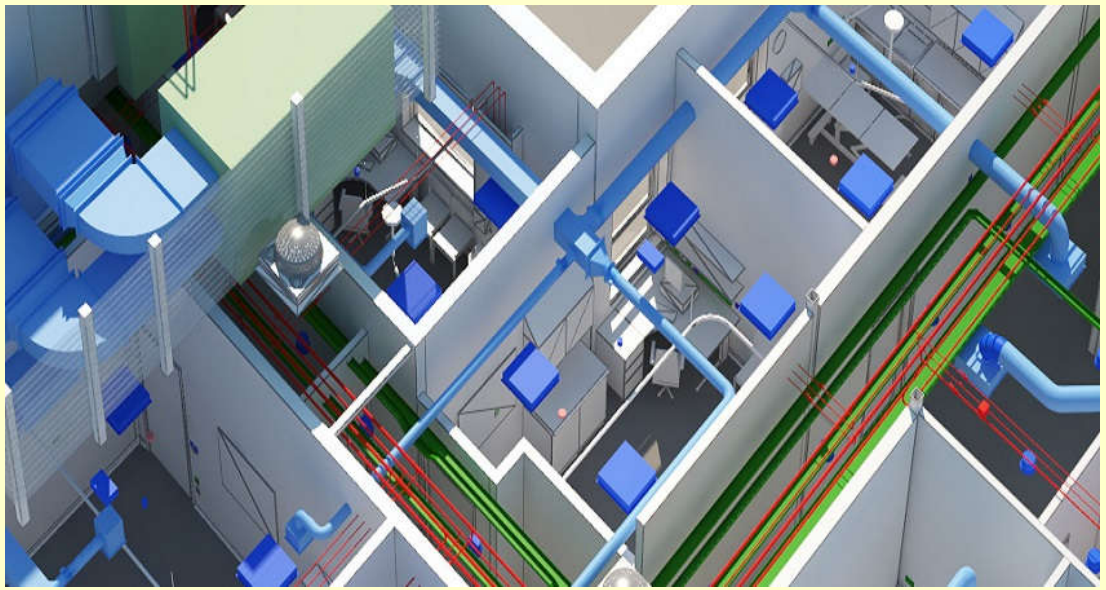

4. Plumbing and Drainage Part 2

4.2 Practical examples

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Mar 2021

Contents 內容

- Plumbing installations
- Drainage installations
- Plumbing works submissions
- Operation & maintenance

Hong Kong's lead-in-drinking-water incidents 香港食水含鉛事件

Water checks widen as more lead found

Amy Nip

The lead-in-water scare widened yesterday, with Wing Cheong Estate in Sham Shui Po becoming the latest victim.

The discovery comes as the Secretary for Transport and Housing Anthony Cheung Bing-leung announced that water checks are to be extended to another 12 public housing estates that were completed in 2011 and 2012.

"We have decided to expand the scope to all estates completed since 2011," Cheung said. "It involves an additional 12 estates comprising 35 blocks and 26,000 flats."

After lead in water was found at Kai Ching Estate in Kowloon City, Kwai Luen in Kwai Tsing and Shui Chuen O in Sha Tin, the govern-

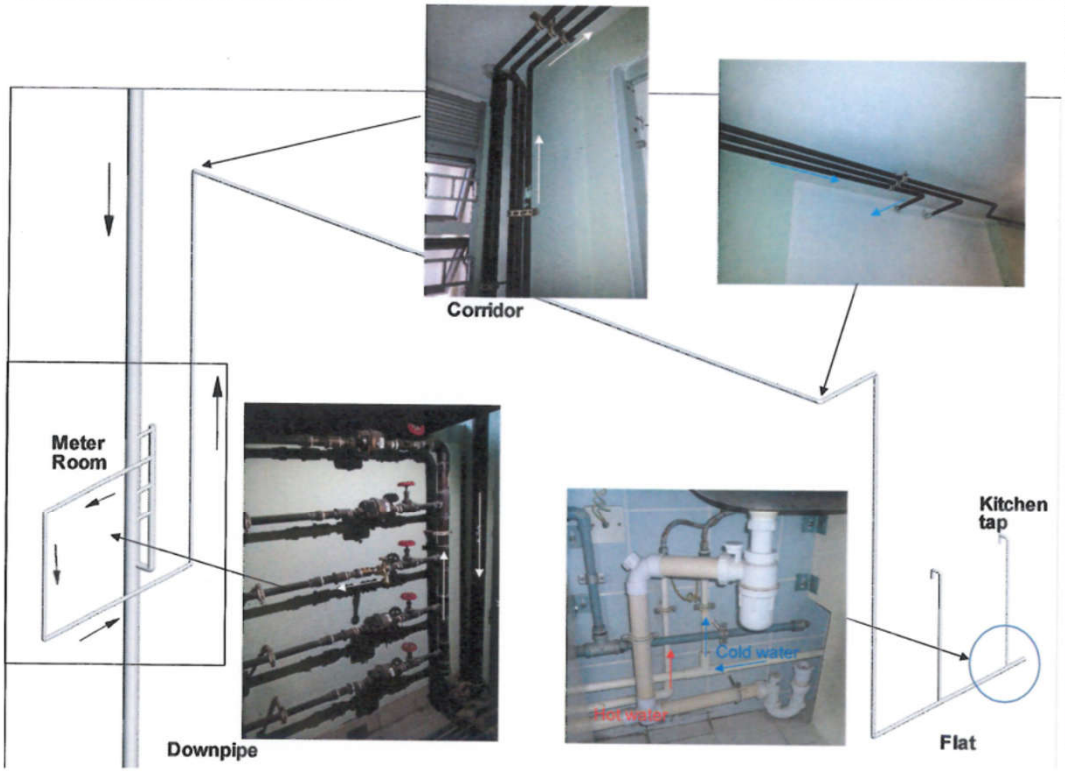
Wing Cheong is the latest public estate dragged into the contaminated water scandal. SING TAO

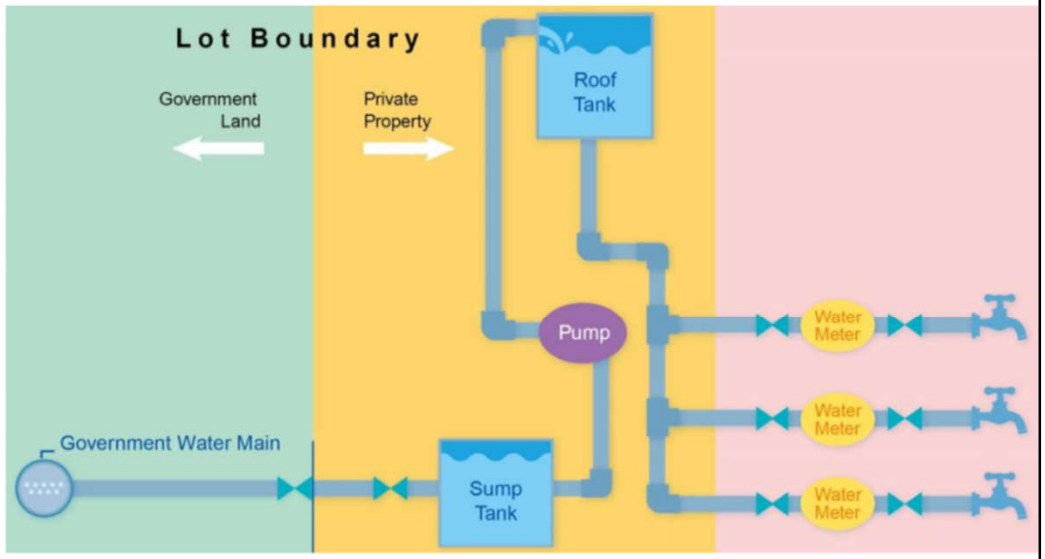
contractor of Wing Cheong Estate and Golden Day Engineering was responsible for pipe works. The plumber was not named yesterday.

The companies are different to those responsible for the construction at Kai Ching and Kwai Luen. At Wing Cheong, water tanks have been arranged for each block and bottled water is provided for the vulnerable.

The 12 estates to have their water tested are Shin Ming, Tin Ching, Sha Tin Pass, Yan On, Choi Tak, Choi Fook, Yau Lai, Hung Hom, Tung Wui, Shek Kip Mei Estate, Lower Ngau Tau Kok and Un Chau.

Cheung said after tests at the additional 12 estates were completed, he would not rule out further extending the coverage of water tests to more public estates.



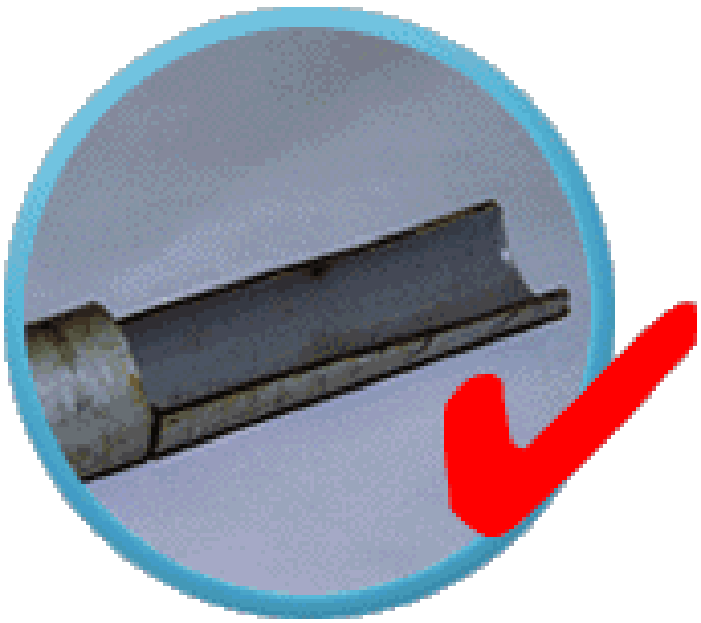


(Source: https://www.isd.gov.hk/drinkingwater/)

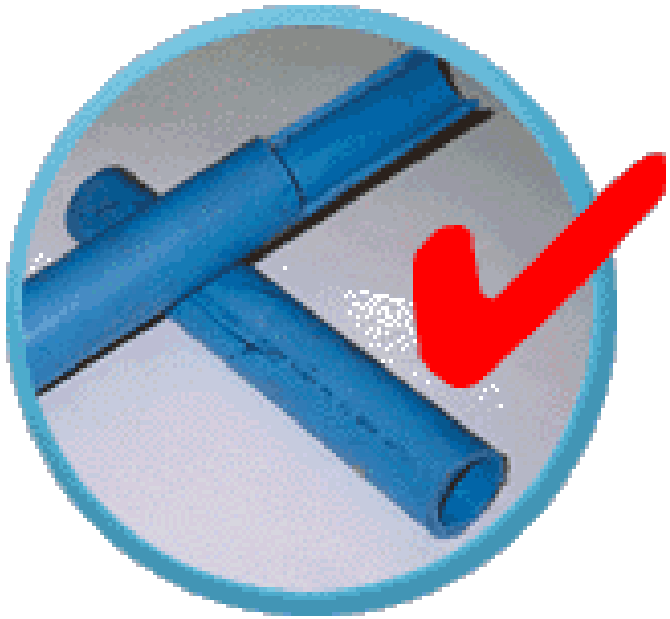
Plumbing installations

- Commonly used pipe materials, such as:
  - Copper (BS EN 1057)
  - Galvanised iron (GI) w/ PVC-C lining (BS 1387)
  - PVC, unplasticized PVC, PB, PE, PE-X
  - Stainless steel (BS 4127)
  - Ductile iron (BS EN 545) (for pipe dia. > 80 mm)
  - Mild steel (for pipe dia. > 600 mm)
- * Plastic material generally will degrade on prolonged exposure to ultra-voilet light

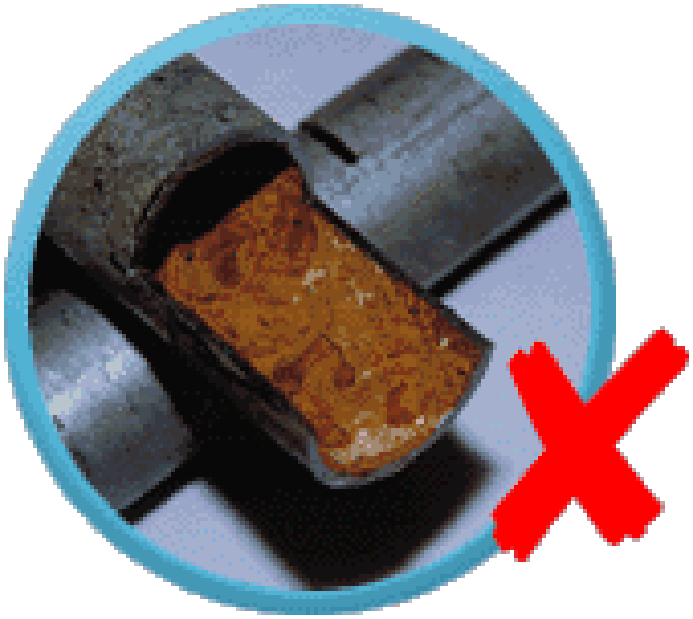
Copper pipe



Lined galvanized steel pipe



Polyethylene pipe



Rusty unlined galvanized steel pipe

(Source: Water Supplies Department, www.wsd.gov.hk)

Applicable materials for fresh water and salt water inside service

Pipe/ Pipe fitting material	Fresh Water Inside Service		Salt Water Inside Service(1)
	Cold Water	Hot Water	
Copper	✓	✓	✗
Ductile iron (with internal coating)	✓	✓	✓
Polyethylene (PE)	✓		✓(2)
Polyethylene-cross-linked (PE-X)	✓	✓	✗
Plastic lined steel (PVC-C lining)	✓	✗	✗
Plastic lined steel (PVC-U/ PE lining)	✓	✗	✗
Polyvinyl chloride - chlorinated (PVC-C)	✓	✓	✗
Polyvinyl chloride - unplasticized (PVC-U)	✓		✓
Stainless steel	✓	✓	✗

✓ : Suitable for use when the relevant standards are complied with in general

✗ : Not suitable for use in general

(1) : Suitable location(s) for installation may refer to fresh water inside service

(2) : When installed in exposed condition, black pipe and pipe fittings shall be used.

