IBTM6010H Utility Services

http://ibse.hk/IBTM6010H/

Revision Class

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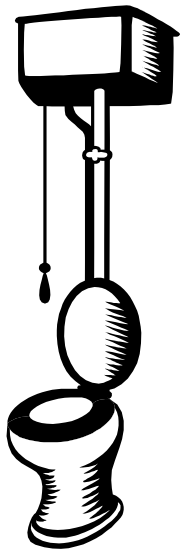
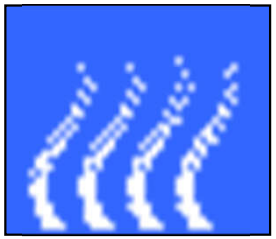
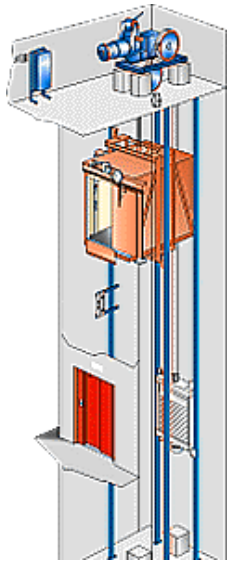
IBTM 6010H Utility Services: Study topics

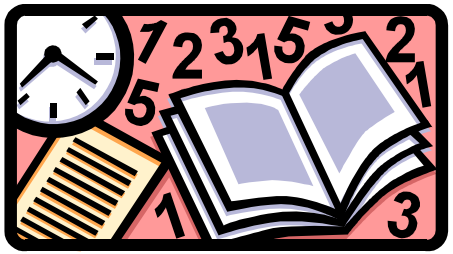
1. Introduction to Utility Services	7. Steam Systems
2. Cold Water Supply	8. Fuel gas supply
3. Hot Water Supply	9. Vertical Transportation (I)
4. Design of Water Supply Systems	10. Vertical Transportation (II)
5. Sanitation and Drainage	11. Telecommunication Services
6. Sewage Disposal	12. Extra Low Voltage Systems



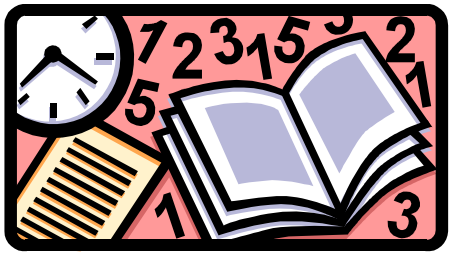


Course background



- Educational Objectives:
  - To introduce the important design concepts, principles and engineering calculations of utility services systems
  - To enable students to appreciate the design practice and proper operation of different types of utility services systems

Course background



- Learning Outcomes:
  - To explain the important design concepts, principles and engineering calculations of utility services systems
  - To evaluate the design practice and operation of different types of utility services systems

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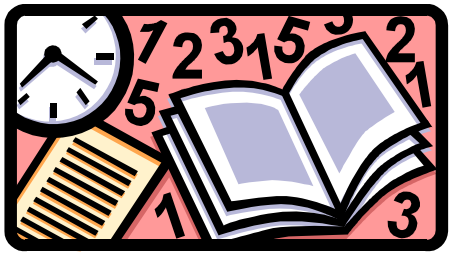


- Assessment Methods:
  - 60% by written examination (2 hours)
    - Answer 5 out of 6 questions, each 20 marks
    - Descriptive (Describe/Explain/Discuss/Draw)(~75%)
    - Calculations (~25%)
  - 40% by continuous assessment (2 nos. assignments)
    - Assignment 01 -- Water Supply Systems, Drainage and Sewage Disposal
    - Assignment 02 -- Steam Systems, Fuel Gas Supply, Vertical Transportation, Telecommunication and Extra Low Voltage Systems

Online, open book

Written exam arrangement

Online proctored exam through Canvas (with Zoom to monitor students' headshot)

- Download the exam questions from Canvas
- Handwrite the answers on paper
- Scan the answers into a PDF file
- Upload the file back to Canvas

Guidelines for students:

- Zoom Proctoring Option 1: Guides for Students
http://cei.hkust.edu.hk/files/public/zoom_proctoring_option_1_student_guides.pdf
- The HKUST Academic Honor Code
http://cei.hkust.edu.hk/files/private/hkust_honor_code.pdf

What are Utility Services?

- Utility Services 公用設施
  - Infrastructure services or “public” services, e.g.
    - Electricity, water supply, drainage & wastewater treatment, gas supply, telephone services
  - Provided by government departments, public utility companies & private companies
  - Fundamental to modern living
  - Essential components of the basic infrastructure





Related government departments & utility companies in Hong Kong

Government Departments	Utility Companies
• Water Supplies Department (WSD) • Housing Department (for housing area) • Fire Services Department (FSD) • Architectural Services Department (ArchSD) (for government residential area) • Buildings Department (BD) (for private buildings) • Drainage Services Department (DSD) • Highways Department • Electrical and Mechanical Services Department (EMSD)	• China Light and Power Company Limited • Hong Kong and China Gas Company Limited • Hongkong Electric Company Limited • Hong Kong Broadband Network Limited • Hong Kong Cable Television Limited • Hong Kong Tramway Limited • Hutchison Communications Limited • Mass Transit Railway Corporation • New T & T Hong Kong Limited • New World Telecommunications Limited • PCCW-HKT • Telstra International HK Limited • Wharf Communications Ltd

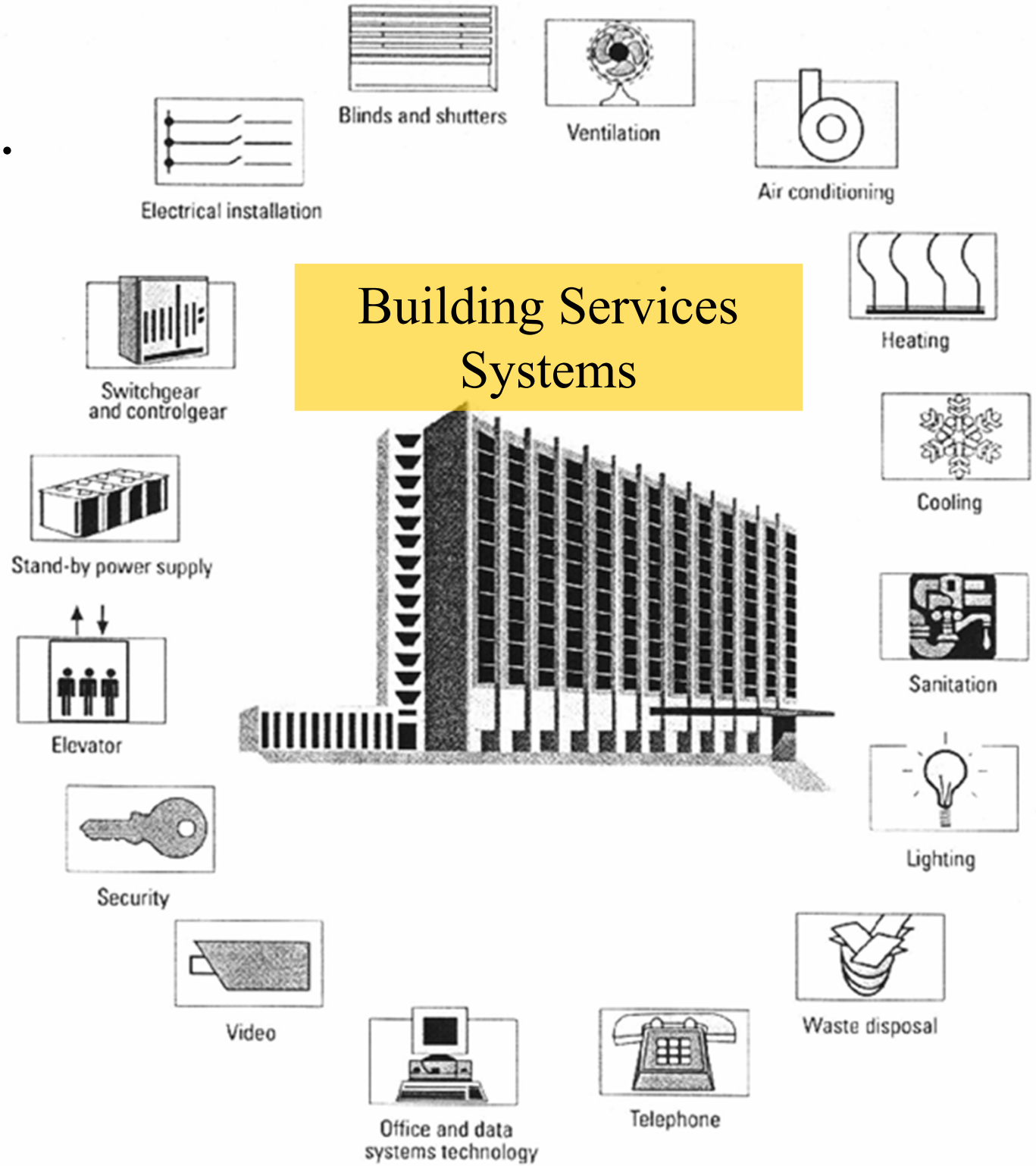
水務署 Water Supplies Department
屋宇署 BUILDINGS DEPARTMENT
渠務署 Drainage Services Department
機電工程署 EMSD

(Source: UTI, 2011. *Guide to Utilities Management*, Utility Training Institute (UTI), Hong Kong. http://www.hkius.org.hk/uploads/2/8/1/3/28134743/k.um.pdf)

Major ordinances in Hong Kong on utility services
(Can be read at https://www.elegislation.gov.hk/)

- Buildings Energy Efficiency Ordinance (Cap. 610) 《建築物能源效益條例 》(第610章)
- Buildings Ordinance (Cap. 123) 《建築物條例》(第123章)
- Electricity Ordinance (Cap. 406) 《電力條例》(第406章)
- Fire Safety (Buildings) Ordinance (Cap. 572) 《消防安全(建築物)條例》(第572章)
- Gas Safety Ordinance (Cap. 51) 《氣體安全條例》(第51章)
- Land Drainage Ordinance (Cap. 446) 《土地排水條例》(第446章)
- Lifts and Escalators Ordinance (Cap. 618) 《升降機及自動梯條例》(第618章)
- Sewage Services Ordinance (Cap. 463) 《污水處理服務條例》(第463章)
- Waterworks Ordinance (Cap. 102) 《水務設施條例》(第102章)

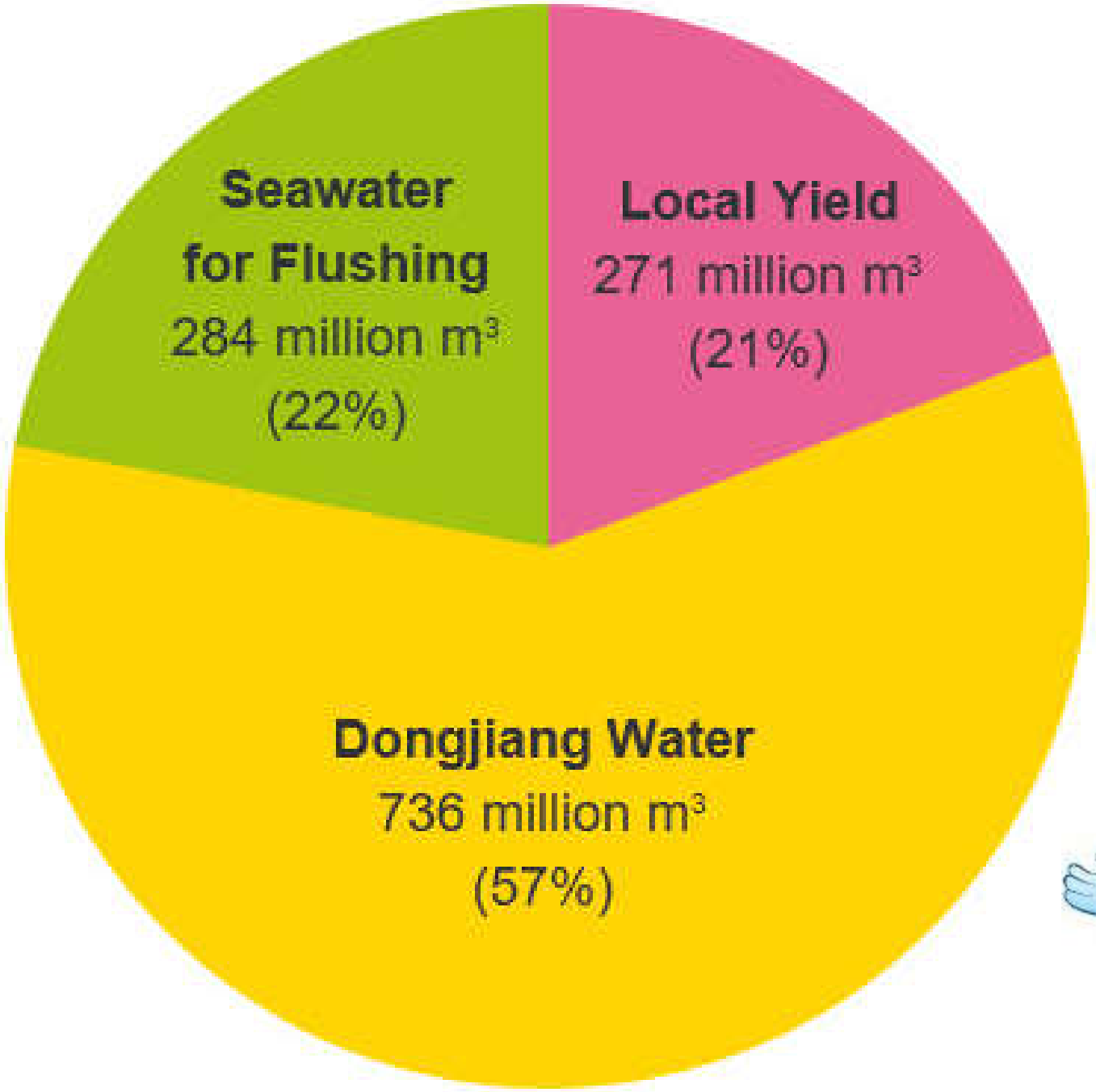
More …


Blinds and shutters
Ventilation
Air conditioning
Electrical installation
Heating
Switchgear and controlgear
Building Services Systems
Cooling
Stand-by power supply
Sanitation
Elevator
Lighting
Security
Waste disposal
Video
Office and data systems technology
Telephone

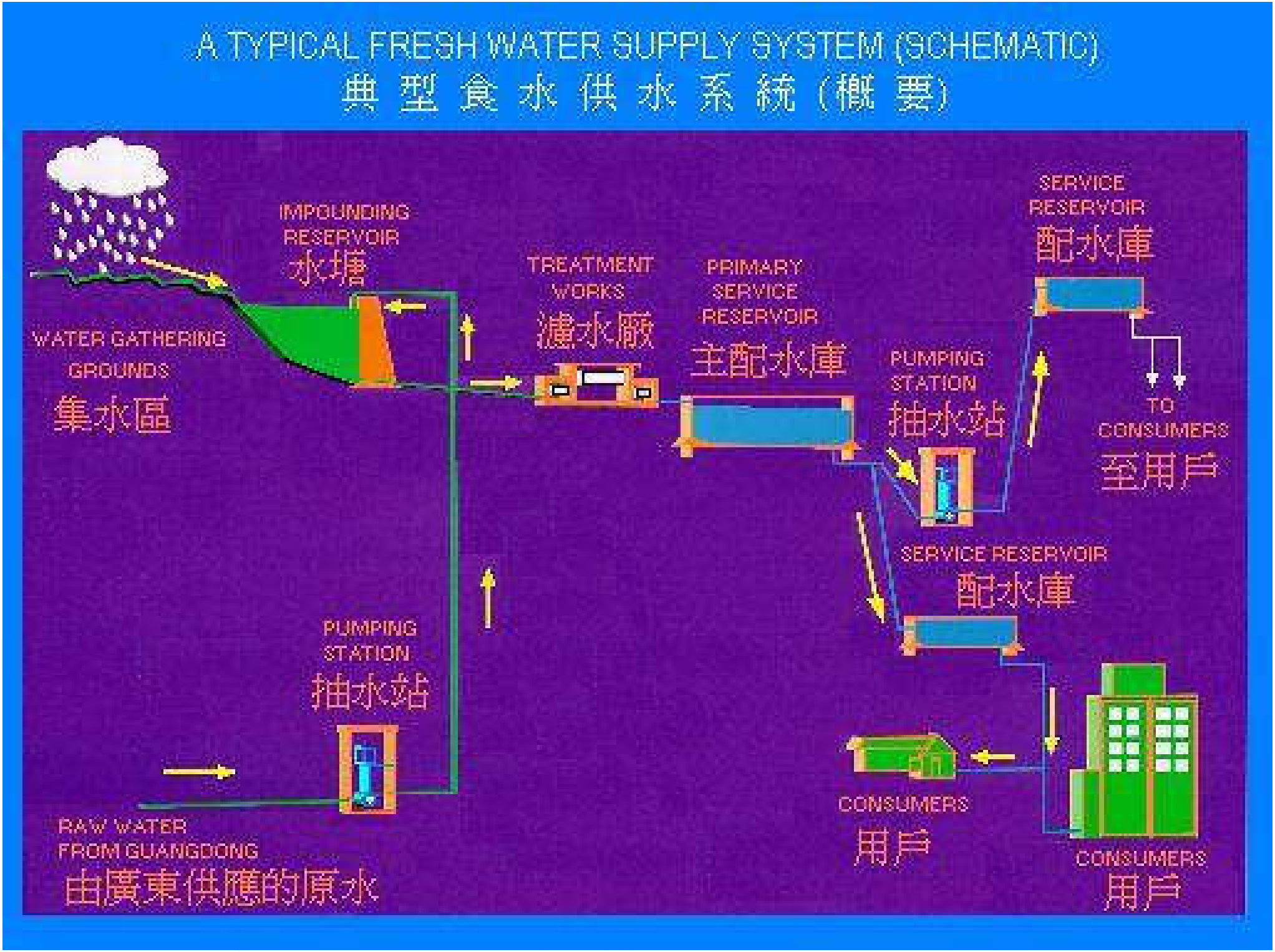
Water Supply Systems

Cold Water Supply	Hot Water Supply	Design of Water Supply Systems
• Water supply in Hong Kong • Water sources & treatment • Water supply distribution • Water tanks & pumps • Water quality & management	• System selection • Gas & electric water heaters • Solar hot water & heat pumps • Centralised hot water systems • Design practice in Hong Kong	• Design considerations • Water demand & storage • Pipe sizing • Pipe materials • Pump systems

Water consumption in Hong Kong in 2018 (1.292 billion m^3)

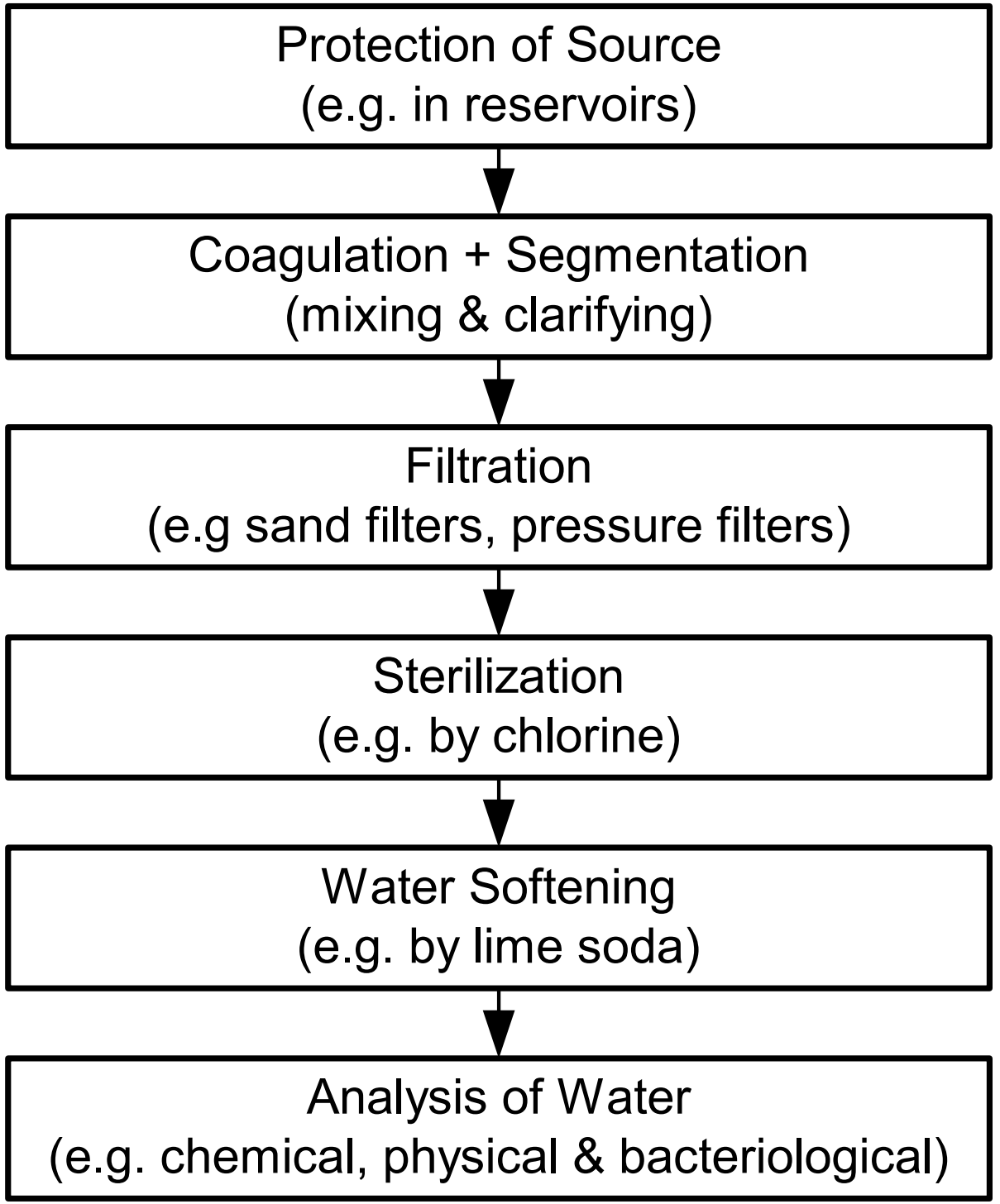


(Source: Water Supplies Department www.wsd.gov.hk)

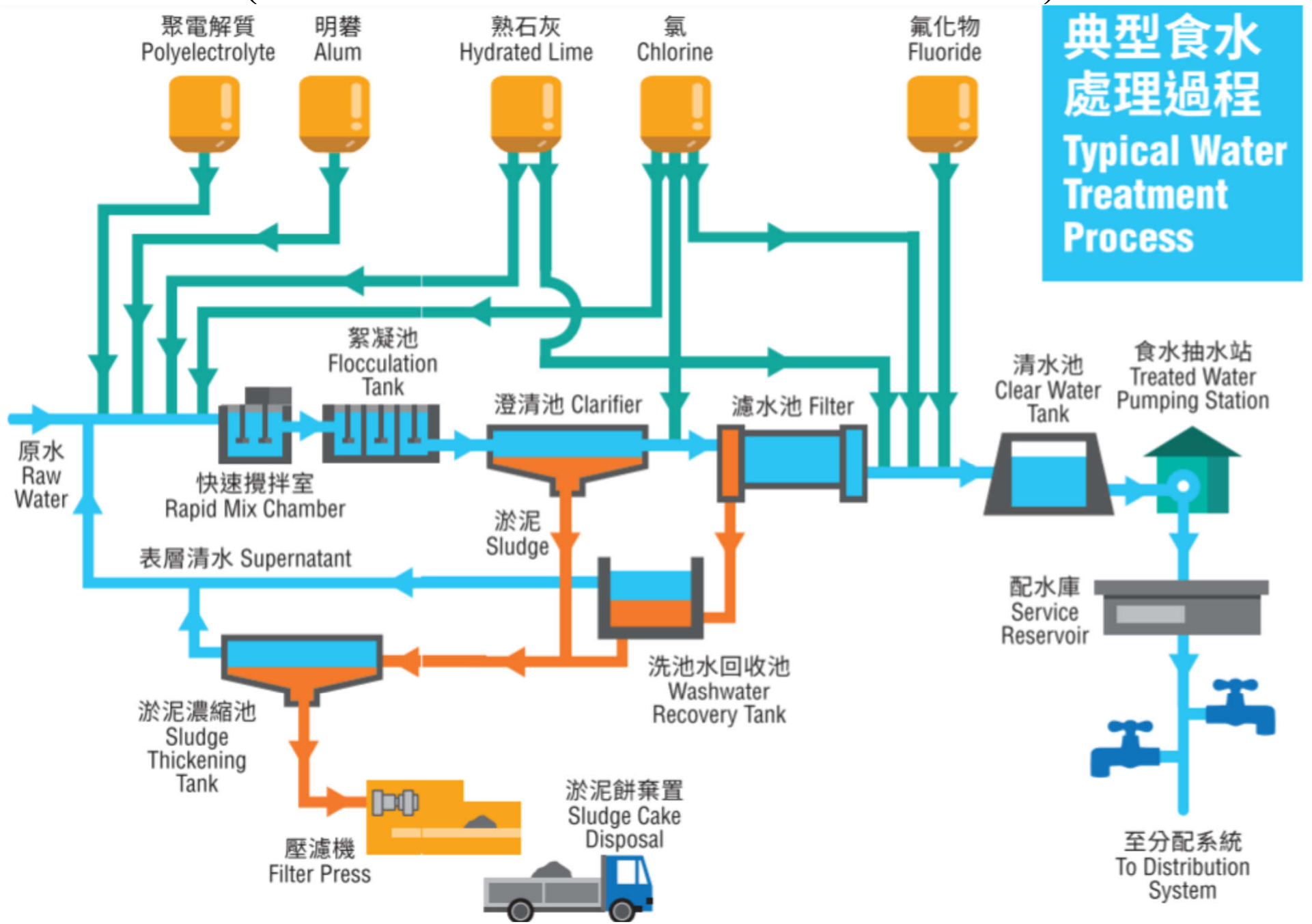


(Source: Water Supplies Department www.wsd.gov.hk)

