UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2022

Module Number: CE6251 **Module Name: Building Services Engineering**

[Three Hours]

[Answer **all questions**, each question carries twelve marks]

Q1. a) What are the challenges faced by a building services engineer in designing high-rise elevator systems?

[2.0 Marks]

b) Briefly discuss three ways to optimize traffic performance in high rise buildings.

[3.0 Marks]

c) You are required to design a lift (elevator) system for a 25-storey (excluding ground floor) mixed use tower. The ground floor is designed as a shopping space whereas the next 15 floors are designed for "investment downtown" type offices. The remaining 10 floors are designed for "midrange" type apartment living. Each apartment floor contains six number of two-bedroom apartments. The floor to floor height of the building is 3.6 m. Client's objective is to maximize the passneger service using lifts. Design a suitable lift system for this building including a zoning arrangement if required. Building footprint is 42 m ×3.5 m, and 25% of the building footprint is the core area. Your answer should contain the number of lifts, the size of a lift and shaft, and the capacity of a lift. Use the information given in Data Sheets (1-3). Any assumptions made should be clearly mentioned and justified.

[5.0 Marks]

d) Briefly discuss what types of arrangements can be made to use elevators for emergency evacuation of occupants from a skyscraper.

[2.0 Marks]

Q2. a) Discuss what is meant by "loading unit rating" in designing water supply pipe networks for sanitary appliances and, mention two situations in which loading unit rating method cannot be applied.

[3.0 Marks]

b) Consider the following project description for a three-storey building which is proposed to be used as a students' hostel. Each floor contains separate toilets and bathrooms. It is proposed that main distribution pipe from the overhead tank is located centrally outside the building. From the main distribution pipe, two branch pipes at each floor supply water to the toilets and bathrooms.

One branch pipe supplies water to 6 water closets and 6 washbasins; the horizontal distance to the last appliance from the main distribution pipe is 12 m. Each appliance is located 1 m above the floor level.

The other branch pipe supplies water for 8 showers. Showers are considered as

having high peak demands. The distance to the last shower is 8 m in each floor. Floor to floor height is 4 m and showers are located 2 m above the floor level.

i. Draw a schematic diagram of the proposed pipe network.

[2.0 Marks]

ii. Determine the diameters of main distribution pipe and two branch pipes at 2nd floor. PVC pipes are to be used for the entire pipe network. Information given in Data Sheets 4 and 5 can be used when answering the question. State any assumptions made in your calculations.

[7.0 Marks]

Q3. a) Briefly explain two advantages of fire compartmentation in a high-rise building.

[2.0 Marks]

b) What is meant by "Travel Distance" and "Direct Distance" in Fire Regulations?

[2.0 Marks]

c) Explain how wet and dry riser systems function, giving details about their installation procedures.

[2.0 Marks]

d) You are required to design an automatic sprinkler system for a three-storey rubber factory. Inside space of the building is 60 m long and 30 m wide. Assume that the sprinkler system can function without any structural obstructions such as beams and columns. Design a sprinkler system and graphically illustrate a suitable arrangement for sprinkler installation following standard spacing of sprinkler heads. Use information given in Data Sheet 6.

[4.0 Marks]

e) Briefly discuss the key areas that should be assessed during and after a fire drill.

[2.0 Marks]

Q4. An office is located in a single-storey building with dimensions 40 m x 28 m. The plan of the building is shown in Figure Q4. This building consists of steel framed glass windows, with a flat roof and brick walls. There are four sets of windows (1.2 m x1.5 m each) and two door openings (2.5 m x 2.2 m and 0.9 m x 2.2 m). The height of the building is 4 m.

a) Select a suitable orientation for this building (assuming the North direction by yourself, and ignoring wind direction) to minimize the external thermal gains. Give reasons for your selection.

[3.0 Marks]

b) Determine the total cooling load capacity required to air condition the building. You can assume that 25 staff, 10 computers and 6 printers are there in the building. Each computer emits 25 W of heat while a printer emits 10 W of heat. In addition, 20 bulbs each emitting 10 W serve the building. Assume outside temperature is 90^0F. Use Data Sheet 7 in answering the question. State any assumptions made.

[5.0 Marks]

c) Using sketches of a psychometric chart, discuss how "Cold and Dry" and "Hot and Humid" conditions can be brought to the comfort zone using air conditioning systems.

[2.0 Marks]

d) Briefly discuss how a tall building can be naturally ventilated using stack ventilation.