(Source: Water Supplies Department, www.wsd.gov.hk)

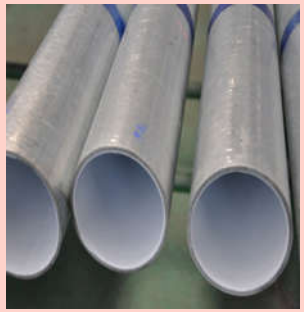
Comparison of difference types of pipe materials

Pipe Material		Advantages	Disadvantages
Copper Pipe (BSEN 1057)*		- High pressure capability - Good formability - Good corrosion resistance - High strength and durability to withstand external loading - Ease of jointing - Suitable for conveying hot water - Readily available in local market	- Soft water can cause internal corrosion attack of copper pipes giving rise to 'blue' water
Stainless Steel Pipe (BS 4127)*		- High pressure capability - Good corrosion resistance - High strength and durability - Ease of jointing - Suitable for conveying hot water	

* Commonly used in Hong Kong

[Source: Mr. Eddy Chan of ATAL]

Comparison of difference types of pipe materials

Pipe Material		Advantages	Disadvantages
Lined Galvanized Steel (PVC-U, PVC-C, PB, Polyethylene or Epoxy Resin Lining)*		- Good resistance to internal corrosion and encrustation - Smooth internal surface to give better flow characteristic - Readily compatible with existing commonly used unlined steel pipe	- Heavy weight - Susceptible to impact damage, greater care required in handling - The cutting, threading, chamfering and jointing of the piping system demands higher skill and is susceptible to poor installation practice.
PVC-U (Unplasticised Polyvinyl Chloride) Pipe (BS3505 Class E)*		- Good corrosion resistance - Light weight - Ease of jointing - Low cost - Smooth internal surface giving low frictional resistance and preventing scale build-up - Readily available in local market	- Brittle, susceptible to impact damage - Long drying time of solvent cement in jointing - Low abrasion resistance - Susceptible to permeation /degradation by certain organic contaminants - UV degradation on prolonged exposure to direct sunlight

* Commonly used in Hong Kong

[Source: Mr. Eddy Chan of ATAL]

Comparison of difference types of pipe materials

Pipe Material		Advantages	Disadvantages
MDPE (Medium Density Poly Pipe (BS6572 and BS 6730)*	 	- Good corrosion resistance - Good formability - Fusion and mechanical joint available - Low frictional resistance - Strong and tough - Flexible and durable, light and easy to handle - Good resistance to impact - Light weight	- Fusion jointing requires skilled installers and special equipment (electricity supply is required) - Subject to creep - Strength decreasing with time though at a very slow rate - MPDE pipes made by different manufacturers may not be compatible for direct fusion jointing - Susceptible to ultra-violet degradation on prolonged exposure to direct sunlight - Susceptible to permeation /degradation by certain inorganic and organic contaminants
PVC-C (Chlorinated Polyvinyl Chloride) pipe (BS 7291)		- Good corrosion and chemical resistance - Light weight - Smooth bore giving low frictional resistance and preventing scale build-up - No galvanic or oxidative corrosion - Can be connected to other materials easily - Suitable for conveying hot water	- Brittle, susceptible to impact damage - Long drying time of solvent cement in jointing - Can be flammable - Reduction in strength and rigidity with increase of temperature - Susceptible to permeation /degradation by certain organic contaminants - Susceptible to ultra-voilet degradation on prolonged exposure to direct sunlight - Susceptible to poor installation practice

* Commonly used in Hong Kong

[Source: Mr. Eddy Chan of ATAL]

Comparison of difference types of pipe materials

Pipe Material		Advantages	Disadvantages
PE-X (Crosslinked Polyethylene) Pipe (BS7291)		- Light weight - Good corrosion and chemical resistance - Smooth bore giving low frictional resistance and preventing scale build-up - Can withstand an excessive temperature of up to 120°C for a short period - Flexible, can be cold bent - Suitable for conveying hot water	- Subject to creep - Susceptible to ultra-voilet degradation on prolonged exposure to direct sunlight - Can only be jointed together by mechanical jointing - Can be flammable
PB (Polybutylene) Pipe (BS7291)		- Good corrosion and abrasion resistance - Flexible, can be cold bent - Durable, light and easy to handle and repair - Smooth internal surface giving low resistance to flow and preventing scale build-up - High temperature resistance - Can be welded to form a leak free system (the British Standard has not yet been amended to include this aspect) - Suitable for conveying hot water	- Susceptible to ultra-violet degradation on prolonged exposure to direct sunlight - Susceptible to corrosion attack by organic solvents - Reduction in strength with increase of temperature - Subject to creep

[Source: Mr. Eddy Chan of ATAL]

Comparison of difference types of pipe materials

Pipe Material		Advantages	Disadvantages
ABS (Acrylonitrile Butadiene Styrene) pipe (BS 5391)		- Ability to absorb impact energy without failure - Ductile compared with PVC-U and PVC-C - Light and durable - Good resistance to corrosion - Smooth internal surface giving low resistance to flow and preventing scale build-up - No galvanic or oxidative corrosion	- Reduction in strength and rigidity with increase of temperature - Susceptible to slight surface degradation on prolonged exposure to direct sunlight - Susceptible to corrosion attack by organic solvents - Susceptible to poor installation practice - Long drying time of solvent cement in jointing
PEX-AL-PEX (Crosslinked Polyethylene/ Aluminium / Crosslinked Polyethylene) Composite Pipe		- Can be exposed to direct sunlight (black pipe) - Can withstand an excessive temperature of up to 110°C for a short period - Light weight - Can be cold bent to a minimum of five times of its diameter - Smooth internal surface giving low resistance to flow and preventing scale build-up - The pipe is not permeable to oxygen which cannot thus enter recirculating water and be deleterious to other system components - Suitable for conveying hot water - No galvanic or oxidative corrosion	- Can only be jointed together by mechanical jointing - Susceptible to corrosion attack by organic solvents - Susceptible to ultra-violet degradation (except black pipe) on prolonged exposure to direct sunlight

[Source: Mr. Eddy Chan of ATAL]

Comparison of difference types of pipe materials

Pipe Material		Advantages	Disadvantages
PEX-AL-PE (Crosslinked Polyethylene/ Aluminium / Polyethylene) Composite Pipe		- Light weight - Good corrosion and chemical resistance - Smooth bore giving low frictional resistance and preventing scale build-up - Can be cold bent to a minimum of five times of its diameter - No galvanic or oxidative corrosion	- Susceptible to ultra-violet degradation on prolonged exposure to direct sunlight - Can only be jointed together by mechanical jointing - Susceptible to corrosion attack by organic solvents
Ductile Iron Pipe (BSEN 545)*		- High pressure capability - Good corrosion resistance - High strength and durability - Ease of jointing	- Heavy weight - Susceptible to impact damage, greater care required in handling

* Commonly used in Hong Kong

[Source: Mr. Eddy Chan of ATAL]

Examples of pipe supports and hangers

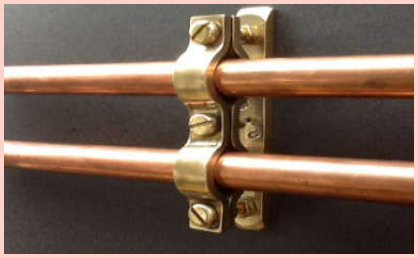
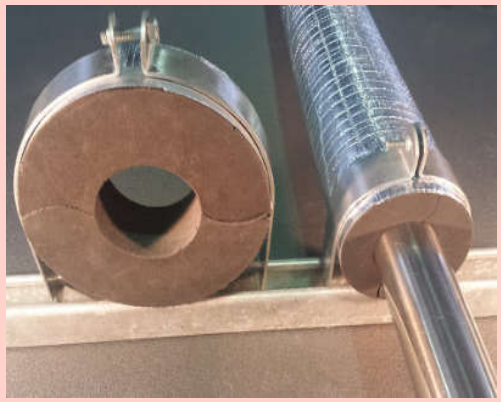
Photo: Double bolt pipe hanger	Photo: Brass pipe clamp bracket wall mount	Photo: Copper pipe hanger
		

Photo: 304 Stainless Steel Pipe Bracket	Photo: Acoustic Spring Hanger	Photo: Pipe hanger with thermo-insulation
		

[Source: Mr. Eddy Chan of ATAL]

Plumbing installations

- Pipes & fittings for plumbing systems
  - Water supply pipes & fittings with valid General Acceptance (GA)
  - Applicable standards
  - Voluntary GA labelling scheme for plumbing products
  - Voluntary quality assurance information scheme (GA+)
  - Voluntary low metal leaching rate pipes and fittings scheme (GA*)

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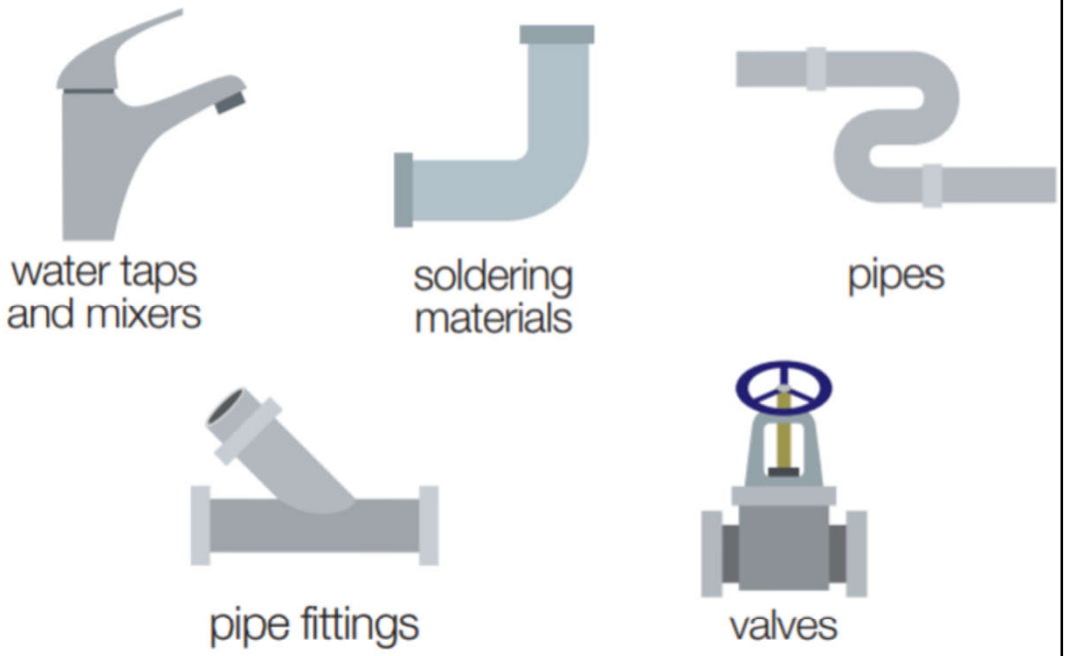
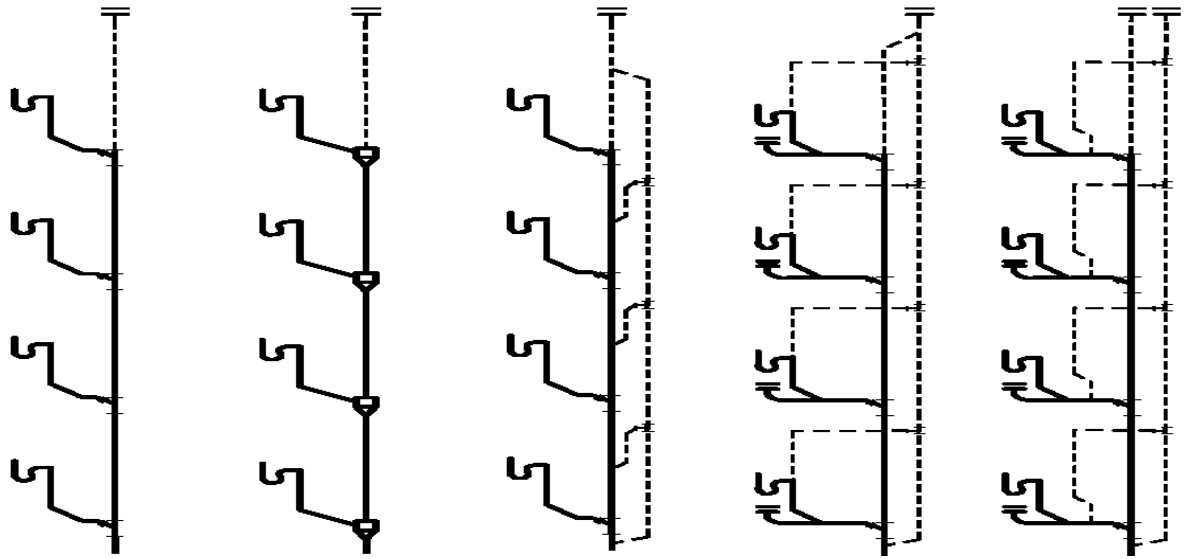
(Source: https://www.wsd.gov.hk/en/plumbing-engineering/pipes-and-fittings-to-be-used-in-inside-service-or/)

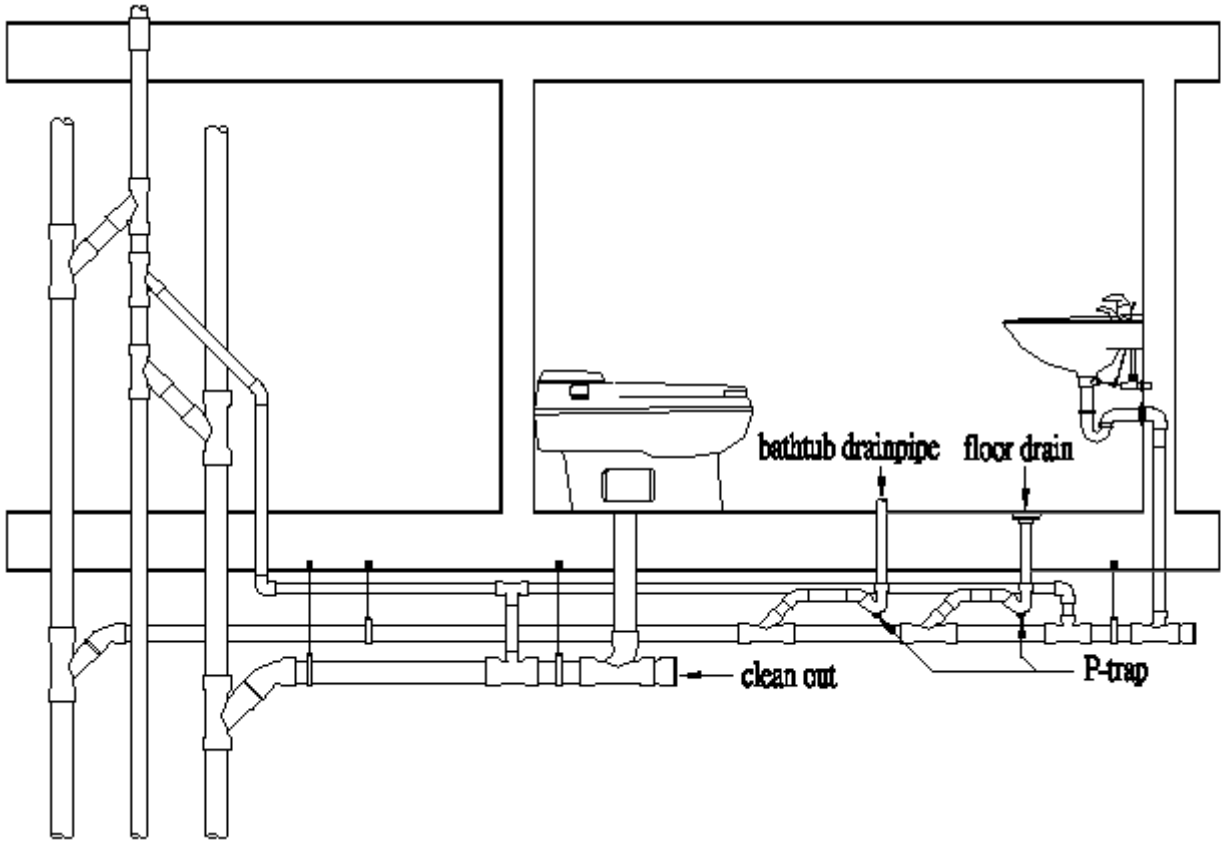
Voluntary GA (General Acceptance) Labelling Scheme for plumbing products

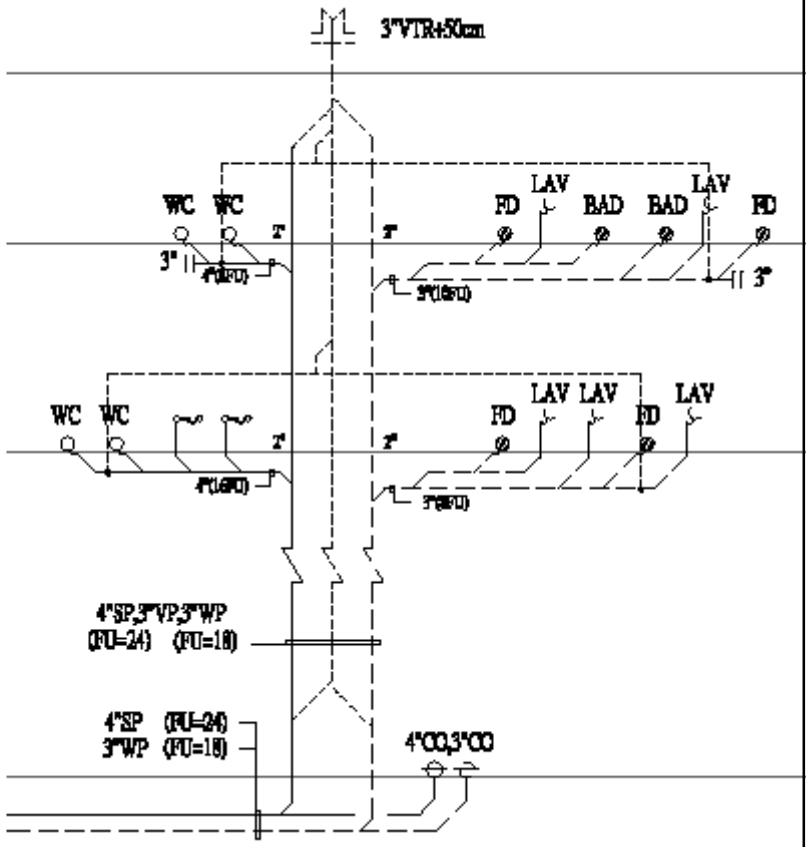


(Source: https://www.wsd.gov.hk/en/plumbing-engineering/pipes-and-fittings-to-be-used-in-inside-service-or/voluntary-ga-shop-scheme/)

