16 Plant and service areas

Learning objectives

Study of this chapter will enable the reader to:

1. identify the actions necessary prior to commencement of a construction, in order to facilitate the correct provision of utility services;
2. coordinate utility services under public footpaths;
3. design suitable routes for utility services;
4. calculate the areas of buildings needed for services plant;
5. find the sizes of plant room needed for all services from preliminary building information at the design stage;
6. allocate routes for services through the building structure;
7. understand the need for fire barriers in service ducts and correctly locate them;
8. choose suitable sizes for pipe service ducts;
9. understand the need to allow space for pipes crossing over each other;
10. estimate sizes for service shafts carrying air ducts;
11. know the requirements for walkway arid crawl way ducts;
12. understand the need for expansion provision in pipework;
13. identify the ways in which pipes can be supported with allowance for thermal movement;
14. understand the ways in which thermal movement is accommodated;
15. know how thermal, fire, support and vibration measures are applied to pipes air ducts passing through fire barriers;
16. apply flexible connections to plant;
17. appreciate the need for coordinated drawings;
18. understand the use of services zones;
19. be able to design boiler house ventilation.

Key terms and concepts

air-duct support 376; air-handling plant 366; boiler room 365; cold- and hot-water storage 365; combustion air ventilation 378; cooling plant 366; coordinated drawings 377; coordinated service trench 362; crawl ways and walkways 370; electrical substation 367; fire compartment 368; flexible connection 377; foam seal 375; footpath 363; fuel handling 366; highway 363; lifts 367; noise and vibration 376; pipe anchor, guide, roller, loop expansion and insulation 375; pipe bellows, articulated and sliding joint 375; public utilities 362; service ducts 368; service plant area 363; services identification 364; services zones 377; standby generator 367; telephones 366; temporary works 362; under floor pipe ducts 369.

Introduction

The building design team needs information on the size and location of services plant spaces and their interconnecting ducts before the engineer has sufficient data on which to base calculations. There may be only general definitions of the spaces to be heated or air conditioned and preliminary design drawings. Past experience of similar constructions reveals the likely plant and service duct requirements.

The use of such data is explained and worked examples are used. The planning of external utility supplies is shown, together with typical arrangements for internal multi-service ducts.

Support and expansion provision for distribution services is demonstrated, as is the design of combustion air ventilation for boilers.

Mains and services

The planning and liaison with public utilities (National Joint Utilities Group, 1979) must be included in the initial application made by the developer for planning permission. Each utility requires detailed information at the estate design stage in order to facilitate the following:

1. siting of plant or governor houses, substations, service reservoirs, water towers and other large items of apparatus and also early completion of associated easements and acquisition of and early access to land in order to ensure service to the development by the programmed date;
2. design of mains and service layouts;
3. location of and requirements for road crossings;
4. provision and displacement of highway drainage;
5. programming of cut-offs from existing premises that are to be demolished;
6. arrangements for protecting and/or diverting existing plant and services;
7. provision of supplies to individual phases of the development, including temporary works services;
8. acquisition of materials and manpower resources;
9. siting of service termination and/or meter positions in premises and service entry details;
10. provision of meter-reading facilities;
11. provision of public lighting.

Developers must provide information on the following:

1. the intended position of public carriageways, verges, footpaths, amenity areas and open spaces;
2. existing and proposed ground levels;

3. the position and level of proposed foul and surface-water sewers and any underground structures.

The utility will inform the developer of the need to close or restrict roadways, and these matters will then be discussed with the local authorities.

All main services to more than one dwelling should be located on land adopted by the Highway Authority. The location on private property of a main designed to serve a number of dwellings can lead to friction between residents if excavation for repairs or maintenance is needed, and also makes it difficult for the utilities to gain ready access in an emergency.

With the exception of road crossings, mains and services other than sewers should not be placed in the carriageways. The routes chosen should be straight and on the side of the carriageway serving most properties. Any changes of slope should be gradual. The prior approval of the utilities must be sought if landscaping will alter the levels of underground services.

Public sewers must be laid to appropriate levels and gradients in straight lines between manholes, usually under the carriageway.

An underground clear width of 1.8 m is needed between a private boundary and the kerb foundations but extra allowance should be agreed for the following:

1. fire hydrants;
2. inspection covers and manholes;
3. large radius bends for pipes and cables;
4. fuel oil distribution pipes;
5. district heating pipework and manholes;
6. through-services not connected to the development;
7. cross-connections between services to form ring mains rather than dead ends;
8. imposed loads from adjacent buildings – medium-pressure gas mains must be 2 m from the building line.

Protective measures are taken where there is a risk to pipes or cables from vehicles that may park on soft ground. Where special paving is used, early consultation with the utilities will help to avoid subsequent defacement due to maintenance work.

Footpaths should be used for the utilities. Sewers need to be laid in conjunction with the early stages of road building. Utilities operate under statutory powers and will not carry out work as a subcontractor. On completion of site construction, a copy of the plans showing the installed routes and details of the mains and services is sent to each utility to enable permanent records to be established.

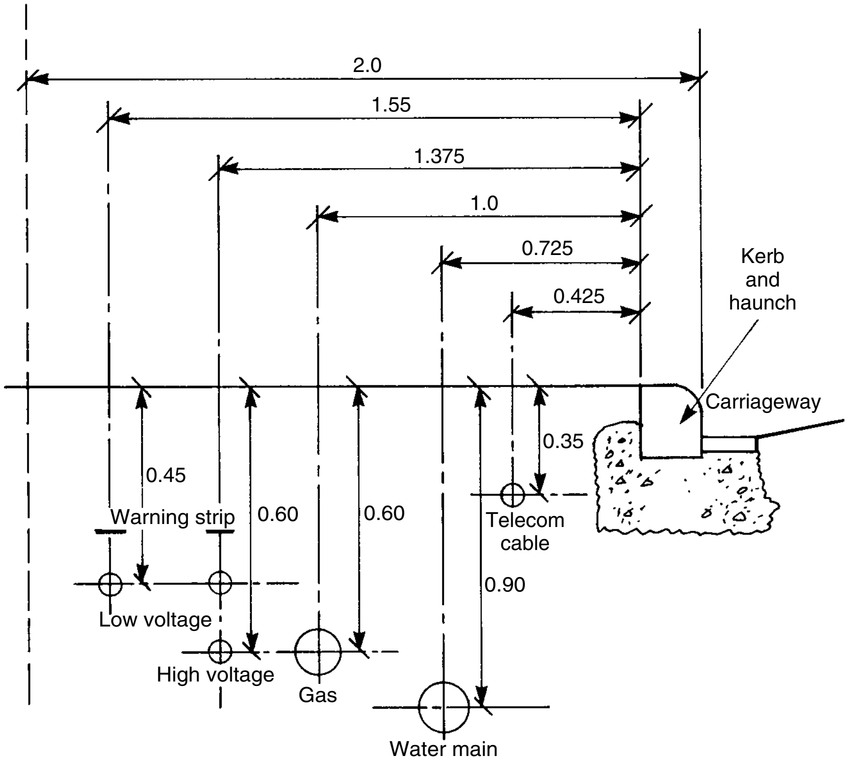
The minimum dimensions for the locations of mains and services under a pavement are shown in Fig. 16.1. Brick tiles, concrete covers or yellow marker tapes are put over 11 kV and 415 V electricity cables. The 11 kV cables have a red PVC over-sheath and 415 V cables have a black PVC over-sheath.

