



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: March 2026

Module Number: CE5201

Module Name: Building Services Engineering (C-23)

[Three Hours]

[Answer all questions, each question carries twelve marks]

Q1.

- a) Derive an expression for the theoretical transportation capacity of an escalator. [3.0 Marks]
- b) Discuss the principles that should be considered in the design of circulation routes within buildings. [3.0 Marks]
- c) You are required to design a lift (elevator) system for a 22-storey (including the ground floor) prestige type apartment building. The first two floors (ground floor, and 1st floor) are designed as shopping spaces and the vertical movement is facilitated only using escalators and staircases. The remaining twenty floors are designed for apartment living with a lift system starting from the ground floor. Please note that the lift does not stop at the 1st floor. Each of the apartment floors contains eight number of three-bedroom apartments. The floor-to-floor height of the building is 3.3 m. The Client's objective is to maximize the passenger service using the provided lifts. Design a suitable lift system for this building including a zoning arrangement if required. 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 assumption made should be clearly mentioned and justified. [4.0 Marks]
- d) Briefly discuss two challenges inherent in designing lift systems for skyscrapers. [2.0 Marks]

Q2.

- a)
 - i. State four important fire protection factors to be considered in ensuring fire safety in buildings. [2.0 Marks]
 - ii. Briefly explain the various fire protection devices available to address fire safety in buildings. [2.0 Marks]
- b) Briefly explain how fire compartmentation is achieved in buildings. [2.0 Marks]
- c) Outline the role of fire drills in ensuring fire safety in buildings. [2.0 Marks]
- d) You are required to design an automatic sprinkler system for a two-storey paint factory. There are two identical rooms at each level. Inside space of a room is 25 m long and 20 m wide. Assume that the sprinkler system can function without any

structural obstructions such as beams and columns. Design and sketch a suitable arrangement for the sprinkler system by following the standard spacing of sprinkler heads. Use the information given in the Data Sheet 4.

[4.0 Marks]

Q3.

- a) Briefly discuss how building orientation should aim to exclude the sun year-round.
[2.0 Marks]
- b) Briefly discuss various natural ventilation methods that can be applied for houses.
[2.0 Marks]
- c) What is meant by the comfort zone on a psychrometric chart? Discuss the necessary modifications required to bring the indoor environment of cold-weather countries into the comfort zone.
[3.0 Marks]
- d) A single-storey office building with plan dimensions of $30\text{ m} \times 18\text{ m}$ and a height of 4 m is to be air-conditioned. The building is constructed of brick masonry, with a flat roof without insulation and steel-framed glass windows. It includes three windows (each measuring $2.5\text{ m} \times 1.5\text{ m}$) and two doors (measuring $2.0\text{ m} \times 2.2\text{ m}$ and $1.2\text{ m} \times 2.2\text{ m}$) as shown in Figure Q3. The office accommodates 25 occupants and contains 10 computers, 3 printers, and 20 lighting fixtures. Each computer emits 25 W of heat, each printer 10 W , and each light fixture 10 W . The outside temperature is 90°F . Assume that $1\text{ W} = 3.41\text{ BTU/h}$ and $1\text{ m} = 3.28\text{ ft}$. Estimate the total cooling load of the building and determine the number of $12,000\text{ BTU/h}$ split-type air conditioners required. Clearly state any assumptions made. Use Data Sheet 7 in answering the question.

[5.0 Marks]