Schematic diagrams and design of building drainage systems

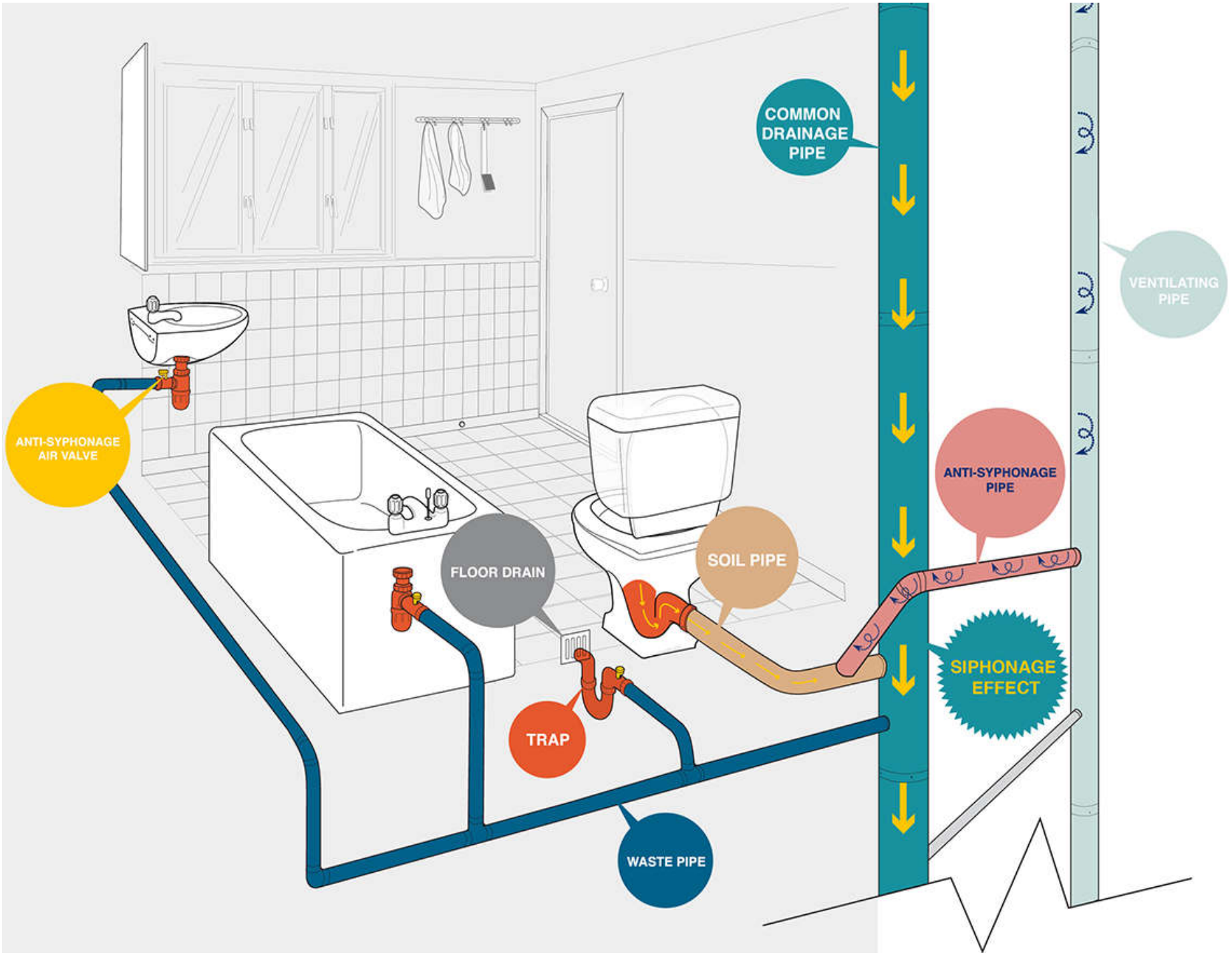






(Source: https://www.irbnet.de/daten/iconda/CIB10559.pdf)

Traps and anti-siphonage pipes/air valves in drainage system

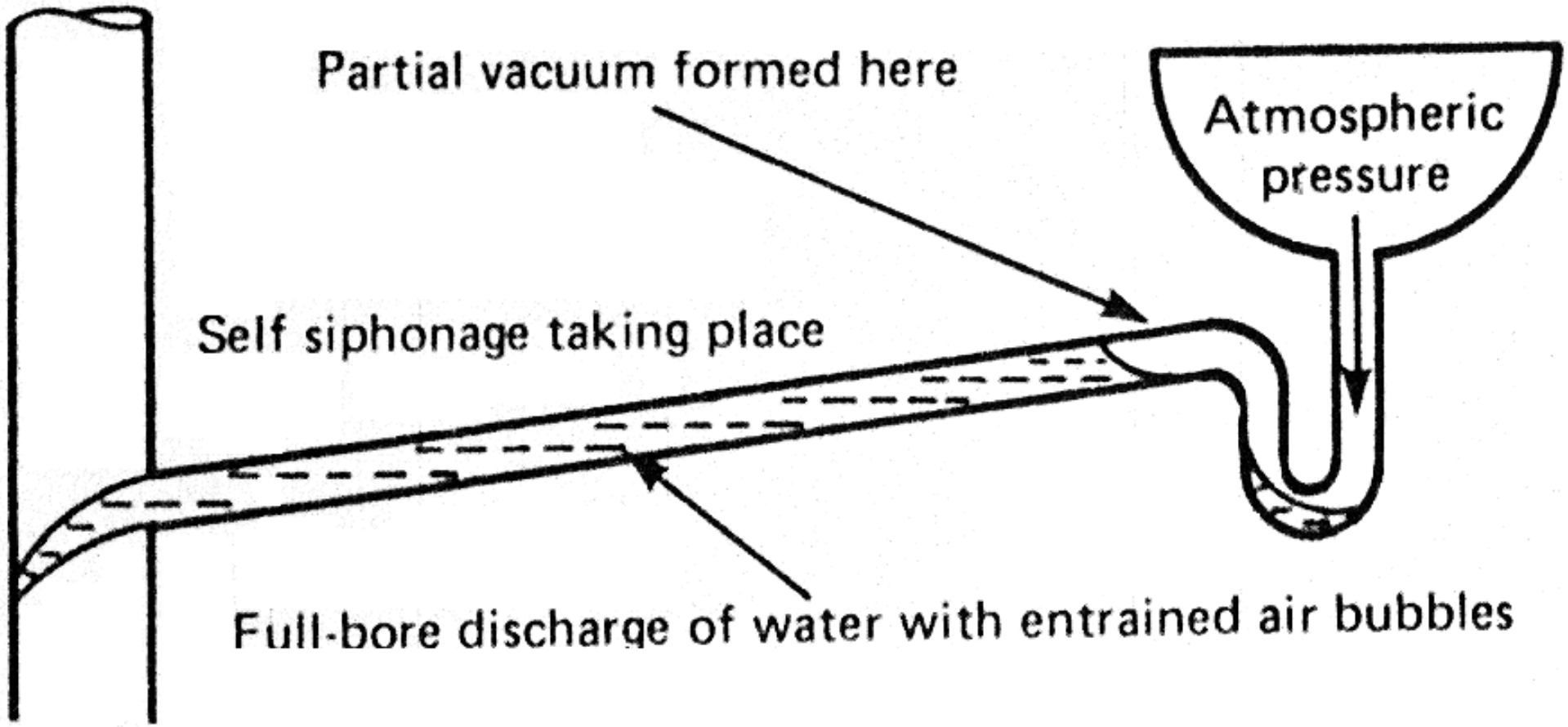


(Source: Buildings Department)

Drainage installations

- Loss of water seal can occur through:
  - Self-siphonage
  - Induced siphonage
  - Compression or back pressure
  - Capillary action
  - Wavering out
  - Other causes:
    - Evaporation, cross-flow, bends and offsets, surcharging, intercepting traps, leakage

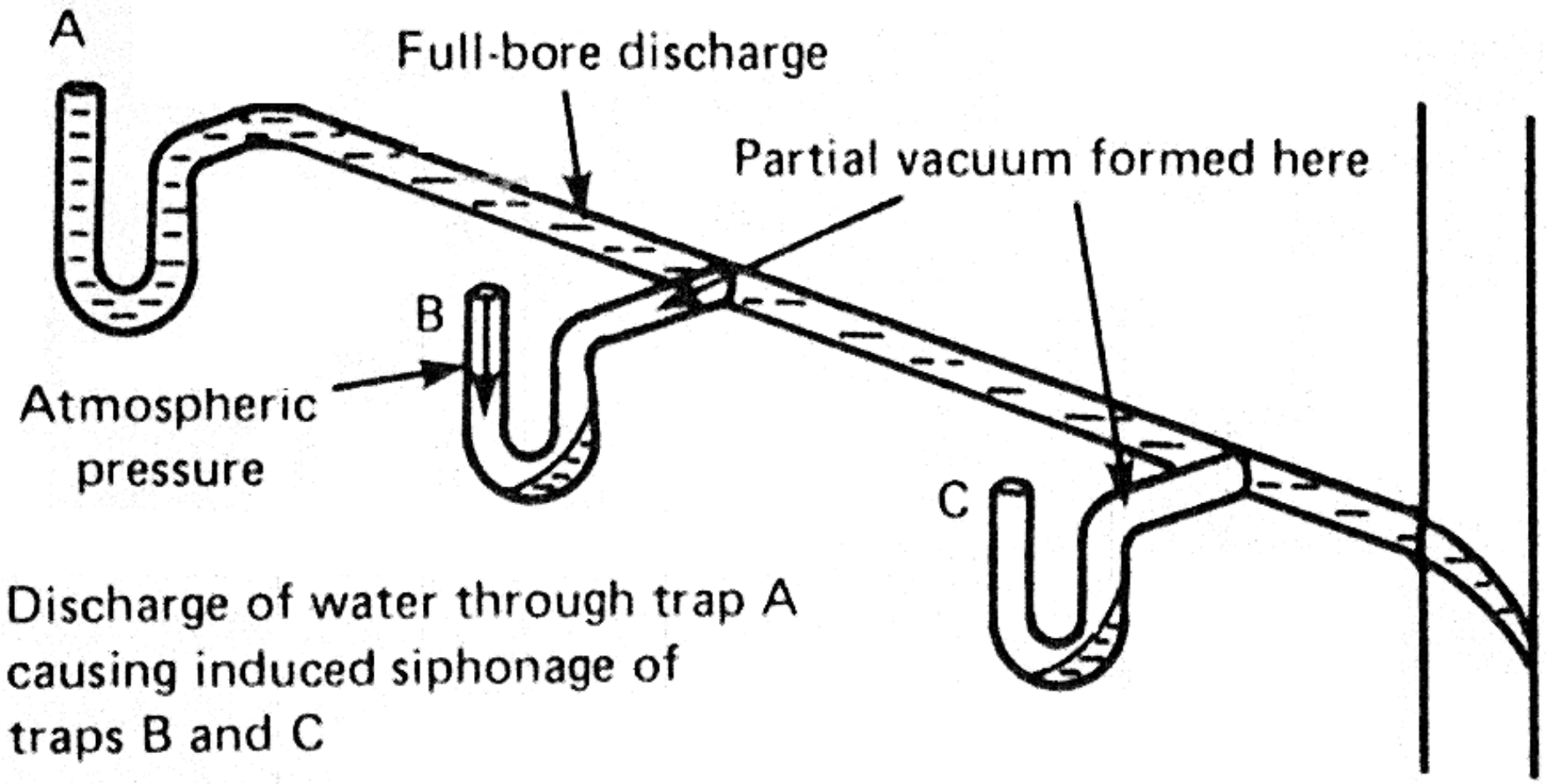
Self siphonage



- Caused by: a moving plug of water in the waste pipe
- Avoided by: placing restrictions on lengths and gradients and venting long or steep gradients

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

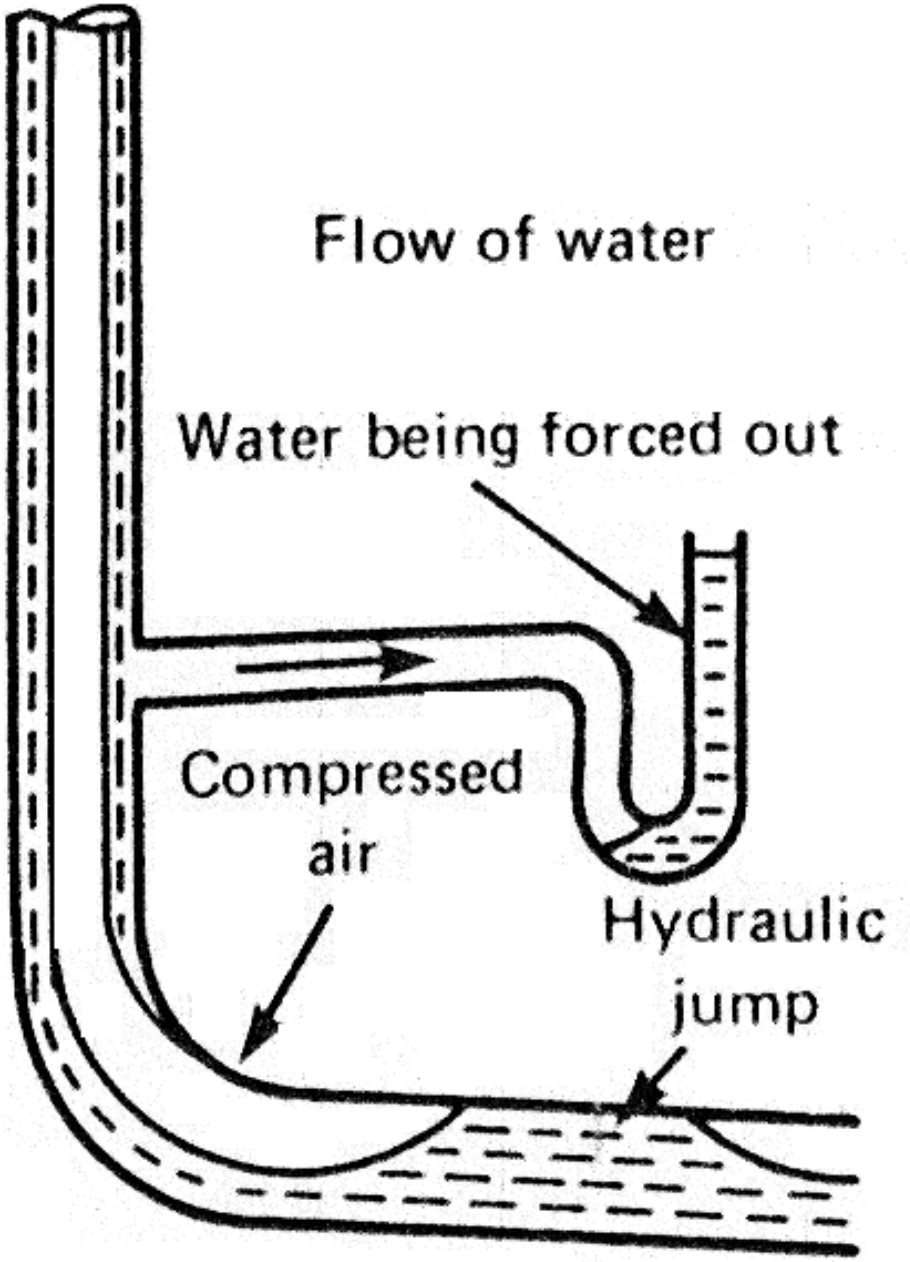
Induced siphonage



- Caused by: discharge from one trap
- Overcame by: design of the pipe diameters, junction layouts and venting arrangements

(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Compression or back pressure

