UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: February 2020

Module Number: CE4251 **Module Name: Building Services Engineering**

[Three Hours]

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

Q1.

a) List parameters to be considered in designing an escalator system for a shopping complex.

[2.0 Marks]

b) List four types of safety features available in modern lifts (elevators) and identify the role of each feature in providing a safe vertical movement for passengers.

[2.0 Marks]

c) You are required to design a lift (elevator) system for a 20-storey (excluding ground floor) mid-range type apartment building. The ground floor is designed for a shopping space whereas the remaining twenty floors are designed for apartment living. Each floor (from 1st floor to 20th floor) contains eight units of two-bedroom apartments. The floor to floor height of the building is 4m. Bulding owner's objective is to maximize the passenger service provided using 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 and capacity of a lift and the shaft size. Use information given in data sheets 1, 2 and 3. Any assumption made should be clearly mentioned and justified.

[4.0 Marks]

d) What are the challenges of providing lift services in complex mix use towers?

[2.0 Marks]

e) Briefly discuss how green building concepts can be used in designing lift systems.

[2.0 Marks]

Q2.

a) List parameters to be considered when designing a pipe network to supply cold water to a building.

[2.0 Marks]

b) Briefly explain why the use of equivalent pipe length is more effective than the use of actual pipe length when deciding a diameter of a water supply pipe network.

[2.0 Marks]

c) A garment manufacturing company owns a two-storey building in an urban area. Layout of the pipe network (PVC) for this building is shown in Figure Q2. Pipe 2 and pipe 5 consist of six water closets, two showers and a sink (with 13mm tap). Pipe 3 and pipe 6 consist of six urinals, two showers and a sink (with 13mm tap).

Urinals (4.0 *l* capacity) are operated in every 30 minutes. Two main pipes (pipe 1 and pipe 4) are controlled by stop valves located at the beginning of each pipe. Outside diameters of each main and branch pipes are also given in Figure Q2. During peak hours, it is noted that water outflow from some appliances are not adequate. Therefore, company wants to check whether provided diameters are sufficient or not. Assuming that you are given this assignment by the company, determine the diameters of main distribution pipe and two branch pipes at 2nd floor and, give your recommendation regarding each pipe diameter. 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.

[8.0 Marks]

Q3.

a) List different types of fire extinguishers and identify their usages in responding to various classes/types of fires.

[3.0 Marks]

b) Briefly explain what is meant by "fire compartmentation"? Illustrate how it can be used in high rise buildings as a passive fire protection measure.

[2.0 Marks]

c) 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 50m long and 35m wide. Assume that the sprinkler system can function without any structural obstructions such as beams and columns.

i. Design a suitable arrangement for the sprinkler system by following standard spacing of sprinkler heads.

ii. Draw the pipe network diagram for this sprinkler system of the entire factory including the source of water supply and other key features in the network.

[5.0 Marks]

d) Briefly explain essential features of a "fire evacuation plan" developed for a high rise building.

[2.0 Marks]

Q4.

a) Discuss two types of natural ventilation provisions that can be used to control heat gain in buildings.

[2.0 Marks]

b) Determine the total cooling load capacity required for an office room on the upper floor of a two storey factory building in which ground floor is not air conditioned. There will be a total of twelve clerical staff in the office. It is planned to have eight computers, and a photocopy machine. Each computer will emit about 25W of heat and the photocopy machine will emit about 15W of heat. A 40W bulb will be provided for each 100ft^2 floor area. There are three glass windows of 10ft ×5ft on the wall facing the West direction as shown in Figure Q4. Wall height is 10ft. Outside temperature is 32^{0}C. Clearly state all the assumptions you made. Use data sheet 7 and attach it to the answer booklet.

[6.0 Marks]

c) Cooling or heating only is not sufficient to bring the condition of a room to a comfortable level. Explain this statement using a rough sketch of a psychrometric chart and suggest solutions that can be applied along with heating and cooling applications to bring the room to a level required for human comfort.

