

Lecture 04

Plumbing of Multistoried Building



References

- 1) World Health Organization (2015). Design of Plumbing Systems for Multi-storey Buildings. Addressing [Http://Www. Who. Int/Water_sanitation_health/Hygiene/Plumbing14](http://www.who.int/Water_sanitation_health/Hygiene/Plumbing14). Pdf Accessed on Feb, 10.
- 2) Building Engineering and Systems Design. Springer Science & Business Media. Frederick S. Merritt. & James Ambrose (2012).
- 3) Building design and construction handbook (6th ed). New York: McGraw-Hill. Frederick S. Merritt. & Jonathan T. Ricketts (Eds.). (2001).
- 4) *Building Systems for Interior Designers*. John Wiley & Sons. Corky Binggeli, A.S.I.D. (2003).

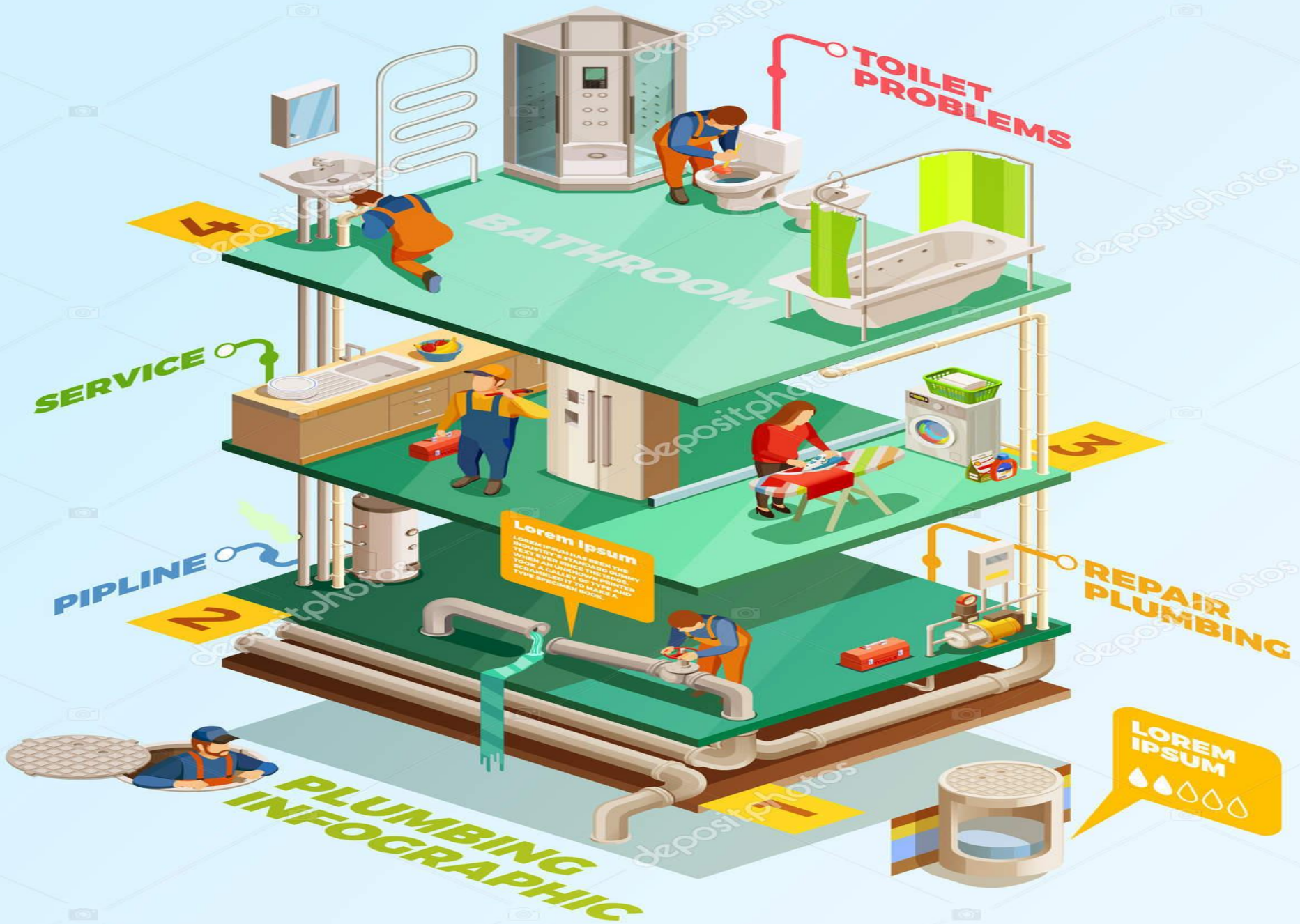


Design of plumbing systems for multi-storey buildings

- For plumbing purposes, the term “multi-storey” is applied to buildings that are too tall to be supplied throughout by the normal pressure in the public water mains. These buildings have particular needs in the design of their sanitary drainage and venting systems. Water main supply pressures of 8–12 metres (25–40 feet) can supply a typical two-storey building, but higher buildings may need pressure booster systems. In hilly areas, the drinking-water supply pressures will vary depending on the ground elevation.

Plumbing System in High Rise Building

- In these cases, the water authority may have to specify areas where particular supply pressures can be relied upon for the design and operation of buildings. Where a building of three or more storeys is proposed a certificate should be obtained from the drinking-water supply authority guaranteeing that the present and future public drinking-water supply pressure will be adequate to serve the building. If the public water pressure is inadequate, suitable means shall be provided within the building to boost the water pressure.



Systems for boosting water pressure

Pressure-boosting systems can be of several different types:

- ❑ pumping from a ground level or basement gravity tank to a gravity roof tank;
- ❑ pumping from a gravity storage tank or public water main into a hydro pneumatic pressure tank that uses captive air pressure to provide adequate drinking-water supply pressure;
- ❑ installation of booster pump sets consisting of multiple staged pumps or variable speed pumps that draw water directly from a gravity storage tank or the public water main. Multistage booster pump sets typically include discharge pressure regulating valves to maintain a constant drinking-water supply pressure.

Systems for boosting water pressure

