HOT WATER ASSOCIATION SPECIFICATION

HWA 001:2012

Stainless Steel Vented Cylinders for Domestic Purposes

Specification of Requirements and test methods

August 2012 Edition

Foreword

This publication (HWA 001:2012) has been prepared by industry experts as a new specification to cover stainless steel vented cylinders.
These products are alternatives to copper vented cylinders thus their performance requirements closely mirror those of BS1566-1, Copper Cylinders for domestic purposes and wherever possible use similar test methodology and apparatus so that their hot water and energy performance can be directly compared with the copper alternatives.
The specification allows for two types of cylinder. Cylinders without an internal primary heater are classified as Direct and those with a primary heater as Indirect.

Installation Notes

a) In order to comply with Part G Building Regulations these cylinders must be installed with a suitable open vent to atmosphere. It should be noted that these cylinders are NOT designed to be used as part of an unvented storage system.

b) Cold feed cisterns and their installation must be fully compliant with the guidance in Part G Building Regulations

c) Immersion heaters shall be fitted with non auto resetting energy cut-outs and be manufactured from suitable materials such as stainless steel (e.g Incoloy) or titanium.

d) Cylinders with a 19 mm minimum internal diameter draw off and vent connection are limited to a maximum heat input of 45kW.

1 Scope

This specification covers the requirements for open vented vertically mounted stainless steel cylinders for the storage of hot water where the water is either heated indirectly by primary water using pumped circulation in an integral primary heater and/or directly via either an external heat source or an electric immersion heater subsequently fitted inside the cylinder.
The scope of this specification is limited to nominal storage capacities of up to and including 500 litres and primary heat inputs of up to and including 45kW.
The specification includes the possible provision of one or more additional integral primary heaters for use with a second primary source such as a second boiler, thermal solar panel or heat pump. This specification does not permit the use of single feed primary heaters.

2 Terms and Definitions

For the purposes of this specification, the following terms and definitions apply.

2.1 cylinder

closed cylindrical vessel for the heating and storage of hot water

2.2 nominal storage capacity (Gross capacity)
total volume of water, in litres, that can be stored in the cylinder including the volume of water in the primary heater.
Note: Sometimes referred to by manufacturers as Specified or Rated Capacity.

2.3 net storage capacity
total volume of secondary water, in litres, that can be stored in the cylinder, excluding the volume of the primary water heat exchanger/s in cylinders with indirect heat exchangers.
Note: Sometimes referred to by manufacturers as Measured Capacity

2.4 hot water capacity
maximum volume of water that can be heated by the heat sources as measured in Annex A

2.5 dedicated solar volume
In cylinders with additional primary heaters this is the volume of water which can only be heated by means of the solar input minus the volume that can be heated by means of the backup heat sources.

2.6 model range
cylinders which share the same common diameter, heat exchanger design (where applicable) and general overall configuration.

2.7 primary heater
heat exchanger/s mounted inside a cylinder for the transfer of heat from the primary water to the stored water.

2.8 primary water
water circulating through the primary heater in indirectly heated cylinders.

2.9 reheat performance
primary heater performance measured in Kilowatts

2.10 cylinder maximum working head
The maximum permitted working head of the cylinder in metres as declared by the manufacturer , the minimum value shall be 10 metres.

2.11 primary heater maximum pressure
The maximum permitted pressure of the primary medium in bars as declared by the manufacturer , the minimum value shall be 3.5 bar.

3 Information to be supplied by the purchaser

The following information shall be supplied by the purchaser at the time of enquiry or order.

a) the nominal storage capacity in litres
b) the maximum working head of cylinder in metres
c) the designation and height above datum of any connections if other than those indicated in the manufacturers published product specification.
d) the internal working pressure of the primary heater if greater than 3.5 bar

4 Connections

4.1 General
Connections shall be either threaded or plain.

4.2 Secondary feed (cold water inlet)
All cylinders shall have a secondary feed to deliver cold water into the cylinder. The designation and height above datum (normally lowest point of cylinder and/or casing) shall be clearly indicated in the manufacturers literature unless otherwise specified by the purchaser .