[4.0 Marks]

Q5.

a) Discuss two different ways of water seal losses in traps beneath sanitary fittings and mention how to prevent them in designing sanitary drainage systems.

[3.0 Marks]

b) i. Briefly describe what is meant by "discharge unit values" related to sanitary appliances.

ii. Briefly explain why are the discharge unit values for a sanitary appliance in an education building different compared to a public office building.

[3.0 Marks]

c) i. Briefly describe what is meant by a sunken slab.

ii. List two advantages of having a sunken slab in a residential building design.

[2.0 Marks]

d) Explain one waste separation method, which is applicable in waste disposal via chutes and, that facilitates the operation with minimum labour requirement.

[2.0 Marks]

e) Illustrate an onsite system to treat sewage collected within a multi-storey building.

[2.0 Marks]

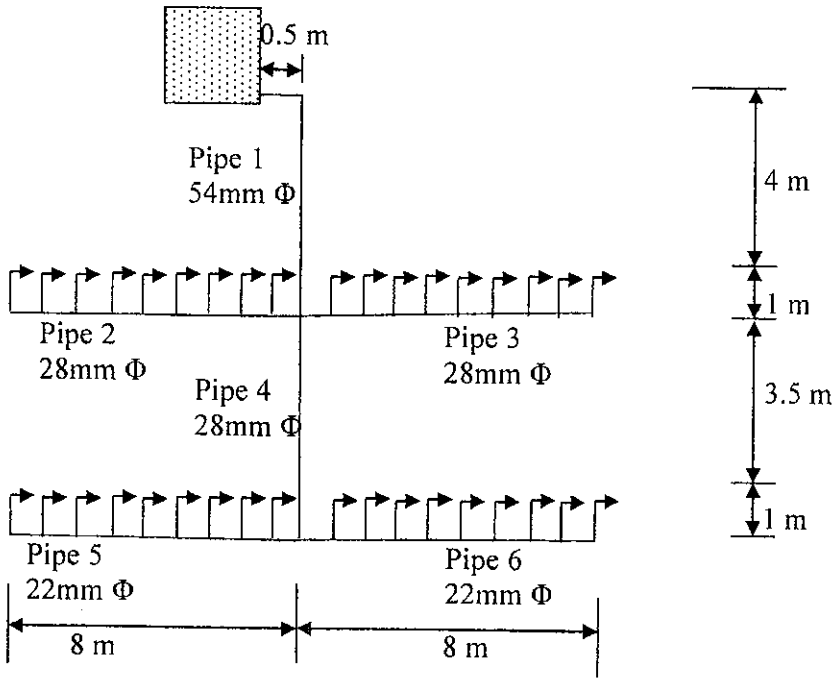


Figure Q2: Pipe Network for the Garment Factory

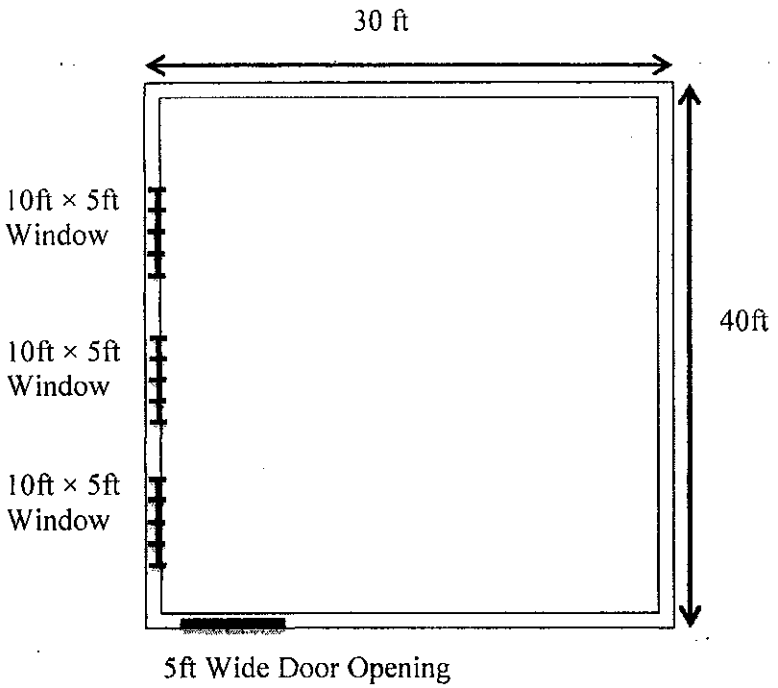


Figure Q4: Office Room Plan

Data Sheet 1

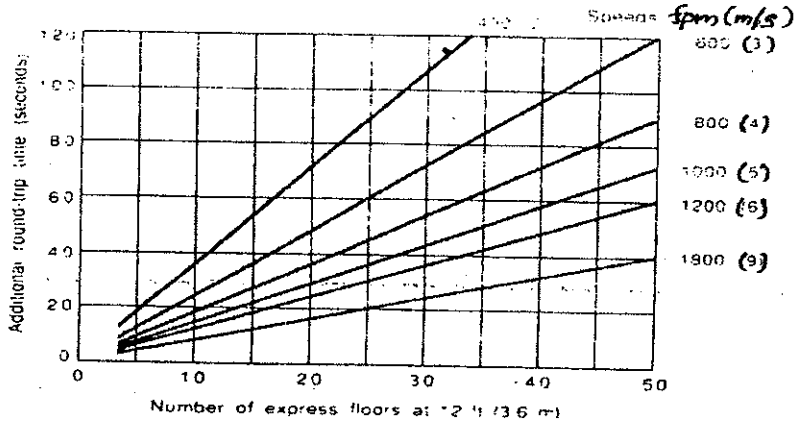
Elevator Speeds for Various Occupancies

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

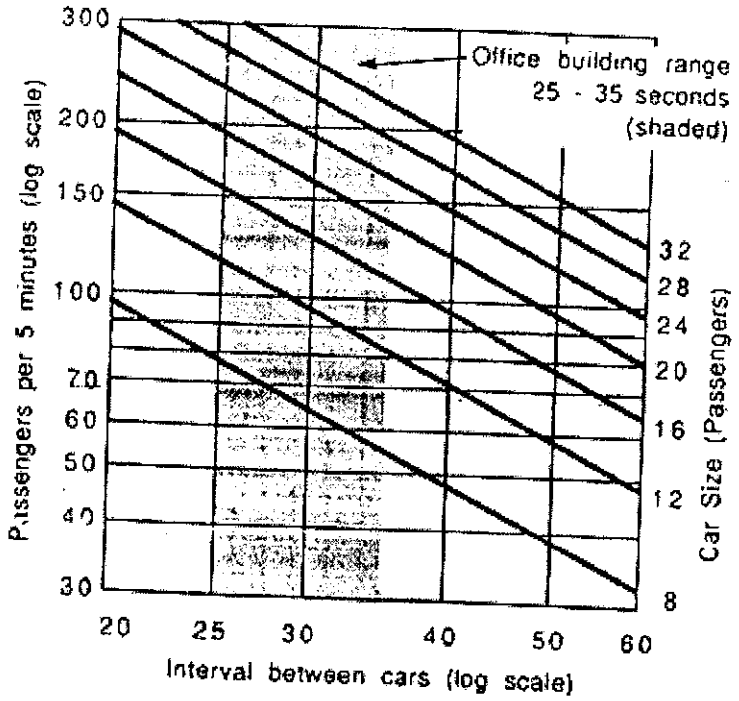
Design Parameters for Elevators

Building type	*Population Density*		*% Population Handled in 5 minutes*	*Average Interval Seconds*
	ft²/person	*m²/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 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