Typical water treatment process

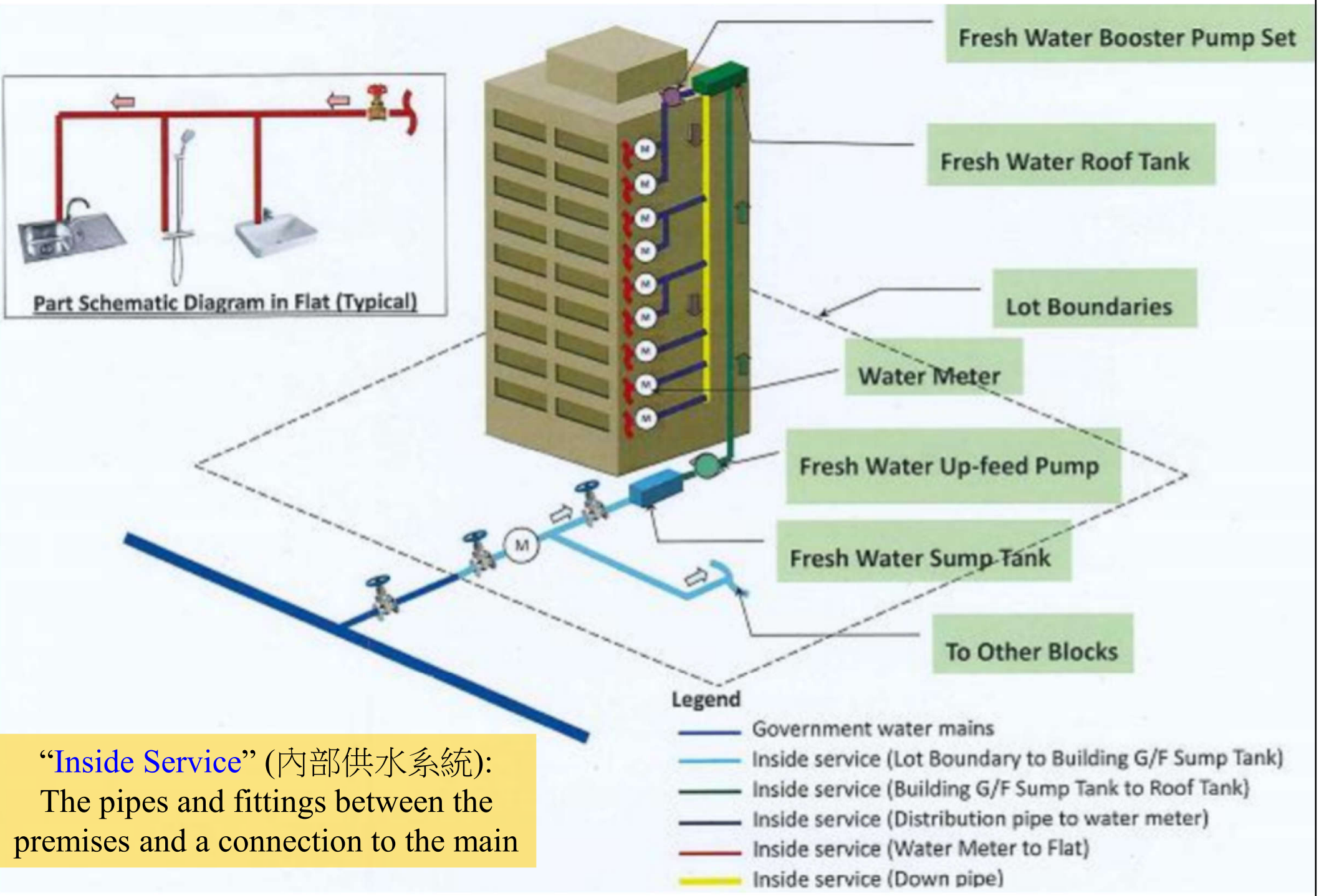


Typical water treatment process in Hong Kong (clarification >> filtration >> disinfection)



(Source: https://www.wsd.gov.hk/filemanager/en/share/pdf/water_treat.pdf)

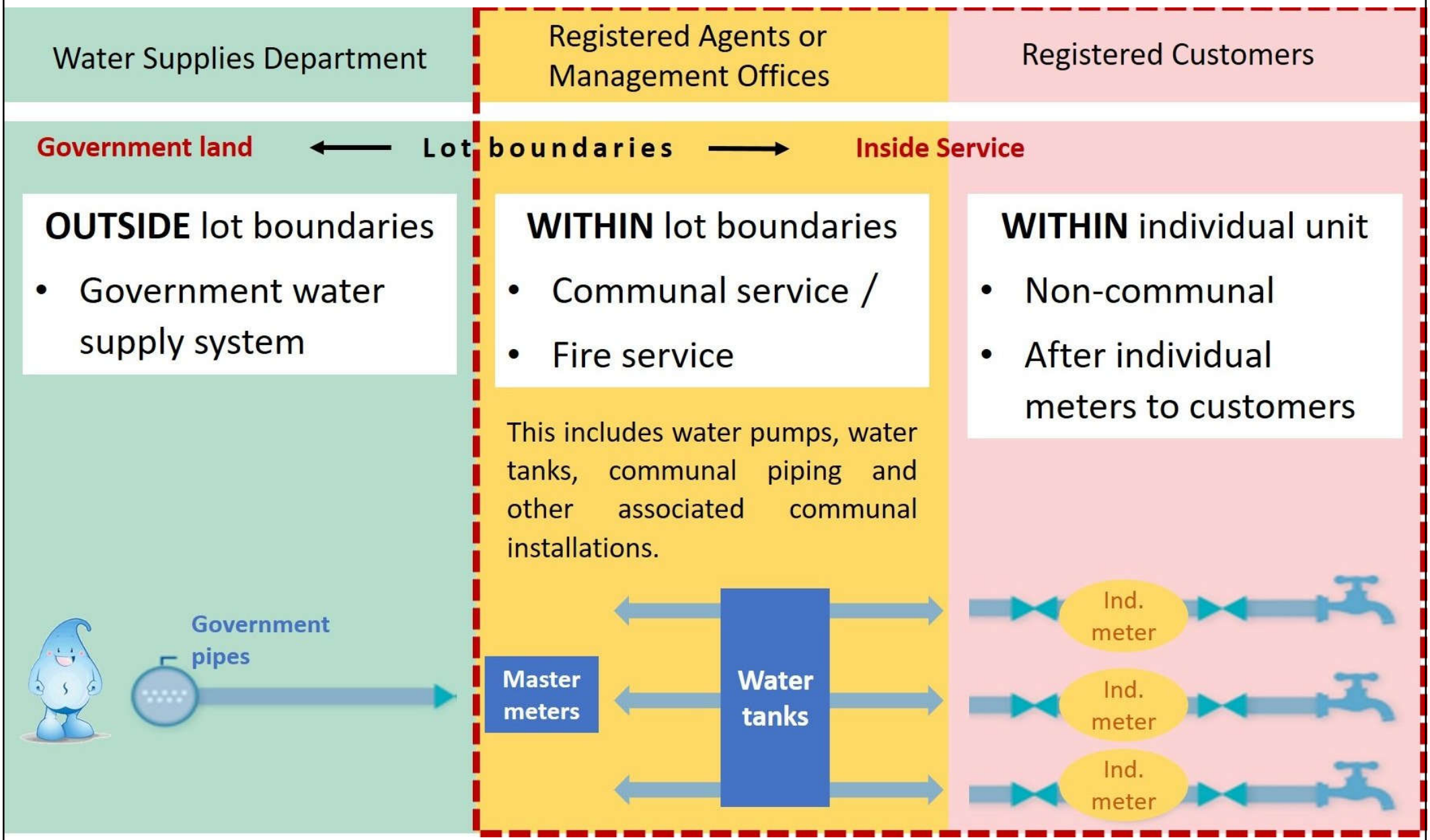
Schematic diagram of a typical inside service



"Inside Service" (內部供水系統):
The pipes and fittings between the premises and a connection to the main

(Source: https://www.devb.gov.hk/filemanager/en/Content_3/TF_Final_Report.pdf)

Maintenance responsibility of government waterworks and inside service

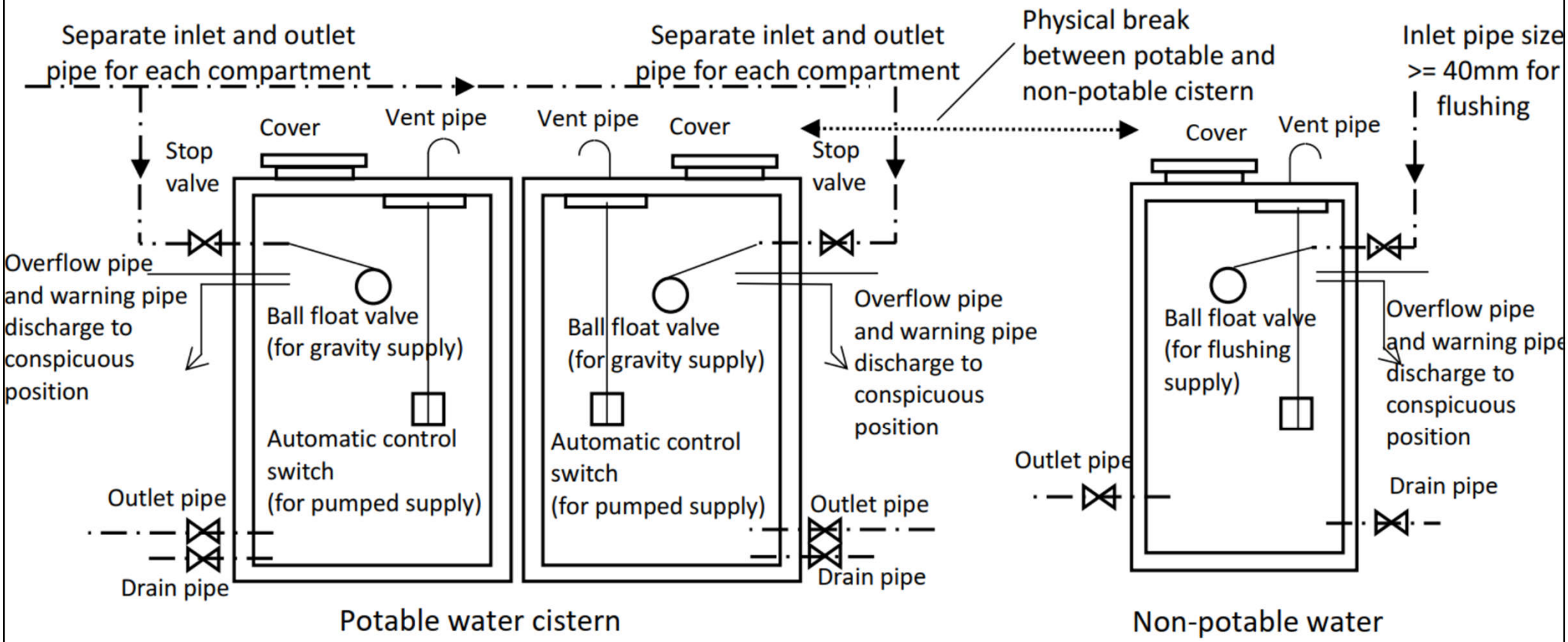


(Source: https://www.brplatform.org.hk/en/defects-and-orders/common-building-defects/defective-fresh-water-pipe)

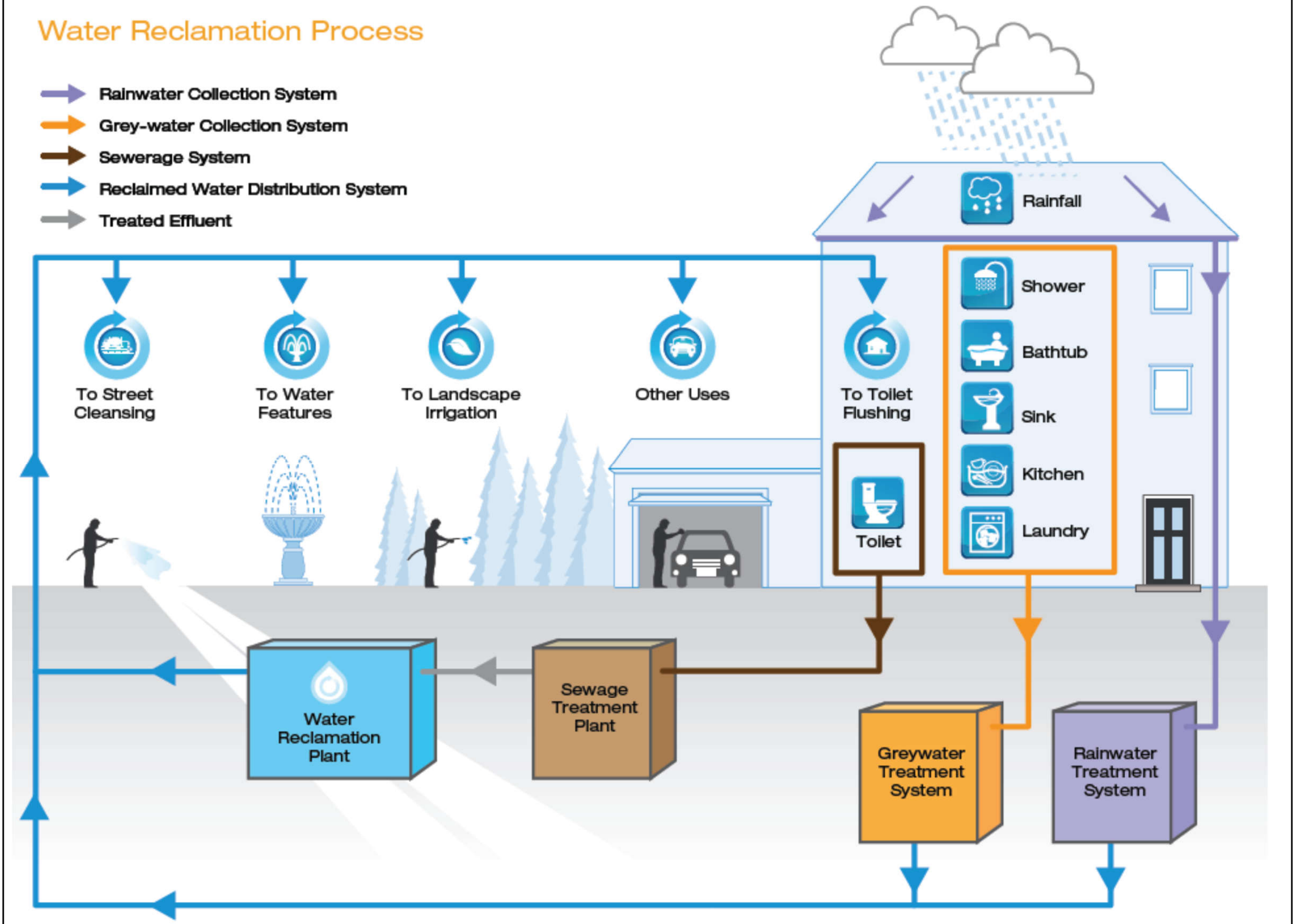
Water supply distribution

- Water supply systems in buildings
  - *Direct supply system*: conveys water directly from water mains to the point of usage without any transit water storage tanks
  - *Indirect supply system*: conveys water from water mains to the point of usage through a transit water storage tank (usually a sump water tank and a roof water tank)
- Potable/fresh water, flushing/salt water and water for fire services (e.g. FH/HR, sprinkler)

Typical components of water cisterns (storage tanks)

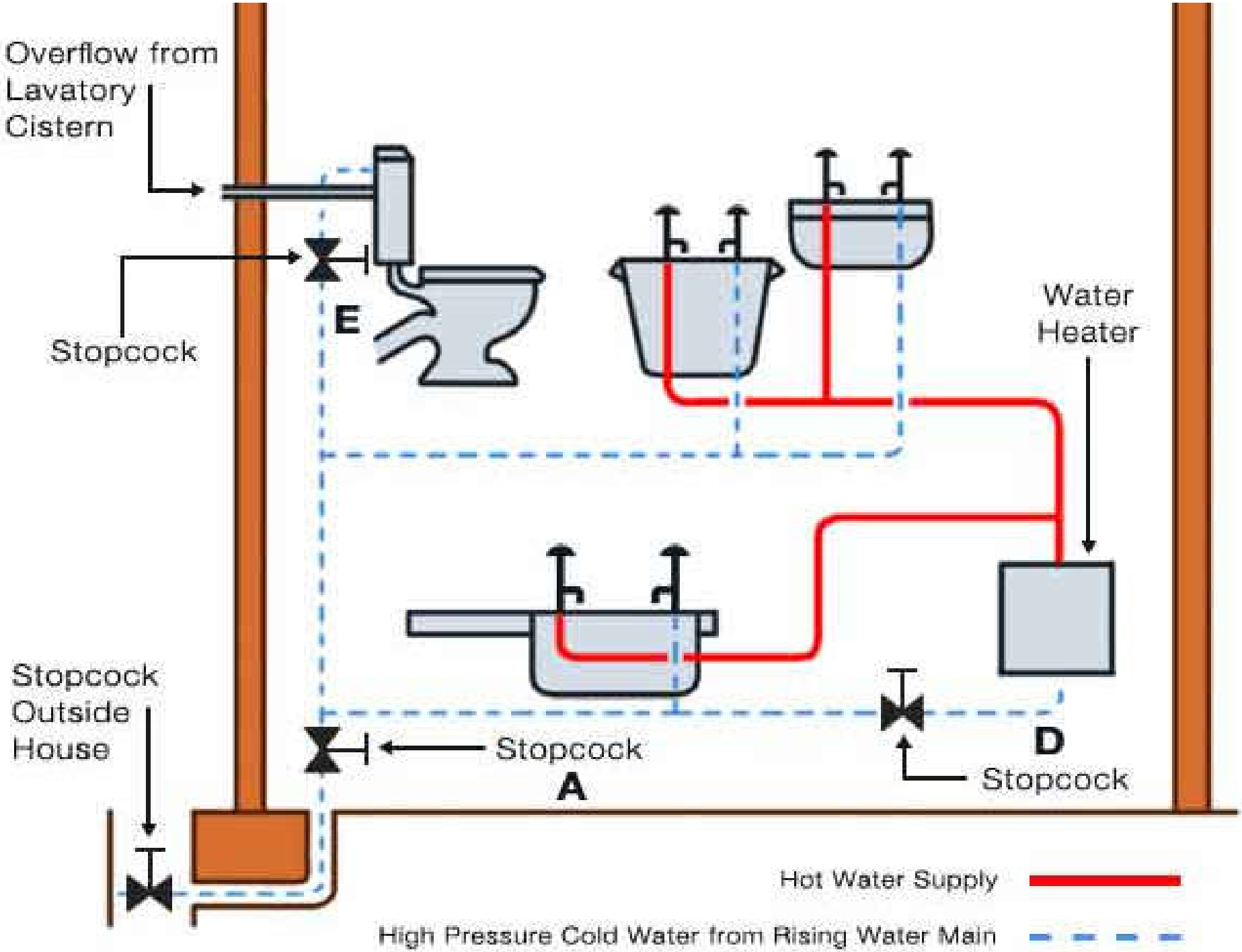


(Source: WSD, 2020. *Technical Requirements for Plumbing Works in Buildings (November 2020 version)*, Water Supplies Department (WSD), Hong Kong. https://www.wsd.gov.hk/en/plumbing-engineering/requirements-for-plumbing-installation/technical-requirements-for-plumging-works-in-bldgs/)



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

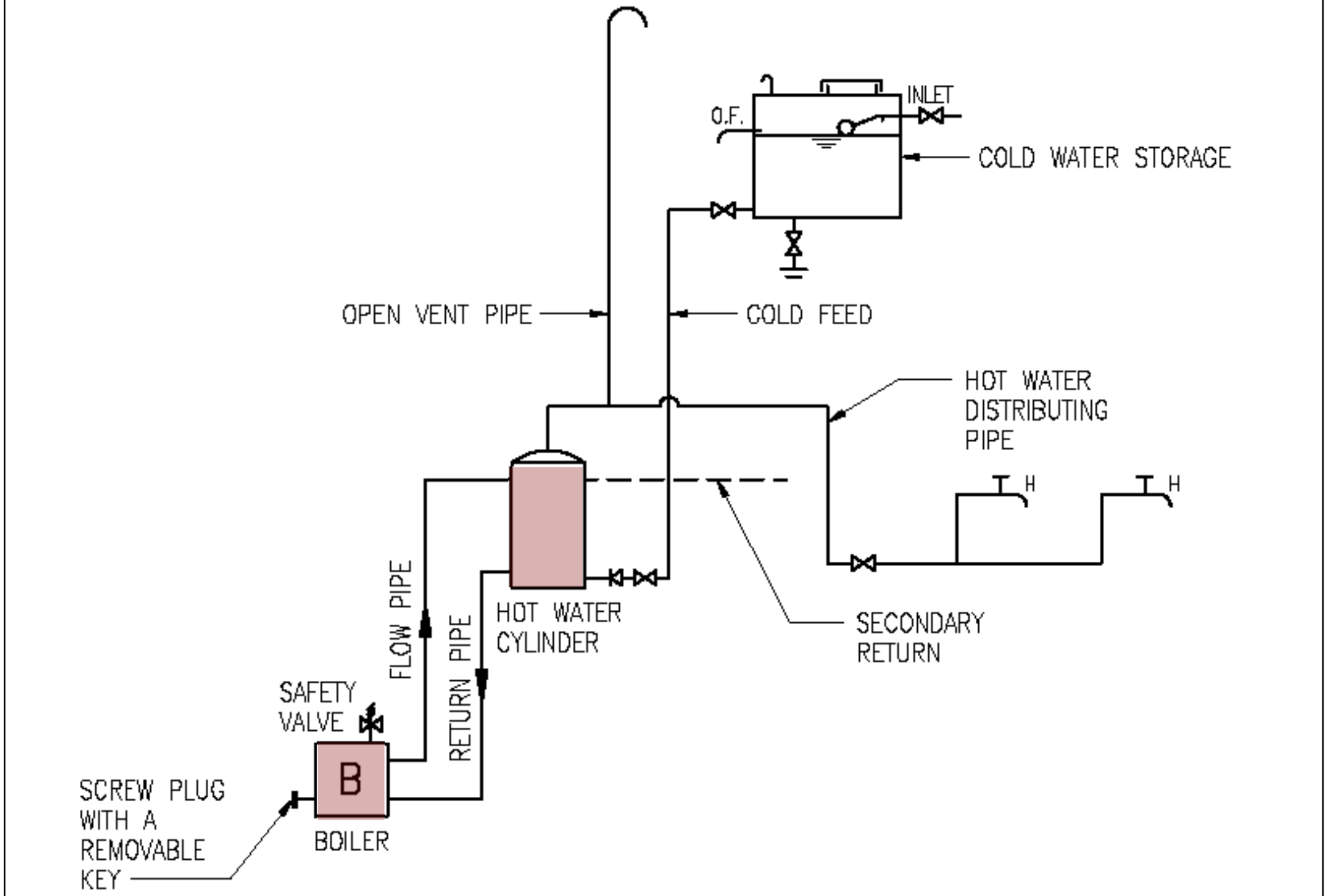
An example of cold and hot water supply system



System selection

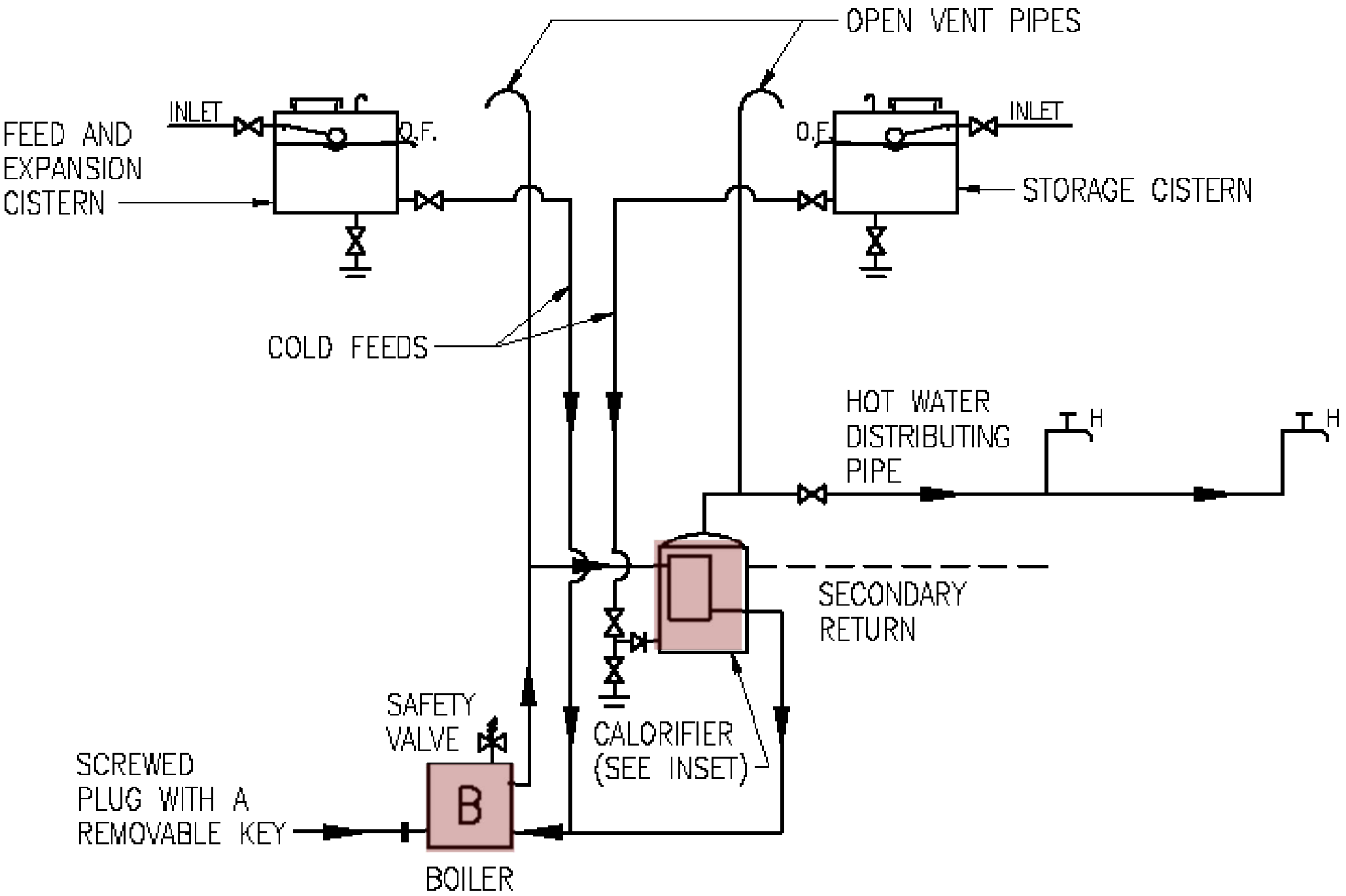
- Common types of water heaters
  - Gas-fired water heaters
  - Electric water heaters
  - Water-jacketed tube heaters
  - Solar water heating
  - Heat pump water heaters

Direct centralised hot water system



(Source: WSD, 2006. *Handbook on Plumbing Installation for Buildings*)

Indirect centralised hot water system



(Source: WSD, 2006. *Handbook on Plumbing Installation for Buildings*)

Requirements for non-centralised hot water systems

Type of water heater	Requirements for direct connection (without storage tank) to supply pipe
Non-pressure type heaters Cistern type water heaters Instantaneous water heaters	The factory test pressure of the heater is in excess of 1.5 times the maximum static pressure at the water mains supply point
Unvented electrical thermal storage water heaters	HKWSR Clause 5.11 and with safety devices complying with Electrical Products (Safety) Regulation
Pressure type thermal storage heaters other than unvented heaters	Storage tank is required in all cases with a vented pipe

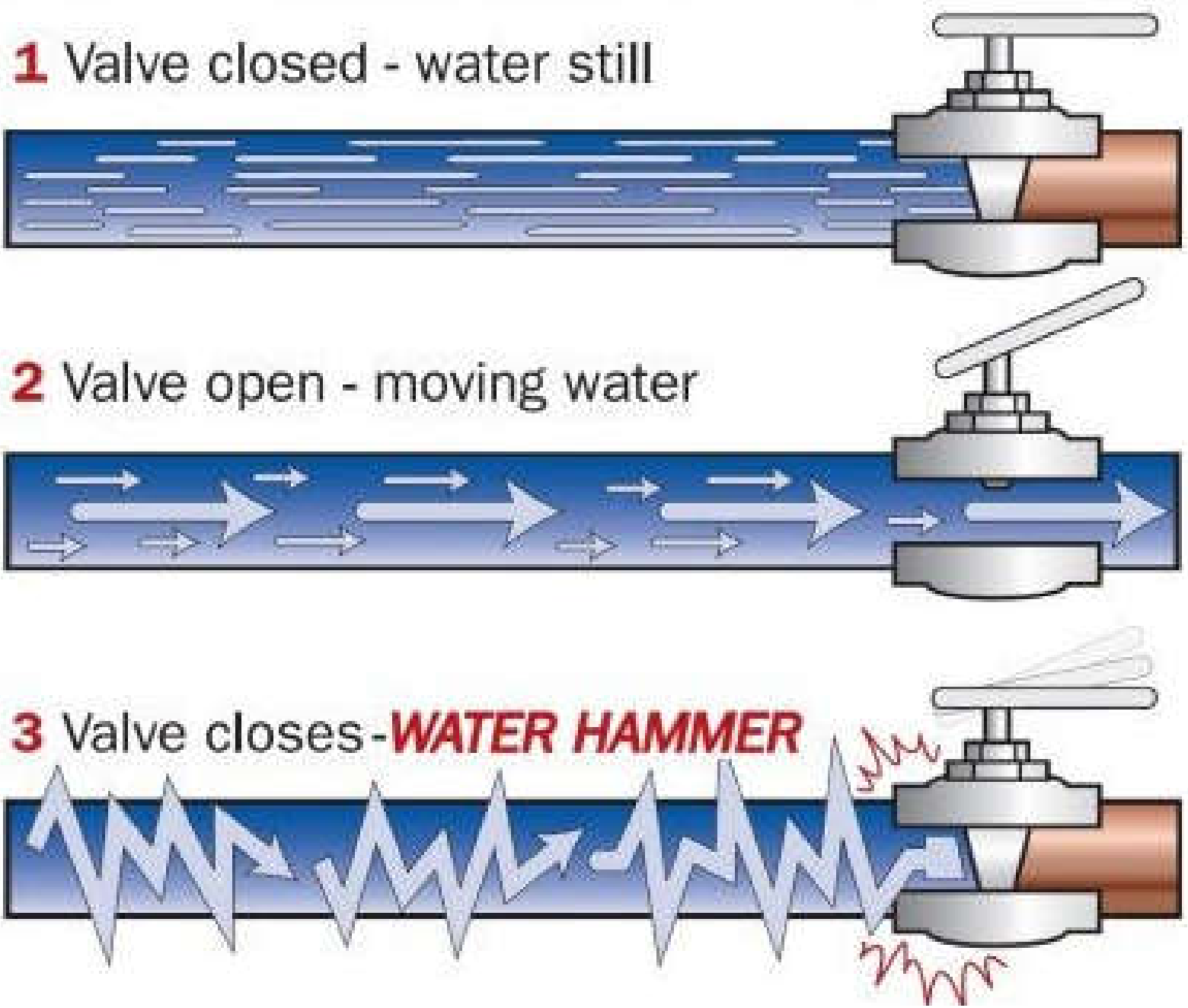
(Source: WSD, 2006. *Handbook on Plumbing Installation for Buildings*)

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/)

What is Water Hammer?



