

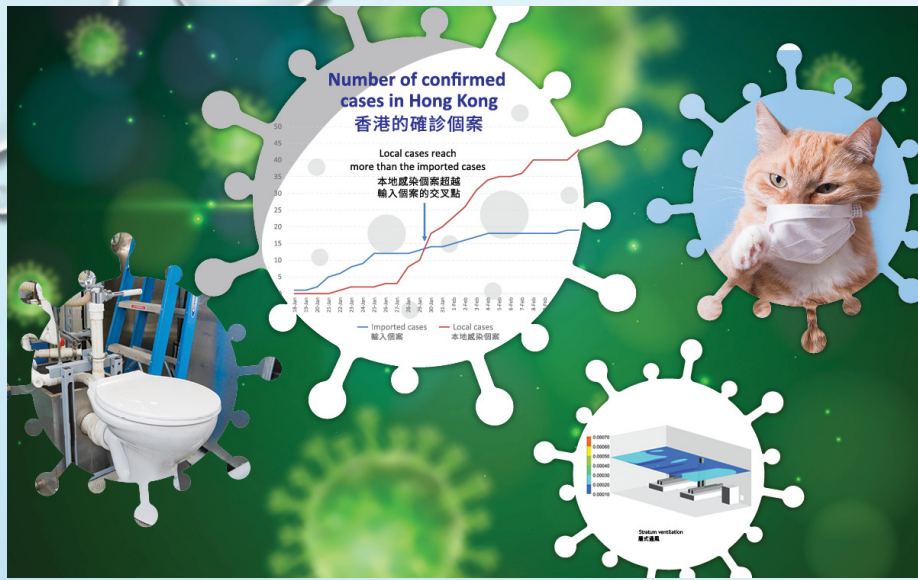
**CIPHE** The Chartered Institute of Plumbing  
and Heating Engineering  
英國特許水務工程師學會  
Hong Kong Branch 香港分會

**13<sup>th</sup> World Plumbing  
Conference  
世界水務大會  
WPC 2023**

***Water & Energy Saving Features in Highrise  
Building Plumbing Systems***

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**WSP (Asia) Ltd (Technical Director)**

**19 Oct 2023**



Everyone must have **sustainable sanitation, alongside clean water and handwashing facilities**, to help protect and maintain our health security and stop the spread of deadly infectious diseases such as COVID-19, cholera, and typhoid.



**THE SANITATION CRISIS**

Right now, there are **3.5 billion people** still living without safe toilets. **419 million people** still practice 'open defecation'. In these situations, diseases spread, killing **1,000 children under-five every single day**. This global crisis poses a threat to nature and everyone's health, particularly women, girls, and other vulnerable groups.

**WORLD WATER DAY - 22 MARCH 2023**  
**ACCELERATING CHANGE**

This World Water Day is about accelerating change to solve the water and sanitation crisis.

And because water affects us all, we need everyone to take action.

That means you!

You and your family, school and community can make a difference by changing the way you use, consume and manage water in your lives.

Your commitments will be added to the Water Action Agenda, to be launched at the UN 2023 Water Conference – the first event of its kind for nearly 50 years.

This is a once-in-a-generation moment for the world to unite around water.

Play your part. Do what you can.

# Agenda

- **Technical difficulties on Highrise buildings' Plumbing systems**
- **Water Saving Provisions**
- **Tackle System Pressure against Building Height**
- **System planning and Features to Reduce Energy Consumption**

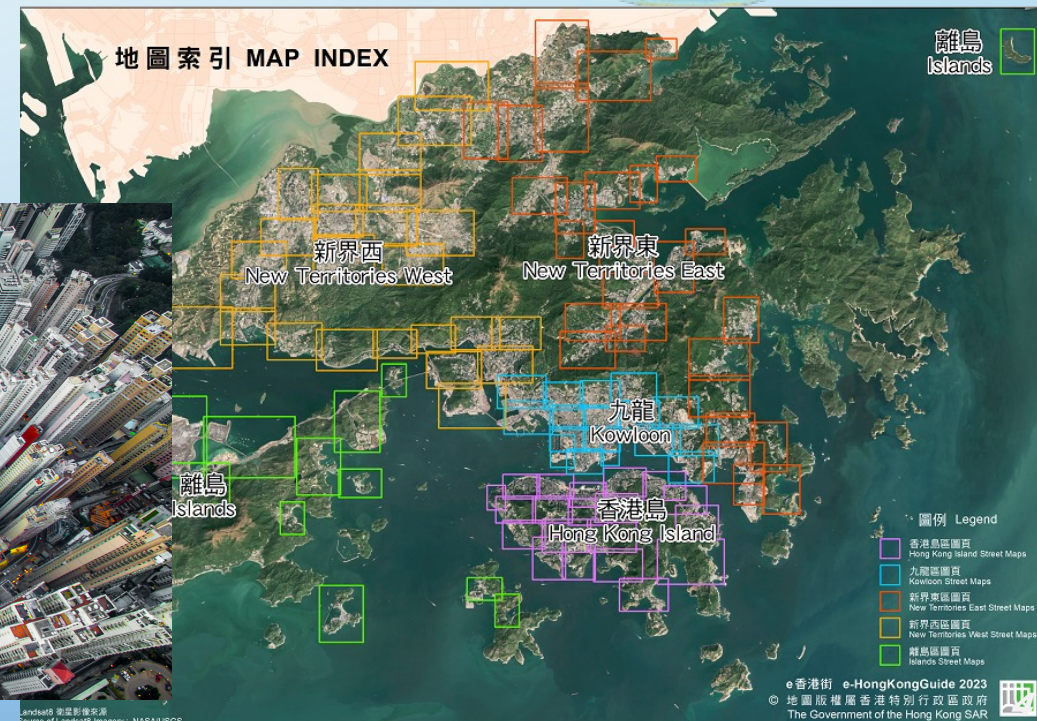


# Highrise Building Plumbing Systems

- Hong Kong, China is a most unique city in the World
- Large population in a tiny urban space
- Well developed infra-structural
- The highest density of skyscrapers and the highest skyline,

i.e.

➤ *with the largest numbers of high-rise buildings*



# Highrise Building Plumbing S

- HK is the most Vertical City.

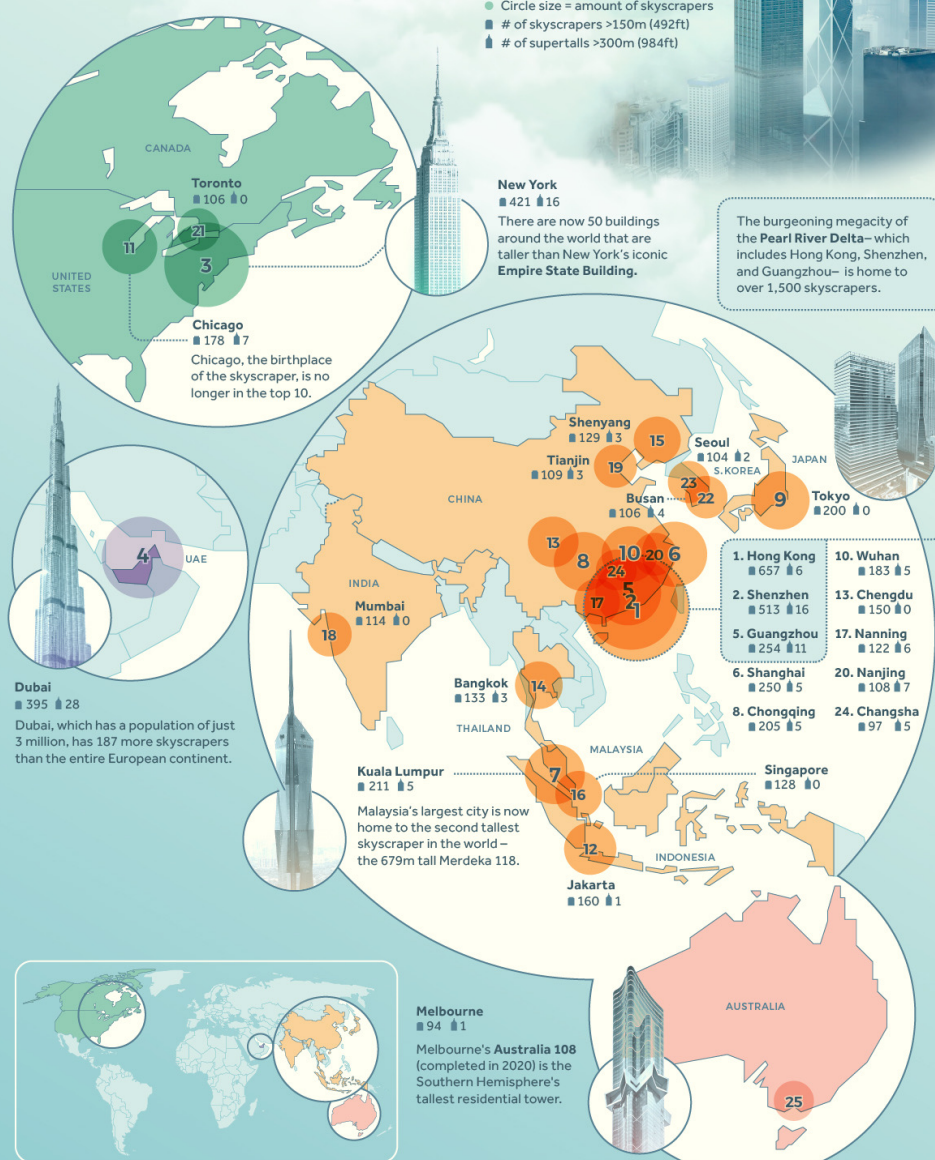
## The 25 Top Cities by Skyscraper Count

Topping the charts is Hong Kong, with an impressive 657 skyscrapers, including six supertalls (buildings over 300 meters tall).

Search:

Rank	City	Country	Skyscrapers (>150m)	Supertalls (>300m)
1	Hong Kong	China	657	6
2	Shenzhen	China	513	16
3	New York City	United States	421	16
4	Dubai	United Arab Emirates	395	28
5	Guangzhou	China	254	11
6	Shanghai	China	250	5
7	Kuala Lumpur	Malaysia	211	5
8	Chongqing	China	205	5
9	Tokyo	Japan	200	0
10	Wuhan	China	183	5

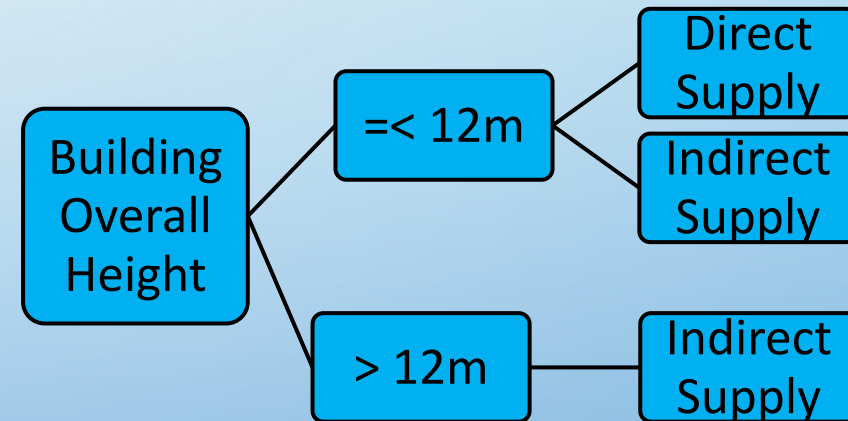
## The TOP 25 CITIES with the most SKYSCRAPERS



<https://www.visualcapitalist.com/cities-with-the-most-skyscrapers-2023/>

# Highrise Building Plumbing Systems

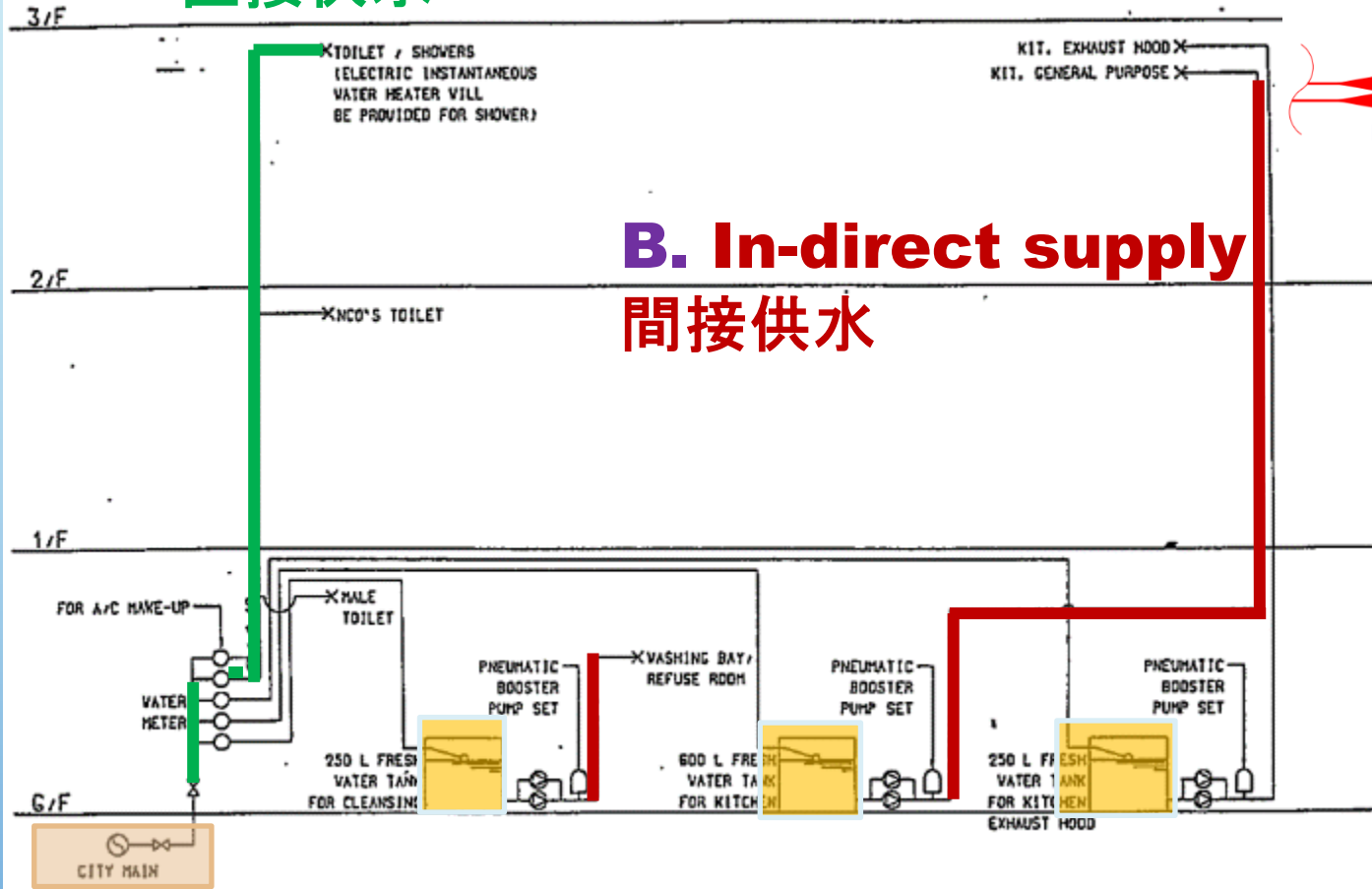
- HK with very **reliable infrastructure utilities**, majority water source for premises are from city mains along the public road level
- Min. town main pressure ~ 1.5 bar for most of the urban area --- minimize water leakage risk in network
- All buildings should be facilitated with in-direct water supply system, unless small houses.



