



System design

Fault finding

Jonathon Hallam

Disclaimer

The following information is a guide only
for training purposes, under no
circumstances will Jonathon Hallam or
Warriors of Warmth be laible for any
content

Happy to help, here to help

			Tools required for fault finding	
				
				
				



Tools required to be
an engineer

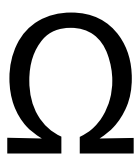
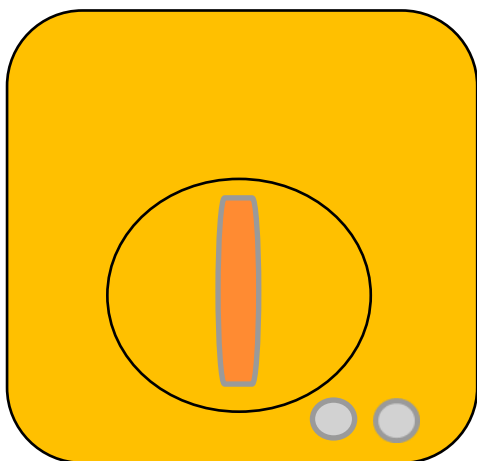
Disclaimer

It is illegal to work on gas appliances if you are not qualified or registered.

Do not work with electricity if you are not qualified

The following information is a guide for training purposes only. Under no circumstances will Warriors of Warmth or Jonathon Hallam be liable for any consequence relating to information from this booklet

Understanding your Multi meter



Permissionable allowance-



mA

μ A

k Ω

Com

NC

NO

Electrical safety



External fuse _____

Internal fuse _____

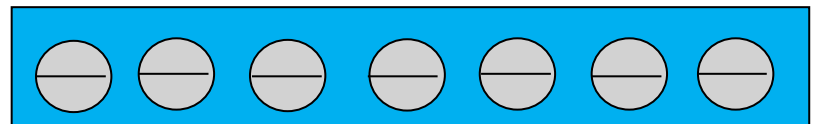




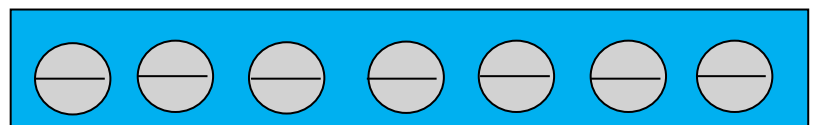
Methods of electrical testing



Earth to terminal



Terminal to terminal



Notes;



Ingression Protection (IP) Rating Chart

IP67

SOLIDS

Protection against solid object greater than 50mm	1
Protection against solid object greater than 12.5mm	2
Protection against solid object greater than 2.5mm	3
Protection against solid object greater than 1mm	4
Limited ingress of dust. Will not interfere with equipment	5
No ingress of dust permitted	6
Protection level not formally tested	X

1

2

3

4

5

6

X

1

2

3

4

5

6

7

8

9k

X

WATER

Protection against vertically falling droplets	1
Protection against vertically falling droplets when tilted up at 15°	2
Protection against spraying water up to an angle of 60°	3
Protection against splashes of water from all directions	4
Protection against low pressure jets of water	5
Protection against high pressure jets of water	6
Protection against immersion in water between 15cm - 1m deep for 30 minutes	7
Protection against immersion in water under pressure for long periods	8
Protection for close-range, powerful, high-temperature water jets	9k
Protection level not formally tested	X

Above: Guidelines for installing appliances in bathrooms

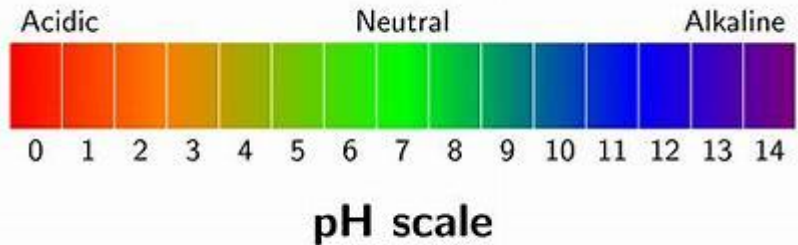
Left: IP codes which are mentioned for Heat pumps

BS7671
Covers electrical installations



Testing Ph levels for heating warranty results should be between 8 – 8.5

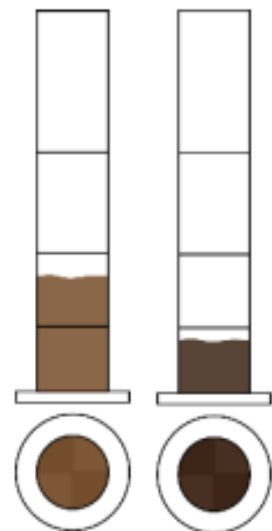
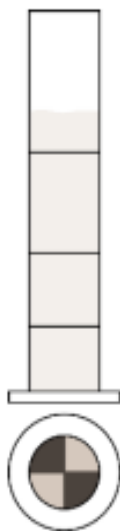
Water Quality



Turbidity

A turbidity tube is a visual tool to help you judge which water treatment best practice solution is appropriate.

Examples



Clean System

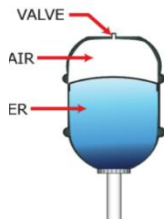
Recommend check inhibitor levels.

Light Fouling

Recommend drain system and re-dose with inhibitor.

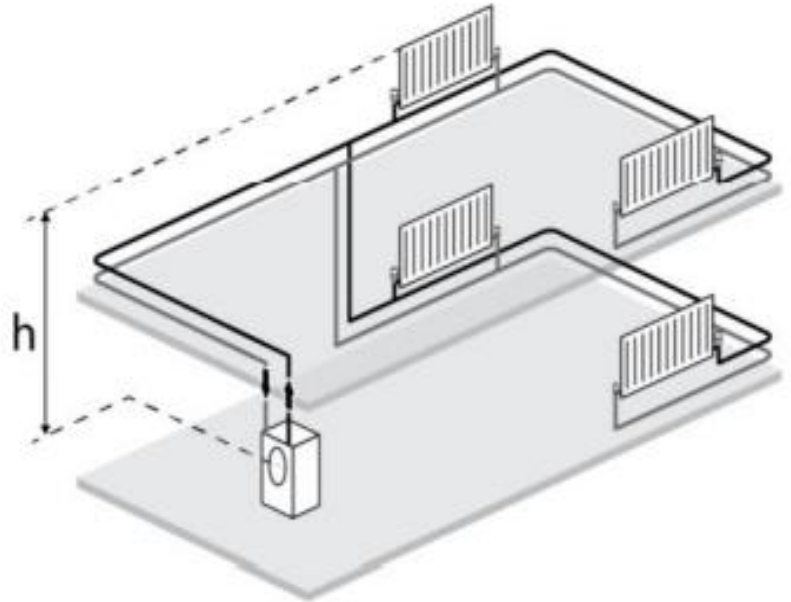
Heavy Fouling

Recommend system to be cleaned.



Vessel Pressures

Static Height, h (m)	Pre-Charge Pressure (bar)
0	0.5
1	
2	
3	
4	
5	0.6
6	
7	
8	
9	
10	1.0



Example 150litres @1bar/PRV3bar = 16.3litre vessel

Or

$$150 \times 0.109 = 16.3$$

Fact

Connections on heating vessels can block with sludge, when charging vessels lubricate Schrader valve

Safety valve setting (bar)	3.0			2.5			2.0	
Vessel charge and initial system pressure (bar)	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0
Total water content of system (litres)	Select an Expansion Vessel with a nominal volume not less than that given below (litres)							
25	2.1	2.7	3.9	2.3	3.3	5.9	2.8	5.0
50	4.2	5.4	7.8	4.7	6.7	11.8	5.6	10.0
75	6.3	8.2	11.7	7.0	10.0	17.7	8.4	15.0
100	8.3	10.9	15.6	9.4	13.4	23.7	11.3	20.0
125	10.4	13.6	19.5	11.7	16.7	29.6	14.1	25.0
150	12.5	16.3	23.4	14.1	20.1	35.5	16.9	30.0
175	14.6	19.1	27.3	16.4	23.4	41.4	19.7	35.0
200	16.7	21.8	31.2	18.8	26.8	47.4	22.6	40.0
225	18.7	24.5	35.1	21.1	30.1	53.3	25.4	45.0
250	20.8	27.2	39.0	23.5	33.5	59.2	28.2	50.0
275	22.9	30.0	42.9	25.8	36.8	65.1	31.0	55.0
300	25.0	32.7	46.8	28.2	40.2	71.1	33.9	60.0
Multiplying factors for other system volumes	0.0833	0.109	0.156	0.094	0.134	0.237	0.113	0.2



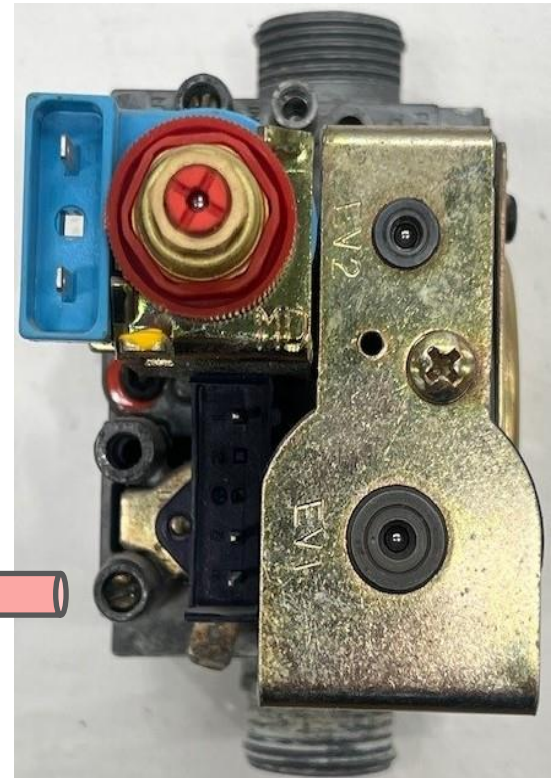
Remove harness and measure resistance should be within 10% of manufacturers guidelines

Check filter to gas valve is clear
Warm base with hair dryer this may free solenoid jumper

NTC

Isolate power and remove cables before using a multi metre on NTC

Vaillant/Glow Worm NTC



Place U gauge/manometer on gas valve inlet & isolate gas, check tightness then put boiler in demand, if pressure lost then gas valve is functioning



Clean wet pocket



Move clip on NTC to reconnect on pipe surface

Temperature	Resistance
-15 °C	30.501 Ω
-10 °C	27.917 Ω
-5 °C	25.537 Ω
0 °C	22.913 Ω
5 °C	20.387 Ω
10 °C	17.862 Ω
15 °C	15.649 Ω
20 °C	12.486 Ω
25 °C	10.000 Ω
30 °C	8.060 Ω
35 °C	6.535 Ω
40 °C	5.330 Ω
45 °C	4.372 Ω
50 °C	3.605 Ω
55 °C	2.989 Ω
60 °C	2.490 Ω
65 °C	2.084 Ω
70 °C	1.753 Ω
75 °C	1.481 Ω
80 °C	1.256 Ω
85 °C	1.070 Ω
90 °C	0.916 Ω
95 °C	0.786 Ω
100 °C	0.678 Ω
105 °C	0.586 Ω
110 °C	0.509 Ω
115 °C	0.443 Ω

Temp (°C) ± 10%	Resistance (Ω)	Temp (°C) ± 10%	Resistance (Ω)
5	28,490	50	4,608
10	22,161	55	3,856
15	18,088	60	3,243
20	14,772	65	2,744
25	11,981	70	2,332
30	9,786	75	1,990
35	8,047	80	1,704
40	6,653	85	1,464
45	5,523	90	1,262

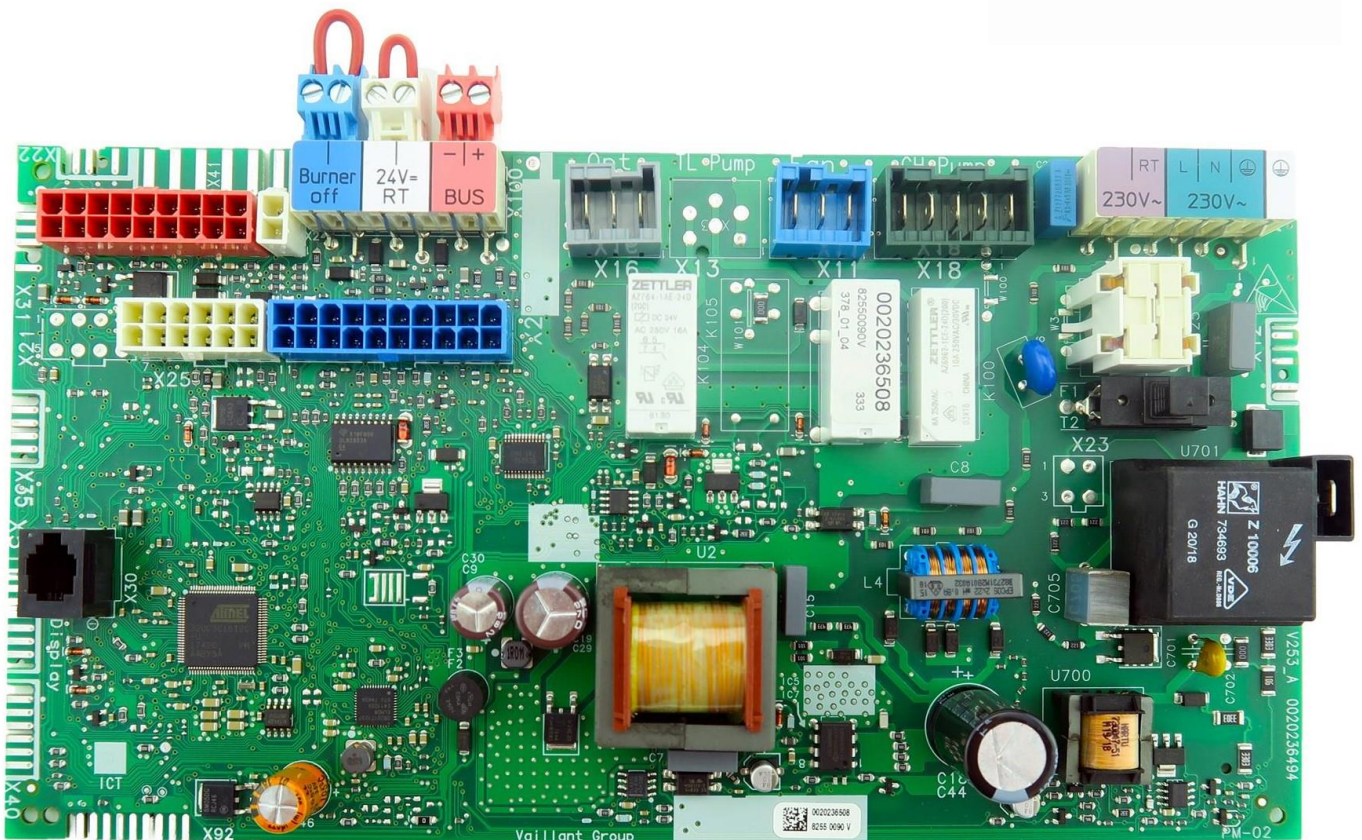


Check internal fuse, usually most Boilers are 1amp slow blow



Try warming hair PCBs with hair dryers to reenergise capacitors

Whilst carrying out wet repairs on appliances use cling film to protect PCB

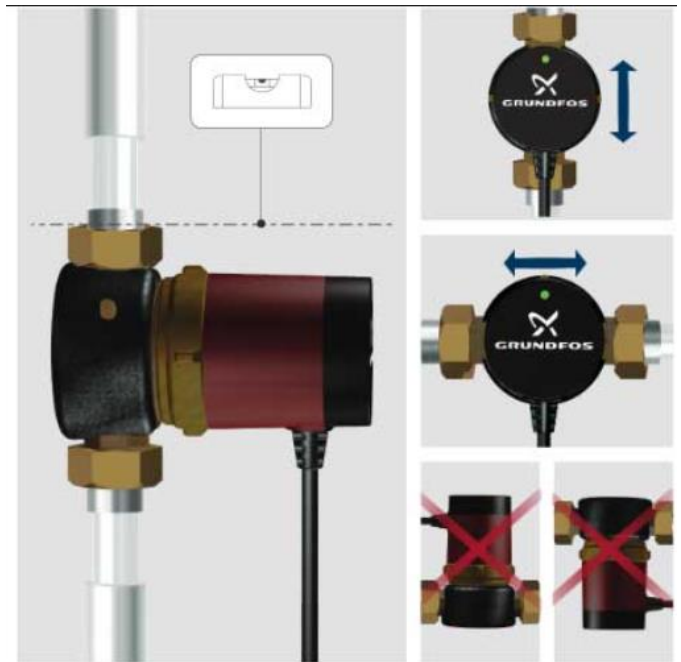


Youtube Video

<https://youtu.be/mLzEWmsyKwE>

Heating pumps

- Set multi meter to resistance Ω
- Use probes across L & N
- Less than 100Ω = replace
- No resistance/infinity = replace
- Approx $120 - 250\Omega$ = Ok
- If loud clean bearings
- Free & bleed shaft using anti seize screw
- If water runs out anti seize screw pump insufficient
- Usually blows fuse



Above are recommended pump positions



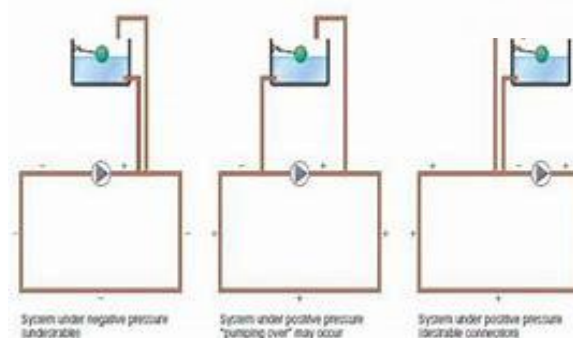
Above is an unprofessional situation the pump screw is above the electrical connections so ideally the head needs rotating



Stock pump nuts, incase old connections are cut off



Pump positions



Pump settings

Flow rate =

10m = 1bar

1bar = 9.807Kpa

Kw = Kw of boiler

TD = temperature difference 20

SH = Specific heat 4.2

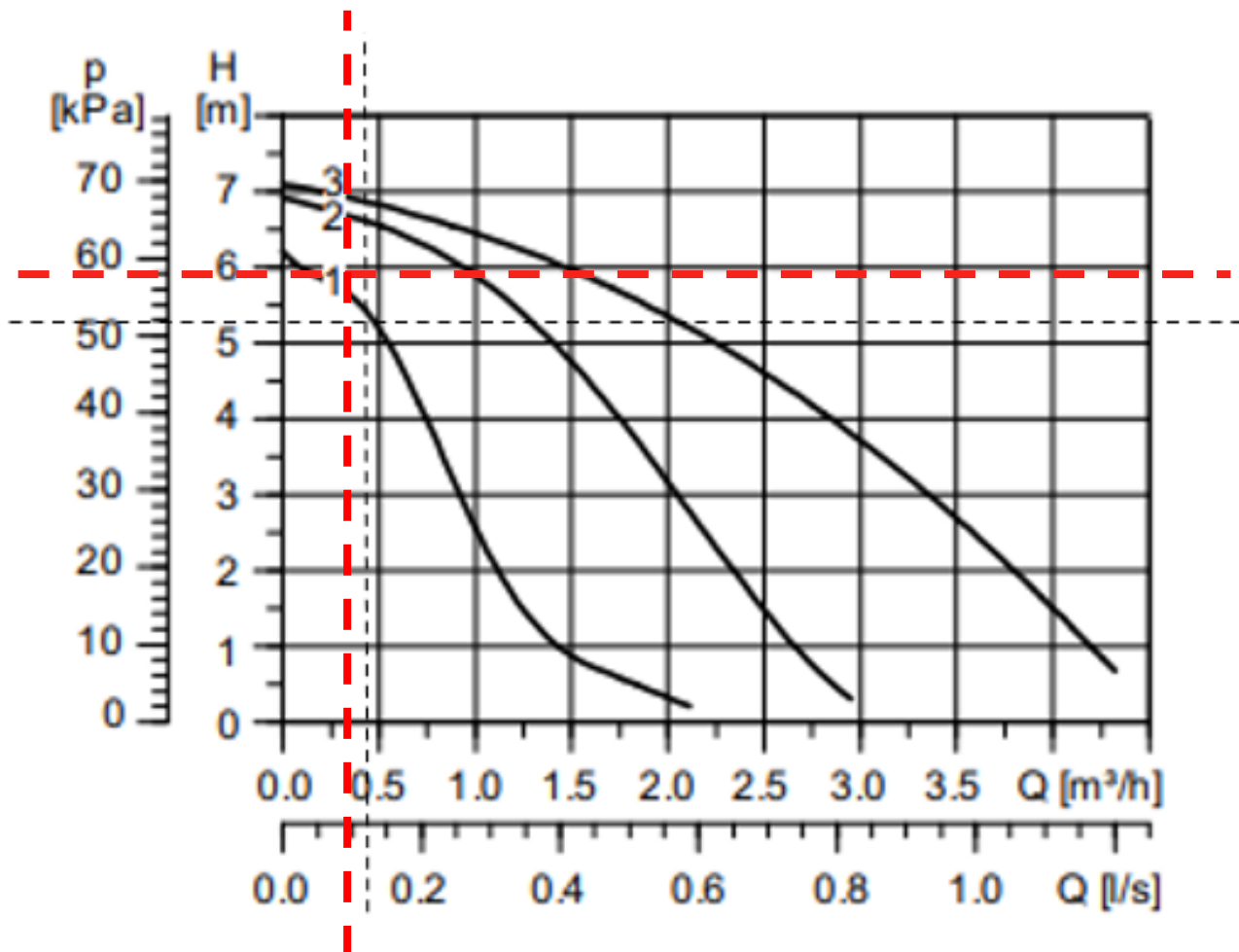
Multiply by 1000 for kg/s

Example;