4.3 Hot water draw off connection and cylinder vent
All cylinders shall have a hot water connection of at least 19 mm internal diameter , positioned at the highest point of the cylinder.

4.4 Primary flow and return connections
Indirect cylinders shall have primary flow and primary return connections The designation and height above datum shall be as clearly indicated in the manufacturers literature unless otherwise specified by the purchaser .

4.5 Secondary return connection
When required the designation and height above datum shall be as clearly indicated in the manufacturers literature unless otherwise specified by the purchaser .

4.6 Drain connection
All cylinders shall have provision for draining off at least 85% of their nominal storage capacity. This shall be achieved either by means of a separate drain connection or by means of a drain tap subsequently fitted on installation to the cold feed connection.

4.7 Immersion heater connection
One or more connections may be provided for fitting an immersion heater or heaters. The type of connection must be clearly indicated in the manufacturer's literature.
Where a top mounted immersion heater connection is provided it should be fitted such that it does not produce an air pocket in the cylinder.
Immersion heaters shall be manufactured from suitable materials such as stainless steel (e.g Incoloy) or titanium and a warning label to this effect shall be attached next to the connection . See clause 14.2

5 Tolerances

5.1 Dimensions
For all cylinder types the tolerance on the specified cylinder height, diameter and connection positions shall be ± 6 mm.

5.2 Volumes
For all cylinder types the tolerance on the declared net and gross capacities shall be ± 5%

6 Manufacture

6.1 Materials in Contact with Drinking Water

All materials in contact with water must not adversely effect the quality of water and shall comply with the UK Regulatory Requirements e.g Water Supply (Water Fittings) Regulations 1999

6.2 Cylinder construction

The cylinder complete with insulation if factory fitted , shall be self supporting on a level surface when mounted in a vertical position such that, when empty, it is able to resist tilting of up to 5 degrees from the vertical without falling over.

6.3 Method of manufacture

Cylinders to this specification shall utilise welded construction, the use of brazing or soldering is not permitted on any joint exposed to either primary or secondary water.

7 Standing heat loss

If cylinders are supplied factory insulated then they should carry a declaration of standing heat loss in kWh/day as measured in accordance with Annex B.

8 Nominal storage capacity (Gross)

The nominal storage capacity of all cylinders shall be measured in accordance with A.3.1.1

9 Net storage capacity

The net storage capacity of all cylinders shall be measured in accordance with A.3.1.2

10 Hot water capacity

Cylinders shall be capable of delivering at least 75% of the net storage capacity above 40^{o}C when tested in accordance with Annex A.

11 Reheat Performance

For Indirect cylinders where net capacity *Vn* in litres is less than 200 , the ratio of *Vn* to heat exchanger performance (in kW) shall not exceed 10 ; eg a 150 litre cylinder shall have a minimum heat exchanger performance of 15 kW. Where *Vn* is 200 or above the cylinder shall have a minimum heat exchanger performance of 20 kW.

12 Pressure testing

12.1 Type Testing

After completion of fabrication but before insulation a sample cylinder shall be tested for a minimum period of 15 minutes at an inlet pressure of at least 1.5 times the maximum working head. After testing the cylinder shall show no leakage, cracking or significant permanent distortion likely to be detrimental to the products performance.

12.2 Production Testing

12.2.1 Internal pressure testing of primary heaters

Before assembly into the cylinders, all primary heaters shall be subjected to an internal test pressure of at least 1.5 times the declared primary working pressure and held at this pressure for at least 1 minute. After testing the primary heater shall show no leakage, cracking or significant permanent distortion likely to be detrimental to the products performance.

