



Environment
Canada

Environnement
Canada

CI

REVIEW OF MUNICIPAL
WASTEWATER EFFLUENT
Chlorination/Dechlorination
PRINCIPLES, TECHNOLOGIES AND
PRACTICES

TD
758.5
.C45
R4813
2006

Canada



Library and Archives Canada Cataloguing in Publication

Review of Municipal Wastewater Effluent Chlorination/Dechlorination Principles, Technologies and Practices

Issued also in French under title: *Examen des principes, des techniques et des procédés de chloration et de déchloration des effluents d'eaux usées municipales.*

Rev. ed. Previously issued 2003 by Environment Canada, Pacific and Yukon Region.

ISBN 0-662-42545-6 Cat. no.: En84-36/2006E

1. Sewage—Purification—Chlorination. 2. Sewage—Purification—Chlorine removal. 3. Sewage disposal plants—British Columbia—Management. I. Canada. Municipal Wastewater Effluent Division.

TD758.5.C45R3814 2006

628.3'2'09711

C2006-980007-3

This document has been reprinted and translated with permission of Associated Engineering (B.C.) Ltd.

This document is part of Environment Canada's compliance promotion activities related to the *Notice Requiring the Preparation and Implementation of Pollution Prevention Plans for Inorganic Chloramines and Chlorinated Wastewater Effluents* published in the *Canada Gazette*, December 2004.

A copy of the *Canada Gazette* Notice is included for your convenience.

This publication may be reproduced without permission provided that its use falls within the scope of **fair dealings** under the *Copyright Act*, and is solely for the purpose of study, research, criticism, review or newspaper summary. The source must be fully acknowledged. However, reproduction of this publication in whole or in part for purposes of resale or redistribution requires the prior written permission from the Minister of Public Works and Government Services Canada, Ottawa, Ontario, K1A 0S5 or copyright.droitdauteur@communication.gc.ca.

Additional information can be obtained at Environment Canada's website at www.ec.gc.ca or at the Inquiry Centre at 1-800-668-6767.

ENVIRONMENT CANADA

Review of Municipal Wastewater Effluent Chlorination/Dechlorination Principles, Technologies and Practices

Prepared by:
Associated Engineering, (B.C.) Ltd.

November 2003

EXECUTIVE SUMMARY



1 PROJECT BACKGROUND AND OBJECTIVES

Municipal wastewater contains pathogenic microorganisms, i.e. bacteria, viruses and protozoa. The safe discharge of municipal wastewater back into the receiving water is perhaps the most important function of the treatment plant since the receiving water is expected to be safe for both human and aquatic life. Failure to provide due diligence to the treatment and disinfection of the wastewater can result in the spread of waterborne disease and lead to significant health risk.

Risk of waterborne disease can occur through the contamination of the potable water supply, recreational water use and/or consumption of shellfish that can concentrate the pathogens. Under normal conditions, the waterborne pathogens are naturally controlled by decay, predation or dilution. However, the high concentration of these microorganisms in wastewater makes in-plant treatment, i.e. disinfection, prior to discharge, essential in these situations.

Since the early 1900's, disinfection of municipal wastewater has typically been done through the use of some form of chlorine. Chlorination, as this type of disinfection is called, has often been selected on the basis of its relatively low cost, the availability of a wide range of chlorine-related disinfectant chemicals and its effectiveness in achieving the required pathogen kills.

While much good has come about from the use of chlorination, in recent years there have been concerns raised about the downsides of chlorination. In particular, concerns about the toxicity of even very low levels of chlorine residuals to fish and other aquatic life have been raised, especially under Section 36(3) of the Federal *Fisheries Act*, (i.e. the "no deleterious substances" clause). In addition, there have been operator safety issues raised regarding certain types of chlorination. This has led to increased attention to disinfection practices and efforts to improve disinfection technologies and equipment.

The problems with chlorine residuals have been addressed, with mixed success, through the control of chlorine addition and the use of dechlorination chemicals, introduced after the required chlorine contact time has been achieved. Over time, there have been significant improvements to chlorination and dechlorination equipment, testing procedures, and control equipment.

Despite the improvements in chlorination and dechlorination technology, Environment Canada, Fisheries and Oceans Canada, and the B.C. Ministry of Water, Land and Air Protection (MWLAP) know that there are still problems. Many chlorination/dechlorination systems currently in use are either not adequately designed or operated to consistently meet their target effluent pathogen content or chlorine residual levels. In many cases, especially at the smaller treatment plants, the chlorination/dechlorination equipment is complex and automated, and is often beyond what can be operated and maintained by the plant operators. In addition, variations in both flow rates and chlorine demand, inaccurate testing procedures and poor facilities maintenance, make proper operation of the chlorination/dechlorination system difficult. For this reason, Environment Canada and Fisheries and Oceans Canada, have been encouraging the use of non-chlorine-based disinfection technologies such as ultraviolet (UV) irradiation.

While the eventual move to other forms of disinfection such as UV may occur, the fact remains that, to many wastewater treatment plant owners and/or operators, chlorination involves relatively low capital and operating costs, reliability, low maintenance, and a "well known" technology. At present, there are over 40 municipal wastewater treatment plants in B.C. that chlorinate and over 20 of these also dechlorinate. While new wastewater treatment plants are discouraged from including chlorination/dechlorination systems, it will likely be some time before these existing plants that chlorinate or chlorinate and dechlorinate make the switch to another disinfection technology.

Where disinfection is required and chlorine is used, the regulation requires the residual chlorine is to be limited to 0.01 mg/L (10 µg/L) (*Waste Management Act – 1999 Municipal Sewage Regulation* (MSR) – Part 8: Effluent disinfection). Ensuring that this level is met is one concern of the Georgia Basin Ecosystem Initiative (GBEI).

The Georgia Basin ecosystem extends as far north as Pemberton, as far east as Boston Bar, Yale and Hope and south, past the US border. The GBEI has identified that liquid waste management programs need to be developed and implemented to arrest and reverse pollution trends and, therefore, minimize health risks in the Georgia Basin. Many of the plants that discharge into the Georgia Basin use chlorine to protect the public from waterborne diseases that are concentrated in the wastewater effluent. Unfortunately, this same chlorine poses a potential risk to the aquatic biota in the Georgia Basin ecosystem.

An ultimate goal of the GBEI is to reverse pollution and minimize public health risks in the Georgia Basin. To this end, optimal control of chlorine to protect the public and optimal control of the final chlorine residual to protect the aquatic life falls well into the GBEI mandate.

Given that chlorine and chlorine residuals are toxic to fish and other aquatic life, and the likelihood that current chlorination and dechlorination installations are not going to be abandoned overnight, it was appropriate that a review of chlorination/dechlorination principles, technologies and practices be conducted. To this end, this report has been developed. This has included a comprehensive review of the current state-of-the-art methods for chlorine-based disinfection, residual chlorine control, dechlorination chemicals and procedures, and the related chlorination and dechlorination equipment used in the wastewater treatment.

2 CHLORINATION AND DECHLORINATION CHEMICALS

The report summarizes chlorination/dechlorination theory and documents a wide range of chlorination and dechlorination chemicals that are available in the marketplace. The survey of B.C. plants found that the chemicals used in chlorination and dechlorination of wastewater treatment plant effluent are a function of plant size and safety concerns. For larger plants, with more trained staff and resources, chlorine gas (Cl_2) for chlorination and sulphur dioxide gas (SO_2) for dechlorination have been popular, due to their lower bulk chemical costs and fast reaction rates. However, the high equipment costs associated with these gas-based systems are typically considered to be prohibitively expensive for smaller plants. Additionally, safety concerns surrounding the storage and handling of the pressurized gas have forced some larger capacity treatment plants away from the use of gas. In addition, the complexity of gas storage and dosing systems also requires more experienced and highly trained operators. As a result, for smaller treatment plants, either sodium or calcium hypochlorite for disinfection and sodium sulphite, thiosulphate, bisulphite or metabisulphite for dechlorination are preferred based on ease of handling and relatively low hazards. While calcium hypochlorite is typically 1.5 to 2 times the cost of liquid sodium hypochlorite, it may be preferred by smaller users since it requires less infrastructure for transport, storage, and handling. This is especially true of the newer "puck"-type calcium hypochlorite systems.

There are difficulties measuring chlorine and sulphite residuals accurately at very low levels. As a result, the operators of these plants could consider using alternate chemicals for dechlorination that will have little or no impact on receiving environment if spilled or overdosed. Two such options are ascorbic acid and hydrogen peroxide. However, hydrogen peroxide reacts very slowly with combined chlorine and may not meet the technical requirements, i.e. it may require more contact time than is normally available. Ascorbic acid is very expensive in comparison with other dechlorination methods. However, safety issues and protection of the environment may justify its use.

Regardless of treatment plant size, chlorination and dechlorination chemical feed systems need to be designed so that spills of toxic chemicals do not enter the environment. Secondary containment and spill containment need to be incorporated into each design. Consideration should be given to chemicals that present low risk to the surrounding environment.

3 CHLORINE AND SULPHITE RESIDUAL TESTING

While the methods of measuring chlorine residual in wastewater are essentially the same as those used for potable water, the larger concentrations of dissolved and suspended solids in wastewater create increased interferences. The target of less than 10 µg/L (0.01 mg/L) total chlorine residual is much higher than that required for potable water analysis. Control to these low levels is at the current limit of feed and measurement technology.

In order to properly monitor and control chlorination and dechlorination, operators require simple, accurate techniques for determining chlorine and sulphite residuals. Several field test kits are commercially available that duplicate laboratory procedures including the diethyl-p-phenylenediamine (DPD), amperometric, and iodometric methods. Each methodology and associated field test kit has particular strengths and weaknesses in terms of accuracy, precision (reproducibility), interferences, ease of use, and applicability for use in municipal wastewater treatment plants.

The Free Available Chlorine Test-syringaldazine (FACTS) method of chlorine residual measurement provides a simple and accurate test for free available chlorine but is not commercially available as a field test kit. The method is limited to free chlorine analysis, therefore it is of limited use for wastewater, as most chlorine is in a combined form. The orthotolodine method, despite previous widespread use, has been discontinued in favour of other measurement techniques. The iodometric method is only suitable for measurement of high strength chlorine (hypochlorite) solutions and is not suitable for measuring levels of chlorine residual below 1 mg/L.

The amperometric titration method of determining chlorine residual was concluded to be the most accurate method of determining chlorine residual. However, the off-line manual method requires a high level of training and skill to produce the required accuracy. Portable test instruments using amperometric titration are commercially available and can be used on grab samples from both large and small treatment plants, provided the operators have the skill and training to use the equipment. There are many cases in B.C. where the treatment plants have amperometric titration equipment that was once used but now sits under the equipment dust cover while other, easier, but less accurate, methods are used on a regular basis to measure the chlorine residual. This may change with the commercial release of small automated amperometric titration devices that should be suitable for use in small treatment plants.

The DPD colourimetric test was found to be the simplest, most versatile field test available on the market for the measurement of chlorine residual. It can be a very simple test based on a hand-held colour comparator or it can be more sophisticated based on spectrophotometer techniques. In either case, the operator must take care to minimize interferences and possible false positive values, particularly in the presence of organic chloramines. While the DPD method is relatively accurate, it is only accurate above concentration of approximately 30 to 50 µg/L for chlorine residual measurement. Since the objective of chlorine residual is 10 µg/L in the B.C. *Waste Management Act – Municipal Sewage Regulations* – Part 8 Effluent Disinfection (provided in Appendix A), one can not assume the required low chlorine level is being met by using a DPD method.

Low chlorine limits required for municipal effluent discharge are at the lowest detection limits of chemical feed and control equipment. Though published data indicates that devices can measure chlorine residuals down to levels as low as 1 µg/L, control at these levels is not practical. Feed and measurement of a slight sulphite or sulphate residual represents a more practical means of dechlorination. A slight sulphite/sulfate residual is an indication that the chlorine has been neutralized. The detection limits and control for meeting discharge limits are well within the ability of current chemical feed technology.

Sending a grab sample of wastewater effluent to a lab off-site for more accurate measurement of chlorine residual is unacceptable. The chlorine residual will completely dissipate between the time the grab sample is captured and the time when the lab does the analysis.

4 ON-LINE CONTROL OF CHLORINE RESIDUALS

On-line measurement of chlorine residuals in wastewater is based on techniques that have been developed for on-line measurement of chlorine residuals in potable water. However, many of the units commercially available for residual chlorine measurement are not acceptable for use in wastewater. Manufacturers promote their use in wastewater; however, most of these installations are only for high quality tertiary applications. Care is required in applying technology and where possible, a long term pilot study of the unit should be completed. In all cases of on-line monitoring, it is also important that the sample lines between the sampling point and the measurement cell be continuously cleaned and flushed if accurate results are to be achieved.

For tertiary wastewater treatment plants and high quality secondary plants, membrane-type residual chlorine analyzers represent the best combination of accuracy and ease of operation for on-line residual chlorine measurement. However, these units will be quickly biologically and chemically

fouled if used on lower quality effluents. In addition, when used at treatment plants that are nitrifying, any changes in nitrogen levels will cause significant inaccuracy in the measured residual.

Gas phase and Oxidation Reduction Potential (ORP) analyzers are suitable for primary and low quality secondary effluents. They have demonstrated success with the higher solids contacts involved.

Bare electrode, amperometric, on-line analyzers provide the most accurate indication of chlorine residual for both free and combined chlorine. Units with the 3-probe sensors provide better accuracy and better stability as the units are designed to adjust to background interferences. The units are, however, more difficult to operate and require the highest level of operator intervention.

5 THE CURRENT PRACTICES SURVEY

The study began with the initial understanding that chlorination and dechlorination practices vary throughout the province and within the Georgia Basin. In order to provide a full picture of the existing situation, it was necessary to conduct a survey on current chlorination and dechlorination practices. In determining the plants to be surveyed, all B.C. wastewater treatment plant discharge permits were initially reviewed to determine which plants were required by permit to disinfect. Further information was obtained from the GBEI report EC/GB-99-022 that was compiled from MWLAP data. Since, in the GBEI study, plants under 10 m³/day were eliminated from the inventory, the same has been done in this study. This current study also added known B.C. installations outside of the Georgia Basin in order to get as large a database for equipment verification as possible. Fifty-six plants were surveyed, forty-four in the Georgia Basin and twelve outside the Basin.

Chemicals used for chlorination and dechlorination in B.C. tend to be a function of the economies of scale and the operator training and certification level related to treatment plant size. Chlorine gas for disinfection and sulphur dioxide for dechlorination have been the chemicals of choice for the medium to larger capacity wastewater treatment plants that disinfect by chlorination. Sodium hypochlorite for disinfection and liquid sulphate/sulphite compounds for dechlorination tend to be used at the smaller plants. Due to safety concerns regarding chlorine gas and improvements in the accuracy of calcium hypochlorite systems, many operators are moving away from chlorine gas to sodium hypochlorite at larger plants and from sodium hypochlorite to calcium hypochlorite "pucks" at smaller plants. It is not clear what chemicals will be preferred for dechlorination. For the smaller plants, there are some chemicals such as ascorbic acid that present little or no environmental impact if overdosed. For the larger plants, it is not clear that those moving from chlorine gas will also abandon sulphur dioxide gas as the dechlorinating agent. In any event, there are several non-gas methods of dechlorination.

Of the most commonly used test methods available for chlorine residual measurement, the most accurate method is amperometric titration. However, since this method has required considerable operator training and skill to be accurate, other methods, particularly the DPD colourimetric method, have been widely used in B.C. While the simplicity and relative accuracy of the DPD method typically ensures that the test will be done regularly, the detection limit of the DPD method makes it impossible to positively confirm that the chlorine residual is meeting the 10 µg/L target level set out in the 1999 *B.C. Municipal Sewage Regulations* (BCMSR). Many B.C. operators typically deal with this by slightly over dosing their dechlorination chemicals since a dechlorination chemical residual is not as harmful as chlorine residuals above 10 ppb. New automatic amperometric chlorine residual measurement units will provide the accuracy of the amperometric devices, with the simplicity of the DPD measurement devices. The units are only available for chlorine measurement; however, they will have sulphite/sulfate measurement ability by early 2003. The use of this device should allow plants large and small to have more accurate monitoring and control of plant effluent.

There is not a strong trend in B.C. to use on-line chlorine residual monitoring devices since they tend to only work reliably at plants with tertiary treatment effluent. Since there are very few plants in B.C. that produce this quality effluent, most chlorination systems are flow-paced rather than chlorine residual-paced. Some (three plants) use a combination of flow and chlorine residual feedback. It is very common to set the dechlorination equipment to pace the chlorination equipment so that a slight excess of dechlorination chemical is added at all times. This trend is expected to remain in the future.

The majority of the measurement and/or confirmation of chlorine residuals in B.C. is done through the DPD method even though the method is not accurate enough to measure the BCMSR target of 10 µg/L. The majority of these DPD tests are done colourimetrically using a spectrophotometer. This trend may change when automated amperometric chlorine and sulphite residual analyzers are installed into the plants.

6 OVERALL SUMMARY

Based on the above, the following are evident:

- Chlorination of wastewater effluent in B.C. will continue for some time in the future.
- The trend in chlorination/dechlorination in B.C. will be towards safer to handle and easier to use chemicals, despite increases in costs.
- While the amperometric titration method is the most accurate means of measuring chlorine and sulphite residuals, the test requires time and operator skill that is often beyond the plant resources available.
- The DPD method of manual chlorine residual measurement is easy to use, but it isn't accurate enough to actually measure a 10 µg/L chlorine residual.
- Operators tend to slightly overdose dechlorination chemicals to ensure that the chlorine residual is "zero".
- New automated amperometric titration systems may permit easy measurements of low chlorine residual levels.
- Selection of on-line residual monitoring is dependent on effluent quality.

TABLE OF CONTENTS



SECTION	PAGE NO.
EXECUTIVE SUMMARY	ii
TABLE OF CONTENTS	x
DEFINITION OF TERMINOLOGY	xii
1 INTRODUCTION	1-1
1.1 Study Background	1-1
1.2 Chlorination Under B.C. Wastewater Disposal Regulations	1-2
1.3 The Needs of the Georgia Basin Ecosystem Initiative	1-5
1.4 Need for a Survey of Current Practices	1-6
1.5 Project Objectives	1-6
1.6 Summary of Report Contents	1-6
2 THE TECHNOLOGY OF CHLORINATION	2-1
2.1 The Chlorine Disinfection Process	2-1
2.2 Overview of Chlorine Chemistry in Wastewater Treatment	2-2
2.3 Factors Influencing Disinfection by Chlorination	2-5
2.4 Chlorination Chemicals	2-11
2.5 Toxicity of Chlorine Residuals	2-18
2.6 Chlorination By-products	2-19
3 CHLORINATION CHEMICAL DOSING EQUIPMENT	3-1
3.1 Dosing Equipment Selection Criteria	3-1
3.2 Chlorination Chemical Dosing Range	3-1
3.3 Chlorination Chemical Dosing Control	3-2
3.4 Chemical Dosing Equipment	3-5
3.5 Chlorination Chemical Delivery Issues	3-9
4 MEASUREMENT OF CHLORINE RESIDUALS	4-1
4.1 Chlorine Residual Analytical Methods	4-1
4.2 Chlorine Test Method Interferences	4-9
4.3 Comparison of Chlorine Test Methods	4-10
4.4 Off-Line Chlorine Residual Measurement	4-13
4.5 On-Line Chlorine Residual Measurement Considerations	4-17
4.6 On-Line Residual Analyzers	4-23

5	DECHLORINATION	5-1
5.1	Dechlorination Substances and their Chemistry	5-2
5.2	Toxicity and Other Environmental Concerns of Dechlorination Chemicals in the Environment	5-8
5.3	Dechlorination Chemical Dosing Equipment	5-9
5.4	Dechlorination Control	5-10
5.5	Calibration of Dechlorination Equipment	5-11
5.6	Off-Line Measurement of Dechlorination	5-12
5.7	On-Line Measurement of Dechlorination Residuals	5-13
6	CURRENT PRACTICES SURVEY	6-1
6.1	Chlorination Chemicals Being Used	6-1
6.2	Dechlorination Chemicals Being Used	6-3
6.3	Off-Line Methods of Residual Analysis	6-4
6.4	On-Line Chlorine Residual Measurement	6-4
6.5	Disinfection by UV Irradiation	6-7
6.6	Treatment Plant Staffing Levels	6-7
6.7	Wastewater Re-use	6-8
7	SUMMARY	7-1
7.1	Chlorination and Dechlorination Chemicals	7-1
7.2	Chlorination and Dechlorination Residual Test Methods	7-2
7.3	Survey Results	7-4
7.4	Overall Summary	7-5
7.5	Recommendations	7-6
	REFERENCES	R-1
APPENDIX A	B.C. MUNICIPAL SEWAGE REGULATION DISINFECTION REQUIREMENTS	A-1
APPENDIX B	EXAMPLE MSDS SHEETS FOR CHLORINATION AND DECHLORINATION CHEMICALS	B-1
APPENDIX C	SODIUM HYPOCHLORITE SOLUTION STABILITY AND PRODUCT QUALITY CONSIDERATIONS	C-1

DEFINITION OF TERMINOLOGY



AWWA	American Water Works Association
Baumé	Specific gravity of a solution, used to measure the strength of aqueous ammonia.
BCMSR	British Columbia Municipal Sewage Regulation
BOD	Biochemical oxygen demand
BNR	Biological nutrient removal
CAEAL	Canadian Association for Environmental Analytical Laboratories
CEPA	<i>Canadian Environmental Protection Act</i>
chloramines	Group of chlorine and ammonia compounds.
chlorination	Process of addition of any of the forms of chlorine to the wastewater
chlorine	Any of the forms of chlorine used in the disinfection process
CI	Chlorine Institute
contact chamber	Tank at a wastewater plant that provides chemical mixing and contact time
Ct	Chlorine residual x contact time
DBP	Disinfection byproducts
dechlorination	Process of removing all or some of the chlorine residual after disinfection
demand	Amount of chemical consumed by the wastewater, expressed as milligrams per litre
dichloramine	Chlorine/ammonia compound containing two nitrogen atoms
disinfectant	Chemical added for the purposes of disinfection of the wastewater
disinfection	Process that removes pathogenic organisms from the wastewater
dissociation	The separation in a water solution of a compound to its components or ions
DO	Dissolved oxygen
dose	Amount of chemical added to wastewater, expressed as milligrams per litre
DPD	Diethyl-p-phenylenediamine
elemental chlorine	Name sometimes used to define gaseous chlorine
FAC	Free available chlorine
FACTS	Free available chlorine test-syringaldazine
FRC	Free Residual Chlorine
GBEI	Georgia Basin Ecosystem Initiative
HPLC	High Pressure Liquid Chromatograph
hypochlorite	One of the forms of chlorine (sodium, calcium, or lithium hypochlorite)
ICRC	Inorganic combined residual chlorine
liquid chlorine	Any one of many solutions of sodium hypochlorite
LWMP	Liquid Waste Management Plan
µg	Microgram = 0.001 milligram
µg/L	One part per billion
mg	Milligram = 0.001 gram

mg/L	One part per million
monochloramine	Chlorine and ammonia compound containing one nitrogen atom
MSDS	Material safety data sheet, required by OSHA for facilities with chemicals on site
MWLAP	Ministry of Water, Land and Air Protection
mV	Millivolts
OCRC	Organic combined residual chlorine
ORP	Oxidation reduction potential
OTA	Orthotolodine arsenite
PAO	Phyenylarsine oxide
PID	Proportional integral derivative
residual	Amount of chemical remaining after treatment, expressed as milligrams per litre
SBR	Sequencing batch reactor
sulphide	Product of sulphur reduction reaction
sulphur dioxide	Gaseous chemical compound used in dechlorination
sulphite salts	Salts formed by the reaction of sulphurous acid
TCRC	Total combined residual chlorine
THM	Trihalomethane
TRC	Total residual chlorine
trichloramine	Chlorine and ammonia compound containing three nitrogen compounds
TSS	Total suspended solid
WERF	Water Environment Research Foundation
WWTP	Wastewater Treatment Plant

INTRODUCTION

SECTION 1

1.1 STUDY BACKGROUND

Municipal wastewater treatment effluents contain pathogenic microorganisms, i.e. bacteria, viruses and protozoa. Where the effluent is discharged to rivers or lakes that are drinking water sources, or into recreational or shellfish waters, it is necessary to reduce the quantity of pathogens through disinfection. Since the early 1900's, disinfection of municipal wastewater has typically been done through the use of some form of chlorine. Chlorination, as this type of disinfection is called, has often been selected on the basis of its relatively low cost, the availability of a wide range of chlorine-related disinfectant chemicals and its effectiveness in achieving the required pathogen kills.

The first time that chlorine was applied as a wastewater disinfectant was in 1879 when William Soper of England used chlorinated lime to treat the faeces of typhoid patients before disposal into the sewer⁽⁷⁾. The first time that chlorine was applied as a drinking water disinfectant on a plant scale basis was in 1893 at Hamburg, Germany after studies by Dr. Robert Koch concluded that a 1892 cholera epidemic was the result of sewage contaminated drinking water⁽⁷⁾. The first full scale wastewater chlorination system was applied in 1910 in Philadelphia, PA and has been widely used throughout the world since that time⁽⁷⁾.

One of the most respected chlorination researchers, George Clifford White⁽⁷⁾, noted that wide spread wastewater disinfection began in the US and Canada around 1945. Chlorine was used for wastewater prior to this time; however, it was more specifically used for odour control, hydrogen sulphide destruction and prevention of septic conditions (no dissolved oxygen). By 1958, 2200 plants serving over 50% of the US population were equipped with chlorination facilities⁽²⁶⁾.

While much good has come from the use of chlorination, in recent years there have been concerns raised about the downside of chlorination. In particular, concerns about the toxicity of even very low levels of chlorine residuals to fish and other aquatic life have been raised, especially under Section 36(3) of the Federal *Fisheries Act*, (i.e. the "no deleterious substances" clause). Chlorinated wastewater effluent and inorganic chloramines have been declared toxic under the *Canadian Environmental Protection Act* (CEPA), through which pollution prevention and control strategies are currently being developed. In addition, there have been operator safety issues raised regarding certain types of chlorination. This has led to increased attention to disinfection practices and efforts to improve disinfection technologies and equipment.

The problems with chlorine residuals have been addressed, with mixed success, through the control of chlorine addition and the use of dechlorination chemicals, introduced after the required chlorine contact time has been achieved. Over time, there have been significant improvements to chlorination and dechlorination equipment, testing procedures, and control equipment.

Despite the improvements in chlorination and dechlorination technology that have occurred over the years, Environment Canada and Fisheries and Oceans Canada know that there are still problems. Many chlorination/dechlorination systems currently in use are either not adequately designed or operated to consistently meet their target effluent pathogen content or chlorine residual levels. In many cases, especially at the smaller treatment plants, the chlorination/dechlorination equipment is complex and automated, and is often beyond what can be operated and maintained by the plant operators. In addition, variations in both flow rates and chlorine demand, inaccurate testing procedures and poor facilities maintenance make proper operation of the chlorination/dechlorination system difficult. For this reason, Environment Canada and Fisheries and Oceans Canada have been encouraging the use of non-chlorine-based disinfection technologies such as ultraviolet (UV) irradiation.

While the eventual move to other forms of disinfection such as UV may occur, the fact remains that, to many wastewater treatment plant owners and/or operators, chlorination represents relatively low capital and operating costs, reliability, low maintenance, and a "well known" technology. At present, there are over 40 municipal wastewater treatment plants in B.C. that chlorinate and over 20 of these also dechlorinate. While new wastewater treatment plants are unlikely to include chlorination/dechlorination systems, it will likely be some time before these existing plants (that chlorinate or chlorinate and dechlorinate), make the switch to another disinfection technology.

1.2 CHLORINATION UNDER B.C. WASTEWATER DISPOSAL REGULATIONS

In B.C., many wastewater treatment plants initially included chlorine-based effluent disinfection systems. However, the risks associated with discharge of chlorinated water into sensitive fish-bearing streams was eventually considered to be a greater risk than the microbiological risk of the spread of disease. The regulations in place in B.C. allow for an assessment of the release of pathogens into the receiving water and if there is no risk to the public, no disinfection is required. In some regions, disinfection is limited to periods of high recreational surface water use in the summer. In these cases, the effluent is disinfected over a 6 month summer "bathing" (swimming) period. Outside this period, the wastewater effluent is typically discharged without any disinfection.

In B.C., discharges to the ground of under 22,700 L/day (5000 Imperial gallons/day), and discharges to surface waters from up to and including duplex dwellings, fall under the *Sewage Disposal Regulation of the Health Act*. Under Section 2 (2) of this Regulation, it is specified that "it is the duty of the owner or occupier of every building to ensure that domestic sewage emanating from the building does not reach the surface of land or discharge into a surface body of fresh water." However, Schedule 6 ⁽²⁾ of this regulation states that, should there be a point of discharge to the environment, the effluent must not exceed the following criteria:

- 400 CFU of fecal coliforms per 100 mL;
- 10 mg of suspended solids and biochemical oxygen demands per litre;
- 20 mg of nitrate, over unconfined aquifers, per litre.

Flows over 22,700 L/day and flows from dwellings larger than a duplex discharging to surface waters fall under the *Waste Management Act*. Effective July 15, 1999, the requirements for the disinfection of effluents are defined in the *Municipal Sewage Regulations* (MSR). Disinfection is limited to applications where the effluent will impact:

- domestic or agricultural water extraction
- recreational use of water
- aquatic food production

Where disinfection is required and chlorine is used, the regulation requires the residual chlorine is to be limited to 10 µg/L (*Waste Management Act Municipal Sewage Regulation* (MSR) Part 8 Effluent disinfection). The "Effluent Disinfection" section of the regulation, as well as the "Toxicity" section, are presented in Appendix A to this report. In addition, the effluent water quality requirements for discharge to receiving waters are defined in the BCMSR, Schedule 3 – Standards for Discharges (also presented in Appendix A).

Once it is established that disinfection is required under the MSR, the level of treatment is set by the receiving environment, the type of use of the receiving water, and the level of dilution available. For the precise requirements of the MSR, the exact wording of the B.C. Regulations is included after Table 1-1.

Table 1.1
B.C. Municipal Sewage Regulation Wastewater Effluent
Disinfection Requirements (Simplified)

Receiving water that may be impacted	Median fecal coliform count not to be exceeded outside initial dilution zone (unless otherwise noted)	Other fecal coliform limitations
Shellfish bearing water	14 counts/100 mL	No more than 10% of samples to exceed 43 counts/100 mL
Recreational use	200 counts/100 mL	Not listed
Domestic water extraction	2.2 counts/100 mL (in effluent)	No sample to exceed 14 counts/100 mL

The exact wording of the B.C. regulation is as follows:

"The allowable number of fecal organisms in the effluent is dependent on the use of the receiving water. For discharges to shellfish bearing waters, the number of fecal coliform organisms outside the initial dilution zone must be less than 14/100 mL ("the median number of fecal coliform organisms in a water sample does not exceed 14/100 mL, with no more than 10% of the samples exceeding 43/100 mL", from Canadian Shellfish Sanitation Program, Manual of Operation). For discharges to recreational use waters the number of fecal coliform organisms outside the initial dilution zone must be less than 200/100 mL. Where domestic water extraction occurs within 300 metres of a discharge, the median number of fecal coliform organisms must be less than 2.2/100 mL in the effluent with no sample exceeding 14/100 mL. The geometric mean, as determined from the bacteriological results of the last 5 samples for which analysis have been completed over the last 30 days, must not exceed the coliform limits specified, and for this purpose, "geometric mean" means the anti-logarithmic of a calculation in which the logarithms of a series of numerical measures are summed and divided by the numerical measures."

It should be noted that the B.C. regulations do not have any standards listed for the maximum residual concentration of any dechlorination chemicals.

Plants that chlorinate are required to provide reports to confirm pathogen control. The sampling requirements are a function of the discharge volumes. The samples taken need to be tested in a certified lab (CAEAL) using Standard Methods ⁽¹⁴⁾ procedures. Appendix A contains the testing requirements as listed in Schedule 6 the BCMSR.

It should be noted that the BCMSR primarily applies to new plants. Older plants will be authorized by either an existing Waste Management permit or an approved Liquid Waste Management Plan (LWMP). If these permits, or approved LWMP's, do not require disinfection, the plant is effectively exempt from this requirement. This situation would change if:

- The discharger decides voluntarily to register under the MSR.
- The public instigates an amendment to the approved LWMP.
- The Ministry of Water, Land and Air Protection (MWLAP) manager initiates changes through amendments to the existing permit.
- Through an order pursuant to the WMA.

In the later cases where a manager's decision is involved, there would need to be compelling technical reasons to the need for disinfection as a manager's decision is appealable to the Environmental Appeal Board.

1.3 THE NEEDS OF THE GEORGIA BASIN ECOSYSTEM INITIATIVE

The Georgia Basin ecosystem extends as far north as Pemberton, as far east as Boston Bar, Yale and Hope and south past the US border, as shown in Figure 1-1. The Georgia Basin Ecosystem Initiative (GBEI) has identified that liquid waste management programs need to be developed and implemented to arrest and reverse pollution trends and, therefore, minimize health risks in the Georgia Basin. In the GBEI Sewage Treatment Facility Inventory and Optimization study (28), the total BOD loading into the basin was estimated to be 52,791 tonnes/year and the total suspended solids loading 37,804 tonnes/year. Many of the plants that discharge into the Georgia Basin use chlorine to protect the public from waterborne diseases that may be concentrated in the wastewater effluent. Unfortunately, it is the same chlorine that poses a potential risk to the aquatic biota in the Georgia Basin ecosystem.

An ultimate goal of the GBEI is to reverse pollution and minimize public health risks in the Georgia Basin. To this end, optimal control of chlorine to protect the public and optimal control of the final residual to protect the aquatic life falls well into the GBEI initiative.

1.4 NEED FOR A SURVEY OF CURRENT PRACTICES

The study began with an initial understanding that chlorination and dechlorination practices vary throughout the province and within the Georgia Basin, in order to provide a full picture of the existing situation, it was necessary to conduct a survey on current chlorination and dechlorination practices. In determining the plants to be surveyed, all B.C. wastewater treatment plant discharge permits were initially reviewed to determine which plants were required by permit to disinfect. Further information was obtained from the GBEI report EG/GB-99-002 ⁽²⁸⁾ that was compiled from MWLAP data. Since, in the GBEI study, plants under 10 cu.m./day were eliminated from the inventory, the same has been done in this study. It should be noted that our study added some B.C. installations outside of the Georgia Basin to get as large a database for equipment verification as possible. Details of the survey are presented in Section 6.

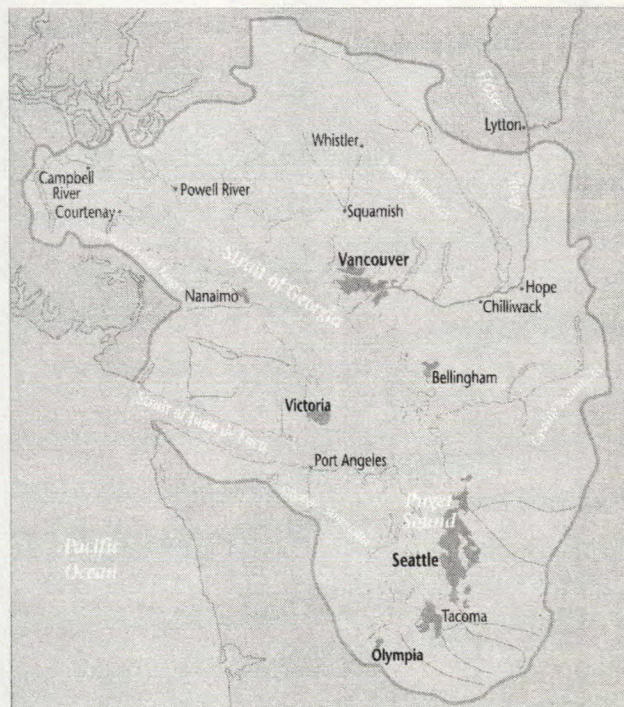


Figure 1-1: The Georgia Basin Area

1.5 PROJECT OBJECTIVES

As a result of the above, the purpose of this project is to identify practical chlorination/dechlorination systems for wastewater treatment plants that will achieve fish protection requirements as well as public health and shellfish resource protection requirements. It is hoped that this report will provide guidance to local governments considering chlorination as a disinfection method.

1.6 SUMMARY OF REPORT CONTENTS

Given that chlorine and chlorine residuals are toxic to fish and other aquatic life, and the likelihood that current chlorination and dechlorination installations are not going to be abandoned overnight, it is appropriate that a review of chlorination/dechlorination principles, technologies and practices be conducted. To this end, this report has been developed. This has included a comprehensive review of the current state-of-the-art methods for chlorine-based disinfection, residual chlorine control, dechlorination chemicals and procedures, and the related chlorination and dechlorination equipment used in the wastewater treatment.

This report provides a review of current knowledge of chlorination and dechlorination of municipal wastewater, including chemical processes, analytical test methods and equipment, and the fate and impacts of chlorination/dechlorination residuals and/or byproducts on the receiving environment. Specifically, the report includes the following sections:

- Section 2: The Technology of Chlorination
- Section 3: Chlorine Chemical Dosing Equipment
- Section 4: Measurement of Chlorine Residuals
- Section 5: Dechlorination
- Section 6: Current Practices Survey
- Section 7: Summary

THE TECHNOLOGY OF CHLORINATION

SECTION 2

2.1 THE CHLORINE DISINFECTION PROCESS

Disinfection, in relation to wastewater, refers to operations intended to destroy, inactivate, or render harmless, pathogenic micro-organisms. These micro-organisms include bacteria, protozoa, and viruses. Disinfection is usually required where wastewater treatment plant effluent may come into contact with humans, via a drinking water source or through water contact sports (including wading and swimming), or with shellfish and other aquatic life that are used for direct human consumption. Chlorination, the addition of a chlorine compound to water or wastewater, is a very common form of disinfection.

Chlorine and other oxidants act to destroy the cellular structure of pathogenic organisms or interfere with the ability of the organism to grow and/or reproduce. Wastewater disinfection targets are typically based on reducing fecal coliform to acceptable levels. As discussed in Section 1.2, in B.C., maximum fecal coliform concentrations are stipulated in the 1999 *Waste Management Act* MSR according to the end uses of the receiving water, e.g. recreation, shellfish habitat, or a source of drinking water.

There are many factors that effect the efficiency of chlorine disinfection. These include:

- The level of treatment to which the wastewater has been subjected.
- The influence of organic and ammonia nitrogen.
- The influence of variable wastewater strength including industrial wastewater discharges.
- Specific wastewater parameters including pH and oils and greases.

Chlorine is an oxidant and, as such, if there is more oxidizable material in a wastewater effluent, for a given chlorine dosage, the less chlorine there is available for disinfection. As a result, the level of wastewater treatment affects the chlorine dosage required to achieve a given level of effluent pathogen concentration. For example, primary treatment effluent contains more pathogens and more soluble and suspended organics than does secondary treatment effluent. As a result, for a given flow rate and effluent pathogen criteria, e.g. 200 fecal coliforms/100 mL, the chlorine dosage for primary treatment will be greater than that for secondary treatment.

The presence of organic nitrogen compounds in a wastewater treatment plant effluent will affect the efficiency of the chlorination process. Organic nitrogen compounds will combine with the chlorine and produce organic chloramines that have less "germicidal" (pathogen killing) effect.

Industrial discharges can have a significant impact on the wastewater chlorination demand. If industry discharges into the wastewater treatment plant, there are often cyclic demands for chlorine that may not be accurately predicted with instrumentation in the plant. Examples of industrial contaminants are tannins used in leather production and phenols in chemical plants. In both these examples, the chemicals will pass through the typical wastewater treatment processes untreated then react with the chlorine, leaving little or no residual for pathogen reduction. A review of the industrial contribution to the treatment plant would be prudent. Based on the results, unique chemical dosing strategies may be required to provide higher disinfectant dosing to accommodate the industrial flows.

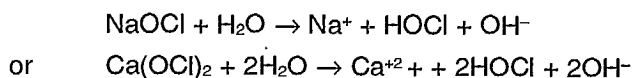
The pH of the wastewater is important, as the effectiveness of the disinfectant is pH sensitive. Typical wastewater chlorine dosages are an order of magnitude higher than those required for disinfection of potable water sources. This is due to the increased pathogen concentrations in wastewater relative to drinking water sources and the presence of several other competing agents such as ammonia, suspended solids, fats, oils and grease as well as other compounds that exert an additional chlorine demand. For example, typical chlorine dosages for secondary treated effluent can range from 2-10 mg/L, compared to a required chlorine dose of 0.2 to 2 mg/L for disinfection of potable water⁽⁷⁾.

2.2 OVERVIEW OF CHLORINE CHEMISTRY IN WASTEWATER TREATMENT

Chlorine can be added to water as a gas (Cl_2) or in ionized form as sodium or calcium hypochlorite. In the presence of water, chlorine gas rapidly hydrolyzes into hypochlorous acid (HOCl), the oxidizing agent, according to the following reaction:



Hypochlorous acid is also formed from the disassociation of sodium or calcium hypochlorite according to the following reaction:



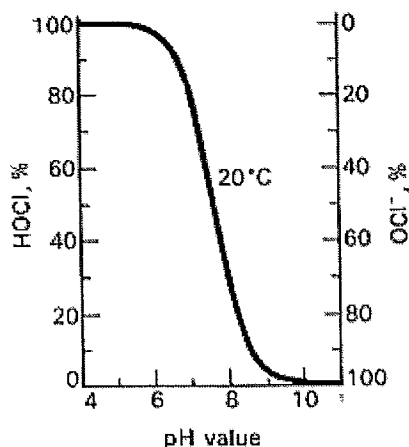
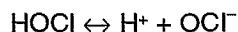


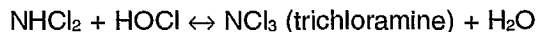
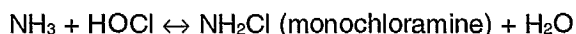
Figure 2-1
Distribution of hypochlorous
acid and hypochlorite in water
at different pH values
(Ref. 10)

Hypochlorous acid is a weak acid and will tend to partially disassociate into the hypochlorite ion per:



The relative concentration of HOCl and OCl⁻ in solution is strongly dictated by pH, with HOCl concentration approaching 100 percent at pH 5 and below. As the pH rises, the relative fraction of HOCl decreases as the corresponding fraction of OCl⁻ increases as shown in Figure 2-1. The HOCl form is preferred in terms of germicidal efficiency, having 60 to 120 times the disinfection power of the OCl⁻ form. Therefore, as pH increases, chlorine dosages must be increased to obtain an equivalent kill rate. The concentration of hypochlorous acid (HOCl) and hypochlorite ion (OCl⁻) is commonly referred to as free available chlorine or free chlorine residual.

When chlorine is added to water containing ammonia (NH₃), as is the case with chlorination of many wastewaters, except those that have been completely nitrified (when ammonia is converted to nitrate), chloramines are formed according to the following reactions:



In the above reactions, a double arrow has been used to indicate that both forward and reverse reactions occur and that species on both sides of the equation will be present to some extent. It should be noted that the formation of chlorine residual compounds is always in a state of dynamic equilibrium. Monochloramine (NH₂Cl) has a higher disinfecting power than dichloramine (NHCl₂) and trichloramine (NCl₃). The chloramine species formed is dependent on several factors, the most important of which are pH, temperature, alkalinity, chlorine dose, and the ratio of chlorine to ammonia – nitrogen. At low pH, monochloramine will tend to disassociate to the less desirable dichloramine. At pH 6.5 and above, monochloramine is the predominant species. The optimum pH for formation of monochloramine is around pH 8.4.

The reaction of chlorine with organonitrogen compounds, (e.g. amino acids, proteins, humic materials, etc) produces organochloramines (e.g., N-chloramines and N-chloramino acids). In municipal wastewater, chlorine residual typically consists mostly of organochloramines, rather than inorganic chloramines. For example, for primary treatment effluents, which typically contain ammonia, amino acids and proteins, there can be a high proportion of inorganic chloramines formed. In one case (Ladysmith, B.C.), the free chlorine residual was <0.02 mg/L, prior to dechlorination, whereas the monochloramine and organochloramines were 0.41 and 0.78 mg/L, respectively, prior to dechlorination ⁽²⁴⁾.

Total chloramine concentration is referred to as combined chlorine. The terms total chlorine and residual chlorine refer to the sum of free available chlorine (HOCl , OCl^-) and combined chlorine (NH_2Cl , NHCl_2 , NCl_3 and organochloramines).

Chlorination of water containing ammonia and organonitrogen compounds is described by the breakpoint curve (Figure 2-2). The initial chlorine dosage is consumed by readily oxidizable materials, including iron, manganese, hydrogen sulphide, and organics. Until this demand is met, no chlorine residual can be established and the curve is flat. As the chlorine dose increases, increasing the chlorine to ammonia ratio, chlorinated organic compounds and chloramines, predominantly monochloramine, are formed. The chlorine residual rises to a maximum at a chlorine-to-ammonia weight ratio of 5, at which time monochloramine dissociates into nitrogen gas, nitrous oxides, as well as reduced chloramine compounds, i.e. dichloramine ⁽⁶⁾. The chlorine residual drops to a minimum or breakpoint, after which there is no longer any ammonia left to react with the chlorine. At this point, chlorine residual begins to rise in direct relation to chlorine dose, indicating the dominance of HOCl and OCl^- , or free chlorine, with perhaps traces of trichloramine (also known as nitrogen trichloride). The formation of trace trichloramine and other related compounds is responsible for the odour problems sometimes experienced with breakpoint chlorination of wastewater ⁽⁷⁾.

Specific lethality refers to the relative potency of a disinfectant. The most effective chlorine-based disinfection agent is hypochlorous acid (HOCl), followed by chlorine dioxide (ClO_2), hypochlorite ion (OCl^-), and finally the chloramines, which have the least specific lethality. However, for contact times greater than 45-50 minutes monochloramine has been found to be as germicidal as free chlorine ⁽⁷⁾. Only HOCl has any recorded lethality for enteric viral cysts ⁽⁵⁾. Organic chloramines have significantly lower biocidal effect than inorganic chloramines ⁽²⁵⁾.

The germicidal efficiency of HOCl is due to the relative ease with which it can penetrate the cell wall of the target organisms ⁽⁷⁾. Hypochlorite (OCl^-) is a poor disinfectant, as the negative charge makes diffusion through the cell wall more difficult.

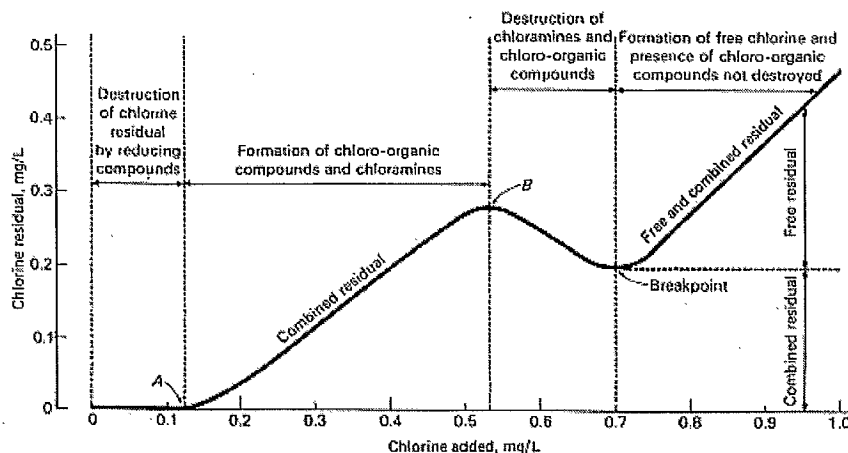


Figure 2-2
Generalized curve obtained during breakpoint chlorination
 (pH 7, 25°C) (Figure 7-3 in Ref. 10)

2.3 FACTORS INFLUENCING DISINFECTION BY CHLORINATION

2.3.1 Disinfection Kinetics

Disinfection of wastewater is described by the Collins model⁽¹⁰⁾ which relates disinfectant concentration, contact time, and number of organisms in the empirical "Collins" equation, shown below:

$$Y = Y_0[1 + 0.23CT]^{-3}$$

where: Y = number of organisms after chlorination at time, T

Y_0 = original number of organisms

T = contact time

C = residual disinfectant concentration (at end of contact time, T)

The above equation shows a linear relationship between contact time, T, and concentration, C, i.e. that the product of concentration and time, or CT, is constant for a given kill rate. Therefore, equal microbial destruction can be achieved by using an increased chlorine concentration over a shorter period of time, or by using a lower disinfectant dosage but increasing contact time. While this is true in most instances, the product of concentration and time depends on the type of chemical compound and is not always constant. The relationship is expressed as⁽⁴⁾:

$$C^n T = \text{constant}$$

where: C = concentration of disinfectant

T = time required to achieve a percentage kill

n = constant (a function of chemical compound)

Plotting concentration versus time for a given percentage kill on log-log paper gives a straight line with slope $-1/n$. If n is less than 1, contact time is more important than dosage, which would be the case with chloramination of wastewater, which achieves the same kill rates as HOCl, but over a longer contact time. If n equals one, as is often the case, the effect of dose and contact time are equal. Ideally, a minimum contact time of 30 minutes is desirable to ensure full contact between the disinfectant and the microbial population.

The residual disinfectant concentration, C, does not include the initial ammonia chlorine demand (chlorine dose to the left of the breakpoint) nor the gradual loss in disinfection efficiency found when disinfecting wastewater. Typically, overall chlorine dose needs to be two to three times the desired residual concentration, C, calculated using the Collins equation ⁽⁴⁾.

2.3.2 Effects of Effluent Quality

Effluent quality has an effect on chlorination, chlorine demand, and disinfection. Poorer quality effluents contain more organics and nitrogenous compounds that exert a chlorine demand that must be met before a free residual can be obtained. Chlorine is consumed through oxidation of organic solids as well as adsorption onto particulate matter.

The degree of treatment will affect the effectiveness of disinfection. Solids and soluble Biochemical Oxygen Demand (BOD) will consume the added chlorine plus the solids can shield the micro-organism from contact with the chlorine. Though BOD or Total Suspended Solids (TSS) concentrations cannot be used to accurately predict the interference with chlorine, the chlorine demand will increase with increasing BOD and TSS concentrations.

The effectiveness of chlorine is a function of the concentration of the residual chlorine and the time that it is in contact. White ⁽⁷⁾ provides the following data for estimated chlorine demand (assuming chlorine gas) for various wastewater treatment plant processes at 15 minutes contact time:

- | | |
|-----------------------------|------------|
| • Raw fresh domestic waste | 10-15 mg/L |
| • Raw septic domestic waste | 15-40 mg/L |

• Primary effluent	10-16 mg/L
• Biofilter effluent (secondary)	4-8 mg/L
• Trickling filter effluent	4-10 mg/L
• Well oxidized secondary effluent	3-8 mg/L
• Multimedia filter effluent	3-6 mg/L
• Slow sand filter effluent	2-4 mg/L
• Nitrified filtered effluent	2-10 mg/L
• Septic tank effluent	30-45 mg/L

In practice, lower quality effluents, such as raw sewage or septic effluent, cannot be reliably disinfected at all without at least some primary treatment to decrease the suspended solids concentrations that tend to "shield" pathogens from the chlorine disinfectant.

2.3.3 pH and Temperature

The disinfecting ability of chlorine is dependent on its aqueous form, the chemistry of which is largely dependent on pH. The dissociation of the desired hypochlorous form (HOCl) to the weaker hypochlorite form (OCl⁻) is strongly pH-dependent as shown in Figure 2-1. As can be seen from Figure 2-1, a change from pH 7 to pH 8 will result in a 50 percent drop in the relative concentration of HOCl.

The chemistry of chloramines, formed when chlorine is added to wastewater containing ammonia, is also strongly influenced by pH. At low pH, monochloramine will tend to dissociate to the less desirable dichloramine. Hydrochloric acid (HCl) formed during chlorination will consume alkalinity and sometimes contribute to slight pH depression. Approximately 15 mg/L of alkalinity, expressed as CaCO₃, will be consumed during oxidation of 1.0 mg/L of ammonia nitrogen.

Temperature affects the reaction rates of disinfection chemical processes as well as the rate of chlorine diffusion through the cell walls of pathogenic micro-organisms. Lower temperatures will slow the dissociation of the preferred hypochlorous acid to the less effective hypochlorite form. Diffusion through the cell walls is more efficient at low temperatures.

2.3.4 Presence of Nitrogen and Other Compounds

Organic nitrogen compounds are present in all municipal wastewater. These compounds react with the chlorine to produce N-Chloro compounds or organic chloramines that have

no germicidal characteristics ⁽⁷⁾. Other compounds in wastewater that are readily oxidized by chlorine include Iron, manganese, hydrogen sulphide, and cyanides.

2.3.5 Reaction Rates vs. Concentration

High concentrations of the chemical reactants can increase the speed of the reactions. For disinfection of wastewater, a higher chlorine concentration will increase the rate of degradation of ammonia such that the breakpoint is reached sooner.

2.3.6 Resistant Organisms

The organisms of concern in wastewater include enteric bacteria, bacteria spores, viruses, and protozoan cysts and oocysts. Of these pathogenic organisms, enteric bacteria are easier to destroy than bacterial spores and viruses. *Giardia* and *Cryptosporidium* protozoan cysts and oocysts, respectively, are particularly resistant to chlorination ⁽⁷⁾. In general, active bacteria cells (i.e. not spores) are relatively easy to kill. Resistance to chlorine differs among enteric viruses, with poliovirus being significantly more resistant than the indicator organism *E. coli*. Adenovirus has low resistance to chlorine and is easier to destroy.

The age of the micro-organisms also affects chlorination efficiency. Older bacterial cultures, with an age of 10 days or more, are significantly more resistant to disinfection than young bacterial cultures ⁽¹⁰⁾.

Usually, bacteria are more sensitive to chlorination than viruses and thus require lower Ct values. A study done by WERF in 1995, developed a table showing the relative dosages of chlorine for bacteria and viruses, as shown in Table 2-1.

The table shows relative doses in comparison bacteria (used as a reference).

White notes that it is difficult to compare virus inactivation due to detection limits, and seeding and analytical procedures ⁽⁷⁾. He notes that virus inactivation studies are a "bit murky". A study by Lui and co-workers ⁽²⁹⁾ tested enteric viruses for resistance to free chlorine in the Potomac River water. Their criteria was 4-log inactivation by a 0.5 mg/L free chlorine residual at pH 7.8 and 2°C, as shown in Table 2-2.