The mains and services are surrounded with selected backfill that is free of sharp or hard objects, and the trench is filled and compacted with earth that is free of rubble or site debris.

Plant room space requirements

General provision

Coordination of the services with architectural and structural design is required at the earliest possible moment during conception of the project. Plant rooms are places of physical work as



16.1 Positions of main services in straight routes under footpaths on residential estates.

well as equipment locations. Access to them is restricted to approved people under the control of the building manager. Safety, noise control, natural and mechanical ventilation, heating and cooling, ease of access from stairways and lifts, equipment and exit signage, adequate lighting and low-voltage power outlets all make for a successful building. Many plant rooms remain almost unchanged for 25 years or more, so a well thought-out facility that can be maintained is more than an after-thought. Keeping them clean, decorated and well lit is an important part of the workplace. Telephone communication with the building manager from each plant room is a life-safety issue as well as a vital means of communication when work is being conducted or faults occur; mobile phones may be out of contact due to the heavy presence of concrete, steel and noise. Plant rooms must not be used to store flammable materials, cleaning fluids, cleaning machines, furniture; they are not junk or store rooms, they are specialist and dangerous work places, often hot and noisy. Inappropriate access is not permitted.

New plant rooms must be designed to provide full access for maintenance and repair. Existing plant rooms often appear overcrowded to the maintenance engineer and energy auditor. Adequate head room for safe access and movement is necessary. Noise from refrigeration compressors, hospital medical air compressors and hospital medical suction vacuum pumps is always uncomfortable; hearing protection often advisable. Large fans generally do not create excessive noise within plant rooms; if they did, duct-borne noise would be troublesome downstream and possibly elsewhere. Fuel-fired water heaters and steam boilers usually do not make excessive noise that leaves the plant room. Large main plant rooms house the maintenance engineers office, record drawings and commissioning manuals of everything installed, equipment

Table 16.1 Services plant room space requirements.

Building type	*Plant room floor area as a percentage of building floor area, excluding the plant room*
Simple factory or warehouse	4
Most types	9
Small, well-serviced hospital	15

storage, duplicated water pumps, isolating valves, extensive pipework, water treatment tanks, anti-corrosion dosing tanks, mechanical switch boards and building management system field panels. This is where the building management system front end computer is often located as continuous access use is made of it by the maintenance team and contractors.

The design stage of a new building is too early for heating and cooling loads, plant sizes and system types to be known with any certainty, but reliable information is required to form the basis for decisions. Building Services Research and Information Association (BSRIA) surveys (Bowyer, 1979) of existing buildings have shown that their plant room requirements can be expressed as a percentage of floor area, as given in Table 16.1.

Some of the outline requirements for services plant rooms quoted by Bowyer (1979) are as follows.

Cold-water storage

The volume of cold water to be stored to cover a 24-h period is calculated from the building's occupancy and type. An incoming break tank may be required at ground or basement level for pneumatically boosted systems. Fire-fighting services may need water storage at ground level.

Tanks can be 1, 2 or 3 m high, with 1 m clearance allowed around them for insulation, pipework and access.

Hot-water storage

The space needed for vertical indirect hot-water storage cylinders, secondary pumps, pipework, valves, controls and heater coil withdrawal is given by:

$$\text{plant room floor area m}^2 = 1.7 \times \text{cylinder volume m}^3 + 10$$

Room heights of 3–4.8 m are needed depending on cylinder height.

Boilers

For buildings constructed to the Building Regulations, an assessment of the boiler power in watts can be made by multiplying the heated volume in metres cubed by 30.

The required boiler plant room floor area is:

$$\text{plant room floor area m}^2 = 80.99 + 31.46 \times \ln(\text{boiler capacity MW})$$

Plant room heights are up to 5 m. Domestic and small commercial boilers are accommodated within normal ceiling heights and their floor areas are not predicted with this equation. The area calculated allows for two equally sized boilers, pipework and water treatment, pressurization and pumping equipment.

Fuel storage and metering

Electricity and gas meters are part of the incoming services accommodated within the plant room space calculated for other equipment. Partition walls and access for reading and removal are required.

Two equally sized oil storage tanks, supports, tanked catch pit and access are accommodated in:

$$\text{oil storage tank room area m}^2 = 22.52 + 0.64\ (\text{oil storage volume m}^3)$$

Plant room height is up to 4.5 m. Tanks are frequently located externally and stood on three brick or concrete block piers so that oil will flow by gravity to the burners. They are of mild steel and protected with bitumen paint.

Air handling

The air-handling plant room size is assessed by assuming that the mechanically ventilated parts of the building have between 6 and 10 air changes/h. The expected supply air volume flow rate is:

$$Q = \frac{NV}{3600}\ \text{m}^3/\text{s}$$

where V is the volume of ventilated space (m^3) and N is the number of air changes per hour (6–10).

The plant room will be 2.5–5 m high depending on the sizes of fans, ducts, filters, heater and cooler coils, humidifiers and control equipment. The floor area is:

$$\text{plant room floor area m}^2 = 6.27 + 7.8 \times Q\ \text{m}^3/\text{s}$$

A fresh-air-only system, such as an induction system, is sized on 1 air change/h.

Cooling plant

Refrigeration plant capacity may be as high as 30 W/m^3 of building volume, and an early estimate of heat gains should be made. A Building Energy Estimating Programme (BEEP) is available through the electricity supply authority, and other computer packages are in use.

Plant room height is 3–4.3 m and the floor area is:

$$\text{plant room floor area m}^2 = 80.49 + 35.46 \times \ln(\text{cooling load MW})$$

The area is for two refrigeration machines, pumps, pipework and controls. Additional space on the roof is needed for the cooling tower.