3 bed house, 2 storey 6m head & 12Kw boiler

$$0.6 \times 9.807 = 5.88\text{kpa}$$

$$20 \times 4.2 = 84 \quad 20 \div 84 = 0.24$$



Fact

If you remove anti seize cap and water runs out when pump is on, this can indicate pump is running too slow

Motorised valves

- Check for demand
- Confirm arm / ball has moved
- Check power is present

Y Plan system

- Set multi meter to Ω
- From white to Neutral 2000 - 2500 Ω

Cables

White = Htg on

Grey = Htg off

Orange = Boiler pump live

S Plan system

- Brown to Neutral 2000 - 2500 Ω

Cables

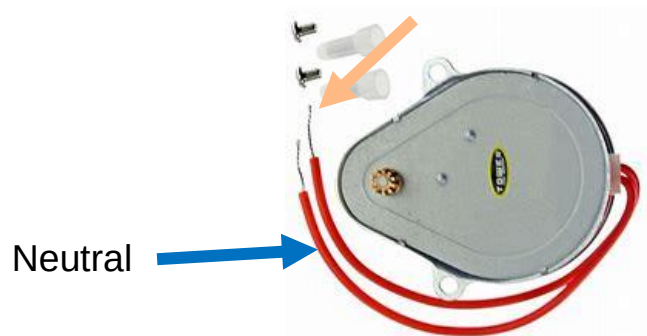
Grey = Permanent live

Brown = Htg / DHW

Orange = Boiler pump live



Live (brown)
From room/cylinderstat
Opens zone



Permanent live(Grey)

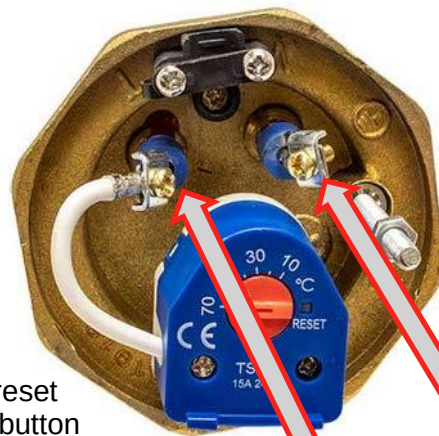
Switch live (Orange)
Sends power to pump & boiler



Plate



Immersion heater



Eco reset
safety button

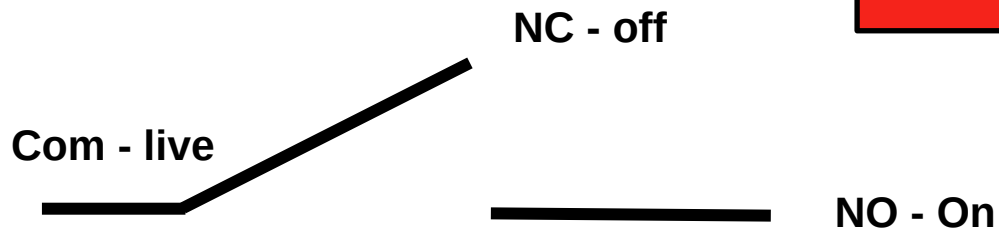


Listen for thermostat
clicking, 0 good or 1 Ω would
indicate burnout stat

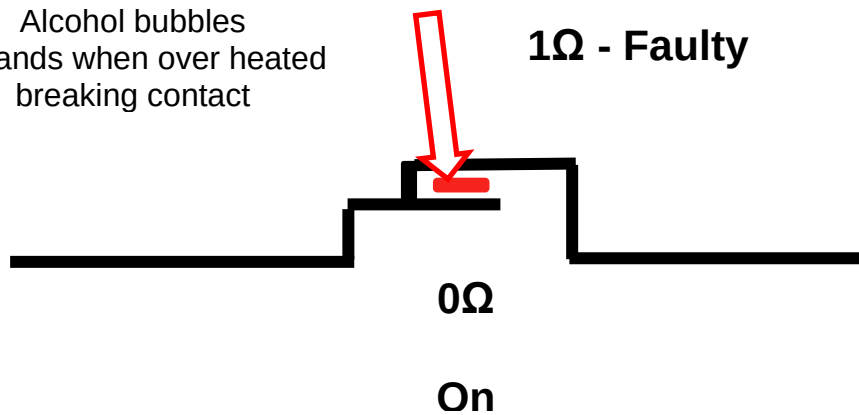
Between elements
connections 15-20 ohms

NO = Normally open
NC = Normally closed
Com = Live

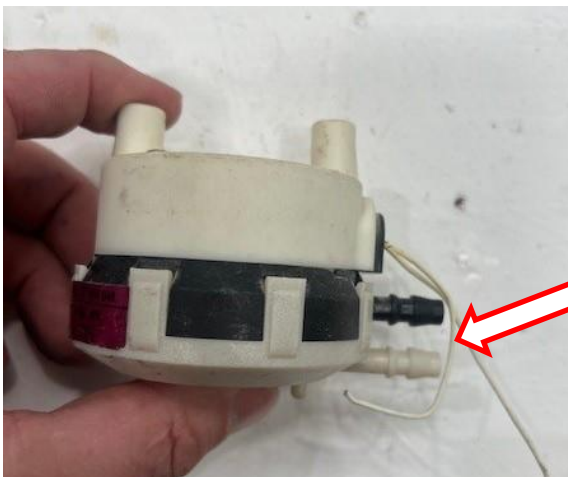
Microswitches



Alcohol bubbles
Expands when over heated
breaking contact



Highlimit stat



Air tubes connecting air pressure
switch must be assessed for
blockages, water or blocked
...

Air pressure switch

Air pressure can give various faults when the
micro switch seizes either leaving the appliance
permanently off or on

Servicing



**White vinegar diluted mix
or condensate from trap
can be sprayed into Hex
for cleaning.**

Aluminium hot water only



Appliance type	Co/Co2 Ratio	
	No Air Gas ratio	With air gas ratio
Central heating boiler	0.008	0.004
BBu	0.008	0.004
Fire	0.020	N/A
Fires (Flueless)	0.001	N/A
Flues (LFE)	0.020	N/A

Using a Flue Analyzer

Flue intake tegrity check

20.9%

% Oxygen	% CO ¹	CO ppm															
		10	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750
3.0	10.2	0.0001	0.0005	0.0010	0.0015	0.0020	0.0025	0.0029	0.0034	0.0039	0.0044	0.0049	0.0054	0.0059	0.0064	0.0069	0.0074
4.0	9.6	0.0001	0.0005	0.0010	0.0016	0.0021	0.0026	0.0031	0.0036	0.0042	0.0047	0.0052	0.0057	0.0063	0.0068	0.0073	0.0078
4.5	9.3	0.0001	0.0005	0.0011	0.0016	0.0022	0.0027	0.0032	0.0038	0.0043	0.0048	0.0054	0.0059	0.0065	0.0070	0.0075	0.0081
5.0	9.1	0.0001	0.0005	0.0011	0.0016	0.0022	0.0027	0.0033	0.0038	0.0044	0.0049	0.0055	0.0060	0.0066	0.0071	0.0077	0.0083
5.5	8.8	0.0001	0.0006	0.0011	0.0017	0.0023	0.0028	0.0034	0.0040	0.0046	0.0051	0.0057	0.0063	0.0068	0.0074	0.0080	0.0086
6.0	8.5	0.0001	0.0006	0.0012	0.0018	0.0024	0.0029	0.0035	0.0041	0.0047	0.0053	0.0059	0.0065	0.0071	0.0076	0.0082	0.0088
6.5	8.2	0.0001	0.0006	0.0012	0.0018	0.0024	0.0030	0.0037	0.0043	0.0049	0.0055	0.0061	0.0067	0.0073	0.0079	0.0085	0.0091
7.0	7.9	0.0001	0.0006	0.0013	0.0019	0.0025	0.0032	0.0038	0.0044	0.0051	0.0057	0.0063	0.0070	0.0076	0.0082	0.0088	0.0095
7.5	7.6	0.0001	0.0007	0.0013	0.0020	0.0026	0.0033	0.0039	0.0046	0.0053	0.0059	0.0066	0.0072	0.0079	0.0086	0.0092	0.0099
8.0	7.3	0.0001	0.0007	0.0014	0.0021	0.0027	0.0034	0.0041	0.0048	0.0055	0.0062	0.0068	0.0075	0.0082	0.0089	0.0096	0.0103
9.0	6.8	0.0001	0.0007	0.0015	0.0022	0.0029	0.0037	0.0044	0.0051	0.0059	0.0066	0.0074	0.0081	0.0089	0.0096	0.0103	0.0110
10.0	6.2	0.0002	0.0008	0.0016	0.0024	0.0032	0.0040	0.0048	0.0056	0.0065	0.0073	0.0081	0.0089	0.0097	0.0105	0.0113	0.0121
11.0	5.6	0.0002	0.0009	0.0018	0.0027	0.0036	0.0045	0.0054	0.0063	0.0071	0.0080	0.0089	0.0098	0.0107	0.0116	0.0125	0.0134
12.0	5.1	0.0002	0.0010	0.0020	0.0029	0.0039	0.0049	0.0059	0.0069	0.0079	0.0089	0.0099	0.0109	0.0119	0.0129	0.0139	0.0147
13.0	4.5	0.0002	0.0011	0.0022	0.0033	0.0044	0.0056	0.0067	0.0078	0.0089	0.0100	0.0111	0.0122	0.0133	0.0144	0.0155	0.0167
14.0	3.9	0.0002	0.0013	0.0026	0.0038	0.0051	0.0064	0.0077	0.0090	0.0103	0.0116	0.0129	0.0141	0.0154	0.0167	0.0179	0.0193
15.0	3.4	0.0002	0.0015	0.0029	0.0044	0.0059	0.0074	0.0089	0.0103	0.0118	0.0133	0.0147	0.0161	0.0175	0.0189	0.0203	0.0217

Example: 5.1% Oxygen (closest to) 5.0

8.99 CO2 (closest to) 8.8

89ppm meaning the test results come back at 0.0006 in shaded area above

this means that it is safe and doesn't require a service

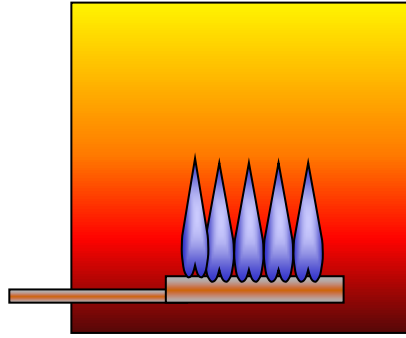
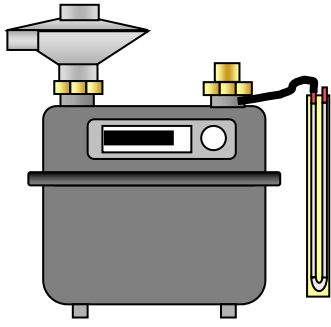


Boiler Requires Service
Boiler may be NCS or AR



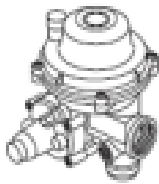
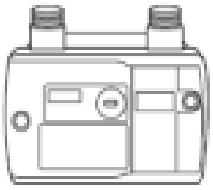
Shut boiler down as either AR or ID (Unsafe to use)

Before using gas analyser use outside air to purge (20.9 air)
Check air intake to flue is at the same level or flue may be broken

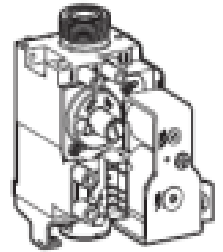


Appliance ON

Working Pressure



WORKING Pressure

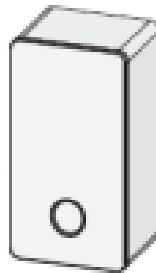


Meter or LPG Supply
[A]

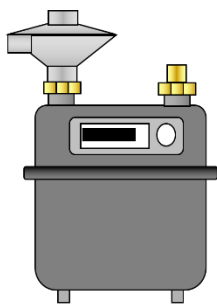
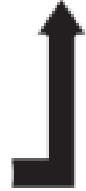
Gas Valve Inlet
Test Point
[D]



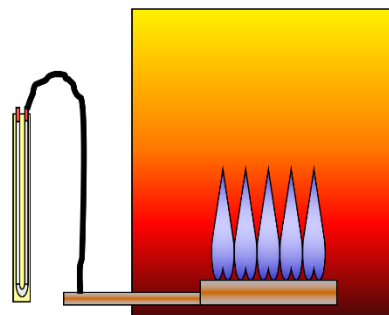
1mb



1.5mb



WORKING Pressure at Appliance



Appliance ON

Gas	
Minimum pressure loss	
Minimum pressure allowed	
Water	
Minimum water pressure	
Minimum flow rate	

2 min gas flow m³	Heat input Kw (gross)	Heat input Kw (net)	Answer	Answer
0.034	10.98	9.89	Boiler Kw (net)	Kw
0.036	11.63	10.48	Gas m³/hr	M³/hr
0.038	12.27	11.06		
0.040	12.92	11.64		
0.042	13.57	12.22		
0.044	14.21	12.80		

**Gas
rating**

Gross input gas rate ready reckoner for domestic metric index meters

2 minutes gas flow rate	Gas rate per hour		Calculated heat input		2 minutes gas flow rate	Gas rate per hour		Calculated heat input	
m³	m³	ft³	kW	Btu/hr	m³	m³	ft³	kW	Btu/hr
0.001	0.03	1.06	0.3	1,100	0.020	0.60	21.22	6.4	22,000
0.002	0.06	2.12	0.6	2,200	0.030	0.90	31.83	9.7	33,000
0.003	0.09	3.18	1.0	3,300	0.040	1.20	42.44	12.9	44,000
0.004	0.12	4.24	1.3	4,400	0.050	1.50	53.06	16.1	55,000
0.005	0.15	5.31	1.6	5,500	0.060	1.80	63.67	19.3	65,900
0.006	0.18	6.37	1.9	6,600	0.070	2.10	74.28	22.5	76,900
0.007	0.21	7.43	2.3	7,700	0.080	2.40	84.89	25.8	87,900
0.008	0.24	8.49	2.6	8,800	0.090	2.70	95.50	29.0	98,900
0.009	0.27	9.55	2.9	9,900	0.100	3.00	106.11	32.3	109,800
0.010	0.30	10.61	3.2	11,000	0.200	6.00	212.22	64.4	219,700

Gas Pipe sizing

Nominal Pipe Size			Equivalent Length (m)				
Steel		Copper	Bends		Fittings		
			45°	90°	90° elbow	Tee ^{A)} (Entering Branch)	Tee ^{A)} (Exiting Branch)
≤ 15 mm	R 1/2	≤ 15 mm	0.15	0.20	0.40	0.75	1.20
20 mm	R 3/4	22 mm	0.20	0.30	0.60	1.20	1.80
25 mm	R 1	28 mm	0.25	0.40	0.80	1.50	2.30
32 mm	R 1 1/4	35 mm	0.30	0.50	1.00	2.00	3.00

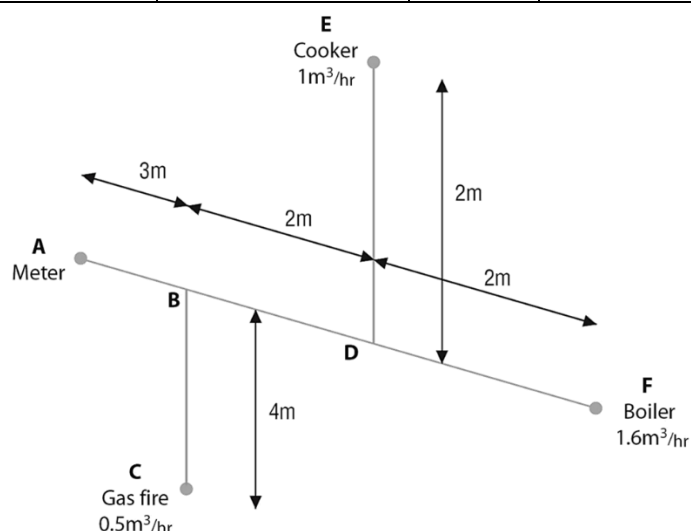
A) Use the largest connection size on the fitting that is not necessarily the branch size

Flow Rate (m ³ /h)	Heat Input		Nominal Pipe Size (mm) A)						
	Gross (kW)	Net (kW)	8 (6)	10 (8)	12 (10)	15 (13)	22 (19)	28 (25)	35 (32)
0.25	2.70	2.46	0.2675	0.0710	0.0255	0.0077	0.0014	0.0004	0.0001
0.50	5.40	4.91	0.8348	0.2188	0.0777	0.0231	0.0040	0.0011	0.0004
0.75	8.10	7.37		0.4285	0.1514	0.0447	0.0077	0.0022	0.0007
1.00	10.81	9.82		0.6940	0.2444	0.0719	0.0123	0.0035	0.0011
1.25	13.51	12.28			0.3553	0.1042	0.0178	0.0050	0.0016
1.50	16.21	14.73			0.4833	0.1414	0.0240	0.0067	0.0021
1.75	18.91	17.19			0.6276	0.1832	0.0311	0.0086	0.0027
2.00	21.61	19.65			0.7877	0.2296	0.0388	0.0108	0.0034
2.25	24.31	22.10			0.9630	0.2804	0.0473	0.0131	0.0042
2.50	27.01	24.56				0.3353	0.0565	0.0156	0.0049
2.75	29.72	27.01				0.3945	0.0663	0.0183	0.0058
3.00	32.42	29.47				0.4577	0.0769	0.0212	0.0067
3.25	35.12	31.93				0.5249	0.0880	0.0243	0.0077
3.50	37.82	34.38				0.5960	0.0998	0.0275	0.0087
3.75	40.52	36.84				0.6709	0.1123	0.0309	0.0097
4.00	43.22	39.29				0.7496	0.1253	0.0345	0.0108
4.25	45.92	41.75				0.8321	0.1390	0.0382	0.0120
4.50	48.63	44.20				0.9182	0.1533	0.0421	0.0132
4.75	51.33	46.66					0.1681	0.0462	0.0145
5.00	54.03	49.12					0.1836	0.0504	0.0158
5.25	56.73	51.57					0.1996	0.0548	0.0172
5.50	59.43	54.03					0.2162	0.0593	0.0186
5.75	62.13	56.48					0.2334	0.0640	0.0200

Pressure loss to the appliance must be lower than 1mb in total pipe route.

Incorrect sized pipe can lead too poor combustion readings

Pipe section	Gas rate M3/h	Pipe length	Estimated Pipe dia	Fitting allowance		Corrected length	Pressure loss Mb/pm	Calculated pressure loss
				Type	length			
A - B	3.1	3	22	Elbow x 2	1.2	4.2	0.0880	0.37
B - C	0.5	4	15	Elbow x 3 Tee(exit) x 1(22m)	3	7	0.0231	0.1617



Heating

Pipe sizing.