Similar results were not found for chloramine. The time for inactivation would be higher as the chloramines have a lower biocidal effect. The above can be used as a rough comparison of the resistance of the viruses.

Table 2-1
Estimated Relative Effectiveness of Chlorine for
Representative Microorganisms of Concern in Wastewater⁽³⁸⁾

Organism	Dosage of Chlorine Relative to Total Coliform Dosage
<i>Bacteria</i>	
Fecal coliform	1.0
<i>Salmonella typhi</i>	1.0
<i>Staphylococcus aureus</i>	2.5
Total coliforms	1.0
<i>Viruses</i>	
Adenovirus	0.5
Coxsackie A-2	6-7
F-specific bacteriophage	5-6
Polio 1	6-7

Table 2-2
4-Log Inactivation of Viruses⁽²⁹⁾

Virus	Time in minutes for 4-log inactivation
polio type II	36.5
Coxsackie B5	34.5
<i>E.coli</i> type 29	18.2
<i>E.coli</i> type 12	16.7
polio type III	16.6
Coxsackie B3	15.7
adenovirus 7a	12.5
Coxsackie B1	8.5
adenovirus 12	8.1
Coxsackie A9	7.0
<i>E.coli</i> 7	6.8
adenovirus 3	4.3
reovirus 2	4.2
reovirus 3	4.0
reovirus 1	2.7

2.3.7 Mixing

In both chlorination and chemical dechlorination, initial mixing ensures a uniform chemical concentration in the effluent and aids in breaking up material that may shield micro-organisms. Mixing particularly enhances disinfection of viral pathogens and nitrified effluent⁽¹¹⁾.

The disinfection of the wastewater depends on the chlorine coming into contact with the pathogens in the water. If adequate mixing is not present, a percentage of the water could flow through the plant with no chlorination. This is especially true during lower flows when the water has less agitation as it flows through the channel or pipe. As further complication to this is the fact that wastewater can have a high degree of ammonia. As the reaction of the ammonia and chlorine is almost immediate, the disinfection of wastewater would be by the less reactive monochloramine⁽⁷⁾.

Typical mixers are hydraulic such that the chemical is added through a diffuser pipe system or a jet system. Chemical injection by these diffuser pipes is common as these installations are relatively inexpensive. If properly designed, this can work; however, many installations do not have effective energy and thus require excess chemical for an equivalent kill rate.

The key to any diffuser is to have sufficient energy or velocity gradient at the application point to ensure complete mixing. It is critical to insure rapid and uniform distribution of the chlorination and dechlorination chemicals to optimize the operation of the disinfection system.

The materials of construction of the diffusers and mixers is important as chlorine is very corrosive. Early diffusers were constructed of rubber-lined steel. The cost of these units has become prohibitive and most diffusers are now constructed of PVC.

Often the need for more mixing is found in the dechlorination process. Unlike the disinfection process, which is time dependent, the dechlorination step is a virtually instantaneous chemical reaction. The dechlorination reaction does however require contact with the full stream. In many plants, the chemical is added at the end of the contact chamber where there is very little mixing energy. Often the flow is stratified such that the dechlorination chemical does not reach sections of the flow therefore only parts of the effluent would get adequately dechlorinated. In addition, the dechlorination chemical concentration will require higher dose concentrations. The net result of poor mixing is higher operating cost with poorer performance.

This situation can be remedied by better chemical diffusion, installation of mixing baffles or mechanical mixers. Care must be exercised if adding mixing baffles as this will create a pressure drop that may cause problems upstream.

2.4 CHLORINATION CHEMICALS

There are a number of different chlorine-based chemicals that, when added to wastewater, produce hypochlorous acid (HOCl). The principal chlorine compounds are chlorine gas (Cl_2), chlorine dioxide (ClO_2) gas, liquid sodium hypochlorite (NaOCl), and solid calcium hypochlorite [$\text{Ca}(\text{OCl})_2$]. Chlorination by sodium or calcium hypochlorite is often referred to as "hypochlorination".

The following sections discuss the nature of each of these chlorination chemicals, their popularity in municipal wastewater treatment plants, and their relative risks and cost. The American Water Works Association (AWWA) produces standards for each of these chemicals. Several publications are available that outline safe handling practices for the various chlorine products, including the Chlorine Institute's "The Chlorine Manual" and the AWWA's "Safety Practice for Water Utilities".

Example MSDS sheets for the most common of these chemicals are included in Appendix B.

2.4.1 Chlorine Gas, Cl_2

Chlorine gas (Cl_2) is the most common source of chlorine in larger wastewater facilities. Chlorine gas is heavier than air, is highly toxic and is very corrosive when mixed with water. Cl_2 is supplied as a pressurized, liquefied gas and stored in either 150 lb (68 kg) cylinders or 1 ton (909 kg) steel containers. Larger plants usually use the 1 ton (909 kg) containers. Smaller plants, when they do use chlorine gas, typically use the smaller (68 kg) cylinders. The limiting factor for container selection is the maximum withdrawal rate. For the 68 kg containers, the chlorine can be withdrawn at a daily rate of about $14.545 \text{ kg} + 0.817 \text{ kg}/^\circ\text{C}$ ($0 \text{ lb.} + 1 \text{ lb. per } ^\circ\text{F}$), where the temperature roughly equals the storage room temperature. The larger 909 kg container can be withdrawn at rate of about $181.8 \text{ kg} + 6.45 \text{ kg}/^\circ\text{C}$ ($0 \text{ lbs} + 8 \text{ lb.}/^\circ\text{F}$). If these rates are exceeded, the chlorine starts to freeze at the vacuum regulator and eventually closes off delivery of chlorine. As a result, using the above as a rough guideline, a 10°C (5°F) room temperature would allow approximately 20 kg (50 pounds) per 24-hour day of chlorine dosing using the 68 kg (150 lb) cylinders. Under the same conditions, the 909 kg (1 ton) containers could each deliver approximately 180 kg (400 lbs) per 24 hour day. Demands greater than these would require multiple cylinders be arranged in parallel. Alternatively, it is possible to withdraw liquid from the 1 ton (909 kg) cylinders at higher rates, and then use an evaporator system.

One benefit of using chlorine gas over other alternatives is that the conversion from gaseous chlorine to hypochlorous acid consumes approximately 1.3 part alkalinity per part of chlorine added⁽¹¹⁾. As a result, chlorine gas tends to lower the pH of poorly buffered wastewater, which has been found to increase overall germicidal efficiency⁽¹²⁾.

Transport, storage and use of chlorine gas presents safety concerns, particularly within populated areas. For this reason, gaseous chlorination systems require special rooms or separate buildings. In addition, there must be hazardous materials handling and evacuation equipment and procedures in place.

In any chlorine gas dosing system, safety is an essential design parameter for the operations staff, public, and the surrounding environment. Some plants have installed automated valves for remote shutdown of chlorine dosing and chlorine gas scrubbers. In the event of a chlorine leak, the chlorine scrubbers draw the contaminated air from the chlorine room and run the gas through a caustic soda mist. The chlorine gas will be neutralized by the caustic and the vented air is rendered safe for the surrounding area. There are only a handful of these units installed in B.C., as the cost of these units is quite expensive (approximately \$100,000 CDN).

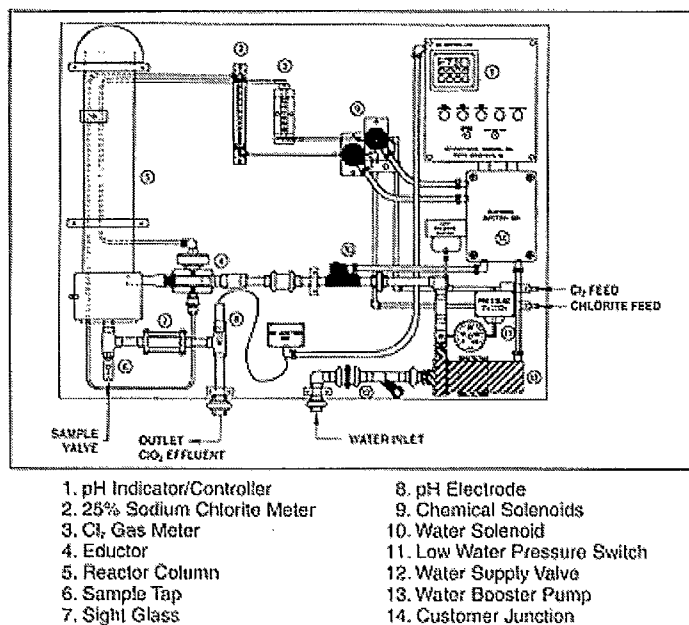
Safety valves on the chlorine cylinders have become more common. These valves automatically close the supply of chlorine gas should a leak be detected in the storage room. The operators must then enter the room with proper safety equipment to repair the offending leak.

2.4.2 Chlorine Dioxide, ClO₂

The use of chlorine dioxide (ClO₂) as a disinfectant has gained popularity in North America, especially for wastewater disinfection in larger facilities. Chlorine dioxide maintains its efficiency at high pH and does not react with ammonia nitrogen to produce chloramines, which allows disinfection at lower dosages than with other chlorine disinfectants. Also, ClO₂ does not react with pre-cursors, such as total organic carbon (TOC) to form trihalomethanes (THM's) which are considered to be carcinogenic. However, other chemical byproducts are produced by disinfection with ClO₂, including chlorinated aromatic hydrocarbons and chlorate (ClO₃) which may have significant human health impacts.

Chlorine dioxide is highly soluble, but will readily off-gas and is photo-oxidized in the presence of light⁽⁴⁾. Therefore, ClO₂ gas is typically generated on-site by mixing chlorine solution with sodium chlorite solution at low pH. The chlorine solution is formed by vapourizing chlorine gas using evaporators and chlorinators and then converting the vapour to chlorine solution using an injector. Several manufacturers offer pre-engineered, packaged chlorine dioxide generating equipment, as shown schematically in Figure 2-3.

Figure 2-3
An Example Chlorine Dioxide Generator



Due to the high equipment cost and complexity, as well as chemical supply and storage requirements, use of ClO₂ disinfection is typically restricted to only larger water and wastewater treatment plants or industrial facilities, including pulp mills.

2.4.3 Sodium Hypochlorite, NaOCl

Sodium hypochlorite, NaOCl, is well known as "liquid bleach". Because of issues related to the safe handling and control of chlorine gas, sodium hypochlorite is becoming more popular where chlorination is the means of wastewater disinfection. It is produced commercially by electrolytic hydrolysis of water in a NaCl brine solution, which results in NaOCl and OH⁻, i.e. the solution has a very high pH. NaOCl is a clear, light yellow liquid, which is highly alkaline, and corrosive. It typically contains 5 to 15% available chlorine. Off-gassing is a problem at higher concentrations. Sodium hypochlorite solution must be stored in closed fibreglass tanks or rubber-lined steel containers to prevent corrosive attack and to minimize off-gassing of chlorine gas.

Because of the manner of production of sodium hypochlorite, hypochlorination has a tendency to raise pH of the solution to which it is added. The increase in pH tends to cause disassociation of the desired hypochlorous form (HOCl) to the weaker hypochlorite form (OCl⁻), leading to reduced disinfection efficiency.

Sodium hypochlorite is readily available and is safer to store and handle than gaseous chlorine. As a result, for small to medium-sized disinfection systems, it is often the chlorination chemical of choice.

Sodium hypochlorite loses its strength during storage, such that after 30 days, up to 10% of its strength can be lost. Storage of the chemical should always include secondary containment to avoid escape of chemical into the environment.

There a number of ways of expressing the strength of sodium hypochlorite. A common method is to describe its trade percent (or percent by volume) in terms of available chlorine in one litre of hypochlorite solution. Trade percent is defined as:

$$\text{Trade \% (percent by volume)} = \frac{\text{g/L available Cl}_2}{10}$$

Alternative expressions are:

$$\text{Weight \% available chlorine} = \frac{\text{Trade percent}}{\text{s.g. of solution}}$$

$$\text{Weight \% NaOCl} = \text{Weight \% available chlorine} \times 1.05$$

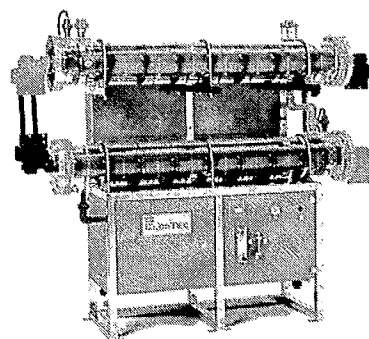
Table 2-3 provides the more commonly used hypochlorite strengths:

Table 2-3
Sodium Hypochlorite Solution Strengths

Trade Percent	Density		Availability chlorine (weight percent)	
	kg/L	lb/USgal	g/L	lb/USgal
-	1.011	8.44	8	0.067*
1	1.014	8.45	10	0.083
5	1.070	8.92	50	0.416
10	1.139	9.50	100	0.833
12	1.168	9.74	120	0.999
13	1.183	9.86	130	1.08
15	1.211	10.1	150	1.25

*On-site generation systems provide hypochlorite solution strengths of 0.8%.

Sodium hypochlorite is available for the industrial and municipal markets in the 10 to 16% trade percent range; whereas typical household bleach is 6% trade percent or less. By far, 12% is the most common solution strength. Weaker solutions of <1% can also be produced by using on-site sodium hypochlorite generation equipment.



2.4.4 On-site Sodium Hypochlorite/Chlorine Gas Generation

Figure 2-4: An On-Site Sodium Hypochlorite Generator

On-site sodium hypochlorite generation systems produce chlorine from sodium chloride (NaCl) salt and water. In these systems, the NaCl salt is charged into a brine tank to produce a saturated salt solution. Power is applied and catalytic reactions produce the hypochlorite, OCl^- , sodium hydroxide, NaOH (or "caustic soda" – a very strong base) and hydrogen gas. The hypochlorite generators and gas generators are similar, except the gas generators require a step to separate the gas from the sodium hydroxide that is also produced. These chemicals are produced at the cathode during the electrolysis of the brine solution. The complete scope of supply for these systems include water softener, salt saturator, brine pumps, electrolytic cells, pumps, and controls. Units are typically pre-packaged and are easily installed. These systems only produce the gas that is required for the process, therefore, risk of escape to the environment is virtually eliminated. The advantage of these systems is that the chemical delivery and storage is made safer as the only chemical involved is common salt.

For the sodium hypochlorite generators, the chemical is produced from the brine, and then stored in a tank to be metered to the process in a similar manner to typical sodium hypochlorite systems. The risk of 12% hypochlorite spills into the environment is eliminated. With proper secondary containment of the chemical storage tank, risk of chemical contamination of the environment is extremely low.

These systems are much more expensive to purchase than typical chlorine gas and liquid sodium hypochlorite systems. Typically, there is payback as the cost of power and salt is typically lower than purchased chemicals. However, it is not possible to make a blanket statement regarding potential cost savings as the size of the system and freight costs for chemical delivery will make each site unique.

Care must be exercised in properly venting hydrogen gas as this can be explosive at high concentrations. Diluting the vent gas with air easily prevents this problem.

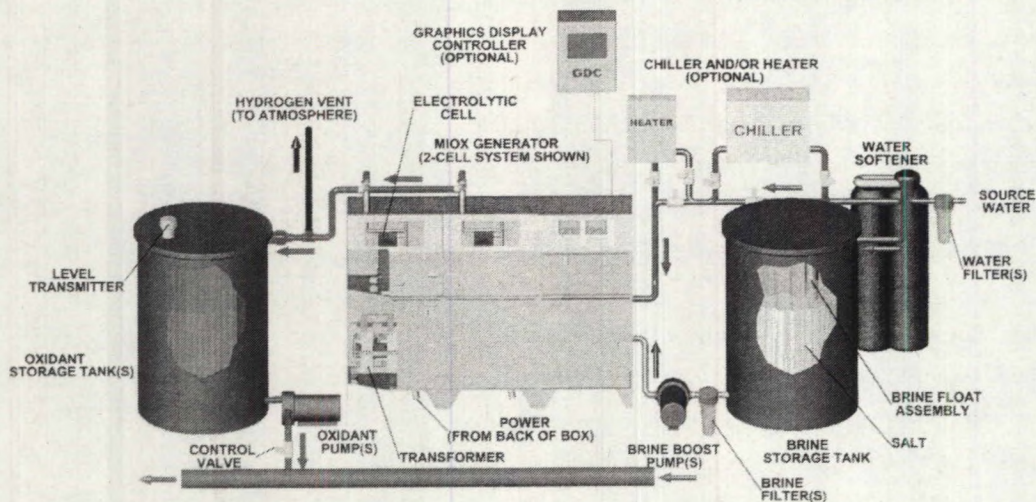


Figure 2-5: A Schematic of an On-Site Chlorine Gas Generation Unit

2.4.5 Calcium Hypochlorite, $\text{Ca}(\text{OCl})_2$

Calcium hypochlorite, $\text{Ca}(\text{OCl})_2$, is a white solid chemical which is commercially available as a powder, granules, pellets, or tablets. Tablet and pellet systems (sometimes called "pucks") are used for small treatment plants, and are often directly applied in solid form. Granules are often added to a solution tank and injected through a solution feeder. "High test" calcium hypochlorite (i.e. high test hypochlorite "HTH") contains about 70% available chlorine by weight (as a dry powder).

Calcium hypochlorite is typically 1.5 to 2 times the cost of liquid sodium hypochlorite, but may be preferred by smaller users as it requires less infrastructure for transport, storage, and handling. While calcium hypochlorite is readily soluble in water, it also tends to crystallize, leading to clogging of dosing pumps and lines.

As the calcium hypochlorite is a solid form, it represents the safest storage of the various forms of chlorine. The chemical is harmless unless water is added. A spill from a container would require only picking up the chlorine powder or "puck". In contrast, a sodium hypochlorite spill could escape to the surrounding soil or water course, with potential deleterious results to the environment.

There are dosing systems that control the dose of chemical to the final application. However, it should be noted that simply dropping pucks into a chlorine contact chamber or chemical storage sleeve, is not acceptable. This method offers no control of the actual dose. This

practice will tend to under-deliver chlorine during high flow and over-deliver during low flow periods. The number of pucks and size of puck will also affect the dose. The practice is acceptable in swimming pool operations where the flow and demand is relatively constant. In municipal wastewater applications, with diurnal flow patterns, this method of chemical addition has typically been ineffective and represents a high potential for chlorine residual discharge into the receiving environment. Section 3.4.3 contains a discussion of an improved method of using calcium hypochlorite feed systems.

2.4.6 Chemical Costs

Chlorination chemical costs vary considerably, based on the form of chlorine used. Chlorine gas is the least costly chemical and calcium hypochlorite is the most costly. However, chlorine gas also requires the most equipment and controls, including safety controls. Calcium hypochlorite requires the least equipment and controls. As result, a decision regarding which chemical should be used is a function of dosage and life cycle costs, which are typically application specific. However, it is safe to say that in the past, the larger treatment plants, where the extra capital cost for the chlorine gas equipment is a small fraction of the total plant capital cost, tended to use chlorine gas systems. Similarly, the medium-sized systems tended to use either chlorine gas or sodium hypochlorite. Only the very small systems typically used calcium hypochlorite.

Table 2-4 shows chlorine costs from the fourth quarter of 2002. Chlorine gas is used as the benchmark for comparison of chlorine forms. Chemical costs vary considerably with demand in the marketplace. Plant operators should verify the actual chemical costs before selecting a chemical.

In a study completed for the US Army entitled "Disinfection Technologies for Potable Water and Wastewater Treatment: Alternatives to Chlorine Gas", ⁽³⁰⁾ a table was completed showing the capital costs associated with the various systems.

Table 2-4
Relative Chlorination Chemical Costs

Chemical	Equivalent Cost to Chlorine Gas
Chlorine Gas	1
Sodium Hypochlorite	2.5
Calcium Hypochlorite	8.75

Table 2-5
**Approximate Costs: Gaseous Chlorine and NaOCl Technology (Potable water, 1.2 USMGD,
 1 mg/L chlorine dose) (30)**

	Cl₂ With Scrubbers (150# Cylinders)	Cl₂ Without Scrubbers (150# Cylinders)	NaOCl (Off-Site Generated)	NaOCl (On-Site Generated)
Capital	\$65,000	\$15,000	\$2,500	\$18,000
Operating	\$3,600	\$3,600	\$4,400	\$1,500
Maintenance	\$2,600	\$2,600	\$5,000	\$1,600

Sources: Matheson Gas Products (Cl₂); Van Waters and Rogers (NaOCl).

Note: All values are stated in US funds.

The table has two columns for gas feed with one system incorporating a gas scrubber system and the other without. Although not reflected in the table, scrubber systems generally have higher maintenance costs. The intent of the table is to show approximate values for comparison. All values are expressed in 1998 US Funds per the source document.

2.5 TOXICITY OF CHLORINE RESIDUALS

Chlorine residuals, even in low concentrations are, at best, irritants and, at worst, toxic to most fish and other aquatic life. Fish bioassay tests in California demonstrated that, in all cases, chlorination increased the toxicity of effluents in the aquatic environment over non-chlorinated effluent⁽⁶⁾. In general, smaller fish (fingerlings and minnows) are much more susceptible to chlorine toxicity.

Studies show that chlorine residuals of 0.02 mg/L affect aquatic biota in waters receiving municipal effluent⁽¹⁾. Salmon and rainbow trout mortalities have been recorded in receiving streams with total chlorine concentrations as low as 0.02 mg/L and 0.026 mg/L, respectively⁽²⁾.

The fate of chlorine residual in an effluent plume, once it enters receiving water, depends on the chlorine demand and also the salinity of the receiving environment. Chlorine, when mixed with seawater, produces other oxidants such as bromines, hypobromous acid, and bromochloramines. The highest rate of residual chlorine decay occurs in the presence of organic materials that exert a chlorine demand. Depletion of chlorine residual is mainly by dilution for chlorinated secondary effluent discharged to receiving waters low in organic matter.

2.6 CHLORINATION BY-PRODUCTS

Free chlorine combines with organic constituents in wastewater (humic and fulvic acids) to produce an array of undesirable haloform compounds including trihalomethanes (THM's), mostly as chloroform, and other chloro-organic by-products. To date, focus has been on the impacts of THM's in drinking water rather than wastewater. At the concentrations found in drinking water, THM's are not considered to be acutely toxic to humans⁽⁷⁾. However, THM's have been found to be carcinogenic to laboratory rats following prolonged ingestion⁽⁷⁾. The long-term, chronic impacts to human health of ingesting THM's is unknown. Due to the potential for human carcinogenicity, a precautionary approach has been taken to limit the formation of THM's in drinking water.

However, these reactions do not typically occur in wastewater, as there is no free chlorine. As discussed in previous sections, most of the chlorine is in the chloramine form. Chloramines are not active in the formation of THM's⁽³¹⁾.

Other toxic compounds can be formed through the disinfection process. Cyanogen chloride, a compound highly toxic to fish in small concentrations, can be formed as a result of chlorinating effluents that contain thiocyanate from industrial sources.

CHLORINATION CHEMICAL DOSING EQUIPMENT

SECTION 3

Proper chlorination (and dechlorination) practice requires selection of the chlorination chemical dosing equipment. The systems supplied for dosing chlorination chemicals must be continuous, accurate, and reliable. When dangerous chemicals, such as chlorine gas, are used, it is imperative the equipment be safe for the operators, as well as the surrounding environment.

3.1 DOSING EQUIPMENT SELECTION CRITERIA

Section 2 contains a discussion on the chlorine-based chemicals typically used in wastewater complete with the costs and risks associated with each chemical. When selecting the chemical to be used, the considerations to review are:

- Cost
- Effectiveness of treatment
- Ease of handling and delivery
- Safety in transport and at the plant
- Environmental impact in receiving water

The chemical dosing equipment plays an important role in determining the final selection of the chlorination chemical. The following subsections provide a brief overview of the equipment required for dosing as well as operational options to provide superior control.

3.2 CHLORINATION CHEMICAL DOSING RANGE

In order to select the appropriate dosing system for the chlorination chemicals, the required dosing rate must be determined. As a starting basis, one should review the chlorine dosage requirements from White ⁽⁷⁾, as reproduced in Section 2.3.2. The table defines the concentration of chlorine that is required to achieve pathogen removal. The reaction in the water with the chlorine is time dependent as defined by the Collins formula per Section 2.3.1. Full analysis of design is well outside the scope of this paper; however, the understanding of the required dosage is critical for understanding the operational requirement.

All dosing equipment will have a published maximum dosing rate. The minimum feed rate is typically a percent of this maximum dosing rate. The chemical dosing will generally be linear within a range, but the accuracy drops as the dosing rate reaches the lower limit of the dosing device. It is important to ensure the installed dosing equipment is not continuously dosing at this lower, non-linear level. Too often, the

chemical dosing equipment is sized for a future flow or unusual peak event and will be unable to deliver accurate dosing at present conditions. If chlorine gas dosing equipment is used, it is typically very simple to exchange the flow valve and rotameter for smaller size units. Chemical doses for metering pumps can be reduced by both stroke length and stroke frequency. It is often better to replace large pumps with smaller units as chemical delivery is typically much more reliable with the pump operating with more frequent and longer strokes.

Typically, the dosage is stated in either mg/L or parts per million (ppm). The peak wastewater flow rate, stated in megalitres/day (ML/day), is then multiplied by the dosage to provide the chemical dosing rate in kg/day. It is not uncommon to verify the result through lab analysis to ensure proper dosing.

In most cases the actual demand will not be known until the plant has been operational for some time, and has become stable. The chemical feed system should be sized to operate in the middle to upper end of the maximum dosing rate.

3.3 CHLORINATION CHEMICAL DOSING CONTROL

The control of chlorination chemicals is an important element in the process as this will assure effluent permit levels are consistently met. There are a number of dosing strategies that can be employed. These strategies and the related cost implications are discussed in the following subsections.

3.3.1 Manual Control

This is the most basic of the control philosophies. The operator must manually turn the dosing equipment on and pre-set the rate. Any adjustment of the dosing rate will require input from the operator. This type of control would be appropriate for batch discharges where the quality of the effluent is consistent and the operator is present for the complete discharge cycle.

3.3.2 Semi-Automatic

For this operation, the discharge is typically intermittent and the effluent is of a consistent quality. Controls would be installed such that the chemical dosing equipment would turn on when the effluent is discharged. The flow during the discharge cycle must remain constant for this process to work as there is no adjustment to the dose. Should the flow rate decline, a higher concentration will result. Sequencing Batch Reactors (SBR's) are an example where this control would be used in wastewater treatment plants. The decant cycle of the SBR process would transfer a volume of treated effluent into the contact tank. In this case, when the valve opens to initiate the batch cycle, the chlorine would be turned on simultaneously, and turn off once the cycle ends.

3.3.3 Variable Flow Rate-Constant Demand

In the previous two control strategies, the flow rate remains fixed. More typically in wastewater treatment, the flows are continuously fluctuating. The operator cannot be expected to continuously adjust the dosing rate. Flow meters are used to generate an electrical signal that is proportional to the flow. The electrical signal is used to pace a chemical addition system such that the chemical is added in direct proportion to the flow. Typical control signals are 4–20 mA or 0–10 mV. Other types of signals available are pulse, 0–16 mA, 0–20 mA, 0–1 mV, 1–5 mV, and 0–5 mV. In all cases, the output from the flow meter is some form of electrical signal that rises and falls in response to the flow. The chlorine dosing equipment will interpret the dosing rate and pace the chlorine in proportion to the changes seen from the input flow signal.

If one is using a metering pump to deliver liquid sodium hypochlorite, the pump stroke speed would increase with the input flow. In setting up the system for a 4–20 mA circuit, the flow at 0 would produce an output signal of 4 mA. The pump would interpret this input as 0% of the pumping speed and therefore deliver no chlorine. If the flow rate is 100% of the maximum flow, an output signal of 20 mA is produced. The metering pump flow will then deliver 100% of the chlorine dose.

It is very important to size the equipment to the demand when using this type of control logic. The flow meter and chemical dosing equipment should be as close as possible to operating conditions such that the flow meter's maximum flow is calibrated to the plant's maximum flow. The dosing equipment must be sized such that the maximum dosing of chemical is equal to the maximum demand at peak flow. If the equipment is undersized, then insufficient chemical will be delivered. If the components are oversized, inaccurate dosing occurs when the units are run at the lower levels.

3.3.4 Constant Flow Rate-Variable Demand

In this type of control scenario, the chlorine demand is assumed variable and the flow is constant. This is a more typical in wastewater applications since chlorine demand has so many variables, and it is not typical that demand remains constant. For this type of control, the dosing equipment is paced by the measurement of chlorine residual. The same type of signal (i.e. 4 – 20 mA) is used as in the flow proportional control; however, in this case, the signal would come from the residual chlorine analyzer.

3.3.5 Variable Rate with Variable Chlorine Demand (Compound Loop)

This is the most typical situation that occurs in a wastewater treatment plant. In this case, both the flow and the chlorine demand are fluctuating. In this type of control, the plant flow rate is typically used to do the basic control of the chlorine dosing. The chemical is added based on flow, then a sample will be taken automatically to determine the actual chlorine residual. If the

chlorine residual is equal to the set point (i.e. desired chlorine residual) the dosing will remain at that level for the given flow. However, if the residual is below the set point, the dosing equipment will increase until the set point is reached.

This system is the best method of control as it assures proper dosage at all times. The residual based system (Constant Flow Rate – Variable Demand) would appear to be as good; however, the residual type control does not react well to flow variations and typically continually searches for the set point. Very few systems employ direct residual control, as this control circuit tends to be unstable.

3.3.6 Costs of Control Systems

Manual control is the least expensive method of control as there is no automated equipment involved. However, if the plant has variable flow or demand, an operator would be required to control the dosing equipment continually in order to control the effluent quality. This would be unaffordable to operate. In addition, the plant would likely not meet the required dose requirements.

The semi-automatic control typically requires only some form of relay contact and level control to turn the system on and off. Generally, this type of control would cost approximately \$500 – 1,000 to incorporate. For a typical plant, one would also require a tank in order to batch the effluent. The tankage required, plus the potential for odours, can make this option costly.

Flow proportional control requires the addition of a flow meter plus the ability for the dosing equipment to accept a flow signal. Flow meter costs are difficult to define as they are dependent on the size of pipe or channel where they are installed. If the plant already has a flow meter, then a second meter should not be required. To add the ability to pace the chemical dosing, the cost would range from about \$250 for very small metering pumps up to about \$15,000 for chlorine gas dosing equipment.

The compound loop control requires the addition of a residual chlorine analyzer as well as the flow meter. It also requires a controller that can accept two control signals. These devices are referred to as PID (Proportional Integral Derivative) controllers. PID controllers have the logic required to bias the flow signal with the residual signal and produce a control signal to the dosing equipment. Another method used in compound loop is to use the flow signal to control the speed of the pump and the residual to control the stroke length. This type of system is seldom used as the PID controllers are now substantially less costly than the stroke length positioners. Generally the PID controllers range from about \$4,000 to \$8,000 plus the cost of the on-line analyzer (discussed in later sections).

3.4 CHEMICAL DOSING EQUIPMENT

3.4.1 Chlorine Gas Dosing Equipment

The equipment used to deliver chlorine gas from a pressurized container (either 68 kg or 1000 kg) uses a vacuum extraction process. Raw water is pumped through an eductor (or venturi) that creates the required vacuum. The vacuum pulls open a valve mounted directly on the chlorine tank to allow the gas to flow. Loss in vacuum will result in the valve closing immediately, thus reducing the risk of chlorine gas being emitted from the system. The gas is extremely dangerous to human health, even in small concentrations.

The control of the dosing is by a valve between the eductor and the vacuum shut-off valve. This valve can be either manually operated or can be controlled by an external signal. The control can be manual, semi-automatic, flow proportional or compound loop.

For manual and semi-automatic control, the gas chlorinators are activated by turning the water on to the eductor. This produces the required vacuum to open the gas flow then the rate setting valve will allow the dosing to be delivered at the preset rate.

For either flow proportional or compound loop control, the unit will accept a proportional signal and set the valve to a level appropriate for the input signal. The positioner will constantly adjust the dose to meet the plant demand, therefore continuous operator intervention is not required.

The turndown of the gas dosing system is typically about 4% of full scale. Generally speaking, it is best to have the unit selected to run no lower than 20% of the units full scale. In systems that have combined sewers or high degrees of infiltration, it is not uncommon to have very high seasonal flows. If this is the case, the gas chlorination can be fitted with a larger rotameter and rate set valve to allow for the high seasonal demand. The units are very easy to modify and, once changed to a dose rate with a capacity closer to the peak feed rate, the chemical delivery is far more accurate. Each time a new rotameter with a new capacity is installed, re-calibration of the dosing rate is required.

Small systems requiring chlorine under 227 kg (500 pounds) per day are typically wall mounted and range in price from \$20,000 to \$50,000. Larger systems using 909 kg (1 ton) cylinders typically cost \$30,000 to \$60,000.

Gas chlorine systems are inherently dangerous units and require special design features to ensure operator and public safety. The chlorine bottles are typically stored in separate locked rooms. These rooms typically have two doors, a window for viewing the operation from a safe area, and a dedicated heating and ventilation system. In the room, a leak detector is required to

alert the operation staff of any chlorine emission. Should a leak occur, all staff must immediately leave the room and can only re-enter while wearing appropriate personal protection clothing and a self-contained breathing apparatus (SCBA). The most recent safety features for gas chlorine systems are automated shut off valves for the cylinders plus chlorine gas scrubbers. The automated valves cost about \$5,000 per bottle and the gas scrubbers are roughly \$100,000.

Although the gas is very inexpensive to purchase, all the equipment and safety equipment can make gas quite expensive to utilize, especially for small systems. In addition, more training is required for the operation and maintenance of the gas systems than is necessary for other chlorination methods, including the use of sodium hypochlorite (see next section).

Older gas chlorination systems operated under pressure. These systems are inherently dangerous to the operator and the environment and should be decommissioned.

3.4.2 Sodium Hypochlorite Dosing Equipment

The sodium hypochlorite (NaOCl) (commonly referred to as "hypo") chemical dosing systems are very simple in operation and design. The chemical does not possess the health risk of the pressurized gas chlorine therefore it can be shipped and handled in a far easier manner. While the chemical cost is substantially higher than for gaseous chlorine, the initial capital cost to install the "hypo" dosing systems typically make this the chemical of choice for smaller applications.

The system requirements are limited to a storage tank and a metering pump. All control strategy options are available for this type of system. For flow paced or compound loop control systems, the pump must accept a control signal to vary the output of the pump. There are two basic types of pumps that are commonly used for this application. The first is a solenoid actuated metering pump. In this type of pump, an electrical current is passed through a core which then pulls the diaphragm back. When the current is turned off a spring will push the diaphragm back. When the diaphragm is pulled backwards, it fills the head with chemical and as it is pushed backwards the fluid is pumped out.

The frequency of the current being turned on determines the dosing rate. Most metering pumps also have a stroke length adjustment. If less chemical is required, the length of the stroke is shortened. For the same frequency of stroke, the pump will deliver less chemical.

Another type of metering pump is a mechanically-driven unit. These pumps operate in a similar fashion, but use an electric motor to drive the diaphragm, rather than a solenoid. Other pumps that are used include peristaltic pumps, progressing cavity pumps, and magnetic drive pumps.

Care must be exercised with hypo systems as the hypo solution will off-gas in the suction line. This occurs as the fluid is drawn into the head via vacuum. The low pressure will reduce the vapour pressure of the hypo solution and produce very fine bubbles. If enough of these bubbles are produced, they begin to accumulate and form larger bubbles. As the flow is controlled by ball valves in the pump head, a bubble will cause the ball to unseat and the pump will discontinue dosing. If undetected, the plant will not dose any chlorine and it will require the operator to remedy the situation by priming the pump before chlorine dosing is restored.

There are means to reduce the off-gas risk; however, this level of detail is outside the scope of this study. It is important to take this into account, though, as when the pump is not running, the plant may not meet permit and exceed the allowable fecal count. A brief discussion of sodium hypochlorite off-gassing is presented in Appendix C. Use of peristaltic pumps, progressing cavity pumps and gear pumps will eliminate the off gas problems.

Small sodium hypochlorite systems consist of a storage tank, secondary containment, and metering pumps. The typical price range for the feed equipment only is \$2,000 to \$5,000, depending on the size of the required storage tank.

3.4.3 Calcium Hypochlorite Dosing Equipment

The dry form of calcium hypochlorite ($\text{Ca}(\text{OCl})_2$) has existed for some time. However, as discussed in Section 2.4, in the past the control of the chemical dosing for the dry form typically did not have the accuracy required for municipal applications. The chemical can be used if the powder is completely dissolved and metered with a typical metering pump. The higher chemical cost in comparison to sodium hypochlorite and chlorine gas makes this a non-viable alternative for disinfection and sodium hypochlorite is normally selected.

To address calcium hypochlorite control issues and expand the market for the chemical, the PPG Corporation introduced the Accu-Tab™ Calcium Hypochlorite system in 1993. Other manufacturers such as US Filter and Hammond Technical Services have since introduced competing systems.

The Accu-Tab™ system has a dissolving system that uses 3 inch diameter tablets in a dissolving chamber. Water is introduced such that only the tablets at the bottom of a dissolving tray are dissolved. Tablets on the top remain dry. The dissolving system allows for a predictable rate of erosion, thus allowing for the accurate control of the chlorine dose. The dose control is accomplished by adding more dissolving water. This is not a linear relationship (i.e. adding a percentage increase of dissolving water will not increase the chemical to the same percent). With feedback controls, the non-linear dissolving rate is not important. The key importance is that more dissolving water will result in more chlorine dosing. As the control system recognizes a

need for more chemical, the control valve will supply more dissolving water until the demand is met.

The key advantage with this system is that potential discharge of toxic gas or accidental spills of hazardous liquid chemical is eliminated. These are documented in earlier sections of this report. With sodium hypochlorite solution, there is the risk of leakage seeping in the soil and escaping into the watercourse. If the calcium hypochlorite tablets are dropped, there is no risk of chemical incursion into the surrounding environment (unless they are dissolved). The system is relatively compact and will typically fit in the area required for a typical sodium hypochlorite system. The system can be adapted for automatic control by including a control valve on the dissolving water.

The operation of the system is easy and requires a minimal amount of maintenance as there are no moving parts.

The downside of this system is that the chemical costs are much higher. At the time of writing, chemical is delivered in 25 kg (55 pound) pails of the 75 mm (3 inch) "pucks". A pail of pucks costs about \$120. The strength of the calcium hypochlorite pucks is about 68% and for equivalent chlorine the cost would be roughly \$7.00/kg. It is well beyond the scope of this study to do a detailed analysis of the economics however, in general, for very small systems the lower operation cost offset the higher chemical costs.

The rough costs of calcium hypochlorite metering systems with automated control are shown in Table 3-1.

The above prices would include a system with an automated control valve to be adjusted by input from the plant flow meter and/or the chlorine residual analyzer. The puck container and dissolving unit accept water from a fresh water supply and the chlorine uses the fresh water pressure to transfer the chemical to the application point. The system cost does not include a dosing pump. The system can include a solution injection pump; however, this is not typically required for wastewater where the injection pressure is very low. If a pump is required, the simplicity of the system is lost and a conventional sodium hypochlorite system would likely prove to be a better approach.

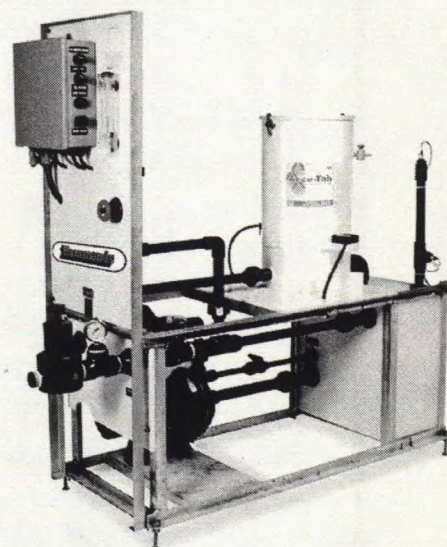


Figure 3-1
Schematic and Photo of an
Accu-Tab™ Chlorinator

Table 3-1
Calcium Hypochlorite Feed Equipment Costs

Equivalent Chlorine Dosing Rate kg/day	Cost \$Cdn Equipment Supply Only
5.5	\$9,500
11	\$10,500
26	\$11,500
136	\$13,500
272	\$16,500

Source: PPG c/o BI Purewater, Vancouver, 2002.

The final analysis of the system must also account for shipping and handling. The long term storage of sodium hypochlorite is not recommended as the solution strength will degrade over time (see Appendix C). Once the hypo carton is opened and is transferred into the solution tank the strength can degrade by up to 2% in one month. Once the strength has degraded to 9-10%, it is relatively stable. In contrast, the strength of calcium hypochlorite is unaffected by time provided the chemical stays dry. As a result, a treatment plant can order much larger volumes and thus reduce the per kilogram shipping costs.

3.5 CHLORINATION CHEMICAL DELIVERY ISSUES

In selecting the chemicals for the disinfection process, the delivery of the chemicals should be considered. The first consideration is that of storage. Based on the demand, the plant should have adequate chemical on hand to provide at least several days of chemical supply. The amount of on-site storage should be based on the reliability of the delivery method. For plants close to the main suppliers of chemical, storage can be as low as 7 days. For more remote locations in areas where winter conditions can delay shipments, a higher level of storage needs to be considered.

If gas is to be used, the storage room for the cylinders needs to be completely sealed and have safety equipment to provide alarms should a leak escape. The Workers Compensation Board requires that warning level be set at 0.5 ppm and an alarm be set at 1 ppm. At this point, any work within the building must be done with breathing apparatus, following very rigid guidelines. In some systems, chlorine scrubbers are installed to neutralize the escaped gas.

For sodium hypochlorite systems, excessive storage should be avoided as the liquid is unstable. Over a period of 1 month, the concentration can be reduced by as much as 2%. The calcium hypochlorite (dry form) has an advantage for storage as the concentration of the chlorine is much higher than the sodium hypochlorite plus spills will not create any problems, unless the chemical is dissolved. For sodium hypochlorite, a spill is not as easily contained and could potentially cause serious problems if dumped by accident.

MEASUREMENT OF CHLORINE RESIDUALS

SECTION 4

Regardless of the form of the chlorine or the chemical feed equipment used in the chlorination process, accurate measurement of total residual chlorine (TRC) is necessary to ensure proper disinfection, while avoiding chemical wastage and potential environmental impacts in receiving waters.

Total chlorine residual during the chlorination process may be in the 2 to 45 mg/L range, whereas, the post-dechlorination TRC values typically must be in the 0.002 to 0.020 mg/L range. As a result, the analytical methods for chlorine residual testing must cover a wide range of values, each with an appropriate level of accuracy and reproducibility.

This chapter provides information about the chemical and/or electrical methods to measure chlorine residual and a discussion of potential interferences to the test methods. This is followed by subsections regarding the application of the chlorine residual test methods to manual off-line chlorine residual testing and on-line chlorine residual testing.

4.1 CHLORINE RESIDUAL ANALYTICAL METHODS

The following subsections cover the analytical methods for chlorine residual measurement that are most widely used (or have been used). Detailed procedures can be found in Standard Methods⁽¹⁴⁾.

4.1.1 Orthotolodine Method

The orthotolodine or orthotolodine arsenite (OTA) method was the first quantitative test for chlorine residual. However, the OTA method has poor accuracy and precision and tends to underestimate chlorine residuals. This has resulted in significant over-chlorination and subsequent environmental impacts of high chlorine residuals in receiving waters. In addition, one of the reagents used in the OTA test, aromatic amine, is listed as a carcinogen. Because of accuracy problems, as well as the health hazard posed by the reagent, the OTA method is now considered to be obsolete and was dropped by "Standard Methods" several editions ago. Because of the limited shelf life of the reagents, it is highly unlikely that any treatment plants are still using this test procedure. If they are still using the OTA method, their results are likely in error and the plant should switch to another method.

4.1.2 The DPD Method

The DPD (N, N diethyl-p-phenylene diamine) method was developed in 1957 by Thomas Palin, Ph.D. and has been commercially marketed since the early 1970's. It is likely the most widely used method for measuring residual chlorine in both water and wastewater. It is a colourimetric test based on the conversion of DPD to a dye in the presence of chlorine.

In the test, the colourless DPD amine is oxidized by free chlorine to produce a magenta-coloured "Wurster" dye, in proportion to the original chlorine residual content. As a result, the residual chlorine concentration can be determined based on the amount of Wurster dye produced and the intensity of the resulting magenta colour.

Both free and combined chlorine can be tested with the DPD method. However, chloramines are slow to react with DPD, which can result in underestimation of chlorine residual. To counter this, the reaction is conducted at a pH of 6.2 to 6.5, and potassium iodide is added. The iodide ion reacts with the chloramines to form iodine, which reacts with the DPD in the same way as free chlorine. The amount of iodide can be varied to determine specific chloramine species. According to "Standard Methods for the Examination of Water and Wastewater", only 0.1 mg of potassium iodide is required per 10 mL sample to determine monochloramine⁽¹⁴⁾. Dichloramine is quantified by adding 100 mg of iodide per 10 mL sample. It is thought that trichloramine does not react with DPD.

Using the DPD method, chlorine residual is measured either using a titration method or colourimetrically. The titration method uses a ferrous iron titrant (ferrous ammonium sulphate) to reduce the Wurster dye to a colourless end point. The DPD colourimetric method relies on accurate comparison of samples to known coloured standards. Highly accurate spectrophotometry equipment is available for precisely determining the magenta-colour species and hence the chlorine residual (i.e. to the second decimal place) based on absorbance at a 515 to 530 nanometre wavelength. Standard Methods⁽¹⁴⁾ states that either spectrophotometers or photometers be used in colourimetric testing. However, most small wastewater facilities do not possess sophisticated spectro-photometers and, instead, rely the operator's visual acuity in comparing samples to known colour standards. The accuracy of so-called "permanent" colourimetric standards can reduce with time, especially if not stored in cool, dark conditions. The shelf life of reagents; including DPD, Wurster Dye, and iodide; is also subject to deterioration if sufficient storage conditions are not maintained. Reagent blanks should be used to determine the effects of reagent deterioration.

The "normal" DPD method, using a powdered buffer reagent (to maintain the required pH), can be reasonably accurate over the 0.005 to 5 mg/L range with a relatively tight 2% standard deviation using colourimetric measurement techniques. This is based on results by the supplier (Hach) using water. At higher chlorine concentrations (i.e., >1 mg/L), a non-linear response has been reported for the DPD method which tends to cause underestimation of chlorine residual⁽¹³⁾⁽¹⁷⁾. This is caused by the fact that, at higher oxidant levels, the reaction favours the formation of the colourless iodine final product over the coloured Wurster dye product. Also, the instability of the liquid DPD reagent at higher chlorine residuals contributes to this non-linearity. Monochloramine breakthrough at higher oxidant concentrations also interferes with the measurement of free chlorine such that higher than actual free chlorine residuals are measured.

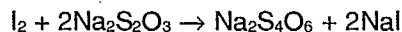
For lower residual chlorine concentrations (i.e., following dechlorination), there is an Ultra Low Range DPD method (ULR-DPD) that uses liquid reagent sealed in an Argon gas atmosphere in a glass ampule. Using this ULR-DPD technique, it is possible to colourimetrically measure total chlorine residual (but not free or combined) down to the 10 µg/L range, i.e. 0.010 mg/L⁽³¹⁾. This method is best used in the 0 to 0.5 mg/L total residual chlorine (TRC) range.

4.1.3 Iodometric Method

The iodometric method iodide is converted to elemental iodine as chloramine (or combined residual) is converted as follows (simplified reactions shown):



The chlorine residual and KI reaction will go to completion quite quickly. A reducing agent is added until the brown colour of the elemental iodine disappears. Liquid starch solution is added and the blue-coloured complex is formed. When the solution is buffered to pH 3 to 4, sodium thiosulphate can be used to titrate this blue-coloured solution. Under this titration, the elemental iodine is converted back to sodium iodide and the blue colour disappears.



By knowing the strengths of the potassium iodine and the thiosulphate, it is possible to calculate the amount of chlorine residual in the solution.

This method is good for very strong chlorine solutions, i.e. hypochlorite stock solutions which are measured in percent, and is only accurate down to as low as 1 mg/L total residual chlorine.

As a result, the iodometric method is not suitable for use in measuring the required low levels of chlorine residuals in wastewater effluent (i.e., following dechlorination).

Sources of error for the iodometric method include oxidation of iodide reagent solutions, contamination of iodide reagents by iodine and iodate, and adsorption of iodine on suspended particles, particularly in highly organic wastewaters.

Temperature has been shown to have a marked affect on the release of triiodide from starch. For this reason, the test should be carried out at sample temperatures below 20°C ⁽¹⁸⁾. Also, where potential chemical interferences exist, a back titration method can be used where the sample is "fixed" with thiosulphate and then titrated using an iodine solution.

4.1.4 Amperometric Method

When a voltage is applied across two oppositely charged electrodes in a liquid solution, there will be potential for current flow. However, the current will not flow between the electrodes unless there are two substances present, one that can be oxidized at the anode and one that can be reduced at the cathode. This is the basis for the amperometric method of chlorine residual analysis.

The amperometric method is typically only used in a laboratory and involves the use of a two electrode system (often silver and platinum), a microampere meter, a titration device (calibrated burette) and a titrant. To conduct the test, a small current is applied across the two electrodes in the solution (buffered to pH 7). The titrant, a reducing agent that is typically phenylarsine oxide (PhAsO or "PAO"), is slowly added. At that point, if there is a chlorine residual, there will be a current across the cell. However, as the titrant is added, chlorine is reduced at the cathode as the PAO is oxidized from the +3 valence to +5 valence at the anode, as shown in the equation below:



As long as there is free chlorine present in the sample being titrated, the current flows across the electrodes, albeit in lower and lower amounts. When the free chlorine has all reacted, the rate of current change across the electrodes is zero (the current is constant) and the end point of the titration is reached. Since the amount of PAO used in the titration process to the end point is proportional to the original chlorine concentration in the sample, it is possible to calculate the chlorine concentration.

To do combined chlorine (chloramine) residuals with the amperometric technique, it is necessary to convert the chloramines to another equivalent and reducible form. Typically, this involves lowering the pH to 4 and adding potassium iodide, KI. This converts the chloramines to an equivalent amount (one mole per mole) of triiodide, I_3^- . The amperometric titration with PAO proceeds as normal and the end point is when the triiodide is reduced to iodide, $3I^-$. By modifying the pH of this procedure it is possible to sequentially measure both monochloramines and dichloramines. The monochloramines are measured at pH 7 and when that titration is complete, the pH is lowered to 4 and more potassium iodide is added. After noting the amount of titrant that was used in the "overshot" of the pH 7-based end point, the titration proceeds to the new amperometric end point. The dichloramines content is calculated based on the total titrant used to the second end amperometric point minus the titrant used to determine the monochloramine end point (including any "overshot" volume).

The process described above is typically called direct titration or "forward" titration. It is also possible to do a "back" titration of total chlorine residual. This back titration involves addition of excess reductant (PAO), and then back titrating to the "end point" when the triode is present and there is a current flow between the electrodes. Back titration has some benefits in that it permits field samples to be "fixed" through the addition of the excess reductant and there is also less interference from substances that exert an iodine demand.

Substances with an iodine demand and nitrite, present in partially nitrified wastewaters, can interfere with amperometric chlorine residual measurements⁽¹¹⁾. Small quantities of iodide ion can cause errors in differentiating free and combined chlorine. Therefore, titrators must be thoroughly rinsed when used for both tests⁽¹³⁾. Electrodes can also become fouled by oil, foam, and positive metallic ions including copper, silver, and iron; resulting in reduced sensitivity⁽¹⁷⁾. Manganese and nitrates have been found to oxidize KI to iodine, causing a higher estimation of residual chlorine⁽⁷⁾. Iodine also adsorbs onto organic suspended particles in wastewater, resulting in a shift of the end titration point⁽¹⁷⁾.

Compared to some other methods, such as the DPD colourimetric method, the amperometric titration method is more time-consuming, which may lead to errors due to volatilization or conversion of Cl species, i.e. where measurement of free chlorine residual is required.

Standard Methods, 20th Edition⁽³²⁾ states titration using method 4500-Cl E is accurate down to 10 µg/L. Manufacturers of titrators advertise accuracy down to 1 µg/L. This low level may be possible in very controlled conditions with clean samples and clean glassware. However, in a wastewater application, this range would be overly optimistic.

Despite the above problems and interferences, amperometric titration is the standard method used in the laboratory for determination of chlorine species. The amperometric method is used in the lab to confirm the accuracy of other types of field analyzers. Portable test instruments using amperometric titration are commercially available, but require a more experienced operator than colourimetric methods ⁽¹³⁾.

4.1.5 Syringaldazine (FACTS) Method

Free available chlorine test-syringaldazine or "FACTS" method is a colourimetric method used to test for free chlorine in the 0.1 to 10 mg/L range ⁽¹⁵⁾. Syringaldazine (3,5 – dimethoxy – 4- hydroxy – benzaldine) is oxidized by chlorine, producing a coloured product that can be measured using a colourimeter or spectrophotometer. The pH of the sample is critical and must be maintained between pH 6.5 and 6.8 using a buffer ⁽⁷⁾.

The FACTS procedure is not affected by the presence of chloramines, manganese, ferric iron, and nitrite at concentrations normally found in wastewater ⁽⁷⁾. However, under the FACTS test, other strong oxidants – such as iodine, bromine, and ozone – will produce false (high) free chlorine measurements.

Because the FACTS method only measures free available chlorine, its applicability to wastewater disinfection, which typically results in chloramination, is limited.

4.1.6 Oxidation Reduction Potential (ORP)

Oxidation Reduction Potential (ORP), or Redox, is a measure of the activity or strength of the oxidizers and reducers in a solution. In wastewater, where ORP is a positive charge indicating an oxidative environment, ORP is used to estimate the ability of a disinfectant to oxidize organic material. ORP is based on the concept that it is the oxidation potential of the residual as opposed to the residual concentration that provides the killing power. ORP has become a popular alternative for measurement and control of wastewater disinfection.