Communications

Digital telephone technology has generally taken over from mechanical switch rooms within buildings. Telephone server computers may be required. Roof-mounted microwave communication transmitters, receivers and satellite dishes need clearly defined manual exclusion space due to high-intensity radiation hazards. A secure fenced communication roof area separates regular daily access from that to mechanical plant rooms and cooling towers. There are no water or gas services within communications plant rooms.

Computer servers

Commercial buildings with workstation computers have a server room in continuous operation. An office of 20 or more workstations has a significant server requirement and external cable data modem link equipment to the internet. Intermittent work at the PC front end computer by the network operator is needed, as well as space for expansion of electrical equipment, more cabling, fault servicing and storage of documents relating to the network. Continuous server computers with backup data storage disk drives generate considerable heat gains, often within internal closed rooms having no natural ventilation or cooling. Dedicated 24-h operation mechanical ventilation, recovery of useful heat and mechanical cooling often does not coordinate easily with the general office air-conditioning systems and requires careful design and implementation. Electrical equipment is only rated for operation at up to 40°C, easily reached within an unventilated closed internal room full of computers and screens, making suitable temperature control vital for the functioning of the purpose of the building, reliability of computer systems and physical security of the server installation. There are no water or gas services within these rooms. Adequate lighting and low-voltage power outlets are provided.

Lifts

An early assessment of requirements is made in conjunction with the lift engineer. Bowyer (1979) gives further information. Each electrical lift has a lift motor room on top of the shaft that is several times the floor area of the shaft. Lifts are grouped close together and the room level lift motor room covers all shafts plus control equipment. Older electrical lifts have mechanical switch control panels of considerable size. A lifting beam, lifting gear and lift motor concrete bases along with one or more spare lift motors are provided for repair work. Digital control with frequency inverters is normal for modern lift installations, requiring a large control panel. Lighting and access for regular inspections, maintenance and large item replacement add to the lift motor room size. A lift motor room on top of a tall air-conditioned building has significant internal and external heat gains. Natural ventilation is always provided but mechanical air flow and cooling are provided where there is a significant risk of the lift motor room exceeding a safe environmental working temperature for the staff and the electrical equipment. Smaller capacity electric lifts have the driving motor and control gear installed on the support frame of the top of each car, so only wire ropes and the counterweight are within the lift shaft and there is no lift motor room.

Hydraulic lifts may be used to service up to around six floors. The lift car is raised from hydraulic rams and cables within the lift shaft. They are silent and slow speed, some allowing glass-sided cars as there are no visible cables. Motive power comes from a hydraulic pump within the oil storage tank alongside the base of the lift shaft. Lowering the car pushes oil back into the tank while car raising is pumped. The submerged pump is oil cooled and uses minimum energy.

Electrical substation

The incoming high-voltage supply is located in a substation, which may be external or on an external wall of the building. The floor area needed is 35 m^2 for a 200 kVA load and up to 48 m^2 for a 2000 kVA load.

Standby diesel electric generator

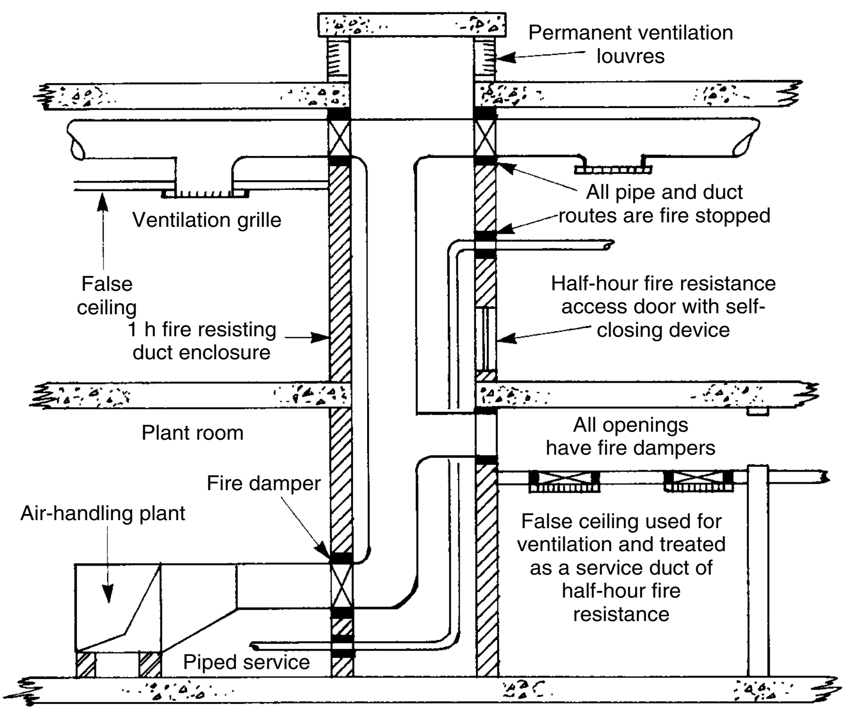
A standby diesel electric generator supplies emergency electrical power of up to 100% of the connected load from the mains. Often only having the capacity to maintain essential lighting, a minimum lift service, stairway pressurization fans, hospital operating theatres and any other essential service for the site. The plant room will be adjacent to the substation and will be up to 4 m high. The floor area required is 18 m^2 for 50 kVA up to 37 m^2 for 600 kVA, plus a diesel oil storage tank for 7 days of continuous running.

Service ducts

Service ducts are passageways that traverse vertically and horizontally throughout a building, or between buildings, large enough to permit the satisfactory installation of pipes, cables and ducts, together with their supports, thermal insulation, control valves, expansion allowance and access for maintenance. Each service duct might be constructed as a fire compartment, and BS Code of Practice 413: 1973 should be consulted. An example of current practice is given in Fig. 16.2.

Casings and chases of 100 mm diameter or less are fire stopped to the full thickness of the wall or floor. The passage of a service must not reduce the resistance of the fire barrier. Plastic pipes can soften and collapse during a fire and allow the passage of flames and smoke. A galvanized steel sleeve with an intumescent liner can be used to surround the plastic pipe where a fire stop is needed. When its temperature rises to 150°C, the intumescent liner expands inwards to close the softened pipe and seal the wall aperture.

Service duct sizes can be found from an estimate of ventilation air supply rate Q m^3/s, doubled to allow for the recirculation duct, with an assumed air velocity of 10 m/s for vertical ducts within brick or concrete enclosures or 5 m/s in false ceilings where quiet operation is important. At least 150 mm clearance is allowed between ducts and other surfaces for thermal insulation, jointing, supports and access.