# Highrise Building Plumbing S

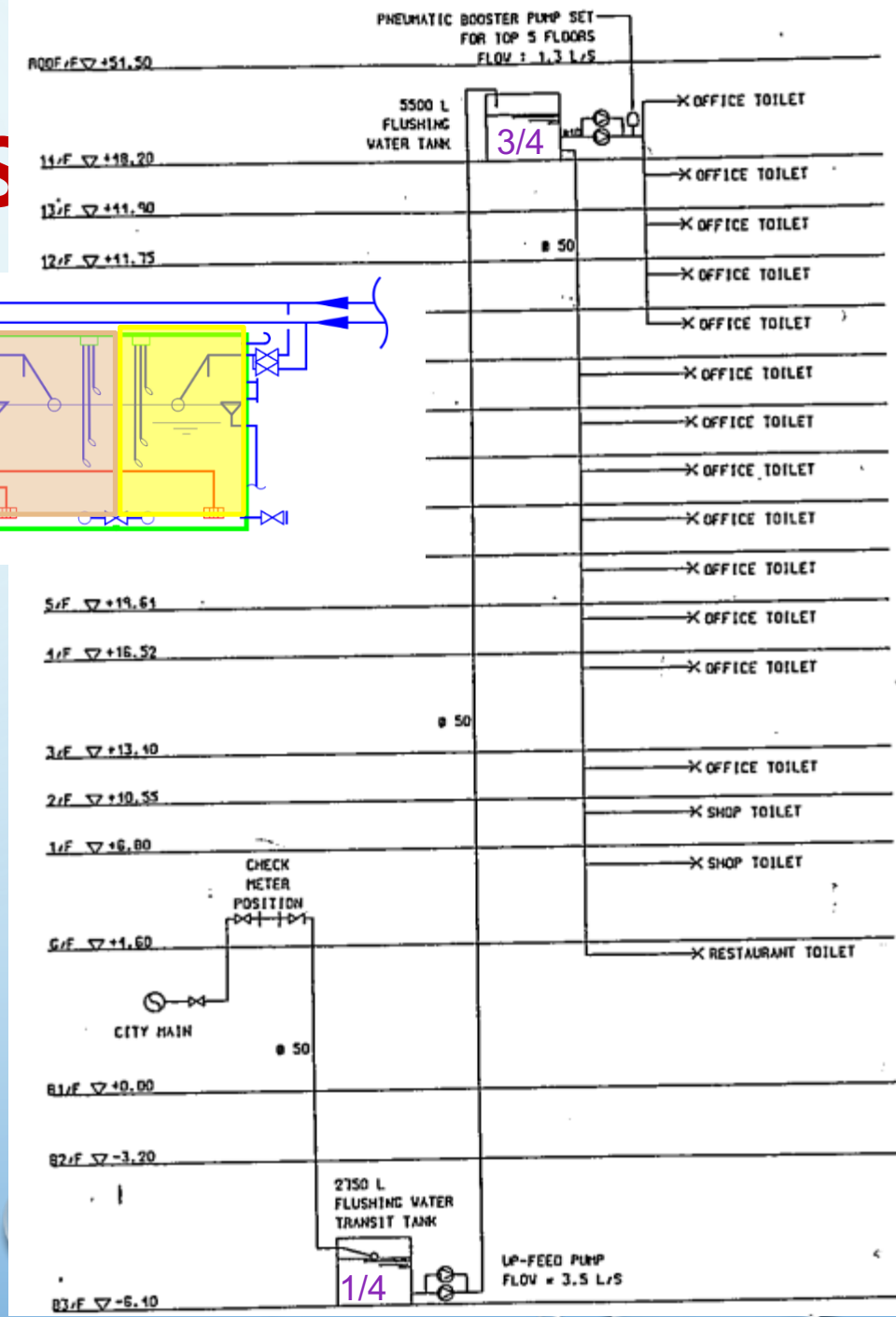
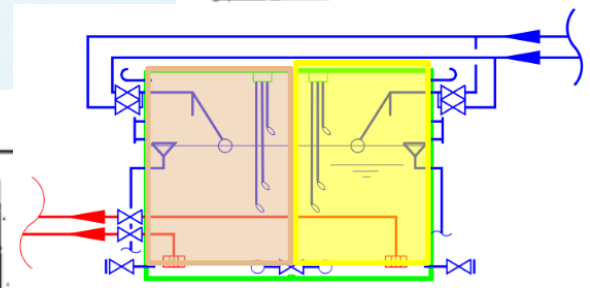
## A. Direct supply

直接供水



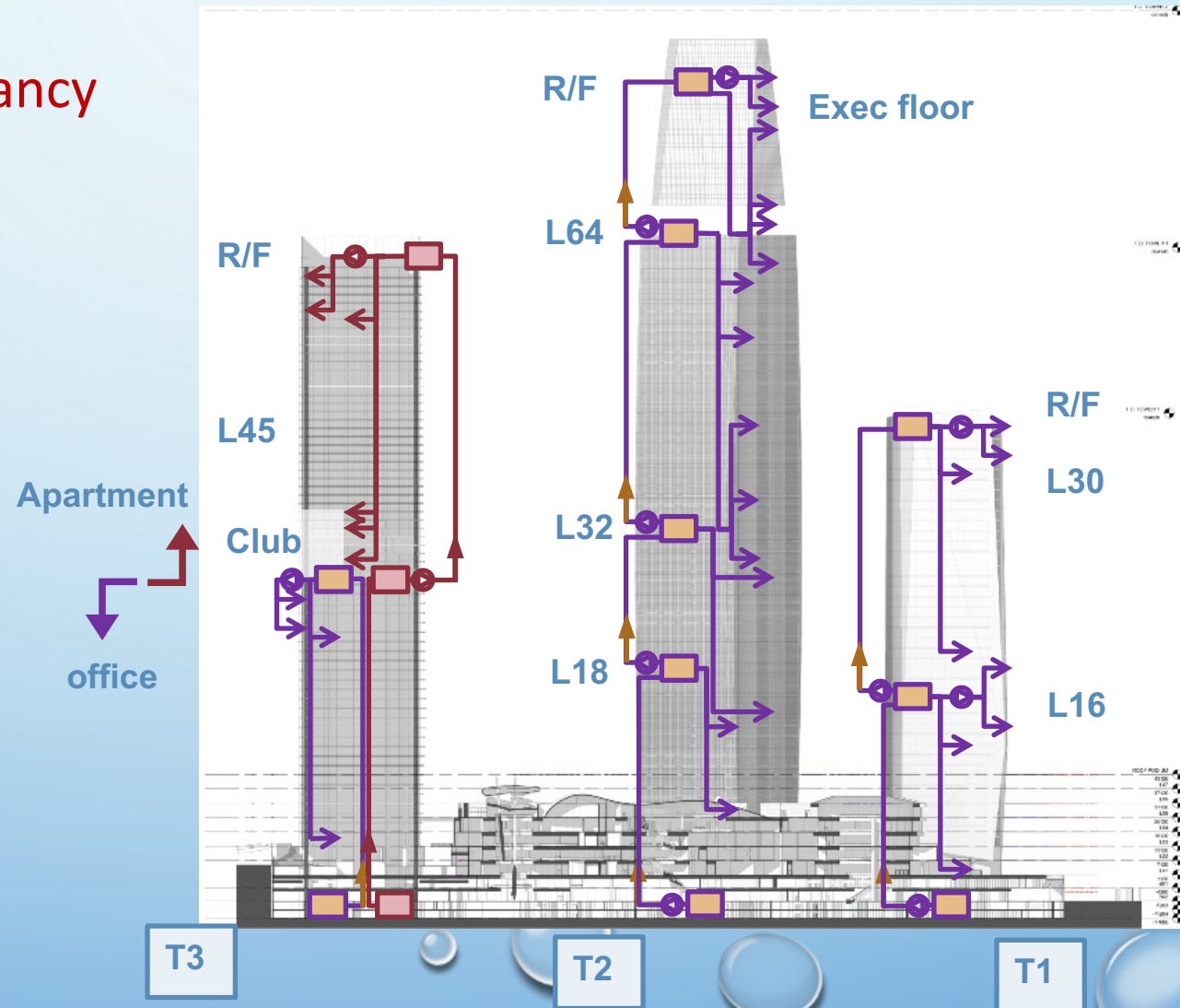
## B. In-direct supply

間接供水



# Highrise Building Plumbing Systems

- Building in composite occupancy
  - ❖ Podium
  - ❖ Tower
  
- Plumbing systems against
  - ❖ Height
  - ❖ Occupancy / nature





# Highrise Building Plumbing Systems

## Water Supply System Planning

### ➤ Water supply pressure

≈ 1.5 ~ 4.5 Bar

### ➤ Vertical zoning Plan

Pipeline and fittings pressure rating

- ❖ PN 10
- ❖ PN 16
- ❖ PN 25
- ❖ PN 40 !!!!!

### ➤ High-rise building need to divide vertical zoning as per occupancy / nature

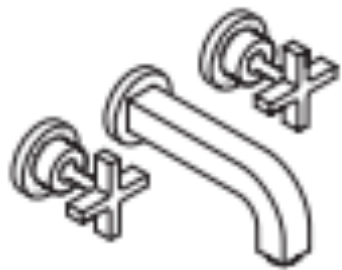
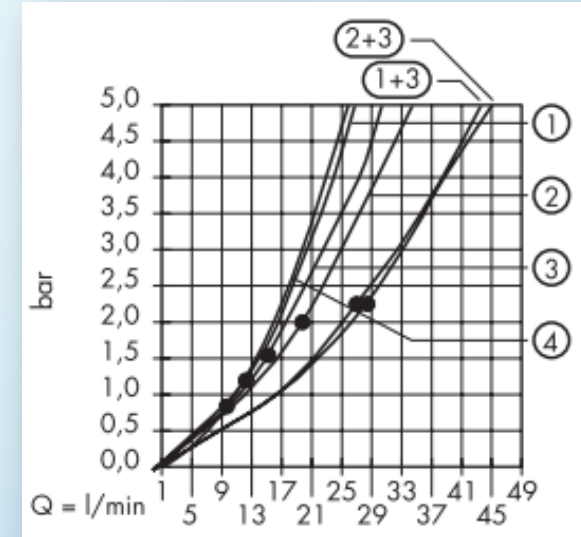
### ➤ Prevent high pressure rating application.

### ➤ Backflow prevention

# Highrise Building Plumbing Systems

## ❖ Operation Pressure

Basin tap  
 7 L/min ~ 0.116 L/s  
 (with dimmer)  
 @ 3 bar

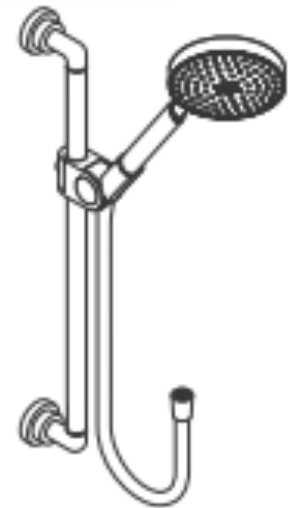


### Technical Data

**This mixer series-produced with water-dimmer (flow limiter)**

Rate of flow with waterdimmer::	7 l/min 3 bars
Rate of flow without waterdimmer::	14 l/min 3 bars
Operating pressure:	max. 10 bars
Recommended operating pressure:	1 - 5 bars
Test pressure:	16 bars
Hot water temperature:	max. 80° C
Recommended hot water temp.:	65° C

Shower head  
 ~ @7 L/min ~ 0.116 L/s



The hand shower is suitable for continuous flow water heaters with a heat output of 21 kW on a minimum through flow of 7 l/minute.

### Technical Data

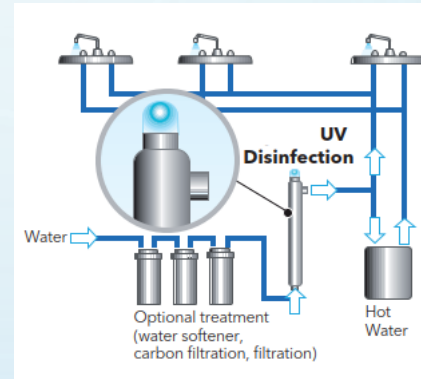
Operating pressure:	max. 0,6 MPa
Recommended operating pressure:	0,1 - 0,4 MPa
Hot water temperature:	max. 60° C