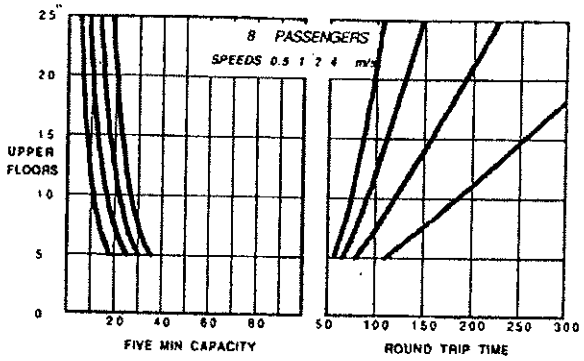


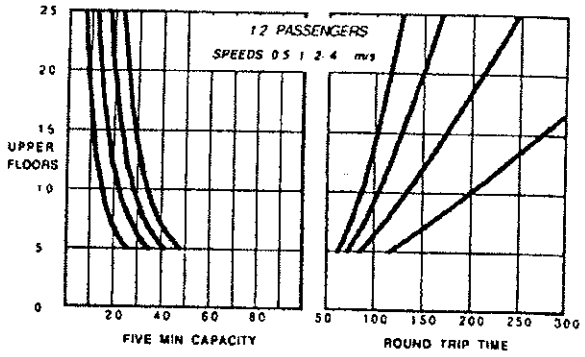
The five-minute handling capacity of sets of various sized elevator cars, plotted against the interval between them. First determine the required handling capacity of the group. Enter the graph from the left, and continue across to find the intersection of an acceptable car size and interval. If the 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 elevatoring. 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.

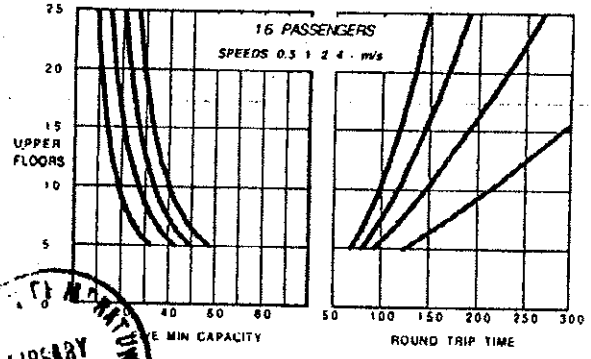
Approximate Sizes and ratings of Elevator Cars

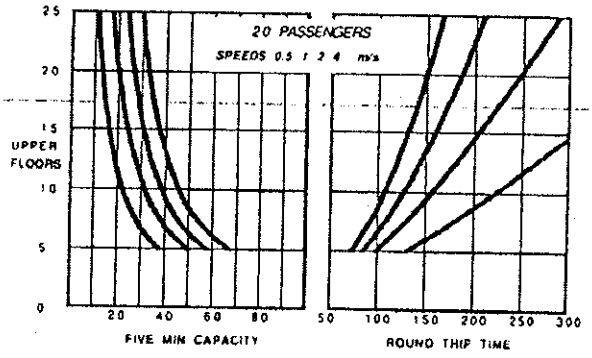
Capacity		*Passengers*		*Inside W x D*		*Shaft W x D*	
lb	*kg*	*Max*	*Average*	*in*	*mm*	*in*	*Mm*
2000	900	12	10	68 x 51	1700 x 1300	89 x 83	2200 x 2100
2500	1150	16	13	82 x 51	2100 x 1300	102 x 83	2550 x 2100
3000	1350	20	16	82 x 55	2100 x 1400	102 x 88	2550 x 2200
3500	1600	24	19	82 x 66	2100 x 1650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

