

MEBS6000 Utility Services

Self-Evaluation Exercise (2008-2009) (solution outline)

Cold and Hot Water Supplies

1. Briefly explain the water treatment process for fresh water supply in Hong Kong. Illustrate with diagrams if needed.

Answer:

Water treatment process for fresh water supply in Hong Kong: (w/ brief description)

- 1) Raw water
- 2) Mixing
- 3) Flocculation and Sedimentation
- 4) Rapid Gravity Filtration
- 5) Clear Water Tanks
- 6) Pumping (to the distribution)
- 7) Sludge disposal & wastewater recovery
- 8) Water quality control

Diagram to show the typical water treatment process:

Slide 23 of mebs6000_0809_01_cold_water.pdf

2. With the help of schematic diagrams, describe the following methods of water supply distribution in buildings.
 - i) Direct supply system (with storage tank)
 - ii) Indirect supply system (with sump and pump)
 - iii) Indirect supply system (with pneumatic vessel)

Answer:

Schematic diagrams of methods of water supply distribution in buildings:

- Direct supply system (with storage tank):
Slide 40 of mebs6000_0809_01_cold_water.pdf
- Indirect supply system (with sump and pump):
Slide 41 of mebs6000_0809_01_cold_water.pdf
- Indirect supply system (with pneumatic vessel):
Slide 42 of mebs6000_0809_01_cold_water.pdf

3. Briefly describe the Quality Water Recognition Scheme for Buildings as operated by the Water Supplies Department in Hong Kong.

Answer:

Quality Water Recognition Scheme for Buildings (w/ brief description)

- To encourage building owners to maintain their plumbing systems properly
- There are 3 grades of certificates:
 - Blue Certificates: New participation or continuous participation with less than 3 years
 - Silver Certificates: Continuous participation 3-5 years
 - Gold Certificates: Continuous participation ≥ 5 years

4. Briefly explain the Total Water Management (TWM) strategy set up in recent years by the Hong Kong Government.

Answer:

Total Water Management (TWM) strategy (w/ brief description)

1) Water demand management

- To enhance public education on water conservation
- To promote use of water saving devices
- To enhance water leakage control
- To extend use of seawater for toilet flushing

2) Water supply management

- To strengthen protection of water resources
- To actively consider water reclamation (reuse of greywater & rainwater harvesting)
- To develop the option of seawater desalination

5. Discuss the key factors to be considered when selecting and designing hot water supply systems.

Answer:

Key factors when selecting and designing hot water supply systems (w/ brief discussion):

- Quantity of hot water required
- Temperature in storage & at outlets
- Cost of installation & maintenance
- Fuel energy requirements & running costs
- Conservation of water & energy
- Safety of the user

6. Compare the characteristics of flat-plate and evacuated-tube solar collectors for providing hot water to buildings.

Answer:

Flat-plate collectors:

- Pros:

- capable to deliver moderate temperature hot water
- lower cost compared with evacuated tube

- Cons:

- heavier weight
- larger wind load
- more susceptible to pipe blockage & leakage
- more complications in maintenance

Evacuated-type collectors:

- Pros:

- lower heat loss to surrounding
- capable to deliver moderate to high temperature water (60-80 °C)
- lighter support structure
- simplicity in maintenance

- Cons:

- higher capital cost compared with flat plate

7. Draw schematic diagrams to show the typical designs of direct and indirect centralised hot water systems.

Answer:

Direct centralised hot water systems:

Slide 42 of mebs6000_0809_02_hot_water.pdf

Indirect centralised hot water systems:

Slide 44 of mebs6000_0809_02_hot_water.pdf

8. Briefly explain what are “dead legs” in hot water systems and suggest two methods to avoid them.

Answer:

‘Dead legs’ occur in hot water systems where water does not move for a period of time. For example, at night when hot water is not used and the contents of the pipes and appliances cools down. Water cooled to 20 to 45 °C becomes more susceptible to bacteria growth, and overnight gives adequate time for possible bacteria to multiply

Two common approaches to avoid dead legs:

- 1) Install a secondary return pipe
- 2) Maintain the water temperature at all times

9. Discuss the impacts of oversizing and undersizing for the pipework in the cold and hot water supply systems.

Answer:

The impacts of oversizing and undersizing for the pipework:

1) Oversizing

- Additional & unnecessary installation costs
- Delays in obtaining hot water at outlets
- Increased heat losses from hot water pipes