12.2.2 Internal pressure testing of complete cylinders

After completion of fabrication but before insulation the cylinder shall be tested for a minimum period of 1 minute at an inlet pressure of at least 1.5 times the maximum working head. After testing the cylinder shall show no leakage, cracking or significant permanent distortion likely to be detrimental to the products performance.

13 Designation of open vented stainless steel cylinders for ordering purposes.

13.1 Indirectly heated cylinders

For ordering purposes indirect cylinders shall be designated by the number of this specification “HWA 001:2011), followed by “V Ind” to indicate the cylinder type as vented Indirect. This shall be followed by the nominal storage capacity and final designation shall be the cylinder maximum working height in metres

e.g HWA 001:2011 V Ind 120L 10M

13.2 Direct Cylinders

For ordering purposes direct cylinders shall be designated by the number of this specification “HWA 001:2011”, followed by “V Dir” to indicate the cylinder type as Vented Direct .This shall be followed by the nominal storage capacity and final designation shall be the cylinder maximum working height in metres

e.g HWA 001:2011 V Dir 120L 10M

14 Marking

14.1Data Label

All cylinders shall have a label firmly stuck to the outside of the cylinder insulation or case, which shall be indelibly marked with the information specified below :-

a) the number of this specification i.e HWA 001:2012
b) the type of cylinder , i.e V Ind or V Dir
c) the nominal (gross) storage capacity in litres
d) the maximum working head of the cylinder in metres
e) the manufacturers name or identity mark
f) the net storage capacity in litres
g) the hot water capacity in litres
h) the number of primary heaters (if more than one)
i) For Indirect cylinders the maximum permissible internal working pressure of each primary heater in bars.

j) For Indirect cylinders the pressure drop through each primary heater in bars at a flow rate of 0.25 l/s
k) The standing heat loss in kilowatt hours per 24 hours (kW h/24) as determined by Annex B.
l) For Indirect cylinders the reheat performance in kilowatts for each primary heater as determined in accordance with Annex A. If more than one primary heater is fitted the reheat performance of the lower coil is quoted first.
m) For cylinders with additional primary heaters intended for solar use then the dedicated solar volume should be stated.
n) The thread sizes and maximum lengths for immersion heaters
o) A statement about suitable immersion heater materials.
p) A Safety warning that the cylinder must be vented to BS 6700 requirements

e.g Example of external marking label for an Indirect twin coil cylinder approx 1200 high by 450 diameter with a heat loss of 1.5 kWh/day . This information can be on one label as shown in the example below or incorporated into other labels provided the information is likely to be clearly visible on the installed cylinder.

The Stainless Steel Cylinder Company Ltd

HWA 001:2011 ,V Ind , 165L, 10M

Net capacity **160L**

Hot water capacity **119L**

Number of primary heaters **2**

Maximum working head **10 metres**

Maximum primary pressure **3.5 bar**

Primary pressure drop at 0.25 l/s flow , lower coil **0.5 bar** ,upper coil **0.25 bar**

Standing heat loss **1.5 kWh** per 24 hours

Reheat performance (at primary temperature of 80^{o}C and flow of 0.25 l/s)
lower coil **25 kW** , upper coil **17 kW**

Dedicated solar volume **105 L**

Immersion heater thread **G1 ¾** , max heater length **300 mm**

Immersion heaters shall be either stainless steel (e.g Incoloy) or Titanium

Screw in thermostats or thermostat pockets shall be either stainless steel (e.g Incoloy) or Titanium

Safety warning : the cylinder must be fitted with a vent pipe

14.2 Labelling of Immersion Heater Connection

A label should be affixed next to or around the connection stating that only stainless steel or titanium immersion heaters shall be fitted.

14.3 Labelling of Dedicated thermostat pockets (where designated)
A label should be affixed next to or around the connection stating that any pocket or thermostat in contact with the water shall be made of stainless steel.

