Why disinfect?
Which method do I use?

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(Revision C)

Abstract

In this thesis I am going to investigate whether or not disinfecting pipework which carries potable water is really necessary, hence the title of my thesis - Why Disinfect? Which method do I use?

During this thesis, I will be investigating,

- Reasons for disinfection
- Types of bacteria found in water
- Local water board regulations and guidelines
- Methods of disinfection & which method is most effective / practical

I am performing this investigation as I hope to attain a good understanding of the disinfection process, and hopefully be competent enough to perform disinfection if necessary.

I obviously know that disinfection of potable water systems is vital, but I wanted to know which method is most effective / practical to irradiate water borne bacteria.

To come to a conclusion, I will look at water borne bacteria, water board guide lines, and types of disinfection. Then I will cross reference the different methods, and decide upon which method is most effective / practical for the process of disinfection.

Ultimately I feel this is a worthy subject as the conclusion will further my personal understanding of the whole disinfection process, and hopefully this will be of benefit to my career.

Contents

Section 1: Reasons for disinfection

1.1

Introduction

In this section I will investigate why disinfection of potable water pipework is so important, and what could happen if it is not carried out.

Basically there are two standards that relate directly to disinfection of systems, they are BS 6700 which refers to new installations and HS(G)70 which deals with the control of Legionella and legionnaires disease.

BS 6700 : 2006 states that new installations should be disinfected and this standard details the oxidising agent and contact times to be used.

The HSE – Legionnaires' Disease, The control of Legionella bacteria in water systems, (Previously HS(G)70) is an ongoing disinfection schedule that details a risk assessment and disinfection of all water systems that may harbour Legionella or other water borne bacteria. While these standards are not law in Ireland it is considered good practice to disinfect any system that may lead to an outbreak of Legionnaires disease which, could prove costly to a company who had not taken sufficient measures to reduce the risk of exposure to their employees. This document also provides us with a breakdown of the health & safety law.

1.2

H.S.E - Health & Safety Law

Duties and actions required by the H.S.E are extensive, I have bullet-pointed the most relevant, and these are as follows:

- All operatives must have access to a risk assessment & method statement prior to any works.
- All operatives must have access to COSHH data to control the risk of the substance used, and to provide actions to be taken in the event of a emergency e.g spillage.
- All operatives to be trained and competent in the use of equipment and substances.
- All accidents, injuries, or dangerous occurrences must be reported to the H.S.E for their records, and for possible investigation.
- Employers must register any "notable devices" e.g cooling towers, and dry air coolers with the local water authority.
- Employers must consult employees or employee's representatives of any changes to their works that may affect their health and safety at work.

(See appendices A - Health & Safety Law)

Section 2: Examples of bacteria found in water

2.1

Legionella:

Legionellosis is an infectious disease caused by bacteria belonging to the genus Legionella. Over 90% of legionellosis cases are caused by Legionella pneumophila, an ubiquitous aquatic organism that thrives in warm environments (25 to 45 °C with an optimum around 35 °C).
Legionellosis takes two distinct forms:
Legionnaires' disease is the more severe form of the infection and produces pneumonia.

Pontiac fever is caused by the same bacterium, but produces a milder respiratory illness without pneumonia which resembles acute influenza.[4]

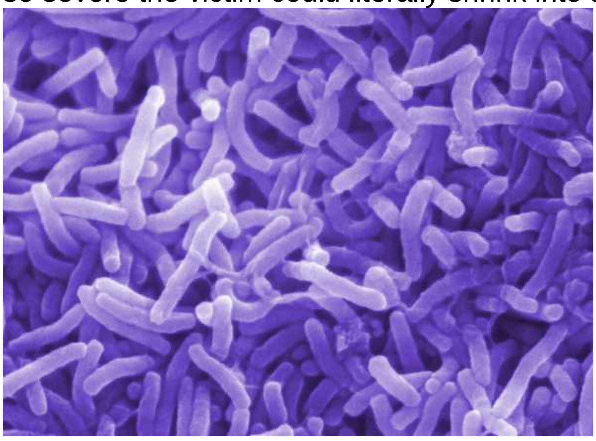
Legionnaires' disease acquired its name in July 1976 when an outbreak of pneumonia occurred among people attending a convention of the American Legion in Philadelphia. On January 18, 1977 the causative agent was identified as a previously unknown bacterium, subsequently named Legionella.
An estimated 8,000 to 18,000 people get legionellosis in the United States each year. Some people can be infected with the Legionella bacterium and have only mild symptoms or no illness at all.