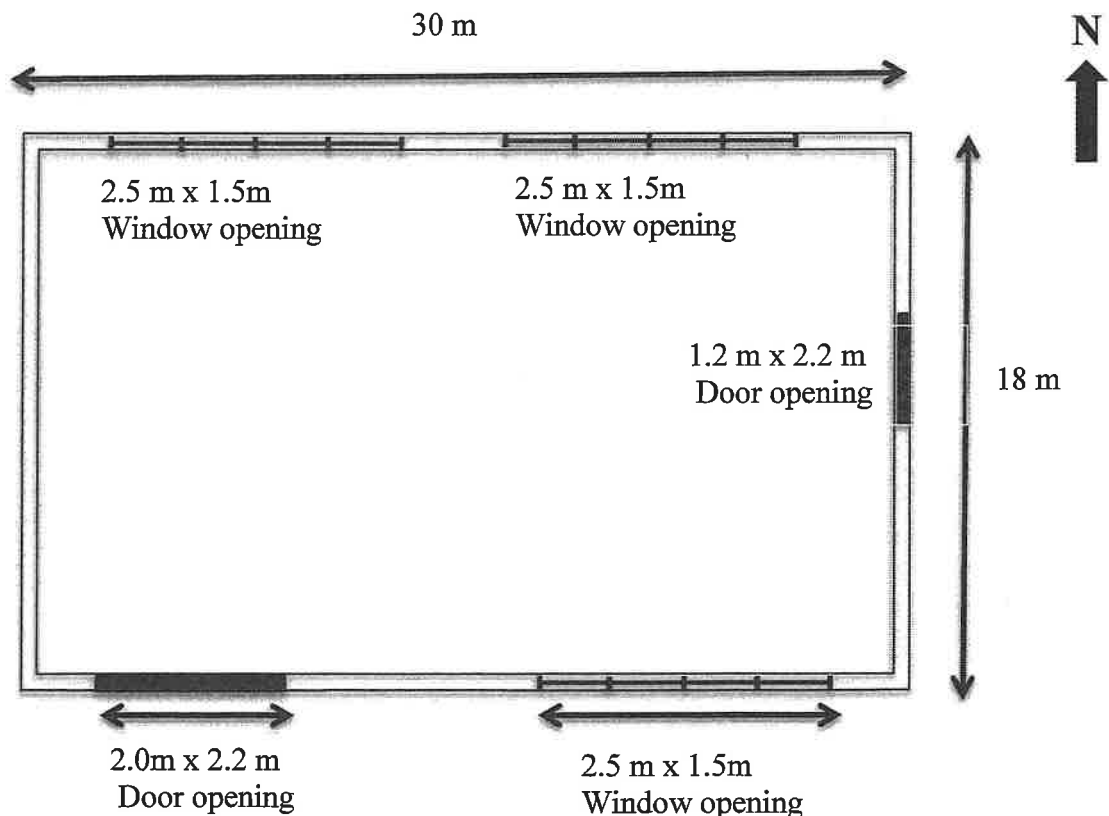


Figure Q3: Building Layout

Q4.

- a) Briefly explain the meaning of 'loading unit rating' in the design of water supply pipe networks for sanitary appliances and mention two situations in which the loading unit rating method cannot be applied. [3.0 Marks]
- b) Determine the design flow rate for a cold water distribution pipe supplying 20 water closets, 24 wash basins, 15 urinals, and 10 showers in a factory where there is a high peak demand for shower use. The urinals require flushing every fifteen minutes, with each flush using 4.5 litres of water. You may use the information given in Data Sheets 5-6. [3.0 Marks]
- c) i. Identify and explain four features that should be available in the design and construction of sanitary appliances. [1.5 Marks]
- ii. Briefly discuss, with illustrations, the various water-seal traps available for sanitary appliances. [1.5 Marks]
- d) i. Compare and contrast a single-stack system with a fully ventilated one-pipe system. [1.5 Marks]
- ii. Briefly explain why the maximum stack capacity is normally limited to about one-quarter ($\frac{1}{4}$) full bore. [1.5 Marks]

Q5.

- a) List four challenges of providing building services in a complex mixed-use tower. [2.0 Marks]
- b) Briefly discuss how refuse disposal is facilitated in a complex mixed-use tower. [2.0 Marks]
- c) Briefly explain how the efficient use of energy can be applied in a building to make it sustainable. [2.0 Marks]
- d) Briefly discuss the factors to be considered when locating plant and equipment in a high-rise building. [3.0 Marks]
- e) Integrated Design and Delivery using BIM ensures coordination of all building services, structural elements, and architectural components. Elaborate this statement, highlighting the role of a building services engineer. [3.0 Marks]

