

# Storage Calorifiers/Cylinders



# Contents

• STORAGE CALORIFIERS	1	• UNVENTED CALORIFIER SYSTEMS	10
• CALORIFIER CODES OF PRACTICE	2	• STORAGE CAPACITY	11
• SHELL MATERIALS	3-4	• CONNECTIONS	12
• STORAGE CALORIFIERS	5	• ACCESSORIES	13-14
• INDIRECT CYLINDERS	6	• CONTROL VALVE SELECTION FOR STORAGE CALORIFIERS	15-16
• BUFFER VESSELS	7	• CALORIFIER PERFORMANCE TESTING	17
• HEAT EXCHANGER TYPES	8	• WATER QUALITY AND TREATMENT	18
• VENTED CALORIFIER SYSTEMS	9		

## Storage Calorifiers

CALORIFIER IS A TERM USED TO DESCRIBE AN EXTENSIVE RANGE OF INDUSTRIAL AND COMMERCIAL HOT WATER HEATERS. HIGH PERFORMANCE TUBULAR HEAT EXCHANGERS ENSURE RYCROFT CALORIFIERS OFFER THE MOST FLEXIBLE AND ECONOMIC SOLUTION TO PROVIDE YOUR HOT WATER HEATING REQUIREMENTS. RYCROFT HEAT EXCHANGERS UTILISE A RANGE OF PRIMARY HEATING SYSTEMS.

### Primary Heating Systems

#### LTHW (maximum temperatures of 100°C)

Low temperature hot water is the most common means of heating. Flows are usually based on a temperature drop of 11°C (from 82–71°C).

#### MTHW (100°C–120°C)

Medium temperature hot water systems are generally designed on a temperature drop of 30°C (from 120–90°C).

#### HTHW (temperatures above 120°C)

High temperature hot water systems are generally designed on a temperature drop of 40°C (from 150–110°C).

Another important factor in the selection of primary water heating systems is the working pressure. Where the primary working pressure is greater than the shell design pressure the calorifier must be fitted with a bursting disc sized in accordance with the requirements of BS 853.

Primary water pressure drops are generally not greater than 25 kPa.

With HTHW Systems we recommend the use of flanged connections rather than screwed joints.

#### Steam

Steam is an ideal medium for water heating. Tubular heat exchangers can be designed to accommodate a wide range of pressures, although most users prefer to have calorifiers operating with pressures below 10 Bar g. Superheat can be accommodated and the degree of superheat should always be stated at the enquiry stage.

#### Condensate

Condensate tubular heat exchangers can be used to accommodate flash steam and subcool condensate. This harnesses the available heat which would otherwise be discharged from a traditional two pass tubular heat exchanger.

#### Heat Transfer Oil

Thermal oils have the benefit of high temperature combined with low operating pressures. Tubular heat exchangers are generally manufactured from cupro-nickel or stainless steel, depending on oil type.

#### Refrigerant

Generally only superheat is taken from systems although condensing units are available. Tubular heat exchangers are designed with double tube sheets incorporating a tell tale leak path. This reduces the risk from cross contamination between the secondary and primary sides.

#### Waste Heat

Storage calorifiers are a useful means of recovering waste heat from a variety of liquids or vapours and Rycroft offer a special design service for this purpose. Where the temperature or quantity of waste heat is insufficient for the desired output, supplementary heating can be incorporated into the calorifier to boost the storage temperature. The calorifier should be sized to absorb the maximum quantity of waste heat during the time it is available.

#### Water Hardness

Where it is required to heat water with a high degree of hardness, special precautions should be taken. This is especially true where high primary temperatures are encountered.

#### Rycroft References for Storage Calorifiers

---

CE Copper vertical calorifier.

---

CF Copper horizontal calorifier.

---

ZE Steel vertical calorifier.

---

ZF Steel horizontal calorifier.

---

CZE Copperlined steel vertical calorifier.

---

CZF Copperlined steel horizontal calorifier.

---

SSE Stainless steel vertical calorifier.

---

SSF Stainless steel horizontal calorifier.

---

# Calorifier Codes of Practice

## BS 853

Rycroft manufacture BS 853 calorifiers strictly in accordance to the standard. This standard specifies requirements which ensure the calorifier meets with all current Health and Safety legislation.

Unvented calorifiers should be built in accordance with BS 853 as stipulated in BS 6700. G3 building regulations states the safety protection requirements for unvented systems.

Although not a requirement of the code, a full material traceability can be offered. This requirement must be stipulated at the quotation stage. As standard, Rycroft can supply a letter of material conformity for all BS 853 calorifiers.

Third party inspection control can be accommodated. This requirement must be stipulated at the quotation stage.

## BS 5500

The design and manufacture of equipment built in accordance with this specification must be endorsed by a third party inspectorate. Full material traceability is a mandatory requirement.

Shells built in accordance with this standard are supplied with a Form X endorsed by the manufacturer and third party inspectorate.

## Commercial Calorifiers

Rycroft supply a range of commercial vented calorifiers based upon extensive in-house research and operating experience.

All commercial calorifiers carry a Rycroft nameplate specifying the following:

- Date of manufacture
- Maximum working pressure
- Test pressure

A letter of material conformity can be supplied with any Rycroft commercial calorifier.

## Calorifiers and the Pressure Equipment Directive (97/23/EC)

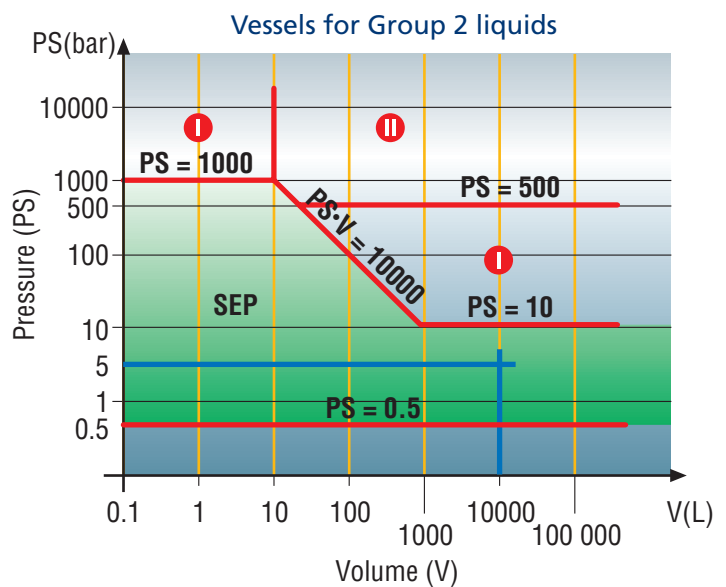
From 29 May 2002 calorifiers must meet the mandatory requirements of the PED. Rycroft calorifiers will meet the requirements from the transition date of 29 November 1999.

The majority of fluids found in calorifier systems including steam will be classified as group 2 fluids. The following rules pertain to calorifiers containing group 2 fluids:

Where the maximum design pressure in Bar g multiplied by the calorifier volume in litres is not greater than 10,000 or the design pressure is not greater than 10 bar g the calorifier must comply with SEP (Sound Engineering Practice). SEP calorifiers cannot carry the CE mark.

Calorifiers which fall outside of the above parameters must carry the CE mark.

The table below illustrates the SEP sector for calorifiers. For example, consider a 10,000 litre calorifier with an allowable pressure of 5 Bar g. To determine the group classification draw a horizontal line across the graph at 5 Bar. At the 10,000 litre point on the horizontal axis draw a vertical line. The intersection of these two lines falls in the SEP sector of the graph. A 10,000 litre calorifier with an allowable pressure of 12 Bar falls into the category 1 requirements. The requirements for each category can be found in the Directive Journal 97/23/EC.



## Storage Temperature

Several standards and guides specify required storage temperatures. Some of the common specifications are listed below:

### CIBSE TM 13

Recommends a storage temperature of 60°C.

### CIBSE Guide

Examples quote storage temperatures of 65°C.

### National Health Service Model Engineering Specification C 07

60°C requirement.

### HSG70

Temperature treatment control regimes specify a storage temperature of 60°C.

### BS 6700

Recommends a storage temperature of 60°C.

It should be noted that temperature control is generally considered the preferred means of reducing the risk from Legionnaires disease. Calorifiers and their associated systems can be designed to ensure compliance with specified temperature regimes. Existing systems may also be upgraded. Please contact our design department for further information.

# Shell Materials

## Copper Shells

Solid copper has proved to be a reliable and economical non ferrous metal for the construction of hot water storage vessels. It is used extensively throughout the world due to its long life and an ability to withstand most concentrations of corrosive elements found in domestic hot water. Modern fabrication has further improved the quality of welded joints and copper alloy fittings can be selected to avoid dezincification.