Annex A
Type testing of cylinders for hot water performance

A.1 General
This annex specifies the test requirements necessary to determine:

a) the gross and net storage capacity of cylinders;

b) the hot water capacity of cylinders

c) whether indirect cylinders have a primary heater performance such that wastage of energy is minimized.

The testing of cylinders shall be carried out in accordance with Table A.1

Table A.1 — Type testing requirements for cylinders

Test Clause	Test	Indirect	Direct
A.3.1.1	Nominal storage capacity (Gross)	Yes	Yes
A.3.1.2	Net storage capacity	Yes	No
A.3.2.1	Primary heater pressure drop	Yes	No
A.4	Hot water capacity Indirects	Yes	No
A.5	Reheat performance	Yes	No
A.7	Hot water capacity from immersion heater	No	Yes
A.8	Hot water capacity from immersion heater	Yes	No

A.2 Apparatus for performance on pumped primaries (Fig A Applies)

1 *Cold feed cistern* , connected to a cold water supply with a temperature not exceeding 15º C and with a suitable means of filling (normally via a float operated valve), mounted at a suitable head above the cylinder to ensure that an adequate flow (at least 0.25 l/s) is available from the cylinder.

2 *Circulator* , capable of maintaining a primary flow of (0.25 ± 0.01) l/s to the primary heater.

3 *Primary Heat source* , comprising a thermostatically controlled heat source capable of providing a primary flow temperature of (80 ± 2)º C at 0.25 l/s to the inlet of the primary heater T1.

4 ***Weighing machine*** , fitted with a suitable container (with draining mechanism), capable of indicating the mass of hot water drawn off to an accuracy of ±1 %. If desired, an automatic system such as a data logger may be used to record the temperature/draw off data. It is essential that any such equipment has an accuracy at least equal to that specified for the weighing machine and temperature sensor.

5 ***The Cylinder under test,*** *for clarity the cylinder is shown unlagged in Fig A2 , the test will normally be carried out on a factory insulated cylinder.*

FL1 , FL2 ***Flow meters*****,** comprising a flow meter (FL1) calibrated for water at 80º C and accurate to ±0.01 l/s at a flow rate of 0.25 l/s. An optional second flow meter (FL2), calibrated for water at 60 °C is used to speed up calibration of the test rig.

V1 , V2 ***Primary By-Pass Arrangement*** , employing two full flow lever operated, quarter turn spherical valves.

V3 , V4 ***Flow control valves*** , comprising two needle valves or similar devices for regulating the primary and secondary flows respectively.

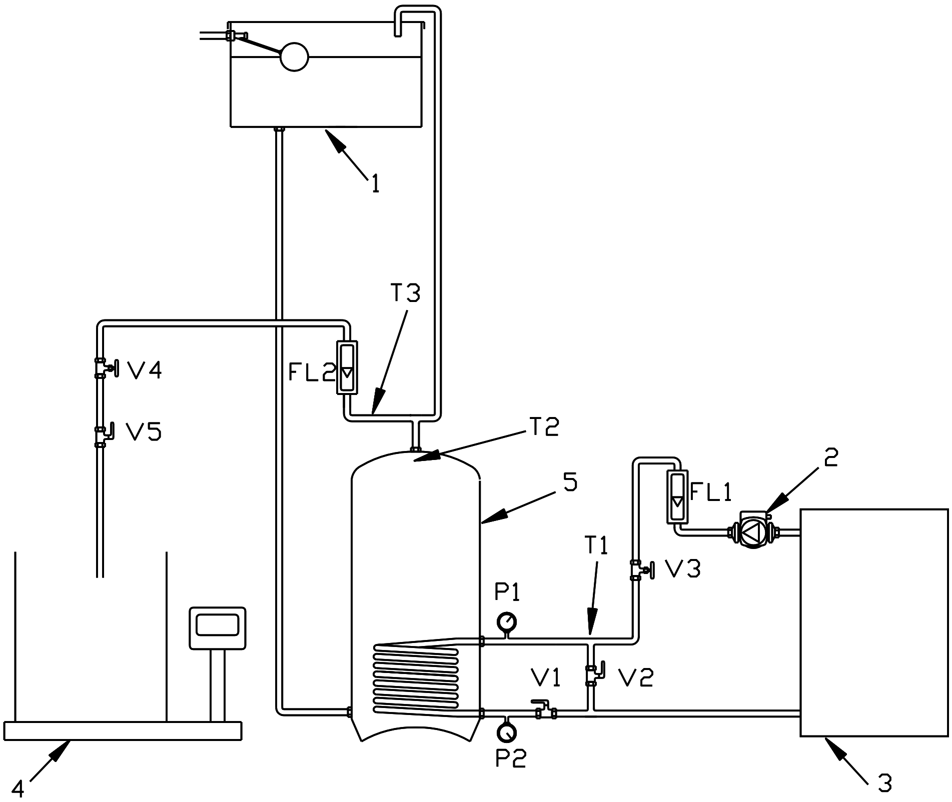
V5 ***Outlet valve*** , A full flow lever operated, quarter turn spherical valve.