An ORP sensor consists of a platinum surface that accumulates charge without reacting chemically with the solution. The voltage signal, measured in millivolts, is correlated in the lab to a corresponding chlorine level, in mg/L. This correlation must be verified periodically at different chlorine concentrations. As a measure of oxidation potential, the ORP method is robust and accurate over a wide pH range. However, ORP cannot be used as a direct indicator of chlorine residual, because it does not account for the effect of pH and temperature on the chlorine chemistry.

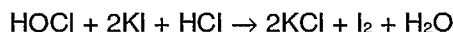
The speed of response using ORP is related to the concentration, meaning that the instrument response is very slow if the ORP of the wastewater is similar to redox of the electrode. This effectively reduces the accuracy of ORP at low chlorine concentrations. Also, because ORP measures the oxidation potential of all oxidizers, it is not specific to only chlorine. Variations in wastewater make-up and strength can cause errors in chlorine measurement.

Based on the literature search, ORP technology appears to be more appropriate for predicting disinfection efficiency than directly measuring chlorine residual. For this reason, the use of ORP as a replacement for chlorine residual measurement has been deemed inappropriate by WEF ⁽¹⁵⁾.

4.1.7 Gas Phase Measurement

Gas phase residual chlorine meters use the same standard iodometric method as used in the amperometric units. The difference is that the released iodine is stripped from the sample by introducing air in the reaction chamber of the unit. The released iodine in the gas phase travels through a gas permeable membrane that allows only the iodine to permeate into the sensor.

Rather than phenylarsine oxide, the gas phase uses potassium iodide as well as a pH 4 buffer. The reaction is as follows:



The released iodine diffuses across the membrane and is reduced to iodide at the sensor. The reduction of iodine generates an electrical current that is sensed at the electrode surface. The current is correlated to chlorine residual.

For highly contaminated samples, the released gas is transferred to a separate chamber to avoid liquid contact with the membrane.

The range of this technology is 0 – 20 mg/L with an accuracy of +/- 0.02 mg/L and repeatability of 0.01 mg/L. As the liquid never comes in contact with the sensor, there are no interferences from dissolved ions.

4.1.8 Probe-Based Chlorine Residual Measurement

In addition to the wet chemistry and amperometric titration systems for determining chlorine residuals, there are also probe-based systems. These probes are basically membrane-covered amperometric detectors. They are typically designed to directly measure free chlorine residual.

The probes consist of a membrane, a platinum cathode, a silver anode, and an electrolyte solution (typically potassium chloride, KCl). The membranes are typically proprietary in nature based on micro-porous polymers. Regardless, the membranes are hydrophilic and allow passage of both forms of free chlorine, hypochlorous acid and hypochlorite ion (and other substances). The free chlorine forms dissolve into a thin layer in the electrolyte surrounding the cathode. A polarizing voltage is applied to the cathode where the hypochlorous acid is reduced to chloride. The electrons for this reduction to chloride come from the silver anode where silver is oxidized to silver chloride. The current produced by these electrochemical reactions is proportional to the free chlorine in the sample. This process is pH and temperature sensitive and the better probe systems have automatic built-in corrections.

Probes are quick and relatively easy to use. However, they are also sensitive to biological fouling and need to be calibrated against another method, e.g. through the DPD or amperometric titration methods, on a daily to weekly basis, depending on the quality of sample water. Since this calibration equipment is used to do the grab sample residual determination, the usefulness of the probe system is diminished, except in continuously-reading systems to be discussed further in later sections.

4.1.9 High-Pressure Liquid Chromatography (HPLC)

High-pressure liquid chromatography (HPLC) with post-column electrochemical detection can be used to quantify inorganic chloramines in potable water and industrial or municipal wastewaters. However, the HPLC method requires substantially more expensive equipment and more analytical skills than the traditional analytical techniques. The main advantage of the HPLC technique is that it does not detect organochloramines which many of the other methods, including the DPD ferrous ammonium sulphate (FAS) titration, do. As a result, the HPLC method can be used to calculate total organic chloramines in conjunction with a DPD (FAS) technique.

The method to differentiate the chloramine residuals would be to use both the DPD (FAS) method and the HPLC methods. The procedure would be to first determine the total residual chlorine (TRC) and Free Residual Chlorine (FRC) by the DPD (FAS) method and then calculate the total combined residual chlorine, i.e. $TCRC = TRC - FRC$. By using the HPLC method, the inorganic combined residual chlorine (ICRC) can be determined and the organic combined residual chlorine calculated as $OCRC = TCRC - ICRC$. The HPLC method has a detection limit of 0.01 mg/L as Cl_2 and can be used to measure both inorganic chloramines and inorganic combined bromine residuals. However, unless organic chloramines are significant (usually only for primary wastewater treatment plants), the usefulness of HPLC does not overcome the added expense and analytical skills that are required to complete the analysis. On this basis, it is unlikely to be necessary at most secondary treatment plants that are achieving the required secondary quality. Where the treatment is primary, like at the GVRD's Lions Gate and Iona Island treatment plants, the Ladysmith plant and the Regional District of Nanaimo's Greater Nanaimo Water Pollution Control Centre, when there is chlorination, they may have to take samples and have them analyzed in a laboratory using DPD or amperometric and HPLC techniques in order to fully understand and quantify their chlorine residuals.

4.1.10 Other Methods

Ultraviolet absorbance and absorption spectrophotometry analysis have been used for measurement and determination of chlorine species in water, but their use with wastewater is not considered practicable.

4.2 CHLORINE TEST METHOD INTERFERENCES

While the methods of disinfection of wastewater are essentially the same as those used for disinfection of potable water, the larger concentrations of dissolved and suspended solids in wastewater create increased interferences. Interferences common to all methods include turbidity, organic matter (including colloidal colour), ionic materials, and buffering capacity. Specific method-related interferences are included under the methodology sections.

Turbidity and colour in the sample directly affect colourimetric tests. Photometers can be zeroed to the sample residual colour. However, the trace colour associated with low chlorine residuals can be lost in the high background colour of the sample. Methods of filtering out the turbidity without removing chlorine have been developed by Hach⁽¹⁷⁾.

Generally, all methods measure the total oxidizing capacity of chlorine plus other oxidants, including chlorine dioxide (ClO_2), ozone (O_3), bromine (Br_2) and hydrogen peroxide (H_2O_2) ⁽¹⁷⁾. Measurement of combined chlorine residual in wastewater is affected as these oxidants will oxidize iodide to iodine and result in a higher than actual chlorine residual. Inorganic and organic chloramines can also combine with HOCl leading to false high free chlorine measurements.

Recent test results suggest that sulphite in wastewater (i.e. following dechlorination) may produce lower total chlorine readings than actual, particularly if organic chloramines are also present ⁽¹⁶⁾. The findings suggest that, when iodide is added, the pH drops, causing sulphite to react with chlorine before the chlorine-iodide reaction can occur.

Sampling inconsistencies, failure to obtain a representative sample, and losses during sample transport and storage are common problems that affect all methodologies. This is especially true when measuring free chlorine which is reactive and unstable. Measurement errors include variations in pipetting technique and misreading of colour standards.

4.3 COMPARISON OF CHLORINE TEST METHODS

The following section examines and compares current analytical methods for the measurement of chlorine residual in terms of accuracy, precision (reproducibility), interferences, ease of use, and applicability for use in small, municipal wastewater treatment plants.

Table 4-1 summarizes the most widely used methodologies for the determination of chlorine residual including application (species detected), analysis range, detection limit and interferences.

Manufacturers make many claims of accuracy and sensitivity in their literature. Approved analytical methods are found in *Standard Methods for the Examination of Water and Wastewater* ⁽³²⁾. Water and wastewater plants and laboratories have used the book as a reference since originally published in 1905. The current edition is the 20th edition published in 1998.

The *Chlorination/Dechlorination Handbook* by WEF summarizes the measurement techniques in Table 4.1 ⁽³¹⁾.

Manufacturers advertise low-level amperometric methods at a low range of 1 $\mu\text{g/L}$ versus the 10 $\mu\text{g/L}$ in Table 4-1 ⁽³²⁾. This level may be possible under clean conditions however, for wastewater applications, this would not be practical. The table does not include ORP measurement. This is because ORP does not directly measure chlorine and *Standard Methods* does not accept the method for laboratory testing. However, the method does have merit for on-line measurement covered in later sections.

Table 4.1
Chlorine Residual Testing Techniques ⁽³¹⁾

Method	Standard Methods Procedure Number	Residual Type	Interferences	Detection Limit	Comments
Iodometric I & II	4500-Cl B & C	Total	Manganese oxide; oxidizing & reducing agents, ferric & nitrite ions	1 mg/L with starch iodide or 40 µg/L with thiosulfate	Simple to perform
Amperometric	4500-Cl D	Free, combined or total	Other halogens, chlorine dioxide, and nitrogen trichloride, high-speed mixing	0.1 to 2 mg/L	Higher degree of training than test kits
Low-level amperometric	4500-Cl E	Total	Same as above	10 to 100 µg/L	
DPD ferrous titrimetric	4500-Cl F	Free, combined, or total	Strong oxidants, manganous oxide, copper, chromate	<0.1 mg/L	More difficult to perform, requires math calculations for different components
DPD colourimetric	4500-Cl G	Free, combined, or total	Strong oxidants, colour, turbidity, chromate	<0.1 mg/L	Subjective and lacks precision and accuracy of titration methods
FACTS (syringaldazine)	4500-Cl H	Free	Colour, turbidity, and other oxidants	0.1 to 10 mg/L	Same as above
Iodometric electrode	4500-Cl I	Total	Oxidizing agents, manganese oxide, iodate, bromine, and cupric ions	<1 mg/L	No direct reading

The WEF Chlorination/Dechlorination handbook notes that the measurement of residual requires skill to operate the equipment⁽³¹⁾. The skill level takes some time to develop and once developed, must be maintained. Operators must execute each step of the procedure at a high level of precision as the method prescribes. As the chlorine will decay naturally over time, operators must ensure the tests are completed as quickly as possible. For very low level detection, measurement equipment should be situated at the sample point to reduce the time from capturing the sample to the test time. Method selection should be determined by the degree of precision, known or suspected interferences, budget constraints and level of operator training⁽³¹⁾.

Gordon et al⁽¹³⁾ compared several of the most popular test methods against an ideal test method, based on a number of criteria including:

- Specificity to free chlorine species (HOCl or OCl^-) or chloramine fraction detection limit.
- Interferences.
- Detection limit.
- Precision or reproducibility (ideal $\pm 0.1\%$ or better).
- Accuracy (ideal $\pm 0.5\%$ or better).
- Operator skill required.
- Stability of reagents.
- Speed.
- Cost.

In the review, one of the most important criteria is accuracy, defined as the ability of the method to correctly measure chlorine concentration. The other is precision, or reproducibility of the method over multiple tests. Based on these two criteria, the titration method is considered best overall. DPD colourimetric (using a colourimetric method or a spectrophotometer) are considered to be good. Iodometric method is considered to have poor accuracy and precision for use in wastewater treatment testing.

In terms of ease of use, an especially important criteria in smaller treatment plants, the various DPD test kits (colour comparitors and colourimeters) are considered to require the least operator skill. The amperometric method requires considerable operator skill, which explains why this method is confined mostly to laboratory analyses as opposed to use as a field testing technique. The ability to conduct tests quickly is also of prime concern for operators. The titration method is more time-consuming and

may lead to errors due to volatilization or conversion of Cl species. The DPD colourimetric method is preferred.

The overall conclusion of the comparison is the amperometric titration technique remains the preferred laboratory methodology for accurate residual chlorine measurement due to its ability to differentiate between chlorine species and relatively few interferences. Standard Methods considers the amperometric titration method as the standard of comparison for the determination of free or combined chlorine ⁽¹⁴⁾. However, amperometric methods are not particularly suited to testing in the field or at smaller treatment plants. For field testing and testing at small treatment plants, the DPD colourimetric method of determining the chlorine residual is considered to be the most appropriate method based on accuracy, precision, ease of use, speed, and cost.

4.4 OFF-LINE CHLORINE RESIDUAL MEASUREMENT

With off-line chlorine residual measurement, the treatment plant operator takes a grab sample of the chlorinated effluent and immediately initiates a manual residual measurement procedure. When complete, the operator then disposes of the sample and cleans the measurement device. The measurement, if done correctly, will provide an indication of the residual at the location of sample at the point in time when the grab sample was taken.

A number of test kits are available commercially for off-line, field or laboratory testing of chlorine residuals. These methods use modified, simplified versions of residual or potentiometric laboratory procedures discussed in Section 4.1. Each test kit and methodology has inherent advantages and disadvantages.

4.4.1 DPD Analyzers

A number of companies supply colourimeter or colour comparator field kits based on the DPD colourimetric method. These companies include Hach, LaMotte, Taylor Industries, Hanna Instruments, Palintest Ltd. and Orbeco-Hellige (formerly Wallace & Tiernan). The kits are suitable for measuring free and total chlorine on site. Field DPD test kits are typically used where high accuracy or precision is not required, i.e. for routine checks of chlorine residual.

The simplest test kits are basically "pool test" kits that utilize either liquid or tablet reagents and a permanent colour chart or "colour wheel" for visually comparing reagent-treated samples. Manufacturers sensitivity ranges are advertised from 0.05 to 0.3 mg/L.

One of the greatest problems with the DPD method is the quality of the reagents and buffers. Liquid reagents and buffers are subject to degradation by oxidation and microbial action⁽¹⁷⁾. To reduce degradation, reagents should be stored at a temperature of 10 to 25°C. Iodide is oxidized by light and oxygen and must be stored in a dark, sealed container. Many suppliers provide dry tablet or powdered reagents in unit-dose foil pouches. Hach supplies pre-measured, unit-dose liquid reagents in air-evacuated "Accupac" ampules to ensure accuracy and prevent degradation.



Figure 4-1: Field DPD Kit Utilizing Tablet Reagents (LaMotte)

Hach offers several versions of these test kits, including their CN-70 and CN-80 series colour discs. Two test ranges are available: 0-0.7 mg/L and 0-3.5 mg/L – to allow testing of both chlorinated and dechlorinated effluents. LaMotte offers a DPD chlorine comparator kit that employs a DPD indicator in a convenient tablet form. A different DPD tablet is used to measure free and total chlorine. The sample is compared visually to permanent colour standards between 0.2 and 3.0 ppm chlorine. The test typically takes less than 10 minutes to perform. Cost for these kits typically ranges between \$50 and \$200.

An improvement is the Orbeco-Hellige comparator, a device that enhances the optics and thereby reduces errors associated with direct visual comparison of sample and standard. The device accepts colour discs, each containing up to 10 colour standards. The colour disc is rotated and compared to the reagent-treated sample until a match is found. Cost is approximately \$150.

The use of compact, portable colourimeters has improved colourimetric analysis by eliminating errors associated with visual colour matching. LaMotte provides a direct-reading



Figure 4-2: DPD Colour Disc (Hach)

colourimeter (photometer) which automatically reads mg/L chlorine from 0 to 4 mg/L with a detection limit of 0.05 mg/L (33). Cost for photometer units range from \$500 to \$600 dollars. Orbeco-Hellige also offer a hand-held colourimeter that contains calibrations and wavelength filters to enable testing of a number of parameters and compounds in addition to free, combined and total chlorine. Cost for colourimeter and reagents is approximately \$1,500. Hach has a wide range of products starting with their Pocket Colorimeter, which costs about \$600, to complete portable labs utilizing either a colourimeter or full spectrophotometer (DR/2500) which cost about \$4,500. Palintest Ltd. also has a portable colourimeter.

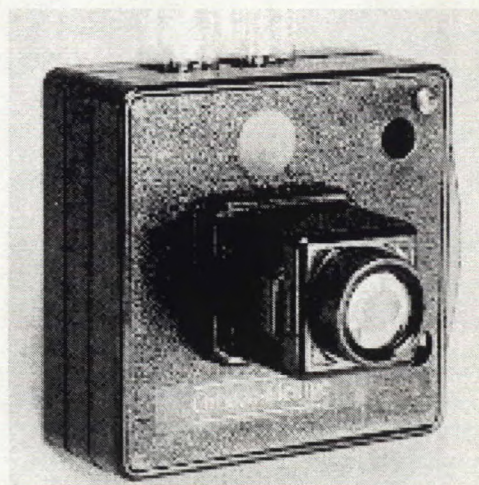


Figure 4-3: Colour Disc Comparator (Orbeco-Hellige)

Where wastewater is highly coloured, use of the iodometric titration method may be preferred over the DPD colourimetric method. For testing of very low chlorine residuals, i.e. following dechlorination, the ULR-DPD method can be used with a spectrophotometer, such as the Hach DR/2010. For trace chlorine residual measurements, the purity of reagents and buffers is critical as impurities can exert a chlorine demand, causing underestimation of the chlorine residual. One way to address this issue is to prepare a reagent blank so that interference can be measured.

4.4.2 Amperometric Titration Kits

Portable amperometric titration systems are now available that essentially duplicate the Standard Methods amperometric lab procedure. As with the lab procedure, the portable units utilize a two-electrode system (often silver and platinum) that causes the disassociation of hypochlorous acid in the solution. An oxidizing agent is added to allow measurement of hypochlorite ion to find the free chlorine residual. Potassium Iodide is added to further convert chloramines to a reducible form that can be detected amperometrically.



Figure 4-4: Hach Pocket Colorimeter DR 100

Titration follows residual tests as defined in Standard Methods and ASTM D-12353. Titration represents the most accurate method of residual measurement used and is typically utilized in lab residual verification.

Hanna Instruments provides a portable amperometric titration system (PL 100/101) that duplicates the Standard Methods lab procedure for measuring both free and total chlorine. Accuracy and reliability is reported to be comparable to lab results. The unit uses a dual platinum electrode and is provided with a built-in stirrer for constant mixing. Cost is approximately \$1,000 plus \$350 for their portable colourimeter. While the unit's small size lends itself to on-site chlorine spot checks, required operator skill level is considered to be greater than other methods.

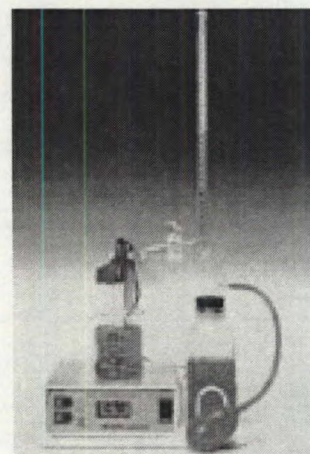


Figure 4-5: Portable Amperometric Titration System (Hanna Instr.)

Hach also has a digital titrator that does not require the use of a conventional burette, thus removing variations due to operator technique. Titrants are packaged in interchangeable, sealed cartridges. The cartridge is attached to the titrator, and titrant is dosed by pulling a trigger which dispenses a measured dose. Total volume of titrant is measured by the volume counter. Laboratory stands and a stirrer are also available.

The amperometric titration procedure is useful down to about 0.010 mg/L (10 µg/L) free and/or total chlorine residual. Companies such as Wallace & Tiernan claim a lower detection limit of about 0.001 mg/L at a 2% relative standard deviation⁽³⁵⁾.

There is now an automated titrator on the market as manufactured by Hach (AutoCAT™ 9000) that allows the operator to simply capture a sample and automatically conduct the test⁽³⁴⁾. Whereas the historical manual titrators required some degree of operator skill and time to measure the residuals, the manufacturer claims that the automated system can detect to 0.005 mg/L for forward titration and 0.010 mg/L for back titration. The unit was released in September of 2002 and costs approximately \$5,000.

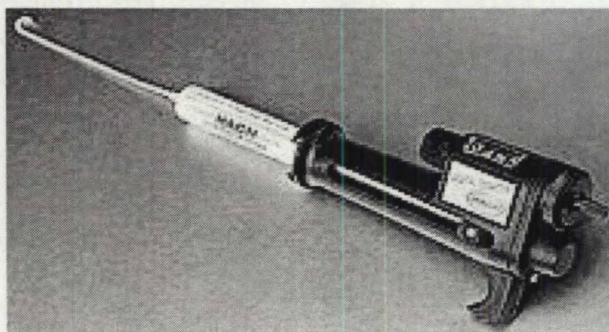


Figure 4-6: Hach Digital Titrator

4.4.3 Summary of Test Kits

Based on the above, it is clear that the amperometric titration method of chlorine residual analysis is the most accurate and most sensitive method available for use in treatment plants. However, the units require more operator time, care and attention in order to be used properly to make full use of the accuracy and sensitivity. In contrast, the DPD method is much more user friendly and there is little or no possibility of operator error. However, in review of Standard Methods, manufacturers literature, and discussions with the manufacturers, the DPD method has a lower detection limit (using the manufacturer's most optimistic claims) of 0.050 mg/L chlorine residual, which is higher than the required 0.010 mg/L chlorine residual discharge target. Despite the problems with low level sensitivity, at the present moment, the DPD method may represent the best practical chlorine residual measurement technique for small plants. This may change when the HACH AutoCAT™ 9000 automatic amperometric analyzer (or its equivalent from other manufacturers) becomes widely available.



Figure 4-7: A Hach AutoCAT™ 9000 Automatic Amperometric Titrator

Method selection should be determined by the degree of precision, known or suspected interferences, budget constraints, and level of operating training ⁽³¹⁾.

4.5 ON-LINE CHLORINE RESIDUAL MEASUREMENT CONSIDERATIONS

In the previous sections, the various types of off-line methods for measurement of chlorine residuals in grab samples were reviewed. The implementation of on-line residual chlorine measurement allows a continuous readout of the chlorine residual level at all times. It also ensures that the sample is always taken at the exact same location in the plant. This measurement can also be used to flow pace the chlorine dosing system automatically to ensure suitable chemical dosing with variable wastewater flows and/or wastewater strengths.

The drawback of on-line measurement of wastewater treatment chlorine residuals is that the measurement device is constantly in contact with a "dirty" environment. The sample will contain particulate matter, potentially corrosive chemicals and bacteria (that will tend to grow on the testing equipment). Caution is required in selecting suitable a technology for on-line measurement because some methods are more sensitive to solids loading than others.

This study has included an extensive Internet search for on-line chlorine residual measurement units that are available in the market place. At first glance, many devices were discovered for wastewater chlorine residual measurement. However, on closer review, many of these devices are applicable to only highly treated tertiary wastewater treatment plants. In review of the plants in the Georgia Basin, there are few plants that meet this high effluent quality. As a result, the use of many of these on-line chlorine residual measurement technologies may result in very short-term operation or complete failure. Therefore, the sample water quality and the location of the sampling point are of great importance for reliable operation.

4.5.1 Sampling Point Location

General practice is to locate the on-line chlorine residual analyzer as close to the chlorine contact tank as possible. This limits the chance for bacterial growth and/or deposition in the sample line. It is also important that the sample point provide a meaningful data point that is representative of the entire flow. If the sample is extracted too close to the chemical injection point, the chemical may not have time to disperse and react completely. In most installations, the mixing is done hydraulically as the water moves along a tortuous path. Minimum contact times are typically 30 minutes. Should an area not have sufficient space for mixing and contact, mechanical mixers can implemented to improve the mixing and dispersion.

It should be noted that the sample line from the contact chamber to the analyzer is a maintenance item. The operators should be able to withdraw a sample from both ends of the sample line to determine if the residual differs within the sample line. Should the residual vary, the line should be flushed. It is common practice to have a chemical dosing pump (typically sodium hypochlorinate) to back flush the line. Care must be exercised to ensure the high strength chlorine flushing solution does not come in direct contact with the measuring cell. Contact may cause the unit to fall out of calibration or cause damage to the sensor element.

4.5.2 Level of Treatment

The level of treatment upstream of the on-line chlorine residual monitoring device is of paramount importance in the final selection of the unit. The majority of the units available on the market today are for use in water treatment. Many of the units are not designed for

the added solids found in wastewater and cannot operate for long periods of time without significant maintenance.

Primary wastewater treatment plants have a very limited selection of suitable on-line analyzers. In general, a pilot study of the analyzer is recommended as the amount of variables of a primary effluent is great. If the wastewater has high levels of oils, fats and grease, care must be exercised in selection of the probe. These materials, if present in high levels, will continuously coat the electrodes used in measurement and reduce the output signal.

In a pilot test completed at Lions Gate Wastewater Treatment Plant, the signal from a bare probe amperometric-type unit decayed from a reading of several ppm residual to a tenth of that in about two hours of service due to coating. To extend the running time, acetic acid and sulphuric acid were used for buffer/cleaning agent, with no success. Emulsifiers and detergents were considered but the complexity and operator intervention of integrating a detergent dosing system was considered impractical. In this application, it was determined that the cost of a cleaning the probe and controlling the grease was cost prohibitive, so it was abandoned. This example highlights the complexity related to on-line measurement of chlorine and should help in understanding the issues related to implementing a reliable system.

The use of a strainer, or filter, in front of the chlorine residual measurement system, to protect the system, is generally not an acceptable solution. This is because the materials caught on the filter represent an artificial chlorine demand. As the solids from the plant effluent accumulate on the filter, the chlorine level will be reduced as the sample passes through captured organics. The resulting reading will be lower than the actual sample in the main line. If the unit is used to pace the chlorine dosing equipment, the plant will overdose chlorine. In addition, the filter will require a high degree of operator intervention.

An option is the use of a flushing Y-strainer. For a moderate degree of solids, this technology has been successful. Figure 4.8 illustrates a typical flow system for the sample into a monitor, complete with a Y-strainer. Any addition of pre-treatment onto the unit should always be viewed a maintenance issue and checked on a regular basis. The process must be reviewed to ensure the pre-treatment has no effect on the measured chlorine values.

Provisions should be made to enable the operator to complete a residual analysis at the sample point as well as at the main where the sample is initially drawn from. Operators must continually determine if the sample line is affecting the chlorine residual.

The selection of an on-line residual monitor requires careful analysis of the dosing arrangement. Flow controllers and pressure regulators are required on some systems to maintain flow and maintain the accuracy. In review, it was found that these devices are prone to plugging. Often units have a constant level box for the sample and a flow control orifice based on gravity. These flow controllers may not handle heavy solids and the accuracy will be affected by the flow changes. In general, if the unit has large flow passages, has some degree of back flushing ability, and is easily disassembled for cleaning, it can work well.

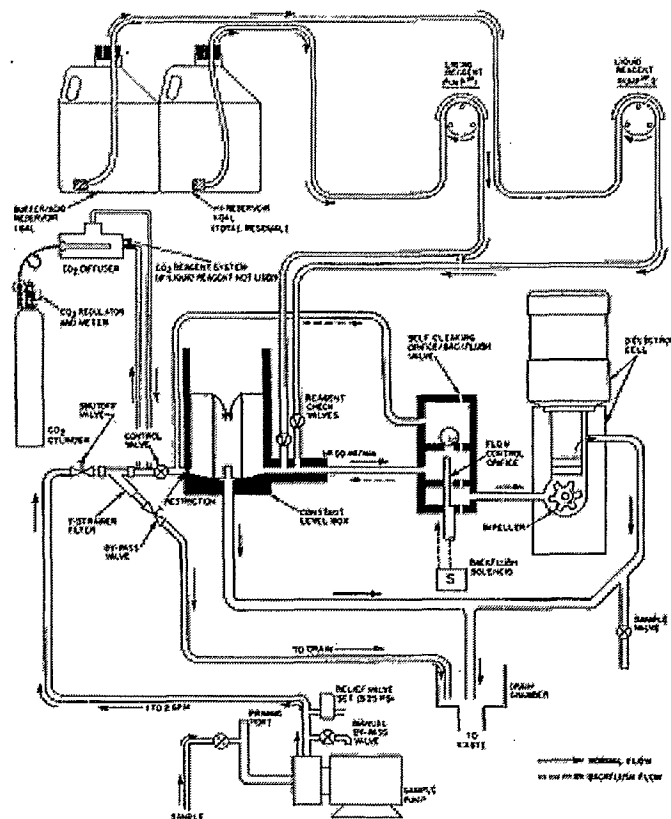


Figure 4-8: Schematic of a "Centre Zero" On-Line Residual Measurement Device (C/W "Y" Strainer)

4.5.3 Plant Effluent

The key consideration of implementing on-line analysis of chlorine residual is an evaluation of the water quality in the sample line. The quality of the sample will be a function of the wastewater treatment process.

Within the Georgia Basin, there is a diversity of treatment plants which operate at various levels of treatment. For simplicity, plants that disinfect their effluents can be divided into three major categories:

- | | |
|------------------------------------|---------------------------------|
| • Primary Treatment | typically BOD/SS up to 130 mg/L |
| • Secondary Treatment | typically BOD/SS up to 45 mg/L |
| • High Quality Secondary Treatment | typically BOD/SS under 10 mg/L |

An understanding of the level of treatment is important in defining the residual measurement technology that will function well. Plants that operate at higher levels of treatment do not have the high levels of solids and BOD in the stream that will cause fouling of the measuring device. A primary plant will have a high amount of solids and nutrients that will cause bio-fouling of sensitive measuring devices. Wastewater also contains fats oils and greases that can coat probes that require contact with the water surface.

In review of the literature, there is little data published for limits on BOD or solids loading limits for the analyzers. Most of the literature is written for potable water residual chlorine applications. The best indication of level of service is to review the manufacturer's installation list and request contact numbers of the plants that use their technology. In the review of references, many of vendors promoted their products for wastewater, but were unable to provide any wastewater treatment plant references worldwide.

For primary plants, the choices are very few due to the amount of solids in the measurement stream. For secondary plants, the references tended to be varied. It is suspected that the reliability of the units is subject to good control of the plant and diligent intervention of the operation staff. For high quality secondary treatment, it was found that most probes had success and operation was not as maintenance intensive.

4.5.4 On-Line Analyzer Evaluation Criteria

Once the specific requirements are determined for the on-line unit, the selected unit must meet the following criteria⁽⁷⁾.

Species Measurement

As discussed in previous sections, chlorine will exist in equilibrium with other chemicals in the water and may exist as free or combined chlorine. Plants that nitrify and de-nitrify will affect the chlorine measurement for some devices as the measurement is species dependent. The unit may have excellent capabilities on clean water; however, the high concentration of chloramines in wastewater will limit the accuracy of the measurement device. Some devices can not measure chloramine at all and should, therefore, not be considered for wastewater.

Accuracy

Accuracy is typically indicated as a percentage over the full scale of the instrument. For example, a chlorine set point of 1.5 mg/L, with an on-line unit with a full scale reading of 2 mg/L and an accuracy of 10% would result in a reading of 1.5 mg/L plus or minus

0.2 mg/L. This would be an acceptable accuracy for chlorination. However, for the dechlorination, where the set point chlorine residual is to be 0.02 mg/L or less, this accuracy would be unacceptable. For this reason, units appropriate for chlorination monitoring are often inappropriate for dechlorination chemical monitoring.

Reproducibility

This measurement typically indicates the stability of the measurement device. Measured in percent of full scale, this represents the ability to provide the same results consistently. As in accuracy, the low measurement levels of acceptable chlorine residual levels makes this more important for the dechlorination process.

Sensitivity

This unit describes the lowest level of the chemical that can be detected in a sample. As an example, Standard Methods indicate amperometric titrators have a sensitivity of 10 µg/L or 0.010 mg/L ⁽³²⁾. Some membrane cell units have sensitivity to 0.10 mg/L. This ten-fold difference in sensitivity would make this unit ineffective for control to 0.02 mg/L required for discharge permit.

Range

Depending on the manufacturer and type of technology, analyzers may be limited to a narrow range of detection limits. Generally, analyzers with ranges up to 10 mg/L are less expensive; however, these units typically are not accurate enough for low level detection. Some units have adjustable ranges depending on the application. This type of feature is excellent for plants that wish to standardize on one measurement unit.

Response Time

Depending on the method of measurement, on-line units will have some period of time to respond to a change in concentration. The response time is not overly important if the on-line unit is to be used for monitoring. Should the unit be used to control the chemical dosing rate, this can become a more important design issue.

Temperature Compensation and pH Compensation

Units are typically equipped with temperature compensation to correct for variations in sample temperature. Some units also have pH compensation to correct for pH. Some units are designed to add buffer solutions to fix the pH to a set level (typically 4 to 5).

4.6 ON-LINE RESIDUAL ANALYZERS

Wastewater treatment plant operators, can monitor chlorine residual on a continuous basis. This helps to control chlorine dosing while flows and loads vary over a given day. In turn, this helps to minimize the utilization of chlorination and dechlorination chemicals. These cost savings can then be used to off-set the additional initial capital and on-going operating costs of the continuous reading, on-line, chlorine residual analyzers.

There are several types of on-line chlorine residual analyzers available. A discussion of what is available in the market place is provided below.

4.6.1 Amperometric On-Line Residual Analyzers

The amperometric types of in-line chlorine monitors can be subdivided into membrane and non-membrane sensors. As stated in previous sections, the relative amount of hypochlorous and hypochlorite ions depends on the pH of the sample. Increasing the pH reduces the fraction of free chlorine present as hypochlorous acid and increases the fraction present as hypochlorite ion. All the while, the sum of the hypochlorous acid and hypochlorite ion, which is the free chlorine level, remains constant. Because the sensor current is determined by the hypochlorous acid level, a change in pH will cause the sensor signal and, therefore, the analyzer reading to change even though the free chlorine level remains constant.

There are two ways to solve the problem. One approach is to add acid to the sample to reduce the pH to about 5.5. At pH 5.5, nearly all the free chlorine is present as hypochlorous acid. The disadvantage to this approach is the need for a sample conditioning system upstream of the sensor and the need to replace reagent every month or so. The reagent for pH control is typically acetic acid, white vinegar or carbon dioxide gas. The other way to solve the pH problem is to measure the pH and continuously correct the raw sensor current for changes in pH. The pH correction is good to waters up to pH 9.5.

The pH corrected sample comes in contact with two bare electrodes. A current will flow between the two electrodes as a proportion to the free halogen concentration of the sample.

In order to measure all forms of halogens, potassium iodide is added to the sample. The reaction with the chlorine will release elemental iodine per the following reactions:

- Chlorine $\text{HOCl} + \text{KI} \rightarrow \text{KCl} + \text{I}_2 + \text{H}_2\text{O}$
- Chloramine or combined $\text{NH}_2\text{Cl} + \text{KI} \rightarrow \text{KCl} + \text{I}_2 + \text{NH}_4\text{OH}$

(Note: These are simplified reactions.)

The iodine is measured providing a very accurate indication of the residual. The current flow is affected by temperature, therefore, units are equipped with internal temperature correction.

As the measurement is dependent on electron flow, on-line units include a system to continually scour the sensors. US Filter uses grit and Capital Controls and GLI use PVC ball for the purpose. As the sensors are nothing more than battery terminals, this abrasion does not reduce the life of the sensor.

These units are advertised to provide a sensitivity of 0.001 mg/L (or 1% of full scale, whichever is greater). The full range output of these units range from 0-0.1 mg/L to 0.50 mg/L. Standard Methods show a lower limit of 10 µg/L ⁽³²⁾. Operation at the low levels advertised are optimistic and Standard Methods is likely a more reasonable indication of accuracy. The wide range of outputs allows this unit to be used for both chlorine and dechlorination practices. The response time is 90 seconds so it is useful in residual chlorine control.

The unit cost is roughly \$12,000, making this one of the more expensive options. The reagent lasts about four to six weeks from the 3.78 L (1 US gallon) bottle and the reagent is about \$10.00 bottle.

The operation and maintenance of this type of unit is higher than most other systems, due to the reagent requirements. The system is fairly complicated and needs a higher level of operator skill, if the device is to be operated properly.

The accuracy from sample line to the sensor cell make this an excellent choice for chlorination and dechlorination. There are successful installations on secondary plants; however, there have been some failures. It is likely those plants that do not routinely flush and clean the system, that will have operating problems.

4.6.2 Membrane Cells

Typical amperometric residual analyzers add a reagent to the sample and measure the released iodine. The maintenance of such units involves maintaining the reagent levels and recalibrating each time the reagent supply is changed. Membrane-type residual chlorine monitors were developed to eliminate the reagent and allow more direct measurement of chlorine residuals. The sensor, which consists of a pair of electrodes, is immersed in a conductive electrolyte that is isolated from the sample by a permeable membrane. The chlorine migrates through the membrane and migrates to the sensor. The residual chlorine that diffuses past the membrane causes a flow of electrons across the two electrodes that creates a current much like a battery. The resulting measured current flow is directly proportional to the residual chlorine.

The response of the membrane units is temperature dependent, as the current flow is reduced with reduced temperature. As a result, these units are typically equipped with internal temperature compensation.

The units are specifically developed for a specific chlorine species. For wastewater, a chloramine cell is required, as chloramine dominates the chlorine residual. For plants that have nutrient removal, the units can be problematic, as the resulting readout will be sensitive to ammonia concentrations.

The flow to these units must be controlled, as the pressure and flow rate will affect the reading. Units are typically supplied with sensor flow assemblies to ensure minimum flow rates and pressures are achieved.

These units have been used successfully on very clean effluents. These devices can not be used for unfiltered effluent, therefore, are limited to plants with high quality secondary treatment. The City of Penticton provided an excellent reference (see Section 6), noting

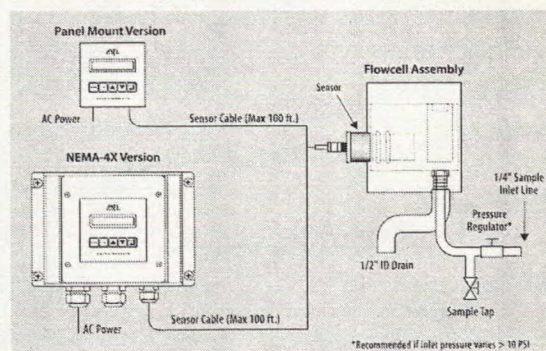


Figure 4-9: Schematic of a Membrane Cell Residual Analyzer



**Figure 4-10:
A Membrane Cell**

they only calibrate the membrane unit every two months. However, manufacturers typically suggest a more frequent calibration, due to variation in electrolyte and membrane.

The cost of these membrane chlorine residual measurement units is approximately \$5,000, making it one of the lowest cost units on the market for on-line chlorine residual measurement. The units have sensitivity of approximately 0.02 mg/L. They can be used for applications up to 200 ppm chlorine residual; however, at those levels, the sensitivity is lost. The device has very quick response time so it is acceptable for residual control of chlorine addition.

The operation and maintenance of the units is simple, with easy menu driven calibration procedures. The ease of maintenance has been one of the most important features of plants selecting the technology.

4.6.3 On-line Colourimetric Analyzers

Units have recently been developed by Hach using the DPD colourimetric method of residual chlorine measurement. These units are designed to work with relatively clean samples. The advertised low level detection limit is 30 µg/L of chlorine. Below this level, the amperometric systems (bare electrode or membrane-type) are better suited. The lab-type colourimetric analyzers, and the on-line units, are very similar except the on-line unit takes a sample automatically. Operators are only required to make reagents (the reagents have a limited shelf life once made) and perform periodic system calibrations. The chemistry for analysis is identical using analytical Method 408.E in Standard Methods of Examination of Water and Wastewater.

In these colourimetric units, a small amount of effluent flow is continuously flushed through a glass cell in the instrument. At the time of residual measurement, a three-way valve stops the flow to the cell and directs it to waste. Then, a series of valves open and close and a linear peristaltic pump adds reagents to the sample. A magnetic stirring bar in the glass cell mixes the reagents with the sample. The reagents react with the chlorine in the sample to produce the characteristic pink DPD chlorine residual colour. The darker the colour, the more chlorine in the sample. After a wait

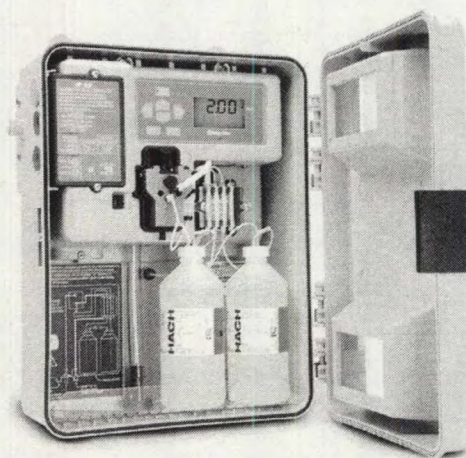


Figure 4-11: An On-Line DPD-Based Chlorine Residual Analyzer

of about 90 seconds, (to allow complete colour development) the analyzer automatically measures the intensity of the colour. To measure the colour intensity, the analyzer uses a tungsten lamp and an interference filter that isolates the band of wavelengths the sample absorbs most intensely. The beam of light passes through the sample and then falls on a photo-detector, which measures the light intensity. Electronics then convert the colour intensity results into a ppm chlorine residual reading.

The overall O&M is not proven in municipal wastewater applications, as the unit is new. The unit will require continual cleaning of bio-growth, and has been designed to allow easy cleaning. The cost of the unit is approximately \$5,000 and a one-month supply of reagents would be approximately \$55.00.

The sensitivity of the unit is 0.035 mg/L with an accuracy of 5%. The measurement range of the unit is 0 to 5 mg/L for free or total chlorine.

The unit takes a sample and completes a test every 2.5 minutes. This represents the slowest response time of any technology; however, for a wastewater treatment plant, this should not pose operational problems, even for residual control.

With a lack of installed units in wastewater applications, it is difficult to determine how well this unit will operate. The unit is not designed to handle a large degree of solids, therefore, the application may have to be limited to high quality secondary treatment. The degree of biogrowth in the measuring cell is a concern and there is currently no option available for automated flushing. The sensitivity and accuracy of the unit is not to the level of amperometric methods. As a result, this unit should not be used for analysis or control of dechlorination.

4.6.4 On-line Oxidation Reduction Potential (ORP) Analyzers

Oxidation Reduction Potential (ORP) is a measurement of the sum total of all oxidants and reductants in the water. As a result, ORP does not actually measure the chlorine residual directly. For this reason, it is not accepted as an approved analytical method in Standard Methods. The challenge in applying ORP for on-line chlorine residual measurement is to isolate the chlorine from all the other background oxidants and reducing agents in the water. With less treatment, more background material exists. Higher levels of wastewater treatment have lower theoretical background materials to interfere with a "clean" ORP reading of chlorine residual. One option that exists is to use ORP sensors both upstream of the chlorine addition and after chlorine addition. The difference in the ORP would thus be an indication of the chlorine residual.

ORP technology cannot directly measure the concentration of the chlorine (i.e. control the ppm) but it can measure and control the oxidation potential voltage. Typically, a set point of 425-450 millivolts insures satisfactory disinfection as measured in fecal counts.

The key advantage of the ORP technology is that the probe measures a voltage in the water. As long as the probe is wetted by the effluent, ORP can be measured. This is a significant advantage over the DPD and amperometric methods. Amperometric analysers rely on the measurement of current. This measurement is directly influenced by the surface area of the electrodes and conductivity in the measuring cell. The amperometric units must have clean probes to provide accurate results. Therefore, in primary wastewater treatment plants or plants with a high level of fats oils and greases, the amperometric units will not function well. Fouling from primary plants is not a problem with ORP as the electrodes measure voltage. As long as any of the probe surface contacts the water, it will provide a measurement of the ORP. A plant in Ontario is apparently operating well on ORP with the suspended solids at 125-160 mg/L and the BOD at 60-100 mg/L. Since the installation of the ORP unit in place of manual dosing, there has been a reduction in chlorine consumption of 20-30% and *E. coli* levels are consistently below the permitted discharge level ⁽²⁷⁾.

In most wastewater treatment plants, the free chlorine will combine with the ammonia present in the wastewater to form the chloramines. The ORP probes must be installed such that all the chlorine is converted to chloramines. Depending on the level of mixing, the ORP probe is usually installed 5-10 minutes downstream from the chlorine injection point.

Some ORP units can be installed with a probe cleaning system that will prevent build-up and plugging of the interface and coating of the probe. For the cleaning system, a pump injects a cleaning solution onto the probe tip. After a chemical clean, air is bubbled to provide a scouring action. Automated control to allow adjustment of the duration and frequency of wash cycles is available.

A technology that uses the ORP probe is the Stranco Strantrol. This company developed a probe technology that allows it to function in a wastewater environment and to provide stable millivolt measurements of 1 or 2 millivolts. Prior to the development of the Strantrol unit, ORP technology had not been able to control to this level of accuracy. The Strantrol ORP unit has an impressive list of wastewater installations that have been proven to control the disinfection/dechlorination processes. The installations typically are able to control the chlorine dosing to the required kill as there is a direct relation between ORP and coliform kill. The installations still maintain the required kill at the lower levels of chlorine dosing. Cost for

the Strantrol technology is a major impediment for smaller systems as the complete unit ranges from \$35,000 to 40,000.

4.6.5 Gas Phase Measurement

As in the amperometric devices, the gas phase units rely on the chlorine compounds to react with potassium iodide. In a pH 4 buffered sample, the iodide is reduced to an amount of iodine equal to the chlorine. As discussed in the amperometric section, the shortfall in the technology is that the probe is immersed in the dirty plant effluent and is inaccurate if it becomes coated.

In the gas phase method, the sample is aerated after the chemical is added. The unit has a membrane that is permeable to iodine. The electrodes measure the iodine that passes through the membrane as in the amperometric devices. This membrane and the sensor are not in contact with the liquid, only the aerated gas stream, therefore this technology can handle high BOD and suspended solids loadings. The unit includes a mixing block where the reagents are added to the raw sample, an air pump, and sensor.

The range of the unit can go up to 20 ppm. The accuracy is slightly lower than a bare electrode amperometric unit at ± 0.02 ppm. The device has excellent repeatability at 0.01 ppm (10 ppb). The cost of the unit is approximately \$7,500.

This technology is only offered by Analytical Technology Inc. (ATI). While ATI was able to provide excellent references in the U.S., there are currently no B.C. references for this device.

The ability to service very dirty water makes this the best selection for chlorine residual measurement in primary and secondary treatment plants. As the unit reads chlorine concentration directly, it is a more positive indication of chlorine levels than the ORP technology. However, the accuracy of the unit would make it somewhat marginal for measurement of chlorine for dechlorination monitoring.

4.6.6 Summary of On-line Monitoring Devices

In summary, there are many factors that will influence proper on-line monitoring of residual chlorine levels. Care is required in selecting the unit for this application. It should be noted that most of the units on the market today (for on-line measurement of wastewater effluent chlorine residual) were originally designed for potable water service. As a result, many of the units advertised as being suitable for wastewater applications will not work reliably. Some of these units will work well in high quality secondary treatment (high quality, low turbidity) effluent, but not at all on lower levels of treatment. As a result, care must be exercised in determining that the unit can provide accurate data for the level of treatment at the plant.

From the discussion above, membrane-type chlorine residual analyzers are generally the most economical (least capital and operating cost) choice for on-line chlorine residual monitoring. However, the capabilities of membrane units are extremely limited by effluent quality. In addition, these units should not be used in plants that only partially nitrify since the membrane is chlorine species dependent.

Colourimetric units, including the DPD methods, are available for on-line use. However, there are currently very few references in wastewater applications. As a result, they can not be recommended at this time.

Gas phase and ORP analyzers are suitable for both primary and low quality secondary effluents. They also have demonstrated success with the higher solids content of wastewaters. The gas phase technique provides a true reading of the chlorine residual. The ORP technique can only measure a relative change in the oxidation reduction potential, not chlorine residual per se. Nevertheless, ORP is widely used and has a solid reference base for use in on-line chlorination and dechlorination control. For small plants, the cost of an ORP control system (approximately \$30,000) is likely to be unaffordable.

Bare-electrode amperometric on-line analyzers provide the most accurate indication of chlorine residual for both free and combined chlorine. Units with the three-probe sensors provide better accuracy and better stability as the units are designed to adjust to background interferences. However, these amperometric units are difficult to operate and require the highest level of operator intervention when compared to gas phase, ORP analyzers and membrane techniques.

The disinfection of treated wastewater effluent is the last step in a municipal wastewater treatment plant, before the effluent is discharged. Typically, there is no further ability to recover from any upsets in the treatment process or errors in plant operation that may result in potential damage to the receiving water ecosystem. In the context of this document, this includes the operation of the chlorination system and the potential for discharging higher than desirable chlorine residuals to the environment. As a result, the design of the dechlorination system must provide reliable service that will assure consistent removal of residual chlorine. The installation should allow for redundancy of components to allow for continual operation in case of routine maintenance as well as unscheduled repairs. The plant must also develop a maintenance program that is based on the equipment included in the chlorination/dechlorination system to ensure the process consistently operates at optimal performance.

The dechlorination equipment systems available are typically more complicated and require a higher level of operator intervention than for chlorination. In making a selection of the equipment to be used, the design engineer must ensure that the municipality has qualified operators to complete the required maintenance. This becomes more of an issue in very small plants that do not have dedicated (full time) treatment plant operations staff.

Operators must keep adequate spare parts in inventory to assure short turnaround should the unit fail. Plants should never rely on immediate delivery of parts from suppliers as parts, typically stocked by the manufactures, are often oversold and extended lead-times are quite common.

Given that the discharge from a wastewater treatment plant is not clear water, providing an automated chemical dosing system can be a challenge.

Dechlorination is defined as the conversion of Cl_2 (or its HOCl or OCl^- forms) to chloride, Cl^- . This occurs when electrons combine with the chlorine, i.e. the chlorine gains electrons and is reduced as a result. These electrons can be donated by a variety of natural sources and, therefore, dechlorination is a natural process that occurs in the absence of further human intervention. However, the problem with natural dechlorination is that the numbers of free electrons naturally occurring are relatively low and, therefore, the rate of dechlorination is slow. From a wastewater treatment and disinfection view point, if chlorine residual in the receiving water is an issue, natural dechlorination is not going to be fast enough to adequately protect the fish or other aquatic species. As a result, chemically-induced dechlorination, through the addition of a material that can supply electrons, is used to remove chlorine residual in the wastewater in order to reduce the toxic effects of chlorinated effluent on the receiving environment. Complete dechlorination minimizes the risk of

forming potentially toxic disinfection by-products by removing both free and combined residual chlorine.

Chemically-induced dechlorination is accomplished by adding a reducing chemical, i.e. one which releases electrons while at the same time being oxidized (raised to a higher, more positive valence state). Some chemicals that can be used to accomplish this reduction include sulphur dioxide (SO_2) gas, sulphite (SO_3 and S_2O_5) salts, or hydrogen peroxide (H_2O_2). SO_2 gas is the most widely used dechlorination chemical for larger facilities. Sulphite salts produce the same sulphite ion as sulphur dioxide when added to water and are preferred for use in small wastewater treatment plants, due to the handling and safety issues associated with gaseous sulphur dioxide use. Sulphite salts include sodium sulphite (Na_2SO_3), sodium bisulphite (NaHSO_3), and sodium metabisulphite ($\text{Na}_2\text{S}_2\text{O}_5$).

The choice of sulphite salt is typically made based on availability and economics⁽³¹⁾. The cost of the chemicals is often a function of the freight cost, therefore, each location will require an economic review to determine the best choice. Sulphite salts are also available as ammonium salts. As the addition of ammonia nitrogen to wastewater is undesirable as ammonia can be toxic, these are not used⁽³¹⁾.

In addition to the above, there are also galvanic electron release methods, – hydrogen peroxide, activated carbon, and ascorbic acid systems – that can be used to dechlorinate water. The largest problem is accurately controlling the addition of dechlorination chemicals where near-zero concentrations of residual chlorine are required. Adding a dechlorination step typically adds 30 to 50% to the overall cost of disinfection⁽⁹⁾.

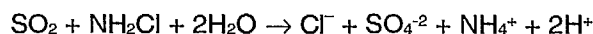
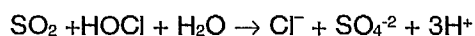
5.1 DECHLORINATION SUBSTANCES AND THEIR CHEMISTRY

As discussed above, numerous options exist for the dechlorination of the wastewater. These are described in more detail below. Further information on the most common dechlorination chemicals are found in Appendix B.

5.1.1 Sulphur Dioxide, SO_2

Sulphur dioxide (SO_2) gas is the most commonly used chemical for effluent dechlorination, whether as a polishing step following breakpoint chlorination to remove ammonia, or to reduce effluent chlorine toxicity. SO_2 is a corrosive, nonflammable and odorous gas at atmospheric pressure and temperature. SO_2 is normally stored in liquid form under low temperature and pressurized conditions. SO_2 gas is primarily used in facilities where SO_2 usage exceeds 45 kg/day. For smaller treatment plants, dry chemicals (salts) are often added to water to form SO_2 solution instead of using SO_2 gas.

Adding SO₂ to wastewater results in the following reactions⁽¹⁰⁾:



These reactions are instantaneous and require little contact time, although adequate mixing should be provided to ensure uniform SO₂ concentrations in the effluent. For complete dechlorination, SO₂ is added in a 1:1 ratio with Cl₂.

Sulphur dioxide, SO₂, consumes about 2.8 mg/L of alkalinity (as CaCO₃) per mg/L added, which does not usually result in a reduction of pH in most chlorinated wastewater effluents⁽⁷⁾.

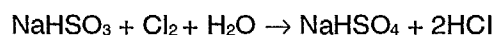
Sulfur dioxide is a reactive chemical and, in the presence of moisture, will react with common metals⁽³¹⁾. Plastics such as Teflon, PVC and CPVC are typically used for seals and piping.

5.1.2 Sodium Sulphite

Sodium sulphite (Na₂SO₃) is added in powder or crystal form. It is difficult to handle on a large scale⁽⁷⁾ and, therefore, is typically not used as a dechlorinating agent, for larger installations. For dechlorination, the reaction requires 1.78 kg of pure sodium sulphite per kg of chlorine. Use of the chemical will typically require mixing with water for a 20% solution strength⁽³¹⁾. The reaction speed is similar to sulphur dioxide. The system would require a storage tank and metering pump.

5.1.3 Sodium Bisulphite

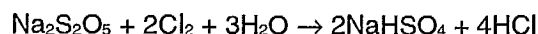
Sodium bisulphite (NaHSO₃) is used most frequently in small wastewater treatment plants⁽³¹⁾. Sodium bisulphite is typically provided as a 38 to 44% by weight solution with a specific gravity of 1.3 (7, 10). The reaction between bisulphite and chlorine is as follows:



Dosage is 1.46 mg bisulphite per mg of chlorine residual removed. During this reaction, 1.38 parts of alkalinity (as CaCO₃) are consumed per part of chlorine removed⁽⁷⁾. Cost is \$55 – \$60 per 25 kg pail (40% solution) which is more expensive than either SO₂ or sodium metabisulphite.

