Cork Institute of Technology

Bachelor of Engineering in Building Services Engineering – Stage 2

(EBSEN_7_Y2)

Autumn 2008

Building Services and Equipment II

(Time: 3 Hours)

Instructions
Answer FIVE questions,
All questions carry equal marks.

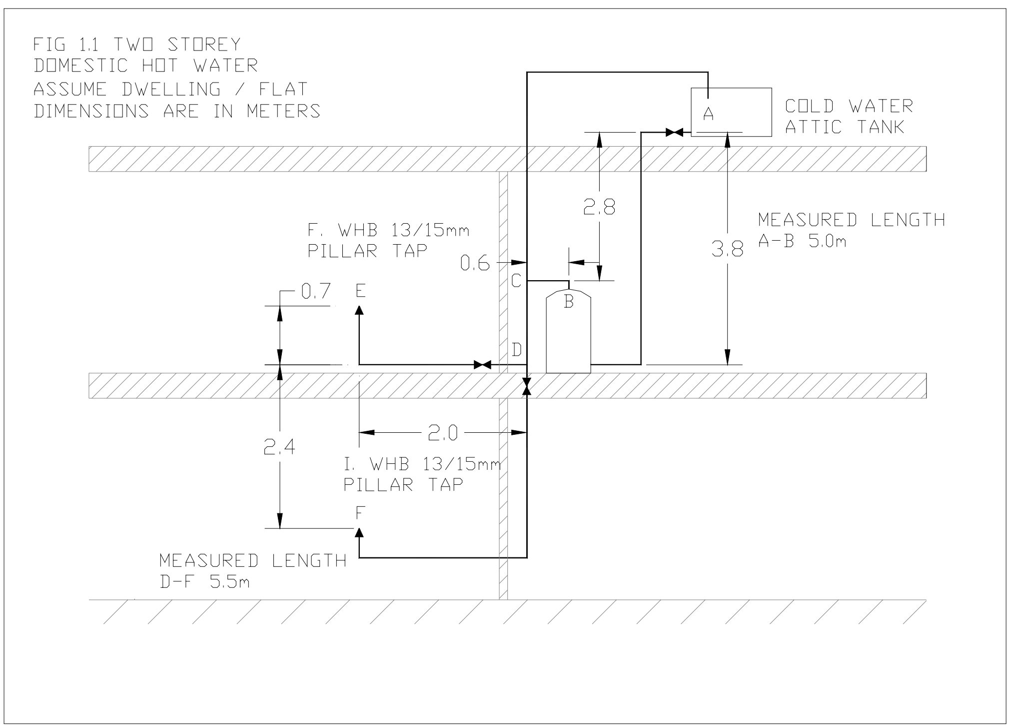
Examiners: Mr. Will Bateman
Dr. Mervyn Smyth
Mr. Declan Leonard

	Reference Material to be provided.	**Question**	**Location**
1.	Table 1, 2, 3and 4 – Hot and Cold Water Pipe work Design	Q1	(attached)
2.	CIBSE Table 4.13 Page 4-23 – Water 75^{0}C Copper Pipe.	Q1	(attached)
3.	Hot and Cold Water design Spreadsheet	Q1	(attached)
4.	CIBSE Table C4.11, Page 4-15 - Water 75^{0}C Med Grade Steel	Q4	(attached)
5.	CIBSE Table 3.17 – Heat Emissions from single horiz pipe.	Q4	(attached)
6.	CIBSE Table 4.36. -Velocity press loss factors for pipe work	Q4	(attached)
7.	Ductwork Design Sheet	Q5	(attached)
8.	CIBSE Fig C4.2 – Pressure Drop for air in galvanised circ ducts	Q5	(attached)
9.	CIBSE Table 4.42 – Velocity pressure of air.	Q5	(attached)
10.	Table 4.35. –Velocity press loss factors for duct fittings. 2pages	Q5	(attached)

Q1 (a) Under EU guidelines list five general conditions that specify the quality of water for human consumption. [5 marks]

(b) For each of these five conditions, list a water treatment process that would be used to achieve that condition. [5 marks]

(c) Determine the most economical diameters of the copper distribution pipes labelled AB, BC, etc in Fig 1.1 below. The pipe work is located in a domestic house.
Reference - Tables 1, 2, 3 and 4 – Hot and Cold water pipe work design.
Reference – CIBSE Table C4.13 – Flow of Water at 75 Deg C in Copper Pipe.
Fill in the relevant data on the Hot and Cold Water design spreadsheet supplied.
Ensure you put your name on the sheet and attach the sheet to your answer book.
Show all rough work used to calculate the initial flow rates in each section. [10 marks]



Q2 (a) A flat roof consists of 150mm thick concrete covered by 20mm layer of asphalt. The inside surface has a layer of 50mm thick expanded polystyrene insulation, supported by a 13mm plasterboard and has a 5 mm coat of plaster on the inside. The internal ceiling and external surface of the asphalt have a low emissivity. The roof is in a sheltered location. Calculate the U Value for this roof if the Thermal conductivity (k) of the individual layers are as follows, all units W/m ^{0}C

Asphalt 0.7	Concrete 2.0	Expanded Polystyrene 0.04
Plaster board 0.25	Plaster 0.4	

Tables for – Rsi Table 3.9, Rse Table 3.10 below as reference

NB Use resistance data for BS EN ISO 6946 [6 marks]

Table 3.9 Internal surface resistance, R_{si}

Building element	Direction of heat flow	Surface resistance ($m^2 \cdot K \cdot W^{-1}$)	
		BS EN ISO 6946 design value	Traditional UK value
Walls	Horizontal	0.13	0.12
Ceilings or roofs (flat or pitched), floors	Upward	0.10	0.10
Ceilings or floors	Downward	0.17	0.14

Table 3.10 External surface resistance, R_{se}

Building element	Direction of heat flow	Surface resistance ($m^2 \cdot K \cdot W^{-1}$)			
		BS EN ISO 6946 design value	Traditional UK values for stated conditions of exposure		
			Normal	Sheltered	Exposed
Wall	Horizontal	0.04	0.06	0.08	0.03
Roof	Upward	0.04	0.04	0.07	0.02
Floor	Downward	0.04	0.04	0.07	0.02

(b) Calculate the additional thickness of expanded polystyrene insulation required to improve the construction to achieve a U value of 0.22 W/m^2 ^{0}C to comply with current building regulations. [4 marks]

(c) Calculate the total heat loss from **Bedroom No 1** as shown in Fig 2.1 attached when using convective heating.

(10 marks)

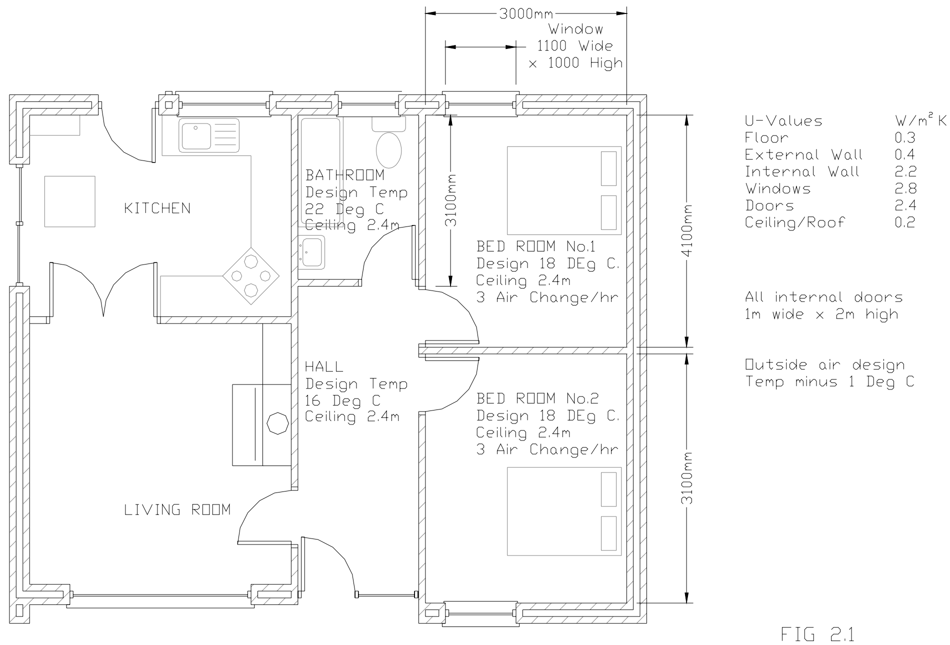


FIG 2.1
QUESTION 2c

Q3 (a) Fig 3.1 shows an un-insulated mild steel Two Pipe Parallel LPHW heating system with four sections. Bends are welded mild steel elbows.

The primary calculations of pipe sizing and pressure loss for sections 1, 2, and 3 have already been found and are listed in Table 3.2 below.

For pipe section 4 calculate the pipe diameter required to supply the heat load given that the 6kW load is part of pipe section 4. Show all rough work calculations.

Compare the actual heat loss from the pipe work in section 4 against the theoretical.

