MEBS6000 Utility Services

http://www.hku.hk/mech/msc-courses/MEBS6000/index.html

Session 2: Hot Water Supply

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Contents for this session

- System selection and calculation
- Water heaters
- Centralised hot water systems
- Safety & statutory requirements in HK




System Considerations and Calculation

System Consideration

- Design of a hot water system:
  - Determine the demand of hot water - quantity and temperature
  - Selecting the type, capacity and heating surface of the calorifier - or heat exchanger
  - Selecting the water heater or boiler
  - Design pipe scheme and size pipes

System Consideration

- Key factors to consider:
  - Quantity (*storage and flow*) of hot water required
  - Temperature of hot water in the system (55-65 ℃)
  - Cost of installation & maintenance
  - Fuel energy requirements & running costs
  - Conservation of water & energy
  - Safety of the user
- Hot water supply may be combined with central heating systems (*space heating*) or even with the air-conditioning system!

Hot Water Required

- The hot water demand is usually combined with the cold water supply (hot & cold combined), therefore, the overall storage requirements as follows:
  - Domestic – 135L for first 10 flats, 90L thereafter
  - Recreation Clubs – 90L per shower
  - Hotels – 45L for single room, 68L for double room
  - Boarding House – 22.5L per bed
  - Police & Fire Station – 45L per man x 50% of establishment

Hot Water Required

- Actual storage allowances for hot water:
  - Domestic – 32L
  - Hotels – 36L to 45L per room
  - Boarding House – 23L per person
  - Offices – 4.5L per person
  - Restaurants – 6L per person

Source: Plumbing Engineering Services Design Guide

Analysis of Storage and Heating based on Actual Consumption

- Hot water storage and the heating required are closely related
  - Large hot water storage (e.g. storage for 24hr consumption) will lead to a tremendous waste of heating energy due to equipment heat loss and extremely large storage space
  - Insufficient heating capacity may, otherwise, lead to insufficient hot water temperature during peak consumption periods
  - **Larger storage tanks → smaller heaters**
  - **Larger heaters → smaller storage tanks**

- If consumption profile can be obtained (e.g. from previous records of the same premise, or from similar premises)
- Then the relationship between the storage (in L) and the heater capacity (in kW) can be obtained

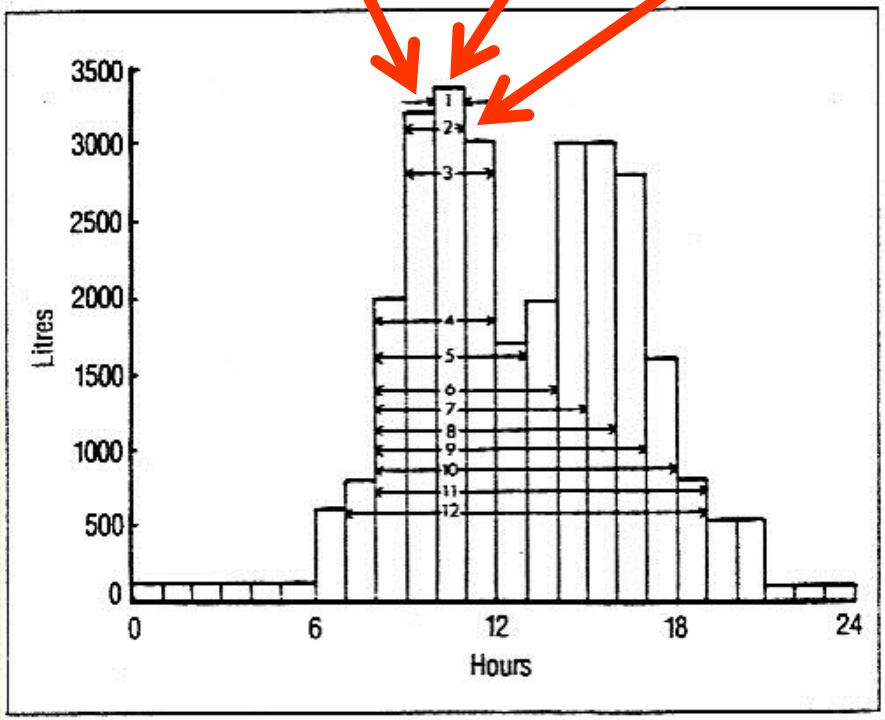
Table A12 Peak hourly loads

1 Peak hours	2 Litres used	3 Litres per hour	1 Peak hours	2 Litres used	3 Litres per hour
1	3400	3400	13	27000	2130
2	6600	3300	14	28300	2021
3	96[illegible]	3200	15	28800	1920
4	11600	2900	16	28900	1806
5	13300	2660	17	29000	1705
6	16300	2716	18	29100	1616
7	19300	2757	19	29200	1536
8	22000	27[illegible]0	20	29300	1465
9	24000	2666	21	29400	1400
10	25600	2560	22	29500	1340
11	26400	2400	23	29600	1286
12	27200	2266	24	29700	1237

Calculation for 2 hours Peak Hour
= 3400L + 3200L = 6600L
Thus, average consumption
= 6600L / 2 hr = 3300L/hr

3200L 3400L 3000L

Figure A1 Demand pattern histogram



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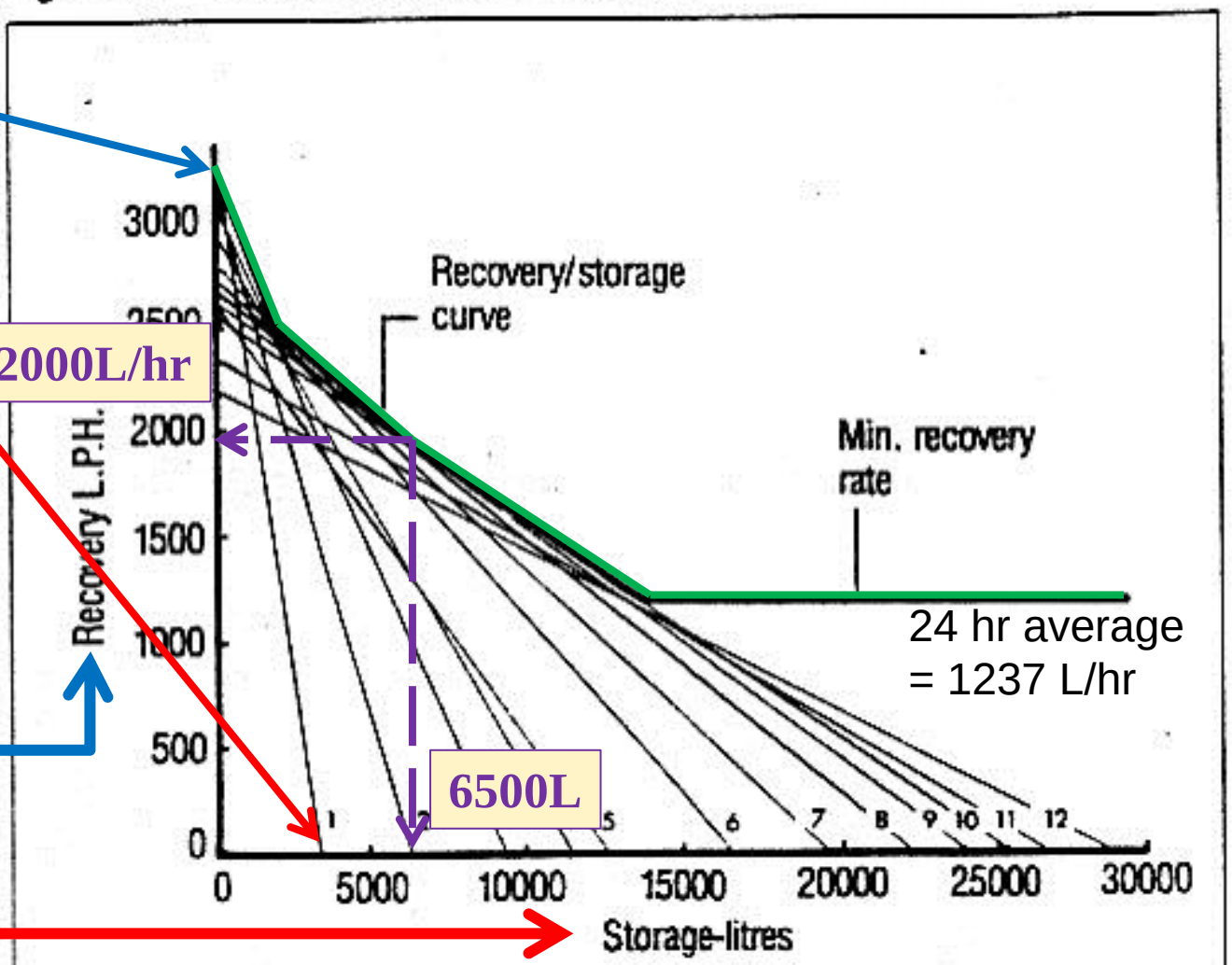
6	16300	2716
7	19300	2757
8	22000	2750
9	24000	2666
10	25600	2560
11	26400	2400
12	27200	2266

Figure A2 Storage make-up ratio curve

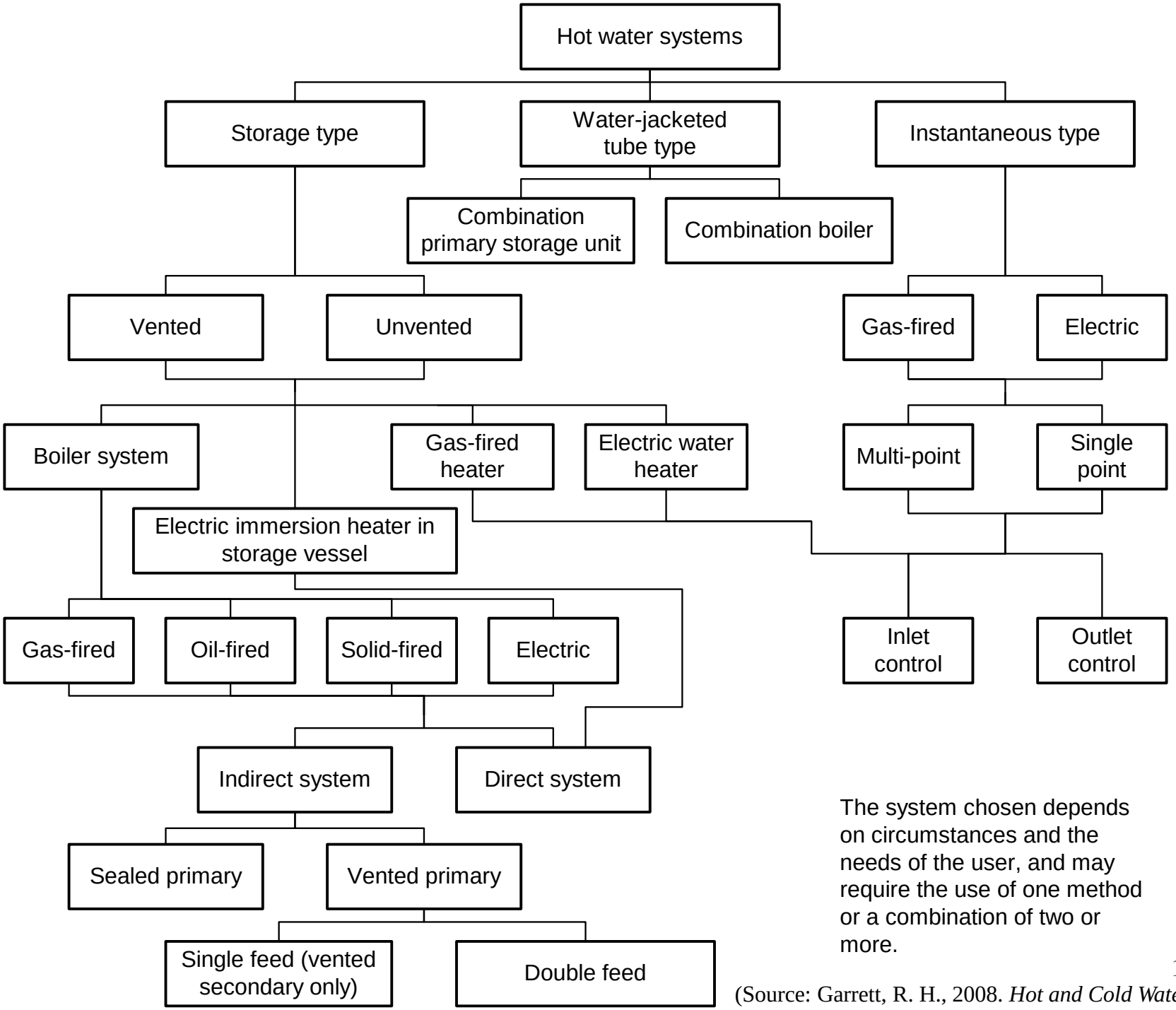


2000L/hr heater + 6500L storage combination

Source: Plumbing Engineering Services Design Guide

Hot Water Storage Temperature

- Design temperature at around **60 – 65°C**
  - Prevent Legionnaire Disease
  - Higher temperature than 65°C will be dangerous
- Consider cold water at 20°C and hot water at 60°C
  - Mix of cold and hot water at 1:1 will give 40°C
  - Common for bathing and other washing purposes
  - Therefore, most **cold and hot water systems** follow this approach of **1:1** consumption
  - Pipe sizing, however, consider both at 100% consumption (i.e. only cold water or only hot water at design flow)



The system chosen depends on circumstances and the needs of the user, and may require the use of one method or a combination of two or more.

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

System selection

- System types:
  - Instantaneous & storage type
  - Central & local
  - Gas-fired & electric
  - Single point & multi-point
  - Vented & unvented
  - Direct & indirect