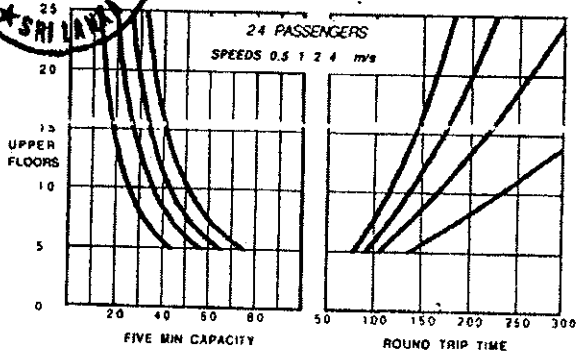
Data Sheet 3

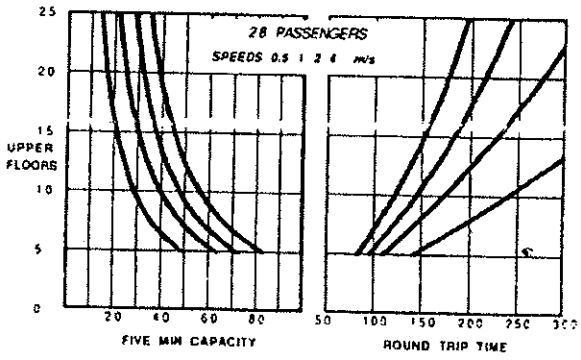












The round trip time, and five-minute carrying capacity, for single elevator cars from 8 to 28 passenger nameplate capacity, and speeds from 100 to 800 fpm (0.5 to 4 m/s). All upper floors are assumed to have equal attraction. Figures are based on up peak conditions. Assumptions made about door operations 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.

Loading Units

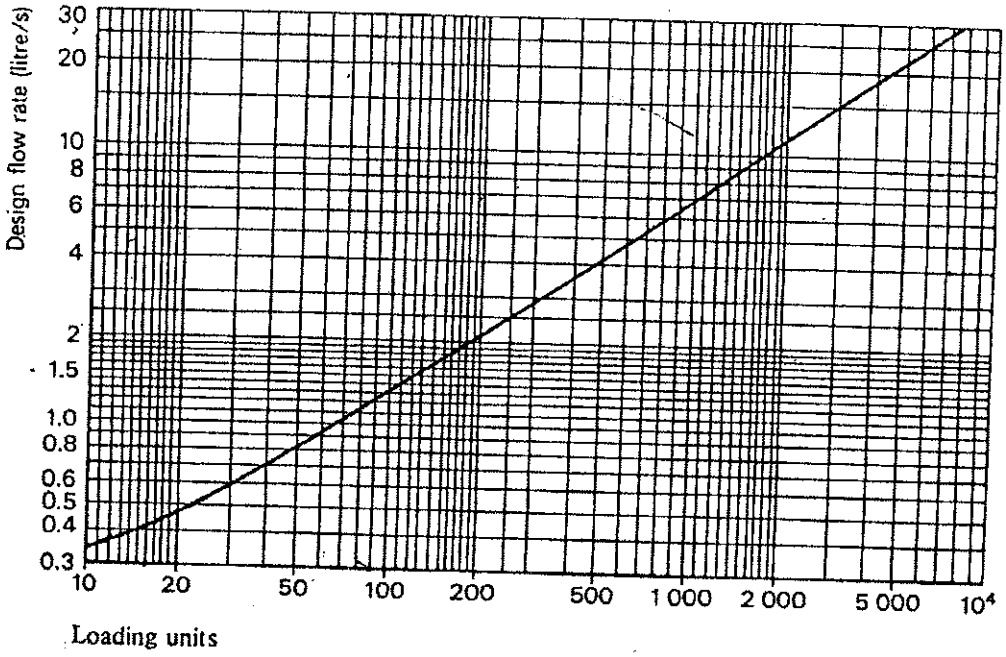
	Loading unit rating
Dwellings and flats	
W.C. flushing cistern	2
Wash basin	1 ½
Bath	10
Sink	3-5
Offices	
W.C. flushing cistern	2
Wash basin (distributed use)	1 ½
Wash basin (concentrated use)	3
Schools and industrial buildings	2
W.C. flushing cistern	3
Wash basin	3
Shower	
Public bath	22