Data Sheet 1

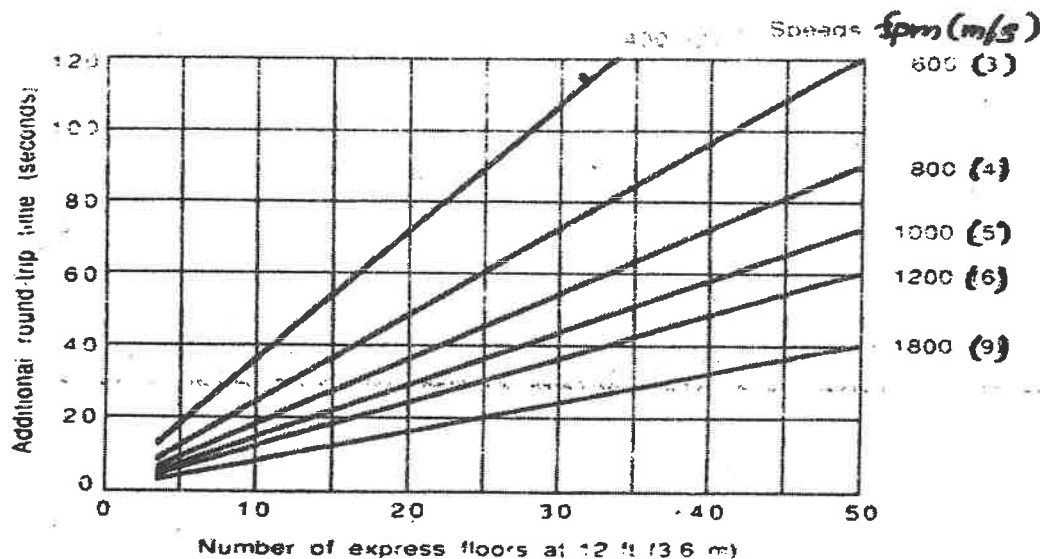
Elevator Speeds for Various Occupancies

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

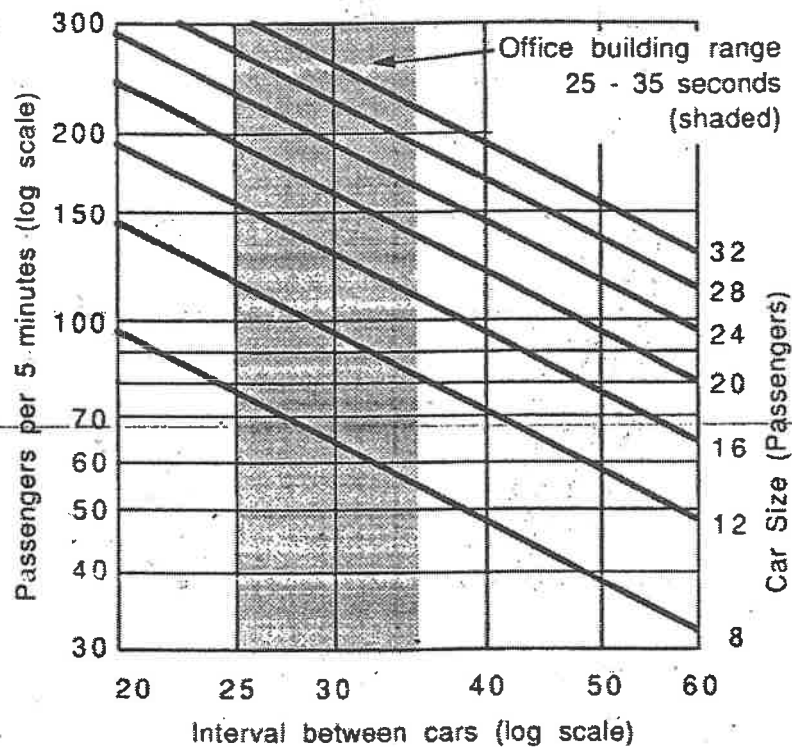
Design Parameters for Elevators

Building type	Population Density		% Population Handled in 5 minutes	Average Interval Seconds
	ft ² /person	m ² /person		
<u>Offices</u>				
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
<u>Apartment</u>				
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
<u>Hotels</u>				
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 divided by the speed, and therefore allows for both the up and down travel through the express zone at rated car speed.