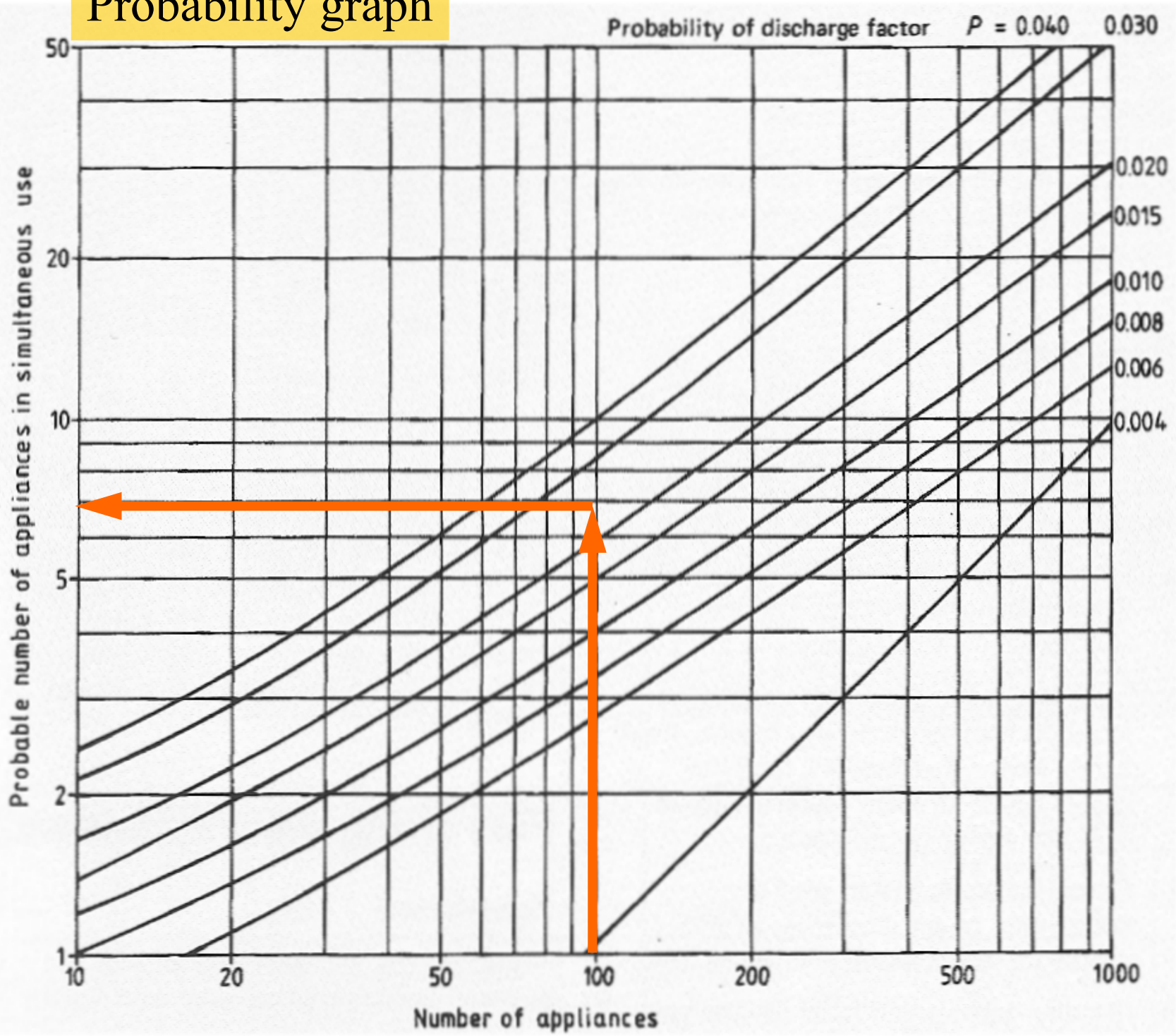
Video: What is Water Hammer? | DFT Inc. (2:38) https://youtu.be/6ydsAIHWVNM

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

Design considerations

- Major tasks of water systems design:
  - 1. Assessment & estimation of demands
  - 2. Supply scheme & schematic
  - 3. Water storage requirements
  - 4. Piping layout
  - 5. Pipe sizing
  - 6. Pipe & fitting materials
  - 7. Pump system design

Probability graph



(Source: IOP, 2002. *Plumbing Engineering Services Design Guide*)

Example:
If 100 appliances each take 30 sec to be filled, and are used at 1200 sec (20 min) frequency interval, then:

$P = t / T$
$= 30/1200$
$= 0.025$

Using the graph, out of 100 appliances, only 7 would be in use at any one time.

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

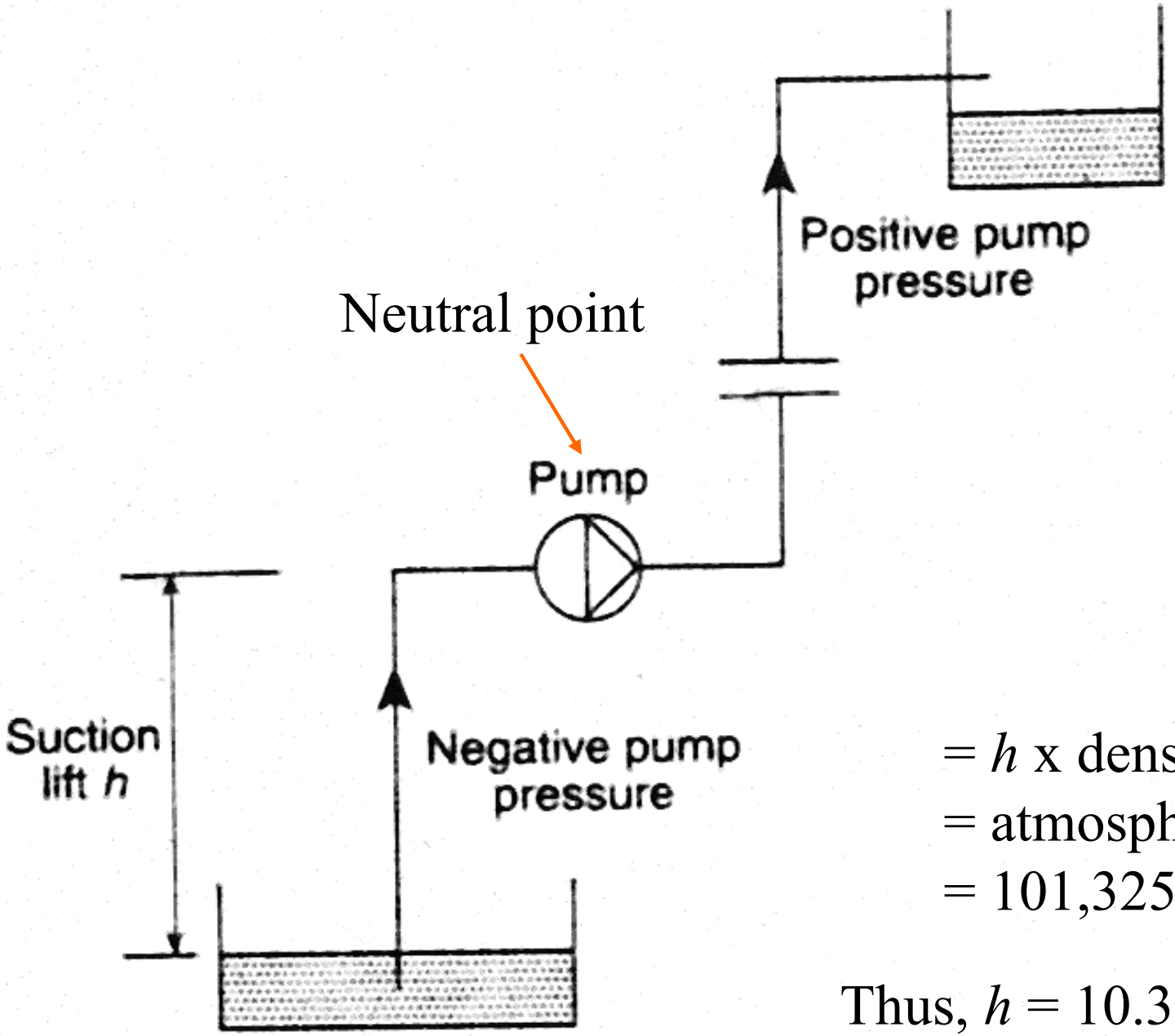
✗ : Not suitable for use in general

(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)

Pump pressure effects in an open system



= *h* x density x 9.81
= atmospheric
= 101,325 Pa

Thus, *h* = 10.33 m

Drainage, Sewage Disposal & Steam Systems

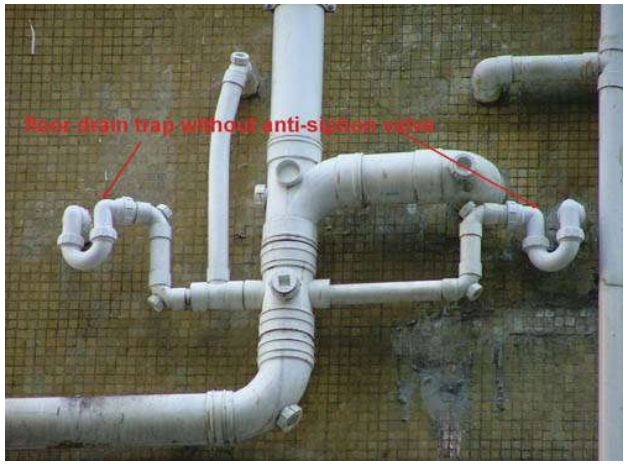
Sanitation and Drainage	Sewage Disposal	Steam Systems
• Design concepts • Basic principles • Sanitary drainage • Stormwater drainage • Important issues	• Drainage below ground • Sewage pumping • Methods of sewage disposal • Sewage treatment process	• Properties of Steam • Uses of Steam • Steam System • Steam Traps and Components • Boilers • Design Considerations • Condensate Recovery

Basic concepts of sanitary plumbing & drainage systems

Plumbing system (water supply)

Sanitary fitments

Rainfall, surface water & stormwater



Above ground drainage

Sometimes, sump & pump system is required for disposal e.g. in basement

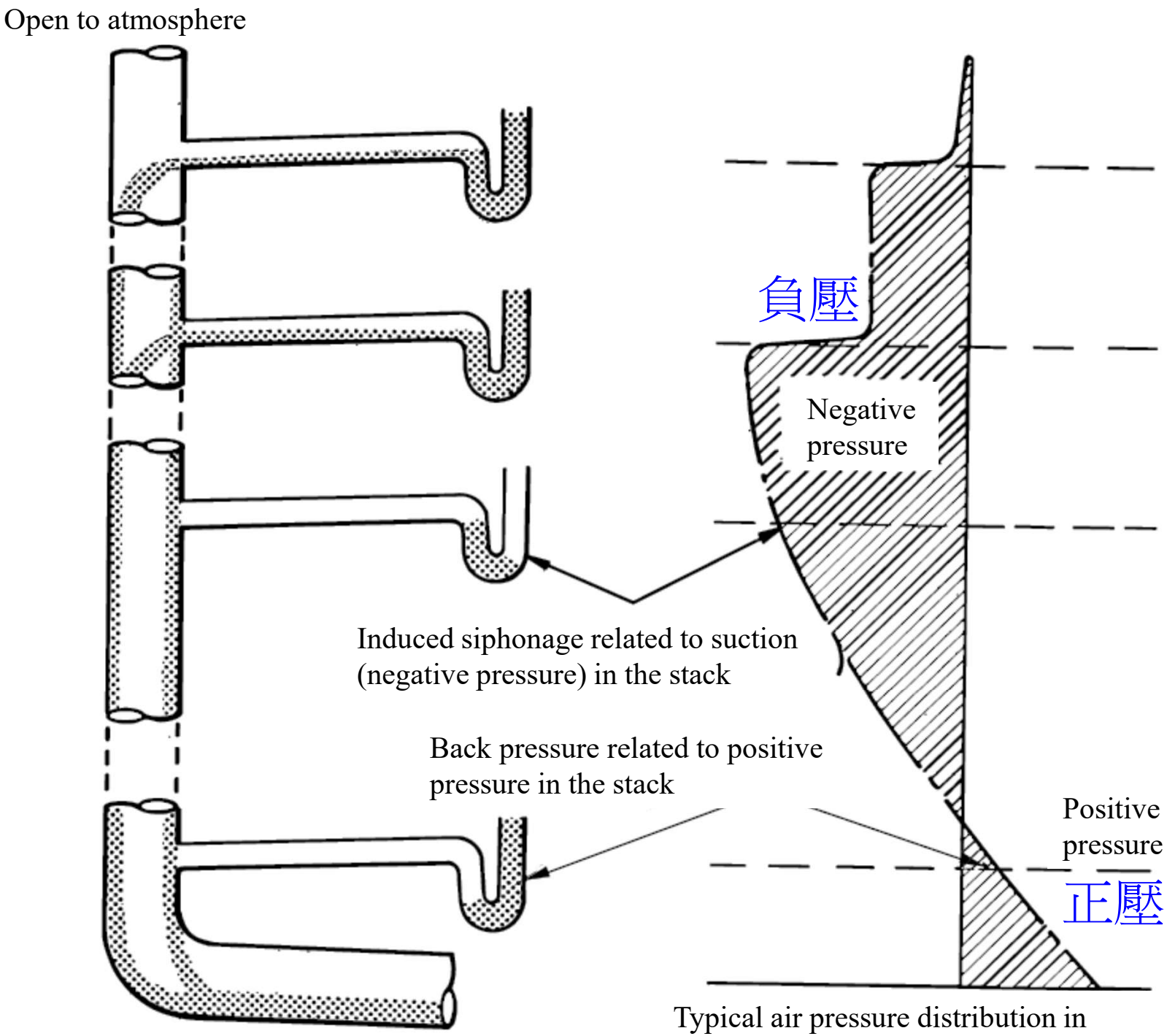
Below ground drainage

Sewage disposal (and treatment)

Design concepts

- Types of sanitary drainage stack systems
  - Single stack system
  - Collar boss system
  - Modified single stack system
  - Fully ventilated one-pipe system
  - Two-pipe system
- Selection depends on situations, costs & local design practices
- Design considerations: e.g. pipe size, distance

Pressure effects and seal losses due to water flow in a discharge stack



Typical air pressure distribution in stack with two branches discharging

(Source: Bristish Standard BS EN12056-2:2000)

Discharge unit (DU) for common appliances & K factor

Appliance	DU (l/s)*
Wash basin or bidet	0.3
Shower without plug	0.4
Shower with plug	1.3
Single urinal with cistern	0.4
Slab urinal (per person)	0.2
Bath	1.3
Kitchen sink	1.3
Dishwasher (household)	0.2
Washing machine (6 kg)	0.6
Washing machine (12 kg)	1.2
WC with 6 litre cistern	1.2 – 1.7
WC with 7.5 litre cistern	1.4 – 1.8
WC with 9 litre cistern	1.6 – 2.0

* For a single stack system with full bore branch discharge pipes

Usage of appliance	K
Intermittent use, e.g. dwelling, guesthouse, office	0.5
Frequent use, e.g. hotel, restaurant, school, hospital	0.7
Congested use, e.g. toilets and/or showers open to the public	1.0
Special use, e.g. laboratory	1.2

$$\mathbf{Qww = K \sqrt{\Sigma DU}}$$

where

Qww = wastewater flow rate (l/s)

K = frequency of use

ΣDU = sum of DUs

$$\mathbf{Qtot = Qww + Qc + Qp}$$

Qtot: total flowrate (l/s)

Qc: continuous flowrate (l/s)

Qp: pumped flowrate (l/s)

(Source: IOP, 2002. *Plumbing Engineering Services Design Guide*)

Stormwater drainage

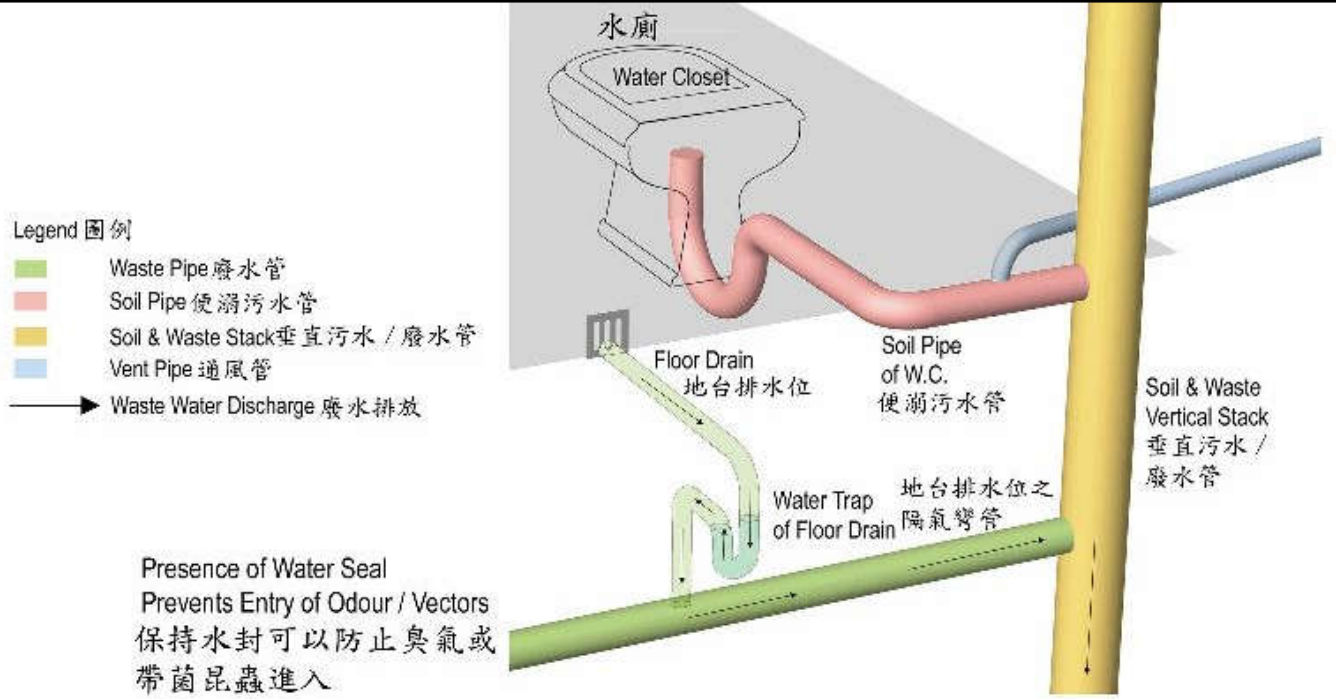
- Stormwater or rainwater drainage systems
  - Design for roofs, walls and ground drainage
    - Include rain water outlets, gutters, rain water stacks and occasional require sum and pump system for disposal
    - Require integration with architect
- Rain water flow rate, Q (l/s)
  - $Q = C \times A \times I / 3600$
    - C : impermeability factor or run-off coefficient
    - A : drainage or catchment area (m^2)
    - I : rainfall intensity (mm/hr)

Importance of access for inspection, maintenance & repair of drain pipes

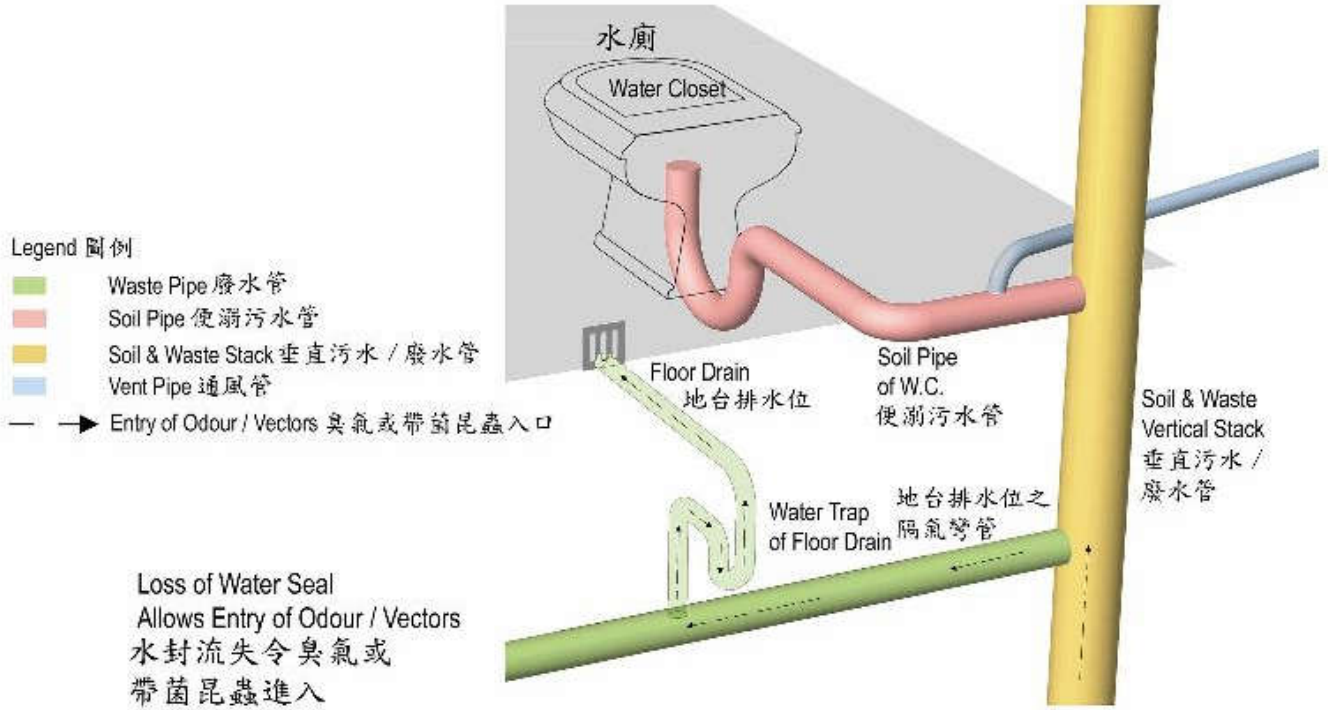
External wall of the building

Internal pipe duct accessible from common parts

(Source: Buildings Department)



Loss of water seal allows entry of odour/vectors

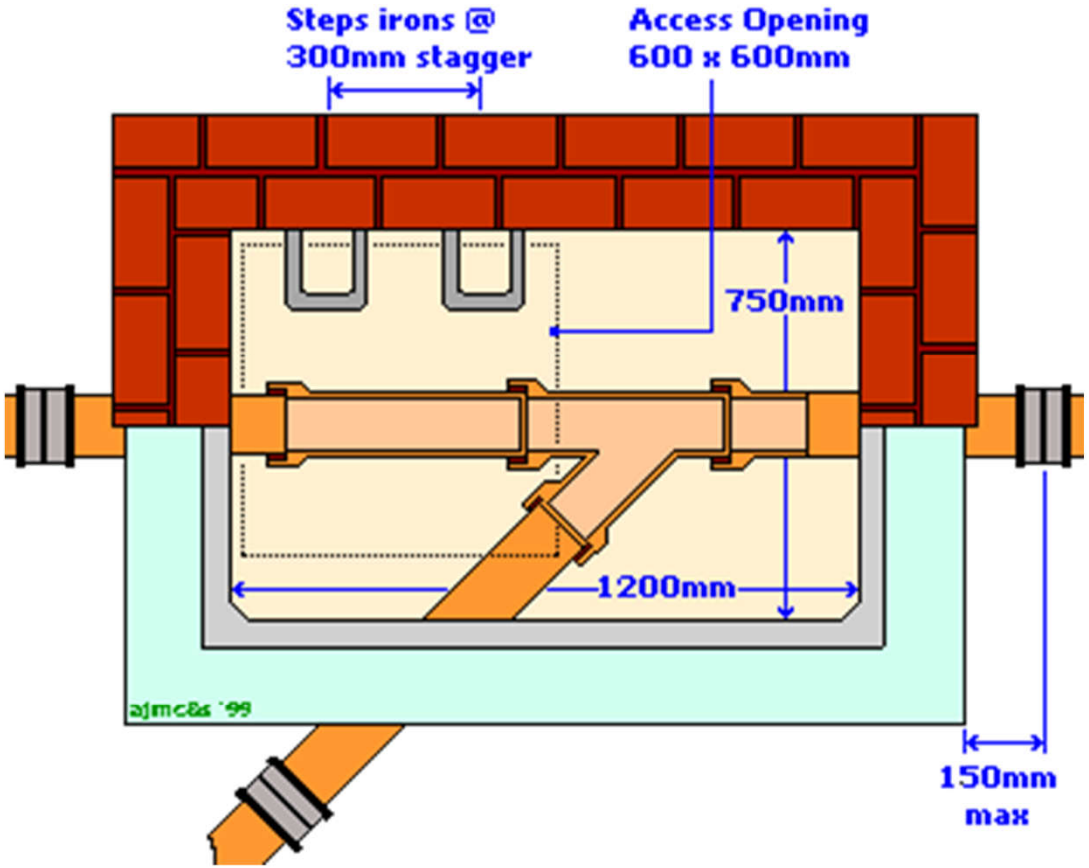


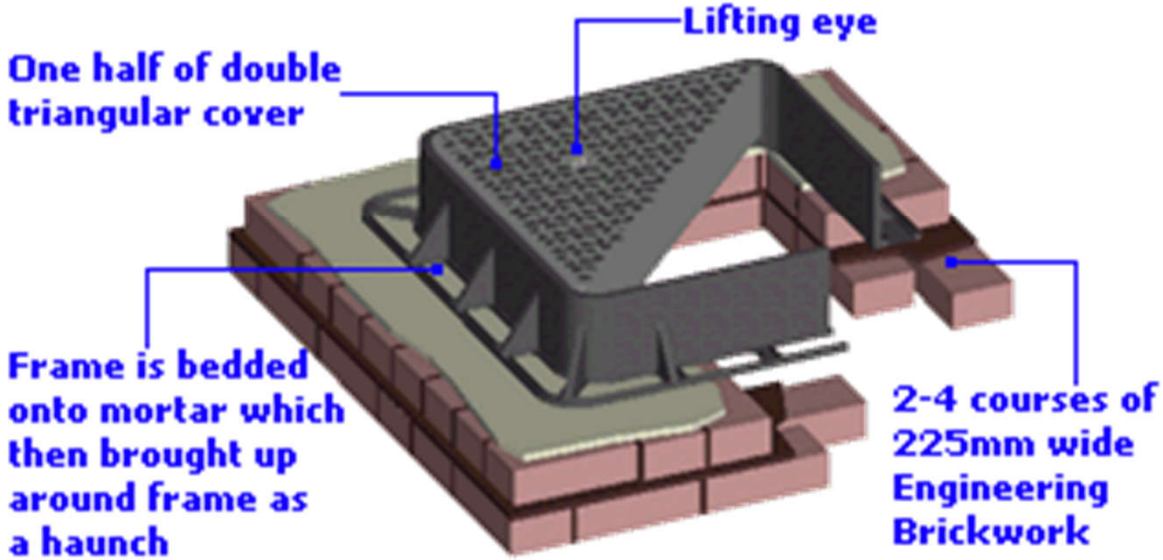
(Source: https://www.info.gov.hk/info/sars/en/report.htm)

