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Electromechanical Systems in Building Services Engineering

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Abstract

There are myriad of electromechanical systems in domestics, commercial and industrial buildings. Part or most of these systems hardware are hidden from the public though they do account for between 50% to 75% of the total construction cost and take up to 15% of the building volume. This paper is aimed at enumerating their functions as a prerequisite for designing (including modelling and simulation), selecting, integrating, managing and reduction in energy usage. The electromechanical systems included in this paper are cold and hot water supplies, heating, ventilation, air conditioning, drainage, sanitation, refuse and sewage disposal, gas, electricity, access control, communication, oil installation, fire fighting and transportation.

Key words: building services engineering, water supply, air conditioning, fire fighting

1. Introduction

The capital and installation costs of building services in modern buildings can take up 50% of the total construction budget. For highly serviced buildings such as sports centres, this figure can easily exceed 75%. Services can also take up 15% of a building's volume. Therefore building services cannot be ignored. Architects have learnt to accept and accommodate the increased need for pipes, ducts and cabling encroaching on to their designs. Building services are the dynamics in a static structure, providing movement, communications, facilities and comfort. As they are unavoidable, it is imperative that architects, surveyors, builders, structural engineers, planners, estate managers and all those concerned with the construction of buildings have a knowledge and appreciation of the subject.

This paper incorporates a wide range of building services. The services included in this paper are cold and hot water supplies, heating, ventilation, air conditioning, drainage, sanitation, refuse and sewage disposal, gas, electricity, oil installation, fire services, transportation, accommodation for services, energy recovery and alternative energy. Illustrations shall be used to show the principles and operations of various services. The building services industry is based on engineering principles that are applied to the construction of buildings and the built environment. Its origins as a science and technology are well documented, not least the use of Archimedes ` spiral for movement of water ' and the concept of under floor heating in Roman palaces. More recently, it has evolved in response to the demands of population growth and the expectation of comfortable shelter, convenience and a healthy home and workplace environment. As an industry it is vast in terms of the diversity of professions and trades that it encompasses.

The industry is generally divided between design and installation. Design is undertaken by specialist consultancies and installation undertaken by specialist contractors. The latter sub-contracted on site under the overall administration of a construction management main contractor.

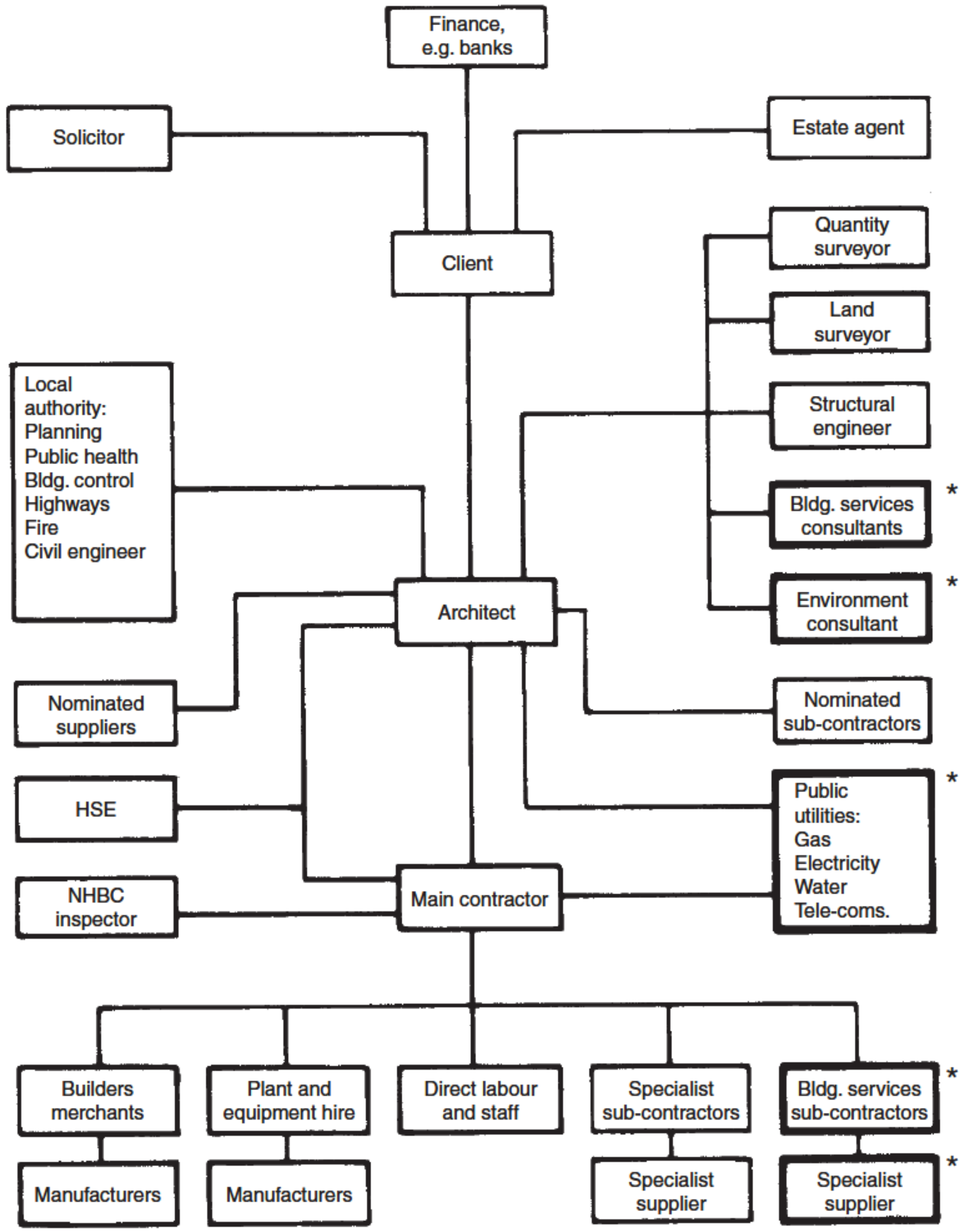


Figure 1. The Building Industry (Greeno and Hall, 2009)

2. The Electromechanical Systems

The electromechanical systems are cold and hot water supplies, heating, ventilation, air conditioning, drainage, sanitation, refuse and sewage disposal, gas, electricity, access control, communication, oil installation, fire fighting and transportation. Table 1 Typical Plumbing Schedule

PLUMBING FIXTURE CONNECTION SCHEDULE

SYM	DESCRIPTION	CONNECTION SIZE W	V	CW	HW
WC-1	WATER CLOSET : ARMITAGE SHANKS TIFFANY RANGE, WHITE CLOSED COUPLED WASHDOWN UNIT IN VITREOUS CHINA COMPRISING OF: (i) TIFFANY WC PAN (1543014) (ii) CISTERN (1778574) FOR BOTTOM SUPPLY AND OVERFLOW WITH FREE-FLOW PLASTIC SYPHON FITTINGS 15mm MICROVALVE HP/LP BALLVALVE WITH WHISPERFLOW REFILL UNIT AND CLOSE-COUPLING FITMENT, WITH CHROME-PLATED SIDE LEVER (iii) SATURN SEAT AND COVER (8950091) (iv) DOMEX SCREWS (7000800) (v) S AND P TRAP PANEXTA CONNECTORS (9014030 AND 9013020 RESPECTIVELY)	100	50	15	-
L-1	LAVATORY WASHBASIN: ARMITAGE SHANK TIFFANY RANGE (1218141), WHITE GENERAL PURPOSE WASHBASIN IN VITREOUS CHINA, COMPLETE WITH A SINGLE TAP HOLE FOR MONOBLOC FITTINGS, CONCEALED HANGERS, MILLENIA 15mm MONOBLOC MIXER AND 32mm POP-UP WASTE (9124000)	50	32	15	15
U-1	URINAL BOWL: ARMITAGE SHANKS SANURA WALL URINAL IN VITREOUS CHINA COMPRISING MURA AUTO CISTERN IN VITREOUS CHINA COMPLETE WITH FITTINGS-9.0 LITRES CAPACITY (1734296) SANURA 600mm URINAL (2611290), TOP INLET SPREADER (7434441(i)), CONCEALED STEEL HANGERS (7220000), 40mm PLASTICS BOTTLE TRAP WITH 75mm SEAL (7023504), 40mm PLASTICS DOMED WASTE (9056990), DIVISION WITH HANGER AND SCREW (2606000)	50	32	15	-
SH-1	SHOWER TRAY: ARMITAGE SHANKS TREM SHOWERS (L3174), WHITE LINCOLN CAST ACRYLIC SHEET,FULLY REINFORCED, FOUR UPSTANDS, FRONT AND END PANEL AND 1 1/2 IN STRAINER WASTE.COMPLETE WITH TREM SHOWER KIT (EUR18AA), CAVITY SLIDE BAR, SOAP SHELF AND WALL CONNECTION (BV/TV SHOWER KIT FOR BUILT-IN OR EXPOSED SHOWER MIXER) CHROME PLATED	50	40	15	15
RD-1	ROOF DRAIN: GENERAL PURPOSE, 400 MM DIAMETER BODY, FLASHING CLAMP/GRAVEL STOP AND DOME, UNDERDECK CLAMP, SUMP RECEIVER, ALL COMPONENTS OF CAST IRON CONSTRUCTION J.R.SMITH 1010	100	-	-	-
FD-1	FLOOR DRAIN: CAST-IRON BODY WITH ADJUSTABLE ROUND POLISHED NICKEL BRONZE TOP, STRAINER DIAMETER 150 MM VANDAL-PROOF SCREWS, TRAP PRIMER CONNECTION, PROVIDED WITH P-TRAP (J.R.SMITH 2005-A) TRAP PRIMER, CAST BRASS TRAP SEAL PRIMER VALVE WITH AUTOMATIC VACUUM BREAKER J.R.SMITH 2699	50	-	-	-
EWH-1	ELECTRIC WATER HEATER; CORROSION PROOF STEEL CENTRE, ENAMEL STOVE FINISH, ARISTON ENAMEL SERIES ST 50 CAPACITY; 100 LITRES	-	-	15	15
EWH-2	ELECTRIC WATER HEATER (UNDER SINK TYPE), GLASS-LINED TANK WITH POLYURETHANE FOAM INSULATION, STAINLESS STEEL ELEMENT CAPACITY; 15 LITRES	-	-	15	15
EWH-3	INSTANTANEOUS ELECTRIC WATER HEATER COLD WATER FEED, FLOW CONTROL, REMAX MODEL EX95, FLOW RATE: 1.5 GPM (18.3°C RISE)	-	-	15	15
S-1	KITCHEN SINK: 18 GUAGE STAINLESS STEEL, SINGLE DRAINER WITH 40mm WASTE OUTLET AND OVERFLOW HOLE FITTINGS, POLISHED CHROMEPLATED FINISH CONCEALED FAUCET- JUST SI-2467-A-GR J.R.SMITH 1010 BOTTLE TRAP: TWYFORDS WF 8481CP PILLAR TAPS: 15mm HIGH-NECK PILLAR TAPS-TWYFORDS SF 5211 CP	40	50	15	15
H-1	SLOP HOPPER: 18 GUAGE STAINLESS STEEL, WITH BUCKET GRATING AND REMOVABLE SUMP GRID, S-STRAP OUTLET (S32560R) ARMITAGE SHANKS DU-6 LEVER	100	75	15	-
GT-1	GREASE TRAP: INTERCEPTOR GRADE POLYETHYLENE GREASE TRAP HAVING A FLOW RATE OF 7gpm AND GREASE CAPACITY OF 14lbs, SEAMLESS CONSTRUCTION INSTALLATION ABOVE GROUND OR FLUSH TO THE FLOOR, 212°F CONTINUOUS SERVICE WITH POLYETHYLENE COVER SECURED BY STAINLESS STEEL SCREWS, O-RING GASKET AND INLET AND OUTLET FITTINGS OF 50mm, FLOW CONTROL DEVICE AND INTERNAL AIR-RELIEF	50	25	-	-