Tables C4.11, and C3.14 attached for reference. [10 marks]

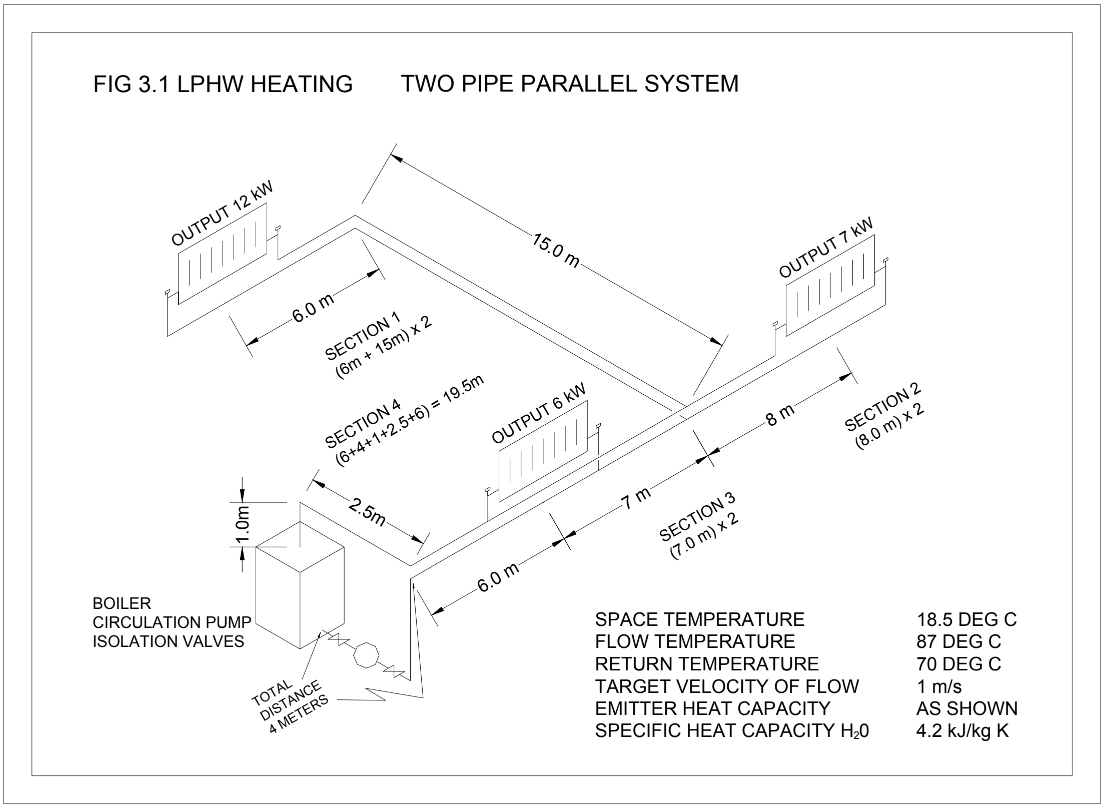


FIG 3.1 LPHW HEATING TWO PIPE PARALLEL SYSTEM

Table 3.2. LPHW Sizing Sections 1, 2 and 3.

Pipe Section	Cumulative Heat Loss (kW)	Calculated mass flow (kg / s)	Calculated Pipe Diam (mm)	Effective Pipe Length(m)	Delta P Pa/ m run	Section delta P (Pa)
Sect 1	14.9 (Sect 1)	0.202	15	44.7	900	40230
Sect 2	8.10 (Sect 2)	0.117	10	17.8	1200	21360
Sect 3	24.2 (Sect 1+2+3)	0.386	20	15.1	700	10570
Sect 4						

(b) For pipe section 4, calculate the effective length of the pipe work plus fittings and their associated pressure loss. Combine these results with existing results in table 3.2 to establish the duty and head of the circulating pump required. Tables C4.36 attached for reference. [10 marks]

Q4 (a) Explain the terms BMS and BEMS. [2 marks]

(b) Describe how a BMS LAN might be configured to allow monitoring and control of a large number of pieces of equipment within a site. Use a sketch to support your description. [6 marks]

(b) List three items of hardware associated with a BMS system and briefly explain the function of each item within the system. [6 marks]

(c) With the aid of a neat sketch show how a BMS system might be linked to the various components for the optimum control of a Fan Terminal Unit used for room heating. [6 marks]

Q5 (a) Ventilation is the process of changing the air in a given space.
List six reasons why ventilation is needed. [6 marks]

(b) Air conditioning is the process of treating air to meet the requirements of the conditioned space. List four items treated during air conditioning. [4 marks]

(c) Briefly describe three types of air filters that may be found in air conditioning systems indicating how each works. [6 marks]

(d) Air conditioning can be achieved using “centralised air conditioning systems” or “Split unit Heat Pump systems”. List two advantages of each system. [4 marks]

Q6. (a) With the aid of a neat sketch show all the equipment associated with a typical "wet" sprinkler system for a two storey building. [6 marks]

(b) Using a neat sketch show the general arrangement of an on site automatic sprinkler pump system including the water storage and water supply. [6 marks]

(c) Outline the type of portable fire extinguishers you would recommend for use on fires involving four of the following materials :- [4 marks]

Table 6

No.	(i)	(ii)	(iii)	(iv)	(v)
Class	A	B	C	D	E
Fire Type	Wood & textiles	Petroleum	Gases	Inflammable metals	Electrical

(d) Briefly explain how each type of extinguisher described above is effective in fighting the relevant fire. [4 marks]

Q7 (a) The industrial revolution began about the mid 1800's. Since then there have been huge advances in technology. Explain briefly how and why these advances have had a negative impact on our global climate. [6 marks]

(b) List 3 types of pollutants that have increased dramatically with increasing industrialisation. For each list typical sources, impacts and possible controls to minimise their future impact. [9 marks]

(c) Explain the term EPA and explain this organisations role in pollution control in Ireland. [5 marks]

Cork Institute of Technology

Attachments

for

Higher Certificate in Engineering

Building Services Engineering

(NFQ – Level 6)

Autumn 2008

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Tables 1, 2, 3 and 4 - Hot and Cold Water Pipework Design.

Table 1

Loading Units for various types of Sanitary Applications.

Location / Appliance	Loading Units
Dwellings, Flats, Offices, Schools, Industrial Buildings	
W.C flushing cistern	2
Wash basin (distributed use)	1.5
Wash basin (concentrated use)	3
Bath Private 19mm taps	10
Bath Public 25mm taps	22
Showers (Gravity feed)	3
Shower (Power shower)	12
Kitchen Sink 13/19/25mm taps	3 / 4 / 5

It should be noted that certain sanitary appliances such as those fitted with spray taps, umbrella taps, shower nozzles or similar fittings require a continuous flow of water as long as such appliances are in use.

Table 2

Recommended minimum flow rates for Sanitary Appliances.

Type of appliance	Rate of Flow (l/s)
W.C flushing cistern (Private)	0.13
W.C flushing cistern (Public)	0.15
Wash basin	0.15
Bath 19mm Taps(private)	0.30
Bath 25mm Taps (public)	0.60
Showers (Gravity feed)	0.20
Shower (Power shower)	0.35
Kitchen Sink with 13mm taps	0.20
Kitchen Sink with 19mm taps	0.30
Dish / clothes washing machine	0.15
Urinal Flushing Cistern	0.03 max

Table 3

Frictional resistance of Fittings expressed in Equivalent Pipe Lengths

Copper			Galvanised Steel			
Nominal outside diameter (mm)	Equivalent length Meter run of pipe Elbow	Tee	Nominal outside diameter (mm)	Equivalent length Meter run of pipe Elbow	Bend	Tee
15	0.5	0.6	15	0.5	0.4	1.2
22	0.8	1.0	20	0.6	0.5	1.4
28	1.0	1.5	25	0.7	0.6	1.8
35	1.4	2.0	32	1.0	0.7	2.3
42	1.7	2.5	40	1.2	1.0	2.7
54	2.3	3.5	50	1.4	1.2	3.4
62	3.0	4.5	65	1.7	1.3	4.2
76	3.4	5.8	80	2.0	1.6	5.3
108	4.5	8.0	100	2.7	2.0	6.8

Table 4

Frictional resistance of draw off taps and globe type isolation valves expressed as equivalent pipe lengths

	Equivalent lengths in meters for nominal diameter fittings					
	13/15mm	19/22mm	25/28mm	35mm	42mm	54mm
Bib Tap, Pillar Tap, Globe type Isol v/v	5m	6m	9m	11m	14m	18m
Ball Float Valves HP	75m	40m	40m	35m	21m	20m
Ball Float Valves LP	8m					

Table 4.13 Flow of water at 75°C in copper pipes — *continued*

q_m = mass flow rate kg.s^{-1}
c = velocity m.s^{-1}
$\Delta p/l$ = pressure drop per unit length Pa.m^{-1}
l_e = equivalent length of a component for $\zeta = 1$ m