Drainage below ground

- System types
  - 1. Combined system (foul water + rainwater)
  - 2. Separate system
  - 3. Partially separate system
- Design considerations: costs, load on sewers
- Common fittings
  - Rainwater gully (RWG), yard gully (YG)
  - Inspection chamber (IC), rodding pod (RP)
  - Shoe and rest band (smooth connection)

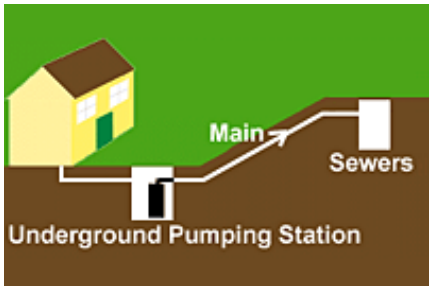
Manhole in plan view and manhole covers



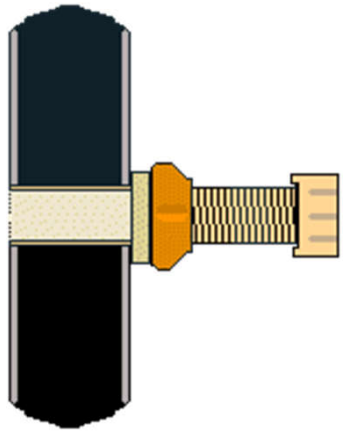


(Source: https://www.pavingexpert.com/drain05)

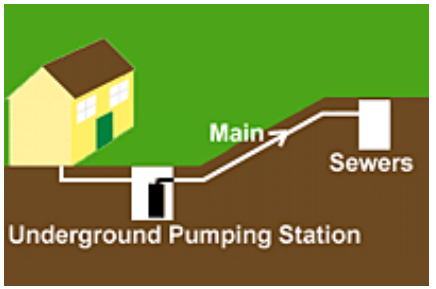
Testing & sewage pumping



- Acceptance tests of drainage systems
  - 1. Air test
    - With hand pump and stoppers
  - 2. Smoke test
    - With smoke machine and stoppers
  - 3. Water test (most common for u/g drains)
    - Seal ends of drains & connections with approved plugs
    - Fill with water to produce 1.5m head at high end
    - Allow for initial absorption
    - Measure loss of water over 30 minutes

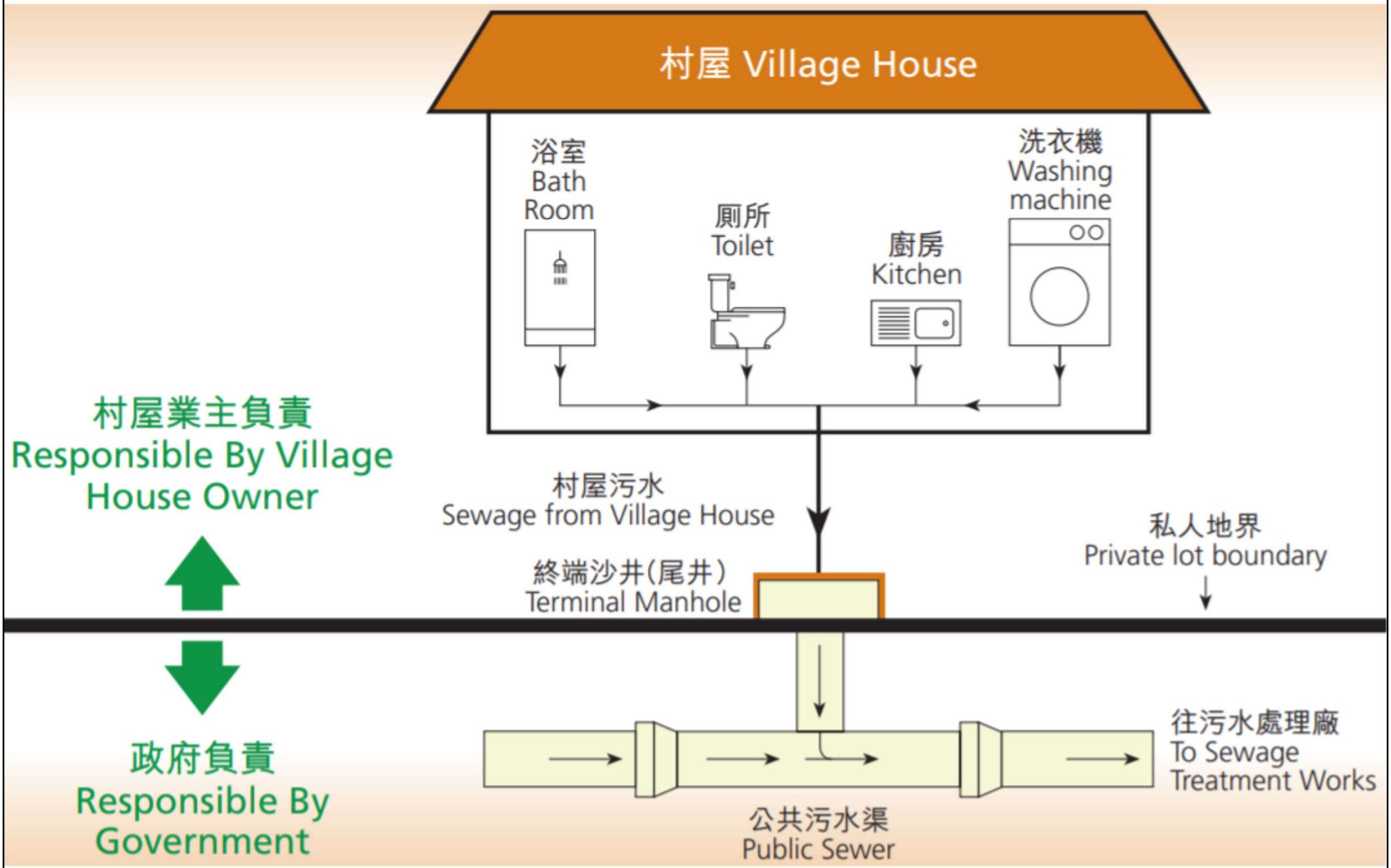


Testing & sewage pumping



- Classification of sewage pumping stations
  - (a) Wet well/dry well pumping stations
  - (b) Submersible pumping stations
  - (c) Screw pumping stations (or Archimedean screw pumping station)
- Design considerations
  - Land/space requirements, structural design
  - Electrical system supply
  - Odour & noise control

Arrangement for connection of village sewer

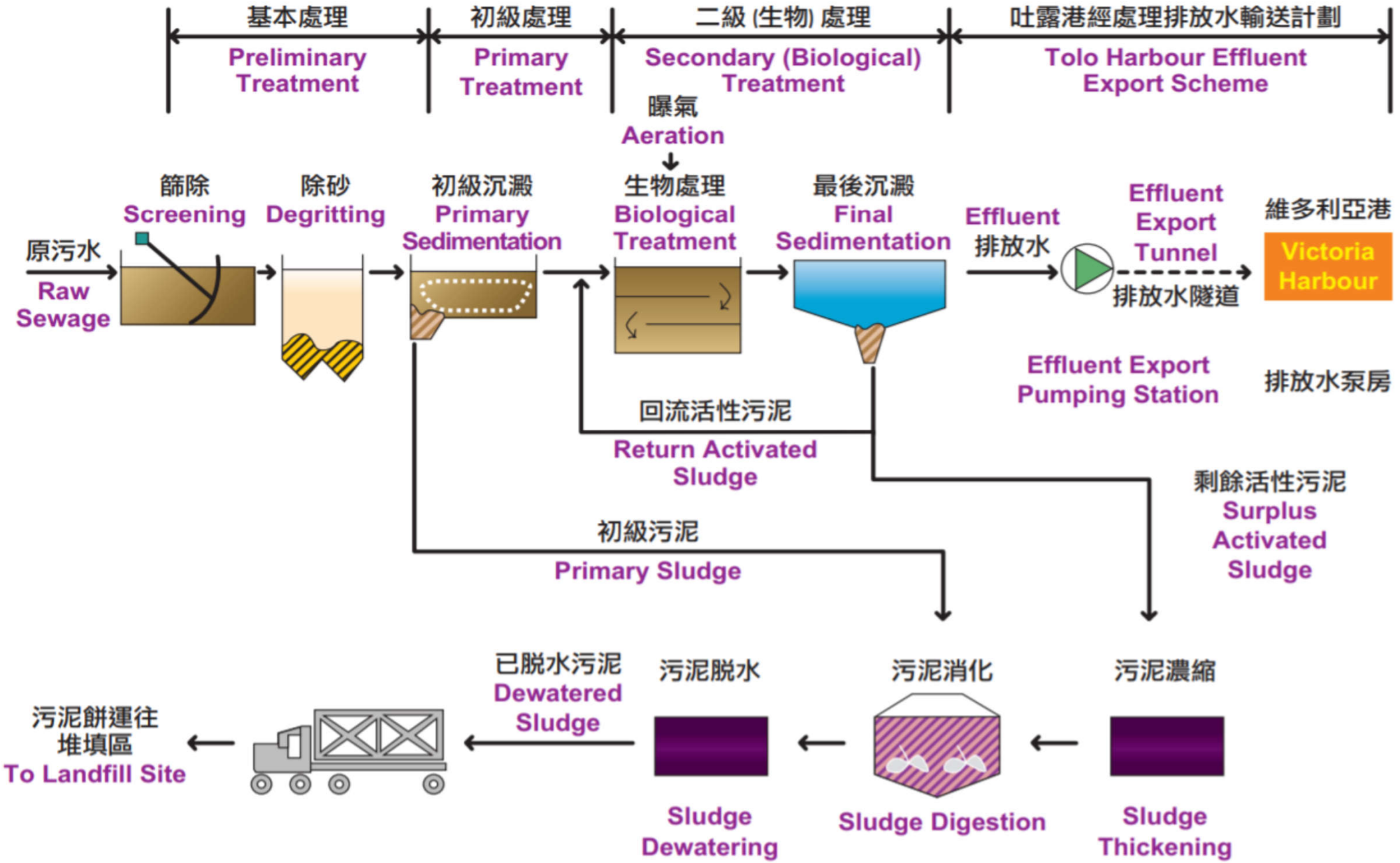


(Source: Drainage Services Department http://www.dsd.gov.hk/)

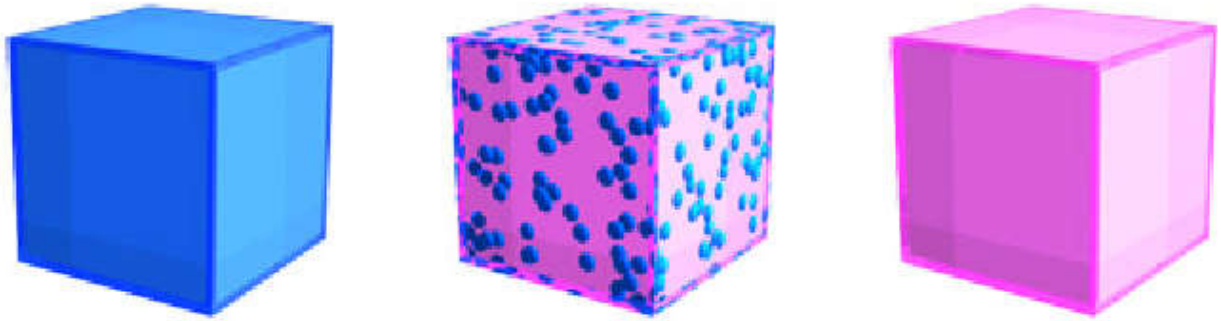
Methods of sewage disposal

- Disposal of stormwater or rainwater
  - Sewer: combined or a separate surface-water
    - Interceptors required for car parks and kitchens
  - Soakaway: ground permeability
    - Using perforated precast concrete, dry stone or brick pit
  - Storage (see Drainage Services Dept.'s example)
    - Artificial pond or lake, or underground storage tank
  - Watercourse
    - Expected flow rates at normal and flood levels

Sewage treatment process in Shatin Sewage Treatment Works



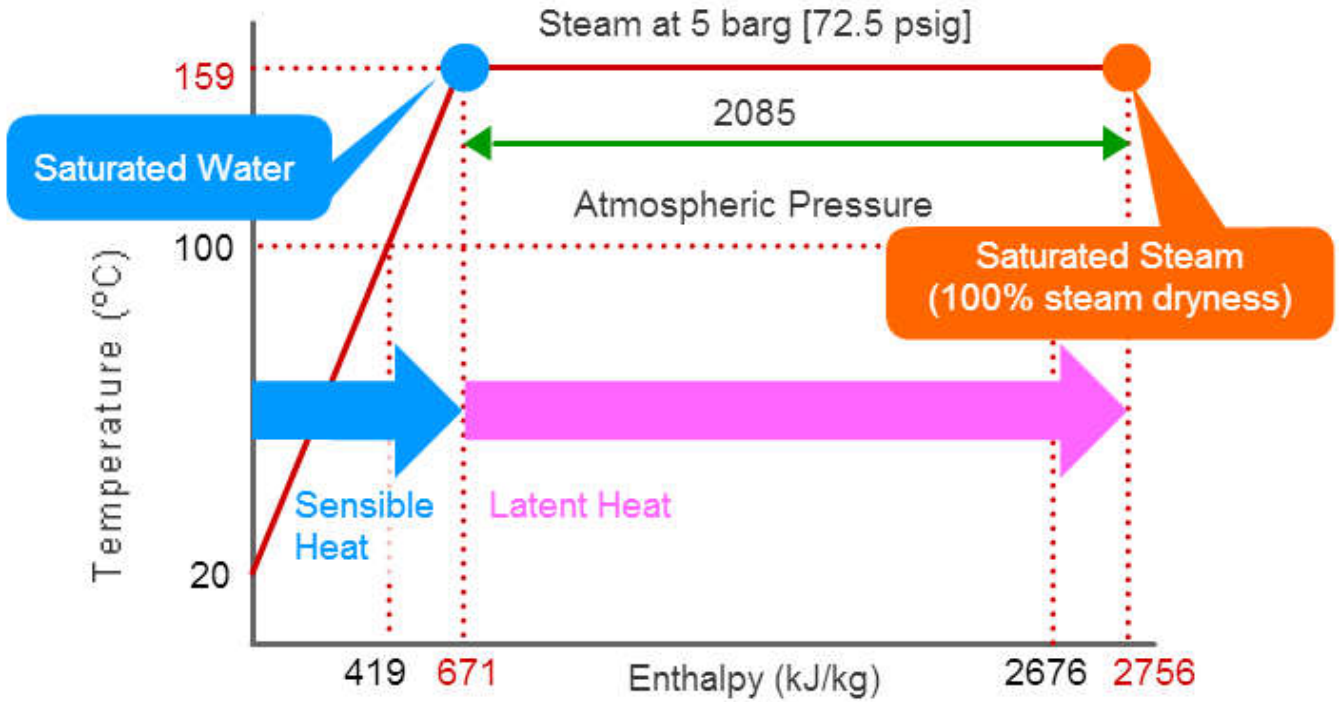
(Source: https://www.dsd.gov.hk/TC/Files/publications_publicity/publicity_materials/leaflets_booklets_factsheets/Sha%20Tin%20STW.pdf)



Saturated Water (0% Dryness)
Temperature: 100 °C [212 °F]
Total Heat: h_f + 0%·h_{fg}
= 419 kJ/kg [180 BTU/lb]

Wet Steam (x% Dryness)
Temperature: 100 °C [212 °F]
Total Heat: h_f + x%·h_{fg}
< 2676 kJ/kg [1150 BTU/lb]

Saturated Steam (100% Dryness)
Temperature: 100 °C [212 °F]
Total Heat: h_f + 100%·h_{fg}
= 2676 kJ/kg [1150 BTU/lb]



Steam Table (abs) (m³/kg) (kJ/kg)

P (bar)	T (°C)	v_f	v_g	h_f	h_{fg}	h_g
1	100	0.00104	1.673	419	2257	2676
6	159	0.00110	0.3213	671	2085	2756

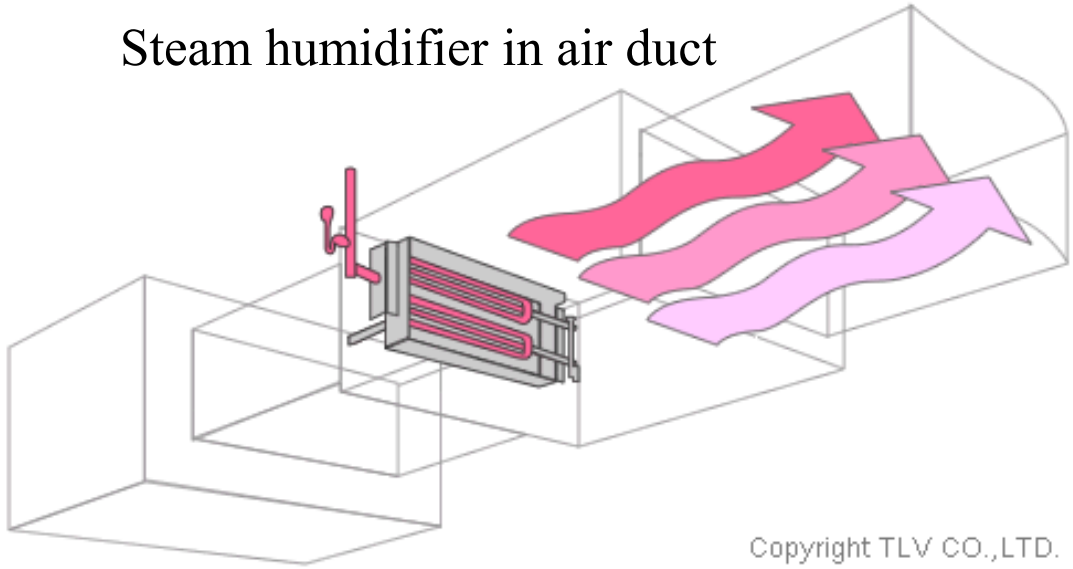
(Source: http://www.tlv.com/global/AU/steam-theory/wet-steam-dry-steam.html)

The relationship between steam dryness and enthalpy

Uses of Steam

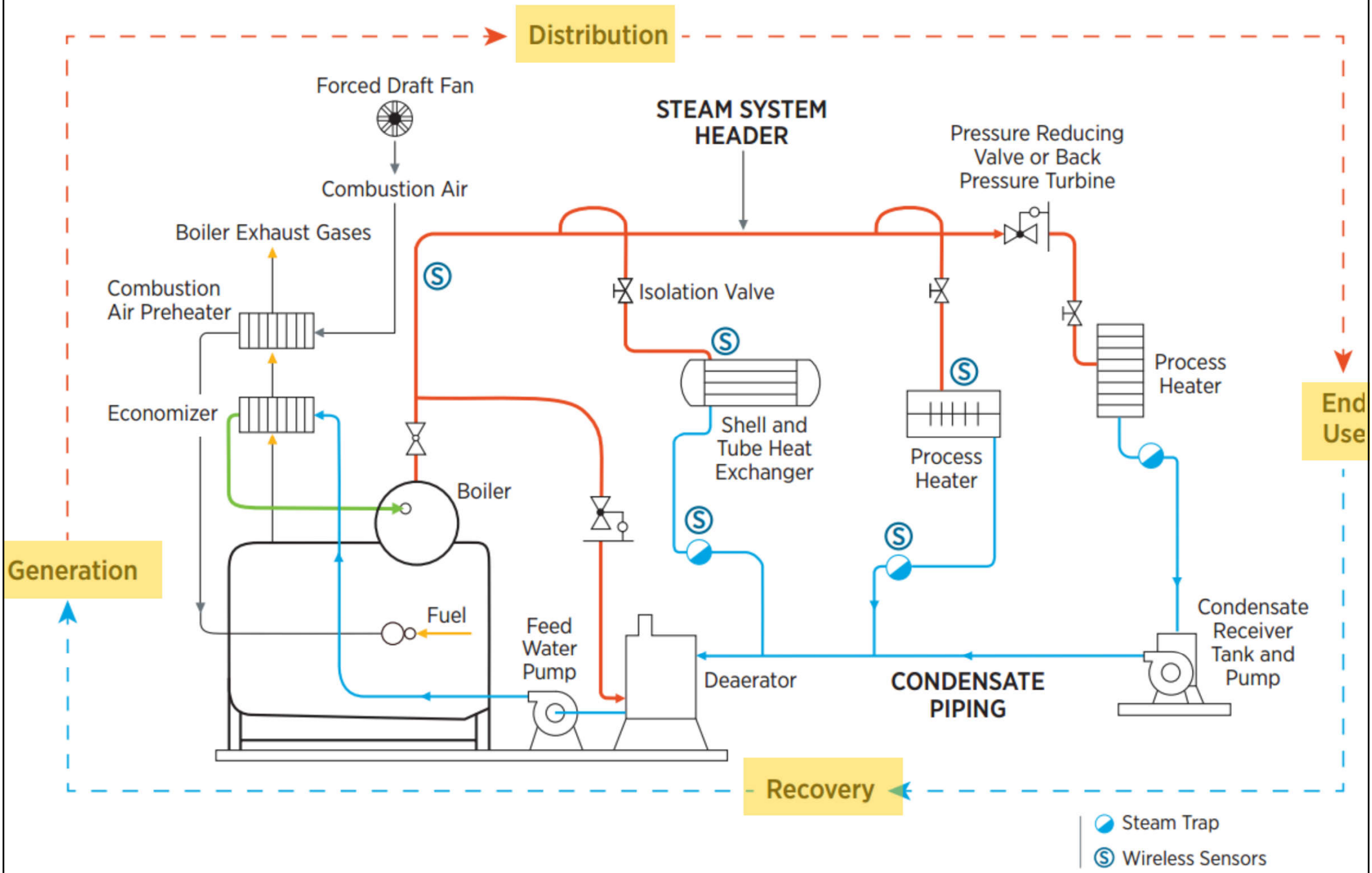
- Typical applications for steam in industry: *
  - Heating/Sterilization
  - Propulsion/Drive
  - Motive
  - Atomization
  - Cleaning
  - Moisturization
  - Humidification

Steam humidifier in air duct



(* Further info: http://www.tlv.com/global/AU/steam-theory/principal-applications-for-steam.html)

Four principal areas of a steam system



(Source: US-DOE, 2012. *Improving Steam System Performance: A Sourcebook for Industry*, Second Edition https://www.energy.gov/sites/prod/files/2014/05/f15/steamsourcebook.pdf)

Typical types of steam traps

Ball float type

Thermodynamic type

Thermostatic type

Inverted bucket type

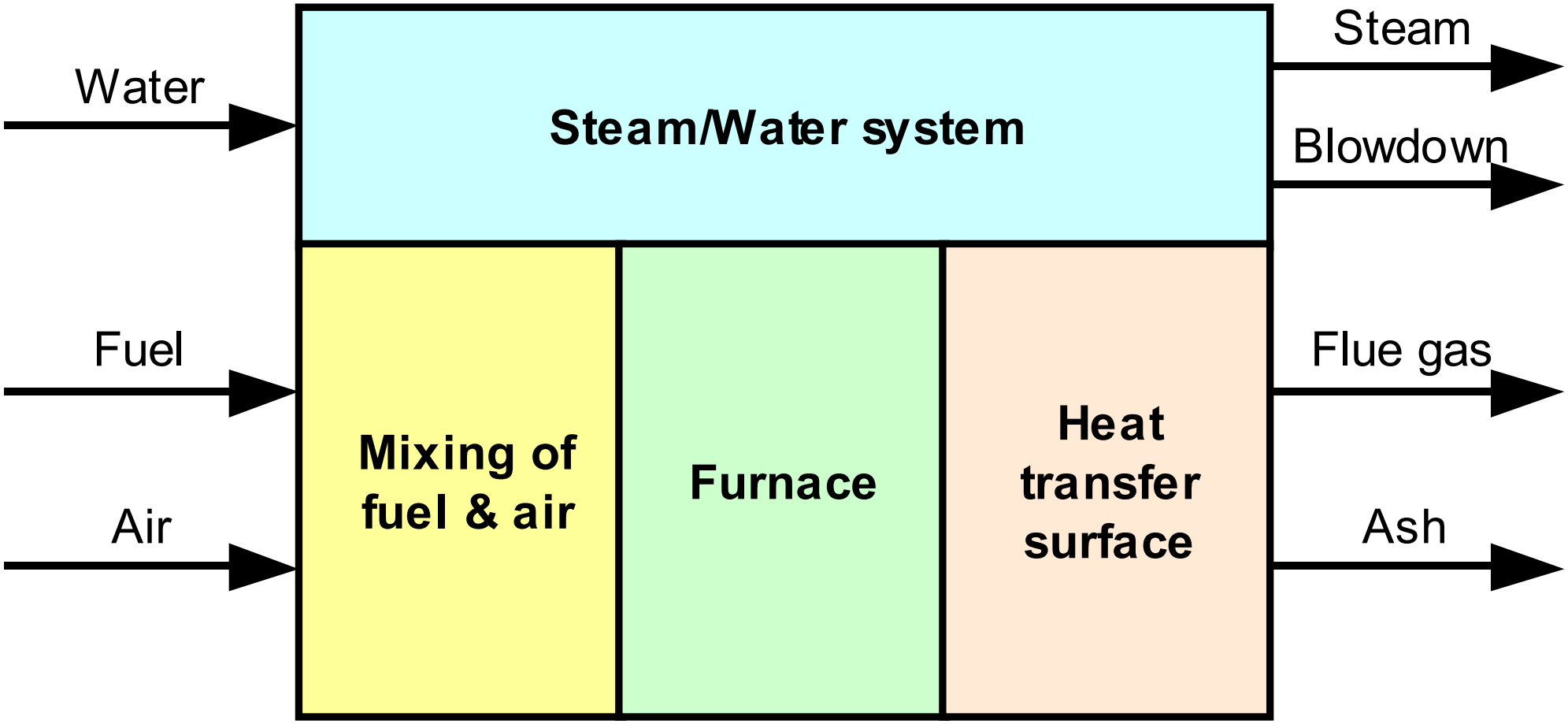
"The duty of a steam trap is to discharge condensate while not permitting the escape of live steam"

New functions in modern steam traps:
e.g. automatic air venting and scale removal

(See also: The History of Steam Traps
http://www.tlv.com/global/AU/steam-theory/history-of-steam-traps-pt1.html
http://www.tlv.com/global/AU/steam-theory/history-of-steam-traps-pt2.html)

(Source: www.spiraxsarco.com)