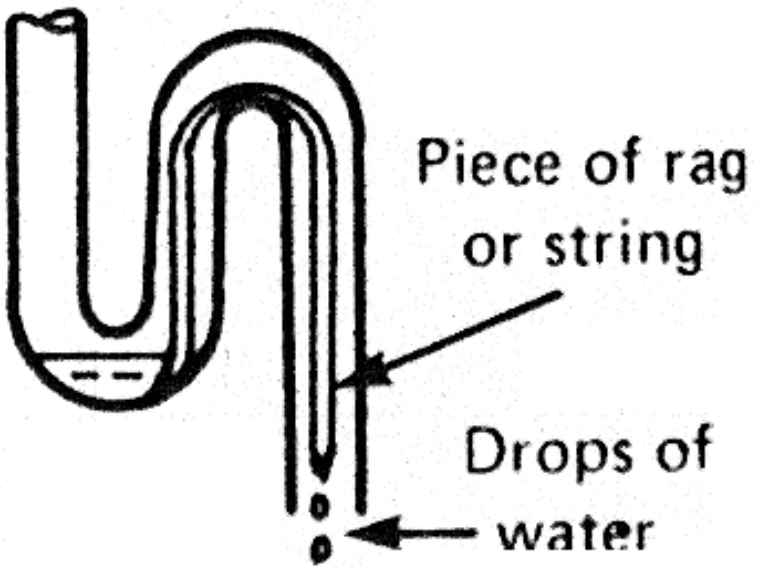


- Water flowing → compresses air in pipe → forces out the trap water seal

- Prevention: waste pipes not connected to the lower 450 mm of vertical stacks (measured from the bottom of the horizontal drain); waste discharges at the lower floors must be connected separately to drain

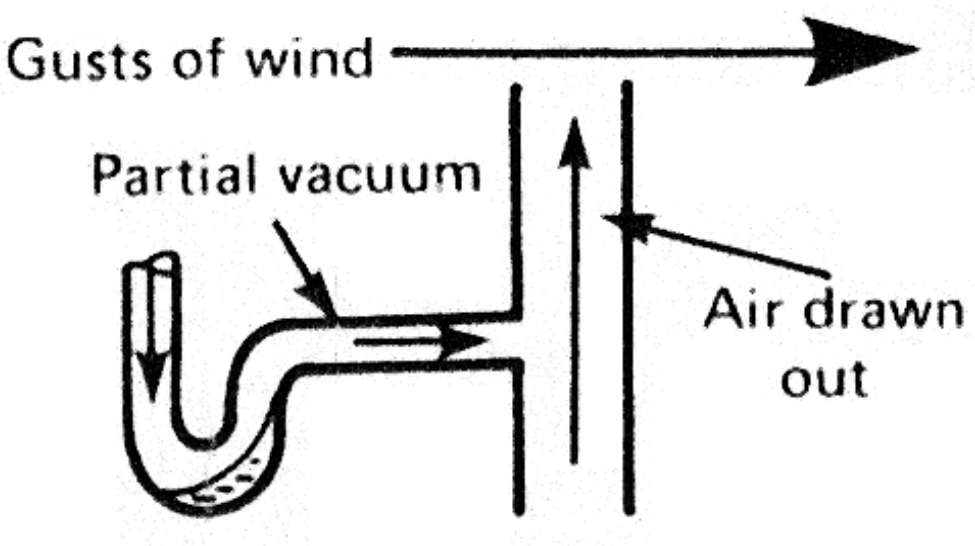
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Capillary action



- A piece of rag or string caught on the outlet of the trap
- Additional maintenance should be carried out in high-risk locations

Wavering out



- Gusts of wind blowing across the top of a stack
- Site the vent terminal away from areas with troublesome effects

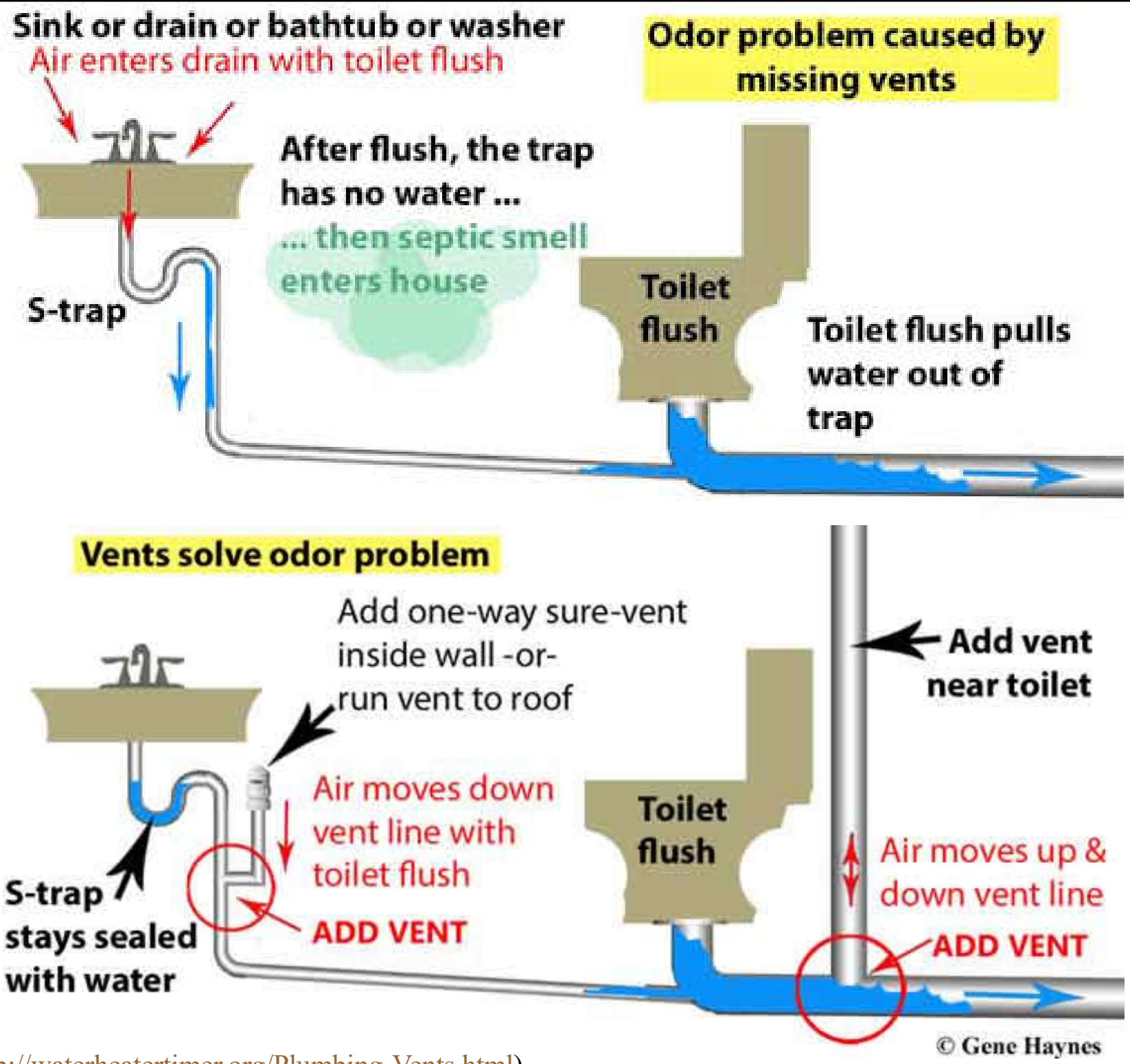
(Source: Hall, F. and Greeno, R., 2008. *Building Services Handbook*)

Drainage installations

- Loss of water seal (cont'd)
  - Evaporation:
    - About 2.5 mm of seal loss per week while appliances are unused
  - Bends and offsets:
    - Sharp bends in a stack → partial or complete filling of the pipe → large pressure fluctuations
    - Foaming of detergents through highly turbulent fluid flow increases pressure fluctuations
    - A bend of minimum radius 200 mm at the base of a soil stack

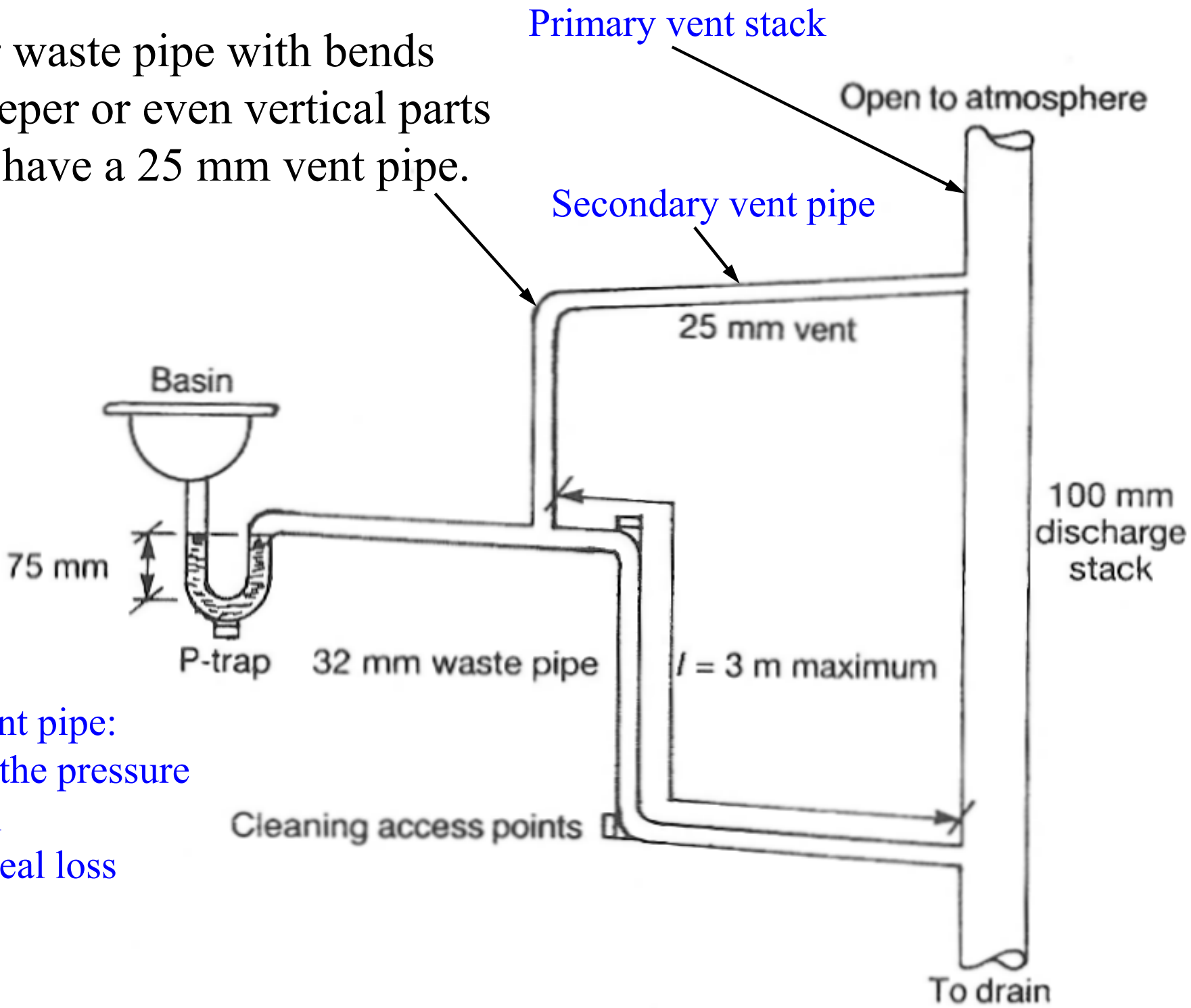
Drainage installations

- Loss of water seal (cont'd)
  - Surcharging:
    - An underground drain that is allowed to run full causes large pressure fluctuations
    - Solution: additional stack ventilation
  - Intercepting traps:
    - Where a single-stack system is connected into a drain with an interceptor trap nearby, fluid flow is restricted
    - Additional stack ventilated is used
  - Leakage:
    - Can occur through mechanical failure of joints or the use of a material not suited to the water conditions



(Source: http://waterheatertimer.org/Plumbing-Vents.html)

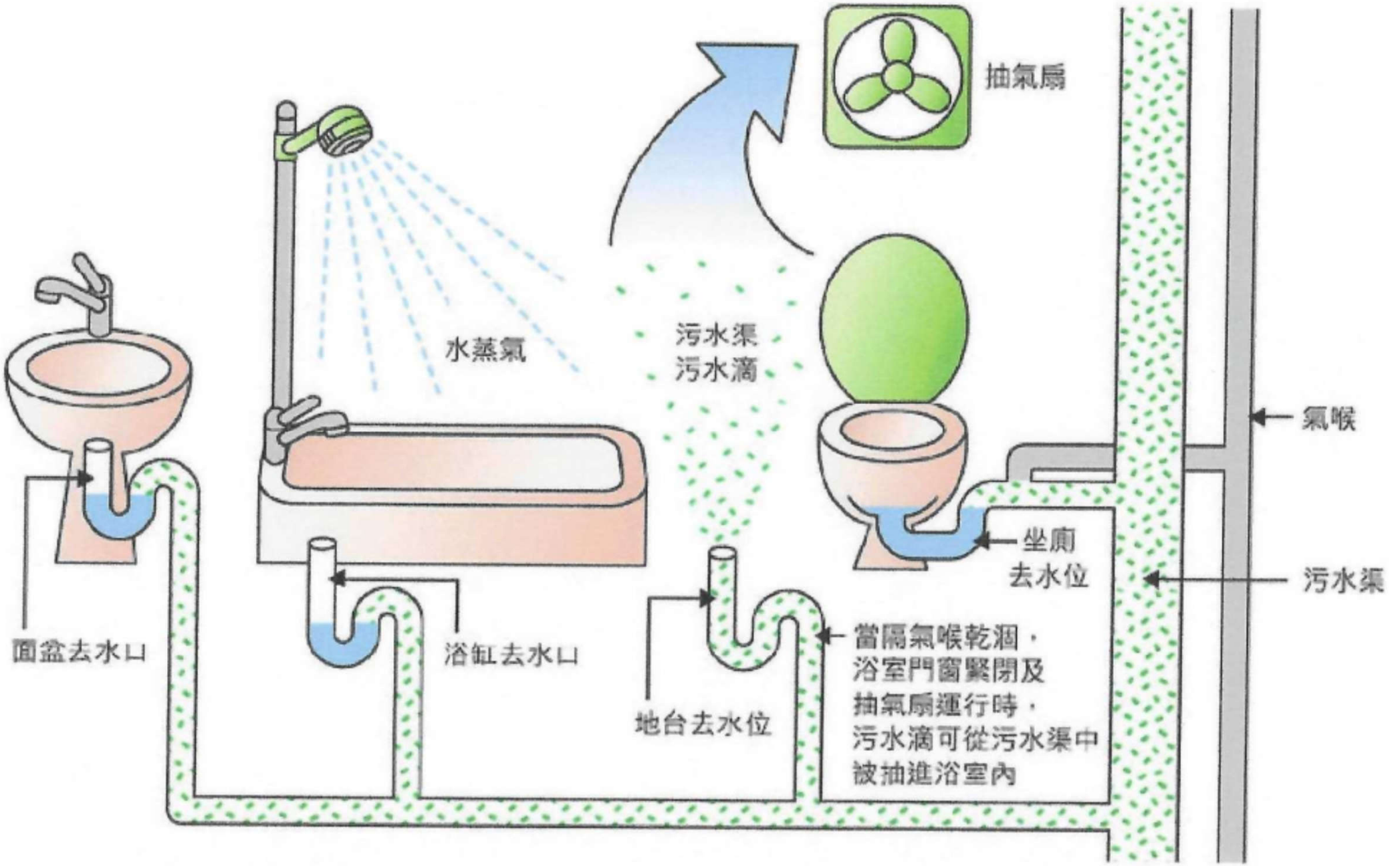
Longer waste pipe with bends and steeper or even vertical parts should have a 25 mm vent pipe.