Fact

Flow rate for heating should be 1m/s, lower sludge can settle, 1.5 can be disruptive, 2.5 can erode pipes, Part L, states flow temperatures should be 55° with a DT of 20°

System design

Pipe Dia (mm)	Watts
8	1500
10	2500
15	6000
22	13000
28	22000
35	34000

Reference;

BS 5449
BS EN 806

Pipe Flow rates

H = Rad Watts

TD = Temp diff

SHC = Specific Heat

Low loss header sizing (m/s)

Kw = Boiler output

SHC = Specific heat

DT = Temperature diff

Bypass setting

KW / Dt x 4.20

Manufacturers guidelines mini flow & system head

$$\frac{H}{TD \times 4.186} =$$

$$\frac{Kw \times 3600 \div 1000}{SHC \times DT}$$



Radiator Sizing

Ventilation heatloss

V = Room volume m²

N = Air change p/hour

0.33 = Specific heat of air

TD = Temp diff, between -3° + desired room temp

i.e;

living room 1980 3m x 3m x 4m @21

0.33 x 36 x 1.5 x 24 = 427.68

$$0.33 \times V \times N \times TD = \text{heat loss}$$

In Coastal areas
-5 can be used
for outside

Room	Category A (Pre 2000)	Category B (2000)	Category C (New build)
Lounge/living room	1.5	1	0.5
Dining/breakfast room	1.5	1	0.5

U-Values for new build	
Room	U-Value
Pitched insulated roof	0.20
Flat roof	0.20
Walls	0.30
Internal walls	1.6
Floors	0.25
Windows & doors	2

Correction factors

Htg flow – htg return = water temp

Water temp – desired room temp =

Boiler flow is 70 return temperature is 50, Water mean temperature is 60

Deduct room temperature of 21, equals 39.

39 falls between figures so accurate

Calculations are needed.

$$0.748 - 0.629 = 0.119$$

$\frac{0.119}{5} = 0.024$ – the figure per °C difference

5

$$0.748 - 0.024 = 0.748$$

25	0.406
30	0.515
35	0.629
40	0.748
45	0.872
50	1.000
55	1.132
60	1.267

Further details in Glossary

Room heat loss								
Surface element	area (m2)	x	U Value (W/m2k)	x	Temp dif (oC)	=	Design heat loss watts	Totals
		x		x		=		
		x		x		=		
		x		x		=		
		x		x		=		
		x		x		=		
		x		x		=		
		x		x		=		
Air heat loss								
Air changes (1.5)	x	Room volume (m3)	x	Temp/diff (21 + -3°)	x	Vent factor 0.33	=	
			x		x		=	
Fabric heat loss		+	Air heat loss		+ 15%		=	
		+					=	
Total design heat loss Add boxes 1 & 2 = 3							=	
Heat emitter size								
Flow 70	+	Return 55	÷ 2	- Room temp 21		=	MWT	
	+		÷ 2			=		
MWT		x	CF correct factor			=	Radiator size	
		x				=		

Part L now states all heating systems should be design for a 55° flow temperature

Heating Pipe sizing

Flow rates = Flow rate kw

TD x 4.187

6.05Kw

0.072kg/s

Dia

15mm

Pressure
loss P/m

0.026

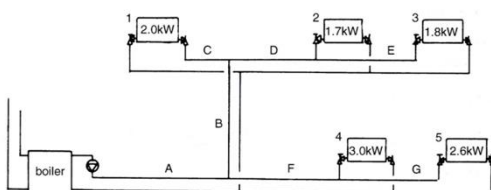
Effective
length (m)

7.5

Pressure
required

0.195m

Always design heating with
0.5 – 1.5m/s Velocity



Pressure loss (m/m)	8 mm kg/s	10 mm kg/s	15 mm kg/s	22 mm kg/s	28 mm kg/s	35 mm kg/s	Velocity m/s
0.008		0.0108	0.0380	0.109	0.227	0.400	0.50
0.009		0.0114	0.040	0.117	0.235	0.424	
0.010	0.0064	0.0122	0.042	0.124	0.250	0.448	
0.011	0.0067	0.0129	0.044	0.131	0.263	0.475	
0.012	0.0071	0.0135	0.047	0.137	0.277	0.499	
0.013	0.0074	0.0141	0.049	0.144	0.289	0.523	
0.014	0.0077	0.0147	0.052	0.150	0.302	0.543	
0.015	0.0081	0.0154	0.054	0.156	0.314	0.564	
0.016	0.0084	0.0159	0.056	0.161	0.325	0.594	
0.017	0.0086	0.0165	0.058	0.167	0.336	0.604	0.75
0.018	0.0089	0.0171	0.060	0.172	0.348	0.623	
0.019	0.0092	0.0176	0.061	0.178	0.359	0.645	
0.020	0.0095	0.0182	0.063	0.183	0.369	0.669	
0.021	0.0098	0.0185	0.065	0.188	0.380	0.686	
0.022	0.0101	0.0192	0.067	0.193	0.390	0.704	
0.024	0.0106	0.0203	0.070	0.203	0.408	0.735	
0.026	0.0111	0.0212	0.073	0.212	0.428	0.773	
0.028	0.0116	0.0221	0.076	0.221	0.446	0.805	1.00
0.030	0.0120	0.0230	0.080	0.230	0.464	0.838	
0.032	0.0125	0.0238	0.082	0.238	0.482	0.869	
0.034	0.0129	0.0245	0.085	0.247	0.500	0.898	
0.036	0.0133	0.0253	0.088	0.255	0.518	0.925	
0.038	0.0138	0.0261	0.091	0.263	0.533	0.952	
0.040	0.0142	0.0268	0.094	0.270	0.548	0.982	
0.042	0.0146	0.0276	0.096	0.278	0.564	1.010	1.25
0.044	0.0150	0.0283	0.099	0.286	0.578	1.035	
0.046	0.0154	0.0290	0.101	0.293	0.592	1.048	
0.048	0.0158	0.0298	0.104	0.300	0.608	1.075	
0.050	0.0162	0.0305	0.106	0.307	0.622	1.100	
0.052	0.0167	0.0312	0.108	0.314	0.637	1.123	
0.054	0.0170	0.0320	0.111	0.321	0.651	1.150	
0.056	0.0173	0.0326	0.113	0.328	0.665	1.178	
0.058	0.0177	0.0332	0.115	0.334	0.678	1.194	1.50
0.060	0.0180	0.0339	0.117	0.340	0.691	1.215	
0.062	0.0184	0.0345	0.120	0.347	0.705	1.235	
0.064	0.0187	0.0351	0.122	0.353	0.718	1.253	
0.066	0.0190	0.0358	0.124	0.359	0.724	1.272	
0.068	0.0193	0.0364	0.126	0.364	0.736		
0.070	0.0196	0.0370	0.128	0.370	0.750		
0.072	0.0200	0.0377	0.130	0.375	0.762		
0.074	0.0203	0.0382	0.132	0.381	0.774		
0.076	0.0206	0.0388	0.134	0.386	0.785		
0.078	0.0208	0.0394	0.136	0.391	0.797		
0.080	0.0211	0.0400	0.138	0.397	0.808		
0.082	0.0215	0.0406	0.140	0.402	0.819		
0.084	0.0217	0.0411	0.142	0.407	0.830		
0.086	0.0220	0.0417	0.144	0.412	0.841		
0.088	0.0223	0.0423	0.146	0.417	0.851		
0.090	0.0226	0.0429	0.148	0.422	0.862		
0.092	0.0229	0.0433	0.149	0.426	0.872		
0.094	0.0231	0.0439	0.151	0.431			
0.096	0.0234	0.0445	0.153	0.435			
0.098	0.0237	0.0450	0.155	0.440			
0.100	0.0240	0.0455	0.156	0.445			
0.102	0.0243	0.0460	0.158	0.449			
0.104	0.0245	0.0465	0.160	0.453			
0.106	0.0247	0.0469	0.162	0.458			
0.108	0.0250	0.0474	0.164	0.462			
0.110	0.0253	0.0479	0.165	0.466			
0.112	0.0256	0.0484	0.167	0.471			
0.114	0.0258	0.0488	0.169	0.475			
0.116	0.0261	0.0493	0.170	0.479			
0.118	0.0264	0.0498	0.172				
0.120	0.0266	0.0502	0.174				
0.130	0.0279	0.0523	0.181				
0.140	0.0291	0.0548	0.189				
0.150	0.0302	0.0568	0.197				
0.160	0.0314	0.0588	0.204				
0.170	0.0326	0.0608	0.211				
0.180	0.0336	0.0628					
0.190	0.0347	0.0648					
0.200	0.0357	0.0668					

0.072kg/s flow rate

0.026 x 7.5 = 0.195

Pipe section	A	B	C	D	E	F	G
Measured length (m)	9	7.5	6	9	8	6	9

1	2	3	4	5	6	7	8	9	10	11
Pipe Section	Total heat emitter value	10% addition for heat loss from pipes	Total heat requirements	Specific Heat x temperature drop	Flow rate (l/s)	Pipe size (mm)	Pressure loss (m/m)	Effective Pipe length (m)	Pressure required(m)	Remarks
A	11.1	1.11	12.21	84	0.145	15	0.088	11.8	1.038	
B	5.5	0.55	6.05	84	0.072	15	0.026	7.5	0.195	
C	2.0	0.2	2.2	84	0.026	8	0.116	15.4	1.786	
D	3.5	0.35	3.85	84	0.045	10	0.098	16	1.568	
E	1.8	0.18	1.98	84	0.023	8	0.094	17.2	1.616	
F	5.6	0.56	6.16	84	0.073	15	0.026	14.4	0.374	
G	2.6	0.26	2.86	84	0.034	8	0.19			

Pipe resistances are in
glossary

Pipe Centres	Conversation factor
100	10
150	6.6
200	5

Pipe lengths

RA = Area of room
PC = Pipe centre
DfM = Distance from manifold x 2
Add 5%

UFH facts

ie;

RA – 12M² PC - 150MM DfM - 6

12 x 6.6 = 79.2m

DfM = 12m

Sub total = 91.2m + 5%(4.5)

Total = 95.7m

ie;

RA – 24m² PC 150mm DfM – 6m

24 x 6.6 = 158

158/2 = 79.50

6 x 2 = 12

91.5 + 5% = 95.8m

Below is the W/m² produced from the pipe centres, as you can see 100mm centres provides more heatput



DFM;
Distance from manifold

Flow Rate (L/min)	Friction Loss (kPa/m)			
	16mm PE-X	20mm PE-X	25mm PE-X	32mm PE-X
0.5	0.01	0.00	0.00	0.00
1	0.04	0.01	0.00	0.00
2	0.15	0.04	0.01	0.00
3	0.31	0.09	0.03	0.01
4	0.53	0.15	0.05	0.02
5	0.80	0.23	0.08	0.02
10	2.88	0.84	0.28	0.08
12	4.04	1.18	0.39	0.12
14	5.37	1.57	0.51	0.15
16	6.88	2.00	0.66	0.20
18	8.55	2.49	0.82	0.24
20	10.39	3.03	1.00	0.30
25	15.70	4.58	1.50	0.45
30	22.00	6.41	2.11	0.63
35	29.26	8.53	2.80	0.83
40	37.46	10.92	3.59	1.07
45	46.58	13.57	4.46	1.33

30 MWT 18 rtemp	100	150	200	250	300
30	37	34	31	29	26

ie,
80 x 0.15 = 1.2

Pipe centres(mm)	Heat output W/m. 2
100	91.4
150	82
200	74
250	66.4
300	60
Based on 75mm screed & 45° mean temp	

Hot & Cold Pipe Sizing

Below example

Garden tap x 2	10
Bath x 2	8
Sink	2
shower	2
Wash basin	1
W/machine	2
D washer	2

Draw-off point	Q_A	Q_{min}	Loading units
	l/s	l/s	
Washbasin, handbasin, bidet, WC-cistern	0,1	0,1	1
Domestic kitchen sink, - washing machine ^a , dish washing machine, sink, shower head	0,2	0,15	2
Urinal flush valve	0,3	0,15	3
Bath domestic	0,4	0,3	4
Taps /garden/garage)	0,5	0,4	5
Non domestic kitchen sink DN 20, bath non domestic	0,8	0,8	8
Flush valve DN 20	1,5	1,0	15

^a For non domestic appliances check with manufacturer.

Maximum flow rate velocity 3m/s this prevents water hammer, 27 LU against the chart equals too 5.5l/s & flow rate of 1.7l/s which points to 22mm pipe

Table 3.2 — Copper													
Max. load	LU	1	2	3	4	6	10	20	50	165	430	1050	2100
Highest value	LU		2		4	5	8						
$d_s \times s$	mm	12 x 1,0		15 x 1,0		18 x 1,0	22 x 1,0	28 x 1,5	35 x 1,5	42 x 1,5	54 x 2	76,1 x 2	
d_i	mm	10,0		13,0		16,0	20,0	25	32	39	50	72,1	
Max length of pipe	m	20	7	5	15	9	7						

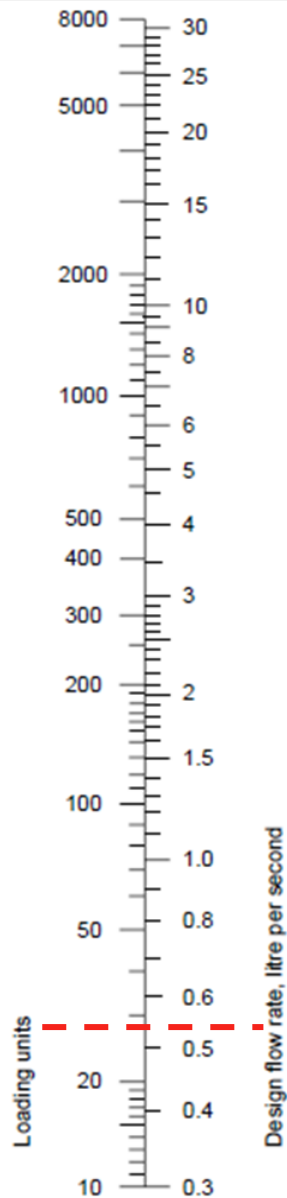


Figure D.1 Conversion of loading units to design flow rate

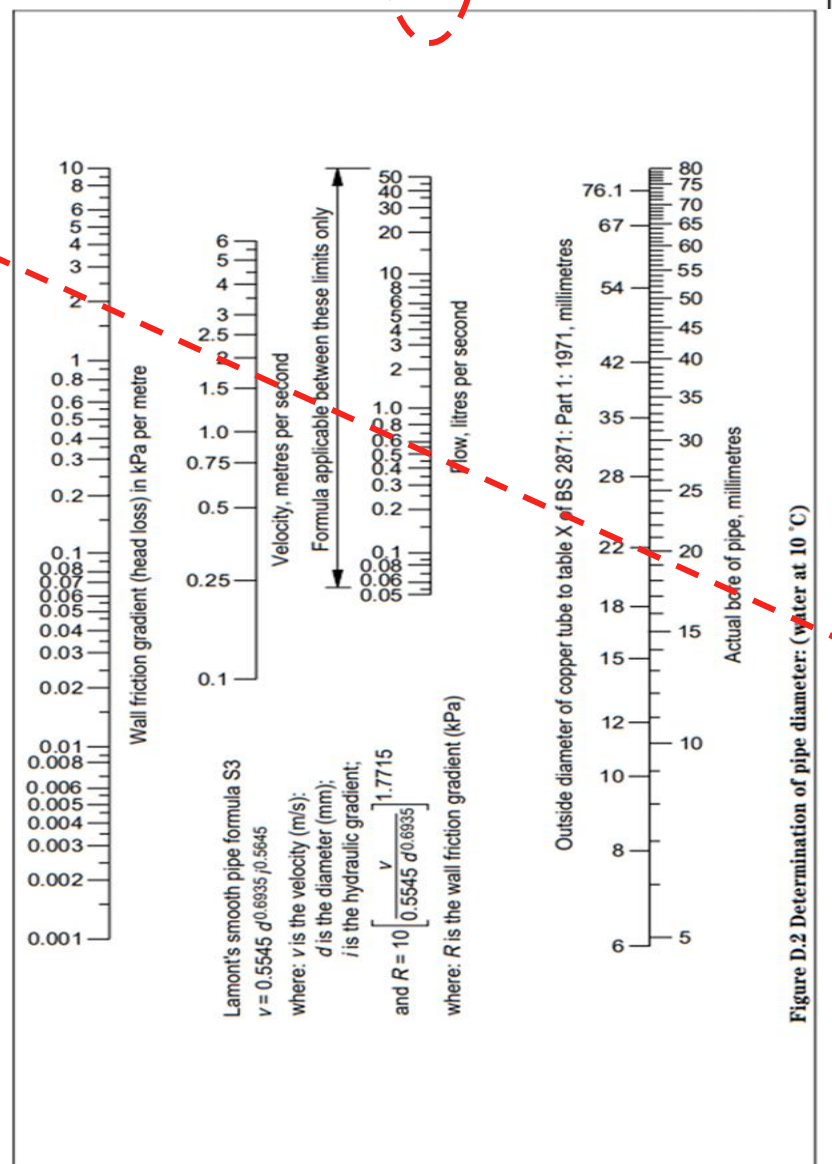


Figure D.2 Determination of pipe diameter: (water at 10 °C)

Hot water demand

Hot water Demand

Basic

Demand	Cylinder size	Kw req	Boiler allowed
2 bed, 1 bath	125	7.2	2
3 bed, 1 bath	145	8.4	2.5
4 bed, 1 bath	165	8.4	2.5
4 bed, 1 bath + 1 shower	175	10	2.5
4 bed, 2 bath	225	13	3.0

Calculated formula

Heat required

$$SHC \times Kg \times Tr =$$

SHC =

Kg = litres of water

Tr = Temperature rise

Period

$$\frac{SHC \times Kg \times Tr}{\text{Secs}}$$

Hot & Cold Pipe sizing (unvented DHW)

Loading units

Appliance	Loading units
Basin/WC	1
Sink/Shower/W.machine	2
Urinal	3
Bath	5
Non domestic	8
Taps/Garden	5

Diameter per Units

LU	1	2	3	3	4	6	10	20	50	165	430
Dia (mm)	15	15	15	15	15	15	22	22	28	35	42

Hot water ventilation pipe

150mm standard number
40mm per metre height

$150 + 40 = \text{vent height}$

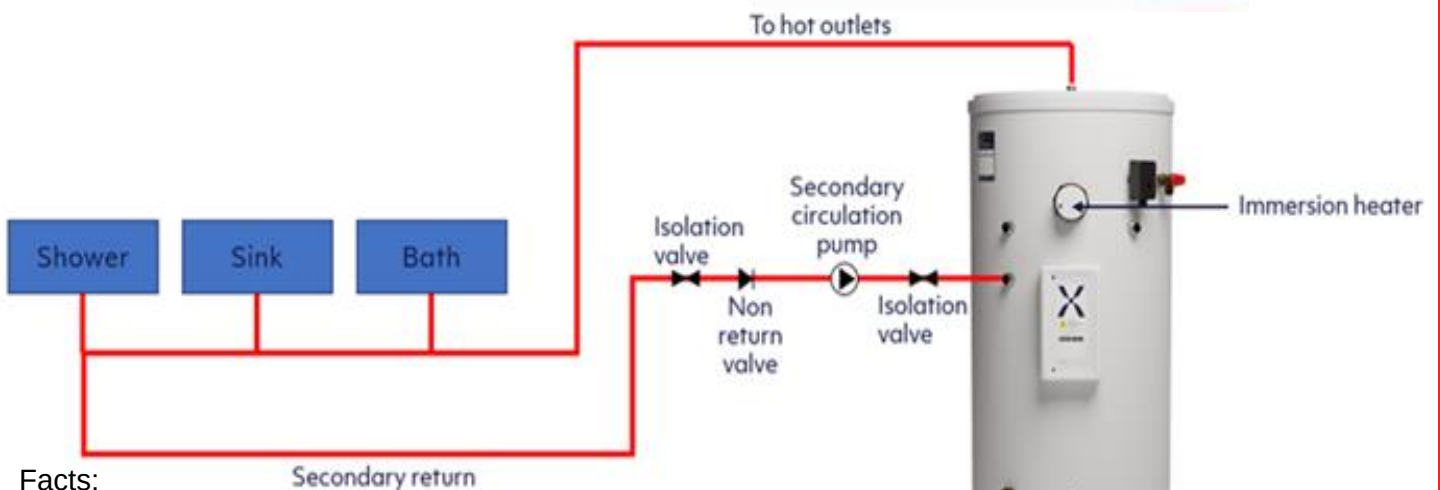
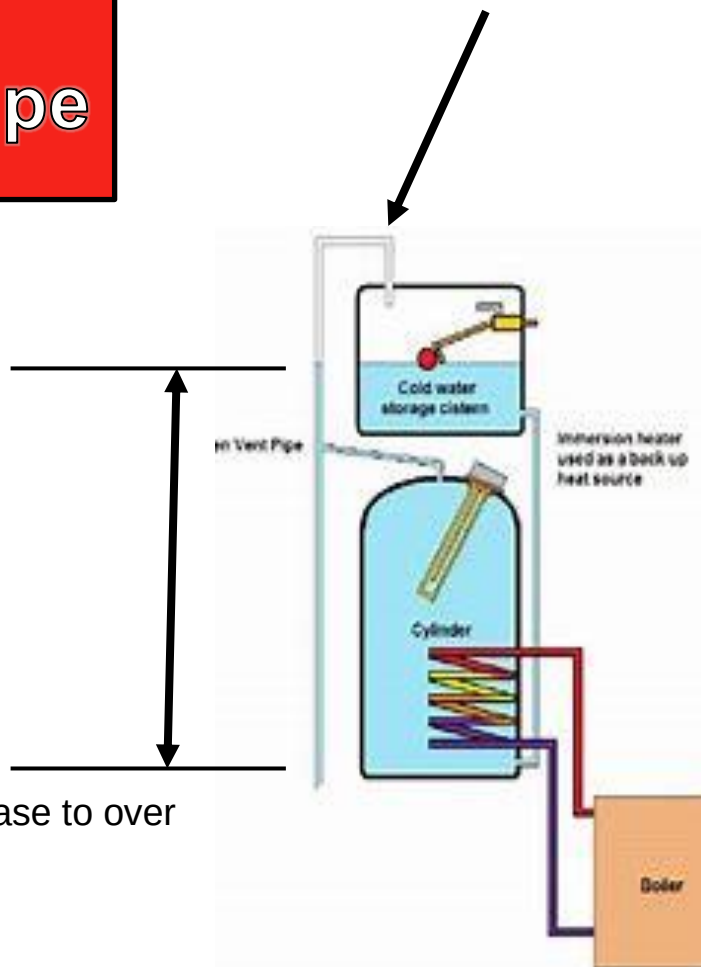
Height from cylinder base
to over pipe level

i.e

4m height from cylinder base to over
flow pipe

$4 \times 40 + 150 = 310\text{mm}$

How to calculate vent pipe height?