Basic diagram of a boiler



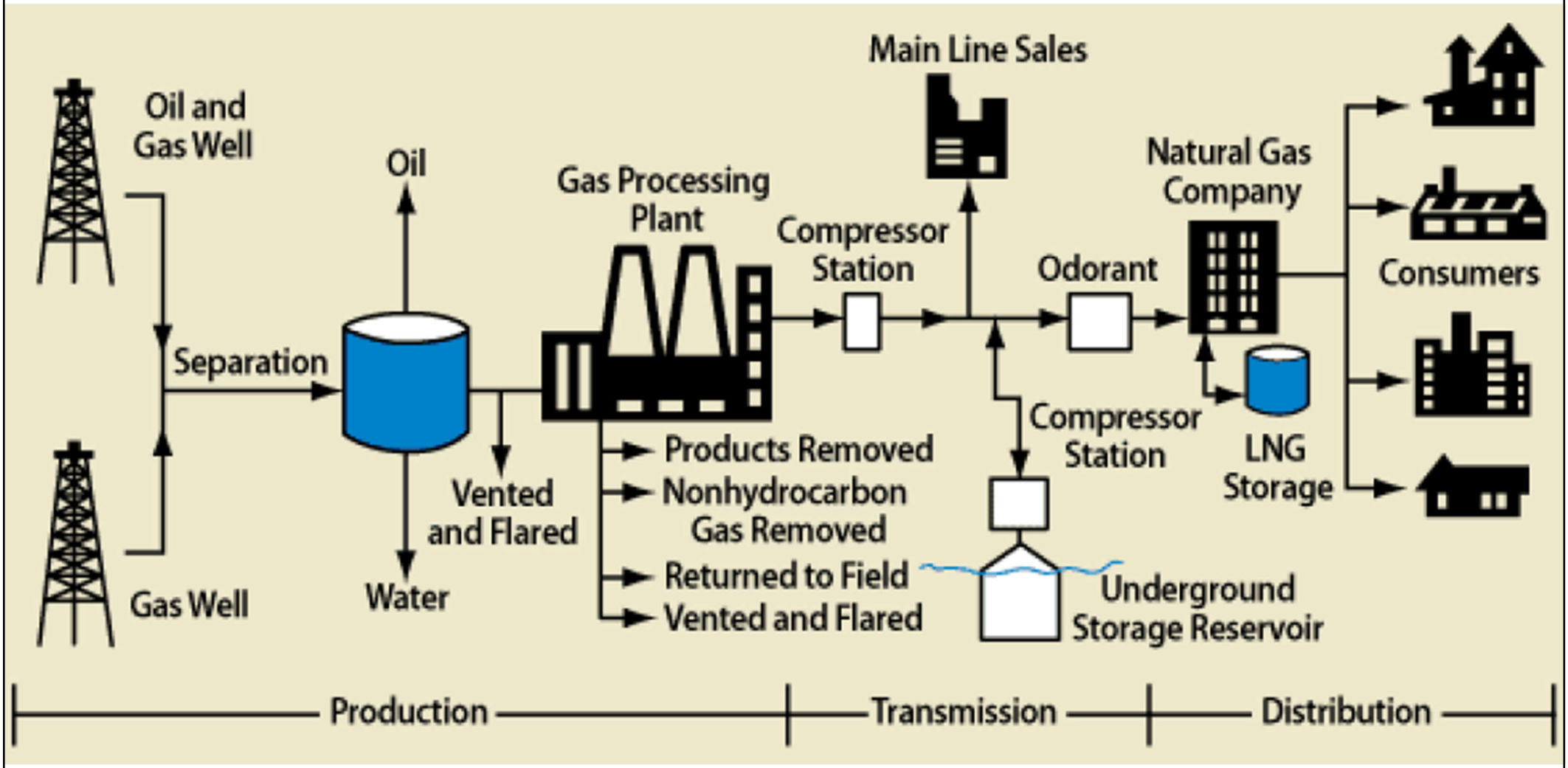
Design Considerations

- Steam Engineering Principles and Heat Transfer (Learn about steam)
  - https://www.spiraxsarco.com/Learn-about-steam
  - 6. Methods of Estimating Steam Consumption
  - 9. Energy consumption of tanks and vats
  - 10. Heating with coils and jackets
  - 11. Heating vats and tanks by steam injection
  - 12. Steam Consumption of Pipes and Air Heaters
  - 13. Steam Consumption of Heat Exchangers
  - 14. Steam Consumption of Plant Items

Fuel Gas Supply & Vertical Transportation

Fuel Gas Supply	Vertical Transportation (I)	Vertical Transportation (II)
• Introduction • Gas Supply in Hong Kong • System Components • Design Considerations • Gas Pipe Sizing	• Basic Principles • Planning & Design Factors • System Types • Regulations and Codes • Lift Traffic Analysis • Advanced Traffic Planning	• Lift Components • Lift Drive Operation • Lift Traffic Control • Operation of Escalators • Safety Issues • Energy Efficiency • Modernisation

Gas supply chain (natural gas)



(Source: https://www.aemc.gov.au/energy-system/gas/gas-supply-chain)

Types of fuel gases and their properties

	Town Gas	Liquefied Petroleum Gas
Materials / Components	Feedstocks: Naphtha and natural gas Constituents: hydrogen, methane, carbon dioxide, and a small amount of carbon monoxide, nitrogen and oxygen	Propane and butane
Calorific Value (MJ/m^3)	17.27	116
Flammable Limits	4.5 ~ 44.3%	1.8 ~ 9.5%
Wobbe Index	24	84
Toxicity	Toxic	Non-toxic
Weight	0.52 times the weight of air	1.91 times the weight of air
Supply Method	It is supplied through a network of pipelines.	It is centrally supplied through a network of pipelines or stored in a cylinder in liquid form.

(Source: https://www.emsd.gov.hk/gsp/en/b02.html)

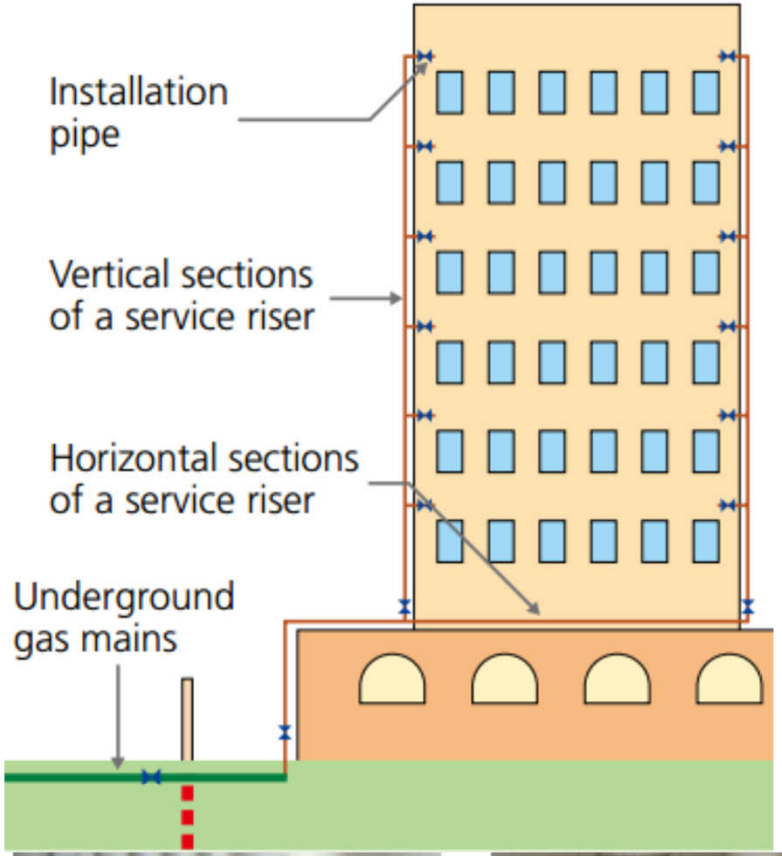


Figure 1: Vertical sections of a service riser

A service valve

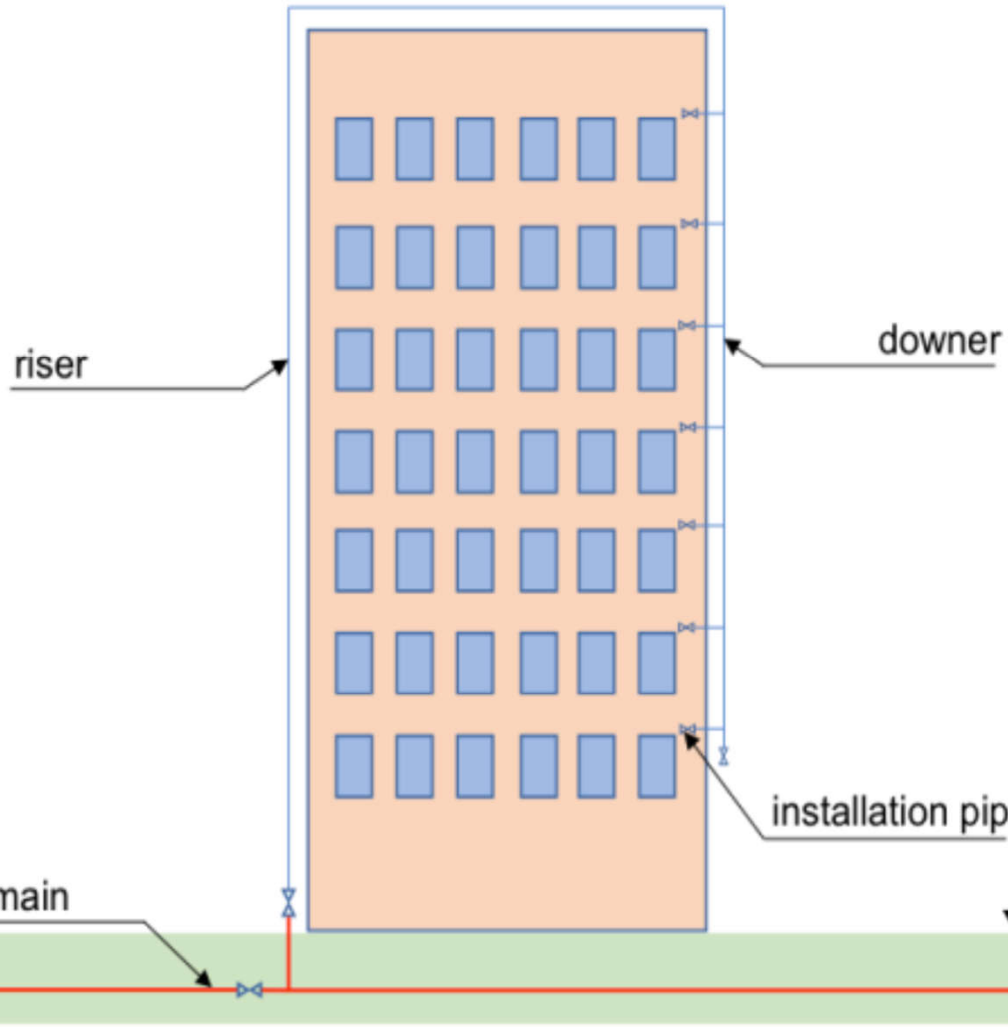
A town gas pipe duct

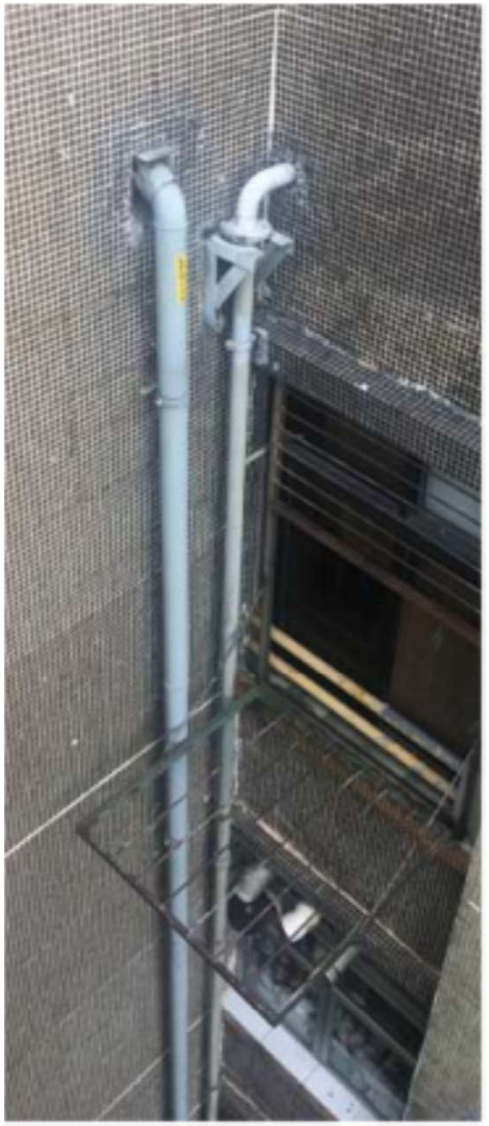
(Source: EMSD)

Figure 2: Horizontal sections of a service riser

Figure 3: An installation pipe and gas fittings

LPG pipework inside and outside a building





(Source: https://www.emsd.gov.hk/filemanager/en/content_266/GSB_30_Eng.pdf)

Gas flow rates in pipes

The Pole formula is used in the gas industry for determining the flow rate of gas in pipes. It is a simplification of the Darcy fluid flow formula.

$$Q = 0.0071\sqrt{\frac{h \times d^5}{s \times l}} \qquad (m^3/hr)$$

where: 0.0071 is a constant friction coefficient

h = pressure loss in millibars (mb)

d = pipe diameter (mm)

s = specific gravity of gas (natural gas approx. 0.6)

l = length of pipe conveying gas (m)

The Pole formula can be rearranged to make pressure loss (h) the subject:

$$h = \frac{Q^2 \times s \times l}{d^5 \times (0.0071)^2} \qquad \text{(millibars)}$$

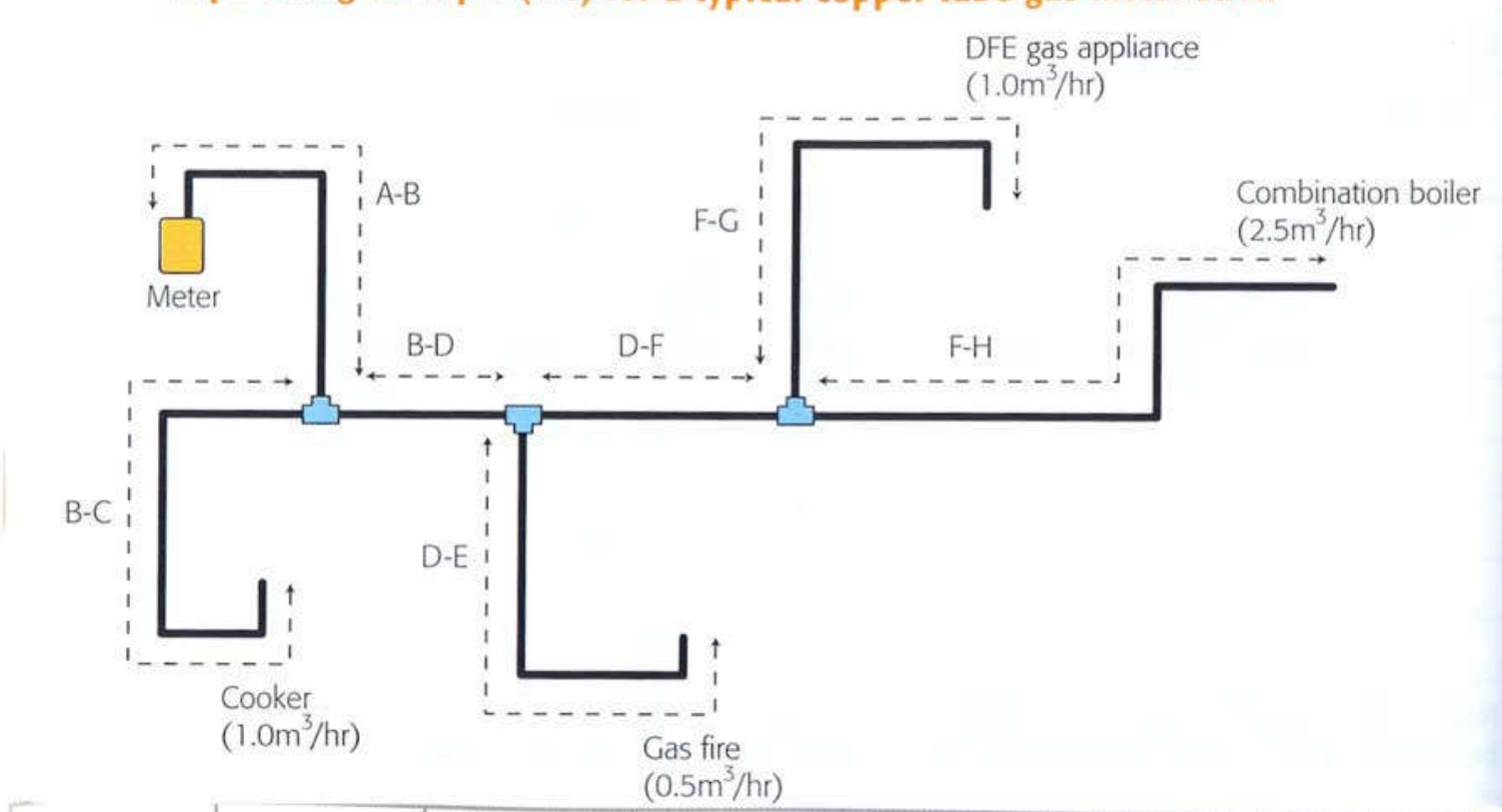
It can be seen that the pressure loss (h) is directly proportional to:

- the square of the flow rate (Q)
- the gas specific gravity (s)
- the pipe length (l)

Note: Pole's formula is limited to normal low-pressure gas installations. Under higher pressure, alternative formulae which incorporate gas compressibility factors are more appropriate.

(Source: Hall, F. and Greeno, R., 2013. *Building Services Handbook*)

Pipe sizing example (NG) for a typical copper tube gas installation

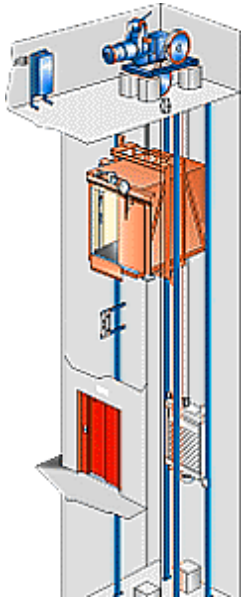


Pipe section	Gas rate	Pipe length	Equivalent length fitting		Total length	Pipe Diameter
(Figure 5.4)	m³/hr	m	Type	Equivalent length m	m	mm
A-B	5	3	2 elbows 1 tee	1 0.5	4.5	28
B-C	1	1	3 elbows	1.5	2.5	15
B-D	4	2	1 tee	0.5	2.5	28
D-E	0.5	1	2 elbows	1	2	10
D-F	3.5	2	1 tee	0.5	2.5	22
F-G	1	1	2 elbows	1	2	15
F-H	2.5	3	2 elbows	1	4	22

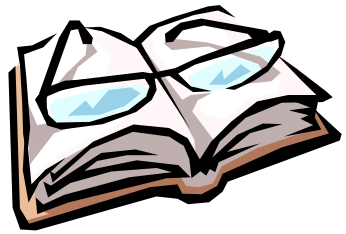
(Source: http://www.upperplumbers.co.uk/plumbing/plumbing_pages.php?title=Pipework%20Sizing&cat=1)

Basic Principles

- Terminology
  - Lifts [UK] = Elevators [US] 升降機/電梯/軚
  - Escalators (moving staircases) 自動扶梯/扶手電梯
  - Conveyors/travelators (moving walkways) 自動行人道



Planning & Design Factors



- Circulation elements in buildings include:
  - Spaces & corridors
  - Portals (e.g. entrance, door, gate)
  - Stairways
  - Ramps

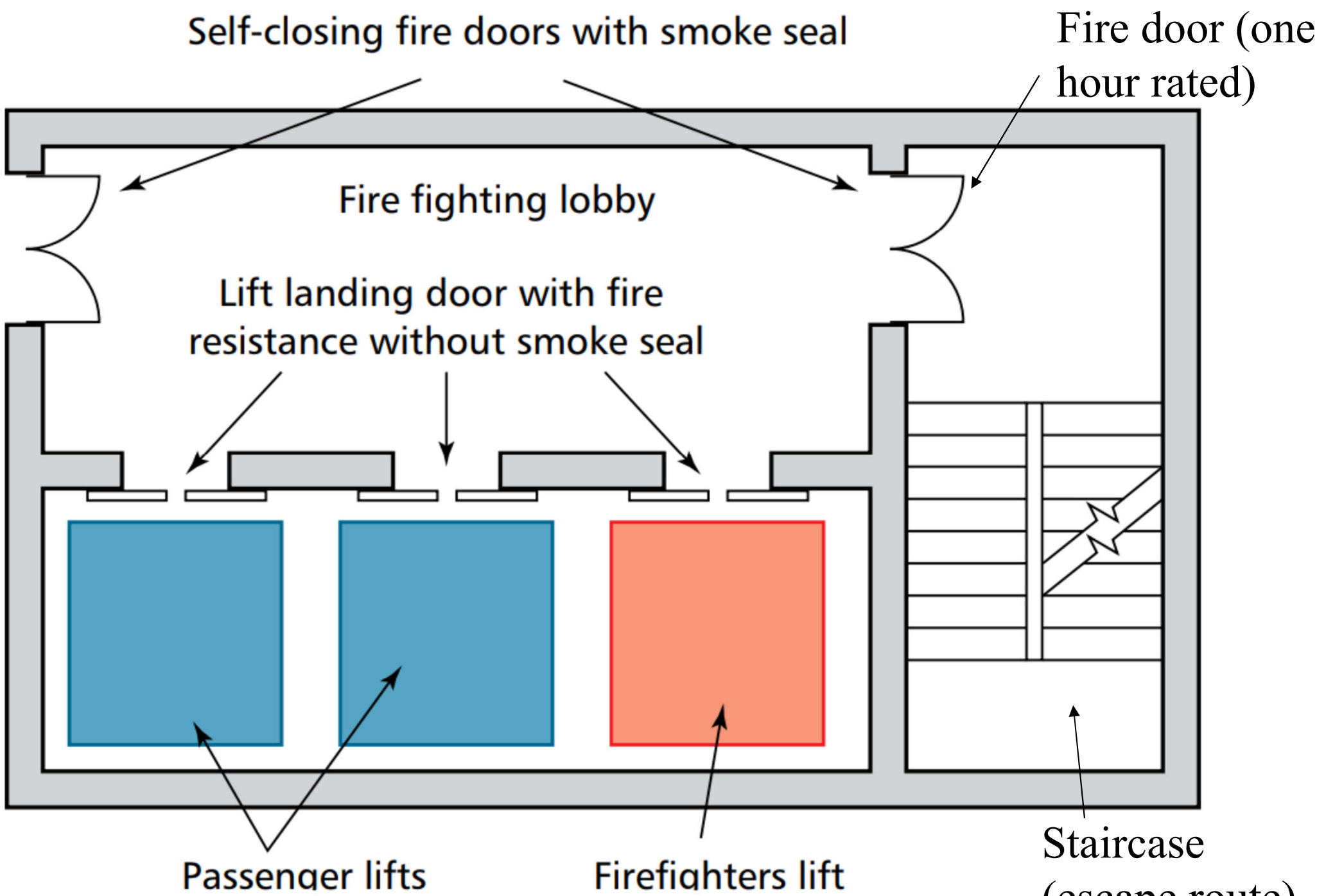
  → Passive circulation elements (physical or architectural)

  - Lifts
  - Escalators
  - Moving walkways

  → Active circulation elements (mechanical or engineering)

* Can you identify them in a building?

