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Minimising the hygiene risks associated with biofilms in hospitals

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Questions

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1. Is it possible to develop a set of general principles that, when applied to water system design, can reduce the incidence of biofilms and thus make sterilisation measures more effective?

2. Can modern plumbing equipment sometimes contribute to the problem?

3. How can that equipment be re-designed to ensure that it is inherently resistant to biofilm formation?

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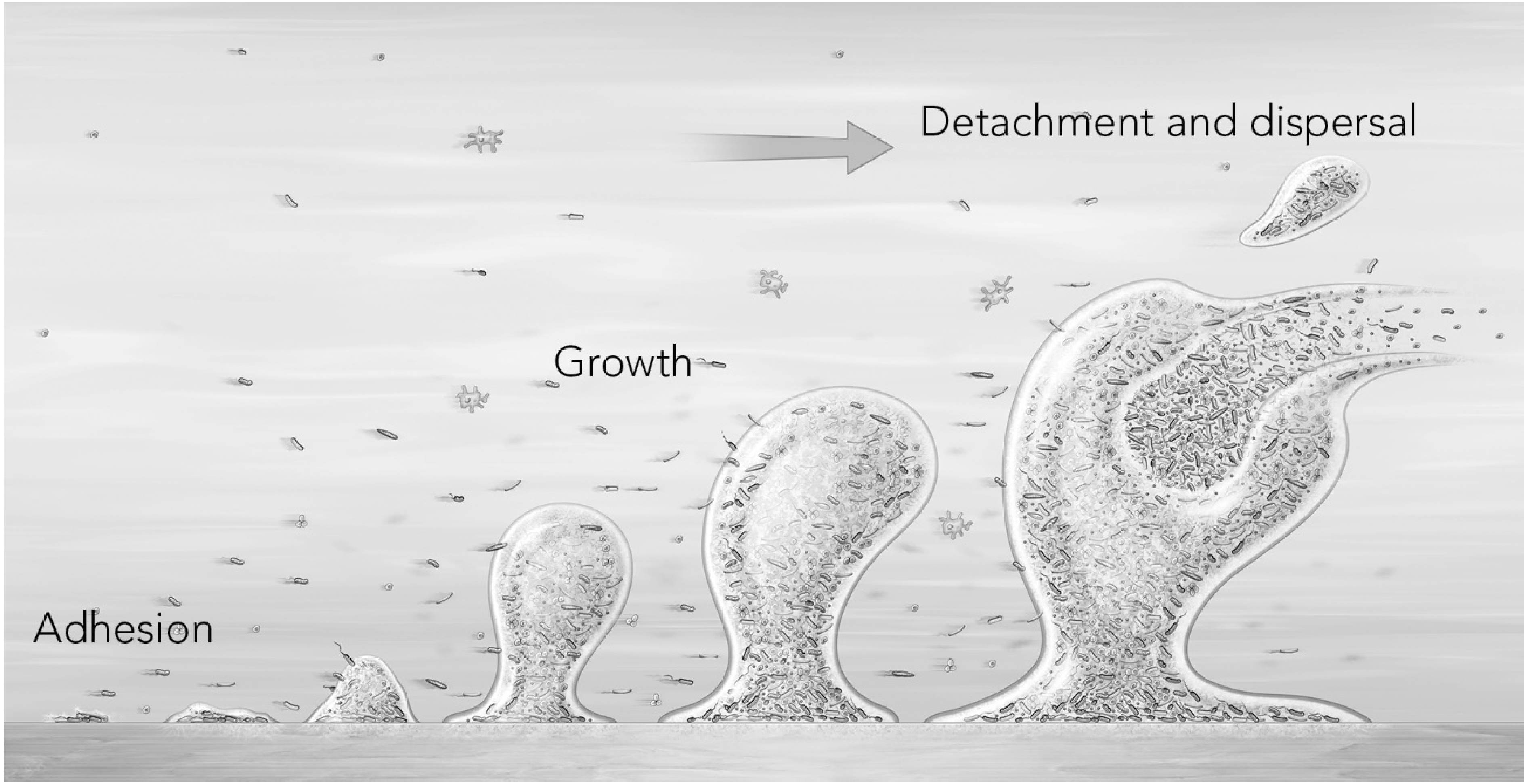
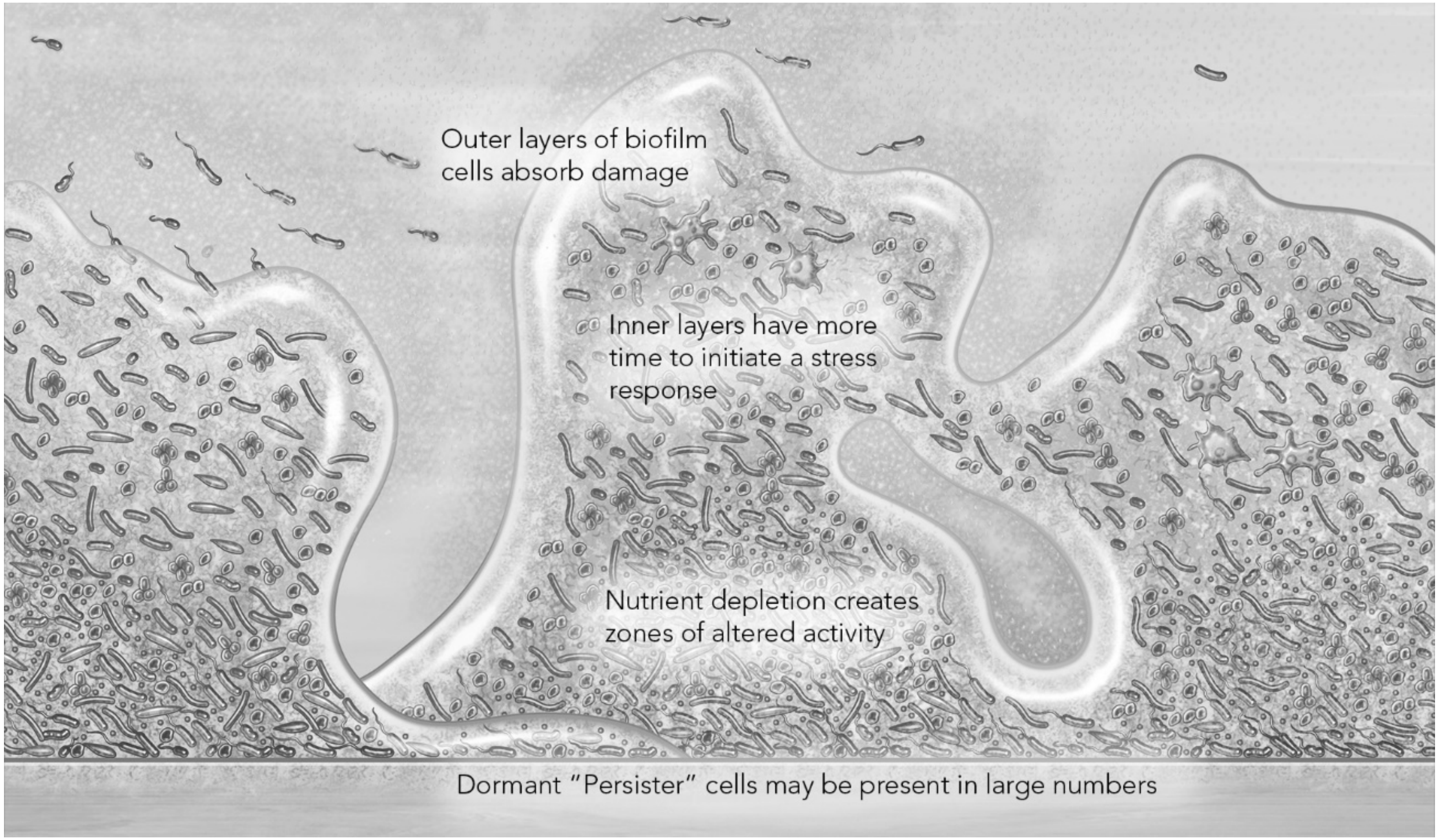
Biofilms

Lifecycle of a biofilm from initial adhesion to detachment and dispersal



Biofilms

The multidimensional structure of biofilms provides a variety of protective mechanisms



Water system design for biofilm resistance

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Basic principles:

1. Prevent bacteria from adhering to surfaces.
2. Minimise the availability of nutrients.
3. Maintain temperature ranges outside those that promote bacterial growth.