# Highrise Building Plumbing Systems

## ❖ Operation Pressure

### Water Supply System Planning

- Disinfection UV lamps
- Filter
- Auto-strainer

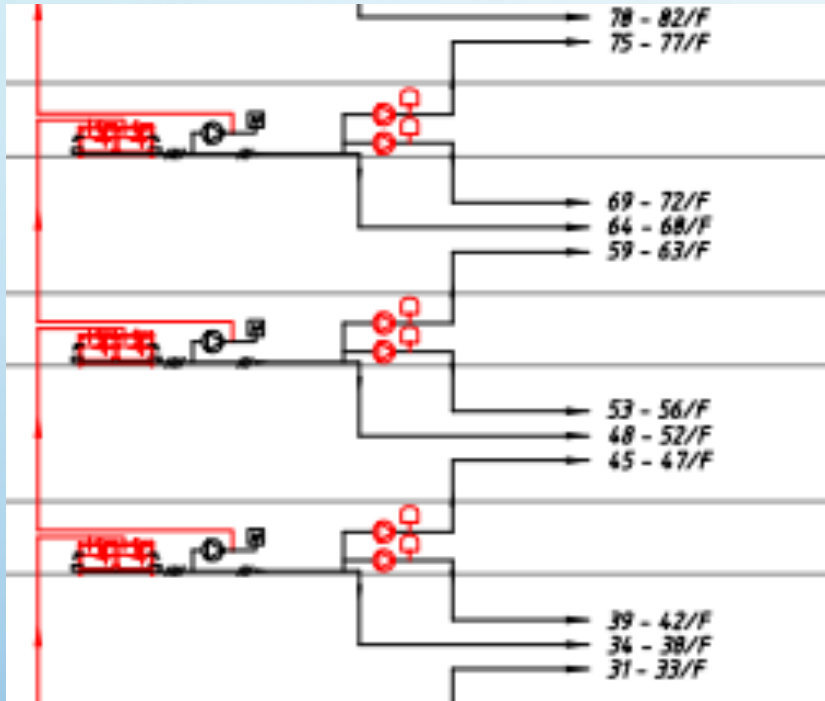


### General Technical Specifications:

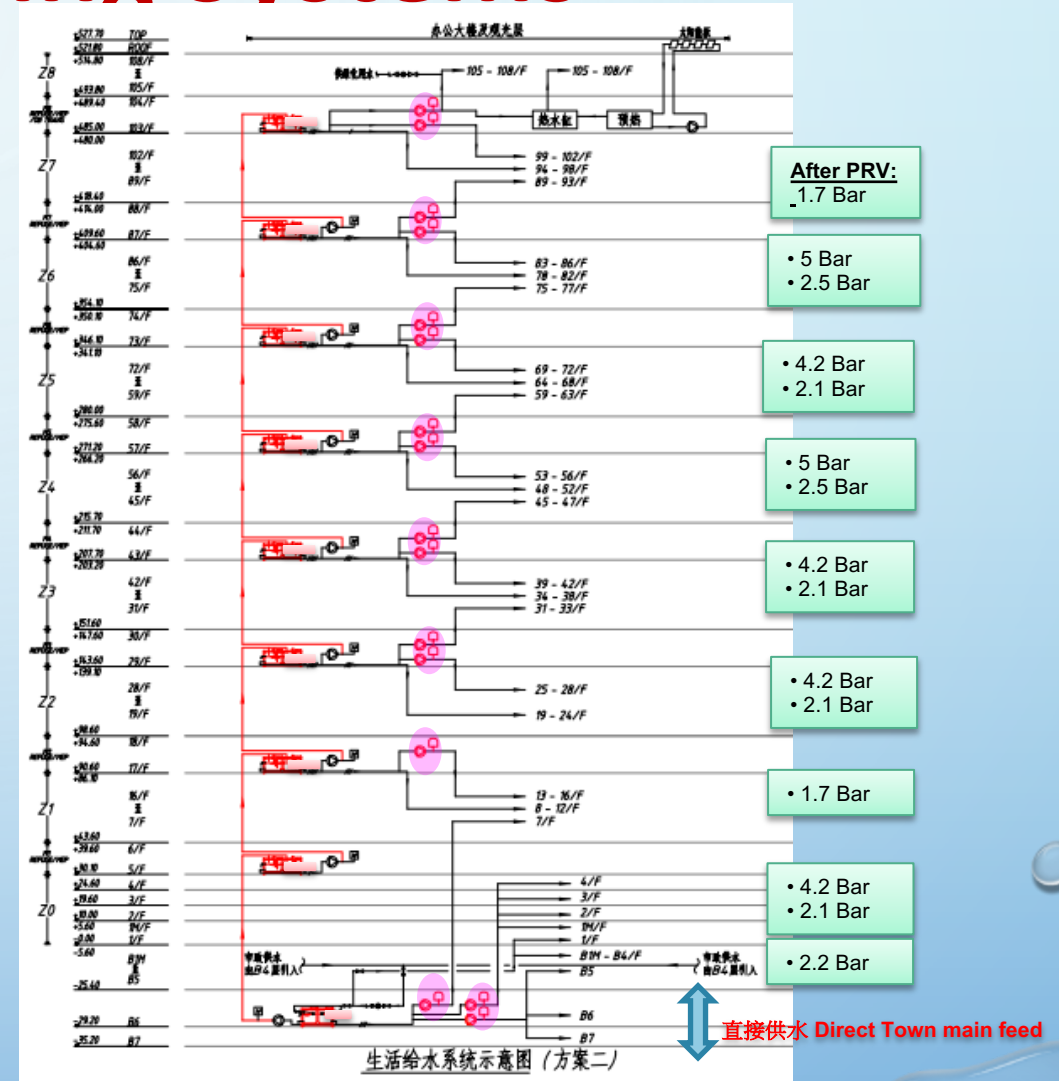
- Body Material : AISI 304 L (316 L optional)
- Screen Material : AISI 316 L
- Max. Operating Pressure : 10 bar (16-25 bar optional)
- Min. Inlet Pressure Required During Back-Flush : 2 bar
- Max. Operating Temperature : 60 °C (90 °C optional)
- Headloss at Max. Flow Rate : 0.2 bar
- Approximate Back-Flush Time : 10-15 sec. max.
- Approximate Back-Flush Water Consumption : 80-120 l/back-flush
- Control System : Hydraulic or Electric



# Highrise Building Plumbing Systems

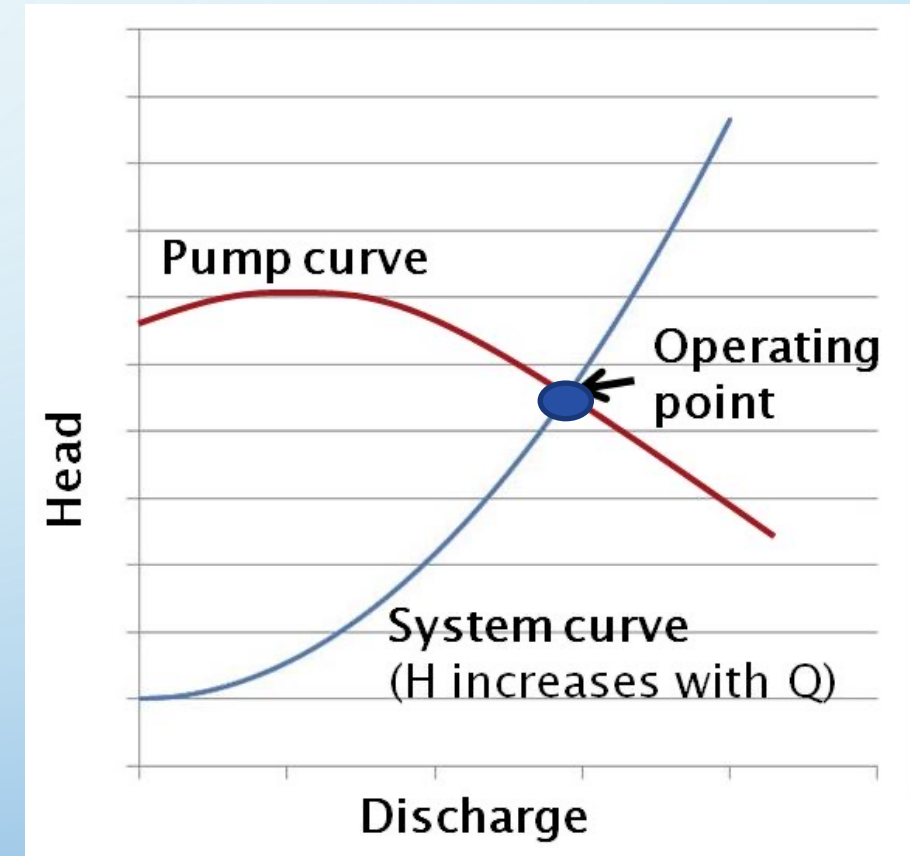
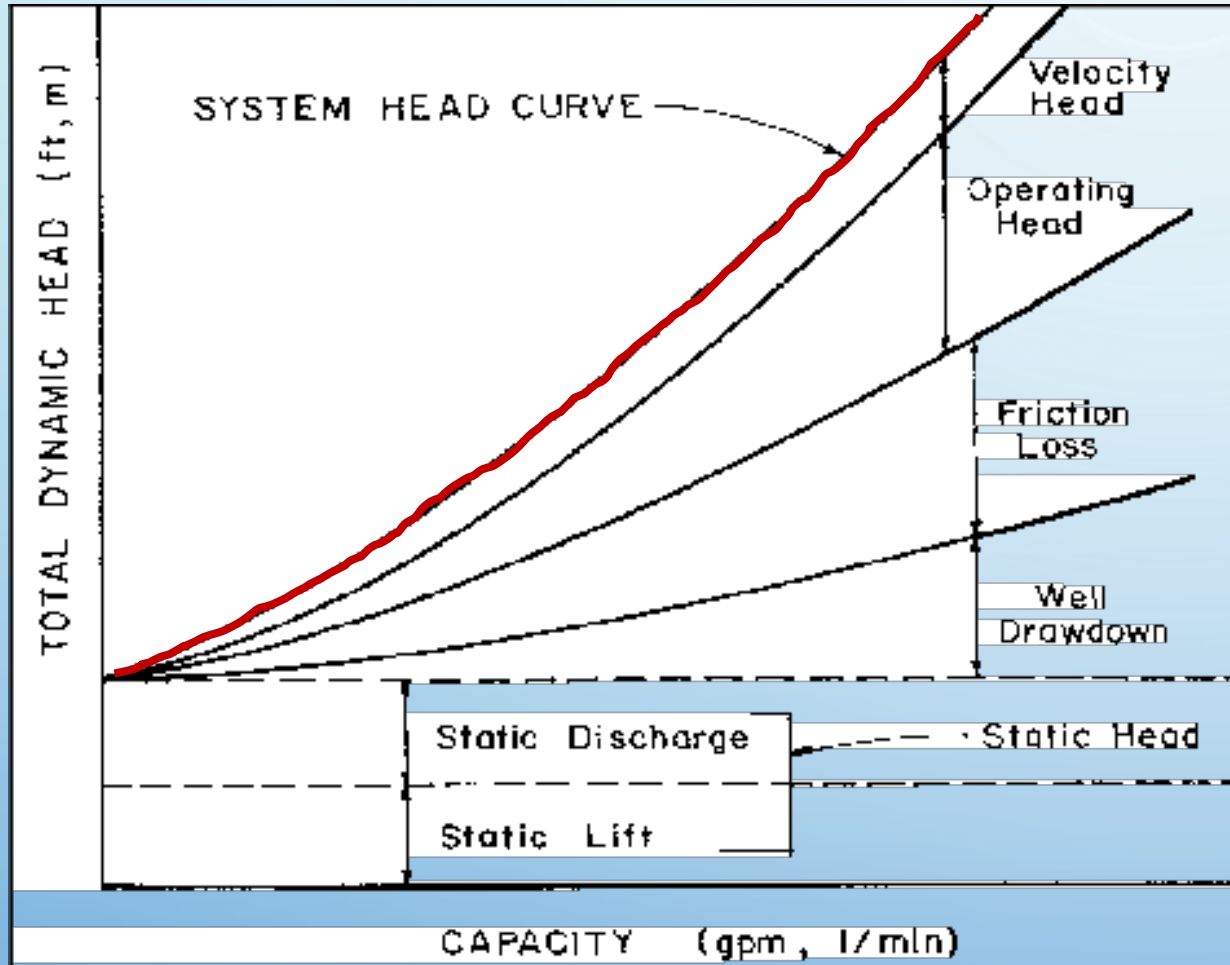


Booster Pump sets



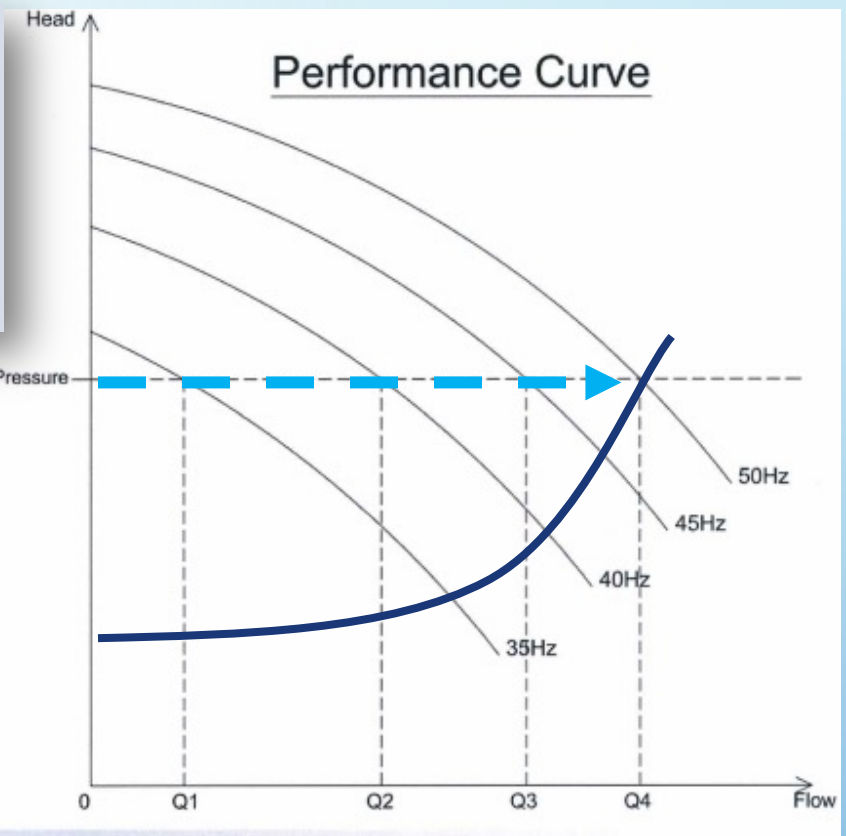
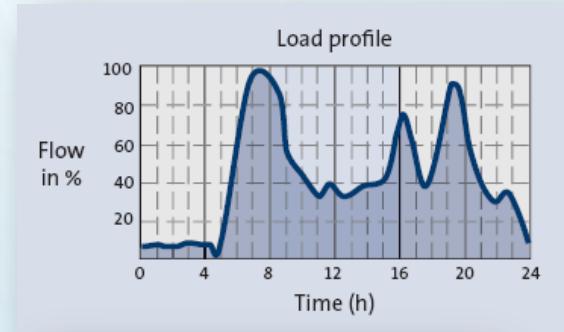
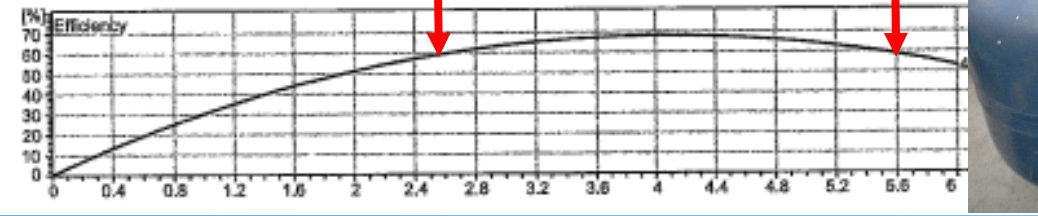
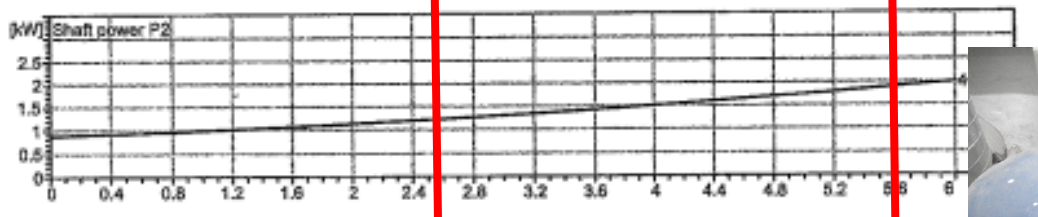
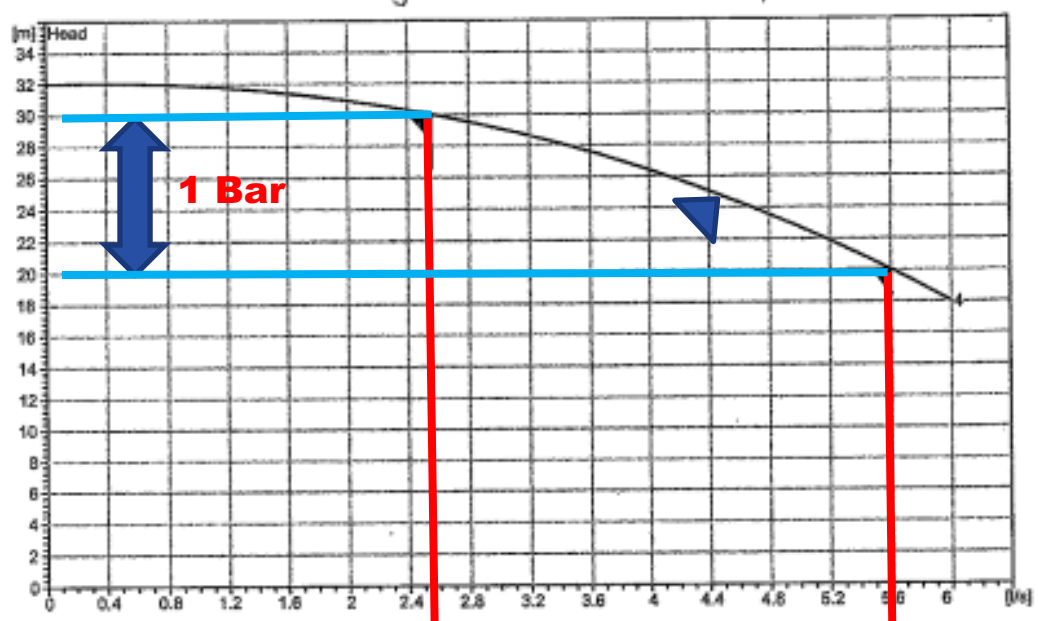
Vertical Zoning