Facts;

- Return pump must be bronze
- Must connect onto cylinder $\frac{1}{4}$ from top
- 5°TD from draw off & return
- Minimum return temp 50° within 1min
- Minimum 0.5l/s
- Secondary return must be a minimum 2 x dia smaller then distruption
- Return with more than 15ltres needs expansion vessel
- Pump works on timer

Pipe dia	15ltr in m
15	107
22	48
28	30

Secondary circulation

Unvented Hot water

20lpm
1.5 – 3.5 bar

- D2 next dia above D1
- Discharge should be copper
- Terminate 100mm above ground with cage
- Must terminate 3m from plastic surface (gutter/roof sheeting)
- D2 discharges in solvent weld must be clipped every 300mm/labelled with a HepVo valve
- Warning audio light device for disable tennants

Valve Outlet size	Minimum size of discharge D1	Minimum size of discharge D2 (From tundish)	Maximum resistance, expressed as a length of straight pipe	Resistance created by each bend or elbow
G1/2"	15mm	22mm 28mm 35mm	Up to 9m Up to 18m Up to 27m	0.8m 1m 1.4m
G3/4"	22mm	28mm 35mm 42mm	Up to 9m Up to 18m Up to 27m	1m 1.4m 1.7m
G1"	28mm	35mm 42mm 54mm	Up to 9m Up to 18m Up to 27m	1.4 1.7m 2.3m

Example:

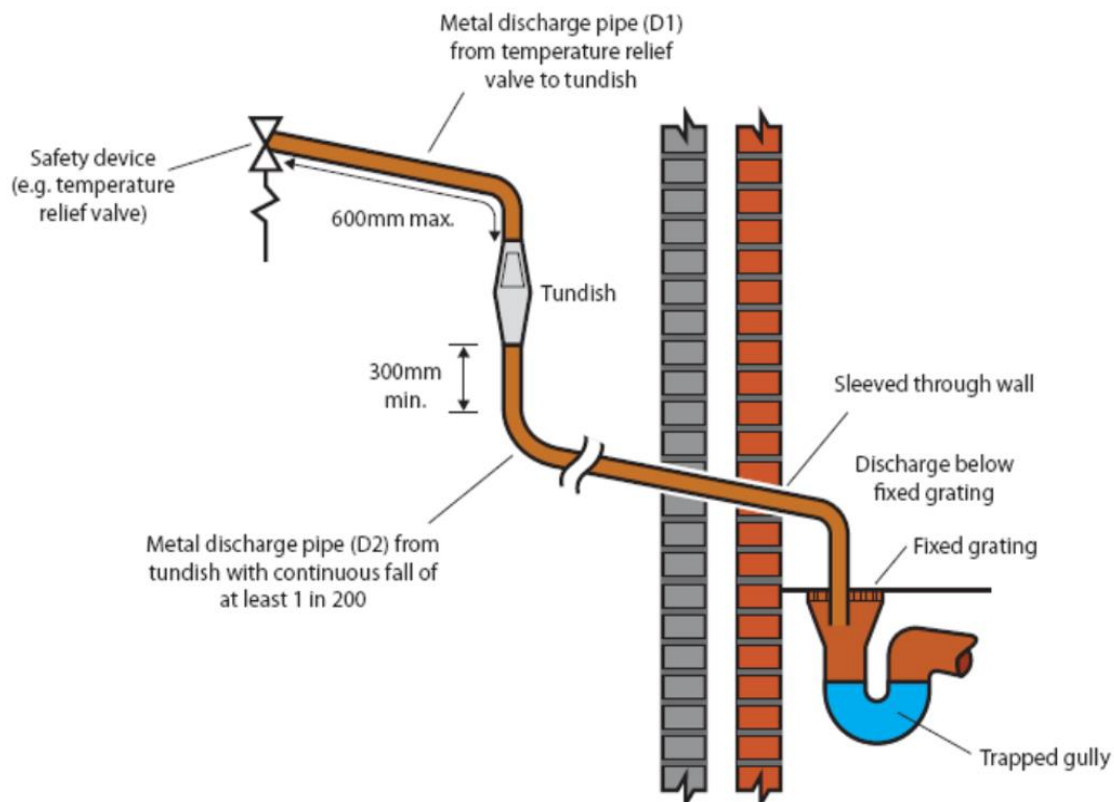
Current install, cylinder has G1/2" exit, 6 bends on D2 route which is 8m long

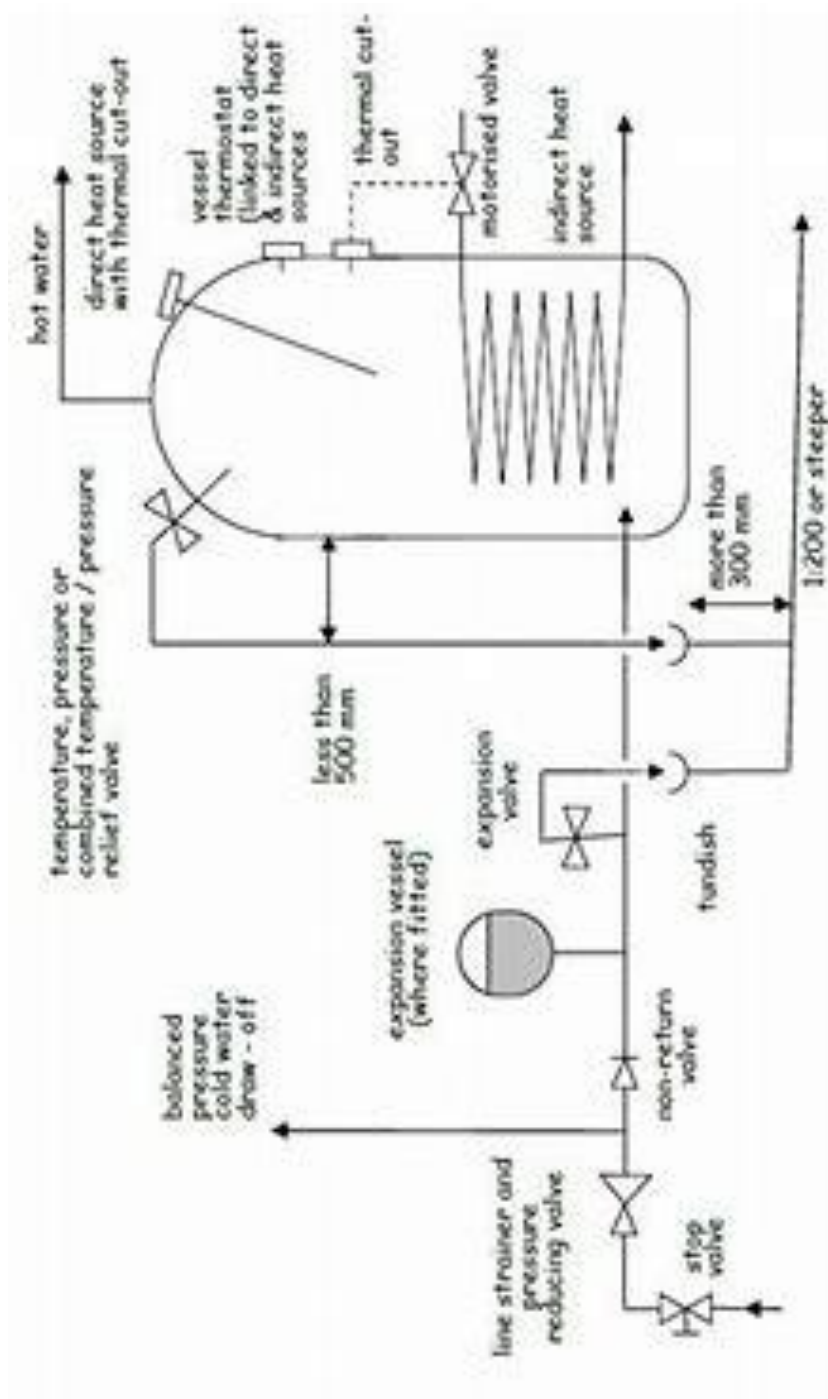
Two options follow;
D2 -- 22mm

$D1 = 15\text{mm} \rightarrow D2 \text{ } 22\text{mm } 6 \times 0.8 + 8 = 12.8\text{m}$ incorrect too long for 22mm

D2 – 28mm

$D1 = 15\text{mm} \rightarrow D2 \text{ } 28\text{mm } 6 \times 1 + 8 = 14\text{m}$ correct for 28mm as actual length is under 18m





Temperature guidelines

60° daily for 60mins

Showers 43°

Care home 43°

Basin 38 – 41°

Sinks 46 – 48°

Bath 44°

Unvented Cylinder safety temperatures

Thermostat 60°

ECO 85°

Energy cut off
(switches electric off to boiler)

Temperature relief valve 95°
(Poopet valve)

Booster pumps



Pump pressure adjustment

Pressure on/off adjustment switch

Run time

Pump run times

$L/m \times \text{Run time} = \text{flow rate}$

$66l/m \times 10 = 660\text{litres}$

Operating pressures:

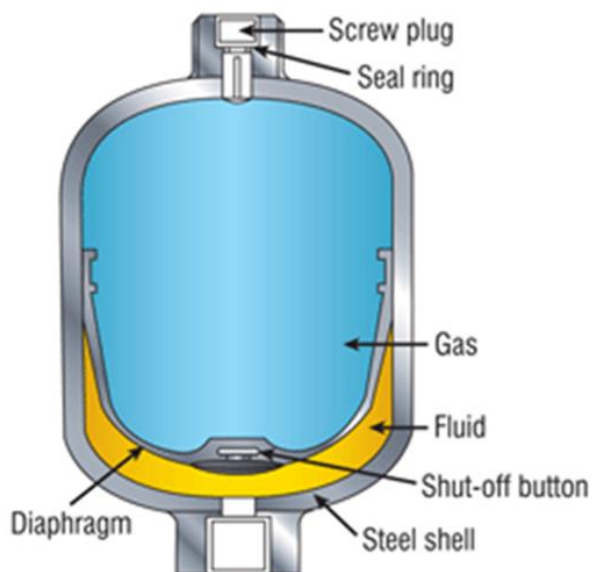
Accumulator operates between P1 and P2

P1 = minimum operating pressure

P2 = maximum operating pressure

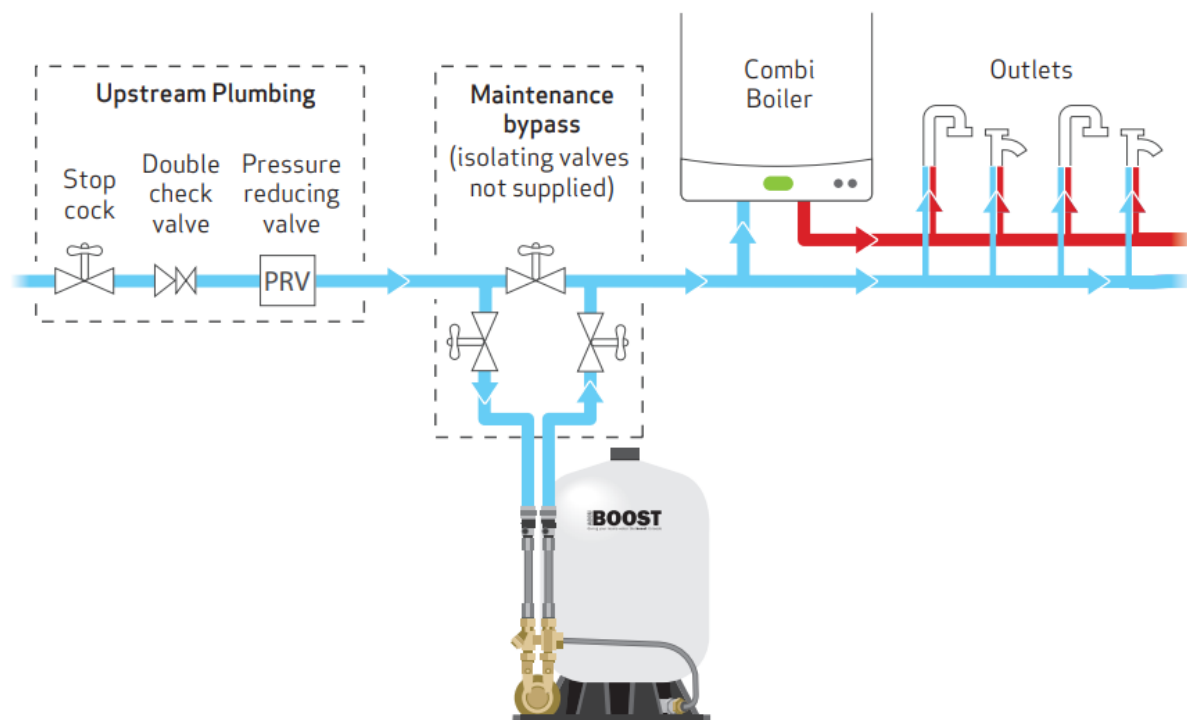
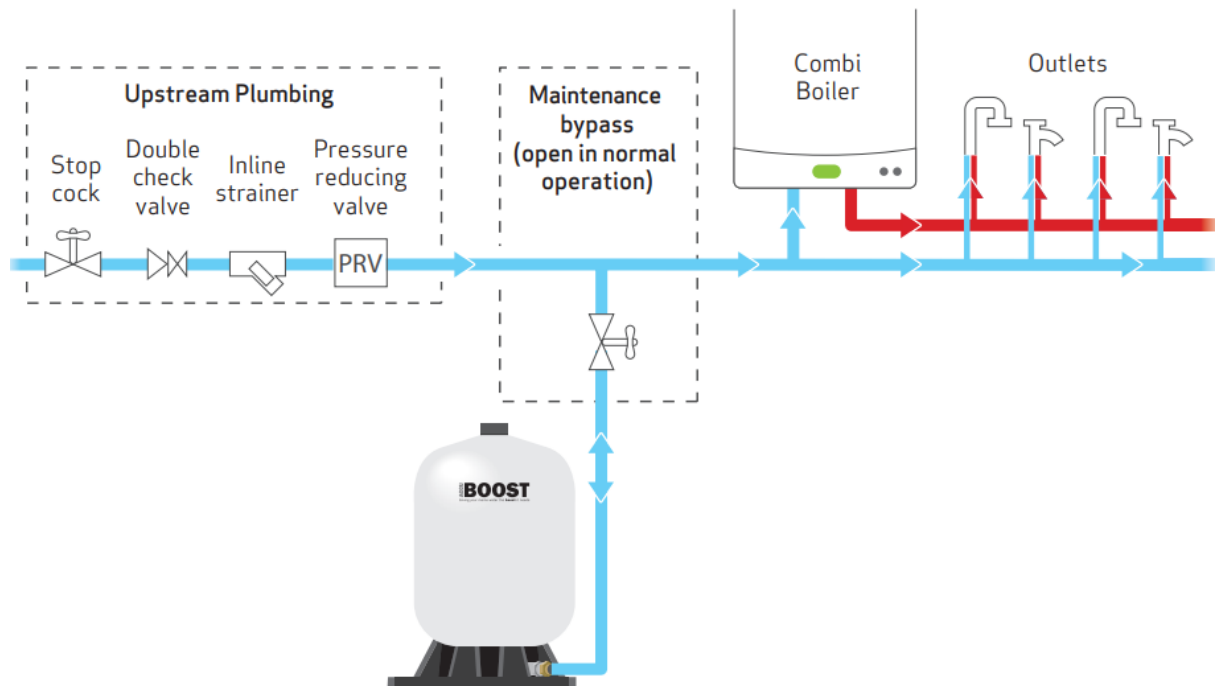
PO = pre-charge pressure (normally 90% of P1)

- allows a small amount of water to remain in the vessel at all times
- prevents the bladder collapsing completely during each operating cycle.