EQUIPMENT SCHEDULE

SYMBOL	DESCRIPTION	ELECTRICAL
DTP-1	DIESEL TRANSFER PUMP : 3.5L/S AT A HEAD OF 20m MAKE : STORK	1.5kW 230V/1PH/50Hz
CWP-1	COLD WATER PUMP , CAPACITY : 3.04L/S AT 60m HEAD MAKE : PULLEN PUMP , MODEL : HYDROPAK SV8	4.0kW 400V/3PH/50Hz
SP-1	SUMP PUMP : 1.5L/s AT A HEAD OF 9m MAKE : PULLEN PUMP , MODEL : AS 10-2 CB	2.2kW 230V/1PH/50Hz
DST-1	BULK STORAGE DIESEL TANK , CAPACITY :- 45m³ SIZE :- 2.75m Dia x 7.88m LENGHT	-
DT-1	DIESEL OIL DAY TANK CAPACITY— 8m³ SIZE:- 2mLx2mWx2mH	-
WTP-1	WATER TREATMENT PLANT, CAPACITY :- 5m³/hr SIZE:- 5.0mLx1.67mWx2.08mH, SATEC MODEL IRS 84	2.5kW 400V/3PH/50Hz
STP-1	SEWAGE TREATMENT PLANT (GALVANISED STEEL) : SATEC MODEL 50 B 144 SIZE :- 7.0mLx4.95mWx3.05mH, WEIGHT FULL :- 84 TONNES	3.0kW 400V/3PH/50Hz
OWT-1	OVERHEAD WATER STORAGE TANK TYPE :- BRAITHWAITE, CAPACITY :- 40m³ SIZE :- 7.32mLx4.88mWx1.22mH	-
RWT-1	UNDERGROUND CONCRETE WATER TANK, CAPACITY :- 120m³ SIZE :- 9.0mLx8.0mWx1.7mD	-
BH-1	BOREHOLE INCLUDING DRILLING AND CONSTRUCTION COMPLETE WITH SUBMERSIBLE PUMP & PIPE WORK CAPACITY :- 5.0m³/hr. HEAD : - 100m. MAKE:- LOWARA 4GS22T OR APPROVED EQUAL	3.0kW 415V/3PH/50Hz
AE-1	AERATOR SIZE :- 600mmDx2817mmH	-
PSF-1	PRESSURE SAND FILTER: 5m³/hr COMPLETE WITH 2No PRESSURE GUAGE, RELIEF VALVE, AUTOMATIC AIR VALVE AND FILTRATION MEDIA - SAND/GRAVEL OF VARYING GRADES. MAKE:- SATEC MODEL FML 30/L OR APPROVED EQUAL MAXIMUM OPERATING PRESSURE:- 53m MINIMUM OPERATING PRESSURE:- 25m SIZE:- 800mmØ x 2820mmH	-
PSF-2	PRESSURE SAND FILTER : SAME AS PSF-1 BUT FILTRATION MEDIA TO CONSIST OF ACTIVATED CARBON AND VARYING GRADES OF SANDS/GRAVEL. MAKE:- SATEC'S MODEL FML 30/L OR APPROVED EQUAL. MAXIMUM OPERATING PRESSURE:- 53m MINIMUM OPERATING PRESSURE:- 20m SIZE:- 800mmØ x 2820mmH	-
AT-1	STEEL AERATION TANK SIZE:- 5.0mL X 1.872mW X 2.080mH	-
DP-1	DOSING PUMP WITH MIXING DRUM, LEVEL INDICATOR, CHEMICAL (POTASH) AGITATOR AND LOW LEVEL SWITCH CAPACITY :- 15.75L/hr HEAD :- 45m. MAKE :- CHEM-TECH SERIES 150, MODEL:- 100 OR APPROVED EQUAL.	1.1kW 240V/1PH/50Hz
DP-2	DOSING PUMP WITH MIXING DRUM, LEVEL INDICATOR, CHEMICAL (ALUM) AGITATOR AND LOW LEVEL SWITCH CAPACITY :- 15.75L/hr HEAD :- 45m. MAKE :- CHEM-TECH SERIES 150, MODEL:- 100 OR APPROVED EQUAL.	1.1kW 240V/1PH/50Hz
DP-3	DOSING PUMP WITH MIXING DRUM, LEVEL INDICATOR, CHEMICAL (CHLORINE) AGITATOR AND LOW LEVEL SWITCH CAPACITY :- 15.75L/hr HEAD :- 45m. MAKE :- CHEM-TECH SERIES 150, MODEL:- 100 OR APPROVED EQUAL.	1.1kW 240V/1PH/50Hz
TP-1	WATER TRANSFER PUMP CAPACITY :- 5.0m³/hr. HEAD :- 30.0m. MAKE :-PULLEN, MODEL:- KC60L	1.5kW 230V/1PH/50Hz
BP-1	BACKWASH PUMP CAPACITY :- 5.0m³/hr. HEAD :- 30.0m MAKE :-PULLEN, MODEL:- KC60L	1.5kW 230V/1PH/50Hz
AC-1	AIR COMPRESSOR. CAPACITY :- 5.0m³/hr. MAKE: ATLAS COPCO HEAD:- 50m.	1.2kW 230V/1PH/50Hz
DF-1	ELECTRIC HOT/COLD WATER DISPENSER WITH WOODEN RACK AND BOTTLES CAPACITY : 19 LITRES, ASTRAL MODEL 89CH	230V/1PH/50Hz
HD-1	HAND DRIER INFRA-RED SENSOR SYSTEM AND FULLY AUTOMATIC OPERATION MAKE: AIRDRI COMPACT SERIES AIR VOLUME :- 190m³/hr. DRYING TIME : 25 SECONDS	1.5kW 220-240V/1PH/50Hz
TD-1	PROVIDE ALLOWANCE OF 250mmW x 200mm IN GRADE FOR TRENCH DRAIN	-
CWP-2	COLD WATER PUMP COMPLETE WITH PRESSURE VESSEL CAPACITY :- 2.0L/S HEAD :- 10.0m MAKE :-PULLEN KC 40L	1.1kW 230V/1PH/50Hz

Table2. Typical Equipment Schedule-HVAC

AIR HANDLING UNIT SCHEDULE

FAN SECTION												COOLING COIL									HOT DECK/ REHEAT COIL KW	SUPPLY AIR DISCHARGE	FILTER SECTION	OUTSIDE AIR (L/S)	UNIT SIZE USED IN DESIGN CARRIER MODEL	MAX. UNIT WEIGHT. KG	REMARKS
MARK	AIR FLOW L/S	TSP KPa	RPM	WHEEL	FAN POWER KW	MOTOR				AIR SIDE								ROWS NO.	FIN MAX (F/IN)	COIL FACE VEL. (m/s)							
				TYPE		KW	V	ø	HZ	SENS. KW	TOTAL KW	L/S	E.A.T. DB °C	E.A.T. WB °C	L.A.T. DB °C	L.A.T. WB °C	MAX P.D. KPa										
AHU−1	6654	1.55	1696	AIR FOIL	16.5	24	460	3	60	143.8	213.8	6654	31.5	22.8	13.29	13.20	0.282	8	14	2.4	−−	VERTICAL	FLAT AND BAG CARTRIDGE	1500	39T32	−−	VERTICAL DRAW THRU UNIT

EQUIPMENT SCHEDULE

SYMBOL	DESCRIPTION	ELECTRICAL
CDU−1	PACKAGED OUTDOOR AIRCOOLED CONDENSING UNIT 274KW COOLING CAPACITY AT 10°C AND 35°C OUTDOOR TEMPERATURE. UNIT TO HAVE MINIMUM (2) COMPRESSORS 6−STEP CONTROL. REDUCED VOLTAGE STARTING TYPE COMPRESSOR MOTOR. WEIGHT : 1729KG UNIT MODEL: CARRIER TYPE 38AH074	89.3kW 460V/3PH/60HZ
SU−TI CU−TI	FLOOR MOUNTED INDOOR SPLIT UNIT AIRCONDITIONER COOLING CAPACITY: 3.30KW WEIGHT: 18KG UNIT MODEL: CARRIER 42VRC012 OUTDOOR CONDENSING UNIT WEIGHT: 41KG UNIT MODEL: CARRIER 38CH−012	1.2kW 230V/1PH/60HZ

DIFFUSER, REGISTER AND GRILLE SCHEDULE

SYMBOL	TYPE	FACE	FRAME	DAMPER	FINISH	MODEL NO.	REMARKS
CD−1	CEILING DIFFUSER	LOUVERED	T−BAR	NONE	WHITE	TITUS TDC−AA	600x600 SURFACE MOUNTED TYPE WITH UNIFORM FACE APPEARANCE
CRG−1	CEILING RETURN GRILLE	LOUVERED	T−BAR	NONE	WHITE	TITUS TDC−AA	600x600 SURFACE MOUNTED TYPE WITH UNIFORM FACE APPEARANCE
CEG−1	CEILING EXHAUST GRILLE	LOUVERED	T−BAR	NONE	WHITE	TITUS TDC−AA	600x600 SURFACE MOUNTED TYPE WITH UNIFORM FACE APPEARANCE
SR−1	SIDE WALL SUPPLY GRILLE	DOUBLE DEFLECTION	32mm BORDER	NONE	WHITE	TITUS 272FS	ALUMINIUM CONSTRUCTION
RG−1	SIDE WALL RETURN GRILLE	FIXED BAR 0° DEFLECTION	32mm BORDER	NONE	WHITE	TITUS 3FL	ALUMINIUM CONSTRUCTION
EL−1	EXTENAL AIR LOUVRE	SURFACE MOUNTED	32mm BORDER	NONE	WHITE	TITUS 350FL	FIXED DEFLECTION ALUMINUM CONSTRUCTION

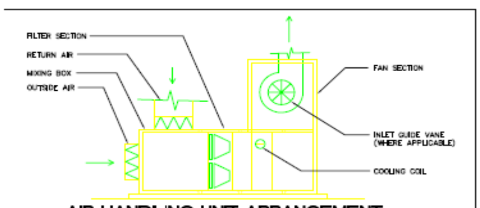
EXHAUST FAN SCHEDULE

SYMBOL	SERVICE	L/S	T.S.P. KPa	FAN POWER KW	MOTOR 60 HZ VOLTS	MOTOR 60 HZ PHASE	MAX. SONES AT 1.5 METRE	TYPE	REMARKS
EF−1	TOILETS	733	0.10	0.830	230	1	5.5	CEILING MOUNTED EXTRACT FAN	GREENHECK MODEL CSP−265
EF−2	TOILETS	498	0.10	0.455	230	1	5.5	CEILING MOUNTED EXTRACT FAN	GREENHECK MODEL CSP−262
EF−3	TOILET CONTROL TOWER	120	0.1	0.129	230	1	5.5	CEILING MOUNTED EXTRACT FAN	XPELIR MODEL XDFAS−200