Outbreaks of Legionnaires' disease receive significant media attention. However, this disease usually occurs as a single, isolated case not associated with any recognized outbreak. When outbreaks do occur, they are usually recognized in the summer and early autumn, though cases may occur at any time of year. The fatality rate of Legionnaires' disease has ranged from 5 to 30% during various outbreaks.
Legionellosis infection occurs after inhaling water droplets that originated from a water source contaminated with Legionella. It must be inhaled through a fine aerosol of tiny water droplets that are strung with the bacteria. (It is often thought that a water spray is an aerosol but in fact the water droplets involved are very tiny and evaporate very quickly leaving only a dry nucleus which is invisible to the naked eye but can be inhaled into the lungs.) This often occurs in poorly ventilated areas such as prisons where a condensating air conditioner can spread it throughout the entire room, infecting anyone not immune to the strand of bacteria. Potential sources of such contaminated water include cooling towers used in industrial cooling water systems as well as in large central air conditioning systems, evaporative coolers, hot water systems, showers, whirlpool spas, architectural fountains, room-air humidifiers, ice making machines, misting equipment, and similar disseminators that draw upon a public water supply. The disease may also be spread in a hot tub if the filtering system is defective. Freshwater ponds, creeks, and ornamental fountains are also potential sources of Legionella. Also Legionella will grow in water at temperatures from 20 °C to 50 °C (68 °F to 122 °F). However, the bacteria reproduce at the greatest rate in stagnant water at temperatures of 35 °C to 46 °C (95 °F to 115 °F).

2.2

Cholera:

The diarrhea associated with cholera is acute and so severe that, unless oral rehydration therapy is started promptly, the diarrhea may within hours result in severe dehydration (a medical emergency), or even death.
According to novelist Susan Sontag, cholera was more feared than some other deadly diseases because it dehumanized the victim. Diarrhea and dehydration were so severe the victim could literally shrink into a wizened caricature of his or her former self before death.
Other symptoms include rapid dehydration, rapid pulse, dry skin, tiredness, abdominal cramps, nausea, and vomiting.
Traditionally, Cholera was widespread throughout third world countries, however more recently



outbreaks have occurred in more rural parts of England and the United States' mid-west region.
All water used for drinking, washing, or cooking should be sterilised by boiling or chlorination in any area where cholera may be present.
Boiling, filtering, and chlorination of water kill the bacteria produced by cholera patients and prevent infections from spreading. Water filtration, chlorination, and boiling are by far the most effective means of halting transmission.

Section 3: Methods of disinfection

Sodium hypochlorite:

3.1

A Basic Example

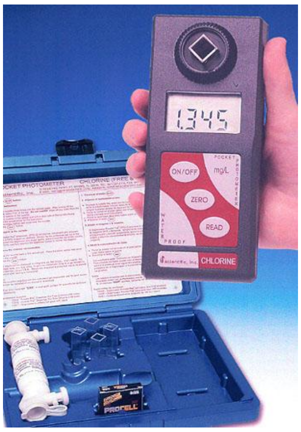
Sodium hypochlorite will be introduced into the water course, either by injecting into the incoming M.C.W supply, or by diluting into the cold water storage tank.
The solution will then be pulled to all outlets, until 50ppm of sodium hypochlorite is detected, and then left for a 1 hour contact period.
After the 1 hour contact period, the outlets will be again tested, this time a minimum of 30ppm sodium hypochlorite is required. If 30ppm+ is detected, the solution can then be flushed from the system. If there is below 30ppm, then the process must be repeated in order to achieve a successful process.
Samples must then be taken and submitted to an independent laboratory for testing.