COPPER, TABLE X

WATER AT 75°C

$\Delta p/l$	c	12 mm		15 mm		22 mm		28 mm		35 mm		42 mm		c	$\Delta p/l$
		q_m	l_e	q_m	l_e	q_m	l_e	q_m	l_e	q_m	l_e	q_m	l_e		
92.5		0.022	*0.3*	0.041	*0.4*	0.120	*0.8*	0.242	*1.1*	0.437	*1.5*	0.737	*2.0*		92.5
95.0		0.222	*0.3*	0.042	*0.4*	0.122	*0.8*	0.246	*1.1*	0.444	*1.5*	0.748	*2.0*		95.0
97.5		0.022	*0.3*	0.042	*0.4*	0.124	*0.8*	0.250	*1.1*	0.450	*1.5*	0.759	*2.0*		97.5
100.0		0.023	*0.3*	0.043	*0.4*	0.125	*0.8*	0.253	*1.1*	0.457	*1.5*	0.769	*2.0*		100.0
120.0	0.3	0.025	*0.3*	0.047	*0.5*	0.139	*0.8*	0.281	*1.2*	0.506	*1.6*	0.852	*2.0*		120.0
140.0		0.028	*0.3*	0.052	*0.5*	0.152	*0.8*	0.306	*1.2*	0.551	*1.6*	0.928	*2.1*		140.0
160.0		0.030	*0.3*	0.056	*0.5*	0.164	*0.8*	0.330	*1.2*	0.594	*1.6*	1.00	*2.1*		160.0
180.0		0.032	*0.3*	0.060	*0.5*	0.175	*0.8*	0.352	*1.2*	0.635	*1.6*	1.07	*2.1*		180.0
200.0		0.034	*0.4*	0.064	*0.5*	0.186	*0.9*	0.374	*1.2*	0.673	*1.7*	1.13	*2.2*		200.0
220.0		0.036	*0.4*	0.067	*0.5*	0.196	*0.9*	0.394	*1.2*	0.710	*1.7*	1.19	*2.2*	1.0	220.0
240.0		0.038	*0.4*	0.071	*0.5*	0.206	*0.9*	0.414	*1.3*	0.745	*1.7*	1.25	*2.2*		240.0
260.0		0.039	*0.4*	0.074	*0.5*	0.215	*0.9*	0.433	*1.3*	0.779	*1.7*	1.31	*2.2*		260.0
280.0		0.041	*0.4*	0.077	*0.5*	0.224	*0.9*	0.451	*1.3*	0.812	*1.7*	1.37	*2.2*		280.0
300.0		0.043	*0.4*	0.080	*0.5*	0.233	*0.9*	0.469	*1.3*	0.844	*1.7*	1.42	*2.3*		300.0
320.0	0.5	0.044	*0.4*	0.083	*0.5*	0.242	*0.9*	0.486	*1.3*	0.874	*1.8*	1.47	*2.3*		320.0
340.0		0.046	*0.4*	0.086	*0.5*	0.250	*0.9*	0.503	*1.3*	0.904	*1.8*	1.52	*2.3*		340.0
360.0		0.048	*0.4*	0.089	*0.5*	0.258	*0.9*	0.519	*1.3*	0.934	*1.8*	1.57	*2.3*		360.0
380.0		0.049	*0.4*	0.092	*0.5*	0.266	*0.9*	0.535	*1.3*	0.962	*1.8*	1.62	*2.3*		380.0
400.0		0.050	*0.4*	0.094	*0.5*	0.274	*0.9*	0.551	*1.3*	0.990	*1.8*	1.66	*2.3*		400.0
420.0		0.052	*0.4*	0.097	*0.5*	0.282	*0.9*	0.566	*1.3*	1.02	*1.8*	1.71	*2.3*		420.0
440.0		0.053	*0.4*	0.099	*0.5*	0.289	*0.9*	0.581	*1.4*	1.04	*1.8*	1.75	*2.4*		440.0
460.0		0.055	*0.4*	0.102	*0.5*	0.297	*1.0*	0.595	*1.4*	1.07	*1.8*	1.80	*2.4*	1.5	460.0
480.0		0.056	*0.4*	0.104	*0.6*	0.304	*1.0*	0.610	*1.4*	1.10	*1.8*	1.84	*2.4*		480.0
500.0		0.057	*0.4*	0.107	*0.6*	0.311	*1.0*	0.624	*1.4*	1.12	*1.8*	1.88	*2.4*		500.0
520.0		0.059	*0.4*	0.109	*0.6*	0.318	*1.0*	0.637	*1.4*	1.15	*1.8*	1.92	*2.4*		520.0
540.0		0.060	*0.4*	0.112	*0.6*	0.324	*1.0*	0.651	*1.4*	1.17	*1.9*	1.96	*2.4*		540.0
560.0		0.061	*0.4*	0.114	*0.6*	0.331	*1.0*	0.664	*1.4*	1.19	*1.9*	2.00	*2.4*		560.0
580.0		0.062	*0.4*	0.116	*0.6*	0.338	*1.0*	0.677	*1.4*	1.22	*1.9*	2.04	*2.4*		580.0
600.0		0.064	*0.4*	0.119	*0.6*	0.344	*1.0*	0.690	*1.4*	1.24	*1.9*	2.08	*2.4*		600.0
620.0		0.065	*0.4*	0.121	*0.6*	0.350	*1.0*	0.703	*1.4*	1.26	*1.9*	2.12	*2.4*		620.0
640.0		0.066	*0.4*	0.123	*0.6*	0.357	*1.0*	0.715	*1.4*	1.28	*1.9*	2.16	*2.4*		640.0
660.0		0.067	*0.4*	0.125	*0.6*	0.363	*1.0*	0.728	*1.4*	1.31	*1.9*	2.19	*2.5*		660.0
680.0		0.068	*0.4*	0.127	*0.6*	0.369	*1.0*	0.740	*1.4*	1.33	*1.9*	2.23	*2.5*		680.0
700.0		0.069	*0.4*	0.129	*0.6*	0.375	*1.0*	0.752	*1.4*	1.35	*1.9*	2.26	*2.5*		700.0
720.0		0.070	*0.4*	0.131	*0.6*	0.381	*1.0*	0.764	*1.4*	1.37	*1.9*	2.30	*2.5*		720.0
740.0		0.072	*0.4*	0.133	*0.6*	0.387	*1.0*	0.775	*1.4*	1.39	*1.9*	2.33	*2.5*		740.0
760.0		0.073	*0.4*	0.135	*0.6*	0.392	*1.0*	0.787	*1.4*	1.41	*1.9*	2.37	*2.5*		760.0
780.0		0.074	*0.4*	0.137	*0.6*	0.398	*1.0*	0.798	*1.4*	1.43	*1.9*	2.40	*2.5*	2.0	780.0
800.0		0.075	*0.4*	0.139	*0.6*	0.404	*1.0*	0.810	*1.4*	1.45	*1.9*	2.44	*2.5*		800.0
820.0		0.076	*0.4*	0.141	*0.6*	0.409	*1.0*	0.821	*1.4*	1.47	*1.9*	2.48	*2.5*		820.0
840.0		0.077	*0.4*	0.143	*0.6*	0.415	*1.0*	0.832	*1.5*	1.49	*1.9*	2.50	*2.5*		840.0
860.0		0.078	*0.4*	0.145	*0.6*	0.420	*1.0*	0.843	*1.5*	1.51	*1.9*	2.54	*2.5*		860.0
880.0		0.079	*0.4*	0.147	*0.6*	0.426	*1.0*	0.853	*1.5*	1.53	*2.0*	2.57	*2.5*		880.0
900.0		0.080	*0.4*	0.149	*0.6*	0.431	*1.0*	0.864	*1.5*	1.55	*2.0*	2.60	*2.5*		900.0
920.0		0.081	*0.4*	0.151	*0.6*	0.437	*1.0*	0.875	*1.5*	1.57	*2.0*	2.63	*2.5*		920.0
940.0		0.082	*0.4*	0.153	*0.6*	0.442	*1.0*	0.885	*1.5*	1.59	*2.0*	2.66	*2.5*		940.0
960.0		0.083	*0.4*	0.154	*0.6*	0.447	*1.0*	0.896	*1.5*	1.61	*2.0*	2.69	*2.5*		960.0
980.0		0.084	*0.4*	0.156	*0.6*	0.452	*1.0*	0.906	*1.5*	1.62	*2.0*	2.72	*2.6*		980.0
1000.0	1.0	0.085	*0.4*	0.158	*0.6*	0.457	*1.0*	0.916	*1.5*	1.64	*2.0*	2.75	*2.6*		1000.0
1100.0		0.090	*0.4*	0.167	*0.6*	0.482	*1.1*	0.965	*1.5*	1.73	*2.0*	2.90	*2.6*		1100.0
1200.0		0.094	*0.5*	0.175	*0.6*	0.506	*1.1*	1.01	*1.5*	1.82	*2.0*	3.04	*2.6*		1200.0
1300.0		0.098	*0.5*	0.183	*0.6*	0.529	*1.1*	1.06	*1.5*	1.90	*2.0*	3.18	*2.6*		1300.0
1400.0		0.103	*0.5*	0.191	*0.6*	0.551	*1.1*	1.10	*1.5*	1.98	*2.0*	3.31	*2.6*		1400.0
1500.0		0.107	*0.5*	0.198	*0.6*	0.573	*1.1*	1.15	*1.5*	2.05	*2.1*	3.44	*2.7*		1500.0
1600.0		0.111	*0.5*	0.205	*0.6*	0.593	*1.1*	1.19	*1.6*	2.13	*2.1*	3.56	*2.7*	3.0	1600.0
1700.0		0.114	*0.5*	0.213	*0.6*	0.614	*1.1*	1.23	*1.6*	2.20	*2.1*	3.68	*2.7*		1700.0
1800.0		0.118	*0.5*	0.219	*0.6*	0.633	*1.1*	1.27	*1.6*	2.27	*2.1*	3.80	*2.7*		1800.0
1900.0		0.122	*0.5*	0.226	*0.7*	0.653	*1.1*	1.31	*1.6*	2.34	*2.1*	3.91	*2.7*		1900.0
2000.0		0.125	*0.5*	0.233	*0.7*	0.671	*1.1*	1.34	*1.6*	2.40	*2.1*	4.02	*2.7*		2000.0