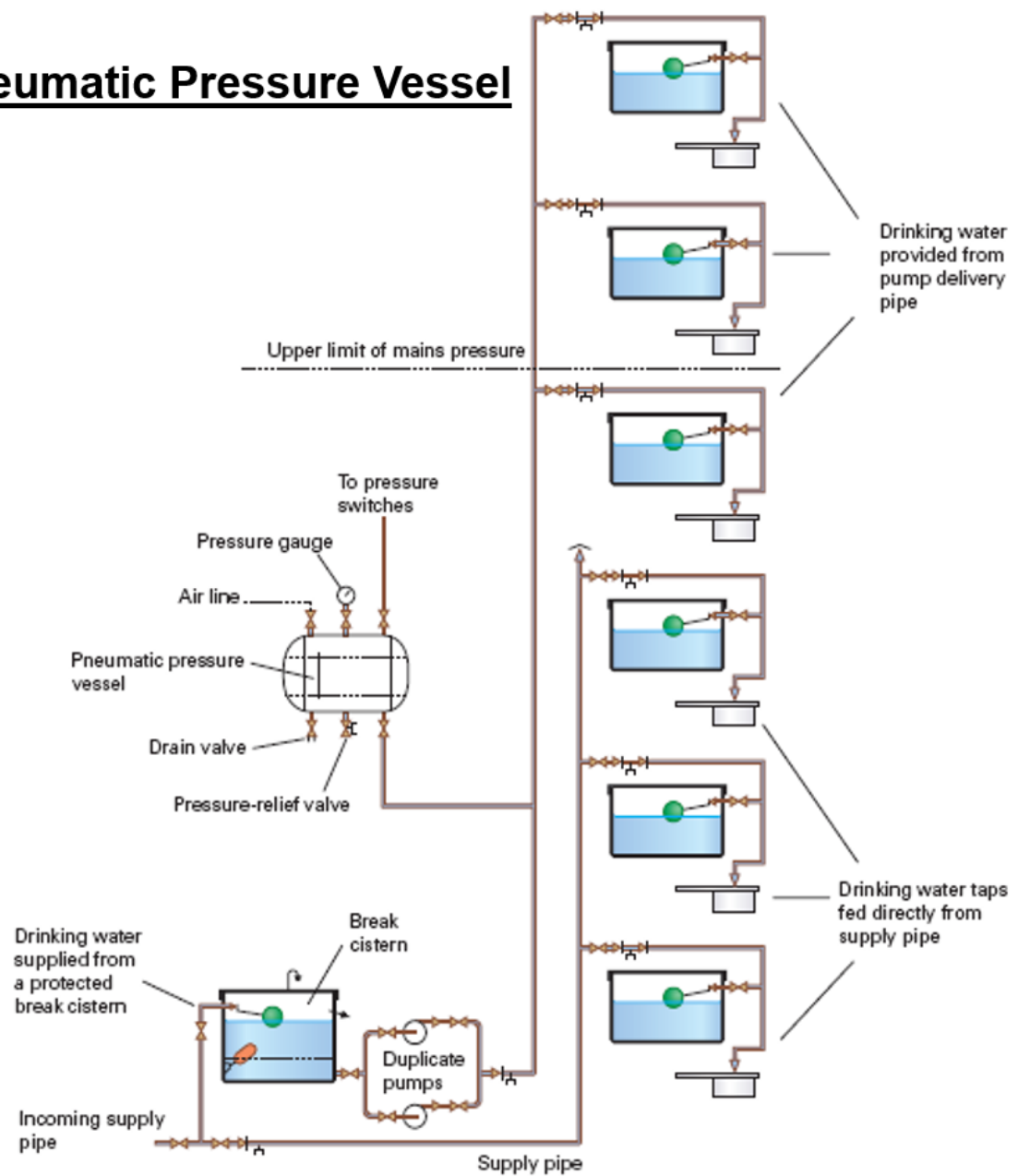


Pre charge in some vessels simulate charging pump

Unpumped



Pneumatic Pressure Vessel



Header Pipe System

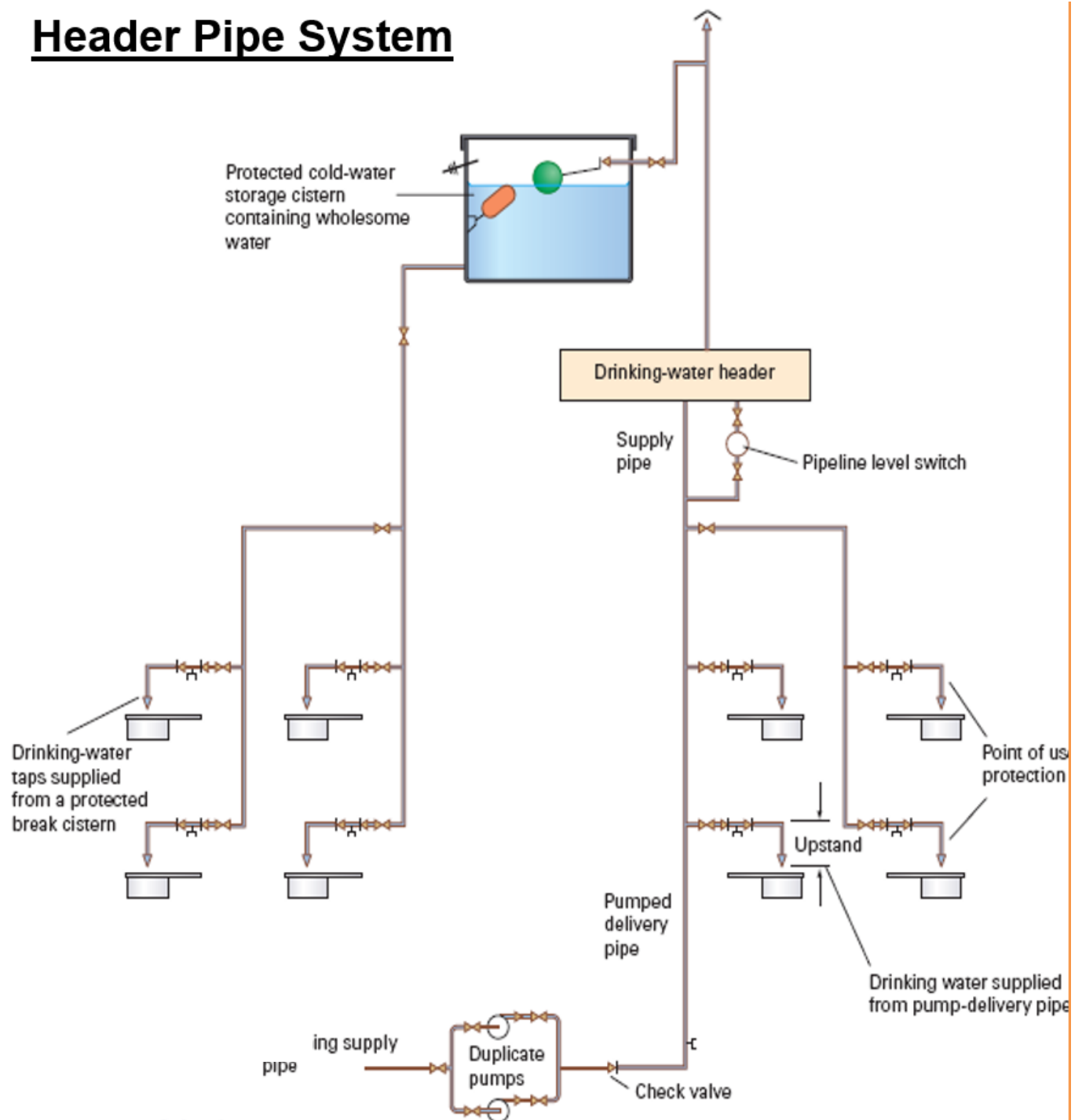


Figure 2.96 Use of a header pipe

Fig 1

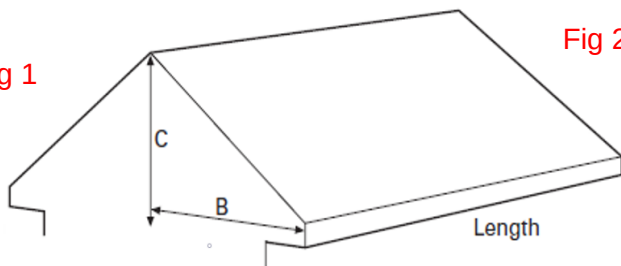


Fig 2

Type of surface	Effective design area
1 Flat roof	plan area of relevant portion
2 Pitched roof at 30° Pitched roof at 45° Pitched roof at 60°	plan area of portion x 1.29 plan area of portion x 1.50 plan area of portion x 1.87
3 Pitched roof over 70° or any wall	elevational area x 0.5

For roofs between 10° and 50° pitch, this can be calculated by using the following formula:

$$\left[\frac{C + B}{2} \right] \times \text{length of roof} = \text{effective roof area in m}^2$$

Gutter sizing

Fig 3

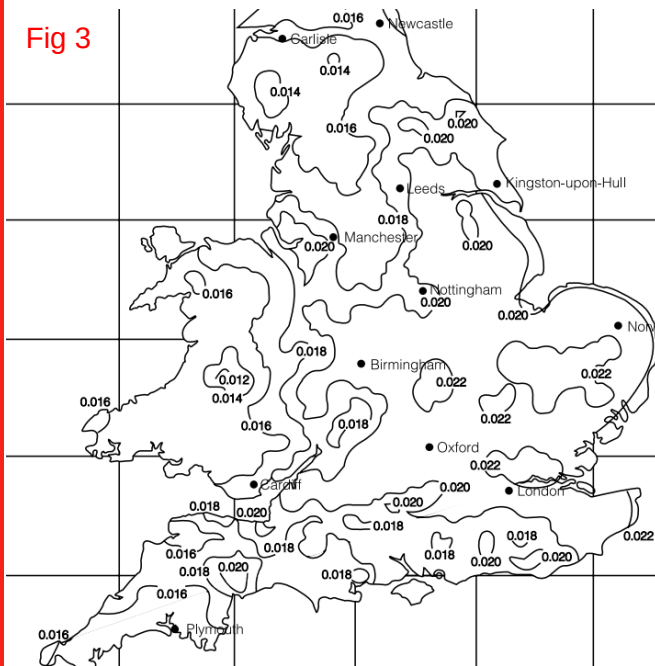


Fig 4

Situation	Risk factor
Eaves gutters	1,0
Eaves gutters where water overflowing would cause particular inconvenience, e.g. over entrances to public buildings	1,5
Non-eaves gutters and in all other circumstances where abnormally heavy rain or blockage in the roof drainage system could cause water to spillover into the building	2,0
For non-eaves gutters in buildings where an exceptional degree of protection is necessary, e.g. - hospital operating theatres - critical communications facilities - storage for substances that give off toxic or flammable fumes when wet - buildings housing outstanding works of art	3,0

Q = Fall (dia 2) R = Rain fall intensity (dia 3)
C = Risk factor of dwelling (dia 4) A = area (dia 1)

$$A \times Q \times R \times C =$$

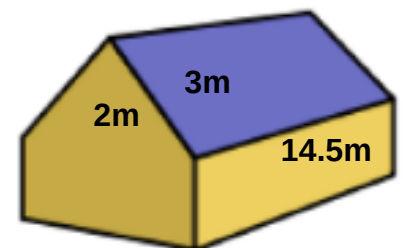
$$1+3 \times 14.5 \times 1.5(\text{fall}) = 87$$

$$87 \times 0.020(\text{rain intensity}) = 1.74$$

$$1.74 \times 1(\text{Risk factor}) = 1.74$$

Location	Nottingham
Pitch	45
Dwelling	House no risk factor

Max. effective roof area (m ²)	Gutter size (mm diam.)	Outlet size (mm diam.)	Flow capacity (litres/sec)
6.0	—	—	—
18.0	75	50	0.38
37.0	100	63	0.78
53.0	115	63	1.11
65.0	125	75	1.37
103.0	150	89	2.16



Distance from outlet & stop end.

Gutter depth x 50 =

Distance between outlets.

Gutter depth x 100 =

100m gutter 50mm depth

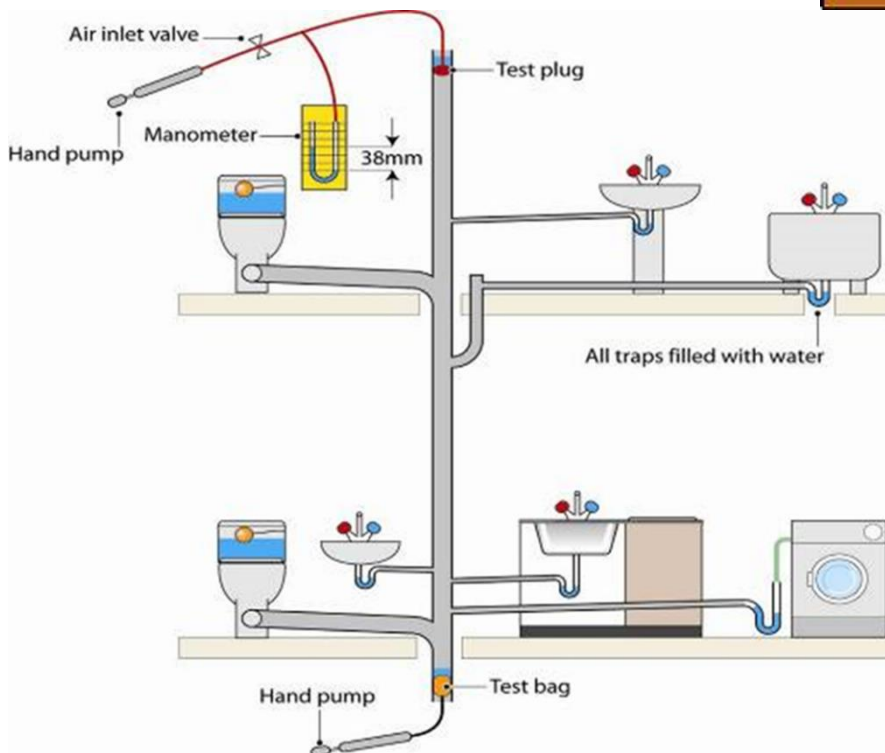
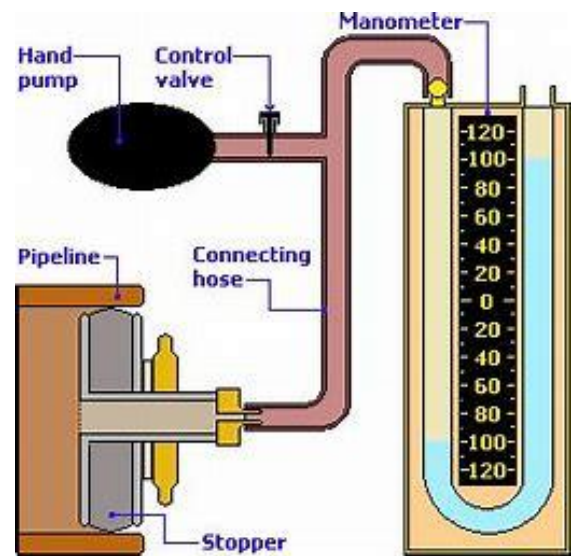
100 x 50 = 5m

Ref: Reg H BS 12056

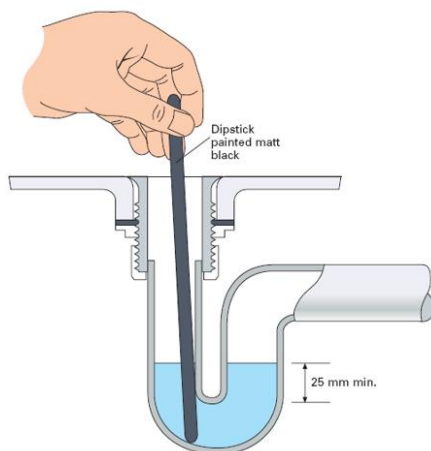
Areas greater than 25m² needs a Shoe exit

Drainage testing

- Fill trap seals with water
- Bung ventilation pipe with stop
- Using hand pump charge to 38mm
- Should be no drop after 3 minutes



Drainage performance testing



To performance test sanitation, run at least 3 – 4 appliances WC, bath, basin and sink. Once water has drained away, using a dipstick check the trap seals must have at least 25mm water depth, this process should be carried out 3 times

Heat Pump design

GUIDANCE TABLE

	Temperature Star Rating	Heating circuit flow temperature °C	Likely space heating SPF		Oversize Factors for other emitters			Underfloor heating: screed			Underfloor heating: Aluminium panel		
			GSHP	ASHP	Domestic Fan Convectors/Fan-assisted Radiator	Standard Radiator	Fan Coil Unit	with TILE	with WOOD	with CARPET	with TILE	with WOOD	with CARPET
Room specific heat loss less than 30 W/m²	★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS±300	PS±300	PS±200	PS±200	PS±200	PS±150
	★★★★★	40	4.1	3.4	3.1	4.3	3.5	PS±300	PS±300	PS±300	PS±300	PS±300	PS±200
	★★★★★	45	3.7	3	2.4	3.1	2.6	PS±300	PS±300	PS±300	PS±300	PS±300	PS±300
	★★★★★	50	3.4	2.7	2.0	2.4	2.1	PS±300	PS±300	PS±300	PS±300	PS±300	PS±300
	★★★★★	55	3.1	2.4	1.7	1.9	1.7	PS±300	PS±300	PS±300	PS±300	PS±300	PS±300
	★★★★★	60	2.8	2.1	1.4	1.6	1.5	PS±300	PS±300	PS±300	PS±300	PS±300	PS±300
Room specific heat loss 30 to 50 W/m²	★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS±300	PS±100		PS±100	Reduce heat loss	
	★★★★★	40	4.1	3.4	3.1	4.3	3.5	PS±300	PS±200	PS±150	PS±200	PS±200	PS±150
	★★★★★	45	3.7	3	2.4	3.1	2.6	PS±300	PS±300	PS±300	PS±200	PS±200	PS±150
	★★★★★	50	3.4	2.7	2.0	2.4	2.1	PS±300	PS±300	PS±300	PS±300	PS±200	PS±200
	★★★★★	55	3.1	2.4	1.7	1.9	1.7	PS±300	PS±300	PS±300	PS±300	PS±300	PS±300
	★★★★★	60	2.8	2.1	1.4	1.6	1.5	PS±300	PS±300	PS±300	PS±300	PS±300	PS±300
Room specific heat loss 50 to 80 W/m²	★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS±100	Reduce heat loss			Reduce heat loss	
	★★★★★	40	4.1	3.4	3.1	4.3	3.5	PS±200	Reduce heat loss			Reduce heat loss	
	★★★★★	45	3.7	3	2.4	3.1	2.6	PS±300	PS±100	PS±100	PS±150	PS±100	
	★★★★★	50	3.4	2.7	2.0	2.4	2.1	PS±300	PS±200	PS±150	PS±200	PS±100	
	★★★★★	55	3.1	2.4	1.7	1.9	1.7	PS±300	PS±200	PS±200	PS±300	PS±150	PS±100
	★★★★★	60	2.8	2.1	1.4	1.6	1.5	PS±300	PS±300	PS±300	PS±300	PS±200	PS±150
Room specific heat loss 80 to 100 W/m²	★★★★★	35	4.3	3.6	4.3	6.8	5.0		Reduce heat loss			Reduce heat loss	
	★★★★★	40	4.1	3.4	3.1	4.3	3.5	PS±150	Reduce heat loss			Reduce heat loss	
	★★★★★	45	3.7	3	2.4	3.1	2.6	PS±200			PS±100		
	★★★★★	50	3.4	2.7	2.0	2.4	2.1	PS±250	PS±100	PS±100	PS±150		
	★★★★★	55	3.1	2.4	1.7	1.9	1.7	PS±300	PS±200	PS±150	PS±200	PS±100	
	★★★★★	60	2.8	2.1	1.4	1.6	1.5	PS±300	PS±250	PS±250	PS±200	PS±150	PS±100
Room specific heat loss 100 to 120 W/m²	★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★	40	4.1	3.4	3.1	4.3	3.5						
	★★★★★	45	3.7	3	2.4	3.1	2.6						
	★★★★★	50	3.4	2.7	2.0	2.4	2.1	Reduce heat loss			Reduce heat loss		
	★★★★★	55	3.1	2.4	1.7	1.9	1.7	Reduce heat loss			Reduce heat loss		
	★★★★★	60	2.8	2.1	1.4	1.6	1.5	Reduce heat loss			Reduce heat loss		
Room specific heat loss 120 to 150 W/m²	★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★	40	4.1	3.4	3.1	4.3	3.5						
	★★★★★	45	3.7	3	2.4	3.1	2.6						
	★★★★★	50	3.4	2.7	2.0	2.4	2.1	Reduce heat loss			Reduce heat loss		
	★★★★★	55	3.1	2.4	1.7	1.9	1.7	Reduce heat loss			Reduce heat loss		
	★★★★★	60	2.8	2.1	1.4	1.6	1.5	Reduce heat loss			Reduce heat loss		

Reducing fabric and/or ventilation heat losses can move a room up to the next specific heat loss band, making it easier to achieve a good SPF.

Changing the emitter specification can reduce the flow temperature and therefore increase SPF.

Changing the emitter type can enable the emitter to operate at a lower temperature.

Changing the floor covering on UFH can reduce the required emitter temperature.