[2.0 Marks]

Q5. a) Briefly discuss the followings.

i. The causes of Sick Building Syndrome

ii. Innovative building designs for mitigating Urban Heat Island effect

[4.0 Marks]

b) List any four green building features that can be applied to a multi-storey building.

[2.0 Marks]

c) Briefly discuss what exactly makes a "green building" with each of the above green building features, as a "sustainable building".

[4.0 Marks]

d) Graphically illustrate a sustainable water management system that can be used in a high-rise building.

[2.0 Marks]

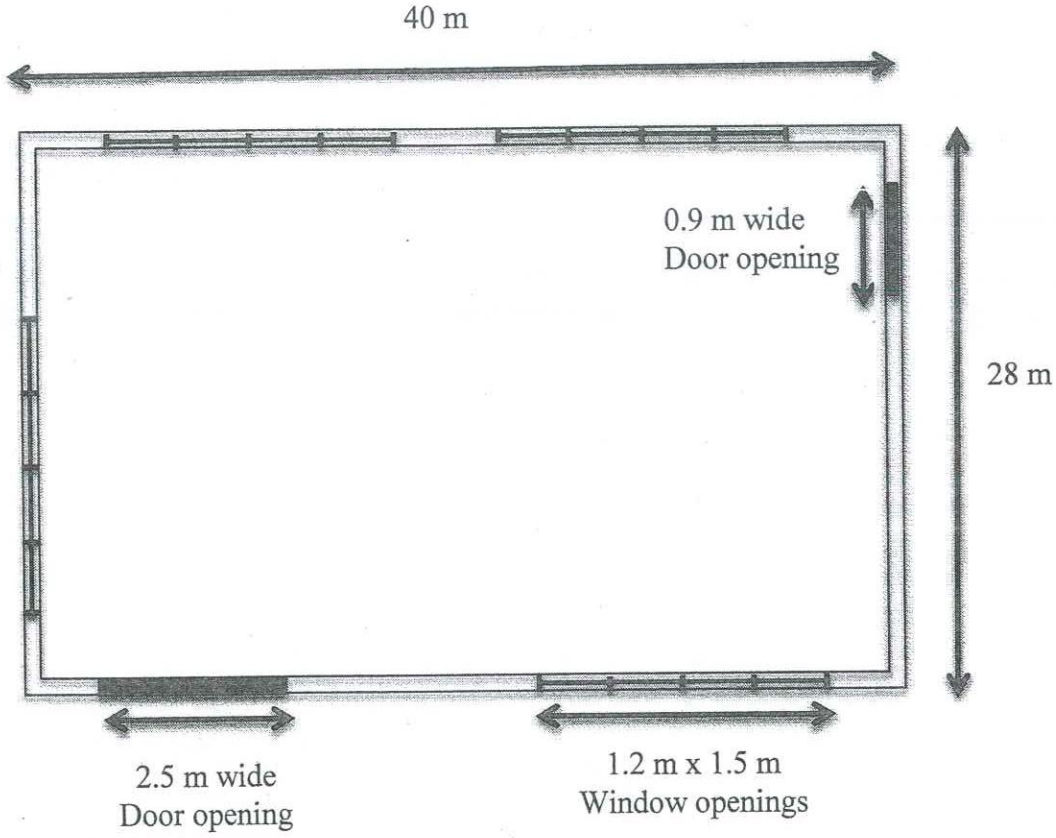


Figure Q4: Building plan (Not to a scale)

