UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2018

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

[Three Hours]

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

Q1.

a) List four factors to be considered in designing vertical circulations in multi-story buildings.

[2.0 Marks]

b) Derive an equation to determine the theoretical transportation capacity of an escalator. Assume notations appropriately.

[2.0 Marks]

c) List four types of safety features available in modern lifts and briefly describe the role of each feature in providing a safe vertical movement for passengers.

[2.0 Marks]

d) You are required to design a lift (elevator) system for a 25-storey (including ground floor) mid-range type apartment building. The ground floor is designed as a shopping space whereas the remaining twenty-four floors are designed for apartment living. Each floor (from 1st floor to 24th floor) contains six number of three-bedroom apartments. The floor to floor height of the building is 3.6 m. Client's objective is to maximize the passeger 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 of a lift and shaft, and the capacity of a lift. Use information given in data sheets (1-3). Any assumption made should be clearly mentioned and justified.

[4.0 Marks]

e) Explain advantages of having multiple sky lobbies in a lift system of a skyscraper?

[2.0 Marks]

Q2.

a) 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 either side are served at each floor.

One branch pipe supplies water to 4 water closets and 4 washbasins; the horizontal distance to the last appliance from the main distribution pipe is 8 m. Each appliance is located 1 m above the floor level.

The other branch pipe supplies water for 6 showers respectively. Showers are considered as having high peak demands. The distance to the last shower is 6 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.

[8.0 Marks]

b) Briefly describe one possible method applicable for indoor water conservation.

[2.0 Marks]

Q3.

a) Explain using figures how the spread of fire can be limited by a good fire compartmentation practice in designing a multi-storey building.

[2.0 Marks]

b) What is meant by "Travel Distance" and "Direct Distance" according to ICTAD Fire Regulations?

[2.0 Marks]

c) Explain how sprinkler systems function, giving details of different operating system types available.

[2.0 Marks]

d) You are required to design an automatic sprinkler system for a two-storey paint factory. Inside space of the building is 50m long and 35m wide. Assume that the sprinkler system can function without any structural obstructions such as beams and columns. Design a suitable arrangement for the sprinkler system following standard spacing of sprinkler heads. Use information given in Data sheet 6.

[4.0 Marks]

e) Briefly describe important fire emergency preparedness measures to be implemented in a multi-storey building.

[2.0 Marks]

Q4.

An office is located in a single-storey building with dimensions 30 m x 16.5 m. The plan of the building is shown in Figure Q4. Building consists of steel framed glass windows, with a flat roof. There are three 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 so that it will be possible to provide thermal comfort without air conditioning. 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 20 staff, 8 computers and 5 printers will be there in the building. Each computer will emit 25 W of heat while a printer will emit 10 W. In addition, 20

bulbs each emitting 10 W will be there in the building. Use Datasheet 7 in answering the question. State any assumptions made.

[6.0 Marks]

c) Discuss possible actions, which could be taken in construction stage of a building to avoid or minimize air conditioning cost.

[3.0 Marks]

Q5.

a) Describe the information required by a building services design engineer, to determine the number of sanitary appliances to be provided in a building.

[3.0 Marks]

b) In a five-storey building, there are about six water closets and washbasins to be installed at each floor. However, client wants them to apart from each other. Select the most appropriate aboveground drainage system for this building. Explain the reasons for your selection.

[3.0 Marks]

c) In belowground drainage manholes play an important role. Describe two situations at which manholes are installed.

[3.0 Marks]

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

[3.0 Marks]