Water Heaters

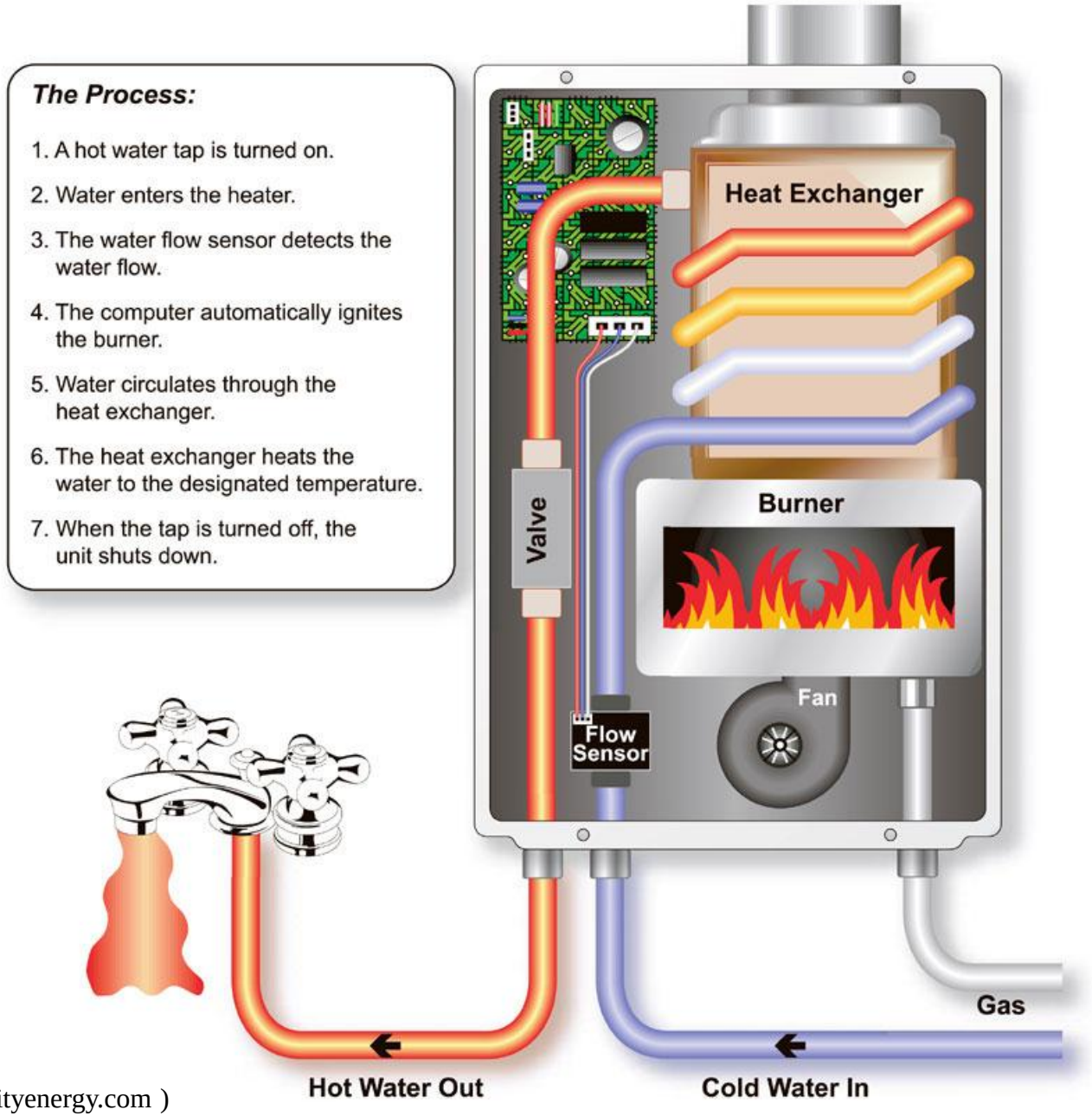
Water heaters

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

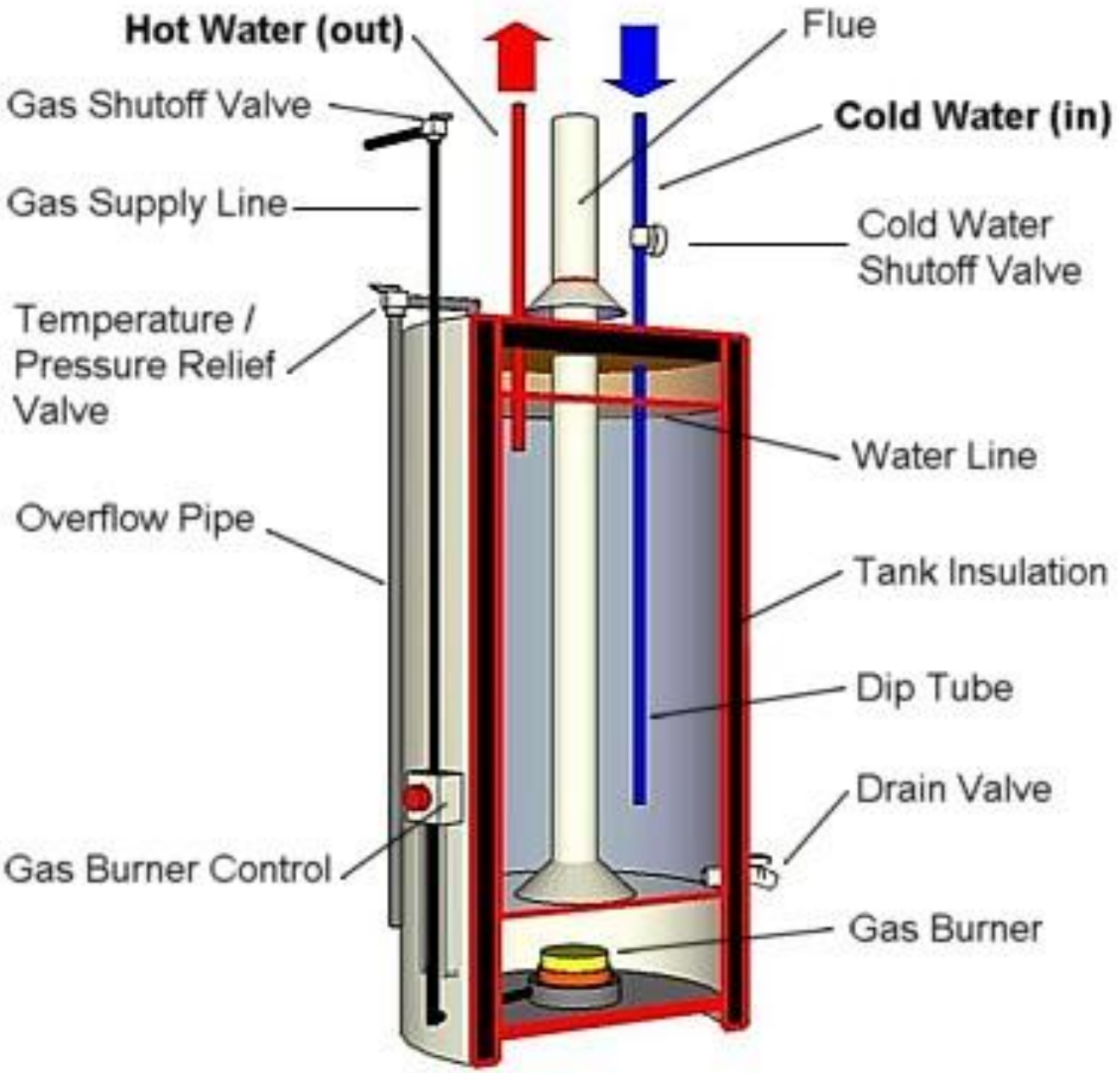
Water heaters

- Consider instantaneous water heaters
  - Adequate gas or electricity supplies (*3 phase electric power supply to 18kW is required*)
  - Where constant flow temperature is important, the heater should be fitted with a water governor at its inflow
    - Close control of temperature for showers
  - Variations in pressure can cause flow and temperature problems
  - Multi-point heaters for showers should be avoided
  - Room-sealed types are preferred for gas-fired
  - Electric heaters must comply safety regulations

How Does a Tankless Water Heater Work?



(Source: www. affinityenergy.com)

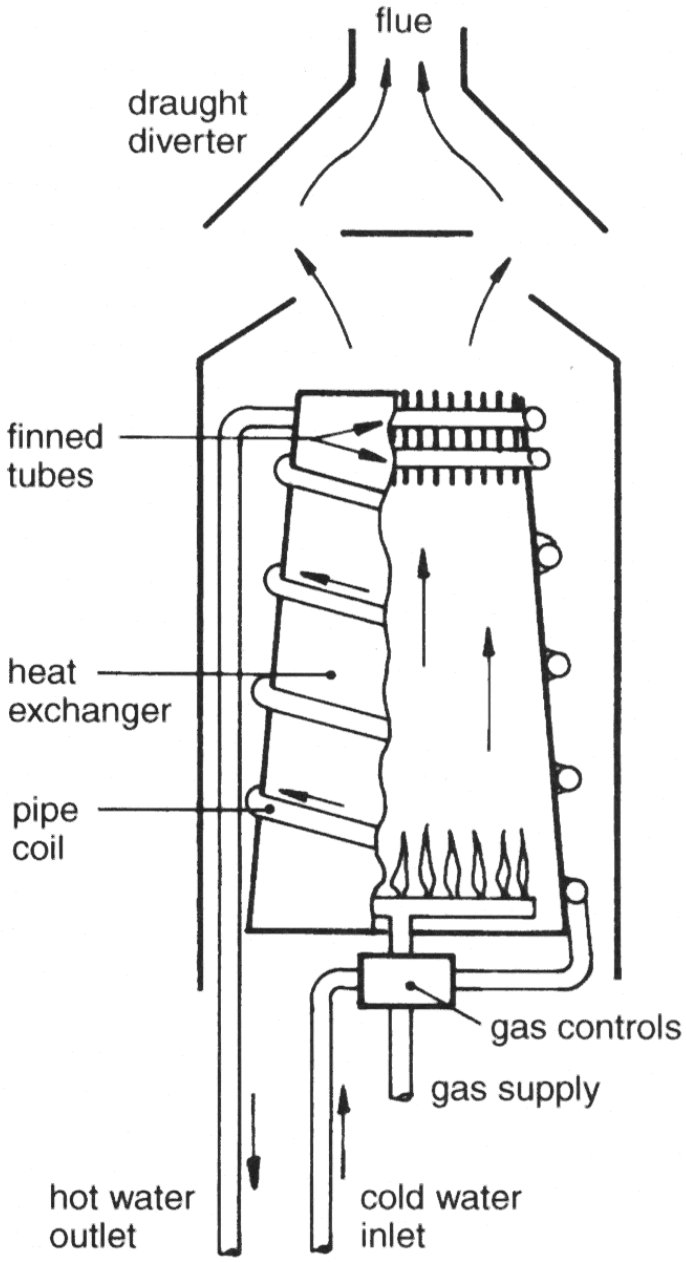


Gas Hot Water Heater Components

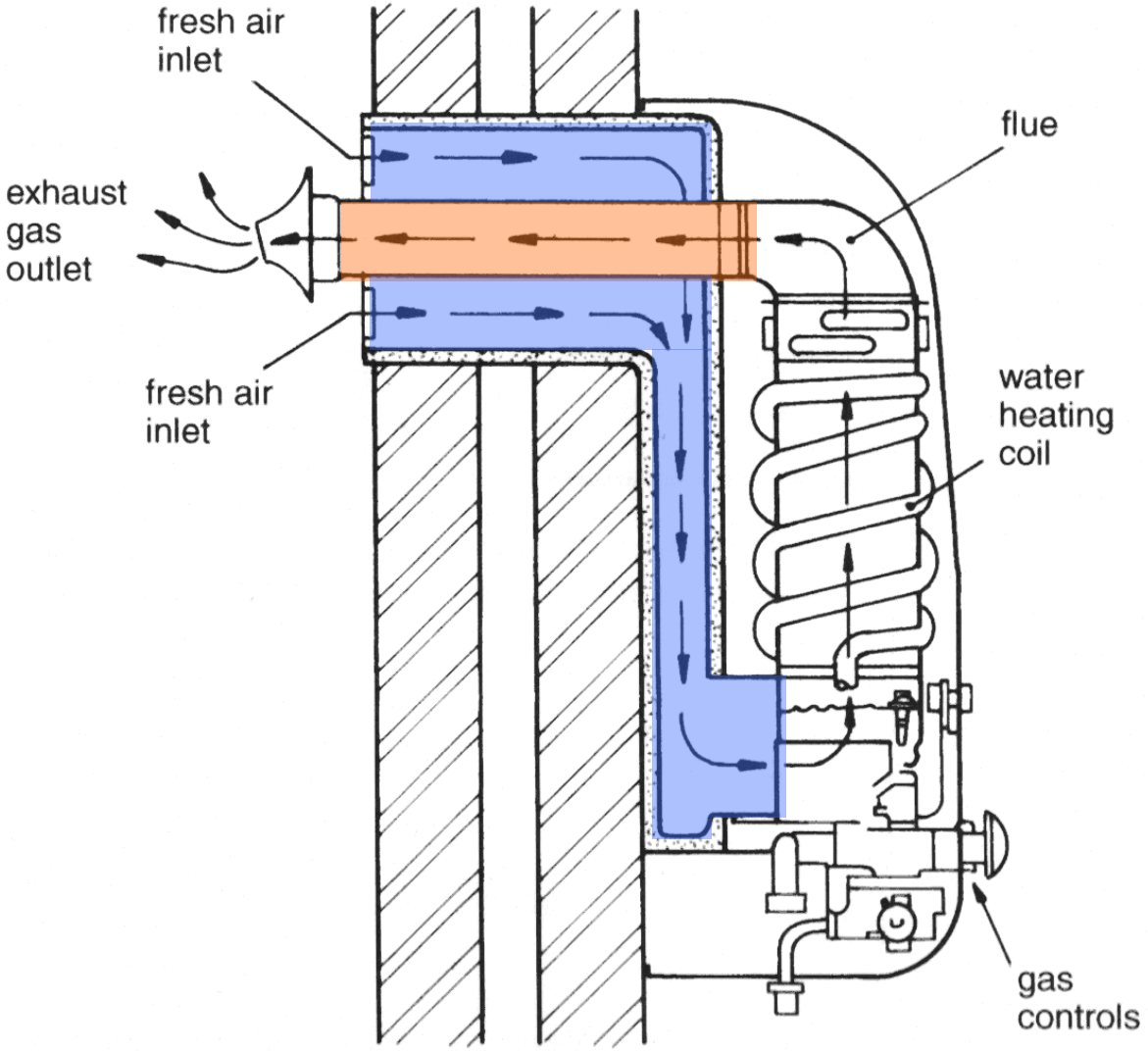
(Source: http://homerepair.about.com)

Water heaters

- Gas-fired water heaters
  - Three types:
    - Instantaneous
    - Storage
    - Circulatory
  - With conventional or balanced flue (common for domestic)
  - Pilot flame lights the burner
  - The heater may be supplied direct from the water mains or from a cold water storage tank



With conventional flue



With balanced flue

Gas-fired instantaneous water heater

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

禁止使用無煙道式氣體熱水爐以供浴室或淋浴使用

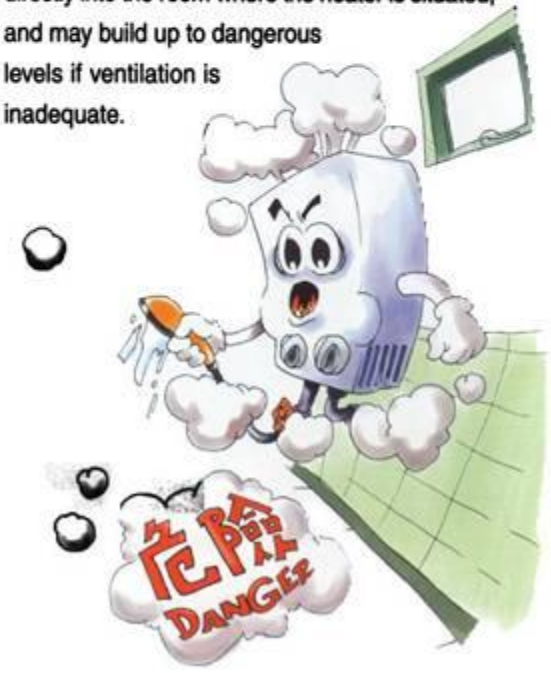
Prohibition of Flueless Gas Water Heaters Used to Serve a Bathroom or Shower

機電工程署
Electrical & Mechanical Services Department

1. 不合規格的無煙道式氣體熱水爐裝置
Substandard Flueless Gas Water Heater Installations

無煙道式氣體熱水爐供浴室或淋浴用途屬於危險的裝置，因為該熱水爐會從室內抽取供燃燒用之空氣，而燃燒後之廢氣(包括有毒的一氧化碳)會直接帶進裝有這類熱水爐的房間內，如在通風不足下可能積聚至危險水平。

Flueless gas water heaters serving bathrooms or showers are considered dangerous because they consume the air inside the room and the products of combustion containing toxic carbon monoxide discharge directly into the room where the heater is situated, and may build up to dangerous levels if ventilation is inadequate.



2. 禁止使用無煙道式氣體熱水爐以供浴室或淋浴用途
Prohibit Use of Flueless Gas Water Heaters Supplying Bathroom or Shower

為防止不適當使用無煙道式氣體熱水爐而引致危險，立法局於1999年11月通過氣體安全規例修訂，禁止使用無煙道式氣體熱水爐以供浴室或淋浴用途。該項修訂將於**2000年4月1日**正式實施。此外，新規例亦禁止任何人供應或安裝新的無煙道式熱水爐，或以其他無煙道式型號替換現時無煙道式氣體熱水爐。

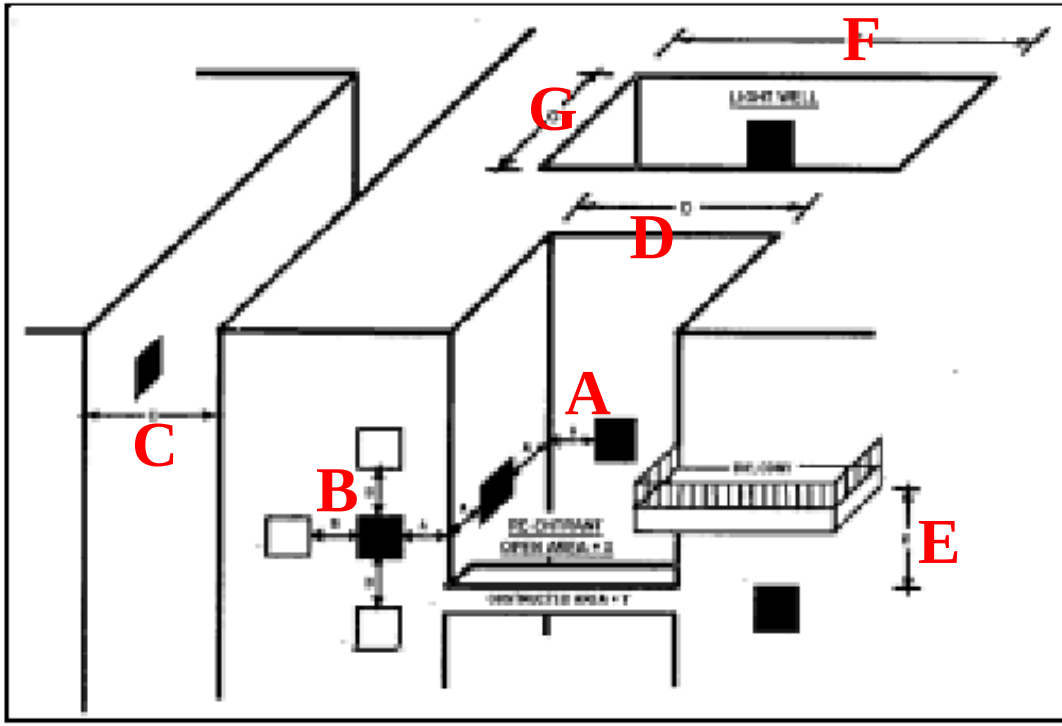
In order to eliminate dangers from improper use of flueless gas water heaters, LEGCO passed an Amendment of the Gas Safety Regulations in November 1999, which prohibits the use of a flueless gas water heater to serve a bathroom or shower. The Amendment will come into effect on **1 April 2000**. In addition, the new law also prohibits anyone from supplying or installing a new flueless gas water heater or replacing an existing flueless gas water heater by another flueless model.

