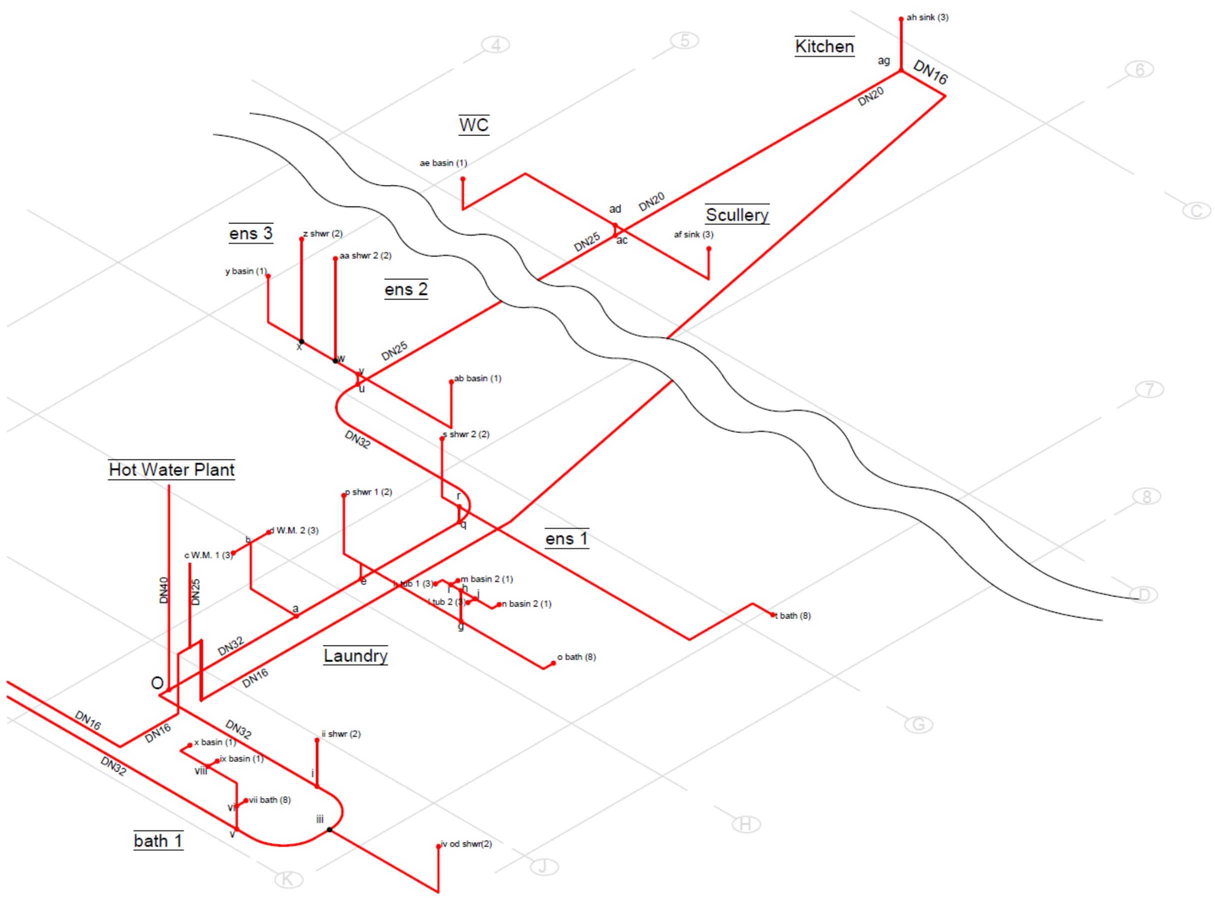
At the simplest level, a ring-main is a standard hot water plumbing system with the addition of small diameter return pipe from the furthest fixture and a small circulating pump returning water to the hot water plant. There are hidden complexities, however.

Plumbers often ask the best way to install Rinnai water heaters in these systems.

This guide has been prepared to answer the questions we receive most often. It also addresses the issues we see when called to systems with problems.

The focus of this document is stand-alone residential homes and smaller commercial premises. Obtain further advice for larger and multi-unit projects.

General requirements for high temperature ring-main systems are contained in Section 10 of AS/NZS 3500.4. Many of these principles can also be applied to low temperature ring-main systems.



Ring Main Types

Ring mains can be broadly divided into two types:

High temperature where mixing valves are installed on branch take-offs to lower water temperature.

Low temperature where a mixing valve reduces the temperature of the whole ring-main and the branch take-offs do not have mixing valves installed. The ring-main circulation temperature is below that at which legionella bacteria will be killed and so an ultraviolet sterilizer is installed on the ring main re-circulation leg.

There are many possible combinations of the above, including but not limited to:

Multiple-loop ring main systems

Low temperature ring-main with high temperature dead-leg from hot water plant to an adjacent kitchen.

Separate high and low temperature ring mains from the same hot water plant.

Low temperature ring-main with a local temperature boost for non-personal hygiene fixtures (e.g. under-bench electric cylinder supply kitchen fixtures)

High temperature where a mixing valve reduces the whole ring main below the hot water plant temperature but above the legionella sterilizing level. Further mixing valves are installed at off-takes for personal hygiene.

Low temperature ring-mains with mixing valves installed at branch off-takes for vulnerable persons (see G12/AS1 6.14.1a)

In most small residential and small commercial premises, high temperature ring mains with mixing valves at branch off-takes are the best solution.

When the number of sanitary fixtures for personal hygiene become large, low temperature ring mains are often lower cost and easier to maintain.

This publication covers both these main types.

High temperature ring-main

A high temperature ring-main is defined as one circulating water at a temperature that will require reducing before connection to sanitary fixtures for personal hygiene. **Error! Reference source not found.** illustrates a typical small high temperature ring main system.

Table 8A or 8B of G12/AS1 Amendment 13 lists the standards for mixing valve compliance. Check with your valve supplier to ensure the mixing valves you intend to use are suitable for this application.

Where practical, mixing valves can be sized to serve adjacent groups of fixtures. This reduces the number of connections to the ring main and hence pressure loss around the loop.

Mixing valves must have non-return valves on both the hot and cold connections. Over time these non-returns may pick up debris and no longer fully close. This can cause cross-connection and result in reduced hot water and increased cold water temperatures.

For this reason, it is imperative that the valves can be accessed. To allow maintenance and replacement, isolation valves and swivels should be installed at all mixing valves.

Discuss with your customer proposed locations for the valve sets. Where attic or underfloor locations are not practical, consider ceilings behind bathroom and WC doors, rear of adjacent closets, under kitchen benches etc.

Some valve suppliers provide kits with right angle connections, shut-off valves and access hatches such as shown in **Error! Reference source not found.**.

Figure 1: Mixing valve set in recessed hatch

It is permissible to deliver high temperature water to sanitary fixtures not for personal hygiene such as kitchen, scullery and laundry sinks. Discuss with your customer what temperature they would like at these fixtures. Where the hot water plant is set to a high temperature it is recommended to install a mixing valve at these outlets. Where the set temperature of the hot water plant is easily adjustable by the consumer, discuss with them the scalding hazard from non-temperature-limited fixtures.

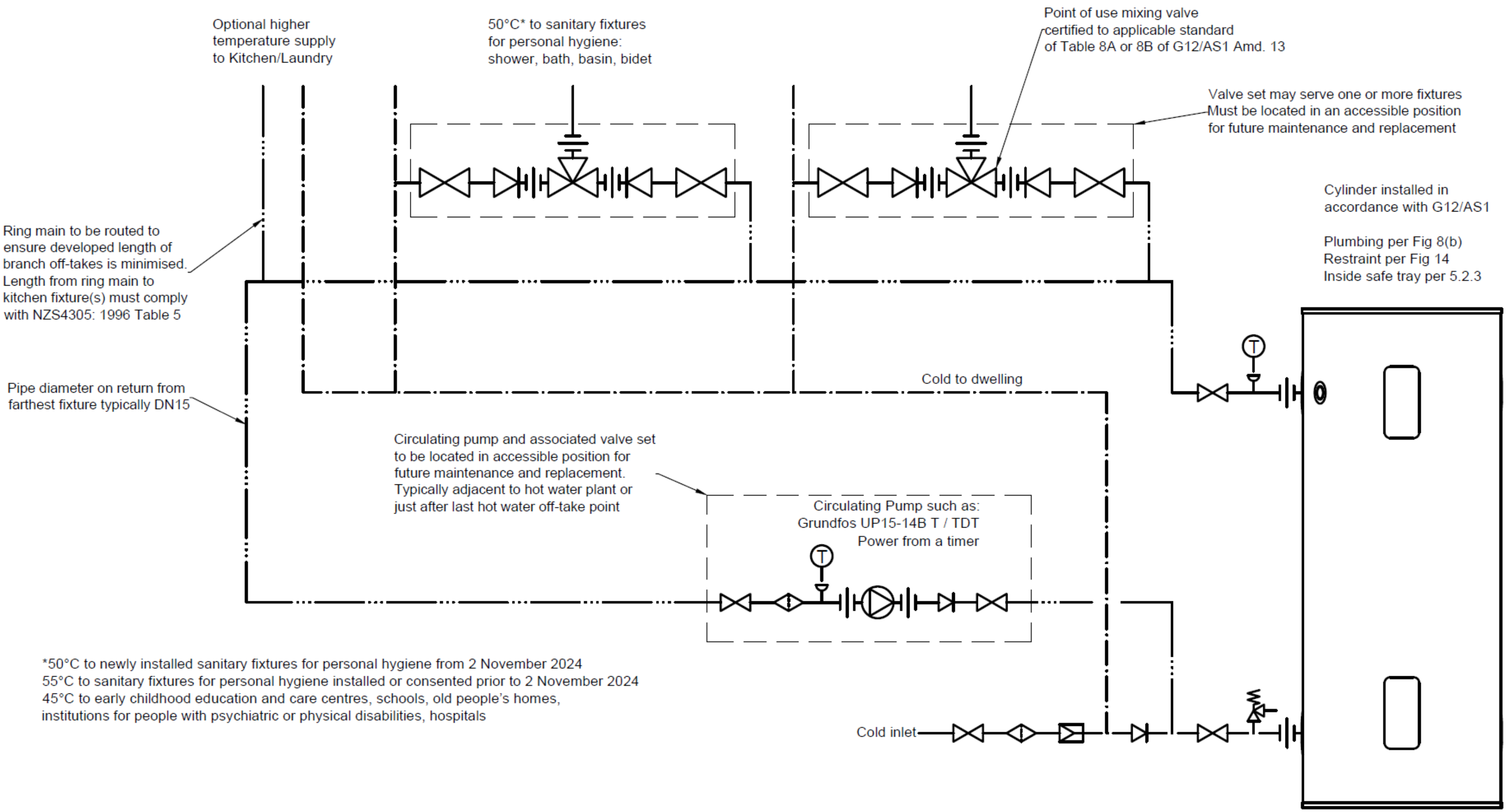


Figure 2: Small high-temperature ring-main system

Low temperature ring-main

A low temperature ring-main is defined as one circulating water at temperatures suitable for use in sanitary fixtures for personal hygiene generally (but not always) without further temperature reduction. **Error! Reference source not found.** illustrates a small low temperature ring-main system.

The mixing valve controlling the system should be adjusted so that the temperature at the closest sanitary fixture for personal hygiene does not exceed:

55°C for fixtures installed or consented prior to 2 November 2024

50°C for fixtures installed or consented on or after 2 November 2024

45°C for fixtures installed at early childhood education and care centres, schools, old people's homes and institutions for people with psychiatric or physical disabilities. (ref: G12/AS1 6.14.1a)

Legionella bacteria will either slowly multiply or be disinfected only very slowly at the water temperature in these systems. To protect against this, recirculated water is usually disinfected by a UV sterilizer. (please refer to the UV sterilizer section of this manual)

To allow water to circulate in these systems when there is no hot water draw, the domestic hot water return line splits in two. One leg returns to the hot water plant. The other leg recirculates water around the ring-main joining with the cold supply to the mixing valve (or to the dedicated 4th port of Jrgutherm valves). Ring-main heat losses are made up as small amounts of hot water enter the mixing valve from the hot water plant.

Rinnai have encountered many systems where the return is not split and the ring-main recirculation leg to the mixing valve is omitted. This can stop water circulation and damage both the mixing valve and pump.