VAV TERMINAL UNIT SCHEDULE

SYMBOL	AREA SERVED	L/S MAX	MIN INLET STATIC PRESSURE LOSS Pa	MAX. Nc AT ΔSP = 250Pa
VB−1.1	HELICOP.HALL 017, DISPATCHER 018, SNACKS 014	1412	50	33
VB−1.2	CREW RM 008, OFFICE 006, 005, CORR.014, KIT.013 TOILETS 016, 010, 015, 011, TELECOMS ROOM 037	1012	50	31
VB−1.3	DEPART. CON.003, CHECK−IN−AREA	983	50	31
VB−1.4	BAGGAGE DISPATCH 019	389	50	31
VB−1.5	FIXED WING DEPT. HALL 021, SNACKS 023	899	50	31
VB−1.6	AIRPORT DIRECT.020, OFFICE 024, CREW RM. 029, V.I.P 030 IMMIGRAT. 031, CORR. 032, TOILETS 025, 026, 027, 028	1068	50	31
VB−1.7	FIXED WING ARRIV.HALL 022, PROCESS 032, EXIT 034	984	50	31

NOTES
1. ΔSP IS STATIC PRESSURE DIFFERENCE FROM INLET TO DISCHARGE
2. UNIT MODEL : CARRIER MODEL 35DA
3. ALL TERMINAL UNITS TO BE EQUIPPED WITH ANALOG ELECTRONIC CONTROLS, SPACE TEMPERATURE SENSOR / THERMOSTAT AND CONTROL TRANSFORMER.



AIR HANDLING UNIT ARRANGEMENT
NO SCALE

2.1 Cold water and supply systems

Water piping systems to distribute potable water throughout the building from source (borehole), treatment plant and storage tanks.

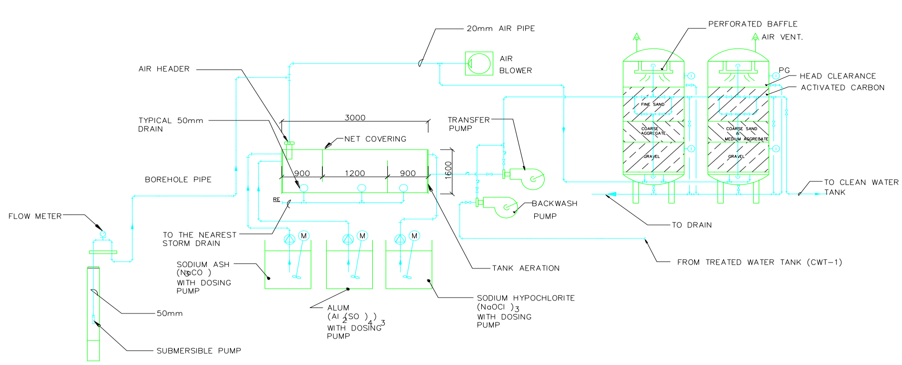


Figure 2. Water treatment plant

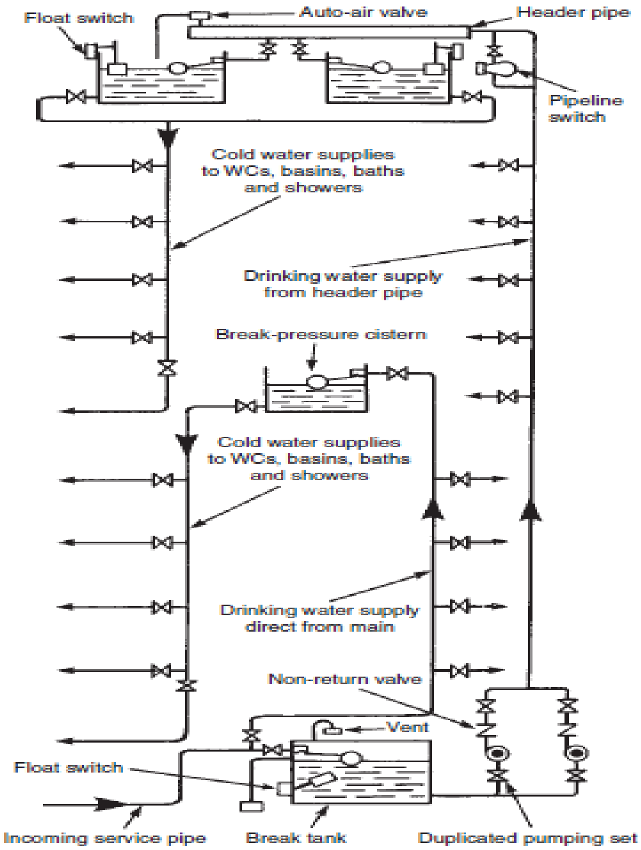


Figure 3. Typical Boosted Cold Water System (Greeno and Hall, 2009)

2.2 Hot Water Supply Systems

Hot water from water heater is connected to the hot water fixtures in the domestic building, kitchen, laboratory, laundry and so on. The water heater may be wall hung water heater, calorifier and boiler. Energy source may be electrical, gas, liquid or solid fuels depending on the application and the magnitude of the project.

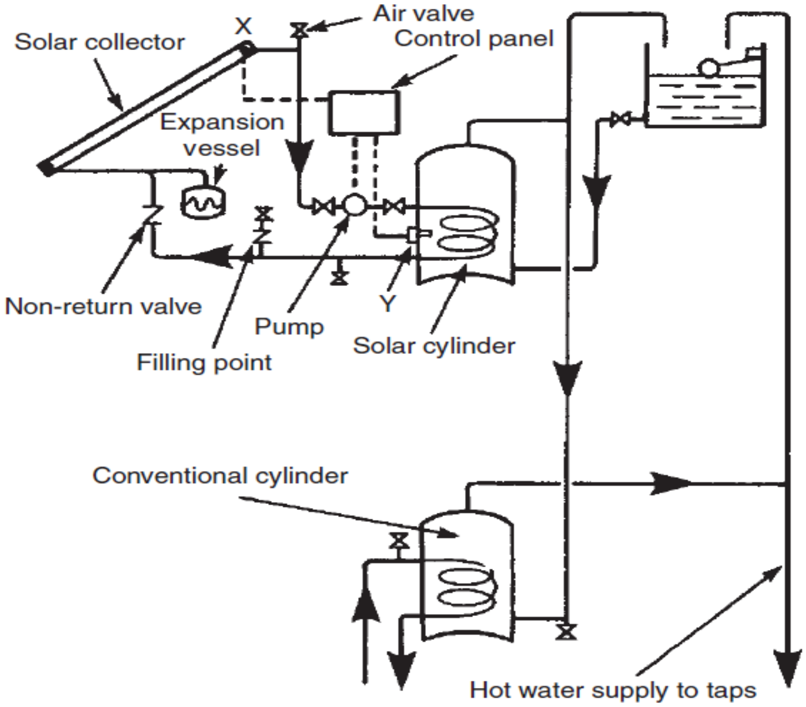


Figure 4. Typical Hot Water System with integral solar collected (Greeno and Hall, 2009)

2.3 Heating systems

Heating systems for human comfort is less desire in the tropical region and hence will not be given adequate attention. However, heat energy sources may be electrical, gas, liquid, solid fuels or heat pump.

2.4 Fuel Supply Systems

The system involves piping, pump and fuel storage tank to the point of use. Point of use may be power generator, calorifier, boiler et cetera.

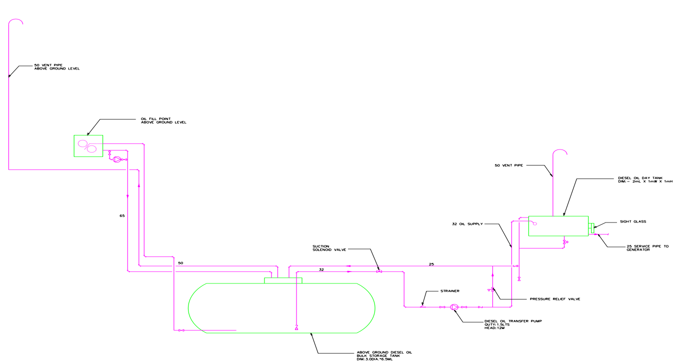


Figure 5. Fuel storage

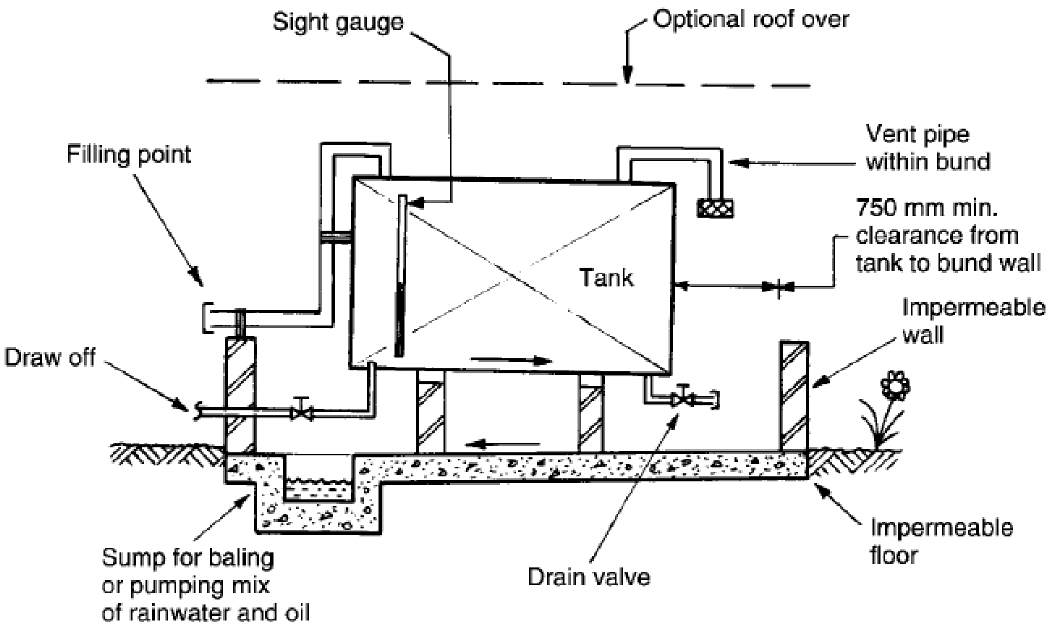


Figure 6. Oil Tank in bund wall

2.5 Ventilation Systems

Ventilation system is an integral part of air conditioning. It is the removal of unwanted or spent air from occupied zone. Some ventilation systems address safety issue during fire outbreak in high rise buildings.