The mechanism which protects copper from corrosion is the formation of a copper oxide on the metal surface. There are very few sources of fresh water which are sufficiently aggressive to prevent the formation of this oxide film. However, where such conditions do exist they are generally known locally and preventive action can be taken when the unit is first installed. The correct procedure is to fit an aluminium anode in the base of the cylinder. This sacrificial anode deposits an aluminium compound on the copper surface, which gives permanent protection and does not require further anodes to be fitted.

## Steel Copper Lined

The fabrication of large high pressure cylinders from solid copper is normally considered uneconomical and has generally been superseded by the alternative construction of steel shells lined with copper. This arrangement combines the strength of a steel vessel with the superior corrosion resistance of copper. It is essential that the copper lining is absolutely waterproof and the 'Rycolyna' technique developed by Rycroft has proved most reliable for many years. The recommended thickness of lining for the shell is 1.6mm (3lb/sq.ft.) and this increases with the shell diameter. The lining is attached to the steel shell at points around the circumference and is pulled back by vacuum during manufacture to produce a good fit. Joint construction is such that longitudinal and lateral movement due to temperature and pressure changes can be accommodated without additional compensation.

An anti-vacuum valve is fitted to all copper lined shells. This valve prevents partial vacuum from forming in the shell during drain down or unusual operating conditions.

## Galvanised Steel Shells

The coating of steel with zinc by hot dipped galvanising or by metal spray has proved good protection for hot water storage cylinders over many years providing the water is hard. It is essential that a deposit of lime forms rapidly on the surface with the galvanised parts before the zinc is dissolved or deposited in other parts of the system by electrolytic action. Local knowledge will generally decide whether a galvanised cylinder is suitable for the water conditions on site, but guidance from the water supply authority should be sought if there is any doubt.

To extend the life of the zinc coating and allow further time for the scale deposit to form cylinders are supplied with magnesium anodes. This disposable element is mounted inside the shell to be sacrificed by electrolytic action in preference to the galvanised surface. Once a satisfactory scale has formed the electrolytic action ceases and this can be checked by the continued presence of the wasted magnesium anode.



Hot dipped galvanised cylinders are coated by immersing the steel shell in a molten bath of zinc. When the vessel is too large for this dipping process the zinc can be applied by hot metal spray. The technique is well proved and conforms to BS 2569. The life of a steel calorifier sprayed with zinc is comparable to a galvanised unit. The use of copper pipework in association with a galvanised cylinder is to be avoided, particularly on the hot water side if there is a secondary return to the shell. Apart from electrolytic action between copper and galvanised steel connections there is a serious risk of damaging the zinc surface. This is caused by minute particles of dissolved copper settling on the galvanised surface and producing local cells which dissolve the zinc coating and expose the steel shell beneath.

### Warning

Galvanised steel cylinders rely upon hardness salts in the water to form a protective scale. Galvanised cylinders are therefore not suitable for use with soft water. Water supplies which have traditionally been hard and satisfactory may now prove unsuitable due to changes in source.

It is therefore wrong to assume a replacement cylinder will necessarily have the same life as the original unit. With all new galvanised cylinders secondary temperatures should not exceed 60°C until a protective scale has formed and combination with copper pipework should be avoided.

Less than 0.1 part per million of copper in the water is sufficient to cause pitting corrosion and the degree of copper solvency is increased with hot water. The risk of pitting corrosion with hard water can be reduced by fitting a sacrificial anode.

The use of a copper heater with a galvanised cylinder does not present the same problem because the heated element is quickly oxidised and coated with a deposit of hardness salts. It is therefore quite normal for copper heaters to be fitted to galvanised cylinders.

Other shell materials such as austenitic and duplex stainless steels, copper-nickel alloys and epoxy coatings are also available for special applications.

The following materials are available:

Standard shells are manufactured from

Copper	BS 2870-C 106
Steel	BS 1501-151 / 161-430A
Galvanising	BS 2569
Austenitic Stainless Steels	BS IS01-316 S11
Duplex	SAF 2304
Cupro Nickel	BS 2871

### Stainless Steel

Austenitic Stainless Steel 316L is suitable for storage calorifiers, it contains 18% Chromium, 8% Nickel, 2-3% Molybdenum and has a low carbon content 0.003% to improve corrosion resistance after welding. The passivity and general corrosion resistance of Austenitic stainless steel is well known but they do suffer from chloride attack. This can happen in the form of crevice, stress or pitting corrosion. Good manufacturing techniques and a correct post manufacture treatment to restore the stainless steel to its original properties can reduce the susceptibility but cannot completely prevent corrosion attack. Hot water containing quite small quantities of chlorides has been found to be quite aggressive to stainless steel at calorifier operating temperatures. Therefore unless local experience has shown that Austenitic stainless steel is suitable for storing hot water other superior grades of stainless steel, eg Duplex or other materials should be considered.



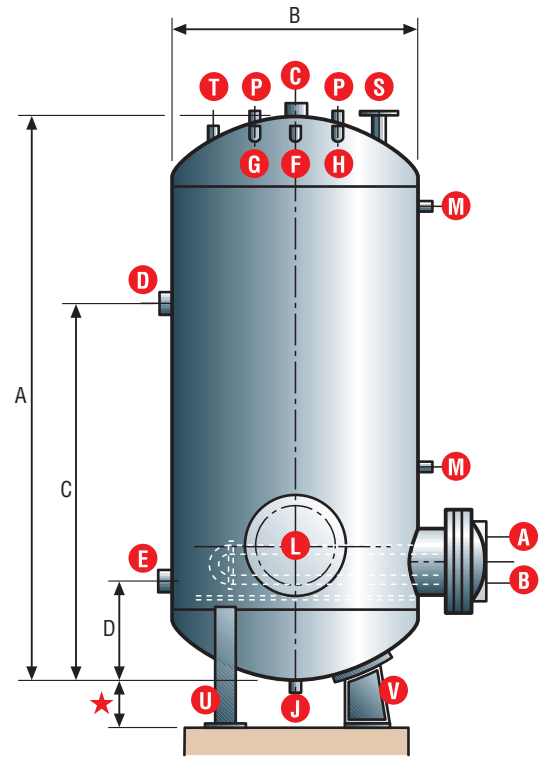
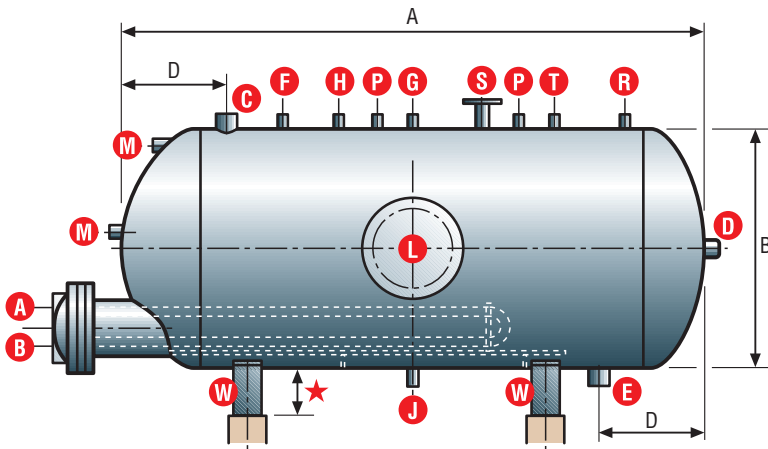
# Storage Calorifiers

## STANDARD CONNECTIONS

- A** Primary Flow or Steam
- B** Primary Return or Condensate
- C** Secondary Flow
- D** Secondary Return
- E** Cold Feed
- F** Thermometer
- G** Safety Valve
- H** Altitude gauge
- J** Drain
- L** Manhole
- M** Thermostat x 2
- P** Lifting Eyes x 2

## OPTIONAL CONNECTIONS

- R** Vent
  - S** Bursting Disc
  - T** Anti-Vacuum Valve
  - U** Typical Leg for Steel Vessel
  - V** Leg for Copper Vessel
  - W** Cradles
- Other connections available on request.  
★ Standard Cradle/leg height 150mm



CAPACITY Litres	DIMENSIONS (mm)				DRY WEIGHTS (kg)			
	A	B	C	D	Copper Test 1.5 bar Design 1.0 bar	Copper Test 2.5 bar Design 1.7 bar	Copper Test 4.0 bar Design 2.7 bar	Steel Test 4.0 bar Design 2.7 bar
440	1800	600	1350	250	115	125	140	250
550	1700	675	1150	300	130	140	160	240
700	1750	750	1150	300	155	155	190	280
800	1950	750	1300	300	160	160	200	300
900	2000	800	1350	330	185	195	225	335
1000	1950	850	1300	330	195	205	250	340
1200	2100	900	1400	345	225	240	280	395
1350	2350	900	1550	345	240	250	300	420
1500	1950	1050	1300	395	285	305	365	500
1800	2300	1050	1550	395	315	335	405	565
2000	2500	1050	1650	395	325	345	430	600
2300	2400	1150	1600	410	370	370	500	640
2500	2450	1200	1650	430	380	405	510	685
3000	2900	1200	1950	430	435	460	585	985
3500	2700	1350	1800	475	555	555	715	1025
4000	3050	1350	2050	475	580	600	770	1135
4500	3400	1350	2250	475	615	645	845	1240
5000	3200	1450	2400	500	685	755	964	1245
6000	3800	1450	2850	500	800	885	1130	1460
7000	3300	1680	2475	475	925	1010	1355	1830
8000	3700	1680	2850	475	1020	1120	1510	2050
9000	4200	1680	3150	475	1100	1210	1590	2230
10000	4600	1680	3600	475	1215	1340	1820	2490
12500	5000	1830	3750	550	1510	1780	2335	2825
15000	6000	1830	4500	550	1775	2100	2760	3310

The dimensions shown should be used for general information only and are subject to change at Rycroft discretion. Fully detailed drawings are produced for each order.