Hot and Cold Water Pipework Design Spreadsheet

Pipework Description. ____

Student / Project name.

Effective Pipe lengths

Pipe Section	Design Flow l/s	Est Pipe diam 1m/s	Measured length (m)	No. of T's x Equiv L	No. elbow x Equiv L	No.Valve x Equiv L	No.Taps x Equiv L	Effective Length
AB								
BC								
CD								
DE								
DF								

Critical Run

Pipe Section	Effective Length (m)	Head Available Meters	kPa	Pa	Less residual Head req'd	Total dP (Pa) Allowable	Max dP / m allowable	Critical Run (min)

Pipe section sizing

Pipe Section	Effective Length (m)	Design Flow l/s	Chosen Pipe diam	Relevant dP_L(Pa/m)	dP for this section	Cumulative dP this run	Avaliable Head (Pa)	Confirm diam

Table 4.11 Flow of water at 75°C in medium grade steel pipes — *continued*

q_m = mass flow rate kg.s^{-1}
c = velocity m.s^{-1}
$\Delta p/l$ = pressure drop per unit length Pa.m^{-1}
l_e = equivalent length of a component for $\zeta = 1$ m

MEDIUM GRADE STEEL

WATER AT 75°C

$\Delta p/l$	c	10 mm		15 mm		20 mm		25 mm		32 mm		40 mm		50 mm		c	$\Delta p/l$
		q_m	l_e	q_m	l_e	q_m	l_e	q_m	l_e	q_m	l_e	q_m	l_e	q_m	l_e		
92.5		0.029	*0.3*	0.060	*0.5*	0.132	*0.7*	0.247	*1.0*	0.518	*1.5*	0.778	*1.8*	1.45	*2.4*		92.5
95.0		0.030	*0.3*	0.061	*0.5*	0.134	*0.7*	0.251	*1.0*	0.526	*1.5*	0.789	*1.8*	1.48	*2.4*		95.0
97.5		0.030	*0.3*	0.062	*0.5*	0.136	*0.7*	0.254	*1.0*	0.533	*1.5*	0.800	*1.8*	1.50	*2.4*		97.5
100.0		0.031	*0.3*	0.062	*0.5*	0.138	*0.7*	0.258	*1.0*	0.540	*1.5*	0.810	*1.8*	1.52	*2.4*		100.0
120.0	0.30	0.034	*0.3*	0.069	*0.5*	0.152	*0.7*	0.284	*1.0*	0.595	*1.5*	0.893	*1.8*	1.67	*2.4*		120.0
140.0		0.037	*0.3*	0.075	*0.5*	0.165	*0.8*	0.308	*1.0*	0.646	*1.5*	0.968	*1.8*	1.81	*2.5*		140.0
160.0		0.040	*0.4*	0.081	*0.5*	0.178	*0.8*	0.331	*1.0*	0.693	*1.5*	1.04	*1.8*	1.94	*2.5*		160.0
180.0		0.042	*0.4*	0.086	*0.5*	0.189	*0.8*	0.353	*1.0*	0.738	*1.5*	1.11	*1.8*	2.06	*2.5*	1.0	180.0
200.0		0.045	*0.4*	0.091	*0.5*	0.200	*0.8*	0.373	*1.1*	0.780	*1.5*	1.17	*1.9*	2.18	*2.5*		200.0
220.0		0.047	*0.4*	0.096	*0.5*	0.211	*0.8*	0.392	*1.1*	0.820	*1.5*	1.28	*1.9*	2.29	*2.5*		220.0
240.0		0.050	*0.4*	0.100	*0.5*	0.221	*0.8*	0.411	*1.1*	0.858	*1.5*	1.29	*1.9*	2.40	*2.5*		240.0
260.0		0.052	*0.4*	0.105	*0.5*	0.230	*0.8*	0.428	*1.1*	0.895	*1.5*	1.34	*1.9*	2.50	*2.5*		260.0
280.0		0.054	*0.4*	0.109	*0.5*	0.239	*0.8*	0.445	*1.1*	0.931	*1.5*	1.39	*1.9*	2.60	*2.6*		280.0
300.0		0.056	*0.4*	0.113	*0.5*	0.248	*0.8*	0.462	*1.1*	0.965	*1.5*	1.44	*1.9*	2.69	*2.6*		300.0
320.0	0.50	0.058	*0.4*	0.117	*0.5*	0.257	*0.8*	0.478	*1.1*	0.998	*1.6*	1.49	*1.9*	2.78	*2.6*		320.0
340.0		0.060	*0.4*	0.121	*0.5*	0.265	*0.8*	0.493	*1.1*	1.03	*1.6*	1.54	*1.9*	2.87	*2.6*		340.0
360.0		0.062	*0.4*	0.125	*0.5*	0.273	*0.8*	0.508	*1.1*	1.06	*1.6*	1.59	*1.9*	2.96	*2.6*		360.0
380.0		0.064	*0.4*	0.128	*0.5*	0.281	*0.8*	0.523	*1.1*	1.09	*1.6*	1.63	*1.9*	3.04	*2.6*		380.0
400.0		0.065	*0.4*	0.132	*0.5*	0.289	*0.8*	0.537	*1.1*	1.12	*1.6*	1.68	*1.9*	3.12	*2.6*		400.0
420.0		0.067	*0.4*	0.135	*0.5*	0.297	*0.8*	0.551	*1.1*	1.15	*1.6*	1.72	*1.9*	3.20	*2.6*	1.5	420.0
440.0		0.069	*0.4*	0.139	*0.5*	0.304	*0.8*	0.564	*1.1*	1.18	*1.6*	1.76	*1.9*	3.28	*2.6*		440.0
460.0		0.070	*0.4*	0.142	*0.5*	0.311	*0.8*	0.578	*1.1*	1.21	*1.6*	1.80	*1.9*	3.36	*2.6*		460.0
480.0		0.072	*0.4*	0.145	*0.5*	0.318	*0.8*	0.591	*1.1*	1.23	*1.6*	1.84	*1.9*	3.43	*2.6*		480.0
500.0		0.074	*0.4*	0.148	*0.5*	0.325	*0.8*	0.603	*1.1*	1.25	*1.6*	1.88	*1.9*	3.51	*2.6*		500.0
520.0		0.075	*0.4*	0.151	*0.5*	0.332	*0.8*	0.616	*1.1*	1.29	*1.6*	1.92	*1.9*	3.58	*2.6*		520.0
540.0		0.077	*0.4*	0.154	*0.6*	0.338	*0.8*	0.628	*1.1*	1.31	*1.6*	1.96	*1.9*	3.65	*2.6*		540.0
560.0		0.078	*0.4*	0.157	*0.6*	0.345	*0.8*	0.640	*1.1*	1.34	*1.6*	2.00	*1.9*	3.72	*2.6*		560.0
580.0		0.080	*0.4*	0.160	*0.6*	0.351	*0.8*	0.652	*1.1*	1.36	*1.6*	2.03	*1.9*	3.78	*2.6*		580.0
600.0		0.081	*0.4*	0.163	*0.6*	0.355	*0.8*	0.664	*1.1*	1.38	*1.6*	2.07	*1.9*	3.85	*2.6*		600.0
620.0		0.082	*0.4*	0.166	*0.6*	0.364	*0.8*	0.675	*1.1*	1.41	*1.6*	2.10	*1.9*	3.92	*2.6*		620.0
640.0		0.084	*0.4*	0.169	*0.6*	0.370	*0.8*	0.686	*1.1*	1.43	*1.6*	2.14	*1.9*	3.98	*2.6*		640.0
660.0		0.085	*0.4*	0.172	*0.6*	0.376	*0.8*	0.697	*1.1*	1.45	*1.6*	2.17	*1.9*	4.04	*2.6*		660.0
680.0		0.087	*0.4*	0.174	*0.6*	0.382	*0.8*	0.708	*1.1*	1.48	*1.6*	2.21	*1.9*	4.11	*2.6*		680.0
700.0		0.088	*0.4*	0.177	*0.6*	0.388	*0.8*	0.719	*1.1*	1.50	*1.6*	2.24	*1.9*	4.17	*2.6*		700.0
720.0		0.089	*0.4*	0.180	*0.6*	0.393	*0.8*	0.730	*1.1*	1.52	*1.6*	2.27	*1.9*	4.23	*2.6*		720.0
740.0		0.091	*0.4*	0.182	*0.6*	0.399	*0.8*	0.740	*1.1*	1.54	*1.6*	2.31	*2.0*	4.29	*2.6*	2.0	740.0
760.0		0.092	*0.4*	0.185	*0.6*	0.405	*0.8*	0.750	*1.1*	1.56	*1.6*	2.34	*2.0*	4.35	*2.6*		760.0
780.0		0.093	*0.4*	0.187	*0.6*	0.410	*0.8*	0.761	*1.1*	1.59	*1.6*	2.37	*2.0*	4.41	*2.6*		780.0
800.0		0.094	*0.4*	0.190	*0.6*	0.416	*0.8*	0.771	*1.1*	1.61	*1.6*	2.40	*2.0*	4.46	*2.6*		800.0
820.0		0.096	*0.4*	0.192	*0.6*	0.421	*0.8*	0.780	*1.1*	1.63	*1.6*	2.43	*2.0*	4.52	*2.6*		820.0
840.0		0.097	*0.4*	0.195	*0.6*	0.426	*0.8*	0.790	*1.1*	1.65	*1.6*	2.46	*2.0*	4.58	*2.6*		840.0
860.0		0.098	*0.4*	0.197	*0.6*	0.431	*0.8*	0.800	*1.1*	1.67	*1.6*	2.49	*2.0*	4.63	*2.6*		860.0
880.0		0.099	*0.4*	0.200	*0.6*	0.437	*0.8*	0.810	*1.1*	1.69	*1.6*	2.52	*2.0*	4.69	*2.6*		880.0
900.0		0.100	*0.4*	0.202	*0.6*	0.442	*0.8*	0.819	*1.1*	1.71	*1.6*	2.55	*2.0*	4.74	*2.6*		900.0
920.0		0.102	*0.4*	0.204	*0.6*	0.447	*0.8*	0.828	*1.1*	1.73	*1.6*	2.58	*2.0*	4.80	*2.6*		920.0
940.0		0.103	*0.4*	0.207	*0.6*	0.452	*0.8*	0.838	*1.1*	1.75	*1.6*	2.61	*2.0*	4.85	*2.6*		940.0
960.0		0.104	*0.4*	0.209	*0.6*	0.457	*0.8*	0.847	*1.1*	1.76	*1.6*	2.64	*2.0*	4.90	*2.6*		960.0
980.0		0.105	*0.4*	0.211	*0.6*	0.462	*0.8*	0.856	*1.1*	1.78	*1.6*	2.66	*2.0*	4.95	*2.6*		980.0
1000.0		0.106	*0.4*	0.213	*0.6*	0.467	*0.8*	0.865	*1.1*	1.80	*1.6*	2.69	*2.0*	5.00	*2.6*		1000.0
1100.0		0.112	*0.4*	0.224	*0.6*	0.490	*0.8*	0.909	*1.1*	1.89	*1.6*	2.83	*2.0*	5.26	*2.7*		1100.0
1200.0	1.0	0.117	*0.4*	0.235	*0.6*	0.513	*0.8*	0.950	*1.1*	1.98	*1.6*	2.96	*2.0*	5.49	*2.7*		1200.0
1300.0		0.122	*0.4*	0.245	*0.6*	0.535	*0.8*	0.990	*1.1*	2.06	*1.6*	3.08	*2.0*	5.72	*2.7*		1300.0
1400.0		0.127	*0.4*	0.254	*0.6*	0.555	*0.8*	1.03	*1.1*	2.14	*1.6*	3.20	*2.0*	5.94	*2.7*		1400.0
1500.0		0.131	*0.4*	0.263	*0.6*	0.576	*0.8*	1.07	*1.1*	2.22	*1.6*	3.31	*2.0*	6.16	*2.7*		1500.0
1600.0		0.136	*0.4*	0.272	*0.6*	0.595	*0.9*	1.10	*1.1*	2.29	*1.6*	3.42	*2.0*	6.36	*2.7*	3.0	1600.0
1700.0		0.140	*0.4*	0.281	*0.6*	0.614	*0.9*	1.14	*1.2*	2.37	*1.6*	3.53	*2.0*	6.56	*2.7*		1700.0
1800.0		0.144	*0.4*	0.290	*0.6*	0.632	*0.9*	1.17	*1.2*	2.44	*1.6*	3.64	*2.0*	6.76	*2.7*		1800.0
1900.0		0.148	*0.4*	0.298	*0.6*	0.650	*0.9*	1.20	*1.2*	2.50	*1.6*	3.74	*2.0*	6.94	*2.7*		1900.0