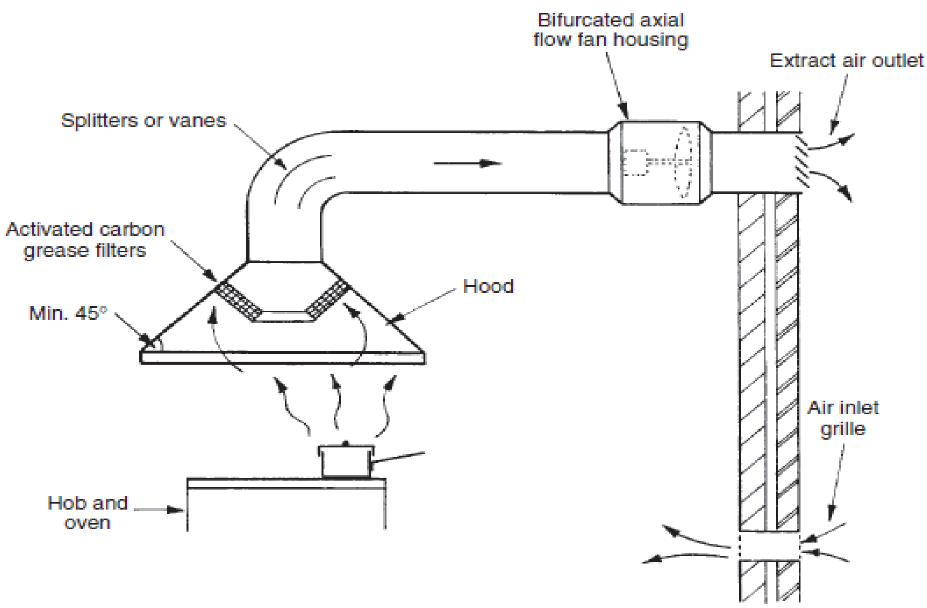


Figure 7. Typical ventilation application

Table 3. Air changes rate for room/building/accommodation (Greeno and Hall, 2009)

Room/building/accommodation	Air changes per hour
Assembly/entrance halls	3–6
Bathrooms (public)	6*
Boiler plant rooms	10–30†
Canteens	8–12
Cinema/theatre	6–10
Classrooms	3–4
Dance halls	10–12
Dining hall/restaurants	10–15
Domestic habitable rooms	approx. 1*
Factories/garages/industrial units	6–10
Factories – fabric processing	10–20
Factories (open plan/spacious)	1–4
Factories with unhealthy fumes	20–30
Foundries	10–15
Hospital wards	6–10
Hospital operating theatres	10–20
Kitchens (commercial)	20–60*
Laboratories	6–12
Laundries	10–15
Lavatories (public)	6–12*
Libraries	2–4
Lobbies/corridors	3–4
Offices	2–6
Smoking rooms	10–15
Warehousing	1–2

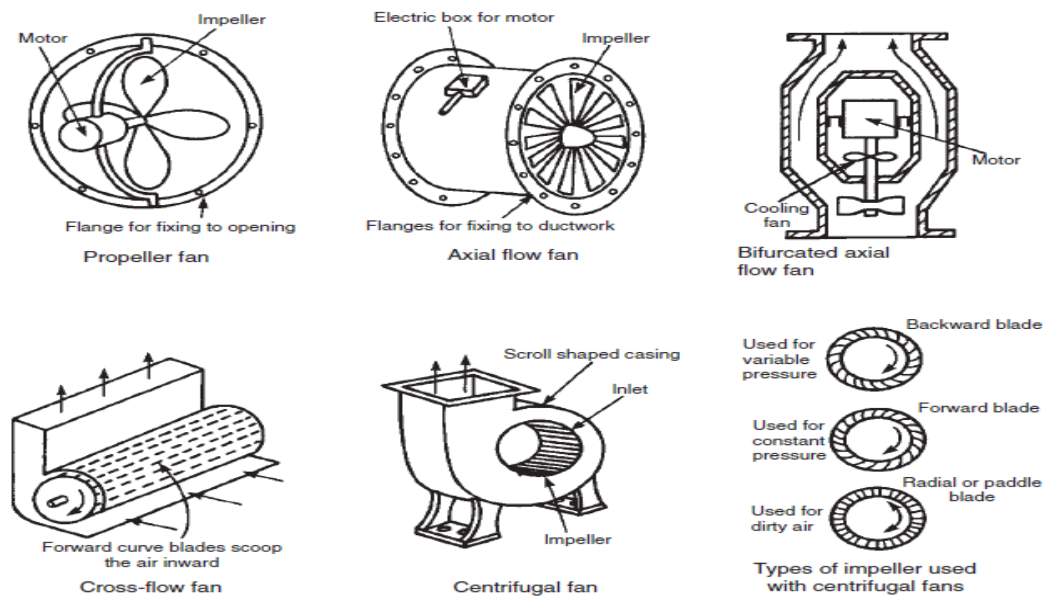


Figure 8. Types of fan

2.6 Air Conditioning

Air conditioning equipment are used to enhance the air quality, quantity and characteristics for human comfort. For buildings with human occupancy, the design specification is likely to include an internal air temperature of 19 – 23 ^{0}C and relative humidity between 40 and 60%.

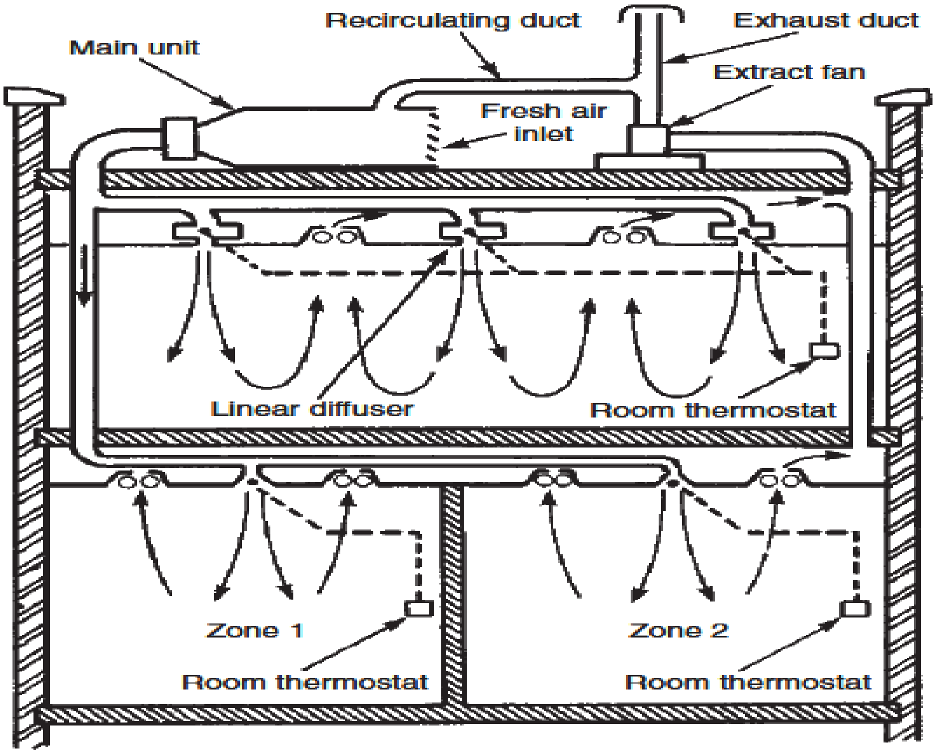


Figure 9. Typical (Air Conditioning) layout of variable air volume system

2.7 Drainage Systems, Sewage Treatment and Refuse Disposal

Drainage systems are the piping network conveying liquid sewer from sanitary appliances to the point of sewage treatment. Sewage treatment, depending on the magnitude of the generated sewer might be kept simple as in septic tank and soak away pit or elaborate treatment plant. Solid wastes in high rise buildings are conveyed to the ground or basement floor through the refuse chute.

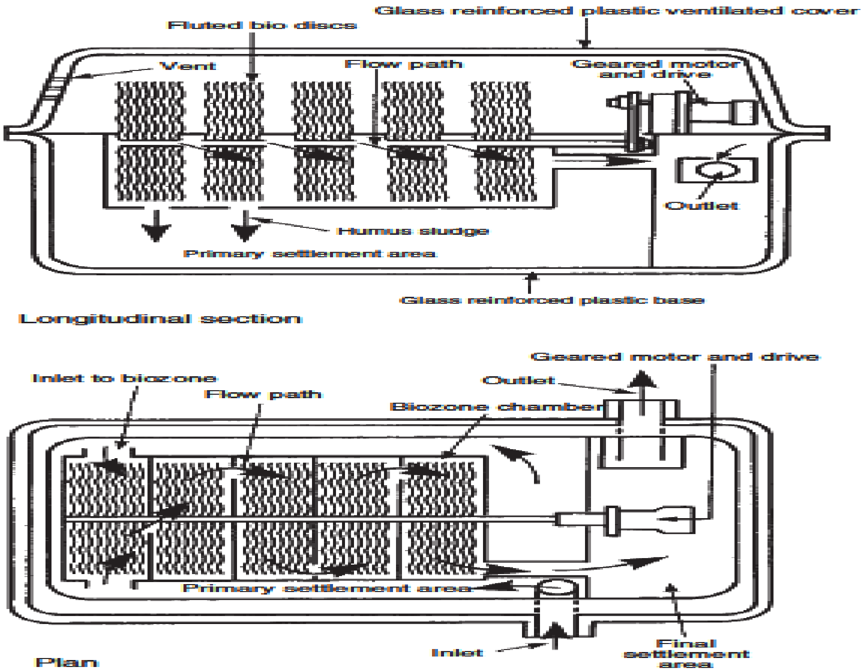


Figure 10. Biodisc sewage treatment plant

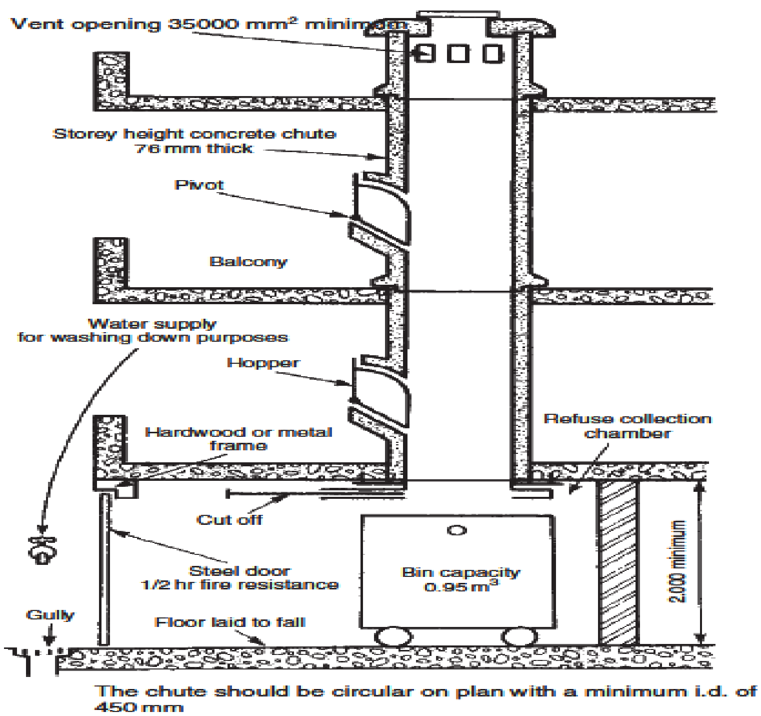


Figure 11. Refuse chute

2.8 Sanitary Appliances: Discharge and Waste Systems

Sanitary appliances have transformed from pure mechanical appliances to mechanical, electrical and electronic fixtures. For example, Jacuzzi is a glorified bath tub which is now not only bigger, but now has inbuilt pumps, electric heater, water filter, water spray nozzles and electronic controls.