P1, P2 ***Pressure gauges*** , two pressure gauges or equivalent device/s such as a differential manometer capable of measuring the pressure drop across the primary heater to an accuracy of ±2 %.

T1, T2, T3 ***Temperature sensors*** , comprising three thermometers or thermocouple type devices capable of measuring the temperature of water to an accuracy of ±1º C. The temperature sensors shall be positioned as follows:

- (T1) in the primary flow pipe from the circulator to sense the primary water temperature immediately prior to the tee off to the by-pass arrangement;
- (T2) inside the cylinder to sense the stored water temperature at a point 25 mm ± 20mm below the hot water outlet;
- (T3) in the outlet pipe, no more than 150 mm downstream from the cylinder outlet, to sense the temperature of hot water leaving the cylinder;

Figure A Apparatus



A.3 Procedure

A.3.1.1 Nominal (gross)_storage capacity
Weigh a cylinder without a primary heater (i.e Direct) cylinder empty, using a weighing machine capable of indicating the mass to an accuracy of ±1 % and record the mass. Fill the cylinder with cold water until it emerges from the hot water draw off pipe and weigh the cylinder again, recording the mass. The difference in mass between the full cylinder and the empty cylinder in kilograms is deemed to be the nominal storage capacity in litres.

A.3.1.2 Net storage capacity
Weigh the empty cylinder complete with primary heater/s (if indirect) using a weighing machine capable of indicating the mass to an accuracy of ±1 % and record the mass. Fill the cylinder with cold water until it emerges from the hot water draw off pipe and weigh the cylinder again, recording the mass. The difference in mass between the full cylinder and the empty cylinder in kilograms is deemed to be the nominal storage capacity in litres.

A.3.2 Hot water performance

Set up the apparatus for testing as shown in Figure A.1

Fill the primary heater and associated primary circuit and expel all excess air.

Switch on the primary heater and allow the primary water to heat up to a flow temperature of 80º C, as measured at T1, with valves V1, V2 and V3 open and any excess air allowed to escape.

Close valve V2, leave valve V1 open and adjust valve V3 to give a primary flow rate of 0.25 l/s through the primary heater as measured by flow meter FL1. Once this is achieved, open valve V2 and close valve V1.

Turn on the water supply to the cold feed cistern, open valves V4 and V5 and expel any excess air from the system until water flows freely from the cylinder outlet.

With valve V5 fully open, adjust valve V4 to give a primary flow rate of 0.25 l/s as measured either by flow meter FL2 or by timing the rate of increase in discharged water mass using a timer in conjunction with weighing machine . Once a flow rate of 0.25 l/s is achieved, close valve V5.

With valves V5 and V1 closed and V2 open, allow the primary heater to heat the water up to a primary flow temperature of 80º C.