# Highrise Building Plumbing Systems



# Highrise Building Plumbing Systems

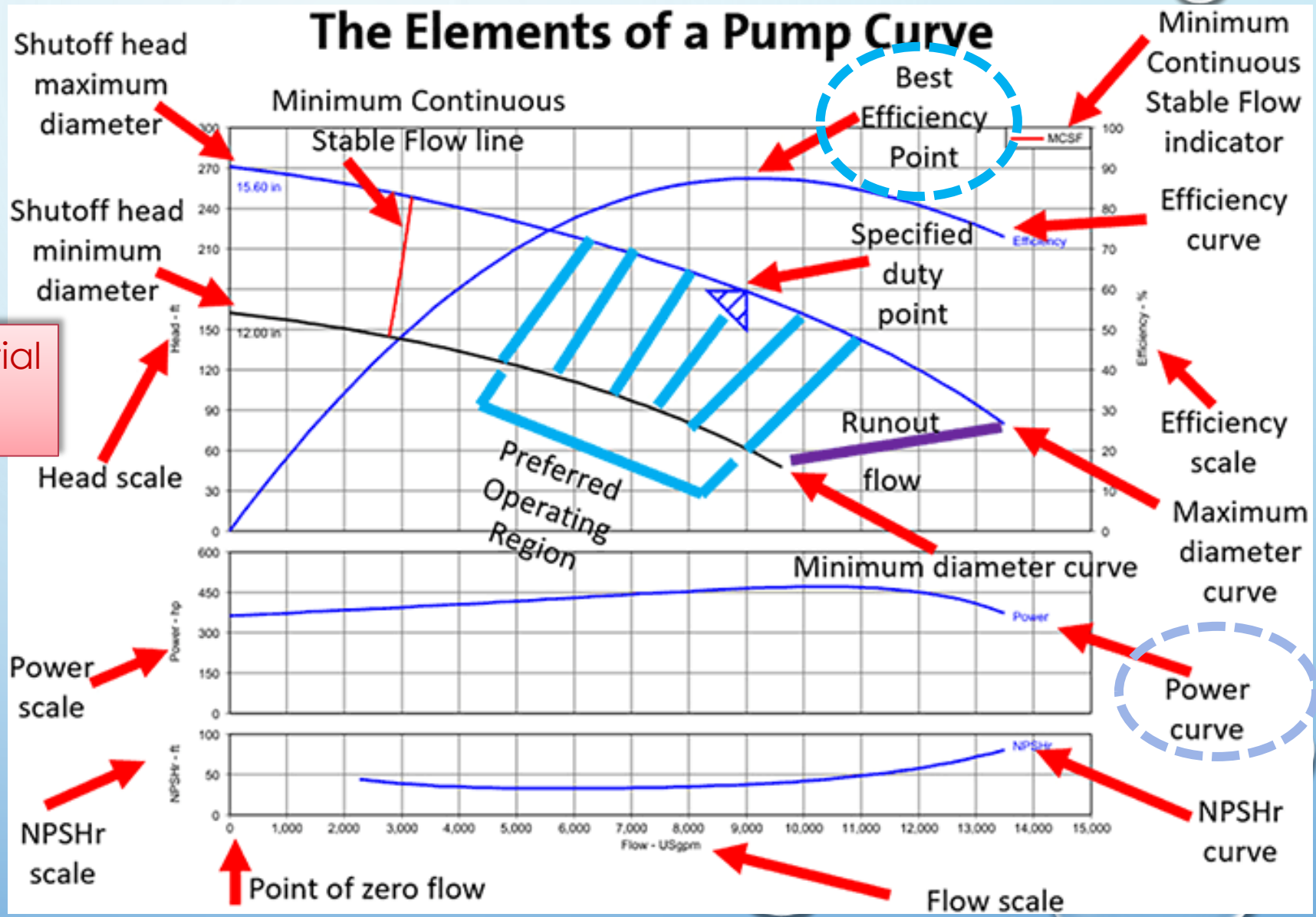
- Pump Selection and concerns



**Predict loading vs Combination of PUMP SET**  
**1 x 100%**  
**2 x 50%**  
**3 x 33%**  
**1 x 50% + 2 x 30% ... ..**

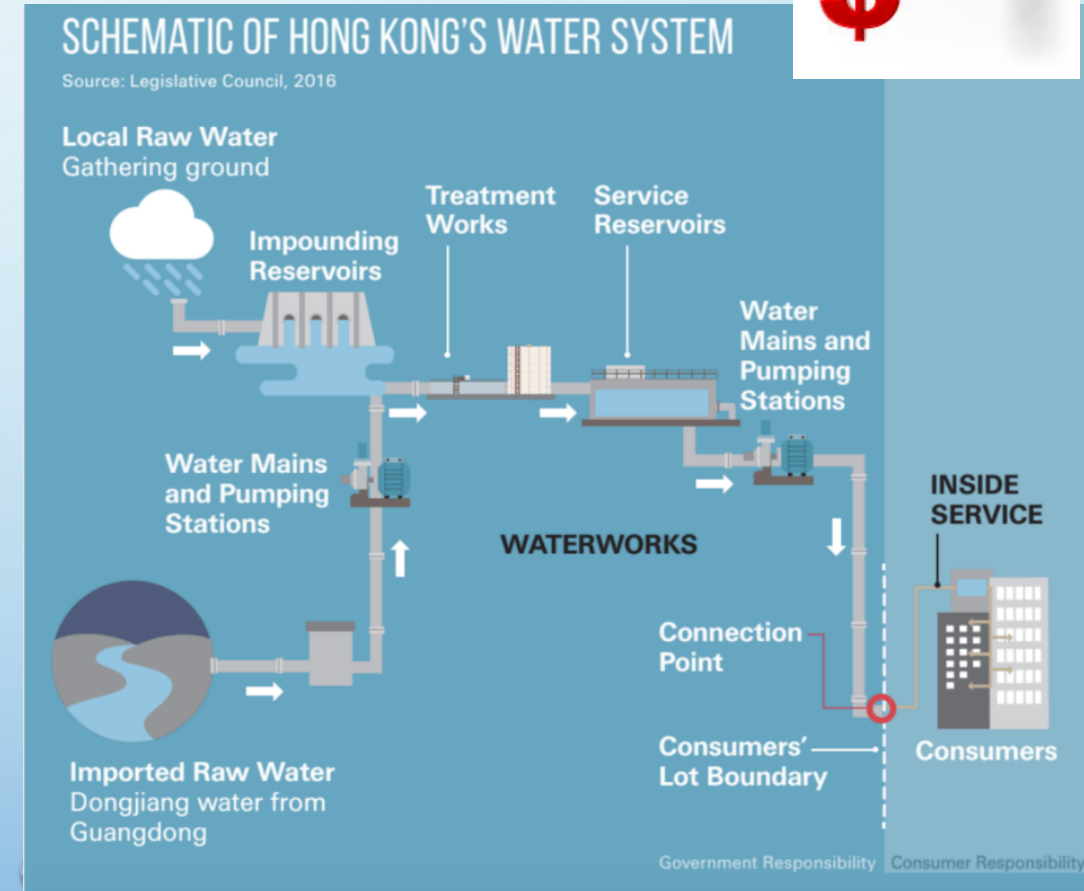
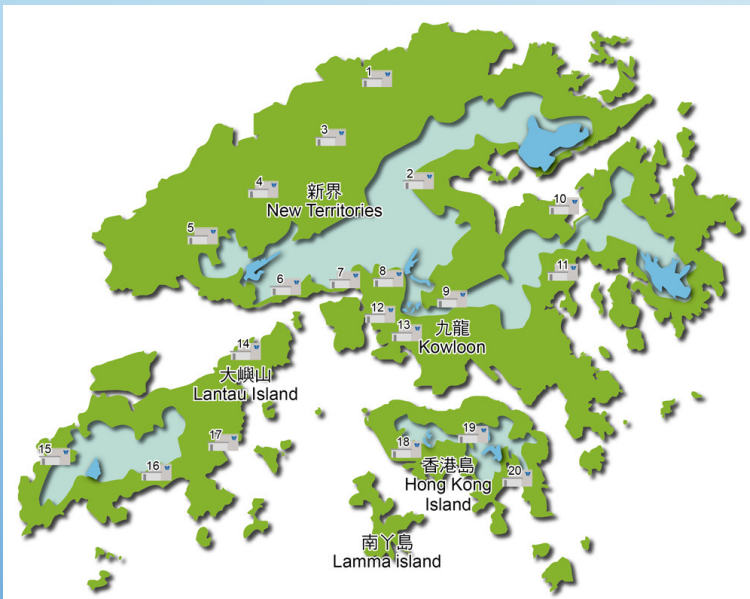
# Highrise Building Plumbing Systems

• Energy against gravity / potential  
 $P.E. = m \cdot g \cdot h$



# Water Saving Features

- **Save water = save energy**
  - Less the amount of mass, water flow demand, less energy will be consumed for transportation
- **Utilize non-traditional water sources**
  - Reclaim water
  - Sea water
  - Desalination water





# Water Saving Features

Utilize non-traditional water sources

- ✓ Hong Kong is a coastal city, Authority had planned for using sea water for flushing water source since **1950s**.
- ✓ Sustainable resource to play an important role in Hong Kong's water management.
- ✓ ~ 320 million cubic metres per annum of seawater for population's toilet flushing application, ~ 20% of total fresh water supply.
- ✓ Save fresh water treatment quantity and less dependent on water source but also can save on the energy on water treatment and transportation from reservoir to urban / buildings.
- ✓ Although Sea water supply will also be treated and quality control, much less than fresh water, mainly be passing through filtration and disinfection processes for flushing water supply application.
- ✓ Transport to the premises through another separated water supply network mains.
- ✓ Hence, all buildings / development will be equipped with min. 2 sets of plumbing systems, one for potable and another flushing water system;
- ✓ they are individual and totally separated, both plumbing systems will not have any cross and interfacing to avoid any risk of cross contamination and mis-connection.
- ✓ Flushing water can flatten the demand of fresh water, even shortage or suspension of fresh water, it will not have implication to flushing which lead to subsequent hygiene problem, Hence the sustainability and reliability of the City can be guaranteed.

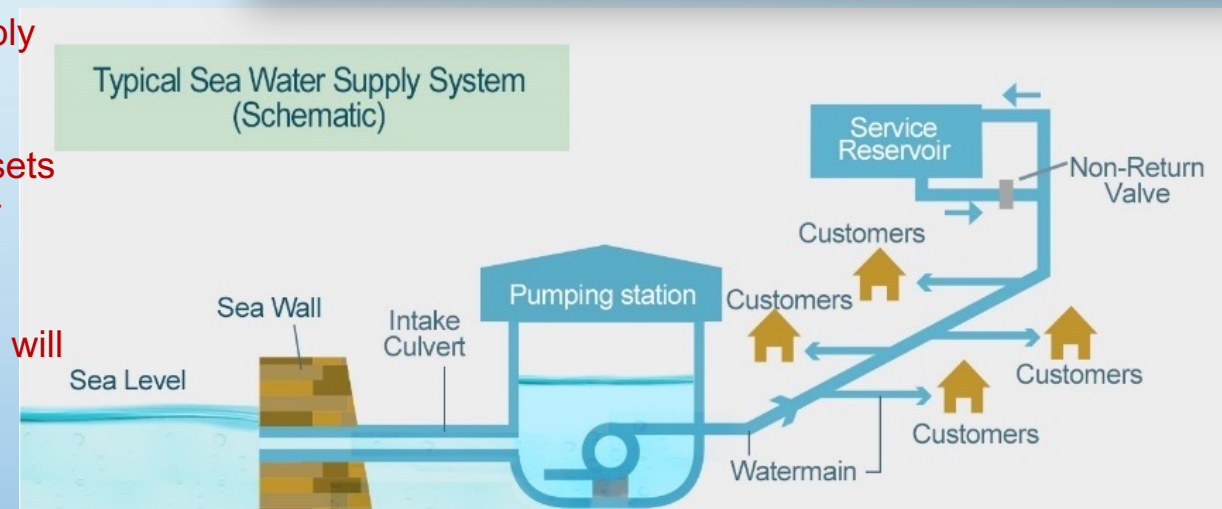
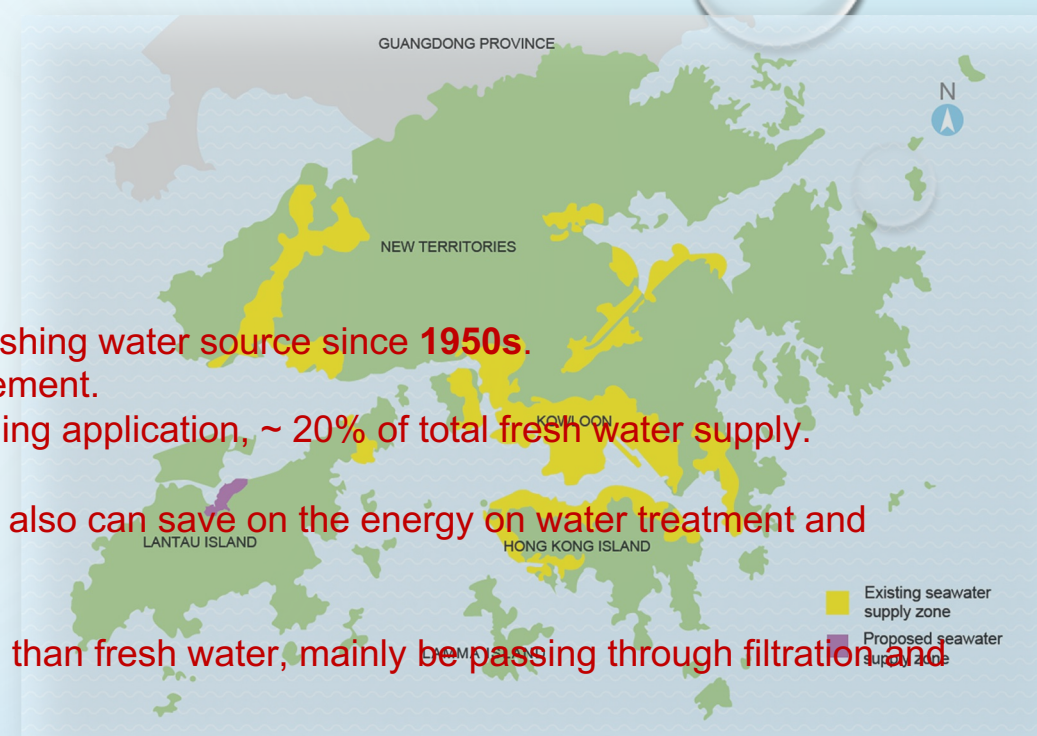