3. 氣體安全規例修訂內容
Details of Amendment to Gas Safety Regulations

修訂主要分為二部份，第一，<氣體安全(裝置及使用)規例>修訂確立自**2000年7月1日**開始任何人不得將無煙道式氣體熱水爐供浴室或淋浴間使用。

Acceptable Locations of Room-Sealed Gas Water Heater Terminals

EXTERNAL VIEW



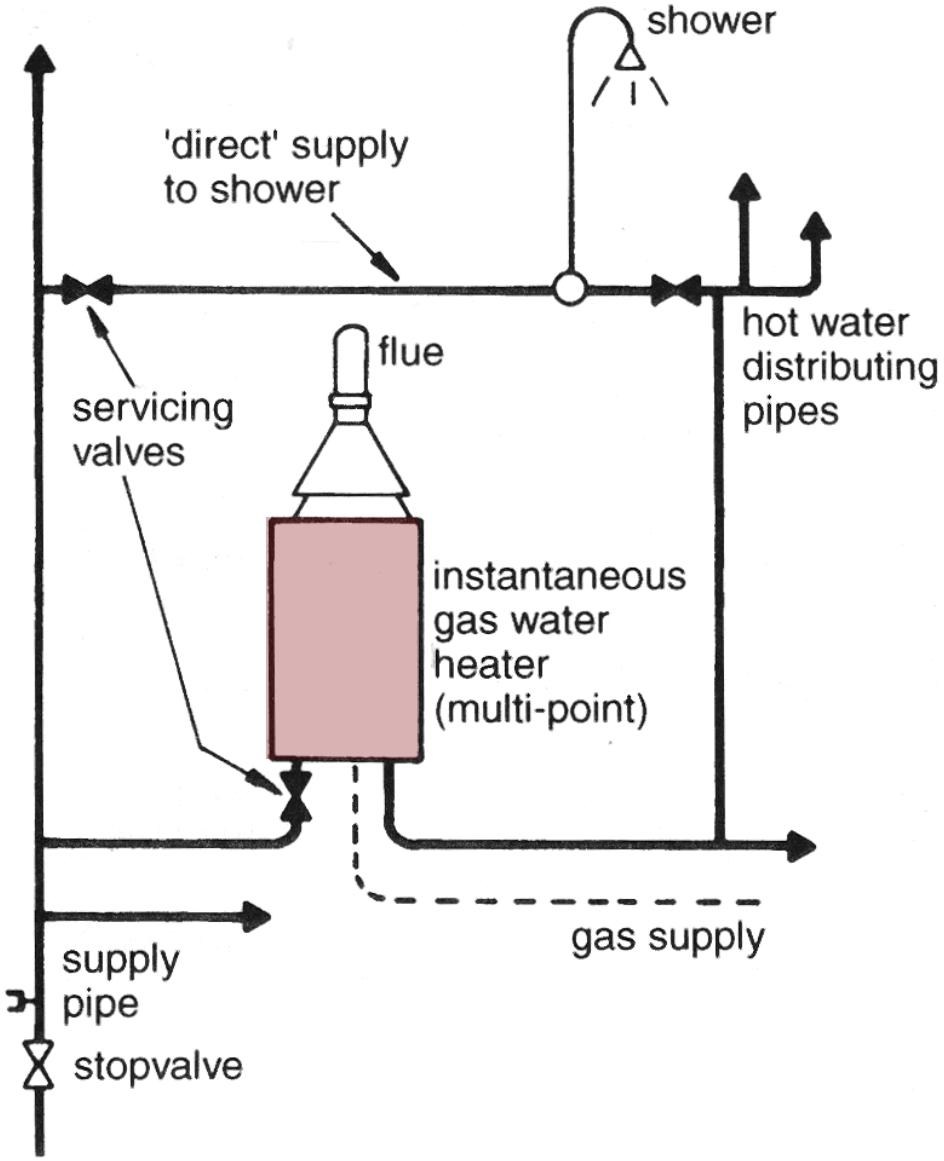
Dimension		Minimum Distance
A	From any corner of building	300 mm*
B	From any adjacent opening into building	300 mm
C	From facing wall or boundary	1 500 mm*
D	Minimum plan width of re-entrant	1 500 mm*
E	Below a balcony or similar projection	300 mm*
F & G	Light well plan area (F x G) 10 or less storeys 11-19 storeys 20 or more storeys	 3 000 mm 4 000 mm 5 000 mm

* May be reduced for fanned draught models.
See manufacturer's instructions.

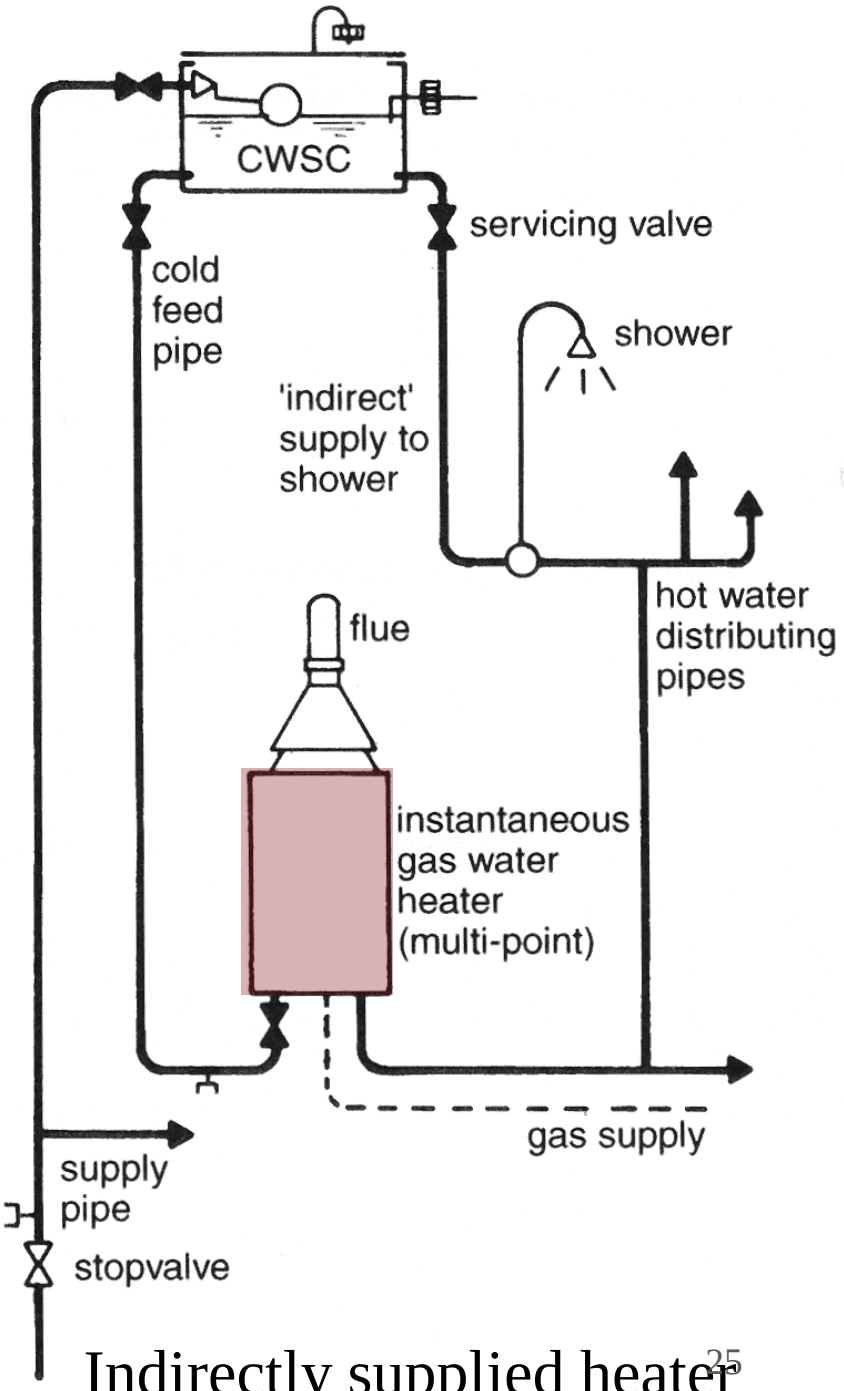
(Source: EMSD Gas Authority, www.emsd.gov.hk)

Water heaters

- Gas-fired instantaneous water heaters
  - Directly supplied heater
    - Constant flow rate needed to maintain 55 ℃ (minimum)
    - Pressure & flow variations will affect temp. at outlets
    - Only applicable for low rise buildings
  - Indirectly supplied heater
    - Higher installation cost compared with mains-fed system
    - Constant pressure from storage for shower & other fittings give more stable temp. control

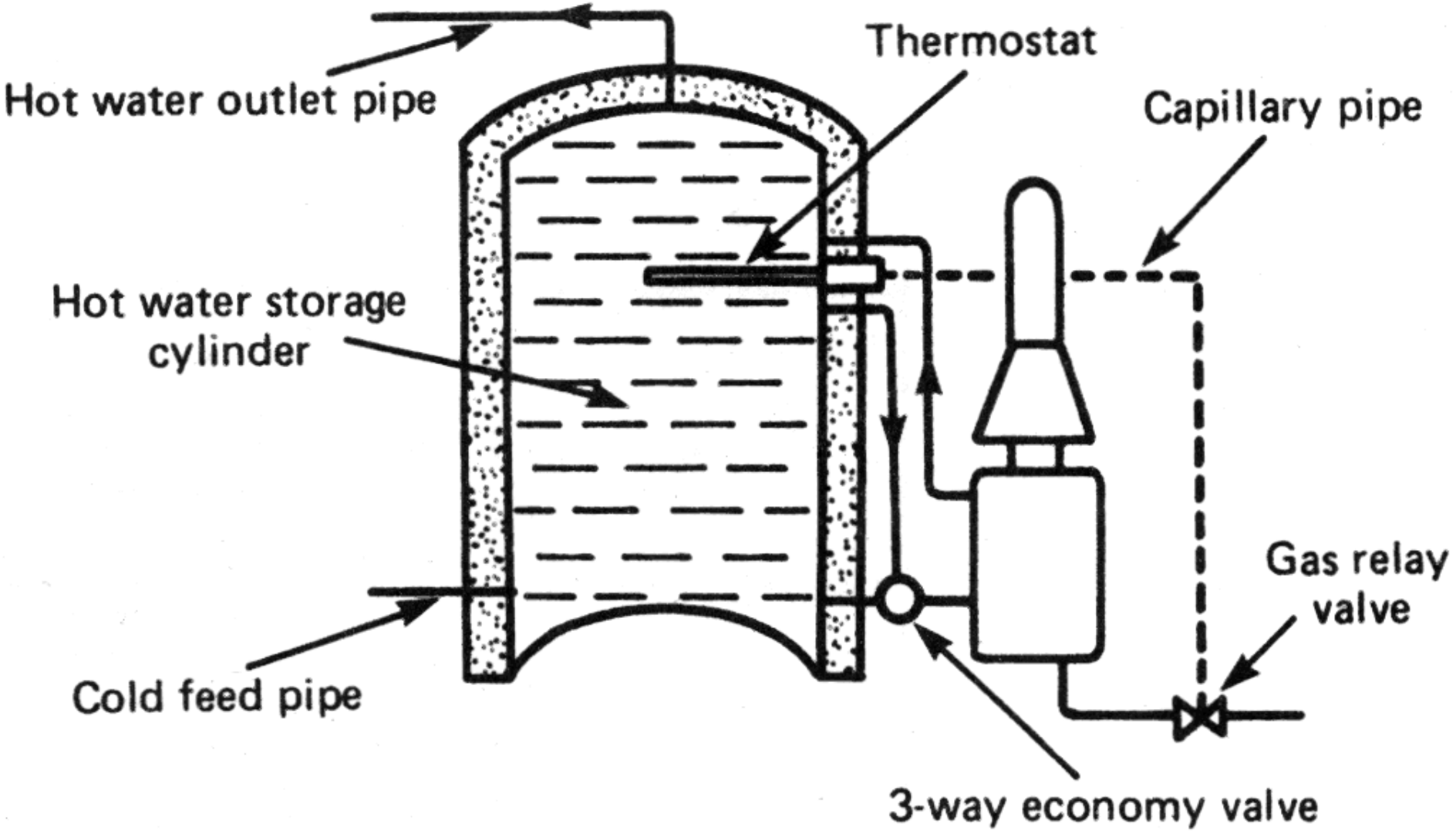


Directly supplied heater



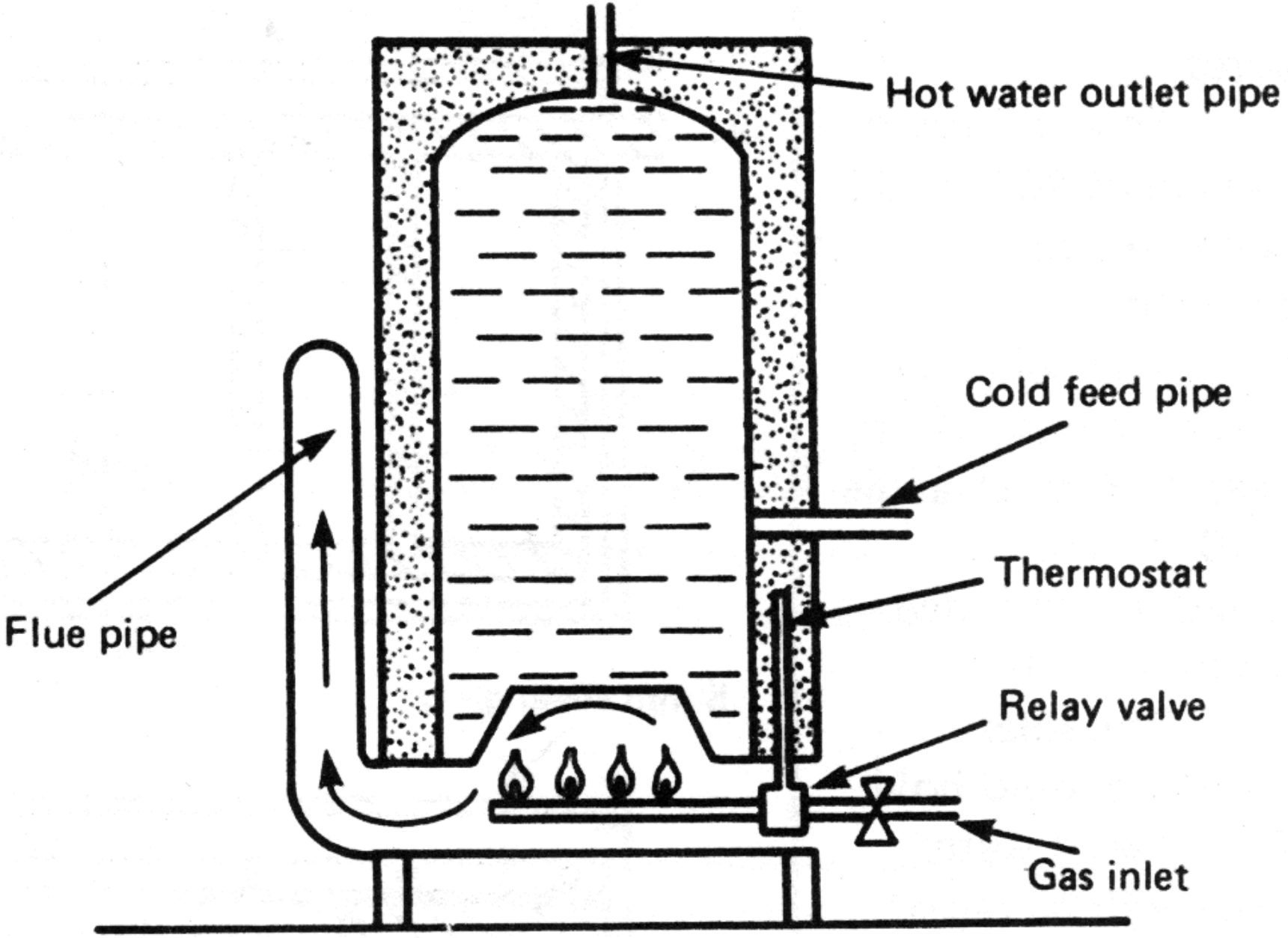
Indirectly supplied heater

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)