5.1.4 Sodium Metabisulphite

Sodium metabisulphite ($\text{Na}_2\text{S}_2\text{O}_5$), like sodium bisulphite, is a preferred dechlorination chemical for use in small wastewater treatment plants. It is available in solutions of various strengths and in solid (powder) form. The reaction between metabisulphite and chlorine is as follows:



Dosage is 1.34 mg metabisulphite per mg of chlorine residual removed. As with sodium bisulphite, 1.38 parts of alkalinity (as CaCO_3) are consumed per part of chlorine removed⁽⁷⁾. Cost is \$25 – \$40 per 25 kg bag (dry).

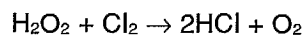
5.1.5 Sodium Thiosulphate

Sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3$) is extensively used in aquarium applications and often for dechlorination of water releases.

The dose ranges from 0.5 mg of sodium thiosulphate per mg of chlorine at pH 11 to 2.2 mg of sodium thiosulphate per mg of chlorine at pH 6.5⁽⁷⁾. The cost of chemical is about \$40 per 22.7 kg. bag.

5.1.6 Hydrogen Peroxide

Hydrogen peroxide (H_2O_2) reacts with free available chlorine (hypochlorous acid and hypochlorite) in solutions with pH above 7. Where there is free available chlorine, H_2O_2 reacts with free available chlorine in solutions with pH above 7 according to the following reaction:



At the preferred pH of 8.5, the reaction is complete and instantaneous. Approximately 0.5 mg of H_2O_2 is required to remove 1 mg of chlorine⁽¹⁵⁾. Oxygen is released during the reaction that has been shown to increase DO in wastewater⁽¹⁵⁾ and slight over feed into the receiving environment is not considered harmful to aquatic life.

Hydrogen peroxide reacts rapidly with free chlorine, but very slowly with combined chlorine, i.e. chloramines. The sulphur-based chemicals react far faster, making them more ideal for dechlorination of wastewater. Dechlorination using H_2O_2 for municipal wastewater treatment plants can be used where long contact is available for dechlorination, where high levels of mechanical mixing are present, or where full nitrification/denitrification is practiced. One hydrogen peroxide supplier (FMC) specifically notes that it is only appropriate for "municipal wastewater effluent that has been denitrified prior to chlorination".

Hydrogen peroxide is unstable and difficult to handle. Because of these factors and the need for nitrification and denitrification, the use of H_2O_2 in dechlorination at small wastewater treatment plants is considered limited ⁽⁷⁾.

Handling peroxide is more complicated and more dangerous than other chemicals. Spills of the chemical can result in combustion of materials in contact. The handling of the material would pose personal risk even greater than the use of sodium hypochlorite.

To reduce the risk of spills, hydrogen peroxide should only be withdrawn directly from the delivery container. This reduces the chance of spills. Operators need to be trained on the handling of the chemical. The chemical supplier typically does this training.

When in storage, the chemical is stable. Off-gassing is not typically a problem as it is for sodium hypochlorite. However, if liquid hydrogen peroxide comes in contact with contaminants, gases are emitted. Pressure reducing valves are required between any two valves that could represent a closed container.

Based on the above, with the difficulty in chemical handling and the slow speed of chemical reaction, hydrogen peroxide is generally not recommended for wastewater applications.

5.1.7 Ascorbic Acid

Ascorbic acid (Vitamin C) is another method of dechlorination that results in the reduction of chlorine to chloride. Ascorbic acid is organic, completely soluble and provides safe, rapid, and complete dechlorination. The chief advantage of ascorbic acid is that it can be used to dechlorinate drinking water without producing any harmful chemicals ⁽²³⁾. The manufacturer's claim that ascorbic acid has benefits to aquatic life. It is most typically used as an anti-microbial or antioxidant for foods. As such, ascorbic acid could find a niche for dechlorinating wastewaters. Unfortunately, the cost of ascorbic acid for large flows would be prohibitive.

No references for municipal wastewater applications using ascorbic acid (or the brand name "Vita-D") were found. The installation list provided by suppliers appears to be for very small or specialized dechlorination applications.

The chemical is widely used in aquarium applications. Other uses of the chemical are as an essential nutrient, and a food additive. When mixed in water, the solution has a pH of 2 and is corrosive due to the low pH. The WHMIS sheet (attached in Appendix B) lists the chemical as potentially harmful to aquatic life. There is little detail regarding the concentration where a spill would be harmful. In the Vita-D literature, they note that the compound is beneficial to

fish as it boosts the immune system of the fish ⁽³⁶⁾. Plant operators would have to employ similar precautions of secondary containment as in storage and handling of sodium hypochlorite.

The low risk to the environment and ease of operation may make this an ideal chemical for very small installations. For larger applications, the high cost of chemical will likely render this too expensive versus other chemicals and more sophisticated feed and monitoring systems. Plants should pilot the chemical before installation of a full scale installation.

5.1.8 Activated Carbon

Activated carbon is created by pressure, temperature and moisture "cracking" charcoal to form a very light but high surface area media. The high surface area is the result of the microscopic fissures that are formed during the conversion from charcoal. This surface area has a high molecular charge and can be used to remove many chemicals, including chlorine residual. The problem is the activated carbon beds have a finite life and tend to either clog with physical matter (e.g. from suspended solids) and/or the reaction sites become saturated and the carbon becomes "spent". Activated carbon is sometimes used for dechlorination of drinking water but it is not practical for dechlorination of wastewater because it would physically clog before all the available surface charge sites for dechlorination were saturated.

5.1.9 Redox Alloy Media "RAM"

Redox alloy media or "RAM" for use as a dechlorination method is based on the fundamentals of reduction-oxidation or "redox" reactions. Such redox reactions occur when there is a flow of electrons from one substance to another. One example of this is a galvanic cell between copper and zinc. In this case, two metal electrodes, one zinc (Zn) and one copper (Cu), are electrically connected while the Zn electrode is immersed in a Zn salt brine, and the Cu electrode is in a copper sulphate solution. The zinc becomes the anode at which elemental zinc is oxidized while at the same time the copper becomes the cathode and the copper in solution is reduced, as shown below:



The RAM technique creates an alloy of zinc and copper, which, in the presence of typical waters and wastewaters, results in the evolution of electrons that combine with free and combined chlorine and result in the reduction of chlorine to chloride ⁽²²⁾. Beds of RAM media can be set up and the chlorinated water or wastewater to be dechlorinated, forced to flow through the bed. These RAM beds tend to last much longer than a comparably sized activated carbon bed and can be regenerated. As with activated carbon systems, physical clogging can be a problem. As a result, the RAM beds would only be suitable for very clear,

low suspended solids wastewater effluents. However, typically, if the effluent is such a good quality, UV disinfection may be more appropriate than chlorination and dechlorination.

5.1.10 Dechlorination Chemical Costs

One of the important considerations in choosing a dechlorination chemical is the cost to achieve a given level of dechlorination. Table 5-1 presents some cost data for several of the dechlorination chemical options discussed above.

5.1.11 Summary of Dechlorination Chemicals

The dechlorination chemicals discussed above are application specific. The most commonly used dechlorination chemical is sulphur dioxide due to its availability, price and the speed of reaction. For some smaller plants, where the cost of gas dosing equipment is prohibitive, liquid-based dechlorination chemicals are more common. This includes sodium thiosulphate, sodium bisulphite, sodium metabisulphite and sodium sulphite dosing systems. Table 5-2 summarizes the advantages and disadvantages of the most frequently used chemicals.

Table 5-1
Dechlorination Dosage and Costs

	Dose (mg/mg Residual)	Delivered Concentration	Chemical Formula	Cost/Kg Chemical	Cost/kg Residual
Hydrogen Peroxide	0.488	35%	H ₂ O ₂	\$1.37	\$1.32
Hydrogen Peroxide	0.488	50%	H ₂ O ₂	\$0.96	\$0.92
Sulphur Dioxide	0.903	99.9%	SO ₂	\$2.45	\$2.21
Sodium Thiosulphate	2.225 @ pH 6.5	97%	Na ₂ S ₂ O ₃	\$1.70	\$3.90
Sodium Thiosulphate	0.556 @ pH 11	97%	Na ₂ S ₂ O ₃	\$1.70	\$0.97
Sodium Sulphite	1.775	96%	Na ₂ SO ₃	\$1.22	\$2.26
Sodium Metabisulphite	1.34	97%	Na ₂ S ₂ O ₅	\$0.94	\$1.30
Sodium Bisulphite	1.455	38%	NaHSO ₃	\$2.40	\$9.22
Ascorbic Acid	2.5	99%	C ₆ H ₈ O ₆	\$9.95	\$25.13

(Multiply chlorine residual by above factor to get required dose, e.g. 1 mg/L chlorine residual needs 1.78 mg/L sodium sulphite.)

Table 5-2
Comparison of Dechlorination Agents ⁽³⁷⁾

Chemical	Advantages	Disadvantages
Sodium Thiosulfate	<ul style="list-style-type: none"> • Significant use history • Non-toxic, non-corrosive, easy to use • Low initial capital costs • Easy to inject 	<ul style="list-style-type: none"> • Solutions subject to freezing in cold weather
Sodium Bisulphite	<ul style="list-style-type: none"> • Significant use history • Easy to inject • Low use ratio 	<ul style="list-style-type: none"> • Expensive chemical • Sodium bisulphite is corrosive • Solutions subject to freezing in cold weather
Sodium Sulphite	<ul style="list-style-type: none"> • Significant use history • Non-toxic, non-corrosive, easy to use 	<ul style="list-style-type: none"> • High use ratio • Solutions subject to freezing in cold weather
Sulfur Dioxide	<ul style="list-style-type: none"> • Significant use history • Inexpensive for large installations • Injection equipment similar to that for chlorine gas can be used 	<ul style="list-style-type: none"> • Corrosive and hazardous to use • Initial capital costs are high • May increase hazard liability insurance • Requires special storage and handling equipment • Expensive for small installations
Hydrogen Peroxide	<ul style="list-style-type: none"> • Easy to inject • Inexpensive chemical cost 	<ul style="list-style-type: none"> • Does not remove chloramines at a useful rate • Highly unstable and subject to deterioration

Note: Ascorbic acid is not included in this table as it is not frequently used.

5.2 TOXICITY AND OTHER ENVIRONMENTAL CONCERNS OF DECHLORINATION CHEMICALS IN THE ENVIRONMENT

Toxicity tests conducted in California found that effluent that had been chlorinated and then dechlorinated (with a slight sulphite residual) was less toxic in the aquatic environment than either unchlorinated or chlorinated effluent ⁽⁶⁾. A U.S. study found that sulphite ion (SO_3^{2-}) concentrations under 10 mg/L showed no significant toxic effects in the aquatic environment ⁽⁷⁾.

The BCMSR does not state a maximum discharge limit for sulphite residual. However, compounds containing sulphite can exert an oxygen demand and reduce the oxygen content of the receiving water if dosages are excessive. With the limitations in monitoring and controlling the chlorine residual, slight overfeed of the dechlorinating agent is a far better approach. Although manufacturers claim sensitivity of monitoring devices below the 10 µg/L limit, actually achieving the accuracy in a wastewater environment is extremely difficult. Control of the feed to this low level is not possible.

H₂O₂ concentrations of up to 40 mg/L for 48 hours have been shown to have no effect on fingerling rainbow trout ⁽¹⁶⁾.

5.3 DECHLORINATION CHEMICAL DOSING EQUIPMENT

The dosing equipment for dechlorination chemicals is similar to that used for dosing chlorination chemicals, as discussed in Section 3.4.

The sulphur dioxide gas dosing system for dechlorination is similar the chlorine gas dosing system for chlorination except that the safety equipment demands are not as great for the sulphur dioxide service. The escape of sulphur dioxide is not as toxic nor as harmful to the environment as is the case for chlorine gas escape. An escape of sulphur dioxide will reduce the oxygen in the storage room, therefore an oxygen monitor is typically installed in the gas storage room. A good practice is to have the chlorine and sulphur dioxide stored in separate rooms as a simultaneous escape of these chemical will result in an exothermic (heat releasing) reaction and, therefore, represents a fire hazard.

Since the sulphur dioxide dosing equipment is very similar to the chlorine gas dosing equipment, it is possible to convert one to another. For example, a plant that currently chlorinates with gaseous chlorine and doesn't dechlorinate, could switch to chlorination by sodium hypochlorite. In this case, the redundant gaseous chlorination equipment could be converted to sulphur dioxide dechlorination dosing equipment. However, while this is technically possible, care should be exercised in converting a chlorinator to a sulphonator. There are differences in the seal materials. As a result, before any such conversion is contemplated, the manufacturer of the equipment should be consulted to confirm exact requirements.

The liquid dechlorination chemical dosing systems are similar to the sodium hypochlorite systems using metering pumps. However, the off-gas issues and product degradation are not an issue with the liquid based sulphur systems as they are with sodium hypochlorite.

A typical dry chemical dosing system includes a clear graduated tank with a mixer. The mixer will remain on continuously to ensure chemical is well agitated. For smaller systems, chemical is typically

delivered in a bag or pail. The chemical is manually added into the mix tank while water is simultaneously added. In order to maintain a relatively consistent concentration, the operator should add water and chemical slowly and equally.

In very large systems, chemical is metered into the system with sophisticated dry chemical feeders. On these systems, a hopper accepts larger shipments of dry chemical. This will typically result in lower unit chemical prices due to freight advantages and reduced packing requirements. This results in proportionately lower operation and maintenance costs.

The dry dechlorination chemicals can be shipped in 1 ton (909 kg) 1000 L totes or in 25 ton (22.7 tonne) hopper bottom trucks. The storage vessel for the dry chemical should be a minimum of 150% of the delivered volume. The chemical, once delivered, is transferred into the dosing equipment storage hopper.

The dry dechlorination chemicals can be added in two different ways. In a batch type system, a measured volume of water and a measured volume of chemical are added to maintain constant solution strength. In the variable solution dosing system, the chemical is added into a much smaller solution tank. The level in the solution tank is kept constant by continuously filling with water to meet the demand. The signal to control the chemical dosing is applied to the dry chemical feeder and the concentration within the tank varies.

In the batch type system, the control signal is applied to the metering pump to deliver a variable volume. In the variable concentration system, the pump delivers a fixed volume of chemical dosing. The advantage of the batch system is that a large volume of mixed chemical is present. Should any part of the dry dosing system malfunction or chemical in storage run dry, there is time to react and rectify the situation. The batch type system is therefore the most widely used type of dry dechlorination chemical dosing.

5.4 DECHLORINATION CONTROL

Upper limits for discharge of chlorine residual into the receiving environment are 0.02 ppm (0.02 mg/L) total chlorine residual. Standard Methods⁽³²⁾ states the measurement of 0.010 mg/L (10 µg/L) chlorine residual is possible using a low level amperometric method. However, the control of chlorine residual at this low level is a far greater challenge in that the automated controls, mixing, and response time to changes make this very difficult to maintain. A better approach is to slightly over dose the dechlorination chemicals. If a small excess amount of dechlorination chemical is added, this will verify that the chlorine has been actively removed. An example of this approach is at the University of Victoria at their Aquaculture lab. The University was unable to find a fresh water well and, therefore, city (CRD) water containing chloramines had to be used. As the lab runs experiments

with sensitive fish fry, a very tight tolerance was required for the dechlorination otherwise experiments would be affected by the chloramines in the water. Using a centre zero dechlorination system where the system measures both chlorine and sulphite residuals, the dosing was controlled to provide a slight sulphite residual. This system has worked well for many years.

The challenge for plants is to develop a system that will only slightly over dose the dechlorination chemicals as some dechlorination chemicals can adversely affect the receiving water. In addition, the overdose will add to the operating cost of the plant. One of the difficulties is that the units that have the ability to provide high level control, are the same units that do not work well in "dirty" wastewater environments.

5.5 CALIBRATION OF DECHLORINATION EQUIPMENT

When operating an on-line residual analyzer for either chlorination or dechlorination, it is essential to verify the results with an accurate grab sample. With the necessity to measure low levels of chlorine for dechlorination, high level calibration is essential. As outlined in Section 4.1, the most accurate method of measurement for chlorine residual measurement is the amperometric titrator. However, due to cost and ease of maintenance, most small systems do not use the most accurate measurement device available. It is important that the grab sample be accurate, as the on-line unit will be only as accurate as the calibration.

For calibrating the on-line units, provisions must be made to enable the operator to take a sample directly at the on-line meter. If an operator takes a sample from an alternate location, the results may be different should there be any growth or deposition within the sample line. By taking the sample directly at the unit, most typically at the drain of the unit, the operator can ensure that the sample to the unit is identical to the sample at the measuring cell and can therefore verify the calibration. Each instrument on the market will have a suggested calibration cycle.

Membrane-type units typically require the most calibration and monitoring. As a guideline, the operator should follow the operation and maintenance instructions. As the operations staff become more familiar with the process application, experience will determine if more or less frequent calibration is appropriate. The importance of calibration cannot be overstated, especially for dechlorination, as the on-line meter will be the only indication of the final water quality going into the receiving environment. Once past the monitoring device, there is no ability to protect the receiving water from any contaminants.

5.6 OFF-LINE MEASUREMENT OF DECHLORINATION

The off-line measurement of dechlorination-related chlorine residuals in effluent grab samples is similar to the equipment discussed in the chlorination section. The main difference is, for dechlorination, the measurement units used must be more accurate since the residual levels are much lower.

The reaction of sulphites and chlorine goes to completion very quickly and completely. If there is still chlorine residual after dechlorination, the likely reason is that insufficient dechlorination chemical was added. If there is no chlorine residual after dechlorination, there is very likely at least a slight excess concentration of unreacted sulphite in solution. As a result, because of the difficulties with measuring near-zero chlorine residual, focus has shifted to measuring excess sulphite ion in dechlorinated wastewater. These methods are discussed below.

5.6.1 Wet Chemical Techniques

Sulphite ion concentration can either be measured directly, using the iodometric method (4500-SO-B), phenanthroline method (4500-SO₂-C) or amperometrically, using back titration⁽³²⁾. In amperometric back titration, excess reductant (PAO) is added, then back titrated until current flows between the electrodes, indicating the presence of triode and the end point of the titration⁽⁷⁾. The end result is a calculated sulphite concentration. The objective would be to maintain a very low but measurable concentration of sulphite to ensure that dechlorination has gone to completion. The iodometric method is recommended for clean water with concentrations over 2 mg/L⁽³¹⁾. The phenanthroline method is preferred for wastewater applications. However, the method is very complicated and requires qualified laboratory personnel⁽³¹⁾.

5.6.2 Probe-Based Sulphite Measurement Systems

Like free chlorine residual probes, there are also probes for sulphite. As with the chlorine probes, the measurement of sulphite is based on oxidation-reduction reactions which occur on the cathode-side of the separation membrane. Sulphite probes are particularly sensitive to fouling because any excess sulphite in the liquid will promote the growth of sulphur-reducing bacteria. As with the free chlorine residual probes, sulphite probes need to be calibrated periodically. This calibration would be done through an amperometric back-titration. Since this calibration equipment could also be used to do the residual determination, the usefulness of the sulphite probe system is diminished, except in continuously-reading systems. For this reason, sulphite probes are more appropriate for continuous measurement applications. This will be discussed further in on-line analyzers.

5.6.3 Dechlorination Chemical Test Kits

The same portable amperometric titration systems used to determine chlorine residual can also be used for back titrating to determine sulphite concentration. Firms such as Hanna Instruments, US Filter and Hach provide amperometric titration kits (see Section 4.4.2).

A DPD procedure and portable test kit is now available from Hach for measuring sulphite. The test utilizes a colourimeter or digital titrator. Accuracy is "1 mg/L with a range of 0 to 50 mg/L", which may be within allowable accuracy requirements for sulphite in wastewater discharges. This test kit was originally produced for use in boiler feed water testing, but has not been verified for use on wastewater.

5.6.4 Summary of Off-line Dechlorination Measurement Techniques

The amperometric back titration technique remains the only real methodology for measuring sulphite residuals in wastewater. The use of a DPD-type colourimetric test for sulphite may enable quick, although less accurate, tests to be conducted on a more regular basis.

5.7 ON-LINE MEASUREMENT OF DECHLORINATION RESIDUALS

For dechlorination, it is advantageous to have on-line measurement of either (or both) chlorine or sulphite residuals to ensure that the target levels of residual chlorine are met. An on-line dechlorination residual measurement device can be used to both pace the chemical dosage system as well as to store historical data showing that the required low residual levels are being met consistently. On-line measurement devices suitable for use in dechlorination applications, where the target chlorine residual is 10 µg/L (0.010 mg/L), are limited in number. Only the amperometric units are typically capable of measuring this low residual level. Since control at this low level is nearly impossible, alternative on-line measurement techniques must be evaluated.

The following subsections discuss the location of on-line sampling locations and the types of equipment that are available to conduct on-line measurement of dechlorination-related residuals.

5.7.1 Sampling Point Location

General practice is to locate the on-line dechlorination-related residual analyzers as close to dechlorination chemical injection point as possible. This limits the chance for bacterial growth and/or deposition in the sample line. It is also important that the sample point provide a meaningful data point that is representative of the entire flow. If the sample is extracted too close to the chemical injection point, the chemical may not have adequate time to disperse and react completely. In most installations, the mixing is done hydraulically as the water moves along a tortuous path.

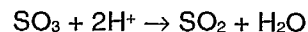
Should an area not have sufficient space for mixing and contact, mechanical mixers can be implemented. This is not uncommon when a plant requires dechlorination. New technology mixers have been developed specifically for this application. The dechlorination chemical is injected into the body of the mechanical mixer and is then simultaneously mixed and dispersed into the channel or pipe by the airfoil propeller. The high energy imparted ensures complete mixing and, therefore, the chlorine residual/dechlorination sample is assured to be representative.

It should be noted that the sample line from the dechlorination chemical contact chamber to the analyzer is a maintenance item. The operators should be able to withdraw a sample from both ends of the sample line to be able to determine if the residual differs within the sample line. Should the residual vary, the line should be flushed. It is common practice to have a chemical dosing pump (typically sodium hypochlorite) to back flush the line. Care must be exercised to ensure the high strength chlorine solution does not come in direct contact with the measuring cell. Contact may cause the unit to fall out of calibration or cause damage to the sensor element.

5.7.2 Gas Phase Measurement of Sulphite Residuals

As discussed in the on-line chlorine measurement section, gas phase measurement of wastewater chlorine residuals is excellent technology. However, the gas-phase chlorine monitor is a marginal fit for the extremely low chlorine levels targeted for the wastewater effluent.

Analytical Technology Inc. (ATI) has introduced a gas phase measurement technology that measures the sulphite residual. It operates in a similar fashion to the gas-phase chlorine monitor, except an acid is used as the reagent. In the acidic solution, the sulphite ion is converted to sulphur dioxide according to the following reaction.



The sample is aerated and the sulphur dioxide is stripped from the sample and diffuses across a gas permeable membrane. A sensor, located in the gas stream, measures the released hydrogen sulphide concentration. The sensor is completely isolated from the liquid stream, therefore, this method can be used for lower quality effluents. The only requirement is that large particles (over 100 microns) that can block the flow cell, should be removed. A flushing Y-strainer would be ideal in this application.

The range of the unit is 0.2 mg/L or 0-20 mg/L. For dechlorination, the lower limit would be selected and the resulting accuracy would be ± 0.03 mg/L, with a repeatability of ± 0.01 mg/L. The units cost approximately \$9,000.

This unit represents the ideal method of confirming low chlorine in the final wastewater discharge. The units will work in primary, secondary, and high quality secondary treatment plants. The ability to control at low levels will also provide long-term chemical savings.

There are no references for this technology in B.C.; however, there are excellent US references provided by ATI.

5.7.3 Centre Zero Control

US Filter and Capital Controls have applied on-line amperometric analyzer technology (as covered in Section 4.6.1) and added the ability to measure sulphite residuals. The probe and electronics automatically determine the residual as a chlorine or a sulphite. The unit produces a 4–20 mA DC analog signal as do other devices. The unique aspect is that the output is zeroed on 12 mA rather than 4 mA. If chlorine is present in the sample, the signal would read greater than 12 mA. The maximum chlorine residual would be at 20 mA. Sulphite zero is also at 12 mA and the maximum sulphite is at 4 mA. There are five ranges available as follows:

- | | |
|-----------------------------|---------------------------|
| • 0.5 mg/L SO ₂ | 0.5 mg/L Cl ₂ |
| • 1.0 mg/L SO ₂ | 1.0 mg/L Cl ₂ |
| • 2.5 mg/L SO ₂ | 2.5 mg/L Cl ₂ |
| • 5.0 mg/L SO ₂ | 5.0 mg/L Cl ₂ |
| • 10.0 mg/L SO ₂ | 10.0 mg/L Cl ₂ |

For best control, the "0.5" configuration above would be used. For system control, a set-point slightly under 12 mA would be selected. The chemical dosing equipment would pace the addition of the dechlorination chemical to maintain this set point. This would ensure all chlorine species were neutralized, while ensuring the dechlorination chemical is not overfed.

The accuracy of this unit is slightly lower than the amperometric device. At the 0.5 mg/L range, the accuracy is ± 0.025 mg/L. It may appear this is a less desirable unit; however, practical control under 0.05 mg/L is extremely difficult. Although amperometric devices claim to be capable of reading to 1 μ g/L, the control of this set point is impossible. The tight control of a sulphite residual represents a far lower risk to the receiving environment and is a far better overall process than the alternatives.

The cost of this unit is roughly \$20,000. It has the same operation and maintenance requirements as the amperometric systems. The unit uses the three bare probe measuring cell technology, therefore, it is able to self reference to background interference. The three electrode arrangement provides a reference to the water such that changes in suspended solids, conductivity or BOD will not affect the output. The unit has the best reliability and stability. Calibration is required during the changing of reagents and a typically weekly check to ensure the monitoring is providing representative results. For wastewater, the calibrations may need to be more frequent due to biological fouling and deposition of oils and grease. The unit has automated controls for cleaning, plus a grit system to keep the bare electrodes clean.

The unit has successful installations in secondary and tertiary applications, but can not be used in primary applications. There are no installations in B.C. for wastewater, but there is the previously mentioned reference at the University of Victoria under Section 5.4.

5.7.4 ORP for Dechlorination Control

The ORP units discussed in the chlorine section (Section 4.6.4) have been successfully used for dechlorination. Although the ORP technology does not read sulphite nor chlorine directly, there have been many successful installations using ORP.

For dechlorination an ORP reading of +180 to 220 mV is typical. The exact set point needs to be determined for each installation and is typically verified with grab samples. For dechlorination, the reaction with sulphites is very quick and the probe is usually installed 1-2 minutes from the sulphite application point.

The Strantrol ORP unit discussed in Section 4.6.4 can also be used to control the dose of dechlorination chemicals. This insures the chlorine discharge is within permit and that the sulphite residual that is discharged is minimized so that it does not affect the oxygen levels in the water.

The cost, and operation and maintenance is similar to the ORP section in the in-line chlorine measurement section. Typically, a treatment plant that uses ORP for chlorination control will also use ORP for dechlorination control.

CURRENT PRACTICES SURVEY

SECTION 6

A survey was conducted to determine the disinfection practices and the chlorine residual measurement procedures being used in B.C.

The initial part of this study was to extensively research available technologies for measurement and control of chlorine residuals for disinfection and dechlorination. Having gained a full understanding of the issues related to the available options, a survey form was developed to confirm actual plant operations. Plant operators were questioned to determine what is being done in the field and to insure that equipment vendor information regarding service could be verified in an operating plant. The research undertaken to review disinfection technologies found that options are available for alternative chlorination, dechlorination and residual testing chemicals. As a result, the questionnaire was tailored to discover if plants were employing any of these alternatives disinfection solutions successfully.

The questionnaire focussed primarily on obtaining information regarding off-line grab sample chlorine measurement techniques and on-line measurement techniques. There were also questions to determine the nature of the plant effluent where the chlorine residual was being measured. This information was considered important since the quality of the effluent to be measured affects the ability of instrumentation to provide meaningful and accurate results.

The final aspect of the survey was to obtain information regarding the staffing levels at the plants and level of operator training. The questions were intended to correlate service of the equipment with the plant operation staff level. Research into the disinfection equipment indicated that some instrumentation would work well in wastewater applications provided there is an extensive level of operator intervention. Once plants using on-line instrumentation were identified, a detailed review of the degree of maintenance was completed through further questioning.

The questionnaire was kept short as possible, while still obtaining the most amount of information. Summaries of the results are presented in Table 6-1 for 56 B.C. treatment plants, including the subset of 44 Georgia Basin treatment plants that responded or were interviewed. A discussion of the survey results is presented below.

6.1 CHLORINATION CHEMICALS BEING USED

Of the 56 B.C. plants that responded to the survey in Table 6-1, 20 used chlorination systems for disinfection. The plants used either gaseous chlorine or sodium hypochlorite as the disinfectant. No plants surveyed are currently using chlorine dioxide or calcium hypochlorite systems.

Some treatment plants were found to have previously used a calcium hypochlorite "puck" system. These calcium hypochlorite dosing systems were described as having been very crude and offered little or no control of dry chemical feed. The method of dosing for these older systems consisted of placing pucks in a feed tube and having effluent water pass through the pucks then flow into the effluent chlorine contact tanks. The systems that have been defined earlier in this report (Section 2.4.5) appear to be more sophisticated and their references in water treatment would indicate they can provide better control than the older-style systems. However, in any event, these older "puck" systems were typically abandoned when chlorination was discontinued in favour of a deep ocean outfall.

At the plants with gaseous chlorine, there are many operations that are reviewing the safety issues associated with chlorine gas supply and delivery. These operators recognize that the chlorine gas is a safety concern and, as a result, in the future, there may be a reduction in the number of chlorine gas dosing systems. However, while most of the plant operators with gaseous chlorine do have a desire to discontinue the practice over the long term, they typically have no immediate plans to make any changes, due to funding constraints. Since gaseous chlorine supply represents the least expensive chemical delivery cost, converting to an alternative chemical such as sodium hypochlorite will not only result in capital costs for new equipment but the alternative chemicals will also result in higher operation costs.

Examples of this situation include the GVRD's Northwest Langley and Lions Gate treatment plants. The GVRD is looking at potentially converting the Northwest Langley plant from gaseous chlorine to sodium hypochlorite. As part of the economic evaluation, they are reviewing the cost of training and the additional safety equipment required to operate a gas chlorine system. The GVRD is also reviewing the Lions Gate Treatment Plant situation and may be replacing the gas dosing equipment with a sodium hypochlorite system. The GVRD cited safety concerns, operation costs, capital equipment requirements and the risk of transporting chlorine gas to the treatment plant sites as the reasons for the potential change. However, it should be noted that the chemical dosing equipment at the Lions Gate Treatment Plant requires replacement in any event, due to the length of time it has been in service. On-site generation of sodium hypochlorite was considered; however, the cost, the requirement for a stand-by system, and references from equal-sized installations made this a less attractive option.

To deal with some of the safety issues at the Annacis Island WWTP, the GVRD has installed automated shut off valves on the pressurized chlorine gas cylinders. In case of a detection of gas leakage, these valves will automatically shut off the gas supply. Operators would then assess the situation and make the necessary repairs.

Table 6-1 Results of the Chlorination/Dechlorination Survey

(Based on responses to questionnaire, emails and/or phone calls - may not be 100% complete or accurate)

Location	Site Name/Owner	Contact Person	E-mail Address	Phone	Fax	Mailing Address	Postal Code	Permit Flow Flow (m³/day)	Georgia Basin?	Discharges to ?	Chlorination Chemical (Yes/No)	Dechlorination Chemical (Yes/No?)	Ave Flow cu.m/day	Peak Flow cu.m/day	Type of Dosage Control	Residual Monitoring Method	Monitoring Kit/Equipment		
GEORGIA BASIN RESPONDENTS																			
Agassiz	Corporation of District of Kent	Keith Paisley	kpaisley@district.kent.bc.ca	604-796-2235	604-796-2235	Box 70, Agassiz	V0M 1A0	200	Yes	Fraser River	Yes	Gas	Yes	SO ₂ gas	1100	2800	flow-paced	DPD	Hach DR 4000
Ashcroft	Village of Ashcroft	Ken Klassen	villageofashcroft@telus.net	250-453-2623	250-453-9664	Box 129, Ashcroft, B.C.	V0K 1A0		Yes	Thompson River	No (UV)			1000					
Black Tusk	Resort Municipality of Whistler	Dave Shyer	dshyer@whistler.ca	604-935-8382	604-932-6636	4325 Blackcomb Way, Whistler, BC	V0N 1B4		Yes	Daisy Lake	Yes	Sodium hypo	Yes	Thiosulphate					
Buck Lake - North Pender	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9576-5th street, Sidney	V8L 2N5	114	Yes	Marine	No								
Central Saanich	First Nation	Alan Palkey		250-652-9101	250-652-9114			5450	Yes	Marine	No								
Chemainus	District of North Cowichan	Clay Reitsma	reitsma@northcowichan.bc.ca	250-746-3159	250-746-3154	Box 278, Duncan	V9L 3X4	2050	Yes	Marine	No								
Comox Valley WPCC	Regional District of Comox-Strathcona	Graeme Faris	gfaris@rdcs.bc.ca	250-334-6040		600 Comox Road, Courtenay, BC	V9N 3P6	30000	Yes	Marine	No								
CRD - Clover Point	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9055 Mainwaring Rd., North Saanich, BC		63000	Yes	Marine	No								
CRD - Ganges	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9055 Mainwaring Rd., North Saanich, BC		1090	Yes	Marine	No								
CRD - Macaulay Point	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9055 Mainwaring Rd., North Saanich, BC		150000	Yes	Marine	No								
CRD - Salt Spring (Maliview)	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9055 Mainwaring Rd., North Saanich, BC		97	Yes	Marine	No								
CRD - Saanich Peninsula Plant	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9055 Mainwaring Rd., North Saanich, BC		30500	Yes	Marine	No								
Duncan	Duncan/North Cowichan Joint Utilities Bd	Clay Reitsma	reitsma@northcowichan.bc.ca	250-746-3159	250-746-3154	Box 278, Duncan	V9L 3X4	17500	Yes	Marine	Yes	Gas	Yes	SO ₂ gas	11000	62000	flow-paced	DPD	
FVRD - Cultus Lake	Fraser Valley Regional District	Trevor Lewis	tlewis@fvrd.bc.ca	604-702-5000	604-792-9684	8430 Cessna Road, Chilliwack	V2P 7K4	360	Yes	Ground	No								
FVRD - North Bend Fraser River	Fraser Valley Regional District	Trevor Lewis	tlewis@fvrd.bc.ca	604-702-5000	604-792-9684	8430 Cessna Road, Chilliwack	V2P 7K4	50	Yes	Ground	No								
FVRD - JAMES Pollution Control	Fraser Valley Regional District	Glen Dumville	glen.dumville@fvrd.bc.ca	604-826-7833	604-826-0261	5959 Gladwin Road, Abbotsford	V4X 3R2	48500	Yes	Fraser River	Yes	Gas	Yes	SO ₂ gas			flow-paced	DPD	HACH DR-2000
Gibsons	Town of Gibsons	Greg Foss	town_of_gibsons@sunshine.net	604-885-8422	604-886-9735	389 Stewart, Gibsons	V0N 1V0	2250	Yes	Marine	No				1200	1800	flow-paced	amp. titration	
GVRD-Annacis Island	Greater Vancouver Regional District	Brian Erikson		604-523-7154	604-432-6714	4330 Kingsway, Burnaby	V5H 4G8	586430	Yes	Fraser River	Yes	Gas	Yes	SO ₂ gas			flow-paced	amp. titration	
GVRD - Iona Island	Greater Vancouver Regional District	Brian Erikson		604-523-7154	604-432-6714	4330 Kingsway, Burnaby	V5H 4G8	1530000	Yes	Marine outfall	No						flow-residual	titration & DPD	
GVRD- Northwest Langley	Greater Vancouver Regional District	Brent Galick	brent.galick@gvrd.bc.ca	604-888-3223	604-888-3223	10301 - 201 St., Langley	V1M 3G6	12700	Yes	Fraser River	Yes	Gas	Yes	SO ₂ gas			flow-residual	titration & DPD	
Lions Gate	Greater Vancouver Regional District	Brian Erikson		604-523-7154	604-432-6714	4330 Kingsway, Burnaby	V5H 4G8	203000	Yes	Marine	Yes	Sodium hypo	Yes	SO ₂ gas			flow-paced	amp. titration	
Lulu Island	Greater Vancouver Regional District	Brian Erikson		604-523-7154	604-432-6714	4330 Kingsway, Burnaby	V5H 4G8	132520	Yes	Fraser River	Yes	Gas	Yes	SO ₂ gas			flow-paced	amp. titration	
Hammond Bay - GNWPCC	Regional District of Nanaimo	Mike Brophy	mbrophy@rdn.bc.ca	250-758-1157	250-758-8628	4600 Hammond Bay Road, Nanaimo	V9T 5A8	80870	Yes	Marine	No				included with French Creek				
Harrison Lake	Village of Harrison Hot Springs	Joe Koczur	jkoczur@shaw.ca	604-796-2913	604-796-2192	495-Hot Springs Road, Harrison Hot Springs	V0M 1K0	378	Yes	Harrison River	Yes	Gas	Yes	Na sulphite	1500	1600	flow-paced	DPD	HACH DR 2000
Ladysmith	Town of Ladysmith	Ken Fleckenstein	kfleckenstein@town.ladysmith.bc.ca	250-245-6446	250-245-6447	Box 223, Ladysmith	V0R 2E0	6100	Yes	Marine	Yes	Gas	Yes	SO ₂ gas	2448	7085	flow-paced	amp. titration	
Lake Cowichan	Town of Lake Cowichan	Dave Conway	dconway@town.lakecowichan.bc.ca	250-749-6244	250-749-6886	Box 860, Lake Cowichan		4500	Yes	River	Yes	Gas	No		1704	3870	flow-paced		
Lions Bay	Village of Lions Bay	Blair Smith	snookie@direct.ca	604 921 9833				340	Yes	Marine	No				108	216			
Lund	Powell River Regional District	Frances Ledret	frances.ledret@powellriverd.bc.ca	604-483-3231	604-438-2229	9810 Finn Bay Road, Powell River	V8A 2M4	113.5	Yes	Marine	n/a				This plant is abandoned				
Lund Strait of Georgia	Powell River Regional District	Frances Ledret	frances.ledret@powellriverd.bc.ca	604-483-3231	604-438-2229	9810 Finn Bay Road, Powell River	V8A 2M4	230	Yes	Marine	No				74.4	128			
Matsqui Abbotsford	Fraser Valley Regional District	Trevor Lewis	tlewis@fvrd.bc.ca	604-702-5000	604-792-9684	8430 Cessna Road, Chilliwack		2271	Yes	Ground	No								
North Pender Island - Magic Lake	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9576-5th street, Sidney	V8L 2N5	68.1	Yes	Marine	No								
NRD - Nanoose	Nanaimo Regional District	H.J. Halvorson	hhalvor@island.net	250-248-5794	250-248-0147	957 Lee Road, Parksville	V9P 1Z4	2270	Yes	Marine	No								
NRD -Parksville French Creek WPCC	Nanaimo Regional District	H.J. Halvorson	hhalvor@island.net	250-248-5794	250-248-0147	957 Lee Road, Parksville	V9P 1Z4	16000	Yes	Marine	No								
Pemberton	Corporation of Village of Pemberton	Bryan Kirk	villageofpemberton@direct.ca	604-894-6135	604-894-5708	7400 Prospect Street	V0N 2L0	455	Yes	River	No								
Pinecrest	Resort Municipality of Whistler	Dave Shyer	dshyer@whistler.ca	604-932-5535	604-932-6636	4325 Blackcomb Way, Whistler, BC.	V0N 1B4		Yes	wetland	No								
Port Alberni	City of Port Alberni	Norm Meunier	nmeunier@city.port-alberni.bc.ca	250-656-2425	250-665-4166	9576-5th street, Sidney	V8L 2N5	34100	Yes	Marine	No				21000	68000			
Port Renfrew	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9576-5th street, Sidney	V8L 2N5	220	Yes	Marine	No								
Port Renfrew	Capital Regional District	George Foley	gfoley@crd.bc.ca	250-656-2425	250-665-4166	9576-5th street, Sidney	V8L 2N5	220	Yes	Marine	No								
Powell River	Powell River Regional District	Frank D'Angio		604-485-6291	604-485-3507	6910 Duncan Street, Powell River,	V8A 1V4	3500	Yes	Marine	No				5000	13640			
Quathiaski Cove, Quadra Island	Regional District of Comox-Strathcona	Sharon Clendenning		250-285-3373				350	Yes	Marine	No (UV)				12000	40000			
Sechelt, District of	District of Sechelt	Ken Tang		604-885-1986	604-885-7591	2nd Floor, 5797 Cowrie St., Sechelt	V0N 3A0	3400	Yes	Marine	Yes	Gas	Yes	SO ₂ gas				DPD	
Squamish	District of Squamish	Roy Mihalic	admdept@district.squamish.bc.ca	604-892-5217	604-815-6870	37955 2 ave Squamish	V0N 3G0	17850	Yes	River	No				4000	14600			
Squamish	District of Central Squamish	Roy Mihalic	admdept@district.squamish.bc.ca	604-892-5217	604-815-6870	37955 2 ave Squamish	V0N 3G0	4550	Yes	Marine	No				3500	4500			
Whistler	Resort Municipality of Whistler	Dave Shyer	dshyer@whistler.ca	604-932-5535	604-932-6636	4325 Blackcomb Way, Whistler, BC,	V0N 1B4	25000	Yes	Cheakamus River	Yes	Gas	Yes	SO ₂ gas			flow-paced	DPD	HACH DR 3000
NON-GEORGIA BASIN RESPONDENTS																			
Armstrong	City of Armstrong	Randy Wagner	amrandy@sunwave.net	250-546-3023	250-546-3710	PO Box 40, 3750 Bridge St., Armstrong, BC	V0E 1B0	1950	No	Spray Irrigation	Yes	Gas	No				flow-paced	DPD	HACH DPD
Clearwater	Clearwater Improvement District	Don McKale	clwcid@mercuryspeed.com	250-674-2257	250-674-2173	105 Webber Road, Clearwater	V0E 1N0	166	No	River	No				25	40			
Fernie	City of Fernie	Dave Cockwell	dave.cockwell@city.fernie.bc.ca	250-423-2224	250-423-3034	Cokato Road		11500	No	River	No				4000	13600			
Kamloops	City of Kamloops	Alan Woodbury	awoodbury@city.kamloops.bc.ca	250-828-3517	250-828-1766	3300 Mission Flats Road, Kamloops		55000	No	Thompson River	Yes	Gas	No		29600	37000	flow-residual	DPD	HACH
Lake Country	District of Lake Country	Keith Gerein	kgerein@earthtech.ca	250-766-1478	250-766-1478	4062 Beaver Lake Road, Lake Country, B.C.	V4V 1T5	800	No		No				545	578			
Penticton	City of Penticton	Bernie Udala	wtp@city.penticton.bc.ca	(250) 490-2558	(250) 712-0980	171 Main Street, Penticton	V2A 5A9	13600	No	River	Yes	Gas	Yes	SO ₂ gas	13200	16500	flow-residual	DPD	HACH DR 2000
Penticton Creek	City of Penticton	Bernie Udala	wtp@city.penticton.bc.ca	(250) 490-2558	(250) 712-0980	171 Main Street, Penticton	V2A 5A9	1700	No	Creek	Yes		Yes						
Prince George	Regional District of Fraser-Fort George	Lila Reynolds	lreynolds@city.pg.bc.ca	250-561-7528	250-612-5620	1100 Patricia BLVD, Prince George	V2L 3V9	47500	No		No				30000	37000			
Prince George	Regional District of Fraser-Fort George	Lila Reynolds	lreynolds@city.pg.bc.ca	250-561-7528	250-612-5620	1100 Patricia BLVD, Prince George	V2L 3V9	50.8	No		No								
Revelstoke Illecillewaet River	Corporation of the City of Revelstoke	Bryant Yeomans	byeomans@city.revelstoke.bc.ca	250-837-2001	250-837-2056	PO Box 170, Revelstoke, BC		4152	No	River	Yes	Gas	No		2800	4000	flow-paced	DPD	HACH DPD
Salmon Arm	District of Salmon Arm	Hart Fries	dsapcc@stream.net	250-832-3500	250-832-0988	121 Nardisse Street NW, Salmon Arm	V1E 4N2	5680	No	Lake	Yes	Gas	Yes	SO ₂ gas	4300	6131	flow-paced	DPD	HACH DR 4000
Vernon	City of Vernon	Al Cotsworth	acotsworth@city.vernon.bc.ca	(250) 545-8882	(250) 545-8882	2400 43 street, Vernon	V1T 6W8	18000	No	Spray Irrigation	Yes		No		12427	14434			

The operator at the Resort Municipality of Whistler Pollution Control Centre had previously operated an on-site chlorine gas generator system and gave this device a very favourable reference. If budget were not a concern, he indicated that he would like to replace the existing gas system.

6.2 DECHLORINATION CHEMICALS BEING USED

The majority of the plants are using sulphur dioxide for dechlorination. One exception is the Harrison Lake treatment plant where sodium sulphite is used for dechlorination. While the plant operators have wanted to change to sulphur dioxide for the ease of operation and maintenance, they have not made any changes, based on the cost for the conversion.

Harrison Lake had originally used sodium meta-bisulphite for dechlorination but had subsequently discontinued its use, as the chemical was very harsh and difficult to handle. Their current use of sodium sulphite is quite interesting as the Handbook of Chlorination by White⁽⁷⁾ indicates that sodium sulphite is "never" used for dechlorination since it is highly hygroscopic and difficult to handle. The WEF Chlorination/ Dechlorination handbook⁽³¹⁾ does not have a similar warning and lists it as an appropriate chemical. The operations staff at Harrison had not experienced any difficulties with the dosing equipment.

The method of chemical dosing that the Harrison Lake staff use is to add 4.5 L (1 gallon) of water to 0.45 kg (1 pound) of the sodium sulphite chemical. They have a 500 L (110 gallon) graduated tank with a mixer and make a batch when the tank is at the 250 L (55 gallon) level (half full). They can measure the added water and add a 22 kg (50 pound) container of the white powder chemical to make a relatively constant concentration solution. To keep the concentration consistent, the staff never allows the chemical to drain completely as the strength of the solution would vary during the mixing phase. Their use of the chemical is roughly 4.5 kg (10 pounds) per day.

The GVRD are currently using gaseous sulphur dioxide for dechlorination at the treatment plants that have to chlorinate during the summer (Lions Gate, Annacis Island and Lulu Island). As a function of operator safety, they reviewed a change to a solid or liquid based system. They selected sodium bisulphite with cost as the key parameter for the selection plus apparent ease of handling.

The GVRD had eliminated sodium thiosulphate as an option since the literature suggests that reaction needs to take place at pH of 2. The Resort Municipality of Whistler, Black Tusk and Pinecrest treatment plants all use sodium thiosulphate for dechlorination. The University of Victoria also uses the thiosulphate for their water treatment dechlorination system at their aquiculture facility previously referenced. During our survey the Resort Municipality of Whistler staff were questioned regarding the effectiveness of the thiosulphate at a high pH. They confirmed that they reach "zero" levels of chlorine in the outfall. Citing information on Table 5-1 of this report (from JCI Chemical), the

demand for thiosulphate is very sensitive to pH. Plants using thiosulphate must be aware of this relationship and make adjustments if pH varies. The operator had indicated he would do some jar testing to determine if sodium bisulphite would work better. The operator was unaware as to why the thiosulphate was being used and had never questioned if an alternate chemical would be more effective or less costly.

6.3 OFF-LINE METHODS OF RESIDUAL ANALYSIS

The feedback from the survey indicated that the hand-held DPD analysers available in the market place offered a very easy method of residual measurement. Operators find that the test is complete in very short period and that the operation of the device is very easy and very repeatable. Positive feedback was gained from all levels of operators.

We found numerous plant operators reporting that their final chlorine residuals, after dechlorination, were "zero", based on grab samples analysed with DPD colorimetric units. However, since the units are accurate to roughly 50 µg/L, the true answer would be between zero and 50 µg/L. As regulations require that the level of residual chlorine is to be 10 µg/L (or at least less than 20 µg/L), the measurement represents insufficient evidence to confirm that the required dechlorination has actually been achieved.

In the survey, some plant operators indicated that they send samples out for chlorine monitoring. This is not an acceptable practice as the sample will naturally dechlorinate over time. The sample must be measured at site, as soon as possible, to achieve meaningful results.

6.4 ON-LINE CHLORINE RESIDUAL MEASUREMENT

Few B.C. plant operators utilize on-line chlorine residual measurement. This is not surprising, given the limited number of plants that have a high level of wastewater treatment and the high cost of implementation of on-line residual analyzers. However, the need is recognized for tighter control and reduced chemical cost.

The Joint Abbotsford Mission Environmental System (JAMES) Pollution Control Centre plant is adding allowance in next year's budget to add an on-line unit for measuring chlorine level after dechlorination. They have not reviewed the available technology therefore and have not yet determined the unit to be used.

As with most plants surveyed, the JAMES plant chlorine addition is intended to remain flow-paced. They are meeting the fecal limits and the cost to add a chlorine dosing on-line indicator is not

considered justifiable. The JAMES chlorine demand is 18,200 kg (40,000 pounds) per year and the sulphur dioxide is 9100 kg (20,000 pounds) per year. At the time of the survey, the chlorine gas cost was just over \$2.20 per kg (\$1.00 per pound) and the sulphur dioxide was about \$4.00 per kg (\$1.80 per pound). However, the JAMES plant operators were informed that the cost of chlorine was likely to go up in 2003. (This information appears to be quite accurate as the chlorine gas production is in balance with the caustic production. Any changes in either market ultimately affects the price of the chemical and with a softening of the caustic market, it appears chlorine prices are on the rise.)

Though they have no references in B.C., the ORP manufacturer Stranco, has numerous references that show the chemical costs can be reduced by accurate monitoring of the chlorine dosing. As described in the previous section, the Stranco Stantrol system has been proven on all types of wastewater quality. With higher chlorine prices, the investigation of larger plants may show that the instrumentation will reduce chlorine costs and, thus, pay for higher levels of monitoring. Side benefits of on-line chlorine measurement would be the reduction in demand for dechlorination chemicals, as excess chlorine is not fed. The system would provide tighter control of final water quality thus ensuring chlorinated water does not enter the watercourse. It should be highlighted that the cost of these systems is \$30,000 and can only be justified by very large users. Using JAMES as an example, the total yearly chemical cost is \$77,000. The manufacturer claims chemical costs have been reduced by over 50% on some of their references due to the demand pacing of chlorine. Assuming a 20% reduction is achieved for a plant the size of JAMES, the ORP system cost would be recovered with approximately two years of chemical cost savings.

The GVRD's Northwest Langley treatment plant represents a very good reference of a well maintained and successful installation of an on-line residual chlorine analyzer. They are using the 3-probe amperometric device as supplied by Capital Controls (the US Filter and GLI International units would be equivalent). The unit is cleaned on a weekly basis and the calibration is done daily. The manufacturer's manual suggests much less maintenance requirement than is practiced. Quoting from the service section of the manual, "*The inherent product design reduces the amount of maintenance required to only buffer addition approximately every 2-4 weeks, periodic (monthly) calibration checks, reference electrode filling solution replacement approximately once per week and flushing of the sample cell and analyzer wet end*". It is not the intent of our discussion to focus attention on Capital Controls, as their competitors also under-estimate wastewater service requirements for their units. These instructions would be appropriate for a water or very high quality secondary effluents.

The Northwest Langley staff uses a far more regimented maintenance regime leading to the success of the Capital Controls Amperometric unit. A flushing Y-strainer installed upstream of the measurement device is cleaned weekly. The complete unit is cleaned weekly and calibrated daily. The buffer solution needs replacement every 2 to 3 weeks, and the spherical balls used to keep the probe clean need to be cleaned every 6 to 8 weeks.

The City of Penticton uses an EIT (now HACH) membrane cell-type probe. There are numerous other suppliers of the membrane type probes and these should all be considered equal. Penticton reports excellent results and they conduct less maintenance than reported on the Langley reference. They do regular calibrations which are very easy to do with the electronic package integral with the unit. They have a minor maintenance routine that takes about 2 hours every 2 months and costs \$80. The major service requirement is completed annually and costs about \$160.

The Penticton plant is a BNR (Biological Nutrient Removal) plant and the ammonia level is consistently maintained at very low level. They also have a higher quality effluent than the GVRD's Northwest Langley plant. The plant reports the suspended solids are 0.7 µg/L and the BOD level is typically less than 5 mg/L. Although both the Langley and Penticton plants would appear to be excellent references for wastewater applications, the applications are substantially different. Should a plant similar to the Northwest Langley plant use the membrane-type probe used in Penticton, they would likely not report good results since the BOD and suspended solids would likely clog the membrane in a relatively short period of time.

It is most interesting to note that the Northwest Langley plant removes ammonia during the summer. The operators allow the plant to nitrify and thus provide a higher level of treatment. The probe has demonstrated excellent operation in this environment. When questioned, the staff were not even aware that fluctuation in ammonia level was an issue with residual chlorine measurement. Per discussion in previous sections, the addition of the potassium iodate reagent and measurement of iodate in the sample allows all species of chlorine to be measured. For the membrane-type units, as the ammonia levels creep up over winter (as the rate of nitrification decreases), the free chlorine would be converted to chloramine. The membrane type cells are species specific and can measure only chlorine or chloramine. As ammonia levels change, the membrane type analyzers will quickly go out of calibration as only chloramine or free chlorine will be measured.

The Northwest Langley plant had tried an on-line unit previous to the unit now installed. While plant staff could not recall the exact unit, the pilot test was remembered to be unsuccessful as the tubing and sample ports were too small and jammed with algae in a very short period of time. As highlighted in an earlier section, the GVRD Lions Gate plant had an unsuccessful trial of an amperometric type unit that failed as a result of high levels of fats, oils and grease concentrations.

6.5 DISINFECTION BY UV IRRADIATION

The investigation of UV irradiation-type disinfection was technically outside the scope of this chlorination/dechlorination investigation. However, since the treatment plant survey tended to "encounter" treatment plants that have converted to UV or are thinking about UV, it was thought some UV-related information should be reported.

The survey found some plants that were using UV, reporting excellent service and meeting permitted fecal coliform counts. In contrast, it is noted that in the Lower Mainland, there are treatment plants that had either piloted or purchased UV systems for disinfection and found the systems ineffective. These plants subsequently reverted back to chemical chlorination and dechlorination. It should be noted that the use of UV is dependent on the transmissivity of the water. Operators recall that the suppliers of the failed systems have suggested that high iron levels were responsible for the difficulties.