Data Sheet 2

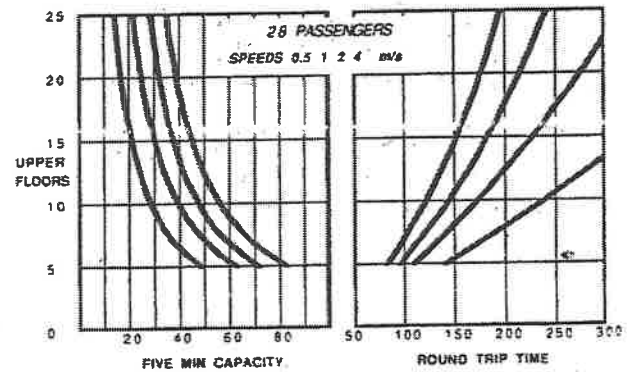
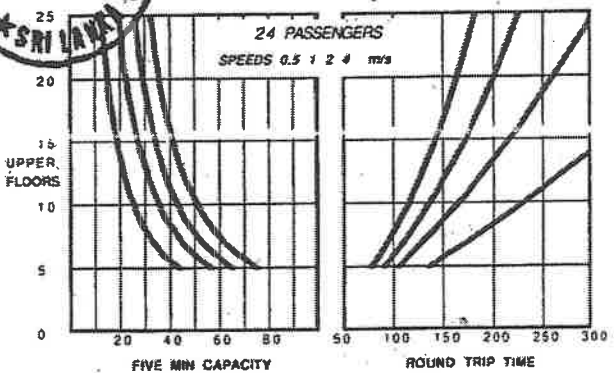
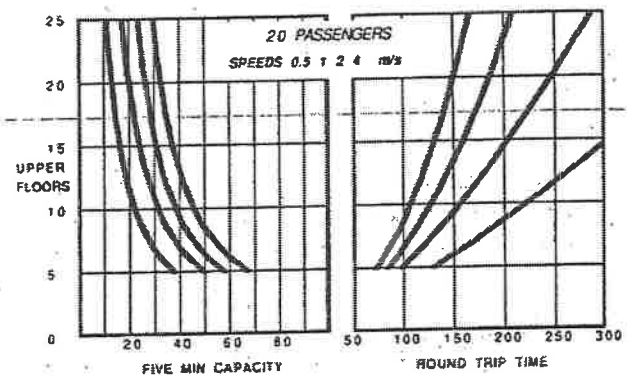
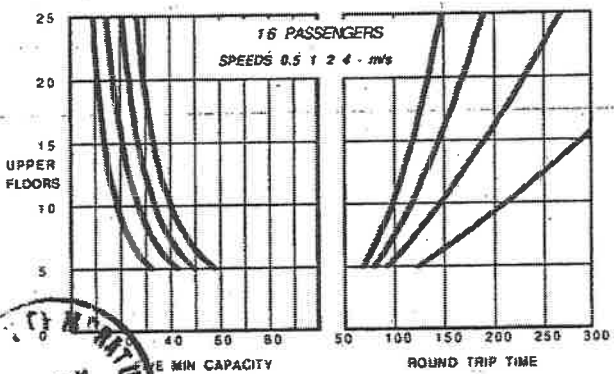
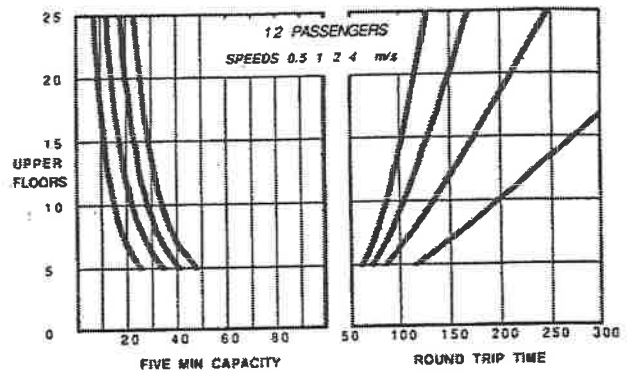
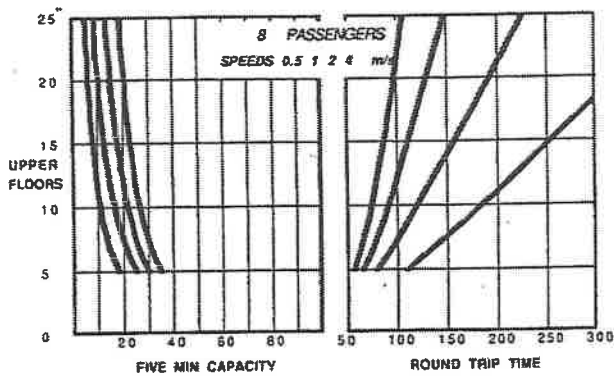