Table 3.17 Heat emission from single horizontal steel pipes ($\varepsilon = 0.95$) freely exposed in surroundings at 20°C

Temp. difference between surface and surroundings (°C)	Heat emission/$W.m^{-1}$ for stated pipe nominal size* and outside diameter† d_{o} (mm)															
	* 15	20	25	32	40	50	65	80	100	125	150	200	250	300	350	400
	† 21.3	26.9	33.7	42.4	48.3	60.3	76.1	88.9	114.3	139.7	168.3	219.1	273.0	323.9	355.6	406.4
−15	−12	−15	−18	−22	−24	−29	−36	−41	−52	−62	−71	−92	−112	−130	−142	−160
−10	−7.7	−9.4	−11	−14	−16	−19	−23	−27	−33	−40	−46	−60	−73	−85	−92	−104
−5	−3.5	−4.3	−5.3	−6.5	−7.3	−8.9	−11	−13	−16	−19	−22	−28	−35	−40	−44	−50
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	3.6	4.5	5.5	6.7	7.5	9.1	11	13	16	19	23	29	36	42	46	52
10	8.1	9.8	12	15	16	20	25	28	35	42	49	63	77	90	98	111
15	13	16	19	23	26	32	39	45	56	67	78	100	123	143	156	176
20	18	22	27	33	37	45	55	63	78	94	109	140	171	199	217	245
25	24	29	35	43	48	58	71	81	102	122	141	182	221	258	281	317
30	29	36	44	53	60	72	88	101	126	151	175	226	275	320	349	393
35	35	43	53	64	72	87	106	122	152	182	211	272	331	385	419	473
40	42	51	62	75	84	102	125	143	179	214	248	319	389	453	493	556
45	48	59	71	87	98	118	145	166	207	247	287	369	449	524	570	642
50	55	67	81	99	111	135	165	189	236	281	327	421	512	597	649	732
55	62	75	92	112	125	152	186	213	266	317	368	474	577	673	732	825
60	69	84	102	125	140	169	207	238	297	354	411	529	644	751	817	921
65	77	93	114	138	155	188	230	263	329	392	456	586	714	832	905	1020
70	84	103	125	152	170	206	253	290	362	432	502	646	786	916	997	1120
75	92	112	137	167	186	226	277	317	396	473	549	706	860	1000	1090	1230
80	100	122	149	181	203	246	301	345	431	515	598	769	937	1090	1190	1340
100	135	164	200	244	273	331	406	466	582	695	808	1040	1270	1480	1610	1820
120	173	211	257	314	352	427	523	600	750	897	1040	1340	1640	1910	2080	2350
140	215	262	320	391	438	532	653	750	937	1120	1310	1680	2050	2400	2610	2950
160	261	318	389	476	534	648	796	915	1140	1370	1600	2060	2520	2940	3200	3620
180	311	380	465	569	638	776	954	1100	1370	1650	1920	2480	3030	3540	3860	4360
200	366	447	547	670	753	916	1130	1300	1620	1950	2270	2940	3600	4200	4580	5180
220	425	520	637	781	878	1070	1320	1510	1900	2280	2660	3450	4220	4930	5380	6090
240	490	600	735	902	1010	1240	1520	1750	2200	2650	3090	4000	4900	5740	6260	7080
260	560	686	842	1030	1160	1420	1750	2010	2530	3040	3550	4610	5650	6620	7220	8180
280	635	780	957	1180	1320	1620	2000	2300	2890	3480	4060	5280	6470	7590	8280	9380
300	717	881	1080	1330	1500	1830	2260	2610	3280	3950	4620	6010	7370	8650	9440	10 700
320	806	990	1220	1500	1690	2060	2550	2940	3710	4470	5230	6800	8350	9800	10 700	12 100

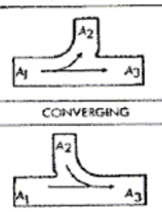
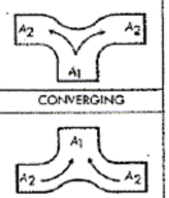
*These pipe sizes are to BS1387: 1967 and BS 3600: 1973[37,38]

†These outside diameters are to BS3600: 1997[39]

TABLE C4.36. Velocity pressure loss factors for pipe fittings.