16.2 Service duct fire compartment.

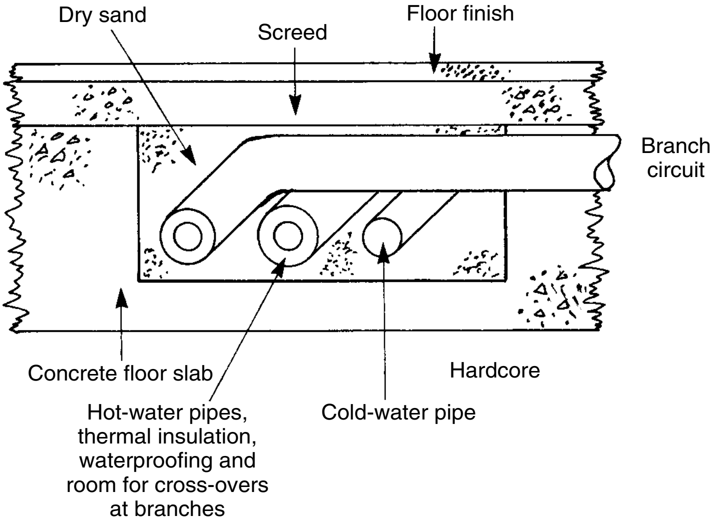
Fan noise is contained within the air-handling plant room by acoustic attenuators, anti-vibration machine mountings and heavy concrete construction.

The total floor space taken by vertical pipe and cable routes will be up to 1% of the gross floor area. Horizontal service ducts and false ceilings 500 mm deep are used for air-conditioning ducts and other services. Recessed luminaires and structural beams encroach into the nominally available spaces.

Under floor service ducts should be constructed to allow access for jointing and maintenance. The minimum standard for an under floor duct is shown in Fig. 16.3. The duct route is accurately marked on installation drawings and access is gained by breaking the screed. Hot-water pipes are insulated with 50 mm thick rigid glass fibre and wrapped with polyethylene sheet, sealed with waterproof tape. The duct is filled with dry sand. Sufficient depth is allowed for branches to cross over the other pipes. Recommended sizes are given in Table 16.2 (Butler, 1979b).

Vertical and other service ducts can be sized in a similar manner by allowing a 50 mm gap between thermal insulation and other surfaces. Additional smaller pipes run in the same duct will require an increase in the width.

When builder's work holes for services are specified, the dimensions of the structural opening required should always be used, rather than the nominal pipe diameter.



16.3 Minimum standard for an under floor service duct for pipework.

Table 16.2 Minimum under floor duct sizes for pipework.

Hot-water flow and return nominal diameter (mm)	*Under floor duct dimensions width and depth (mm)*
15	294
22	304
28	348
35	364
42	376
54	400

An under floor, or underground, crawl way or walkway has the following features:

1. crawl way duct height 1.4 m;
2. walkway duct height 2 m;
3. 750 mm clear width between fixtures;
4. reinforced concrete construction;
5. floor laid to fall to a drainage channel along the length of the duct, with connections to the surface drainage system;
6. watertight access manhole covers at intervals with built-in galvanized steel stepladders;
7. watertight lighting fittings and power sockets;
8. services are painted to appropriate British Standards colours and clearly labelled, and control valves are numbered with an explanation list provided;
9. services branching into side ducts do not block through-access.

EXAMPLE 16.1

A six-storey office building of 30 m × 25 m is to be constructed on a suburban green field site. It is to be air conditioned with a low-energy system using gas and electricity as energy sources. The main air-handling unit, AHU, plant room is to be built on the roof. There will be 225 occupants. Calculate the plant room and service duct space requirements for the preliminary design stage. Only outside air is to be passed through the distribution ductwork system.

It is expected that the plant rooms will require 9% of the floor area of (30 × 25 × 6) m^2, and so a first estimate is 405 m^2. This will be mainly on the roof as the heating system water heater, air-conditioning cooling plant of chiller and cooling tower, domestic hot-water heater and storage cylinder, pumps and main switchboards are normally located there also; thus an oblong room of dimensions l and $2l$ could be used to establish the overall space requirement. This space can then be distributed around the building for the various services. Cold-water storage tanks are often located on a mezzanine floor above the heating plant. Fire-fighting water storage tanks are used in some buildings where needed for the sprinkler system; these, and any oil storage tanks, are always located in basement or ground floor plant rooms; neither are needed in this case. The main electricity meters for the central building services and tenants floors, main electricity distribution board, water and gas meters are usually located in a basement or ground floor plant room. The building management system computer, a server computer with screen, keyboard, printer and data backup storage tape or disc, is sometimes located in a plant room, where only the BMS maintenance contractor ever uses it, but it should definitely be in the building manager’s office where it can be used every day. The building manager should be using this computer for condition, fault and energy monitoring continuously.

$$\text{area} = l \times (2l) = 405\ \text{m}^2$$

$$2l^2 = 405\ \text{m}^2$$

$$l = \left(\frac{405}{2}\right)^{0.5} = 14.23\ \text{m}$$

A plant room of 14.23 m × 28.5 m could be accommodated on the roof. However, some of this space will be located lower down the building.

A further estimate of the requirements can be made through consideration of each service.

1. Cold-water storage of 45 l per person:

$$\text{volume} = 225 \text{ people} \times 45\ \frac{\text{l}}{\text{person}} \times \frac{1\ \text{m}^3}{10^3\ \text{l}} = 10.1\ \text{m}^3$$

$$\text{tank dimensions} = 2.25\ \text{m} \times 4.5\ \text{m} \times 1\ \text{m}$$

   Add 1 m all round the tanks. Thus the plant room floor space is 27.6 m^2. This could be reduced by stacking the tanks if there is sufficient headroom. The water main pressure will be sufficient to reach the roof; ground-level break tanks and pumps will not be needed.

2. Hot-water storage of 5 l per person:

$$\text{volume} = 225 \text{ people} \times 5\ \frac{\text{l}}{\text{person}} \times \frac{1\ \text{m}^3}{10^3\ \text{litre}} = 1.125\ \text{m}^3$$

$$\text{volume of an indirect cylinder} = \frac{\pi d^2}{4} \times l\ \text{m}^3$$

   For a cylinder 1 m in diameter, its length l is:

$$l = 1.125 \times \frac{4}{\pi} = 1.43\ \text{m}$$

   The floor area required is 1 m^2.

