REVIEW OF WATER QUALITY
AFTER STORAGE

COMPARISON OF VENTED AND UN-VENTED
DOMESTIC HOT WATER SYSTEMS

Ref: SLS/W21333

Submitted to:

Drinking Water Inspectorate
Room B148
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43 Marsham Street
London SW1P 3PY

Date of Issue:
8 March 1993
EXECUTIVE SUMMARY

The Water Quality Centre was invited to undertake a review of water quality within vented and un-vented hot water systems. The purpose of the investigation was to highlight any potential for deterioration of water quality within the cold water supply, hot water storage and hot water distribution associated with each of these systems.

A total of 99 samples were taken from 10 vented hot water systems and 10 un-vented hot water systems located in commercial and domestic premises.

No Legionellae, coliforms, *Escherichia coli*, or *Pseudomonas aeruginosa* were detected in any of the samples analysed.

At one site *Aeromonas* bacteria were detected in very low concentrations from a soft water storage cistern (1 per 100ml) and hot water outlet (2 per 100ml).

No significant increases in bacterial numbers (as measured by bacterial colony counts at 22°C and 37°C) were detected from any of the 10 vented systems examined.

Increases in bacterial numbers were detected in 4 of the 10 un-vented systems examined. These increases could be explained by observed design failings of these systems (eg. long runs of unlagged pipework, insufficient hot water temperatures, stratification within calorifiers).

One of the aims of the project was to determine the effect, if any, of the use of expansion vessels within un-vented systems. A slight deterioration in bacterial quality was noted from a sample taken from an expansion vessel fitted to the cold feed to an un-vented calorifier system, although the actual numbers of bacteria detected do not give cause for concern.

The generally satisfactory bacteriological quality of water samples taken may be due to the following reasons:

Water systems within domestic premises generally have a high turnover of water and hot water cylinders are generally set above 50°C.

The increased awareness of the requirement for legionellosis prevention measures in commercial premises means that conditions which permit deterioration of water quality are less likely to be found within such systems.

If a further study of the effect of expansion vessels (or other water system components) on water quality is to be undertaken, consideration should be given to monitoring a small number of sites containing such components over a longer period of time.
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1.0 INTRODUCTION

At the request of the Drinking Water Inspectorate, the Water Quality Centre undertook a survey of water quality within unvented and vented domestic hot water systems. Ten systems of each type were examined. The work was undertaken in line with specifications laid down in DWI correspondence "Proposed Consultancy: Review of Microbiological Quality After Storage" dated 4th November 1993.

2.0 PROJECT OVERVIEW

2.1 Aims

To determine the consequences of cold water storage and cold water supply pipework configuration to vented and unvented hot water systems, with regard to the potential for deterioration of bacteriological quality of water within such systems.

The project involved collection of water samples from representative points from ten unvented hot water systems and ten vented hot water systems. Identical analysis was undertaken on each sample and results of analysis interpreted accordingly.

2.2 Sites

Ten separate sites containing vented hot water systems and ten sites containing unvented hot water systems were chosen by The Water Quality Centre (WQC). Sites were chosen from a range of commercial and domestic sites and are summarised below:

<table>
<thead>
<tr>
<th>VENTED SYSTEMS</th>
<th>Reference</th>
<th>UNVENTED SYSTEMS</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Property</td>
<td>V/1</td>
<td>Depot Building</td>
<td>UV/1</td>
</tr>
<tr>
<td>Domestic Property</td>
<td>V/2</td>
<td>Depot Building</td>
<td>UV/2</td>
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<tr>
<td>Depot Building</td>
<td>V/3</td>
<td>Laboratory</td>
<td>UV/3</td>
</tr>
<tr>
<td>Domestic Property</td>
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<td>Office Building</td>
<td>UV/4</td>
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<td>Office Building</td>
<td>V/5</td>
<td>Hotel</td>
<td>UV/5</td>
</tr>
<tr>
<td>Laboratory</td>
<td>V/6</td>
<td>Office Building</td>
<td>UV/6</td>
</tr>
<tr>
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<td>Office Building</td>
<td>UV/7</td>
</tr>
<tr>
<td>Hotel</td>
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</tr>
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<td>Office Building</td>
<td>V/9</td>
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</tr>
<tr>
<td>Prison Building</td>
<td>V/10</td>
<td>Office Building</td>
<td>UV/10</td>
</tr>
</tbody>
</table>
2.3 Sampling and Analysis

Samples were taken from representative sample points from each system examined. The sample points were chosen to enable the source of any deterioration in water quality within systems to be identified.