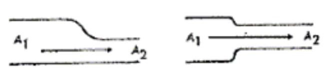
TEES AND JUNCTIONS

(Based on velocity pressure of combined flow. Factors refer to the branch indicated by the subscript, e.g. ζ_2 is for flow to or from branch 2.)

DIVERGING / CONVERGING	ζ_2	ζ_3	DIVERGING / CONVERGING	ζ_2	TONGUE TEE
	0.5 + (factor for bend or elbow as appropriate) + (factor for enlargement or reduction where bores differ)	0.2 + (factor for enlargement or reduction where bores differ)		0.5 + (factor for bend or elbow as appropriate) + (factor for enlargement or reduction where bores differ)	 $\zeta_2 = 4.5$ ($d < 20$ mm) $\zeta_2 = 3.0$ ($d \geq 20$ mm) $\zeta_3 = 3.0$

REDUCTIONS

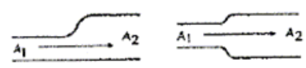
(Based on velocity pressure in smaller pipe.)



A_2/A_1	ζ	A_2/A_1	ζ
0.1	0.55	0.4	0.40
0.2	0.50	0.6	0.25
0.3	0.45	0.8	0.05

ENLARGEMENTS

(Based on velocity pressure in smaller pipe.)

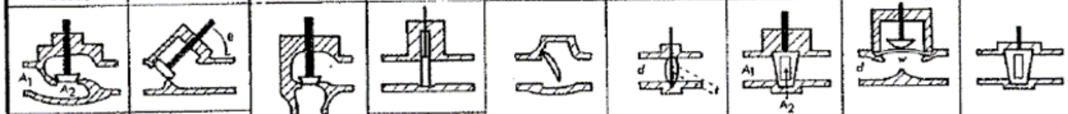


A_1/A_2	ζ	A_1/A_2	ζ
0.1	0.80	0.4	0.35
0.2	0.65	0.6	0.15
0.3	0.50	0.8	0.05

VALVES

(Figures are for valves fully open.)

GLOBE, OBLIQUE, ANGLE, GATE, NON-RETURN, BUTTERFLY, PLUG, DIAPHRAGM, COCK or TAP



GLOBE

d/mm	ζ for A_2/A_1 = 0.7	ζ for A_2/A_1 = 1.0
15	—	12
25	10	7
50	7	5
≥75	6	4

OBLIQUE

d/mm	ζ for θ = 45°	ζ for θ = 60°
15	3	6
25	1.8	4
50	1.3	2.5
≥75	1.0	2.0

ANGLE: $\zeta = 5.0$

GATE

d/mm	ζ
15	0.5
25	0.3
50	0.2
≥75	0.1

NON-RETURN: $\zeta = 2.0$

BUTTERFLY

t/d	ζ
0.1	0.1
0.2	0.3
0.3	0.8

PLUG

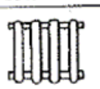
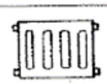
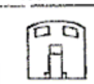
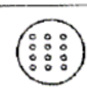
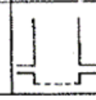
A_2/A_1	ζ
0.7	1.0
1.0	0.4

DIAPHRAGM

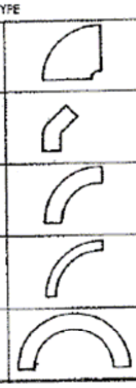
w/d	ζ
0.5	7.0
1.0	2.5
Venturi	0.5

COCK or TAP: $\zeta = 10$

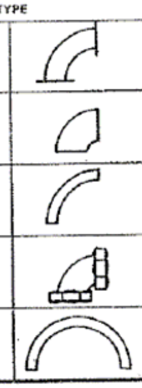
OTHER ITEMS

COLUMN RADIATOR	PANEL RADIATOR	SECTIONAL BOILER	TUBE BOILER	LARGE VESSELS
 $\zeta = 5.0$	 $\zeta = 2.5$	 $\zeta = 2.5$	 $\zeta = 8.0$	 ENTRY $\zeta = 1.0$ EXIT $\zeta = 0.4$

ELBOWS AND BENDS



TYPE	10-25 mm	32-50 mm	65-90 mm	≥100 mm
MALLEABLE CAST IRON 90° ELBOW	0.8	0.7	0.6	0.6
MALLEABLE CAST IRON 45° ELBOW	0.6	0.6	0.5	0.5
MALLEABLE CAST IRON BEND	0.7	0.5	0.4	0.4
SCREWED MILD STEEL BEND	0.7	0.5	0.4	0.3
MALLEABLE CAST IRON RETURN BEND	0.9	0.8	0.8	—



TYPE	10-25 mm	32-50 mm	65-90 mm	≥100 mm
FLANGED CAST IRON BEND	0.5	0.5	0.5	0.5
WELDED MILD STEEL ELBOW	0.4	0.4	0.3	0.3
WELDED MILD STEEL BEND	0.4	0.3	0.3	0.2
COPPER PIPE ELBOW	1.0	0.8	0.5	—
PANEL RETURN BEND	0.6	—	—	—

Notes to Table C4.36.

Convergent flow at junctions
Where the velocity of flow in one branch of a tee, at a converging junction, is high relative to the velocity in the other, the pressure loss factor for the latter may be negative due to the injection effect.

Tapers
Where the included angle is 10° or less, take a factor of 0.2 for an enlargement and ignore for a contraction.

Valves
Individual designs may show wide variations over the values tabulated.

Radiators
The resistance to flow through a cast iron column radiator with S columns may be approximated by: $p = 5720\ M^2\ S^{0.35}$

Specialist equipment
Manufacturers' data should be consulted in these cases.

CORK INSTITUTE OF TECHOLOGY

Project:

DUCTWORK DESIGN SHEET

	Duct Sizing (Fig C4.2)					Duct Loss (C4.2)			Fittings Losses (C4.35)													Sect dP		Grille		
	A	B	C	D	E	F	G	H	I		J	K	L	M	N	O		P	Q	R	S	T	U	V	W	X	Y
	Duct Reference	Air Flow m3/s	Duct Diameter m	Velocity m/s	Rectangular mm	Straight Length m	Pressure Loss Pa/m	Total Duct Loss Pa	No. Bends,Tees	Details = B or T or V2/V1	Zeta factor bends etc	Sub-Total for bends	No. Transitions	Zeta factor Transitions	Sub-Total for Transitions	No. Other Fittings	Details	Zeta factor Other fittings	Sub-Total for others	Total Zeta factor (all fittings)	Velocity press Pv (Pa) C4.3	Total Fittings Loss (Pa) =ζ (zeta) x Pv.	Total Section Loss Straight + Fittings		Total Loss	Type	Size
1																											
2																											
3																											
4																											
5																											
6																											
7																											
8																											
10																											

	List Possible Index Runs here	List actual dP for each possible index run here	List Grille dP here	dP Index run
1				
2				
3				
4				
5				
6				
7				
8				