It is important that cold the cold connection to the ring-main mixing valve is "virgin" cold water protected by a non-return valve. Water expanded from the storage cylinder should not be able to enter the cold connection to the mixing valve. This may affect the ability of the mixing valve to control the temperature correctly, resulting in temperature fluctuations at fixtures.

Consult the mixing valve manufacturer's instructions to ensure the valve selected is suitable for ring main applications.

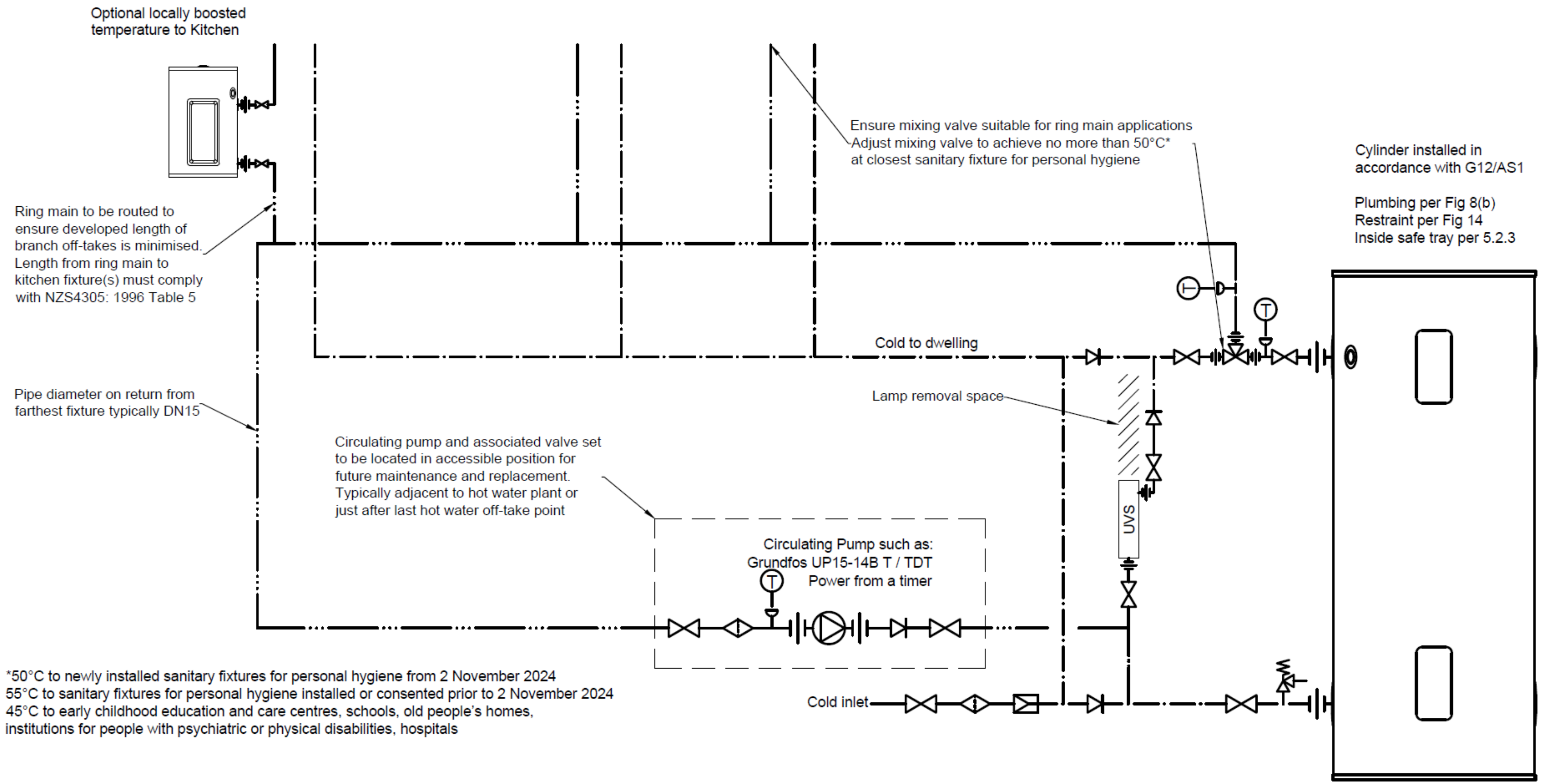


Figure 3: Small low-temperature ring-main system

Pipe sizing

Sizing pipe for ring main systems is like other potable water applications. Size for pressure and flow using usual methods such as outlined in AS/NZS 3500.1:2021 Appendix D.

There is an additional step to ensure the pipe velocity requirements of AS/NZS3500.4 are met. This is to prevent pipe erosion from constantly circulating water.

Velocity in return pipes should be less than 1 m/s.

Velocity in supply pipes of the ring-main loop should be less than 1.2 m/s for copper, or 2.0 m/s for other materials.

Table 1 converts these velocity limits to maximum flow rates for common pipe bores used in small ring main systems in New Zealand

When sizing supply pipes add the ring main flow rate (see circulating pump sizing section) to the probable simultaneous flow rate (PSFR) for each pipe section of the ring main.

Table 1: AS3500.4 ring main flow rate limits

Actual pipe bore mm	**Flow rate l/min @**		
	1.0 m/s (return lines)	1.2 m/s (copper)	2.0 m/s (other materials)
10	4.7	5.7	9.4
12.7	7.6	9.1	15.2
15	10.6	12.7	21.2
19	17.0	20.4	34.0
25.4	30.4	36.5	60.8
31.8	47.6	57.2	95.3

General pipe layout

The ring main should pass as close as practicable to each fixture. The branch off-take to the kitchen sink must be within the limits shown in Table 5 of NZS4350. Having gone to the expense of fitting a ring main, the client is unlikely to be satisfied with the water delay resulting from the limits shown in that table. Branch off-takes to sinks and other fixtures should be as short as possible.

Pipe branches

Minimise the number of branch-off-takes from the ring main to reduce circulation pressure loss. This is particularly important for some PEX piping systems where T-fittings reduce the bore considerably and have significant resistance to flow.

Ring-main non-return

Fit a non-return after the circulating pump to prevent water short-circuiting to fixtures via the ring main return. Ensure the non-return selected does not require a head to open more than what the circulating pump can provide. A horizontally oriented swing-check valve may be required for small circulating pumps. Avoid spring-type check valves that may have large spring forces acting against them.

Temperature Gauges

Water temperature gauges are useful on the DHW flow and return lines. These allow quick verification that the 5°C maximum heat loss has not been exceeded. (Ideally heat loss should be closer to 2°C.)

In small single-dwelling residential systems, permanent temperature and pressure gauges are not likely to be regularly referenced. Pete's plugs are useful for commissioning systems with small diameter piping as they allow the temperature probe to be in the flow stream without interrupting flow. Ensure the Pete's plug model selected is suitable for potable water (stainless steel or lead-free brass).

In larger systems, where permanently fixed temperature gauges are fitted, they should be installed in pockets (thermowell) that ensure the sensing element is in the water flow stream.

> Rinnai see many temperature gauges fitted to small branches with sense elements some distance from the water flow stream. These do not give useful readings of the temperature in the flowing water.

Pete's plugs are available from a number of distributors. Measurement kits with two temperature and one pressure gauge are available from distributors or online.

Teltherm instruments and Homershams usually stock suitable analogue temperature gauges and thermowell pockets.

Air-release

Depending on pipe layout, small systems may sometimes work without automatic air release valves. Some thought should be given when laying out the system as to how air will be bled from the pipes. A drain (to a gully) between the circulating pump and DHWR check-valve is often a good way to both bleed air from the system and quickly fill the system with hot water after commissioning or maintenance.

In systems with longer ring-main pipes over multiple levels, automatic air release valves may be required at high points of the system.

Single stage circulators are commonly equipped with a manual air bleed valve in the centre of the motor housing for use when commissioning.

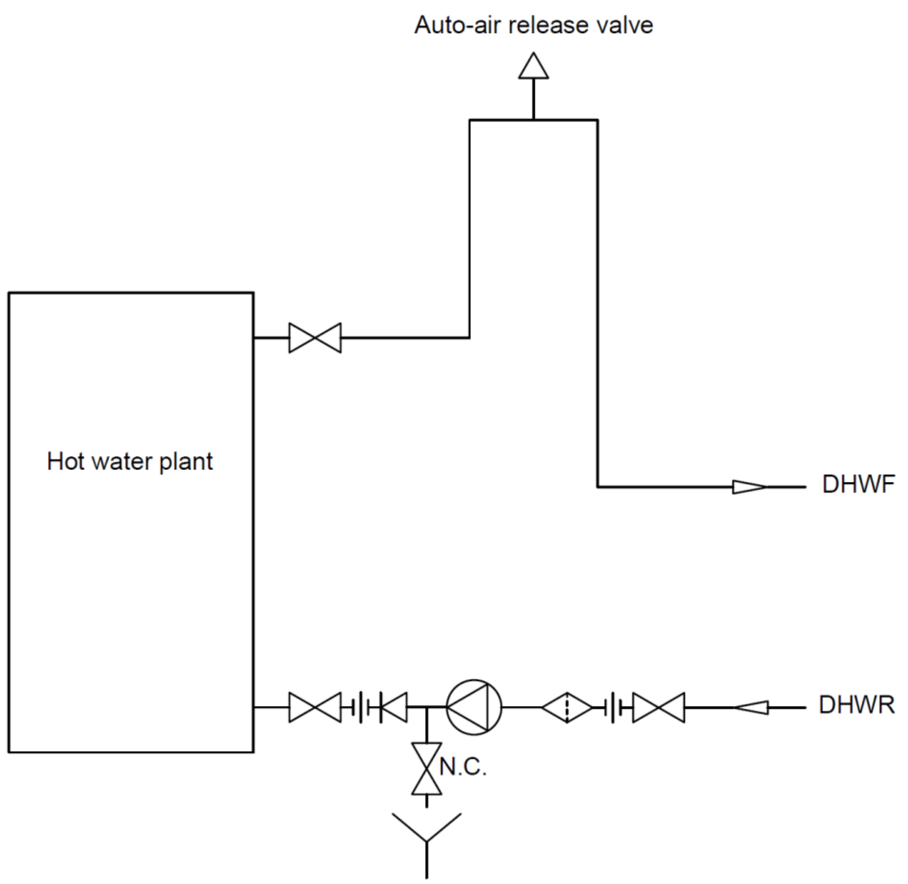


Figure 4: Air bleeding from ring-main system

Like all other components, automatic air release valves should be suitable for potable water.

Pressure relief

When ring-mains are heated from hot to cold the volume of water within them will expand as on any other occasion. The ring-main needs to include over-pressure protection.

This can be provided by:

1. Pressure relief valve (expansion control valve)
2. Pressure relief valve in conjunction with an expansion vessel.
3. Expansion vessel; alone where there is secondary pressure relief available.

Expansion vessels are not required in potable systems. Where water and energy costs are modest, they are unlikely to offer a payback. The eventual failure of an expansion vessel may not be noticed by the occupants. In a hydronic heating system, they are used to prevent water exiting the system carrying with it treatment chemicals preventing corrosion. That is not the case with a potable water system. Some customers and territorial authorities encourage them as energy saving measures.

Pressure relief valve

In most systems incorporating a storage tank, pressure relief can be provided by the expansion control valve servicing the cylinder. Check to ensure no parts of the system that include heating are isolated from the ECV by non-return valves.

Ensure the pressure relief capacity marked on the ECV exceeds all energy inputs to the water heating system.

Where an electric ring-main re-heating cylinder is used, check that the ECV on the main storage water tank has sufficient thermal relief capacity for all the system energy inputs.

Expansion vessel with TPR

Expansion vessels can be used without ECVs provided they are not isolated from the storage system TPR valve by non-return valves. This allows the TPR to operate as a back-up when the expansion vessel fails.

Sizing Expansion Vessels

The expansion vessel needs to be sized to accommodate the volume of water expanded in the hot water plant plus the flow and return piping.

AS/NZS 3500.4: 2021 Appendix P provides a step-by-step method for sizing expansion vessels. G12/AS1 Section 6.6.8 provides a simplified version of this. Many expansion vessel suppliers will also provide sizing tables.