(See appendices B - *Internal Chlorination using Sodium Hypochlorite, a detailed example*)

3.2

Equipment required

Method statement
COSHH Data
Full P.P.E e.g.: safety goggles & gloves
Hoses & Associated Couplings
Mechanical Hand Tools
Spill Kits
Sodium hypochlorite solution *(Fig a)*
Detection kit e.g.: photometer *(Fig b)*
Injection kit *(Fig c)*
Warning signs *(Fig d)*



(Fig a) *(Fig b)*

(Fig c)

(Fig d)

Chlorine Dioxide

3.3

A Basic Example

Chlorine Dioxide will be introduced into the water course, either by injecting into the incoming M.C.W supply, or by diluting into the cold water storage tank.
The solution will then be pulled to all outlets, until 50ppm of sodium hypochlorite is detected, and then left for a 1 hour contact period.
After the 1 hour contact period, the outlets will be again tested, this time a minimum of 30ppm chlorine dioxide is required. If 30ppm+ is detected, the solution can then be removed from the system, by means of a neutralising agent. If there is below 30ppm, then the process must be repeated in order to achieve a successful process.
Samples must then be taken and submitted to an independent laboratory for testing.

(See appendices C - *Internal Chlorination using Chlorine Dioxide, a detailed example*)

3.4

Equipment required

Method statement
COSHH Data
Full P.P.E e.g.: safety goggles, gloves & ventilator
Hoses & Associated Couplings
Mechanical Hand Tools
Spill Kits
Chlorine Dioxide Solution
Chlorine Dioxide Activating agent
Detection kit e.g.: Ph Strips

Injection kit
Warning signs

<u>Thermal Disinfection:</u>

<u>3.5</u>

<u>A Basic Example</u>

Thermal disinfection can be carried out by raising the temperature of the whole of the contents of the calorifier then circulating this water throughout the system for at least an hour. All return loops should be checked for the circulation temperature. To be effective, the temperature at the calorifier should be high enough to ensure that the temperatures at the taps and appliances do not fall below 60°C. Each tap and appliance should be run sequentially for at least five minutes at the full temperature, and this should be measured. For effective thermal disinfection the water system needs to be well insulated.

Alternatively, the circulating pipework and deadlegs / ends may be thermally disinfected by means of trace heating. As before, the system should be capable of raising temperatures of the whole distribution system to 60°C or more for at least an hour.

The risk of scalding should be considered and particular care taken to ensure that water services are not used, other than by authorised personnel, until water temperatures have dropped to their normal operating levels.

<u>3.6</u>

<u>Equipment required</u>

A Heat source e.g.: A calorifier *(Fig e)*
The D.H.W. Circulating Pump *(Fig f)*
Warning Signs
Calibrated Thermometer *(Fig g)*

(Fig e)

(Fig f)

(Fig g)

Section 4: Discussion - Which method is most effective / practical?

In this section I will analyse the advantages and disadvantages of each process. This will aid me in making my conclusion, as to which method is most effective / practical.

4.1

Advantages & Disadvantages

Sodium hypochlorite – Advantages

- Sodium hypochlorite disinfectants can reduce the level of many disease-causing microorganisms in drinking water to almost immeasurable levels
- Chlorine disinfectants reduce many disagreeable tastes and odors. Chlorine oxidizes many naturally occurring substances such as foul-smelling algae secretions, sulfides and odors from decaying vegetation
- Chlorine disinfectants eliminate slime bacteria, molds and algae that commonly grow in water supply reservoirs, on the walls of water mains and in storage tanks.
- Chlorine disinfectants destroy hydrogen sulfide (which has a rotten egg odor) and remove ammonia and other nitrogenous compounds that have unpleasant tastes and hinder disinfection. They also help to remove iron and manganese from raw water.
- Minimal chemical storage and transport, the solution is fairly cheap costing approximately £25 per 5 litre tub.

Sodium hypochlorite – Disadvantages

- Limited shelf-life
- Potential to add inorganic byproducts (chlorate,

chlorite and bromate) to water
- Corrosive to some materials and more difficult to store than most solution chemicals

Chlorine Dioxide – Advantages

- Effective against *Cryptosporidium*
- Up to five times faster than chlorine at inactivating *Giardia*
- Disinfection is only moderately affected by pH
- Will not form chlorinated byproducts (THMs, HAAs)
- Does not oxidize bromide to bromine (can form bromate in sunlight)
- More effective than chlorine in treating some taste and odor problems
- Selective oxidant used for manganese oxidation and targeting some chlorine resistant organics

Chlorine Dioxide – Disadvantages

- Inorganic byproduct formation (chlorite, chlorate)
- Highly volatile residuals
- Requires on-site generation equipment and handling of chemicals (chlorine and sodium chlorite)
- Requires a high level of technical competence to operate and monitoring equipment, product and residuals
- Occasionally poses unique odor and taste problems
- High operating cost (chlorite chemical cost is high)

Thermal Disinfection – Advantages

- Thermal treatment has the advantages that no particular equipment is required so that the procedure can be carried out immediately, provided there is sufficient heat capacity in the system to raise to 80 degrees celcius.