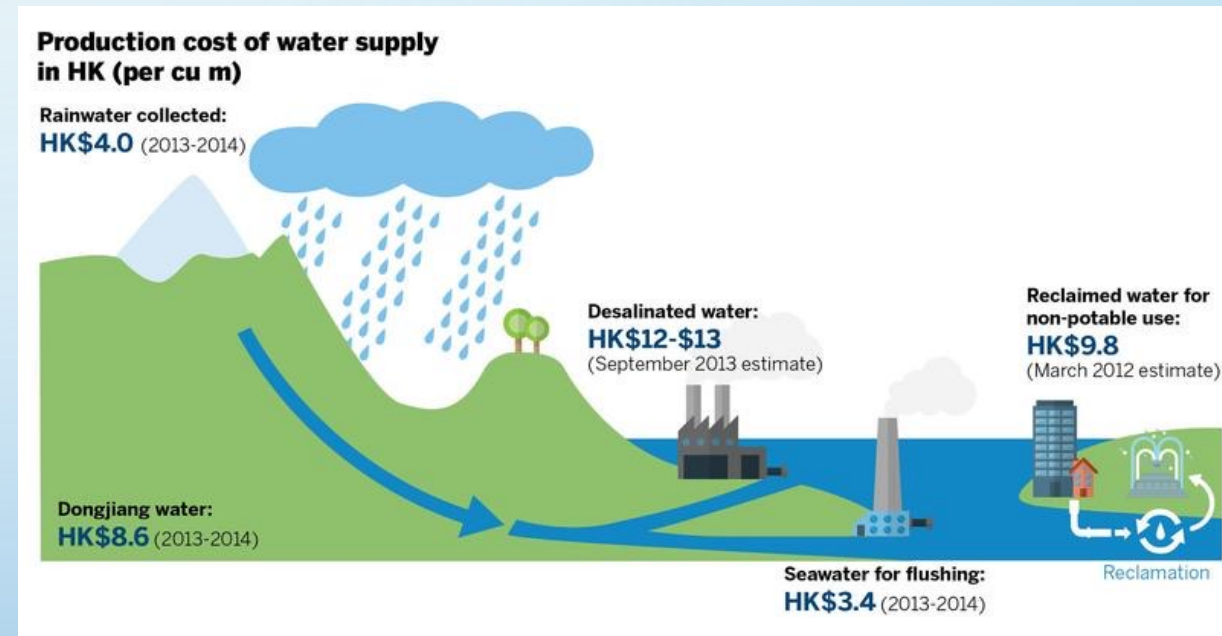
Figure 2: HK Water Services Department (WSD) - <https://www.wsd.gov.hk/en/core-businesses/water-resources/seawater-for-flushing/index.html>

# Water Saving Features

- **Sea water plumbing system**
  - Utilizing sea water for flushing application can satisfactory in fresh water saving to the City
  - Supply is tend to be unlimited.

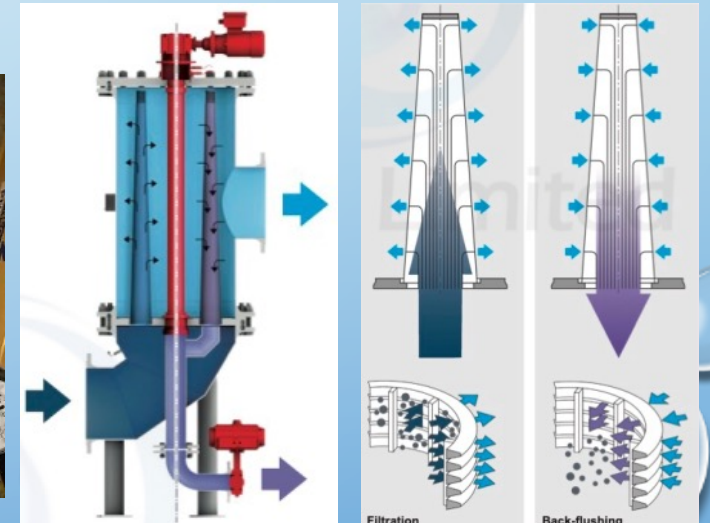
But .....

- considered NOT popular throughout the World.
- In recent decades, more cities utilize reclaim water for non-potable application, including flushing, by means of the process of converting municipal wastewater (sewage) or industrial wastewater into water that can be reused for a variety of purposes
- it is particular to facing shortage risk of fresh water sources, such as inner / northern regions China, Australia, Singapore, US (continental), etc.



# Water Saving Features

- Sea water plumbing system >>> Barrier :
  - *Additional Infrastructural planning and urban investment*
    - ✓ construction from water intake, treatment, pump house, supply network,
    - ✓ series of codes and regulations to govern the application and installation.
  - Building owners / developer need to have separated flushing water system,
    - ✓ tanks, pump sets, pipeline and accessories, take up more building services installation space planning complexity
    - ✓ Installation cost
- Water Quality
  - ✓ Sea water near costal area or river delta area will not be in very good quality, full of sand / mud and sediment, even worst if the city with uncontrolled waste disposal
  - ✓ fine sediment in sea water will be accumulated leading to leakage and blockage
  - ✓ Enhancement by auto-backwash filters / branch strainers



# Water Saving Features

- Sea water plumbing system >>> Barrier :
  - Corrosive Properties
    - ✓ Sea water with high corrosive properties, presence of dissolved ions, and higher conductivity and the penetrating power of the chloride ion through surface films on a metal;
    - ✓ these ions allow electrons to move faster on the metal, speeding up the formation of rust.
    - ✓ High demand on material of valve & fittings / pump sets / pipeline

Table B2.1.1.1 Applicable materials for fresh water and salt water inside service at different locations

Pipe/ Pipe fitting material	Fresh Water Inside Service		Salt Water Inside Service <sup>(1)</sup>
	Cold Water	Hot Water	
Copper	✓	✓	✗
Ductile iron (with internal coating)	✓	✓	✓
Polyethylene (PE)	✓	/	✓ <sup>(2)</sup>
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	✓	✓	✗

Table B2.1.1.3 Fitting materials for inside service and fire service

Valve/Strainer component materials	Fresh water inside service		Salt water inside service	Fire service	
	Cold water	Hot water		Fresh water	Salt water
<i>A. Body and bonnet</i>					
Cast iron (with internal coating)*	✓	✓	✓	✓	✓
Copper alloy – brass**	✓	✓	✗	✓	✗
Copper alloy – dezincification resistant (DZR) brass (e.g. CW602N/CZ132)	✓	✓	✗	✓	✗
Copper alloy – bronze (gunmetal)	✓	✓	✓	✓	✓
Ductile iron (with internal coating)*	✓	✓	✓	✓	✓
Polyethylene (PE)	✓	✗	✓	✗	✗
Polyvinyl chloride - unplasticized (PVC-U)	✗	✗	✓	✗	✗
Stainless steel (Grade 304)	✓	✓	✗	✓	✗
Stainless steel (Grade 316)	✓	✓	✗	✓	✗
Duplex Stainless steel (Grade 1.4462 or superior)	✓	✓	✓	✓	✓

# Water Saving Features

## • Other Reclaim Water Systems:

### *Localized / regional application*

- ✓ Water sources will be close to the users points
- ✓ Less energy required for water transporting from pump station / treatment plant to premises, and the energy for disposal from premise to city network / treatment plant.

### ➤ *Rainwater re-cycling system*

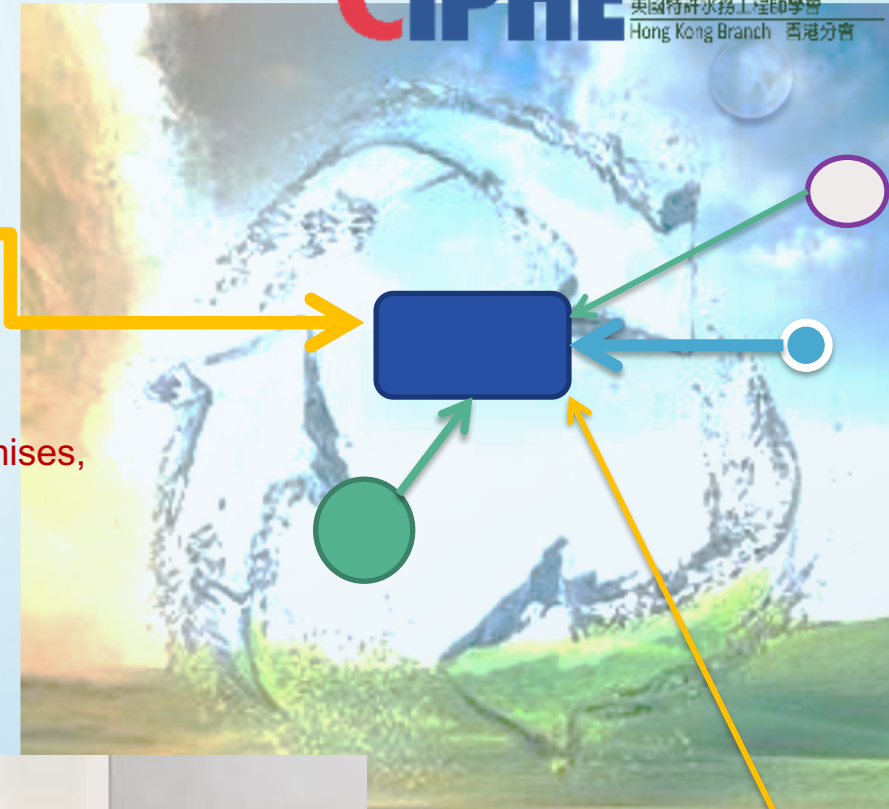
- ✓ HK heavy rainfall but premises with limited footprint
- ✓ Local application for non-portable applications



### ➤ *Grey water reclaim*

### *Regional gray water treatment / recycling systems*

- ✓ Collect water >> treat >> re-use in non-potable application
- ✓ Domestic waste water / cooling tower bleed-off / condensate



# Water Saving Features

- Water Saving Sanitary Application

- *BEAM plus*

- ✓ **1 credit** for installing water efficient appliances with Water Efficiency Labelling Scheme
- ✓ Grade 2 ( $>9$  &  $\leq 12$  L/ min)  
or
- ✓ Grade 1 ( $\leq 9$ L/min)

- *LEED*

- ✓ appliance comply with Water Sense: an EPA partnership program:
- ✓ Bathroom sink faucet & accessories  $< 1.5$  gallon / min ( $< 6.75$  L/min)
- ✓ Shower heads  $< 2$  gallon / min ( $< 9$  L/min)
- ✓ Hence the requirements of LEED credit are a little higher than that of BEAM plus

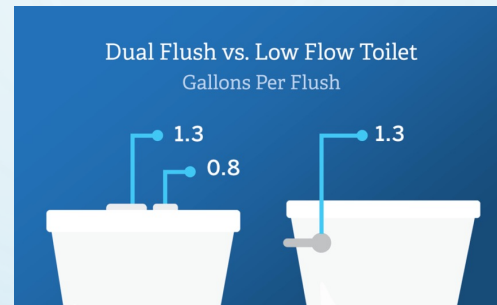


Water Efficiency Labelling  
(HK WSD)

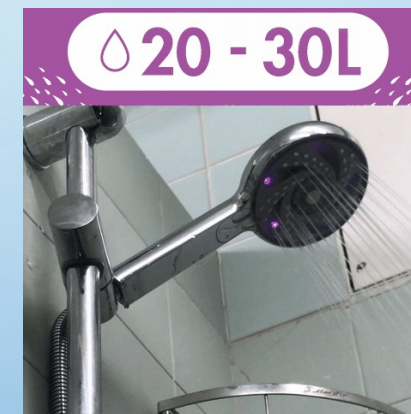
# Water Saving Features

- Water Saving Sanitary Application

*Human Behavior*

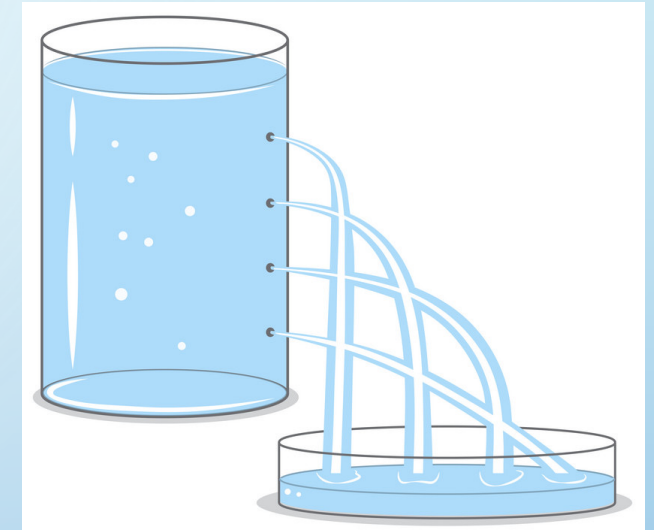
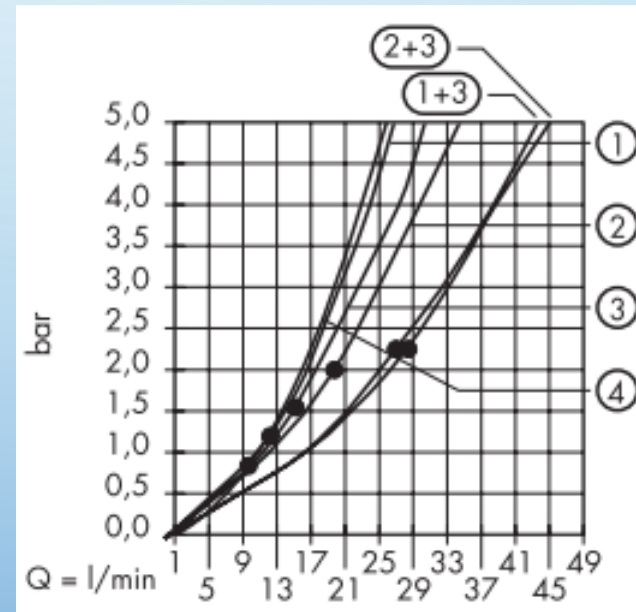