Once stable primary conditions are established at 80 °C and 0.25 l/s, open valve V1 and then immediately close valve V2. Once the temperature of water at the top of the cylinder, as measured using temperature sensor T2, reaches 15º C start a timer for the reheat period. If necessary, adjust valve V3 to maintain a primary flow rate, as measured at FL1 of 0.25 l/s.

Note :- The test cycle shall only be started when the temperature of water as measured using temperature sensor T2 is between 13º C and 15º C. This might require fresh water to be drawn off via valve V5 or (in exceptionally cold conditions) the cylinder to receive a "pulse" of heat from the primary heater.

A.3.2.1 During the reheat period, record the pressure drop across the coil at P1 and P2 by calculating the difference between the readings.

A.3.2.2 Once the temperature of water measured using temperature sensor T2 reaches 60º C disconnect the heat source by opening valve V2 and immediately closing valve V1. Note the time taken for the temperature to reach 60 °C and record this as the reheat time t. Allow the system to stabilize for one minute.

One minute after closing valve V1 commence the draw off by opening valve V5. Measure the flow rate either by means of flow meter FL2 or by starting a timer as V5 is opened and using weighing machine W to record the mass. If necessary adjust valve V4 in order to maintain the 0.25 l/s flow rate. Record the temperature of the water drawn off in 5 l increments at T3. Once the water temperature at T2 drops to below 40º C then at the end of the 5 l increment when this occurs, immediately close valve V5.

A.4 Hot water capacity of Indirect Cylinders

The hot water capacity is derived from the hot water draw off profile as determined by the volume of water drawn off at above 40°C, this is determined as follows .
The hot water draw off shall be plotted graphically with draw off in litres plotted in 5 l increments on the horizontal axis, and temperature at T3 on the vertical axis.
If automatic recording equipment was used, a continuous plot can be substituted for the manual 5 l incremental plot.

For the cylinder to be deemed as satisfying the requirements of this specification then at least 75 % of the net storage capacity (as measured in accordance with A.3.1b) shall be drawn off as hot water at 40º C or above. The Hot Water capacity *Vh* is the volume drawn off at 40º C or above as determined by reference to the graph of the draw off profile.

A. 5 Reheat performance of Indirect Cylinders

The reheat performance *P*, expressed in kilowatts, is given by the equation:

$$P = \frac{(T_{av} - 15) \times Vh}{14.3 \times t}$$

Where

T_{av} is the average temperature of the water drawn off at 40º C, established from the graph of the draw off profile;

Vh is the volume of water drawn off at 40º C or above (Hot Water Capacity)

t is the reheat time in minutes

A.6 Cylinders with additional primary heaters

Where the cylinder has more than one primary heater then the hot water capacity and reheat performance shall be determined separately for each primary heater.
For Solar cylinders the Dedicated Solar Volume can be determined by subtracting the hot water capacity determined from the top coil from the hot water capacity determined from the lower coil.
Where a range of cylinders is to be tested which are of constant diameter and utilise changes in height as a means of achieving different capacities then by agreement between the manufacturer and the test house, it is permitted to use calculation as a means of assessing the dedicated solar volumes of intermediate sizes.

A.7 Hot Water Performance of Direct Cylinders

The cylinder shall be heated using the immersion heater (lowest immersion heater if two are fitted) until the temperature at T2 reaches 60°C.
A hot water draw off shall be carried out in the same manner as for Indirect cylinders so that the volume of water at above 40°C may be determined.

A.8 Direct heating of Indirect cylinders for heat loss testing to Annex B

When used for heat loss testing for an Indirect cylinder (see Annex B) it must be demonstrated that during the heat loss test the immersion heater is positioned such that it is heating at least 75% of the net contents to an average of above 40°C.