Buffer Sizing

$$V = \frac{Q \times t \times 60}{4.18 \times DT}$$

i.e

$$\frac{5 \times 15 \times 60}{4.18 \times 5}$$

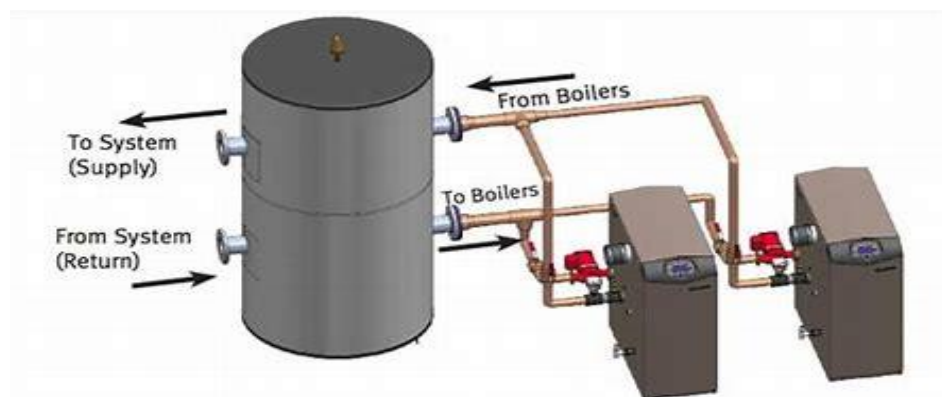
V = tank volume

Q = heat load (5kw)

DT = Delta T (rads 10° / Udfr 5°)

60 = 60 seconds

T = HP compressor starts in hour



Sizing Volumizers

Volumisers are installed to prevent systems freezing, should the primary pipework be lower than 20l then a volumiser should be installed



0.14l	15mm copper
0.31l	22mm copper
0.5l	28mm copper
600 x 1000 rad	6l

Heat pump performances with outside temperatures

Output Water 45°C		UNITS	4	6	8	12	15
			kW	kW	kW	KW	KW
Outside Air at 0°C	Qh	KW	3.17	4.02	5.11	8.03	9.80
	COP	kW/kW	2.57	2.43	2.42	2.44	2.48
Outside Air at -3°C	Qh	KW	2.93	3.71	4.41	7.39	9.06
	COP	kW/kW	2.42	2.31	2.34	2.32	2.36

Heat Pump location

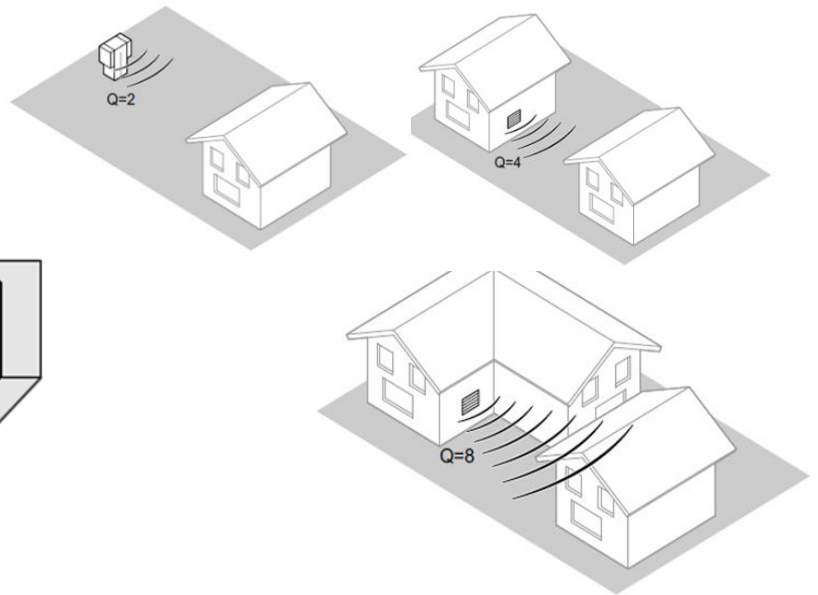
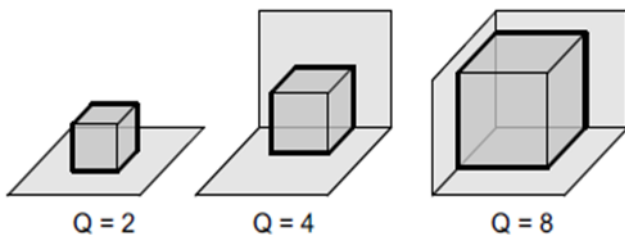


Table 1:

Q rating	4	5	6	8	10	12	15	20	25
<u>2</u>	-20	-21	-23	-26	-28	-29	-31	-34	-36
<u>4</u>	-17	-19	-20	-23	-25	-26	-28	-31	-33
<u>8</u>	-14	-16	-17	-20	-22	-23	-25	-28	-30

Table 2:

Restriction	db reduction
Solid barrier between assessment position	-10
Move HP 25cm to be seen from assessment position	-5

Table 3:

Difference between two noise levels	Correction factor
5	1.2
6	1
7	0.8
8	0.6

Scenario; ASHP installed against wall, manufacturers data states 55db, this install is partially covered with wall and the assessment position is 4metres away

Description	Result
1 Manufacturers db	55db
2 Installed against single wall	Q4
3 Distance from wall	4m
4 Db reduction 4m @Q4 (table 1)	-17
5 Brick wall between assessment (table 2)	-5
5 $55 + -17 + -5 =$	33db
6 MCS approval guide (table 3) $40 - 33 = 7$	0.8
7 Final $40 + 0.8 =$	41
8 figure is below 42	Permitted

Heat Pump Sizing

Dwelling 1970 no improvements

	No improvement to insulation	UPVC/wood Double glazing, + loft insulation	UPVC/wood Double glazing, + loft & cavity wall insulation
1970 to 1995	100 W/m ²	85 W/m ²	70 W/m ²
1996 to 2005	80 W/m ²	70 W/m ²	60 W/m ²
2006 to 2010	50 W/m ²	50 W/m ²	50 W/m ²
New build	40 W/m ²	40 W/m ²	40 W/m ²

Ground floor 45m² + f/floor 45m² = 90m²

90 x 100 = 9Kw

After adding improvements

Loft insulation & glazing

90 x 85 = 7.65Kw

UPVC/wood Double glazing, + loft insulation
85 W/m ²

	No improvement to insulation	UP
1970 to 1995	100 W/m ²	

	Temperature Star Rating	Heating circuit flow temperature °C	Likely space heating SPF		Oversize Factors for other emitters			Underfloor heating: screed			Underfloor heating: Aluminium panel		
			GSHP	ASHP	Domestic Fan Convector/Fan-assisted Radiator	Standard Radiator	Fan Coil Unit	with TILE	with WOOD	with CARPET	with TILE	with WOOD	with CARPET
Room specific heat loss 100 to 120 W/m ²	★★★★★	35	4.3	3.6	4.3	6.8	5.8						
	★★★★☆	40	4.1	3.4	3.1	4.3	3.5						
	★★★☆☆	45	3.7	3	2.4	3.1	2.6						
	★★★☆☆	50	3.4	2.7	2.0	2.4	2.1						
	★★☆☆☆	55	3.1	2.4	1.7	1.9	1.7						
	★★☆☆☆	60	2.8	2.1	1.4	1.6	1.5						

Scenario

Bungalow with 90m² floor area, dwelling heat loss of 10500kw 1980 built located in Humberside.

Heating system 35 under floor heating system incorporating HPC cylinder

$$\frac{10500}{90} = 117\text{w/m}^2 \text{ heat loss}$$

90

Solar sizing

Sap Calculation methods

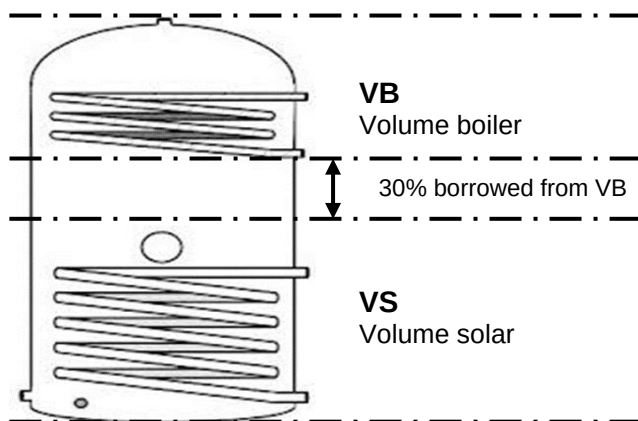
Below table is for new build properties where number of people is unknown

For example 120m² TFA equals 111litres VD

The solar VS must be able to hold 80% of the VD

$$110 \times 0.8 = 88.8$$

88.8litres is lower than the VS volume of 105litres so therefore the cylinder is correct



BSRIA method

$$46 + (26 \times \text{number of occupants})$$

For example 3 people

$$46 + 78 = 124$$

$$124 \times 0.8 = 99.2$$

99.2 VS

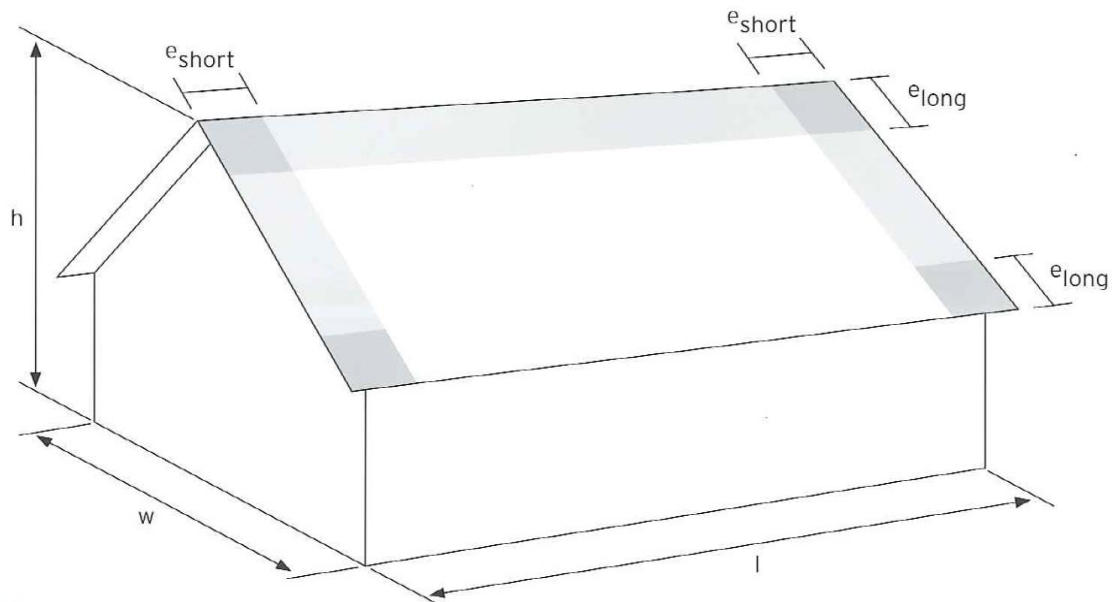
Total Floor area TFA (m2)	Assumed Occupancy	Hot water demand (litre/day)
40	1.4	72
80	2.5	100
120	3.0	111
200	3.2	116
300	3.4	121
400	3.6	127

Solar panel sizing

50 litres per panel
South facing
30°

Purge for 30mins remove air

Fact



Key:

w. Building width
h. Building height
l. Building length

Calculate the building width w, building height h and building length l.

The values for the edge clearances to be observed, e_{short} and e_{long} can be found in the following tables.

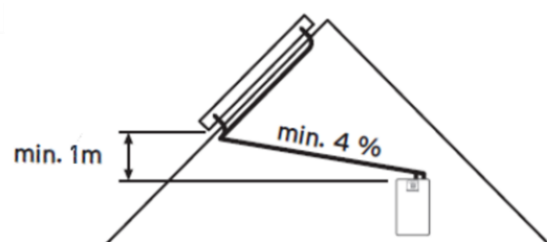
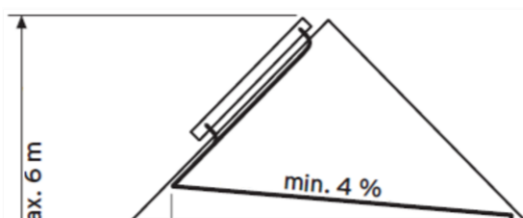
Building width w (m)	w (m)	Building height h (m)										
		5	6	7	8	9	10	11	12	13	14	15
8		1.0										
9		1.0										
10		1.0										
11	1.0	1.1										
12	1.0	1.2										
13	1.0	1.2	1.3									
14	1.0	1.2	1.4									
15	1.0	1.2	1.4	1.5								
16	1.0	1.2	1.4	1.6								
17	1.0	1.2	1.4	1.6	1.7							
18	1.0	1.2	1.4	1.6	1.8							

Edge clearances: e_{short} (m)

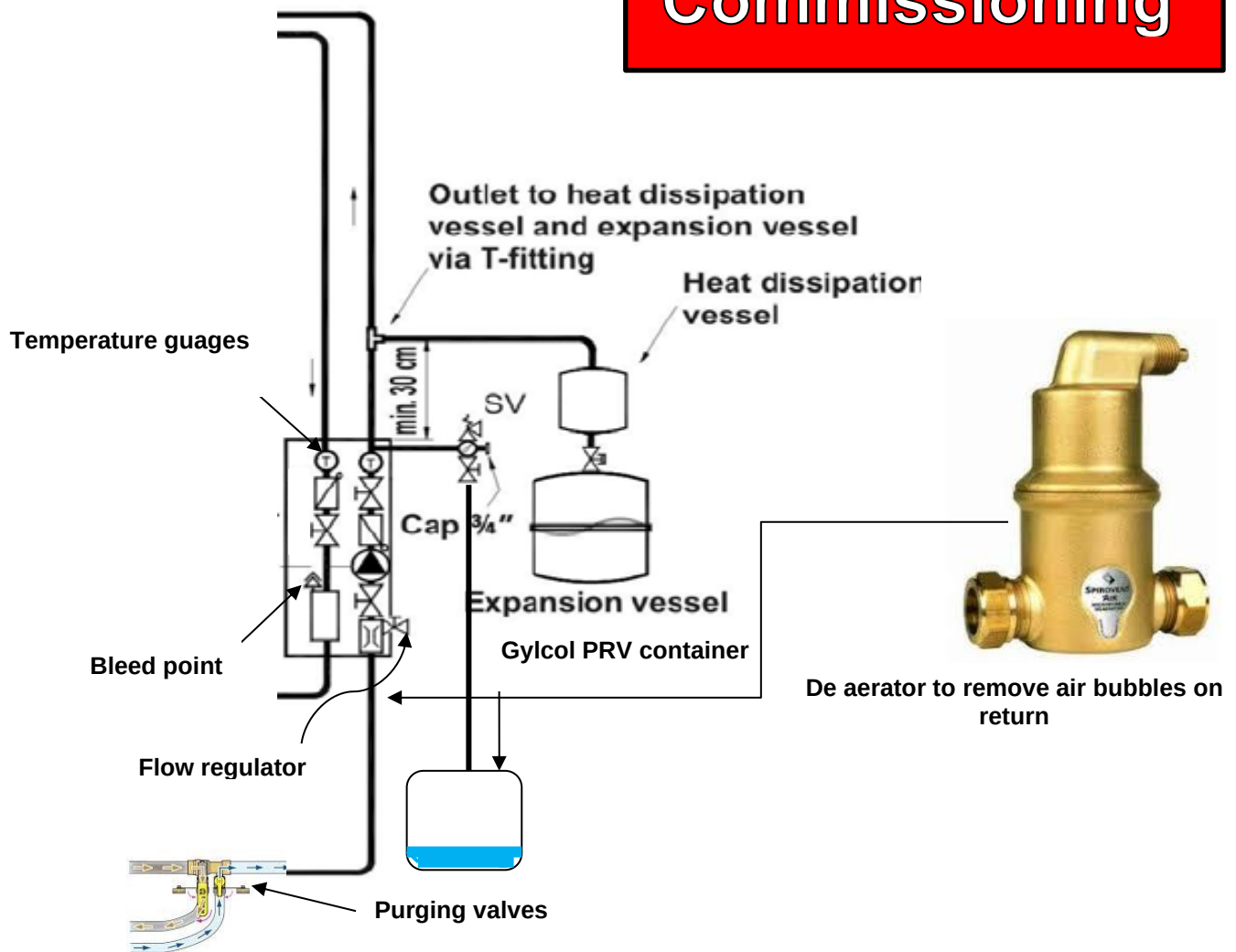
Building length l (m)	l (m)	Building height h (m)										
		5	6	7	8	9	10	11	12	13	14	15
	10	1.0										
	11	1.0	1.1									
	12	1.0	1.2									
	13	1.0	1.2	1.3								
	14	1.0	1.2	1.4								
	15	1.0	1.2	1.4	1.5							
	16	1.0	1.2	1.4	1.6							
	17	1.0	1.2	1.4	1.6	1.7						
	18	1.0	1.2	1.4	1.6	1.8						
19	1.0	1.2	1.4	1.6	1.8	1.9						
20	1.0	1.2	1.4	1.6	1.8	2.0						

Edge clearances: e_{long} (m)

NTC black / external - Grey / Internal
 Pump installed on the return
 Insulation must be 150°
 Coil hex should be 10% of collector
 No PTFE, No solder, No plastic, Metal clips only, Brass olives
 Higher than 4m planning needed
 5m from boundary
 Rafters at least 50mm
 Trac pipe 10m max 4cm fall



Solar Commissioning



Servicing

Comissioning	min	max
Flow rate	2l/m	3l/m
Ph levels	7	9
Refractometer	-16	-26
Sanitise	30mins	retest
Flush	30mins	Assess no air bubbles
Pressure	2bar	6bar

How to calculate flow rates for solar

$$\frac{Kw \times T}{SHC \times TD}$$

Kw amount of energy collector can absorb,
 Time 1sec
 SHC fluid glycol 3.9
 Temperature difference 6

Sizing air conditioning units

Calculating air conditioning required to meet demands,

allow 0.15 per Kw

elements to consider;

- Deduct by 10% if room in shaded area
- Add 10% if in high sun light exposure
- If oven in room incase by 1.15Kw
- If more than 2 individuals add 0.18kw pp

(Floor width x Floor length) x 0.15 =

Example room 5.5m by 7.5m, 20 people inside

$$\begin{aligned} 5.5 \times 7.5 &= 41.25 \\ 41.25 \times 0.15 &= 6.19 \\ 20 - 2 &= 18 \\ 18 \times 0.18 &= 3.24 \\ 9.42 &\text{ Kw} \end{aligned}$$

Temperature Conversion

Celsius to Kelvin

$$\begin{array}{cc} \text{Celsius} & \text{Kelvin} \\ & + 273 \end{array}$$

Conversation for Fahrenheit

$$\begin{array}{cc} \text{Celsius} & \text{Fahrenheit} \\ & (^\circ\text{c} \times 1.8) + 32 = \end{array}$$

$$\begin{array}{cc} \text{Fahrenheit} & \text{Celsius} \\ & \text{F} - 32 \div 1.8 = \end{array}$$

Boyes Law

Example

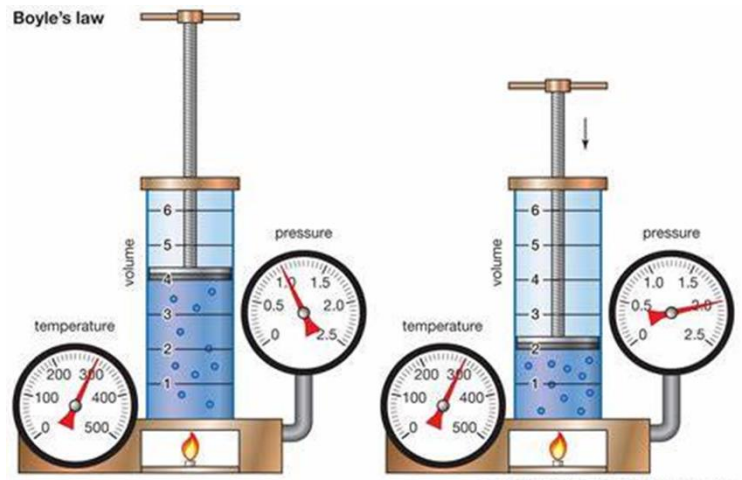
Tyre pressure is 11.41l @44psi,

What will the pressure be at 10.66l?