Design Techniques:

- The design and physical layout of pipework.
- Careful choice of materials that are in contact with the water.
- Reviewing the systems and operating procedures used to manage the system.
- Changing the internal design of taps, shower controllers and valves.

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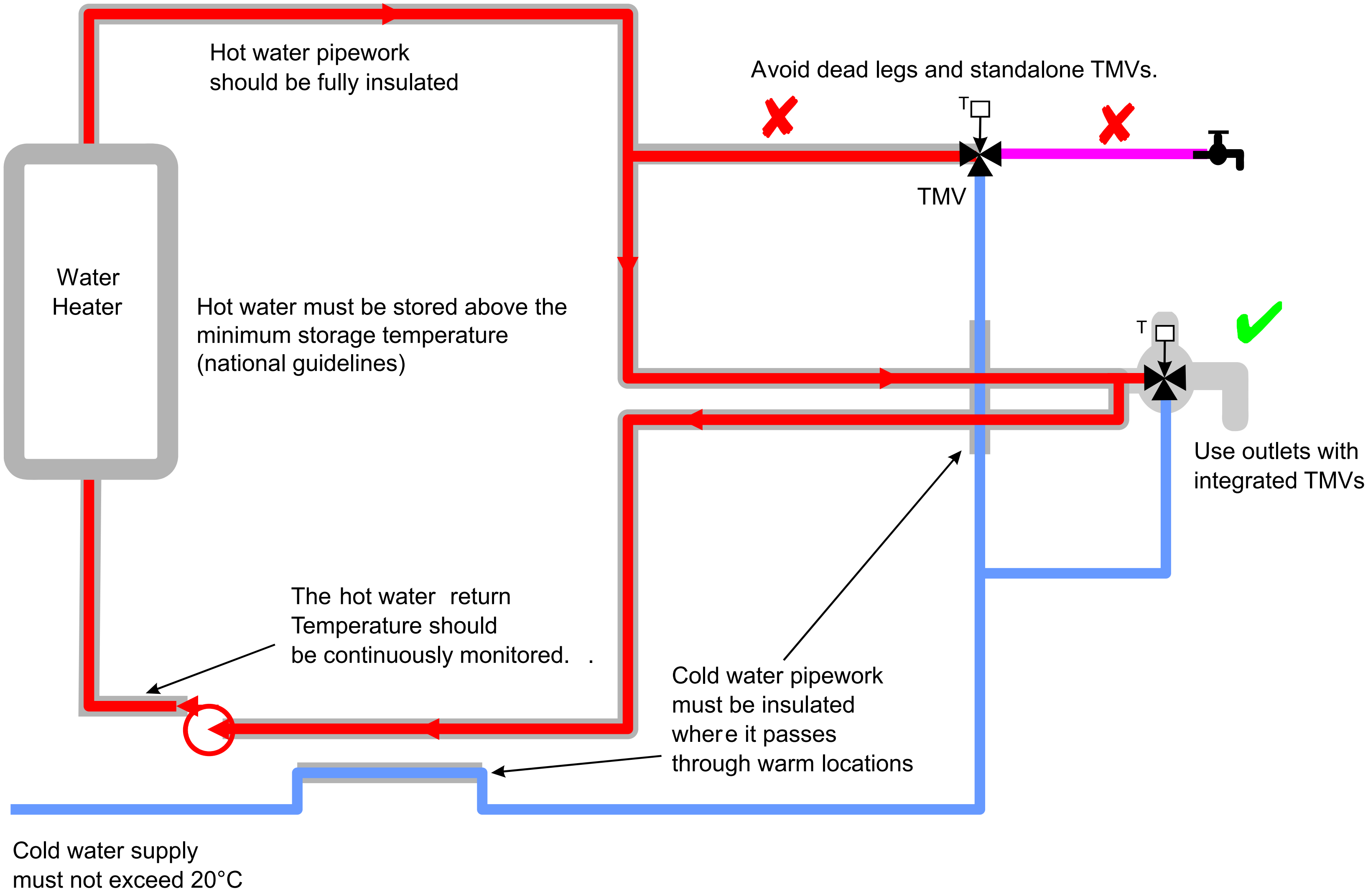
The design and layout of pipework