3. The boiler power is given by:

$$\begin{aligned}\text{boiler power} &= (30 \times 25 \times 6 \times 3)\ \text{m}^3 \times 30\ \frac{\text{W}}{\text{m}^3} \times \frac{1\ \text{MW}}{10^6\ \text{W}}\\ &= 0.405\ \text{MW}\end{aligned}$$

$$\begin{aligned}\text{plant room floor area} &= 80.99 + 31.46 \times \ln 0.405\ \text{m}^2\\ &= 52.6\ \text{m}^2\end{aligned}$$

4. Gas and electricity meters will be housed either in the roof plant room or in cubicles at the rear of the building on the ground floor.

5. The low-energy system air-handling plant will pass only the fresh air supply. The volume flow rate of supply air will be a maximum of 10 l/s per person,

$$\begin{aligned}Q &= \frac{10\ \text{l}}{\text{s}} \times 225\ \text{people} \times \frac{1\ \text{m}^3}{10^3\ \text{l}}\ \text{m}^3/\text{s}\\ &= 2.25\ \text{m}^3/\text{s}\end{aligned}$$

$$\begin{aligned}\text{plant room area} &= 6.27 + 7.8 \times 2.25\ \text{m}^2\\ &= 23.8\ \text{m}^2\end{aligned}$$

Air change rate from the provision of outdoor air is:

$$N = 3600 \times \frac{2.25\ \text{m}^3}{\text{s}} \times \frac{1\ \text{air change}}{30 \times 25 \times 6\ \text{m}^3}$$
$$= 1.8\ \text{air changes/h}$$

This is acceptable and reasonable. There may be additional recirculated air within the floors from distributed terminal heating/cooling air control units such as variable air volume, induction or fan coil units.

6. The cooling plant capacity is 30 W/m^3 = 0.405 MW, same as heating power calculated.

$$\text{plant room floor area} = 80.49 + 35.46 \times \ln 0.405\ \text{m}^2$$
$$= 48.4\ \text{m}^2$$

Data provided by Bowyer (1979) do not cover plant smaller than 0.3 MW, so this is likely to be realistic. The floor space needed for chillers and cooling towers does not increase as fast as for heating plant with increasing capacity.

Thus the total plant room space requirements are estimated to be

$$(27.6 + 1 + 52.6 + 23.8 + 48.4)\ \text{m}^2 = 153.4\ \text{m}^2$$

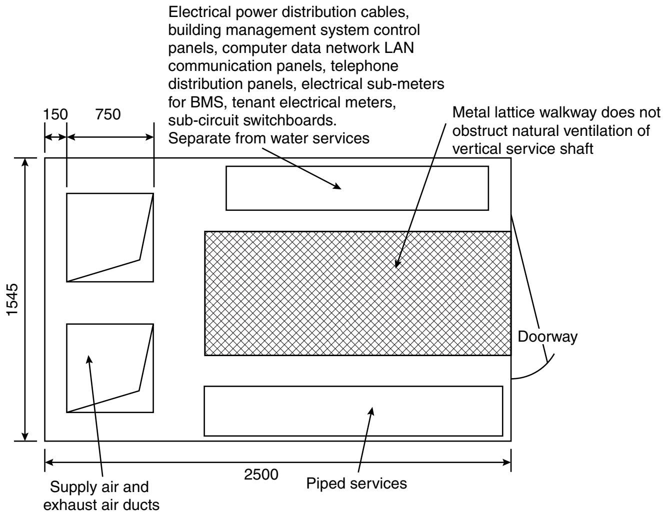
These two methods of estimation show that plant room space requirements are of the order of 153–405 m^2. This is a wide spread of answers provided for the design concept stage. It will be refined by detailed design and better knowledge of the plant loads and locations to be used. A low-energy building has the minimum of mechanical services plant for air handling and cooling. Heating systems have traditionally not required much plant room space and hot water radiators and convectors are very compact, mainly consuming wall space. The historical precedent for a 9% floor area requirement is likely to be too high for a modern system.

A vertical service duct is needed from the roof plant room to ground level carrying supply and exhaust air ducts, drainage and water pipework and cables. If the maximum air velocity in the air ducts is 6 m/s, their sizes will be

$$\text{duct cross-sectional area} = \frac{Q\ \text{m}^3/\text{s}}{V\ \text{m/s}}$$
$$= \frac{2.25}{6}\ \text{m}^2$$
$$= 0.375\ \text{m}^2$$

If square ducts are used, they will be 612 mm × 612 mm or larger, such as with standard sizes of 700 mm × 600 mm. An estimated service duct arrangement is shown in Fig. 16.4. This allows for thermal insulation and access to all the services.

False ceilings provide space for the horizontal distribution of services. The induction units will be located along the external perimeter under the windows or within the false ceiling. Holes 150 mm in diameter are needed in the floor slab, one for each unit, for the air duct and, close by, two holes 50 mm in diameter for pipes.



16.4 Layout of the vertical service duct in Example 16.1.

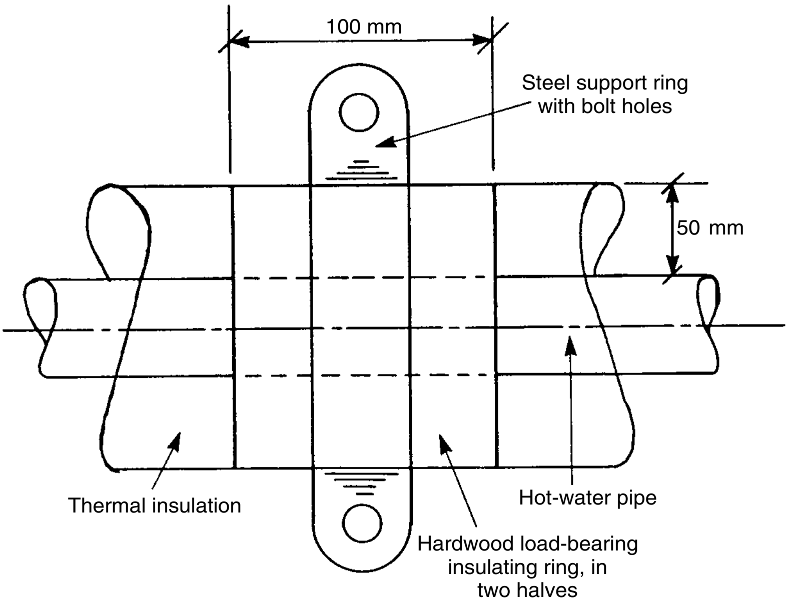
Pipe, duct and cable supports

Hot-water pipework can be supported with hardwood insulation rings clamped in mild steel brackets, as shown in Fig. 16.5. Saddle pipe and cable clips, shown in Fig. 16.6, are extensively used because of their low cost. They should be made of a material that is compatible with that of the service. A row of services may be bolted to a mild steel angle iron whose ends are built into the structure. The longitudinal spacing of supports depends on pipe size, material and whether the service is horizontal or vertical. Rollers, as shown in Fig. 16.7, allow pipes to move freely during thermal movement.