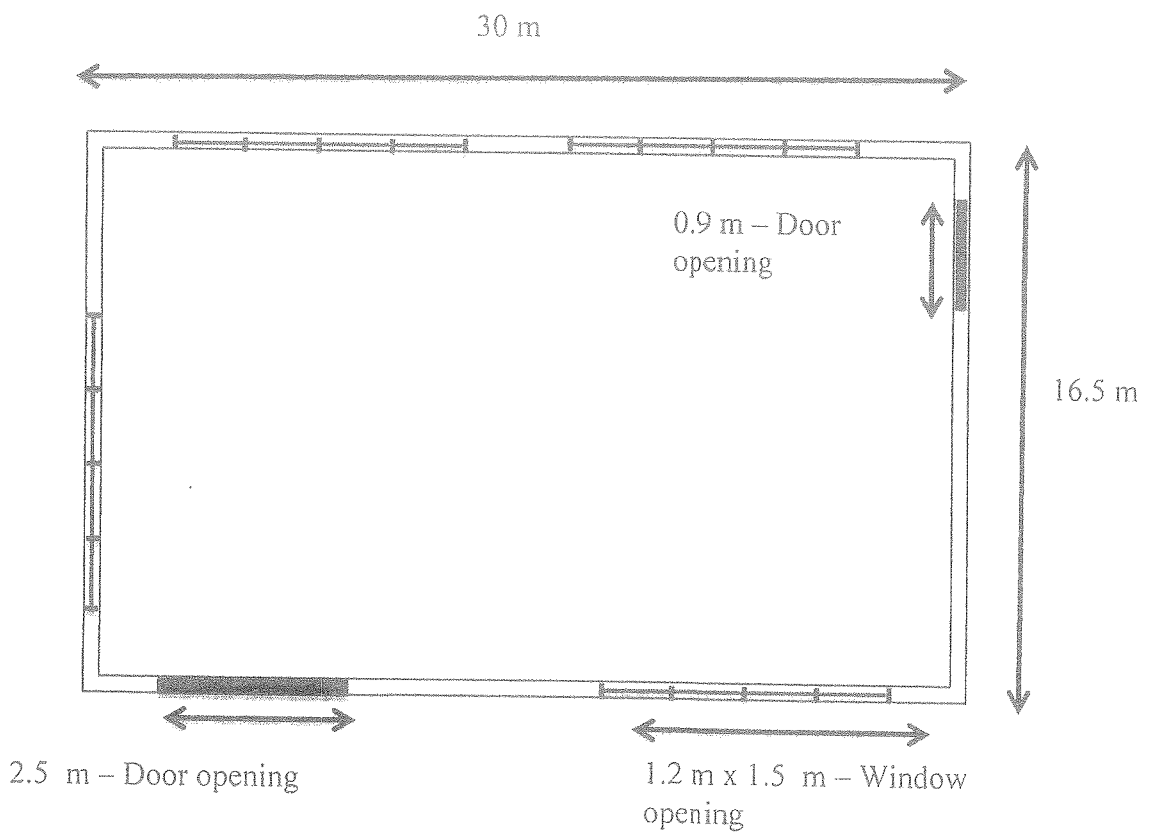


Figure Q4: Building plan

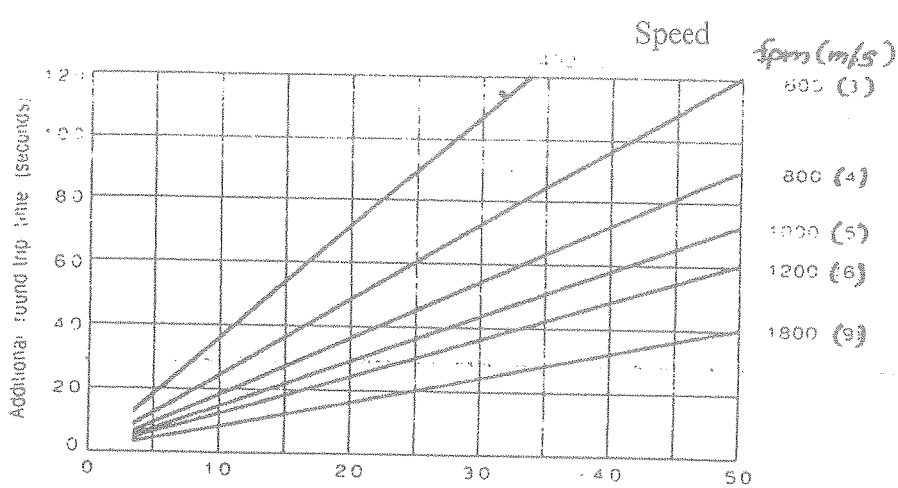
Elevator Speeds for Various Occupancies

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				

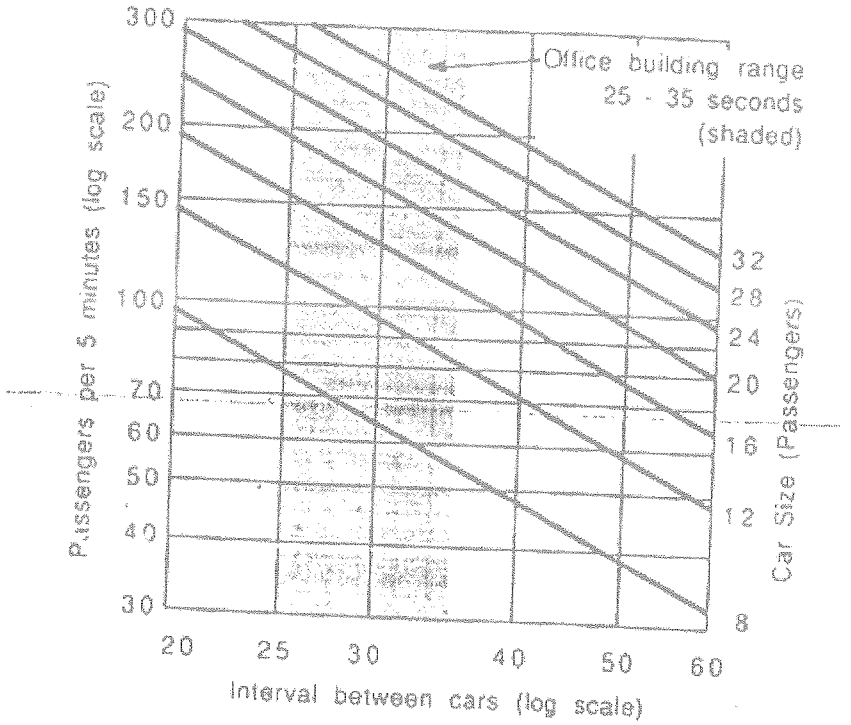
fpm: feet per minute

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