The five-minute handling capacity of sets of various sized elevator cars, plotted against the interval between them. First determine the required handling capacity of the group. Enter the graph from the left, and continue across to find the intersection of an acceptable car size and interval. If the required capacity is too high for an acceptable solution, try zoning. If it is too low, then the building is less than optimum size for elevating. Once a size and interval is determined, refer to Fig. 25.7.2 to determine the round-trip time of cars of various speeds. The number of cars required in the group is the round-trip time divided by the required interval.

Approximate Sizes and ratings of Elevator Cars

<i>Capacity</i>		<i>Passengers</i>		<i>Inside W x D</i>		<i>Shaft W x D</i>	
<i>lb</i>	<i>kg</i>	<i>Max</i>	<i>Average</i>	<i>in</i>	<i>mm</i>	<i>in</i>	<i>Mm</i>
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

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

$S \times D = \begin{cases} 21 \text{ m}^2 \text{ or less, extra light hazard} \\ 12 \text{ m}^2 \text{ or less, ordinary hazard} \\ 9 \text{ m}^2 \text{ or less, extra high hazard} \end{cases}$

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 5

Loading Units

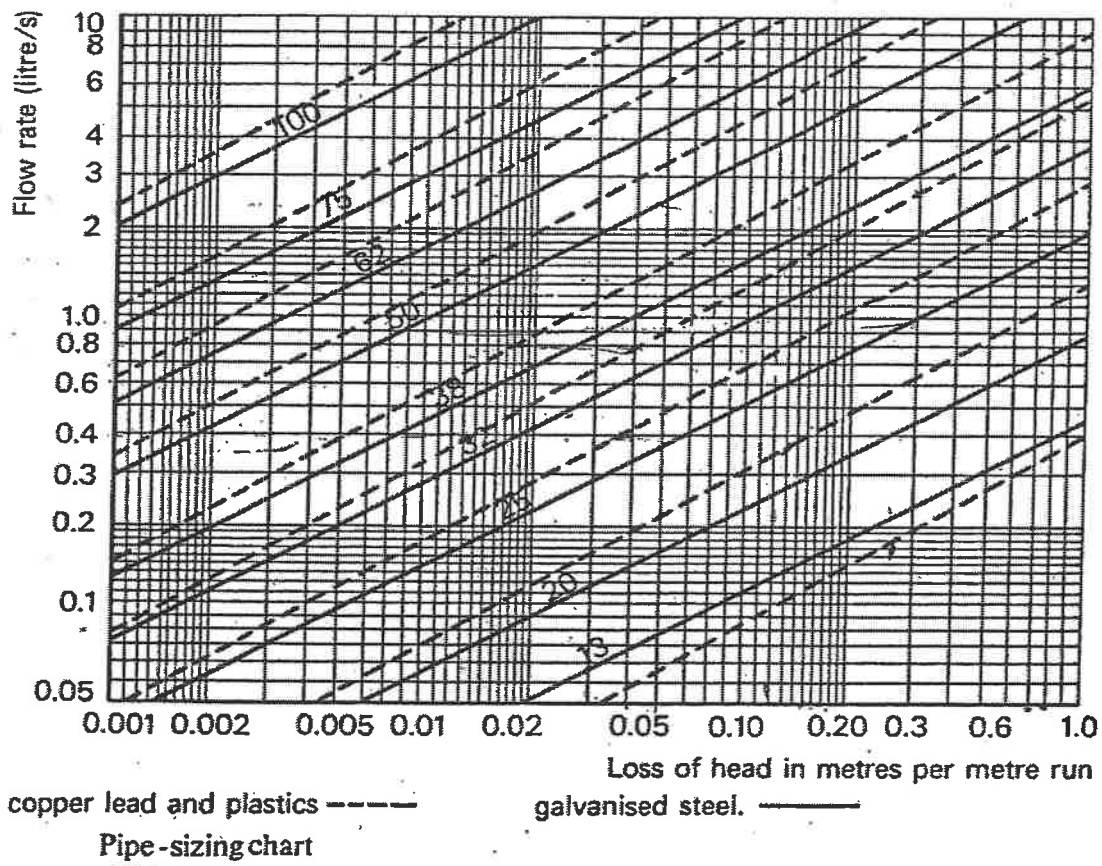
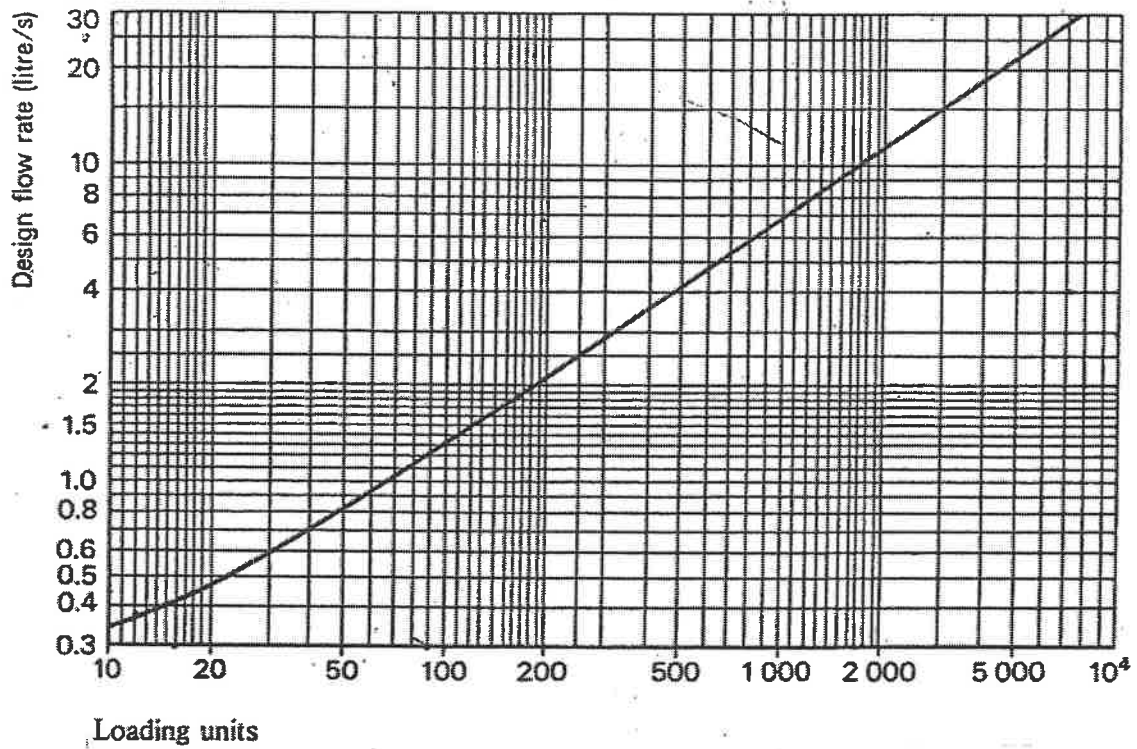
Minimum flow rate with high peak demand

	Loading unit rating	Type of appliances	Rate of flow (l/s)
Dwellings and flats			
W.C. flushing cistern	2	W.C. flushing cistern	0.12
Wash basin	1 ½	Wash basin	0.15
Bath	10	Wash basin with spray taps	0.04
Sink	3-5	Bath (private)	0.30
		Bath (public)	0.60
Offices			
W.C. flushing cistern	2	Shower	0.12
Wash basin (distributed use)	1 ½	Sink with 13mm taps	0.20
Wash basin (concentrated use)	3	Sink with 19mm taps	0.30
		Sink with 25mm taps	0.60
Schools and industrial buildings			
W.C. flushing cistern	2		
Wash basin	3		
Shower	3		
Public bath	22		

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

Data Sheet 6



Data Sheet 7

	Item	Quantity		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 space	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 W is equal to 3.41 BTU/h
 1 meter (m) = 3.28 feet (ft)