Written approval should be obtained from the appropriate authority before any pump or booster is connected to the supply. Where booster pump sets are permitted to draw directly from public water mains, the public drinking-water supply must be adequate to meet the peak demands of all buildings in the area. Otherwise, there is a high risk of backflow and subsequent contamination of the mains from buildings not equipped with a booster pump. Building booster pumps are not a solution to the problem of inadequate drinking-water supply.

Systems for boosting water pressure

Where public drinking-water supply systems are overburdened and cannot provide adequate pressure on a continuous basis, water must be stored on site during periods when adequate pressure is available to fill a gravity storage tank. The size of the storage tank will vary according to the daily water demand of the building, and the availability of adequate pressure available in the public water mains. **It should not be excessively oversized to avoid stagnation due to inadequate turnover.**

Systems for boosting water pressure

Multi-storey buildings can usually be divided into zones of water pressure control. The lower two to three storeys can generally be supplied directly from the pressure in the public water main. Upper storeys, usually in groups of five to eight storeys, can be supplied from pressure-boosted main risers through a pressure reduction valve for each group.

Systems for boosting water pressure

Systems can be up-fed or down-fed. Up-fed systems usually originate from a pressure booster pump set or hydro pneumatic tank in the basement of the building. Down-fed systems usually originate from a rooftop gravity tank. Where a building is divided into water pressure zones, care must be taken not to cross-connect the piping between two or more zones. This is a particular problem when domestic hot water is recirculated from a central supply system.

Systems for boosting water pressure

Where hydropneumatic tanks are used for storage, the tank is filled to one third to a half full by a float level device that controls the drinking-water supply source (a well pump or pressure booster pump). The pressure is maintained at the desired operating level by an air compressor. As the building uses water from the tank, the water level and air pressure drop. When the water level drops to the “on” setting of the float level control, the well pump or booster pump starts and raises the water level in the tank to the “off” level. This restores the pressure in the tank.