Uses of vent pipe:
- Equalise the pressure fluctuation
- Prevent seal loss

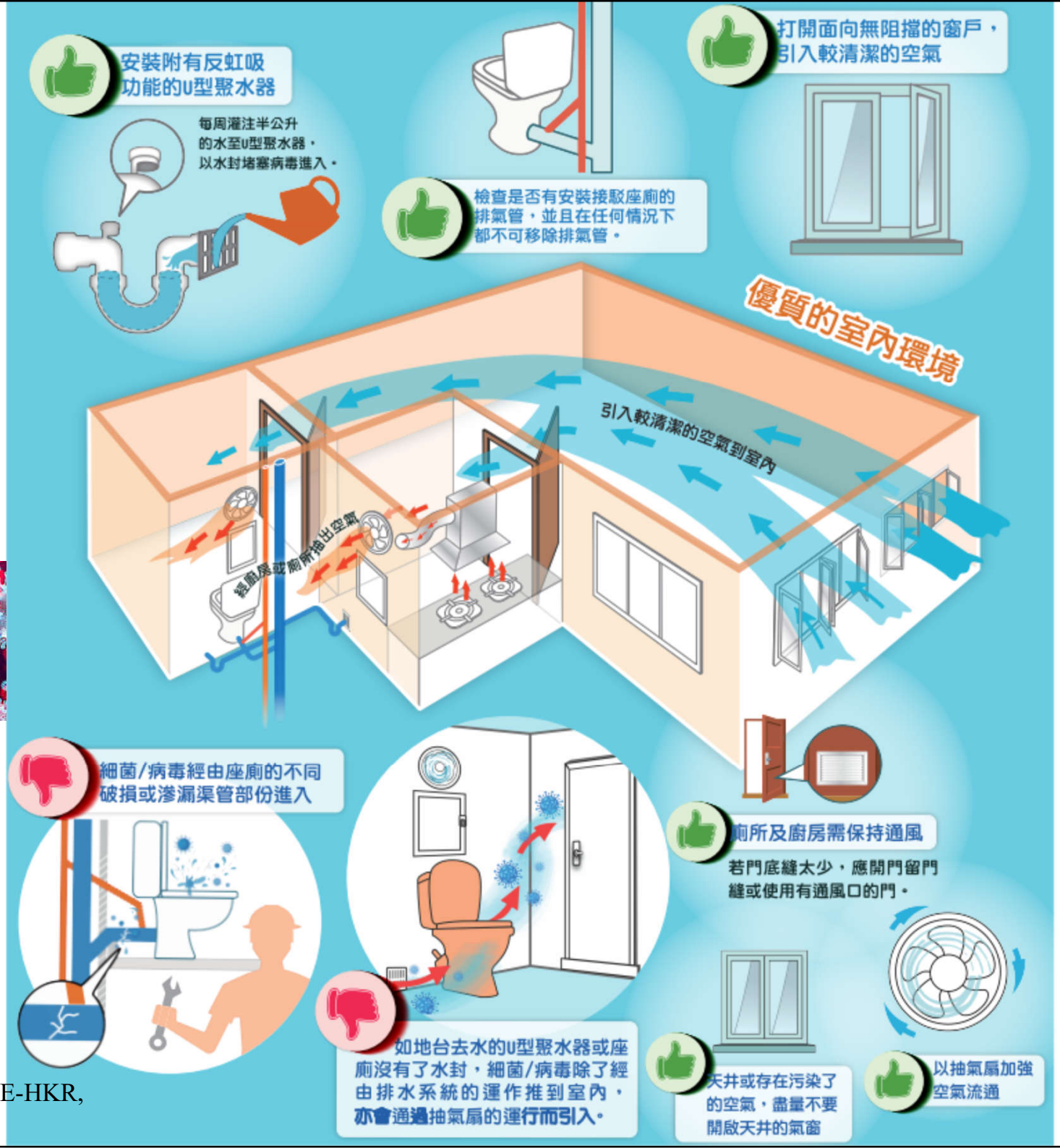
(Source: Chadderton, D. V., 2007. *Building Services Engineering*)

SARS infection and transmission 沙士感染和傳播方式



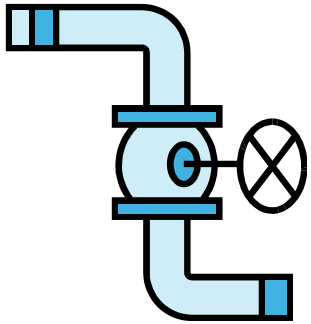
(Source: HKU SARS research team)

Leaky drain busters
渠漏解決師



(Source: HKIE-BSD, CIBSE-HKR, CIPHE-HK & BSOMES)

Plumbing works submissions



- Application for Water Supply in HK https://www.wsd.gov.hk/en/customer-services/application-for-water-supply/
  - Waterworks Ordinance (Cap. 102) (WWO)
  - Water Supply for New Buildings https://www.wsd.gov.hk/en/customer-services/application-for-water-supply/water-supply-for-new-buildings/
  - Plumbing proposal, Form WWO 542 (apply for supply), Form WWO 46 (commence works)
  - Licensed Plumbers (持牌水喉匠) & Registered Plumbing Workers (註冊水喉技工)

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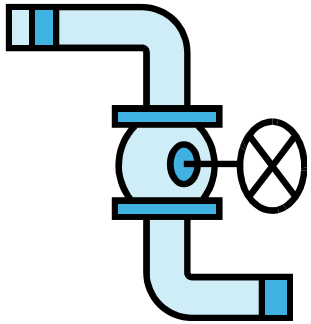
Guide to application for water supply

Submission Requirements at Proposal Stage - Form WWO542, plumbing proposal with vertical plumbing line diagram (VPLD) & other drawings - Replumbing works (refurbishment & replacement) - For fresh water cooling towers - For fire services - For high draw-off rate non-domestic supply
Submission Requirements at Construction Stage - Before commencement of works (Form WWO46 Parts I&II) - Inspection stage (Form WWO46 Part IV) - Issue Form WWO46 Part V(a) & (b) after inspection & water sampling tests - Issue Form WWO1005
Application for Temporary Water Supply for Systematic Flushing
Application for Water Supply for Two-Storey Warehouse through One Stop Centre (OSC)
Provision of Sanitary Fitments and Fittings or Water Heaters in New Buildings
Random Inspection of New Plumbing Works during Construction Stage

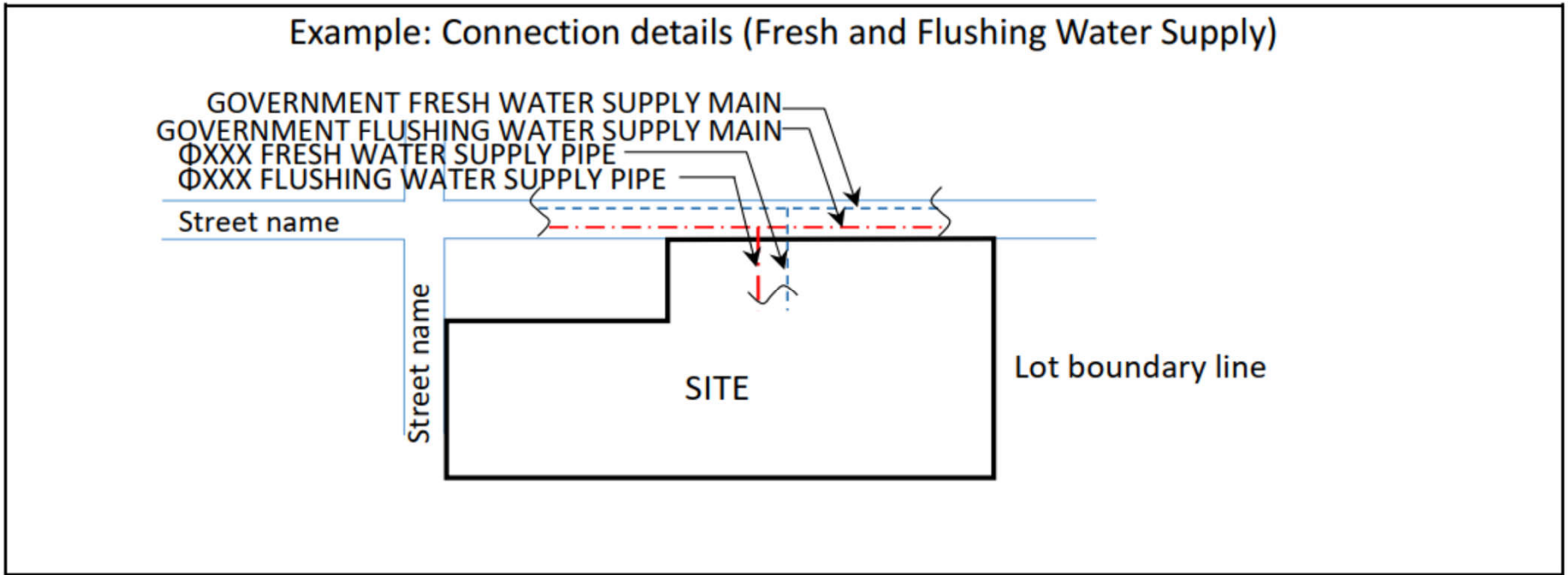
(Source: WSD, 2020. *Guide to Application for Water Supply (November 2020 version)*, Water Supplies Department (WSD), Hong Kong. https://www.wsd.gov.hk/en/plumbing-engineering/requirements-for-plumbing-installation/guide-to-application-for-water-supply/)

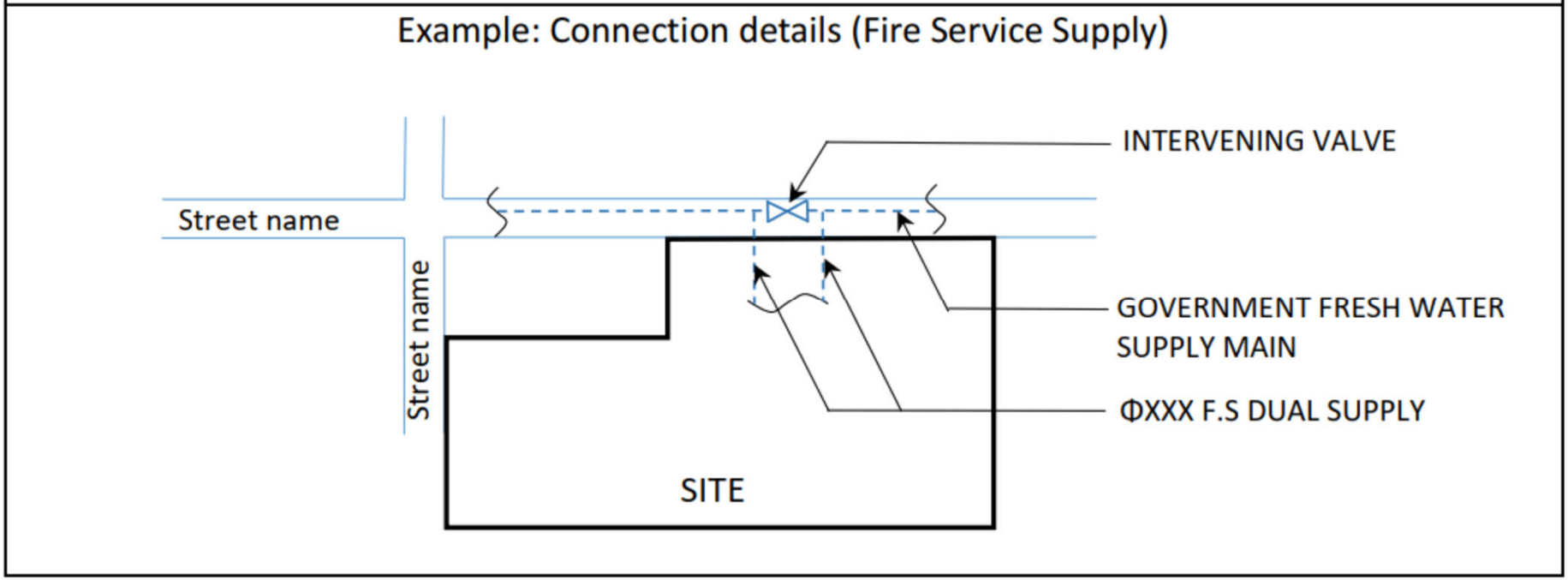
Plumbing works submissions



- General principles for installing plumbing works (from *WSD Plumbing Installation Handbook*)
  - All water fittings and pipework shall comply with the relevant Waterworks Regulations
  - All plumbing works shall be carried out in accordance with the Hong Kong Waterworks Requirements and by a licensed plumber
  - System main pipes should preferably not be run through the individual premises
- Also, Building (Standards of Sanitary Fitments, Plumbing, Drainage Works and Latrine) Regulations https://www.elegislation.gov.hk/hk/cap123I

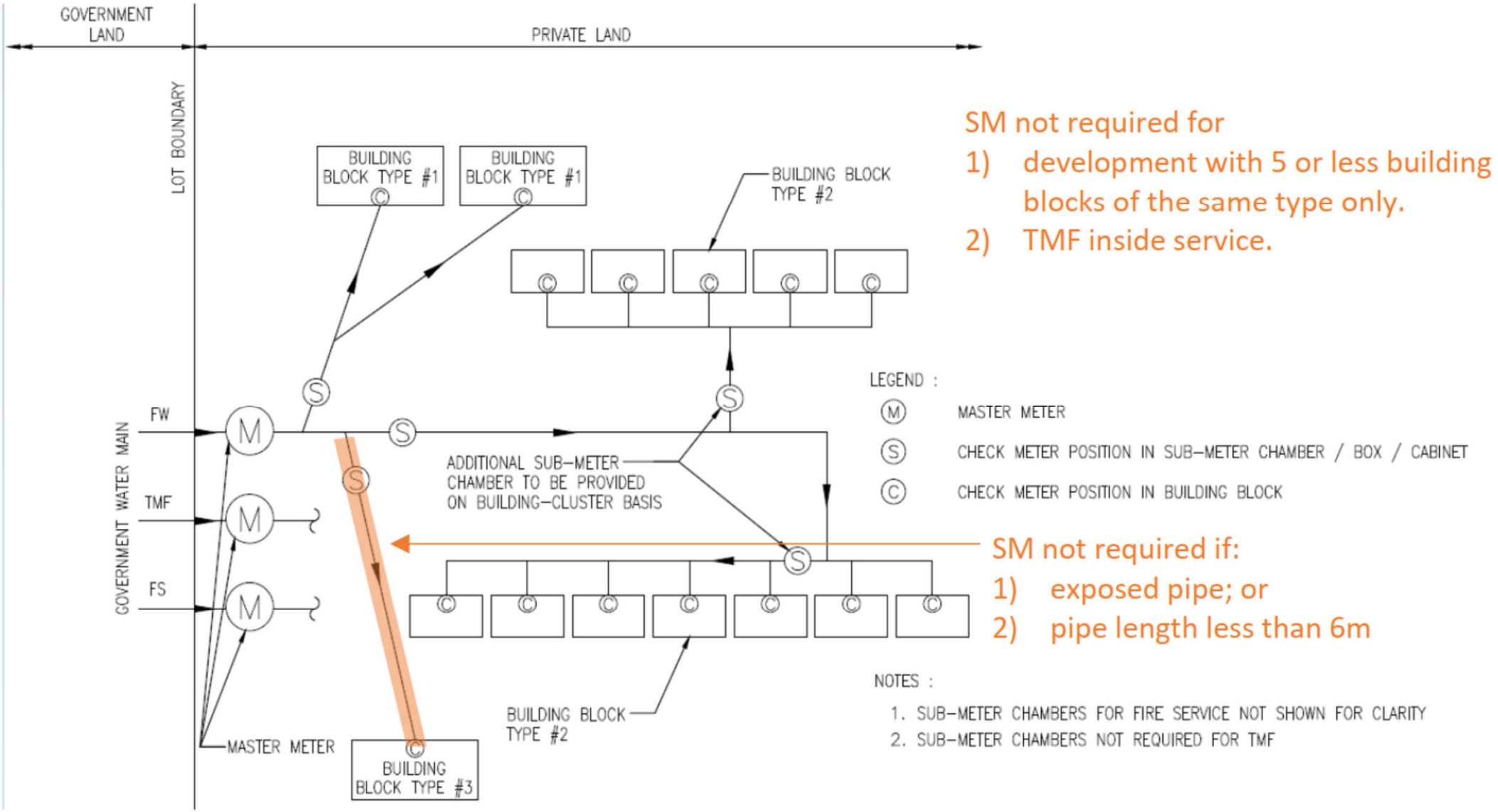
Essential aspects of plumbing design in new buildings