- ✓ Behavior govern the actual water consumption rather than advance of any sanitary fitment



# System pressure vs Bldg Height

- Water supply to Tall building need be separated into multiple Vertical Zones.
- Gravity lead to static pressure & increase water system pressure in the system
- Domestic sanitary fitting
  - residual pressure : 1.5 ~ 4.5 bar
- Control System pressure by means of application of
  - pressure reducing valve sets
  - Or
  - Different pump outlets

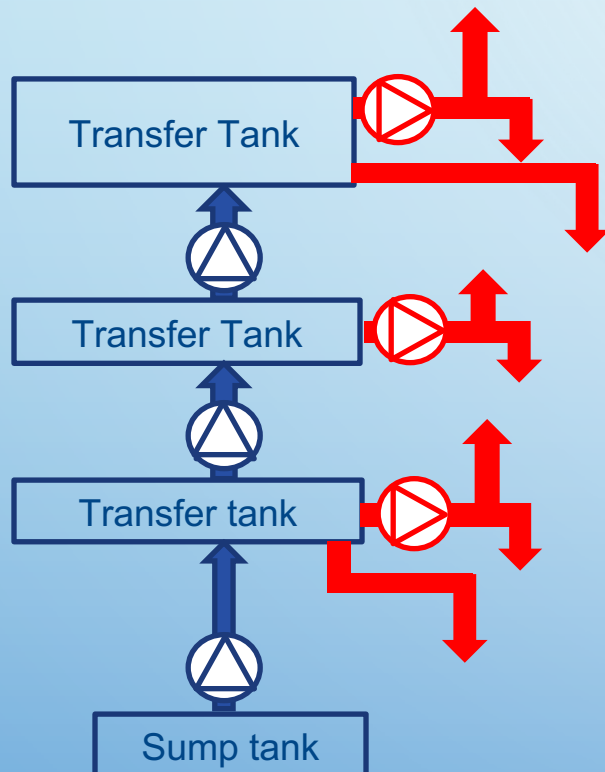




# System pressure vs Bldg Height

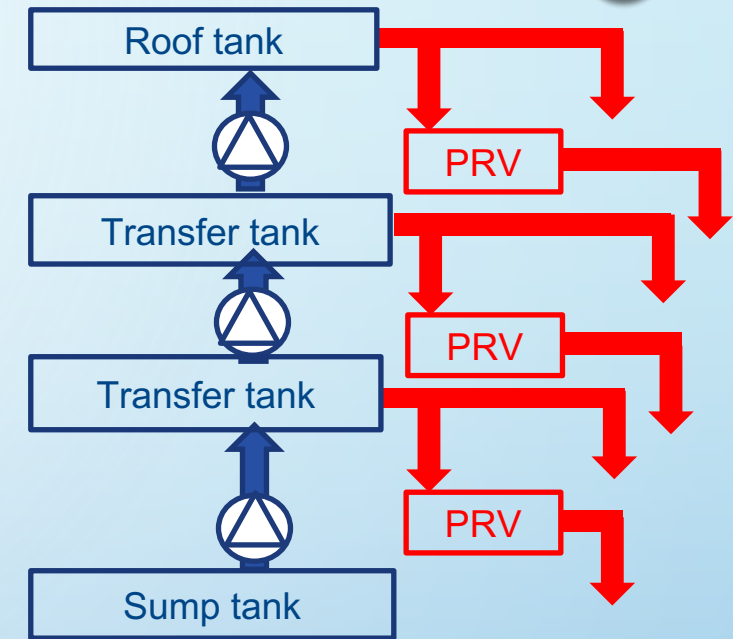
## Gravity flow 重力自流

- ✓ Transfer tank from low level
- ✓ Transfer water to upper tanks
- ✓ Water supply downward to floors below
- ✓ Apply Pressure Reducing Valve to control the pressure range < 16 bar



## Booster Pump System 加压系统

- ✓ Transfer tank from low level
- ✓ Transfer to upper tanks
- ✓ Water supply downward to floor below by gravity
- ✓ Water supply upward to floor above by booster pump
- ✓ Minimize apply Pressure Reducing Valve to control the pressure range



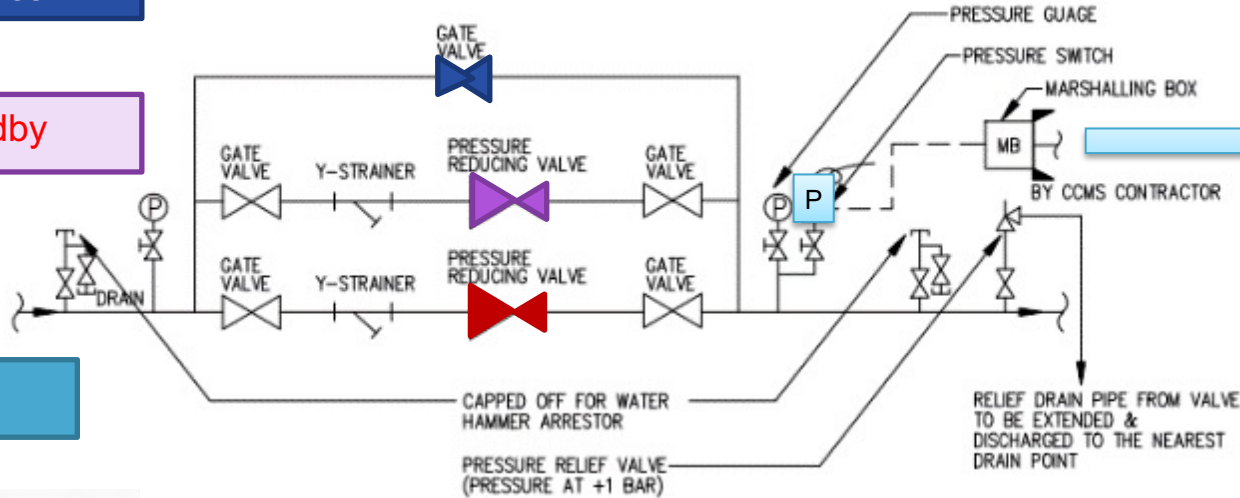
# System pressure vs Bldg Height

Typical installation details for Pressure Reducing Valve Station

By-pass

Standby

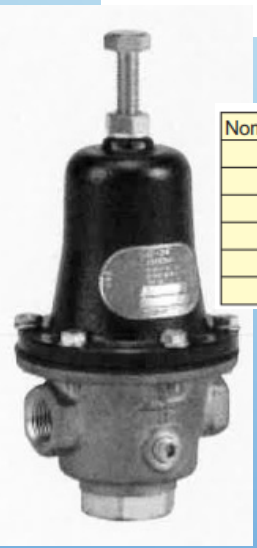
Duty



Pressure switch for **High Pressure ALARM** – indicate PRV in failure



Cavitation increases the magnitude of these pressure fluctuations also increase. System vibrations, pipe wall vibration

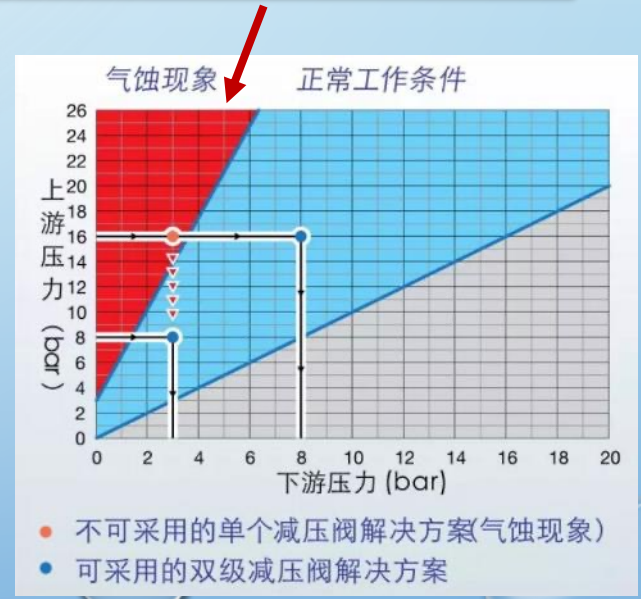


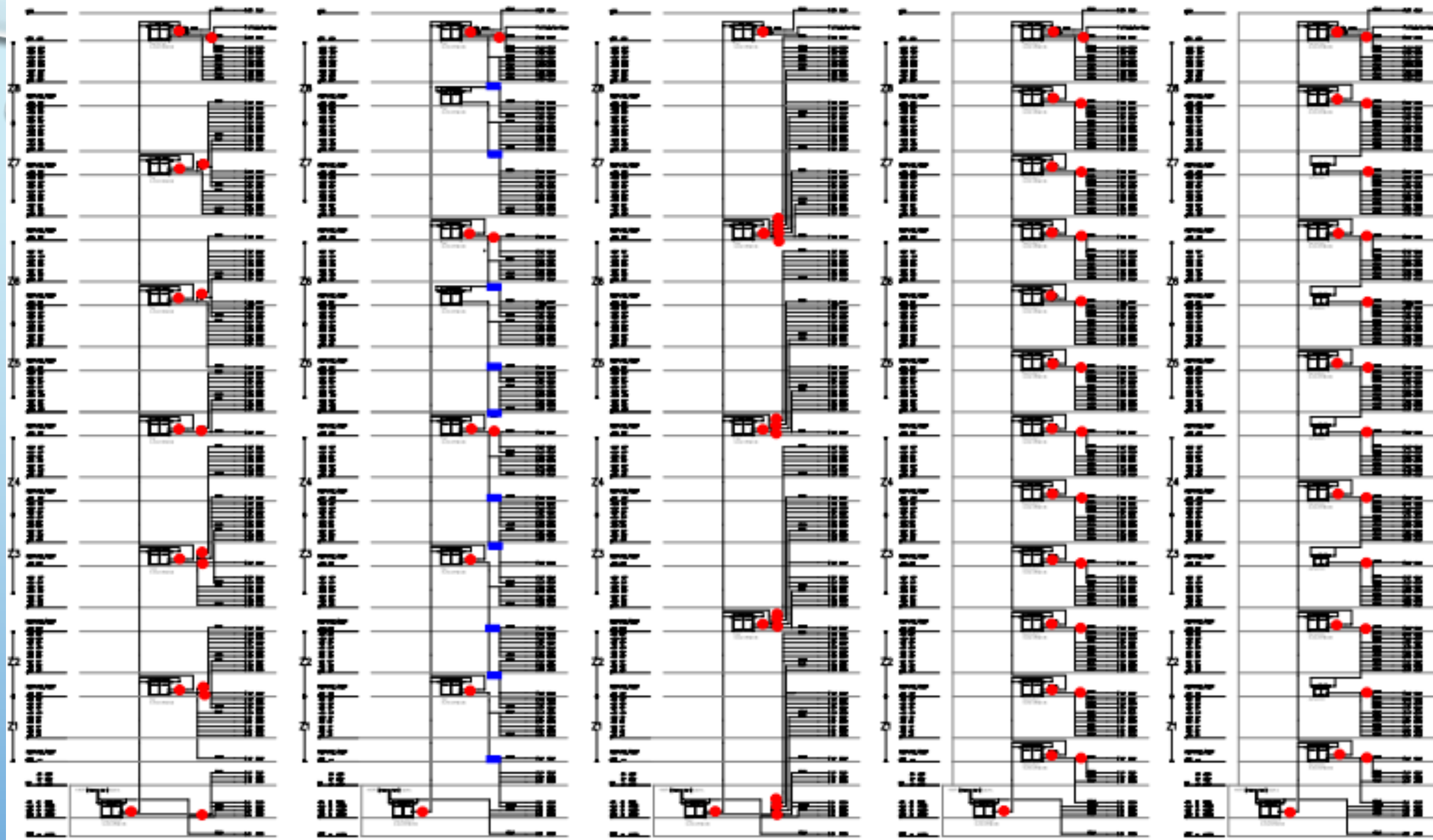
Nominal size	d	L	H
15A	Rc 1/2	80	193
20A	Rc 3/4	90	210
25A	Rc 1	100	230
32A	Rc 1-1/4	120	265
40A	Rc 1-1/2	150	315
50A	Rc 2	185	365