Installation of gas circulator

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

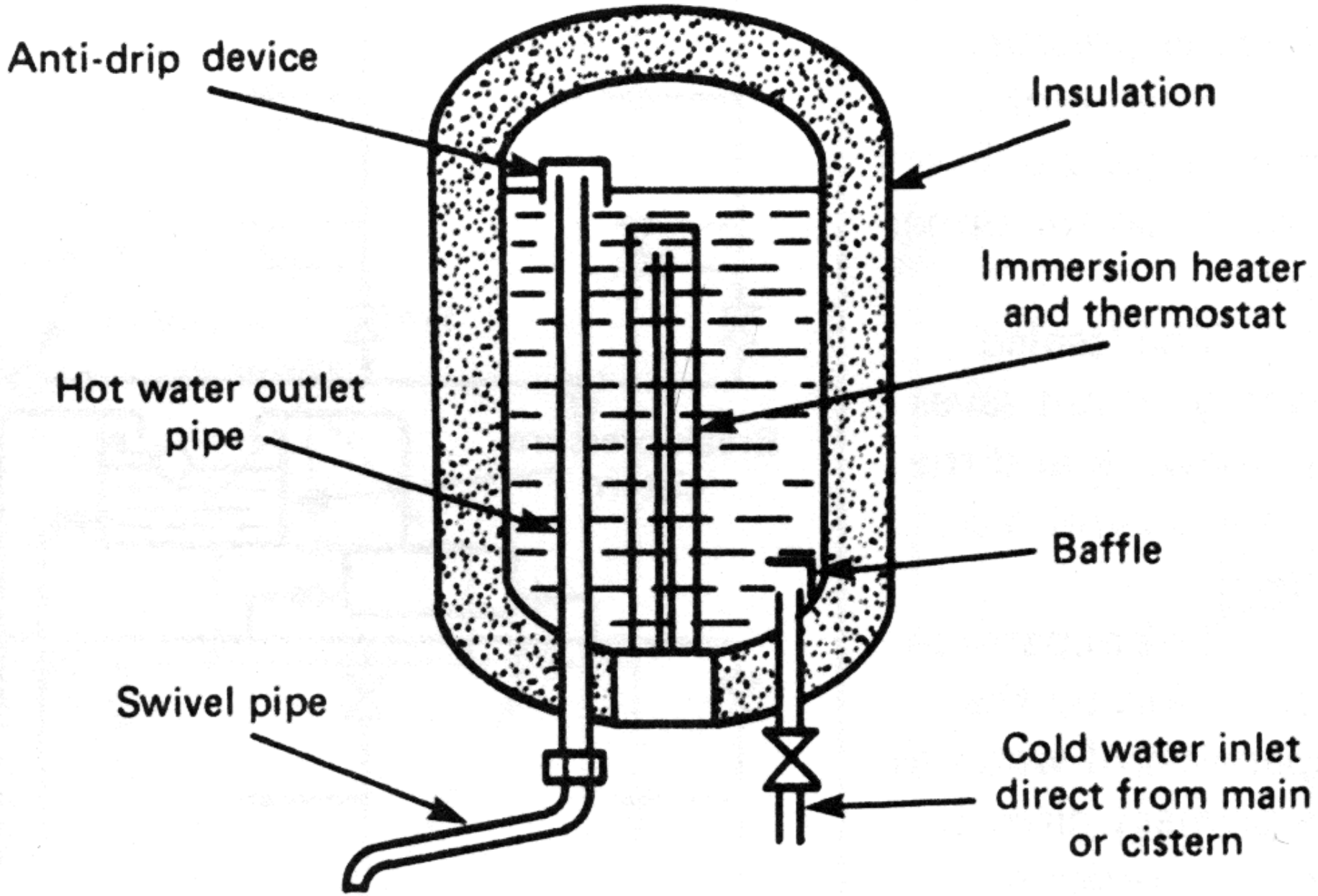


Storage type gas water heater

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

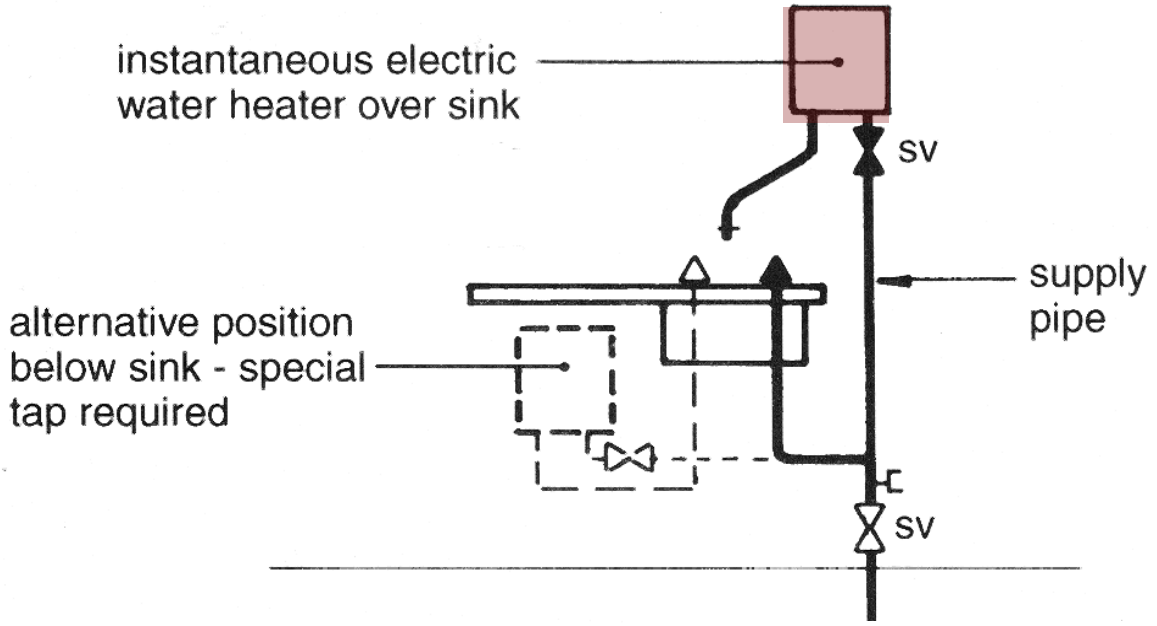
Water heaters

- Electric water heaters
  - Common types:
    - Instantaneous
    - Cistern type
  - Usually power consumptions of up to 6 kW (1 phase) for cistern type and 18kW (3 phase) for instantaneous type
  - May be fitted above basins, baths or sinks
  - Hot water pipes must be as short as possible
  - Immersion heater must be electrically earthed
  - Cable of appropriate size

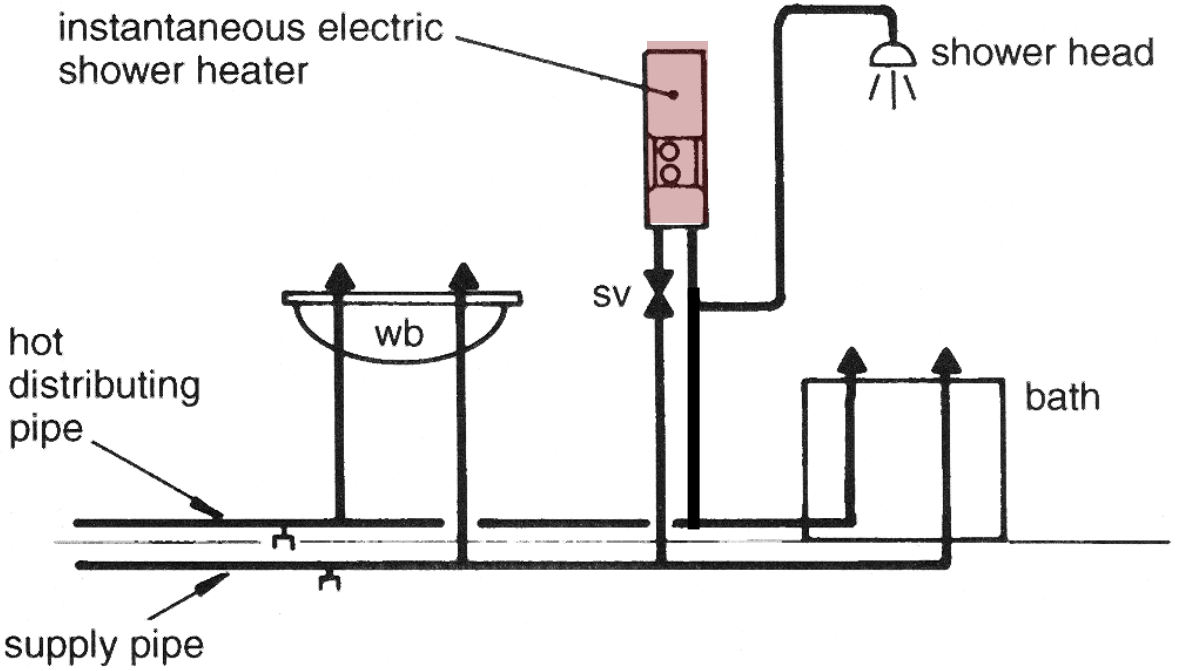


Instantaneous electric water heater (non-pressure type)

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



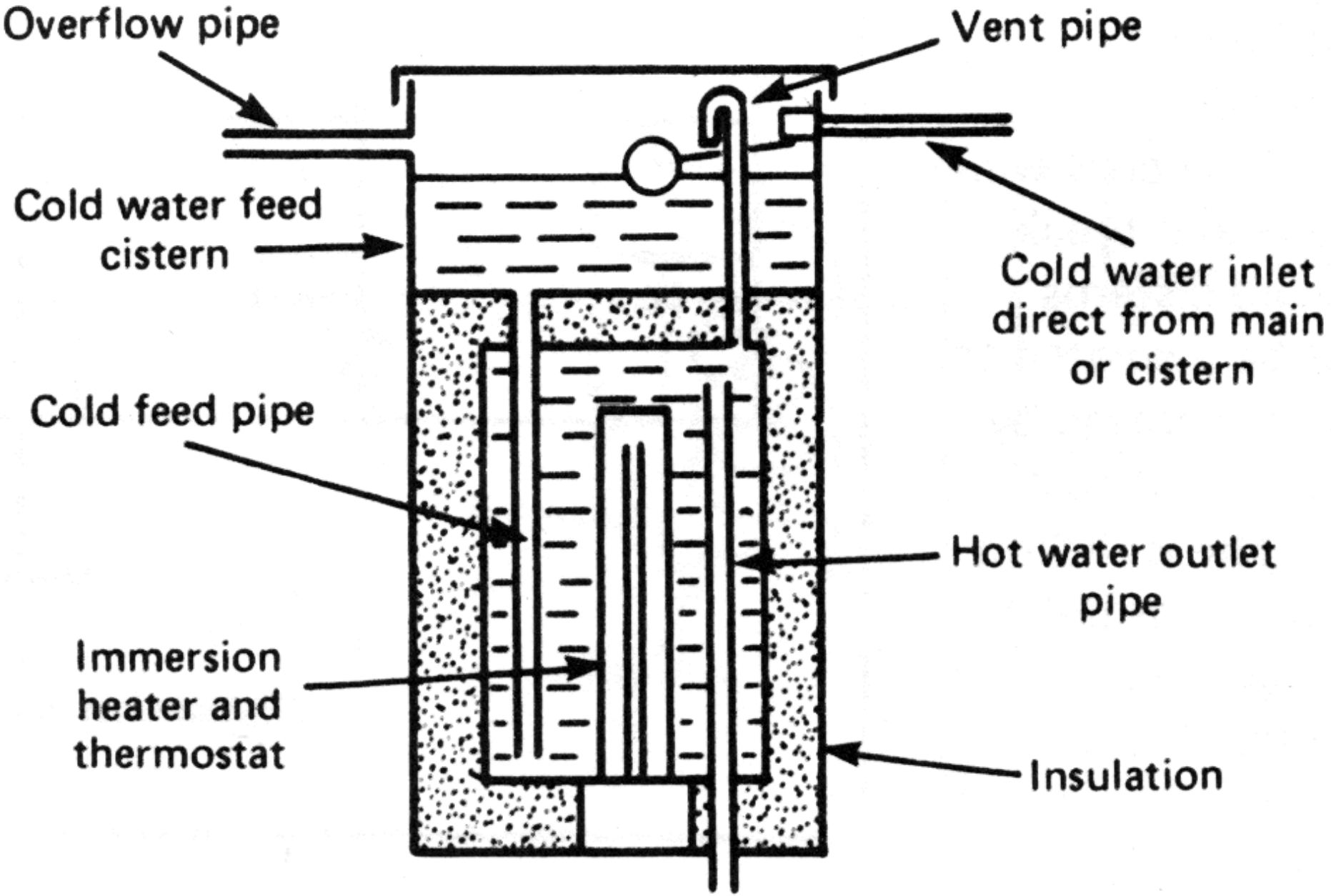
Sink installation



Shower installation

Typical uses for instantaneous electric water heaters

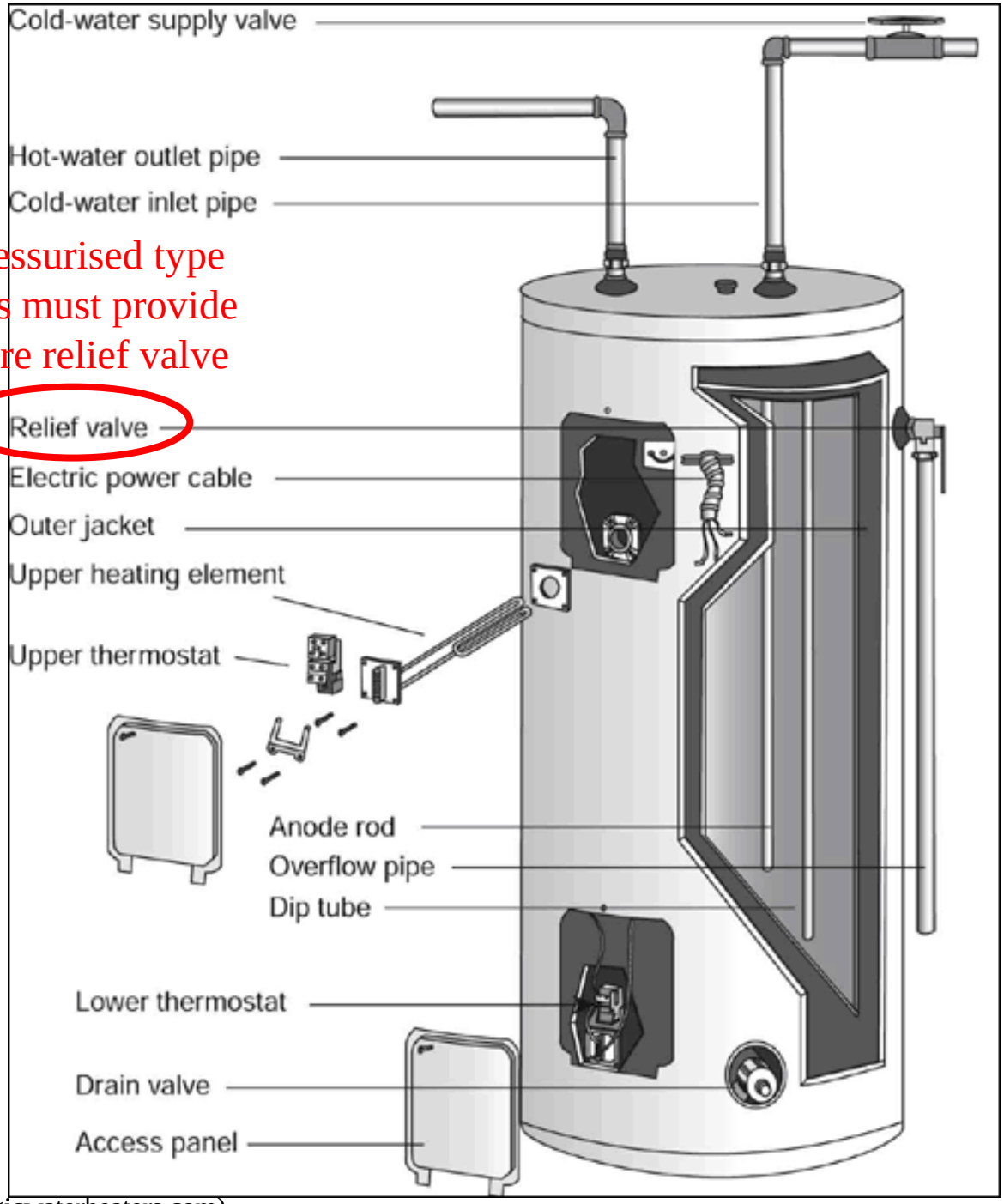
(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)