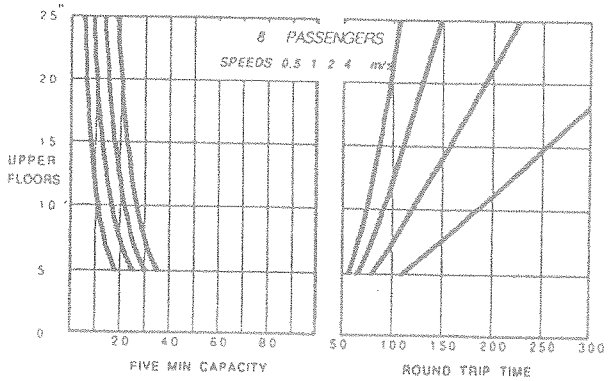


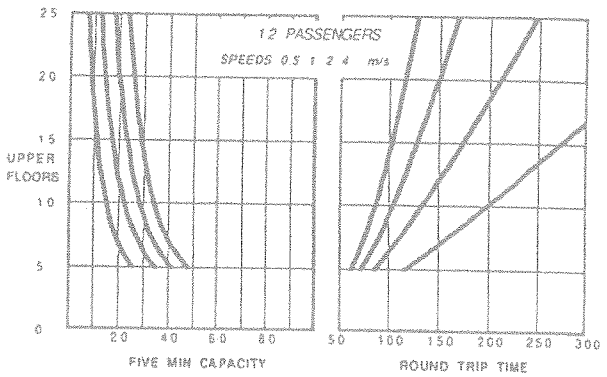
. Additional time to be added to the round-trip time when a car operates express through the lower floors of a building.

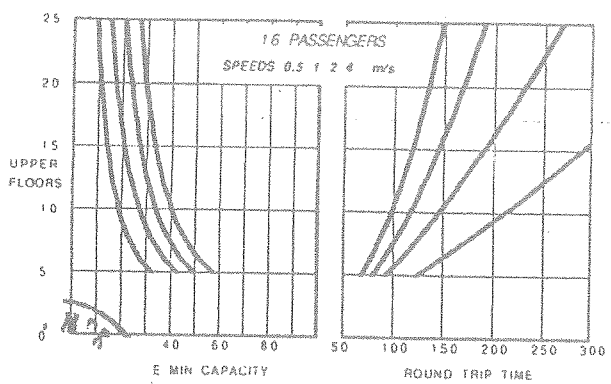


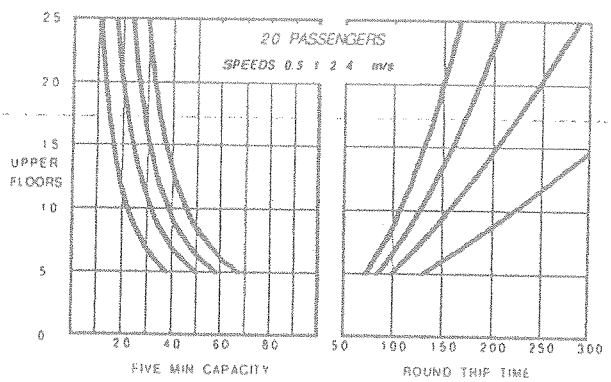
Approximate Sizes and ratings of Elevator Cars