# Indirect Cylinders

Indirect cylinders fitted with double tube heaters are predominately used in low pressure systems up to a maximum design pressure of 3 bar. The double tube heater is made up of pairs of concentric copper tubes. The primary hot water flows down the annular space between each pair of tubes. The secondary storage water is heated by natural convection around the annular space. The tubes are joined together by horizontal manifolds top and bottom, which are connected to the primary circuit. The inner tubes of each pair extend beyond the two manifolds so that the secondary water can pass up the centre core. Double tube heaters are suitable for vertical or horizontal cylinders. Recovery periods from 20 minutes to three hours can be achieved. Primary pressure drops are comparatively low for this type of heater. On vertical cylinders the primary inlet is near the top of the cylinder and the primary outlet near the bottom. Horizontal cylinders have their primary connections in the top and bottom of the shell at opposite ends.

An extensive range of indirect cylinders is available with copper coils. This type of unit can be used for a wide range of pressures. Three diameters of copper coil are readily available, ie 20, 25 and 32mm. Larger diameters are available, please contact our sales department for details. All Rycroft coils are appropriately stayed to ensure trouble free operation. For large primary flows, double coil arrangements are also available. Coil connections are positioned on the same side of the cylinder.

## STANDARD CONNECTIONS

- A** Primary Flow
- B** Primary Return
- C** Secondary Flow
- D** Secondary Return
- E** Cold Feed
- F** Thermometer
- G** Safety Valve
- H** Altitude Gauge
- J** Drain
- L** Manhole

- M** Thermostat x 2
- P** Lifting Eyes x 2

## OPTIONAL CONNECTIONS

- R** Vent
- S** Bursting Disc
- T** Anti-Vac Valve

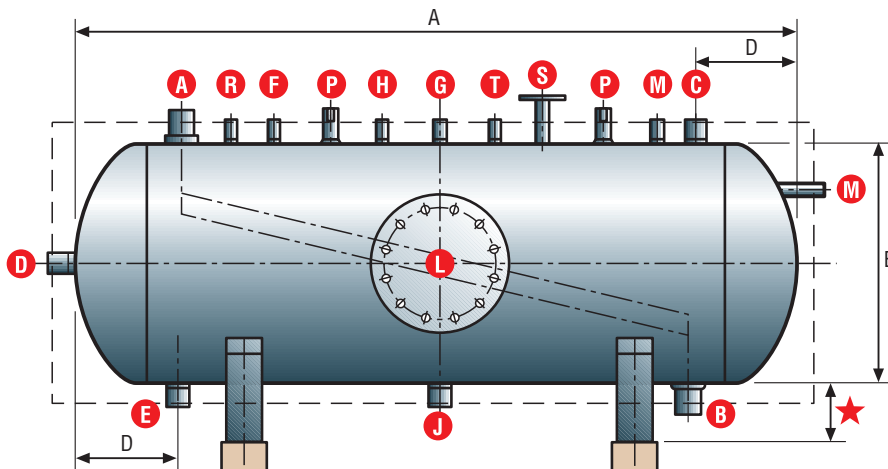
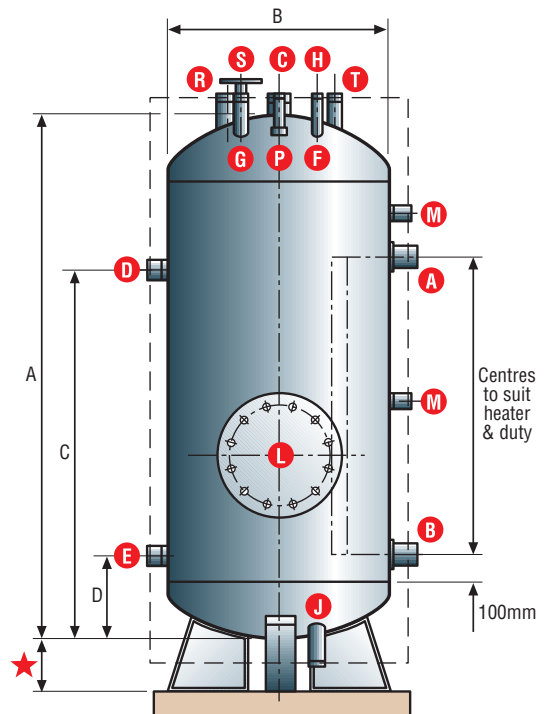
Other connections available on request.

★ Standard Cradle/Leg height 150mm

Capacity (Litres)	Dimensions (mm)				Weight (kg)*	
	A	B	C	D	Dry	Wet
440	1800	600	1350	250	140	580
550	1700	675	1150	300	160	710
700	1750	750	1150	300	190	890
800	1950	750	1300	300	200	1000
900	2000	800	1350	330	225	1125
1000	1950	850	1300	330	250	1250
1200	2100	900	1400	345	280	1480
1350	2350	900	1550	345	300	1650
1500	1950	1050	1300	395	365	1865
1800	2300	1050	1550	395	405	2205
2000	2500	1050	1650	395	430	2430
2300	2400	1150	1600	410	500	2800
2500	2450	1200	1650	430	510	3010
3000	2900	1200	1950	430	585	3585
3500	2700	1350	1800	475	715	4215
4000	3050	1350	2050	475	770	4770
4500	3400	1350	2250	475	845	5345

The dimensions shown should be used for general information only and are subject to change at Rycroft discretion. Fully detailed drawings are produced for each order.

\* Weights are approximate and based on 2.7 bar design and 4.0 bar test copper vessels.



# Buffer Vessels

## Domestic hot water systems

There are occasions when a storage vessel is required without an internal heater. A typical example is a cylinder added to a domestic hot water service to provide extra storage capacity.

When coupled with instantaneous water heaters buffer vessels are generally connected in parallel. Pump circulation is required to ensure a flow between the buffer vessel and water heater.

## Chiller systems

In this application buffer vessels are used to prevent rapid cycling of the chiller sets. The vessels are located between the chillers and distribution system.

Special consideration must be made regarding the type of insulation material used. Rycroft can supply various insulation combinations for this application. For additional information please contact our sales office.

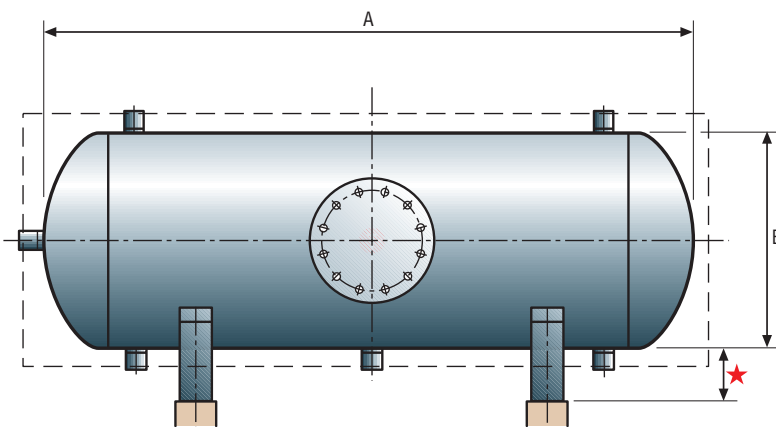
## Materials of construction

Buffer vessel material selection must complement that of the entire system. The design and fabrication of the shell is generally similar to an indirect cylinder and constructed in accordance with BS 853.