Rinnai have translated Appendix P on worksheet 2 of an excel spreadsheet available at this link or from the QR code below. When the spreadsheet opens from the link, click >File>Create a copy > Download a copy to save on your own system.

The spreadsheet is based on NZS3501 copper pipe bore sizes.

Enter the lengths of the various diameters of pipe in the flow and return system in metres. Do not include branch lengths. The spreadsheet will calculate and display the pipe volumes.

Next, enter the volumes of storage tanks, boilers, plant room pipes etc in litres.

With reference to the table on the right of the spreadsheet, enter the expansion factor; based usually on mid-winter cold water and system set temperature.

Finally enter the pressure reducing valve setting at P_{low} and the expansion control valve setting.

In this example we have entered pipe lengths for a modest residential system, a 270 litre storage vessel with a Rinnai INFINITY® connected and an expansion factor for 10°C mid-winter incoming water with a system heating to 60°C.

An expansion vessel of 19 litres is required for this example.

NZS 3501 Pipe Lengths

DN	OD	Wall	Id	litres/m length	length (m)	volume		
15	14.73	1.02	12.69	0.12641	15	1.8962	litres	
20	21.08	1.02	19.04	0.28458	10	2.845795	litres	
25	27.43	1.02	25.39	0.50605	10	5.060519	litres	
32	34.19	1.22	31.75	0.79133	0	0	litres	
40	40.54	1.22	38.1	1.13951	0	0	litres	
50	53.24	1.22	50.8	2.02580	0	0	litres	
65	65.94	1.22	63.5	3.16532	0	0	litres	
80	79.04	1.42	76.2	4.55806	0	0	litres	
100	104.85	1.83	101.19	8.03794	0	0	litres	
Storage tanks volume						270	litres	
Infinity						2	litres	2 per boiler
Plant room pipes						20	litres	
Total System Volume litres						301.8025		
Water expansion factor						0.0168		enter from table above
Volume Expanded						5.07	litres	
Expansion Control Valve Setting						850		usually 0.85 * expansion control valve setting kPa OR the pressure at the plant room you want to stay under
Phigh						722.5	kPa	enter cold water pressure available at plant room
Plow						500	kPa	
Acceptance Factor						0.27		
Expansion Tank Volume						19	litres	

Water Expansion Factor

		Heated water °C									
		4	10	20	30	40	50	60	70	80	90
Cold water °C	4	0	0.0003	0.0018	0.0043	0.0078	0.0121	0.0171	0.0227	0.029	0.0356
	10		0	0.0015	0.0041	0.0075	0.0118	0.0168	0.0224	0.0287	0.0356
	20			0	0.0026	0.006	0.0103	0.0153	0.0209	0.0272	0.0340
	30				0	0.0035	0.0077	0.0127	0.0183	0.0245	0.0314
	40					0	0.0042	0.0092	0.0148	0.021	0.0278
	50						0	0.0049	0.0105	0.0167	0.0235
	60							0	0.0055	0.0117	0.0185
	70								0	0.0061	0.0129
	80									0	0.0067
	90										0

Rather than entering the actual ECV setting, you can enter a value to manipulate the cell below – p_{high}. This is the highest pressure you will get in see system.

If there is a large difference between p_{high} and p_{low}, this will manifest itself as the "morning splash factor". That is the pressure relieved by a tap when first opened after the system has fully heated without pressure being relieved by a fixture opening during the heating cycle.

In the example above there is potential for water at a bit over 700kPa to initially flow from a tap when opened reducing quickly to 500 kPa.

Altering the ECV setting to 700 kPa reduces p_{high} to 595 kPa and the splash-factor to a less noticeable 95 kPa. To achieve a lower splash-factor, an expansion chamber of nearly double the volume is required. The installed ECV remains the preferred pressure rating – the change here is just to manipulate p_{high} to the desired level by increasing the size of the expansion vessel.

21	Expansion Control Valve Setting	700	
22	Phigh	595	kPa
23	Plow	500	kPa
24			
25	Acceptance Factor	0.14	
26			
27	Expansion Tank Volume	37	litres

[Waiting Brown Bros for challenger tank permission]

Expansion vessel plumbing and pressurizing

Expansion vessels are usually placed at the cold inlet to the hot water plant storage.

On Rinnai Demand Duo type systems, expansion vessels must not be placed between boiler circuit pumps and the boilers. This will cause large numbers of "ghost" boiler starts as water exiting the expansion vessel when system pressure drops re-enters the system via the boilers.

A pressure gauge close to the expansion vessel connection point is very useful when commissioning even if only fitted temporarily. During commissioning, the connection to the expansion vessel must be isolated from the system and vented to atmosphere. This allows the internal bladder to be pressurized in its fully expanded position.

Operate the water heating system with one or more fixtures open and note the typical pressure observed. Pressurize the vessel to this operating pressure. Finally, open the connection between the vessel and the water heating system, bleed the air from the connection, and then isolate from atmosphere.

Heat the system from cold with fixtures off. The observed pressure should remain below the calculated p_{high}, and there should be no discharge from any ECV or TPR.

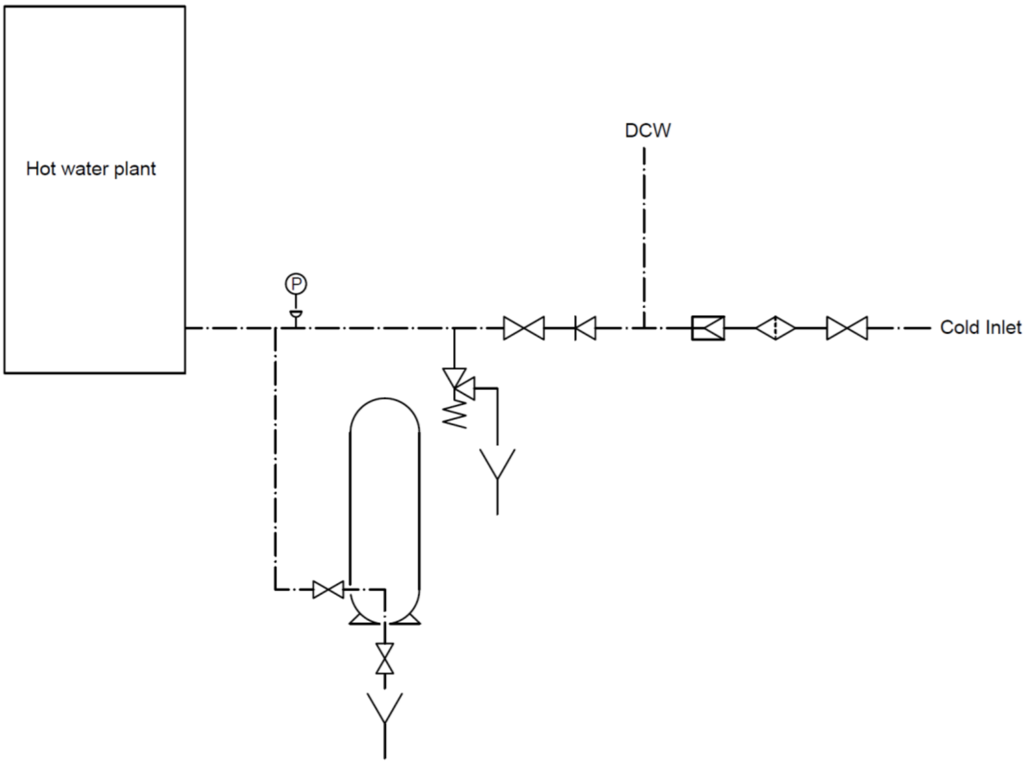


Figure 5: Expansion vessel installation

Multiple loop ring-main systems

Where the hot water plant is located central to two different areas requiring hot water circulation, using more than one ring main loop may be the tidiest and most economical solution.

A single circulating pump commonly serves multiple loops. Water will flow at a higher rate around shorter loops as there is less friction loss. To ensure hot water is available in all parts of the system, water flows around all loops need to be balanced.

There are two main ways of achieving this: temperature or flow regulation. Temperature regulation is preferred for small systems. Thermal regulating valves are more expensive but usually use smaller circulating pumps. Flow regulation may require calculations from an engineer to provide the balancing valve settings required.

<u>Temperature regulation</u>

In this method thermal balancing valves are installed on all but the longest ring-main return pipe.

Water will circulate through the shorter loops at a higher flow rate than the longest loop. As fully heated water reaches the thermal balancing valve at the end of the shortest loop, it will begin to close and reduce flow. This will progressively force water through the longer loops until the ring-main is fully heated.

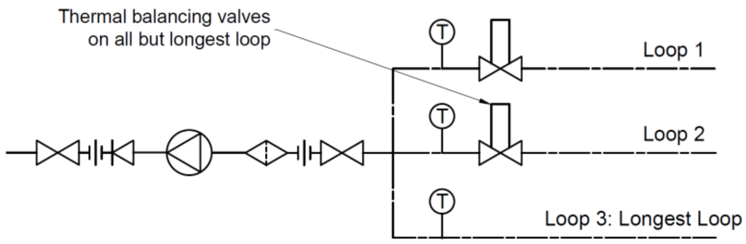


Figure 6:Thermal balancing of multiple loop ring-main system

The pump only needs to provide sufficient flow and head to circulate a little more water than is required for the longest loop. Single-stage circulators are usually sufficient for these applications.

Figure 7: Caleffi 116 themostatic flow regulating valve

Multi-speed pumps are usually incompatible with temperature regulated installations. Flow may reduce below their minimum permissible rate. This can cause overheating and early pump failure as well as noise from the thermal balancing valves.

Flow regulation

In this arrangement each return pipe is fitted with a flow restrictor. The valves on shorter loops are set to provide a greater pressure loss than those on longer loops. With all ring-main loops having equal pressure losses, flow in each loop will be equal.

The pump is then sized for a total flow of the number of return pipes x restricted flow value.

In buildings with large numbers of loops, a hydraulic engineer may need to calculate the valve settings.

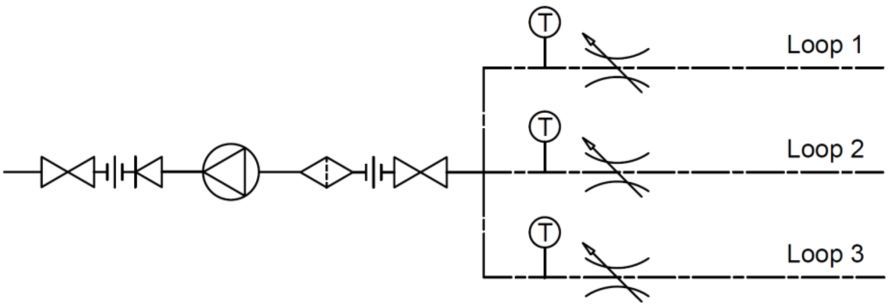


Figure 8: Flow balancing of multiple loop ring-main system

Figure 9: Stad balancing valve with Pete’s plugs and Caleffi balancing valve with flow meter

> **IMPORTANT:** The concepts and components of these thermal and pressure/flow balanced systems should not be mixed and matched. Small single stage circulator pumps are unlikely to provide enough flow for a flow regulated system. Multi-stage pumps are likely to be too large for temperature regulated systems.

Balancing valves of any type must be certified for potable water.

Circulating pumps

Circulating pumps must be suitable for potable hot water. Generally, this means stainless steel or bronze with watermark or AS4020 certification.

We see many cast iron pumps not certified for drinking water used for ring-main systems.

Figure 10: Grundfos single-stage circulators: left-to-right: bodies in stainless steel, bronze and cast iron: easily identifiable by the escutcheon colour

Ensure pumps are orientated in accordance with the manufacturer's instructions. In some models this can be achieved by unbolting and re-orienting the motor housing.

Check the IP rating of the pump is sufficient for the installation location. Small circulators installed outside may require a weather-shield to protect from direct rain and sunlight.

Pumps should ideally have a strainer immediately before them and be fitted with isolation valves and swivels for easy removal, servicing and replacement.

The pump must be sized correctly for the system. The pump must be large enough to overcome the pipe friction loss in the flow and return loops but not so big that it exceeds the pipe velocity limitations (see AS/NZS 3500.4: 2021 Table 1.8). Small single stage circulating pumps are usually sufficient for most applications.