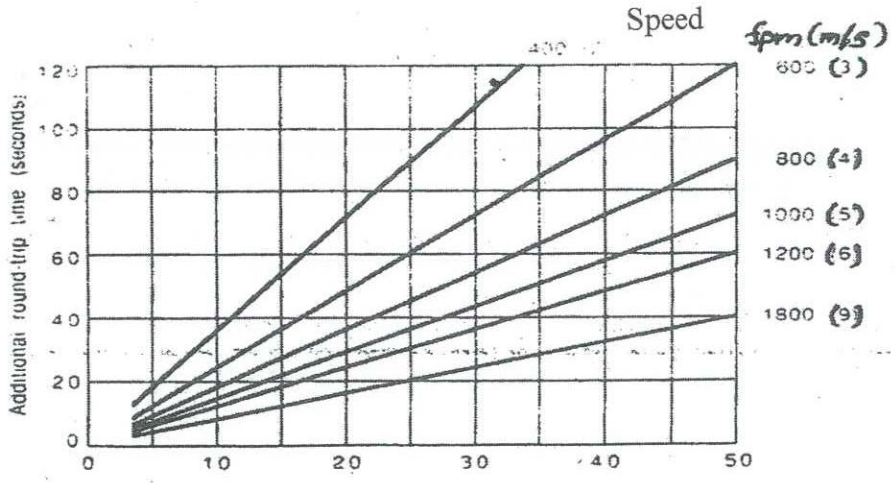
Elevator Speeds for Various Occupancies

Travel Distance		*Offices and Hotels*		*Retail Stores*		*Apartments*	
ft	*m*	*fpm*	*m/s*	*fpm*	*m/s*	*fpm*	*m/s*
0-60	0-20	200-400	1-2	200	1	100	0.5
60-120	20-36	300-400	1.5-2	200-300	1-1.5	200	1
120-240	36-72	500-600	2.5-3	200-400	1-2	200-400	1-2
240-500	72-150	800-1000	4-5				

fpm: feet per minute

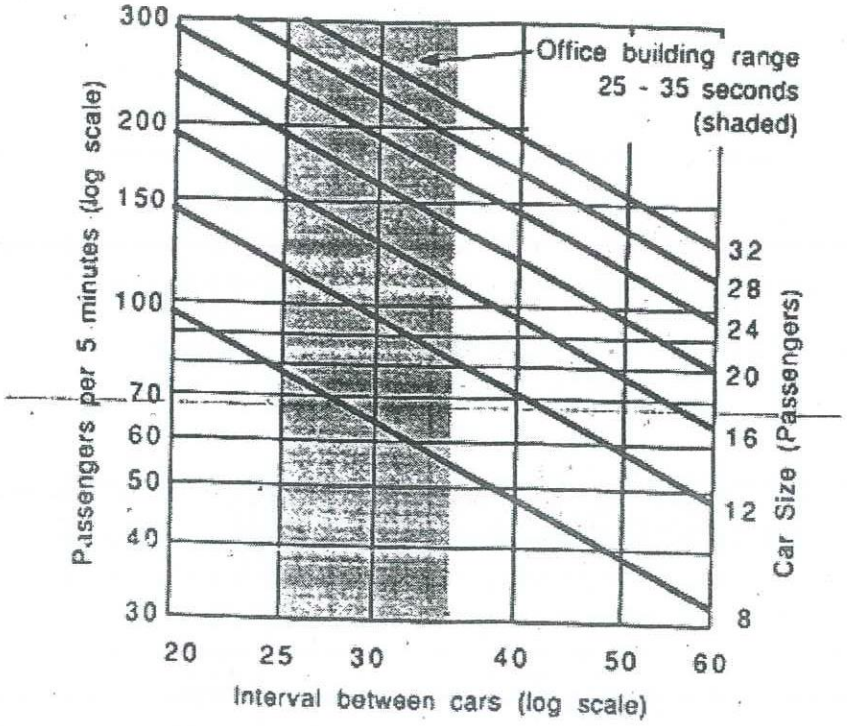
Design Parameters for Elevators

Building type	*Population Density*		*% Population Handled in 5 minutes*	*Average Interval Seconds*
	ft^2/person	*m^2/person*		
Offices				
Prestige, single tenant	300	12	12-17	25-30
Investment downtown	100-110	9-10	12-14	30-35
Investment suburban	90-100	8-9	12-14	30-45
Apartment				
Prestige	1.5 per bedroom		5-7	50-70
Midrange	2 per bedroom		6-8	60-80
Low rental	2-3 per bedroom		6-8	80-120
Hotels				
4-5 star	1.5-2 per room		12-15	40-60
3 and less star	1.5-2 per room		10-12	50-70



. Additional time to be added to the round-trip time when a car operates express through the lower floors of a building. The additional time is calculated as twice the distance di-