Direct Acting



Pilot Type



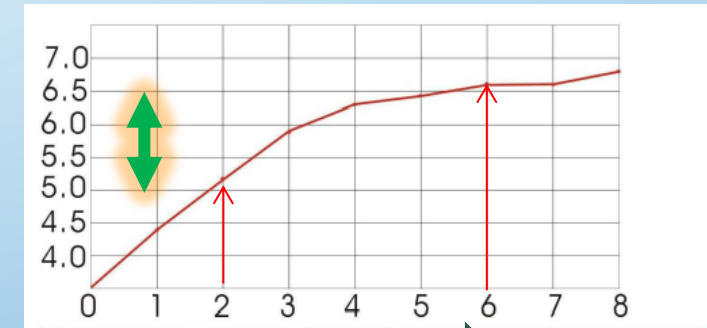
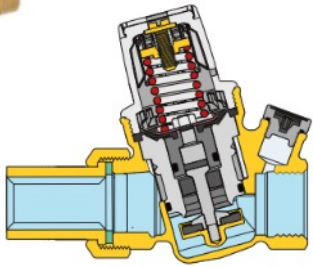
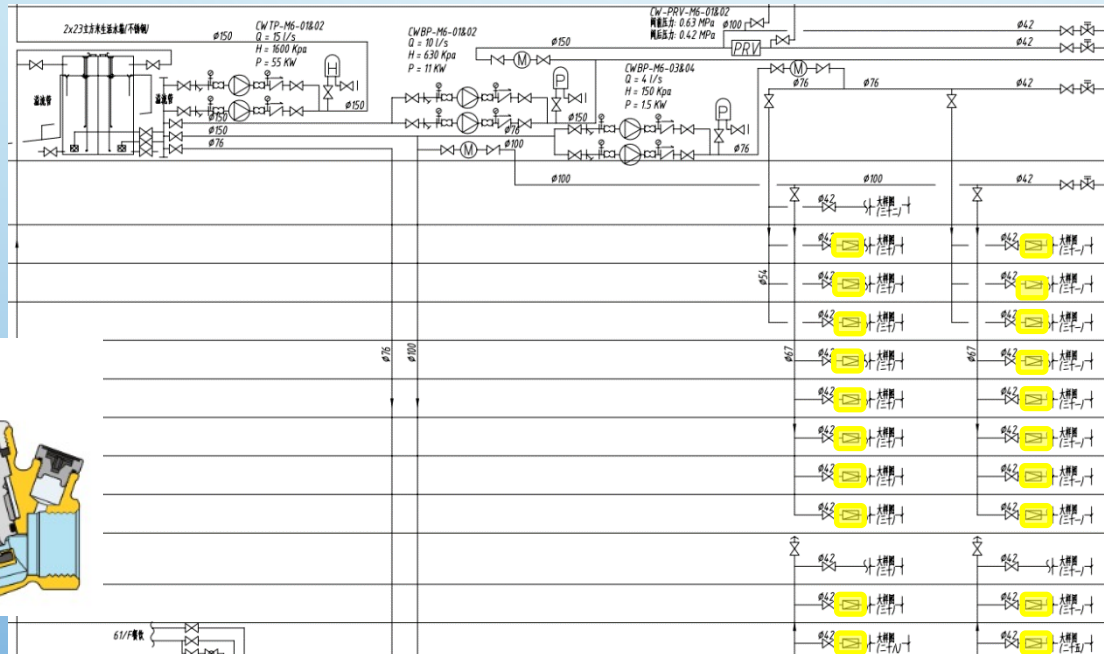


System Description	Vertically zoned to Gravity or booster pump for adjacent upward and downward zone nil PRV	Vertically zoned to depend on Gravity and PRV	Vertically zoned all by booster pumps upward only	Vertically zoned to Gravity or booster pump downward only nil PRV	Vertically zoned to Gravity or booster pump downward only Use break tank & nil PRV
Tanks arrangement	Each tank for 2 zones	Each tank for 2 zones	Each tank for 3 zones	Each tank for each zone	Each tank for each zone
Major equipment	Transfer pump: 6 sets Booster pump: 13 sets PRV: 0 Tank : 6 nos.	Transfer pump: 5 sets Booster pump: 3 sets PRV: 10 Tank : 7 nos.	Transfer pump: 4 sets Booster pump: 17 sets PRV: 0 Tank : 12 nos.	Transfer pump: 12 sets Booster pump: 12 sets PRV: 0 Tank : 12 nos.	Transfer pump: 7 sets Booster pump: 12 sets PRV: 10 Tank : 7 nos. Break tank : 5 nos.
Props	<ul style="list-style-type: none"> <li>✓ Mainly utilize VSD booster pump maintain water supply – steady on flow and pressure</li> <li>✓ Less water tanks – less flood risk</li> <li>✓ Partial of water supply will NOT be affected in power suspension</li> </ul>	<ul style="list-style-type: none"> <li>✓ Utilize PRV – nil power req't</li> <li>✓ Less pump &amp; less maintenance</li> <li>✓ PRV need less installation space</li> <li>✓ Less in tanks</li> <li>✓ Less in initial cost</li> <li>✓ Water supply will NOT be affected in power suspension</li> </ul>	<ul style="list-style-type: none"> <li>✓ Mainly utilize VSD booster pump maintain water supply – steady on flow and pressure</li> <li>✓ Can dedicated a plant room – easy in main't &amp; noise control</li> <li>✓ Less power cost</li> <li>✓ Less tank capacities</li> </ul>	<ul style="list-style-type: none"> <li>✓ Each zone with its system, higher feasibility</li> <li>✓ Mainly supply by gravity, higher reliability</li> <li>✓ Water supply will NOT be affected in power suspension</li> <li>✓ Each plant room space smaller, easier to incorporate</li> </ul>	<ul style="list-style-type: none"> <li>✓ Each zone with its system, higher feasibility</li> <li>✓ Mainly supply by gravity, higher reliability</li> <li>✓ Water supply will NOT be affected in power suspension</li> <li>✓ Each plant room space smaller, easier to incorporate</li> </ul>
Cons	<ul style="list-style-type: none"> <li>✗ High initial cost</li> <li>✗ More spatial req't for pump installations</li> <li>✗ Larger in tank capacities to serve more floors</li> <li>✗ Partial of water supply WILL be affected in power suspension</li> </ul>	<ul style="list-style-type: none"> <li>✗ Mainly depend on PRV, qty more and rely on this quality</li> <li>✗ Water quality and model selection will affect the performance of PRV</li> <li>✗ High flooding risk if PRV in failure</li> <li>✗ More power cost</li> <li>✗ Larger in tank capacities to serve more floors</li> </ul>	<ul style="list-style-type: none"> <li>✗ More pump set qty</li> <li>✗ High initial cost</li> <li>✗ More spatial req't for pump installations</li> <li>✗ water supply WILL be affected in power suspension</li> <li>✗ More pipe duct spatial requirements</li> </ul>	<ul style="list-style-type: none"> <li>✗ High initial cost</li> <li>✗ More equipment and more maintenance works</li> <li>✗ More tanks – flooding risk higher</li> </ul>	<ul style="list-style-type: none"> <li>✗ High initial cost</li> <li>✗ More tanks – the highest flooding risk</li> </ul>

# System pressure vs Bldg Height

- Control System pressure is not just aim for protecting the pipeline and fittings
- But also, it can
- Save water

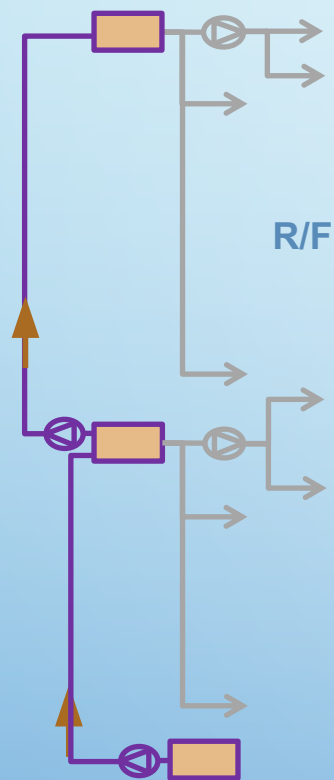
Pressure (bar)	2	3	4	5	6
Water Flow (w/o restrictor) (L/min)	5.2	6.4	7.4	8.2	9.0



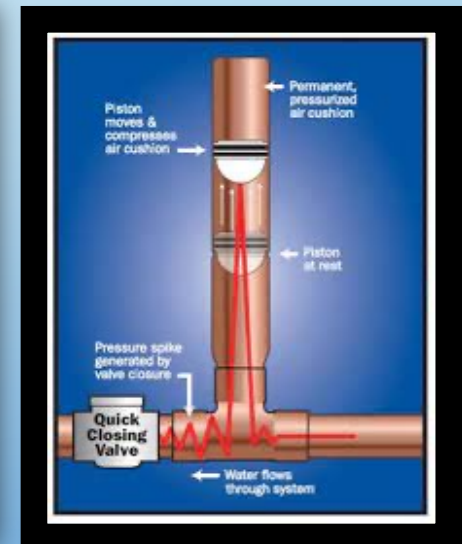
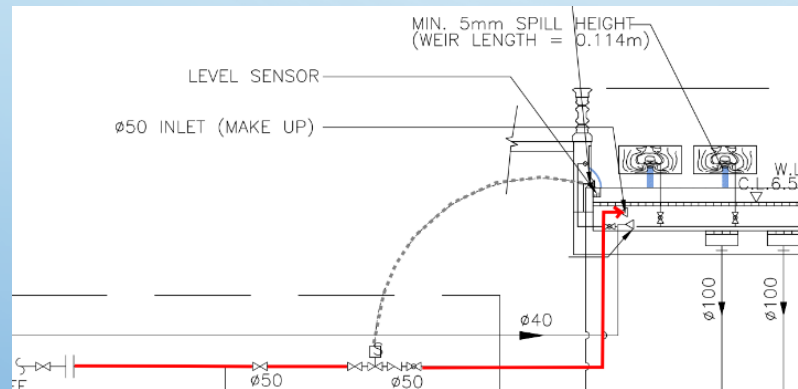
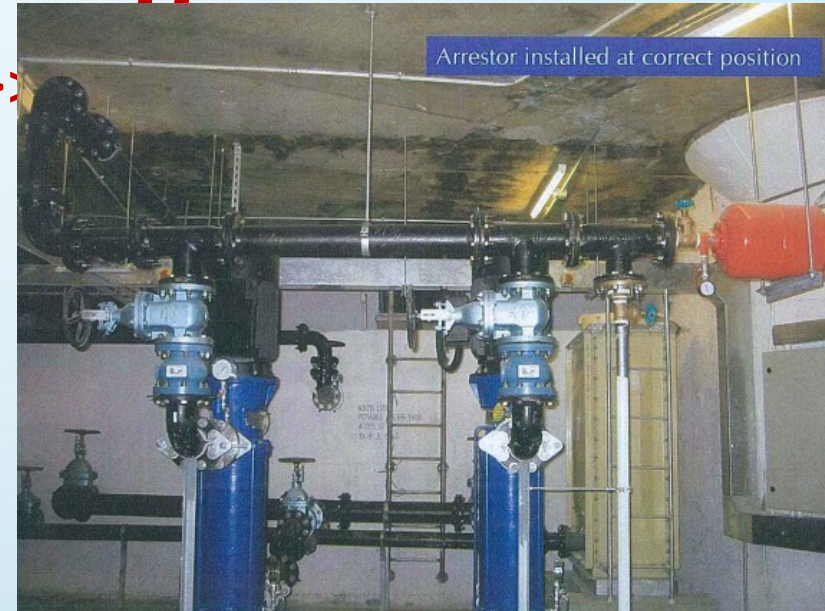
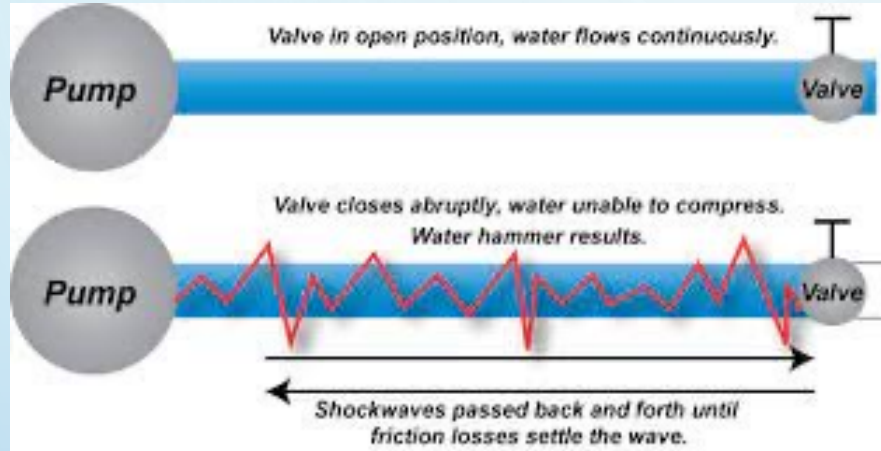
- PRV in parallel
- Control Water supply pressure at design point

# System pressure vs Bldg Height

- Vertical risers and pump on/off control >>>>



Transfer pump sets c/w Soft top / start



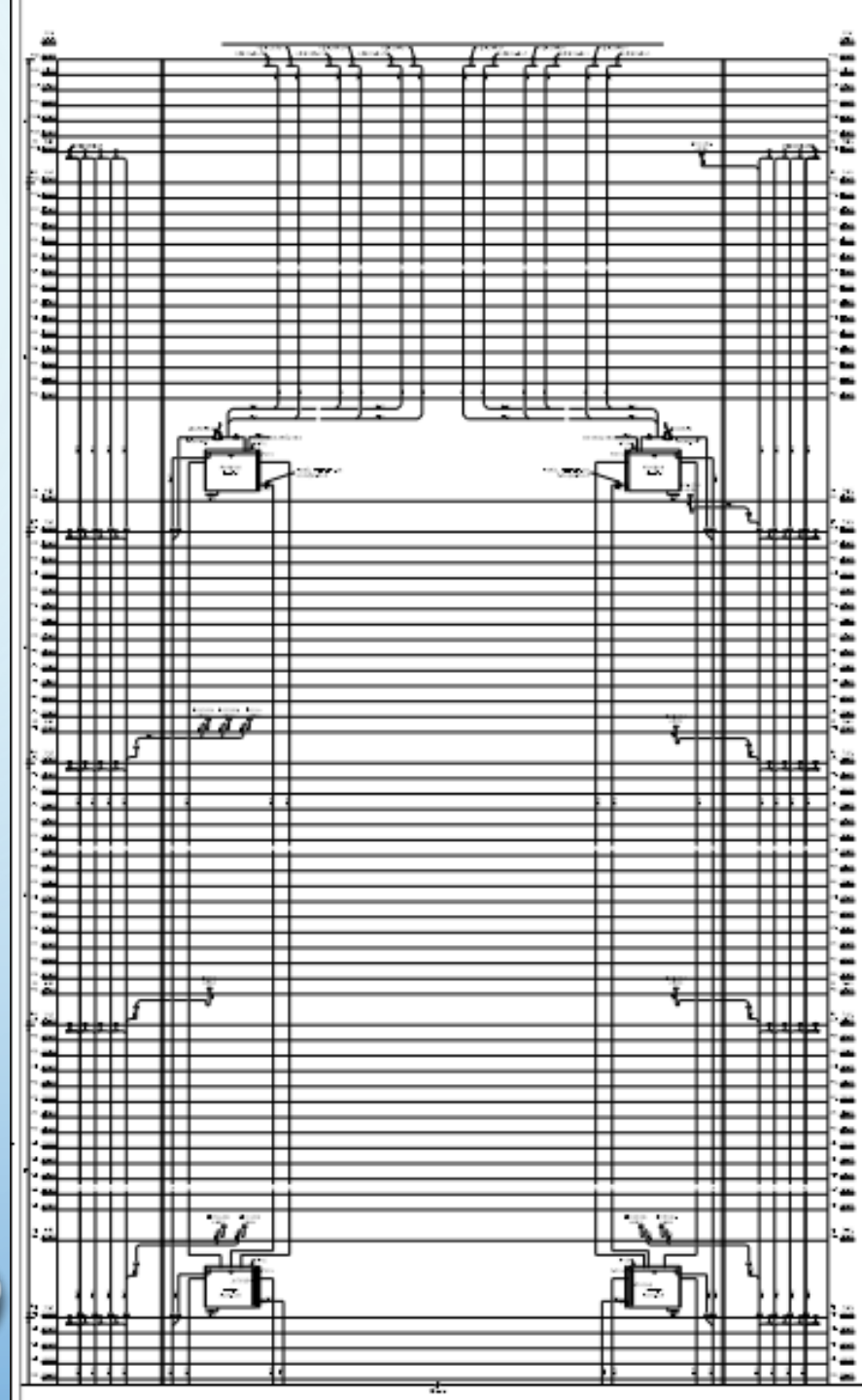
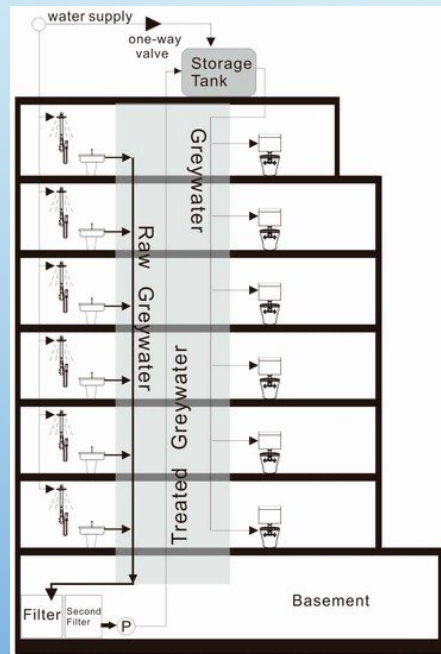
# Energy saving Provisions