Full details of the sampling protocol followed are given in Appendix A of this report.

All samples taken were analysed for the following determinands:

- Bacterial Colony Counts at 22°C, 72 hrs - cfu/ml
- Bacterial Colony Counts at 37°C, 48 hrs - cfu/ml
- Coliforms - /100ml
- *Escherichia coli* - /100ml
- *Pseudomonas aeruginosa* - /100ml
- Aeromonads - /100ml
- Legionellae - cfu/l

Certificates of Analysis for each system from which samples were taken are provided in Appendix B.
3.0 DISCUSSION

A total of 99 samples were taken from twenty domestic hot water systems in total. No coliforms, *Escherichia coli*, *Pseudomonas aeruginosa* or Legionella bacteria were detected from any of the samples.

*Aeromonas* bacteria were detected in very low numbers from one vented system examined (V/8). These organisms were detected in the samples taken from a soft water storage cistern (1 per 100ml) and a domestic hot water outlet (2 per 100ml). No aeromonads were detected from any of the other samples taken. The very low numbers of bacteria detected do not permit confident speculation as to the source of *aeromonas* contamination within the system, although it is noted that they were detected in hot water at a temperature of 55°C.

Given the absence of pathogens and/or faecal indicator organisms detected in all other samples, interpretation of any possible deterioration on water quality is considered with respect to changes in bacterial colony counts at 22°C and 37°C.

For the purposes of this discussion, a significant deterioration in water quality is defined as a greater than ten-fold increase in bacterial numbers over that observed in the incoming mains supply reference sample. Discussion of bacterial colony count analysis, with respect to vented and un-vented systems examined is given below:

**Vented Systems**

Of the ten systems examined (V/1 to V/10), no significant increase in bacterial numbers was detected in sequential samples taken from the reference sample to the calorifier drain.

At one site (V6) an extra sample was taken from a domestic hot water outlet which characteristically failed to deliver hot water at temperatures greater than 50°C. Bacterial colony counts detected from this sample were very high (7,000 cfu/ml [22°C] and 5,400 cfu/ml [37°C]). This outlet was supplied from a long leg of pipework and was rarely used. Deterioration of water quality within this leg of pipework would be expected to occur given these observations. Numbers of bacteria detected in a sample taken from another domestic hot water outlet were satisfactorily low.

**Un-vented Systems**

Of the ten systems examined (UV/1 to UV/10), six systems (UV/1 to UV/3, UV/6, UV/7, and UV/10) showed no significant increase in bacterial numbers detected from sequential samples taken from the reference sample to the calorifier drain.

The four remaining systems contained elevated bacterial numbers in some samples and these are discussed below.

Site UV/4 showed elevated numbers of bacteria in the sample taken from the supply to a storage cistern supplying the calorifier. No sample was taken from within this cistern, due to unsafe access. Pipework supplying the cistern was unlagged and subject to warming (the cistern was located above a suspended ceiling). It is assumed that the increase in bacterial numbers observed was due to growth within the long run of pipework supplying this cistern. The bacterial quality of samples taken from the calorifier and a hot water outlet supplied from it was satisfactory.
Site UV5 showed a slight increase in bacterial numbers from a sample taken from the base of the expansion vessel fitted to the cold feed to the calorifier. Although, the numbers of bacteria detected were not alarmingly high, this observation may suggest some potential for deterioration of the quality of water held within this expansion vessel.

Site UV8 revealed an unusually high 37°C colony count (19,000 cfu/ml) from a sample taken from a mains water break cistern. This result cannot be explained as bacterial numbers detected from samples taken from a storage cistern supplied from this break cistern were significantly lower.

Site UV9 revealed high numbers of bacteria (4,200 cfu/ml [37°C]) present in the sample taken from the calorifier drain. Numbers of bacteria detected in a subsequent hot water sample supplied from this calorifier were satisfactorily low.

4.0 CONCLUSIONS

This study has not revealed any clear evidence of significant deterioration of water quality that can be attributed to the components of either vented or un-vented domestic hot water systems.