Thermal Disinfection – Disadvantages

- The procedure requires considerable energy and manpower and is not normally practical for large buildings, however it may be suitable for smaller systems.
- It will not disinfect downstream of thermostatic mixer valves and so is of limited value where such valves are installed.
- There is a severe risk of scalding at these temperatures.
- Although the numbers of Legionella may be reduced, recolonisation of the water system can occur from as little as a few weeks after treatment, therefore this measure would have to be carried out on a regular basis.
- Can not be used in situations as discussed in 4.2 & 4.3.
- The procedure obviously can not be carried out on the cold water service, due to the lack of a heat source, and the fact the cold water service will not have the ability to circulate (No return pipework).

4.2

Flushing post disinfection / prior to occupation

In some cases the handover / occupation date can be put back to a later date, I will now briefly discuss how each method can be used in order to maintain a disinfected system, until handover / occupancy is completed.

In cases like this I would suggest a automated injection unit to be used. This injection unit would be connected to the buildings water supply, and would inject the correct amount of chemical proportional to the water flow through the injection unit, to ensure bacterial growth does not occur.

If the DHWS has been heated to its operating temperature 55°c - 60 °c, then this temperature should never be lowered, and the circulating pump should always be left running. This will ensure all return loops have a high enough temperature to stop any bacterialogical growth.

Once the automated injection unit has been commissioned, all outlets should then be subject to a “draw off regime”. This “draw off regime” briefly consists of all outlets being ran for approximately 5 minutes, and chemical levels checked. If the chemical levels are low, then the outlet shall be ran until the automated injection unit replenishes the chemical levels in the system.

I advise the “draw off regime” should be carried out every 3 days, in order to keep a good vigil on the chemical levels. I would also advise on a tracker log to keep record of chemical levels, for a total overview of the process.

Once the handover / occupation is complete, the automated injection unit should be de-commissioned and removed. One last “draw off” should take place, but in this case to remove the residual chemical levels, and return the system to a useable state. Bacterialogical samples will then be taken, to demonstrate the systems water quality. Personally I would suggest that bacterialogical samples are taken post disinfection, and then on a 2 weekly rota, until handover / occupation. This would create a “history of samples”, this documentation can then be used to demonstrate to the end user that the domestics are safe and have been safe since the initial disinfection. This will also protect the contractor performing the disinfection in case of any future problems caused by the end users actions.

Sodium hypochlorite, and chlorine dioxide can be used in automated injection units, obviously the thermal disinfection method does not apply in this situation.

4.3

Partial disinfection

In some cases the handover / occupation can be staged / staggered, for instance half of a building may become occupied, and the other half left unoccupied I will briefly discuss how each method can be used in order to maintain a disinfected system, until handover / occupancy is totally completed.

I this case I would suggest that the unoccupied area is physically isolated from the live system, by means of isolation valves or lock shield valves, and these valves should be locked off to ensure nobody can open them.

Once it is time to perform the disinfection of the unoccupied area, sodium hyperchlorite, and chlorine dioxide can be used (As demonstrated in 3.1 and 3.3).

However because you are disinfecting a isolated section of the system, a temporary water supply will be needed, of a break tank. This will be the water supply to the isolated section.

Once the disinfection has taken place bacterialogical samples would then be taken, and the results issued to the client. If deemed safe, then the isolated area can be opened up to the live system.

Sodium hypochlorite, and chlorine dioxide can be used in this situation, obviously the thermal disinfection method does not apply in this situation.