WC	7	discharge units
Shower	1	discharge unit
Basins	2	discharge units
Sinks	12	discharge units
Group	14	discharge units
Washing machine	4	discharge units
Dishwasher	4	discharge units

Total = 44 discharge units × 500 dwellings = 22000 discharge units.

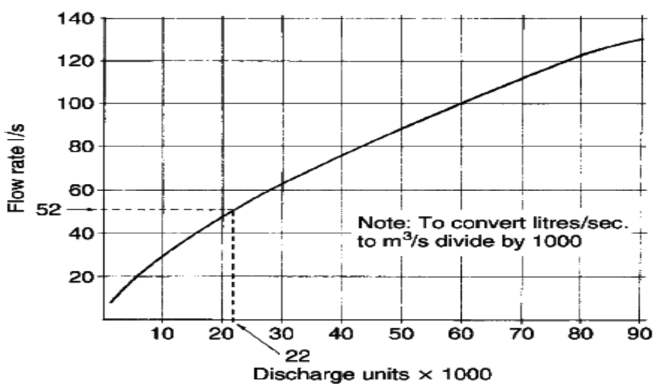


Figure 12. Calculation of drainage flow rate

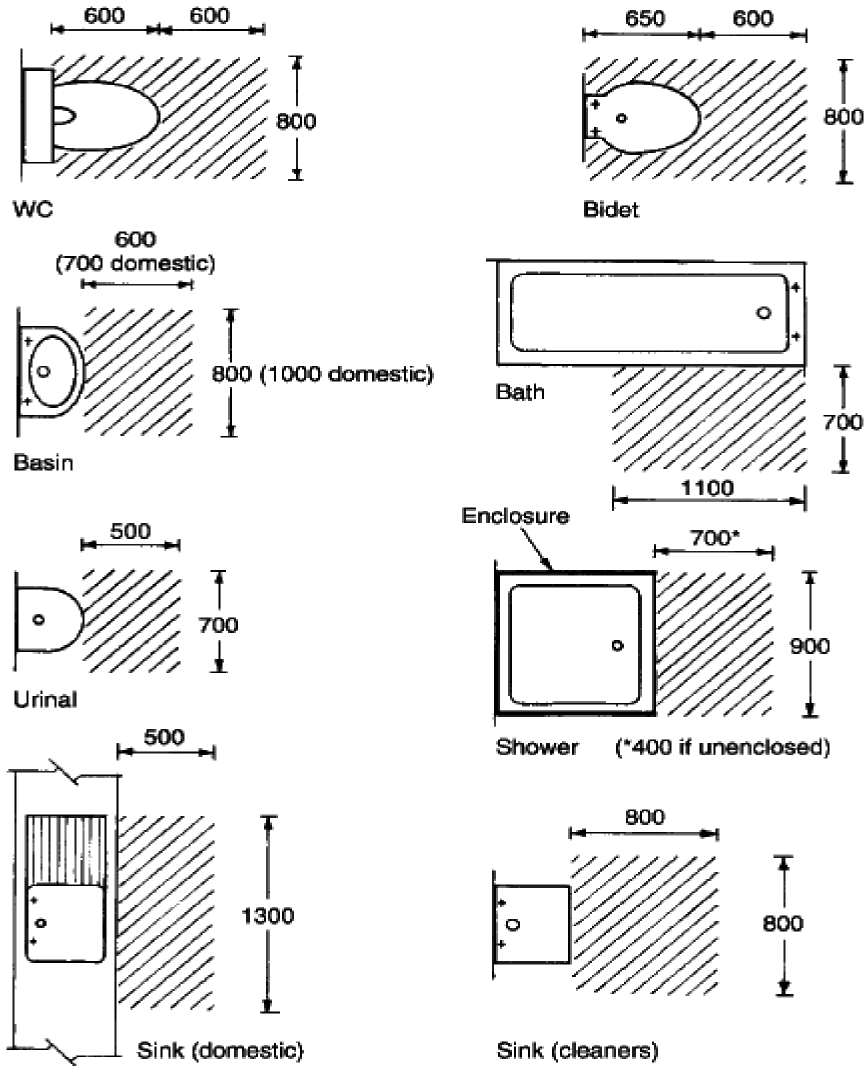


Figure 13. Typical activity spaces (mm) for plumbing fixtures

2.9 Gas Supply and Installation

Gas are stored under high pressure in pressure vessel and piped to point of use in the kitchen, laboratory, workshop or other applications.

2.10 Electrical Supply and Installations

This installation includes electricity distribution, power and lighting circuits, earthing system, light sources, lamps and luminaires and extral-low-voltage and telecommunications installation.

Table 4. Minimum provision of power sockets in domestic accommodation

Location	Minimum quantity of sockets
Living rooms	8
Kitchen	6
Master bedroom	6
Dining room	4
Study bedroom	4
Utility room	4
Single bedrooms	4
Hall and landing	2
Garage/workshop	2
Bathroom	1 – double insulated shaver socket

Maximum appliance load (watts) and plug cartridge fuse (BS 1362) selection for 230 volt supply:

Maximum load (W)	Plug fuse rating (amp)
230	1
460	2
690	3
1150	5
1610	7
2300	10
2900	13

Calculated from: Watts = Amps × Voltage.

Table 5. Examples of illumination levels and limiting glare indices for different activities:

Activity/location	Illuminance (lux)	Limiting glare index
Assembly work: (general)	250	25
(fine)	1000	22
Computer room	300	16
House	50 to 300*	n/a
Laboratory	500	16
Lecture/classroom	300	16
Offices: (general)	500	19
(drawing)	750	16
Public house bar	150	22
Shops/supermarkets	500	22
Restaurant	100	22

*Varies from 50 in bedrooms to 300 in kitchen and study.

2.11 Mechanical Conveyors- Lifts, Escalators and Travelators

To transport men, goods and food in the building, passenger lift, good lift, escalator, travelator and cleaning cradle are used.

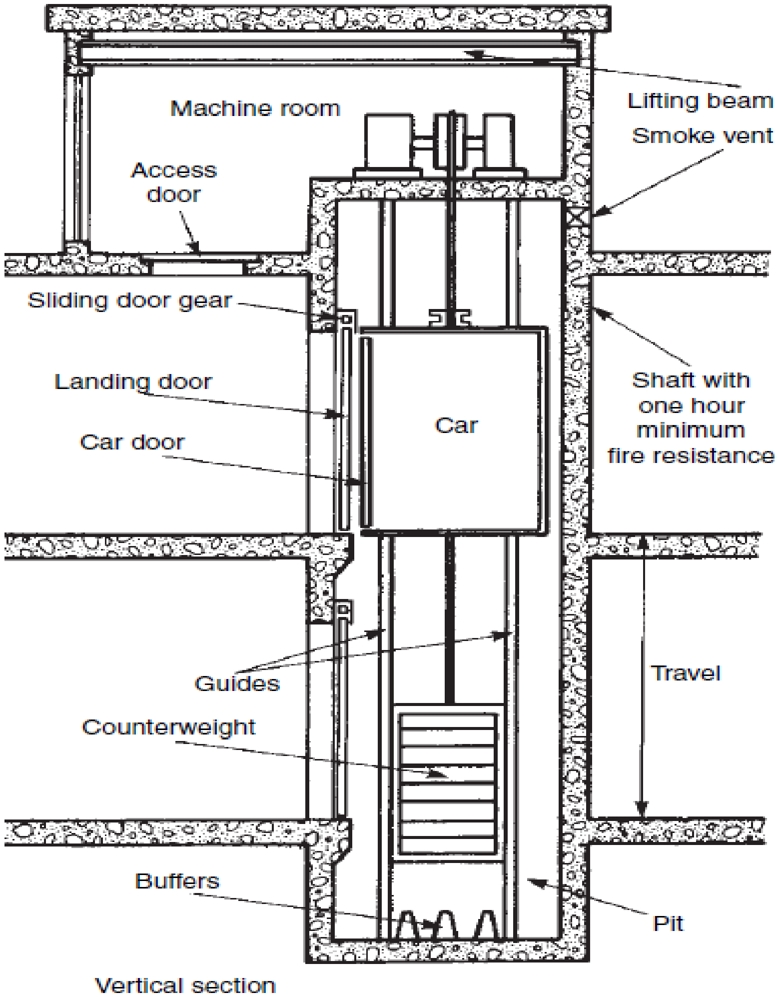


Figure 14. 2Electric Lift Installation

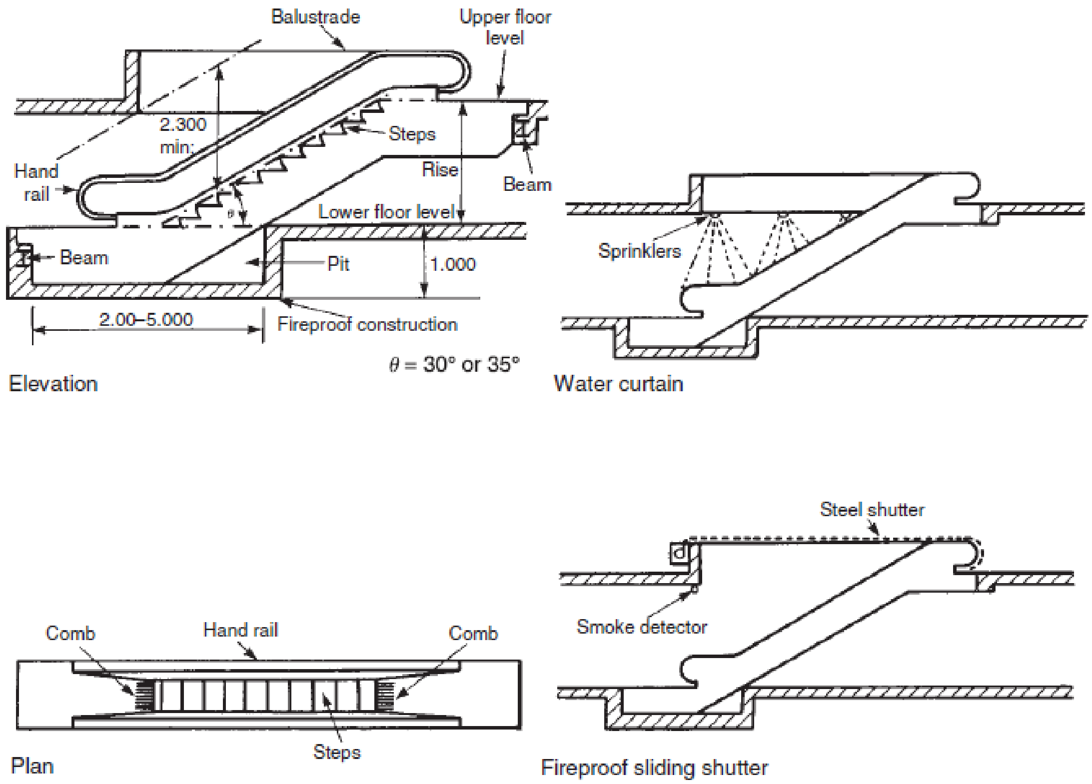


Figure15. Escalator

2.12 Fire Protection Systems

These are systems used to prevent, detect or fight fire outbreak. They include but not limited to fire hose reel, fire hydrant, automatic fire sprinkler systems, portable fire extinguishers, FM200 system, form installations, smoke, fire and heat detectors, fire alarms and fire pumps.