2) Undersizing

- Inadequate delivery from outlets
- Some variation in temperature & pressure at outlets (e.g. showers and other mixers)
- Some increase in noise levels

10. Briefly describe the pros and cons of using the following pipe materials in water systems.

- i) Copper
- ii) Stainless steel
- iii) Lined galvanized steel

Answer:

1) Copper pipes (BS EN 1057)

- Advantages:
 - High pressure capability
 - Good formability
 - Good corrosion resistance
 - High strength & durability to withstand external loading
 - Ease of jointing (compression & capillary joints)
 - Smooth surface: low resistance to water flow
 - Suitable for conveying hot water

- Disadvantages:
 - Soft water can cause internal corrosion attack (give rise to 'blue' water)

2) Stainless steel (BS 4127)

- Advantages:
 - High pressure capability
 - Good corrosion resistance
 - High strength & durability
 - Ease of jointing
 - Good resistance to accidental damage
 - Suitable for conveying hot water
- Disadvantage:
 - More expensive than copper

3) Lined galvanised steel (PVC-U/PVC-C/Polyethylene or epoxy resin lined)

- Advantages:
 - Good resistance to internal corrosion & encrustation
 - Smooth surface: lower resistance to water flow
 - Can be used in vulnerable conditions e.g. exposure to direct sunlight & traffic loads
 - Readily compatible with existing commonly used unlined steel pipe
- Disadvantages:
 - Heavy weight
 - Susceptible to impact damage (great care in handling)
 - Higher skills required for cutting, threading, jointing

11. Compare the main characteristics of centrifugal & positive displacement pumps.

Answer:

1) Centrifugal pumps: (w/ brief description)

- Capacity varies with head
- Capacity proportional to pump speed
- Head proportional to the square of pump speed
- Non self-priming
- Suitable for low-viscosity liquid

2) Positive displacement pumps: (w/ brief description)

- Capacity substantially independent of head
- Capacity proportional to speed
- Self-priming
- Suitable for various liquids (reduced speeds usually necessary for high viscosity)

12. Discuss the possible methods to achieve better water efficiency and conservation in buildings.

Answer:

Possible methods to achieve better water efficiency and conservation in buildings:

1) Economy of water (to conserve water)

- Detect water leakage
- Reduce water consumption
- Reuse or recycle water

- 2) Water saving devices
- Low-flow showerheads
 - Taps with flow restrictors
 - Flow control valves
 - Washing machines & dish-washers with high water efficiency
 - Water plugs, self-closing taps, spray taps, aerators, etc.

Steam Systems and Drainage Systems

13. Briefly describe the advantages of using steam over hot water as a heating medium in building applications. What are the major drawbacks of the steam system?

Answer:

Advantages of steam over hot water systems: (w/ brief description)

- No pumps needed: steam flows through system unaided
- Smaller heat emitters
- Steam can be used in tall buildings where water systems create excessive pressure
- Terminal units can be added/removed easily
- Steam components can be repaired or replaced just by closing the steam supply (no associated draining and refilling a water system)
- Steam system temperature can be controlled by varying either steam pressure or temperature

Disadvantages: (w/ brief description)

- More complicated, more maintenance & supervision

14. Briefly explain the operating principles of the following types of steam traps. Illustrate with diagrams if needed.

- Thermostatic steam trap
- Open bucket steam trap
- Thermodynamic steam trap

Answer:

Thermostatic steam trap:

Slide 25 of mebs6000_0809_04_steam.pdf

Open bucket steam trap:

Slide 27 of mebs6000_0809_04_steam.pdf

Thermodynamic steam trap

Slides 29,30 of mebs6000_0809_04_steam.pdf

15. Draw a diagram to explain the basic structure of a boiler. Clearly indicate the inputs and outputs.

Answer:

Basic structure of a boiler:

Slide 33 of mebs6000_0809_04_steam.pdf

16. What are the three methods of estimating steam consumption? Briefly describe each of them.

Answer:

Three methods of estimating steam consumption:

- 1) Calculation - By analysing the heat output on an item of plant using heat transfer equations
- 2) Measurement - By direct measurement, using flowmetering equipment (for an existing plant)
- 3) Thermal rating - design rating displayed on the equipment name-plate (in kW). The steam consumption required in kg/h will depend on the recommended steam pressure.