4.4

Costs / Overheads

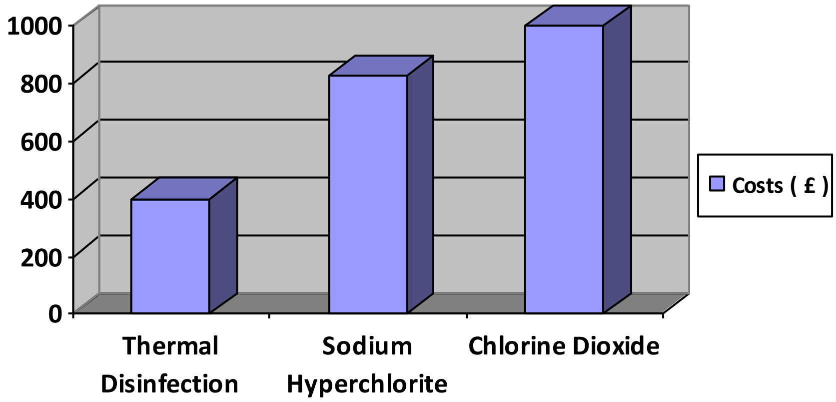
After a basic price comparison, *(See tables a, b, c & d,)* we can see that the thermal disinfection method is by far the cheaper, roughly £600 cheaper than the other 2 methods.

By performing the thermal disinfection method we are saving money on test equipment required, and chemical costs. *(See Table d, page 31)*
The only other cost incurred would be the cost of the energy required to heat the water to its required temperature, then keeping it circulating at this temperature for the contact period.

The sodium hyperchlorite method comes in 2nd most cost effective, even though all in all it would cost £825 for materials and labour. *(See Table a)*

Finally, the Chlorine Dioxide method comes in least cost effective, costing over 250% more than the thermal disinfection, and 121% more than the sodium hyperchlorite method. *(See Table a)*

- *Table a - Comparison Chart*



- *Table b - Sodium Hyperchlorite*

Item	Cost	Info Source
Sodium Hyperclorite Solution	£25.00 Per 15L Drum	Water Treatment Products
Test Kit	£500.00	Palintest Ltd
Water Treatment Specialist	£300.00 Per Day	Average Self Employed Rate
Total cost for materials & labour	£825.00	

- *Table c - Chlorine Dioxide*

Item	Cost	Info Source

Chlorine Dioxide Solution	**£200.00 Per 25L Drum**	**Water Treatment Products**
Test Kit	**£500.00**	**Palintest Ltd**
Water Treatment Specialist	**£300.00 Per Day**	**Average Self Employed Rate**
Total cost for materials & labour	**£1000.00**	

- *Table d - Thermal Disinfection*

Item	Cost	Info Source
Touch Probe Thermometer	**£100.00**	**Palintest Ltd**
Water Treatment Specialist	**£300.00 Per Day**	**Average Self Employed Rate**
Total cost for materials & labour	**£400.00**	

Section 6: Conclusion

After reviewing the 3 methods advised by Northumbrian water *(See page 7 - Control measures & remedial works)* Sodium Hypochlorite, Chlorine Dioxide & Thermal Disinfection, I have came to the conclusion that Sodium Hyperclorite is the most effective / practical.

Thermal disinfection is by far the most economical, and is as effective as using Sodium Hypochlorite & Chlorine Dioxide in disinfecting internal pipework. However it can only be carried out on systems which have a energy source e.g a domestic hot water service, or a service which has trace heating serving it. For example, it would not be practical to add an energy source to a Mains cold water service, in order to raise the temperature to an acceptable level. Therefore this method is deemed by far the most practical for Domestic hot water systems, however this method must be carried out on a regular basis to avoid recolonisation.

Chlorine Dioxide is the most expensive method, with a 25L drum costing around £200. This method also requires a large amount of safety awareness by the user, as once activated the solution releases poisonous gases into the local atmosphere. Therfore - ventilators, goggles and gloves must be worn at all times, and the area local to the sterilization cordoned off for safety.

Sodium Hyperclorite is my chosen method. It is reasonably cheap to buy at approximately £25 per 15L tub.
Unlike Chlorine Dioxide, it does not need an "activating agent", so does not produce any harmful gases / byproducts.
This method is also the favored method described in BS6700 : 2006 - 6.1.10.4.2 Methods using chlorine as a disinfectant *(See page 9)* Like Chlorine Dioxide, this method is also universal. By universal I mean it can be carried out on any service e.g: M.C.W.S, D.H.W.S, C.H.W.S and cooling towers. Also it does not require any energy input e.g heat source.