Circulating water temperature

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Guideline	Country	Min. Storage temp	Min. Temp at outlets	Min. Return temp
L8	UK	60°C	50°C within 1 minute	N/A
ASHRAE Guideline 12	USA	60°C	N/A	51°C
ISSO 55.1	Netherlands	60°C	60°C	60°C
W551	Germany	Not specified	55°C	55°C
WHO	International	60°C	50°C within 1 minute	50°C

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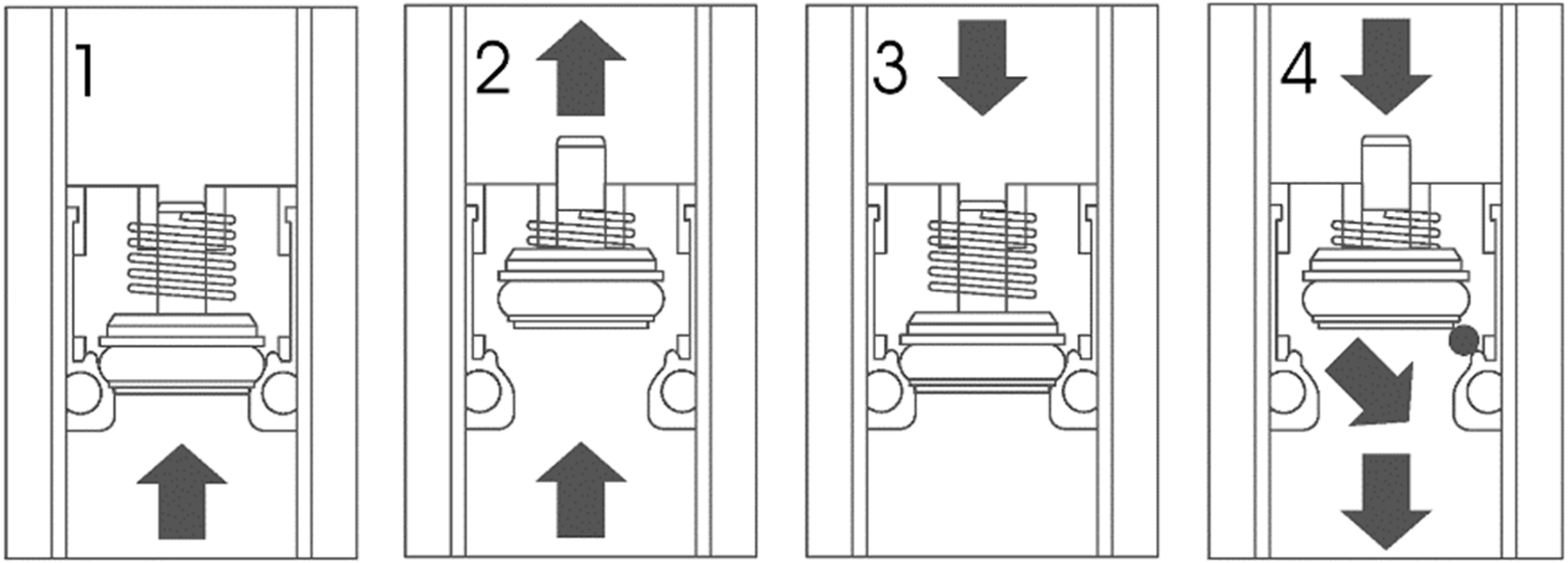
Check valves



Outlet closed: no flow

Outlet open: water flows

Higher pressure on outlet side: no backflow

Debris in valve: backflow occurs with no indication

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Choice of materials

Polymers and elastomers

National water quality standards that include
a test for resistance to microbial growth

Standard	Country	Method
BS6920	UK	MDOD
NVN1225	Netherlands	BPP
W270	Germany	SP

Anti-microbial metals

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Flushing

- Regular flushing is one of the most effective ways of minimising biofilm growth

- Flushing:

  - Stops water stagnating

  - Ejects organisms

  - Helps the system to reach temperatures that inhibit or destroy biofilms

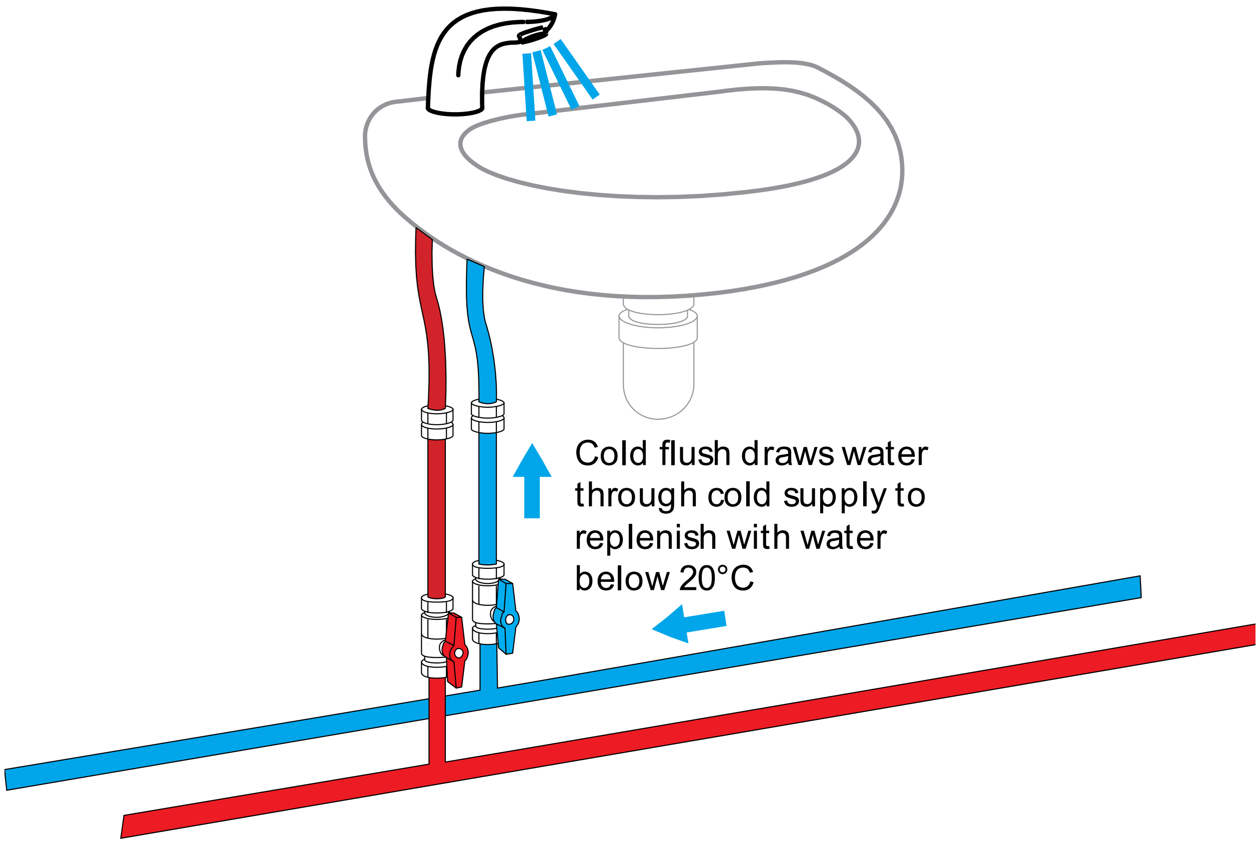
  - Ensures that chemical disinfectants can reach all parts of the system