Where a UV sterilizer is used in a low temperature system, the pump and UV unit should be specified together. Increasing the pump size and flow rate will reduce the time the return water spends in the UV unit and hence the degree of disinfection.

Pump Sizing

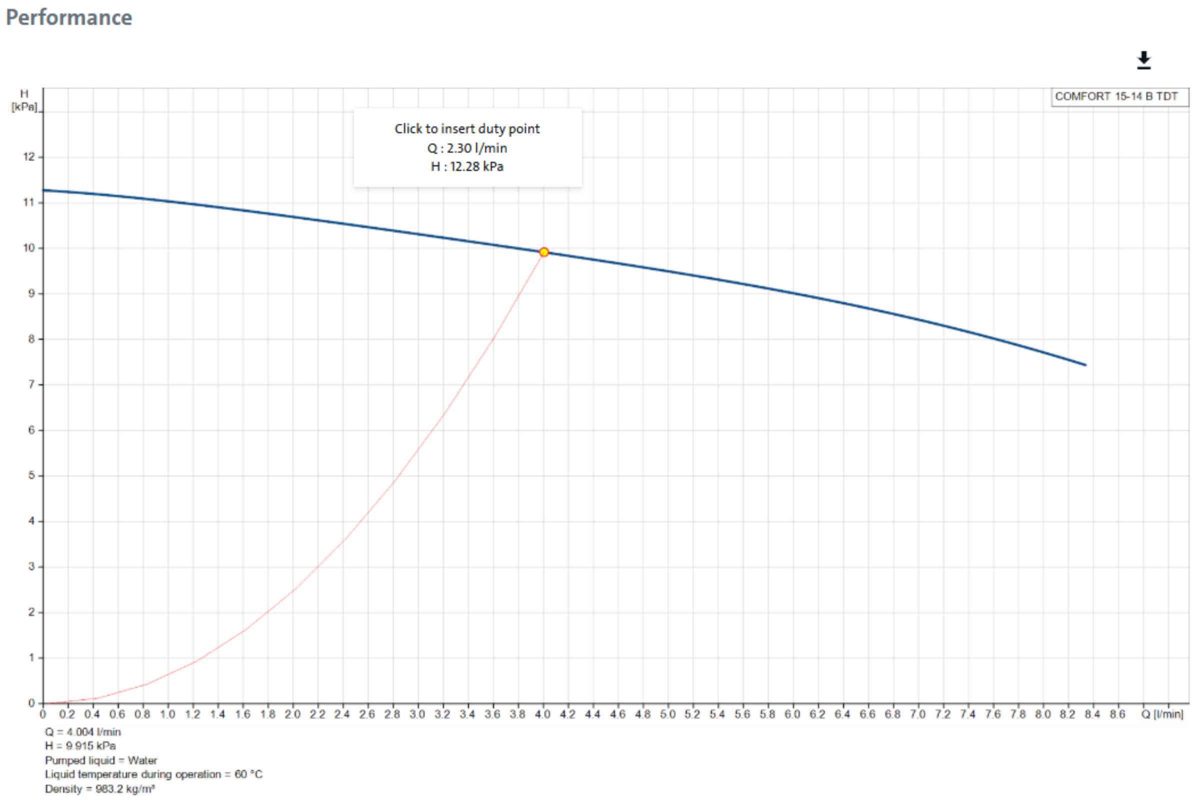
Sizing the pump is an iterative process.

Step 1:

Obtain the pressure-flow curve for a pump you think is about the right size.

Select the mid-point of the curve for the first iteration.

In this case for a Grundfos Comfort 1514B, 4 litres per minute against a head of 10 kPa.



Step 2:

Determine the approximate length and sizes of pipe to be used in the ring-main.

Increase the pipe lengths to account for the fittings to be placed in the ring-main in accordance with the pipe manufacturer's instructions.

For this example, we have selected NZS3501 copper: DN25 x 10m + DN20 x 10m + DN15 x 15m (return line)

Use the manufacturers sizing charts to determine the pressure loss through the ring-main pipe and fittings at the pump flow rate mid-point.

Rinnai has created a spreadsheet (link here or from the QR code below) converting the Kembla NZS3501 copper specification sheet for ease of use.

When the spreadsheet opens from the link, click >File>Create a copy > Download a copy to save the spreadsheet in your own system.

Enter the pump mid-point flow rate in litres per minute. Next complete the straight lengths of each pipe diameter. Finally insert the number of fittings in the respective sizes of pipes.

In this example, the initial DN25 pipe has 3 elbows, 3 branch take-offs and one reducer to DN20. The fittings in the other pipes are similarly entered. Two valves and a non-return are entered in the DN15 return pipe for the pump isolation valves and non-return.

Flow and pressure loss for NZS 3501 copper

Flow	4	litres per minute
	0.067	litres per second

	Velocity	kPa/m	Pipe Length	Qty of fittings						Fitting Equiv. Pipe Length	Total Equiv. Pipe length	Total loss
			metres	Elbow	Long Bend	T	Reducer	Gate valve	Non-return			
Pipe Size	m/s	Loss 60°C										6.3
10	0.94	1.1								0.0	0.0	0.00
15	0.53	0.3	15	2	0			2	1	4.5	19.5	5.44
20	0.23	0.0	10	2		2	1			6.6	16.6	0.65
25	0.13	0.0	10	3		3	1			11.7	21.7	0.21
32	0.08	0.0								0.0	0.0	0.00
40	0.06	0.0								0.0	0.0	0.00
50	0.03	0.0								0.0	0.0	0.00
65	0.02	0.0								0.0	0.0	0.00
80	0.01	0.0								0.0	0.0	0.00
100	0.01	0.0								0.0	0.0	0.00
150	0.00	0.0								0.0	0.0	0.00

In this example, at 4 l/min, there would be a 6.3 kPa pressure loss through the pipes.

As the pump can maintain a greater head than this, the flow rate will be a little higher. Further iterations are required to determine the flow rate and pressure loss.

Step 3:

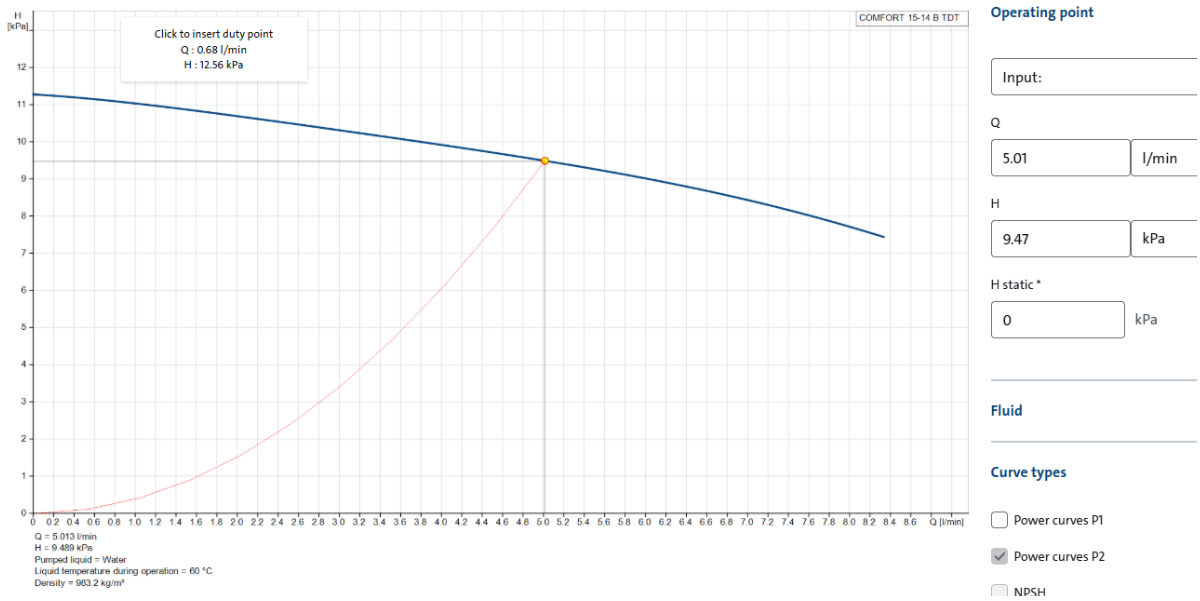
Increase or reduce the flow rate until the pipe and pump flow rate and pressures match. Here, at 5 l/min, the pressure loss in the ring-main matches that available from the pump.

The last column shows ~85% of the pressure loss has occurred in the DN15 return pipe. Consider adjusting this pipe diameter for some of its length if required.

Flow and pressure loss for NZS 3501 copper

Flow 5 litres per minute
0.083 litres per second

	Velocity	kPa/m	Pipe Length	Qty of fittings						Fitting Equiv. Pipe Length	Total Equiv. Pipe length	Total loss
			metres	Elbow	Long Bend	T	Reducer	Gate valve	Non-return			
Pipe Size	m/s	Loss 60°C										9.5
10	1.17	1.7								0.0	0.0	0.00
15	0.66	0.4	15	2	0			2	1	4.5	19.5	8.23
20	0.29	0.1	10	2		2	1			6.6	16.6	0.98
25	0.16	0.0	10	3		3	1			11.7	21.7	0.31
32	0.11	0.0								0.0	0.0	0.00



As a rule-of-thumb, avoid specifying a pump where the flow will be in the bottom 10 – 15% of the pump flow range. This will allow for unforeseen extra flow resistances that might be present in the actual build. If this is the case, select a larger pump.

Step 4

Check the pipe flow velocities don't exceed those shown in AS/NZS3500.4. (See Table 1 above)

For circulatory flow pipes, add the flow rate calculated in step 3 to the probable simultaneous flow rate (PSFR) for each pipe section of the ring main. Then check pipe velocities are acceptable.

In the return pipe: for this example, DN15 NZS3501 copper has a bore of 12.7mm (1/2"). From Table 1, the maximum flow rate is 7.6 l/min; the return pipe is large enough.

UV sterilisers

Low temperature ring-mains require an ultra-violet sterilizer (UVS) on the ring-main recirculation pipe connecting to the mixing valve. This ensures returning water is either disinfected by the UV steriliser or by returning to the hot water plant.

UVS must be sized correctly for this application. Warm water applications have a recommended UV dose of 40 mJ / cm^2.

Amalgam lamps regulate their internal vapour pressure, so doses are maintained at temperatures over 40°C. They are therefore suitable for warm water applications. Non-amalgam lamp dose typically reduces past this temperature.

Smaller units with pipe connections compatible with DHWR pipe sizes we are looking at here, are typically non-amalgam units. Refer to manufacturer's specifications and guidance for performance of these units at temperatures above their specified limit.

For example, above 40°C, to ensure a 40 mJ / cm2 dose, UVGuard recommend halving the maximum flow rate specification of their non-amalgam lamp systems.

Providing the ring main is insulated to a high standard, most of the ring main flow will pass through the recirculation connection and the UVS to the mixing valve. Only a small portion of the flow will return to the hot water plant. Assuming 100% of ring main return flow passes through the UVS is only a slight increase over the actual flow rate. This provides a small additional factor of safety.

Table 2: UVGuard S-series non-amalgam lamp specifications

Model	Flow Rate@ 30mJ/cm^2	Flow Rate @40mJ/cm^2	Inlet/Outlet
S20	0.52 m^3/hr	0.39 m^3/hr	½", ¾" BSPT
S30	1.35 m^3/hr	1.01 m^3/hr	¾", 1" BSPT
S40-62	2.19 m^3/hr	1.64 m^3/hr	1" BSPT
S40-76	2.94 m^3/hr	2.2 m^3/hr	1", 1 ½" BSPT
S40X2	5.64 m^3/hr	4.23 m^3/hr	2" BSPT

The pipe-sizing worked-example above had a flow rate of 5 litres per minute, or 300 litres per hour. (0.3 m^3/hr).

Halving the flow rates at a 40mJ / cm2 dose, shows the S30 model should be used (~ 0.5 m^3/h capacity).

The S20 would provide insufficient protection (~0.2 m^3/h):

Consider now the higher specification Armour range units from UVGuard.