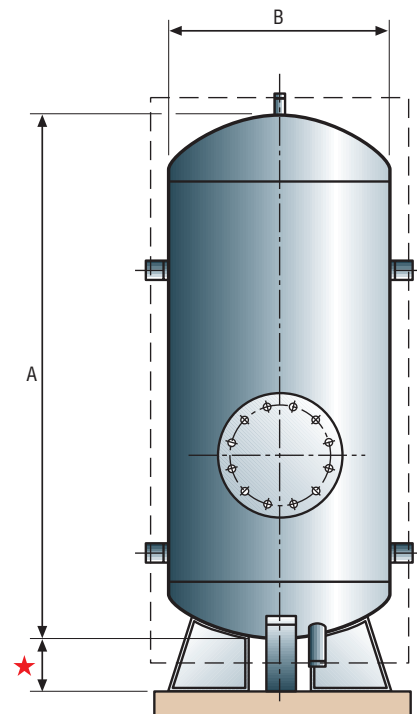
Capacity (Litres)	Dimension (mm)		Weight (kg)*	
	A	B	Dry	Wet
440	1800	600	140	250
550	1700	675	160	240
700	1750	750	190	280
800	1950	750	200	300
900	2000	800	225	335
1000	1950	850	250	340
1200	2100	900	280	395
1350	2350	900	300	420
1500	1950	1050	365	500
1800	2300	1050	405	565
2000	2500	1050	430	600
2300	2400	1150	500	640
2500	2450	1200	510	685
3000	2900	1200	585	985
3500	2700	1350	715	1025
4000	3050	1350	770	1135
4500	3400	1350	845	1240
5000	3200	1450	964	1245
6000	3800	1450	1130	1460
7000	3300	1680	1355	1830
8000	3700	1680	1510	2050
9000	4200	1680	1590	2230
10000	4600	1680	1820	2490
12500	5000	1830	2335	2825
15000	6000	1830	2760	3310

The dimensions shown should be used for general information only and are subject to change at Rycroft discretion. Fully detailed drawings are produced for each order.

\* Weights are approximate and based on 2.7 bar design and 4.0 bar test copper vessels.



Typical horizontal buffer vessel arrangement.



Typical vertical buffer vessel arrangement.

★ Standard Cradle/Leg height 150mm.



# Heat Exchanger Types

## U-Tube Battery = Calorifier

This is the most common type of heat exchanger used in calorifier manufacturing. High efficiency tubes unaffected by thermal expansion provide extremely high levels of reliability. To ensure a high heat transfer capacity a wide range of multi-pass exchangers are available.

Standard bundle arrangements are manufactured from 20mm tube although other diameters are used depending upon the duty requirement. Finned and plain tube options enable Rycroft to offer economic solutions to meet the most demanding duties.

Tubes are generally expanded into the tube plates and do not require sealing gaskets or ferrules. For high pressures and temperatures doubled grooved tube plates are offered.

For tube bundles with straight lengths greater than 1250mm support baffles are fitted as standard.

In order to ease disassembly batteries greater than 380mm in diameter are fitted with a tapped hole to accept a lifting eye. In addition runner wheels, collar bolts and starting screws can be supplied.

Tubes are available in copper, stainless steel, 90/10 and 70/30 Cu-Ni.

## Double Tube Heaters = Indirect Cylinder

Double tube heaters have replaced annular heaters. Whilst retaining low primary pressure drops and double sided heating surfaces, double tube heaters are of a much stronger construction. The heater is manufactured from pairs of concentric copper tubes and the primary water circulates through the annular spaces with collection headers at the top and bottom of the assembly.

By varying the length and number of tubes a wide range of heating surfaces can be fitted using standard components to construct the different headers. The secondary water is heated by natural convection with an added boost to the water passing the inner tube. The overall heat transfer rate is considerably greater than that achieved by a single annular heater and recovery rates in the order of 20 minutes can be achieved.

Double tube heaters are generally used for low pressure applications where the removal of the heater is not required.

## Copper Coil

Generally produced from a single tube formed into a helical coil and can operate at a greater pressure than a double tube exchangers.

Unfortunately as the cylinder size increases the length of heating coil becomes disproportionately greater and this heater is therefore only practical for moderate size cylinders.

The single coil is particularly useful for small flow rates with a large temperature drop such as those found in waste heat recovery and solar heating installations. Double coils are available for low pressure drop applications.

Coils are able to withstand high working pressures. They can be safely used for high temperature water systems operating up to 200°C and in small cylinders for high pressure steam applications.

## Plate Heat Exchangers

Plate Heat Exchangers are compact and assembled from pressed stainless steel plates. Standard material for plates is 316L stainless steel. The plates are held in the exchanger by two methods, brazed and gasketed.

In brazed exchangers the stainless steel plates are copper brazed together to form a very compact and economic design suitable for pressure and temperature limitations 30 Bar g, 185°C.

Gasketed plate exchangers use a gasket to seal the plate gap. The gasket is glued to the plate. The plates can be easily removed for cleaning or maintenance. Maximum design pressure and temperature is dependent upon the frame rating, plate thickness and type of gasket selected. Refer to Supapac catalogue for further information.

### The plate exchanger offers the user several advantages.

In areas where maintenance space for 'U' tube withdrawal is limited then a plate heat exchanger offers a practical alternative.

A plate heat exchanger can be serviced without any special tools or requiring heavy lifting tackle.

If at a later date the design duty has increased then the plate pack can be easily extended by the addition of plates to increase the output for gasketed unit or replaced by a brazed unit with a larger plate pack.

U-tube batteries, double tube and coil heaters rely on hot water convection currents to distribute the hot water within the storage volume. Plate heat exchangers will require a pump to circulate water from the storage volume and through the exchanger. A plate heat exchanger coupled with a pump on the cylinder side can offer an economic high output calorifier.

## Selection Guide

Exchanger Type	Max. Design Pressure	Max. Design Temperature	Exchanger Material	Serviceability	Primary Medium	Typical Applications
Double Tube	3 Bar g	95°C	Cu	Nil	Water	Standard indirect cylinders, hourly recovery
Coil	10 Bar g	200°C	Cu, 316L	Nil	Water, Oil, Steam, Refrigerant	Indirect cylinders, higher recovery rates, solar heating
'U' tube	30 Bar g	300°C	Cu, 316L, 90/10 Cu.Ni, Steel	Good	Water, Oil, Steam, Refrigerant	Storage calorifiers, high recovery rate
Gasketed Plate	16 Bar g	120°C	316L, Titanium	Good	Water, Oil, Steam, Refrigerant	Waste heat recovery, high performance duties
Brazed Plate	30 Bar g	185°C	316L	Nil	Water, Oil, Steam, Refrigerant	Waste heat recovery, high performance duties

# Vented Calorifier Systems

As the name implies vented calorifiers are installed with an atmospheric open vent. This serves many purposes including:

- Release of air when it is displaced from the heated water.
- Free movement of air when the calorifier is filled or drained down.
- Change in volume of stored water when it is heated or allowed to cool down.

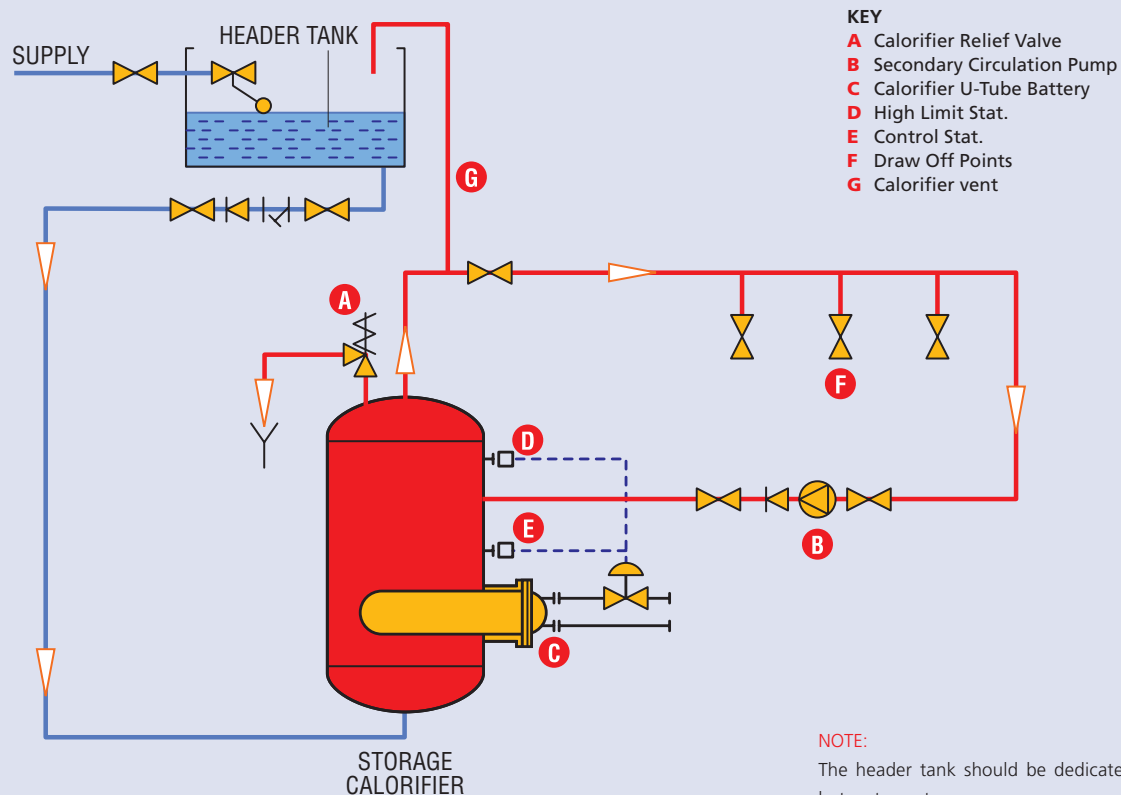
Ideally the vent pipe should extend vertically upwards from the calorifier. If horizontal displacement is necessary at some point an upward gradient should be maintained and the horizontal displacement kept as short as possible. Isolating valves must not be fitted in the vent.