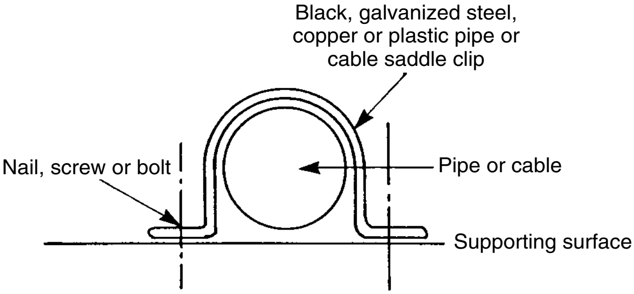
Expansion and contraction of short pipe runs is accommodated at frequent bends and branches, the pipes moving within their thermal insulation and non-rigid brackets. Spaces between pipes are sufficient to avoid contact. Long pipe runs need expansion devices, anchors and guides.

1. With a pipe anchor the pipe is rigidly bolted or welded to a steel bracket which is firmly built into a brick or concrete structure.
2. Pipes can be supported by tubular guides, as shown in Fig. 16.8, which allow longitudinal movement with minimum metal contact.
3. Several types of thermal expansion device are used, depending on application, space available and fluid pressure.

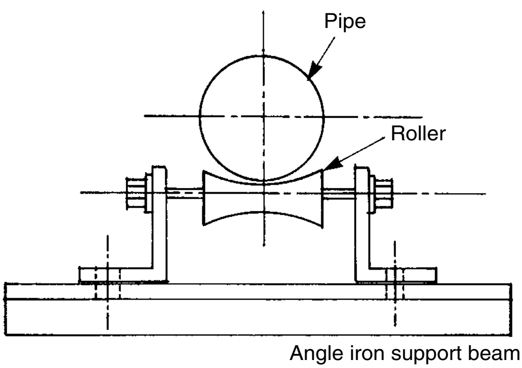
   (a) Pipe loops are least expensive in some cases and can be formed where external pipes pass over a roadway. They can be prefabricated with pipe fittings, welded, bent or factory formed, as shown in Fig. 16.9.
   (b) Bellows are made of thin copper or stainless steel and have hydraulic pressure limitations. A complete installation is shown in Fig. 16.10.
   (c) Articulated ball joints take up pipe movement at a change in direction, as shown in Fig. 16.11.
   (d) Sliding joints are packed with grease and the pipe slides inside a larger diameter sleeve.



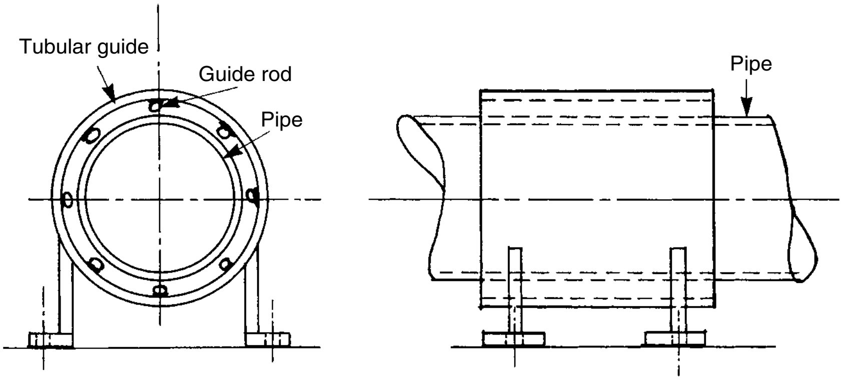
16.5 Insulated pipe support ring.



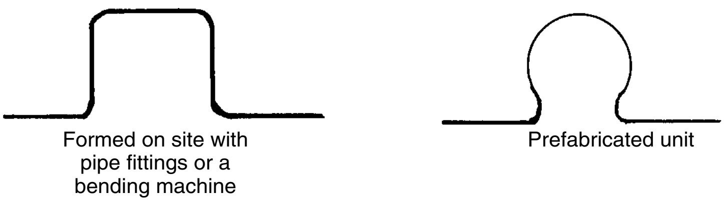
16.6 Pipe and cable saddle clip.



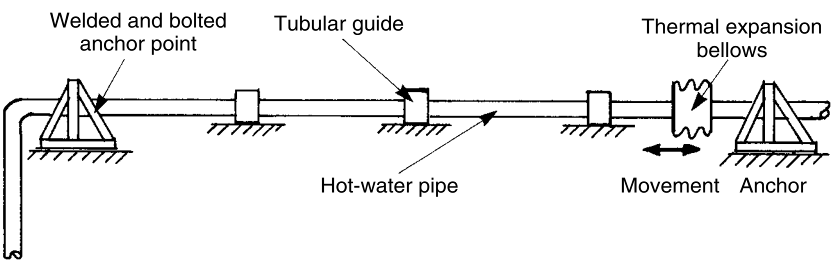
16.7 Roller pipe support.



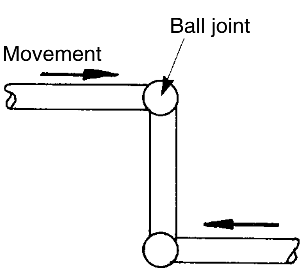
16.8 Tubular guide support.