Performance		
Flow Rate @ 30mJ/cm²	0.87 m³/hr	UV dose calculated based on 95% UV Transmittance and lamp output at the end of life.
Flow Rate @ 40mJ/cm²	0.65 m³/hr	

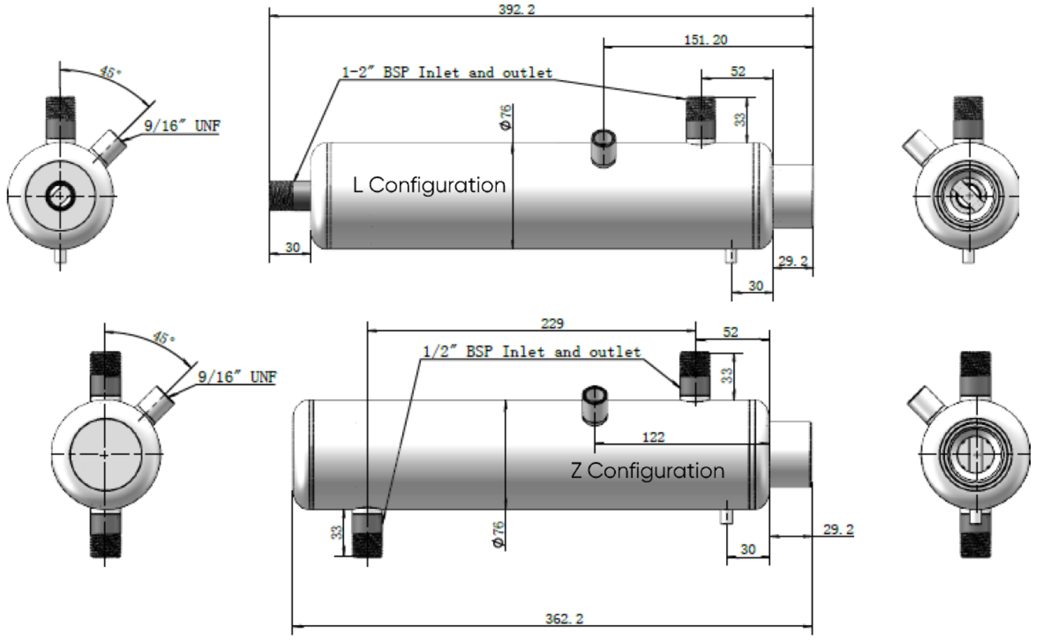


Figure 11: UVGuard ARM1 amalgam lamp model

The small ½" BSP connection ARM1 model has a 40mJ/cm² flow rate of 650 litres/hour - considerably higher than the S20 model. Again, halving this to 325 litres per hour converts to 5.4 l/min. So this would be suitable for the worked-example above. The pipe connections are also compatible with the DN15mm return pipe. The overall length is a little under 400mm compared to nearly 600mm for the S30 model.

<u>Installation and maintenance</u>

UVS consist of a long bulb inside a quartz sleeve.

The bulb needs to be replaced annually as its dose will drop over time even if it is still working.

The quartz sleeve should be checked when the lamp is first replaced. If it has become opaque and cannot be cleaned it should be replaced as this will affect the sterilizing effectiveness. If the sleeve does not need replacement, based on its condition, a program for replacement can be planned at the time of the first lamp replacement.

To provide for sleeve removal, UVS should be fitted with isolation valves upstream and down. To provide for both bulb and sleeve removal, at least one overall length of the sleeve needs to be clear next to the UVS to allow removal and replacement.

To help ensure timely maintenance, UVS are usually fitted with a count-down timer that has an alarm indicating when replacement is required.

On larger commercial systems, particularly for multi-unit premises, the UVS is often installed with a flow bypass. This ensures uninterrupted supply during annual maintenance.

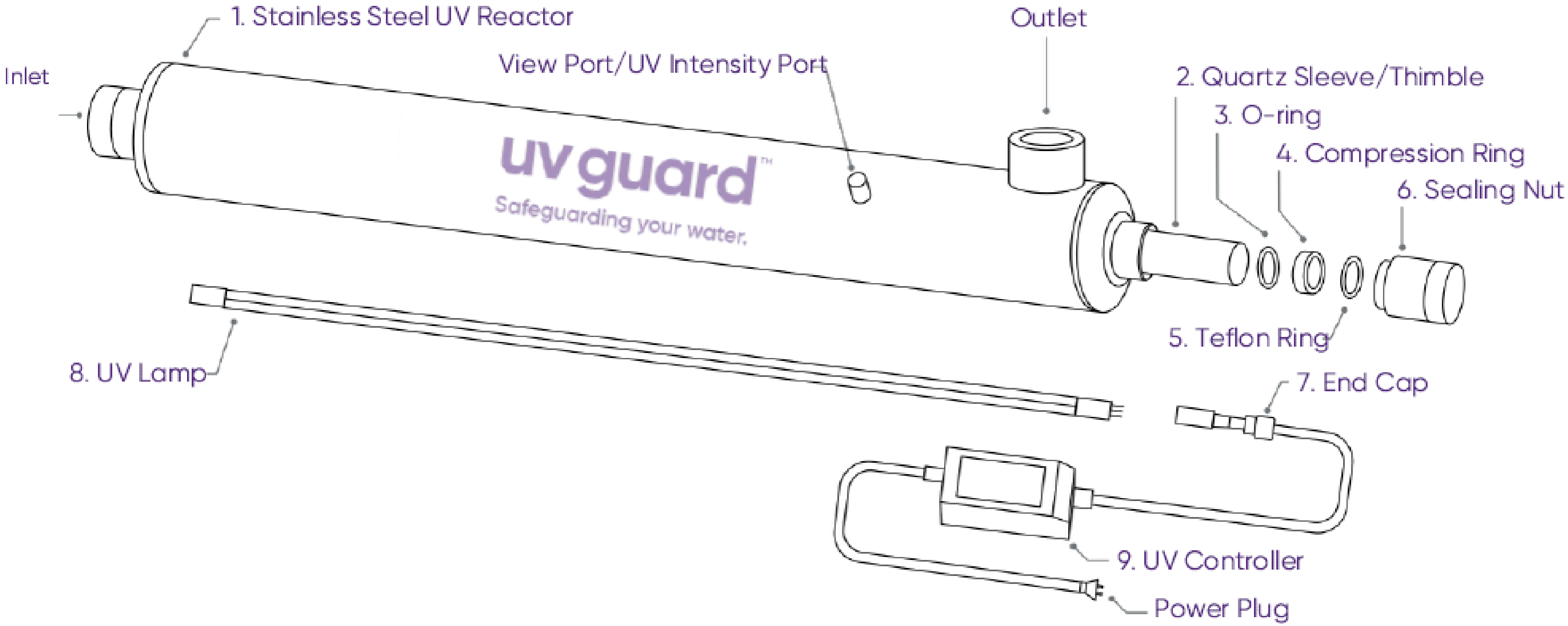


Figure 12: UVS system components

As part of a quote for a system, plumbers may wish to include replacement bulbs and quartz sleeves sufficient to last a number of years to be held on site for replacement. It should be noted that while bulb replacement is not plumbing, sleeve removal and replacement is.

Energy efficiency

Ring-mains deliver hot water quickly to outlets. However, achieving this results in additional energy lost as heat from the ring main. This heat loss becomes a fixed overhead for the system. It will occur even when no hot water is used.

There are two main ways to reduce energy loss; insulation and circulating pump control.

Insulation

New Zealand building code clause H1 (energy efficiency) has acceptable solutions:

H1/AS1 Housing/buildings up to 300m^2

H1/AS2 Buildings greater than 300m^2

For hot water systems both these documents reference NZS4305.

Clause 3.7.5 of this standard requires ring-main loops to be completely insulated.

Clause 3.8.2 specifies closed cell foam with 12mm wall thickness. This is insufficient to minimize heat loss from a ring main.

Plumbing systems meeting the New Zealand building code via G12/AS3, (in other words AS/NZS3500.4), require 25mm of closed cell foam on the flow and return pipes of ring main systems.

The exception is piping installed outside, which requires 38mm insulation in Taupō District, Ruapehu District, the northern part of the Rangitikei district together with the south island.

This should be considered the minimum insulation requirement for energy efficient systems.

The standard to which the insulation is fitted should also be considered. Figure X shows a potable water system with insulation completed to the highest standard.

Figure 13: DHW plant insulation of the highest standard

Circulating pump control

The second way to minimize the fixed operating cost is with the circulating pump.

The simplest way to do this on domestic and small commercial ring main systems is to switch off the pump using a timer when hot water is not required. For example outside of normal business hours for commercial premises, and say 10pm to 6am at a residence.

This can be done with a low cost, off-the shelf clockwork style timer.

One Rinnai customer with a large house reduced their gas use by 40% after fitting a simple timer to the ring-main circulating pump power supply.

Manufacturers also have pumps for small ring main systems that incorporate energy-saving features. Pumps with advanced energy saving features include the Grundfos Comfort range shown in Figure 14.

Figure 14: Grundfos Comfort T, Comfort TDT, Comfort TA pumps

The Comfort T model has an internal temperature sensor. The pump will sample maximum and minimum temperatures in the ring main and determine when to turn off and on to keep the ring main heated to a satisfactory level.

The TDT model has the same internal temperature sensor as the T model with the addition of a simple digital time clock to shut the pump down overnight.

These pumps can make additional savings when located just after the last branch off-take rather than at the hot water plant. This saves energy as the ring-main return line is not fully heated.

The TA pump has both internal and external temperature sensors. This pump is located close to the hot water plant. The internal sensor measures the ring-main temperature. The external sensor is placed on the hot water delivery line. When a rise in temperature in the delivery line is detected it notes this as a fixture being turned on. The water use pattern of the system is learned and the pump turns on in preparation for those times of use. If no hot water is used in 24 hours, the pump goes into vacation mode. To come out of vacation mode two hot water draws are needed within 80 minutes. While in vacation mode, the pump sterilizes the system by running for 15 minutes every 8 hours.

To access the specifications of these pumps, search in your internet browser for “Grundfos comfort” and the 8-digit number below. Open the result from the “Grundfos Product Center”. Using this 8-digit number will ensure you are viewing the version of the pump available in New Zealand.

Comfort 15-14 B	99164484	Standard pump – power from external timer
Comfort 15-14 B	93095535	Internal temperature sensor
Comfort 15-14 B	93093802	Internal temperature sensor + digital timer
Comfort 15-14 B	99164487	Internal + external temperature sensor: Auto Adapt

The comfort range pumps deliver only a small head of around 10 kPa. They will not be suitable for larger systems. Use the steps described in the pump sizing section to ensure they are sufficient for the application. Larger single-stage circulators can be used with external timers. Other manufacturers also offer pumps with energy-saving features.

Ring-mains with different Rinnai water heater technologies

The following pages contain sketches of how to incorporate various types of Rinnai water heaters into ring-main systems. The sketches illustrate the hot water plant. Ring main detail is shown in Figure 2 and Figure 3.

For clarity, these sketches are simplified to illustrate concepts. They are not complete hydraulic specifications. Good trade practice will ensure all major components are fitted with isolation valves and unions to allow for removal, maintenance and replacement, as far as possible without draining the system. Installations must incorporate all building code requirements including pressure and temperature relief, seismic restraint, safe trays etc.

While these sketches may be applicable to other brands of water heaters, please check with the water heater manufacturer. Rinnai accepts no responsibility for issues arising with the water heaters of other suppliers installed in accordance with this guide.

Only some of our extensive drawing library is shown here. If you need assistance with other combinations or systems with multiple water heaters, please contact sales@rinnai.co.nz. Sketches are available in pdf, Autocad dwg, or dxf formats.

Figure 15: Rinnai heat pump water heater range

Ring-main re-heating cylinders

Heat pump, gas continuous flow, solar and wetback water heating systems shown below use small volume electric cylinders to maintain ring-main temperature.

This is a practical way to get an electric element into the ring-main flow to keep it heated. These cylinders need to be rated at pressures suitable for the system, and with all the usual installation requirements of a stand-alone electric cylinder. When used in a system with stored hot water, the expansion control valve for the main storage cylinder can be used to protect the smaller cylinder provided there is no non-return valve between the two cylinders.

Figure 16: Rinnai 30 & 57 litre electric cylinders often used as ring-main re-heaters

The Rinnai 30 litre under sink cylinder is suitable for smaller systems. The 57-litre heavy duty electric cylinder is used for larger systems with bigger pipe connections and heat losses. The 57 litre is a multi-element cylinder but connect only the number of elements required to make up the ring-main heat low.