When two or more calorifiers are fitted to the common vent, three way vent valves can be used. Installed correctly these valves can enable a single calorifier to be isolated from the system without closing the vent path. Please refer to the diagram below.

## Secondary Circulation

In order to meet the requirements of the CIBSE guide TM 13, hot water is generally circulated around the building to maintain the system temperature at a level which will not sustain Legionella bacteria. We recommend that the secondary circulation flow rate should not be greater than half the hourly duty of the calorifier.

## Storage Calorifier fitted in a typical vented DHW system



# Unvented Calorifier Systems

Unvented hot water systems have become extremely popular for building applications. With all the mandatory requirements addressed, unvented systems provide a highly efficient means of storing and distributing water.

The mandatory requirements for unvented systems can be found in the Building Regulations (1991–Second impression 1992) Section 3 and 4 of G3. Unvented systems have been divided into two categories labelled as Sections 3 and 4 of the G3 building regulations.

- Section 3 Systems up to 500 litres and 45 kW.
- Section 4 Systems over 500 litres or over 45 kW.

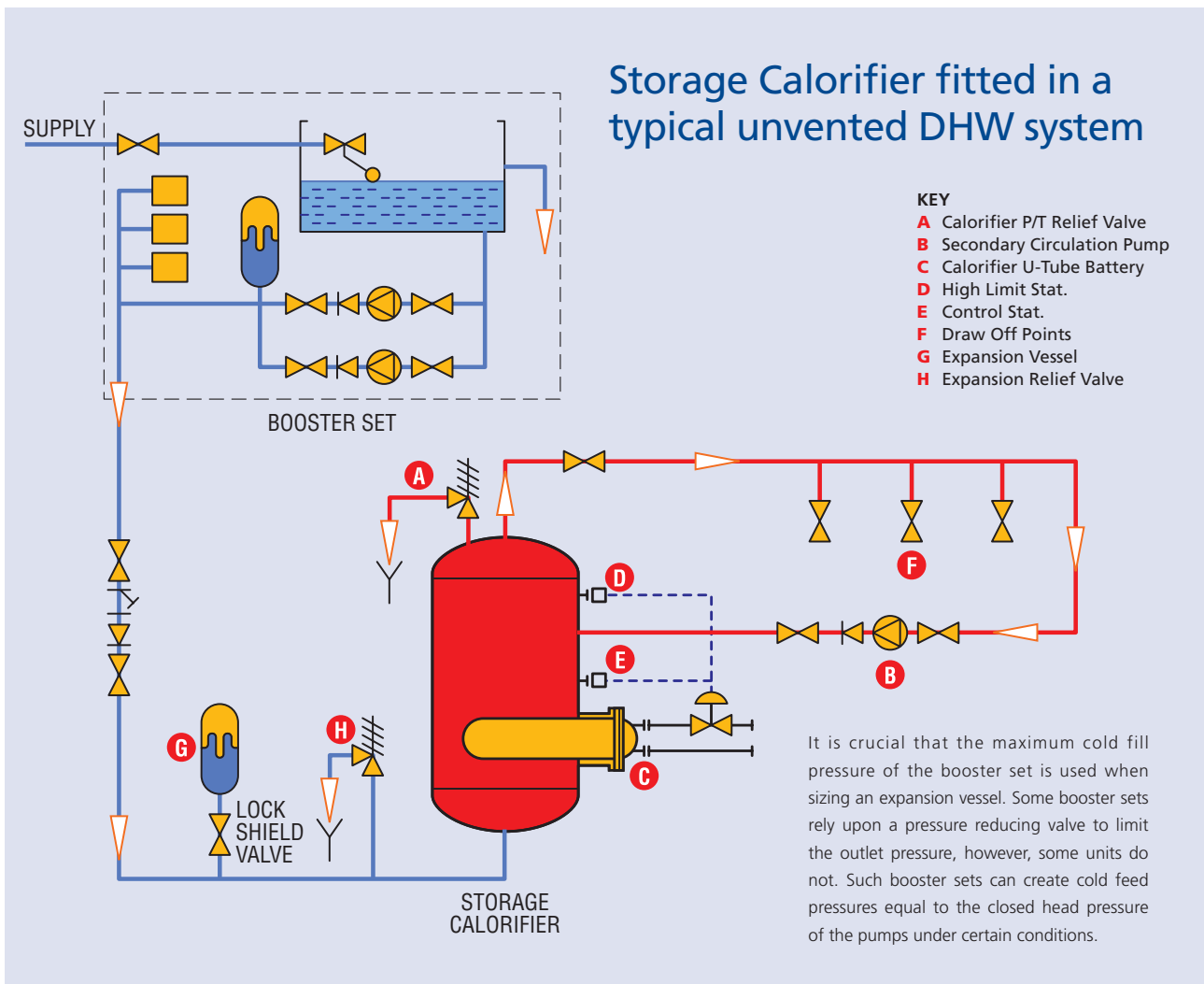
Section 4 Systems should comply with the requirements of BS 6700:1987 (Specification for the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages). BS 6700 Section 2.3.9.3.1. calls for calorifiers to conform with BS 853.

It is vitally important that the safety requirements of BS 6700 are met. Calorifiers must be fitted with the appropriate number of temperature pressure relief valves. G3 regulations require the safety devices to comply with BS 6283:1991 Part 2 or Part 3. The discharge ratings must be measured in accordance with BS 6283:1991 Part 2 App. F or Part 3 App G.

## Note

Most relief valve capacity charts refer to BS 6759. Reference to the valve manufacturer must be made to ensure ratings to BS 6283 are used.

Rycroft has vast experience in the design and manufacture of unvented systems. It should be remembered that it is frequently more economical to increase the size of the expansion vessel rather than the design pressure of the calorifier. For further details please refer to the unvented catalogue.



# Storage Capacity

THE TABLE OF DEMAND FACTORS PRINTED BELOW IS A GUIDE TO THE MAXIMUM HOURLY DEMAND FOR VARIOUS FITTINGS IN DIFFERENT ENVIRONMENTS. THE LOAD FACTORS GIVEN IN THE END COLUMN INDICATE TYPICAL DISTRIBUTION OF DEMAND. FOR EXAMPLE ALTHOUGH A HOTEL MAY POSSESS 100 BATHS IT IS UNLIKELY THEY WILL ALL BE USED IN ONE HOUR.

A storage capacity sufficient for one hour with a corresponding heater output is considered adequate for the majority of calorifier applications. If there is insufficient space for one hour storage volume the heater hourly rating should be increased slightly. Below 1/2 hour capacity consideration should be given to the installation of a Rycroft Maximiser.

Where space permits additional storage volume, it provides a useful reserve of hot water for service and maintenance. Dividing the load between two or more calorifiers is another means of safeguarding the supply and allows part of the system to be shut down during off peak periods.

Certain applications have no draw off for long periods and then experience a short heavy demand. The storage capacity in these circumstances is generally sized for the complete demand volume while the heater is rated for the long recovery period.

## Showers

Where the shower demand represents the major proportion of an hourly consumption, efforts should be made to obtain an accurate estimate of the total usage and the time span.