The GVRD has done extensive review of UV and their experience is beneficial in understanding the issues. Prior to completing the GVRD's secondary plants at Annacis Island and Lulu Island, a pilot plant was constructed to emulate secondary treatment and disinfection with UV. The pilot plant did not show effective disinfection. The GVRD subsequently piloted with actual secondary treatment and the results were favourable. The GVRD have tried UV on the primary effluents from the Lions Gate and Iona Island primary treatment plants and have demonstrated poor disinfection performance. On this basis, it is likely that chlorination/dechlorination will remain functional in at least some of the GVRD's plants for some time in the future.

6.6 TREATMENT PLANT STAFFING LEVELS

As part of the survey, information was obtained regarding the level of wastewater treatment operator training and certification. The results showed that the smaller plants are typically operated with limited staff with limited training. Some plants, such as Beecher Bay, are operated by private contractors that visit only on a monthly basis. As another example, the plant at Lund (north of Powell River) is only staffed for one hour per day. The operator's responsibility is limited to monitoring, sampling and minor repairs. Major repairs are done by others. This would be indicative of most plants of this size. Both of these plants do not chlorinate and are meeting all permits. However, this does highlight the difficulty facing smaller installations. The smaller plants typically do not have the budget to have dedicated personnel and are often operated by personal with no direct training in the theory and operation of the wastewater treatment plants.

Lack of operator training and availability is a common concern with very small plants. In recognition of the lack of operator training in small plants, INAC (Indian and Northern Affairs Canada) sponsors

a circuit-rider program to review all water and wastewater plants on First Nation communities in B.C. A highly skilled operator visits these plants and trains the local operator to ensure proper operation and maintenance is completed. INAC assumes part of the cost of the service, therefore the program is well utilized. Unfortunately, very small systems not within INAC can not afford this service and rely on the best people in the area to operate the plants.

The level of operator training and plant staff levels should significantly affect the sophistication of the equipment that can be installed. Although the measurement of residual chlorine after dechlorination using off-line, field test kits, is not as accurate as required, with the limited funding and limited operator education, this may represent the best approach for these very small plants.

6.7 WASTEWATER RE-USE

Some plants on the list in Table 6-1 show the use of chlorination, but not dechlorination. Some of these plants, such as Vernon and Armstrong, use the wastewater for irrigation. In Vernon's case, a large retention pond stores the treated wastewater. During summer months, the recycled water is drawn from the basin, further chlorinated, and used to irrigate a nearby golf course. The trend toward recycled water is growing, especially in areas of high irrigation demand and or shortages of potable water storage. The discussion regarding re-use is beyond the scope of this study. Operators should be aware of the possibility of alternate re-use of wastewater. It is noted that wastewater reuse is also supported by the Provincial MSR.

SUMMARY

SECTION 7

7.1 CHLORINATION AND DECHLORINATION CHEMICALS

Disinfection represents the final step in wastewater treatment and, as such, there is no means to prevent harm to the public if chemical is underfed nor means to protect the environment from toxic chemicals should an overfeed occur. Disinfection of wastewater using chlorine has come under close scrutiny due to the problems associated with haloform compounds and their potential impact on human and aquatic life. The problems with chlorine residuals have been addressed, with mixed success, through the control of chlorine addition and the use of dechlorination chemicals, introduced after the required chlorine contact time has been achieved. However, many chlorination/dechlorination systems currently in use are not adequately designed, operated, and monitored to ensure that they consistently meet their target effluent pathogen content and chlorine residual level, especially in small wastewater treatment plants. Regardless of plant size, all equipment required for disinfection needs to be diligently maintained with stand-by systems in place and adequate spares on site to service normal wearing parts.

The chemicals that are used in chlorination and dechlorination of wastewater treatment plant effluent are a function of plant size and safety concerns. For larger plants, with more trained staff and resources, chlorine gas (Cl_2), followed by sulphur dioxide gas (SO_2), for dechlorination have been popular due to their lower bulk chemical costs. However, the high equipment costs associated with these gas-based systems are typically considered to be prohibitively expensive for many smaller plants. Additionally, safety concerns surrounding the storage and handling of the pressurized gas have forced even some larger capacity treatment plants away from the use of gas. In addition, the complexity of gas storage and dosing systems also requires more experienced and highly trained operators. As a result, for smaller treatment plants, either sodium or calcium hypochlorite for disinfection and bisulphite, thiosulphate or metabisulphite for dechlorination are preferred based on ease of handling and relatively low hazards. While calcium hypochlorite is typically 1.5 to 2 times the cost of liquid sodium hypochlorite, it may be preferred by smaller users as it requires less infrastructure for transport, storage, and handling. This is especially true of the newer "puck"-type calcium hypochlorite systems.

As measuring chlorine accurately at the very low levels (as required by the MSR) is quite difficult, plant operators should consider a slight overfeed of the dechlorination chemicals. The dechlorination chemicals are typically not harmful to receiving water at low levels. Verification of chlorine residual neutralisation can be done with on-line and off-line sulphite residual measurement techniques. Controlling the residual chlorine to the $10 \mu\text{g/L}$ level is not possible; however higher discharge levels

are allowable for sulphite. Measurement and control of sulphite at the higher levels is achievable and possible to maintain.

The capital cost of on-line and offline analytical equipment may be unaffordable to smaller plants. Use of alternate disinfection chemicals for dechlorination such as ascorbic acid (vitamin C) or hydrogen peroxide have almost no impact on the receiving environment. These two options would require pilot studies before implementation. Hydrogen peroxide reacts very slowly with combined chlorine and may not meet technical requirements, i.e. it may require additional contact time than is normally available. Ascorbic acid is very expensive in comparison with other dechlorination methods; however, safety issues and protection of the environment may justify the use.

Regardless of treatment plant size, chlorination and dechlorination chemical feed systems need to be designed so that spills of toxic chemicals do not enter the environment. Secondary containment and spill containment need to be incorporated into each design. Consideration should be given to chemicals that present low risk to the surrounding environment.

7.2 CHLORINATION AND DECHLORINATION RESIDUAL TEST METHODS

While the methods of measuring chlorine residual in wastewater are essentially the same as those used for potable water, the larger concentrations of dissolved and suspended solids in wastewater create increased interferences. In addition, the level of accuracy for chlorine residual measurement, so that the required target of less than 0.010 mg/L (10 µg/L) total chlorine residual (or less) can be achieved, is much higher than that required for potable water analysis.

In order to properly monitor and control chlorination and dechlorination, operators require simple, accurate techniques for determining chlorine and sulphite residuals. Several field test kits are commercially available that duplicate laboratory procedures including the DPD, amperometric, and iodometric methods. Each methodology and associated field test kit has particular strengths and weaknesses in terms of accuracy, precision (reproducibility), interferences, ease of use, and applicability for use in municipal wastewater treatment plants.

The "FACTS" method of chlorine residual measurement provides a simple and accurate test for free available chlorine but is not commercially available as a field test kit. The orthotolodine method, despite previous widespread use, has been discontinued in favour of other measurement techniques. The iodometric method is only suitable for measurement of high strength chlorine (hypochlorite) solutions and is not suitable for measuring levels of chlorine residual below 1 mg/L.

The amperometric titration method of determining chlorine residual is the most accurate method of determining chlorine residual, particularly at low concentrations. However, the off-line manual

method requires a high level of training and skill to produce the required accuracy. Portable test instruments using amperometric titration are commercially available and can be used on grab samples from both large and small treatment plants, provided the operators have the skill and training to use the equipment. There are many cases in B.C. where the treatment plants have amperometric titration equipment that was once used but now sits under the equipment dust cover while other easier, but less accurate methods, are used to measure the chlorine residual. This may change with the imminent commercial release of a small automated amperometric titration device that should be suitable for use in small treatment plants.

The DPD colourimetric test is perhaps the simplest, most versatile field test available on the market for the measurement of chlorine residual. It can be a very simple test based on a hand-held colour comparator or it can be more sophisticated based on spectrophotometer techniques. In either case, the operator must take care to minimize interferences and possible false positive values, particularly in the presence of organic chloramines. While the DPD method is relatively accurate, it is only accurate to between 30 and 50 µg/L for chlorine residual measurement. Since the objective of chlorine residual is 10 µg/L in the *B.C. Waste Management Act – Municipal Sewage Regulation – Part 8 Effluent Disinfection* (provided in Appendix A), one can not assume the required low chlorine level is being met by using a DPD method. A simple and cost effective method is to use amperometric back titration to confirm that there is a small residual sulphite level, i.e. all of the chlorine residual has been removed.

Sending a grab sample of wastewater effluent to a lab off-site for more accurate measurement of chlorine residual is unacceptable. Chlorine residual will dissipate to some extent in the time period between the time of the grab sample and the time when the lab does the final analysis.

On-line measurement of chlorine residuals in wastewater is based on the techniques that have been developed for measurement of chlorine residuals in potable water. However, many of the units commercially available for residual chlorine measurement are not acceptable for use in wastewater. Manufacturers promote their use in wastewater; however, many of these installations are only for high quality secondary treatment applications. Care is required in applying technology and, where possible, long term pilot study of the unit should be completed. In all cases of on-line monitoring, it is important that the sample lines between the sampling point and the measurement cell be continuously cleaned and flushed to achieve accurate results.

For high quality secondary wastewater treatment plants, membrane type residual chloride analyzers represent the best combination of accuracy and ease of operation for on-line residual chlorine measurement. However, these units will become fouled if used on lower quality effluents. In addition, when used at treatment plants that are nitrifying, any changes in nitrogen levels will cause significant inaccuracy in the measured residual.

Gas phase and ORP analyzers are suitable for all effluent qualities including primary and low quality secondary effluents. They have demonstrated success for effluents with higher solids contents.

Bare electrode amperometric on-line analyzers provide the most accurate indication of chlorine residual for both free and combined chlorine. Units with the 3 probe sensor provide better accuracy and better stability as the units are designed to adjust to background interferences. The units are more difficult to operate and require the highest level of operator intervention.

Colorimetric methods, including the DPD method, often represent a better technology fit. Even though the method has a lower accuracy and higher detection limits than desirable, the simplicity of the device ensures monitoring will be completed regularly.

7.3 SURVEY RESULTS

7.3.1 Chlorination/Dechlorination

The survey results indicated that, of those plants that chlorinate, most but not all, dechlorinate. Of the plants that chlorinate, the majority currently use chlorine gas, the remainder use sodium hypochlorite. For those plants that chlorinate with gaseous chlorine and dechlorinate, the majority use sulphur dioxide gas to dechlorinate. One plant uses anhydrous sodium sulphite. Of the plants that chlorinate with sodium hypochlorite and also dechlorinate, sodium thiosulphate is the dechlorination chemical being used, despite potential issues with pH.

Because of safety issues, the trend may be away from chlorine gas to sodium hypochlorite. Some of the smaller plants may choose to use the newer, more accurate, calcium hypochlorite "puck" systems, despite their higher chemical costs.

7.3.2 Controls

Of the plants that chlorinate, not all use automatic controls. For those plants that use automatic controls, most use flow-paced controls. Some (three plants) use a combination of flow and chlorine residual feedback. Control to very low chlorine levels, as required by the BCMSR, is not practical. A slight overdose of dechlorination chemicals is the preferred approach. On-line equipment is available to read the dechlorination chemical residual. The feed control to maintain a slight sulphite residual is well within the practical limit of available technology.

7.3.3 Testing

The majority of the chlorine residual testing, including confirmation of on-line measurements, is done using the DPD method. The majority of these use HACH spectrophotometers to

measure the chlorine residual colourimetrically. Some of the chlorine residual testing is done by amperometric titration.

7.3.4 Overall Survey Summary

Fifty-three plants responded to a survey (41 Georgia Basin/12 non-Georgia Basin). Of the 21 (14 Georgia Basin/7 non-Georgia Basin) plants that are required to disinfect and use chlorination, the majority also dechlorinate. Of those plants that chlorinate, the majority use chlorine gas to chlorinate and sulphur dioxide to dechlorinate. Of the remaining plants that chlorinate, all use sodium hypochlorite to chlorinate and sodium thiosulphate to dechlorinate, despite potential pH problems with the latter.

There may be a trend to move from chlorine gas to sodium hypochlorite at larger plants and from sodium hypochlorite to calcium hypochlorite "pucks" at smaller plants. It is not clear that the plants moving from chlorine gas will also abandon sulphur dioxide gas as the dechlorinating agent. In any event, there are several non-gas methods of dechlorination.

Very few plants currently use on-line control of chlorination and dechlorination and those that do are primarily flow-paced systems rather than through on-line monitoring of chlorine residuals. The majority of the measurement and/or confirmation of chlorine residuals is done through the DPD method. The majority of these tests are done colourimetrically using a spectrophotometer (portable and bench).

7.4 OVERALL SUMMARY

Chlorination continues to be a relatively low cost, effective means of disinfecting wastewater effluents. While the future trend may be towards UV irradiation, there are many plants that currently use chlorination and will continue to do so.

Chemicals used for chlorination and dechlorination tend to be a function of the economies of scale and the operator training and certification level related to treatment plant size and complexity. Chlorine gas for disinfection and sulphur dioxide for dechlorination have been the chemicals of choice for the medium to larger capacity wastewater treatment plants that disinfect by chlorination. Sodium hypochlorite for disinfection and sodium thiosulphate for dechlorination tend to be used at the smaller B.C. plants. Due to safety concerns regarding chlorine gas and improvements in the accuracy of calcium hypochlorite systems, there may be a trend away from chlorine gas to sodium hypochlorite at larger plants and from sodium hypochlorite to calcium hypochlorite at smaller plants. It is not clear what chemicals will be preferred for dechlorination. For the smaller plants, there are some chemicals such as ascorbic acid that present little or no environmental impact if over-dosed.

Of all the test methods available for chlorine residual measurement, the most accurate method is amperometric titration. However, since this method has required considerable operator training and skill to be accurate, other methods, particularly the DPD colourimetric method, have been widely used in B.C. While the simplicity and relative accuracy of the DPD method typically ensures that the test will be done regularly, the lower level of accuracy of the DPD method makes it impossible to positively confirm that the chlorine residual is meeting the 0.010 mg/L (10 µg/L) target level set out in the 1999 B.C. Municipal Sewage Regulation. Many B.C. operators typically deal with this by slightly over dosing their dechlorination chemicals since a dechlorination chemical residual is not as harmful as chlorine residuals above 10 µg/L. Measurement of the sulphite residual is becoming more common. Use of DPD for sulphate measurement has been applied for boiler water application, but does not have widespread use for municipal, wastewater applications. Bench titration or ORP are the most common form of residual dechlorination chemical measurement. This situation may change with the imminent availability of an automated amperometric sulphite residual analyzer.

7.5 RECOMMENDATIONS

- The B.C. wastewater disposal regulations require 10 µg/L residual chlorine levels at the discharge of the plant. Monitoring and control to this level is not practical. Plants should slightly overfeed the dechlorination chemical rather than attempt to control to this low level. The allowable discharge levels for the dechlorination chemicals are much higher.
- Chlorine gas represents the lowest chemical cost for chlorine disinfection chemicals. However, the higher equipment capital cost and operating cost required for the safe feed of gas makes liquid sodium hypochlorite a more attractive alternative for smaller applications.
- New feed systems using dry calcium hypochlorite systems offer adequate control of the dose, in addition, safe and easy operation. Newer feed technology should replace older calcium hypochlorite "puck" systems that do not have sufficient control of the chemical dose.
- On-site hypochlorite generation systems have higher capital cost but lower operating costs than chlorine chemicals (i.e. chlorine gas, sodium hypochlorite and calcium hypochlorite). In addition, the safety and ease of operation can make these systems attractive.
- Amperometric titration is the most accurate method of off-line residual chlorine and sulphite measurement. However, to produce accurate results, the treatment plant requires a trained and experienced operator.

- Off-line DPD method of measurement of chlorine residual is the most popular method due to the low cost of the equipment and ease of operation. The method is good for monitoring the disinfection chlorine levels; however, this method is not accurate enough for use in measurement of the dechlorination residuals of 10 µg/L.
- On-line measurement of chlorine residual is very dependent on the level of treatment. The numerous interferences present in wastewater applications dictate piloting equipment where possible.
- For primary treatment, gas phase residual analysers and ORP techniques have displayed success for measurement of both chlorination and dechlorination residuals. Other on-line units quickly foul and provide inaccurate results.
- Bare electrode amperometric titration units are the most accurate on-line devices but are not suitable for primary treatment plant applications.
- Membrane-type residual chlorine probes are cost effective and offer good accuracy. However, these units require high quality secondary effluents and will foul quickly if exposed to high BOD or suspended solids loading. The units are species dependent, therefore, they are not suitable for plants that have variable ammonia levels.
- Recently developed automated off-line titrators should give the simplicity offered the DPD methods with the accuracy of the amperometric titrators. These units will be suitable for off-line chlorination and dechlorination monitoring. At time of this report, no installations were available to confirm accuracy and reliability.
- Gas phase sulphite monitors are suitable for all levels of treatment as the liquid does not contact the probe. These units can provide a confirmation of low levels of sulphite thus confirming that no low chlorine residual is present.
- Centre-zero systems offer the ability to measure chlorine and sulphite residuals simultaneously and confirm overfeed levels of dechlorination chemicals. Units are not suitable for plants that have only primary treatment and are quite expensive for very small plants.
- ORP systems have been successfully used for chlorination and dechlorination. This technology is the most widely used system; however, the initial cost is prohibitive for small plants. The system is suitable for all levels of treatment.

REFERENCES



1. *Canadian Environmental Protection Act Priority Substances List Assessment Report, Chlorinated Wastewater Effluents*, 1993.
2. Bureau of Water Management, Chlorinated Municipal Waste Toxicities to Rainbow Trout and Fathead Minnows, Water Pollution Control Series No. 18050 GZZ 10/71, Mich. Dept. of Nat. Resources for the EPA, Oct. 1971.
3. Eckenfelder, W.W. *Principles of Water Quality Management*, CBI Publishing, Boston, 1980.
4. Peavey, H.S.; Rowe, D.R.; and Tchobanoglous, G., *Environmental Engineering*, McGraw Hill, 1985.
5. James M. Montgomery, *Water Treatment Principles and Design*, New York, 1985.
6. Esvelt, L.A., Kaufman, W.J., and Selleck, R.E., Toxicity Assessment of Treated Municipal Wastewaters, paper presented at the 44th Annual Conf. of the WPCF, San Francisco, CA, Oct, 1971.
7. White, C., *The Handbook of Chlorination and Alternative Disinfectants*, Third Edition, Van Nostrand Reinhold, New York, 1992. reporting private correspondence with Dr. W. Kaufman in 1972.
8. Stone, R.W., Kaufman, W.J., and Horne, A.J., *Long-Term Effects of Toxicity and Biostimulants on the Waters of Central San Francisco Bay*, SERL Report 73-1, Univ. of California, Richmond, CA, 1973.
9. EPA, National Small Flows Clearinghouse, Environmental Technology Initiative, Chlorine Disinfection Fact Sheet.
10. Metcalf & Eddy, Inc., *Wastewater Engineering: Treatment, Disposal, and Reuse*. 3rd ed. The McGraw-Hill Companies. New York, 1991.
11. Water Environment Federation (WEF), *Design of Municipal Wastewater Treatment Plants*, WEF Manual of Practice No. 8, Alexandria, VA., 1992.
12. Water Pollution Control Federation: Disinfection Committee. *Wastewater Disinfection: A State-of-the-Art Report*. Alexandria, VA, Water Pollution Control Federation, 1984.
13. Gordon, G., Cooper, W.J., Rice, R.G., and Pacey, G.E., "Methods of Measuring Disinfectant Residuals", *AWWA Journal*, Nov 1987.
14. American Public Health Association. *Standard Methods for the Examination of Water and Wastewater*, 19th ed., American Public Health Association, Washington, DC., 1995.
15. Water Environment Federation (WEF), *Wastewater Disinfection: Manual of Practice*, No. FD- 10, Alexandria, VA., 1996.

16. USEPA, *Design Manual: Municipal Wastewater Disinfection*. EPA/625/1-86/021, USEPA, Cincinnati, OH., 1986.
17. Harp, D.L., *Current Technology of Chlorine Analysis for Water and Wastewater*, Hach Company, Technical Information Series – Booklet No. 17, 1995.
18. Hatch, G., Yang, V., *Journal of the American Waterworks Assoc.*, 1983.
19. United States Environmental Protection Agency (USEPA). *Surface Water Treatment Rule (SWTR)*. US Environmental Protection Agency. Available: http://www.epa.gov/safewater/methods/swtr_tbl.html [March 20, 2002].
20. United States Environmental Protection Agency (USEPA). *Additional Drinking Water Methods* (non EPA) for Chemical Parameters. US Environmental Protection Agency. Available: <http://www.epa.gov/OGWDW/methods/indchem.html> [March 20, 2002].
21. Anderson, Robin C. and David J. Nisbet. "Feeding Sodium Chlorate to Livestock to Kill Salmonella and E. Coli". *Agricultural Research*. Vol 49, No. 3 (March 2001). Available: <http://www.ars.usda.gov/is/AR/archive/mar01/sodium0301.html> [March 20, 2002].
22. Beholz, Dr. L.G. "Mastering the Science of Dechlorination, Redox alloy media provides one approach", *Water Technology*.
23. Integra Chemical Co. Vita-D-Chlor product information. Available <http://vita-d-chlor.com/general.html> [March 20, 2002].
24. Priority Substances List Assessment Report, *Inorganic Chloramines*, Environment Canada/Health Canada, March 2001.
25. El-Farra, S., Andrews, S.A., Supporting document No. 2 to *Priority Substances List Assessment Report, Inorganic Chloramines, The Current State of Knowledge of Organochloramines*, Environment Canada, 2000.
26. Thomas, J.R. ,and Jenkins, K.H. *A Statistical Summary of Sewage Chlorination Practices in the U.S.*, *Sew. and ind. Wastes*, 30, 1461, 1958.
27. Stranco, 2002 – Personal communication, Brian Allen, Indachem Ontario.
28. Komex International Ltd., "PPR9-071 – Georgia Basin Ecosystem Initiative – Sewage Treatment Facility Inventory and Optimization", 1999.
29. "Effect of Chlorination on Human Enteric Viruses in Partially Treated Water from Potomac Estuary", *Proc. Cong. Hearings, Proc. Serv. No. 92-94*, Washington, DC, 1973.
30. Snowden-Swan, Leslie et al, "Disinfection Technologies for Potable Water and Wastewater Treatment: Alternatives to Chlorine Gas", Prepared for: U.S. Army Forces Command Air Quality Division, July 1998.
31. Connell, Gerald F., *The Chlorination/Dechlorination Handbook*, Water Environment Federation, 2002.

32. APHA, AWWA, WEF, Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998.
33. Lamotte 1200 Colourimeter Instruction Manual, Lamotte website
<http://www.lamotte.com/pages/common/pdf/manuals/1200.pdf>.
34. Hach product brochure, AutoCAT 9000 Amperometric Titrator, Catalog 5008100.
35. US Filter, Wallace & Tiernan product brochure, A-790 Amperometric Titrator, Technical Data Sheet 50.262, Dec. 1987.
36. Integra Chemical brochure, Vita-D-ChlorTM, Renton, WA.
37. JCI Jones Chemical Inc. website,
<http://www.jcichem/jcpages/prodpgs/sodthiosulfate.html>, 2001.
38. WERF, "Comparison of UV irradiation to chlorination: guidance for achieving optimal UV performance", Water Environment Research Foundation Project 91-WWD-1, 1995.

B.C. MUNICIPAL SEWAGE REGULATION DISINFECTION REQUIREMENTS



Environmental Management Act

MUNICIPAL SEWAGE REGULATION

[includes amendments up to B.C. Reg. 321/2004]

CONTENTS

Part 1 – Interpretation

- 1 Definitions

Part 2 – Exemption under Certain Conditions from Section 6 (2) and (3) of the Act for Discharge

- 2 Exemption
- 3 Registration under section 2 for an exemption

Part 3 – Application of Parts 4 to 8

- 4 Application of Parts 4 to 8

Part 4 – Standards for Effluent Reuse and Discharges to the Environment

- 5 Initial dilution zone: water bodies
- 6 Initial dilution zone: ground
- 7 Effluent quality
- 8 Effluent disinfection
- 9 Toxicity
- 10 Use of reclaimed water
- 11 Discharges to water
- 12 Discharges to ground
- 13 Advanced treatment

Part 5 – Design and Construction of Sewage Facilities

- 14 General
- 15 Design procedure: large municipality

Part 6 – Management and Operations

- 16 General
- 17 Commissioning new and upgraded sewage facilities
- 18 Maintenance of sewage facilities
- 19 Municipal sewage connection to industrial sewer system
- 20 Non-domestic waste connection to municipal sewage system
- 21 Semi-solid wastes
- 22 Operator qualifications and certification
- 23 Fees: operator certification

Part 7 – Monitoring

- 24 General
- 25 Sampling and analysis
- 26 Discharge monitoring
- 27 Receiving environment monitoring
- 28 Reporting requirements

Part 8 – Offences and Penalties

29 Offences and penalties

Schedule 1 – Conditions for Exemption under Section 2 of This Regulation

→ **Schedule 2 – Permitted Uses and Standards for Reclaimed Water**
Appendix 1 to Schedule 2 – Explanatory Notes

→ **Schedule 3 – Standards for Discharges to Water**
Appendix 1 to Schedule 3 – Explanatory Notes

Schedule 4 – Standards for Discharges into Ground
Appendix 1 to Schedule 4 – Explanatory Notes

Schedule 5 – Geographical Areas Requiring Advanced Treatment
Appendix 1 to Schedule 5 – Explanatory Notes

Schedule 6 – Monitoring Requirements
Appendix 1 to Schedule 6 – Explanatory Notes

Schedule 7 – Design Standards for Sewage Facilities
Appendix 1 to Schedule 7 – Equipment and Process Reliability Category for
Treatment Facilities
Appendix 2 to Schedule 7 – Outfall Depth, Flow and Distance Calculations for Marine,
Estuary and Lake Discharges
Appendix 3 to Schedule 7 – Health and Safety Criteria for use of Reclaimed Water

PART 1 – INTERPRETATION

Definitions

1 In this regulation:

“**Act**” means the *Environmental Management Act*;

“**aquifer**” includes any soil or rock formation that has sufficient porosity and water yielding ability to permit the extraction or injection of water at rates greater than or equal to 5 L/minute;

“**average dry weather flow**” or “**ADWF**” means the daily municipal sewage flow to a sewage facility that occurs after an extended period of dry weather such that the inflow and infiltration has been minimized to the greatest extent practicable and is calculated by dividing the total flow to the sewage facility during the dry weather period by the number of days in that period;

“**biosolids**” means inorganic or organic solid residuals from a sewage facility, or septic tank sludge, resulting from a municipal sewage treatment process which has been sufficiently treated to reduce vector attraction and pathogen densities, such that it can be beneficially recycled;

“**BOD₅**” means the total 5-day biochemical oxygen demand;

Initial dilution zone: ground

- 6 (1) If effluent is discharged to ground, the initial dilution zone is the 3 dimensional subsurface zone where mixing of the effluent and groundwater occurs.
- (2) The boundary of the groundwater initial dilution zone is the vertical extension into the ground of the property boundaries of the land into which the ground discharge is occurring.

Effluent quality

- 7 (1) A person must not discharge effluent or provide reclaimed water that exceeds the effluent quality limits for use as reclaimed water or for discharge to the environment set out in Schedules 2 to 5.
- (2) Unless specifically stated otherwise, the effluent quality limits specified in Schedules 2 to 5 are maximum values not to be exceeded.

→ **Effluent disinfection**

- 8 (1) If disinfecting the effluent is required to ensure that water quality parameters for domestic or agricultural water extraction, recreational uses or aquatic food production meet any known water quality guidelines, a person must not discharge the effluent unless the effluent is disinfected.
- * (2) A person must not use chlorine to disinfect an effluent which is to be discharged to surface water unless the effluent is dechlorinated before discharge.
- * (3) If dechlorination is required in accordance with subsection (2) or (7), the discharger must dechlorinate the effluent to reduce the chlorine residual below 0.01 mg/L total residual chlorine before discharge.
- (4) The discharger must review and assess alternative disinfection methods before selecting the chlorination and dechlorination disinfection option.
- (5) If disinfection is required under subsection (1), the median coliform values for 7 consecutive daily tests and any single value test must be less than the value specified in Schedules 2 to 4.
- (6) A person must not discharge effluent to ground within 300 m upgradient, of or within the zone of influence of a water well, unless the effluent has been disinfected.
- (7) For the purposes of subsection (6), chlorination must not be used unless
- (a) dechlorination is provided,
 - (b) the water quality in the water well will not be adversely impacted, and
 - (c) written permission is obtained from a director.
- (8) In this section, "**zone of influence**" means the zone around a water well that in the opinion of a qualified professional supplies water to the well.

SCHEDULE 2

Permitted Uses and Standards for Reclaimed Water

- 13 The reclaimed water provider must demonstrate that reclaimed water does not contain pathogens or parasites at levels which are a concern to local health authorities. Reclaimed water must be clean, odourless, non-irritating to skin and eyes and must contain no substances that are toxic on ingestion.
- 14 Where available agricultural (crop) limits must govern criteria for metals. High nutrient levels may adversely affect some crops during certain growth stages. Crop limits and season must govern nutrient application.
- 15 The reclaimed water provider must obtain monitoring results, and confirm that water quality requirements are met, prior to distribution.
- 16 Based on an initial 60 days of compliance with the quality limit, the discharger must conduct weekly presence or absence testing for coliform monitoring. If presence of any coliform is detected daily fecal coliform testing must be reinstated until the quality limit is in compliance. Fourteen tests must be conducted to demonstrate that the discharge is back in compliance and then weekly presence/absence testing must be resumed.
- 17 Discharger must consult with the Ministry of Agriculture, Food and Fisheries regarding the difference between spraying for frost protection and spring frost protection techniques.
- 18 If chlorine is used as a disinfectant then dechlorination is necessary to protect aquatic species of flora and fauna. The use of alternative disinfection methods is recommended. Possible effects on groundwater must be evaluated. Receiving water quality requirements may necessitate additional treatment. The temperature of the reclaimed water must not adversely affect the ecosystem. Nutrient removal may be necessary to limit algae growth in impoundments.
- 19 Commercially processed food crops are those that, prior to sale to the public or others, have undergone chemical or physical processing such as, but not limited to, canning, heat treatment, fermentation and pickling, sufficient to destroy pathogens.
- 20 Milking animals must be prohibited from grazing for 6 days after irrigation ceases. Other cattle must be prohibited from grazing for 3 days after irrigation ceases unless the meat is inspected under the Federal Meat Inspection Program.
- 21 For restricted public access use, the number of fecal coliform organisms must not exceed 800/100 mL in any sample.
- 22 Worker contact with reclaimed water must be minimized. A higher level of disinfection to achieve the number of fecal coliform organisms < 14/100 mL must be provided where frequent worker contact with reclaimed water is likely.
- 23 Setback distance to potable water well must be > 30 m. A provider of reclaimed water must ensure that windblown spray will not exceed the boundaries of the property to which the reclaimed water is being applied and that windblown spray must not reach areas accessible to the public.
- 24 A provider of reclaimed water must consult specific industry's recommended water quality limits for make-up water.
- 25 Notwithstanding note 21, for wetlands where no diving, swimming, or wading activities occur, the number of fecal coliform organisms must not exceed 1 000/100 mL as determined in accordance with note 11 to this Appendix and the number of fecal coliform organisms must not exceed 4 000/100 mL in any sample.
- 26 For lagoon systems, the maximum TSS level must not exceed 60 mg/L.

SCHEDULE 3

Standards for Discharges to Water (Section 11 of this Regulation)

Portion of Effluent Being Discharged	Receiving Water (1)(5)(6)					Parameter
	Streams, Rivers & Estuaries with Dilution Ratio (2)		Column C Lakes (surface area > 100 ha)(7)	Marine		Column F
	Column A >40:1 (3)	Column B >10:1 (3)		Column D Open Marine Waters	Column E Embayed Marine Waters	
	Maximum Daily Flow > 50 m³/d					
Treatment requirement for daily flows up to 2.0 times ADWF	Secondary	High Quality Secondary	Secondary	Secondary	Secondary	
Effluent Quality for daily flows up to 2.0 times ADWF (4)	45	10	45	45	45	BOD ₅ , mg/L
	45	10	45	45	45	TSS, mg/L (13)
	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	pH
	(8) (11)	(8) (11)	(8) (11)	(8) (11)	(8) (11)	Disinfection, Coliforms
	1.0 (10)	1.0 (10)	1.0 (10)	—	1.0 (10)	Total phosphorus (P), mg/L
	0.5 (10)	0.5 (10)	0.5 (10)	—	0.5 (10)	Ortho phosphate as (P), mg/L
	(12)	(12)	(12)	(12)	(12)	Ammonia
Interim Treatment requirement for daily flows greater than 2.0 times ADWF (4)	Primary	High Quality Secondary	Primary	Primary	Primary	

- 3 If the dilution ratio is less than 100:1 the environmental impact study must determine if effluent quality needs to be better than that shown in Schedule 3. If the dilution ratio is below 40:1 and the receiving stream is used for recreational or domestic water extraction within the influence of the discharge or for seasonal discharge, discharge is not authorized unless an environmental impact study shows that the discharge is acceptable, and, in the opinion of a director, no other solutions are available and written authorization from the director is obtained. For seasonal discharges or where the receiving stream is not used for recreational or domestic water extraction, the director may in writing authorize a minimum dilution ratio of 20:1 for column A.
- 4 Treatment and effluent quality requirements are determined by daily flow multiples which require secondary treatment for all flows up to and equaling 2.0 times the ADWF. As set out in condition 17 to Schedule 1, a liquid waste management plan or specific study and implemented measures are required if flows exceed 2.0 times ADWF during a storm or equivalent snowmelt event with a less than 5-year return period. In the interim, if flows exceed 2.0 times ADWF, a lesser standard of treatment may be allowed for existing discharges, but must not be less than primary. For areas of the province where permafrost or freezing ground conditions require, in accordance with a practice approved by the local building inspector or equivalent, connection of roof drains to the sanitary sewer system, a director may, in writing, increase the factor from 2.0 times to a maximum of 3.0 times.
- 5 All outfalls must be marked on shore with an appropriate sign. Information required is the length and depth of the outfall. The minimum size of the sign is 1.0 m² and the colours of the lettering and the background must be of sufficient contrast that the wording is clearly visible. The wording on the sign must be to the satisfaction of a director.
- 6 The discharger must also ensure that requirements of Schedule 5 are met, if applicable.
- 7 See requirements of Schedule 5.
- 8 The allowable number of fecal coliform organisms in the effluent is dependent on the use of the receiving water. For discharges to shellfish bearing waters the number of fecal coliform organisms outside the initial dilution zone must be less than 14/100 mL ("the median number of fecal coliform organisms in a water sample does not exceed 14/100 mL, with not more than 10% of the samples exceeding 43/100 mL", from "Canadian Shellfish Sanitation Program, Manual of Operations"). For discharges to recreational use waters the number of fecal coliform organisms outside the initial dilution zone must be less than 200/100 mL. Where domestic water extraction occurs within 300 meters of a discharge the median number of fecal coliform organisms must be less than 2.2/100 mL in the effluent with no sample exceeding 14/100 mL. The geometric mean, as determined from the bacteriological results of the last 5 samples for which analyses have been completed over the last 30 days, must not exceed the coliform limits specified, and for this purpose, "**geometric mean**" means the anti-logarithm of a calculation in which the logarithms of a series of numerical measures are summed and divided by the number of numerical measures.

EXAMPLE MSDS SHEETS FOR CHLORINATION AND DECHLORINATION CHEMICALS

APPENDIX
B

MATERIAL SAFETY DATA SHEET

ASCORBIC ACID, SOLID

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

WHMIS Number: 00061799
Index: HCl0661/04B
Effective Date: 2004 April 02
Date of Revision: 2004 April 02

EMERGENCY TELEPHONE NUMBERS

Toronto, ON (416) 226-6117	Montreal, QC (514) 861-1211	Winnipeg, MB (204) 943-8827
Edmonton, AB (780) 424-1754	Calgary, AB (403) 263-8660	Vancouver, BC (604) 685-5036

PRODUCT IDENTIFICATION

Product Name: Ascorbic Acid, Solid.
Chemical Name: 3-oxo-L-Gulofuranolactone.
Synonyms: Vitamin C; L-Ascorbic Acid; Ascorbic Acid U.S.P.-F.C.C.; Ascorbic Acid Coated Type EC; C-90 Ascorbic Acid.
Chemical Family: Unsaturated hydroxylated gamma-Lactone vitamin.
Molecular Formula: C₆H₈O₆.
Product Use: Vitamin. Essential nutrient. Food additive.
CAS #: 50-81-7.
WHMIS Classification / Symbol: Not regulated. / Not required.

READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT.

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Dust is irritating to respiratory tract. See "Other Health Effects" Section. Low hazard for usual industrial or commercial handling. Powdered material may form explosive dust-air mixtures. Can decompose at high temperatures forming toxic gases.

POTENTIAL HEALTH EFFECTS

- Inhalation: Product may be mildly irritating to the nose, throat and respiratory tract and may cause coughing and sneezing. Excessive contact with powder may cause drying of mucous membranes of nose and throat due to absorption of moisture and oils. See "Other Health Effects" Section.
- Skin Contact: This product may cause irritation due to abrasive action. Excessive contact with powder may cause drying of the skin due to absorption of moisture and oils. Prolonged, confined (especially under the finger nails, under rings or watch bands) or repeated exposure may cause skin irritation. Avoid handling when the skin is moist, wet or abraded. In the presence of moisture (perspiration, humidity, tears), the dust dissolves to form a solution which may cause burns.
- Skin Absorption: Not applicable.
- Eye Contact: This product may cause irritation, redness and possible damage due to abrasiveness. Excessive contact with powder may cause drying of mucous membranes of the eyes due to absorption of moisture and oils. In the presence of moisture (perspiration, humidity, tears), the dust dissolves to form a solution which may cause burns.
- Ingestion: This product may cause mild gastrointestinal discomfort. Ingestion of very high levels may cause gastroenteritis, diarrhea.

Other Health Effects: Effects (irritancy) on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential.

Ascorbic Acid: Ascorbic Acid powder is not an irritant. When mixed with water (sweat, tears, mucous) the powder dissolves to form a strong acid which may be irritating to eyes and skin. (3)

A solution of 50 mg/mL Ascorbic Acid in water has a pH of 2.0. The solution could be corrosive to eyes and wet skin. Aqueous solutions of this material are considered to be corrosive because of the low pH. (3)

3. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Hazardous Ingredients: None according to Controlled Products Regulations.

Non-Hazardous Ingredients	CAS No.	ACGIH TLV	%
Ascorbic Acid	000050-81-7	Not Listed.	95 - 100

4. FIRST AID MEASURES

FIRST AID PROCEDURES

- Inhalation: If respiratory problems arise, move the victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Obtain medical advice IMMEDIATELY.
- Skin Contact: Start flushing while removing contaminated clothing. Wash affected areas thoroughly with soap and water. If irritation, redness, or a burning sensation develops and persists, obtain medical advice.
- Eye Contact: Immediately flush eyes thoroughly for 5 minutes with running water. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention.
- Ingestion: Do not attempt to give anything by mouth to an unconscious person. If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. DO NOT induce vomiting. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. Obtain medical attention IMMEDIATELY.

Note to Physicians: Treat symptomatically. Medical conditions that may be aggravated by exposure to this product include diseases of the skin, eyes or respiratory tract.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

Flammability Class (WHMIS): Not regulated.
Flash Point (TCC, Deg. Celsius): Not available.
Autoignition Temperature (Deg. Celsius): Not available.
Flammability Limits in Air (%): LEL: 10 g/ft³. (3) UEL: 20 g/ft³. (3)

Hazardous Combustion Products: Thermal decomposition products are toxic and may include oxides of carbon.

Unusual Fire or Explosion Hazards: In common with many organic chemicals in powder form, this product may be capable of forming flammable dust clouds in air. Avoid accumulation and dispersion of dust to reduce explosion potential. Spilled material may cause floors and contact surfaces to become slippery.

Sensitivity to Mechanical Impact: Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: High voltage static electricity build-up is possible when significant quantities of dust are present.

EXTINGUISHING MEDIA

Fire Extinguishing Media: Foam. Use carbon dioxide or dry chemical media for small fires. If only water is available, use it in the form of a fog.

FIRE FIGHTING INSTRUCTIONS

Instructions to the Fire Fighters: Isolate materials that are not involved in the fire and protect personnel. Spilled material may cause floors and contact surfaces to become slippery.

Fire Fighting Protective Equipment: Use self-contained breathing apparatus and protective clothing.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures: In common with many organic chemicals in powder form, this product may be capable of forming flammable dust clouds in air. Avoid accumulation and dispersion of dust to reduce explosion potential. Eliminate all sources of ignition. Wear respirator, protective clothing and gloves. Avoid dry sweeping. Do not use compressed air to clean surfaces. Vacuuming or wet sweeping is preferred. Return all material possible to container for proper disposal.

Any recovered product can be used for the usual purpose, depending on the extent and kind of contamination. Where a package (drum or bag) is damaged and / or leaking, repair it, or place it into an over-pack drum immediately so as to avoid or minimize material loss and contamination of surrounding environment. Replace damaged containers immediately to avoid loss of material and contamination of surrounding atmosphere. Collect product for recovery or disposal. For release to land, or storm water runoff, contain discharge by constructing dykes or applying inert absorbent; for release to water, utilize damming and/or water diversion to minimize the spread of contamination. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment.

7. HANDLING AND STORAGE

HANDLING

Handling Practices: Follow Good Manufacturing Practices (GMP) when handling or storing this product. Use normal "good" industrial hygiene and housekeeping practices.

In common with many organic chemicals in powder form, this product may be capable of forming flammable dust clouds in air. Avoid accumulation and dispersion of dust to reduce explosion potential. Clean up immediately to eliminate slipping hazard.

Ventilation Requirements: See Section 8, "Engineering Controls".

Other Precautions: Use only with adequate ventilation and avoid breathing dusts. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

STORAGE

Storage Temperature (Deg Celsius): Ideal storage temperature is 8 to 15. (3)

Ventilation Requirements: Avoid accumulation and dispersion of dust to reduce explosion potential. General exhaust is acceptable.

Storage Requirements: Store in a cool, dry and well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Avoid moisture contamination. Prolonged storage may result in lumping or caking. Protect from direct sunlight. Protect against physical damage.

Special Materials to be Used for Packaging or Containers: Equipment for storage, handling or transportation should NOT be made of: copper and its alloys, Iron and its alloys. Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment, which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls: General exhaust is acceptable. Local exhaust ventilation preferred. Make up air should be supplied to balance air that is removed by local or general exhaust ventilation. Avoid accumulation and dispersion of dust to reduce explosion potential. Ventilate low lying areas such as sumps or pits where dense dust may collect.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Eye Protection: Safety glasses with side shields are recommended to prevent eye contact. Use chemical safety goggles when there is potential for eye contact. Contact lenses should not be worn when working with this material.

Skin Protection: Gloves and protective clothing made from cotton, canvas, rubber or plastic should be impervious under conditions of use. Prior to use, user should confirm impermeability.

Respiratory Protection: No specific guidelines available. A NIOSH/MSHA approved dust mask for concentrations of nuisance dust up to 100 mg/M3 particulate. An air-supplied respirator if concentrations are higher or unknown.

Other Personal Protective Equipment: Avoid accumulation and dispersion of dust to reduce explosion potential. Wear an impermeable apron and boots. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

EXPOSURE GUIDELINES

Recommended Exposure Limit: None established for this product.

Particulate Not Otherwise Classified
ACGIH

10 mg/M3 - Inhalable particulate
3 mg/M3 - Respirable particulate.

OSHA

50 mppcf* or 15 mg/M3 - Total Dust
15 mppcf* or 5 mg/M3 - Respirable Fraction

* mppcf = million particles per cubic foot

9. PHYSICAL AND CHEMICAL PROPERTIES (Not intended as Specifications)

Physical State: Solid.

Appearance and Odour: White to off-white powder or crystals. Odourless.

Odour Threshold (ppm): Not available.

Boiling Range (Deg Celsius): Not applicable.

Melting/Freezing Point (Deg Celsius): 190 to 192. (3,4)

Vapour Pressure (mm Hg at 20 Deg. Celsius): Not applicable.

Vapour Density (Air = 1.0): Not applicable.

Relative Density (g/cc): 1.65.

Bulk Density: Not available.
Viscosity: Not applicable.
Evaporation Rate (Butyl Acetate = 1.0): Not applicable.
Solubility: 30 % By Weight, Aqueous Solution.
% Volatile by Volume: 0 %.
pH: 2.0 (50 g/L Aqueous Solution).
Coefficient of Water/Oil Distribution: Not available.
Volatile Organic Compounds (VOC): Not applicable.

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY

Under Normal Conditions: Stable.

Under Fire Conditions: Not readily flammable, but will support combustion. In common with many organic chemicals in powder form, this product may be capable of forming flammable dust clouds in air.

Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition. Avoid accumulation and dispersion of dust to reduce explosion potential. Minimize air borne spreading of dust. Avoid moisture contamination.

Materials to Avoid: Aqueous Solution. Strong oxidizers. Acids. Alkalies. Sodium Salicylate. Sodium Nitrate and Sodium Nitrite. Copper and its alloys. Iron and its alloys. Methenamine. Contact with water or moisture will liberate Strong Acids.

Decomposition or Combustion Products: Thermal decomposition products are toxic and may include oxides of carbon.

11. TOXICOLOGICAL INFORMATION

Toxicological Data:

Ascorbic Acid LD50 (Oral, Rat) = 11,900 mg/Kg (1)

Carcinogenicity Data: The ingredient(s) of this product is (are) not classed as carcinogenic by ACGIH, IARC, OSHA or NTP.

Reproductive Data: No adverse reproductive effects are anticipated.

Mutagenicity Data: No adverse mutagenic effects are anticipated.

Teratogenicity Data: No adverse teratogenic effects are anticipated.

Respiratory / Skin Sensitization Data: None known.

Synergistic Materials: None known.

Other Studies Relevant to Material:

Chronic ingestion of 50-80 g/day may cause gastroenteritis and anal irritation after 10 days consumption. Amounts of 1 g/day chronic ingestion may cause diarrhea. In susceptible individuals, amounts of 4-12 g/day can cause formation of urate and cystine stones in the urinary bladder. (3)

Because of the low pH of aqueous solutions of ascorbic acid, this material is considered to be corrosive. (3)

12. ECOLOGICAL INFORMATION

Ecotoxicity: Not available. May be harmful to aquatic life.

Environmental Fate: Not available. May be harmful if allowed to enter drinking water intakes. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals: Not available.

Waste Disposal Methods: This information applies to the material as manufactured.

Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

Safe Handling of Residues: See "Waste Disposal Methods".

Disposal of Packaging: Empty containers retain product residue. Dispose of waste material at an approved waste incineration facility in accordance with applicable local, provincial and federal regulations.

14. TRANSPORTATION INFORMATION

CANADIAN TDG ACT / U.S. DOT CLASSIFICATION: Not regulated.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR: This material is included on the DSL under the CEPA.

CEPA - NPRI: Not included.

Controlled Products Regulations Classification (WHMIS): Not regulated.

CANADIAN FOOD AND DRUG ACT/REGULATIONS: The use of this material/product as a food additive is regulated by Health and Welfare Canada in the Food and Drug Act and the Food and Drug Regulations. It is incumbent on the user of this material/product to ensure any intended food application is consistent with Health and Welfare Canada guidelines.

Food Grade designation in no way implies that the product is safe for consumption by humans. (3)

USA

Environmental Protection Act: This material is included on the TSCA Inventory.

OSHA Hazard Communication (29CFR 1910.1200) Classification: Not regulated.

U.S. FOOD AND DRUG ADMINISTRATION: This material/product is regulated for use by the US FDA.

It is incumbent on the user of this material/product to ensure any intended food application is consistent with US FDA guidelines. Food Grade designation in no way implies that the product is safe for consumption by humans. (3)

HMIS: 1 Health, 0 Fire, 0 Reactivity. (3)

INTERNATIONAL: The following component or components of this product appear on the European Inventory of Existing Commercial Chemical Substances: Ascorbic Acid.

16. OTHER INFORMATION

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.
2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
3. Supplier's Material Safety Data Sheet(s).
4. "CHEMINFO", through "CCINFODisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
5. Guide to Occupational Exposure Values, 2003, American Conference of Governmental Industrial Hygienists, Cincinnati, 2003.

6. Regulatory Affairs Group, Brenntag Canada Inc.

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Brenntag Canada Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

British Columbia: 20333-102B Avenue, Langley, BC, V1M 3H1
Phone: (604) 513-9009 Facsimile: (604) 513-9010

Alberta: 6628 - 45 th. Street, Leduc, AB, T9E 7C9
Phone: (780) 986-4544 Facsimile: (780) 986-1070

Manitoba: 681 Plinquet Street, Winnipeg, MB, R2J 2X2
Phone: (204) 233-3416 Facsimile: (204) 233-7005

Ontario: 43 Jutland Road, Toronto, ON, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-6175

Quebec: 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Atlantic: A-105 Akerley Boulevard, Dartmouth, NS, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

MATERIAL SAFETY DATA SHEET

CHLORINE, LIQUEFIED GAS

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

WHMIS Number: 00010002
Index: GCD0016/05A
Effective Date: 2005 January 20
Date of Revision: 2005 January 20

EMERGENCY TELEPHONE NUMBERS (FOR EMERGENCIES INVOLVING CHEMICAL SPILLS OR RELEASE)

Toronto, ON (416) 226-6117	Montreal, QC (514) 861-1211	Winnipeg, MB (204) 943-8827
Edmonton, AB (780) 424-1754	Calgary, AB (403) 263-8660	Vancouver, BC (604) 685-5036

PRODUCT IDENTIFICATION

Product Name: Chlorine, Liquefied Gas.
Chemical Name: Chlorine.
Synonyms: Not available.
Chemical Family: Halogen.
Molecular Formula: Cl₂.
Product Use: Bacteriacide in water treatment. Chemical intermediate.
CAS #: 7782-50-5.
WHMIS Classification / Symbol: A: Compressed Gas, C: Oxidizer, D-1A: Very Toxic (acute effects), D-2A: Very Toxic (Chronic Effects), E: Corrosive.



READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT. Consult Product Technical Literature.

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Corrosive! Toxic! May be fatal if inhaled. Causes severe skin and eye burns. Gas is extremely irritating to eyes and respiratory tract. See "Other Health Effects" Section. Strong, offensive odor. Strong oxidizer. Contact with other combustible material can cause fire. Liquefied compressed gas. Contents under pressure. Ruptured containers may rocket.

POTENTIAL HEALTH EFFECTS

- Inhalation: Corrosive! Toxic! Product may cause severe irritation of the nose, throat and respiratory tract. Repeated and/or prolonged exposures may cause productive cough, running nose, bronchopneumonia, pulmonary oedema (fluid build-up in lungs), and reduction of pulmonary function. Toxic effects may be delayed. See "Other Health Effects" Section.
- Skin Contact: Corrosive! Chlorine vapours may cause burning and prickling sensations, reddening and blisters. Direct contact with liquid causes severe local irritation, blistering and burns. Avoid handling when the skin is moist, wet or abraded. Burns (chemical) can occur if not promptly removed.

. Skin Absorption: May be absorbed through intact skin. Skin absorption is a secondary concern to the continual destruction of tissue while the product is in contact with the skin.

. Eye Contact: Extremely corrosive! This product causes corneal scarring and clouding. Glaucoma, cataracts and permanent blindness may occur.

. Ingestion: Corrosive! Product is a gas. Ingestion is not a likely route of exposure.

Other Health Effects: Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential.

May cause frostbite, olfactory fatigue, tooth erosion, cardiovascular effects, shock, central nervous system (CNS) depression and asphyxia and cyanosis. Olfactory fatigue is a term used to describe a condition characterized by the temporary loss of odour perception. CNS depression is characterized by headache, dizziness, drowsiness, nausea, vomiting and incoordination. Severe overexposures may lead to coma and possible death due to respiratory failure. Cyanosis is characterized by navy blue, almost black lips, tongue, and mucous membranes, with skin colour being slate gray. Further manifestation is characterized by headache, weakness, dyspnea, dizziness, stupor, respiratory distress and death due to anoxia. Asphyxia is characterized by increased breathing volume, accelerated pulse rate, muscular incoordination, faulty judgement, emotional instability, fatigue, nausea, vomiting, bewilderment, gasping respiration and unconsciousness.

Chlorine: Inhalation exposure can result in primary irritation of the respiratory tract, gradual loss of pulmonary function and asthma-like attacks in susceptible individuals. Acute exposure is characterized by the irritation of the respiratory tract causing runny nose, sore throat, coughing, chest discomfort, shortness of breath and reduced lung function. Overexposure may lead to bronchitis, bronchial spasm and pulmonary oedema. Chronic exposure may lead to asthmatic attack in certain individuals, with the following symptoms: chest tightness, wheezing, cough and shortness of breath. (3)

3. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Hazardous Ingredients	CAS No.	ACGIH TLV	%
Chlorine	007782-50-5	0.5 ppm *A4	95 - 100

A4 = Not classifiable as a human carcinogen. (ACGIH-A4)

4. FIRST AID MEASURES

FIRST AID PROCEDURES

. Inhalation: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Oxygen administration may be beneficial in this situation but should only be administered by personnel trained in its use. Obtain medical attention IMMEDIATELY.

. Skin Contact: Flush skin with running water for a minimum of 20 minutes. Start flushing while removing contaminated clothing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY. See "Note to Physicians" below.

Treat frostbite by immediately immersing affected areas in warm water until the skin has warmed up and turned pink. Obtain medical attention IMMEDIATELY.

. Eye Contact: Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY. Do not transport victim until the recommended flushing period is completed unless flushing can be continued during transport.

. Ingestion: Do not attempt to give anything by mouth to an unconscious person. If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. IMMEDIATELY contact local Poison Control Centre. Vomiting should only be induced under the direction of a physician or a poison control centre. If spontaneous

vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY transport victim to an emergency facility.