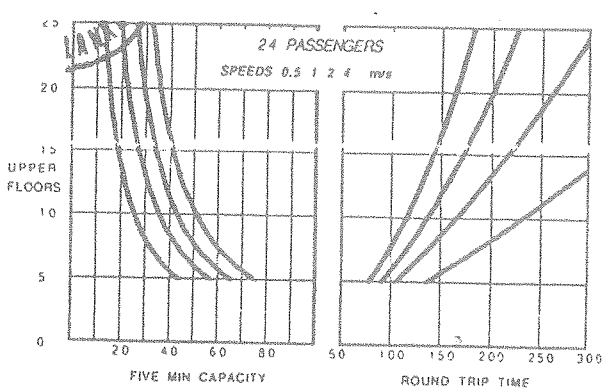
Capacity		*Passengers*		*Inside W x D*		*Shaft W x D*	
lb	*kg*	*Max*	*Average*	*in*	*mm*	*in*	*Mm*
2000	900	12	10	68 x 51	1700 x 1300	89 x 83	2200 x 2100
2500	1150	16	13	82 x 51	2100 x 1300	102 x 83	2550 x 2100
3000	1350	20	16	82 x 55	2100 x 1400	102 x 88	2550 x 2200
3500	1600	24	19	82 x 66	2100 x 1650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

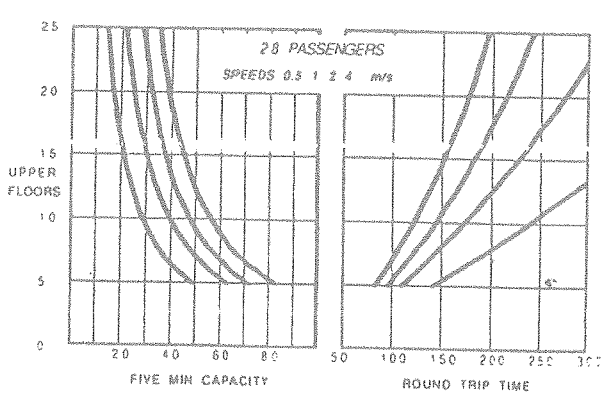












The round trip time, and five-minute carrying capacity, for single elevator cars from 8 to 28 passenger nameplate capacity, and speeds from 100 to 800 fpm (0.5 to 4 m/s). All upper floors are assumed to have equal attraction. Figures are based on up peak conditions. Assumptions made about door operations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