The water in the pipe connecting the primary water heater and the ring-main re-heating cylinder will become cold between draws. When water is drawn, this cooler water will enter the re-heating cylinder before fully heated water arrives. To maintain a uniform temperature in the ring-main when this happens, the volume of the ring-main re-heating cylinder should be at least 10 x the volume of the water in connecting pipe.

The maximum interconnecting pipe lengths are shown in Table 3 below.

Table 3: maximum pipe length between primary water heater and ring-main re-heating cylinders

Model	Volume (litres)	Element (kW)	TPR (kPa)	Connections	Max. interconnecting pipe length (metres)		
					DN20	DN25	DN32
MEU030415E20	30	2	850	DN20	10	6	N/A
MEC060470E333	57	3 x 3.3	1000	DN32	20	11	7

Electric (resistance element) or gas storage

Electric and gas storage tank water heaters are the simplest to incorporate into ring-main systems. The ring-main return can simply be connected to the water heater cold inlet.

Systems comprising electric storage water heaters with all internal elements connected to controlled power sources (i.e. smart-meter interruptible and ripple relay switches), may benefit from using a ring-main reheat cylinder connected to continuous power. See the heat pump water heater section for more information on this arrangement.

Figure 17: Part of the Rinnai indoor-outdoor electric water heater range

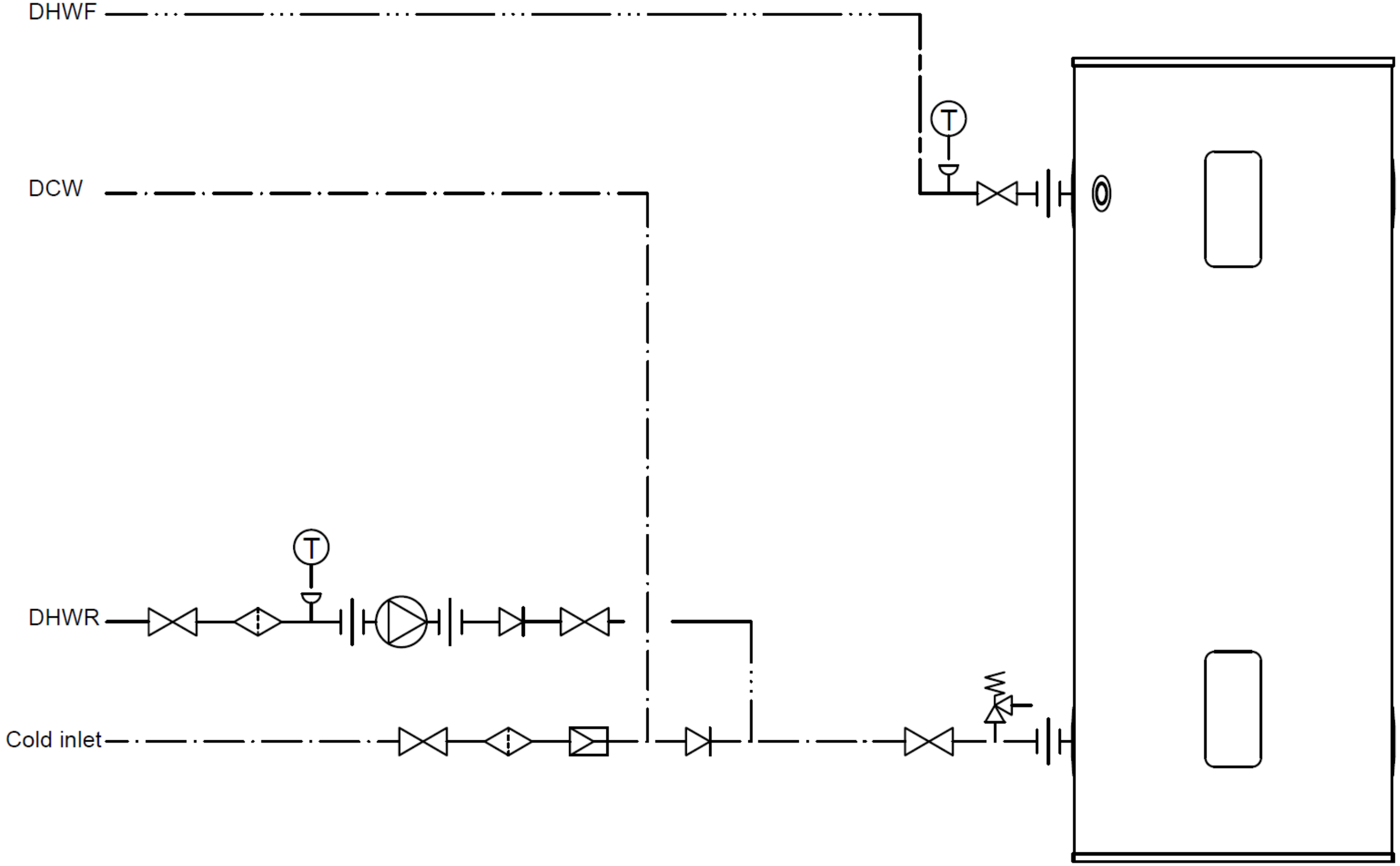


Figure 18: Storage water heater with high temperature ring-main

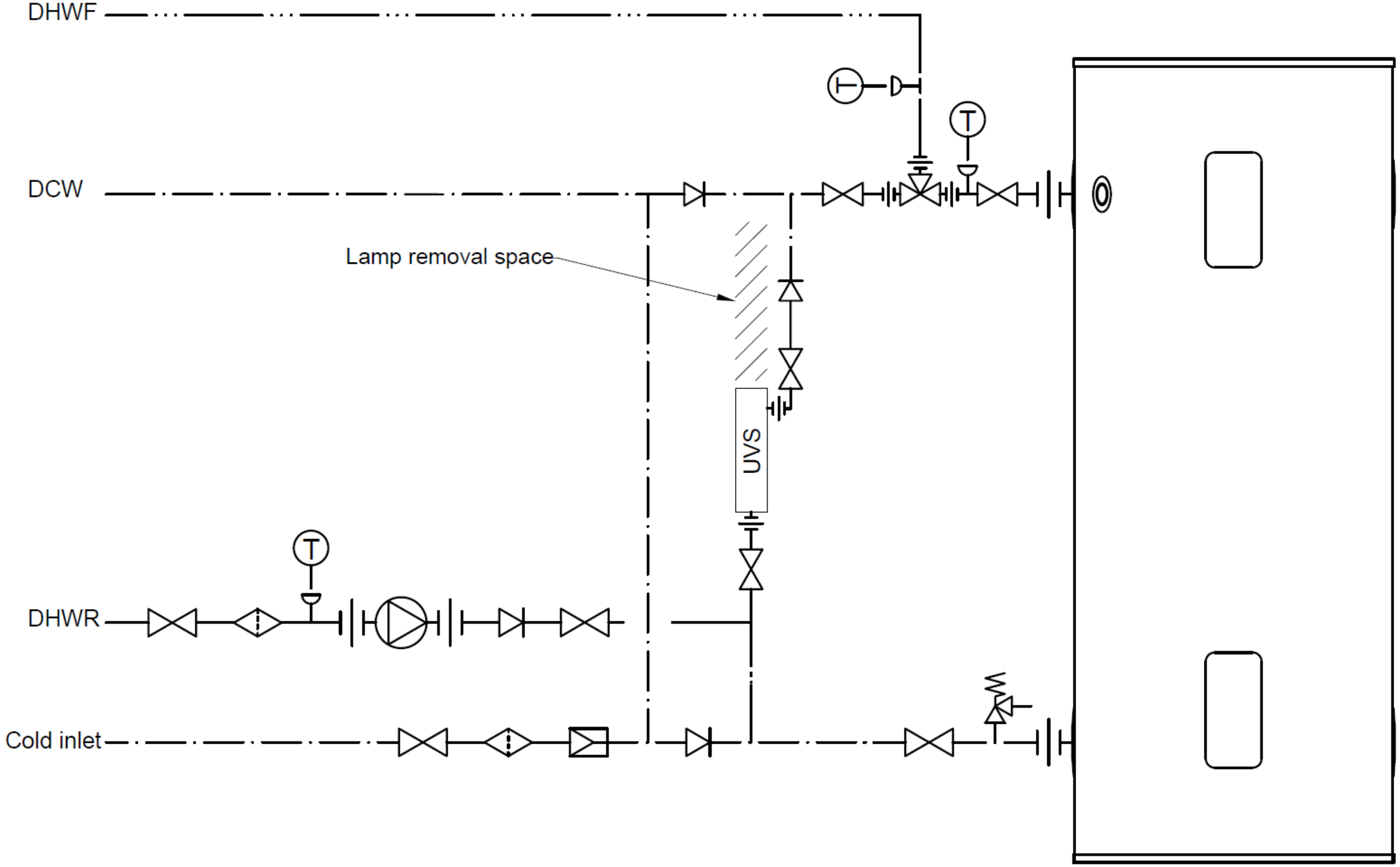


Figure 19: Storage water heater with low temperature ring-main

Electric heat pump water heaters

Heat pump systems are best installed by using a small electric tank to keep the ring-main hot.

There are two main reasons for doing this:

<u>Service life</u>

The economic service life of a heat pump is closely related to the number of start cycles of the compressor. During start-up the compressor draws significant current and works hard to get refrigerant circulating.

Returning the ring-main return to the heat pump storage cylinder will cool the cylinder at times of no hot water draw. This results in the heat pump being activated for relatively short periods to re-heat the cylinder. The compressor will operate for many more cycles reducing the life of the appliance.

<u>Energy Efficiency</u>

Heat pumps are most efficient when heating water from cold. You may have noticed that the thermostat of a heat pump is a little higher than in an equivalent electric tank. This arrangement leaves some cooler water at the bottom of the tank at the end of the heating cycle. This improves the efficiency of the water heater.

Returning the ring-main return to the heat pump cylinder will cause mixing in the tank and warm rather than cooler water to be heated. This will reduce the heat pump overall energy efficiency.