Note to Physicians: Treatment for corrosive chemical contact with skin:

1. Immerse the exposed part immediately in ice water to relieve pain and to prevent swelling and blistering. Place cold packs, ice or wet cloths on the burned area if immersion is not possible.
2. Remove anything that is constrictive, such as rings, bracelets or footwear, before swelling begins.
3. Cover the exposed part with a clean, preferably sterile, lint-free dressing.
4. For severe exposure, immediately seek medical attention and monitor breathing and treat for shock.

When treating frost bite, flush affected areas with water no warmer than 44 Deg. Celsius. Do not use heated water or dry heat and frozen parts should not be rubbed before or after thawing.

Medical conditions that may be aggravated by exposure to this product include neurological, cardiovascular and skin disorders, diseases of the skin, eyes or respiratory tract.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

Flammability Class (WHMIS): Not regulated.
Flash Point (TCC, Deg. Celsius): Not Flammable.
Autoignition Temperature (Deg. Celsius): Not applicable.
Flammability Limits in Air (%): LEL: Not applicable. UEL: Not applicable.

Hazardous Combustion Products: Thermal decomposition products are toxic and may include oxides of Chlorine and irritating gases. Chlorine reacts with water or humidity to produce Hydrochloric Acid and Hypochlorous Acid. These two acids cause metal corrosion. (3,4)

Unusual Fire or Explosion Hazards: Although non-combustible in air, chlorine supports the combustion of other materials. Flammable gases and vapours will form explosive mixtures with chlorine. Chlorine cylinders and tonne containers are equipped with fusible plugs. The fusible plugs are designed to melt at temperatures above 70 Deg. Celsius to reduce the internal pressure of the cylinder by releasing Chlorine gas. Expansion of liquid and change of state from liquid to vapour will allow mixture to encompass a large area. If tank is involved in a fire situation, a BLEVE (Boiling Liquid Expanding Vapour Explosion) may result. Ruptured containers may rocket. Where possible, elevate the leak to the highest position such that gas and not liquid escapes.

This product is a strong oxidizer. Strong oxidizers can cause ignition of combustible or oxidizable materials. May decompose violently on contact with metals, or their salts, dusts or other contaminants.

Sensitivity to Mechanical Impact: Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: Not expected to be sensitive to static discharge.

EXTINGUISHING MEDIA

Fire Extinguishing Media: Use media appropriate for surrounding fire and/or materials.

FIRE FIGHTING INSTRUCTIONS

Instructions to the Fire Fighters: Fire-exposed containers should be kept cool by spraying with water to reduce pressure. Isolate materials that are not involved in the fire and protect personnel. Cool containers with flooding quantities of water until well after the fire is out. Chlorine reacts with water or humidity to produce Hydrochloric Acid and Hypochlorous Acid. These two acids cause metal corrosion. (3,4) Remove containers from fire zone whenever possible. Ventilate low lying areas such as sumps or pits where dense vapours may collect.

Fire Fighting Protective Equipment: Use self-contained breathing apparatus and special protective clothing.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures: In all cases of leak or spill contact vendor at Emergency Number shown on the front page of this MSDS. See Section 13, "Deactivating Chemicals".

Wear respirator, protective clothing and gloves. Ruptured containers may rocket. Ventilate enclosed spaces. Where possible, elevate the leak to the highest position of the cylinder, such that gas and not liquid escapes. Apply emergency device. Eliminate all sources of ignition. Move unprotected personnel upwind of leaking container. Call emergency response naming the chemical and the type of container that is leaking. Consider the use of fog-nozzles to control vapours. Do not immerse in water. Notify applicable government authority if release is reportable or could adversely affect the environment. Vapour knock down water is corrosive and toxic, thus it should be diked for containment. Ensure compatible materials are used. For a leaking container: dispose of contents to a safe out-of-doors area or a hood with forced ventilation. Attach appropriate control valve provided with a trap or check valve and a long piece of flexible hose connected to the valve outlet. Discharge the gas at a moderate rate into an adequate amount of approximately 15% aqueous Sodium Hydroxide or other alkali or reducing solution in suitable container. When all the gas is discharged, close the cylinder valve and tag the cylinder as defective. (3)

7. HANDLING AND STORAGE

HANDLING

Handling Practices: Use normal "good" industrial hygiene and housekeeping practices. Vapours are heavier than air. Use self-contained breathing apparatus. Secure containers at all times. Fix leaks promptly. Immerse contaminated clothing in water immediately and KEEP WET until discarded or laundered. Avoid moisture contamination. Chlorine reacts with water or humidity to produce Hydrochloric Acid and Hypochlorous Acid. These two acids cause metal corrosion. (3,4) Do not store or transport with food or feed. Keep away from combustibles and incompatible materials.

Ventilation Requirements: See Section 8, "Engineering Controls".

Other Precautions: Use only with adequate ventilation and avoid breathing vapours. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

STORAGE

Storage Temperature (Deg Celsius): Ideal storage temperature is 10-27 Deg. Celsius. Do not expose sealed containers to temperatures above 51 Degrees Celsius or Below -29 Degrees Celsius. (3)

Ventilation Requirements: Do not use in poorly ventilated or confined areas without proper respiratory protection. Ventilation should be corrosion proof.

Storage Requirements: Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Do not expose sealed containers to temperatures above 51 Degrees Celsius. Use of a Chlorine gas monitor with local and remote alarms and monitoring is strongly recommended. Secure containers at all times. Fix leaks promptly. Regularly inspect process equipment, piping and detection equipment. Chlorine cylinders and tonne containers are equipped with fusible plugs. The fusible plugs are designed to melt at temperatures above 70 Deg. Celsius to reduce the internal pressure of the cylinder by releasing Chlorine gas.

Special Materials to be Used for Packaging or Containers: Chlorine is stable in steel containers at room temperatures when stored dry. Intense local heat above 200 C on steel walls can cause steel to ignite chlorine. (3) Equipment for storage, handling or transportation should NOT be made of: stainless steel. Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment, which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls: Local exhaust ventilation required. Ventilation should be corrosion proof. Make up air should be supplied to balance air that is removed by local or general exhaust ventilation. Ventilate low lying areas such as sumps or pits where dense vapours may collect. Restrict access to storage area. Post warning signs. Consider leak detection and alarm systems.

For personnel entry into confined spaces (i.e. bulk storage tanks) a proper procedure must be followed. It must include consideration of, among other things, ventilation, testing of tank atmosphere, provision and maintenance of SCBA, and emergency rescue. Use the "buddy" system. The second person should be in view and trained and equipped to execute a rescue. (4)

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Eye Protection: Use full face-shield and gas-tight goggles when there is potential for contact. Contact lenses should not be worn when working with this material.

Skin Protection: Gloves and protective clothing made from neoprene, viton, butyl rubber or nitrile rubber should be impervious under conditions of use. Prior to use, user should confirm impermeability. Skin protection should be insulated against cold temperatures. Do not use gloves or protective clothing made from leather and rubber or plastic. Discard contaminated gloves.

Respiratory Protection: DO NOT USE chemical cartridge respirators with oxidizable sorbents (charcoal). Chlorine: Up to 5 ppm, wear a chemical cartridge respirator with Chlorine or acid gas cartridges; up to 10 ppm self-contained breathing apparatus (SCBA). (3,4) Use an air-supplied respirator if concentrations are high or unknown.

If while wearing a respiratory protection, you can smell, taste or otherwise detect anything unusual, or in the case of a full facepiece respirator you experience eye irritation, leave the area immediately. Check to make sure the respirator to face seal is still good. If it is, replace the filter, cartridge or canister. If the seal is no longer good, you may need a new respirator. (4)

Immediately Dangerous to Life and Health (IDLH) value: 10 ppm. (4) The purpose of establishing an IDLH value is to ensure that the worker can escape from a given contaminated environment in the event of failure of the most protective respiratory equipment. In the event of failure of respiratory protective equipment, every effort should be made to exit immediately. (4)

Other Personal Protective Equipment: Wear an impermeable apron and boots. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact. Use of a Chlorine gas monitor with local and remote alarms and monitoring is strongly recommended.

EXPOSURE GUIDELINES

	ACGIH TLV (STEL)	OSHA PEL (TWA)	(STEL)	NIOSH REL (TWA)	(STEL)
Chlorine	1 ppm	----	1 ppm (Ceiling)	----	0.5 ppm (Ceiling)

9. PHYSICAL AND CHEMICAL PROPERTIES (Not intended as Specifications)

Physical State: Liquefied Gas.

Appearance and Odour: Greenish yellow liquified gas with a sharp, pungent, irritating odour.
Odour Threshold (ppm): 0.08 ppm (Detection); 0.4 ppm (Perception).

Boiling Range (Deg Celsius): -35 to -34.

Melting/Freezing Point (Deg Celsius): -101.

Vapour Pressure (mm Hg at 20 Deg. Celsius): 4,788 to 5,120 (Approximately 82.5 to 85 psig).

Vapour Density (Air = 1.0): 2.47 to 2.67.

Relative Density (g/cc): 1.33 to 1.47.

Bulk Density: 88.76 lb/ft³ at 15.6 Degrees Celsius.

Viscosity: 0.3538 at 15.6 Degrees Celsius.

Evaporation Rate (Butyl Acetate = 1.0): Not available.

Water Solubility: 0.71 % at 1 ATM, 21 Degrees Celsius. Slightly soluble in water. Chlorine reacts with water or humidity to produce Hydrochloric Acid and Hypochlorous Acid. These two acids cause metal corrosion. (3,4)

Solubility: Soluble in alkaline solutions, carbon tetrachloride, hydrochloric acid and sodium chloride solutions.

% Volatile by Volume: 100.

pH: 1.5 to 2.0 (0.8 % Aqueous Solution). Strongly Acidic.

Coefficient of Water/Oil Distribution: Not applicable.

Volatile Organic Compounds (VOC): 0 %.

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY

Under Normal Conditions: Stable.

Under Fire Conditions: Although non-combustible in air, chlorine supports the combustion of other materials.

Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition. Avoid contact with water. Chlorine reacts with water or humidity to produce Hydrochloric Acid and Hypochlorous Acid. These two acids cause metal corrosion. (3,4)

Materials to Avoid: This product is a strong oxidizer. Strong oxidizers can cause ignition of combustible or oxidizable materials. May decompose violently on contact with metals, or their salts, dusts or other contaminants. Reacts with water or humidity to produce Hydrochloric Acid and Hypochlorous Acid. These two acids cause metal corrosion. (3,4)

Chlorine reacts with combustible, organic or nitrogen compounds (hydrocarbons, cleaning solvents, paints or thinners, oil, grease gasoline, petroleum products, turpentine, alcohols, carbon disulphide, hydrogen acetylene, hydrogen, ether and ammonia). (3,4)
Strong oxidizers. Lewis or mineral acids. Metal halides. carbon. Lead. Sulphides. Reducing agents. Fluorine. Metal Acetylides. Halogenated compounds. Carbides. Diethyl Zinc. Metal hydrides. Sulfamic Acid. Diethyl Ether.

At ordinary temperatures: Dry Chlorine (gas or liquid) is not corrosive to most common metals, including steel, stainless steel, silver, iron, cast iron, nickel and its alloys, copper, brass, bronze, lead platinum and tantalum. Dry Chlorine (gas or liquid) reacts with aluminum, zinc, arsenic, gold, mercury, class 300 stainless steel, titanium, selenium, tellurium and tin. (3,4)

At high temperatures: Dry Chlorine is corrosive to most metals. The reaction rate of dry Chlorine increases rapidly above a temperature which is characteristic for the metal. (3,4)

Decomposition or Combustion Products: Thermal decomposition products are toxic and may include oxides of Chlorine and irritating gases. Chlorine reacts with water or humidity to produce Hydrochloric Acid and Hypochlorous Acid. These two acids cause metal corrosion. (3,4)

11. TOXICOLOGICAL INFORMATION

Toxicological Data:

Chlorine LC50 (Inhal'n, Rat, 4h) = 147 ppm (1)

Carcinogenicity Data: The ingredient(s) of this product is (are) not classed as carcinogenic by ACGIH, IARC, OSHA or NTP. See "Other Studies Relevant to Material".

Reproductive Data: No adverse reproductive effects are anticipated.

Mutagenicity Data: No adverse mutagenic effects are anticipated.

Teratogenicity Data: No adverse teratogenic effects are anticipated.

Respiratory / Skin Sensitization Data: None known.

Synergistic Materials: Mortality in Chlorine-Nickel test groups for rainbow trout was found to be higher than that of either nickel or chlorine alone. The relevance to humans is not known. Incidences of respiratory sensitization in platinum refinery workers increased following a spill of chlorine. (3)

Other Studies Relevant to Material: Effects in rats during acute inhalation exposure to Chlorine were primarily attributed to its severe irritant effects. Repeated inhalation of Chlorine (1, 3 or 9 ppm for 6 weeks) by rats resulted in respiratory irritation, reduced body weight gain, organ weight changes, increased white blood cells, some animal deaths and changes in liver, kidney, spleen, thymus and gastric mucosa. Longer term (1 year) inhalation of Chlorine (0.1, 0.5 or 2.3 ppm) by monkeys resulted in eye and upper respiratory tract irritation. Effects observed in rabbits following repeated inhalation (up to 9 months) were weight loss, nasal irritation, sneezing and laboured respiration. Life-time inhalation of Chlorine (up to 2.5 ppm) produced nasal cell injury in rats and mice. No effects were observed in guinea pigs after repeated inhalation (87 days) or in mice after drinking chlorinated water (33 or 55 days). (4)

Repeated exposure of rats to 30 ppm Chlorine in their drinking water resulted in reduced spleen weights and immunological effects. Long term (2 years) administration of Chlorine in drinking water (70, 140 or 275 ppm) resulted in an increase in leukemia in female rats at 140 ppm only. No adverse effects on fertility, life span, growth pattern, hematology or histology were seen in rats given chlorinated water (100 mg Chlorine / Litre daily) throughout the entire lifespan for 7 consecutive generations. No birth defects were observed in mice after drinking chlorinated drinking water during pregnancy. Chlorine produced no genetic changes in standard tests using animals. A positive response was observed in a test using human cells, while mixed responses have been reported in a variety of tests using bacterial cells or animal cells. (3)

12. ECOLOGICAL INFORMATION

Ecotoxicity: Highly toxic to aquatic life.

Fish toxicity: critical concentration = 0.3 mg/L

Aesthetic: critical concentration = 0.5 mg/L

Plant: critical concentration = 100 mg/L

72-HR LC50 = 0.5 mg/L, Daphnia Magna

96-HR LC50 = 0.02 mg/L, Daphnia Magna

96-HR LC50 = 0.08 to 0.18 mg/L, Brook Trout

96-HR LC50 = 0.07 mg/L, Channel Catfish Fingerlings

96-HR LC50 = 0.44 to 2.32 mg/L, Bluegill Sunfish

96-HR LC50 = 1.6 mg/L, Redsid Shiner

96-HR LC50 = 0.70 mg/L, Blackside Dance

Exposure of Sand-dollar sperm to 0.002 mg/L for 5 minutes resulted in a 50 percent reduction in egg fertilization. Depressed shoot and total plant dry weight and shoot length were reported when the aquatic plant *Myriophyllum spicatum* was continuously exposed to chlorine (as low as 0.05 mg total residual chlorine/L) for 96 hours. Chlorine is considered to be phytotoxic and has bactericidal, algicidal and fungicidal properties. Chlorine does not appear to retard seed germination. (3) This product does not bioaccumulate in aquatic or terrestrial food chains. (3)

Environmental Fate: In an uncontrolled spill scenario where the concentration of Chlorine is well above those used for drinking water, it can be dangerous if allowed to contaminate irrigation water supplies, lakes, streams, ponds or rivers.

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals: Chlorine gas will disperse to the atmosphere leaving no residue. Gaseous material can be absorbed in alkaline solutions of Caustic Soda, Soda Ash or Hydrated Lime. When absorbing Chlorine in alkaline solutions, the reaction is exothermic. Ensure the absorption is controlled as to heat and reaction. (3)

Since hypochlorites are formed, solutions must be treated with reducing agents such as sodium sulphite before disposal. Do not immerse container in caustic solution. Liquid and/or solid residues from neutralization must be disposed of in a permitted waste management facility. (3)

Hypochlorites: Carefully neutralize by adding hydrogen peroxide: one US pint of 35 % hydrogen peroxide solution per pound of hypochlorite to be neutralized. Dilute the neutralized residue with water. (3)

Waste Disposal Methods: This information applies to the material as manufactured. Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

Safe Handling of Residues: See "Waste Disposal Methods".

Disposal of Packaging: Empty containers retain product residue (liquid and/or vapour) and can be dangerous. See above, "Deactivating Chemicals". Do not expose such containers to heat, flame, sparks, static electricity, or other sources of ignition; they may explode and cause injury or death. Return empty containers.

14. TRANSPORTATION INFORMATION

Please consult the North American Emergency Guidebook (2004), via Guide number 124 for guidance on addressing spills.

CANADIAN TDG ACT SHIPPING DESCRIPTION:

Chlorine, Class 2.3(8), UN1017.

Placard(s): Toxic. Label(s): Toxic, Corrosive.

ERAP Index: 500 Kg or L. Exemptions: Not available. Marine: P (Marine Pollutant).

US DOT CLASSIFICATION (49CFR 172.101, 172.102):

Chlorine, Class 2.3, UN1017.

Placard(s): Poison Gas. Label(s): Poison Gas, Corrosive.

Reportable Quantity (CERCLA-RQ): 10 lb / 4.54 Kg. Exemptions: Not applicable.

Special Documentation Addition: Chlorine, Poison - Inhalation Hazard, Zone B.

Marine: P (Marine Pollutant).

IMO: Marine Pollutant: Chlorine.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR: This material is included on the DSL under the CEPA.

CEPA - NPRI: This material is on the NPRI list of substances.

Controlled Products Regulations Classification (WHMIS): A: Compressed Gas, C: Oxidizer,

D-1A: Very Toxic (acute effects), D-2A: Very Toxic (Chronic Effects), E: Corrosive.

USA

Environmental Protection Act: This material is included on the TSCA Inventory.

OSHA Hazard Communication (29CFR 1910.1200) Classification: Compressed Gas, Oxidizer, Highly Toxic, Chronic Effects, Corrosive.

HMIS: 3 Health, 0 Fire, 0 Reactivity. (3)

NFPA: 4 Health, 0 Fire, 0 Reactivity. (3)

INTERNATIONAL: The following component or components of this product appear on the European Inventory of Existing Commercial Chemical Substances: Chlorine.

16. OTHER INFORMATION

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.
 2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
 3. Supplier's Material Safety Data Sheet(s).
 4. "CHEMINFO", through "CCINFODisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
 5. Guide to Occupational Exposure Values, 2002, American Conference of Governmental Industrial Hygienists, Cincinnati, 2002.
 6. The British Columbia Drug and Poison Information Centre, Poison Managements Manual, Canadian Pharmaceutical Association, Ottawa, 1981.
-

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Brenntag Canada Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

British Columbia: 20333-102B Avenue, Langley, BC, V1M 3H1
Phone: (604) 513-9009 Facsimile: (604) 513-9010

Alberta: 6628 - 45 th. Street, Leduc, AB, T9E 7C9
Phone: (780) 986-4544 Facsimile: (780) 986-1070

Manitoba: 681 Plinquet Street, Winnipeg, MB, R2J 2X2
Phone: (204) 233-3416 Facsimile: (204) 233-7005

Ontario: 43 Jutland Road, Toronto, ON, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-6175

Quebec: 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Atlantic: A-105 Akerley Boulevard, Dartmouth, NS, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

MATERIAL SAFETY DATA SHEET

SODIUM HYPOCHLORITE, 10 - 15%
(8318, 8378, 8389, 8555, 8619)

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

WHMIS Number: 00060708
Index: GCD0044/04A
Effective Date: 2004 January 20
Date of Revision: 2004 January 20

EMERGENCY TELEPHONE NUMBERS

Toronto, ON (416) 226-6117	Montreal, QC (514) 861-1211	Winnipeg, MB (204) 943-8827
Edmonton, AB (780) 424-1754	Calgary, AB (403) 263-8660	Vancouver, BC (604) 685-5036

PRODUCT IDENTIFICATION

Product Name: Sodium Hypochlorite, 10 - 15% (8318, 8378, 8389, 8555, 8619).
Chemical Name: Hypochlorous acid, sodium salt.
Synonyms: Superchlor; Soda bleach liquor; Javel water; Sodium oxychloride; Clorox; Javex.
Chemical Family: Hypochlorous acid salt.
Molecular Formula: NaOCl.
Product Use: Industrial laundry bleach. Chemical intermediate. Laboratory reagent. Oxidizing agent. Bleaching agent. Water treatment. Fungicide.
Canadian Pest Control Products (PCP) Act and Regulations Registration Number: 13731 (End Use); 23344 (Technical Active).
CAS #: 7681-52-9.
WHMIS Classification / Symbol: D-2B: Toxic (Skin Sensitizer), E: Corrosive.



READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT.

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Corrosive! May be fatal if swallowed. Causes severe skin and eye burns. Mists or sprays are extremely irritating to eyes and respiratory tract. May cause corneal damage and conjunctivitis. See "Other Health Effects" Section. Can decompose at high temperatures forming toxic gases. Contents may develop pressure on prolonged exposure to heat.

POTENTIAL HEALTH EFFECTS

Inhalation: Corrosive! Product may cause severe irritation of the nose, throat and respiratory tract. Repeated and/or prolonged exposures may cause productive cough, running nose, bronchopneumonia, pulmonary oedema (fluid build-up in lungs), and reduction of pulmonary function. If mixed with acids or warmed to temperatures greater than 40 degrees Celsius, Sodium Hypochlorite solutions release Chlorine gas. This gas can cause severe irritation of the nose and throat. Exposure to high levels of Chlorine gas may result in severe lung damage. (4) See "Other Health Effects" Section.

- . Skin Contact: Corrosive! Burns can occur if not promptly removed. Concentrated solutions may cause pain and deep and severe burns to the skin. Prolonged and repeated exposure to dilute solutions often causes irritation, redness, pain and drying and cracking of the skin. Prolonged and repeated contact may lead to dermatitis. Toxic effects may be delayed. Avoid handling when the skin is moist, wet or abraded.
 - . Skin Absorption: Skin absorption is a secondary concern to the continual destruction of tissue while the product is in contact with the skin.
 - . Eye Contact: Extremely corrosive! This product causes corneal scarring and clouding. Glaucoma, cataracts and permanent blindness may occur.
 - . Ingestion: Corrosive! This product causes severe burning and pain in the mouth, throat and abdomen. Vomiting, diarrhea and perforation of the esophagus and stomach lining may occur.
- Other Health Effects: Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential.

May cause skin sensitization or other allergic responses. See Section 11, "Other Studies Relevant to Material".

Ingestion of very high levels may cause shock, coma or death. May cause pulmonary oedema. Pulmonary oedema is the build-up of fluid in the lungs that might be fatal. Symptoms of pulmonary oedema, such as shortness of breath, may not appear until several hours after exposure and are aggravated by physical exertion. (4)

3. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Hazardous Ingredients	CAS No.	ACGIH TLV	%
Sodium Hypochlorite	007681-52-9	Not Listed.	10 - 15
Decomposition product: Chlorine	007782-50-5	0.5 ppm *A4	Not available.

A4 = Not classifiable as a human carcinogen. (ACGIH-A4)

4. FIRST AID MEASURES

FIRST AID PROCEDURES

- . Inhalation: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Oxygen administration may be beneficial in this situation but should only be administered by personnel trained in its use. Obtain medical attention IMMEDIATELY.
- . Skin Contact: Prompt removal of the material from the skin is essential. Remove all contaminated clothing and immediately wash the exposed areas with copious amounts of water for a minimum of 30 minutes or up to 60 minutes for critical body areas. Obtain medical attention IMMEDIATELY. See "Note to Physicians" below.
- . Eye Contact: Immediately flush eyes with running water for a minimum of 30 minutes, preferably up to 60 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Do not transport victim until the recommended flushing period is completed unless flushing can be continued during transport.
- . Ingestion: Do not attempt to give anything by mouth to an unconscious person. IMMEDIATELY contact local Poison Control Centre. If victim is alert and not convulsing, rinse mouth out and give 1 to 2 glasses of milk. Water may be used if milk is not available but it is not as effective. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more milk or water. IMMEDIATELY transport victim to an emergency facility.

Note to Physicians: Due to the severely irritating or corrosive nature of the material, swallowing may lead to ulceration and inflammation of the upper alimentary tract with

hemorrhage and fluid loss. Also, perforation of the esophagus or stomach may occur, leading to mediastinitis or peritonitis and the resultant complications. (3) Mucosal injury following ingestion of this corrosive material may contraindicate the induction of vomiting in the treatment of possible intoxication. Similarly, if gastric lavage is performed, intubation should be done with great care. If oral burns are present or a corrosive ingestion is suspected by the patient's history, perform esophagoscopy as soon as possible. Scope should not be passed beyond the first burn because of the risk of perforation.

This product contains materials that may cause severe pneumonitis if aspirated. If ingestion has occurred less than 2 hours earlier, carry out careful gastric lavage; use endotracheal cuff if available, to prevent aspiration. Observe patient for respiratory difficulty from aspiration pneumonitis. Give artificial resuscitation and appropriate chemotherapy if respiration is depressed.

Medical conditions that may be aggravated by exposure to this product include diseases of the skin, eyes or respiratory tract.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

Flammability Class (WHMIS): Not regulated.
Flash Point (TCC, Deg. Celsius): Non-combustible (does not burn).
Autoignition Temperature (Deg. Celsius): Not applicable.
Flammability Limits in Air (%): LEL: Not applicable. UEL: Not applicable.

Hazardous Combustion Products: Thermal decomposition products are toxic and may include and chlorine gas and oxides of chlorine and sodium. Sodium Hypochlorite solutions decompose slowly. Decomposition is accelerated by heat (temperatures above 40 degrees Celsius) and light. (4)

Unusual Fire or Explosion Hazards: Solutions non-flammable by themselves, but are strong oxidizers which can cause ignition of combustible or oxidizable materials. May decompose violently on contact with metals, or their salts, dusts or other contaminants. Sodium Hypochlorite is a strong oxidant, but solutions do not support combustion.

If mixed with acids or warmed to temperatures greater than 40 degrees Celsius, Sodium Hypochlorite solutions release Chlorine gas. Hypochlorites may react with primary amines to form nitrogen trichloride which explodes spontaneously in air. Damp material may decompose exothermically and may cause combustion of organic material. (4) Closed containers exposed to heat may explode. Spilled material may cause floors and contact surfaces to become slippery.

Sensitivity to Mechanical Impact: Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: Not expected to be sensitive to static discharge.

EXTINGUISHING MEDIA

Fire Extinguishing Media: Use media appropriate for surrounding fire and/or materials.

FIRE FIGHTING INSTRUCTIONS

Instructions to the Fire Fighters: Fire-exposed containers should be kept cool by spraying with water to reduce pressure. This should be done from a safe distance since containers may rupture. Spilled material may cause floors and contact surfaces to become slippery.

Fire Fighting Protective Equipment: Use self-contained breathing apparatus and protective clothing. Protective clothing for skin and eye protection should be worn to protect against highly alkaline materials.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent

or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures: In all cases of leak or spill contact vendor at Emergency Number shown on the front page of this MSDS. See Section 13, "Deactivating Chemicals".

Wear respirator, protective clothing and gloves. Spilled material may cause floors and contact surfaces to become slippery. Do not use combustible materials such as sawdust as an absorbent. For small spill, absorb with an inert dry material. For large spill, absorb with dry earth, sand or other non-combustible material. Notify applicable government authority if release is reportable or could adversely affect the environment. Replace damaged containers immediately to avoid loss of material and contamination of surrounding atmosphere.

7. HANDLING AND STORAGE

HANDLING

Handling Practices: Use normal "good" industrial hygiene and housekeeping practices. Containers exposed to heat may be under internal pressure. These should be cooled and carefully vented before opening. A face shield and apron should be worn.

Ventilation Requirements: Do not use in poorly ventilated or confined areas without proper respiratory protection. See Section 8, "Engineering Controls".

Other Precautions: Use only with adequate ventilation and avoid breathing aerosols (vapours or mists). Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

Corrosive residue is most likely to be deposited at process vents or storage tanks, especially during filling operations. The use of compressed air to force corrosive materials from delivery trucks is of special concern. Scrubbing the exhaust of these vents is highly recommended. Jurisdictional regulations should be consulted to determine required practices.

STORAGE

Storage Temperature (Deg Celsius): Store below 29 Degrees Celsius. Do not freeze.

Ventilation Requirements: Ventilation should be corrosion proof. Strong solutions (greater than 10% available Chlorine) may slowly give off oxygen during storage, especially when warm (above 18 degrees Celsius). Vent caps may be required to prevent a build-up of pressure that could cause containers to burst.

Storage Requirements: Store in a clean, cool well ventilated area, away from organic chemicals, strong bases, metal powders, carbides, sulfides, and any readily oxidizable material. Protect from direct sunlight. Protect against physical damage. Storage area should be equipped with corrosion-resistant floors, sumps and should have controlled drainage to a recovery tank.

Special Materials to be Used for Packaging or Containers: Materials of construction for storing the product include: polyethylene, PVC, viton, Teflon, ceramic or rubber lined steel. Equipment for storage, handling or transport should NOT be made from the following material, or, where applicable, its alloys: aluminum, stainless steel, cast iron, brass, bronze, nylon or phenolic resin. Some metals accelerate the decomposition of Sodium Hypochlorite. Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment, which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls: Local exhaust ventilation required. Ventilation should be corrosion proof. Make up air should be supplied to balance air that is removed by local or general exhaust ventilation. Ventilate low lying areas such as sumps or pits where dense vapours may collect.

For personnel entry into confined spaces (i.e. bulk storage tanks) a proper procedure must be followed. It must include consideration of, among other things, ventilation, testing of tank atmosphere, provision and maintenance of SCBA, and emergency rescue. Use the "buddy" system. The second person should be in view and trained and equipped to execute a rescue.
(4)

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Eye Protection: Safety glasses with side shields are recommended to prevent eye contact. Use full face-shield and chemical safety goggles when there is potential for contact. Contact lenses should not be worn when working with this material.

Skin Protection: Gloves and protective clothing made from butyl rubber, neoprene, natural rubber, nitrile rubber, polyethylene, viton or PVC should be impervious under conditions of use. Prior to use, user should confirm impermeability. Discard contaminated gloves.

Respiratory Protection: No specific guidelines available. A NIOSH/MSHA-approved full facepiece air-purifying respirator equipped with chlorine cartridges for concentrations up to 5 ppm Chlorine vapours. An air-supplied respirator if concentrations are higher or unknown.

Other Personal Protective Equipment: Wear an impermeable apron and boots. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

EXPOSURE GUIDELINES

Recommended Exposure Limit: 0.5 ppm As For Chlorine. (3)

9. PHYSICAL AND CHEMICAL PROPERTIES (Not intended as Specifications)

Physical State: Liquid.

Appearance and Odour: Green to yellow, watery liquid with a chlorine (bleach) odour.

Odour Threshold (ppm): Not available.

Boiling Range (Deg Celsius): Decomposes at 40 Degrees Celsius to Sodium Chloride (NaCl) and Sodium Chlorate (NaClO₃). (3)

Melting/Freezing Point (Deg Celsius): -25 (12%).

Vapour Pressure (mm Hg at 20 Deg. Celsius): 17.5.

Vapour Density (Air = 1.0): Not applicable.

Relative Density (g/cc): 1.165 (12%); 1.21 (14%).

Bulk Density: 1,165 Kg/M³ (12%); 1,210 (14%).

Viscosity: Not available.

Evaporation Rate (Butyl Acetate = 1.0): Not applicable.

Solubility: Miscible in water.

% Volatile by Volume: Not available.

pH: 11.5 to 13.5 (12 to 14%).

Coefficient of Water/Oil Distribution: Not available.

Volatile Organic Compounds (VOC): Not available.

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY

Under Normal Conditions: Unstable. Sodium Hypochlorite solutions decompose slowly. Decomposition is accelerated by heat (temperatures above 40 degrees Celsius) and sunlight. Stability decreases with concentration, heat, light and decrease in pH. Some metals accelerate the decomposition of Sodium Hypochlorite.

Under Fire Conditions: Not flammable..

Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition. Temperatures above 40 Deg. C (104 Deg. F). Avoid direct sunlight. The heat of sunlight can contribute to instability. Avoid a decrease in pH.

Materials to Avoid: Strong oxidizers. Strong Acids. (hydrochloric acid) Contact with acids will liberate corrosive chlorine gas. Reducing agents. Strong bases. Combustibles. Lewis or mineral acids. Methanol. Some metals accelerate the decomposition of Sodium Hypochlorite. Nickel. Copper. Cobalt. Tin. Iron and its alloys. Manganese.

Nitrogen containing compounds. Ammonium hydroxide and ammonium salts. Contact with nitrogen compounds (ammonia, urea, primary amines and isocyanurates) can form toxic, reactive chloramines. Contact with Ammonium salts can form explosive nitrogen trichloride if acid is present. (4) Incompatible materials for storage include aluminum, cast bronze, cast iron, stainless steel, brass, nylon and phenolic resin. (3)

Decomposition or Combustion Products: Thermal decomposition products are toxic and may include oxygen and chlorine gas and oxides of chlorine and sodium.

11. TOXICOLOGICAL INFORMATION

Toxicological Data:

Sodium Hypochlorite	LD50 (Oral, Mouse)	=	5,800 mg/Kg (1)
	LD50 (Oral, Rat)	=	8,910 mg/Kg (3)
	LC50 (Inhal'n, Rat, 4h)	=	Above 5,250 mg/M3 (3)

Chlorine	LC50 (Inhal'n, Rat, 4h)	=	147 ppm (1)
	LC50 (Inhal'n, Mouse, 4h)	=	69 ppm (1)

Carcinogenicity Data: The ingredient(s) of this product is (are) not classed as carcinogenic by ACGIH, IARC, OSHA or NTP.

Reproductive Data: Reproductivity tests in animals have been negative.

Mutagenicity Data: Mutagenicity tests in animals have been negative.

Teratogenicity Data: No adverse teratogenic effects are anticipated.

Respiratory / Skin Sensitization Data: Sodium Hypochlorite may cause skin sensitization or other allergic responses. Sensitization is the process whereby a biological change occurs in the individual because of previous exposure to a substance and, as a result, the individual reacts more strongly when subsequently exposed to the substance. Once sensitized, an individual can react to extremely low airborne levels, even below the TLV, or to skin contact.

Synergistic Materials: None known.

Other Studies Relevant to Material: Rats were fed drinking water containing 0, 0.025, 0.05, 0.1, 0.2 and 0.4% Sodium Hypochlorite for 13 weeks. Slight damage to the liver was observed in the 0.2 and 0.4% groups. Some organ weights (lungs, liver and spleen in males; salivary glands, lungs, heart and brain in females) were significantly lower in the high-dose group. (4)

High doses of Sodium Hypochlorite in drinking water caused a small but significant increase in abnormal sperm in mice. (4)

Sodium Hypochlorite caused mutations in several short-term studies using bacteria and cultured mammalian cells. The significance of these tests is unclear. It was not mutagenic in tests (Chromosome aberration and micronucleus) on live animals. (4)

12. ECOLOGICAL INFORMATION

Ecotoxicity: Sodium Hypochlorite:

96-hour LC50 (Fathead minnows)	=	5.9 mg/l (3)
48-hour LC50 (Rainbow Trout)	=	0.07 mg/L (3)

Environmental Fate: Not available. Do not contaminate domestic or irrigation water

supplies, lakes, streams, ponds, or rivers.

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals: Apply cautiously a dilute solution of a reducing agent such as sodium sulphite or sodium bisulphite to the contained spill. Confirm pH using pH paper. Neutralization is expected to be exothermic. Effervescence may result.

Waste Disposal Methods: This information applies to the material as manufactured. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems. Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification.

Safe Handling of Residues: See above, "Deactivating Chemicals".

Disposal of Packaging: Empty containers retain product residue (liquid and/or vapour) and can be dangerous. Do not expose such containers to heat, flame, sparks, static electricity, or other sources of ignition; they may explode and cause injury or death. Treat package in the same manner as the product.

14. TRANSPORTATION INFORMATION

CANADIAN TDG ACT SHIPPING DESCRIPTION:

Hypochlorite Solutions, Class 8, UN1791, Pk Gp II.
Label(s)/Placard(s): Corrosive. Exemptions: None known.

US DOT CLASSIFICATION (49CFR 172.101, 172.102):

Hypochlorite Solutions, Class 8, UN1791, Pk Gp II.
Label(s)/Placard(s): Corrosive.
Reportable Quantity (CERCLA-RQ): 100 lbs / 45.4 Kg. Exemptions: None known.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR: All constituents of this product are included on the DSL.
CEPA - NPRI: Not included.
Controlled Products Regulations Classification (WHMIS): D-2B: Toxic (Skin Sensitizer), C: Oxidizer, E: Corrosive.
Canadian Pest Control Products (PCP) Act and Regulations Registration Number: 13731 (End Use); 23344 (Technical Active).

USA

Environmental Protection Act: All constituents of this product are included on the TSCA inventory.
OSHA Hazard Communication (29CFR 1910.1200) Classification: Skin Sensitizer, Oxidizer, Corrosive.

HMIS: 3 Health 1 Fire 0 Reactivity (3)
NFPA: 3 Health 1 Fire 0 Reactivity (3)

INTERNATIONAL: This product or its components are on the European inventory of existing commercial chemicals (EINECS).

16. OTHER INFORMATION

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.
2. The British Columbia Drug and Poison Information Centre, Poison Managements Manual,

-
- Canadian Pharmaceutical Association, Ottawa, 1981.
3. Supplier's Material Safety Data Sheet(s).
 4. "CHEMINFO", through "CCINFODisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
 5. Guide to Occupational Exposure Values, 2002, American Conference of Governmental Industrial Hygienists, Cincinnati, 2002.
 6. The British Columbia Drug and Poison Information Centre, Poison Managements Manual, Canadian Pharmaceutical Association, Ottawa, 1981.
 7. NFPA 325M Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, 1994 Edition, Quincy, MA, 1994.
 8. Regulatory Affairs Group, Brenntag Canada Inc.
-

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Brenntag Canada Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

British Columbia: 20333-102B Avenue, Langley, BC, V1M 3H1
Phone: (604) 513-9009 Facsimile: (604) 513-9010

Alberta: 6628 - 45 th. Street, Leduc, AB, T9E 7C9
Phone: (780) 986-4544 Facsimile: (780) 986-1070

Manitoba: 681 Plinguet Street, Winnipeg, MB, R2J 2X2
Phone: (204) 233-3416 Facsimile: (204) 233-7005

Ontario: 43 Jutland Road, Toronto, ON, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-6175

Quebec: 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Atlantic: A-105 Akerley Boulevard, Dartmouth, NS, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

MATERIAL SAFETY DATA SHEET

SULPHUR DIOXIDE

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

WHMIS Number: 00010003
Index: GCD0051/03D
Effective Date: 2003 November 12
Date of Revision: 2003 November 12

EMERGENCY TELEPHONE NUMBERS

Toronto, ON (416) 226-6117	Montreal, QC (514) 861-1211	Winnipeg, MB (204) 943-8827
Edmonton, AB (780) 424-1754	Calgary, AB (403) 263-8660	Vancouver, BC (604) 685-5036

PRODUCT IDENTIFICATION

Product Name: Sulphur Dioxide.
Chemical Name: Sulphur Dioxide.
Synonyms: Sulphurous Oxide; Sulphurous Acid, Anhydrous.
Chemical Family: Inorganic Oxide.
Molecular Formula: SO₂.
Product Use: Chemical intermediate. Refrigerant gas. Bleaching agent.
CAS #: 7446-09-5.
WHMIS Classification / Symbol: A: Compressed Gas, D-1A: Very Toxic (acute effects), D-2A: Very Toxic (Chronic Effects), E: Corrosive.



READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT.

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Corrosive! Causes severe skin and eye burns. Contents under pressure. Toxic/Poisonous! May be fatal if inhaled. Gas is extremely irritating to eyes and respiratory tract. Airborne concentration of dust, mist or spray may cause damage to the lung tissue which could produce chemical pneumonia. May cause chronic effects. See "Other Health Effects" Section. Liquefied compressed gas. Reacts with water. Escaping gas may cause fittings and piping to become very cold, posing a frostbite hazard.

POTENTIAL HEALTH EFFECTS

- Inhalation: Toxic/Poisonous! Corrosive! Acute exposure may result in dryness and irritation of the nose and throat, choking, sneezing, coughing and bronchospasm. Severe overexposure may cause death through systemic acidosis, pulmonary oedema or from respiratory arrest. Prolonged or repeated exposure may cause impaired lung function, bronchitis, hacking cough, nasal irritation and discharge, increased fatigue, alteration in the senses of taste and smell and longer duration of common colds. Dental caries, loss of fillings, gum disorders and the rapid and painless destruction of teeth may result from overexposure. (3) See "Other Health Effects" Section.
- Skin Contact: Corrosive! Causes skin burns. Liquid sulphur dioxide can cause frostbite and skin burns. Sulphur dioxide converts to sulphurous acid on contact with water in moist

environments. Sulphurous acid in turn causes skin irritation and burns if not promptly removed. (3)

- . Skin Absorption: Not likely to be absorbed through the skin.
- . Eye Contact: Corrosive! Causes severe eye burns. This product causes corneal scarring and clouding. Glaucoma, cataracts and permanent blindness may occur. Rapid evaporation may cause frostbite.
- . Ingestion: Product is a gas. Ingestion is not a likely route of exposure. May cause severe burns to the mouth, throat and gastrointestinal system, if product is used improperly.

Other Health Effects: Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential.

May cause asphyxiation, bronchitis, emphysema, lung damage, pulmonary oedema, systemic acidosis, frostbite and central nervous system (CNS) depression. CNS depression is characterized by headache, dizziness, drowsiness, nausea, vomiting and incoordination. Severe overexposures may lead to coma and possible death due to respiratory failure. Pulmonary oedema is the build-up of fluid in the lungs that might be fatal. Symptoms of pulmonary oedema, such as shortness of breath, may not appear until several hours after exposure and are aggravated by physical exertion. (4) Asphyxia is characterized by increased breathing volume, accelerated pulse rate, muscular incoordination, faulty judgement, emotional instability, fatigue, nausea, vomiting, bewilderment, gasping respiration and unconsciousness.

3. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Hazardous Ingredients	CAS No.	ACGIH TLV	%
Sulphur Dioxide	007446-09-5	2 ppm *A4	60 - 100
A4 = Not classifiable as a human carcinogen. (ACGIH-A4)			

4. FIRST AID MEASURES

FIRST AID PROCEDURES

- . Inhalation: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Oxygen administration may be beneficial in this situation but should only be administered by personnel trained in its use. Obtain medical attention IMMEDIATELY.
- . Skin Contact: Flush skin with running water for a minimum of 20 minutes. Start flushing while removing contaminated clothing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY. Do not transport victim unless the recommended flushing period is completed or flushing can be continued during transport. Treat frostbite by immediately immersing affected areas in warm water until the skin has warmed up and turned pink. Obtain medical attention IMMEDIATELY.
- . Eye Contact: Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY.
- . Ingestion: Do not attempt to give anything by mouth to an unconscious person. If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. DO NOT induce vomiting. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. Obtain medical attention IMMEDIATELY.

Note to Physicians: When treating frost bite or exposure to the cooling effects of liquid gas contact, flush affected areas with water no warmer than 44 Deg. Celsius. Do not use heated water or dry heat and frozen parts should not be rubbed before or after thawing.

Freeze burns of mucosal tissue can develop following contact with liquid form of this material.

Persons subject to asthmatic attacks may experience asthmatic paroxysm. Any disorder inhibiting nasal respiration or any cardiovascular disease may preclude exposure to sulphur dioxide. Effects may be exacerbated in smokers. Significant variations in individual susceptibilities to sulphur dioxide probably exist.

Medical conditions that may be aggravated by exposure to this product include neurological, cardiovascular disorders, diseases of the skin, eyes or respiratory tract.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

Flammability Class (WHMIS): Not regulated.
Flash Point (TCC, Deg. Celsius): Does not flash.
Autoignition Temperature (Deg. Celsius): Not applicable.
Flammability Limits in Air (%): LEL: Not applicable. UEL: Not applicable.

Hazardous Combustion Products: Does not decompose, but reacts with water or steam to produce corrosive products. (3)

Unusual Fire or Explosion Hazards: Sulphur dioxide is not explosive. Overheated cylinders and tonne containers will vent through the fusible plug at or above 71 Deg. Celsius (160 Deg. Fahrenheit). Tank cars and tank trucks are fitted with safety relief valves and will vent at 1,550 kPa (225 psig) or 944 kPa (137 psig) in a fire or when unduly high pressure is applied; e.g. excessive air padding. (3)

Sensitivity to Mechanical Impact: Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: Not expected to be sensitive to static discharge.

EXTINGUISHING MEDIA

Fire Extinguishing Media: Use media appropriate for surrounding fire and/or materials.

FIRE FIGHTING INSTRUCTIONS

Instructions to the Fire Fighters: Where possible, shut off supply flow of gas. Ventilate low lying areas such as sumps or pits where dense vapours may collect. When possible, remove Sulphur Dioxide containers from fire zone. Apply water to cool containers unless there is a sulphur dioxide leak. In presense of SO₂, use self-contained breathing apparatus (SCBA). Gas tight suits will be required in higher concentrations (Supplier suggests at or above 1,000 ppm SO₂).

Fire Fighting Protective Equipment: Use self-contained breathing apparatus and protective clothing.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures: In all cases of leak or spill contact vendor at Emergency Number shown on the front page of this MSDS. Move unprotected personnel upwind of leaking container. Call emergency response naming the chemical and the type of container that is leaking. Consider the use of fog-nozzles to control vapours. Do not immerse in water. Where possible, elevate the leak to the highest position of the cylinder, such that gas and not liquid escapes. Apply emergency device. Cover leak area with tarpaulin or plastic sheet to limit the spread of gas.

7. HANDLING AND STORAGE

HANDLING

Handling Practices: Use normal "good" industrial hygiene and housekeeping practices. Secure containers at all times. Fix leaks promptly.

Handling Procedures and Equipment: As a compressed gas, SO₂ must be handled carefully in pressurized containers. Carbon steel meeting the required ASTM specifications is acceptable provided the SO₂ is dry. Suitable relief mechanisms must be installed to protect against equipment rupture. Compressed gas cylinders and tonne containers are equipped with fusible plugs. The fusible plugs are designed to melt at temperatures above 70 Deg. Celsius to reduce the internal pressure of the cylinder by releasing gas.

Caps should always be placed on cylinders until ready for use. Always secure cylinders to a wall, rack or other solid structure in an upright position. Do not handle cylinders with oily hands. Do not use cylinder if damaged. Use an appropriate pressure regulator. Before connecting the cylinder, make sure that back feed from the system to the cylinder is prevented. The valve should be opened slowly to prevent rapid decompression and damage to the valve. Make sure the valves on the gas cylinder is fully opened when gas is in use. The valves should be opened and closed at least once a day, while in use, to prevent freezing. (4) Check to see if the cylinders have been tested within the required time. Check compatibility with other materials and separate at appropriate distance. Empty cylinders should be stored separately from full ones, with valves off, securely capped and clearly labeled EMPTY. (4)

Ventilation Requirements: When necessary, installation of sulphur dioxide monitors is recommended for the warning of dangerous levels of sulphur dioxide gas. See Section 8, "Engineering Controls".

Other Precautions: Use only with adequate ventilation and avoid breathing gas (vapours or mists). Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use. Segregate from combustible materials. Expansion of liquid and change of state from liquid to vapour will allow mixture to encompass a large area. If tank is involved in a fire situation, a BLEVE (Boiling Liquid Expanding Vapour Explosion) may result. Cylinders should not be lifted by the cap or by lifting magnets. Shut flow off at cylinder valve and not just the regulator after use. Replace outlet caps or plugs and cylinder caps as soon as the cylinder is disconnected from equipment. The empty cylinders should be kept under slightly positive pressure. Regularly check the cylinders for corrosion or leakage. (4)

STORAGE

Storage Temperature (Deg Celsius): Do not store below -29 Degrees Celsius. Do not store above 52 Degrees Celsius.

Ventilation Requirements: Ventilation should be corrosion proof.

Storage Requirements: Dry sulphur dioxide is stored in registered steel pressure vessels. (3) Segregate from combustible materials. Avoid moisture contamination. Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Protect from direct sunlight. Protect against physical damage. Secure containers at all times. Fix leaks promptly.

Special Materials to be Used for Packaging or Containers: Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment, which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls: Local exhaust ventilation required. Ventilation should be corrosion proof. Ventilate low lying areas such as sumps or pits where dense vapours may collect.

Vapours should be collected and neutralized in a suitable scrubbing system. Use the "buddy" system. The second person should be in view and trained and equipped to execute a rescue. (4)

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Eye Protection: Use full face-shield and gas-tight goggles when there is potential for contact. Contact lenses should not be worn when working with this material.

Skin Protection: Gloves and protective clothing made from teflon should be impervious under conditions of use. Prior to use, user should confirm impermeability. Skin protection should be insulated against cold temperatures. Do not use gloves or protective clothing made from polyethylene (3) Discard contaminated gloves.

Respiratory Protection: A NIOSH/MSHA-approved air-purifying respirator equipped with acid gas, dust, mist, fume cartridges for concentrations up to 20 ppm Sulphur Dioxide. A NIOSH/MSHA-approved full facepiece air-supplied respirator if concentrations are higher or unknown.

Immediately Dangerous to Life and Health (IDLH) value: 100 ppm (4). The purpose of establishing an IDLH value is to ensure that the worker can escape from a given contaminated environment in the event of failure of the most protective respiratory equipment. In the event of failure of respiratory protective equipment, every effort should be made to exit immediately. (4)

Other Personal Protective Equipment: Wear an impermeable apron and boots. Locate safety shower and eyewash station in area unlikely to be affected by a release of sulphur dioxide and near storage and handling area. Impervious, gas-tight overall body protection depending upon exposure. Take all precautions to avoid personal contact.

EXPOSURE GUIDELINES

	ACGIH TLV (STEL)	OSHA PEL (TWA)	(STEL)	NIOSH REL (TWA)	(STEL)
Sulphur Dioxide	5 ppm	5 ppm	----	2 ppm	5 ppm

9. PHYSICAL AND CHEMICAL PROPERTIES (Not intended as Specifications)

Physical State: Gas.
Appearance and Odour: Colourless gas or liquid. Strong, pungent odour.
Odour Threshold (ppm): 0.5 to 3.0 (Detection). Poor warning properties.
Boiling Range (Deg Celsius): -10.
Melting/Freezing Point (Deg Celsius): -72.7.
Vapour Pressure (mm Hg at 20 Deg. Celsius): 2,475. (3)
Vapour Density (Air = 1.0): 2.26.
Relative Density (g/cc): 1.434 at 0 Degrees Celsius; 1.462 at 10 Degrees Celsius.
Bulk Density: Not available.
Viscosity: Not applicable.
Evaporation Rate (Butyl Acetate = 1.0): Not applicable.
Solubility: 11.9% at 15 Degrees Celsius (By Weight).
% Volatile by Volume: 100%.
pH: Material becomes acidic when dissolved in water.
Coefficient of Water/Oil Distribution: Gas: Not applicable.
Volatile Organic Compounds (VOC): Not available.

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY

Under Normal Conditions: Stable.
Under Fire Conditions: Not flammable.
Hazardous Polymerization: Will not occur.

Conditions to Avoid: Moisture and heat sensitive.

Materials to Avoid: Strong oxidizers. Strong bases. Fluorine. Water contamination. Interhalogens. Bromine pentafluoride. Chlorine trifluoride. Chlorates. Powdered Metals. Metal Oxides. Metal Acetylides. Sodium Hydride. Cesium Azide. Silver Azide. Diethyl Zinc. Combustibles. Reacts with water to form sulphuric acid which will corrode most metals.

Decomposition or Combustion Products: Does not decompose, but reacts with water or steam to produce corrosive products. (3)

11. TOXICOLOGICAL INFORMATION

Toxicological Data:

Sulphur Dioxide LC50 (Inhal'n, Rat, 4h) = 1,260 ppm (1)

Carcinogenicity Data: Not Classifiable as to Carcinogenicity to Humans. (IARC-3). See "Other Studies Relevant to Material".

Reproductive Data: No adverse reproductive effects are anticipated.

Mutagenicity Data: No adverse mutagenic effects are anticipated.

Teratogenicity Data: No adverse teratogenic effects are anticipated.

Respiratory / Skin Sensitization Data: None known.

Synergistic Materials: The presence of soluble particles such as ferrous iron, manganese and vanadium has increased the toxic action of inhaled SO₂. It has been postulated that this maybe due to conversion of SO₂ to sulphurous acid by moisture, the oxidation of SO₂ to sulphuric acid by catalytic metal ions, or the deeper penetration of SO₂ into the lungs because of these particles. (4)

Sulphur Dioxide at 4.3 ppm for 8 hours/day for 5 days, enhances allergic sensitization to inhaled ovalbumin (a known allergen). This sensitization can be blocked if the animals are pretreated with anti-inflammatory drugs. (4)

Other Studies Relevant to Material:

Exposure to 400 ppm Sulfur Dioxide (SO₂) for 4 hours caused temporary clouding of the eyes in rabbits, mice and guinea pigs. Severe eye injury was produced by a 5 second exposure of pure SO₂. (4)

Studies have concluded that Sulphur Dioxide (SO₂) affects the mechanics of respiration. Guinea pigs exposed to 0.2 ppm up to 100 ppm for 1 hour had a dose-related narrowing of the bronchiole tubes leading to bronchoconstriction. Furthermore, nasal cavity injury occurred in mice exposed to 10 ppm for 72 hours. The effects were more severe as the exposure time was increased. The effects on the trachea and lung were less severe. (4)

Long term exposure of dogs to SO₂ produced changes in pulmonary function. There was increased swelling, secretions, reddening of the trachea, and decreased tracheal mucosal flow in dogs exposed to 1 ppm SO₂ intermittently over 12 months. There was no apparent change in pulmonary function over this time period. Experiments in guinea pigs and monkeys showed no adverse effects. (4)

One experiment has shown that there was a significant increase in lung tumours in female mice when exposed to SO₂. However there were numerous design problems such that IARC has concluded that little evidence exists for carcinogenicity. (4)

Mice exposed to 32, 65, 125, or 250 ppm SO₂ has shown signs of decreased birth weight and delayed righting flex. Other studies have also noted that delayed bone formation occurred when mice are exposed to 25 ppm on days 6 - 15 of pregnancy. (4)

When a rats ability to metabolize SO₂ has been impaired, there is a significant decrease in testes weight. It should be noted that these results are not relevant to normal exposure. (4)

Sulphur Dioxide has given both positive and negative mutagenic results. It does not induce sister chromatid exchange, chromosomal aberrations or micronucleus formation in the bone marrow of Chinese hamster or mice in-vivo test. However in-vitro tests of Syrian hamster embryo cells lead to the induction of morphological change. Furthermore, Bisulfite induced both transformation and sister chromatid exchange, but not gene mutation, chromosomal

aberration or DNA repair synthesis in cultured mammalian cells. (4)

12. ECOLOGICAL INFORMATION

Ecotoxicity: Not available. Harmful to aquatic life at low concentrations.