Annex B
Measurement of Standing Heat Loss for factory insulated cylinders

This annex specifies the requirements for measuring the heat loss of vented stainless steel hot water cylinders.

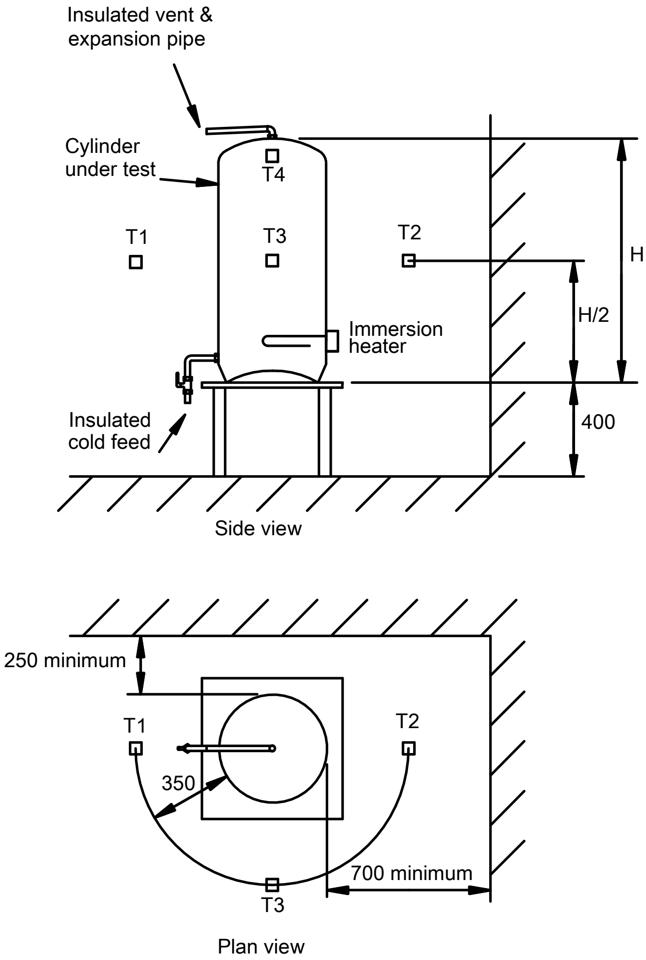
Where a range of cylinders is to be tested which are of constant diameter and utilise changes in height as a means of achieving different capacities then by agreement between the manufacturer and the test house, it is permitted to use interpolation as a means of assessing the heat loss of intermediate sizes. The heat loss of the largest and smallest model in the range shall always be measured plus at least one cylinder closest to the mid range of nominal capacities.

The test is carried out by heating the cylinder using an immersed electrical element (immersion heater) fitted horizontally into the cylinder at a height such that the requirements of A7 and A.8 are satisfied.
In the case of Direct cylinders the normal position as specified by the manufacturer shall be used even if it heats more than 75% of the net cylinder capacity. The immersion heater used for testing shall normally be rated at 3kW but for cylinders of above 250 litres capacity a higher output may be used if normally specified by the manufacturer. For Indirect cylinders the heat loss test is normally carried out on test cylinder without the primary heater such that the immersion heater shall heat 75% of the net capacity to an average of above 40^{o}C. It is important that apart from the possible omission of the indirect heating coil connections the insulation characteristics of the indirect test unit are as identical as possible to the production direct unit.

B.2 Apparatus (Fig B Applies)

B.2.1 *Cylinder support*
The unit to be tested shall be mounted on a base of at least 20mm thick medium density fibreboard at a height of (400mm ± 100mm) above floor level positioned such that there is al least 250mm behind the unit and at least 700mm from any wall or other vertical surface.

Fig B Standing Heat Loss Test Apparatus



B.2.2 *Test Connections*

The cylinder shall be provided with a means of filling with cold water and a vent/expansion pipe as shown on Fig B1. The expansion/vent pipe shall rise vertically from the top connection for no more than 35mm then branch sideways for a length equivalent to the cylinder radius plus 50mm. The sideways branch shall be sloped slightly downwards but by no more than 35mm.