Systems for boosting water pressure

If some of the captive air above the water has been absorbed by the water, the air compressor starts and restores the air charge, raising the system pressure to the normal level. Hydropneumatic tanks are typically made of steel or fibreglass and must be rated for the system operating pressure. Steel tanks must have a protective coating of suitable composition for drinking-water contact on the inside to protect the tank from corrosion and avoid contaminating the water. They should be checked on a regular basis to ensure that the protective coating is intact and the water remains potable.

Systems for boosting water pressure

Smaller hydropneumatic tanks can also be used to help control pressure booster pumps, allowing them to be cycled on and off by a pressure switch. The captive air within the tank keeps the system pressurized while the pump is off. When the water pressure drops to the “on” pressure setting, the pump starts and raises the volume and pressure of the water in the tank. No air compressor is needed where tanks have a flexible diaphragm between the air and the water in the tank, charged with air at initial start-up. The size of pressure tanks for booster pumps must match the capacity of the pump and the peak system demand so that the pump “off” cycle is longer than the “on” cycle and the pump does not cycle too frequently.

Drainage systems- Drainage system considerations

In the drainage system for a multi-storey building, the drains from the plumbing fixtures are connected to vertical drain stacks that convey the waste and sewage to below the lowest floor of the building. The fixture drain traps must be vented to prevent their water trap seal from being siphoned by negative pressure or blown out by positive pressure in the drain piping. The fixture vent pipes must extend through the roof to outdoors. They can be run individually or be combined into one or more vents through the roof. Where buildings are over 10 storeys high, the drainage stacks require relief vent connections at specified intervals from the top, and connected to a vent stack that terminates above the roof. This relieves and equalizes the pressure in the drainage stack to maintain the water seal in traps serving plumbing fixtures.

Drainage systems- Drainage system considerations

Wherever possible, the sanitary drainage system from a building should discharge to the public sewer by gravity. All plumbing fixtures located below ground level should be pumped into the public sewer or the drainage system leading to the sewer. **The pump line should be as short as possible and looped up to a point not less than 0.6 meters (24 inches) above ground level to prevent back siphonage of sewage.** The pump discharge rate should be controlled so as not to cause scouring of the internal bore of the pump line or the drainage or sewer system into which it discharges. High-velocity discharge rates may also cause the flooding of adjoining plumbing fixtures or overloading of the sewer itself. The sump pits for sewage pumps must have sealed covers, be vented to outdoors and have automatic level controls and alarms. Sewage pumps in multiple dwellings and in multi-storey dwellings should be duplex, with each pump having 100% of the required pumping capacity for the building. Alternatively, an approved vacuum drainage system may be considered.

Drainage systems- Vacuum drainage systems

In a vacuum drainage system, the differential pressure between the atmosphere and the vacuum becomes the driving force that propels the wastewater towards the vacuum station. Table 1 provides a summary of the advantages and disadvantages of vacuum drainage systems. Table 2 provides information on specific installation and operation requirements. Vacuum drainage systems should be considered when one or more of the following conditions exist:

- water shortage;
- limited sewerage capacity;
- where separation of black water and grey water is desired;
- where drainage by gravity becomes impractical;

Drainage systems- Vacuum drainage systems

- in penal installations where isolation and control of the appliances is necessary to prevent concealment of weapons and drugs;
- unstable soil or flat terrain;
- where a high water table exists;
- in hospitals, hotels, office buildings or other areas where congested usage occurs, and flexibility in pipe routing is required to drain appliances;
- restricted construction conditions;
- building refurbishment.

Hot water and other dual supply systems

Dual drinking-water supply systems are those in which two different grades of water are available in separate piping systems. An example is the provision of a tap at a sink supplying water directly from the incoming water service while all other fixtures are fed from a storage tank. In developed countries, the most common is a secondary system of piping carrying hot water to sink, washbasin and bath. Occasionally a water softener is installed to treat part of a domestic system, but apart from these cases dual drinking-water supply systems are rarely found within single dwellings. An approach to water conservation being introduced in some communities is to recycle greywater to an outside tap for irrigation uses. A principal concern of all dual systems is the assurance that no cross-connections have occurred during installation or repair.