### Example:

A factory employs 20 men who all take a shower at the end of the shift. Each man uses approximately 50 litres of hot water at 65°C mixed with 30 litres of cold water at 10°C, and the entire shower takes 10 minutes.

$$\begin{aligned} \text{Total shower demand} &= 20 \times 50 \\ &= 1000 \text{ litres} \end{aligned}$$

If other hot water demands only amount to 500 l/hr a storage capacity of 1500 litres would be sufficient. It would be no use installing a storage calorifier with only a 1/2 hour capacity of 750 litres and a battery rated at 1500 l/hr.

## Maximum Demand Rates (litres/hour)

Installation	Private Hand Basin	Public Hand Basin	Shower*	Bath	Slop Sink	Bar Sink	Kitchen Sink	Pantry Sink	Laboratory Sink	Load Factor
Hospital	10	15	70	60	50		80			0.7
Hotel and Residential Hall	10	15	50	50	50	100	80			0.5
Day School	5	20	180		40		80			0.8
Sports Centre	5	15	220		40	100	80			1.0
Restaurant	5	25			100	100	140	120		1.0
University	5	20	220		40		80		40	0.8
Offices	5	10			40		40		40	1.0
Factory	5	20	120		50		80		40	1.0

\* Where a shower and bath are combined in a single cubicle it is only necessary to use one demand rate and the total number of cubicles.

## Example

200 Bedroom Hotel with Restaurant attached:

200 combined bath/showers	50 x 200	=	10000
200 private handbasins	10 x 200	=	2000
12 public handbasins	15 x 12	=	180
5 hotel slop sinks	50 x 5	=	250
5 hotel kitchen sinks	80 x 5	=	400
1 restaurant slop sink	100 x 1	=	100
4 restaurant kitchen sinks	140 x 4	=	560
10 washing machines 50 l/hr	50 x 10	=	500
	TOTAL	=	13990 l/hr
	Load Factor 0.5 x Hourly Rate	=	13990 x 0.5
		=	6995 l/hr

Using the estimated hourly demand of 6995 litres a calorifier with a storage capacity of 7000 litres and a battery rated at 7000 l/hr would be considered adequate. Greater flexibility would be achieved with two calorifiers, each 4500 litres and with heater batteries of 4500 l/hr output.

If storage space was limited to one calorifier of only 3500 litres capacity the battery rating should be increased to approximately 9000 l/hr.

# Connections

## Secondary Connections

All shell connections should be adequately sized to avoid disturbing the stratification, which retains hot water at the top of the cylinder. Under conditions of random usage it is recommended that the secondary flow and cold feed connections are based on the calculated hourly demand figures as listed in Table 1.

Where the demand is known to be short and heavy the secondary flow and cold feed connections should be sized from Table 1 using the expected peak demand figures in litres/second.

It is generally bad practice for the cold feed to be smaller than the secondary flow.

Avoid excessive secondary recirculation. The heat loss from a properly lagged service is quite small and the recirculation rate can be based on a temperature drop of approximately 5°C. For more specific information refer to CIBSE TM13.

Table 1.

Recommended Maximum Flow Rates for Secondary Connections			
Connection Size		Hourly Demand	Peak Demand
ins	mm	l/hr	l/s
1	25	150	0.1
1½	40	400	0.3
2	50	850	0.6
2½	65	1400	1.0
3	80	2500	1.5
4	100	5500	2.5
5	125	11000	4.0
6	150	20000	6.0

## Primary Connections

The size of primary pipework is determined by the flow rate and length of run between the boiler and calorifier. The connection to the calorifier chest however is frequently governed by the size of control valve fitted.

Wherever possible the chest connection is made to suit the plant layout but for primary water the inlet velocity should not exceed 2 m/s.

## Dimensions

The table of sizes given on pages 5, 6 and 7 represent the standard range of Rycroft calorifiers. They have the most economical dimensions and capacities but alternative sizes can be supplied for special purposes.

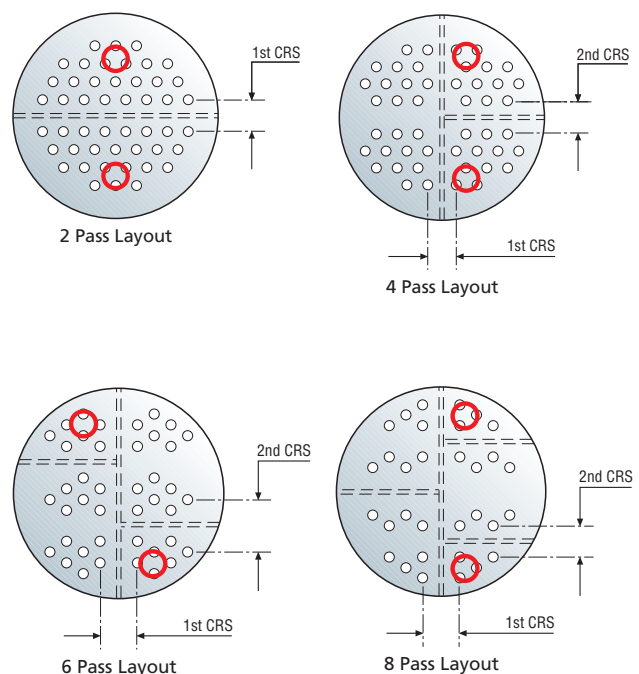
Floor area or limited head room may dictate the shell size. Where access is extremely limited it may be possible to supply a sectionalised cylinder for final assembly on site. Capacities beyond the range listed are readily available and the most economical dimensions will be supplied on request.

## Heater Battery

For steam and condensate the battery is a simple 2-pass U-tube battery. For primary hot water and oil the number of passes may be increased to raise the velocity in the tubes for efficient heat transfer.

The majority of heater batteries are constructed from finned tube. This extended surface reduces the overall size of the battery. Plain tube can be supplied and should be specified at the enquiry or order stage so that provision is made for fitting the larger battery. Plain tube will be recommended when the operating conditions are known to make it advisable.

Fig. 4 Tube Arrangements



# Accessories

## Pressure Temperature Relief Valve

Unvented calorifiers must be fitted with a pressure temperature relief valve to protect the system from excess temperature. The valve is tested to comply with BS 6283. The pressure and temperature elements of the valve operate independently providing dual safety protection in one valve. Temperature protection is provided by a wax capsule thermostat set at 95°C. All the valve wetted parts are manufactured from dezincification resistant materials, approved by Water Research Centre for use in potable water systems.

The valve discharge must be unrestricted and piped to a safe area.

## Anti-vacuum Valve

Copper lined vessels must be protected against partial vacuum so all Rycroft copper lined calorifiers are fitted with wafer type anti vacuum valves as standard.

## Bursting Discs

On indirect systems where a fluid primary working pressure exceeds the secondary design pressure a bursting disc must be fitted to the calorifier. It is extremely important that the discharge from the bursting disc is unrestricted and piped to a safe area. When using BS 853 as code of design, bursting discs are not required when the primary fluid is steam.

## Anodes

Sacrificial anodes can be supplied to counteract certain adverse water properties. Magnesium anodes help to protect galvanised cylinders whilst the initial deposit of scale forms on the shell. The combination of copper pipework and galvanised cylinders should be avoided. The life of the magnesium anode depends on the quality of the water and regular checks should be made to establish a service period.

Aluminium anodes can be fitted to copper cylinders to give lasting protection. This is only necessary for fresh water supplies which are known to prevent the formation of the natural protective oxide film. Aluminium anodes do not require replacement and are maintenance free.

## Expansion Relief Valve

On an unvented system a 20mm expansion relief valve must be fitted to the incoming cold water supply. Isolation valves must not be fitted between this valve and the calorifier.

The expansion relief valve protects the system from overpressure due to failure of the expansion vessel, ie loss of vessel air charge and/or damaged bladder.

## Expansion Vessel

All unvented systems must be fitted with devices to accommodate the expansion of water during the heating cycle. Rycroft offer an extensive range of expansion vessels fitted with replaceable EPDM bags. All Rycroft expansion vessels are WRC approved.

## Control Devices

Direct electric systems are fitted with control thermostats wired to a control panel. All other systems can be fitted with direct acting, electric or pneumatic control valves depending on the installation or clients' requirements.

## Pressure Reducing Valves

Pressure reducing valves maintain a constant cold fill supply pressure to the calorifier. This protects it from the cyclic operation of the booster set and any overpressure as the booster pumps charge accumulator vessels.

Pressure reducing valves are supplied with Water Research Centre approval in bronze and cast iron. Pressure gauges can be supplied on the inlet and outlet flanges for visual verification of pressure drop.

## Insulation

Adequate thermal insulation is essential to prevent unnecessary heat losses from storage calorifiers which may be standing for many hours at working temperature.

Rycroft standard factory-fitted type M insulation consists of 80mm thick fibreglass mattress compressed to 50mm thick which is closely fitted to the shell and encased in rigid galvanised mild steel sheets 1.6mm thick.