  - Removes dead bacteria that could provide a source of nutrients for survivors

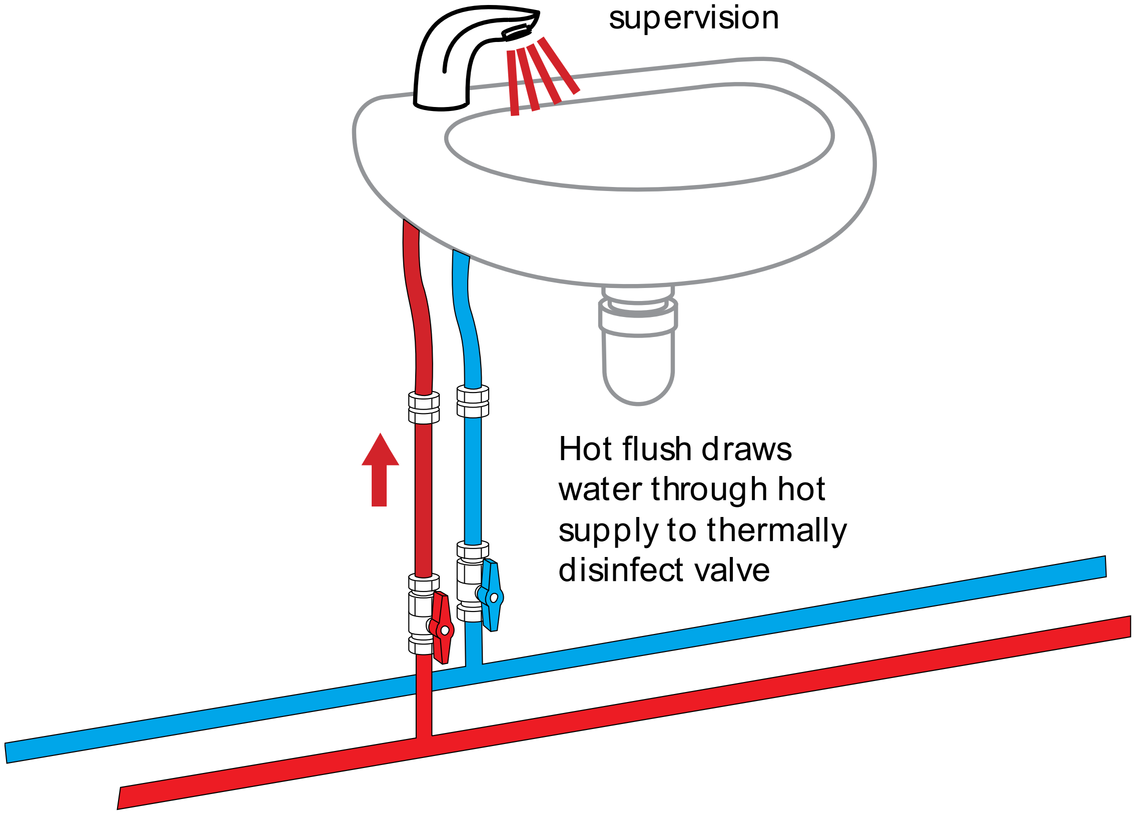
- Disadvantages:

  - May introduce fresh oxygen and nutrients to the system

Cold flushing



Thermal disinfection



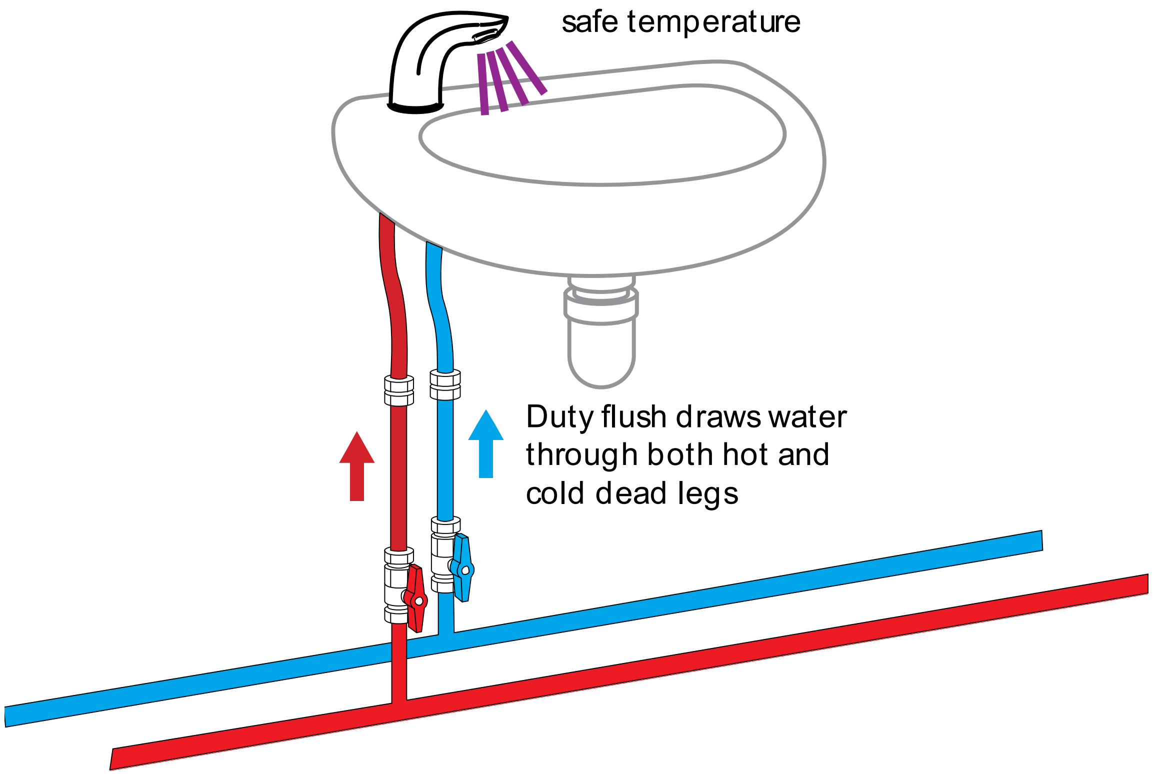
National regulations for thermal disinfection