Cistern type water heater

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

All pressurised type heaters must provide pressure relief valve

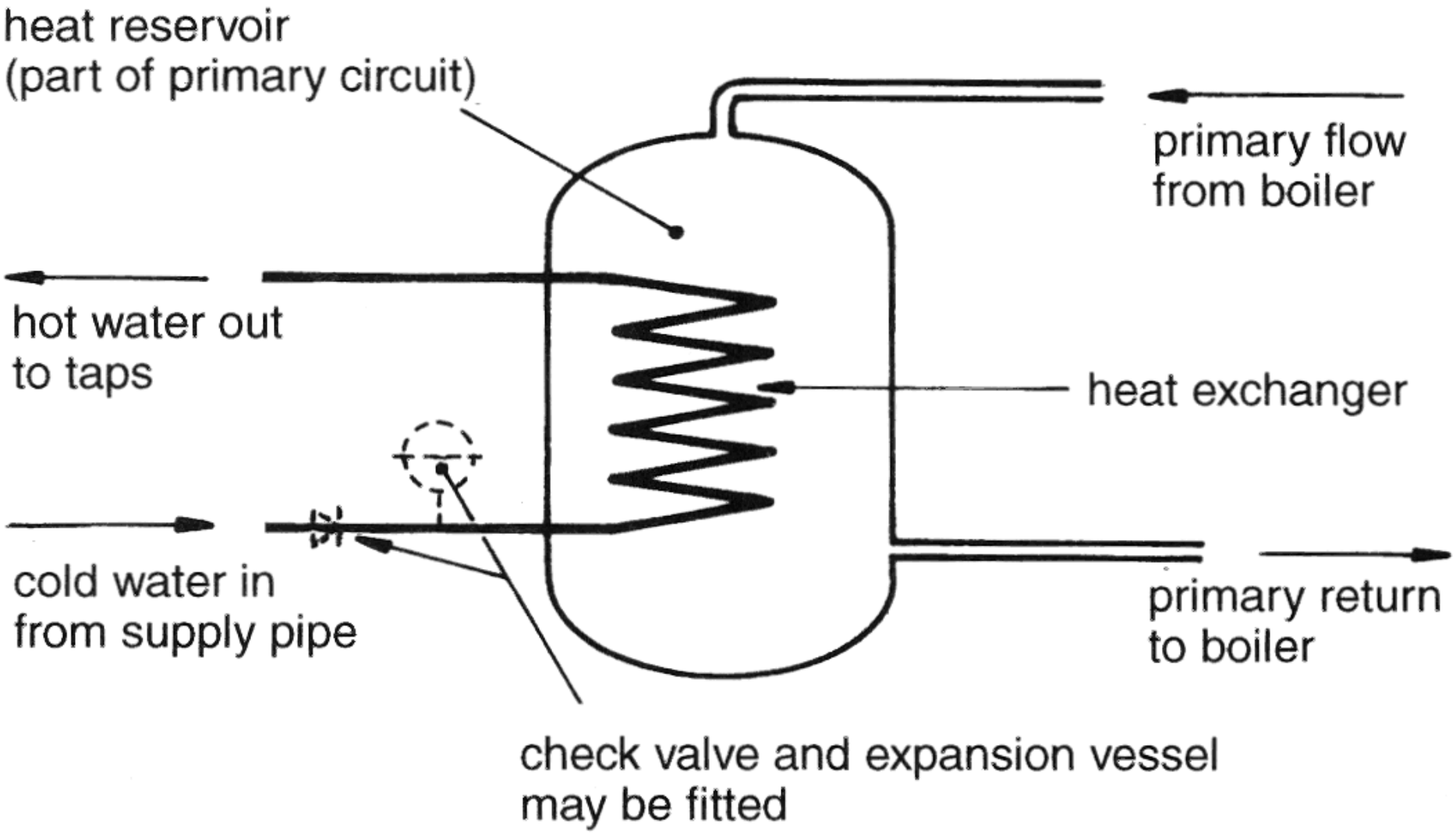


Components of a large electric water heater

(Source: http://magicwaterheaters.com)

Water heaters

- Water-jacketed tube heaters
  - Usually as a form of instantaneous heater
  - Heat exchanger in a reservoir of primary hot water (*the heating source*)
  - Cold water feeds may be from the mains or from a water tank
  - Primary circuit may be vented or sealed system
  - Heat exchanger warms secondary supply water

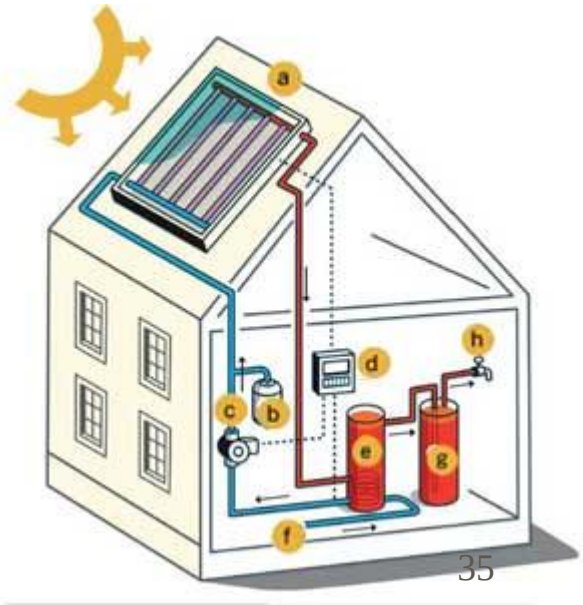


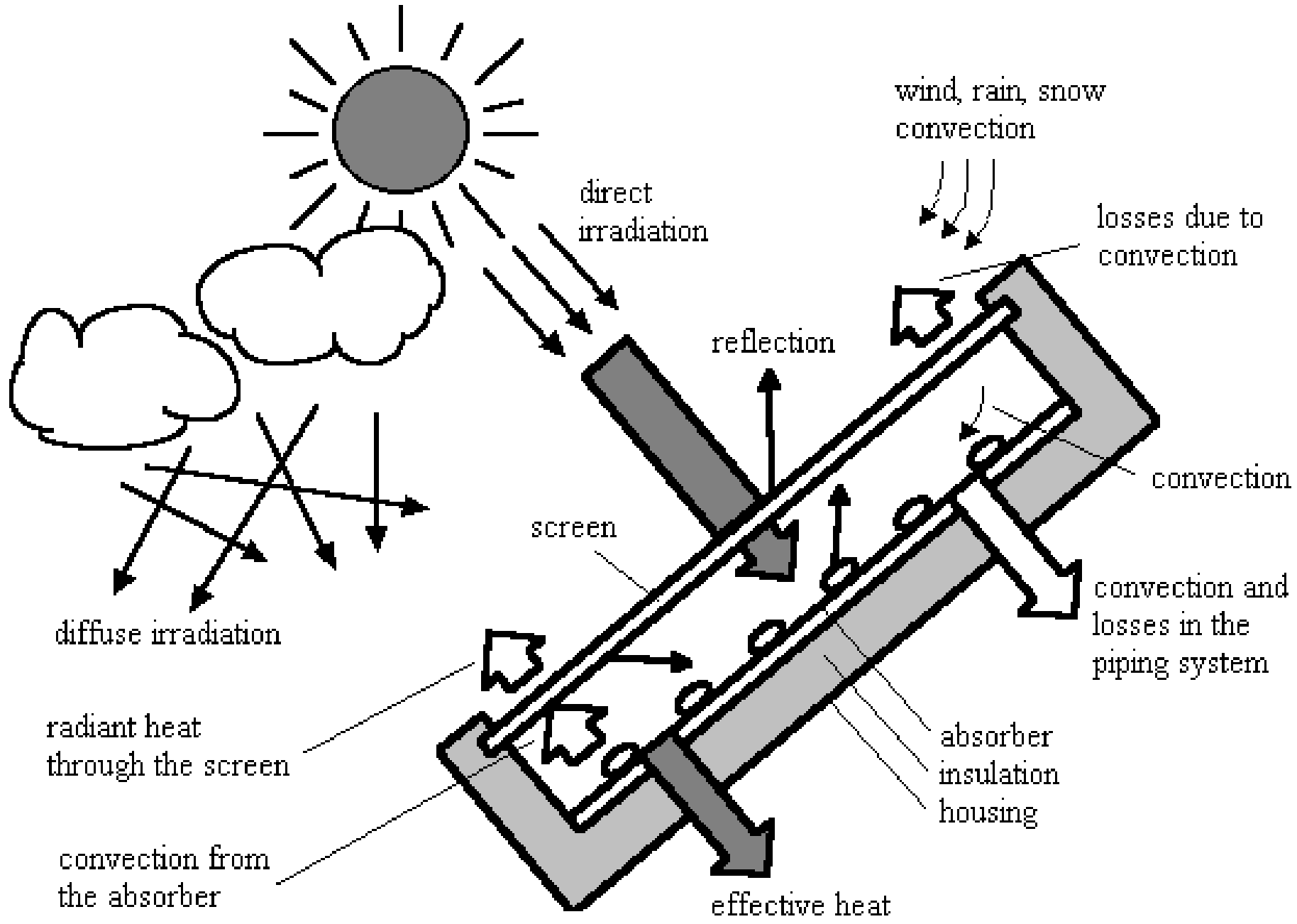
Water-jacketed tube heater

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

Water heaters

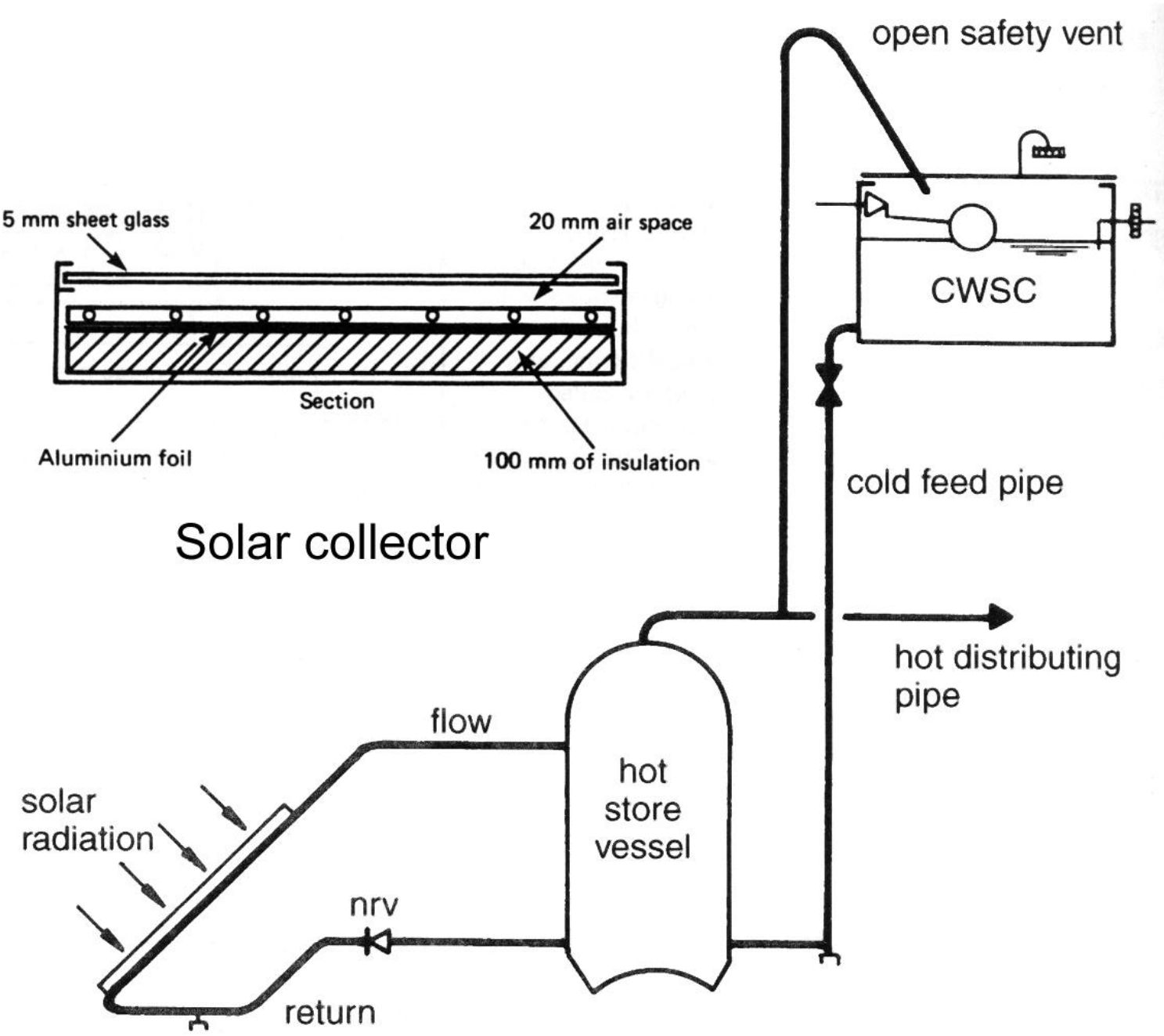
- Solar water heating
  - ‘Renewable’ or green energy
  - Simple system (e.g. domestic):
    - Solar collector + direct feed gravity
- Types of solar collectors:
  - Formed plastic
  - Flat plate
  - Evacuated tube (heat pipe)





Heat transfer processes at a flat-plate solar collector

Solar collector

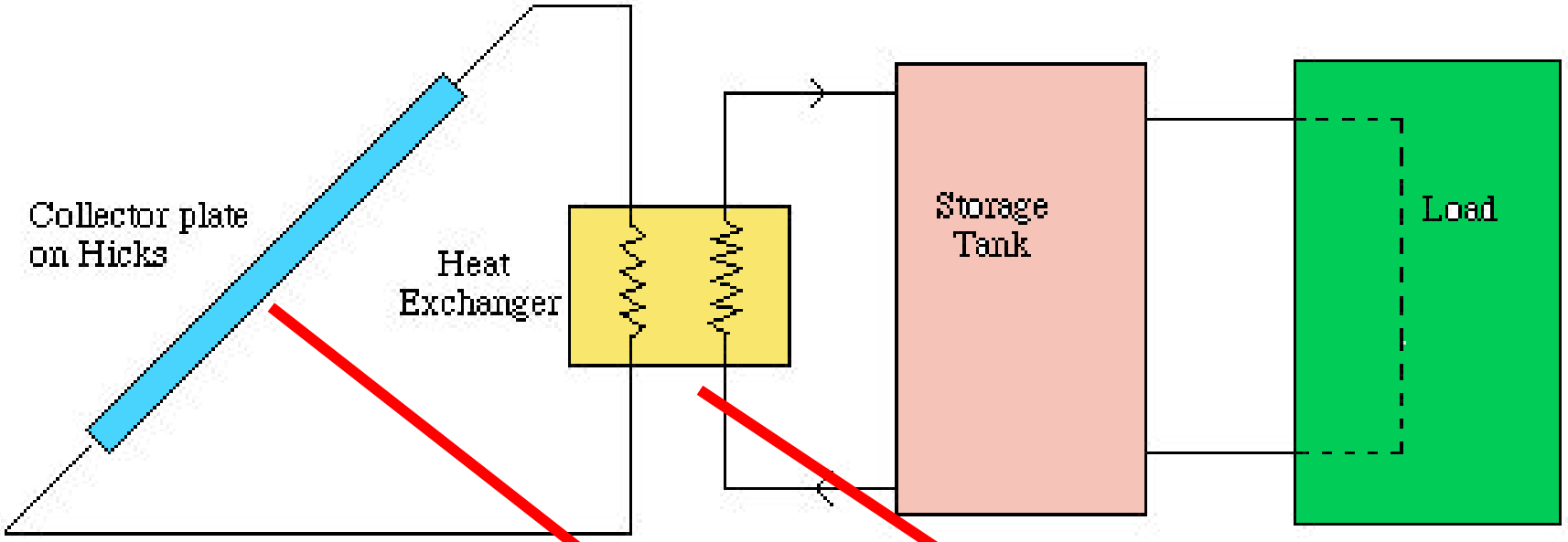


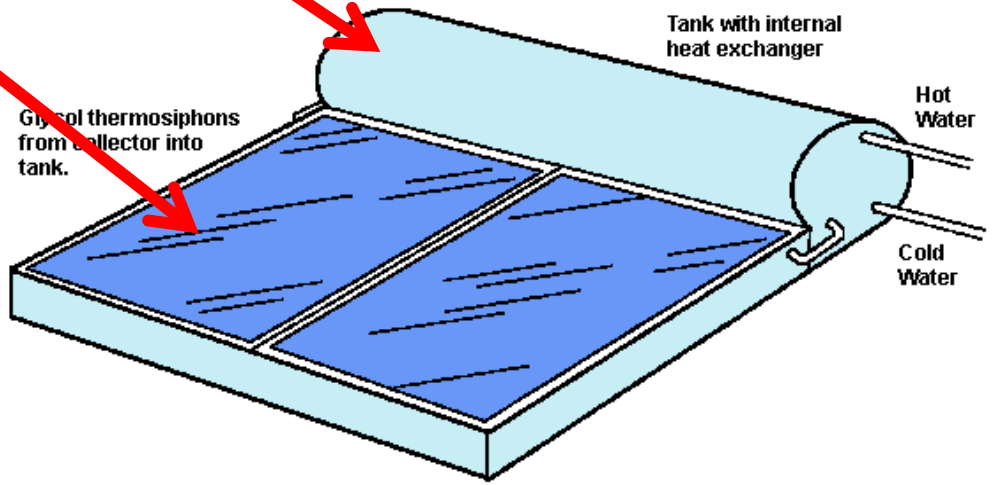
Solar hot water system

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

Inclined Angle?