Norminal density: 95kg/m cu.

Thermal conductivity: 0.04 W/mK

Fire protection: BS 476:Part 4:1970 class I

Alternative insulating materials and aluminium or stainless steel cladding are also available.

## Calorifier Shunt Pump

The volume below a standard battery can become tepid under certain conditions. One method of counteracting this phenomena is to fit a shunt pump. This arrangement pumps hot water from the top of the calorifier and directs it to the volume beneath the tubular heat exchanger. This ensures the entire contents of the calorifier reach the prescribed storage temperature of at least 60°C, sufficient to destroy Legionella bacteria.

## High Limit Cut Out

Direct electrically heated calorifiers must be fitted with an independent high limit cut out device.

All other systems require an independent high limit thermostat directly connected to the control device or to an independent shut off device.

## Manhole

Calorifier access conforms to the minimum requirements of BS 853 unless specified otherwise.

## Booster Sets

Rycroft offer a wide selection of booster pump sets. Various forms of control are available including invertors. Pump arrangements include duty stand-by, duty and jockey and multi pump stations. Please contact our sales department for more details.

## Low Water Level Switch

We strongly recommend the fitting of a low water cut out device on all electrically heated calorifiers. This prevents the risk of switching the immersion heater on when the calorifier is empty.

## General Fittings

Temperature gauges complete with pockets.

Pressure gauges complete with gauge cocks.

Pressure gauge syphons.

Strainers, isolating, check, drain and pressure reducing valves.

## General

All unvented packages are supplied on a purpose made skid, manufactured from BS 4630-43A carbon steel RSC and totally decked. Standard skids are spray painted with protective black gloss. If required the skids can be painted to customers' specification.

## Booster Sets

Rycroft can offer a wide selection of cold water booster sets suitable for Marine, Offshore, Commercial, Industrial and Process application. The pump control methods available are conventional pressure switches or frequency convertor control (invertor) of the motor speed. Pump arrangements include single, dual or triple operating in duty standby mode or duty assist.

Pump materials: Stainless Steel, Cast Iron, Bronze.

Pipework choices: Plastic ABS, Galvanised Steel, Copper, Stainless Steel.

Build Standards: Commercial, Lloyds, American Bureau of Shipping.

All sets mounted in a purpose mild skid.

Please contact our sales department for further information.



# Control valve selection for Storage Calorifiers

A CONTROL VALVE IS DESIGNED TO REGULATE THE PRIMARY MEDIUM TO ACHIEVE THE DESIRED SECONDARY STORAGE TEMPERATURE. THE FLOWRATE OF THE PRIMARY MEDIUM IS DETERMINED BY THE STORAGE CALORIFIER RECOVERY TIME AND TEMPERATURE RISE REQUIRED.

This primary heat load of a storage calorifier can be determined from the simple formulae shown below.

## Calorifier Duty

$$\text{Duty (kW)} = \frac{\text{Storage Cal. Cap. Litres} \times \text{Spec. Heat Cap. kJ/kg C} \times \text{Temp Rise } ^\circ\text{C}}{\text{Recovery Time Seconds}}$$

The specific heat capacity of water is assumed to be constant at 4.187 kJ/kg C.

The required primary flowrate to achieve this recovery time can be calculated by the following:

## Primary Hot Water

$$\text{Mass flowrate kg/s} = \frac{\text{Storage Calorifier Duty kW}}{\text{Pri. Hot Water Temp. Diff. } ^\circ\text{C} \times \text{Specific Heat Cap kJ/kg/C}}$$

Typical Primary Hot Water temperatures are:

LPHW 82-71,  $\Delta T = 11^\circ\text{C}$ . MTHW 120-90,  $\Delta T = 30^\circ\text{C}$ . HTHW 150-110,  $\Delta T = 40^\circ\text{C}$

## Primary Steam

The primary steam flow rate is calculated on the hourly steam consumption.

$$\text{Mass flowrate kg/hr} = \frac{\text{Storage Calorifier Duty kW} \times 3600 \text{ seconds}}{\text{Steam Latent Heat kJ/kg}}$$

The steam latent heat energy is based on the steam pressure supplied to the calorifier chest.

## Control Valves

### Primary Steam Control Valves

Steam Control valves are generally sized to achieve a pressure drop across the valve of between 10-40% to ensure good valve authority. The control valve must not exceed the critical pressure drop. Beyond this critical point any pressure increase is dissipated as noise and cavitation without the flowrate increasing.

Table 1

Steam Inlet Pressure Bar g	Constant	Steam Inlet Pressure Bar g	Constant
1.0	0.0327	6	0.0181
1.5	0.0294	6.5	0.0175
2	0.0271	7	0.0171
2.5	0.0252	7.5	0.0166
3	0.0237	8	0.0162
3.5	0.0223	8.5	0.0157
4	0.0213	9	0.0153
4.5	0.0204	9.5	0.0150
5	0.0196	10	0.0146
5.5	0.0188	10.5	0.0143

As a quick guide the required control valve Kv can be calculated by the formulae below. Please confirm the control valve Kv and size with Rycroft prior to ordering.

$$K_V = \frac{\text{Steam flow quantity kg/hr} \times \text{Constant based on steam inlet pressure Bar g}}{\sqrt{\text{Required Pressure Drop in Bar}}}$$

See table 1 for Steam Constants to calculate control valve Kv.



## Sizing for Primary Hot Water Storage Calorifier

Primary Hot Water Control Valves are available in the following formats:

Two-port valves are generally used for controlling primary water from large distribution heating systems, eg District Heating, where the primary flowrate and return temperature must be as low as possible. The control valve authority is based on the circuit resistance, see Fig. 1 and Fig. 2.

Three port valves can be supplied with three plug arrangements, mixing, diverting and rotary. A Mixing valve is a three port valve with one outlet and two inlets, these valves are generally placed in the primary return line from the calorifier chest. A Mixing valve will ensure a constant volume of primary water through the calorifier at a variable temperature. Diverting three-port valves have one inlet and two outlets these are placed in the primary flow line to calorifier chest. See Figure X2 below. A diverting valve will ensure primary water at constant flow temperature to calorifier with variable flow. Rotary three-port valves are used as mixing valves.

Four-port valves have a rotary plug arrangement and are used in similar applications as three-port rotary valve.

**Control valve authority is calculated from:**

$$\text{Authority} = \frac{P_1}{P_1 + P_2}$$

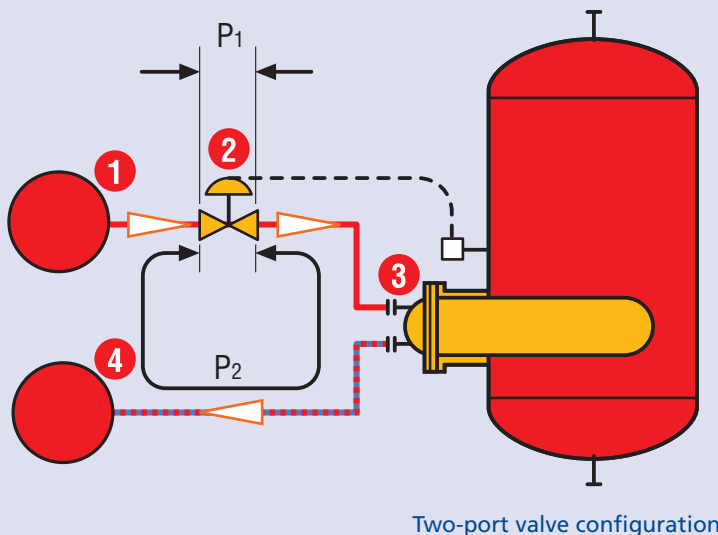
**P1** is the calculated pressure drop across the valve in the fully open position.

**P2** is the pressure drop in the part of the system being controlled where the flow varies.

Generally the valve authority should be between 0.3-0.7 to achieve stable control. For constant volume circuits the valve authority should be at least 0.5.

The diagrams show the control valve in a typical installation, additional valves such as flow regulators, differential pressure controllers and isolation valves have been removed for clarity. The resistance of these valves should be included in P2 calculation if applicable.