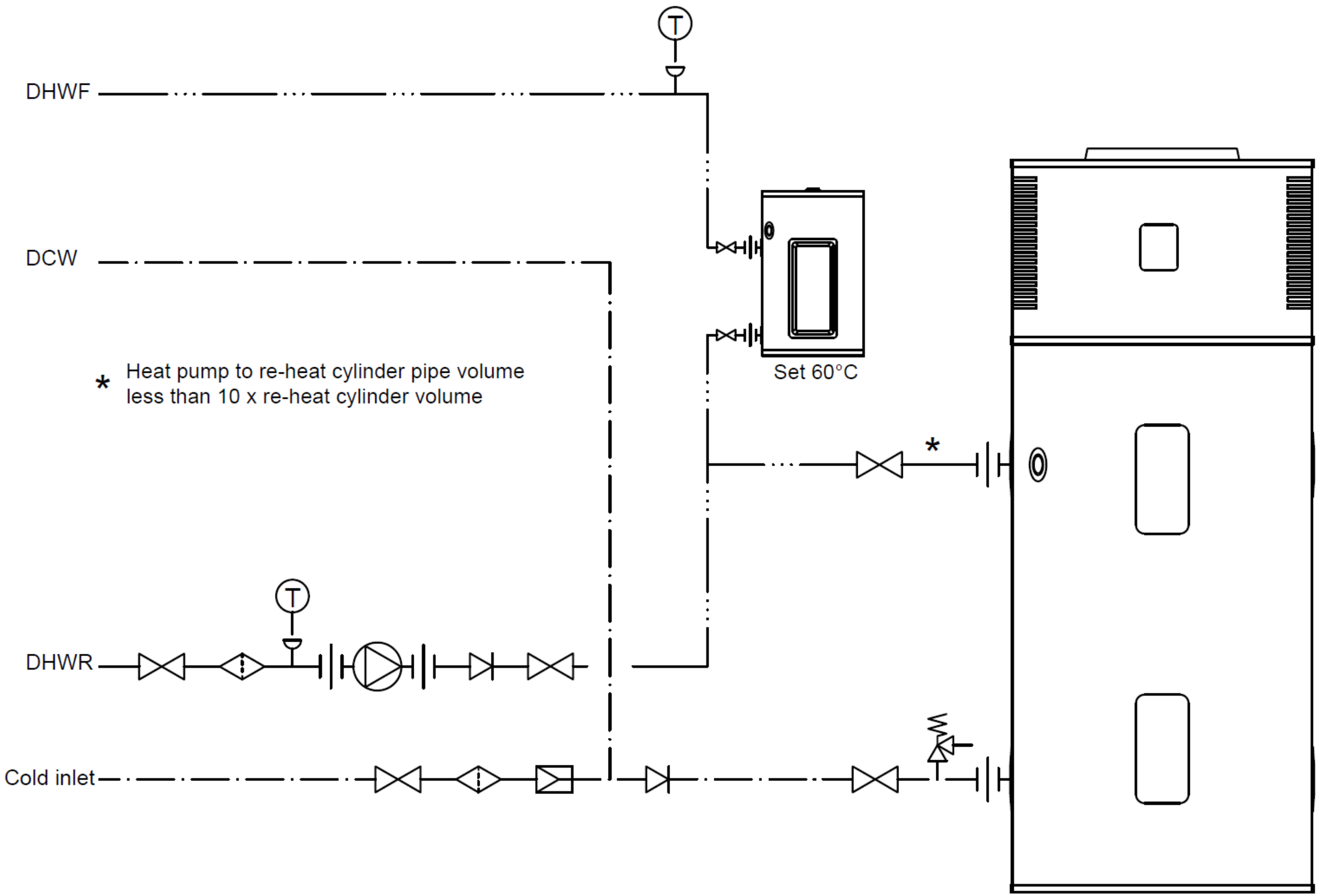


Figure 20: Heat pump with high temperature ring main

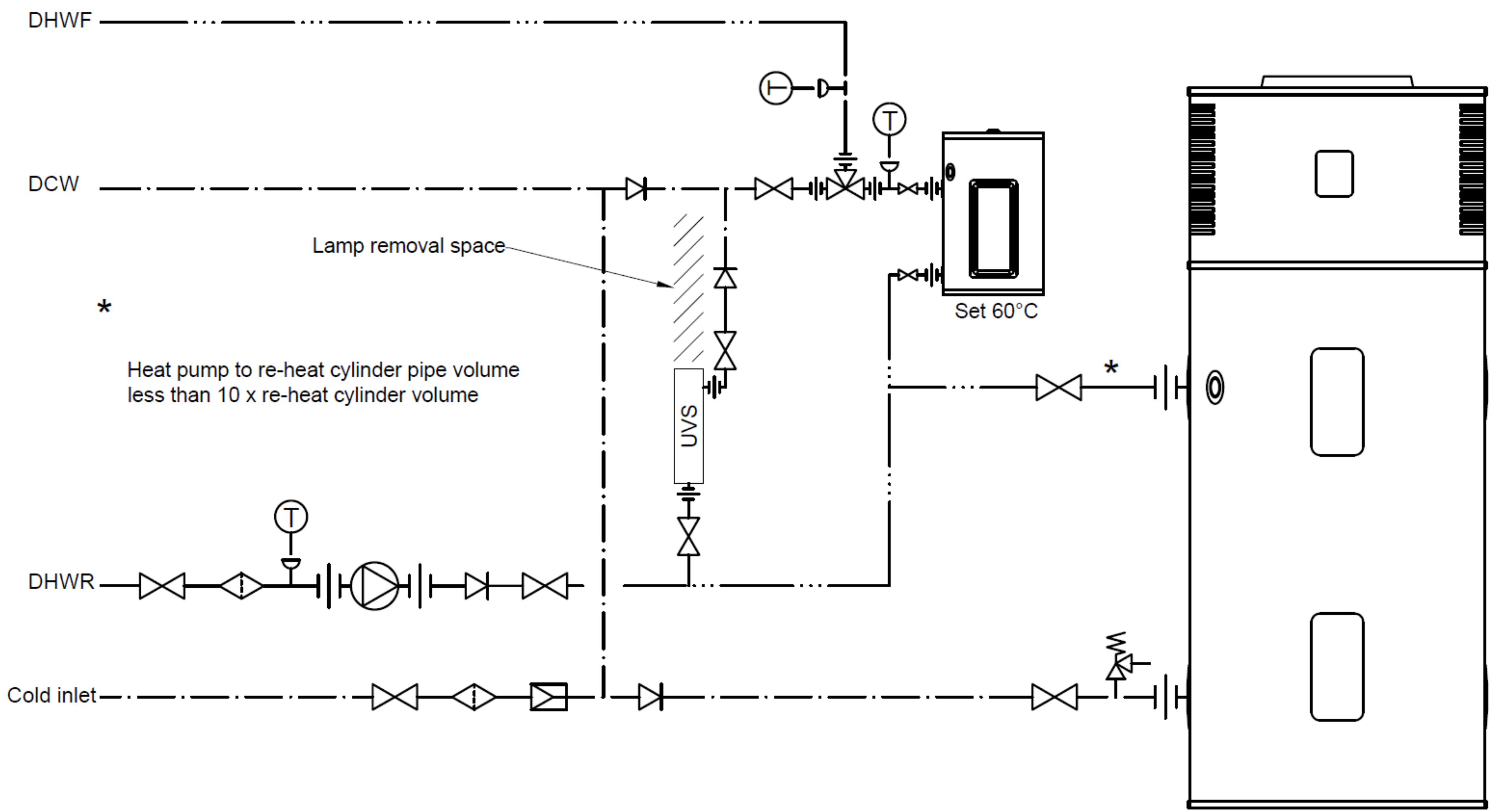


Figure 21: Heat pump with low temperature ring main

Gas continuous flow

Rinnai INFINTY® gas continuous flow water heaters should not have the ring main returned to the cold-water inlet. (The exception is the Rinnai INFINITY® NB56 – see next section for information)

The burner is unable to run low enough to just make-up the ring-main heat loss.

Installing in this manner will cause high cycling and run hours resulting in high maintenance costs and premature failure.

A ring-main reheating cylinder should be used with Rinnai INFINITY® water heaters.

Note also in the sketch the separate hot and cold pressure reducing valves. This will create a "nearly" equal pressure system for more premium homes.

For larger installations with two or more water heaters the ring-main reheating cylinder also acts as a buffer. When an additional boiler starts, it will initially feed cold and then luke warm water into the common hot manifold. The ring-main reheating cylinder will mix out this cold slug so it should be barely noticeable at fixtures.

Insert lo-res png

Rinnai INFINITY® NB56 gas continuous flow

The Rinnai INFINITY® NB56 can be installed with the ring main return connected to the cold inlet provided the boiler is used to power and control the circulating pump.

The NB56, unlike other models of Rinnai INFINITY®, has an inlet water temperature sensor. The NB will power the pump on and circulate water. Once the inlet temperature sensor detects return water is within 5°C of the supplied water, the pump will shut down. Depending on the settings of the boiler, the pump will remain off between 9 and 50 minutes before reheating.

This ring main functionality works up to 65°C set temperature. For temperatures above that please refer to the gas continuous flow section above.

The NB will not heat unless the ring main flow rate is above 6 litres per minute. To ensure reliable activation of the water heater, add 20 kPa to the ring main pressure loss when sizing the pump.

There are a number of ways of shutting the pump off during off-peak hours including an inbuilt learning algorithm option and programmable relay timers.

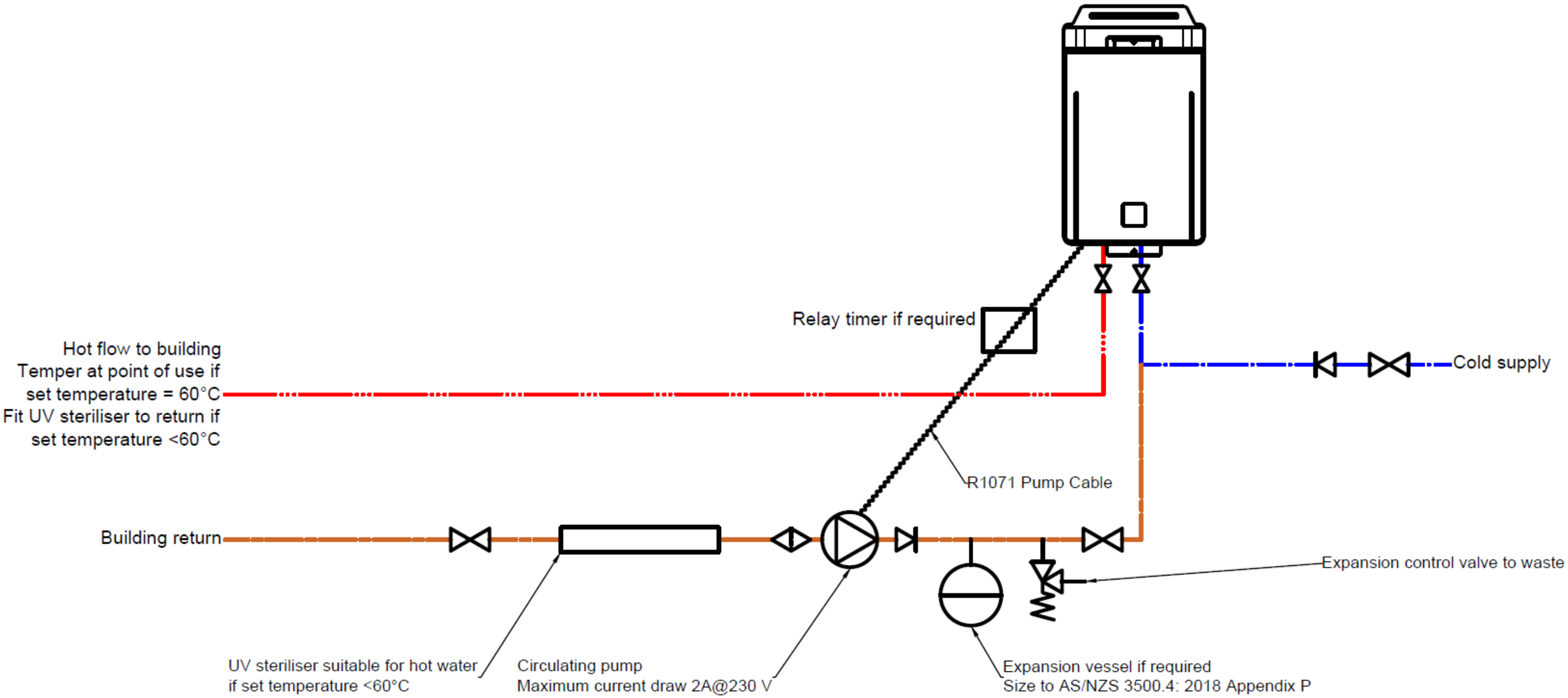
Rinnai have produced a booklet entitled *NB units and ring main systems* that contains extensive information on this option. It is available from the downloads tab of the NB page on the Rinnai New Zealand website.

For high-end stand-alone homes where two or more NBs are connected together, the ring-main reheating option described in the gas continuous flow section above may be a better option. The ring-main reheating cylinder acts to buffer temperature fluctuations when additional boilers start in response to increase flow rates.