(Source: WSD, 2020. *Technical Requirements for Plumbing Works in Buildings (November 2020 version)*, Water Supplies Department (WSD), Hong Kong. https://www.wsd.gov.hk/en/plumbing-engineering/requirements-for-plumbing-installation/technical-requirements-for-plumging-works-in-bldgs/)

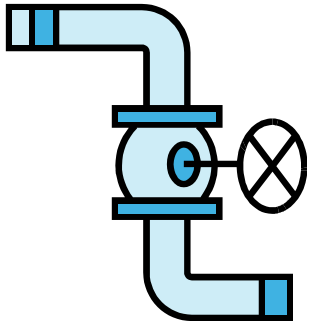
Typical configuration of master meter (MM) and sub-meter (SM) chambers in multiple-block development



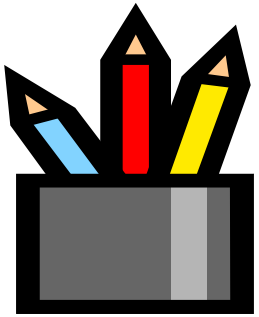
FW: Fresh water; TMF: Temporary mains fresh water for flushing; FS: fire service

(Source: WSD, 2020. *Technical Requirements for Plumbing Works in Buildings (November 2020 version)*, Water Supplies Department (WSD), Hong Kong. https://www.wsd.gov.hk/en/plumbing-engineering/requirements-for-plumbing-installation/technical-requirements-for-plumging-works-in-bldgs/)

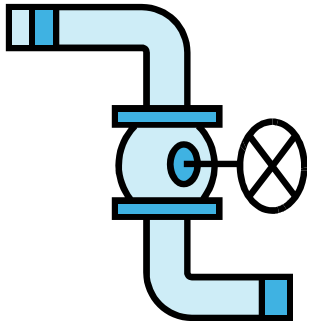
Plumbing works submissions



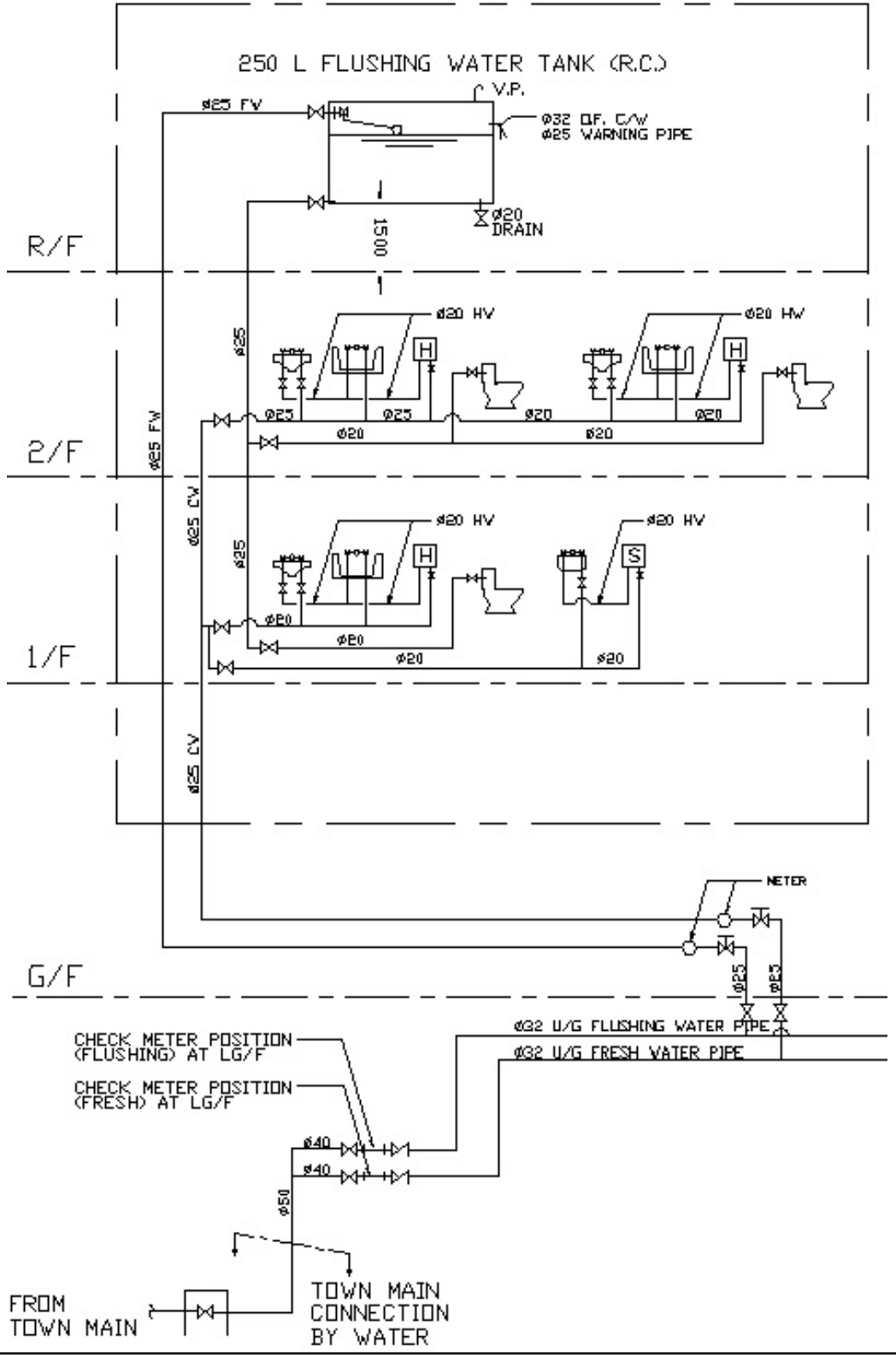
- Plumbing proposal (vetted by WSD)
  - A block plan in a scale of 1:1000 showing the location and boundary of the development
  - The locations should be marked with datum level
  - A plan showing the alignment & size of the proposed connection pipes from the main to the development
  - A plan showing the proposed alignment & size of the internal underground water pipes to be laid
  - Vertical plumbing line diagrams
  - Capacities of the water storage tanks e.g. roof storage tanks
  - Meters arrangement & positions



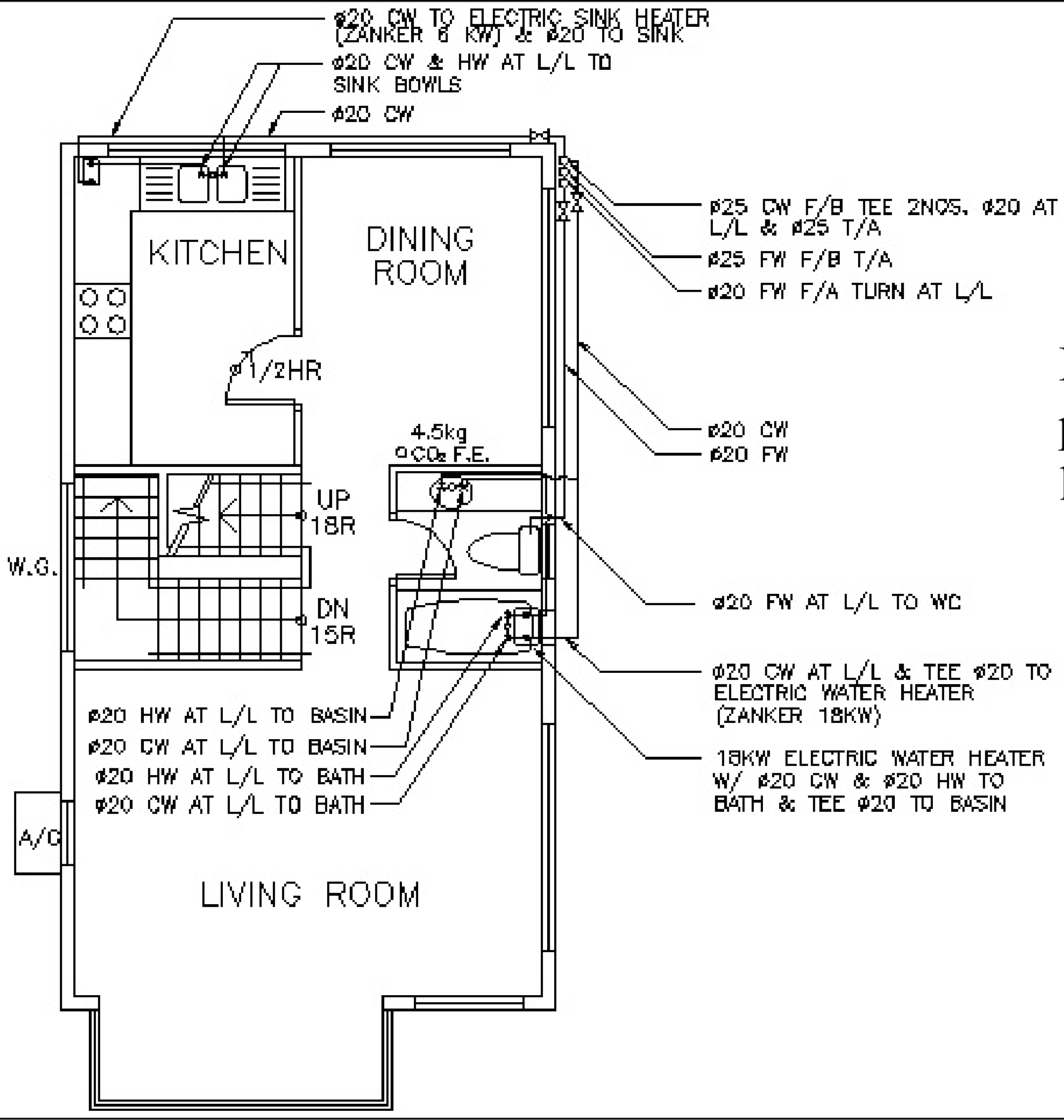
Plumbing works submissions



- Plumbing proposal (cont'd)
  - A schedule containing the following items :-
    - (a) number of flats/units in each block of the building
    - (b) address of each premise needs individually metered water supply
    - (c) number of draw-off points and sanitary fittings in each unit
    - (d) estimated daily consumption for all trade purposes
  - The relevant standards for the pipe materials to be used
- Sample checklists for final inspection of new buildings (from WSD) https://www.wsd.gov.hk/filemanager/en/content_1137/cir0118_sample_new_building.pdf

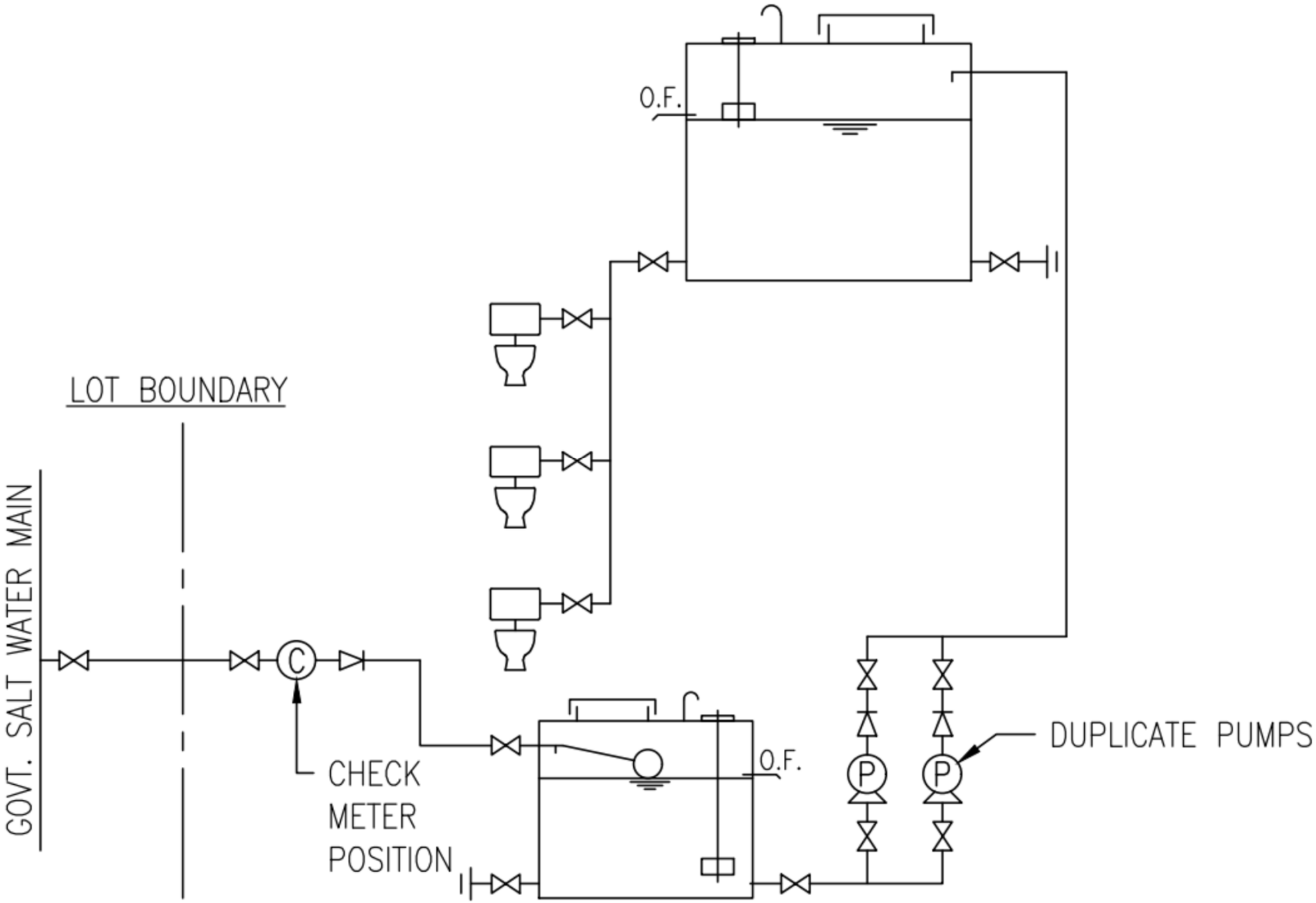


Example of a plumbing system schematic (fresh & flushing water supplies)



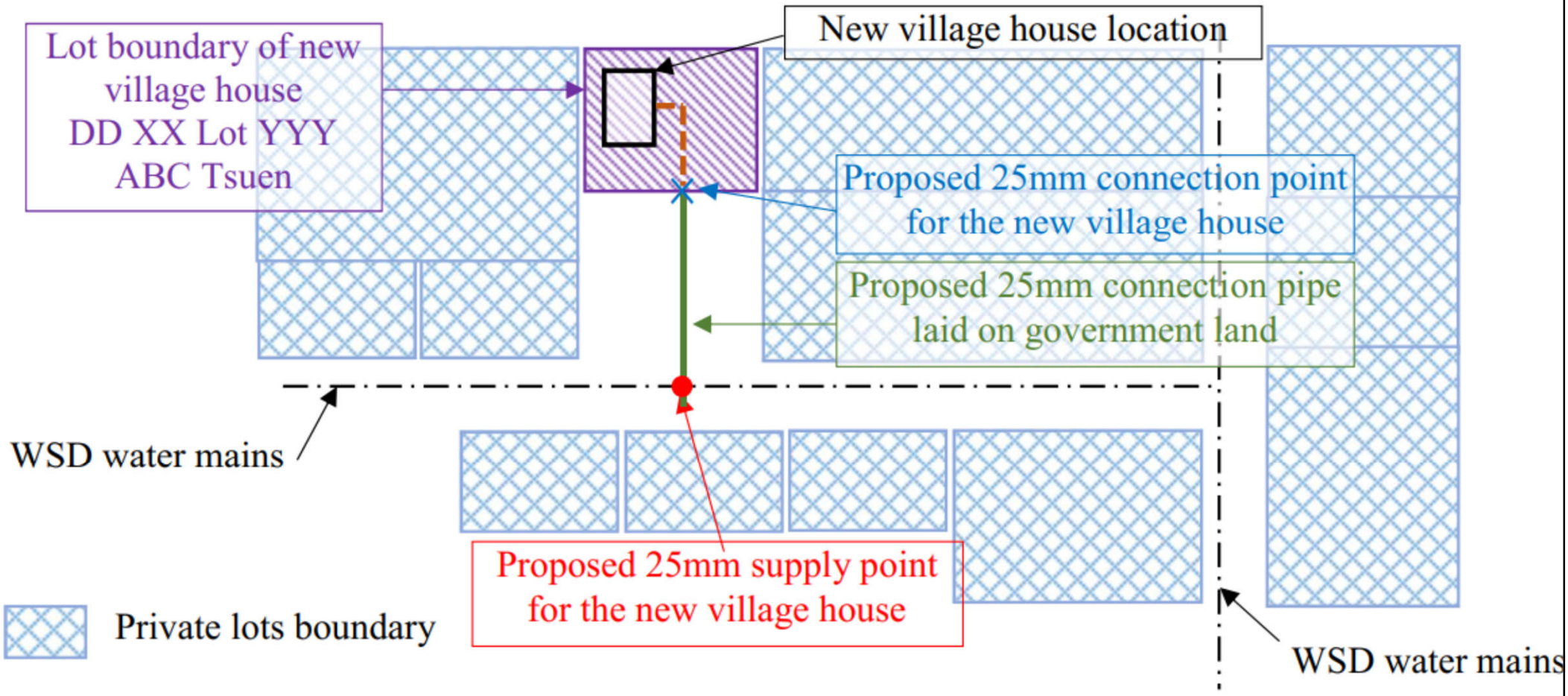
Example of plumbing layout design

Schematic diagram of a flushing water supply system



(Source: Water Supplies Department, www.wsd.gov.hk)