Fire outbreaks result in deaths, more injuries and loss of valuable properties. About a
tenth of all fires occur in homes resulting in deaths and injuries. An early warning device to detect smoke and fire could significantly reduce the number of human casualties. There smoke, heat, light obscuring and radiation detecting devices.

Smoke detectors are available in two basic types. Each can be powered by a simple battery cell or by mains electricity. The latter will normally have battery backup if the mains supply fails.

● Ionisation: an inexpensive device, sensitive to tiny smoke particles and fast burning fires such as a flaming chip pan.

● Light scattering or optical: this is more expensive but more sensitive in slow burning and smouldering fire produced by burning fabrics or upholstery and overheating PVC wiring.

● Combined: a unit containing both ionisation and optical detection.

Heat detectors are used where smoking is permitted and in other
situations where a smoke detector could be inadvertently actuated by process work in the building, e.g. a factory. Heat detectors are designed
to identify a fire in its more advanced stage, so their response time is longer than smoke detectors.
*Fusible type: has an alloy sensor with a thin walled casing fitted with heat collecting fins at its lower end. An electrical conductor passes through the centre. The casing has a fusible alloy lining and this functions as a second conductor. Heat melts the lining at a pre-determined temperature causing it to contact the central conductor and complete an alarm relay electrical circuit.
Bi-metallic coil type: heat passes through the cover to the bi-metal coils. Initially the lower coil receives greater heat than the upper coil. The lower coil responds by making contact with the upper coil to complete an electrical alarm circuit.

Light obscuring: a beam of light is projected across the protected area close to the ceiling. The light falls onto a photo-electric cell which produces a small electrical current for amplification and application to an alarm circuit. Smoke rising from a fire passes through the light beam to obscure and interrupt the amount of light falling on the photo-electric cell. The flow of electric current from the cell reduces sufficiently to activate an alarm relay.
A variation is the light-scatter type. In normal use the light is widely dispersed and no light reaches the photo-electric cell receptor. In the presence of smoke, particulates deflect light on to the receptor to energize the cell.

Laser beam: a band of light which can be visible or infra-red projected onto a photo-electric cell. It does not fan out or diffuse as it travels through an uninterrupted atmosphere. The beam can operate effectively at distances up to 100 m. If a fire occurs, smoke and heat rises and the pulsating beam is deflected away from the cell or reduced in intensity. As the cell is de-energised, this effects on alarm relay.

In addition to producing hot gases, fire also releases **radiant** energy in the form of visible light, infra-red and ultra-violet radiation. Radiant energy travels in waves from the fire.
Infra-red detector : detectors have a selective filter and lens to allow only infra-red radiation to fall on a photo-electric cell. Flames have a distinctive flicker, normally in the range of 4 to 15 Hz. The filter is used to exclude signals outside of this range. The amplifier is used to increase the current from the photo-electric cell. To reduce false alarms, a timing device operates the alarm a few seconds after the outbreak of fire.

Ultra-violet detector: these detectors have a gas-filled bulb which reacts with ultra-violet radiation. When the bulb receives radiant energy, the gas is ionised to produce an electric current. When this current exceeds the set point of the amplifier the alarm circuit closes to operate the alarm system.

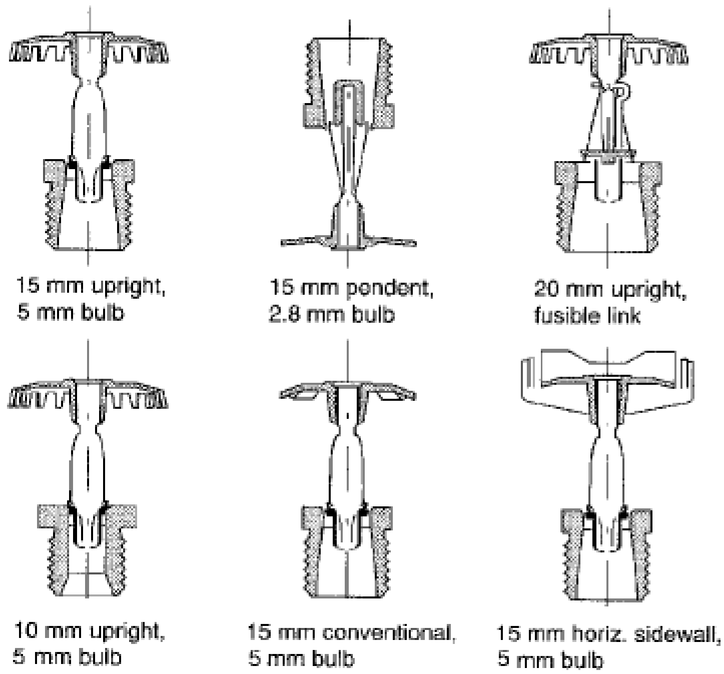


Figure16. Typical sprinklers (Knight and Jones, 2004)