Drainage systems- Vacuum drainage systems

TABLE 1: ADVANTAGES AND DISADVANTAGES OF VACUUM SYSTEMS (VERSUS GRAVITY SYSTEMS)

Advantages	Disadvantages
Low installation costs	High component costs
Environmentally safe	Mechanical components – possibility of failure
Electrical power only required at vacuum station	Skilled design, installation and maintenance required
Always self-cleansing	Regular maintenance required
No possibility of vermin in pipelines	Standby facilities required
Possible water-saving technique if vacuum toilets used	Require area for situation of vacuum tanks and vacuum generation equipment
High water velocities prevent deposits in pipework	High-velocity water may cause transient plumbing noise
Minimal risk of leakage	
Can use small-diameter lightweight pipes that can be installed without a continuous fall	
Vertical lifts are possible	
Ability to easily separate greywater and black water	
High turnaround time – no need for cistern to refill for subsequent flushes	

Drainage systems- Vacuum drainage systems

TABLE 2: COMPARISON OF INSTALLATION AND OPERATION REQUIREMENTS OF DRAINAGE SYSTEMS

Parameter	Conventional (gravity)	Conventional (pumped)	Vacuum
Pipe size (mm)	Branches 32–100 Stacks 100–150	Branches 32–100 Stacks 100–150	Discharge from valves 32–50 Service connection 38–90
Pipeline gradient	To a fall	To a fall	Flexible arrangements, with minimal gradients or saw tooth profile. Vertical upward flow sections lifts can be used
Maintenance requirements	Negligible, only after abuse or blockage	Regular planned servicing of pumps and interface units	Regular, planned servicing of pumps and interface units
Energy requirements	At time of installation	At time of installation and throughout lifetime of building	At time of installation and throughout lifetime of building
Retrofit or extension of system within building	May be difficult to accommodate pipework and falls	May require additional pumps	Flexible layout makes installation simple
Conventional water consumption WCs	7.5 litre flush WC	7.5 litre flush WC	NA
Low water consumption WCs	6 litre flush WCs	6 litre flush WCs	1.5–3 litre flush vacuum toilets
Loading of sewerage system	Dependent upon appliances installed	Dependent on pumping rate	Discharge from forwarding pumps can be timed to coincide with low-flow periods



Water storage vessels

Separate water storage vessels are an integral part of many dual supply systems. This section deals with requirements for the storage of water supplied from the water main or other drinking-water sources. In the design of these systems, it is important to ensure that the required air gap is established between the drinking water supply inlet and the overflow spill level of the fixture. Water storage tanks are appropriate for use in the following circumstances:

- sanitary flushing
- supply of drinking-water
- firefighting
- air-conditioning
- refrigeration
- ablutions
- prevention of cross-connections
- make-up water
- contingency reserve.



Water storage vessels

Requirements relating to installation and protection of water storage tanks:

- Tanks must be installed on bases, platforms or supports designed to bear the weight of the tank when it is filled to maximum capacity, without undue distortion taking place.
- Metal tanks (and other tanks when similarly specified) should be installed with a membrane of non-corrosive insulating material between the support and the underside of the tank.
- Tanks must be supported in such a manner that no load is transmitted to any of the attached pipes.
- Tanks must be accessible for inspection, repairs, maintenance and replacement.
- Tanks must be provided with a cover, designed to prevent the entry of dust, roof water, surface water, groundwater, birds, animals or insects.
- Insulation from heat and cold should also be provided.
- Tanks storing potable water should not be located directly beneath any sanitary plumbing or any other pipes conveying non-potable water.

Water storage vessels

Requirements relating to access to water storage tanks:

- Adequate headroom and side access must be provided to enable inspection, cleaning and maintenance of the interior and exterior of the tank.
- Where the interior depth of any storage tank exceeds 2 metres, access ladders of standard design should be installed and entry safety codes complied with.