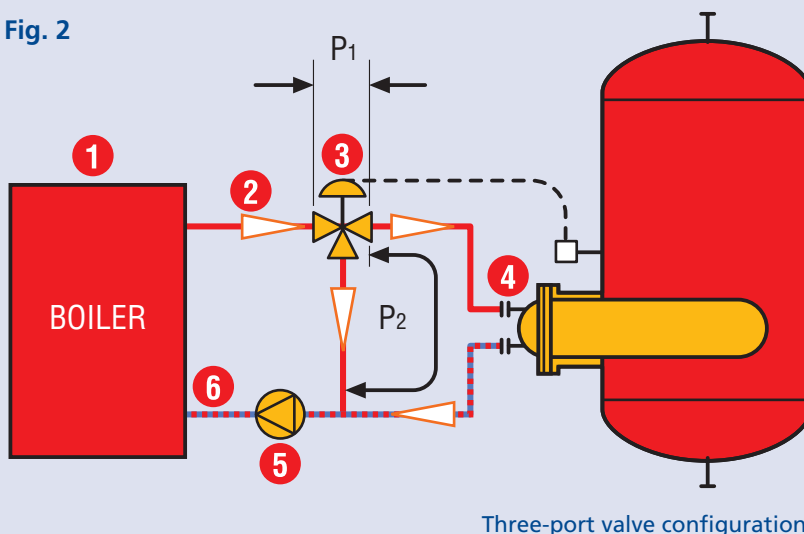
**Fig. 1**



1. Primary flow header
2. Primary control valve two-port
3. Storage calorifiers 'U' tube heat exchanger
4. Primary return header

P1 Pressure drop across fully opened valve  
 P2 Pressure drop across remainder of circuit

**Fig. 2**



1. Primary hot water source
2. Primary flow pipe
3. Primary control valve three-port. Diverting one inlet two outlets
4. Storage calorifier 'U' tube heat exchanger
5. Primary circulation pump
6. Primary return pipe

P1 Pressure drop across fully opened valve  
 P2 Pressure drop across remainder of circuit

# Calorifier Performance Testing

When a calorifier has been in service for several months the user may wish to check that efficiency is being maintained.

## A Simple Test

The output of a storage calorifier is normally defined by the time taken to heat the contents from cold feed temperature to storage temperature. The performance can therefore readily be checked by isolating the secondary flow and return and recording the time taken to reach storage temperature from cold.

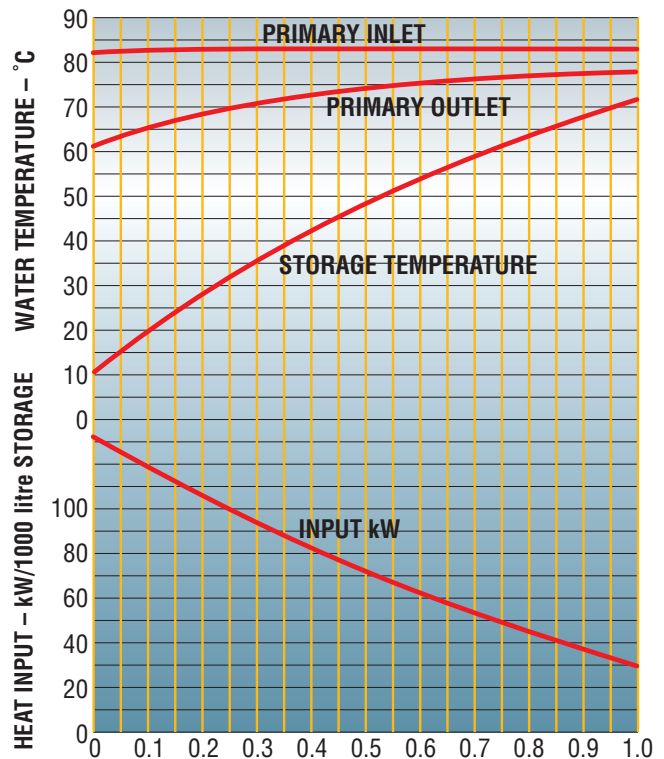
For this to be a reliable test it is necessary to see the primary flow temperature does not fall below the specified figure. Where possible the primary circulating rate should be checked against the calculated figure using a flow balancing valve or other measuring device.

## The Heat Up Cycle

As can be seen from the curves opposite the primary temperature drop and the calorifier output both vary throughout the cycle. They are greatest when the cylinder is cold and least when the storage temperature is reached. This change in output from the calorifier is reflected in the temperature rise of the secondary water which is steep at low temperatures and flattens out as the storage temperature approaches the primary temperature.

## A Quick Estimate

It is clear from these curves that any estimate of the calorifier's output based on the primary figures would be misleading. When primary inlet and outlet temperatures are specified the outlet temperature is only an average figure to enable the primary circulation rate to be calculated.



It would also be inaccurate to estimate the heat up time by recording part of the cycle and projecting the time scale in a linear manner. However, the logarithmic curve for secondary rise printed with this leaflet can be a useful guide to the heat up time, using the appropriate portion of the graph for the temperature rise recorded. Remember no draw-off or secondary recirculation can be allowed whilst these measurements are being taken.

## Check List

When preparing an enquiry or order for a calorifier the following check list will help to ensure all relevant data is received for a prompt service.

- Storage capacity
- Vertical or horizontal cylinder
- Shell material
- Any critical dimensions – height or length
- Storage temperature
- Time to heat contents or hourly draw off rate
- Primary hot water or thermal oil inlet and outlet temperature
- Steam pressure after the control valve
- Maximum pressure of primary system
- Maximum pressure on secondary side including any additional pump head on the cylinder
- Alternatively the design pressure at which any safety valve will be set.
- Size, type and position of any critical connections
- Details of connections for mountings and whether mountings or controls are to be supplied with the calorifier
- Requirements for a manhole
- Supply of loose cradles for horizontal cylinder
- Design to Ryco standard or other standard
- Use of finned or plain tubes
- Requirements for test certificates or independent inspection at Ryco Works
- Details of water if aggressive, brackish or impure and need for anode
- Supply of insulation and type of lagging
- Any additional heating capacity to allow for recirculation losses in secondary pipework

# Water Quality and Treatment

## Water Hardness

All waters contain dissolved substances. A large proportion of these dissolved substances are generally calcium and magnesium carbonates and sulphates. The concentration of these salts in the water define how hard water is: the greater their concentration then the harder the water, the smaller their concentration then the softer the water.

Generally, water which can be considered as slightly hard to moderately hard, in itself does not necessarily require the use of softening water plant. However, where water is heated electrically we must consider the effects on the immersion heaters and other components within the calorifier shell.

## Softening

Remove or replace Calcium and Magnesium salts with Sodium. This process employs beds of small resin beads which are chemically prepared and contain Sodium Ions such that when water containing Calcium and Magnesium passes through the bed, the beads allow an exchange between them and the Sodium. Sodium Ions do not give rise to scale formation. This chemical exchange continues until the supply of Sodium Ions runs out and the bed is described as being exhausted.

The unit is then taken off line backwashed to remove any suspended matter collected in the preceding run, then regenerated with 10% brine (Sodium chloride solution). This brine treatment replenishes the resin with Sodium and drives off the previously accumulated Calcium and Magnesium Ions to drain.

Brine solutions are made by dissolving salt in predetermined volumes of water between regenerations. Typical periods for plant to be on line would be 10-12 hours, with regenerations taking about 1.5 hours. Base exchange softening is the most widely used process to soften water – it is not considered to constitute an environmental risk.

Softening is used within such industries as Laundries, Hotels and the Home, where a relatively cheap supply of soft water is required.

## Chemical Conditioning

Instead of replacing or removing Calcium it is possible to make the Calcium less available for formation of deposits. This can be achieved by adding to the water Polyphosphates in a liquid or solid form. The effect of this is to cause the water to behave in some ways as if it has been softened, although the water is not softened in the true sense of the word. (Removal or replacement of Calcium.)

## Warning

Some people have skin which is sensitive to Polyphosphates.

## Physical Conditioning

There are a number of devices on the market which generate a magnetic or electrical field for the water to pass through. Some of these devices must be plumbed in the pipework. It is important to know that the chemical composition is not changed, salts may precipitate when the water is heated.



- SUPAPAC Plate Heat Exchangers
- Shell and Tube Heat Exchangers
- COMPAC Plate Heat Exchanger Packages
- MAXIMISER Semi-Storage Calorifiers
- Calorifiers/Cylinders
- Unvented Packages
- Pressurisation
- Electric Water Heaters
- Rycroft Process Solutions

Airtrend Limited  
 27 Eyre Court  
 Finchley Road  
 London NW8 9TT, UK  
 Tel: ++ 44 20 77224277  
 Fax: ++ 44 20 75867357  
 E-mail: airtrend@airtrend.co.uk  
 Web: www.airtrend.co.uk

Airtrend Limited  
 Representative office  
 Kumanovska 14  
 11000 Belgrade, Serbia  
 Tel: +381 11 383 68 86  
 Fax: +381 11 344 41 13  
 E-mail: gobrid@eunet.rs  
 Web: www.airtrend.rs



**Rycroft**  
 HEATING THE WORLD'S WATER