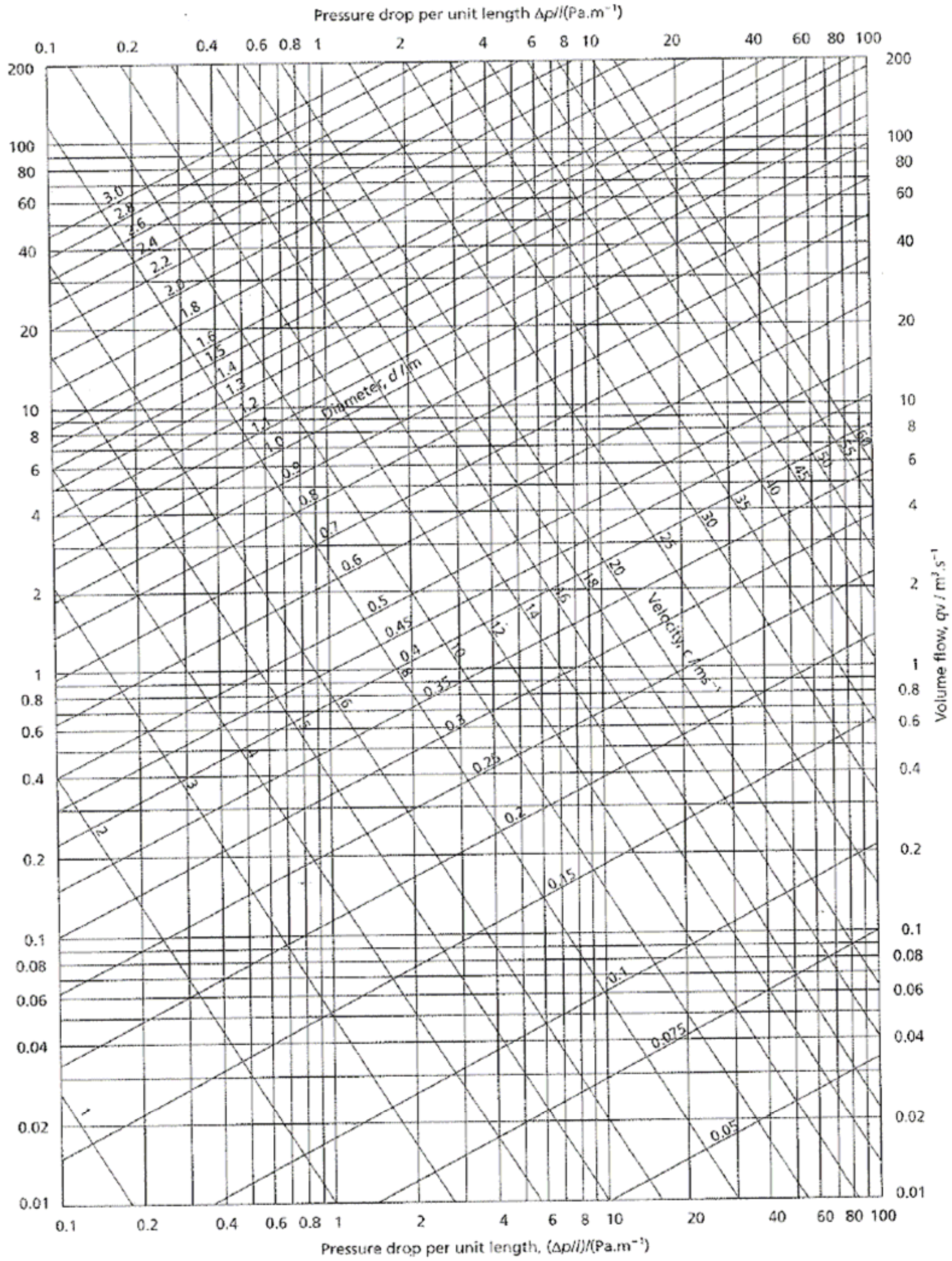


Figure 4.2 Pressure drop for air in galvanised circular ducts (ρ = 1.2 kg.m^{-3}; T = 293 K)

4.5.8 Velocity pressures of air

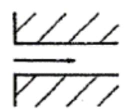
Table 4.42 Velocity pressures ($\frac{1}{2}\rho c^2$) in Pa for air having a density ρ = 1.20 kg.m^{-3}. This is the case at 20°C, percentage saturation 50% and a pressure of 101.325 bar. For other conditions see section 4.5.3 and Table 4.36

Velocity c/m.s^{-1}	Velocity pressure / Pa for stated velocity c/m.s^{-1}									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.00	0.01	0.02	0.05	0.10	0.15	0.22	0.29	0.38	0.49
1	0.60	0.73	0.86	1.01	1.18	1.35	1.54	1.73	1.94	2.17
2	2.40	2.65	2.90	3.17	3.46	3.75	4.06	4.37	4.70	5.05
3	5.40	5.77	6.14	6.53	6.94	7.35	7.78	8.21	8.66	9.13
4	9.60	10.09	10.58	11.09	11.62	12.15	12.70	13.25	13.82	14.41
5	15.00	15.61	16.22	16.85	17.50	18.15	18.82	19.49	20.18	20.89
6	21.60	22.33	23.06	23.81	24.58	25.35	26.14	26.93	27.74	28.57
7	29.40	30.25	31.10	31.97	32.86	33.75	34.66	35.57	36.50	37.45
8	38.40	39.37	40.34	41.33	42.34	43.35	44.38	45.41	46.46	47.53
9	48.60	49.69	50.78	51.89	53.02	54.15	55.30	56.45	57.62	58.81
10	60.00	61.21	62.42	63.65	64.90	66.15	67.42	68.69	69.98	71.29
11	72.60	73.93	75.26	76.61	77.98	79.35	80.74	82.13	83.54	84.97
12	86.40	87.85	89.30	90.77	92.26	93.75	95.26	96.77	98.30	99.85
13	101.40	102.97	104.54	106.13	107.74	109.35	110.98	112.61	114.26	115.93
14	117.60	119.29	120.98	122.69	124.42	126.15	127.90	129.65	131.42	133.21
15	135.00	136.81	138.62	140.45	142.30	144.15	146.02	147.89	149.78	151.69
16	153.60	155.53	157.46	159.41	161.38	163.35	165.34	167.33	169.34	171.37
17	173.40	175.45	177.50	179.57	181.66	183.75	185.86	187.97	109.10	192.25
18	194.40	196.57	198.74	200.93	203.14	205.35	207.58	209.81	212.06	214.33
19	216.60	218.89	221.18	223.49	225.82	228.15	230.50	232.85	235.22	237.61
20	240.00	242.41	244.82	247.25	249.70	252.15	254.62	257.09	259.58	262.09
21	264.60	367.13	269.66	272.21	274.78	277.35	279.94	282.53	285.14	287.77
22	290.40	293.05	295.70	298.37	301.06	303.75	306.46	309.17	311.90	413.65
23	317.40	320.17	322.94	325.73	328.54	331.35	334.18	337.01	339.86	342.73
24	345.60	348.49	351.38	354.29	357.22	360.15	363.10	366.05	369.02	372.01
25	375.00	378.01	381.02	384.05	387.10	390.15	393.22	396.29	399.38	402.49
26	405.60	408.73	411.86	415.01	418.18	421.35	424.54	427.37	430.94	434.17
27	437.40	440.65	443.90	447.17	450.46	453.75	457.06	460.37	463.70	467.05
28	470.40	473.77	477.14	480.53	483.94	487.35	490.78	494.21	497.66	501.13
29	504.60	508.09	511.58	515.09	518.62	522.15	525.70	529.25	532.82	536.41
30	540.00	543.61	547.22	550.85	554.50	558.15	561.82	565.49	569.18	572.89
31	576.60	580.33	584.06	587.81	591.58	595.35	599.14	602.93	606.74	610.57
32	614.40	618.25	622.10	625.97	629.86	633.75	637.66	641.57	645.50	649.45
33	653.40	657.37	661.34	665.33	669.34	673.35	677.38	681.41	685.46	689.53
34	693.60	697.69	701.78	705.89	710.02	714.15	718.30	722.45	726.62	730.81
35	735.00	739.21	743.42	747.65	751.90	756.15	760.42	764.69	768.98	773.29
36	777.60	781.93	786.26	790.61	794.98	799.35	803.74	808.13	812.54	816.97
37	821.40	825.85	830.30	834.77	839.26	843.75	848.26	852.77	857.30	861.85
38	866.40	870.97	875.54	880.13	884.74	889.35	893.98	898.61	903.26	907.93
39	912.60	917.29	921.98	926.69	931.42	936.15	940.90	945.65	950.42	955.21
40	960.00	964.81	969.62	974.45	979.30	984.15	989.02	993.78	998.78	1003.69

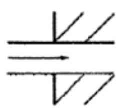
TABLE C4.35 Velocity pressure loss factors for duct fittings.

DUCT ENTRIES

(Factors refer to the velocity pressure in the duct.)

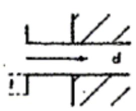


$\zeta = 0.5$



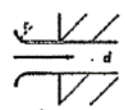
$\zeta = 0.95$

FLANGE



$t > d/25$, $\zeta = 0.5$

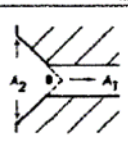
BELLMOUTH



$r = d/20$, $\zeta = 0.5$

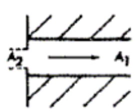
$r = d/12$, $\zeta = 0.15$

REDUCING



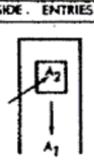
A_2/A_1	ζ $\theta=60°$	ζ $\theta=90°$	ζ $\theta=120°$
1.2	0.25	0.32	0.40
1.5	0.17	0.23	0.35
2.0	0.12	0.21	0.31
2.5	0.12	0.20	0.30

ORIFICE



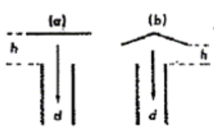
A_2/A_1	ζ
0.5	5.7
0.6	3.0
0.7	1.8
0.8	1.2
0.9	0.7
1.0	0.5

SIDE ENTRIES



$\Sigma A_2/A_1$	ζ
0.4	13.5
0.6	7.5
0.8	4.5
1.0	3.0
1.2	2.0
1.4	1.5
1.6	1.2
1.8	1.2

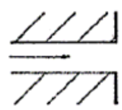
HOODS



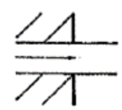
h/d	ζ a	ζ b
0.2	4.4	1.8
0.4	1.8	1.4
0.6	1.4	1.2
1.0	1.1	1.1

DUCT EXITS

(Factors refer to the velocity pressure in the duct and include the discharge.)