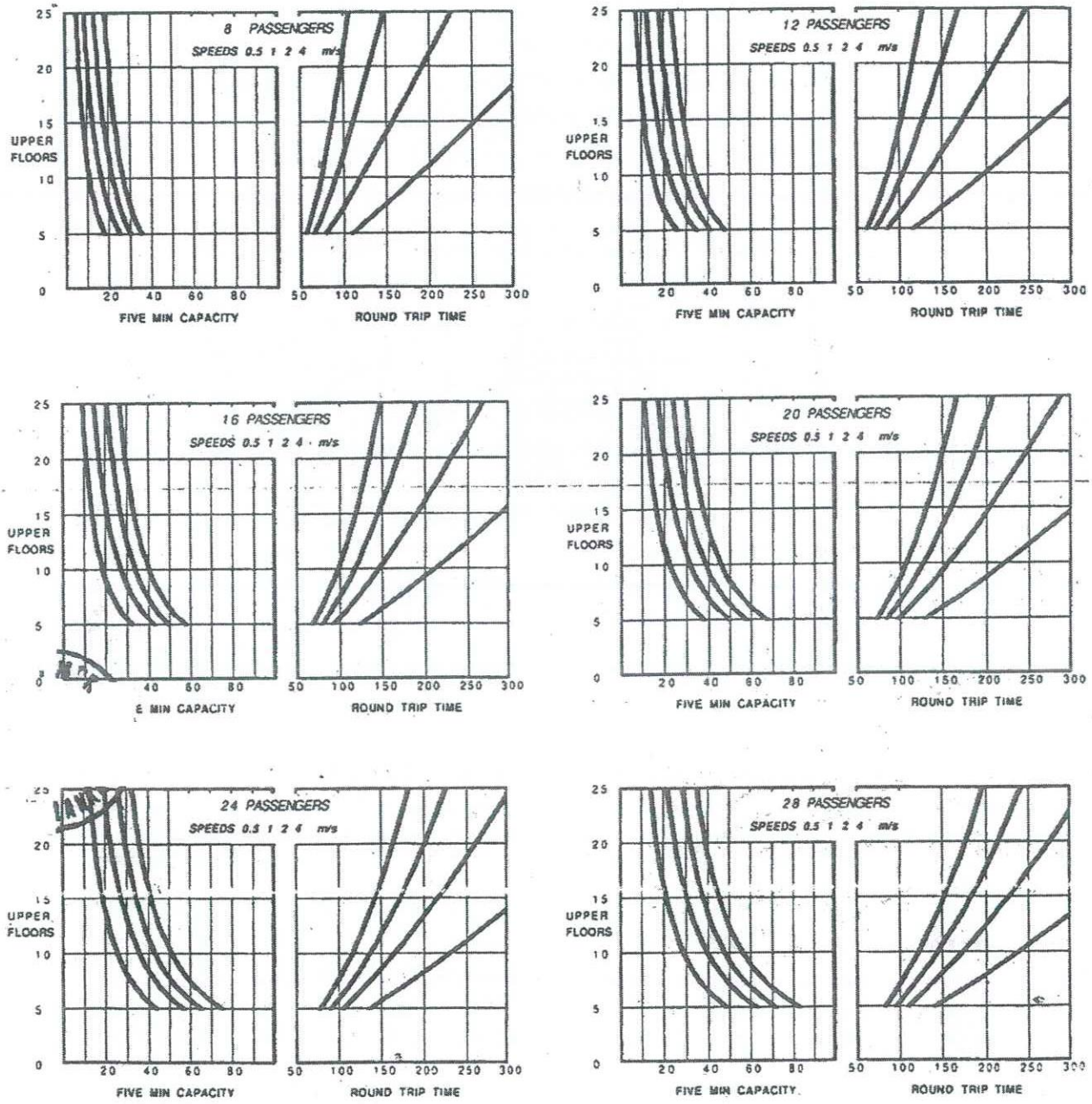
Data Sheet 2



Approximate Sizes and ratings of Elevator Cars

Capacity		*Passengers*		*Inside W x D*		*Shaft W x D*	
lb	*kg*	*Max*	*Average*	*in*	*mm*	*in*	*Mm*
2000	900	12	10	68 x 51	1700 x 1300	89 x 83	2200 x 2100
2500	1150	16	13	82 x 51	2100 x 1300	102 x 83	2550 x 2100
3000	1350	20	16	82 x 55	2100 x 1400	102 x 88	2550 x 2200
3500	1600	24	19	82 x 66	2100 x 1650	102 x 96	2550 x 2400
4000	1800	28	22	92 x 66	2300 x 1650	114 x 96	2850 x 2400

Data Sheet 3



The round trip time, and five-minute carrying capacity, for single elevator cars from 8 to 28 passenger nameplate capacity, and speeds from 100 to 800 fpm (0.5 to 4 m/s). All upper floors are assumed to have equal attraction. Figures are based on up peak conditions. Assumptions made about door operations and landing dwell times are intended to reflect good conditions. Slight to moderate downgrading is likely with nonstandard conditions such as extended door-open times and narrow or deep car shape.