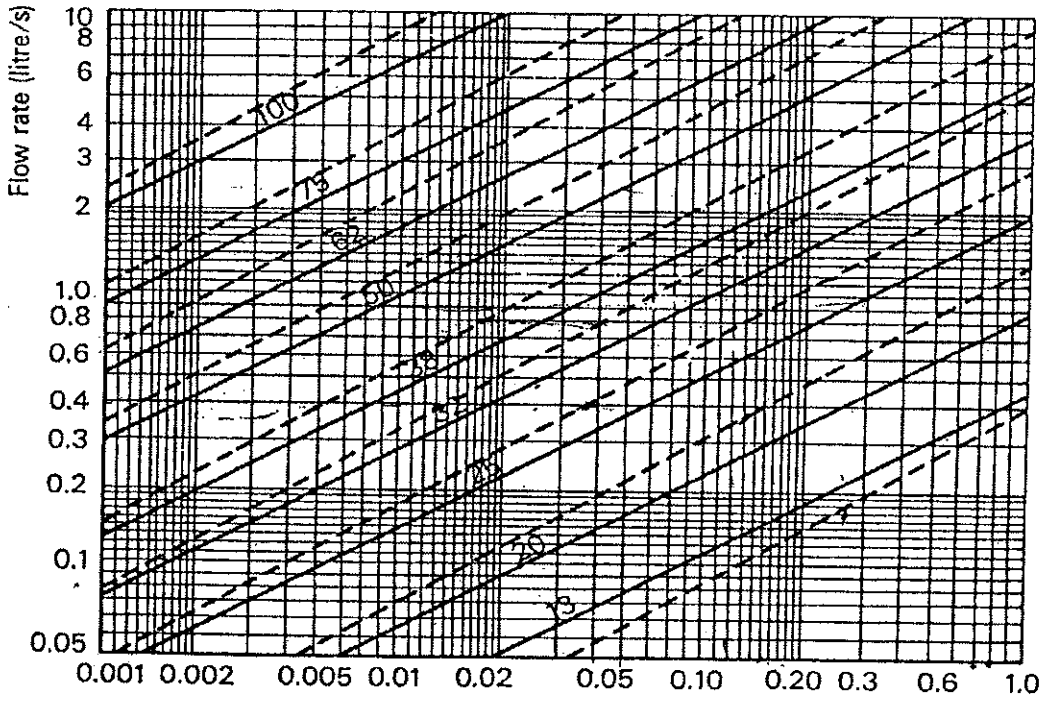
Minimum flow rate with high peak demand

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





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

Item		Quantity	Factor		Btu/hr
			90*	95*	
1. Window exposed to sun	N or E	Sqft		42	47
	NW	Sqft		77	80
	W	Sqft		85	100
	NE & SW	Sqft		57	60
2. All windows not included in Item 1		Sqft		20	25
3. Wall exposed to Sun	Light construction	Lnft		60	70
	Heavy Construction	Lnft		40	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	Ceiling with unconditioned space	Sqft		1	3
	Ceiling with no insulation	Sqft		8	10
	Attic space with insulation	Sqft		5	3
	Flat roof with no insulation	Sqft		7	8
	Ceiling below with insulation	Sqft		3	3
	Roof no insulation	Sqft		14	16
7. Floor	Over unconditioned space	Sqft		2	3

8. People	Including allowances for ventilation through unit	No	.....x1000
9. Light and electrical equipment in Nos		W	.....x3.4
10. Doors and Arches continuously open to unconditioned space			.....x250

Total cooling load

* :- outside design condition of

1 W =3.4 BTU/hour

BTU -British Thermal Unit