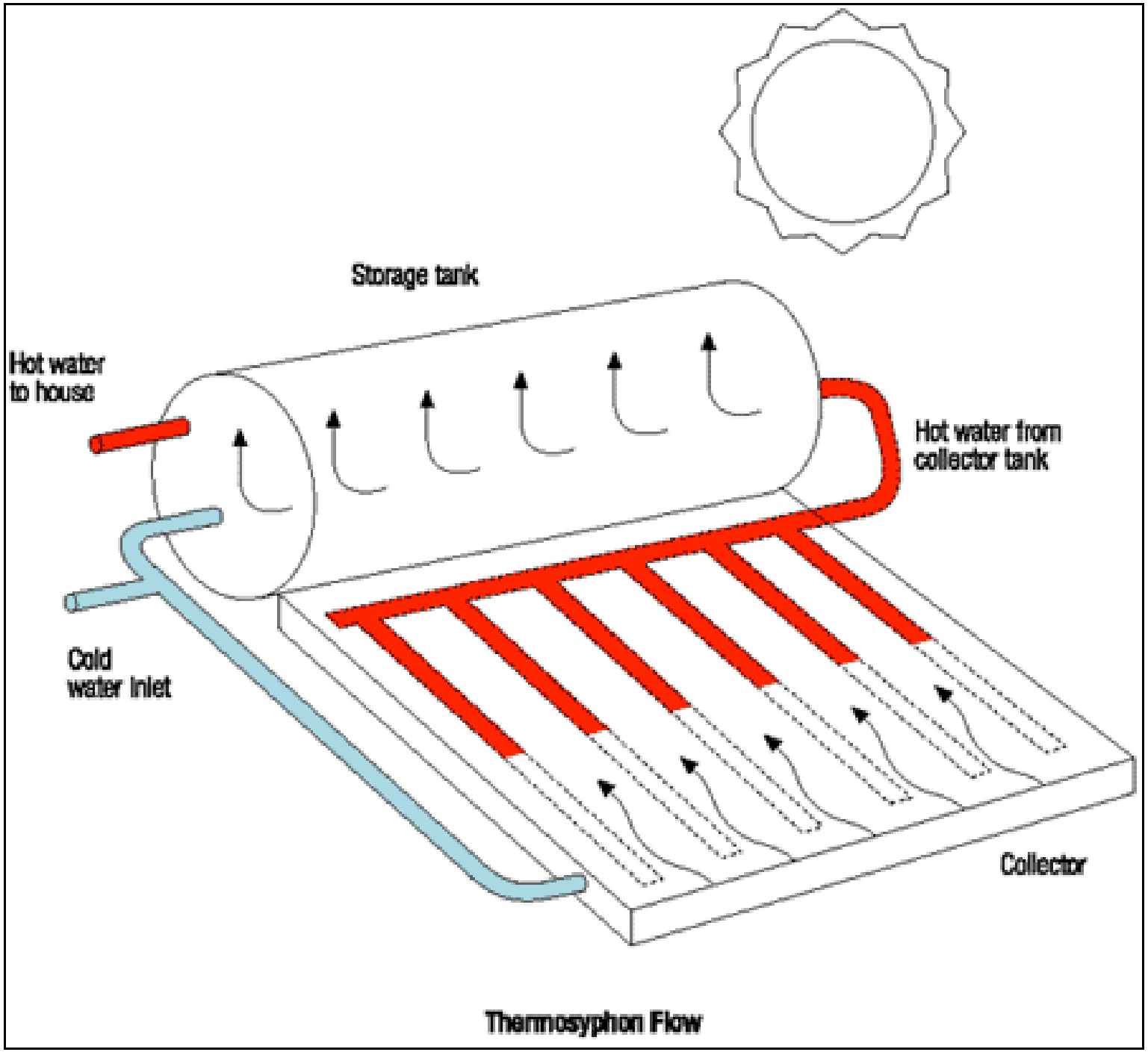
Solar hot water for a school in Guangzhou



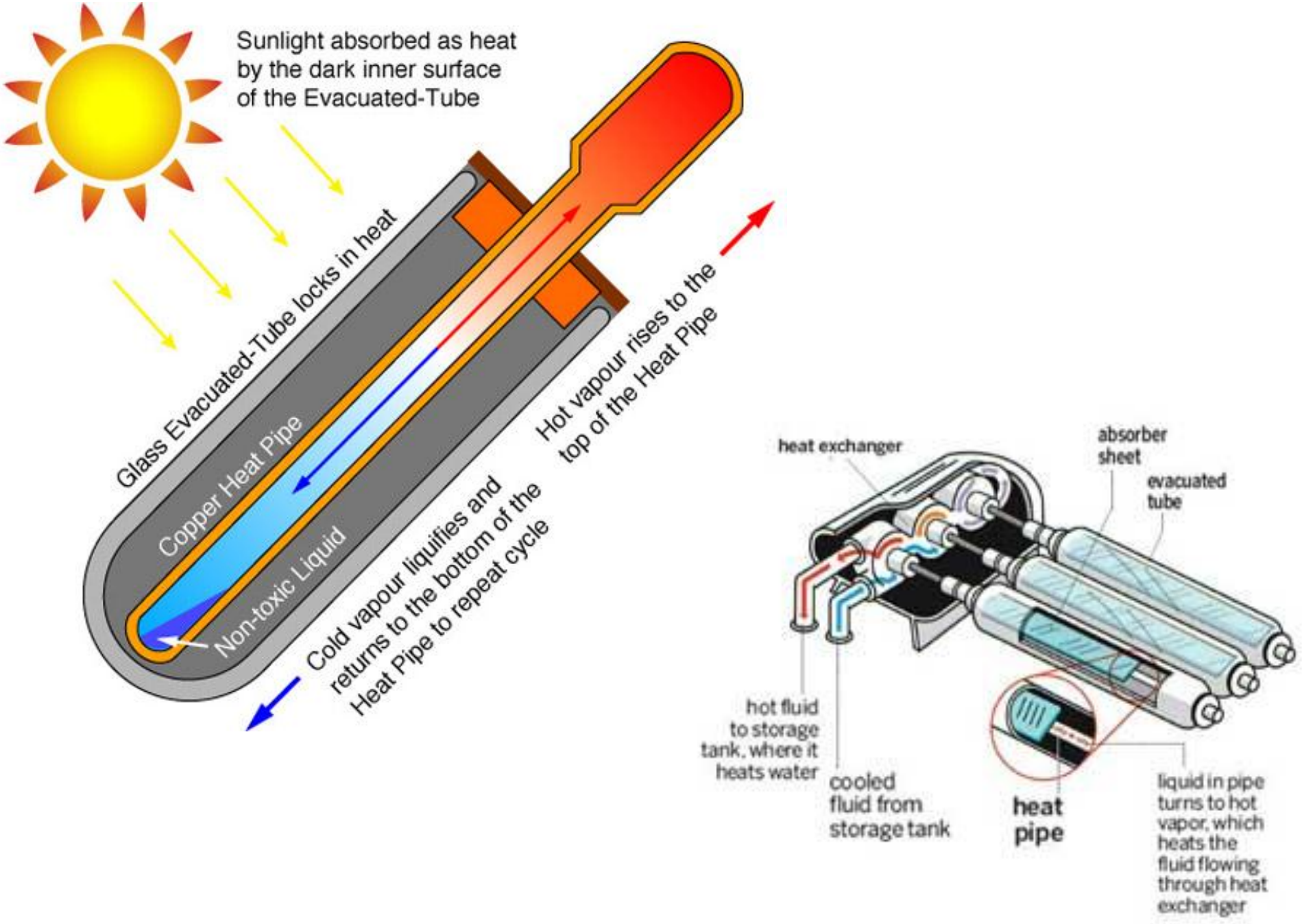


Simple domestic system
(with integral storage tank)

Solar hot water systems



Thermosyphon Flow



Heat pipe evacuated-tube solar collector

Evacuated-tube solar hot water system

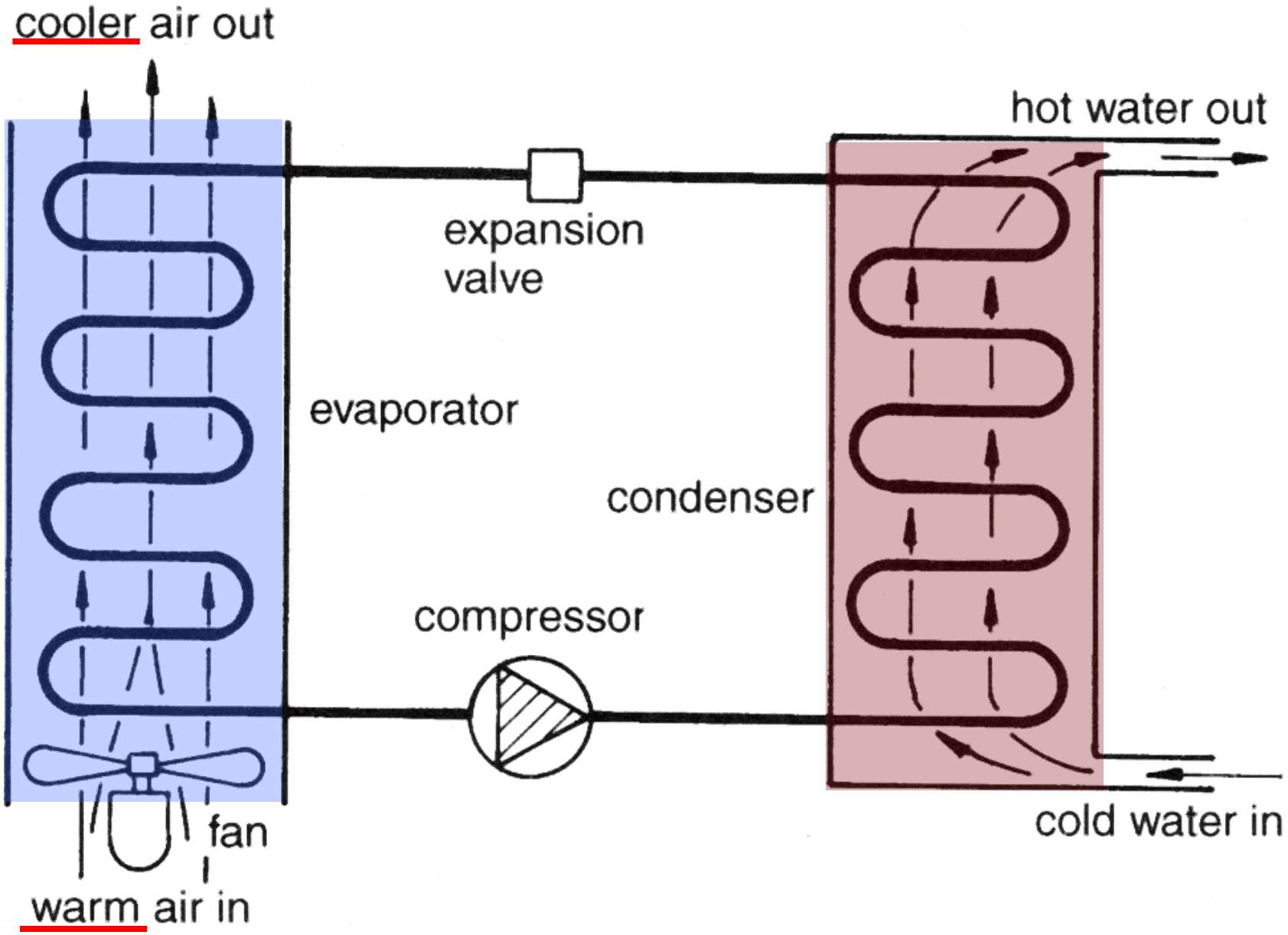
Comparison of flate-plate and evacuated-type collectors

	Pros	**Cons**
Flate-plate collectors 平板式太陽能集熱器	• capable to deliver moderate temperature hot water • lower cost compared with evacuated tube	• heavier weight • larger wind load • more susceptible to pipe blockage & leakage • more complications in maintenance
Evacuated-type collectors 真空管太陽能集熱器	• lower heat loss to surrounding • capable to deliver moderate to high temperature water (60-80 ℃) • lighter support structure • simplicity in maintenance	• higher capital cost compared with flat plate

(Source: EMSD, www.emsd.gov.hk)

Water heaters

- Heat pumps
  - An effective tool to produce hot water
  - Extract energy from ground, water, or even ‘ambient air’!
  - Typical applications:
    - To preheat conventional hot water systems
    - To augment existing systems
    - To supply full hot water
  - Reverse of the normal refrigeration cycle



Basic principles of heat pump

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

Sizing hot water systems for households

Electric storage hot water services

Off-peak electricity rate (storage type heater)*		Peak electricity rate (continuous type heater)**	
Max. no. of persons served	Capacity (litres)	Max. no. of persons served	Capacity (litres)
1 – 3	160	2	40
2 – 4	250	3	63
3 – 6	315	4	80
5 – 8	400	5	125

* Water is heated overnight to provide adequate hot water for daily usage.

** Can be very expensive to run so should only be used when other options are not possible. For example, where space is limited.

(Source: www.energysmart.com.au)

Sizing hot water systems for households (cont'd)

Gas water heaters

Storage		Instantaneous (continuous flow)	
Max. no. of persons served	Capacity (litres)	Max. no. of outlets served at one time	Flow rate (litres per minute)
1 – 3	90	1	16
2 – 4	130	2	20
3 – 5	170	3+	24
4 – 6	200		
5 – 9	260		

(Source: www.energysmart.com.au)

Sizing hot water systems for households (cont'd)

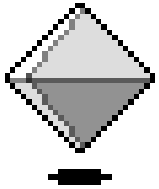
Solar hot water

No. of persons served	Capacity (litres)	Collector (m^2)
1 – 2	160 – 200	2
3 – 4	300 – 370	4
5 – 6	440	6

(Source: www.energysmart.com.au)

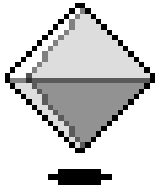
Centralized Hot Water System

Centralised hot water systems

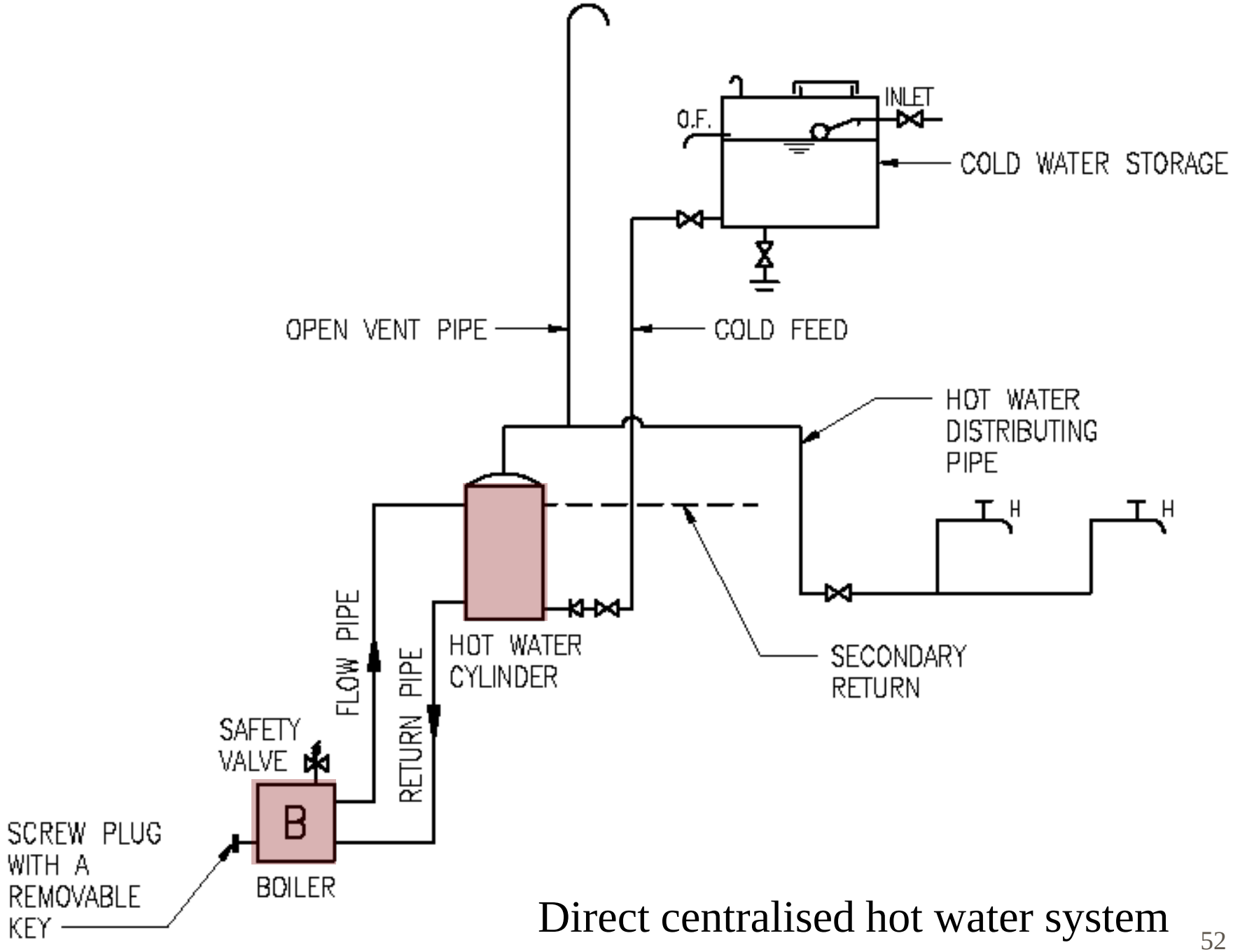


- Major components:
  - A boiler
  - A hot water storage cylinder or calorifier
  - Cold water storage tank linked by supply and circulatory pipework
- Boiler may be heated by gas, solid fuel or oil
  - Position of the boiler plant
- Pipe insulation is essential

Centralised hot water systems



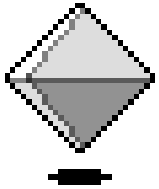
- Direct system
  - Water through the boiler can be drawn off from the taps
  - Saves the cost of a storage and expansion cistern and associated pipework
  - Heated quicker
  - Adequate pressure on the main
  - Sealed primary circuit can be pumped or can circulate by natural convection