Data Sheet 4

Loading units

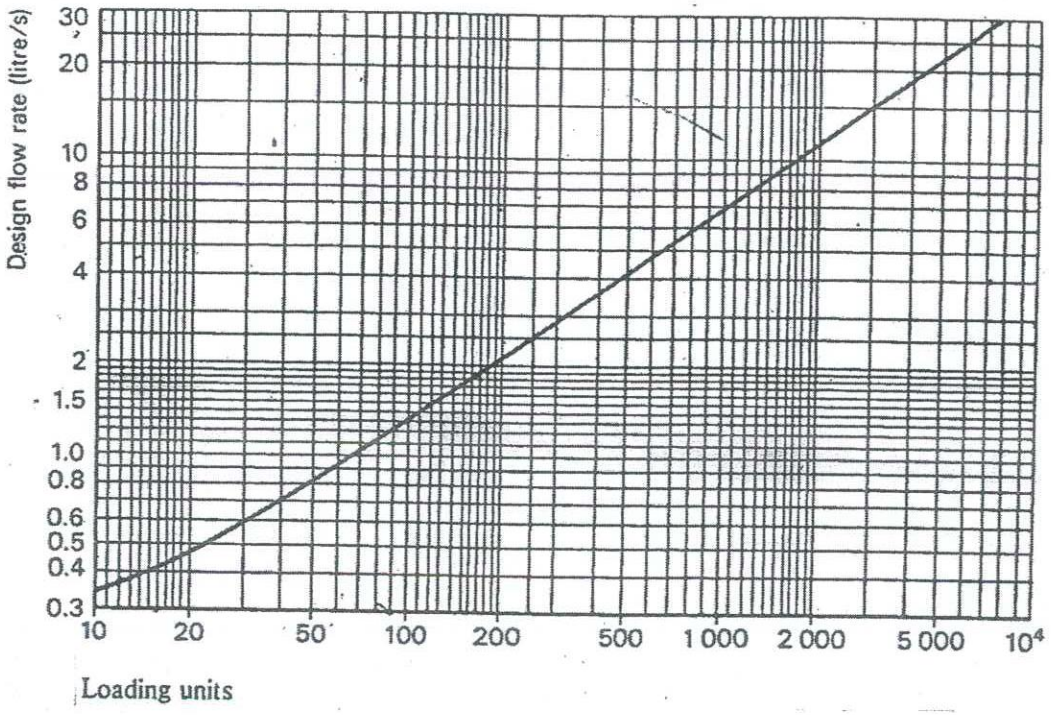
	Loading unit rating
Dwellings and flats	
W.C. flushing cistern	2
Wash basin	1 ½
Bath	10
Sink	3-5
Offices	
W.C. flushing cistern	2
Wash basin(distributed use)	1 ½
Wash basin (concentrated use)	3
Schools and industrial buildings	2
W.C. flushing cistern	3
Wash basin	3
Shower	
Public bath	22