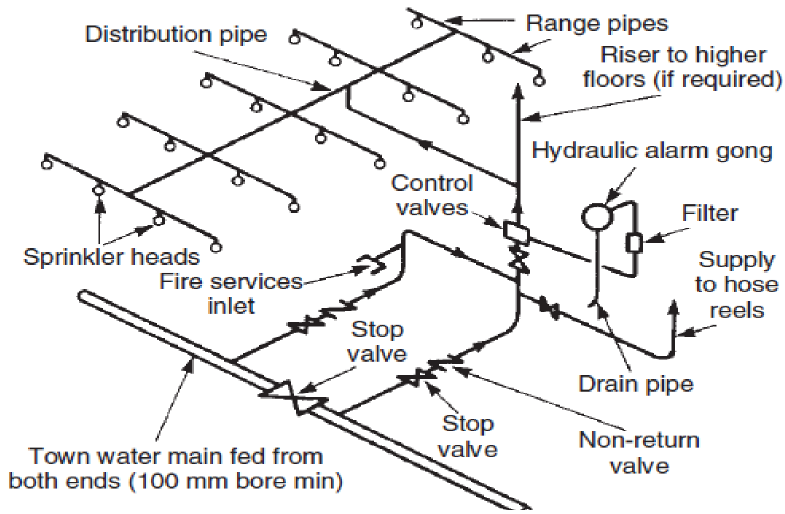


Figure 37. Wet Sprinkler Installation

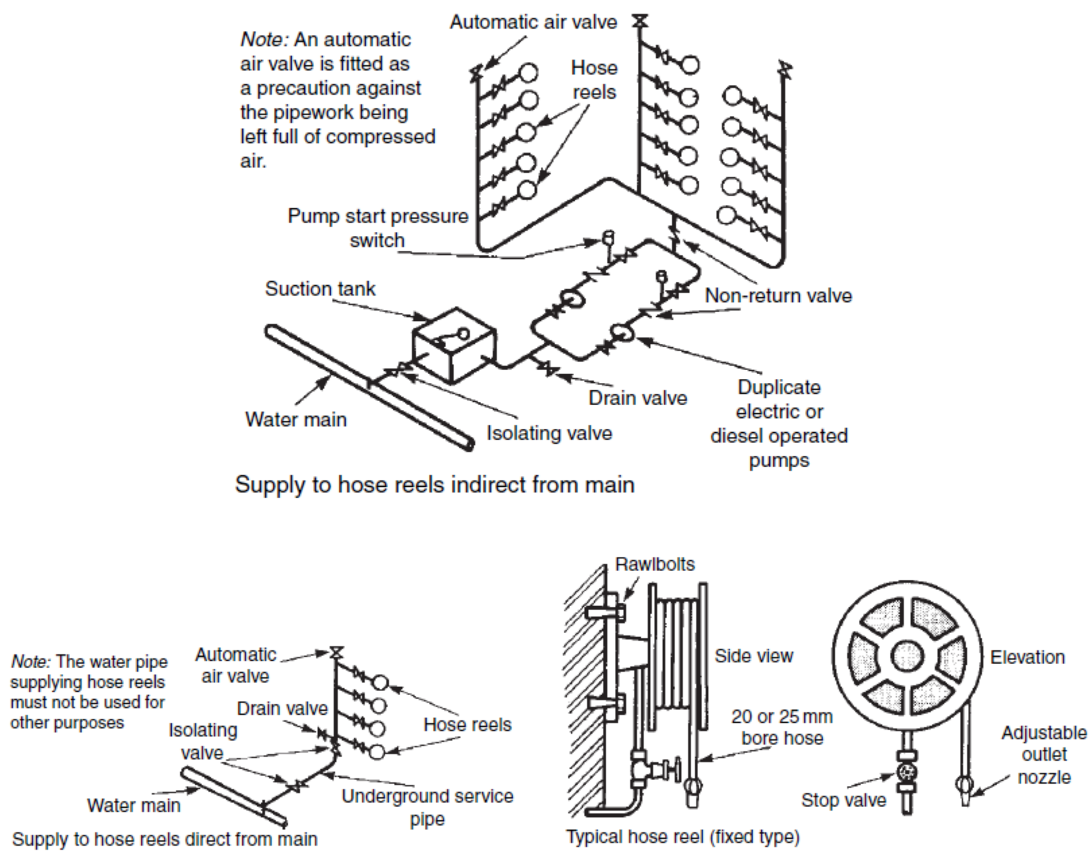


Figure 48. Hose Reel Installations

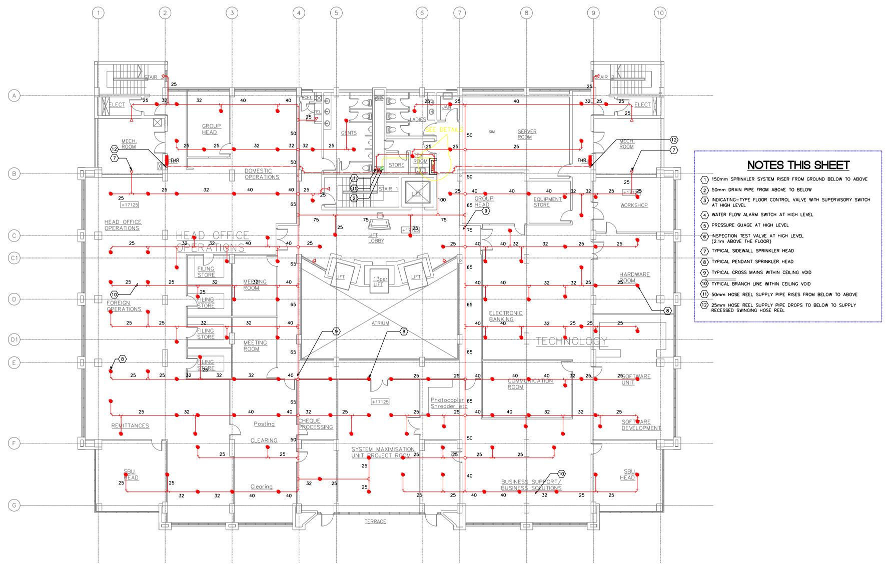


Figure 19. Sprinkler and Hose Reel System

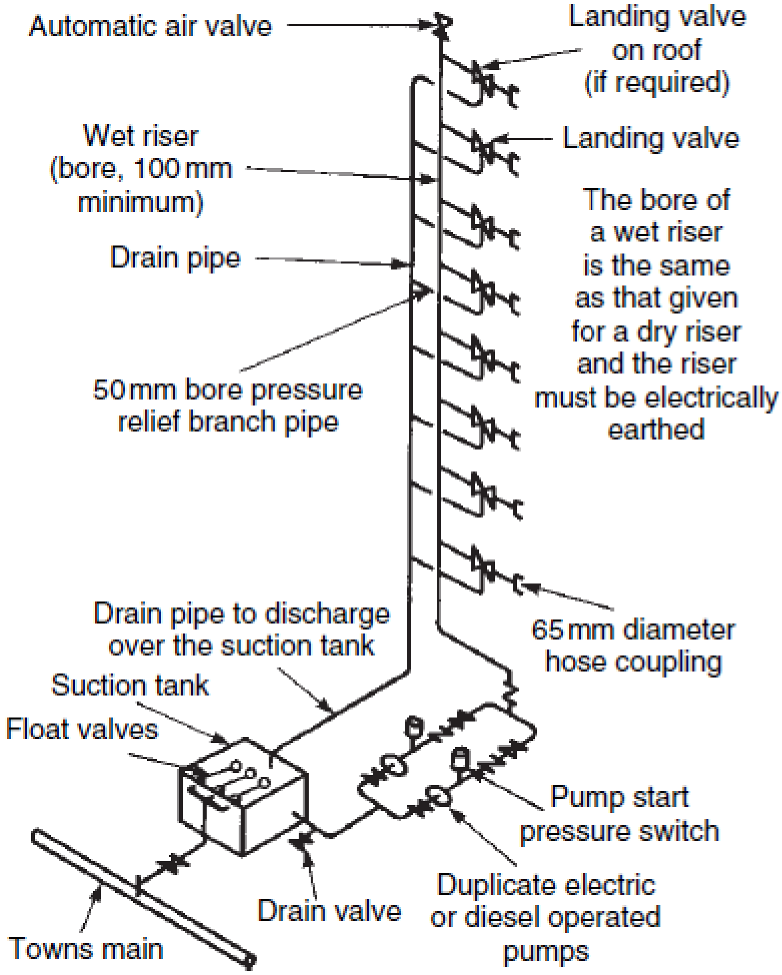


Figure 50. Typical arrangement of a wet riser

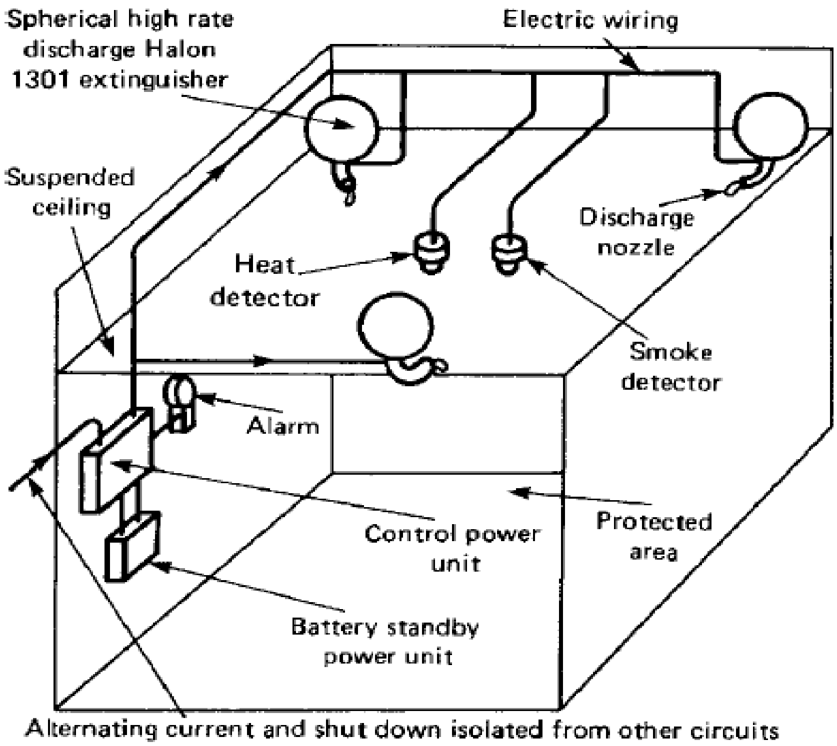


Figure 21.6 Gas Extinguishing Systems

2.13 Security Installations

Security installation includes access control devices (reader in- reader out), CCTV, intruder alarms, infra-red detectors, lightning protection fittings et cetera.

Intruder alarms have developed from a very limited specialist element of electrical installation work in high security buildings to the much wider market of schools, shops, offices, housing, etc. This is largely a result of the economics of sophisticated technology surpassing the efficiency of manual security. It is also a response to the increase in burglaries at a domestic level. Alarm components are an alarm bell or siren activated through a programmer from switches or activators.

Power is from mains electricity with a battery back-up. Extended links can also be established with the local police, a security company and the facility manager's central control by telecommunication connection.

Selection of switches to effect the alarm will depend on the building purpose, the extent of security specified, the building location and the construction features. Popular applications include:

- Micro-switch
- Magnetic reed
- Radio sensor
- Pressure mat
- Taut wiring
- Window strip
- Acoustic detector
- Vibration, impact or inertia detector

The alternative, which may also be integrated with switch systems, is space protection. This category of detectors includes:

- Ultrasonic
- Microwave
- Active infra-red
- Passive infra-red

2.14 Accommodation for Building Services

Building services are the dynamics of the building hence pathway must be provided and concealed from the occupant and general public as much as possible.

These are medium and large horizontal ducts, floor and skirting ducts, raised access floors, suspended and false ceilings, and subways.

Major equipment like power generator, air conditioning plant, water pump et cetera are kept in the plant room.