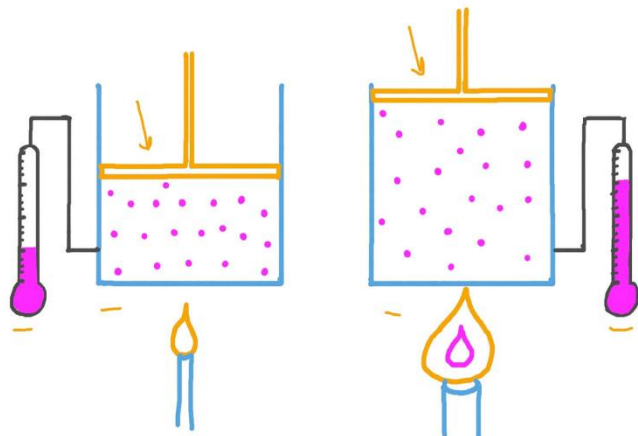
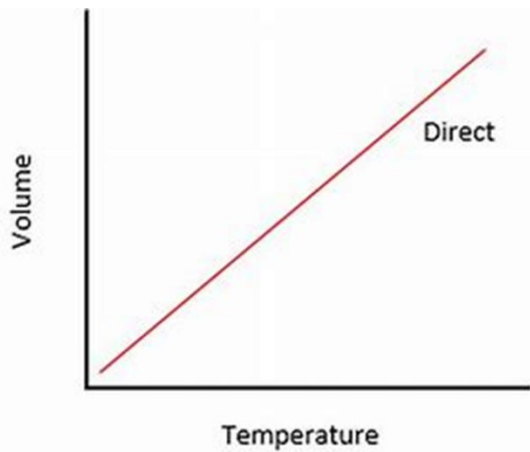
$$P1 \times V2 \div V1 = P2$$

$$44 \times 11.41 \div 10.66 = 47.36$$

10.6



CHARLES' LAW



Example

275ml @ 25°C what will be the volume at 50 °C

Always convert to Kelvin

$$25 + 273 = 298$$

$$50 + 273 = 323$$

$$275 = ??? = 88.825 \text{ divide by lower } T1 \text{ for new } V1 = 298$$

$$298 \text{ Multiply } 323$$

Example

A vessel is 250k in temperature with volume of 3.5l, when the vessel temperature is increased to 400k what will be the new volume?

$$\frac{V1}{T1} = \frac{V2}{T2} \quad \frac{3.5}{250} = \frac{?}{400} = 3.5 \times 400 = 1400$$

$$\text{Ans: } 1400 \div 250 = 5.6$$

Chillers

Calculate the amount of heat that must be removed from 500 kg of poultry that is to be stored at -18°C if it is to enter the refrigerated space at 7°C .

Specific heat of poultry before freezing = 3.18 kJ/kg K

Specific heat of poultry after freezing = 1.55 kJ/kg K

Latent heat of fusion (hfg) = 246 kJ/kg

Freezing temperature of poultry = -2.75°C

$$QT = hSB + hSA + hL$$

Where:- QT = Total heat.

hSB = sensible heat before freezing

hSA = sensible heat after freezing

hL = Latent heat

QSB = sensible heat before freezing

$$QSB = m \times \text{sp.ht} \times \text{td}$$

$$QSB = 500 \times 3.18 \times (7 - (-2.75))$$

$$QSB = 5000 \times 3.18 \times 9.75$$

$$QSB = \text{kg} \times \text{kJ/kg K} \times \text{K}$$

$$QSB = 500 \times 3.18 \times 9.75 = 15502.5 \text{ kJ}$$

QSA = sensible heat after freezing (sensible heat is adding heat)

$$QSA = m \times \text{sp. ht.} \times \text{td}$$

$$QSA = 500 \times 1.55 \times (-2.75 - (-18))$$

$$QSA = 500 \times 1.55 \times 15.25$$

$$QSA = \text{kg} \times \text{kJ/kg K} \times \text{K}$$

$$QSA = 500 \times 1.55 \times 15.25 = 11818.75 \text{ kJ}$$

QL = Latent heat after freezing (heat that doesn't change)

$$QL = m \times \text{hfg}$$

$$QL = \text{kg} \times \text{kJ/kg}$$

$$QL = 500 \times 246 = 123000 \text{ kJ}$$

$$QT = QSB + QSA + QL =$$

$$QT = 15502.5 + 11818.75 + 123000 = 150321.25 \text{ kJ}$$

Air conditioning

Solar gain = radiation

Heat gain = room generated

Heat gain (w) = (Area m²) x (U value W/m² K) x (Sat – Int temp)

- All testing should confirm with BSEN 378

- New or old system

- Refrigeration type

- New systems x 1.43

- Old systems x 1.1

- LP temperature 320

- HP temperature 550 (water cooled 430)

- If needed remove drier

- Nitrogen can cause suffocation

Testing

Existing (c)	New (c)	Side
1.1 x 55	1.43 x 55	HP
1.1 x 32	1.43 x 32	LP
1.1 x 32	1.43 x 43	Water cooled

CALCULATION OF STRENGTH TEST = 1.1 x PS

EXAMPLE

HIGH SIDE (Air cooled condenser)

55°C on R407F = 26.16 Bar

26.16 Bar x 1.1 = 28.78 Bar on the high side

LOW SIDE (Heat exchanger exposed to indoor ambient)

27°C on R407F = 11.07 Bar

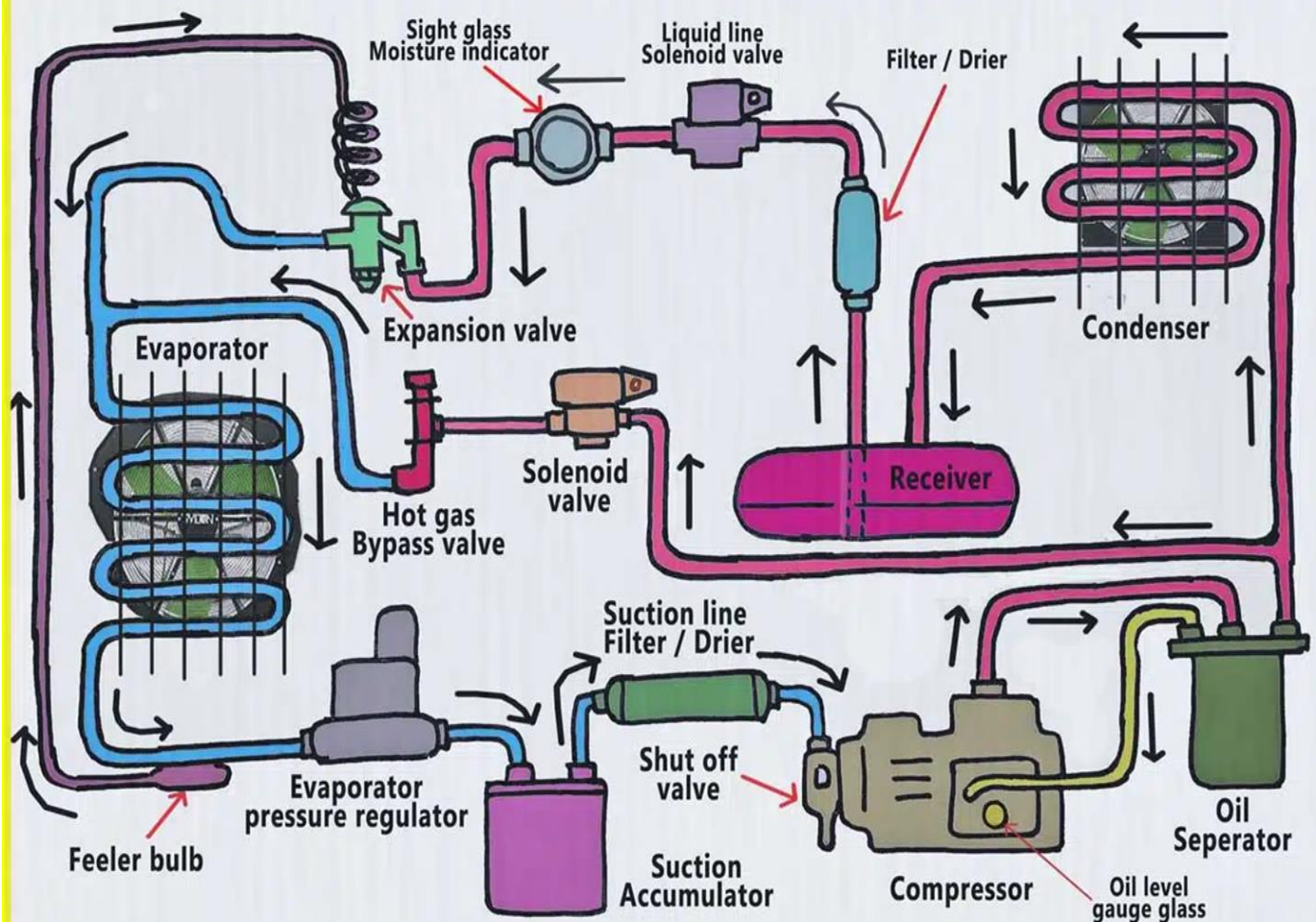
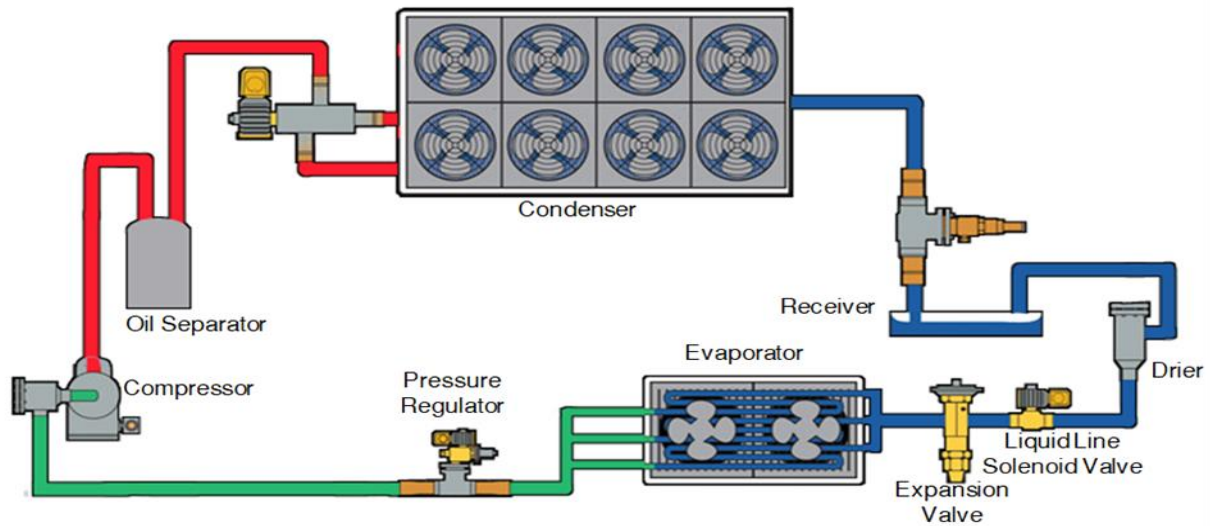
11.072 Bar x 1.1 = 12.18 Bar

High Side Strength Test Pressure = 28.78 Bar

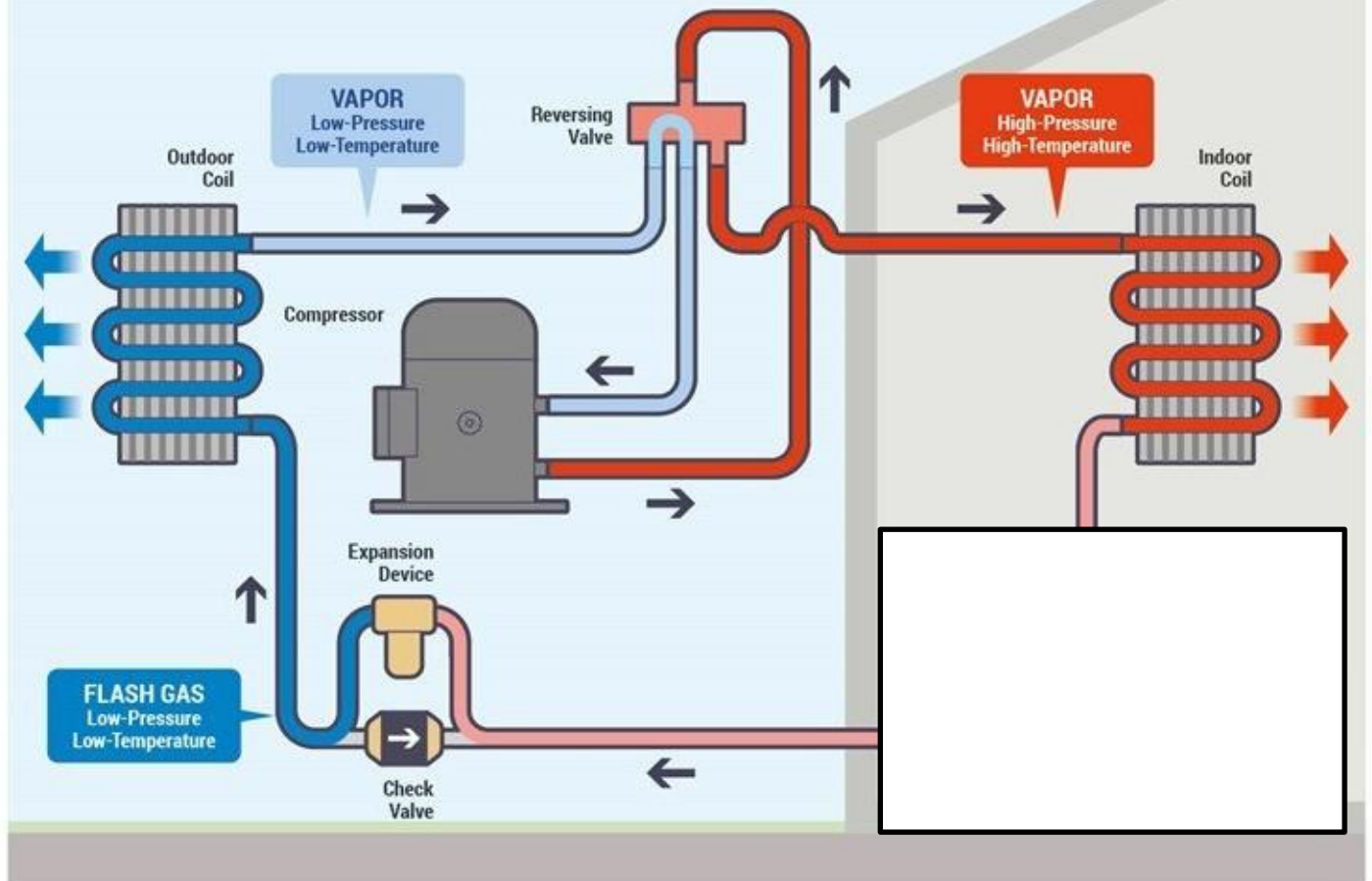
Low Side Strength Test Pressure = 12.18 Bar

REMEMBER: The high side test pressure could exceed the rating of the pressure relief valves (PRV's). If this is the case, then they should be removed and plugged for the strength test procedure.

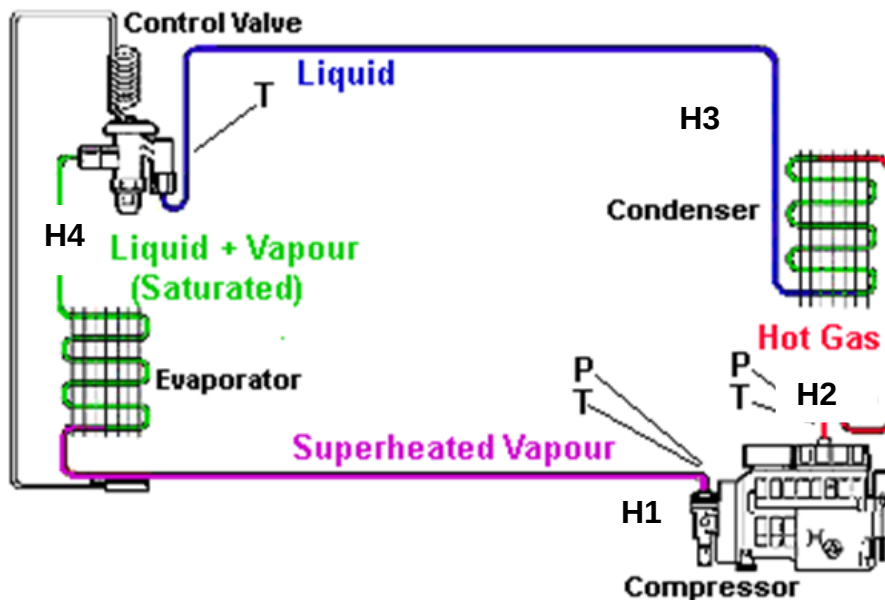
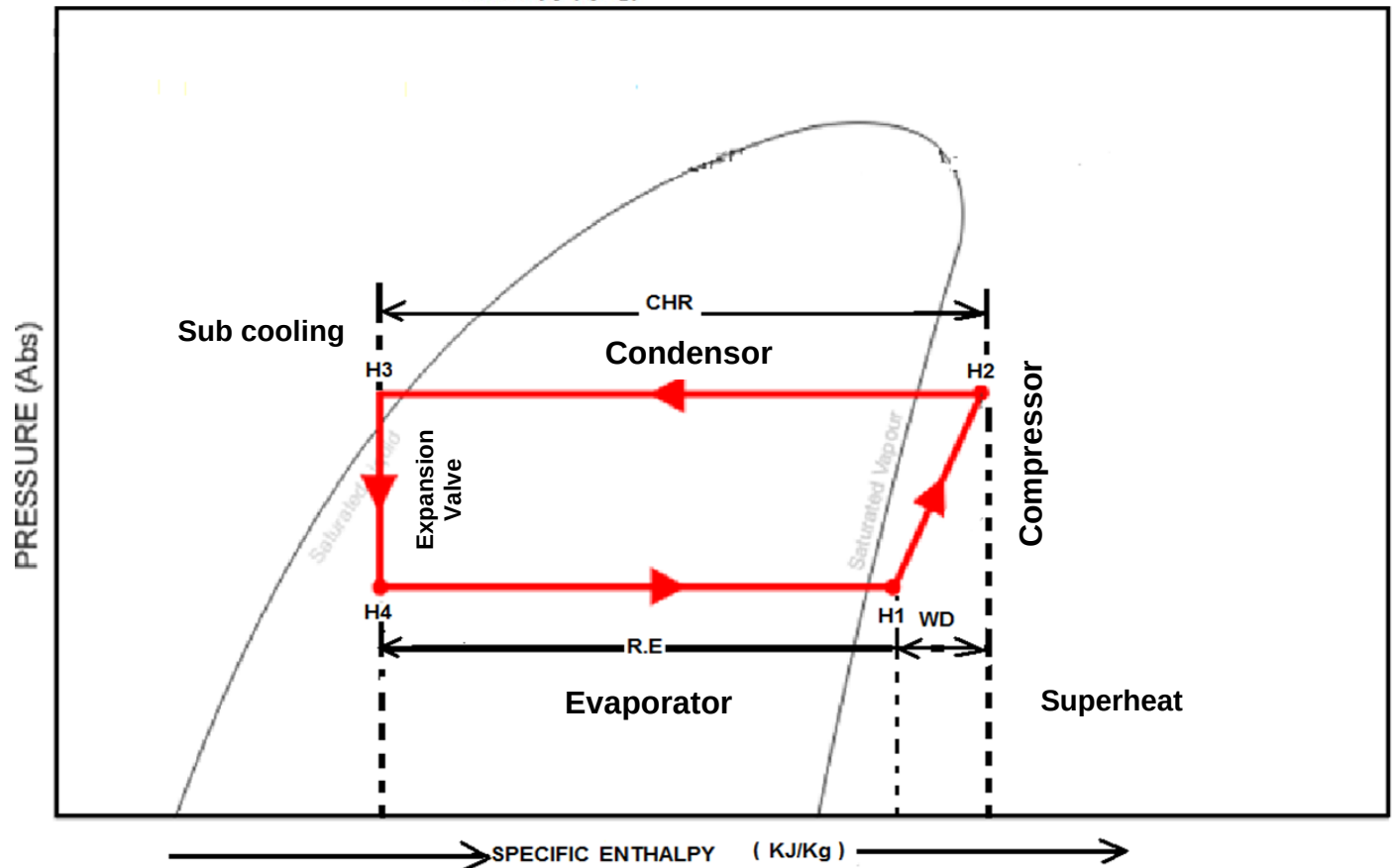
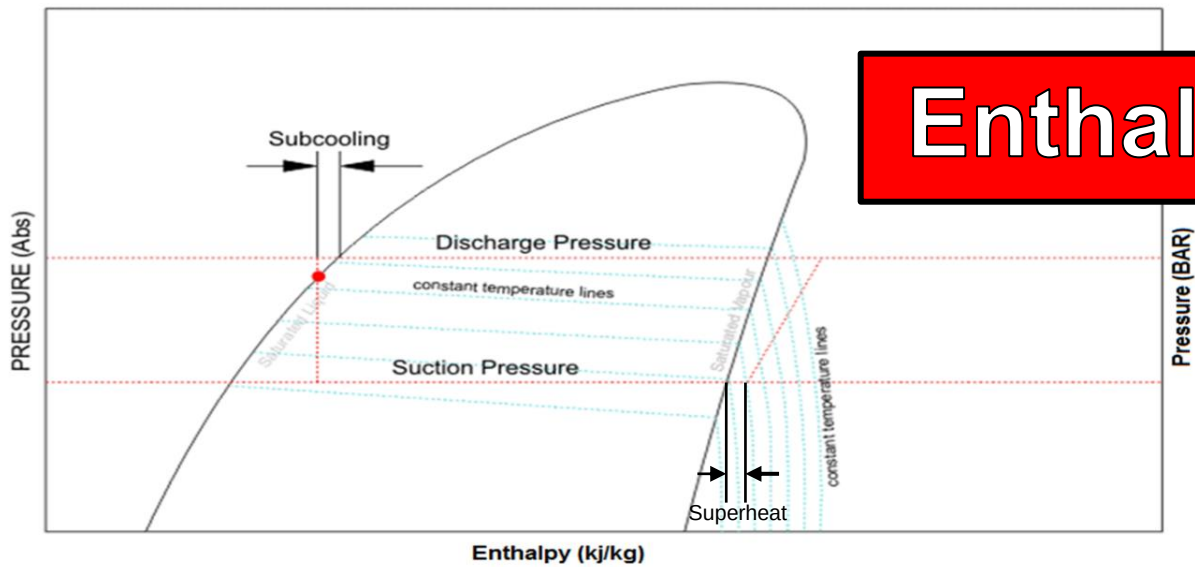
A REFRIGERATION CIRCUIT