Country	MIN. temp (°C)	MIN. time (Mins)	Time reduction
UK	60	5	No
Netherlands	60	20	65°C = 10mins 70°C = 5mins >70°C = 5mins
Belgium	60	2	65°C = 1min 70°C = 30secs >70°C = 30secs
USA	70	30	No
Germany	60	20	65ºC = 10mins 70ºC = 5mins >70ºC = 5mins

The duty flush

National guidelines for duty flush

GUIDELINE	L8	ISSO 55.1	W551
COUNTRY	UK	Netherlands	Germany
TEMPERATURE	Blend	Flush until temperature is stable	Blend
FREQUENCY	Weekly	Daily or Weekly depending on risk	At least 72 hours after last use
DURATION	Several minutes	10 seconds at stable temperature	Not specified



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Monitoring and record keeping

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7 Day Usage - Activs & T... | Duty Flush | Cold Flush | Thermal Disinfection | Temperature Check

Date	Time	Type	Duration (mm:ss)	Temp (°C)	Flow Rate (%)	Warm Up Time (mm:ss)	Cold post flush (mm:ss)	Status	Reason
25/04/2016	14:45	Standard	01:00	39.0	100.0	00:30	00:00	✗	Fail, no hot
24/04/2016	14:45	Standard	01:00	39.0	100.0	00:30	00:00	✓	Pass
23/04/2016	14:45	Standard	01:00	39.0	100.0	00:30	00:00	✓	Pass
22/04/2016	14:45	Standard	01:00	39.0	100.0	00:30	00:00	✓	Pass
21/04/2016	14:45	Standard	01:00	39.0	100.0	00:30	00:00	✗	Fail, no hot
20/04/2016	14:45	Standard	01:00	39.0	100.0	00:30	00:00	✓	Pass
20/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✗	Fail, no hot
19/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✗	Fail, no hot
18/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✗	Fail, no hot
18/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
17/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
17/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✗	Fail, no flow
16/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
16/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
15/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✗	Fail, user cancelled
15/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✗	Fail, no hot
14/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
13/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
13/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
12/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
12/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
11/04/2016	13:41	Standard	03:00	39.0	100.0	01:00	00:00	✗	Fail, user cancelled
11/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
10/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
10/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
09/04/2016	14:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
09/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass
08/04/2016	02:00	Standard	03:00	39.0	100.0	01:00	00:00	✓	Pass

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Outlet valve design principles

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- Reduce the wetted surface area and the internal water volume. This puts limits on both the number of potential bacteria and the opportunities for them to adhere to a surface.

- Keep flow velocities high. Bacteria need to be in good contact with a surface as they adhere. High water velocities help deny the opportunity for this to take place and prevent the formation of long/loose biofilms that can then easily slough off in large chunks.

- Eliminate stagnant areas within the waterway. The internal volume of the outlet must be flushed completely on every use.

- Use materials that reduce the risk of biofilm development within the valve.