Where increases in bacterial numbers within systems supplying domestic hot water systems were detected, these could be explained by observed design failings of such systems (eg runs of unlagged pipework, insufficient hot water temperatures, stratification within calorifiers).

The generally satisfactory bacteriological quality of water samples taken may be due to the following reasons:

Water systems within domestic premises generally have a high turnover of water and hot water cylinders are generally set above 50°C.

The increased awareness of the requirement for legionellosis prevention measures in commercial premises means that conditions which permit deterioration of water quality are less likely to be found within such systems.

One of the aims of the project was to determine the effect, if any, of the use of expansion vessels within un-vented systems. A slight deterioration in bacterial quality was noted from a sample taken from an expansion vessel fitted to the cold feed to an un-vented calorifier system, although the actual numbers of bacteria detected do not give cause for concern.

If a further study of the effect of expansion vessels on water quality is to be undertaken, consideration should be given to monitoring a small number of sites containing such components over a longer period of time.
APPENDIX A - SAMPLING PROTOCOL

Generally, five samples were taken from each vented and unvented domestic hot water systems. The location of sample points is shown in the diagrams below:

VENTED SYSTEM
- 1 - Reference Sample
- 2 - Float Operated Valve - Storage Cistern
- 3 - Near Point Cold Water Outlet
- 4 - Calorifier Drain or Cold Feed Drain
- 5 - Near Point Hot Water Outlet

UNVENTED SYSTEM
- 1 - Reference Sample
- 2 - Float Operated Valve - Storage Cistern
- 3 - Near Point Cold Water Outlet
- 4 - Calorifier Drain or Cold Feed Drain
- 5 - Near Point Hot Water Outlet

Further notes on selection of sampling points are given overleaf.
Sample Identification

Identification of sampling points on Certificates of Analysis is by means of a number (1 to 5) corresponding to the sampling points shown on the schematics above. At some sites it was necessary to either increase or decrease the number of samples taken. Sample identification in such cases is discussed below:

Increase of Sample Numbers

Some sites contained more elaborate cold water distribution systems than those shown in the schematics above. For example, sites containing a mains break cistern and/or water softening plant.

In such cases extra samples were taken and are identified on Certificates of Analysis by the postscript letter A.

For example, in a system containing a break cistern the samples are identified as follows

- Incoming mains supply (Float operated valve to break cistern) Sample 1
- Stored water within break cistern Sample 1A
- Float operated valve to domestic cold water storage cistern Sample 2
- Stored water within domestic cold water storage cistern Sample 3
- Calorifier drain Sample 4
- Hot water outlet Sample 5

Decrease of Sample Numbers

Some unvented systems were supplied directly from a pressurised mains supply (ie no cold water storage). In such cases the samples are identified by the appropriate number corresponding to the sampling points shown on the schematics above eg:

- Incoming mains supply (Float operated valve to break cistern) Sample 1
- Calorifier drain Sample 4
- Hot water outlet Sample 5

Sampling Procedures

Samples from outlets were taken after flushing in accordance with British Standard 7592, Section 3.2.

Calorifier drain samples were taken after flushing in accordance with British Standard 7592, Section 6.2.
APPENDIX B - CERTIFICATES OF ANALYSIS
Certificate of analysis

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Contract Ref: DWI/SLS/W21333
Site Reference: V/1

Page 1 of 1

Type of System: VENTED

Building Type: Domestic Property

System Overview:
- Mains supply
- Cold water storage cistern
- Calorifier
- Domestic hot water outlets

System expansion accommodated by: Open vent from calorifier

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, diluted</th>
<th>Colony Count at 37°C for 48h, diluted</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., eflull</th>
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Sample References:
1 = Incoming mains reference sample
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - stored water
4 = Calorifier drain
5 = Domestic hot water outlet

Temperature (°C)
10
10
9
17
52

NLD = No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Milthorpe Laboratory of Thames Water Utilities,
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Contract Ref: DWI/SLS/W21333

Site Reference: V/2

Type of System: VENTED

Building Type: Domestic property

System Overview: Mains supply  
Cold water storage cistern  
Calorifier  
Domestic hot water outlets

System expansion accommodated by: Open vent from calorifier

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms /100ml</th>
<th>Enterococci coll, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
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Sample References:

1 = Incoming mains reference sample
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - stored water
4 = Calorifier drain
5 = Domestic hot water outlet

Temperature (°C)

- 1 = 8
- 2 = 8
- 3 = 10
- 4 = 12
- 5 = 48

NLD = No legionellae detected
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Contract Ref: DWI/SLS/W21333
Site Reference: V/3

Page 1 of 1

Type of System: VENTED

Building Type: Depot Building

System Overview:
Mains supply
Cold water storage cistern
Calorifier
Domestic hot water outlets

System expansion accommodated by: Open vent from calorifier

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia col, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cult</th>
<th>Temperature [°C]</th>
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</table>

Sample References:

1 = Incoming mains reference sample
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - stored water
4 = Calorifier drain
5 = Domestic hot water outlet

NLD = No legionellae detected
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Contract Ref: DWI/SLS/W21333  
Site Reference: V/4

Type of System: VENTED

Building Type: Domestic property

System Overview: Mains supply  
Cold water storage cistern  
Calorifier  
Domestic hot water outlets

System expansion accommodated by: Open vent from calorifier

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 32°C for 72h, ch model</th>
<th>Colony Count at 37°C for 48h, ch model</th>
<th>Coliform Organisms</th>
<th>Escherichia coli</th>
<th>Aeromonas</th>
<th>Pseudomonas aeruginosa</th>
<th>Legionella spp., cfu/l</th>
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Sample References:
1 = Incoming mains reference sample  
2 = Cold water storage cistern - float operated valve  
3 = Cold water storage cistern - stored water  
5 = Domestic hot water outlet

Temperature (°C)
1 = 9  
2 = 9  
3 = 9  
5 = 54

NLD = No legionella detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analyses undertaken at the Millharbour Laboratory of Thames Water Utilities, Great Eastern Enterprise Centre, 9 Millharbour, Isle of Dogs, London, E14 9XP.
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Certificate of analysis

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Contract Ref: DWI/SLS/W21333
Site Reference: V/5
Page 1 of 1

Type of System: VENTED
Building Type: Offices
System Overview: Mains supply
Cold water storage cistern
Immersion heater cylinder
Domestic hot water outlets
System expansion accommodated by: Open vent from cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 24h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms /100ml</th>
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Sample References:

1 = Incoming mains reference sample
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - nearest outlet supplied from cistern
4 = Immersion heater cylinder drain valve
5 = Domestic hot water outlet

Temperature (°C)

<table>
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<td>39</td>
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<tr>
<td>5</td>
<td>57</td>
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NLD = No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Millharbour Laboratory of Thames Water Utilities, Great Eastern Enterprise Centre, 3 Millharbour, Isle of Dogs, London, E14 9XP.
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London SW1P 3PY

Contract Ref: DWI/SLS/W21333
Site Reference: V/6

Type of System: VENTED
Building Type: Laboratory Building
System Overview:
- Mains supply
- Cold water storage cistern
- Water softener
- Direct gas fired cylinder
- Domestic hot water outlets

System expansion accommodated by: Open vent from cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, colony forming units (cfu)</th>
<th>Colony Count at 37°C for 48h, colony forming units (cfu)</th>
<th>Coliform Organisms, /100ml</th>
<th>Enterococci, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., colony forming units (cfu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

Sample References:
1 = Incoming mains reference sample
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - nearest outlet supplied from cistern
4 = Cold feed to gas fired heater (post softener)
5a = Domestic hot water outlet (23°C)
5b = Domestic hot water outlet (68°C)

Temperature (°C):

9 = 1
10 = 2
11 = 3
24 = 4
23 = 5a
68 = 5b

NLD - No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Millharbour Laboratory of Thames Water Utilities, Great Eastern Enterprise Centre, 3 Millharbour, Isle of Dogs, London, E14 9XP.
Certificate of analysis

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Drinking Water Inspectorate  
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Contract Ref: DWI/SLS/W21333  
Site Reference: V/7  

Page 1 of 1

Type of System: VENTED

Building Type: Domestic property

System Overview: Mains supply
Cold water storage cistern
Immersion heater cylinder
Domestic hot water outlets

System expansion accommodated by: Open vent from cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cfu/l</th>
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</thead>
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</tbody>
</table>

Sample References:
1 = Incoming mains reference sample
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - stored water
5 = Domestic hot water outlet