16.9 Pipe expansion loop.

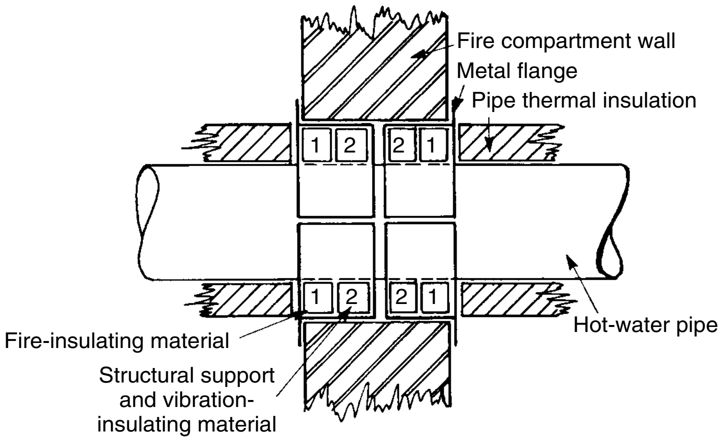


16.10 Complete pipework installation for thermal expansion provision.

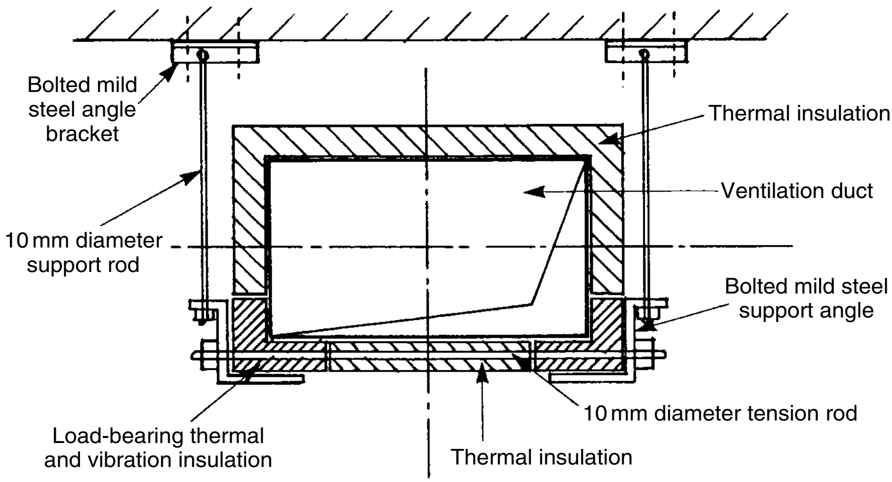


16.11 Articulated expansion joint.

A fire stop unit is used where pipes pass through a fire compartment wall or floor and incorporates structural support, vibration insulation and fire resistance within a steel flanged sleeve which is in two halves, as shown in Fig. 16.12. Silicone fire stop foam is used to seal the space around pipes. When it is exposed to heat, the foam chars to form a hard flame-resistant clinker.



16.12 Insulated pipe sleeve (reproduced by courtesy of Stuart Forbes (Grips Units) Ltd, Working).



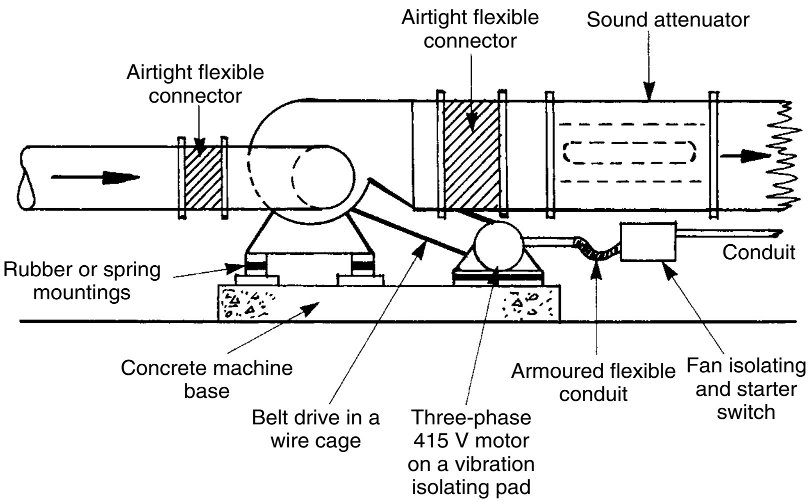
16.13 Insulated duct support.

Ventilation ducts are fixed to the building with galvanized mild steel saddle clips for up to 300 mm diameter light-gauge metal; larger ducts have flanged joints, which are suspended with rods from angle brackets. Figure 16.13 shows a typical fixing.

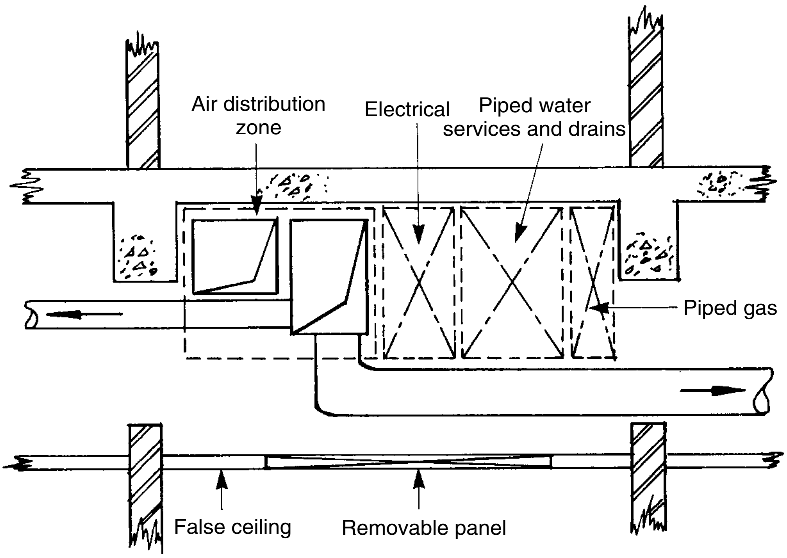
Cables are supported along their entire length by the conduit or a perforated metal tray.

Plant connections

Connections to plant are made in flexible materials to reduce the transmission of vibration from fans, pumps and refrigeration compressors to the distribution services, or to allow greater flexibility in siting the equipment. A fan installation is shown in Fig. 16.14. The discharge air duct has a sound attenuator to absorb excess fan noise. Polyurethane foam held in place by perforated metal sheet is used in the attenuator.



16.14 Flexible connections to an air-conditioning fan.



16.15 Service zones in a false ceiling over a corridor.

Coordinated service drawings

A master set of all service drawings is maintained under the overall charge of a coordinating engineer for the project (Crawshaw, 1976). Drawings and a schedule of builder's work associated with the services are circulated round the construction team. The structural engineering implications of holes through floors and beams are checked at an early stage.

Service space allocation is made on the basis of zones for particular equipment within structural shafts and false ceilings. Each engineering service is restricted to its own zone. Common areas are provided for branches, as shown in Fig. 16.15.

Table 16.3 Minimum free areas of ventilation openings for combustion appliances for outdoor air per kilowatt of heat output.

Position of opening	*Minimum free area (mm^2)*	
	Conventionally flued	*Balanced flue*
High level	550	550
Low level	1100	550

Boiler room ventilation

Combustion appliances must have an adequate supply of outdoor air, otherwise the fuel will not burn properly and carbon monoxide will be produced. Under down-draught conditions, this will be a danger to occupants. Fatalities have occurred through improper appliance operation.

Good installation practice is to introduce combustion air so that it does not cause a nuisance through draught, noise or poor appearance. Heat and fumes produced by the appliance are ventilated to outdoors through high-level openings.