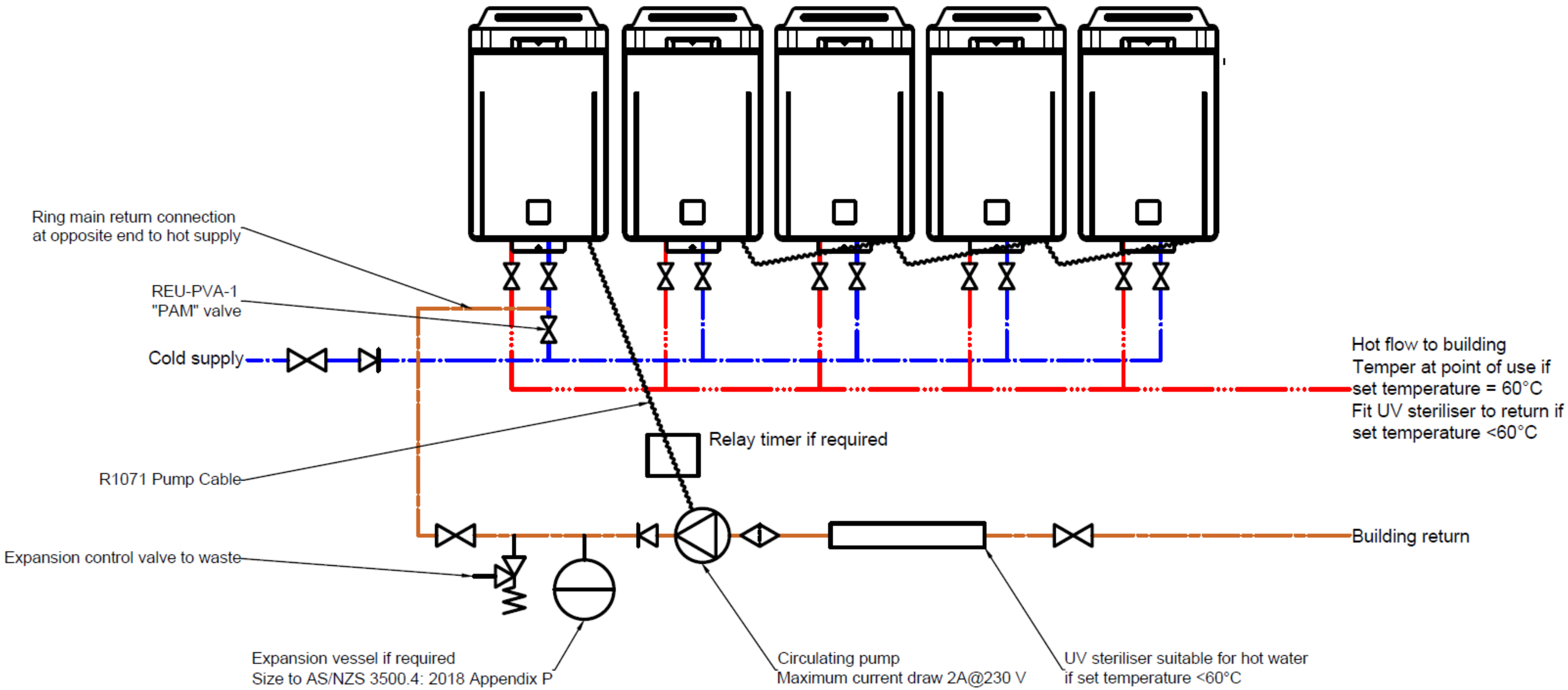
In multiple unit installations for small commercial applications the first boiler controls the ring main pump and heats the ring main. This unit is isolated from the cold supply by a Rinnai pressure activated manifold (PAM) valve. The other unit(s) are electronically connected and provide hot water for usual tap openings. When demand is high the pressure loss through the boilers will increase with flow rate. When the pressure differential between the hot and cold water common manifolds exceeds the spring rating of the PAM, the valve will open and allow the first boiler to assist with meeting peak demand.

To minimize temperature fluctuations as additional boilers start in response to demand increasing, it is important that the hot water flow connection to the building, is made from the hot manifold at the opposite end to the ring main control and heating boiler. An oversize pipe section for the common hot manifold can also assist in minimizing temperature fluctuations.

Please contact Rinnai for further assistance with multiple unit commercial ring-main applications: info@rinnai.co.nz



Relay timer if required
Hot flow to building
Temper at point of use if
set temperature = 60°C
Fit UV steriliser to return if
set temperature <60°C
Cold supply
R1071 Pump Cable
Building return
Expansion control valve to waste
UV steriliser suitable for hot water
if set temperature <60°C
Circulating pump
Maximum current draw 2A@230 V
Expansion vessel if required
Size to AS/NZS 3500.4: 2018 Appendix P


Ring main return connection
at opposite end to hot supply
REU-PVA-1
"PAM" valve
Cold supply
Hot flow to building
Temper at point of use if
set temperature = 60°C
Fit UV steriliser to return if
set temperature <60°C
Relay timer if required
R1071 Pump Cable
Building return
Expansion control valve to waste
Expansion vessel if required
Size to AS/NZS 3500.4: 2018 Appendix P
Circulating pump
Maximum current draw 2A@230 V
UV steriliser suitable for hot water
if set temperature <60°C

Solar and Wetback

The sketches are for systems using unvented cylinders with internal calorifier coils. On the energy input side of the cylinders, please refer to the energy source manufacturer instructions for details.

Do not exceed the wetback rating shown in the Rinnai coiled cylinder installation instructions.

Homes using solar and wetback water heaters that require ring mains, should use an electric ring-main reheating cylinder.

The supply from the primary water heater to the ring-main reheater should be tempered with a suitable high-temperature (solar) mixing valve to 60 – 65°C. Do not exceed the recommended temperature rating of the ring-main reheat cylinder. This is typically 75°C maximum for enameled steel construction.

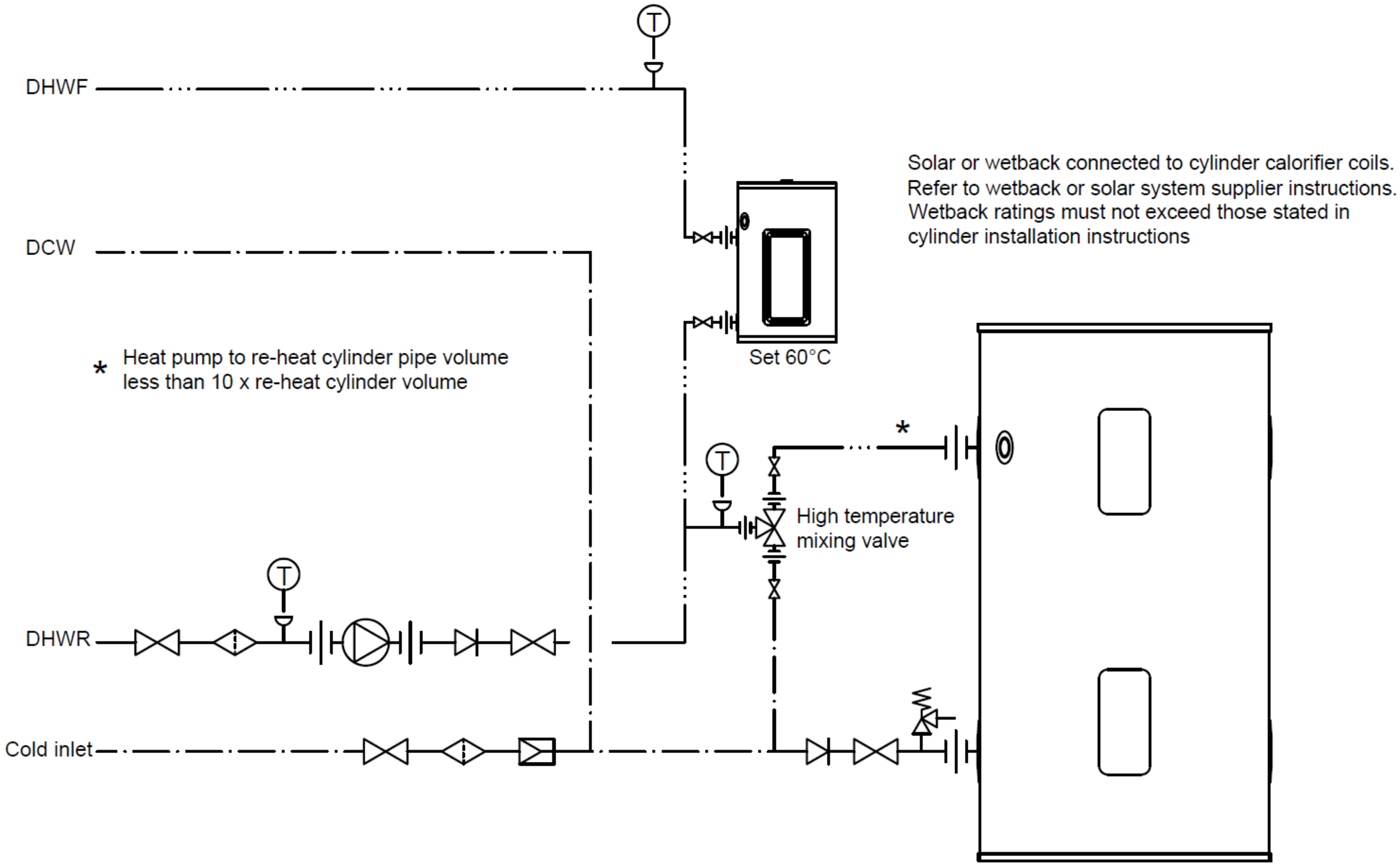


Figure 22: Wetback or solar cylinder with high temperature ring-main

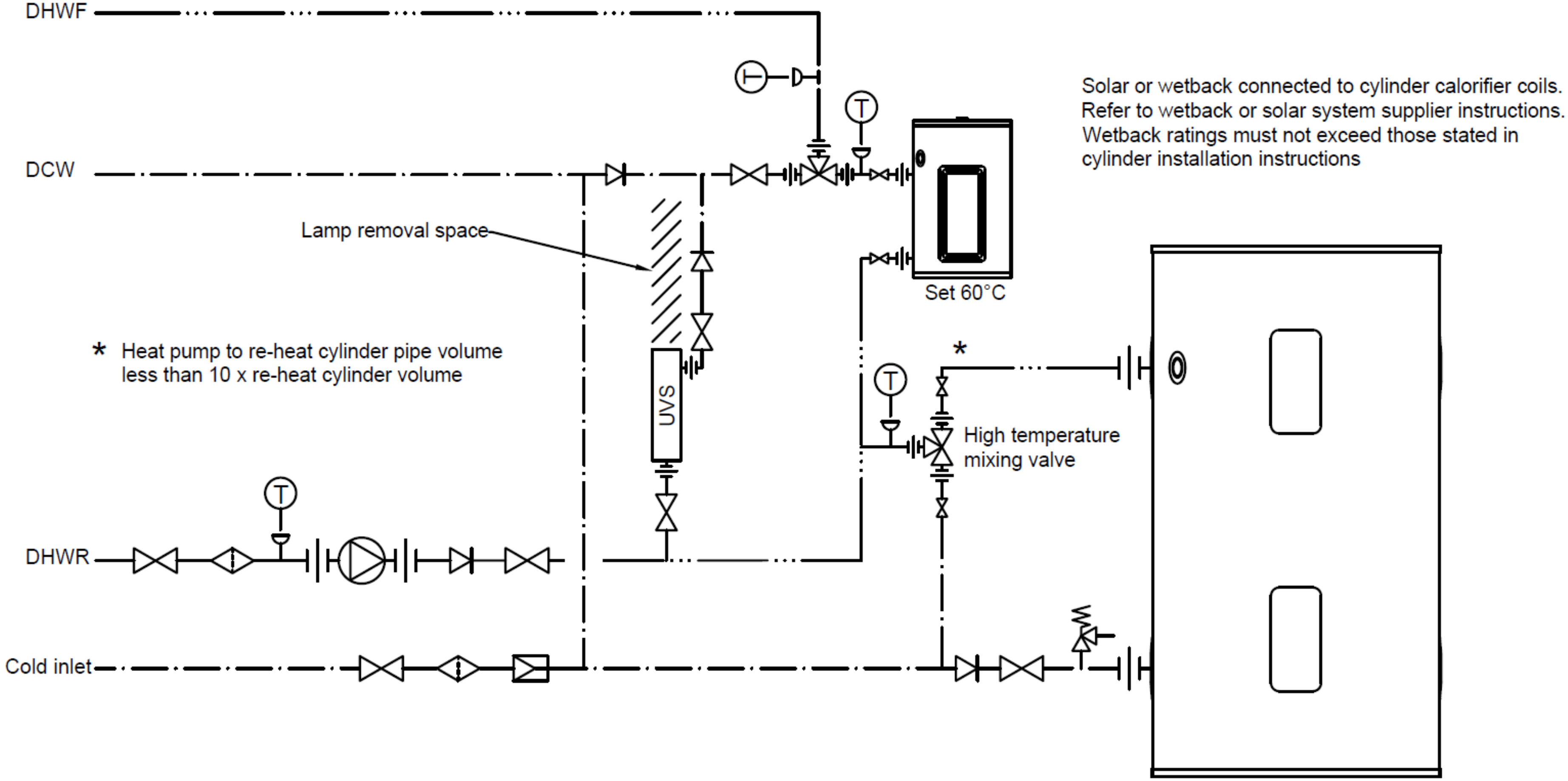


Figure 23: Wetback or solar cylinder with low temperature ring-main