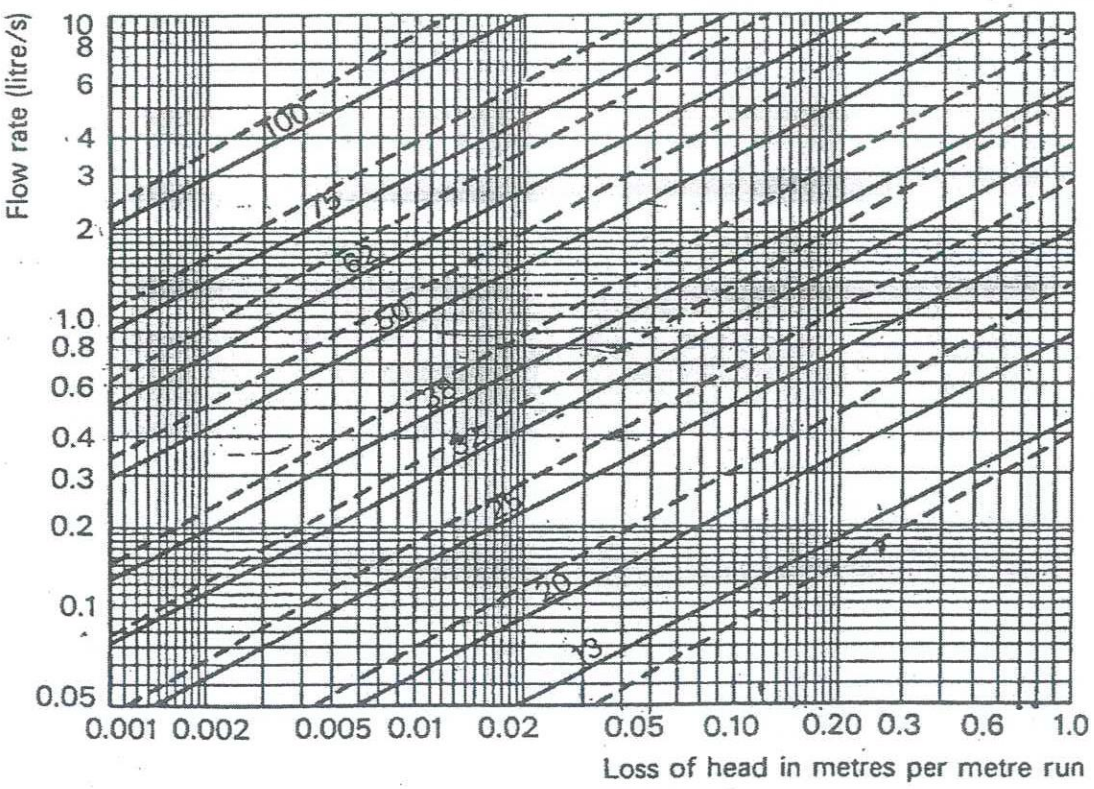
Minimum flow rate with high peak demand

Type of appliances	Rate of flow (*l*/s)
W.C. flushing cistern	0.12
Wash basin	0.15
Wash basin with spray taps	0.04
Bath (private)	0.30
Bath (public)	0.60
Shower	0.12
Sink with 13mm taps	0.20
Sink with 19mm taps	0.30
Sink with 25mm taps	0.60

Equivalent length for frictional resistance

Copper/Plastic			**Galvanized steel**			
Nominal outside diameter (mm)	Meter run of pipe		Nominal outside diameter (mm)	Meter run of pipe		
	Elbow	Tee		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





copper lead and plastics – – – – galvanised steel. ———

Pipe-sizing chart

Loss of Heads in Pipes

Data Sheet 6

Sprinkler arrangements

S= design spacing of sprinkler on range pipes
- Max. 4.6 m extra light hazard
- Max. 4.0 m ordinary hazard
- Max. 3.7 m extra high hazard

D= distance between rows of sprinklers

S x D =
- 21 m^2 or less, extra light hazard
- 12 m^2 or less, ordinary hazard
- 9 m^2 or less, extra high hazard

Classification of occupancies

Extra light hazard
Hospitals, hotels, libraries, museums, nursing homes, offices, prisons, schools, colleges

Ordinary hazard (Group I)
Butchers, breweries, cement works, cafes

Ordinary hazard (Group II)
Bakeries, chemical works (ordinary), engineering works, laundries, garages, potteries, shops

Ordinary hazard (Group III)
Aircraft factories (excluding hangars), boot and shoe factories, carpet factories, clothing factories, departmental stores, plastic factories, printing rooms, saw mills, warehouses

Group III (Special)
Cotton mills, distillers, film and television studios, match factories

Extra high hazard
Celluloid works, foam plastics and rubber factories, paint and varnish factories, wood and wood works, high piled storage risks, oil flammable liquid hazard

Data Sheet 7

Air Conditioner Selection Form

	Item	Quantity	Unit	Factor		BTU/hr
				90 *	95*	
1	Window exposed to Sun	N or E NW W NE & SW	sqft sqft sqft sqft	42 77 85 57	47 80 100 60	=
2	All windows not included in item 1		sqft	20	25	=
3	Wall exposed to Sun (wall considered in item 1)	Light construction Heavy construction	lnft lnft	60 40	70 50	=
4	All exterior walls not included in item 3		lnft	22	27	=
5	Partitions	All interior walls adjacent to an unconditioned spaces	lnft	20	30	=
6	Ceiling or Roof (use only one)	Ceiling with unconditioned space Ceiling with no insulation Attic space with insulation Flat roof with no insulation Ceiling below with insulation Roof no insulation	sqft sqft sqft sqft sqft sqft	1 8 5 7 3 14	3 10 3 8 3 16	=
7	Floor	Over unconditioned space	sqft	2	3	=
8	People	Including allowances for ventilation through unit	No	...x 1000		=
9	Light & Electrical equipment		W	...x 3.41		=
10	Doors or Arches continuously open to unconditioned space		Nos	...x 250		=
					Total cooling load	=

*:- outside design condition of

1 BTU (British thermal unit)/hr=0.2931 Watt

1m = 3.28ft