Connection layout plan of a water supply system



(Source: Water Supplies Department, www.wsd.gov.hk)

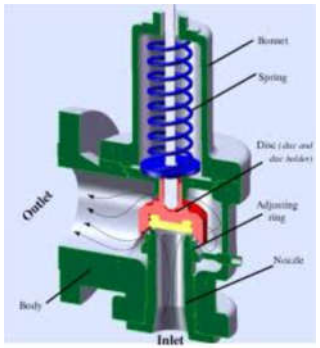
Division of responsibilities on the maintenance of water supply systems

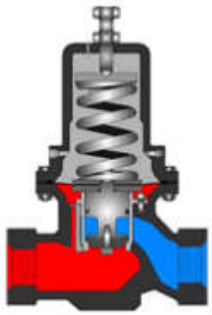
Area of Responsibility	Maintained by
Connexion to the main	Water Authority
Water meter	Water Authority (the Consumer/Agent is however responsible for the safe custody of the meter serving his/her premises)
Communal inside/fire service within the building/lot boundary	Agent (Landlord or Building Management)
Non-communal inside/fire service within the building/lot boundary	Consumer

(Source: Water Supplies Department, www.wsd.gov.hk)

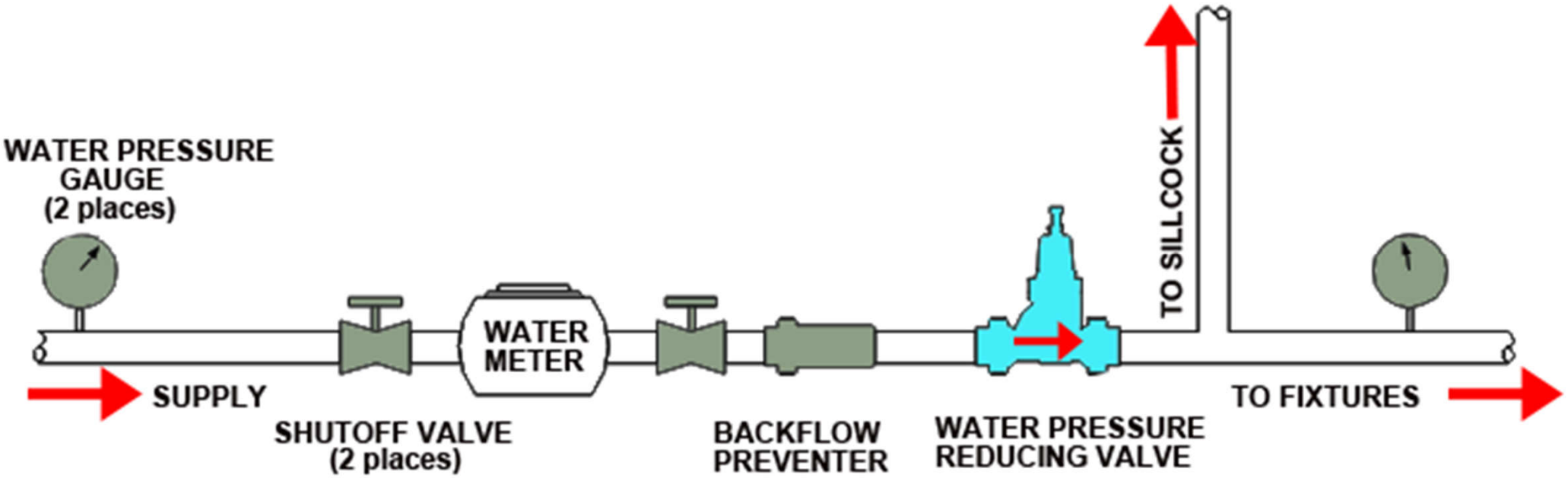
Operation & maintenance

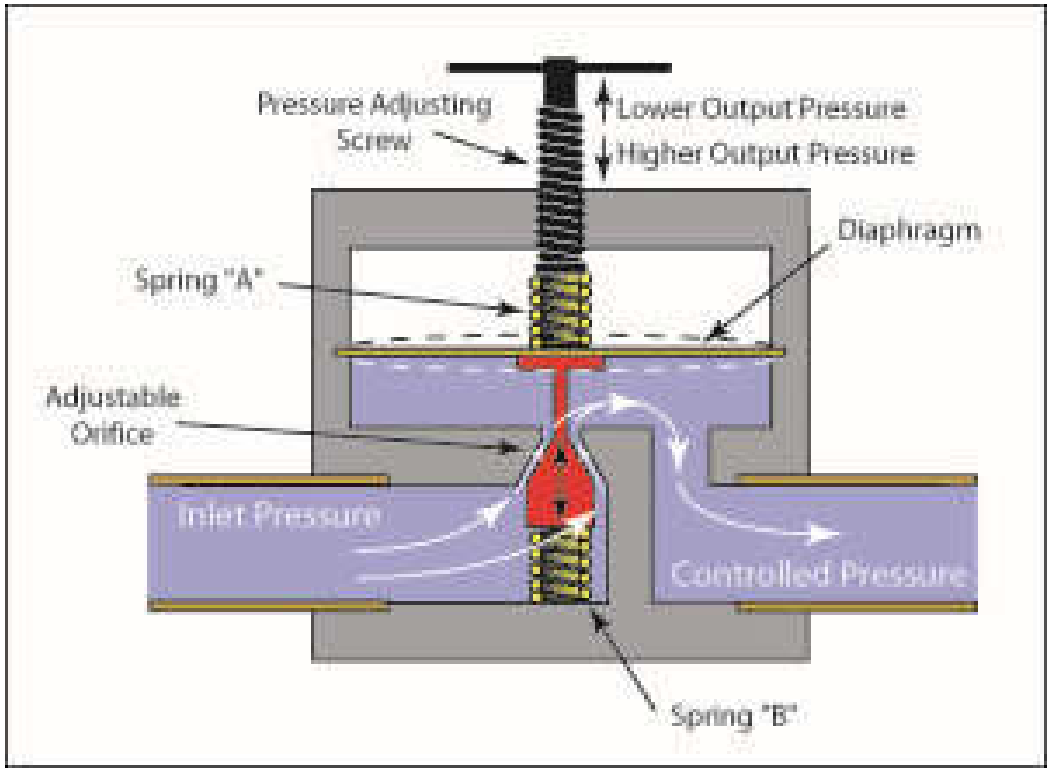
- Prevent excessive water pressure
  - Pipework pressure over 60 m head is not desirable
  - Methods to control water pressure:
    - Pressure reducing valve (PRV): fixed ratio type, spring type & pilot operated type
    - Break tank at a suitable level (quite reliable for highrise buildings)





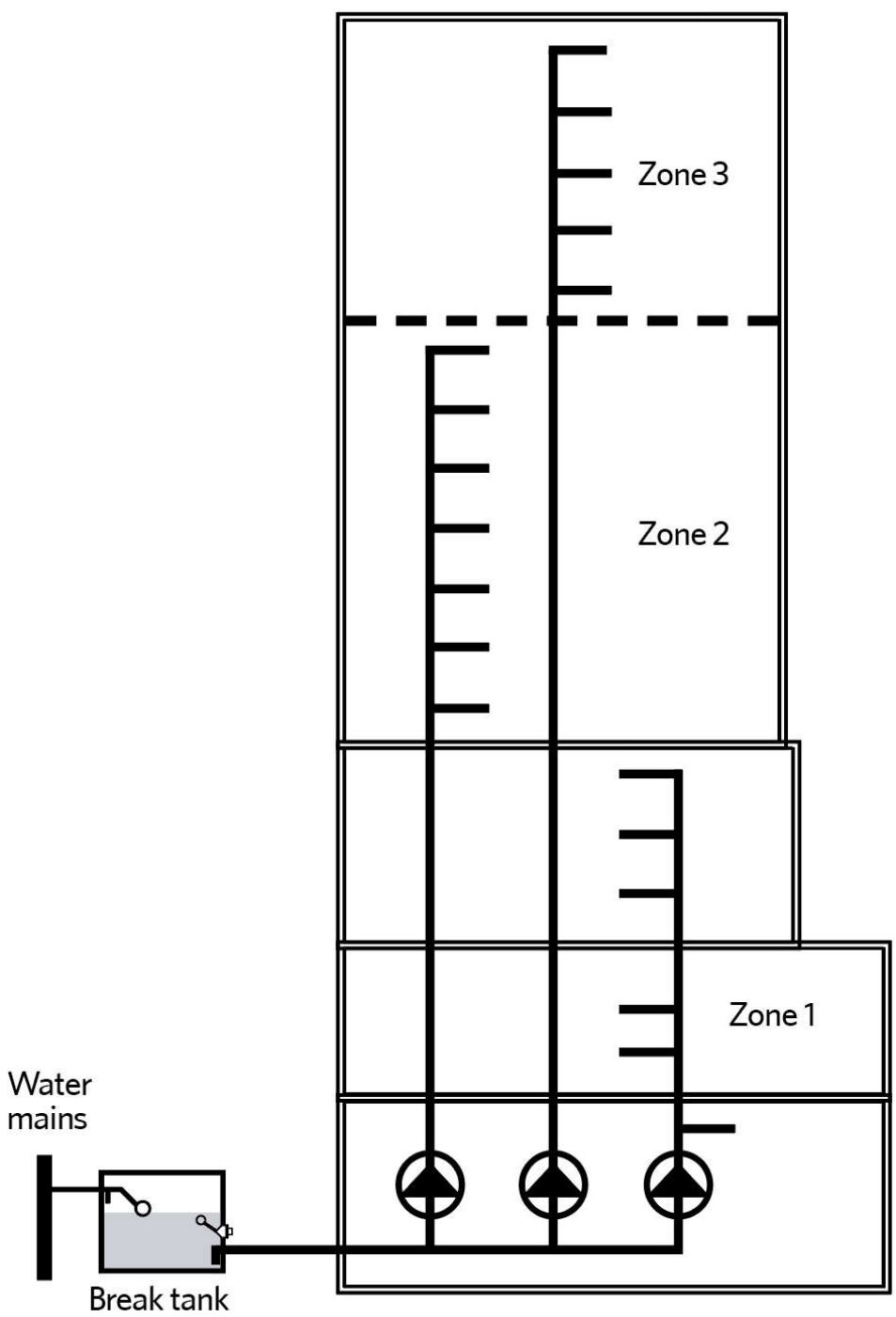
Pressure reducing valve (PRV) installations & working principle

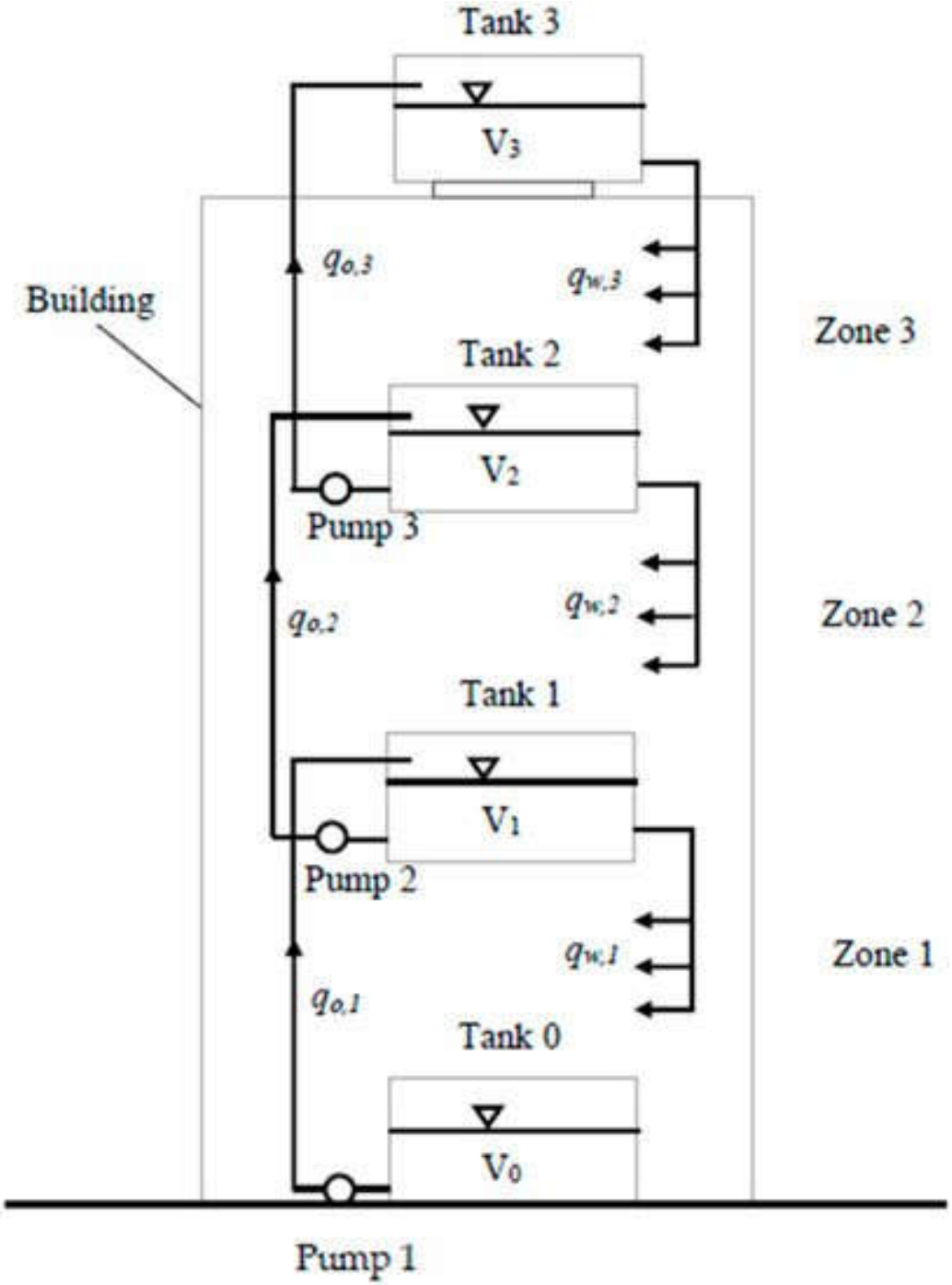




[Source: WSD & http://localplumbingandsewerga.com/service/system-components/pressure-valve-services/]