Requirements relating to materials used in water storage tanks:

- The internal surfaces of tanks should be coated with a protective coating approved for drinking-water contact applied in accordance with the manufacturer's instructions if the tank is to supply drinking-water.
- Storage cylinders should be made of non-corrosive material.
- Tanks, pipes, heating coils and related fittings should all be of a similar metal to prevent electrolysis, which is more likely to cause corrosion in hot water systems than in cold.
- If steel is used for the tank and piping, it should always be heavily galvanized.

Labeling and color coding of non-drinking-water supply systems

Where the alternative supply is a non-potable drinking-water supply, it needs to be clearly and permanently labelled “Caution – not for drinking” at every outlet. Exposed piping must be identified by colour coding (lilac) and permanent markings or labelling. The use of the lilac (light purple) colour on pipes and outlet points has been adopted in some countries to warn that the contents being conveyed within are not for drinking purposes. In the United Kingdom greywater colours are green-black-green, and reclaimed water pipe colours are green-black-green with an additional white band in the centre.

Where the non-potable alternative supply is installed below ground, the service should have a continuous marker tape stating that the pipe below is a “Non-potable drinking-water supply – not for drinking”. The marker tape should be installed in the trench immediately above the service. Where piping conveys water downstream from a high or medium hazard, the backflow prevention device shall be clearly and permanently labelled “Caution – not for drinking” along its length. To further assist in identification, outlet points or taps should be painted or coated lilac and a label or sign should be fixed or erected immediately adjacent stating “Caution – not for drinking”.

Labeling and color coding of non-drinking-water supply systems

The level of potential cross-connection hazard rating should be classified by use of a method that allows easy identification of the risk level. A commonly used approach is to classify the contained fluids according to levels of risk from 1 (no risk or minimal risk) to 5 (highest risk).

Fluid category 1. Drinking-water supplied by the authority and complying with the plumbing code of practice.

Fluid category 2. Water in fluid category 1 whose aesthetic quality is impaired due to change in temperature or the presence of substances or organisms causing a change in taste, odour or appearance. This includes water in a hot water distribution system.

Fluid category 3. Fluid that represents a slight health hazard because of the concentration of substances of low toxicity. This includes any fluid that contains copper sulfate solution or similar chemical additives and sodium hypochlorite (as found in chlorine and common disinfectants).

Labeling and color coding of non-drinking-water supply systems

Fluid category 4. Fluid that represents a significant health hazard because of the concentration of toxic substances. This includes any fluid that contains chemical or carcinogenic substances or pesticides (including insecticides and herbicides) and organisms that pose a potential risk to health at concentrations sufficiently above drinking-water standards or guidelines.

Fluid category 5. Fluid that represents a serious health hazard because of the concentration of pathogenic organisms or radioactive or very toxic substances. This includes any fluid that contains faecal material or other human waste, butchery or other animal waste, or pathogens from any other source.



Situations where there is a risk of cross-connection

There are recognized risks of cross-connection in agricultural and horticultural properties, catering and allied trade installations, domestic installations, health and sanitary service installations, and in industrial and commercial installations. The level of protection required should be determined by identifying the hazards within the premises, then working upstream from each hazard. The water must be regarded as non-potable until a backflow prevention device is provided suitable to the degree of the rated hazard. If a cross-connection has been detected, the pipe system should be taken out of service, flushed, cleaned and disinfected, and the water tested and determined to be safe before it is put back into service. When assessing a potential backflow condition, consideration must be given to the complexity of piping, the possibility that the piping configuration has been altered and the possibility that negligent or incorrect use of equipment has resulted in a backflow condition. The following summarizes the main risks in each of these situations.

Agricultural and horticultural properties

In market gardens, poultry farms and dairy farms there is a risk of cross-connection between the water service and dam water, drinking nipples, fogging sprays, irrigation pipes, antibiotic injectors, cleansing injectors, vertical sprays for vehicle washing or any submerged outlet or hose at tanks or feed troughs.

Catering and allied trade installations

In commercial kitchens, hotels and clubs there is a risk of cross-connection between the water service and water-cooled refrigerant units containing methyl chloride gas or any submerged outlets or hoses that connect to glasswashers and dishwashers, bains-marie, food waste disposal units, garbage can washers, ice-making machines or refrigerators, or hoses supplying water to sinks or other receptacles.