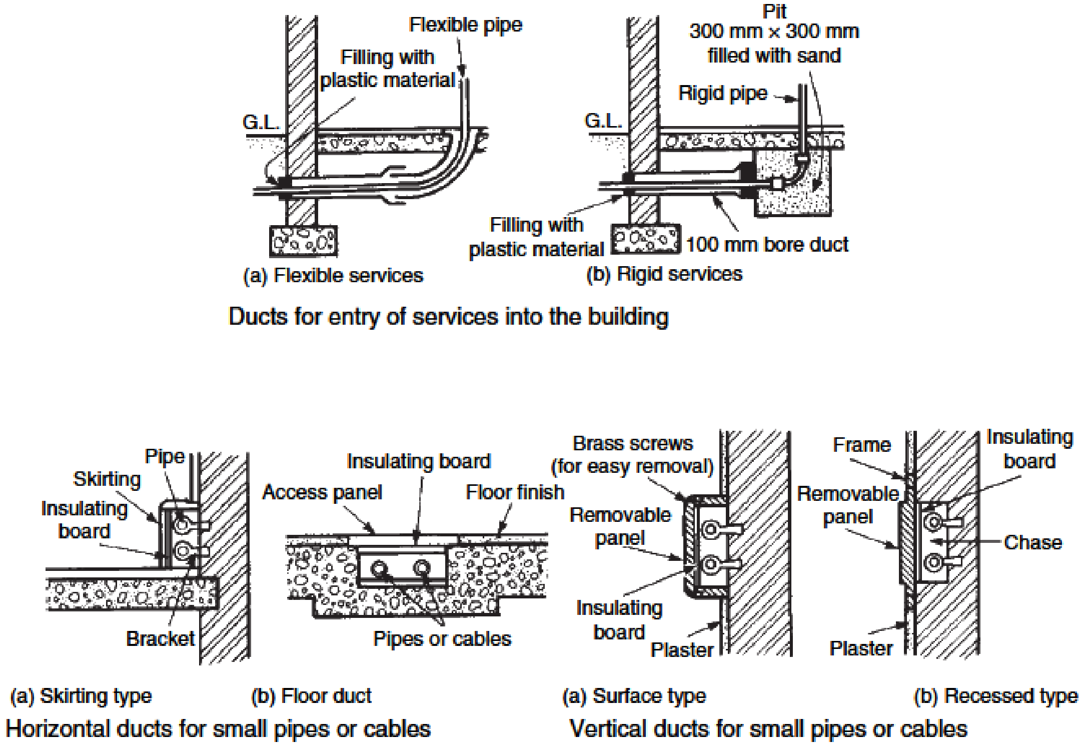


Figure 72. Sleeves, horizontal and vertical ducts for pipes or cables

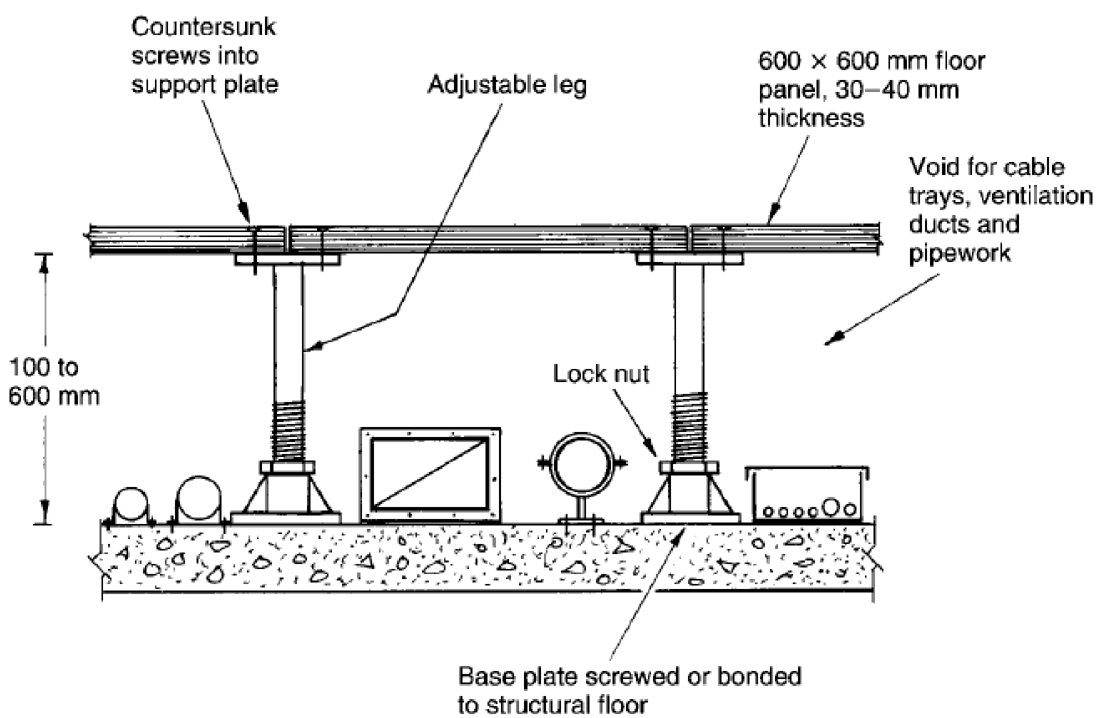


Figure 83. Raised accessed floor

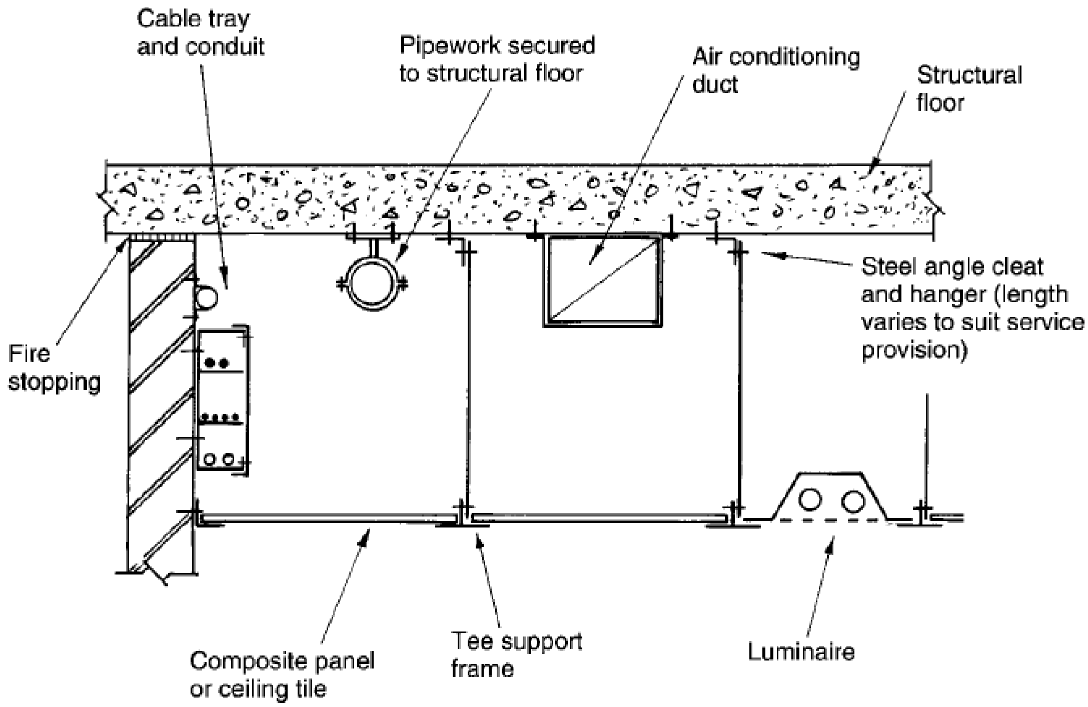


Figure 94. Typical suspended ceiling

3.0 Alternative and Renewable Energy

There quite a number of alternative and renewable energy sources such as wind, fuel cells, water power, geothermal, solar power, photovoltaic and biomass/biofuel.

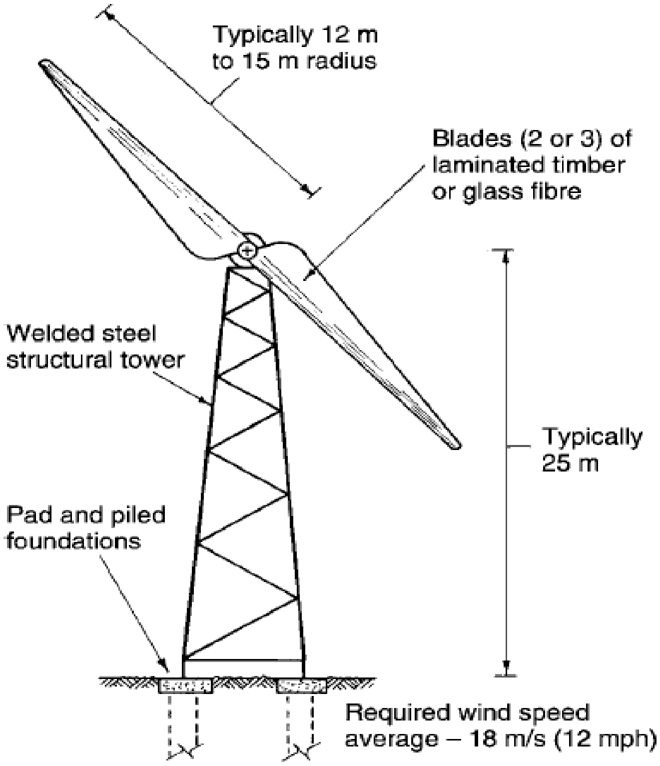


Figure 25. Wind power generator

Solar Pond (Babalola,2009):

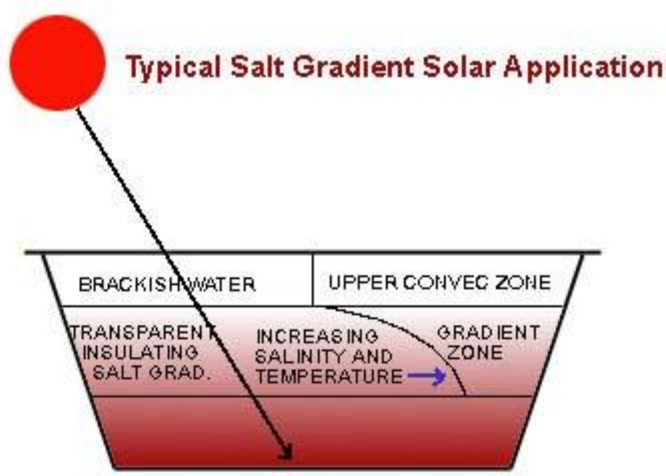


Figure 26. Generic solar pond showing density and temperature gradient

Due to diffusion (though very small indeed) of salt upwards from the higher to lower concentration, the salt gradient will be affected gradually. The rate of movement of salt flux upwards q_s is given by:

$$q_s = vs - k_s \frac{\partial s}{\partial z}$$

where k_s is the coefficient of salt diffusivity, v is the velocity, s is salt concentration and z is depth. Thus, if water is removed from the bottom of the pond to give v a value

$$v = \frac{1}{s}\left(k_s \frac{\partial s}{\partial z}\right)$$

then $q_s = 0$ and salt remain stationary in space. This is known as 'falling pond' concept (19). A flow system to carefully add salt to the bottom at the top had been developed.

Some recent ponds used salt (e.g. borax or potassium nitrate) which exhibits a high increase in solubility with increase in temperature. The pond is filled with a saturated solution with left over at the bottom. When the pond is heated up, more salt goes into solution and convection does not occur. Even some are with transparent membranes that separate the layers. This pond does not even need salt at all.

Generally, inexpensive layer of transparent plastic over the water will suppress heat loss to the environment.

Solar radiation incident upon a horizontal surface of the earth is a function of latitude, the day of the year, the time of the day and the atmospheric conditions. The energy is received as both direct and diffuse radiation and is distributed over the spectrum in the ultraviolet, visible, and infrared.
Fraction of the radiation reaching the surface of the pond will be reflected and the remainder that penetrate the pond result in thermal energy. This fraction in a day can be calculated from the following equations which are obtained from Fresnel's equation (22):

$$E = 2n(a^2 + b^2)\cos i \cos r$$

$$a = 1/(\cos r + n \cos i)$$

$$b = (\cos i + n \cos r)$$

where E is the ratio of radiation penetrating the water surface and incident upon a horizontal plane just below the surface to the radiation incident upon a horizontal plane above the water surface and incident upon a horizontal plane just below the surface to the radiation incident upon a horizontal plane above the water surface; i = the angle made by the incident radiation with the normal (solar zenith distance); n = indexes of refraction of the salt-water solution at the surface (≈1.33 for very dilute solution); and r = the angle made by the refracted ray with the normal.

From Snell's law: $\sin i = n \sin r$

Fraction of diffuse radiation $2\int_0^{\pi} E \cos i \sin i \, \partial i$

The solar zenith distance can be measured or calculated by

$$\cos i = \cos \emptyset \cos \delta \sin 2\pi (t-6)/24 + \sin \emptyset \sin \delta$$

t = time in hours (noon =12)

Ø = declination of the sun ≈

$\delta \sin 2\pi D/365.25$
δ_0 = declination of the sun at equinox

= 23 degree, 27 minutes

D = number of days

From Bonguer's law, transmitted radiation

$$q_\lambda^t = q_\lambda^i e^{-\alpha Z}$$

Where q_λ^i is the intensity of the incident radiation of wavelength λ

α_λ is spectral absorption coefficient

z is the thickness of homogeneous absorber.

Therefore, the spectral transmittance is

$$\tau_\lambda = q_\lambda^t / q_\lambda^i = e^{-\alpha_\lambda Z}$$

and the spectral absorption coefficient is expressed by

$$\alpha_\lambda = \left(\frac{1}{s}\right) \ln \tau_\lambda$$

The heat transfer processes in the solar pond is governed by one-dimensional time-dependent heat conduction equation

$$\frac{\partial T}{\partial t}\rho c = \frac{\partial (K \frac{\partial T}{\partial z})}{\partial z} + q - q_s$$

in which ρ is the fluid density; c is specific heat of fluid; T is temperature; t is time; z is vertical coordinate; K is coefficient of heat diffusion; q is source of thermal energy and q_s is removal rate of thermal energy. A complete treatment is of course complex because of the large number of variables involved.

According to Hull , the thermal efficiency of solar pond is

$$= \alpha\tau = \frac{K\Delta T}{Z_{NCZ} H_S}$$

where ΔT is the temperature difference across the NCZ and H_S is the surface insolation.

Various methods are employed to extract heat energy from the pond. This may be done by applying heat-exchanger equations:

$$q = m_c C_{pc} (T_{co} - T_{ci}) \qquad (1)$$

$$q = m_h C_{ph} (T_{hi} - T_{ho}) \qquad (2)$$

$$q = UA \Delta_c T_{LM} \qquad (3)$$

subscripts c, h refer to cold and hot fluid,

i, o denote inlet and outlet

Another way is the use of hydrodynamic layer flow principle where by the hot fluid is removed at one end into a heat-exchanger external to the pond and then returns the solution to the other end of the pond.

Some applications of solar ponds are for heating and cooling of buildings, and power production.

Heat energy stored in the pond may be used for space heating during the harmattan season. The heat energy is transferred into Air Handling Unit (AHU) containing heat exchanger coil and fan that blows heated air into the space. This arrangement can be incorporated into office complex and estate in the future. Also, hot water can be extracted from the pond for domestic or industrial needs. A typical application is heating of greenhouse in U.S.A.

Cooling can be achieved by absorption refrigeration system with generator heated with solar pond. The chiller side of the refrigerator will then be part of A.H.U.

With suitable fluid (Freons) and two heat exchangers-one on the upper cold water and one on the lower hot water, it is possible to operate a heat engine for power production . This is the most promising application of solar pond especially for small developing countries.

4. Conclusion.

Most electromechanical systems in building are energy consuming. However, with proper design, energy consumption can be reduced or totally eliminated. Also, energy required could be totally met or at least augmented using appropriate renewable energy sources peculiar to the location.

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