- Energy Consumption along Plumbing application
  - ✓ To treat and transfer water from sources to user end-points
  - ✓ Then collect and treat waste water from sewage network
  - ✓ Heat up water for domestic and other applications



# Energy saving Provisions

- Energy required in Water Treatment
  - Water Treatment under utilities provisions
  - Localize water reclaim systems to reduce demand from utilities & necessary energy to transport water to / disposal from buildings
  - Utilize the town main pressure for direct supply





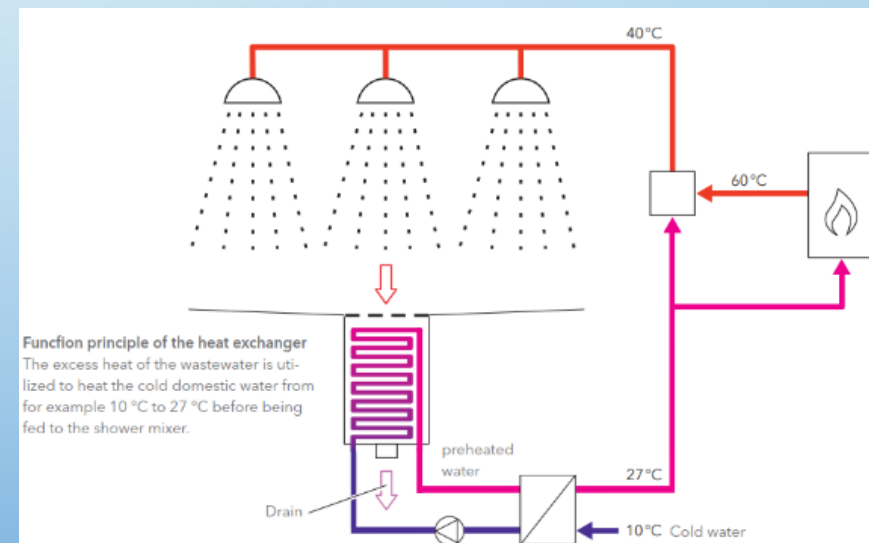
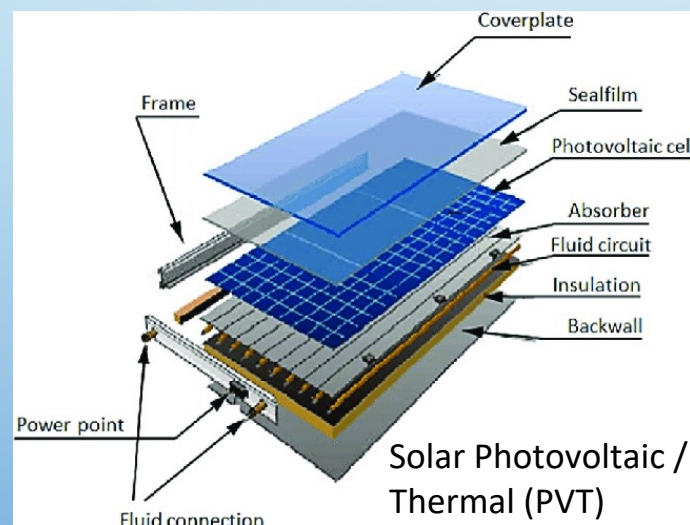
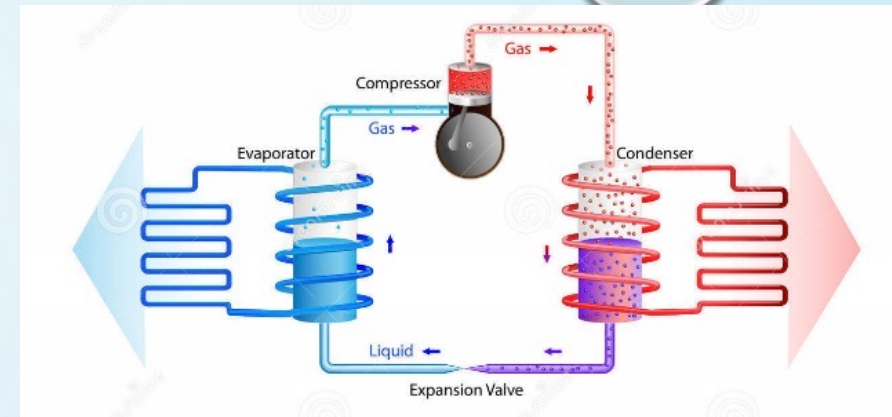
# Energy saving Provisions

- Energy required in Water Heating

$$Q = \dot{M} \cdot c \cdot \Delta T$$

Key factors :

- Mass
  - Less water / Less flow rate & head / Less water loss
- Specific heat capacity 4.2
  - Fixed 4.2 kJ/g°C
- Temperature Different
  - Reclaim heat from other pre-heat device to narrow  $\Delta T$
- Duration
  - Operation time and with suitable storage



- Energy required in Water Transportation

$$Work = \Delta Energy Transferred = Force \times Distance$$

Key factors :

- Mass      ➤ Less water / Less flow rate & head / Less water loss
- Height     ➤ Less excessive head and PRV
- Distance   ➤ Close the water source / tank and user points / better hydraulic performance
- Duration   ➤ Operation time
  - Vertical zone planning and minimize PRV usage
  - Limit system head / Residual head
  - Plant room planning to prevent excessive pipe run and loss
  - Proper pipe sizing / loop / ring circuit
  - Select pump in higher efficiency / adopt variable speed pump set to cater variation of demand profile and consider 2,900 rpm pump
- Zone isolation valves with **timer / remote control** to shut-off all water supply out of operation hours or abnormal long duration operation, such as
  - public / staff changing rooms,
  - production process / factories
  - commercial kitchen,
  - water cooled air-conditioning
  - laundry, etc:
- Allow sub-meter for onward monitoring audit on water usage / consumption in different region of the system.
- Leakage detection for concealed / underground installations / sensitive locations
- Signal to alert operation and Shut off excessive water supply to reduce wastage
- Control water for irrigation against actual planting need and weather situation.



# What's NEXT .....



FEMALE MALE DISABLED 2019/05/27 14:00  
 3 Kai Shing Street  
 4A, LEVEL 4

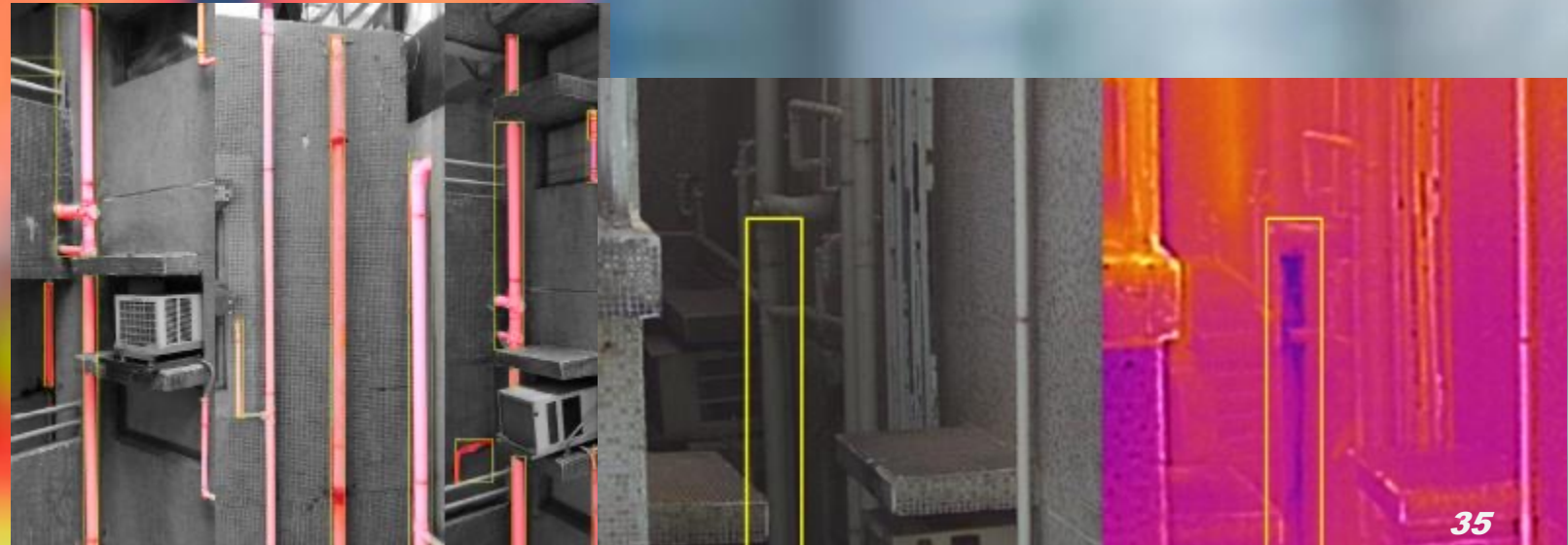
CLEANING MAINTENANCE 4.9

Last used: 13:03p.m.

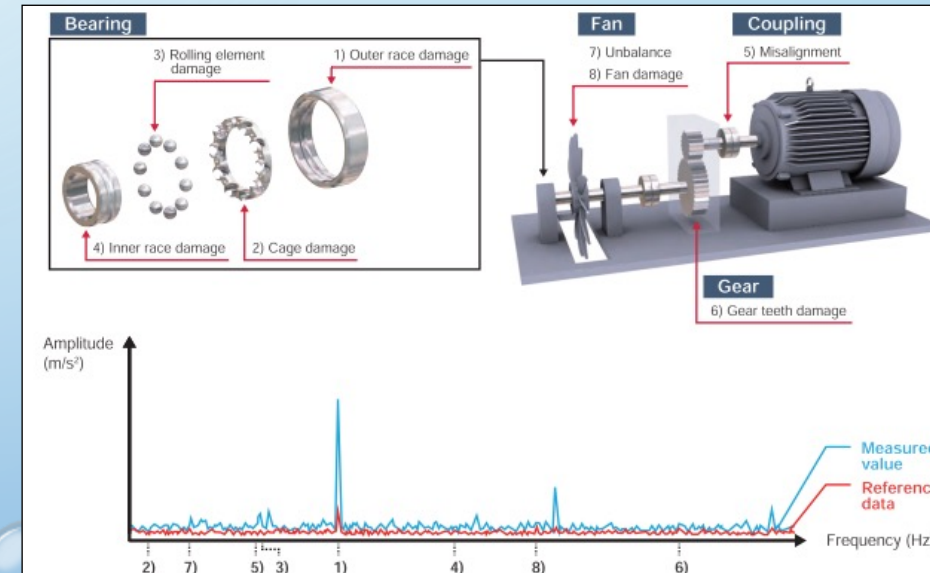
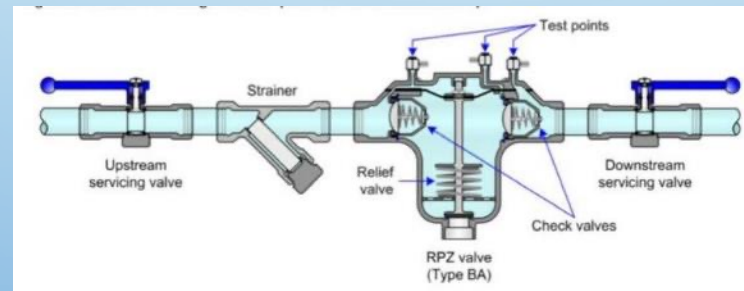
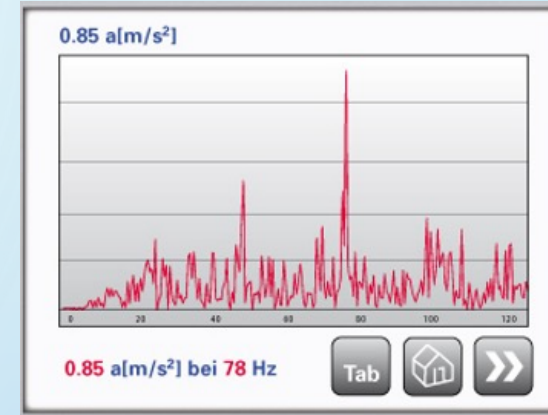
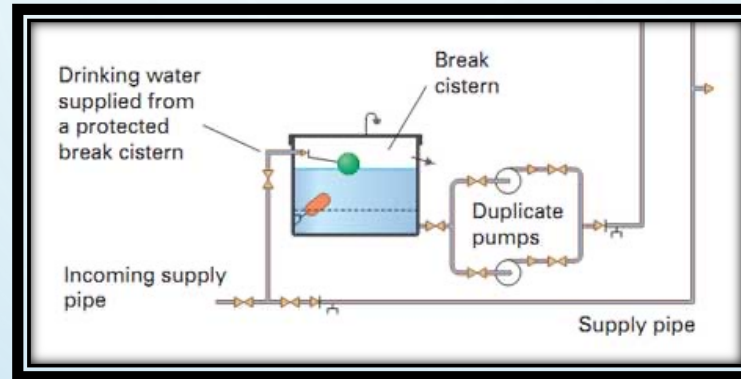
H2S 3PPM	NH3 3PPM
HC HO 3PPM	PM2.5 VOC 3PPM

25°C  
 75%

OCCUPIED



- More engineering study / University research
- Professional responsibility
- Annual maintenance



Thanks for your participate, see you in Hong Kong !!



#FutureReady



Sylvia P. C. Liu  
Chairlady



Y. C. Yiu  
Vice-Chairman

## ***Water & Energy Saving Features in Highrise Building Plumbing Systems***



*Ir. Ben K.C. YUEN*  
[Ben.yuen@wsp.com](mailto:Ben.yuen@wsp.com)



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