Domestic installations

In domestic installations, there is a risk of cross-connection of the water service to a haemodialysis machine, bidet, water-operated venturi-type ejectors attached to garden hoses when used to empty or clean out wastewater pits, septic tanks, gullies or trenches, storm water sumps, domestic grease traps, or any submerged outlets, or discharge point of the water service in sanitary flushing cisterns, garden hoses supplying water to swimming pools, ornamental ponds, fish ponds, hose taps below the flood level rim of any fixture, or located below ground surface level.

Health and sanitary service installations

These installations include the following risks of cross-connection:

- council sanitary depots: cross-connection between the water service and sanitary pan washers, truck washers and pan-dumping machines;
- dental surgeries: any submerged outlets of the water service connected to chair bowls and venturi-type water aspirators;
- funeral parlours: in embalming areas, the cross-connection between the water service and water-operated aspirator pumps;
- hospitals and nursing homes: submerged outlets of the water service at bed pan washers, bed bottle washers, sterilizers, steam autoclaves, instrument washers, and any cross-connection between the water service and steam pipes, steam boilers or steam calorifiers;
- mortuaries: postmortem areas, submerged water service outlets at autopsy tables, flushing rim floor gullies or trenches, specimen tables and instrument-washing sinks.

Industrial and commercial installations

A common site of cross-connection relates to the use of tanks. Any submerged discharge point of hoses or pipes that supply water to rinse tanks, process tanks and other tanks may pose a cross-connection risk. The industries and commercial installations that carry a risk of cross-connection in these installations include the following:

- abattoirs: cross-connection between the water service and steam pipes, steam boilers or steam calorifiers, and the washing sprays in contact with animal carcasses;
- bleaching works: cross-connection between the water service and steam pipes, steam boilers, steam calorifiers, or any submerged outlets at revolving drum washers, or any pipes conveying non-potable water;
- breweries and cordial and soft drink plants: cross-connection between the water service and the contents of gas cylinders, steam pipes, steam boilers or steam calorifiers, or any submerged water service outlets at drum washers, bottle washers or process tanks;

Industrial and commercial installations (Cont.)

- butcher shops: cross-connection between the water service and any water-cooled refrigerant units containing methyl chloride gas, or water-powered food-processing machines;
- chemical plants: cross-connection between the water service and chemical pipelines, or the submerged water service pipe outlets at drum washers and process tanks;
- dry cleaners: cross-connection between the water service and solvent stills;
- dyeing works: cross-connection between the water service pipes and steam

Industrial and commercial installations (Cont.)

- pipes, foul water inlet sprays in process tanks, and any submerged water service pipe outlets at vats, tanks and colanders;
- engineering works: cross-connection between the water service and any steam boilers, diesel oil recirculating systems, recirculated cooling water for machines, testing pressure vessels, oil-cooling coils, pump priming, compressed air pipelines and venturi-type ejectors in vehicle maintenance pits;
 - laboratories: cross-connection between the water service and any aspirator pumps, fume cupboards, stills, centrifuges, blood-testing machines, air scrubbers, test-tube-washing machines, animal feeding troughs, and high-pressure gas cylinders;
 - laundries: cross-connection between the water service and any clothes-washing machines, starch tanks, soap-mixing vats, and recirculated hot water tanks;

Industrial and commercial installations (Cont.)

- milk-processing plants: cross-connection between the water service and any steam pipes, steam boilers, steam calorifiers, or any submerged outlets at bottle-washing machines, milk can-washing machines, and process chilling tanks;
- oil storage depots: cross-connection between the water service and foam firefighting equipment;
- poultry-processing plants: cross-connection between the water service and any steam pipes, steam boilers, steam calorifiers, or any submerged outlets at feather-plucking machines, carcass-washing machines, offal boilers and process tanks;
- photographic developers: cross-connection between the water service and X-ray equipment, or any submerged outlets at tanks and rinse machines;
- plating workings: cross-connection between the water service and solvent, acid or alkali tanks, cooling coils, steam pipes, or any submerged outlets at tanks and rinse machines;
- tanneries: cross-connection between the water service and vats, drum process tanks or steam pipes;

Fixture unit calculations for multiple dwellings

The fixture unit concept is a method of calculating drinking-water supply and drainage piping requirements within large buildings where economies may be made in construction costs. Theoretically all pipes should be of such a size as to be capable of serving the fixtures to which they are connected when all other fixtures in the building are being operated at the same time. In practice, the chances of their simultaneous use are remote and the piping design criteria may be relaxed to some degree.