Section 7: References

- HSE - legionnaires a guide for employers (Rev2) 02/04 C50
- BS6700 - 2006
- HSE - Legionnaires' disease - The control of legionella bacteria in water systems, 6th November 2000
- Vernagene :, Units 2 & 3, Waters Meeting, Britannia Way, Bolton, Lancashire, BL2 2HH
  Water storage vessel disinfection
  Purogene Material safety data sheet, Issue 5 : April 2001
  SCD activator crystals_ Material safety data sheet, Issue 5 : April 2001

- Biolab UK Unit 4, Andoversford Industrial Estate Andoversford, Cheltenham SDS Safety Data Sheet Sodium Hypochlorite 14/15% Ref: SOL8000

- BS 6700:2006 Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Specification

- Northumbrian Water Regulations, By J. McClean, 2007

- Sutton Services International Ltd
  26, Northumberland Square,
  North Shields,
  Tyne & Wear,
  NE30 1PW.

- Water Treatment Products LTD
  (Information via Gareth Wheatley of Sutton Services LTD)

- Palintest LTD
  Palintest House
  Kingsway
  Team Valley
  Gateshead
  Tyne & Wear
  NE11 0NS

Section 8: Appendices

A - Health & Safety Law

H.S.E - Health & Safety Law

12 - Duties under the HSWA extend to risks from legionella bacteria which may arise from work activities. The MHSWR provide a broad framework for controlling health and safety at work. As well as requiring risk assessments, they also require employers to have access to competent help in applying the provisions of health and safety law; to establish procedures to be followed by any worker if situations presenting serious and imminent danger were to arise; and for co-operation and co-ordination where two or more employers or self employed
persons share a workplace.

13 - Only the courts can give an authoritative interpretation of law in considering the application of these Regulations and guidance to people working under another's direction, the following should be considered: if people working under the control and

direction of others are treated as self employed for tax and national insurance purposes they may nevertheless be treated as their employees for health and safety purposes. It may therefore be necessary to take appropriate action to protect them. If any doubt exists about who is responsible for the health and safety of a worker this could be clarified and included in the terms of a contract. However, it should be remembered that a legal duty under section 3 of HSWA cannot be passed on by means of a contract and there will still be duties towards others under section 3 of HSWA. If such workers are employed on the basis that they are responsible for their own health and safety, legal advice should be sought before doing so.

14 - More specifically the COSHH Regulations provide a framework of actions designed to control the risk from a range of hazardous substances including biological agents. The essential elements of COSHH are:

(a) risk assessment;

(b) prevention of exposure or substitution with a less hazardous substance if this is possible, or substitution of a process or method with a less hazardous one;

(c) control of exposure where prevention or substitution is not reasonably practicable;

(d) maintenance, examination and testing of control measures, e.g. automatic dosing equipment for delivery of biocides and other treatment chemicals;

(e) provision of information, instruction and training for employees; and

(f) health surveillance of employees (where appropriate, and if there are valid techniques for detecting indications of disease) where exposure may result in an identifiable disease or adverse health effect.

15 - The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR) require employers and others, e.g. the person who has control of work premises, to report to HSE, accidents and some diseases that arise out of or in connection with work. Cases of legionellosis are reportable under RIDDOR if a doctor notifies the employer and if the employee’s current job involves work on or near cooling systems that use water or hot water service systems in the workplace. Further details can be obtained in HSE guidance.

16 - Those who have, to any extent, control of premises, have a duty under the Notification of Cooling Towers and Evaporative Condensers Regulations 1992 to notify the local authority in writing with details of ‘notifiable devices’. These consist of cooling towers and evaporative condensers, except when they contain water that is not exposed to the air and the water and electricity supply are not connected. Although the requirement is to notify the local authority, the Regulations are enforced by the relevant authority for the premises concerned. Forms are available from local authorities or the local HSE office. If a tower becomes redundant and is decommissioned or dismantled, this should also be notified. The main purpose of these Regulations is to help in the investigation of outbreaks (see Appendix 2).