In order to measure the temperature of stored water Tw , a sensor T4 shall be positioned such as to register the temperature at a point 25mm ± 20mm below the level of the hot water draw off. This can be inserted via a thermostat pocket fitted in the expansion vent pipe, or by a suitable contact probe on the vessel wall. The accuracy of all temperature sensors shall be ±1^{o}C.
During the test it will be necessary to control the temperature at Tw to 65^{o}C ± 3^{o}C , this may require an electronic thermostat which may either use the same sensor or an additional sensor mounted in the same vicinity.

Three additional sensors are required to measure ambient temperature , they shall be positioned at a height of half way up the cylinder wall and at a distance of 350 ±25 mm from the exterior of the unit under test. These sensors shall be positioned at the sides and front of the unit as shown in Fig B1.

During the test the ambient temperature as measured by the mean of readings taken at T1 , T2 and T3 must be 20^{o}C (+ 5^{o}C - 2^{o}C)

All four sensors shall be connected to a data logging device capable of recording the individual temperatures at intervals not exceeding 5 minutes.

In order to measure electricity consumption the supply to the immersion heater shall be connected via a kilowatt hour meter or equivalent device capable of measuring the electricity consumption with an accuracy of ± 0.01kWh.

B.3 Test Procedure

The cylinder to be tested is filled with cold water until it emerges from the vent and expansion pipe. Once excess air is expelled then the inlet valve is closed .
The immersion heater (or external circuit) is then switched on and the temperature of the stored water brought up to 65^{o}C ± 3^{o}C.
At this point the data logging shall begin to monitor all changes in temperature.

The test unit is then allowed to stabilise under thermostatic control for a period of at least 24 hours.

After the 24 hour stabilisation period the cylinder temperature and control thermostat shall be monitored and the thermostat cycling time determined .If the cycling time is greater than one minute then at a point when the thermostat trips out (maximum temperature), a note shall be taken of the time (to the nearest minute) and the reading on the electricity meter noted.
If the cycling time is less than or equal to one minute then the meter reading can be taken without reference to the thermostat trip point.
The cylinder shall then be left to cycle on the thermostat for a minimum period of 72 hours . At the end of the 72 hour period then if the cycling time is greater than one minute then the system shall be closely monitored to determine the next time that the thermostat trips out (maximum temperature). The time shall be noted together with the electricity meter reading.
If the cycling time is less than or equal to one minute then the meter reading can be taken without reference to the thermostat trip point.

B.4 Calculation of Results

The difference between the two meter readings Q_m gives the power consumption during the test period . For systems where the cycling time is greater than one minute this will exceed 72 hours due to the wait for a suitable thermostat trip point and the meter reading needs correcting pro-rata for this additional period. No correction is required if the cycling time is less than or equal to one minute.

As an example if the measurement period was 74 hours and 6.5 Kwh of power was consumed then the corrected figure will be 6.5 x 72 ÷74 = 6.324 Kwh. (note that figures should be to at least three decimal points)
This corrected figure can now be divided by three to give the heat lost Q_c in kwh/day i.e 6.324 ÷ 3 = 2.108 Kwh/day .

The readings from the data logger should now be analysed in order to establish the mean temperature differential between cylinder temperature and mean ambient. This is calculated at each data logging interval (maximum of 5 minutes) as follows.

Differential at each interval is $Tw - ((Ta1 + Ta2 + Ta3) \div 3)$

The mean of all the differentials is calculated to arrive at an overall average differential Td.

Finally a correction is made for the difference between the nominal differential of 45^{o}C and the measured average differential Td.

Heat Loss $Q_{st} = Qc \times 45 \div Td$

The final figure of Q_{st} shall be rounded down for declaration purposes to two decimal points.