Passenger lifts within a fire fighting shaft (with a protected lift lobby)



[Source: CIBSE Guide D]

Comparison of different types of lift & escalator systems

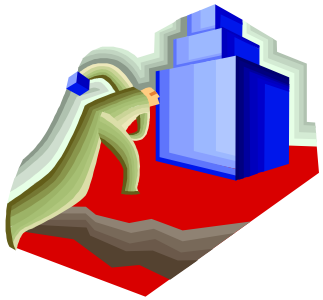
Type of system	Typical applications	Advantages	Disadvantages
Hydraulic	Low rise 2-6 floors	Low cost	Slow, high energy use, maintenance issues
Traction machine room-less	Low-Mid rise 2-10 floors	Easy installation, energy savings, faster then hydraulic option	Higher cost than hydraulic option
Traction geared	Mid rise 3-25 floors	Low cost for application	Speed, energy consumption
Traction gearless (direct drive)	High rise over 25 floors	High speed	High cost

Likely division of traffic between lifts & escalators

Floor travelled	Escalator	Lift
1	90%	10%
2	75%	25%
3	50%	50%
4	25%	75%
5	10%	90%

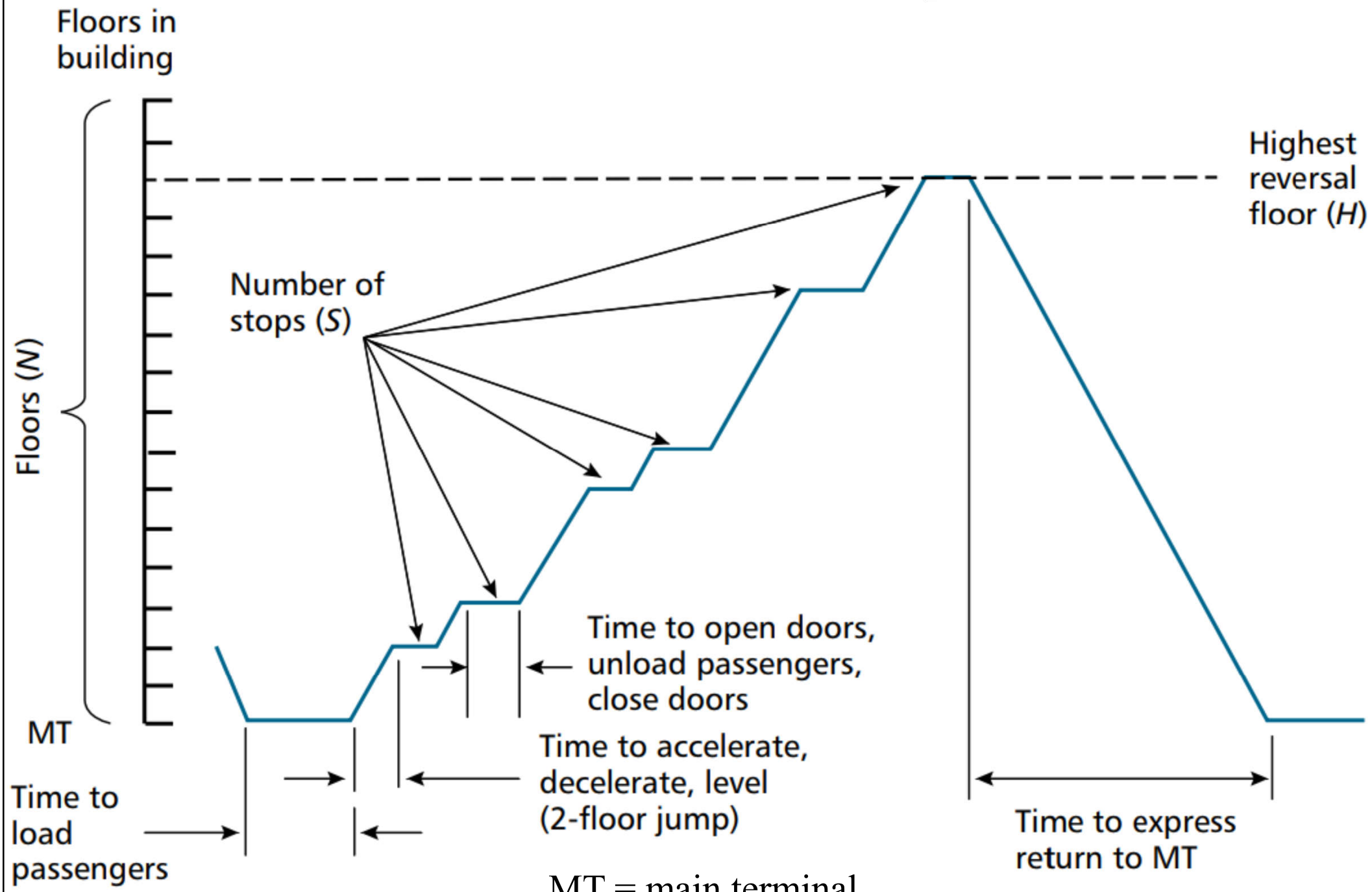
[Source: CIBSE Guide D]

Lift Traffic Analysis



- $\mathrm{RTT} = 2\,H\,t_v + (S+1)\,t_s + 2\,P\,t_p$
  - H = average highest call reversal floor
  - t_v = single floor transit time (s)
  - S = average no. of stops
  - t_s = time consumed when stopping (s)
  - P = average no. of passengers carried
  - t_p = passenger transfer time (s)
- $\mathrm{UPPINT} = \mathrm{RTT} / L$
- $\mathrm{UPPHC} = (300 \times L \times P) / \mathrm{RTT}$

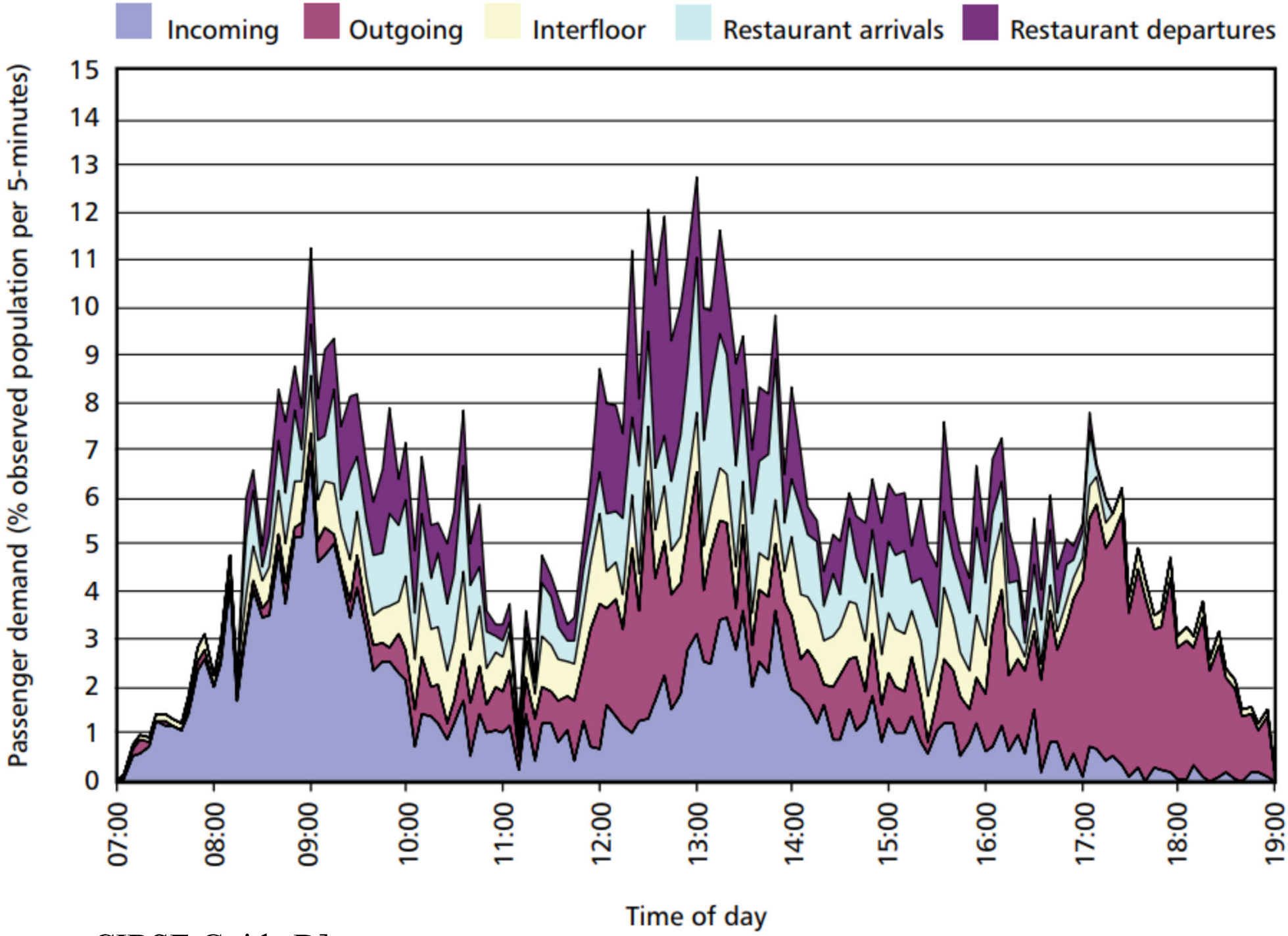
The elements of a round trip



MT = main terminal

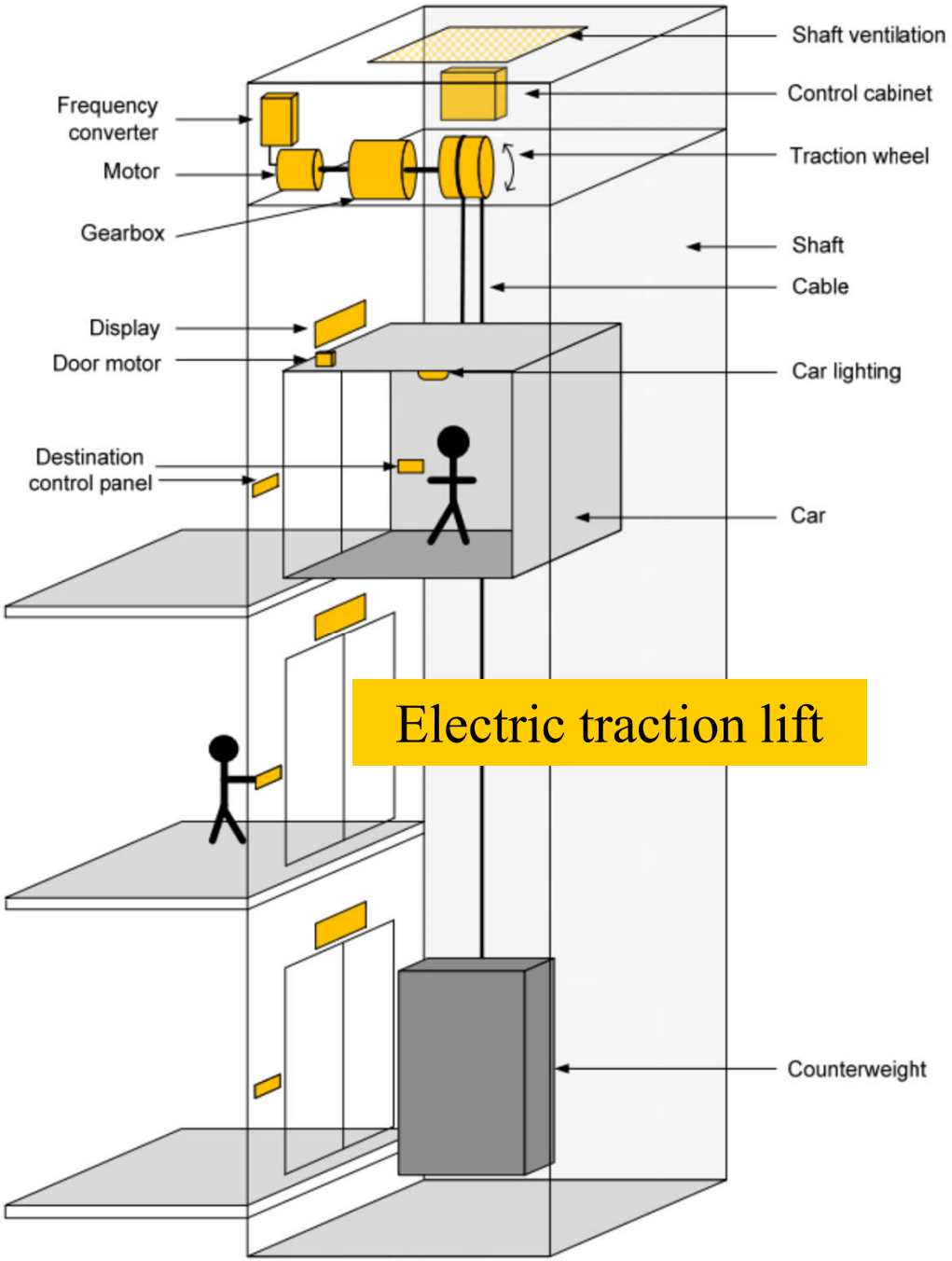
[Source: CIBSE Guide D]

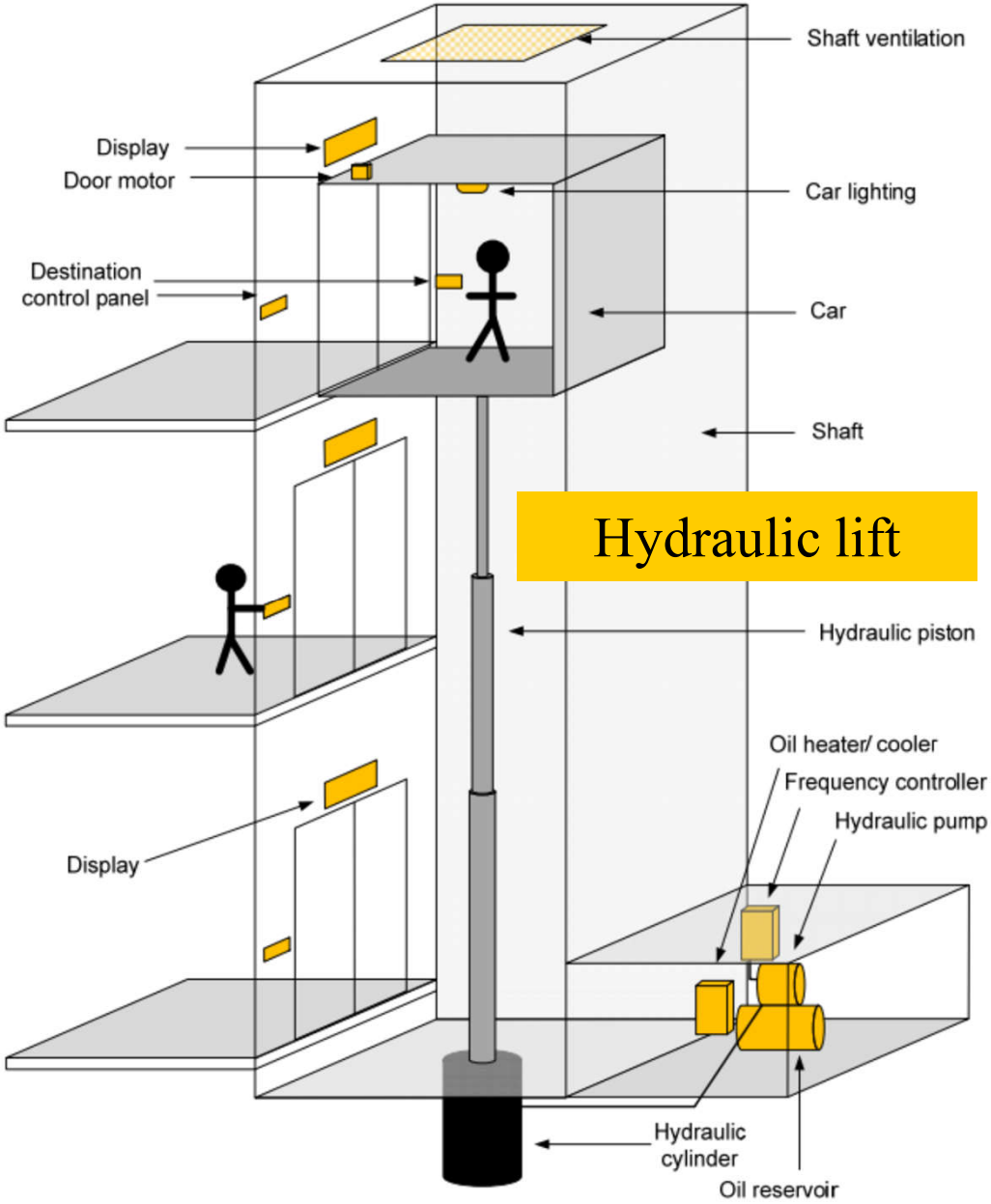
Passenger demand for office building with a restaurant at an upper level



[Source: CIBSE Guide D]

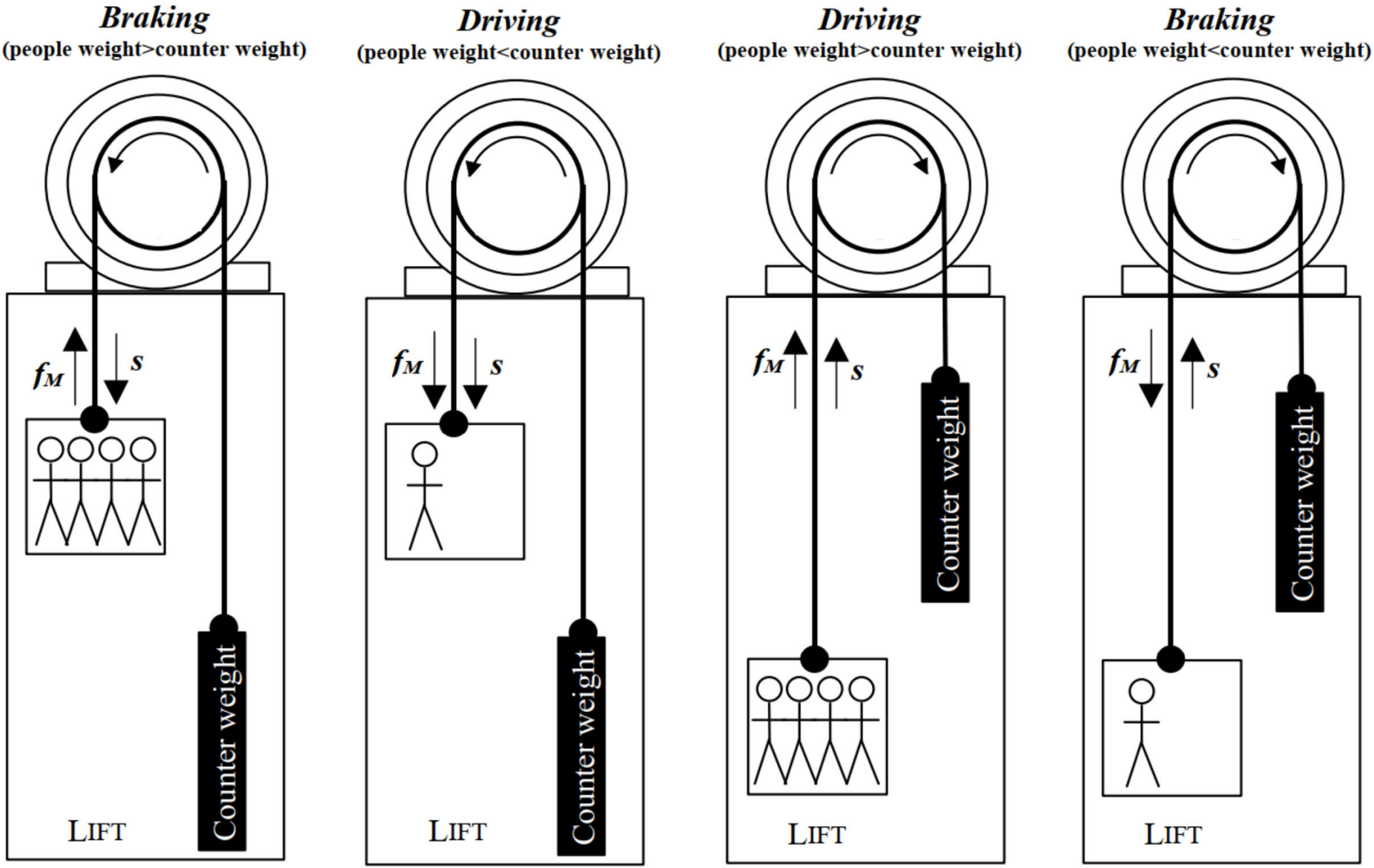
Simplified representation of electric traction lift & hydraulic lift





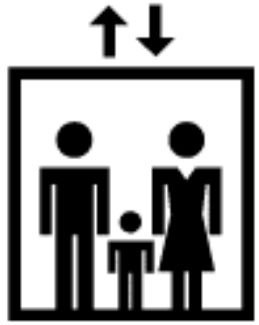
(Source: Fraunhofer ISI)

Lift motor operating modes (f_M - Motor force ; s - Speed)



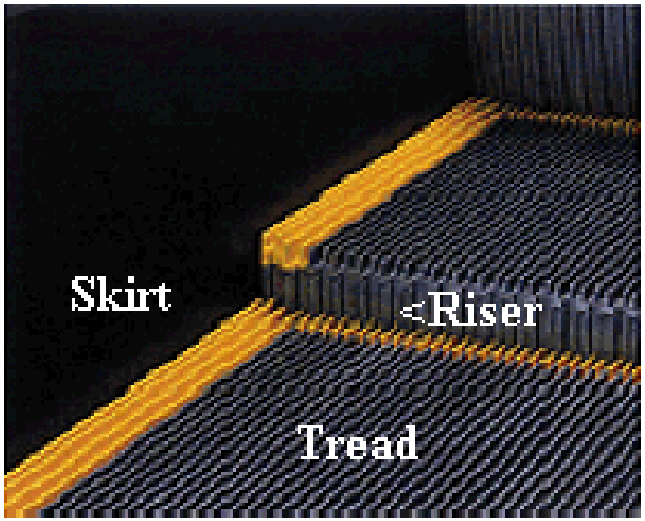
(Source: ISR-University of Coimbra, 2010. E4 Energy-Efficient Elevators and Escalators, brochure prepared for the Intelligent Energy of European Commission, University of Coimbra, Portugal. https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/e4_publishable_report_en.pdf)

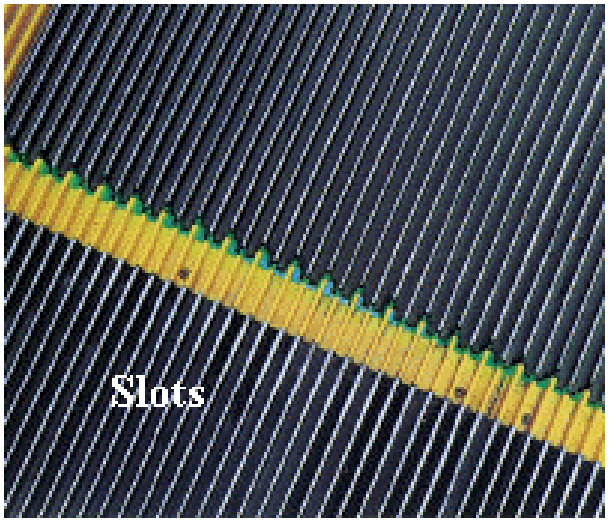
Lift Traffic Control



- Lift (group) control arrangements
  - Operator
  - Single automatic
  - Down or up collective
  - Directional (up & down) collective
  - Group collective
  - Programmed control
  - AI (artificial intelligence) assisted control

Escalator components & safety features





[Image source: http://www.elevator-expert.com]

Classification of energy efficiency of lifts

Energy efficiency class	Energy consumption per day (Wh)
A	$E_d \leq 0.72*Q*n_d*s_{av}/1000 + 50* t_{nr}$
B	$E_d \leq 1.08*Q*n_d*s_{av}/1000 + 100* t_{nr}$
C	$E_d \leq 1.62*Q*n_d*s_{av}/1000 + 200* t_{nr}$
D	$E_d \leq 2.43*Q*n_d*s_{av}/1000 + 400* t_{nr}$
E	$E_d \leq 3.65*Q*n_d*s_{av}/1000 + 800* t_{nr}$
F	$E_d \leq 5.47*Q*n_d*s_{av}/1000 + 1600* t_{nr}$
G	$E_d > 5.47*Q*n_d*s_{av}/1000 + 1600* t_{nr}$

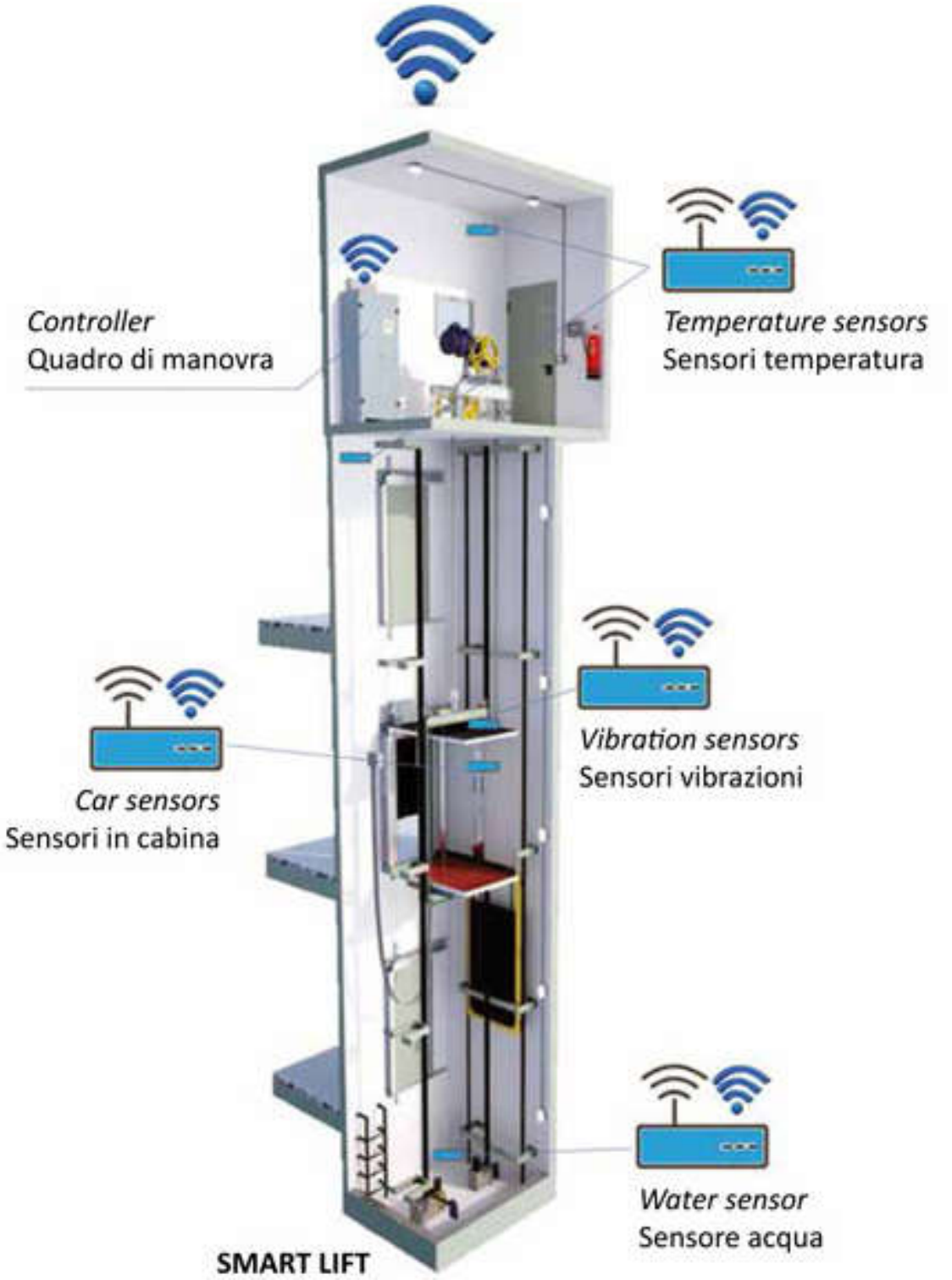
E_d = Total daily energy consumption (Wh)
Q = Rated load (kg)
n_d = Number of trips per day
s_{av} = Average travel distance for target installation (m)
t_{nr} = Non running (idle and standby) time(s) per day (h)

[Source: ISO 25745-2 Energy performance of lifts, escalators and moving walks, Part 2]

Changes or modifications to existing lift during modernisation

- Rated speed
- Rated load
- Travel
- Mass
- Complete controller including door operations
- Drive control system
- From manual to power-operated doors
- Entrances
- Safety components
- Electric safety devices
- (Electric) drive components (lift machine, brake)
- (Hydraulic) jack & lift machine
- Car enclosure or interior finishes
- Door operator
- From gates to doors
- Guide rails

[Source: CIBSE Guide D]



(Source: https://www.elevatorimagazine.com/en/iot-new-challenge/)

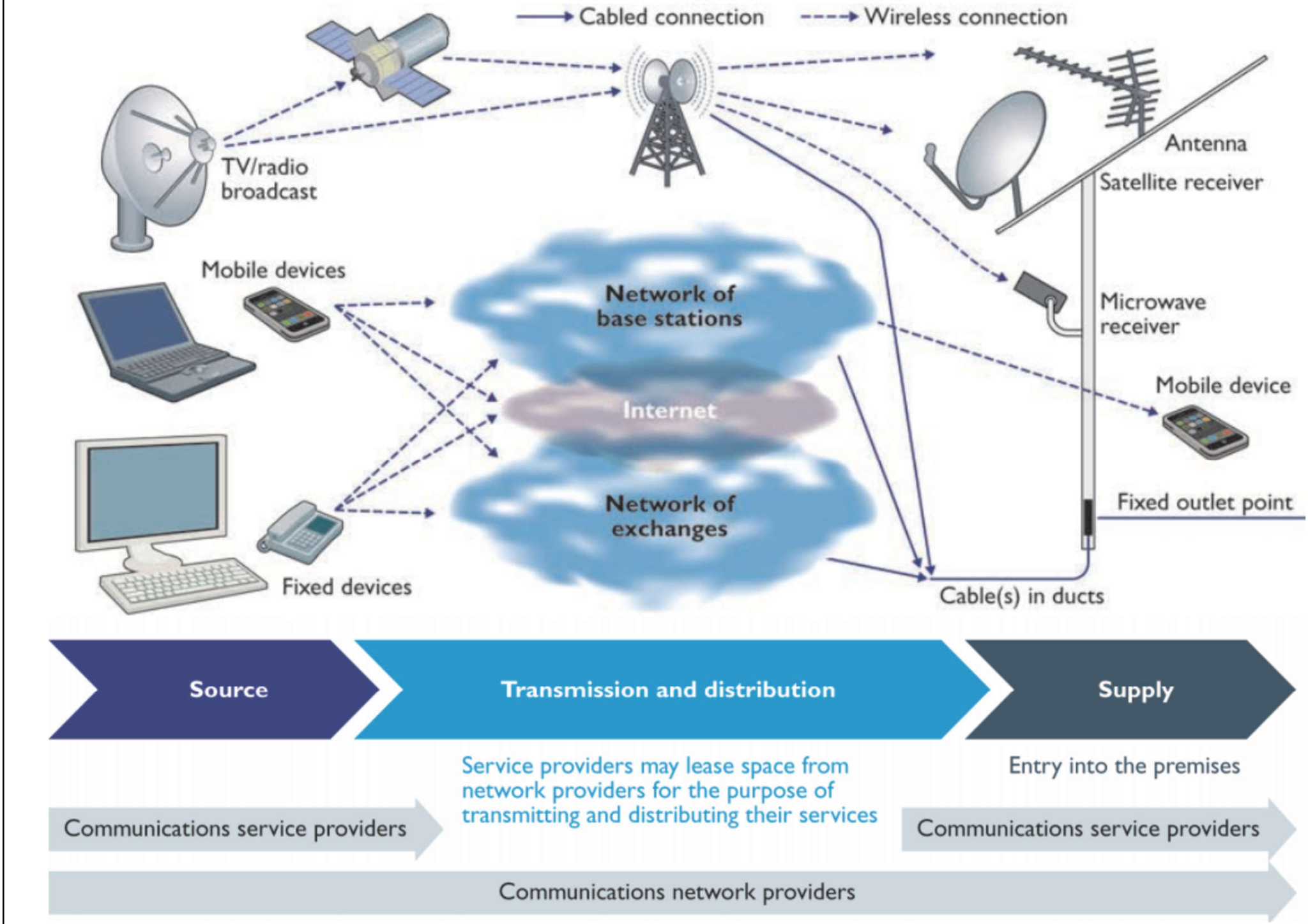
Smart lift and IoT (Internet of Things)

IoT devices are connected to the Wi-Fi network & become an interactive tool that provides and acquires (many times without our knowledge and without our consent) information & data.