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Idealised outlet control valve

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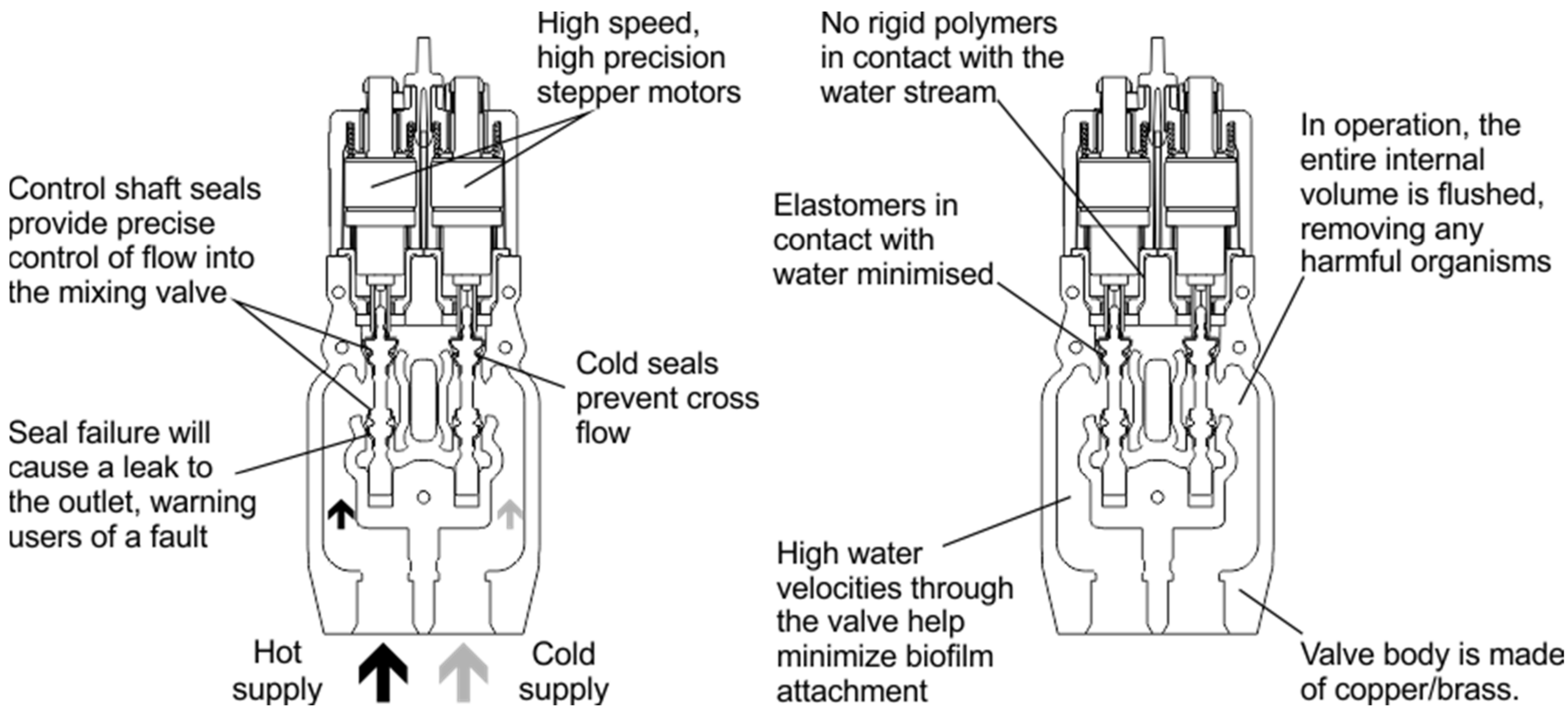

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Conclusion:
some general principles for water system design

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1. The pipework must be installed in a way that minimises the growth of biofilms, both in the choice of materials and in the layout of pipe runs.

2. The layout and equipment must facilitate regular flushing of both hot and cold water systems.

3. As far as possible, the pipework and valves must be constructed from biofilm resistant materials. Metals should be used for water contact parts wherever possible, and any polymers used should comply with the toughest national water quality standards that include a test for the ability to support microbial growth.

4. Control measures, such as duty flushing, as required by national guidelines (or identified through risk assessment) should be consistently applied and monitored.

5. Internal channels of valves must be designed to minimise stagnation and maximise flow velocities. They should present the minimum possible wetted surface area and have the minimum internal water volume.

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Thank you

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