A fixture unit (f/u) value is assigned to each type of fixture based on its rate of water consumption, on the length of time it is normally in use and on the average period between successive uses. Some examples of fixture unit values assigned to the most common fixtures are given in Table 3. When these are added their total gives a basis for determining the flow that may be expected in a water or drainage pipe to which two or more fixtures are connected. The total is then reduced by a factor, usually in the order of 0.6 to 0.7, but depending upon the margin of simultaneous use protection necessary under local conditions (Taylor & Wood 1982).

Fixture unit calculations for multiple dwellings

The total number of fixture units connected to each branch pipe is then added, multiplied by the factor referred to above, and the result used to calculate the flow in water or drainage pipes in accordance with tables such as the following examples. If included in, or annexed to, a plumbing code, these tables should be detailed for a larger schedule covering the whole range of fixture unit values to be expected; examples may be found in various national codes.

TABLE 3 FIXTURE UNIT VALUES FOR SOME COMMON PLUMBING FIXTURES

Fixture	Fixture units
Bath or shower	2
Bidet	2
Clothes washer (automatic)	3
Drinking fountain	3
Kitchen sink	1.5
Urinal or water closet (with flush tank)	3
Urinal or water closet (with flush valve)	6
Washbasin	1

Source: Taylor & Wood 1982 (p. 153).

Fixture unit calculations for multiple dwellings

From Table 4 the size of the water pipes may be calculated using normal design principles (allowing for head loss, friction and other factors). Fixtures using both hot and cold water (such as in baths and sinks) should be assumed to take equal quantities of each for design purposes: a bath would be counted as one fixture unit on the cold water system, and one fixture unit on the hot water. Supply piping would be calculated accordingly, while the total figure of two fixture units would be used to design the drainage piping.

TABLE 4 PEAK WATER DEMAND OF PLUMBING FIXTURES

No. of fixture units	litres per second	US gallons per minute	UK gallons per minute
5	0.23	3.65	3.04
10	0.34	5.39	4.49
20	0.54	8.56	7.14
50	1.13	17.94	14.93
100	1.67	26.51	22.07

Source: Taylor & Wood 1982 (p. 153).

Fixture unit calculations for multiple dwellings

From Table 5 the size of internal and external drains may be calculated according to the total number of fixtures discharging into each section, with the proviso that underground drains shall not be smaller than 100 millimeters (4 inches) diameter, and that no internal branch or drain of less than 80 millimeters (3 inches) diameter should carry the discharge of more than two water closets.

TABLE 5 MAXIMUM LOADS FOR HORIZONTAL FIXTURE BRANCHES AND BUILDING DRAINS OR SEWERS

Diameter of drainpipe		Fixture branch	Building drain or sewer			
mm	inches	Min. slope 2% (1 in 50) f/u ^a	Slope 0.5% (1 in 200) f/u ^a	Slope 1% (1 in 100) f/u ^a	Slope 2% (1 in 50) f/u ^a	Slope 4% (1 in 25) f/u ^a
32	1.25	1	—	—	—	—
40	1.5	3	—	—	—	—
50	2	6	—	—	—	26
65	2.5	12	—	—	—	31
80	3	32	—	36	42	50
100	4	160	—	180	216	250
150	6	620	—	700	840	1000
200	8	1400	1400	1600	1920	2300

