

# Practical Guide to the Operation and Optimisation of Chlorine and Chloramine Disinfection



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## Foreword

## Acknowledgements

## General Introduction

### Chapter 1 Hazards, Risks and Control Points .....

- Hazards and Drinking Water .....
- Pathogens are the Main Hazards in Drinking Water .....
- Other Hazards.....
- Control Points.....
- Critical Limits and Target Criteria .....
- Monitoring .....
- Responsibilities .....

### Chapter 2 The Importance of Disinfection

- A Brief History of Disinfection .....

### Chapter 3 Disinfection: The Final Barrier

- The Mechanism of Chlorine Based Disinfection .....
- The Process of Chlorine Based Disinfection .....

  - *Log Removal*.....
  - *Contact Time*.....
  - *Pathogen Sensitivity to Disinfectants* .....
  - *Effect of Temperature*.....
  - *Effect of Turbidity*.....

- The Chemistry of Disinfection .....

  - *Chlorine*.....

- Chlorine Demand .....
- Breakpoint Chlorination.....
- Chlorine Residuals .....
- Chlorine Decay.....

  - *Chloramine*.....

- Chloramine Toxicity and Public Relations.....
- Disinfection By Products .....
- Comparison of Disinfectants .....

### Chapter 4 Practical Operational Issues

- Safety
  - *Chlorine Gas* .....
  - *Sodium Hypochlorite* .....
  - *Ammonia* .....
  - *Calcium Hypochlorite* .....
- Available Chlorine
- Effect Of Chlorine Products On Water
- Sodium Hypochlorite Solution Strength Decay
- Calcium Hypochlorite Decay
- Chlorine Demand And Chlorine Residual Decay .....
- Contact Structures And Mixing.....

- Detention Time.....
- Minimum Daily Ct.....
- Backup Systems.....
- Disinfection Failure.....
- Discharge Of Chlorinated And Chloraminated Water .....

## Chapter 5 Disinfectant Dosing Calculations

- Calculation Of Dose Rate.....
- Step 1 Calculate The Concentration Of The Active Ingredient .....
- Step 2 Calculate The Dose Rate In The Plant.....
- Verification Of Long Term Dose.....
- Calculation Of Changed Dose.....

## Chapter 6 Chlorine Gas Disinfection Systems

- Types of Vacuum Chlorinators.....
- Differential Pressure Regulated Chlorinators .....
- Sonic Chlorinators.....
- The Gas Chlorination System .....
- Gas Storage Vessels.....
- Venturi.....
- Vacuum Monitors And Alarms .....
- Control Device.....
- Vacuum Regulators.....
- Vent Pipe.....
- Automatic Changeover Systems .....
- Weigh (Load) Scales .....
- Chlorine Leak Detectors.....
- Automatic Drum/Cylinder Shutdown Systems .....
- Chlorine Analysers .....
- Trouble Shooting.....

## Chapter 7 Liquid Sodium Hypochlorite Disinfection Systems

- The Sodium Hypochlorite Dosing System .....
- Sodium Hypochlorite Storage.....
- Removal Of Sodium Hypochlorite .....
- Prevention Of Gassing (Vapour Lock) .....
- Metering Pumps .....
- Metering Pumps And Disinfection .....
- Transfer.....
- Back Pressure Valves .....
- Pressure Relief Valves .....
- Injection (Valves and Lances).....
- Sodium Hypochlorite Generation Systems.....
- Electrochemical Activation (ECA).....

## Chapter 8 Chloramine Disinfection Systems

- Production of Chloramines .....
  - *Control of Monochloramine Production* .....
    - Ratio of Chlorine to Ammonia.....
- Sequence of Addition .....
- Chloramination Systems .....
  - *Chlorine Gas with Ammonia Gas* .....
  - *Chlorine Gas with Liquid Ammonia* .....
  - *Sodium Hypochlorite with Liquid Ammonia* .....
- Nitrification .....
- Management of Chloraminated Systems.....

## Chapter 9 Controlling And Measuring The Addition Of Disinfectant

- Controlling The Dose .....
  - *Manual Dosing* .....
  - *Flow Paced Dosing* .....
  - *Residual Trim Dosing* .....
  - *Flow Paced Residual Trim*.....
- Process Monitoring .....
- Measuring The Chlorine Residual .....
  - *The DPD Test*.....
  - *Field Analysis*.....
    - Colorimeters And Comparators .....
  - *On Line Analysers*.....
    - Free Chlorine Analysers.....
    - pH Correction Of The Chlorine reading .....
    - What Does The Measured Chlorine Residual Really Mean? .....
  - *Total Chlorine Analysers*.....
- Calibration .....
- Measuring Chloramine Residuals.....
- Mass Balance Checks.....
- Secondary Chlorine Dosing And Residual Maintenance In Distribution Systems.....

## Chapter 10 Operation and Optimisation Of Disinfection Systems

1. Review Existing Water Quality Data.....
2. Determine The Available Contact Time .....
3. Assess the Quality Of The Mixing and Contact Structure.....
4. Determine The Target Ct.....
5. Determine The Practical Achievable Ct.....
6. Minimise DBP Formation.....
7. Consider The Length And Complexity Of The Distribution System .....
8. Optimise The Disinfection System.....
  - Gas Chlorination Systems.....
    1. Check For Chlorine Gas Leaks .....
    2. Check For Vacuum Leaks (Drawdown Test).....
    3. Check The Full Capacity Of The System.....

- 4. Check The Vent.....
- 5. Check The Chlorine Leak Detector .....
- 6. Check And Calibrate The Chlorine Analyser .....
- Liquid Chlorination Systems.....
  - 1. Ensure Pipe Work And Metering Pumps Have Been Designed And Installed To Minimise Gassing.....
  - 2. Size The Pumps To Match Current Peak Demand .....
  - 3. Check The Chlorine Analyser.....
- 9. Ensure Failsafe Dosing .....
- 10. Monitor Raw And Treated Water Quality .....
- 11. Visit The Site Regularly .....
- 12. Maintain And Calibrate All Disinfection Equipment.....
- 13. Report On Achievement Of Disinfection Targets .....

**Chapter 11 Closing Words .....**

**References .....**

**Appendix 1 Simple Method for the Measurement of Chlorine Demand .....**