Air Source Heat Pump Heating Cycle



Enthalpy



Enthalpy

Mass Flow Rate of Refrigerant (m) = Cooling duty / (H1 – H4)
Measured in kg/s

Work Done by Compressor = (H2 – H1) x m
Measured In kw

Condenser capacity measured = (H2 – H3) x m
In kw

Refrigeration Effect measured = (H1 – H4) x m
In kw

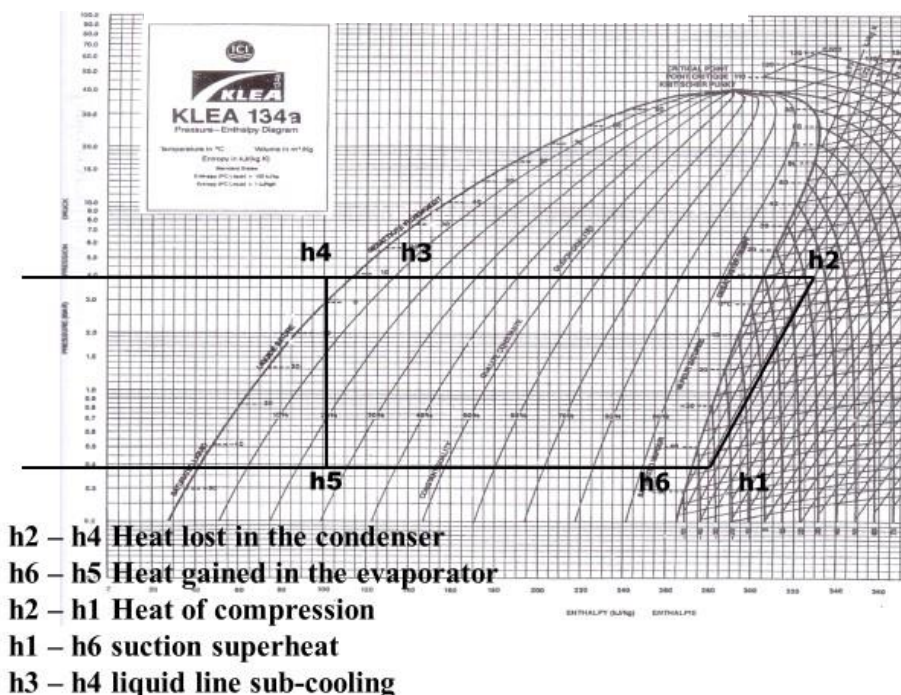
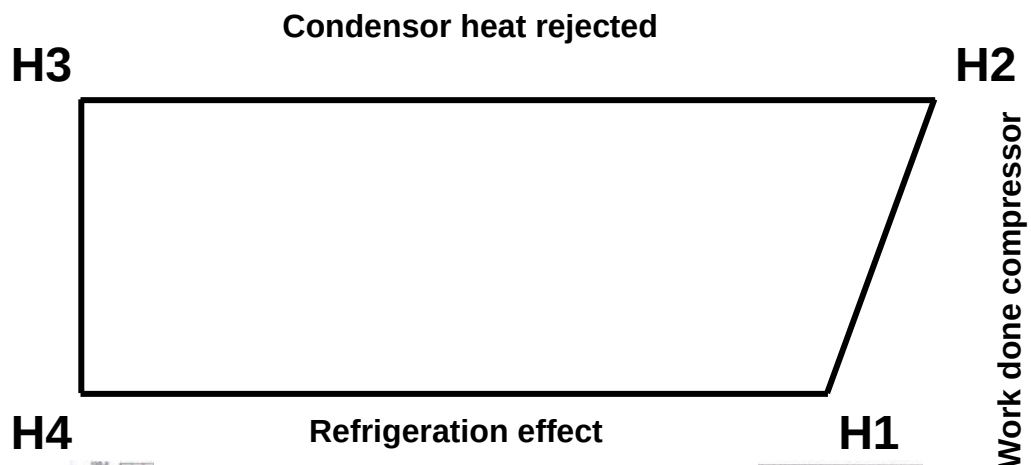
Volume Flow Rate (v) measured = Specific volume x m
In m³ / s

Coefficient of Performance (COP) = Refrigeration effect
No units(simply a ratio) (H1 – H4) / work done (H2 – H1)

Refrigerant flow rates

Kw = 10Kw = 0.05Kg/s

HRE 200kg



Compressor testing



Above: Remove compressor casing

Left: Pull off wiring harness

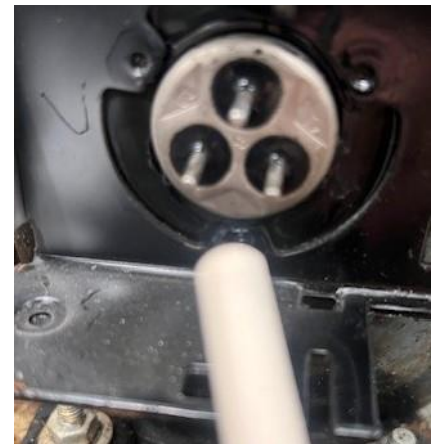


Right: Thermal overload, reset may need pressing instances of overheating, the ohms reading should be lower than 0.3Ω

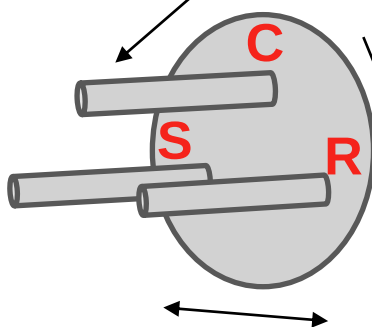


Left: Relay, soft compressor start, Resistance should be lower than 0.3Ω

Right: Behind the thermal overload is compressor winding pins for electrical supply Com, Start and Run. Run is usually on the right and Start usually has the higher Ω



Measure Ω C to S



Measure Ω C to R

Measure Ω S to R which should be equal to CS + CR

Compressors can fail due to low oil levels, overheating from refrigeration pressures, lack of cooling water from condense and fan failure

Tc = condensing temperature
Ta = ambient temperature
te= evaporating temperature
tei = air inlet to the evaporator

TDc = Tc - Ta
TDe = tei - te

For air cooled condensers :
Hot climates ----- TDc = 6 to 8°C
Normal climates ----- TDc = 8 to 10 °C
cold climates ----- TDc = 12 to 15 °C

TEV sizing formula

Ta 32

Te -35

39.4k

JEHS-1400-B4-L-3 EVI

Amount of Sub-cooling (K)					
Ta\Te	-40	-35	-30	-25	-20
27	38.8	37.3	35.8	34.3	32.8
32	41.3	39.4	37.6	35.8	34.0
35	42.7	40.7	38.7	36.7	34.6
38	44.2	42.0	39.7	37.5	35.3
43	46.6	44.1	41.5	39.0	36.5

Glossary

Building Regs approved document J: Combustion appliances & fuel storage systems

Building Regs approved document F: Ventilation

The Water Supply (Water Fittings) Regulations 1999

The Gas Safety (Installation and Use) Regulations 1998

The IET 18th Edition Wiring Regulations BS 7671.

British Standards for designing central heating systems include:

BS EN 12828: Heating systems in buildings. Design water-based heating systems

BS EN 12831: Heating systems in buildings Method for calculation of design load.

BS EN 442: Radiators and convectors. Technical specifications and requirements.

Other correction factors for radiators

Radiator connection factor	f2
Top and bottom same end (TBSE)	1.00
Top and bottom opposite end (TBOE)	1.05
Bottom opposite end (BOE)	0.96

Enclosure factor	F3
Fixed on plain surface	1.00
Shelf over radiator	0.95
Fixed in open recess	0.90
Encased in cabinet with front or top grille	0.70 or 0.80

Paint finish factor	F4
Oil or water based paint	1.00
Metallic based paint	0.85

Desired room temperatures

Room	Room Temperature °C
Living Room	21
Dining Room	21
Bedsitting room	21
Bedroom	21
Hall and Landing	21
Kitchen	21
Bathroom	22
Toilet	21
Unheated (including floor)	10

calculating ventilation heat loss:

Category A

Air change rates for older existing buildings (pre 2000)

Category B

Air change rates for modern buildings (2000 or later) with double glazing and regulatory minimum insulation

Category C

New buildings (constructed after 2006) complying with all current Building Regulations

Room	Category A	Category B	Category C
Lounge/living room	1.5	1	0.5
Dining/breakfast room	1.5	1	0.5
Kitchen	2	1.5	1.5
Hall	2	1	0.5
Cloaks/WC	2	1.5	1.5
Utility room	3	2	0.5
Study	1.5	1.5	0.5
Bedroom	1	1	0.5
Bedroom with ensuite bath	2	1.5	1
Internal room or corridor	0	0	0
Landing	2	1	0.5
Bathroom/shower room	3	1.5	1.5
Storeroom	1	0.5	0.5

Taken from Domestic Heating Design Guide

Softline temperature table

TEMPERATURES

Factors for differences between mean water temperature and room temperature in °C and °F other than 50°C (90°F)

°C		°F	
5	0.050	10	0.057
10	0.123	20	0.142
15	0.209	30	0.240
20	0.304	40	0.348
25	0.406	50	0.466
30	0.515	60	0.590
35	0.629	70	0.721
40	0.748	80	0.858
45	0.872	90	1.000
50	1.000	100	1.147
55	1.132	110	1.298
60	1.267	120	1.454
65	1.406	130	1.613
70	1.549	140	1.776
75	1.694	-	-

Other correction factors for radiators

Radiator connection factor	f2
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Enclosure factor	F3
Fixed on plain surface	1.00
Shelf over radiator	0.95
Fixed in open recess	0.90
Encased in cabinet with front or top grille	0.70 or 0.80

Paint finish factor	F4
Oil or <u>water based</u> paint	1.00
Metallic based paint	0.85

Heating pipe resistances

Fitting description	Equivalent length of straight pipe in metres				
Pipe diameter (copper)	10mm	15mm	22mm	28mm	35mm
Straight valves	0.5	0.5	0.6	0.6	0.8
Angle valves	2.0	2.0	4.5	6.0	N/A
Press fit/ capillary elbow	1.7	1.4	1.3	1.3	1.2
Tee branch (press fit)	1.7	1.5	1.5	1.7	2.0
Tee branch (capillary)	0.6	0.7	1.0	1.3	1.5
Radiator heat emitter	Assume 1 metre pipe per metre of radiator length				

Cylinder heat loss

Norminal Capacity (litres)	Standing heatloss	
	Per day (kwh/24hr)	Per year (kwh/365d)
120	1.24	453
150	1.43	522
170	1.54	562
210	1.89	690
250	2.07	756
300	2.36	961
Tested to BS EN 12897 : 2016 stored 20 heated to 60		

Gas rating chart

Time taken for 1 complete revolution of meter test dial (1ft ³)		Gas flow rate		Calculated heat input	
min	sec	ft ³ /hr	m ³ /hr	kW/hr	BTUs/hr
10	0	6.000	0.168	1.80	6146.15
9	55	6.050	0.169	1.82	6197.80
9	50	6.102	0.171	1.83	6250.32
9	45	6.154	0.172	1.85	6303.74
9	40	6.207	0.174	1.86	6358.09
9	35	6.261	0.175	1.88	6413.37
9	30	6.316	0.177	1.90	6469.63
9	25	6.372	0.178	1.91	6526.88
9	20	6.429	0.180	1.93	6585.16
9	15	6.486	0.182	1.95	6644.49
9	10	6.545	0.183	1.97	6704.89
9	5	6.606	0.185	1.98	6766.40
9	0	6.667	0.187	2.00	6829.05
8	55	6.729	0.188	2.02	6892.88
8	50	6.792	0.190	2.04	6957.90
8	45	6.857	0.192	2.06	7024.17
8	40	6.923	0.194	2.08	7091.71
8	35	6.990	0.196	2.10	7160.56
8	30	7.059	0.198	2.12	7230.76
8	25	7.129	0.200	2.14	7302.36
8	20	7.200	0.202	2.16	7375.38
8	15	7.273	0.204	2.18	7449.88
8	10	7.347	0.206	2.21	7525.90
8	5	7.423	0.208	2.23	7603.48
8	0	7.500	0.210	2.25	7682.69
7	55	7.579	0.212	2.28	7763.56
7	50	7.660	0.214	2.30	7846.15
7	45	7.742	0.217	2.32	7930.52
7	40	7.826	0.219	2.35	8016.72
7	35	7.912	0.222	2.38	8104.81
7	30	8.000	0.224	2.40	8194.87
7	25	8.090	0.227	2.43	8286.94
7	20	8.182	0.229	2.46	8381.11
7	15	8.276	0.232	2.48	8477.45
7	10	8.372	0.234	2.51	8576.02
7	5	8.471	0.237	2.54	8676.92
7	0	8.571	0.240	2.57	8780.21
6	55	8.675	0.243	2.60	8886.00
6	50	8.780	0.246	2.64	8994.36
6	45	8.889	0.249	2.67	9105.41
6	40	9.000	0.252	2.70	9219.22
6	35	9.114	0.255	2.74	9335.92
6	30	9.231	0.258	2.77	9455.61
6	25	9.351	0.262	2.81	9578.41
6	20	9.474	0.265	2.84	9704.45
6	15	9.600	0.269	2.88	9833.84
6	10	9.730	0.272	2.92	9966.73
6	5	9.863	0.276	2.96	10103.26
6	0	10.000	0.280	3.00	10243.58
5	55	10.141	0.284	3.04	10387.86
5	50	10.286	0.288	3.09	10536.26
5	45	10.435	0.292	3.13	10688.96
5	40	10.588	0.296	3.18	10846.15
5	35	10.746	0.301	3.23	11008.03
5	30	10.909	0.305	3.28	11174.82
5	25	11.077	0.310	3.33	11346.74
5	20	11.250	0.315	3.38	11524.03
5	15	11.429	0.320	3.43	11706.95
5	10	11.613	0.325	3.49	11895.77
5	5	11.803	0.330	3.54	12090.79
5	0	12.000	0.336	3.60	12292.30
4	55	12.203	0.342	3.66	12500.64
4	50	12.414	0.348	3.73	12716.17
4	45	12.632	0.354	3.79	12939.26
4	40	12.857	0.360	3.86	13170.32
4	35	13.091	0.367	3.93	13409.78
4	30	13.333	0.373	4.00	13658.11

Time taken for 1 complete revolution of meter test dial (1ft ³)		Gas flow rate		Calculated heat input	
min	sec	ft ³ /hr	m ³ /hr	kW/hr	BTUs/hr
4	25	13.585	0.380	4.08	13915.81
4	20	13.846	0.388	4.16	14183.42
4	15	14.118	0.395	4.24	14461.53
4	10	14.400	0.403	4.32	14750.76
4	5	14.694	0.411	4.41	15051.79
4	0	15.000	0.420	4.50	15365.37
3	55	15.319	0.429	4.60	15692.30
3	50	15.652	0.438	4.70	16033.43
3	45	16.000	0.448	4.80	16389.73
3	40	16.364	0.458	4.91	16762.23
3	35	16.744	0.469	5.03	17152.04
3	30	17.143	0.480	5.15	17560.43
3	25	17.561	0.492	5.27	17988.73
3	20	18.000	0.504	5.40	18438.45
3	15	18.462	0.517	5.54	18911.23
3	10	18.947	0.531	5.69	19408.89
3	5	19.459	0.545	5.84	19933.46
3	0	20.000	0.560	6.00	20487.16
2	55	20.571	0.576	6.18	21072.51
2	50	21.176	0.593	6.36	21692.29
2	45	21.818	0.611	6.55	22349.63
2	40	22.500	0.630	6.76	23048.06
2	35	23.226	0.650	6.97	23791.55
2	30	24.000	0.672	7.21	24584.60
2	25	24.828	0.695	7.45	25432.34
2	20	25.714	0.720	7.72	26340.64
2	15	26.667	0.747	8.01	27316.22
2	10	27.692	0.775	8.31	28366.84
2	5	28.800	0.806	8.65	29501.52
2	0	30.000	0.840	9.01	30730.75
1	55	31.304	0.877	9.40	32066.87
1	50	32.727	0.916	9.83	33524.45
1	45	34.286	0.960	10.29	35120.85
1	40	36.000	1.008	10.81	36876.90
1	35	37.895	1.061	11.38	38817.79
1	30	40.000	1.120	12.01	40974.33
1	25	42.353	1.186	12.72	43384.58
1	20	45.000	1.260	13.51	46096.12
1	15	48.000	1.344	14.41	49169.19
1	10	51.429	1.440	15.44	52681.28
1	5	55.385	1.551	16.63	56733.69
1	0	60.000	1.680	18.01	61461.49
0	58	62.069	1.738	18.63	63580.86
0	56	64.286	1.800	19.30	65851.60
0	54	66.667	1.867	20.01	68290.55
0	52	69.231	1.938	20.78	70917.11
0	50	72.000	2.016	21.62	73753.79
0	48	75.000	2.100	22.52	76826.87
0	46	78.261	2.191	23.50	80167.17
0	44	81.818	2.291	24.56	83811.13
0	42	85.714	2.400	25.73	87802.13
0	40	90.000	2.520	27.02	92192.24
0	38	94.737	2.653	28.44	97044.46
0	36	100.000	2.800	30.02	102435.82
0	34	105.882	2.965	31.79	108461.46
0	32	112.500	3.150	33.78	115240.30
0	30	120.000	3.360	36.03	122922.99
0	28	128.571	3.600	38.60	131703.20
0	26	138.462	3.877	41.57	141834.22
0	24	150.000	4.200	45.03	153653.73
0	22	163.636	4.582	49.13	167622.25
0	20	180.000	5.040	54.04	184384.48
0	18	200.000	5.600	60.04	204871.64
0	16	225.000	6.300	67.55	230480.60
0	14	257.143	7.200	77.20	263406.40
0	12	300.000	8.400	90.07	307307.47
0	10	360.000	10.080	108.08	368768.96

Gas Pipe sizing chart

Based on straight actual length with 1mb droppage from both ends

use 0.5m for a bend & 0.3m for a machine bend

2 (b) Copper pipe in accordance with BS EN 1057								
	Length of pipe (m)							
	3	6	9	12	15	20	25	30
mm (OD)	Discharge (m ³ /hr)							
8	00.29	00.14	00.49	00.07	00.05	–	–	–
10	00.86	00.57	00.50	00.37	00.30	00.22	00.18	00.15
12	01.50	01.00	00.85	00.82	00.69	00.52	00.41	00.34
15	02.90	01.90	01.50	01.30	01.10	00.95	00.92	00.88
22	08.70	05.80	04.60	03.90	03.40	02.90	02.50	02.30
28	18.00	12.00	09.40	08.00	07.00	05.90	05.20	04.70
35	32.00	22.00	17.00	15.00	13.00	11.00	09.50	08.50