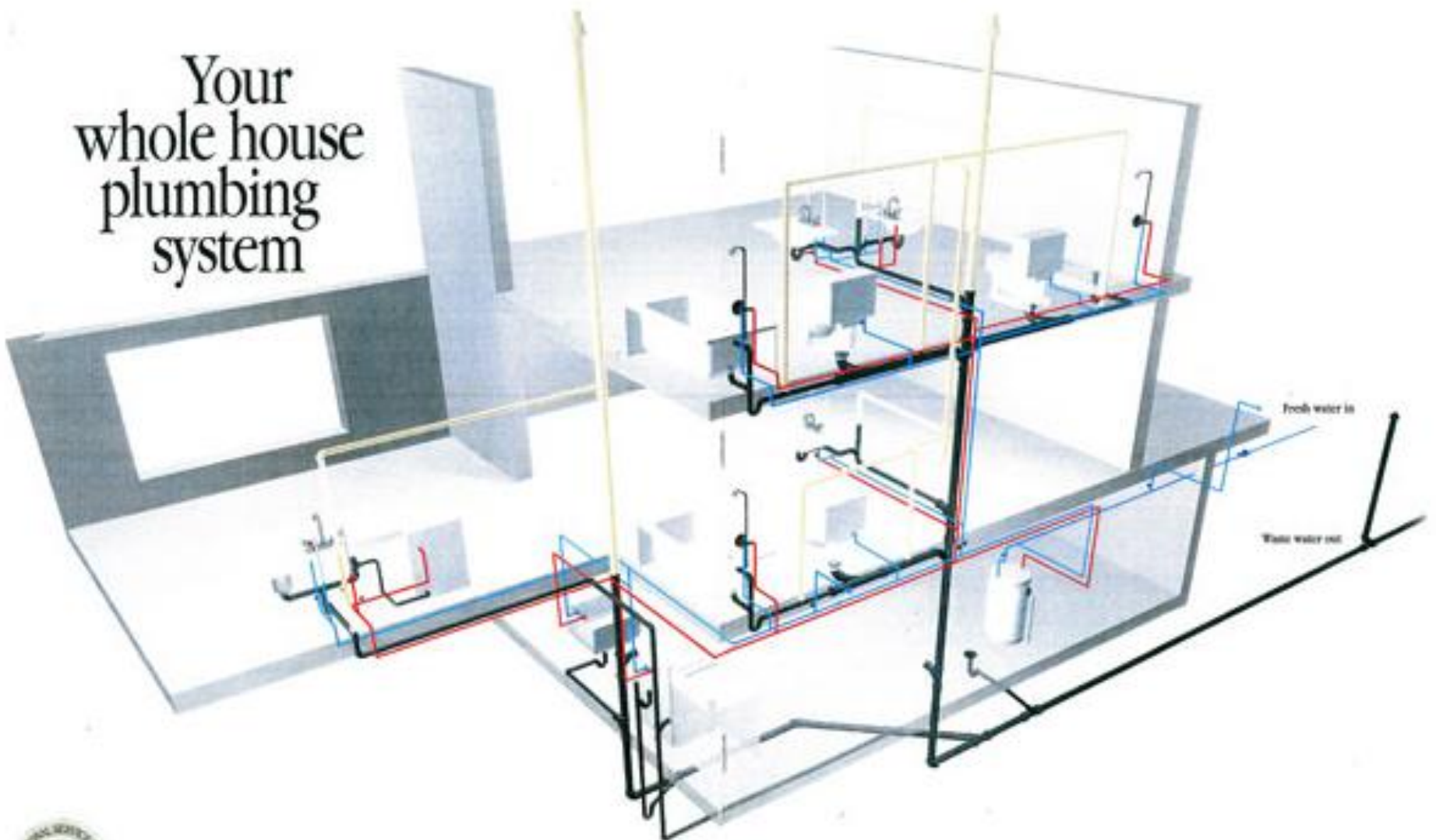
^a f/u = fixture units.

Fixture unit calculations for multiple dwellings (Cont.)

An alternative to the fixture unit method for calculating flows is used in some French-speaking countries. This method assigns individual flow values to each fixture, multiplies the cumulative flow so obtained by a simultaneous use factor obtained from a monogram and curve, and selects pipe sizes by reference to precalculated tables.



Your whole house plumbing system



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