17. Discuss why the drainage system could be a reason for the spread of SARS disease at the Amoy Garden in Hong Kong in 2003. What are the possible methods to prevent this?

Answer:

Why the drainage system could be a reason for the spread of SARS disease:

- Discuss the conditions of the drainage system at the Amoy Garden
- The U-trap of the floor drain was dried out
- Possible path for spread of SARS

Possible methods to prevent this:

- Anti-siphonage pipes and traps
- Back-filling arrangement
- W-trap (proposed by the Housing Authority)
- Self-refilling function

18. Briefly explain the possible reasons for the loss of water seal in building drainage systems. Illustrate with diagrams, if needed.

Answer:

Possible reasons for the loss of water seal: (w/ brief description)

- Self-siphonage
- Induced siphonage
- Compression or back pressure
- Capillary action
- Wavering out
- Evaporation, cross-flow, bends and offsets, surcharging, intercepting traps, leakage

Diagrams to show the possible reasons:

Slides 29-32 of [mebs6000_0809_05_drainage.pdf](#)

19. Briefly describe the design concept of the following sanitary drainage systems.

- i) Single stack system
- ii) Modified single stack system
- iii) Two-pipe system

Answer:

Single stack system:

Slide 46 of [mebs6000_0809_05_drainage.pdf](#)

Modified single stack system:

Slide 48 of [mebs6000_0809_05_drainage.pdf](#)

Two-pipe system:

Slide 50 of [mebs6000_0809_05_drainage.pdf](#)

20. Briefly explain the method to calculate the rain water flow rate for design of the stormwater drainage systems.

Answer:

Method to calculate the rain water flow rate for design of the stormwater drainage systems:

Rain water flow rate, $Q \text{ (l/s)} = C \times A \times I / 3600$

C : impermeability factor or run-off coefficient

A : drainage or catchment area (m^2)

I : rainfall intensity (mm/hr)

(see also Slides 58-65 of mebs6000_0809_05_drainage.pdf)

21. Compare the following arrangements for sewage disposal systems.

- i) Combined system
- ii) Separate system
- iii) Partially separate system

Answer:

i) Combined system

- Pros:

- One drain for both foul & surface water reduces cost of drainage
- No risk of making a wrong connection
- Foul water flushed through the drain by the surface water

- Cons:

- The loss of a trap seal in a rain-water gully allows the foul gas from the drain to pass into the open air around the building
- The size of the sewage disposal plant is greater
- Greater cost of the sewage disposal
- Possibly greater pumping costs (surface water and foul water to reach sewage disposal works)

ii) Separate system

- Pros:

- Sewage disposal plant is much smaller
- The cost of sewage purification is less
- Less sewage is pumped; reduction in pumping cost
- Surface water flow can be by gravity to a nearby river

- Cons:

- Two sets of drains increase the cost of building drainage
- Risk of a wrong connection (a foul water branch drain to a surface water drain)
- The foul water drain not thoroughly flushed by rainwater
- Foul air passing through an unsealed rainwater gully trap

ii) Partially separate system

- Most of the surface water conveyed by a surface water drain to a surface water sewer or soakaway

- Some rain-water is discharged to the foul water drain.

- The pros and cons are between the combined and separate systems

22. What are the possible methods for disposal of stormwater? Briefly describe each of them.

Answer:

Disposal of stormwater or rainwater (w/ brief description)

- 1) Sewer: combined or a separate surface-water
 - Interceptors required for car parks and kitchens
- 2) Soakaway: ground permeability
 - Using perforated precast concrete, dry stone or brick pit
- 3) Storage
 - Artificial pond or lake, or underground storage tank
- 4) Watercourse

23. Draw diagrams to show the basic design of a septic tank.

Answer:

Basic design of a septic tank:

Slide 51 of mebs6000_0809_06_sewage_disposal.pdf

24. Explain the typical process of sewage treatment. Illustrate with diagrams if needed.

Answer:

Typical process of sewage treatment: (w/ brief description)

1. Preliminary works (screens & grit channels)
2. Primary settlement (settlement tanks)
3. Biological treatment (in filter beds, biological contactors or activated sludge)
4. Secondary settlement (humus tanks)
5. Tertiary treatment (needed for high discharge standard or poor raw effluent)

Diagram to show the process:

Slide 72, 73, 76 or 78 of mebs6000_0809_06_sewage_disposal.pdf