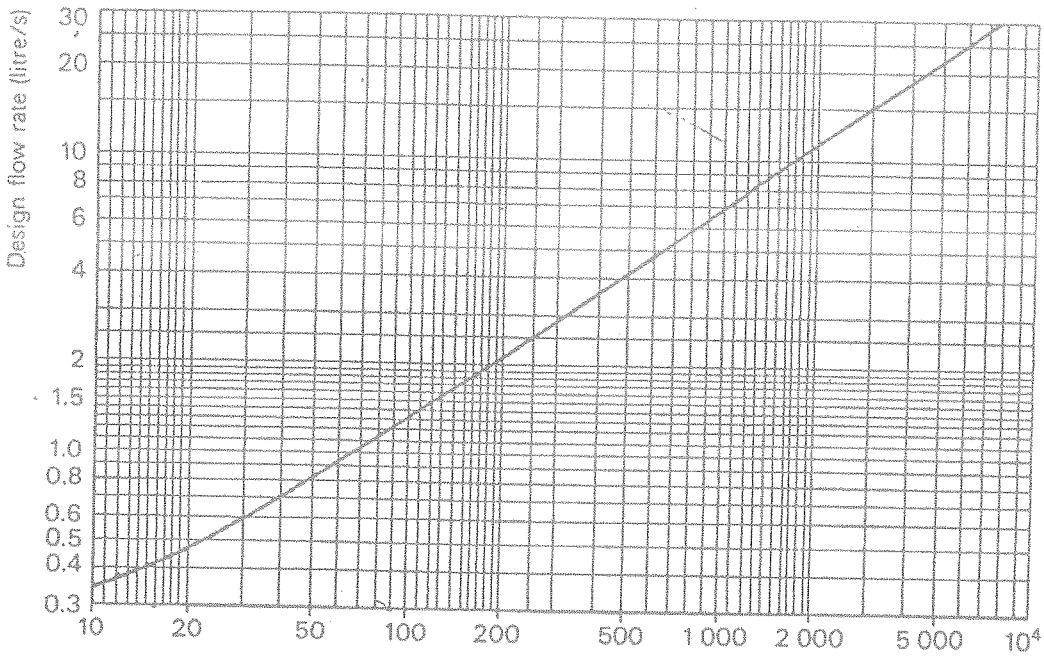
	Loading unit rating
Dwellings and flats	
W.C. flushing cistern	2
Wash basin	1 ½
Bath	10
Sink	3-5
Offices	
W.C. flushing cistern	2
Wash basin(distributed use)	1 ½
Wash basin (concentrated use)	3
Schools and industrial buildings	2
W.C. flushing cistern	3
Wash basin	3
Shower	
Public bath	22

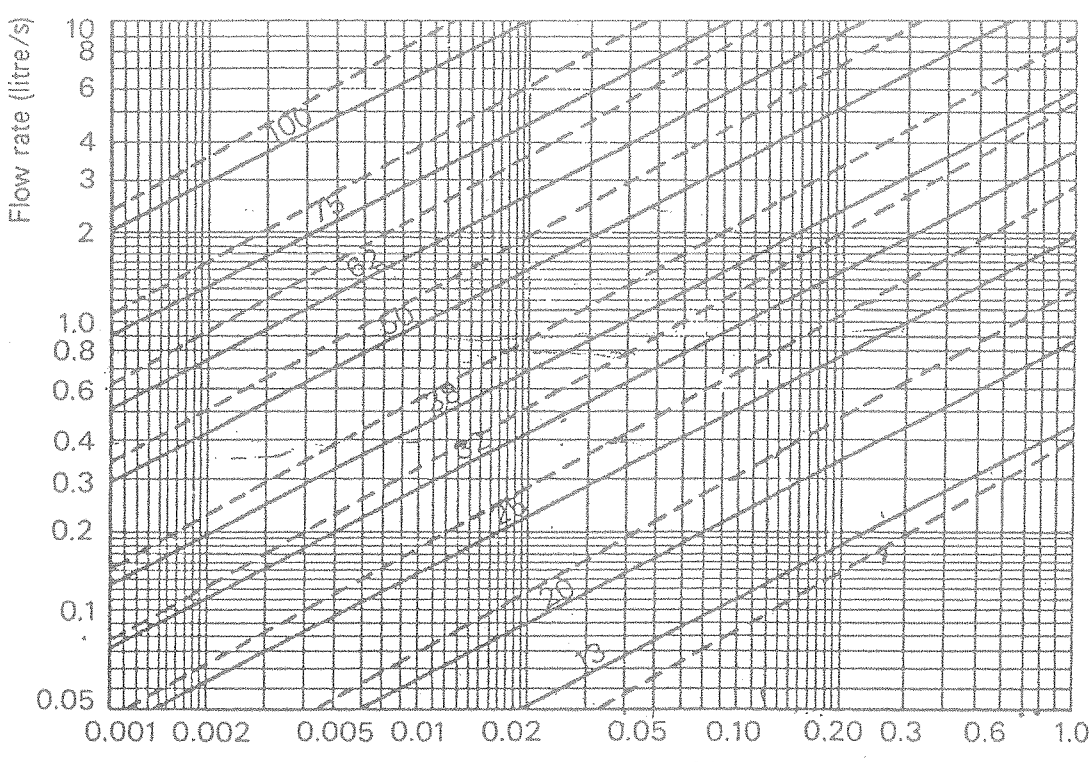
Minimum flow rate with high peak demand

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

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

Item		Quantity	Factor 90*	95*	Btu/hr
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 BTU (British Thermal Unit)=0.2931 Watt