Telecommunication Services & Extra Low Voltage Systems

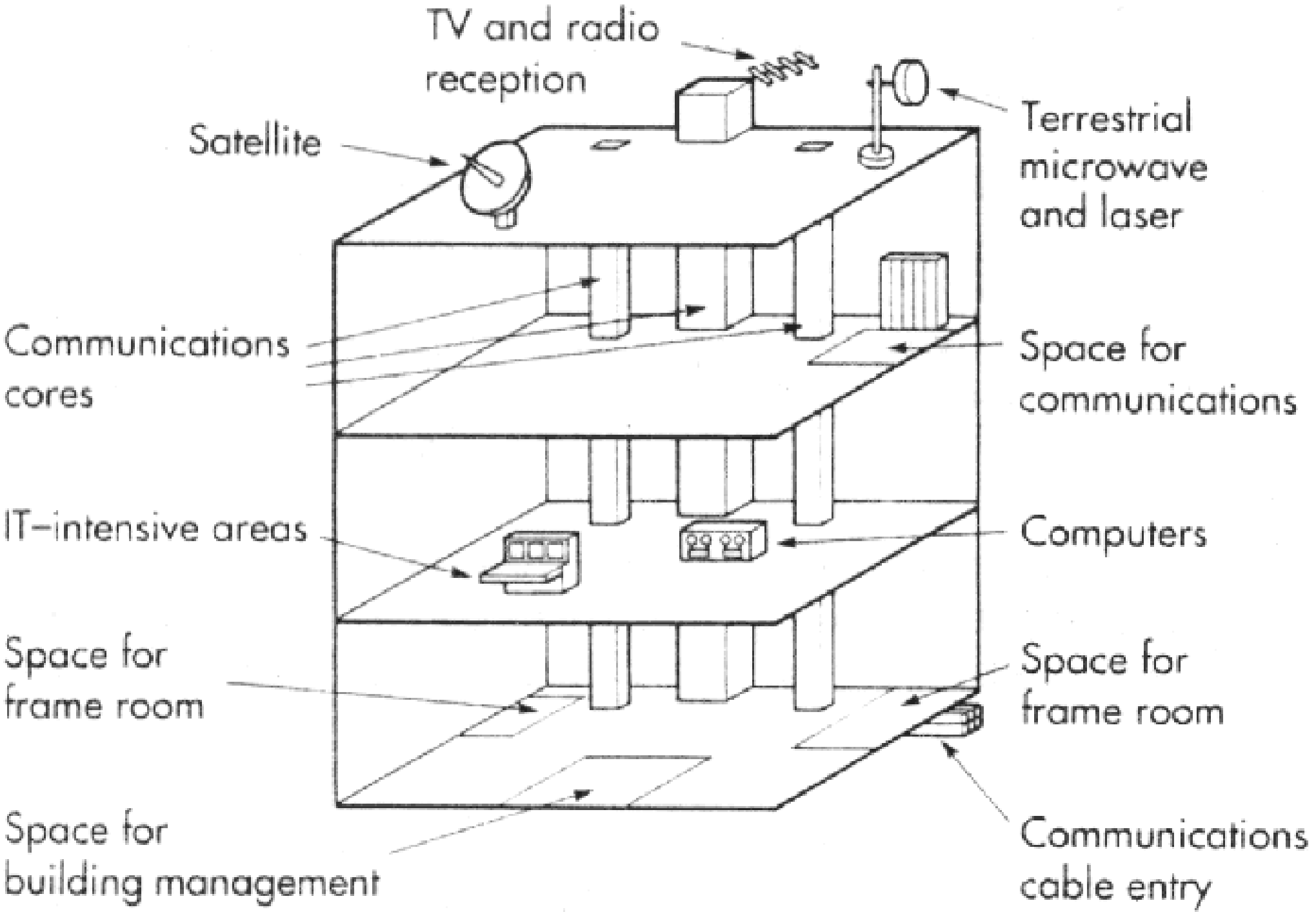
Telecommunication Services	Extra Low Voltage Systems
• Basic Concepts • Design Issues • Cabling Management • Networking • Transmission Methods • In-Building Wireless Systems	• Basic Concepts • CABD and SMATV Systems • PBX and PA Systems • Security Systems • CCTV Systems • Access Control Systems • Burglar & Intruder Alarms

Communications supply arrangement



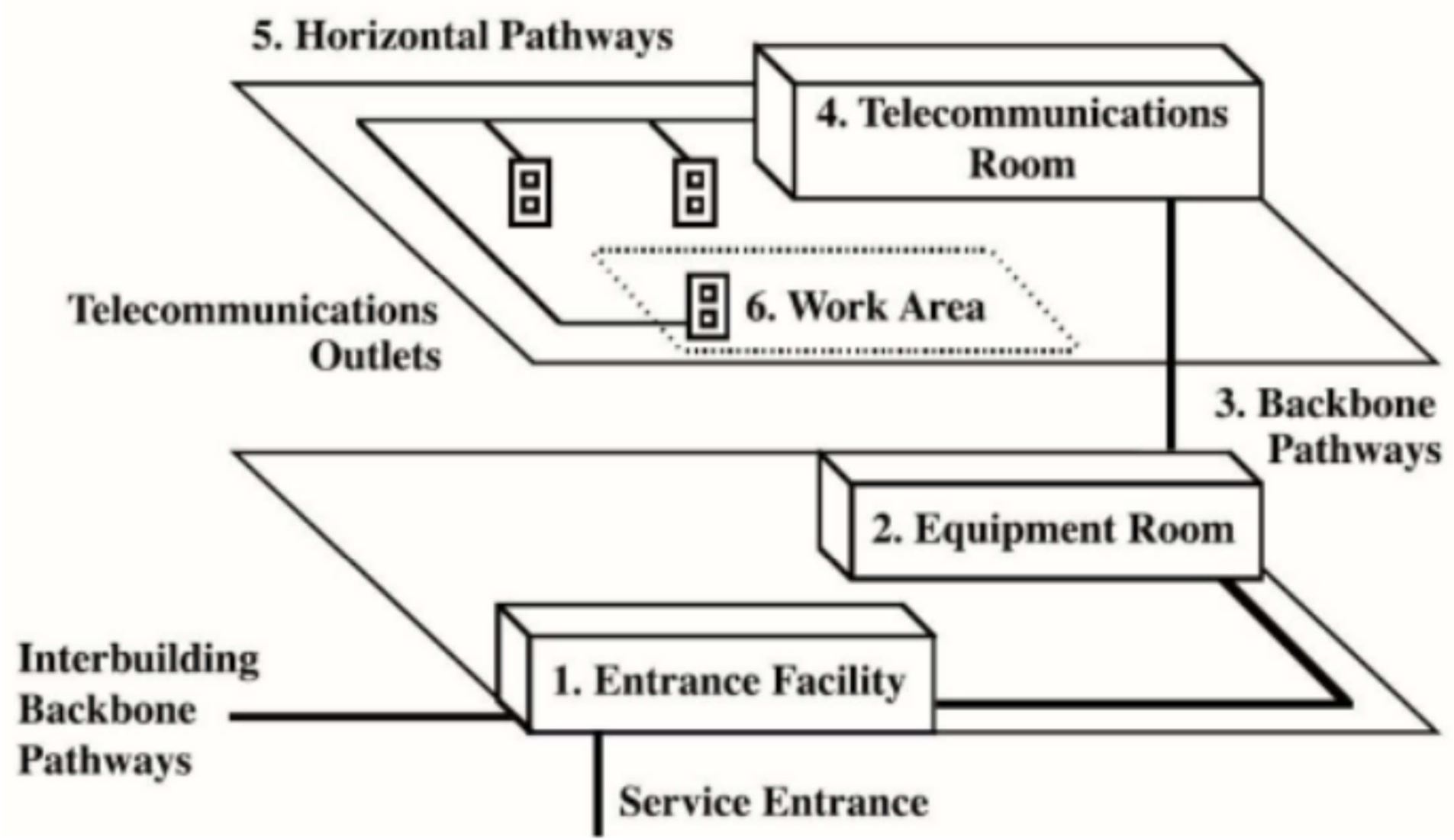
(Source: Portman J. & Bleicher D., 2011. *Utility Connections and Diversions: Planning, design and installation*, BG 37/2011.)

Examples of IT & telecommunication systems in a building



(Source: CIBSE, 1992. Information Technology and Buildings)

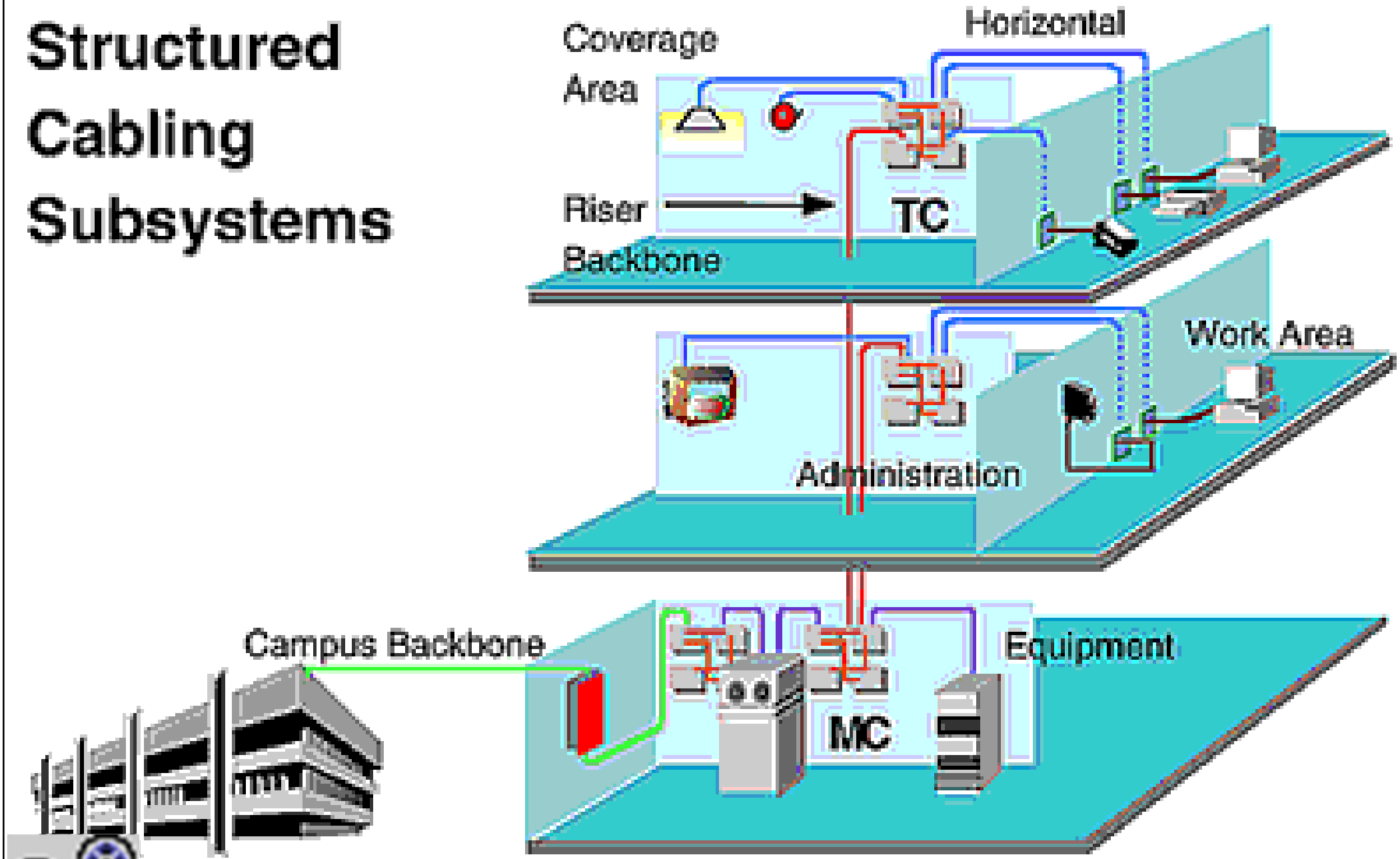
Telecommunication spaces



1. Building Entrance Facility
2. Equipment Rooms
3. Backbone Pathways
4. Telecommunication Rooms
5. Horizontal Pathways
6. Work Areas

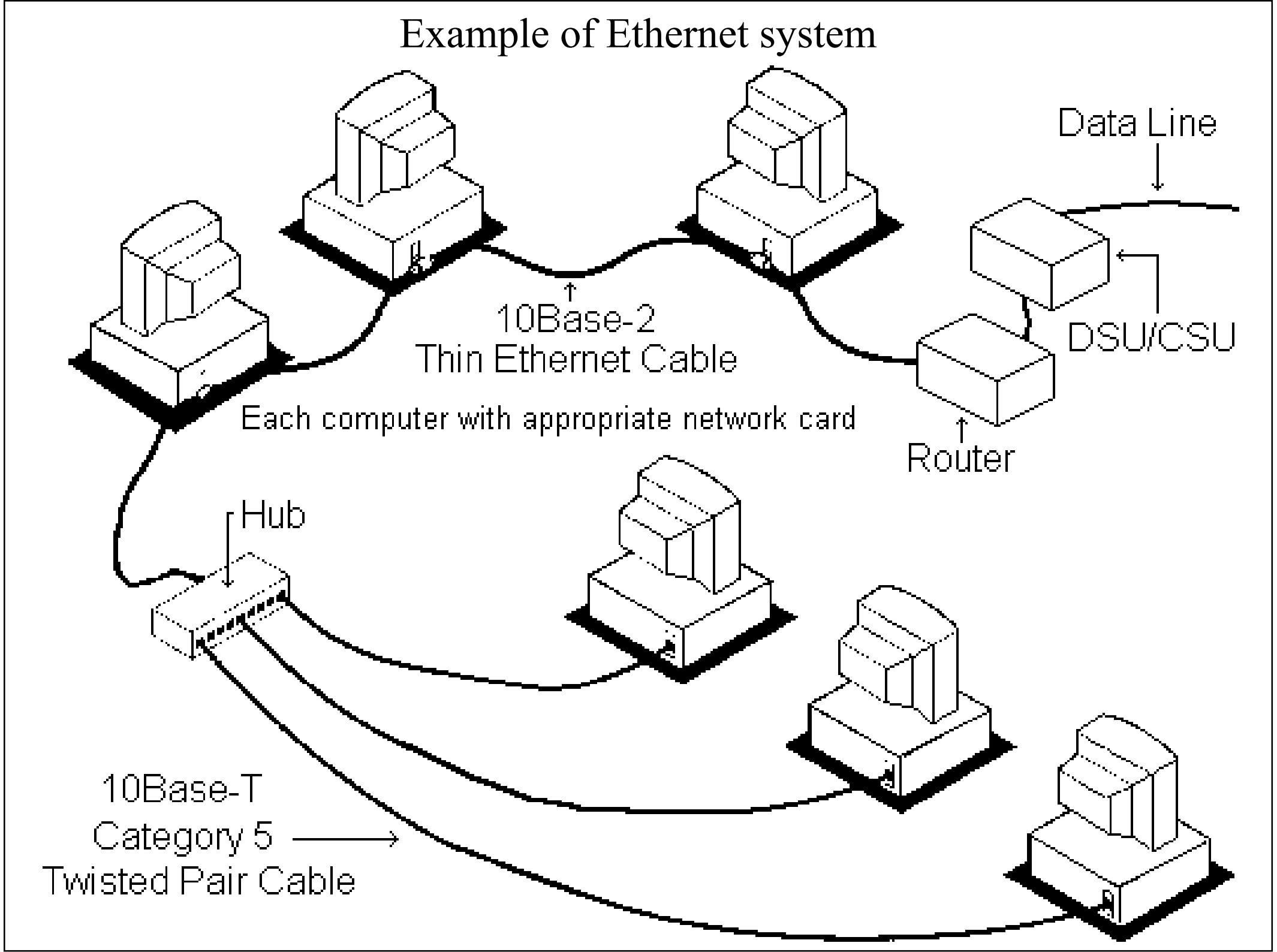
TC = telecomm closet

Structured Cabling Subsystems



(* Video: What is Structured Cabling Standard (TIA-568-C)? (5:48)
http://www.youtube.com/watch?v=NRE6O_mvFus)

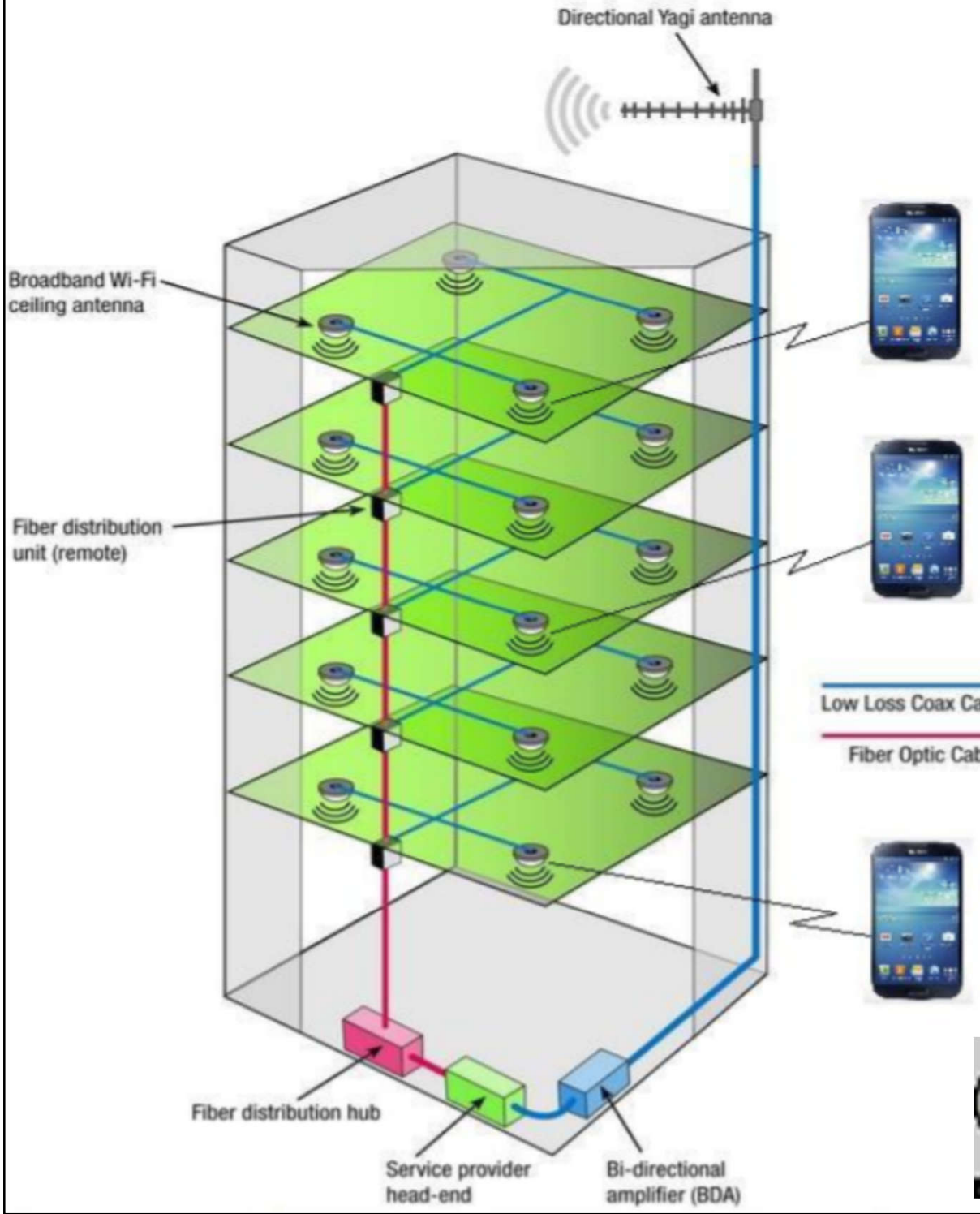
Example of Ethernet system

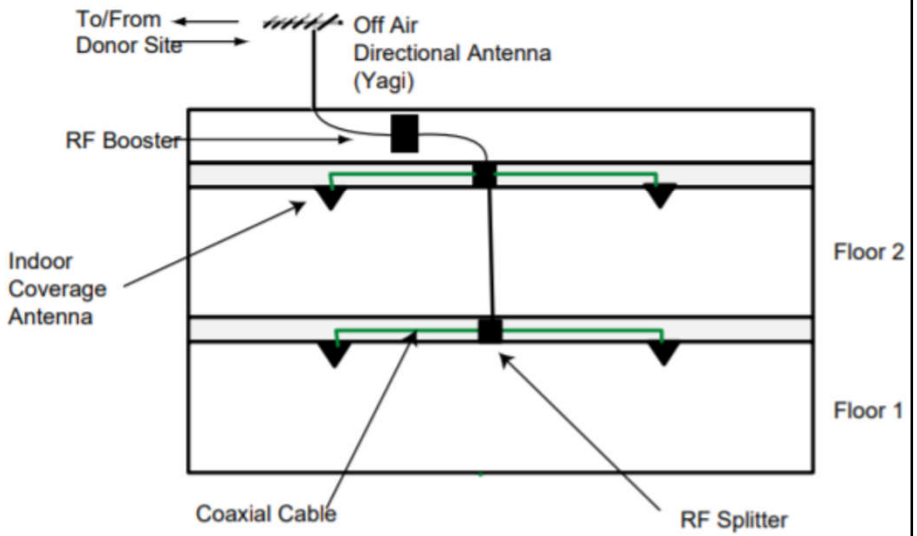


Comparison of transmission methods

Method	First cost	Scan rates	Reliability	Maint. Effort	Expand-ability	Compati-bility
Coaxial	High	Fast	Excellent	Min.	Unlimited	Unlimited
Twisted pair	High	Medium	Very good	Min.	Unlimited	Limited
Radio frequency	Medium	Fast but limited	Low	High	Very limited	Very limited
Microwave	Very high	Very fast	Excellent	High	Unlimited	Unlimited
Telephone	Very low	Slow	Low to high	Min.	Limited	Limited
Fibre optics	High	Very fast	Excellent	Min.	Unlimited	Unlimited

In-building distributed antenna systems (DAS) – a repeater system





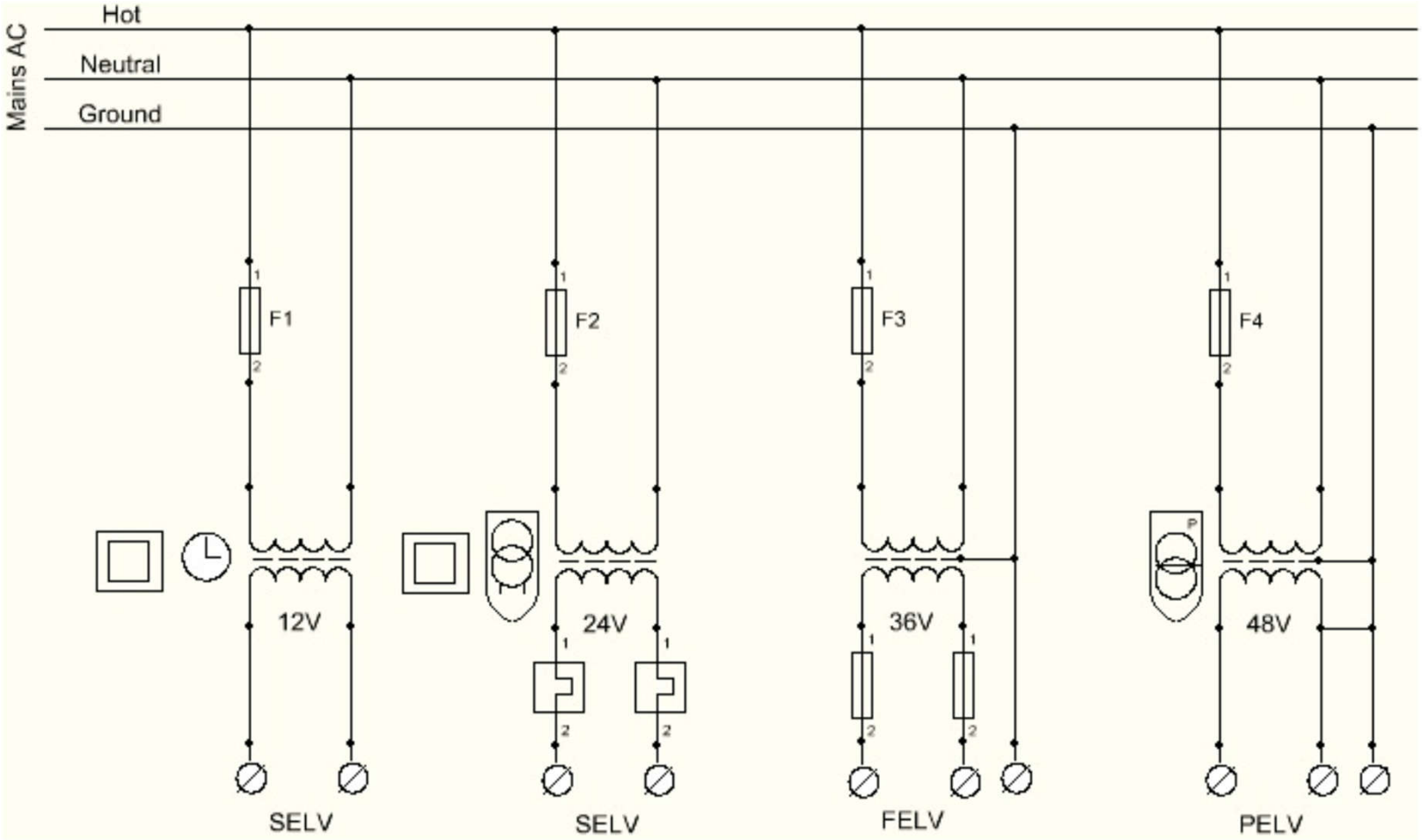
Low Loss Coax Cable

Fiber Optic Cable

Video: What is a DAS? (1:32)
https://youtu.be/kvZEt61GIro

Electricity supply voltage & installations for extra low voltage

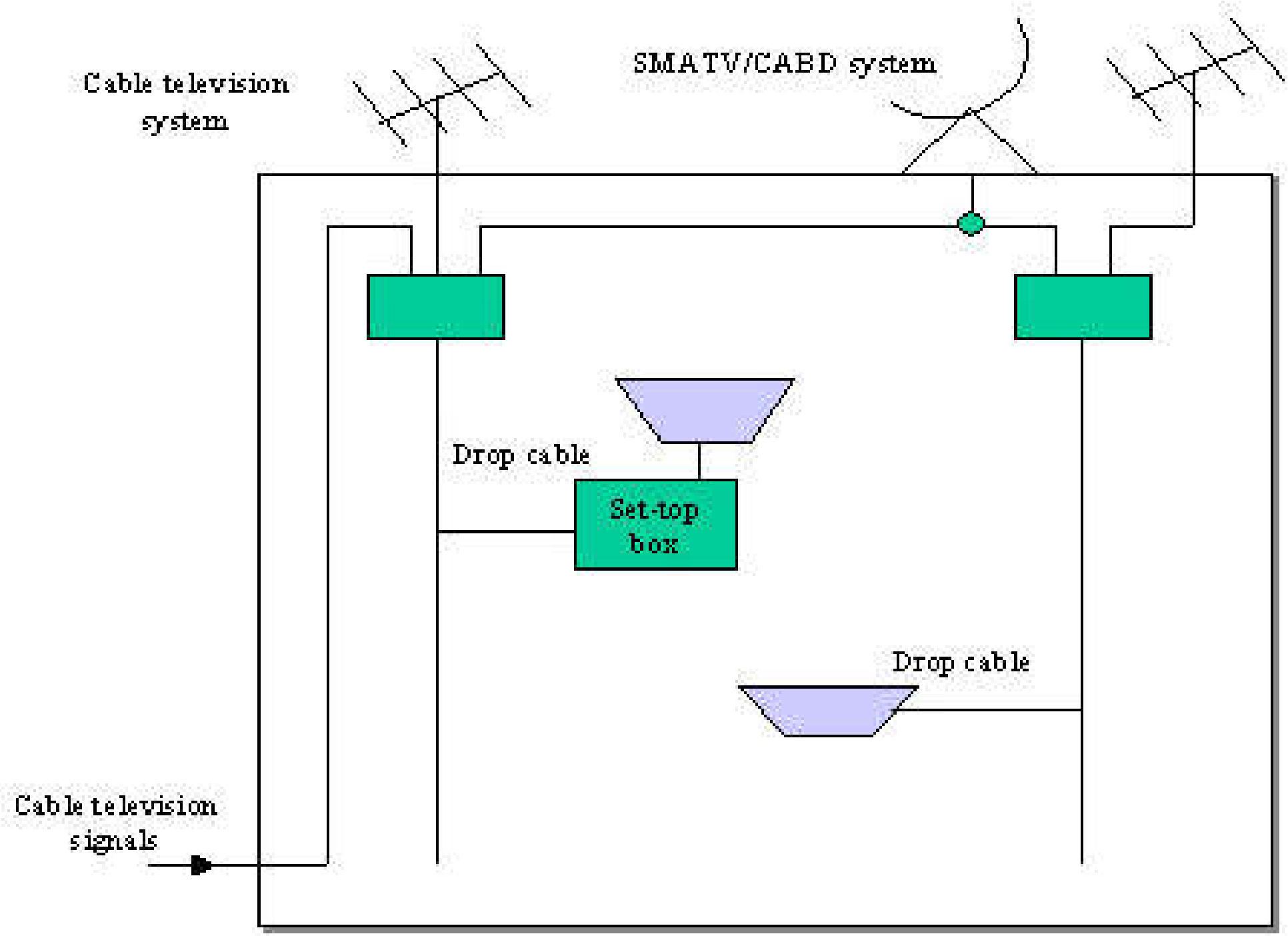
Voltage range	AC RMS voltage (V)	DC voltage (V)	Defining risk
High voltage	> 1000	> 1500	Electrical arcing
Low voltage	50 to 1000	120 to 1500	Electrical shock
Extra-low voltage	< 50	< 120	Low risk