17 - The Safety Representatives and Safety Committees Regulations 1977 and the Health and Safety (Consultation with Employees) Regulations 1996 require employers to consult trade union safety representatives, other employee representatives, or employees where there are no representatives, about health and safety matters. This includes changes to the work that may affect their health and safety at work, arrangements for getting competent help, information on the risks and controls, and the planning of health and safety training. Further information and details of additional guidance can be found in a free HSE leaflet

B - Internal Chlorination using Sodium Hypochloride, a detailed example

The BCW storage tank will be cleaned out using a wet vac, and the internal surfaces will then be sprayed down with chlorine solution.

Once clean the tanks will be re-filled using the newly chlorinated supply

Chlorine solution will be added to the tank until a concentration of 50ppm is reached. The ball valves will then be tied off. Chlorinated water will then be drawn through the hot and cold outlets throughout the building until chlorine is detected at each outlet. To ensure return loop pipework has been chlorinated the main hot water flow will be isolated and water then drawn again through each of the hot water return outlets.

The level of water in each tank will be checked during this operation. If the level falls too low, the ball valve will be untied, the tank refilled, then re-dosed with chlorine solution to return the concentration to 50ppm.

Once chlorine is detected at all outlets, the tanks will be re-filled, topped up with chlorine solution until the concentration is 50ppm, then the systems will be allowed to stand for one hour.

After one hour, the level of chlorine will be checked at a random sample of outlets, which may be chosen by the client if required.

If the concentration is 30ppm or above, the chlorination will be deemed to have been successfully carried out. If the concentration is lower than 30ppm, the chlorination will be repeated.

Once chlorination is successful, a neutralising agent will be added to each tank to neutralise the chlorine. The ball valves will be untied and all outlets opened to flush the chlorinated water out of the system. This exercise will continue until the level of chlorine at each outlet is similar to that of the incoming mains.

Once the systems have been satisfactorily chlorinated, two samples will be taken from the furthest outlet for bacteriological analysis. Location of sample points to be agreed on site.

C - Internal Chlorination using Chlorine Dioxide, a detailed example

A Basic Example

Water Storage Vessel Disinfection

Fill & Soak Method

Chlorine dioxide solution will be added to the tank until a concentration of 50ppm is reached. Chlorinated water will then be drawn through the hot and cold outlets throughout the building until chlorine dioxide is detected at each outlet.

Re-fill the calorifiers with 50ppm chlorine dioxide solution.

The level of water in each tank will be checked during this operation. If the level falls too low, the ball valve will be untied, the tank refilled, then re-dosed with chlorine dioxide solution to return the concentration to 50ppm.

Once chlorine is detected at all outlets, the tanks will be re-filled, topped up with chlorine dioxide solution until the concentration is 50ppm, then the systems will be allowed to stand for one hour.

After one hour, the level of chlorine will be checked at a random sample of outlets, which may be chosen by the client if required.
If the concentration is 30ppm or above, the disinfection will be deemed to have been successfully carried out. If the concentration is lower than 30ppm, the disinfection will be repeated.

Once disinfection is successful, a neutralising agent will be added to the tank to neutralise the chlorine dioxide prior to it being discharged to drain.

The ball valves will be untied and all outlets opened to flush the chlorinated water out of the system.

This exercise will continue until the level of chlorine at each outlet is similar to that of the incoming mains.

The HWS pump will be re-instated and the HW calorifiers will be flushed through to drain using a hose until the level of chlorine is similar to that of the incoming mains water.

The shower heads previously removed will be rinsed and replaced.
Once the systems have been satisfactorily disinfected the following procedures will take place: -
Any un-used chlorine dioxide solution is to be heavily diluted before being discharged to a suitable foul drain.
Sign off and return permit to work as required and remove all warning notices.
Take bacteriological samples from agreed locations throughout the building.

Neutralisation

Normally, Purogene solutions do not require neutralisation prior to disposal to foul sewer. However, if local conditions require it, 50 ppm disinfectant solutions can be neutralised before disposal with sodium bisulphite (SB) or sodium thiosulphate (ST) at the rate of 350 gm SB/m^3 or 525 gm ST/m^3 of disinfectant solution. Do not add neutraliser to disinfectant solution whilst it is in storage vessel/system. Neutralisation must be carried out outside of the storage vessel/system