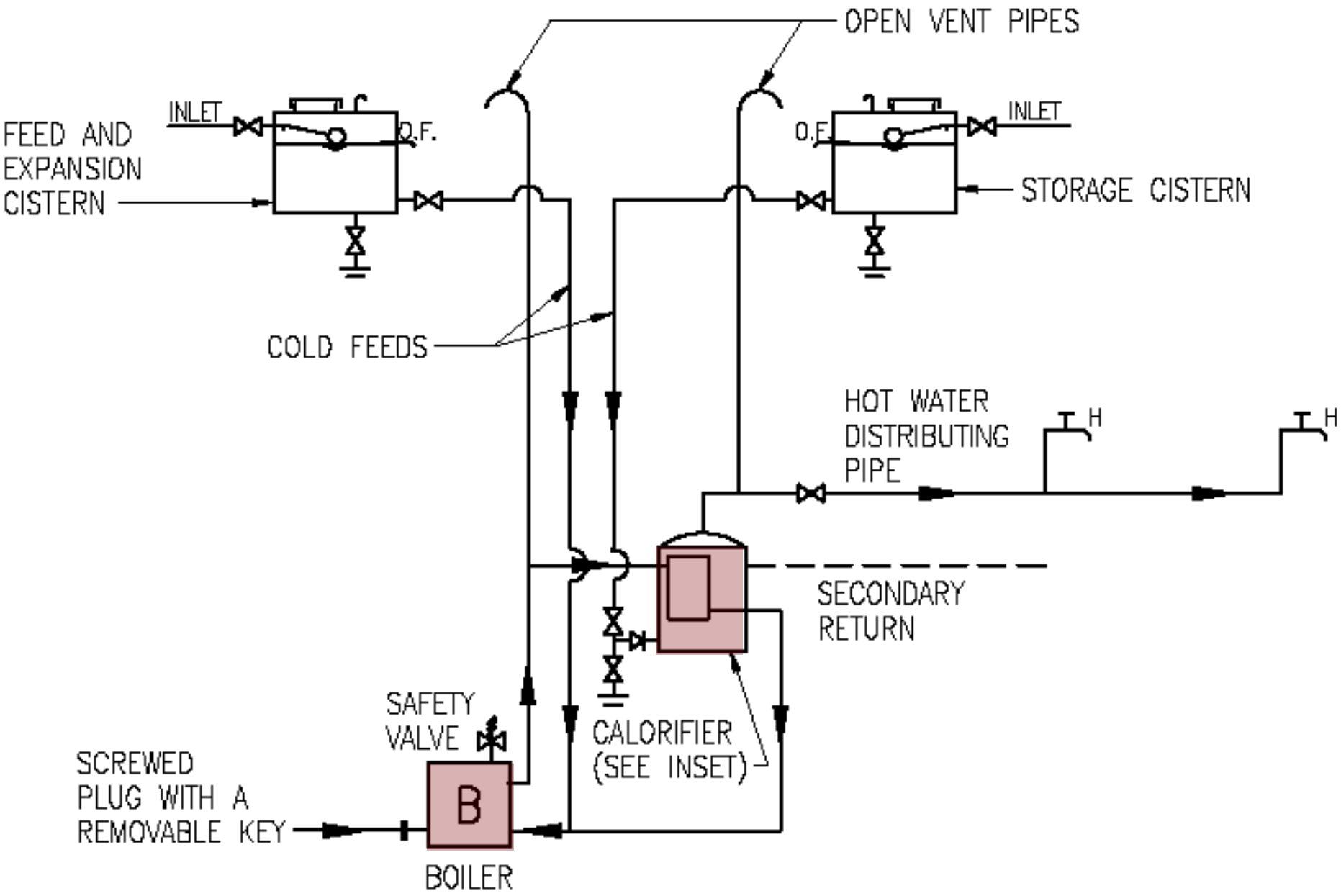
Direct centralised hot water system

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

Centralised hot water systems

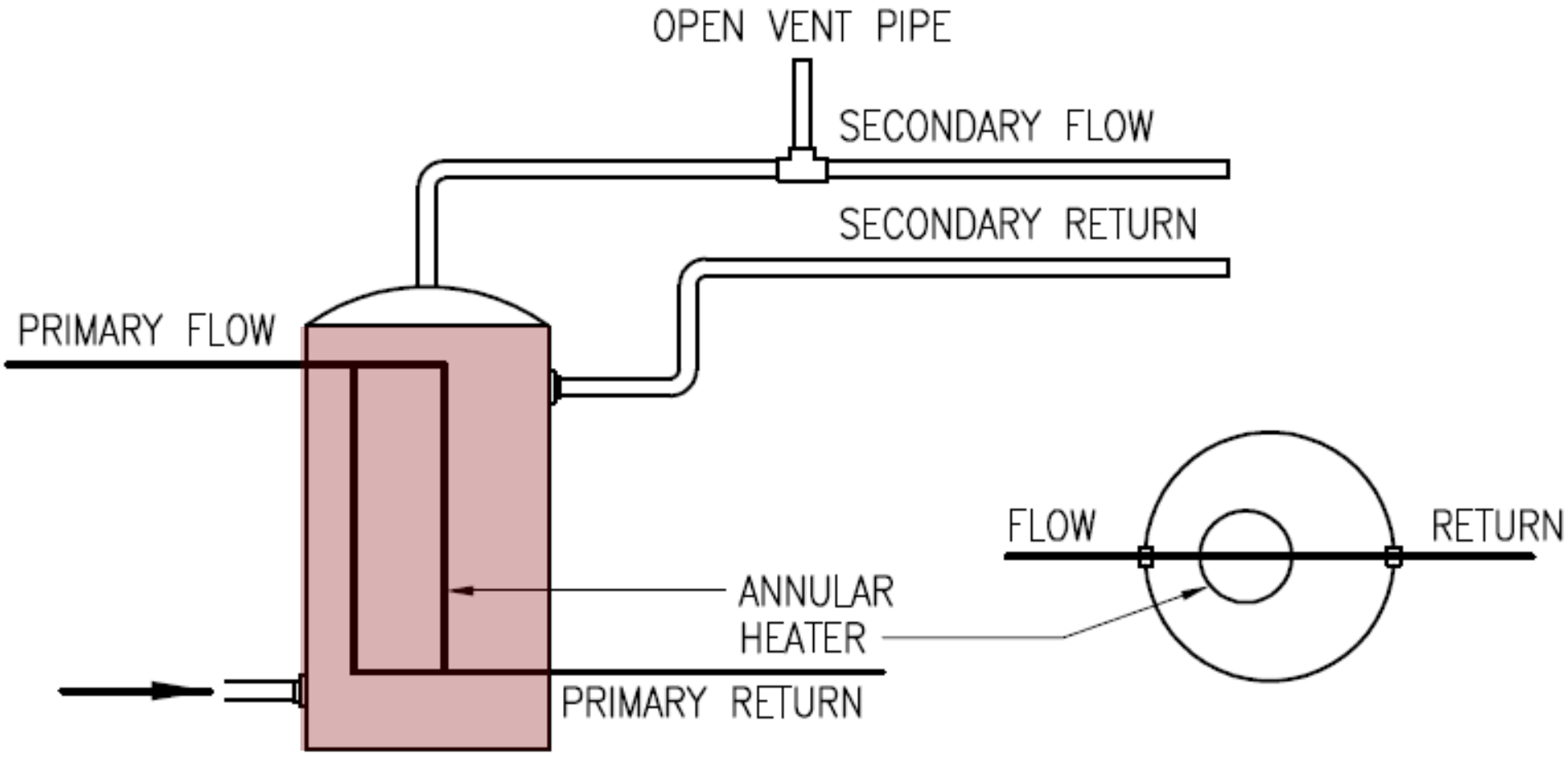


- Indirect system
  - Separate circuit for the water drawn off at taps
  - Used in hard water areas to prevent scaling of boiler and pipes
  - Used when heating is combined with the system
  - It costs more than direct system but requires less maintenance
  - An expansion vessel in primary pipework to eliminate the need for an expansion cistern, expansion pipe and boiler feeder pipe



Indirect centralised hot water system

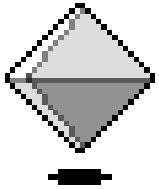
(Source: WSD, 2006. *Handbook on Plumbing Installation for Buildings*)



Essential components of a calorifier

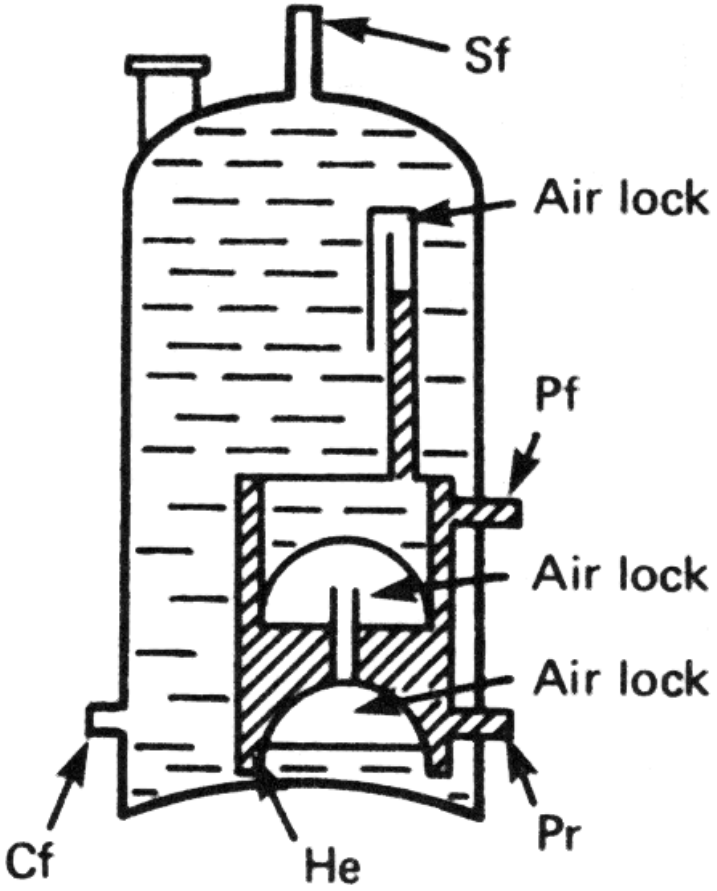
(Source: WSD, 2006. *Handbook on Plumbing Installation for Buildings*)

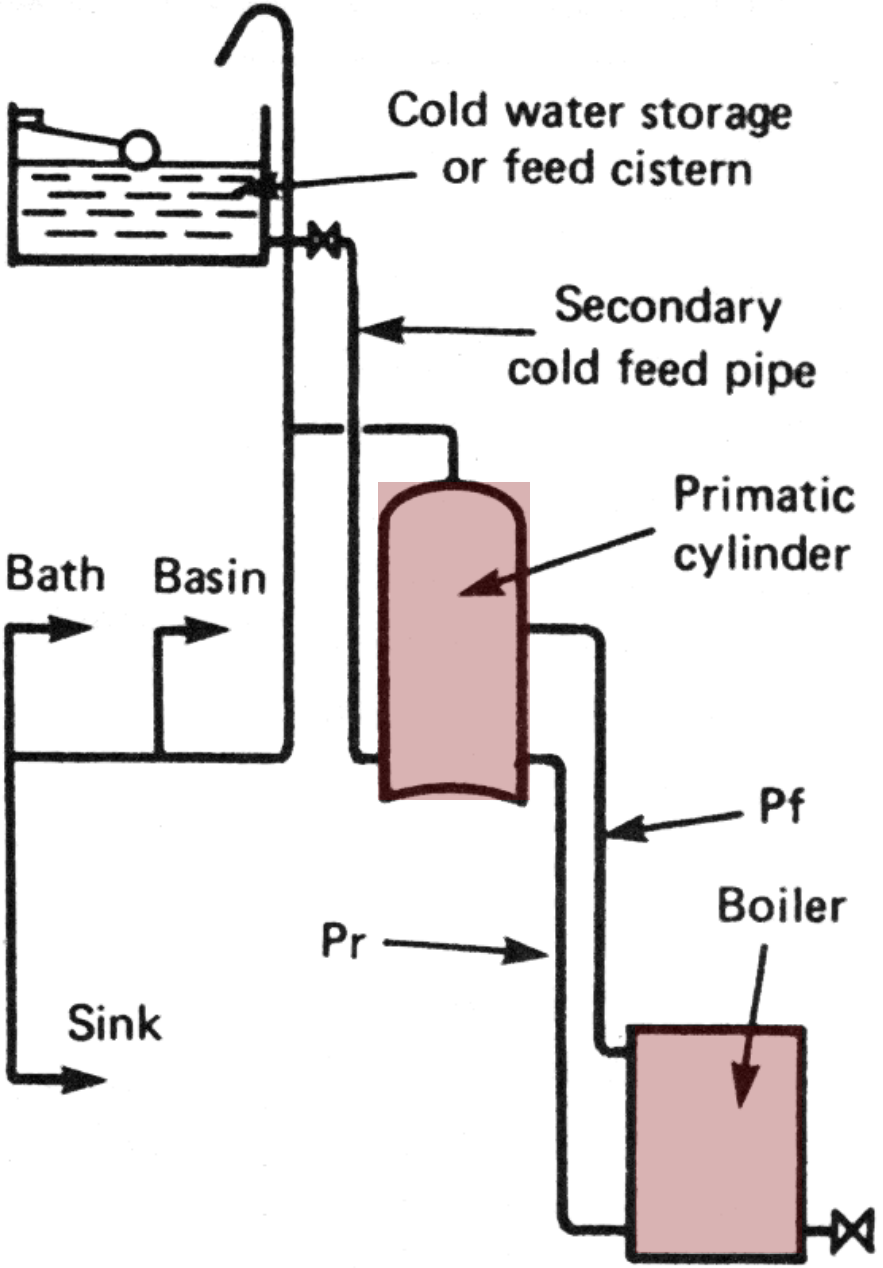
Centralised hot water systems



- Indirect system with a primatic cylinder
  - Three air locks to prevent mixing of the primary and secondary waters
  - Save cost for expansion and feed tank, primary cold feed and primary vent pipe
  - Limited in use to small installations

Sf = Secondary flow pipe
Pf = Primary flow pipe
Pr = Primary return pipe
He = Heat exchanger
Cf = Cold feed pipe

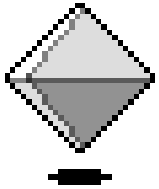




Indirect system with a primatic cylinder

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

Centralised hot water systems

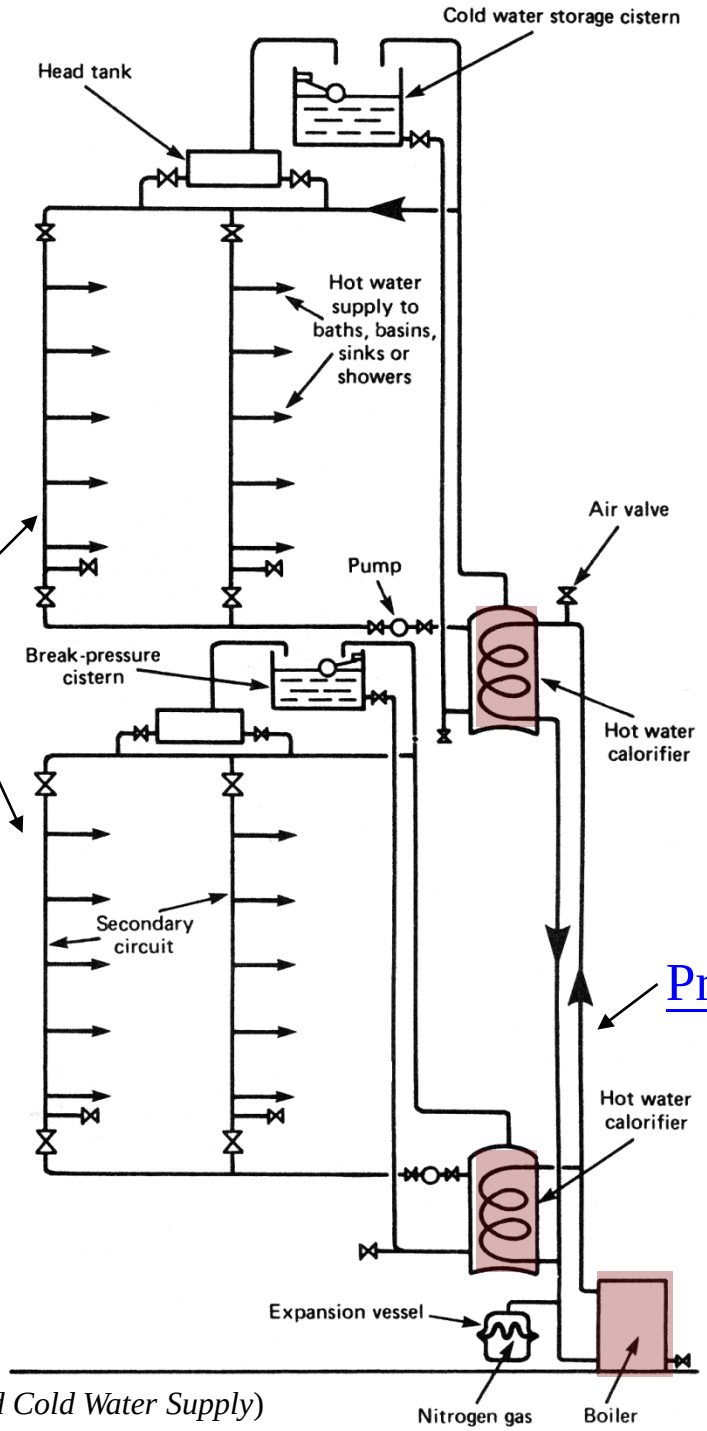


- Systems for high-rise buildings
  - More economical to pressurise water in a sealed system
  - Proper zoning is required (e.g. 30 m)
  - Boiler & calorifiers to withstand water pressure
  - Sealed primary circuit saves on pipework and the expansion and feed tank
  - Expansion vessel takes up the expansion of water in the primary circuit
  - The pipes, calorifiers, head tanks & boiler must be well insulated