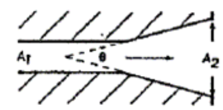


$\zeta = 1.0$



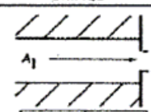
$\zeta = 1.0$

DIFFUSER



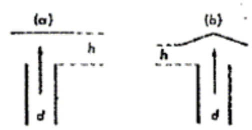
A_1/A_2	ζ $\theta=10°$	ζ $\theta=20°$	ζ $\theta=30°$	ζ $\theta=40°$
0.7	0.64	0.72	0.79	0.86
0.6	0.55	0.64	0.74	0.83
0.5	0.48	0.58	0.70	0.79
0.4	0.40	0.53	0.65	0.76
0.3	0.34	0.48	0.62	0.73

ORIFICE



A_2/A_1	ζ
0.5	7.8
0.6	4.7
0.7	3.0
0.8	2.0
0.9	1.3
1.0	1.0

HOODS

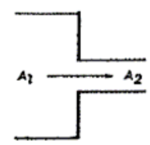


h/d	ζ a	ζ b
0.2	5.3	2.3
0.4	1.7	1.4
0.6	1.2	1.1
1.0	1.0	1.0

CONTRACTIONS

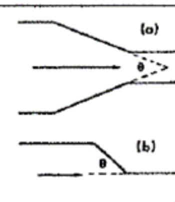
(Factors refer to the velocity pressure at the smaller area.)

ABRUPT



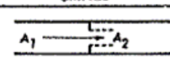
A_2/A_1	ζ
0.25	0.37
0.3	0.34
0.35	0.32
0.4	0.28
0.45	0.25
0.5	0.23
0.55	0.19
0.6	0.16
0.65	0.12
0.7	0.09

GRADUAL



θ	ζ a	ζ b
30°	0.02	0.07
45°	0.04	0.2
60°	0.07	0.4

ORIFICE

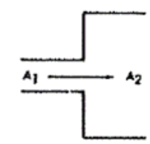


A_1/A_2	ζ
1.1	0.1
1.2	0.4
1.4	1.0
1.7	2.0
2.0	4.0

ENLARGEMENTS

(Factors refer to the velocity pressure at the smaller area.)

ABRUPT



A_1/A_2	ζ
0.25	0.56
0.3	0.49
0.35	0.42
0.4	0.36
0.45	0.30
0.5	0.25
0.55	0.20
0.6	0.16
0.65	0.12
0.7	0.09

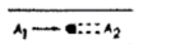
GRADUAL

θ	Multiplying factors to be applied to ζ for abrupt fittings ●	■
10°	0.3	0.3
20°	0.5	0.6
30°	0.6	0.8
40°	0.9	1.0
50°	1.0	1.0

OBSTRUCTIONS

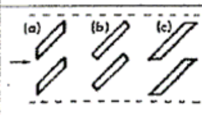
(Factors refer to the velocity pressure in the duct.)

STRUTS



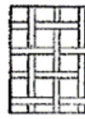
A_2/A_1	ζ ■	ζ ●	ζ (streamlined)
0.5	4.0	2.0	0.9
0.25	1.4	0.6	0.2
0.1	0.7	0.2	0.1

45° LOUVRES



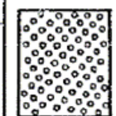
Free area ratio	ζ a	ζ b	ζ c
0.5	6.0	4.5	3.0
0.6	3.6	3.0	1.8
0.7	2.4	2.1	1.1
0.8	1.6	1.4	0.7

WIRE MESH



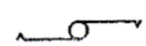
Free area ratio	ζ
0.2	17
0.3	6.2
0.4	3.0
0.5	1.7
0.6	1.0
0.7	0.6
0.8	0.3

PERFORATED SHEET



Free area ratio	ζ
0.2	51
0.3	18
0.4	8.3
0.5	4.0
0.6	2.0
0.7	1.0
0.8	0.4

OPEN DAMPERS



$\zeta = 0.5$

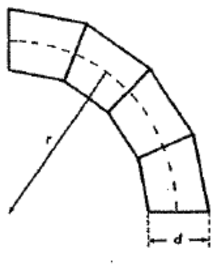
$\zeta = 0.2$

TABLE C4.35 Velocity pressure loss factors for duct fittings – continued

RADIUS BENDS

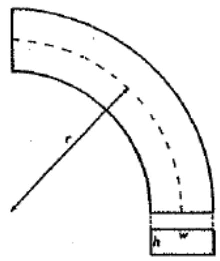
(Factors refer to the velocity pressure in the duct.)

CIRCULAR DUCTS, $\theta = 90°$



No. of pieces	ζ: $r/d = 1$	$r/d = 1.5$	$r/d = 2$	$r/d = 3$
1 (radius)	0.34	0.24	0.23	0.22
3	0.46	0.40	0.42	0.46
4	0.42	0.34	0.32	0.34
5	0.36	0.30	0.26	0.26

RECTANGULAR DUCTS, $\theta = 90°$

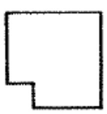


h/w	ζ: $r/w = 1$	$r/w = 1.5$	$r/w = 2$	$r/w = 3$
0.2	0.47	0.44	0.40	0.43
0.4	0.36	0.33	0.28	0.31
0.5	0.29	0.22	0.20	0.22
0.7	0.26	0.18	0.16	0.18
1.0	0.23	0.14	0.13	0.14
1.5	0.21	0.12	0.11	0.11
2.5	0.20	0.11	0.09	0.10
4.0	0.22	0.11	0.10	0.10
6.0	0.26	0.14	0.11	0.11

θ	Multiplying factors for ζ for $\theta \leq 90°$
20°	0.3
30°	0.5
45°	0.6
60°	0.8
75°	0.9
90°	1.0

MITRE BENDS

(Factors refer to the velocity pressure in the duct.)



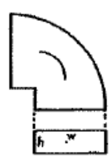
$\zeta = 1.25$

$\zeta = 1.22$

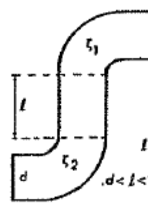
$\zeta = 0.72$

$\zeta = 0.67$

$\zeta = 0.35$
(or manufacturers' data)



h/w	ζ
0.2	0.5
0.4	0.4
0.5	0.3
≤ 0.7	0.2



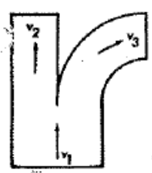
$l \leq d$: $\zeta = 0.9(\zeta_1 + \zeta_2)$

$d < l < 10d$: $\zeta = 0.8(\zeta_1 + \zeta_2)$

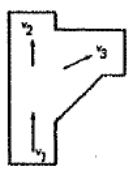
$l \geq 10d$: $\zeta = \zeta_1 + \zeta_2$

RECTANGULAR DUCT BRANCHES

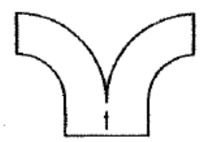
(Factors refer to the velocity pressure in the branch indicated by the subscript, e.g. ζ_2 is to be used with the velocity pressure in branch 2.)



v_2/v_1	ζ_2	v_3/v_1	ζ_3
0.6	0.34	0.6	3.5×bend loss
0.8	0.18	0.8	1.8 —"—
1.0	0.09	1.0	1.0 —"—
1.2	0.05	1.2	1.0 —"—



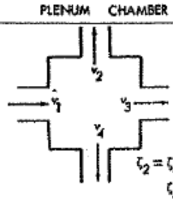
v_2/v_1	ζ_2	v_3/v_1	ζ_3
0.6	0.44	0.6	1.6
0.8	0.09	0.8	0.78
1.0	0.04	1.0	0.55
1.2	0.02	1.2	0.45



Use bend loss factor with entry velocity

RECTANGULAR DUCT BRANCHES — continued

PLENUM CHAMBER



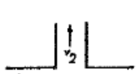
$\zeta_2 = \zeta_4 = 1.4$

$\zeta_3 = 1.3$

CIRCULAR DUCT BRANCHES

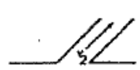
(Factors refer to the velocity pressure in the branch indicated by the subscript, e.g. ζ_2 is to be used with the velocity pressure in branch 2.)

90° BRANCH



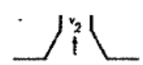
v_2/v_1	ζ_2
0.6	3.7
0.8	2.3
1.0	1.7
1.2	1.4

45° BRANCH



v_2/v_1	ζ_2
0.6	1.5
0.8	0.7
1.0	0.4
1.2	0.4

CONICAL BRANCH



v_2/v_1	ζ_2
0.6	2.0
0.8	1.2
1.0	0.8
1.2	0.6

Notes to Table C4.35.

Bend angles
Where bends turn through angles of less than 90°, the pressure loss factor may be presumed to vary in the proportion $\theta/90$ unless stated otherwise.

Changes of shape (transitions)
For tapered changes of shape where $\theta < 60°$ and $A_1 \approx A_2$, the

Splitters
Where straight ducts have splitters, the straight duct friction loss through each component part should be considered.

Approaches
The values for the pressure loss factors quoted here assume that the approaching velocity profile is regular. Any eccentricity or distortion may increase or decrease the loss.

Diameters
For rectangular ducts, the hydraulic mean diameter as given by