FELV = Functional extra low voltage; PELV = Protective extra low voltage; SELV = Safety extra low voltage

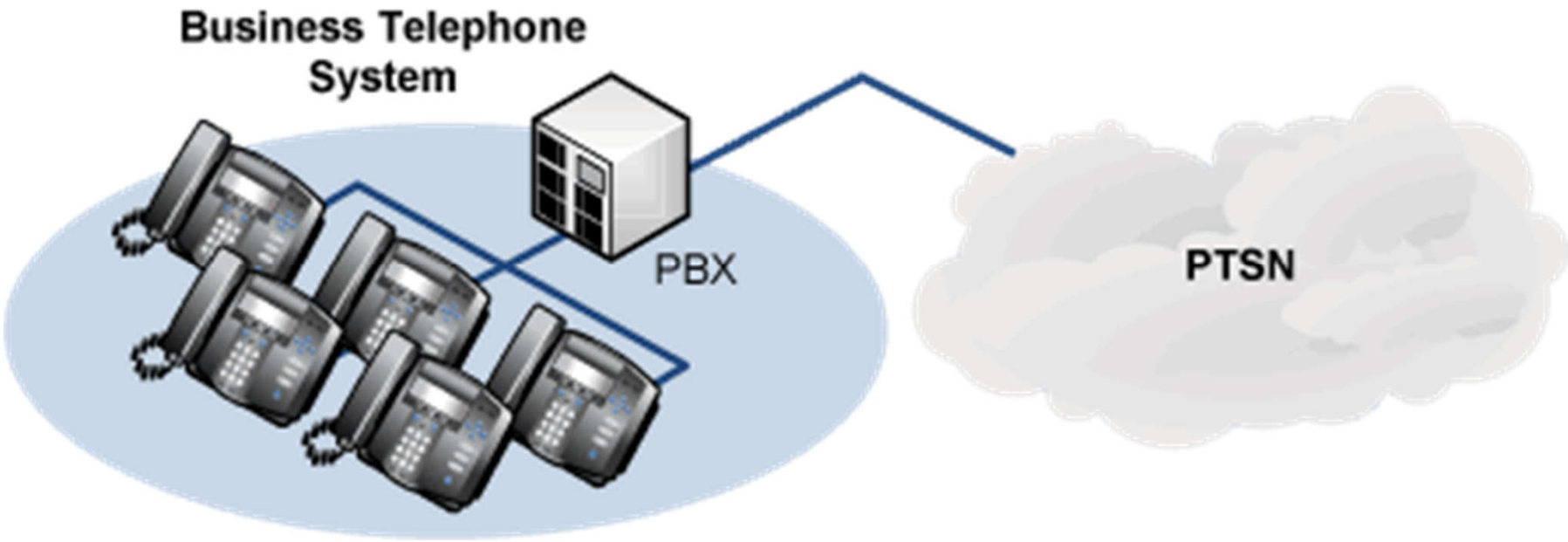
(Source: Extra-low voltage - Wikipedia https://en.wikipedia.org/wiki/Extra-low_voltage)

In-building coaxial cable distribution system (IBCCDS)



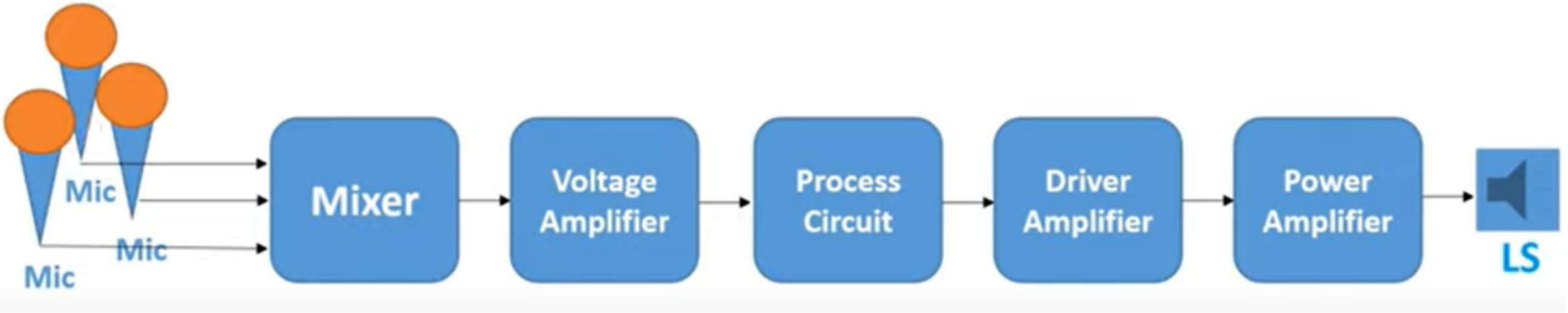
(Source: https://itu-coe.ofca.gov.hk/vtm/fsm/lecture/Lecture_FSM_P7.htm)

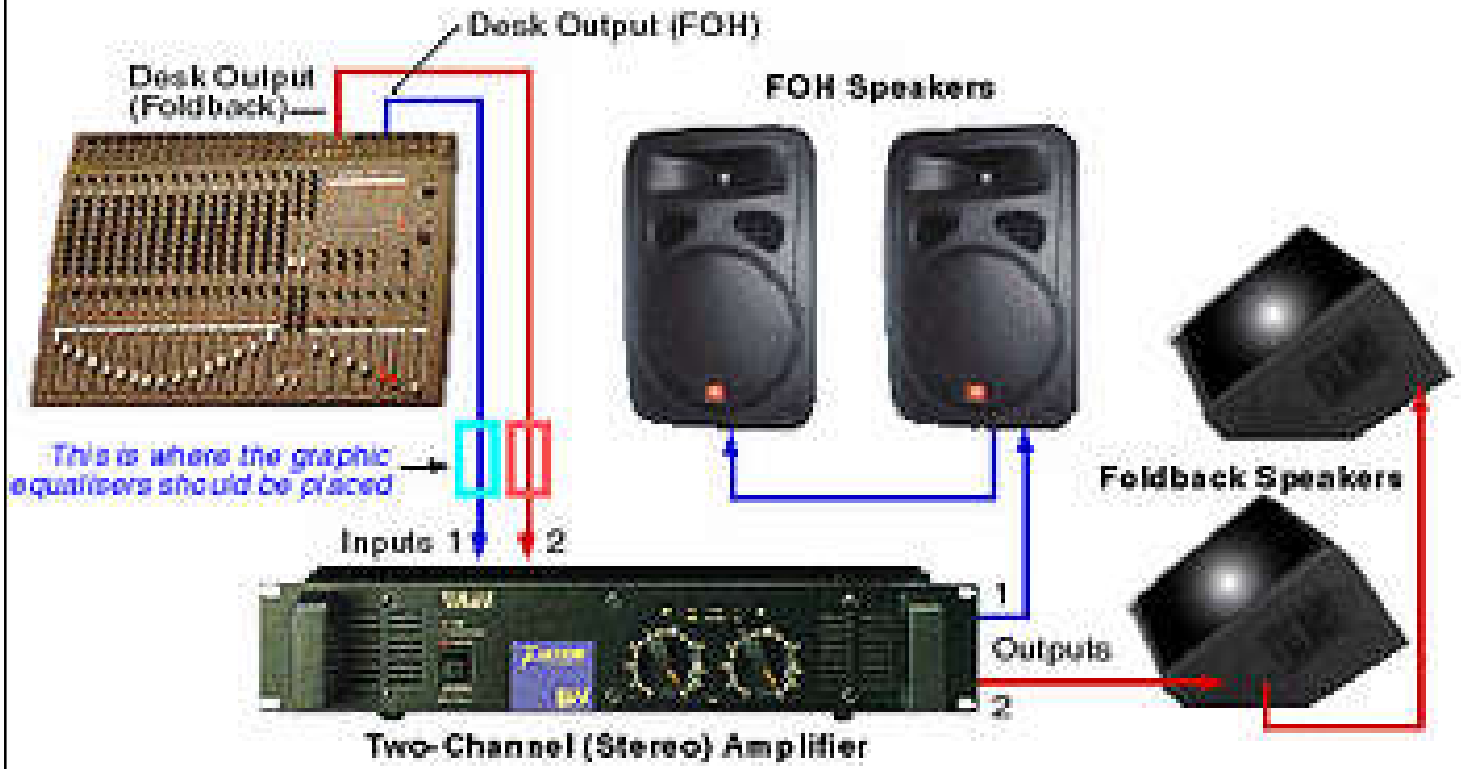
Old PBX with publicly switched telephone network (PSTN) & "IPBX" uses Internet Protocol to carry calls



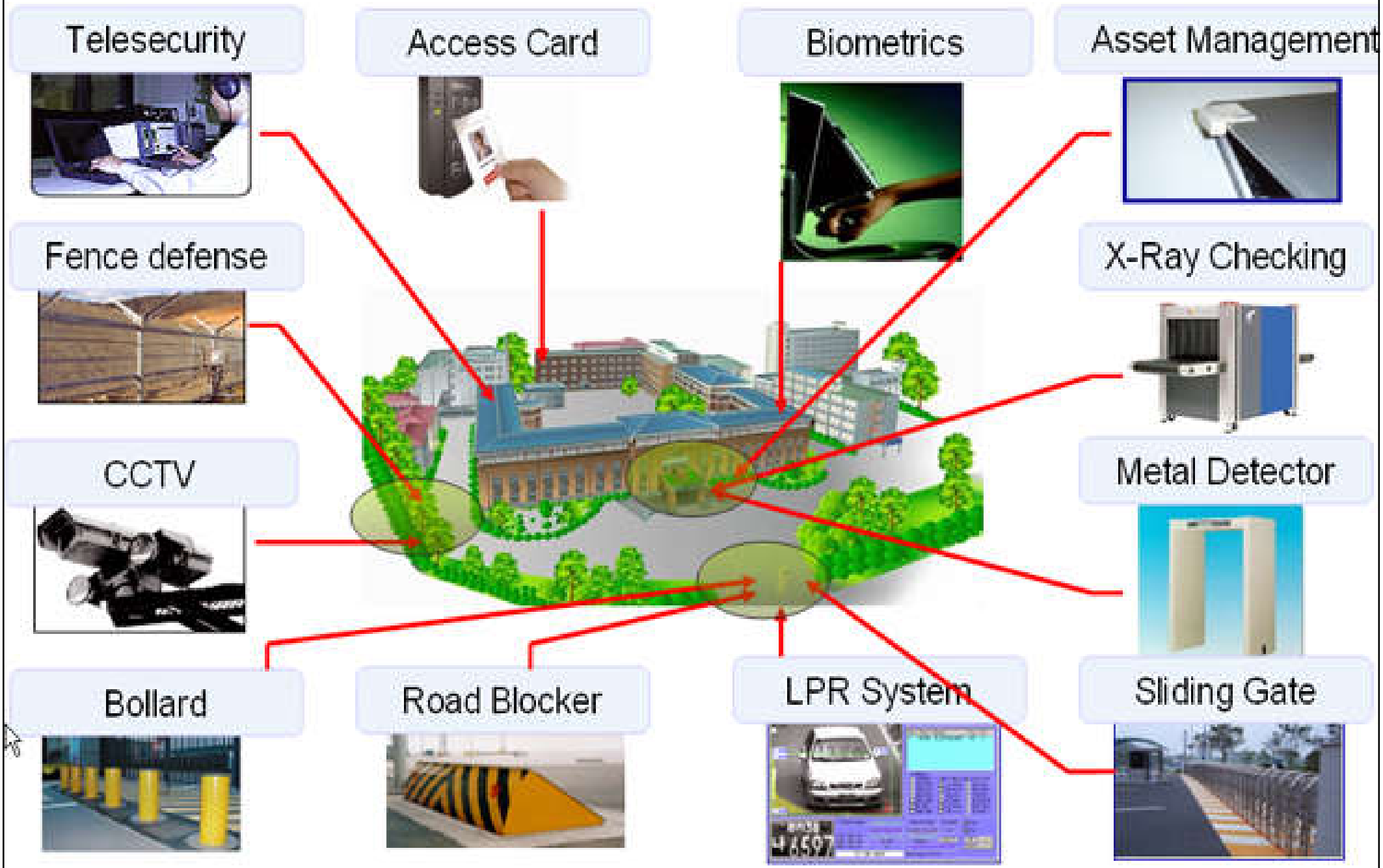
(Source: https://www.businesstelephonesystem.org/pbx-telephone-systems-explained/, https://worlditpark.com/pbx-private-branch-exchange-in-telephony/)

Examples of public address (PA) systems



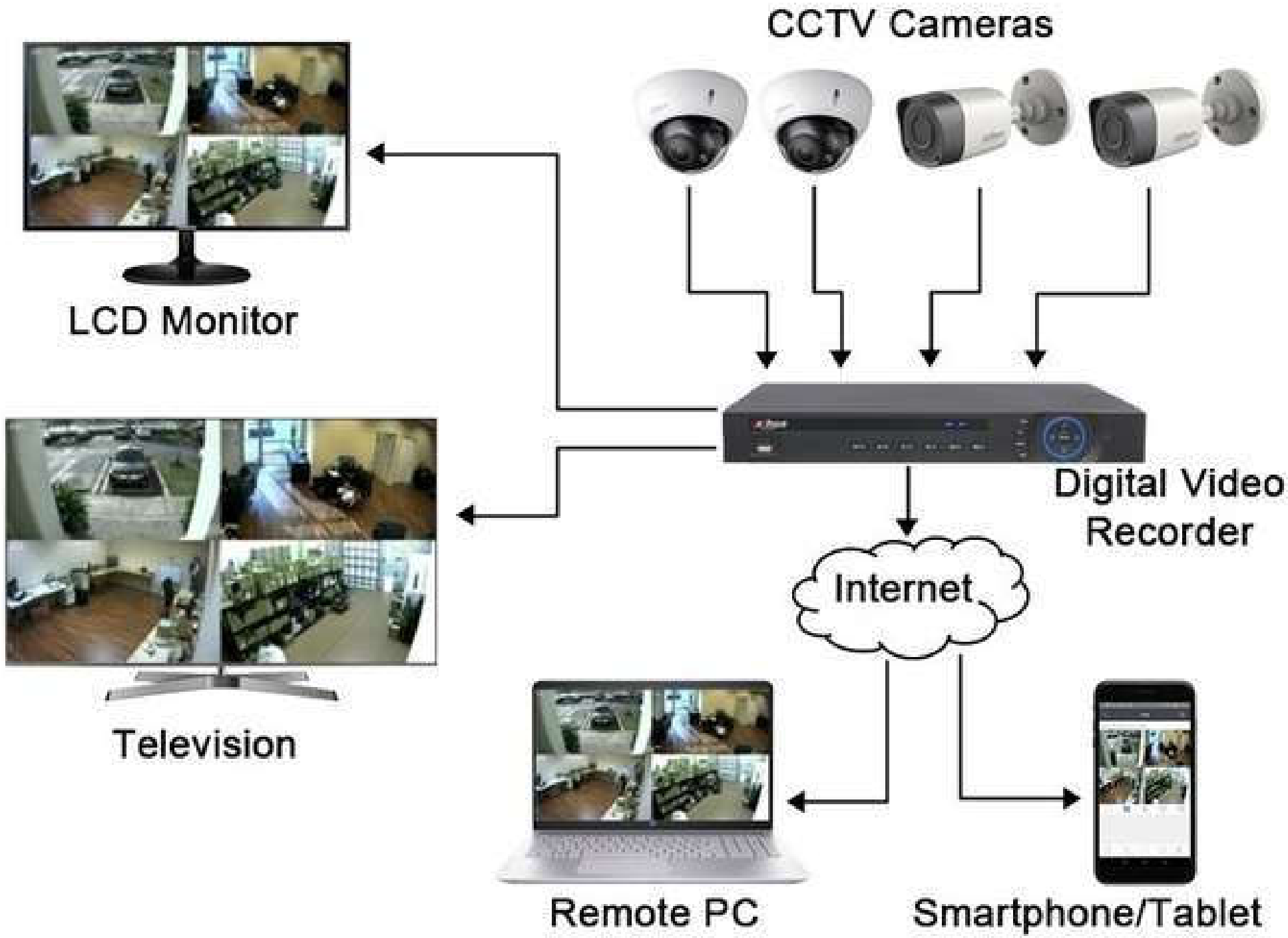


Integrated security in a typical building management solution



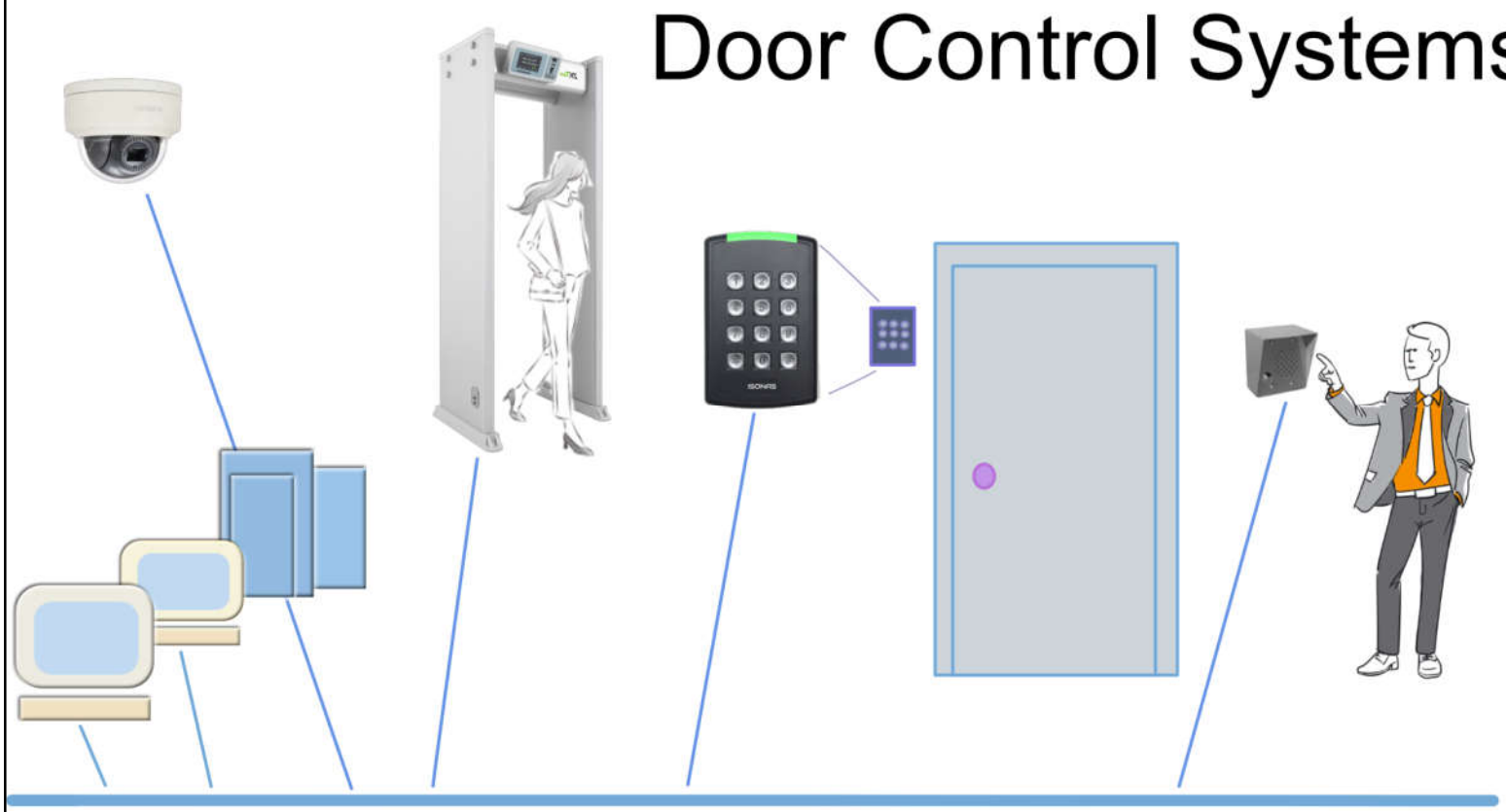
[Source: http://altimaglobal.com/Building-Management-Lighting-Management.html]

Internet-based CCTV systems



(Source: https://57543.8b.io/CCTVSystem.html)

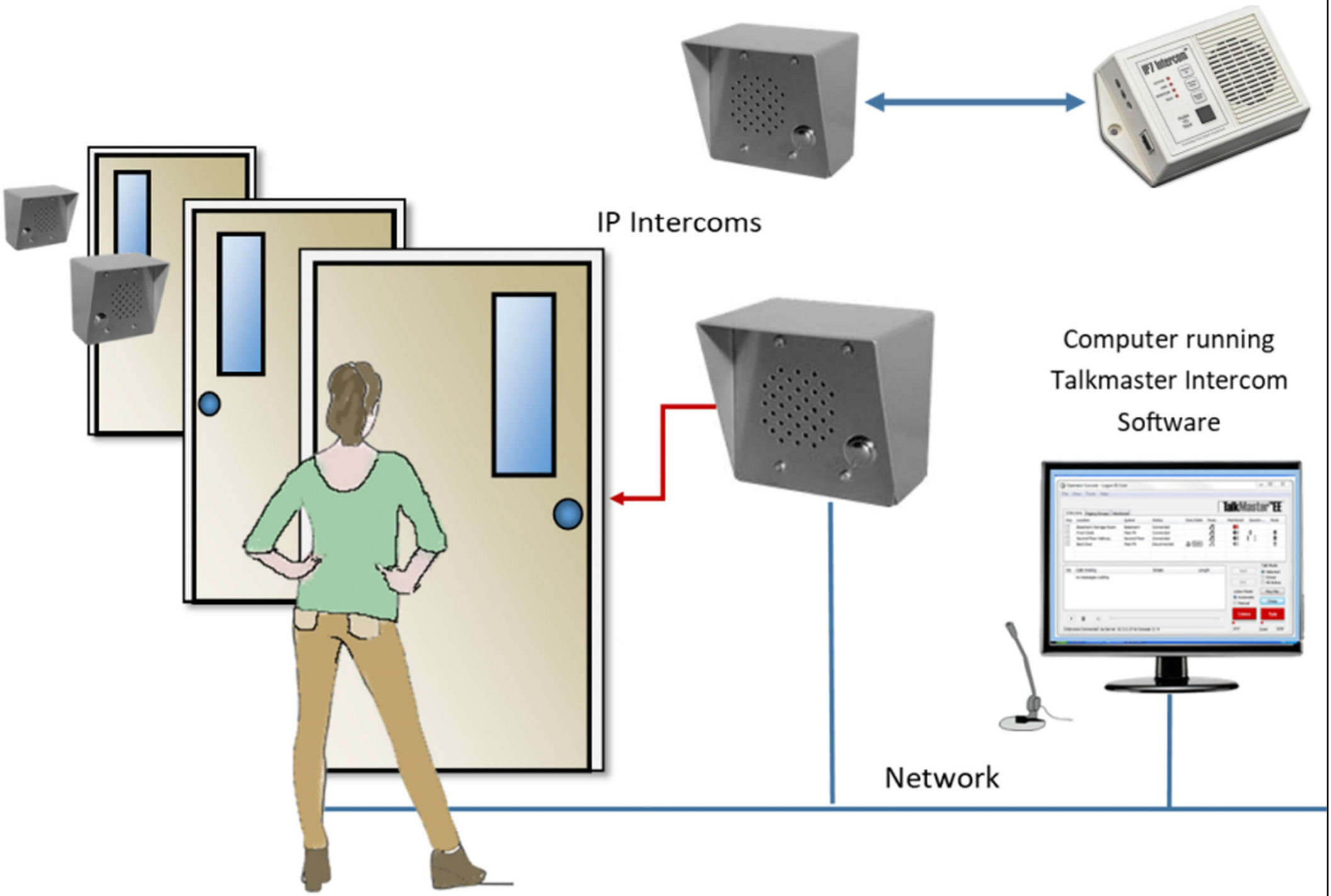
Examples of door access control systems (with door control readers, metal detectors, intercoms, IP cameras & emergency paging system)



What are the key factors for door access control?

(Source: https://kintronics.com/security-provided-access-control-systems/)

Audio intercoms for door access control



(Source: https://kintronics.com/ip-intercom-selection-and-comparison/)

Basic approach of an alarm system

Input → **Control** → **Output**

Input	Control	Output
Sensors	Panel	- Bell, siren, light - Dialer, email - Police-connect

Detection sensors:
- Infrared
- Ultrasonic
- Microwave (droppler effect)
- Dual technology
- Glass breaks, switches

Annunciation/
alarm signaling

(* See also: Alarm Systems – An Overview http://www.shieldjournal.com/alarm-systems-an-overview/)