Temperature (°C)

- 8
- 11
- 10
- 64

NLD = No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Millthorp Laboratory of Thames Water Utilities, Great Eastern Enterprise Centre, 3 Millthorpe, Isle of Dogs, London, E14 9XP.
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Contract Ref: DWI/SLS/W21333
Site Reference: V/8

Page 1 of 1

Type of System: VENTED
Building Type: Hotel
System Overview: Mains supply
Water softener
Soft water break cistern
Cold water storage cistern
Calorifier
Domestic hot water outlets

System expansion accommodated by: Open vent from cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, chl/100ml</th>
<th>Colony Count at 37°C for 48h, chl/100ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Enterobacteria count, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cult</th>
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</thead>
<tbody>
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<td>2</td>
<td>0</td>
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</tr>
</tbody>
</table>

Sample References:
1 = Incoming mains reference sample
1a = Soft water break cistern - float operated valve
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - stored water
4 = Calorifier drain sample
5 = Domestic hot water outlet

Temperature (°C)
7
7
6
8
57
55

NLD – No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Millharbour Laboratory of Thames Water Utilities, Great Eastern Enterprise Centre, 3 Millharbour, Isle of Dogs, London, E14 9XP, B9
Certificate of analysis

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Contract Ref: DWI/SLS/W21333
Site Reference: V/9

Type of System: VENTED
Building Type: Office
System Overview: Mains supply
Break cistern and booster set
Cold water storage cistern
Calorifier
Domestic hot water outlets
System expansion accommodated by: Open vent from cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cfu/l</th>
<th>Temperature (°C)</th>
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<tbody>
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</table>

Sample References:
1 = Incoming mains reference sample
1a = Basement break cistern - stored water
2 = Cold water storage cistern - float operated valve
3 = Cold water storage cistern - stored water
5 = Domestic hot water outlet
5a = Domestic hot water outlet

NLD = No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Millharbour Laboratory of Thames Water Utilities,
Great Eastern Enterprise Centre, 3 Millharbour, Isle of Dogs, London, E14 9XF. B10
Certificate of analysis

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Contract Ref: DWI/SLS/W21333  
Site Reference: V/10

Page 1 of 1

Type of System: VENTED
Building Type: Prison
System Overview: Mains supply  
Cold water storage cistern  
Calorifier  
Domestic hot water outlets
System expansion accommodated by: Open vent from cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, chilled</th>
<th>Colony Count at 37°C for 48h, chilled</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., chill</th>
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</thead>
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</tr>
</tbody>
</table>

Sample References:
1 = Incoming mains reference sample  
2 = Cold water storage cistern - float operated valve  
3 = Cold water storage cistern - stored water  
4 = Calorifier drain sample  
5 = Domestic hot water outlet

Temperature (°C):
1 = 10  
2 = 10  
3 = 11  
4 = 27  
5 = 50

NLD = No legionellae detected

For The Water Quality Centre  
Date of Issue: 7 March 1993

All analyses undertaken at the Millharbour Laboratory of Thames Water Utilities, Great Eastern Enterprise Centre, 3 Millharbour, Isle of Dogs, London, E14 9XP. B11
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Contract Ref: DWI/SLS/W21333

Site Reference: UV/1

Page 1 of 1

Type of System: UNVENTED

Building Type: Depot and Offices

System Overview: Mains supply
Cold water storage cistern
Calorifier
Domestic hot water outlets

System expansion accommodated by: Cold feed to cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, colony</th>
<th>Colony Count at 37°C for 48h, colony</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., colony</th>
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</thead>
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Sample References:
1 = Incoming mains reference sample
3 = Cold water storage cistern - stored water
4 = Calorifier drain
5 = Domestic hot water outlet

Temperature (°C)

10
12
31
56

NLD = No Legionella detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Millharbour Laboratory of Thames Water Utilities,

The Water Quality Centre is part of Thames Water Utilities Limited
Registered in England and Wales No 2366891
Registered Office Auger House Eastern Road Reading RG1 8CB
Part of Thames Water plc Group
M S Smith
Drinking Water Inspectorate
Room B461
Romney House
43 Marsham Street
London SW1P 3PY