Any room containing a fuel-burning appliance may be positively supplied with ventilation air by a fan if this is needed for some other purpose. An extract fan must not be used, as combustion products can be drawn into the occupied room. Natural inlet and outlet ventilation is predominant.

The combustion air inlet for a domestic kitchen or living area can be (CIBSE, 1973):

1. through an external wall, just below ceiling level, to enable the incoming cold air to diffuse with the room air above head height; this avoids most draughts and occasional blockage by snow or debris;
2. through an external wall at low level behind a hot-water radiator or other heat emitter; a frost thermostat switches on the heating system at an internal air temperature of 5°C;
3. by direct connection of the combustion air from outside to the appliance casing, locality or enclosing cupboard with an under floor duct. Two suitably sized air bricks are fitted into the external walls of a suspended timber floor on opposite sides of the building. Either a duct connection between the appliance casing and the floor space or a ventilation grille is put into the floor by the heater. A drain pipe or galvanized steel duct can be cast into a concrete floor slab for this purpose.

An appliance of up to 30 kW heat output may be fitted within a compartment, which is ventilated to an adjoining room, which in turn is ventilated to outdoors by the stated openings. Recommended ventilation openings are given in Table 16.3.

Questions

1. List the principal information and activities involved in the provision of main services throughout a housing estate.
2. Sketch a suitable arrangement for the services beneath the public highway and leading into a dwelling. Show the recommended dimensions and explain how the ground is to be reinstated.

3. Estimate the plant room and service duct space requirements of the following buildings, using the preliminary design information given.

   (a) A naturally ventilated hotel with a hot-water radiator heating system. Roof and basement plant rooms are available. The hotel dimensions are 50 m × 30 m, with 10 storeys 3 m high. Total occupancy is 750. An oil-fired boiler plant is to be used.
   (b) A single-storey engineering factory of dimensions 100 m × 40 m, using overhead gas-fired radiant heating. The roof height slopes from 3 m to 5 m at the central ridge. There are 300 occupants. Mechanical ventilators and smoke extractors will be fitted in the roof. A standby diesel electricity generator and an electrical substation are required.
   (c) A 12-storey city centre educational building of 40 m × 20 m, 3 m ceiling height, with a single-storey workshop block and laboratory area 40 m × 60 m × 4 m. The whole complex is to be mechanically ventilated with 4 air changes/h. Hot-water radiators and fan convectors provide additional heating. Gas and electricity are to be used.

   The tower building has a basement with ramp access to ground level. A refectory is located at ground level. The total building occupancy is 2000.
4. Draw the installation of services in a vertical duct through a three-storey office building. The duct is 2.5 m × 1.2 m. Boiler and ventilation plant are in the basement. There are false ceilings on all floors.
5. Sketch and describe how the spread of fire through a building is limited by the services installation.
6. A false ceiling over a supermarket contains recessed luminaires, sprinkler pipework and a single-duct air-conditioning system. The false ceiling is 400 mm and has structural steel beams 250 mm deep. Extract air from the shop passes through the luminaires. Draw the installation to scale.
7. A concrete floor with a wood block finish houses a service duct carrying two 35 mm heating services, two 28 mm hot-water services, a 42 mm cold-water service and 54 mm gas pipework. Side branches are required to carry a maximum of three 22 mm pipes. Continuous access covers are to be provided. The hot-water pipes are to have 50 mm thick thermal insulation, and at least 25 mm clearance is needed around the pipes. Draw a suitably detailed design showing dimensions, materials, pipe support, cover construction and pipe routes at the branch.
8. Describe, with the aid of sketches, how successful coordination between all the services can be achieved within builders' work ducts.
9. Explain how fuel-burning appliances fitted in kitchens, living rooms, cupboards and domestic garages can be adequately ventilated. Illustrate an example of each location and state the areas of ventilation openings required for appliances of 3, 18 and 40 kW heat output.
10. Who are allowed into plant rooms?

    1. Everyone in the building.
    2. All contractors.
    3. Members of the public.
    4. Only employed maintenance engineers.
    5. Those approved by the building manager.

11. What are plant rooms designed to accommodate?

    1. Only mechanical plant.
    2. Only electrical plant.
    3. Plant and people.
    4. Wiring and pipes.
    5. Pumps and boilers.

12. What are plant room conditions supposed to be?

    1. Safe work places.
    2. Minimum size possible.
    3. Maximum size needed.
    4. Showcase for plant items.
    5. Always out of site.

13. What do we know about computer server spaces?

    1. None needed, located beneath a desk.
    2. Located in roof plant space, out of sight.
    3. Any corner of a room will do.
    4. Secure accessible and safe room to work in.
    5. Always very hot places.

14. What do we know about computer server spaces?

    1. An inconvenient collection of electrical boxes.
    2. Vital hub of every business and office.
    3. Nobody ever works in there.
    4. Do not need ventilation.
    5. Provide useful heat into the building during winter.

15. What is essential for a computer server facility?

    1. Basement store room location.
    2. Empty internal office with lockable door.
    3. Interior secure work room with mechanical ventilation and temperature-controlled cooling 24 h a day, 365 days a year.
    4. Partitioned space in basement car park as it is cool there.
    5. Any office or store room where enough space can be made available.

16. Where is the building maintenance manager's office likely to be located?

    1. Alongside reception area.
    2. By the main plant room, often in the basement.
    3. In the executive office suite on a high-level floor.
    4. Basement car park.
    5. In entrance foyer.

17. Which are the most problematic noise sources in plant rooms for maintenance workers?

    1. None of them are as plant is switched off when work is undertaken.
    2. Toilet exhaust fans.
    3. Air-handling units.

4. Rotary and reciprocating compressors.
5. Gas-fired water heaters.

18. How often do technical workers enter large plant rooms?

    1. Once a year.
    2. Daily, several times.
    3. Monthly service checks and fan belt changes.
    4. Hourly logging of energy and operational data.
    5. Once a week.

19. What is the space temperature control requirement for plant rooms?

    1. None, they always remain cool.
    2. Does not matter as air temperature never gets too hot for the mechanical plant.
    3. Wall and roof ventilation openings.
    4. Nobody works in there so it does not matter.
    5. Natural and mechanical ventilation for workers and where necessary, cooling to limit room temperature for workers and electrical systems.

20. What is involved with lift motor rooms?

    1. Driving motor and winding gear are located in basement plant areas.
    2. Each lift has its driving motor and winding gear mounted above the shaft within a ventilated and cooled roof-level plant room.
    3. All motors are located on top of each passenger car.
    4. One electric motor drives all lift cars in a group from a roof-level plant room.
    5. Sealed concrete plant room above each lift shaft.