Environmental Fate: Can be dangerous if allowed to enter drinking water intakes. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

Sulphur Dioxide dissolved in water, forming sulphurous acid, maybe harmful to aquatic life in low concentrations. Netralized alkaline solutions have high chemical oxygen demands creating anoxic aquatic conditions leading to fish kills. (3)

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals: Neutralizing the gas may not be possible. Neutralize any acidic aqueous residues carefully with soda ash or sodium bicarbonate to a pH of 6 to 9. Neutralization is expected to be exothermic. Effervescence may result. Alkaline solutions must be oxidized (e.g. Hydrogen Peroxide) before disposal due to their oxygen demand.

Waste Disposal Methods: This information applies to the material as manufactured. Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

Safe Handling of Residues: See "Waste Disposal Methods".

Disposal of Packaging: Empty containers retain product residue (liquid and/or vapour) and can be dangerous. Do not expose such containers to heat, flame, sparks, static electricity, or other sources of ignition; they may explode and cause injury or death. Do not re-use empty container. Contact vendor.

14. TRANSPORTATION INFORMATION

CANADIAN TDG ACT SHIPPING DESCRIPTION:

Sulphur Dioxide, Class 2.3(8), UN1079.
Label(s)/Placard(s): Poison Gas and Corrosive.
ERAP Index: 500 Kg or L. Exemptions: Not available.

US DOT CLASSIFICATION (49CFR 172.101, 172.102):

Sulphur Dioxide, Liquified, Class 2.3, UN1079.
Label(s)/Placard(s): Poison Gas and Corrosive.
Reportable Quantity (CERCLA-RQ): Not applicable. Exemptions: None known.
Special Documentation Addition: (i) Toxic Inhalation Hazard. (ii) Hazard Zone C.
IMO: Marine Pollutant: Not included.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR: This material is included on the DSL under the CEPA.
CEPA - NPRI: Not included.
Controlled Products Regulations Classification (WHMIS): A: Compressed Gas, D-1A: Very Toxic (acute effects), D-2A: Very Toxic (Chronic Effects), E: Corrosive

USA

Environmental Protection Act: All constituents of this product are included on the TSCA inventory.
OSHA Hazard Communication (29CFR 1910.1200) Classification: Compressed Gas, Highly Toxic, Chronic Effects, Corrosive.

HMIS: 3 Health, 0 Fire, 0 Reactivity. (3)

INTERNATIONAL: The following component or components of this product appear on the European Inventory of Existing Commercial Chemical Substances: Sulphur Dioxide.

16. OTHER INFORMATION

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.
 2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
 3. Supplier's Material Safety Data Sheet(s).
 4. "CHEMINFO", through "CCINFODisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
 5. Guide to Occupational Exposure Values, 2002, American Conference of Governmental Industrial Hygienists, Cincinnati, 2002.
 6. Regulatory Affairs Group, Brenntag Canada Inc.
-

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Brenntag Canada Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

British Columbia: 20333-102B Avenue, Langley, BC, V1M 3H1
Phone: (604) 513-9009 Facsimile: (604) 513-9010

Alberta: 6628 - 45 th. Street, Leduc, AB, T9E 7C9
Phone: (780) 986-4544 Facsimile: (780) 986-1070

Manitoba: 681 Plinquet Street, Winnipeg, MB, R2J 2X2
Phone: (204) 233-3416 Facsimile: (204) 233-7005

Ontario: 43 Jutland Road, Toronto, ON, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-6175

Quebec: 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Atlantic: A-105 Akerley Boulevard, Dartmouth, NS, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

MATERIAL SAFETY DATA SHEET

SODIUM THIOSULPHATE
(ANHYDROUS AND PENTAHYDRATE)

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

WHMIS Number: 00061328
Index: HCl0168/04A
Effective Date: 2004 March 08
Date of Revision: 2004 March 08

EMERGENCY TELEPHONE NUMBERS

Toronto, ON (416) 226-6117	Montreal, QC (514) 861-1211	Winnipeg, MB (204) 943-8827
Edmonton, AB (780) 424-1754	Calgary, AB (403) 263-8660	Vancouver, BC (604) 685-5036

PRODUCT IDENTIFICATION

Product Name: Sodium Thiosulphate (Anhydrous and Pentahydrate).
Chemical Name: Thiosulphuric Acid, Disodium Salt.
Synonyms: Sodium Thiosulphate Anhydrous; Sodium Thiosulphate Pentahydrate; Sodium Hyposulphite.
Chemical Family: Inorganic salt.
Molecular Formula: Anhydrous: $\text{Na}_2\text{S}_2\text{O}_3$; Pentahydrate: $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$.
Product Use: Chemical intermediate. Gold and silver extraction from mining ores.
Photography. Food additive.
CAS #: Anhydrous: 7772-98-7; Pentahydrate: 10102-17-7.
WHMIS Classification / Symbol: D-2B: Toxic (Skin and Eye Irritant).



READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT.

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Causes skin and eye irritation. Dust is irritating to respiratory tract. See "Other Health Effects" Section. Can decompose at high temperatures forming toxic gases.

POTENTIAL HEALTH EFFECTS

- . Inhalation: Irritates nose, throat and respiratory tract. Excessive contact with powder may cause drying of mucous membranes of nose and throat due to absorption of moisture and oils. Dust may react with moisture in the air to form a weak sulphuric acid mist which can irritate the nose and throat. See "Other Health Effects" Section.
- . Skin Contact: Skin contact can cause irritation, especially under the finger nails (and other confined spaces such as under rings or watch bands). May cause defatting, drying and cracking of the skin. Prolonged and repeated contact may lead to dermatitis.
- . Skin Absorption: Not likely to be absorbed through the skin.
- . Eye Contact: This product causes irritation, redness and pain. May cause corneal damage and conjunctivitis.

- . Ingestion: This product may cause mild gastrointestinal discomfort. Ingestion of large doses can have cathartic (laxative) effects.

Other Health Effects: Effects (irritancy) on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential. Ingestion of very high levels may cause nausea and vomiting and cyanosis. May cause cyanosis (blue-grey skin and lips caused by lack of oxygen). Sodium salts have a hypothetical risk of hypernatremia.

3. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Hazardous Ingredients	CAS No.	ACGIH TLV	%
Sodium Thiosulphate Anhydrous	007772-98-7	Not Listed.	95 - 99
or Sodium Thiosulphate Pentahydrate	010102-17-7	Not Listed.	95 - 99
Decomposition product: Sulphur Dioxide	007446-09-5	2 ppm *A4	Not available.

A4 = Not classifiable as a human carcinogen. (ACGIH-A4)

4. FIRST AID MEASURES

FIRST AID PROCEDURES

- . Inhalation: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Obtain medical attention IMMEDIATELY.
- . Skin Contact: If irritation, redness, or a burning sensation develops and persists, repeat flushing and obtain medical advice. Wash affected areas thoroughly with soap and water. If irritation, redness, or a burning sensation develops and persists, repeat flushing. Obtain medical attention.
- . Eye Contact: Immediately flush eyes with running water for a minimum of 20 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Obtain medical attention IMMEDIATELY.
- . Ingestion: Do not attempt to give anything by mouth to an unconscious person. If victim is alert and not convulsing, rinse mouth out and give 1/2 to 1 glass of water to dilute material. IMMEDIATELY contact local Poison Control Centre. Vomiting should only be induced under the direction of a physician or a poison control centre. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. IMMEDIATELY transport victim to an emergency facility.

Note to Physicians: Treat symptomatically. Sodium salts have a hypothetical risk of hypernatremia. In addition to calcium levels, sodium and phosphate levels should be monitored.

Medical conditions that may be aggravated by exposure to this product include neurological, cardiovascular disorders, diseases of the skin, eyes or respiratory tract.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

Flammability Class (WHMIS): Not regulated.
Flash Point (TCC, Deg. Celsius): Non-combustible (does not burn).
Autoignition Temperature (Deg. Celsius): Not applicable.
Flammability Limits in Air (%): LEL: Not applicable. UEL: Not applicable.

Hazardous Combustion Products: Thermal decomposition products are toxic and may include Sulfur dioxide and oxides of sodium.

Unusual Fire or Explosion Hazards: Minimize air borne spreading of dust. Spilled material may cause floors and contact surfaces to become slippery. Sulphur Dioxide gas, which is toxic, corrosive and an oxidizer, is driven off above 100 degrees Celcius, leaving a Sodium Sulfide residue which is flammable, a strong irritant to skin and tissue and is also incompatible with acids.

Sensitivity to Mechanical Impact: Not expected to be sensitive to mechanical impact.

Rate of Burning: Not available.

Explosive Power: Not available.

Sensitivity to Static Discharge: Not expected to be sensitive to static discharge.

EXTINGUISHING MEDIA

Fire Extinguishing Media: Foam. Dry Chemical, Carbon dioxide or water spray. Use carbon dioxide or dry chemical media for small fires. If only water is available, use it in the form of a fog.

FIRE FIGHTING INSTRUCTIONS

Instructions to the Fire Fighters: Use water spray to cool fire-exposed containers or structures. Use water spray to disperse vapours. Spilled material may cause floors and contact surfaces to become slippery.

Fire Fighting Protective Equipment: Use self-contained breathing apparatus and protective clothing.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures: In all cases of leak or spill contact vendor at Emergency Number shown on the front page of this MSDS. Minimize air borne spreading of dust. Eliminate all sources of ignition. Wear respirator, protective clothing and gloves. Avoid dry sweeping. Do not use compressed air to clean surfaces. Vacuuming or wet sweeping is preferred. Return all material possible to container for proper disposal. Any recovered product can be used for the usual purpose, depending on the extent and kind of contamination. Where a package (drum or bag) is damaged and / or leaking, repair it, or place it into an over-pack drum immediately so as to avoid or minimize material loss and contamination of surrounding environment. Replace damaged containers immediately to avoid loss of material and contamination of surrounding atmosphere. Notify applicable government authority if release is reportable or could adversely affect the environment.

7. HANDLING AND STORAGE

HANDLING

Handling Practices: Use normal "good" industrial hygiene and housekeeping practices. Minimize air borne spreading of dust.

Ventilation Requirements: See Section 8, "Engineering Controls".

Other Precautions: Use only with adequate ventilation and avoid breathing dusts. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use.

STORAGE

Storage Temperature (Deg Celsius): See below. Store below 48 Degrees Celsius. (3)

Ventilation Requirements: Ventilation should be explosion proof.

Storage Requirements: Store in a cool, well-ventilated area. Keep away from heat, sparks and flames. Keep containers closed. Avoid moisture contamination. Prolonged storage may result in lumping or caking. Protect from direct sunlight. Protect against physical damage.

Special Materials to be Used for Packaging or Containers: Multi-layer polyethylene or Polypropylene bags or sacks (3) Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls: Local exhaust ventilation required. Ventilation should be explosion proof. Make up air should be supplied to balance air that is removed by local or general exhaust ventilation. Avoid accumulation and dispersion of dust to reduce explosion potential. Ventilate low lying areas such as sumps or pits where dense dust may collect.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Eye Protection: Safety glasses with side shields are recommended to prevent eye contact. Use dust-tight chemical safety goggles when there is potential for eye contact. Contact lenses should not be worn when working with this material.

Skin Protection: Gloves and protective clothing made from PVC, neoprene, rubber or plastic should be impervious under conditions of use. Prior to use, user should confirm impermeability. Discard contaminated gloves.

Respiratory Protection: No specific guidelines available. A NIOSH/MSHA-approved air-purifying respirator equipped with dust, mist, fume cartridges for concentrations up to 50 ppm Sulphur Dioxide or 100 mg/M3 particulate. An air-supplied respirator if concentrations are higher or unknown.

Other Personal Protective Equipment: Avoid accumulation and dispersion of dust to reduce explosion potential. Wear regular work clothing. The use of coveralls is recommended. Locate safety shower and eyewash station close to chemical handling area. Take all precautions to avoid personal contact.

EXPOSURE GUIDELINES

Particulate Not Otherwise Classified

ACGIH		OSHA	
10 mg/M3 - Inhalable particulate		50 mppcf* or 15 mg/M3 - Total Dust	
3 mg/M3 - Respirable particulate.		15 mppcf* or 5 mg/M3 - Respirable Fraction	
* mppcf = million particles per cubic foot			

ACGIH TLV (STEL)	OSHA PEL (TWA)	(STEL)	NIOSH REL (TWA)	(STEL)
---------------------	-------------------	--------	--------------------	--------

Decomposition product:

Sulphur Dioxide	5 ppm	5 ppm	----	2 ppm	5 ppm
-----------------	-------	-------	------	-------	-------

9. PHYSICAL AND CHEMICAL PROPERTIES (Not Intended As Specifications)

Physical State: Solid.

Appearance and Odour: Odourless, white crystalline powder.

Odour Threshold (ppm): Not available.
Boiling Range (Deg Celsius): Not applicable.
Melting/Freezing Point (Deg Celsius): 48. Decomposition will occur above 48 Degrees Celsius.
Vapour Pressure (mm Hg at 20 Deg. Celsius): Not applicable.
Vapour Density (Air = 1.0): Not applicable.
Relative Density (gm/cc): Anhydrous: 1.67; Pentahydrate: 1.729.
Bulk Density: Not available.
Viscosity: Not applicable.
Evaporation Rate (Butyl Acetate = 1.0): Not applicable.
Solubility: Soluble in water. Hygroscopic (readily absorbs water).
% Volatile by Volume: Not applicable.
pH: 6.5 to 9.5 (20 % Aqueous Solution).
Coefficient of Water/Oil Distribution: Not available.
Volatile Organic Compounds (VOC): Not applicable.

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY

Under Normal Conditions: Stable. Decomposes at or Loses water at temperatures above 100 Degrees Celsius.
Under Fire Conditions: Not flammable.
Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition. Keep tightly closed to protect quality. Avoid moisture contamination. Minimize air borne spreading of dust. Decomposition will occur above 48 Degrees Celsius.

Materials to Avoid: Strong oxidizers. Strong Acids. Silver. Mercury. Lead. Iodine.
Water reactive materials such as Sodium cause strong exothermic reaction with the hydrate.
A violent reaction occurs with Sodium Nitrite when water of crystallization has been driven off by heating.

Decomposition or Combustion Products: Thermal decomposition products are toxic and may include Sulfur dioxide and oxides of sodium.

11. TOXICOLOGICAL INFORMATION

Toxicological Data:

Sodium Thiosulphate LD50 (Oral, Rat) = 8,000 mg/Kg (3)
Anhydrous

Sodium Thiosulphate Meaningful toxicological test data
Pentahydrate could not be found for this substance.

Carcinogenicity Data: The ingredient(s) of this product is (are) not classed as carcinogenic by ACGIH, IARC, OSHA or NTP.

Reproductive Data: No adverse reproductive effects are anticipated.

Mutagenicity Data: No adverse mutagenic effects are anticipated.

Teratogenicity Data: No adverse teratogenic effects are anticipated.

Respiratory / Skin Sensitization Data: None known.

Synergistic Materials: None known.

Studies Relevant to Material: None known.

12. ECOLOGICAL INFORMATION

Ecotoxicity: Not available. May be harmful to aquatic life.

Environmental Fate: This product is biodegradable. May be hazardous if allowed to enter drinking water intakes. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals: None required.

Waste Disposal Methods: This information applies to the material as manufactured.
Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

Safe Handling of Residues: See "Waste Disposal Methods".

Disposal of Packaging: Empty containers retain product residue and can be hazardous. Dispose of waste material at an approved waste incineration facility or (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations.

14. TRANSPORTATION INFORMATION

CANADIAN TDG ACT / U.S. DOT CLASSIFICATION: Not regulated.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR: All constituents of this product are included on the DSL under the CEPA.

CEPA - NPRI: Not included.

Controlled Products Regulations Classification (WHMIS): D-2B: Toxic (Skin and Eye Irritant).

CANADIAN FOOD AND DRUG ACT/REGULATIONS

The use of this material/product as a food additive is regulated by Health and Welfare Canada in the Food and Drug Act and the Food and Drug Regulations. It is incumbent on the user of this material/product to ensure any intended food application is consistent with Health and Welfare Canada guidelines. Food Grade designation in no way implies that the product is safe for consumption by humans. (3)

USA

Environmental Protection Act: All constituents of this product are included on the TSCA inventory under the US-EPA.

OSHA Hazard Communication (29CFR 1910.1200) Classification: Skin and Eye Irritant.

U.S. FOOD AND DRUG ADMINISTRATION

This material/product is regulated for use by the US FDA. It is incumbent on the user of this material/product to ensure any intended food application is consistent with US FDA guidelines. Food Grade designation in no way implies that the product is safe for consumption by humans. (3)

HMIS: 1 Health, 0 Fire, 0 Reactivity. (3)

INTERNATIONAL: Sodium Thiosulphate Anhydrous is found on the following inventories: EINECS (European Inventory of Existing Commercial Chemical Substances).

16. OTHER INFORMATION

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.
2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed.,

-
- Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
3. Supplier's Material Safety Data Sheet(s).
 4. "CHEMINFO", through "CCINFodisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
 5. Guide to Occupational Exposure Values, 2003, American Conference of Governmental Industrial Hygienists, Cincinnati, 2003.
 6. The British Columbia Drug and Poison Information Centre, Poison Managements Manual, Canadian Pharmaceutical Association, Ottawa, 1981.
 7. NFPA 325M Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, 1994 Edition, Quincy, MA, 1994.
 8. Regulatory Affairs Group, Brenntag Canada Inc.
-

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Brenntag Canada Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

British Columbia: 20333-102B Avenue, Langley, BC, V1M 3H1
Phone: (604) 513-9009 Facsimile: (604) 513-9010

Alberta: 6628 - 45 th. Street, Leduc, AB, T9E 7C9
Phone: (780) 986-4544 Facsimile: (780) 986-1070

Manitoba: 681 Plinguet Street, Winnipeg, MB, R2J 2X2
Phone: (204) 233-3416 Facsimile: (204) 233-7005

Ontario: 43 Jutland Road, Toronto, ON, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-6175

Quebec: 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Atlantic: A-105 Akerley Boulevard, Dartmouth, NS, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

MATERIAL SAFETY DATA SHEET

SODIUM BISULPHITE, SOLUTION, 15-40%

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

WHMIS Number: 00061372
Index: HCl0223/03A
Effective Date: 2003 March 25
Date of Revision: 2003 March 25

EMERGENCY TELEPHONE NUMBERS

Toronto, ON (416) 226-6117	Montreal, QC (514) 861-1211	Winnipeg, MB (204) 943-8827
Edmonton, AB (780) 424-1754	Calgary, AB (403) 263-8660	Vancouver, BC (604) 685-5036

PRODUCT IDENTIFICATION

Product Name: Sodium Bisulphite, Solution, 15-40%.
Chemical Name: Sulphurous Acid, Monosodium Salt, Aqueous Solution.
Synonyms: Sodium Bisulphite (8511) Aqueous Solution; Monosodium Sulphite, Aqueous Solution; Sodium Hydrogen Sulphite, Aqueous Solution; Sodium Pyrosulphite, Aqueous Solution.
Chemical Family: Aqueous mixture of Sulfites.
Molecular Formula: $\text{NaHSO}_3 \cdot \text{H}_2\text{O}$.
Product Use: Reducing agent. Pharmaceutical. Antioxidant. Disinfectant. Source of SO_2 .
Industrial Acid. (Additive) Electroplating. Chemical intermediate.
CAS #: See Section 3, "Composition, Information on Ingredients".
WHMIS Classification / Symbol: D-2A: Very Toxic (Respiratory Sensitizer), E: Corrosive.



READ THE ENTIRE MSDS FOR THE COMPLETE HAZARD EVALUATION OF THIS PRODUCT.

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Corrosive! Toxic effects are principally related to its corrosive properties. Harmful if inhaled or swallowed. Causes delayed lung injury. Causes severe skin and eye burns. Mists or sprays are extremely irritating to eyes and respiratory tract. May cause respiratory sensitization or other allergic responses. Can decompose at high temperatures forming toxic gases. A readily obtained degradation product is sulphur dioxide. Contents may develop pressure on prolonged exposure to heat.

POTENTIAL HEALTH EFFECTS

- Inhalation: Corrosive! Product may cause severe irritation of the nose, throat and respiratory tract. Repeated and/or prolonged exposures may cause productive cough, running nose, bronchopneumonia, pulmonary oedema (fluid build-up in lungs), and reduction of pulmonary function. If heated to the point where Sulphur Dioxide gas is driven off, then this gas is highly irritating to the respiratory tract. Toxic effects may be delayed. May cause respiratory sensitization or other allergic responses. See Section 11, "Other Studies Relevant to Material".
- Skin Contact: Corrosive! Concentrated solutions may cause pain and deep and severe burns

to the skin. Prolonged and repeated exposure to dilute solutions often causes irritation, redness, pain and drying and cracking of the skin. Burns (chemical) can occur if not promptly removed. Prolonged and repeated contact may lead to dermatitis. Toxic effects may be delayed.

- . Skin Absorption: Skin absorption is a secondary concern to the continual destruction of tissue while the product is in contact with the skin. Burns (chemical) can occur if not promptly removed.

- . Eye Contact: Extremely corrosive! This product causes corneal scarring and clouding. Glaucoma, cataracts and permanent blindness may occur. May cause corneal damage and conjunctivitis.

- . Ingestion: Corrosive! Ingestion is not a likely route of exposure. This product causes severe burning and pain in the mouth, throat and abdomen. Vomiting, diarrhea and perforation of the esophagus and stomach lining may occur.

Other Health Effects: Corrosive effects on the skin and eyes may be delayed, and damage may occur without the sensation or onset of pain. Strict adherence to first aid measures following any exposure is essential.

May cause violent colic, allergic reactions, bronchoconstriction, cardiovascular effects, chemical pneumonitis, pulmonary oedema and central nervous system (CNS) depression. Pulmonary oedema is the build-up of fluid in the lungs that might be fatal. Symptoms of pulmonary oedema, such as shortness of breath, may not appear until several hours after exposure and are aggravated by physical exertion. (4) CNS depression is characterized by headache, dizziness, drowsiness, nausea, vomiting and incoordination. Severe overexposures may lead to coma and possible death due to respiratory failure.

May cause respiratory sensitization or other allergic responses. Sulphite-sensitive people who inhale or ingest this product may experience severe allergic reaction. Exposure to small amounts of sulfites have been reported to cause hypersensitivity reaction in certain susceptible individuals, especially asthmatics. Symptoms include hives, respiratory distress, flushing, gastro-intestinal disturbances and contact dermatitis. (3)

Sulphur dioxide can be released if it is used improperly in acidic conditions. Sulphur dioxide is toxic and can cause death in extreme cases, eg: if the gas is released into a poorly ventilated area. (3)

3. COMPOSITION, INFORMATION ON INGREDIENTS (Not Intended As Specifications)

Hazardous Ingredients	CAS No.	ACGIH TLV	%
Sodium Bisulphite	007631-90-5	5 mg/M3 *A4	15 - 40
Sodium Sulphite	007757-83-7	Not Listed.	Below 3
Sodium Sulphate	007757-82-6	Not Listed.	Below 3
Decomposition product:			
Sulphur Dioxide	007446-09-5	2 ppm *A4	
A4 = Not classifiable as a human carcinogen. (ACGIH-A4)			

Non-Hazardous Ingredients	CAS No.	ACGIH TLV	%
Water	007732-18-5	Not Listed.	Balance.

4. FIRST AID MEASURES

FIRST AID PROCEDURES

General Guidelines: Prompt removal of the material and obtaining medical attention are essential for all contact. Remove all contaminated clothing and immediately wash the exposed areas with copious amounts of water. Continue the flushing during transportation to the emergency department. Corrosive effects may be delayed (up to 72 hours), and damage may occur without the sensation or onset of pain. Contact local poison control centre for

further guidance.

- . Inhalation: Move victim to fresh air. Give artificial respiration ONLY if breathing has stopped. Give cardiopulmonary resuscitation (CPR) if there is no breathing AND no pulse. Oxygen administration may be beneficial in this situation but should only be administered by personnel trained in its use. Obtain medical attention IMMEDIATELY.
- . Skin Contact: Prompt removal of the material from the skin is essential. Remove all contaminated clothing and immediately wash the exposed areas with copious amounts of water for a minimum of 30 minutes or up to 60 minutes for critical body areas. Obtain medical attention IMMEDIATELY. See "Note to Physicians" below.
- . Eye Contact: Immediately flush eyes with running water for a minimum of 30 minutes, preferably up to 60 minutes. Hold eyelids open during flushing. If irritation persists, repeat flushing. Do not transport victim until the recommended flushing period is completed unless flushing can be continued during transport.
- . Ingestion: Do not attempt to give anything by mouth to an unconscious person. IMMEDIATELY contact local Poison Control Centre. If victim is alert and not convulsing, rinse mouth out and give 1 to 2 glasses of milk. Water may be used if milk is not available but it is not as effective. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more milk or water. IMMEDIATELY transport victim to an emergency facility.

Note to Physicians: Immediate consultation with the local Poison Control Centre should be initiated. Severe and sometimes delayed (up to 72 hours) local and systemic reactions can occur.

Treatment for corrosive chemical contact with skin:

1. Immerse the exposed part immediately in ice water to relieve pain and to prevent swelling and blistering. Place cold packs, ice or wet cloths on the burned area if immersion is not possible.
2. Remove anything that is constrictive, such as rings, bracelets or footwear, before swelling begins.
3. Cover the exposed part with a clean, preferably sterile, lint-free dressing.
4. For severe exposure, immediately seek medical attention and monitor breathing and treat for shock.

This product contains materials that may cause severe pneumonitis if aspirated. If ingestion has occurred less than 2 hours earlier, carry out careful gastric lavage; use endotracheal cuff if available, to prevent aspiration. Observe patient for respiratory difficulty from aspiration pneumonitis. Give artificial resuscitation and appropriate chemotherapy if respiration is depressed.

Due to the severely irritating or corrosive nature of the material, swallowing may lead to ulceration and inflammation of the upper alimentary tract with hemorrhage and fluid loss. Also, perforation of the esophagus or stomach may occur, leading to mediastinitis or peritonitis and the resultant complications. (3) Mucosal injury following ingestion of this corrosive material may contraindicate the induction of vomiting in the treatment of possible intoxication. Similarly, if gastric lavage is performed, intubation should be done with great care. If oral burns are present or a corrosive ingestion is suspected by the patient's history, perform esophagoscopy as soon as possible. Scope should not be passed beyond the first burn because of the risk of perforation.

Sulphur Dioxide: Persons subject to asthmatic attacks may experience asthmatic paroxysm. Any disorder inhibiting nasal respiration or any cardiovascular disease may preclude exposure to sulphur dioxide. Effects may be exacerbated in smokers. Significant variations in individual susceptibilities to sulphur dioxide probably exist.

Medical supervision of all employees who handle or come in contact with respiratory sensitizers is recommended. This should include preemployment and periodic medical examinations with respiratory function tests (forced expiratory volume, forced vital capacity as a minimum). Persons with asthmatic-type conditions, chronic bronchitis, other chronic respiratory diseases or recurrent skin eczema or sensitization should be excluded from working with this product. Once a person is diagnosed as sensitized, no further exposure to any sensitizer should be permitted.

Medical conditions that may be aggravated by exposure to this product include neurological, cardiovascular and skin disorders, diseases of the skin, eyes or respiratory tract and

asthma.

5. FIRE FIGHTING MEASURES

FLAMMABLE PROPERTIES

Flammability Class (WHMIS): Not regulated.
Flash Point (TCC, Deg. Celsius): Non-combustible (does not burn).
Autoignition Temperature (Deg. Celsius): Not applicable.
Flammability Limits in Air (%): LEL: Not applicable. UEL: Not applicable.

Hazardous Combustion Products: Thermal decomposition products are toxic and may include Sulphur Dioxide, oxides of sodium and irritating gases. Sodium sulphide maybe formed after dried solution residues are heated.

Unusual Fire or Explosion Hazards: Not normally a fire hazard. Water content of product prevents ignition. Spilled material may cause floors and contact surfaces to become slippery. Reacts with most metals to produce hydrogen gas which could make an explosive mixture with air.

Sulphur Dioxide: Temperatures at or near boiling point (104 Deg. Celcius) causes evolution of toxic and poisonous sulphur dioxide. Sulphur dioxide will evolve slowly at ambient temperatures.

Sensitivity to Mechanical Impact: Not expected to be sensitive to mechanical impact.
Rate of Burning: Not available.
Explosive Power: Not available.
Sensitivity to Static Discharge: Not expected to be sensitive to static discharge.

EXTINGUISHING MEDIA

Fire Extinguishing Media: Use media appropriate for surrounding fire and/or materials. Use carbon dioxide or dry chemical media for small fires. If only water is available, use it in the form of a fog.

FIRE FIGHTING INSTRUCTIONS

Instructions to the Fire Fighters: Isolate materials that are not involved in the fire and protect personnel. Cool containers with flooding quantities of water until well after the fire is out. Spilled material may cause floors and contact surfaces to become slippery.

Fire Fighting Protective Equipment: Use self-contained breathing apparatus and protective clothing. Protective clothing for skin and eye protection should be worn to protect against corrosive materials.

6. ACCIDENTAL RELEASE MEASURES

Information in this section is for responding to spills, leaks or releases in order to prevent or minimize the adverse effects on persons, property and the environment. There may be specific reporting requirements associated with spills, leaks or releases, which change from region to region.

Containment and Clean-Up Procedures: See Section 13, "Deactivating Chemicals". In all cases of leak or spill contact vendor at Emergency Number shown on the front page of this MSDS.

Wear respirator, protective clothing and gloves. Spilled material may cause floors and contact surfaces to become slippery. Collect product for recovery or disposal. For release to land, or storm water runoff, contain discharge by constructing dykes or applying inert absorbent; for release to water, utilize damming and/or water diversion to minimize the spread of contamination. Ventilate enclosed spaces. Notify applicable government authority if release is reportable or could adversely affect the environment. Replace damaged containers immediately to avoid loss of material and contamination of surrounding atmosphere.

7. HANDLING AND STORAGE

HANDLING

Handling Practices: Use normal "good" industrial hygiene and housekeeping practices. Containers which have been exposed to heat may be under internal pressure. These should be cooled and carefully vented before opening. A face shield and apron should be worn. Vent container frequently, and more often in warm weather, to relieve pressure. Clean all containers of residues before adding the product. This will avoid potential violent reaction with unknown residues. (3) Enforce NO SMOKING rules in area of use.

Ventilation Requirements: See Section 8, "Engineering Controls".

Other Precautions: Use only with adequate ventilation and avoid breathing aerosols (vapours or mists). When necessary, installation of sulphur dioxide monitors is recommended for the warning of dangerous levels of sulphur dioxide gas. Avoid contact with eyes, skin or clothing. Wash thoroughly with soap and water after handling. Wash contaminated clothing thoroughly before re-use. Do not store or transport with food or feed.

Corrosive residue is most likely to be deposited at process vents or storage tanks, especially during filling operations. The use of compressed air to force corrosive materials from delivery trucks is of special concern. Scrubbing the exhaust of these vents is highly recommended. Jurisdictional regulations should be consulted to determine required practices.

STORAGE

Storage Temperature (Deg Celsius): Ideal storage temperature is 10 to 30 Degrees Celsius. Do not store below 10 Degrees Celsius. This product will freeze at 6 Degrees Celsius. (3) Ventilation Requirements: Ventilation should be corrosion proof.

Storage Requirements: Store in a clean, cool well ventilated area, away from organic chemicals, strong bases, metal powders, carbides, sulfides, and any readily oxidizable material. Protect from direct sunlight. Protect against physical damage. Storage area should be equipped with corrosion-resistant floors, sumps and should have controlled drainage to a recovery tank.

Special Materials to be Used for Packaging or Containers: Materials of construction for storing the product include: stainless steel 316, fiberglass-reinforced polyester, cross-linked polyethylene, Polypropylene drum. (3) Equipment for storage, handling or transport should NOT be made from the following material, or, where applicable, its alloys: mild steel, stainless steel 440, aluminum, copper, zinc, nickel, iron, tin, bronze, brass, nylon. Confirm suitability of any material before using.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Recommendations listed in this section indicate the type of equipment which will provide protection against overexposure to this product. Conditions of use, adequacy of engineering or other control measures, and actual exposures will dictate the need for specific protective devices at your workplace.

ENGINEERING CONTROLS

Engineering Controls: Local exhaust ventilation required. Ventilation should be corrosion proof. Make up air should be supplied to balance air that is removed by local or general exhaust ventilation. Ventilate low lying areas such as sumps or pits where dense vapours may collect.

For personnel entry into confined spaces (i.e. bulk storage tanks) a proper procedure must be followed. It must include consideration of, among other things, ventilation, testing of tank atmosphere, provision and maintenance of SCBA, and emergency rescue. Use the "buddy" system. The second person should be in view and trained and equipped to execute a rescue. (4)

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Eye Protection: Safety glasses with side shields are recommended as minimal eye protection. Use full face-shield and chemical safety goggles when there is potential for contact.

Contact lenses should not be worn when working with this material.

Skin Protection: Gloves and protective clothing made from neoprene, butyl rubber, natural rubber, nitrile rubber or PVC should be impervious under conditions of use. Prior to use, user should confirm impermeability. Discard contaminated gloves.

Respiratory Protection: No specific guidelines available. Do not use compressed oxygen in hydrocarbon atmospheres. A NIOSH/MSHA-approved full facepiece air-purifying respirator equipped with acid gas, dust, mist, fume cartridges for concentrations up to 50 mg/M3 Sodium Bisulphite or 20 ppm Sulphur Dioxide. An air-supplied respirator if concentrations are higher or unknown.

If while wearing a respiratory protection, you can smell, taste or otherwise detect anything unusual, or in the case of a full facepiece respirator you experience eye irritation, leave the area immediately. Check to make sure the respirator to face seal is still good. If it is, replace the filter, cartridge or canister. If the seal is no longer good, you may need a new respirator. (4)

Immediately Dangerous to Life and Health (IDLH) value: 100 ppm Sulphur Dioxide. The purpose of establishing an IDLH value is to ensure that the worker can escape from a given contaminated environment in the event of failure of the most protective respiratory equipment. In the event of failure of respiratory protective equipment, every effort should be made to exit immediately. (4)

Other Personal Protective Equipment: Wear an impermeable apron and boots. Locate safety shower and eyewash station in area unlikely to be affected by a release of sulphur dioxide and near storage and handling area. Take all precautions to avoid personal contact.

EXPOSURE GUIDELINES

	ACGIH TLV (STEL)	OSHA PEL (TWA)	(STEL)	NIOSH REL (TWA)	(STEL)
Sodium Bisulphite	----	----	----	5 mg/M3	----
Sulphur Dioxide	5 ppm	5 ppm	----	2 ppm	5 ppm

9. PHYSICAL AND CHEMICAL PROPERTIES (Not intended as Specifications)

Physical State: Liquid.
Appearance and Odour: Pale yellow liquid. Pungent odour of sulphur dioxide.
Odour Threshold (ppm): Not available.
Boiling Range (Deg Celsius): 104. Decomposes at 150 Degrees Celsius.
Melting/Freezing Point (Deg Celsius): 6.
Vapour Pressure (mm Hg at 20 Deg. Celsius): 32.0. 78 mmHg at 38 Degrees Celsius.
Vapour Density (Air = 1.0): 2.2.
Relative Density (g/cc): 1.18 to 1.37.
Bulk Density: 1,180 to 1,370 Kg/M3.
Viscosity: Not available. Similar to water.
Evaporation Rate (Butyl Acetate = 1.0): Below 1.0.
Water Solubility: Soluble in water. 29 g/100 mL at 20 Degrees Celsius.
Solubility: Soluble in Ethyl Alcohol. Not soluble in ammonia. (4)
% Volatile by Volume: 60 to 85.
pH: Acidic. 3.8 to 5.1.
Coefficient of Water/Oil Distribution: Not available.
Volatile Organic Compounds (VOC): Not available.

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY

Under Normal Conditions: Stable. Sulphur dioxide will evolve slowly at ambient temperatures. Slowly oxidized to the sulphate on exposure to air. (4)
Under Fire Conditions: Not flammable.

Hazardous Polymerization: Will not occur.

Conditions to Avoid: High temperatures, sparks, open flames and all other sources of ignition. Temperatures at or near boiling point (104 Deg. Celcius) causes evolution of toxic and poisonous sulphur dioxide. Crystallization Temperature (Deg Celsus): 10. Avoid a decrease in pH. Avoid extended contact with air or oxygen.

Materials to Avoid: Strong oxidizers. Oxidizers may cause strong exothermic reaction. Lewis or mineral acids. Strong bases. Combustibles. Nitrates. Nitrites. Alcohols. Reactions with acids and oxidizing agents can release sulphur dioxide. Acids, water and ice yield sulphur dioxide gas, which is corrosive, toxic and potentially deadly. Water and/or ice increases the natural rate of yield of sulphur dioxide gas. (3) Sulphur dioxide can be released if the product is used improperly in acidic or moist conditions. Sulphur dioxide is toxic and can cause death in extreme cases, eg: if the gas is released into a poorly ventilated area. (3)

Decomposition product (Sulphur Dioxide): Reacts with water to form sulphuric acid which will corrode most metals. Mild steel. 440 Stainless Steel. Aluminum and its alloys. Copper and its alloys. Zinc and its alloys. Tin. Nickel and its alloys. Brass. Bronze. Iron. Nylon

Decomposition or Combustion Products: Thermal decomposition products are toxic and may include Sulphur Dioxide, oxides of sodium and irritating gases. Sodium sulphide maybe formed after dried solution residues are heated.

11. TOXICOLOGICAL INFORMATION

Toxicological Data:

Sodium Bisulphite / LD50 (Oral, Rat) = 2,000 mg/Kg (1)

Carcinogenicity Data: The ingredient(s) of this product is (are) not classed as carcinogenic by ACGIH, IARC, OSHA or NTP.

Reproductive Data: No adverse reproductive effects are anticipated.

Mutagenicity Data: Sodium Bisulphite was found to be mutagenic to human lymphocytes, as well as causing mutagenic and DNA damage to microorganisms. Data are insufficient to classify in accordance with WHMIS criteria.

Teratogenicity Data: No adverse teratogenic effects are anticipated.

Respiratory / Skin Sensitization Data: Sodium Bisulphite may cause respiratory sensitization or other allergic responses. Some individuals are extremely sensitive to minute amounts of ingested sulfites. Symptoms may include broncho constriction, shock, gastro-intestinal disturbances, angio oedema, flushing (reddening of the skin), and tingling sensations.

Sensitization is the process whereby a biological change occurs in the individual because of previous exposure to a substance and, as a result, the individual reacts more strongly when subsequently exposed to the substance. In an industrial setting, the common routes of sensitization, inhalation and skin contact, are addressed by WHMIS. However, sensitization by ingestion is not specifically considered by WHMIS.

Synergistic Materials: None known.

Other Studies Relevant to Material: None known.

12. ECOLOGICAL INFORMATION

Ecotoxicity: Harmful to aquatic life at low concentrations. Toxicity is primarily associated with pH.

Sodium Bisulphite: Fish toxicity: 24, 48, 96-hour TLM = 240 ppm (Mosquito Fish). (4)

Sodium Sulphite:

96-hour LC50 (Leucisus idus) = 220 to 460 mg/L. (3)

Fish toxicity: 96-hour TLM = 789,000 ppb (Benthic Invertebrae). (3)

Environmental Fate: Biodegrades rapidly in waterways and, if in sufficient quantity, can deplete the available oxygen required by aquatic life. Can be dangerous if allowed to enter drinking water intakes. Do not contaminate domestic or irrigation water supplies, lakes, streams, ponds, or rivers.

13. DISPOSAL CONSIDERATIONS

Deactivating Chemicals: Neutralize carefully with soda ash or sodium bicarbonate to a pH of 6 to 9. Dissolve and oxidize to sulphate with weak (3 - 5 %) hydrogen peroxide. Sulphur dioxide may be released during neutralization. Neutralization is expected to be exothermic. Effervescence may result. Flush spill area with water.

Waste Disposal Methods: This information applies to the material as manufactured. Reevaluation of the product may be required by the user at the time of disposal since the product uses, transformations, mixtures and processes may influence waste classification. Dispose of waste material at an approved (hazardous) waste treatment/disposal facility in accordance with applicable local, provincial and federal regulations. Do not dispose of waste with normal garbage, or to sewer systems.

Safe Handling of Residues: See "Deactivating Chemicals". See "Waste Disposal Methods".

Disposal of Packaging: Empty containers retain product residue (liquid and/or vapour) and can be dangerous. Empty drums should be completely drained, properly bunged and promptly returned to a drum reconditioner. Treat package in the same manner as the product.

14. TRANSPORTATION INFORMATION

CANADIAN TDG ACT SHIPPING DESCRIPTION:

Bisulphites, Aqueous Solutions, NOS, (Sodium Bisulphite), Class 8, UN2693, Pk Gp III.
Label(s)/Placard(s): Corrosive. Exemptions: Not available.

US DOT CLASSIFICATION (49CFR 172.101, 172.102):

Bisulphites, Aqueous Solutions, NOS, (Sodium Bisulphite), Class 8, UN2693, Pk Gp III.
Label(s)/Placard(s): Corrosive. Reportable Quantity (CERCLA-RQ): 5,000 lbs / 2,270 Kg.
Exemptions: Not available.

15. REGULATORY INFORMATION

CANADA

CEPA - NSNR: All constituents of this product are included on the DSL.

CEPA - NPRI: Not included.

Controlled Products Regulations Classification (WHMIS): D-2A: Very Toxic (Respiratory Sensitizer), E: Corrosive.

USA

Environmental Protection Act: All constituents of this product are included on the TSCA inventory.

OSHA Hazard Communication (29CFR 1910.1200) Classification: Respiratory Sensitizer, Corrosive.

HMIS: 2 Health, 0 Fire, 1 Reactivity. (8)

INTERNATIONAL: The following component or components of this product appear on the European Inventory of Existing Commercial Chemical Substances: Sodium Bisulphite.

16. OTHER INFORMATION

ADDITIONAL INFORMATION AND SOURCES USED

1. RTECS-Registry of Toxic Effects of Chemical Substances, Canadian Centre for Occupational Health and Safety RTECS database.

-
2. Clayton, G.D. and Clayton, F.E., Eds., Patty's Industrial Hygiene and Toxicology, 3rd ed., Vol. IIA,B,C, John Wiley and Sons, New York, 1981.
 3. Supplier's Material Safety Data Sheet(s).
 4. "CHEMINFO", through "CCINFODisc", Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, Canada.
 5. Guide to Occupational Exposure Values, 2002, American Conference of Governmental Industrial Hygienists, Cincinnati, 2002.
 6. The British Columbia Drug and Poison Information Centre, Poison Managements Manual, Canadian Pharmaceutical Association, Ottawa, 1981.
 7. NFPA 325M Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, 1994 Edition, Quincy, MA, 1994.
 8. Regulatory Affairs Group, Brenntag Canada Inc.
-

The information contained herein is offered only as a guide to the handling of this specific material and has been prepared in good faith by technically knowledgeable personnel. It is not intended to be all-inclusive and the manner and conditions of use and handling may involve other and additional considerations. No warranty of any kind is given or implied and Brenntag Canada Inc. will not be liable for any damages, losses, injuries or consequential damages which may result from the use of or reliance on any information contained herein. This Material Safety Data Sheet is valid for three years.

To obtain revised copies of this or other Material Safety Data Sheets, contact your nearest Brenntag Canada Regional office.

British Columbia: 20333-102B Avenue, Langley, BC, V1M 3H1
Phone: (604) 513-9009 Facsimile: (604) 513-9010

Alberta: 6628 - 45 th. Street, Leduc, AB, T9E 7C9
Phone: (780) 986-4544 Facsimile: (780) 986-1070

Manitoba: 681 Plinquet Street, Winnipeg, MB, R2J 2X2
Phone: (204) 233-3416 Facsimile: (204) 233-7005

Ontario: 43 Jutland Road, Toronto, ON, M8Z 2G6
Phone: (416) 259-8231 Facsimile: (416) 259-6175

Quebec: 2900 Jean Baptiste Des., Lachine, PQ, H8T 1C8
Phone: (514) 636-9230 Facsimile: (514) 636-0877

Atlantic: A-105 Akerley Boulevard, Dartmouth, NS, B3B 1R7
Phone: (902) 468-9690 Facsimile: (902) 468-3085

Prepared By: Regulatory Affairs Group, Brenntag Canada Inc., (416) 259-8231.

SODIUM HYPOCHLORITE SOLUTION STABILITY AND PRODUCT QUALITY CONSIDERATIONS



Sodium hypochlorite is inherently unstable and decomposition of this product is unavoidable. Gradual decomposition, as described here, should not be confused with rapid and dangerous reactions of sodium hypochlorite in the presence of acids or pure ammonia solutions.

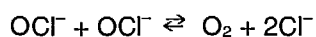
Sodium hypochlorite decomposes and loses strength via two mechanisms (pathways):

- Chlorate (ClO_3^-) formation as follows:



Note: Chlorite (ClO_2^-) is an intermediate product.

- Oxygen formation as follows:



Both of these pathways will occur without catalyst. In the presence of certain catalysts, the rate of decomposition will typically increase. Chlorate ion formation is the predominant decomposition mode while oxygen formation is usually significantly slower. Note that chloride (Cl^-) is also a decomposition by-product.

Chlorate is currently an unregulated inorganic disinfection byproduct (IDBP). Chlorate was once a registered herbicide and there have been reported cases of chlorate poisoning due to ingestion of large quantities. The EPA in the United States is currently undertaking toxicological studies on this inorganic ion. There are indications that chlorate has similar health impacts as chlorite (ClO_2^-) in terms of hemolytic anemia (a blood disorder). It is expected that a chlorate maximum contaminant level (MCL) will be presented by the USEPA in the near future. Currently, there is no practical method of removing chlorate from drinking water.

Oxygen formation is primarily an issue with respect to metering pump facility design. Excessive oxygen 'off-gassing' often results in air-locking of sodium hypochlorite metering pump systems.

As a result of the above, it is important to minimize sodium hypochlorite decomposition from both public health and operations perspectives.

A significant amount of research has been undertaken into the stability of sodium hypochlorite. The major factors affecting product stability are:

- Concentration of the hypochlorite solution.
- pH of the solution.
- Temperature of the solution.
- Presence of trace, catalyzing metals.
- Exposure to light sources.
- Product handling.

Hypochlorite Concentration

Higher hypochlorite concentrations have faster decomposition rates. The loss of OCl^- is typically a second order relationship. As a result, dilution of a sodium hypochlorite solution by a factor of two will increase the half-life by a factor of two. However, due to ionic effects, dilution by a factor of two will decrease the rate of decomposition by a factor five.

pH of the Solution

As described above, stability is promoted with the use of excess caustic. This results in a typical pH of 11.9 to 13. At lower pH (11 or below), decomposition is greatly accelerated by acid catalysis.

As a result, if sodium hypochlorite dilution is practiced at site, it is important to ensure that the target solution has a resulting pH of 12 to 13. Decomposition also starts to accelerate above pH 13 due to higher ionic strength related to the caustic soda.

Temperature of the Solution

Higher solution temperatures increase decomposition. For every 10°C temperature increase the rate of decomposition increases by approximately 3.7 times. Environmental temperature control for the hypochlorite solution storage tank is very important.

Trace Metals

The presence of certain transition metals accelerates the oxygen formation pathway of decomposition. In particular, nickel, copper and cobalt by themselves or in conjunction with other metals such as iron and manganese are a catalyst for increased oxygen generation. These metals are typically associated with the caustic soda used to manufacture the sodium hypochlorite and also water used to dilute the hypochlorite. Secondary sources of metals are the materials of construction used for storage and handling of the solution. These catalytic metals do not accelerate chlorate formation.

The purchaser of the sodium hypochlorite can specify maximum concentrations of these metals in terms of the delivered product.

UV-Light Impact

Exposure of hypochlorite solution to sunlight or other sources of UV radiation accelerates the decomposition of hypochlorite by both the chlorate and oxygen decomposition pathways. Storage location, materials of construction and coatings/linings for storage tanks can be selected to minimize this UV effect.

Product Handling

During sodium hypochlorite handling and pumping, the above noted factors in decomposition may be accelerated by reduced pressure (vacuum lines) and turbulence and mixing.

Extract
Canada Gazette, Part I
December 4, 2004



Extrait
Gazette du Canada, Partie I
Le 4 décembre 2004

**DEPARTMENT OF THE
ENVIRONMENT**

**MINISTÈRE DE
L'ENVIRONNEMENT**

**Notice requiring the preparation and
implementation of pollution prevention
plans for inorganic chloramines and
chlorinated wastewater effluents**

**Avis requérant l'élaboration et l'exécution
de plans de prévention de la pollution à
l'égard des chloramines inorganiques et
des eaux usées chlorées**

DEPARTMENT OF THE ENVIRONMENT

CANADIAN ENVIRONMENTAL PROTECTION ACT, 1999

Notice requiring the preparation and implementation of pollution prevention plans for inorganic chloramines and chlorinated wastewater effluents

Whereas inorganic chloramines and chlorinated wastewater effluents are substances specified on the List of Toxic Substances in Schedule 1 of the *Canadian Environmental Protection Act, 1999*;

Whereas the Minister of the Environment published a Proposed Notice requiring the preparation and implementation of pollution prevention plans for ammonia dissolved in water, inorganic chloramines and chlorinated wastewater effluents in the *Canada Gazette, Part I*, on June 7, 2003;

Whereas persons were given the opportunity to file comments with respect to the Proposed Notice for a comment period of 60 days;

Whereas the Minister has considered all comments received;

MINISTÈRE DE L'ENVIRONNEMENT

LOI CANADIENNE SUR LA PROTECTION DE L'ENVIRONNEMENT (1999)

Avis requérant l'élaboration et l'exécution de plans de prévention de la pollution à l'égard des chloramines inorganiques et des eaux usées chlorées

Attendu que les chloramines inorganiques et les eaux usées chlorées sont des substances figurant sur la Liste des substances toxiques de l'annexe 1 de la *Loi canadienne sur la protection de l'environnement (1999)*;

Attendu que le ministre de l'Environnement a publié un projet d'avis requérant l'élaboration et l'exécution de plans de prévention de la pollution à l'égard de l'ammoniac dissous dans l'eau, des chloramines inorganiques et des eaux usées chlorées dans la *Partie I de la Gazette du Canada* le 7 juin 2003;

Attendu que toute personne a eu la possibilité d'envoyer des commentaires concernant le projet d'avis pendant une période de commentaires de 60 jours;

Attendu que le ministre a considéré tous les commentaires reçus;

Whereas this Notice is issued as an instrument respecting preventive and control action in relation to inorganic chloramines and chlorinated wastewater effluents in application of section 92 of the Act;

And whereas, the Minister has published a *Guideline for the Release of Ammonia Dissolved in Water Found in Wastewater Effluents*;

The Minister of the Environment hereby requires all persons or class of persons described in section 2 of this Notice to prepare and implement a pollution prevention plan in respect of inorganic chloramines and chlorinated wastewater effluents.

STÉPHANE DION
Minister of the Environment

1. Definitions

“Act” means the *Canadian Environmental Protection Act, 1999*.

“effluent” means untreated or treated wastewater that is released from the outfall(s) of a wastewater system, excluding combined sewer overflows from the wastewater system.

“inorganic chloramines” consists of three chemicals that are formed when chlorine and ammonia are combined in water: monochloramine (NH_2Cl), dichloramine (NHC_2) and trichloramine (NC_3).

“representative sampling” means the daily measurement of total residual chlorine concentration in the effluent under normal operating conditions of the wastewater treatment facility.

“surface water” means a lake, pond, marsh, creek, spring, stream, river, estuary or marine body of water, or other surface water-course.

“total residual chlorine”, or TRC, means the concentration of free chlorine and combined chlorine (including inorganic chloramines), expressed as Cl^- .

“wastewater” means a mixture of liquid wastes primarily composed of domestic sewage, that can also include other liquid wastes from industrial, commercial and institutional sources.

“wastewater system” means any works for the collection or treatment and release of wastewater or any part of such works.

2. Person or class of persons required to prepare and implement a pollution prevention plan

This Notice applies to any person who owns a wastewater system at the time of publication of this Notice where the effluent released during either 2004 or 2005 from that system to surface water is greater than or equal to 5 000 m^3 per day, based on an annual average, and where the concentration of total residual chlorine in the effluent released to surface water exceeds 0.02 mg/L in any sample during either 2004 or 2005, based on representative sampling.

3. Activities in relation to which the plan is to be prepared

The Minister requires all persons subject to this Notice to prepare and implement a pollution prevention plan in relation to the use of chlorine or chlorine compounds in wastewater systems and the release of chlorinated effluent to surface water.

Attendu que cet avis est publié comme un instrument concernant les mesures de prévention et de contrôle à l'égard des chloramines inorganiques et des eaux usées chlorées en application de l'article 92 de la Loi;

Et attendu que le ministre a publié une *Ligne directrice sur le rejet de l'ammoniac dissous dans l'eau se trouvant dans les effluents d'eaux usées*;

Le ministre de l'Environnement exige par la présente que toutes personnes ou catégories de personnes, telles qu'elles sont décrites à la section 2 de cet avis, élaborent et exécutent un plan de prévention de la pollution à l'égard des chloramines inorganiques et des eaux usées chlorées.

Le ministre de l'Environnement
STÉPHANE DION

1. Définitions

« chloramines inorganiques » comprend trois substances chimiques formées par la combinaison du chlore et de l'ammoniac dans l'eau : la monochloramine (NH_2Cl), la dichloramine (NHC_2) et la trichloramine (NC_3).