Type of System: UNVENTED

Building Type: Depot and Offices

System Overview:
- Mains supply
- Calorifier
- Domestic hot water outlets

System expansion accommodated by: Expansion vessels on mains supply to calorifier

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cfu/l</th>
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</thead>
<tbody>
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</table>

Sample References:
1 = Incoming mains reference sample
4 = Calorifier drain
5 = Domestic hot water outlet

Temperature (°C)
9
26
59

NLD = No Legionella detected

For The Water Quality Centre
Date of issue: 7 March 1993
Type of System: UNVENTED
Building Type: Laboratory
System Overview:
Cold water storage cistern
Calorifier
Domestic hot water outlets
System expansion accommodated by: Expansion vessel on flow from calorifier

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cfu/ml</th>
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Sample References:
1 = Incoming mains reference sample
2 = Cold water storage cistern - float operated valve
3 = cold water storage cistern - stored water
4 = Calorifier drain
5 = Domestic hot water outlet

Temperature (°C)

9
6
7
38
42

NLD = No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993
Type of System: UNVENTED

Building Type: Offices

System Overview:
- Mains supply
- Cold water storage cistern
- Immersion heater cylinder
- Domestic hot water outlets

System expansion accommodated by: Expansion vessel on cold feed to cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cfu/l</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Sample References:
- 1 = Incoming mains reference sample
- 2 = Cold water storage cistern - float operated valve
- 4 = Calorifier drain
- 5 = Domestic hot water outlet

Temperature (°C):
- 10
- 16
- 20
- 80

NLD - No legionella detected
Certificate of analysis

M S Smith  
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Room B461  
Romney House  
43 Marsham Street  
London SW1P 3PY

Contract Ref: DWI/SLS/W21333  
Site Reference: UV/5

Type of System: UNVENTED

Building Type: Hotel

System Overview:
- Mains supply
- Water softener
- Soft water break cistern
- Cold water storage cistern
- Calorifier
- Domestic hot water outlets

System expansion accommodated by: Expansion vessel on cold feed to cylinder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Oodinium Occurrence, %</th>
<th>Escherichia coli, MPN/100ml</th>
<th>Aeromonas, MPN/100ml</th>
<th>Pseudomonas aeruginosa, MPN/100ml</th>
<th>Legionella spp., cfu</th>
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Sample References:

1 = Incoming mains reference sample  
1a = Soft water break cistern - float operated valve  
2 = Cold water storage cistern - float operated valve  
3 = Cold water storage cistern - stored water  
4a = Expansion vessel on cold feed - sample point at base of unit  
4 = Calorifier drain sample  
5 = Domestic hot water outlet

Temperature (°C):

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NLD - No legionella detected

For The Water Quality Centre  
Date of Issue: 7 March 1993
M S Smith  
Drinking Water Inspectorate  
Room B461  
Romney House  
43 Marsham Street  
London SW1P 3PY  

Contract Ref: DWI/SLS/W21333  
Site Reference: UV/6  

Type of System: UNVENTED  
Building Type: Office  
System Overview:  
- Mains supply  
- Cold water storage cistern  
- Calorifier  
- Domestic hot water outlets  

System expansion accommodated by: Cold feed from to calorifier  

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 24h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>E. coli/100ml</th>
<th>Aeromonas, /100ml</th>
<th>Pseudomonas aeruginosa, /100ml</th>
<th>Legionella spp., cfu/l</th>
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Sample References:  
1 = Incoming mains reference sample  
2 = Cold water storage cistern - float operated valve  
3 = Cold water storage cistern - stored water  
4 = Calorifier drain  
5 = Domestic hot water outlet  

Temperature (°C)  
- 1 = 8  
- 2 = 8  
- 3 = 9  
- 4 = 52  
- 5 = 60  

NLD = No legionellae detected  

For The Water Quality Centre  
Date of Issue: 7 March 1993  

All analysis undertaken at the Millharbour Laboratory of Thames Water Utilities,  
Great Eastern Enterprise Centre, 3 Millharbour, Isle of Dogs, London, E14 9XP.
Certificate of analysis

M S Smith
Drinking Water Inspectorate
Room B461
Romney House
43 Marsham Street
London SW1P 3PY

Contract Ref: DWI/SLS/W21333
Site Reference: UV/7

Page 1 of 1

Type of System: UNVENTED
Building Type: Office
System Overview:
Mains supply
Basement break cistern and booster set
Calorifier
1 lot water outlets
System expansion accommodated by: Expansion vessel on cold feed