Upper zone

Secondary circuit

Lower zone

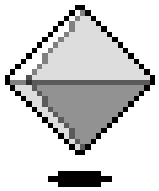


Sealed indirect hot water system for a highrise building

Boiler plant

(Source: Garrett, R. H., 2008. *Hot and Cold Water Supply*)

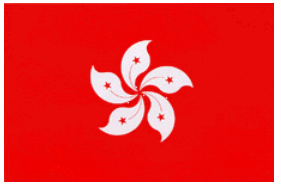
Centralised hot water systems



- Prevent dead legs in hot water systems
  - ‘Dead legs’ occur in hot water systems where water does not flow for a period of time
    - Such as at night when hot water is not used and the contents of the pipes and appliances cools down
  - Water cooled to 20 to 45 ℃ 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 to the furthest draw off point to minimize the length of the dead leg
    - 2. Maintain the water temperature at all times

Statutory Requirements for HK

Safety & statutory req's in HK

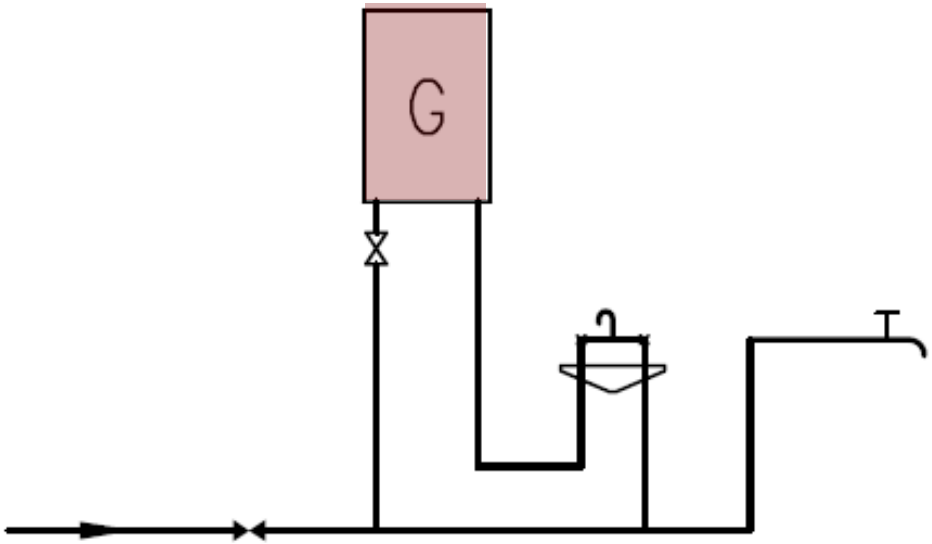


- Safety and statutory requirements
  - Non-centralised hot water systems
  - Centralised hot water systems
- References: (from WSD)
  - Hong Kong Waterworks Standard Requirements for Plumbing Installation in Buildings (HKWSR)
  - Handbook on Plumbing Installation for Buildings

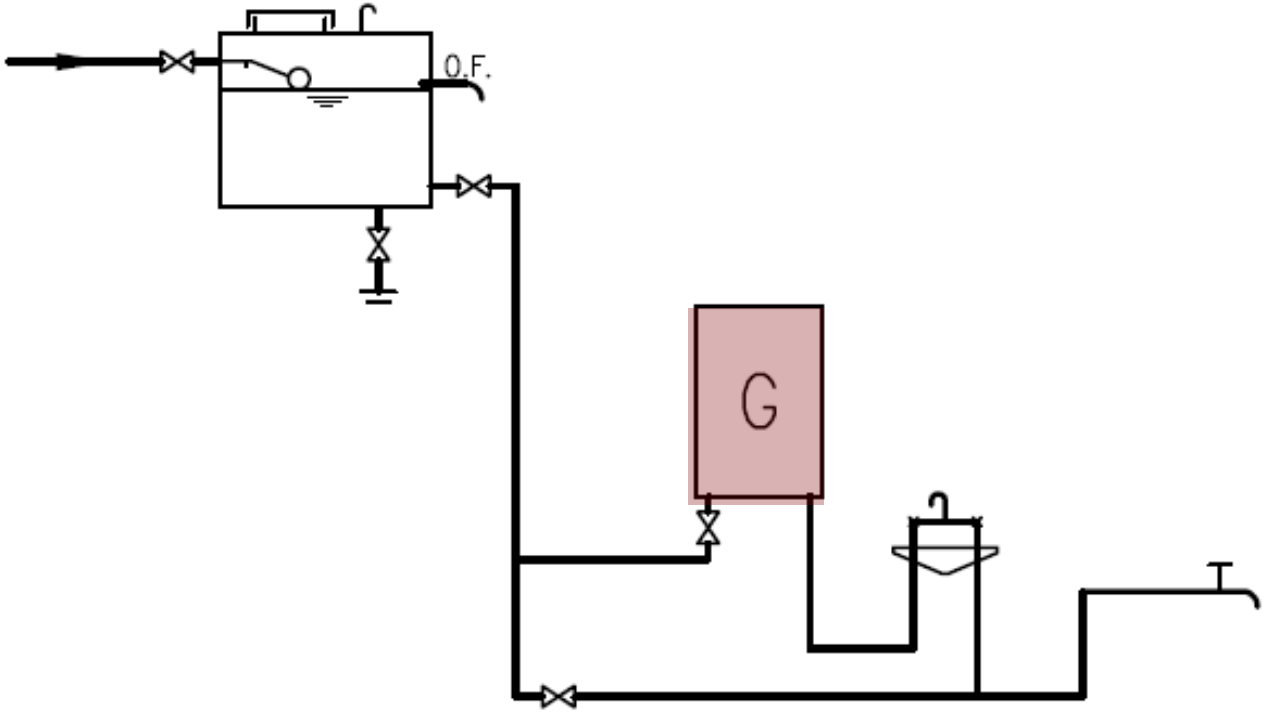
Requirements for non-centralised hot water systems

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*)



Instantaneous gas water heater connected directly to mains supply

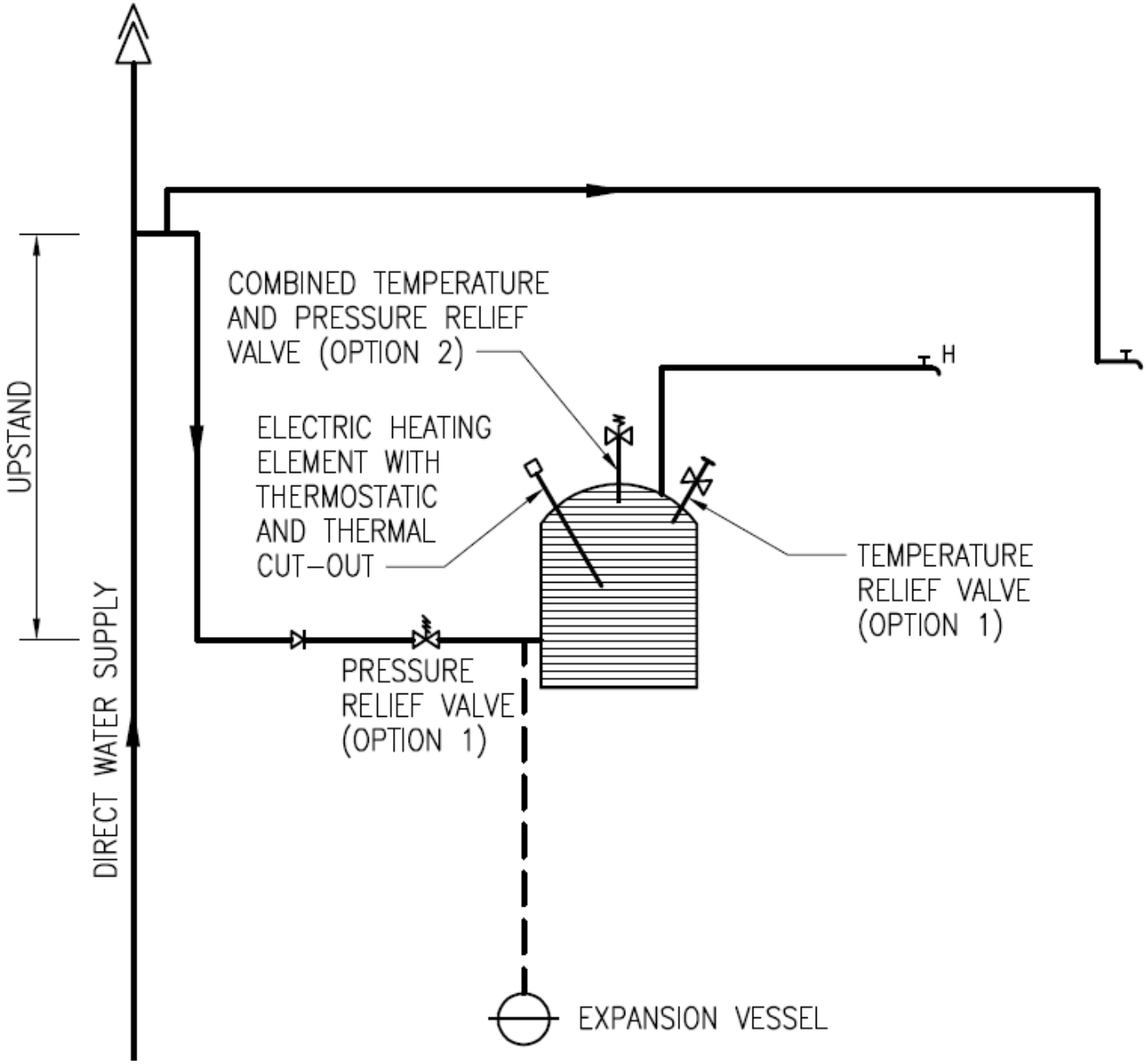


Instantaneous gas water heater connected indirectly to mains supply

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

Safety & statutory req's in HK

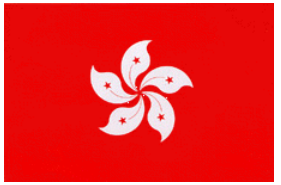
- Unvented electric water heater of storage type (HKWSR Clause 5.11):
  - A supply pipe that branches off from the feed pipe at a point above the top of the water heater, or some other device to prevent the water from draining down from the water heater if the source of water supply fails
  - An anti-vacuum valve complying with BS 6282 or some other device to prevent heated water from being syphoned back to the supply pipe
  - A vessel to accommodate expansion of heated water where that expansion is constrained by a non-return valve or some other device, at the inlet of the water heater



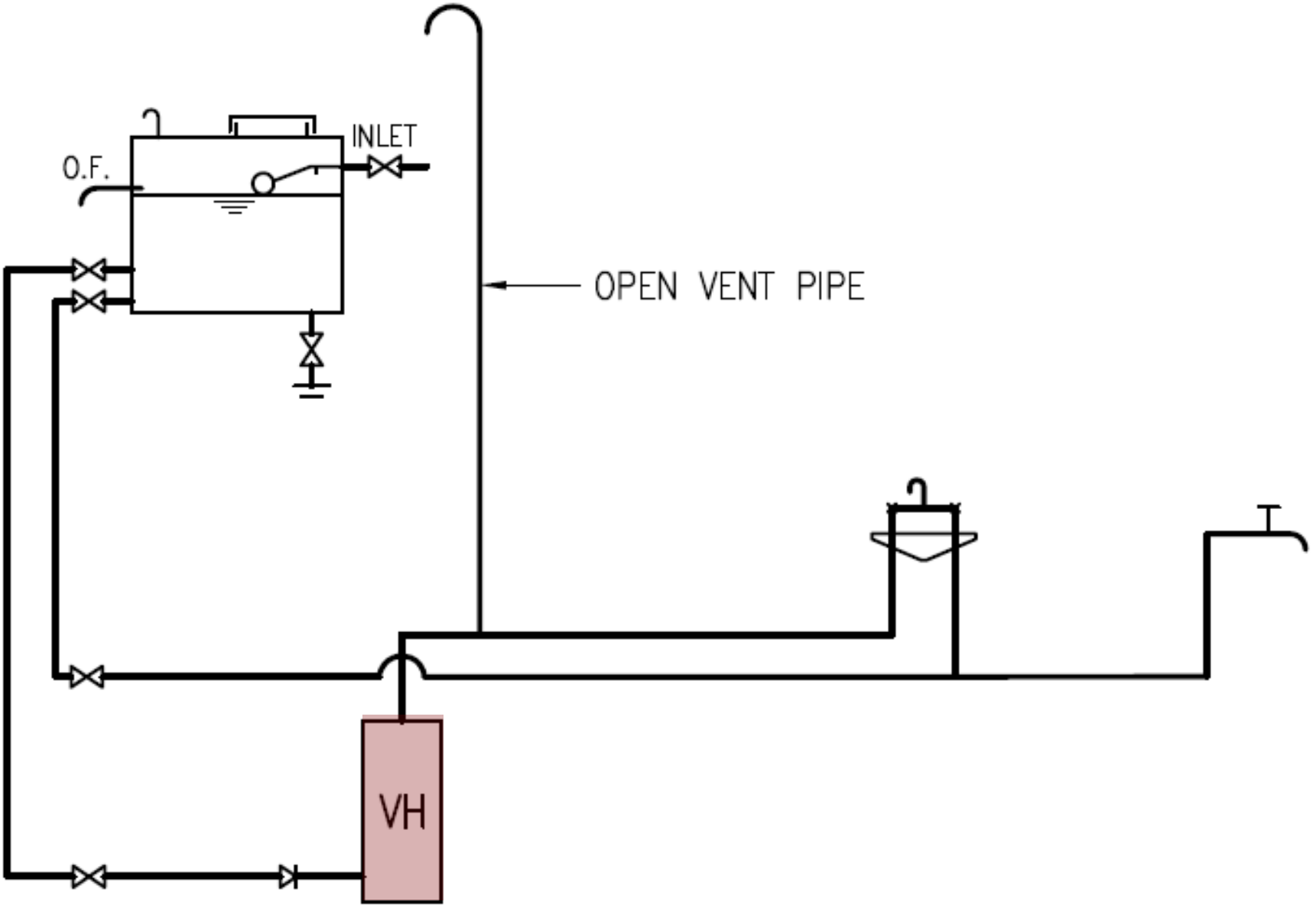
Unvented electric thermal storage type water heater

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

Safety & statutory req's in HK



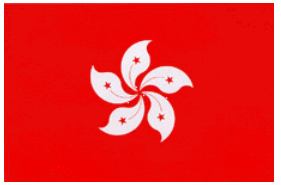
- Pressure type thermal storage water heater:
  - Supplied from a separate water storage cistern, except these are installed in flats supplied through indirect or sump and pump system
  - A vent or an expansion pipe taken from its highest point and discharge in the atmosphere above the storage cistern at sufficient height to prevent a constant outflow of hot water



Pressure type thermal storage water heater

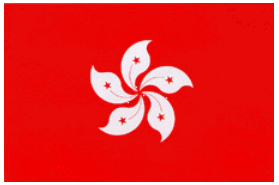
(Source: WSD, 2006. *Handbook on Plumbing Installation for Buildings*)

Safety & statutory req's in HK



- Requirements for non-centralised systems
  - Minimum pressure & flow for proper functioning
  - Mixing valves, water blenders or combination fittings (provide a balanced pressure)
  - Electricity (Wiring) Regulations
  - Electric Products (Safety) Regulations
  - Relief valves and drain pipe
  - Max. hot water pipe length

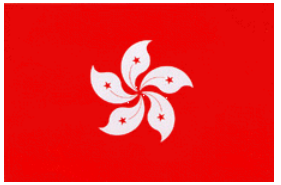
Safety & statutory req's in HK



- Maximum hot water pipe length: (for non-centralised or local systems) (*prevention of dead leg*)

Pipe size diameter	Max. distance between water tap from hot water apparatus
< or = 20 mm	12 m
= 25 mm	8 m
> 25 mm	3 m

Safety & statutory req's in HK



- Requirements for centralised systems
  - Vent or an expansion pipe from the highest point
  - Safety valve or pressure relief valve
  - Mixing valves, water blenders or combination fittings (provide a balanced pressure)
  - Draining down or emptying the system
  - Avoid waste of water