Pressure zoning & break tanks in high-rise buildings

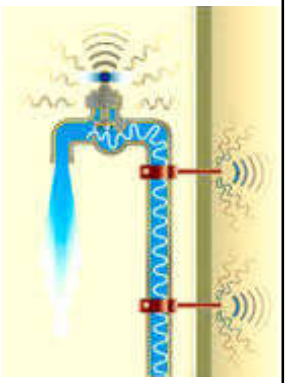


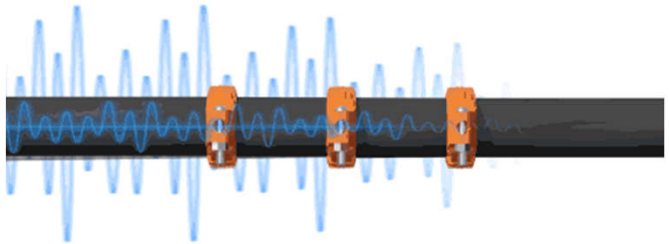


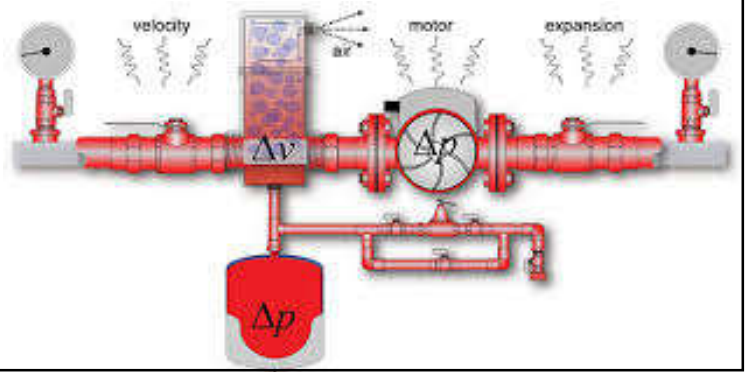
[Source: https://www.cibsejournal.com/cpd/modules/2019-10-wat/ & https://www.mdpi.com/2073-4441/11/12/2580]

Operation & maintenance

- Noise & vibration control
  - Pipe noise
    - Pipe should not be fixed rigidly to lightweight panels
  - Flow noise
    - Keep velocities under control
  - Pump noise
    - Use rubber hose isolators, resilient inserts, acoustic filters





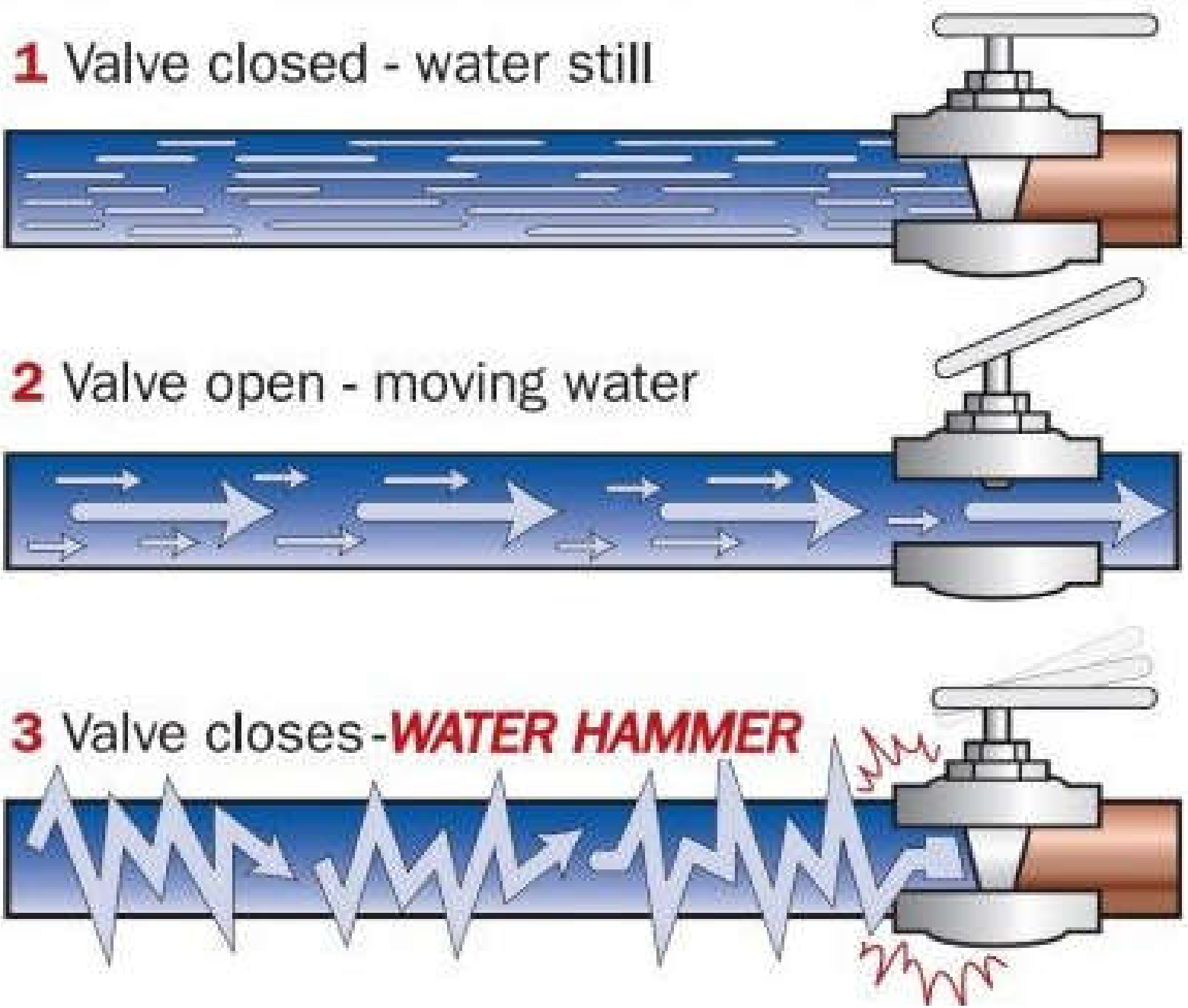


Operation & maintenance

- Water hammer (水錘作用)
  - Such as when a valve is closed rapidly
  - Pulsating type of noise by shock waves
  - Preventive measures:
    - Prevent sudden closing of the valve
    - Absorb pressure peaks (e.g. by pneumatic vessels)
    - Increase the attenuation of pressure waves when transmitted through the pipework
    - Design the pipework to avoid long straight pipe runs
    - Restrict water velocities (e.g. to a maximum of 3 m/s)

(See also: Water Hammer https://www.dft-valves.com/applications/water-hammer/)

What is Water Hammer?

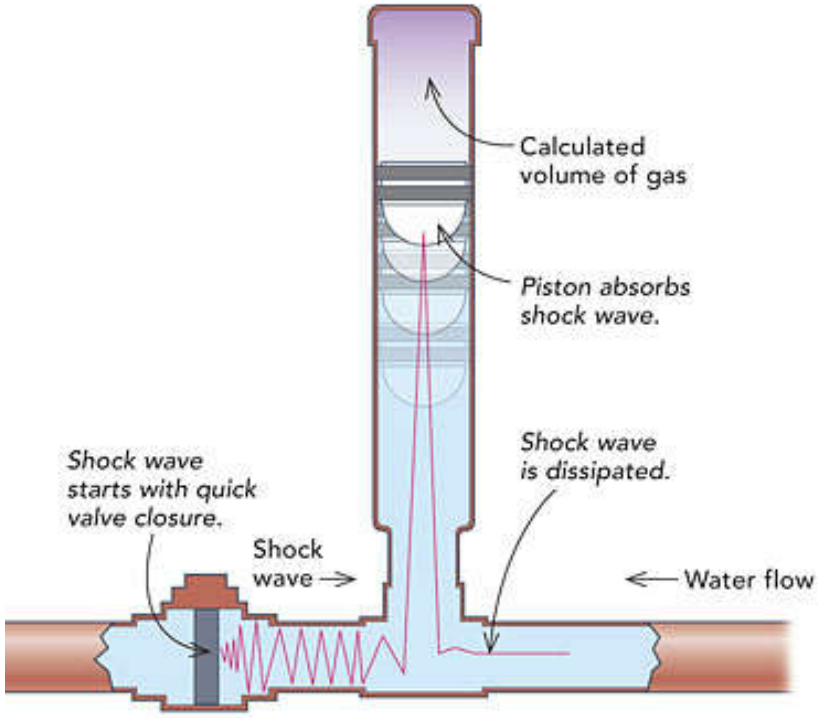


Video: What is Water Hammer? | DFT Inc. (2:38) https://youtu.be/6ydsAIHWVNM

(Source: https://www.pannhomeservices.com/what-is-water-hammer-and-how-can-i-stop-it/)

Operation & maintenance

- Practical methods to prevent or minimize water hammer:
  - Increase pipe size (> reduce water flow velocity)
  - Use slow-closing valves
  - Use soft starter for pumps
  - Provide a surge tank
  - Install water hammer arrestor



Operation & maintenance

- Back siphonage & back pressure
  - Occur when water mains pressure reduces greatly
  - Contamination of water may happen
  - Contamination might also occur due to gravity & backpressure backflow
  - Anti-siphonage device and design precautions
- Backflow/Cross-connection prevention
  - Such as break tank, check valve, non-return valve, anti-vacuum valve, backflow preventer

Properties of common backflow prevention devices

Backflow prevention device	Applicable Cross-connection hazard rating as in AS/NZS 3500.1:2015	Corresponding Fluid category as in BS EN 1717:2000	Protection against back-pressure	Protection against back-syphonage
Break tank	High/ medium/ low	4-5	Yes	Yes
Backflow preventer/ Reduced Pressure Zone (RPZ) Device	High/ medium/ low	4	Yes	Yes
Check valve/ Non-return valve	Low	2	Yes	Yes
Double check valve (in series)*	Low	2	Yes	Yes
Anti-vacuum valve	Low	2	No	Yes

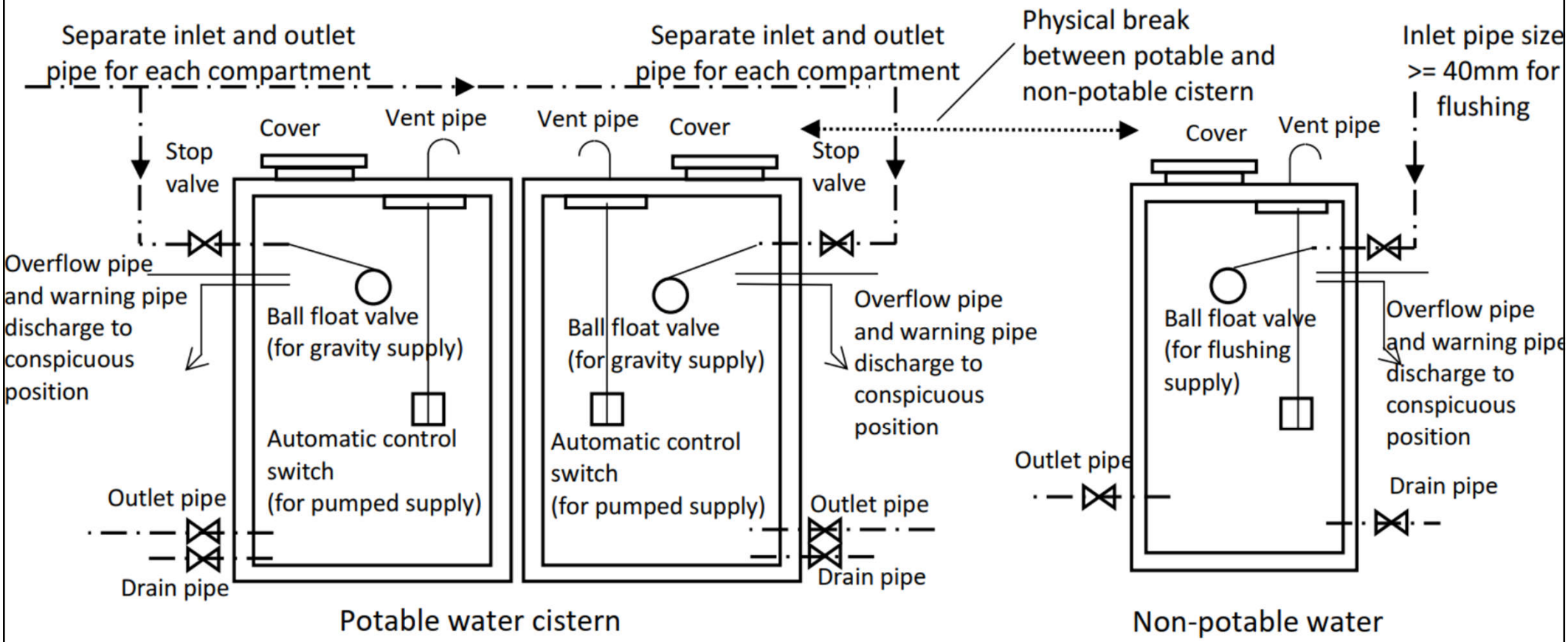
* For flushing meters stipulated in WSD Circular Letter No. 6/2017, Annex II, Village Houses.

(Source: WSD, 2020. *Technical Requirements for Plumbing Works in Buildings (November 2020 version)*, Water Supplies Department (WSD), Hong Kong. https://www.wsd.gov.hk/en/plumbing-engineering/requirements-for-plumbing-installation/technical-requirements-for-plumging-works-in-bldgs/)

Operation & maintenance

- Water storage tanks
  - For storage volume ≥ 5000 litres, it is recommended to divide the tank into two compartments, each compartment need not be but preferably of equal volume
  - The internal surface of the tank wall & bottom shall be rendered with tiles having smooth surface (for easy cleaning)
  - Clean the tank every 3 months

Typical components of water cisterns (storage tanks)



(Source: WSD, 2020. *Technical Requirements for Plumbing Works in Buildings (November 2020 version)*, Water Supplies Department (WSD), Hong Kong. https://www.wsd.gov.hk/en/plumbing-engineering/requirements-for-plumbing-installation/technical-requirements-for-plumging-works-in-bldgs/)

Operation & maintenance

- Cleansing of water storage tanks
  - Such as sump tank & roof tank
  - They should be cleansed once every three months
- Maintenance of internal plumbing
  - WSD maintains the water supply distribution system up to the building lot boundaries
  - Internal & communal plumbing are maintained by the consumers

Common problems for maintenance of water storage tanks

Double sealed tank cover with lock

Damaged water tank cover

Water tank not cleaned

Rusty water tank cover

Storage tank without proper maintenance & management

(Source: Water Supplies Department www.wsd.gov.hk)

Water tank cover and cat ladder

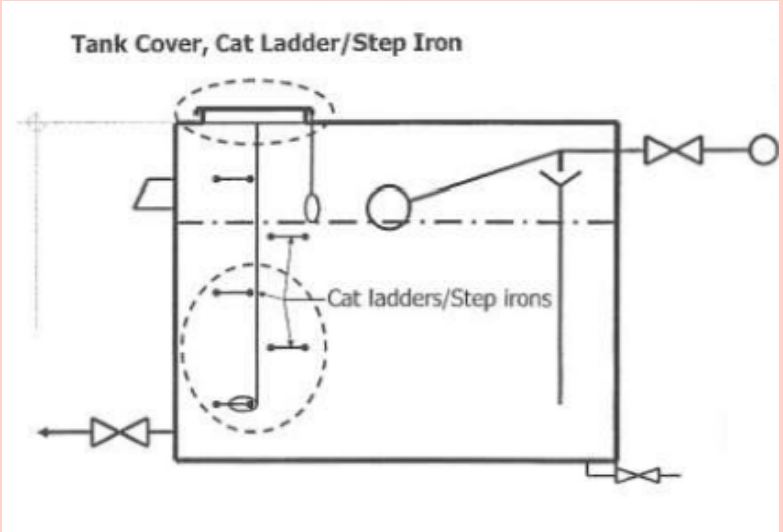
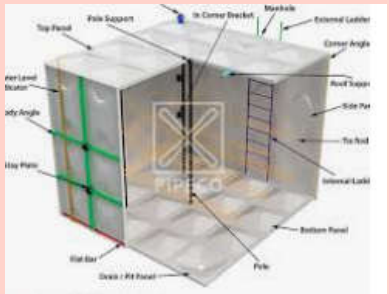
	Picture
Tank Cover, Cat Ladder / Step Iron • Cover shall be of "Cap" type • The cover and frame shall be so design to prevent the ingress of water • Manhole shall located at accessible position • Minimum access size is 675mm x 675mm (550mm x 550mm) clear • Cat ladder / step iron shall be install right below the manhole • Step irons shall be installed at staggered positions • Cat ladder inside the tank shall be made of stainless steel	

Photo: Tank Cover	Photo: Cat Ladder	Photo: Step Iron
		

[Source: Mr. Eddy Chan of ATAL]