<table>
<thead>
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<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, 1/100ml</th>
<th>Escherichia coli, 1/100ml</th>
<th>Aeromonas, 1/100ml</th>
<th>Pseudomonas aeruginosa, 1/100ml</th>
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Sample References:
1 = Basement break cistern - float operated valve (reference sample)
2 = Basement break cistern - stored water
4 = Calorifier drain
5 = Domestic hot water outlet

Temperature (°C)
1 = 10
2 = 11
4 = 40
5 = 60

For The Water Quality Centre
Date of Issue: 7 March 1993

NLD = No legionella detected
M S Smith
Drinking Water Inspectorate
Room B461
Romney House
43 Marsham Street
London SW1P 3PY

Contract Ref: DWI/SLS/W21333
Site Reference: UV/8

Type of System: UNVENTED

Building Type: Office

System Overview:
Mains supply
Basement break cistern and booster set
Cold water storage cistern
Calorifier
Hot water outlets

System expansion accommodated by: Expansion vessel on cold feed

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, col/100ml</th>
<th>Colony Count at 37°C for 48h, col/100ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
<th>Aeromonas, /100ml</th>
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Sample References:

1 = Basement break cistern - float operated valve (reference sample)
2 = Domestic cold water storage cistern - float operated valve
3 = Domestic cold water storage cistern - stored water
4 = Post heat exchanger
5 = Domestic hot water outlet

Temperature (°C):

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Temperature (°C)</th>
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NLD = No Legionella detected

For The Water Quality Centre
Date of Issue: 7 March 1993

All analysis undertaken at the Millharbour Laboratory of Thames Water Utilities, Great Eastern Enterprise Centre, 3 Millharbour, Isle of Dogs, London, E14 9XP, B19
Certificate of analysis

M S Smith
Drinking Water Inspectorate
Room B461
Romney House
43 Marsham Street
London SW1P 3PY

Type of System: UNVENTED
Building Type: Office
System Overview: Mains supply
Raw water break cistern serving whole building
Calorifier
Hot water outlets

System expansion accommodated by: Cold feed to calorifiers

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 72h, cfu/mL</th>
<th>Colony Count at 37°C for 48h, cfu/mL</th>
<th>Coliform Organisms, 1/100ml</th>
<th>Escherichia coli, 1/100ml</th>
<th>Aeromonas, 1/100ml</th>
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Sample References:
1 = Break cistern - float operated valve (reference sample)
2 = Break cistern - stored water
3 = Calorifier
4 = Domestic hot water outlet

Temperature (°C):
1 = 10
2 = 10
3 = 50
4 = 68

NLD = No legionellae detected

For The Water Quality Centre
Date of Issue: 7 March 1993
M S Smith  
Drinking Water Inspectorate  
Room B461  
Romney House  
43 Marsham Street  
London SW1P 3PY  

Contract Ref: DWI/SLS/W21333  
Site Reference: UV/10

Type of System: UNVENTED
Building Type: Office
System Overview: Mains supply  
Mains water break cistern and booster set  
Cold water storage cistern  
Calorifier  
Hot water outlets
System expansion accommodated by: Expansion vessel on cold feed

<table>
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<tr>
<th>Sample Point</th>
<th>Sample Number</th>
<th>Colony Count at 22°C for 24h, cfu/ml</th>
<th>Colony Count at 37°C for 48h, cfu/ml</th>
<th>Coliform Organisms, /100ml</th>
<th>Escherichia coli, /100ml</th>
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Sample References:

1 = Break cistern - float operated valve (reference sample)  
1a = Break cistern - stored water  
2 = Domestic cold water storage cistern - float operated valve  
3 = Domestic cold water storage cistern - stored water  
4 = Calorifier drain  
5 = Domestic hot water outlet

Temperature (°C):

1 = Break cistern - float operated valve (reference sample)  
10
1a = Break cistern - stored water  
10
2 = Domestic cold water storage cistern - float operated valve  
8
3 = Domestic cold water storage cistern - stored water  
8
4 = Calorifier drain  
70
5 = Domestic hot water outlet  
64

For The Water Quality Centre  
Date of Issue: 7 March 1993

NLD = No legionella detected