« chlore résiduel total », ou CRT, désigne la concentration de chlore libre et de chlore combiné (incluant les chloramines inorganiques), exprimée en Cl^- .

« eau de surface » désigne un lac, un étang, un marais, un ruisseau, une source, un cours d'eau, une rivière, un estuaire ou un plan d'eau marin, ou tout autre cours d'eau de surface.

« eaux usées » désigne un mélange d'eaux usées, composé principalement d'eau d'égout domestique, qui peut aussi contenir d'autres eaux usées de sources industrielles, commerciales et institutionnelles.

« échantillonnage représentatif » désigne la mesure quotidienne de la concentration de chlore résiduel total dans l'effluent, selon les conditions opérationnelles normales de l'installation de traitement des eaux usées.

« effluent » désigne les eaux usées traitées ou non traitées qui sont rejetées à l'exutoire d'un réseau d'assainissement, en excluant les débordements de réseaux d'égouts unitaires du réseau d'assainissement.

« Loi » désigne la *Loi canadienne sur la protection de l'environnement (1999)*.

« réseau d'assainissement » désigne tous les ouvrages servant à la collecte ou au traitement et au rejet des eaux usées, ou toute partie de ces ouvrages.

2. Personne ou catégorie de personnes qui sont tenues d'élaborer et d'exécuter un plan de prévention de la pollution

Cet avis s'applique à toute personne qui, au moment de la publication de cet avis, possède un réseau d'assainissement dont le rejet annuel moyen d'effluent dans les eaux de surface, soit en 2004 ou en 2005, est supérieur ou égal à 5 000 mètres cubes par jour et où la concentration du chlore résiduel total dans cet effluent est supérieur à 0,02 mg/L dans tout échantillon, soit en 2004 ou en 2005, tel qu'elle est déterminée d'après un échantillonnage représentatif.

3. Activités en fonction desquelles le plan devra être élaboré

Le ministre exige que toutes les personnes assujetties à cet avis élaborent et exécutent un plan de prévention de la pollution en ce qui concerne l'usage du chlore ou de composés chlorés dans les réseaux d'assainissement et le rejet d'effluents chlorés dans les eaux de surface.

4. Factors to be considered in preparing the plan

During the preparation of pollution prevention plans, the Minister requires all persons subject to this Notice to consider the following factors:

(1) Following detailed scientific assessments, inorganic chloramines and chlorinated wastewater effluents were found to be toxic under the Act. As such, these substances were added to the List of Toxic Substances in Schedule 1 of the Act. Persons subject to this Notice shall consider that these substances are "toxic" in accordance with the criteria set out in section 64 of the Act. In addition, the deposit of a deleterious substance of any type in water frequented by fish is prohibited by the *Fisheries Act*, under subsection 36(3), unless there is a regulation under subsection 36(5) of the *Fisheries Act* or under another federal law authorizing the deposit. With respect to inorganic chloramines and chlorinated wastewater effluents, there is no federal regulation at time of publication. Refer to section 15 of this Notice for links to the *Fisheries Act* and Compliance and Enforcement Policies of the *Fisheries Act* and the Act.

(2) "Pollution prevention", as defined in section 3 of the Act, means the use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste and reduce the overall risk to the environment or human health. Pollution prevention planning is a means of addressing the release, to the environment, of toxic substances or other pollutants. The result of pollution prevention planning is the implementation of preventive and/or control actions. In order to achieve the risk management objective set out in subsection 4(3), persons subject to this Notice shall consider the following activities when preparing and implementing their pollution prevention plans:

(a) Conducting process audits for chlorine by June 15, 2006, and implementing actions based on the audit findings by December 15, 2008, that minimize the use and release of chlorine or chlorine compounds. Refer to section 15 of this Notice for links to technical guidance.

(b) Implementing dechlorination or alternative disinfection technologies. Refer to section 15 of this Notice for links to technical guidance.

(3) The risk management objective for this Notice is to achieve and maintain a concentration of total residual chlorine that is less than or equal to 0.02 mg/L in the effluent released to surface water by December 15, 2009.

(4) The Canadian Council of Ministers of the Environment (CCME) agreed in November 2003 to develop a Canada-wide Strategy for the management of municipal wastewater effluents, which will address specific parameters and governance. The Strategy will be based on the following three cornerstones:

(a) harmonization of the regulatory framework;

(b) co-ordinated science and research; and

(c) an environmental risk management model.

The Strategy is expected to be completed by December 2006, after which it will be implemented by each jurisdiction. Environment Canada intends to use regulations under the *Fisheries Act* as its principal implementation tool to achieve effluent standards for wastewater treatment systems equivalent in performance to conventional secondary treatment, with additional treatment where required. The regulations will also address wastewater systems on federal and aboriginal lands. Refer to section 15 of this Notice for links to the CCME Web site and information on the Canada-wide Strategy.

(5) In order to ensure that the overall risk to the environment or human health is reduced, the pollution prevention plan prepared for this Notice should include, where relevant,

4. Facteurs à considérer lors de l'élaboration du plan

Le ministre exige que toutes les personnes assujetties à cet avis considèrent les facteurs suivants lors de l'élaboration de leur plan de prévention de la pollution :

(1) À la suite d'évaluations scientifiques approfondies, les chloramines inorganiques et les eaux usées chlorées ont été déclarées comme substances toxiques en vertu de la Loi. À ce titre, ces substances ont été ajoutées à la Liste des substances toxiques de l'annexe 1 de la Loi. Les personnes assujetties à cet avis doivent considérer que ces substances sont « toxiques » selon les critères établis à l'article 64 de la Loi. De plus, le dépôt d'une substance nocive dans les eaux où vivent les poissons est interdit par le paragraphe 36(3) de la *Loi sur les pêches* à moins qu'il n'y ait un règlement qui l'autorise, soit en vertu du paragraphe 36(5) de cette même loi ou d'une autre loi fédérale. En ce qui concerne le rejet des chloramines inorganiques et des eaux usées chlorées, il n'existe aucun règlement fédéral au moment de la publication de cet avis. Les adresses Internet des sites d'information sur la *Loi sur les pêches* et les politiques de conformité et d'application des dispositions de cette loi ainsi que de la *Loi canadienne sur la protection de l'environnement* (1999) se trouvent à l'article 15 de cet avis.

(2) La « prévention de la pollution », au sens de l'article 3 de la Loi, désigne l'utilisation de procédés, de pratiques, de matériaux, de produits, de substances ou de formes d'énergie qui, d'une part, empêchent ou réduisent au minimum la création de polluants et de déchets, et d'autre part, réduisent les risques d'atteinte à l'environnement ou à la santé humaine. La planification de la prévention de la pollution constitue un moyen de diminuer le rejet de substances toxiques ou d'autres polluants dans l'environnement. Le résultat de la planification de la prévention de la pollution comporte l'exécution de mesures préventives ou de contrôle. Afin d'atteindre l'objectif de gestion des risques, tel qu'il est décrit au paragraphe 4(3) de cet avis, les personnes assujetties à cet avis doivent considérer les activités suivantes lors de l'élaboration et de l'exécution de leur plan de prévention de la pollution :

a) Entreprendre des vérifications de procédés pour le chlore d'ici le 15 juin 2006 et mettre en œuvre des mesures basées sur les conclusions des vérifications qui minimisent l'utilisation et le rejet de chlore et de composés chlorés d'ici le 15 décembre 2008. Une liste de sites Internet ayant des informations techniques se trouve à l'article 15 de cet avis.

b) Appliquer des techniques de déchloration ou techniques alternatives de désinfection. Se référer à l'article 15 de cet avis pour consulter une liste de sites Internet présentant des documents techniques sur les options de prévention et de contrôle disponibles.

(3) L'objectif de gestion des risques de cet avis est d'atteindre et de maintenir une concentration de chlore résiduel total inférieure ou égale à 0,02 mg/L dans l'effluent rejeté dans les eaux de surface d'ici le 15 décembre 2009.

(4) Le Conseil canadien des ministres de l'environnement (CCME) a convenu en novembre 2003 d'élaborer une stratégie pancanadienne pour la gestion des effluents d'eaux usées municipales qui portera sur l'élaboration de paramètres spécifiques et sur des questions de gouvernance. La stratégie se fondera sur les trois pierres angulaires suivantes :

a) l'harmonisation du cadre réglementaire;

b) la coordination de la science et de la recherche;

c) un modèle de gestion des risques environnementaux.

On prévoit que la stratégie sera complétée d'ici décembre 2006, ce après quoi elle sera mise en œuvre par chaque instance. Environnement Canada a l'intention d'utiliser un

prevention and control actions that address risks posed by other substances that may be found in municipal wastewater effluent, in particular, the following substances which are specified in Schedule 1 of the Act:

- (a) nonylphenol and its ethoxylates;
- (b) effluents from textile mills that use wet processing;
- (c) mercury;
- (d) lead;
- (e) hexavalent chromium compounds;
- (f) inorganic cadmium compounds;
- (g) inorganic arsenic compounds; and
- (h) ammonia dissolved in water.

5. Period within which the pollution prevention plan is to be prepared

The Minister requires that the pollution prevention plan be prepared and implementation be initiated by June 15, 2007.

6. Period within which the pollution prevention plan is to be implemented

The Minister requires that the pollution prevention plan be implemented by June 15, 2010.

7. Content of the pollution prevention plan

Persons preparing the pollution prevention plan are to determine the appropriate content of their own plan; however, the plan must meet all the requirements of this Notice. It must also contain the information required to file the Declaration of Preparation referred to in section 9 and have the capacity to generate the information required to file the Declaration of Implementation referred to in section 10.

8. Requirement to keep plan

Under section 59 of the Act, all persons identified in section 2 shall keep a copy of the pollution prevention plan at the place in Canada in relation to which the pollution prevention plan is prepared. Where a single plan is prepared for more than one wastewater system, a copy of that plan must be kept at each location.

9. Declaration of Preparation

Under subsection 58(1) of the Act, persons identified in section 2 shall file, within 30 days after the end of the period for the preparation of the pollution prevention plan specified in section 5 or extended under section 13, a written *Declaration That a Pollution Prevention Plan Has Been Prepared and Is Being Implemented — Inorganic Chloramines and Chlorinated Wastewater Effluents*, using the form given in Schedule 1 of this Notice, to the Minister. Where a person has prepared a single plan for more than

règlement en vertu de la *Loi sur les pêches* comme son principal outil d'exécution afin que les réseaux d'assainissement atteignent des normes qui seront équivalentes, en performance, au rendement du traitement secondaire conventionnel, avec un traitement supplémentaire au besoin. Le règlement tiendra compte des systèmes d'eaux usées se trouvant sur les terres fédérales et autochtones. L'adresse Internet du site d'information sur la stratégie pancanadienne du CCME se trouve à l'article 15 de cet avis.

(5) Pour s'assurer de réduire le risque global pour l'environnement ou la santé humaine, le plan de prévention de la pollution élaboré pour répondre à cet avis devrait comprendre, s'il y a lieu, des mesures de prévention et de contrôle visant les risques posés par d'autres substances qui peuvent se trouver dans les effluents d'eaux usées municipales, en particulier les substances suivantes figurant à l'annexe 1 de la Loi :

- a) le nonylphénol et ses dérivés éthoxylés;
- b) les effluents des usines de textile qui utilisent des procédés de traitement au mouillé;
- c) le mercure;
- d) le plomb;
- e) les composés de chrome hexavalent;
- f) les composés inorganiques de cadmium;
- g) les composés inorganiques d'arsenic;
- h) l'ammoniac dissous dans l'eau.

5. Délai imparti pour l'élaboration du plan de prévention de la pollution

Le ministre exige que le plan de prévention de la pollution soit élaboré et que l'exécution en soit commencée au plus tard le 15 juin 2007.

6. Délai imparti pour l'exécution du plan de prévention de la pollution

Le ministre exige que l'exécution du plan de prévention de la pollution soit exécutée au plus tard le 15 juin 2010.

7. Contenu du plan de prévention de la pollution

Les personnes chargées de l'élaboration du plan doivent en déterminer le contenu; toutefois, le plan doit satisfaire à toutes les exigences de cet avis. Il doit également inclure les informations exigées pour déposer la déclaration confirmant l'élaboration à laquelle l'article 9 se réfère et pouvoir générer les informations exigées pour déposer la déclaration confirmant l'exécution à laquelle l'article 10 se réfère.

8. Obligation de conserver une copie du plan

En vertu de l'article 59 de la Loi, les personnes identifiées à l'article 2 de cet avis doivent conserver une copie du plan de prévention de la pollution au lieu, au Canada, en faisant l'objet. Lorsqu'un seul plan est élaboré pour plusieurs réseaux d'assainissement, une copie de ce plan doit être conservée à l'emplacement de chacun des réseaux d'assainissement en faisant objet.

9. Déclaration confirmant l'élaboration

En vertu du paragraphe 58(1) de la Loi, les personnes identifiées à l'article 2 doivent déposer par écrit auprès du ministre, dans les 30 jours suivant la fin du délai fixé à l'article 5 pour l'élaboration du plan ou, selon le cas, prorogé en vertu de l'article 13, une *Déclaration confirmant qu'un plan de prévention de la pollution a été élaboré et qu'il est en cours d'exécution — chloramines inorganiques et eaux usées chlorées*, en utilisant le formulaire fourni à l'annexe 1 de cet avis. Dans le cas où une

one wastewater system, a separate Declaration of Preparation must be filed for each of those systems. Section 17 provides further information on completing and filing this form.

10. Declaration of Implementation

Under subsection 58(2) of the Act, persons identified in section 2 shall file, within 30 days after the completion of the implementation of the plan specified in section 6 or extended under section 13, a written *Declaration That a Pollution Prevention Plan Has Been Implemented — Inorganic Chloramines and Chlorinated Wastewater Effluents*, using the form given in Schedule 5 of this Notice, to the Minister. Where a person has prepared a single plan for more than one wastewater system, a separate Declaration of Implementation must be filed for each of those systems. Section 17 provides further information on completing and filing this form.

11. Filing of amended declarations

Under subsection 58(3) of the Act, where a person specified in section 2 has filed a declaration under section 9 or 10, and the declaration contains information which, at any time after the filing, has become false or misleading, that person shall file an amended declaration to the Minister within 30 days after the time that the information became false or misleading, using the appropriate form referred to in section 9 or 10.

12. Use of a plan prepared or implemented for another purpose

Under subsection 57(1) of the Act, a person may use an existing pollution prevention plan or other plan in respect of pollution prevention prepared or implemented for another purpose to satisfy the requirements of sections 2 to 8 of this Notice. Under subsection 57(2) of the Act, where a person uses a plan that does not meet all the requirements of this Notice, the person shall amend the plan so that it meets all of those requirements or prepare an additional plan that meets the remainder of those requirements. Persons using existing plans must nonetheless file a Declaration of Preparation under section 9, a Declaration of Implementation under section 10, and any amended declarations under section 11.

13. Extension of time

Under subsection 56(3) of the Act, where the Minister is of the opinion that further time is necessary to prepare the plan as specified in section 5 or to implement the plan as specified in section 6, the Minister may extend the period for a person who submits a written *Request for Time Extension — Inorganic Chloramines and Chlorinated Wastewater Effluents*, using the form given in Schedule 3 of this Notice, before the expiry of the date referred to in the applicable section 5 or section 6 or before the expiry of any extended period. Section 17 provides further information on completing and filing this form.

14. Application for waiver of factors to consider

Under subsection 56(5) of the Act, the Minister may waive the requirement for a person to consider a factor specified in section 4 where the Minister is of the opinion that it is not reasonable or practicable to consider that factor on the basis of reasons provided by that person when submitting a written *Request for Waiver of the Requirement to Consider a Factor or Factors — Inorganic*

personne a élaboré un plan unique pour plus d'un réseau d'assainissement, une déclaration confirmant l'élaboration séparée doit être déposée pour chacun des réseaux. Les détails sur la façon de produire et de déposer ce formulaire se trouvent à l'article 17.

10. Déclaration confirmant l'exécution

En vertu du paragraphe 58(2) de la Loi, les personnes identifiées à l'article 2 doivent déposer par écrit auprès du ministre, dans les 30 jours suivant la fin de la période de l'exécution du plan comme prescrit à l'article 6 ou, selon le cas, prorogé en vertu de l'article 13, une *Déclaration confirmant l'exécution d'un plan de prévention de la pollution — chloramines inorganiques et eaux usées chlorées*, en utilisant le formulaire fourni à l'annexe 5 de cet avis. Dans le cas où une personne a élaboré un plan unique pour plus d'un réseau d'assainissement, une déclaration confirmant l'exécution doit être déposée individuellement pour chacun des systèmes. Les détails sur la façon de produire et de déposer ce formulaire se trouvent à l'article 17.

11. Dépôt d'une déclaration corrective

En vertu du paragraphe 58(3) de la Loi, lorsqu'une personne, telle qu'elle est identifiée à l'article 2 de cet avis, dépose une déclaration confirmant l'élaboration ou l'exécution dont il est question à l'article 9 ou 10, et que la déclaration contient des renseignements qui deviennent faux ou trompeurs à une date ultérieure, cette personne doit déposer auprès du ministre une déclaration corrective dans un délai de 30 jours de la date où les renseignements sont devenus faux ou trompeurs, en utilisant le formulaire approprié mentionné à l'article 9 ou 10, selon le cas.

12. Utilisation d'un plan élaboré ou exécuté à une autre fin

En vertu du paragraphe 57(1) de la Loi, une personne peut utiliser un plan de prévention de la pollution déjà élaboré ou exécuté à d'autres fins pour satisfaire aux exigences des articles 2 à 8 de cet avis. En vertu du paragraphe 57(2) de la Loi, lorsqu'une personne utilise un plan qui ne répond pas à toutes les exigences de cet avis, cette personne doit modifier le plan afin qu'il réponde à toutes ces exigences ou élaborer un plan complémentaire qui satisfait aux exigences non remplies. Une personne qui utilise un plan existant doit néanmoins déposer une déclaration confirmant l'élaboration conformément à l'article 9, une déclaration confirmant l'exécution conformément à l'article 10 et, le cas échéant, toute déclaration corrective dont il est question à l'article 11.

13. Prorogation du délai

En vertu du paragraphe 56(3) de la Loi, lorsque le ministre estime qu'un délai plus long est nécessaire pour l'élaboration du plan, tel qu'il est précisé à l'article 5, ou pour l'exécution du plan, tel qu'il est précisé à l'article 6, le ministre peut proroger le délai pour une personne qui présente par écrit une *Demande de prorogation du délai — chloramines inorganiques et eaux usées chlorées*, en utilisant le formulaire fourni à l'annexe 3 de cet avis, avant la date dont il est question à l'article 5 ou à l'article 6 ou avant l'expiration de toute autre prorogation de délai. Les détails sur la façon de produire et de déposer ce formulaire se trouvent à l'article 17.

14. Demande de dérogation à l'obligation de prendre en considération certains facteurs

En vertu du paragraphe 56(5) de la Loi, lorsque le ministre estime qu'il est déraisonnable ou impossible de tenir compte d'un facteur précisé à l'article 4, le ministre peut approuver une dérogation à l'obligation de tenir compte de ce facteur pour une personne qui présente par écrit une *Demande de dérogation à l'obligation de prendre en considération certains facteurs —*

Chloramines and Chlorinated Wastewater Effluents, using the form given in Schedule 2 of this Notice. Such a request must be made before June 15, 2007, or before the expiry of any extended period. Section 17 provides further information on completing and filing this form.

15. Additional information

Environment Canada has published a *Guideline for the Release of Ammonia Dissolved in Water Found in Wastewater Effluents*. To obtain a copy of the Guideline, refer to the CEPA Registry Web site at www.ec.gc.ca/ceparegistry.

To obtain a copy of the document *Review of Municipal Sewage Effluent Chlorination/Dechlorination Principles, Technologies and Practices* (November 2003), refer to Environment Canada's Georgia Basin Web site at www.pyr.ec.gc.ca/georgiabasin/reports_e.htm.

To obtain a copy of the document *U.V. Guidance Manual for Municipal Wastewater Treatment Plants in Canada* (October 2003), refer to the Great Lakes Sustainability Fund Web site at <http://sustainabilityfund.gc.ca> or contact the Manager, Great Lakes Sustainability Fund, 867 Lakeshore Road, Burlington, Ontario L7R 4A6, (905) 336-6273.

To obtain a copy of the document *Guidance Manual for Sewage Treatment Plant Process Audits*, refer to the Great Lakes Sustainability Fund Web site at <http://sustainabilityfund.gc.ca> or contact the Manager, Great Lakes Sustainability Fund, 867 Lakeshore Road, Burlington, Ontario L7R 4A6, (905) 336-6273.

To obtain a copy of the *Fisheries Act*, refer to the Department of Justice Web site at <http://laws.justice.gc.ca/en/f-14>. For more information on the compliance and enforcement policies of the *Fisheries Act* and the *Canadian Environmental Protection Act, 1999*, visit the Environmental Law Enforcement Web site at www.ec.gc.ca/ele-ale/policies/policies_e.asp.

Additional information on pollution prevention and preparing pollution prevention plans is available from the National Office of Pollution Prevention Web site at www.ec.gc.ca/nopp, the Canadian Pollution Prevention Information Clearinghouse Web site at www.ec.gc.ca/cppic, and Environment Canada's regional offices.

To obtain information regarding the CCME Canada-wide strategy for the management of municipal wastewater effluents, visit the CCME Web site at www.ccme.ca/initiatives/water.html?category_id=81.

16. Reference code

For administrative purposes, all communication with Environment Canada concerning this Notice shall refer to the following reference code: P2CLMWWE.

17. Declarations and forms

Declarations and forms referred to in this Notice are available from and are to be submitted to

National Office of Pollution Prevention
c/o CEPA Implementation and Innovation Division
Environment Canada
351 Saint-Joseph Boulevard, 13th Floor
Gatineau, Quebec K1A 0H3

Alternatively, the forms can be completed electronically at the Web site listed below.

chloramines inorganiques et eaux usées chlorées, en utilisant le formulaire fourni à l'annexe 2 de cet avis. Une telle demande doit être faite avant le 15 juin 2007 ou avant l'expiration de tout délai prorogé. Les détails sur la façon de produire et de déposer ce formulaire se trouvent à l'article 17.

15. Information supplémentaire

Environnement Canada a publié une *Ligne directrice sur le rejet de l'ammoniac dissous dans l'eau se trouvant dans les effluents d'eaux usées*. Pour obtenir une copie de cette ligne directrice, visitez le site Web du Registre de la LCPE à l'adresse www.ec.gc.ca/RegistreLCPE.

Pour obtenir une copie du document *Examen des principes, des techniques et des procédés de chloration et de déchloration des effluents des eaux usées municipales* (novembre 2003), visitez le site Web du Bassin de Georgia d'Environnement Canada à l'adresse www.pyr.ec.gc.ca/georgiabasin/reports_F.htm.

Pour obtenir une copie du document *Technologie de la désinfection par rayonnement ultraviolet appliquée aux usines de traitement des eaux usées municipales au Canada* (octobre 2003), visitez le site Web du Fonds de durabilité des Grands Lacs à l'adresse <http://sustainabilityfund.gc.ca> ou communiquez avec le Gestionnaire, Fonds de durabilité des Grands Lacs, 867, chemin Lakeshore, Burlington (Ontario) L7R 4A6, (905) 336-6273.

Pour obtenir une copie du document *Guide relatif aux vérifications des procédés des usines de traitement des eaux usées*, visitez le site Web du Fonds de durabilité des Grands Lacs à l'adresse <http://sustainabilityfund.gc.ca> ou communiquez avec le Gestionnaire, Fonds de durabilité des Grands Lacs, 867, chemin Lakeshore, Burlington (Ontario) L7R 4A6, (905) 336-6273.

Pour obtenir une copie de la *Loi sur les pêches*, visitez le site Web suivant : <http://lois.justice.gc.ca/fr/F-14>. Pour obtenir plus d'information sur les politiques de conformité et d'application des dispositions de la *Loi sur les pêches* et de la *Loi canadienne sur la protection de l'environnement (1999)*, visitez le site Web de l'application des lois sur l'environnement à l'adresse www.ec.gc.ca/ele-ale/policies/policies_f.asp.

De l'information supplémentaire sur la prévention de la pollution et la préparation de plans de la prévention de la pollution est disponible sur le site Web du Bureau national de la prévention de la pollution (www.ec.gc.ca/nopp) et sur celui du Centre canadien d'information sur la prévention de la pollution (www.ec.gc.ca/cppic), ainsi qu'aux bureaux régionaux d'Environnement Canada.

Pour obtenir de l'information concernant la stratégie pancanadienne du CCME sur la gestion des effluents d'eaux usées municipales, visitez le site Web du CCME à l'adresse www.ccme.ca/initiatives/water.fr.html?category_id=81.

16. Code de référence

À des fins administratives, toutes les communications adressées à Environnement Canada au sujet de cet avis doivent mentionner le code de référence suivant : P2CLMWWE.

17. Déclarations et formulaires

Les déclarations et les formulaires dont il est question dans cet avis sont disponibles, et devront être soumis, à l'adresse suivante :

Bureau national de la prévention de la pollution
Division de l'innovation et de la mise en œuvre de la LCPE
Environnement Canada
351, boulevard Saint-Joseph, 13^e étage
Gatineau (Québec) K1A 0H3

De plus, les formulaires peuvent être remplis électroniquement sur le site Internet mentionné ci-dessous.

Electronic copies of this Notice and the instructions for completing the declarations and forms (Schedules 1 to 5) are available from the National Office of Pollution Prevention Web site, at www.ec.gc.ca/nopp/p2p/en/p2notices.cfm or can be requested by telephone at (819) 994-0186, by facsimile at (819) 953-7970, or by electronic mail at cepap2plans@ec.gc.ca.

The Minister of the Environment intends to publish, in part, the information submitted in response to this Notice on Environment Canada's Green Lane Web site. All persons submitting information to the Minister are entitled to submit a request under section 313 of the Act that specific information be treated as confidential.

18. Environment Canada contact information

For residents of Newfoundland and Labrador

Environmental Protection Branch – Atlantic Region
Environment Canada
6 Bruce Street
Mount Pearl, Newfoundland and Labrador A1N 4T3
Telephone: (709) 772-5491
Facsimile: (709) 772-5097

For residents of Prince Edward Island

Environmental Protection Branch – Atlantic Region
Environment Canada
97 Queen Street, Room 202
Charlottetown, Prince Edward Island C1A 4A9
Telephone: (902) 566-7043
Facsimile: (902) 566-7279

For residents of Nova Scotia

Environmental Protection Branch – Atlantic Region
Environment Canada
Queen Square, 16th Floor
45 Alderney Drive
Dartmouth, Nova Scotia B2Y 2N6
Telephone: (902) 426-8926
Facsimile: (902) 426-3897

For residents of New Brunswick

Environmental Protection Branch – Atlantic Region
Environment Canada
77 Westmorland Street, Suite 450
Fredericton, New Brunswick E3B 6Z3
Telephone: (506) 452-3286
Facsimile: (506) 452-3003

For residents of Quebec

Environmental Protection Branch – Quebec Region
Environment Canada
105 McGill Street, 4th Floor
Montréal, Quebec H2Y 2E7
Telephone: (514) 283-4670
Facsimile: (514) 283-4423

For residents of Ontario

Environmental Protection Branch – Ontario Region
Environment Canada
4905 Dufferin Street
Downsview, Ontario M3H 5T4
Telephone: (416) 739-5888
Facsimile: (416) 739-4342

Une copie électronique de cet avis ainsi que les directives nécessaires pour remplir les déclarations et les formulaires (annexes 1 à 5) sont disponibles sur le site Web du Bureau national de la prévention de la pollution à l'adresse www.ec.gc.ca/nopp/p2p/FR/p2notices.cfm ou peuvent être obtenues par téléphone au (819) 994-0186, par télécopieur au (819) 953-7970, ou par courriel à l'adresse cepap2plans@ec.gc.ca.

Le ministre de l'Environnement a l'intention de publier, en partie, les informations présentées en réponse à cet avis sur le site Web de la Voie verte d'Environnement Canada. Toute personne présentant des informations au ministre peut soumettre une demande en vertu de l'article 313 de la Loi, afin que certaines informations spécifiques soient traitées de façon confidentielle.

18. Bureaux d'information d'Environnement Canada

Pour les résidents de Terre-Neuve-et-Labrador

Direction de la protection de l'environnement — Région de l'Atlantique
Environnement Canada
6, rue Bruce
Mount Pearl (Terre-Neuve-et-Labrador) A1N 4T3
Téléphone : (709) 772-5491
Télécopieur : (709) 772-5097

Pour les résidents de l'Île-du-Prince-Édouard

Direction de la protection de l'environnement — Région de l'Atlantique
Environnement Canada
97, rue Queen, Pièce 202
Charlottetown (Île-du-Prince-Édouard) C1A 4A9
Téléphone : (902) 566-7043
Télécopieur : (902) 566-7279

Pour les résidents de la Nouvelle-Écosse

Direction de la protection de l'environnement — Région de l'Atlantique
Environnement Canada
Queen Square, 16^e étage
45, promenade Alderney
Dartmouth (Nouvelle-Écosse) B2Y 2N6
Téléphone : (902) 426-8926
Télécopieur : (902) 426-3897

Pour les résidents du Nouveau-Brunswick

Direction de la protection de l'environnement — Région de l'Atlantique
Environnement Canada
77, rue Westmorland, Bureau 450
Fredericton (Nouveau-Brunswick) E3B 6Z3
Téléphone : (506) 452-3286
Télécopieur : (506) 452-3003

Pour les résidents du Québec

Direction de la protection de l'environnement — Région du Québec
Environnement Canada
105, rue McGill, 4^e étage
Montréal (Québec) H2Y 2E7
Téléphone : (514) 283-4670
Télécopieur : (514) 283-4423

Pour les résidents de l'Ontario

Direction de la protection de l'environnement — Région de l'Ontario
Environnement Canada
4905, rue Dufferin
Downsview (Ontario) M3H 5T4
Téléphone : (416) 739-5888
Télécopieur : (416) 739-4342

For residents of Manitoba

Environmental Protection Branch – Prairie and Northern Region
Environment Canada
123 Main Street
Winnipeg, Manitoba R3C 4W2
Telephone: (204) 983-4811
Facsimile: (204) 983-0960

For residents of Saskatchewan

Environmental Protection Branch – Prairie and Northern Region
Environment Canada
300-2365 Albert Street
Regina, Saskatchewan S4P 4K1
Telephone: (306) 780-6390
Facsimile: (306) 780-6466

For residents of Alberta

Environmental Protection Branch – Prairie and Northern Region
Environment Canada
4999 98th Avenue
Edmonton, Alberta T6B 2X3
Telephone: (780) 951-8860
Facsimile: (780) 495-4099

For residents of the Northwest Territories and Nunavut

Environmental Protection Branch – Prairie and Northern Region
Environment Canada
301-5204 50th Avenue
Yellowknife, Northwest Territories X1A 1E2
Telephone: (867) 669-4725
Facsimile: (867) 873-8185

For residents of British Columbia

Environmental Protection Branch – Pacific and Yukon Region
Environment Canada
201-401 Burrard Street
Vancouver, British Columbia V6C 3S5
Telephone: (604) 666-2799
Facsimile: (604) 666-9107

For residents of Yukon

Environmental Protection Branch – Pacific and Yukon Region
Environment Canada
91782 Alaska Highway
Whitehorse, Yukon Territory Y1A 5B7
Telephone: (867) 667-3401
Facsimile: (867) 667-7962

Environment Canada Headquarters

Environmental Technology Advancement Directorate
Environmental Protection Service
Place Vincent Massey
351 Saint-Joseph Boulevard
Gatineau, Quebec K1A 0H3
Telephone: (819) 953-8074
Facsimile: (819) 953-7253

Pour les résidents du Manitoba

Direction de la protection de l'environnement — Région des Prairies et du Nord
Environnement Canada
123, rue Main
Winnipeg (Manitoba) R3C 4W2
Téléphone : (204) 983-4811
Télécopieur : (204) 983-0960

Pour les résidents de la Saskatchewan

Direction de la protection de l'environnement — Région des Prairies et du Nord
Environnement Canada
2365, rue Albert, Bureau 300
Regina (Saskatchewan) S4P 4K1
Téléphone : (306) 780-6390
Télécopieur : (306) 780-6466

Pour les résidents de l'Alberta

Direction de la protection de l'environnement — Région des Prairies et du Nord
Environnement Canada
4999 98th Avenue
Edmonton (Alberta) T6B 2X3
Téléphone : (780) 951-8860
Télécopieur : (780) 495-4099

Pour les résidents des Territoires du Nord-Ouest et du Nunavut

Direction de la protection de l'environnement — Région des Prairies et du Nord
Environnement Canada
5204 50th Avenue, Bureau 301
Yellowknife (Territoires du Nord-Ouest) X1A 1E2
Téléphone : (867) 669-4725
Télécopieur : (867) 873-8185

Pour les résidents de la Colombie-Britannique

Direction de la protection de l'environnement — Région du Pacifique et du Yukon
Environnement Canada
401, rue Burrard, Bureau 201
Vancouver (Colombie-Britannique) V6C 3S5
Téléphone : (604) 666-2799
Télécopieur : (604) 666-9107

Pour les résidents du Yukon

Direction de la protection de l'environnement — Région du Pacifique et du Yukon
Environnement Canada
91782, route de l'Alaska
Whitehorse (Territoire du Yukon) Y1A 5B7
Téléphone : (867) 667-3401
Télécopieur : (867) 667-7962

Bureau national d'Environnement Canada

Direction générale pour l'avancement de la technologie environnementale
Service de la protection de l'environnement
Place-Vincent-Massey
351, boulevard Saint-Joseph
Gatineau (Québec) K1A 0H3
Téléphone : (819) 953-8074
Télécopieur : (819) 953-7253

EXPLANATORY NOTE

NOTE EXPLICATIVE

(This note is not part of the Notice.)

(Cette note ne fait pas partie de l'avis.)

Compliance

Compliance with the Act is mandatory under subsection 272(1) of the Act. Subsection 272(2) of the Act defines the penalties for persons who commit offenses under the Act. Subsections 273(1) and 273(2) further outline the terms and penalties of those persons providing false or misleading information. Penalties under subsections 272(2) and 273(2) include fines of not more than \$1,000,000, imprisonment for a term of not more than three years, or both.

For additional information on the Act and the *Compliance and Enforcement Policy for the Canadian Environmental Protection Act, 1999* and on applicable penalties, please contact the Enforcement Branch at (819) 953-0331. The Policy is available at www.ec.gc.ca/ceparegistry/enforcement.

Conformité

En vertu du paragraphe 272(1), la conformité à la Loi est obligatoire. Le paragraphe 272(2) de la Loi détermine les peines applicables pour quiconque commet une infraction en vertu de la Loi. De plus, les paragraphes 273(1) et 273(2) déterminent les peines applicables à quiconque communique des renseignements faux ou trompeurs. Les paragraphes 272(2) et 273(2) édictent qu'une amende maximale d'un million de dollars et un emprisonnement maximal de trois ans, ou que l'une de ces peines, peuvent être imposés.

Pour tout renseignement additionnel sur la LCPE (1999), la *Politique d'application de la Loi canadienne sur la protection de l'environnement (1999)* et les peines applicables, veuillez communiquer avec la Direction de l'application de la loi au (819) 953-0331. La politique est disponible sur Internet à l'adresse suivante : www.ec.gc.ca/RegistreLCPE/enforcement.

Note: Please contact the National Office of Pollution Prevention for more information about electronic reporting or the filing of paper forms.

Schedule 1: Declaration That a Pollution Prevention Plan Has Been Prepared and Is Being Implemented – Inorganic Chloramines and Chlorinated Wastewater Effluents (Subsection 58(1) of CEPA 1999)

Notice Reference Code: P2CLMWWE

Please refer to the instruction booklet "Instructions for Completing the Schedules of the *Canada Gazette* Notice Requiring the Preparation and Implementation of Pollution Prevention Plans for Inorganic Chloramines and Chlorinated Wastewater Effluents" for guidance on how to complete this Declaration.

Electronic copies of the Notice, and the instructions for completing the declarations (Schedules 1 to 5), are available from the National Office of Pollution Prevention Web site at www.ec.gc.ca/nopp/p2p/en/p2pnotices.cfm or can be requested by telephone at (819) 994-0186, by facsimile at (819) 953-7970, or by e-mail at CEPAP2Plans@ec.gc.ca.

Is this an amendment to a Declaration previously submitted? ☐ Yes ☐ No

If yes, complete Parts 1.0 and 9.0 and any other Parts of this Declaration where previously reported information has become false or misleading. Previously reported information that is unchanged need not be resubmitted.

1.0 Information on the Person or Class of Persons Subject to the Notice

Name of the Person or Class of Persons Subject to the Notice: _____

Facility Name: _____

Street Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

Telephone Number: _____ E-mail (if available): _____
(with area code)

If different from Street Address
Mailing Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

National Pollutant Release Inventory ID (if no ID, leave blank): _____

Six-digit North American Industry Classification System (NAICS) Code: 221320

Facility Technical Contact: _____

E-mail (if available): _____

Telephone Number: _____ Fax Number (if available): _____
(with area code) (with area code)

2.0 Use of Plans Prepared or Implemented for Another Purpose

Is the pollution prevention plan used to fulfill the obligations of the Notice

- a pollution prevention plan that was previously prepared on a voluntary basis? ☐ Yes ☐ No
- a pollution prevention plan that was previously prepared for another government or under another Act of Parliament?
☐ Yes ☐ No

If yes, identify the other government requirement(s) or Act(s) of Parliament.

3.0 Substance and Activity**Substance and Activity for which information is required**

Inorganic Chloramines and Chlorinated Wastewater Effluents: Persons identified in section 2 of the Notice who are required to prepare and implement a pollution prevention plan for inorganic chloramines and chlorinated wastewater effluents for the use of chlorine or chlorine compounds in wastewater systems and the release of chlorinated wastewater effluent to surface water.

4.0 Baseline Information Prior to Implementation of the Pollution Prevention (P2) Plan

This Declaration requires reporting of data from the Preparation Year, either 2004 or 2005 (January 1 to December 31).

If the person(s) subject to the Notice has been granted a time extension to prepare a plan that requires reporting for a year other than 2004 or 2005, all references to 2004 or 2005 in this Declaration are considered to represent the new Preparation Year for which the person(s) is(are) required to report.

If applicable, indicate the new Preparation Year for which the person(s) is(are) reporting: _____

4.1 - 4.4 No information required for Parts 4.1 to 4.4 of this Declaration**4.5 Additional Baseline Information****4.5.1 Wastewater System Information**

This section requires reporting of information on the wastewater system in place for 2004 or 2005. Check whichever of the following boxes apply to your system. Note that more than one box in each section may apply.

No Treatment

- ☐ No Treatment (e.g. collection system with release to surface water)

Preliminary Treatment

- | | |
|---------------------------------------|---|
| <input type="checkbox"/> None | <input type="checkbox"/> Skimming |
| <input type="checkbox"/> Grit Removal | <input type="checkbox"/> Other (describe) _____ |
| <input type="checkbox"/> Screening | |

Physical/Chemical Primary Treatment

- | | |
|--|---|
| <input type="checkbox"/> None | <input type="checkbox"/> Chemical Flocculation |
| <input type="checkbox"/> Primary Sedimentation/Clarification | <input type="checkbox"/> Other (describe) _____ |

Biological or Secondary Treatment – Mechanical Systems (some systems may have more than one kind of treatment)

- | | |
|---|--|
| <input type="checkbox"/> None | <input type="checkbox"/> Oxidation Ditch |
| <input type="checkbox"/> Conventional Activated Sludge | <input type="checkbox"/> Trickling Filter |
| <input type="checkbox"/> Extended Aeration Activated Sludge | <input type="checkbox"/> Rotating Biological Contactor (RBC) |
| <input type="checkbox"/> Pure Oxygen Activated Sludge | <input type="checkbox"/> Sequencing Batch Reactor (SBR) |
| <input type="checkbox"/> Other Activated Sludge | <input type="checkbox"/> Other (describe) _____ |

Biological or Secondary Treatment – Lagoons or Waste Stabilization Ponds (WSPs) (some systems may have more than one kind of treatment)

- | | |
|--------------------------------------|---|
| <input type="checkbox"/> None | <input type="checkbox"/> Storage Ponds |
| <input type="checkbox"/> Aerated | <input type="checkbox"/> Anaerobic |
| <input type="checkbox"/> Aerobic | <input type="checkbox"/> Other (describe) _____ |
| <input type="checkbox"/> Facultative | |

Advanced or Tertiary Treatment

- ☐ None
☐ Polishing Ponds
☐ Ammonia Stripping or Air Stripping
☐ Biological Nutrient Removal (Nitrogen and Phosphorus)
☐ Biological Ammonia Removal – Nitrification Only ($\text{NH}_3 \rightarrow \text{NO}_3$)
☐ Biological Nitrogen Removal – Nitrification and Denitrification ($\text{NH}_3 \rightarrow \text{N}_2$)
☐ Biological Phosphorus Removal
☐ Chemical Precipitation (Phosphorus)
☐ Filtration
☐ Other (describe) _____

Effluent Disinfection

- ☐ None
☐ Disinfection: All Year
☐ Disinfection: Seasonal or intermittent. If seasonal, specify the period of disinfection (which months) or if it is intermittent, specify the frequency: _____
☐ Chlorination Only
☐ Chlorination and Dechlorination
☐ Ozone
☐ Ultraviolet Irradiation
☐ Other (describe) _____

Other Information

Name of the surface water body that effluent is released to _____ ☐ Freshwater ☐ Saltwater

4.5.2 Releases to Surface Water**4.5.2.1 Inorganic Chloramines and Chlorinated Wastewater Effluents**

Report in the table below the average flow of wastewater effluent and the maximum Total Residual Chlorine (TRC) concentrations. The average monthly flow should be determined on the basis of daily flow measurements. The maximum total residual chlorine concentration should be determined on the basis of representative sampling.

Preparation Year (Month)	Average Flow of Effluent (m ³ /day)	Maximum Total Residual Chlorine (TRC) concentration (mg/L as Cl)
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		

5.0 Anticipated Actions and Results**5.1 Anticipated Action(s)**

The following section (Parts 5.1.1 through 5.1.6) must be completed separately for each anticipated action in the pollution prevention plan, i.e. this section will be completed as many times as there are anticipated actions to report.

In Part 5.1.1, describe for the activity identified in Part 3.0 of this Declaration the anticipated action to be taken in implementing the Pollution Prevention Plan. In Parts 5.1.2 and 5.1.3, for each anticipated action, identify the type of pollution prevention method(s) or environmental protection method(s), by selecting from the list of options provided below. In Part 5.1.4, report, where possible, the corresponding change to the maximum concentration of total residual chlorine measured in the effluent released to surface water, anticipated to be achieved from implementation of that action, in mg/L. Refer to the instructions for specific information on how to report. Indicate a decrease with a negative sign ("–") and an increase with a positive sign ("+") in front of the reported change. Note that predicting a quantitative change as a result of some anticipated actions, such as training, may not be possible. Finally, in Part 5.1.6, identify the planned completion date for the anticipated action.

5.1.1 Anticipated Action: _____

5.1.2 Type of Pollution Prevention Method(s):

- ☐ Equipment or process modifications
☐ Spill and leak prevention

- ☐ On-site reuse, recycling or recovery
☐ Good operating practices or training
☐ Other: _____

5.1.3 Other Type of Environmental Protection Method(s):

- ☐ Energy recovery
☐ Off-site recycling
☐ Waste treatment

- ☐ Pollution control
☐ Disposal
☐ Other: _____

5.1.4 Anticipated Change(s): _____

5.1.5 *No information required for Part 5.1.5 of this Declaration*

5.1.6 Planned Completion Date (year/month/day): _____

This ends the section (Parts 5.1.1 through 5.1.6) that must be completed separately for each anticipated action in the P2 plan.

5.2 *No information required for Part 5.2*

5.3 Detailed Anticipated Results Information**Total Anticipated Results for Inorganic Chloramines and Chlorinated Wastewater Effluents**

The table below summarizes, for the activity identified in Part 3.0 of this Declaration, the anticipated change to the maximum concentration of total residual chlorine (TRC) in the effluent released to surface water, in mg/L and as a percentage relative to the Preparation Year.

Report the total changes anticipated to be achieved from implementing all of the anticipated actions described in Part 5.1 of this Declaration.

Maximum Concentration of TRC in the Preparation Year (mg/L)	Anticipated Maximum Concentration of TRC in the Implementation Year (mg/L)	Anticipated Change* in Maximum Concentration (%)

* Indicate a decrease with a negative sign ("–") and an increase with a positive sign ("+") in front of the reported change.

6.0 Monitoring and Reporting

For the activity identified in Part 3.0 of this Declaration, describe anticipated monitoring and reporting that will be used to track progress in implementing the Pollution Prevention Plan.

7.0 Risk Management Objective

For the activity identified in Part 3.0 of this Declaration, describe how the Pollution Prevention Plan outlined in this Declaration meets the risk management objective identified in subsection 4(3) of the Notice. If this plan does not meet the risk management objective, explain why.

8.0 Factors to Consider

Describe what was done by the person or class of persons subject to the Notice to take into account the other "factors to consider" in subsections 4.2 and 4.5 of the Notice, except those factors for which a waiver has been granted by the Minister.

9.0 Certification

I hereby certify that a Pollution Prevention Plan has been prepared and is being implemented for inorganic chloramines and chlorinated wastewater effluents and that the information provided in this Declaration is true, accurate and complete.

Signature of the Person(s) Subject to the Notice or
Duly Authorized Representative

Date

Name: _____

Please Print

Title/Position: _____

Please Print

Note : Veuillez communiquer avec le Bureau national de la prévention de la pollution pour obtenir plus d'information au sujet de la soumission électronique ou du dépôt des formulaires écrits.

Annexe 1 : Déclaration confirmant qu'un plan de prévention de la pollution a été élaboré et qu'il est en cours d'exécution — chloramines inorganiques et eaux usées chlorées [paragraphe 58(1) de la LCPE (1999)]

Code de référence de l'avis : P2CLMWWE

Pour plus d'information sur la façon de remplir cette déclaration, consulter la brochure « Directives pour remplir les annexes de l'avis de la *Gazette du Canada* requérant l'élaboration et l'exécution de plans de prévention de la pollution pour les chloramines inorganiques et les eaux usées chlorées ».

Une copie électronique de cet avis et les instructions pour remplir les déclarations (annexes 1 à 5) sont disponibles sur le site Web du Bureau national de la prévention de la pollution à l'adresse www.ec.gc.ca/nopp/p2p/FR/p2notices.cfm ou peuvent être obtenues par téléphone au (819) 994-0186, par télécopieur au (819) 953-7970, ou par courriel à l'adresse cepap2plans@ec.gc.ca.

La présente déclaration sert-elle à apporter une modification à une déclaration déjà déposée? ☐ Oui ☐ Non

Si vous avez coché « oui », remplissez les parties 1.0 et 9.0, ainsi que toute autre partie de cette déclaration pour laquelle des renseignements déjà déclarés sont maintenant faux ou trompeurs. Il n'est pas nécessaire de répéter les informations inchangées.

1.0 Renseignements sur la(les) personne(s) ou catégorie de personnes visée(s) par l'avis

Nom de la(des) personne(s) ou catégorie de personnes visée(s) par l'avis : _____

Nom de l'installation : _____

Adresse civique de l'installation : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Téléphone : _____ Courriel (si disponible) : _____
(indicatif régional)

Adresse postale de l'installation,
si différente de l'adresse civique : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Numéro d'identité de l'Inventaire national des rejets de polluants (si aucun, laissez en blanc) : _____

Code à six chiffres du Système de classification des industries de l'Amérique du Nord (SCIAN) : 221320

Responsable des renseignements techniques : _____

Courriel (si disponible) : _____

Téléphone : _____ Télécopieur (si disponible) : _____
(y compris l'indicatif régional) (y compris l'indicatif régional)

2.0 Utilisation de plans déjà élaborés ou exécutés à d'autres fins

Le plan de prévention de la pollution utilisé pour satisfaire aux exigences de l'avis a-t-il :

- été préparé à titre volontaire? ☐ Oui ☐ Non
- été préparé pour un autre gouvernement ou en vertu d'une autre loi fédérale? ☐ Oui ☐ Non

Si vous avez coché « oui », indiquez la ou les exigences de cet autre gouvernement ou de cette(ces) autre(s) loi(s) fédérale(s).

3.0 Substance et activité

Substance et activité pour lesquelles des informations sont requises

Chloramines inorganiques et eaux usées chlorées : Personnes identifiées dans l'article 2 de l'avis, qui doivent élaborer et exécuter un plan de prévention de la pollution pour les chloramines inorganiques et les eaux usées chlorées liées à l'usage du chlore ou de composés chlorés dans les réseaux d'assainissement et le rejet d'eaux usées chlorées dans les eaux de surface.

4.0 Information de base antérieure à l'exécution du plan de prévention de la pollution (P2)

Cette déclaration requiert la présentation des données pour l'année de préparation, soit 2004 ou 2005 (du 1^{er} janvier au 31 décembre).

Si la(les) personne(s) visée(s) par l'avis a(ont) obtenu une prorogation de délai pour préparer un plan qui requiert la présentation de données pour une année autre que 2004 ou 2005, toutes les références aux années 2004 ou 2005 dans la présente déclaration doivent être considérées comme renvoyant à la nouvelle année de préparation pour laquelle la(les) personne(s) doit(doivent) faire rapport.

Le cas échéant, veuillez indiquer la nouvelle année de préparation pour laquelle la(les) personne(s) visée(s) par l'avis doit(doivent) soumettre un rapport : _____

4.1 - 4.4 Aucune information requise pour les parties 4.1 à 4.4 de cette déclaration**4.5 Information de base additionnelle****4.5.1 Information sur le réseau d'assainissement**

Cette section requiert de l'information au sujet du réseau d'assainissement en place pour 2004 ou 2005. Cochez toutes les cases suivantes qui s'appliquent à votre réseau. Notez que plus d'une case par section peuvent s'appliquer.

Aucun traitement

☐ Aucun traitement (par exemple, système de collecte avec déversement dans une eau de surface)

Traitement préliminaire

☐ Aucun

☐ Écrémage

☐ Dessablage

☐ Autre (préciser) _____

☐ Tamis/grilles à barreaux

Traitement primaire physique/chimique

☐ Aucun

☐ Flocculation chimique

☐ Décantation primaire/clarification

☐ Autre (préciser) _____

Traitement secondaire ou biologique — systèmes mécaniques (certains systèmes peuvent avoir plus d'un type de traitement)

☐ Aucun

☐ Fossé d'oxydation

☐ Boues activées conventionnelles

☐ Réacteur à lit fixe ou à lit bactérien aéré

☐ Boues activées par aération prolongée

☐ Disques biologiques

☐ Boues activées par oxygène pur

☐ Réacteur continu

☐ Autres boues activées

☐ Autre (préciser) _____

Traitement secondaire ou biologique — étangs ou bassins de stabilisation (certains systèmes peuvent avoir plus d'un type de traitement)

☐ Aucun

☐ Étangs de stockage

☐ Aéré

☐ Anaérobique

☐ Aérobique

☐ Autre (préciser) _____

☐ Facultatif

Traitement tertiaire ou additionnel

☐ Aucun

☐ Élimination biologique de l'azote — Nitrification et dénitrification ($\text{NH}_3 \rightarrow \text{N}_2$)

☐ Bassins ou étangs de polissage

☐ Élimination biologique du phosphore

☐ Stripage de l'ammoniac ou stripage à l'air

☐ Précipitation chimique (phosphore)

☐ Élimination biologique des nutriments (azote et phosphore)

☐ Filtration

☐ Élimination biologique de l'ammoniac — Nitrification seulement ($\text{NH}_3 \rightarrow \text{NO}_3$)

☐ Autre (préciser) _____

Désinfection des effluents

☐ Aucun

☐ Chloration seulement

☐ Désinfection : continue à l'année

☐ Chloration et déchloration

☐ Désinfection : saisonnière ou intermittente. Si saisonnière, préciser la période de désinfection (quels mois) ou si intermittente, préciser la fréquence : _____

☐ Ozone

☐ Irradiation par ultraviolets

☐ Autre (préciser) _____

Autre information

Nom du cours d'eau où l'effluent est déversé _____ ☐ Eau douce ☐ Eau salée

4.5.2 Rejets à l'eau de surface**4.5.2.1 Chloramines inorganiques et eaux usées chlorées**

Déclarez dans le tableau ci-dessous le débit moyen de l'effluent d'eaux usées et les concentrations maximales de chlore résiduel total (CRT). Le débit moyen mensuel devrait être calculé en fonction des mesures du débit quotidien. La concentration maximale de chlore résiduel total devrait être déterminée en fonction d'un échantillon représentatif.

Année de préparation	Débit moyen de l'effluent (m ³ /jour)	Concentration maximale de chlore résiduel total (CRT) (mg/L en Cl ⁻)
Mois		
Janvier		
Février		
Mars		
Avril		
Mai		
Juin		
Juillet		
Août		
Septembre		
Octobre		
Novembre		
Décembre		

5.0 Mesures et résultats prévus**5.1 Mesure(s) prévue(s)**

Les parties suivantes de la présente déclaration (parties 5.1.1 à 5.1.6) doivent être remplies séparément pour chaque mesure prévue indiquée dans le plan de prévention de la pollution, c'est-à-dire que cette section doit être remplie autant de fois qu'il y a de mesures à déclarer.

Dans la partie 5.1.1, décrivez, pour l'activité identifiée à la partie 3.0 de la présente déclaration, la mesure prévue pour l'exécution du plan de prévention de la pollution. Dans les parties 5.1.2 et 5.1.3, identifiez le type de mesures de prévention de la pollution ou de protection de l'environnement, en choisissant l'une des options fournies ci-dessous. Dans la partie 5.1.4, inscrivez, le cas échéant, le changement prévu à la concentration maximale de chlore résiduel total mesurée dans l'effluent rejeté à l'eau de surface, en mg/L, provenant de la mise en œuvre de la mesure. Pour obtenir des informations spécifiques sur la façon de compléter cette section, référez-vous aux instructions. Indiquez une diminution par le signe « - » et une augmentation par le signe « + » devant la quantité indiquée. Notez que dans certains cas, il peut s'avérer impossible de prévoir un changement quantitatif pour certaines mesures prévues, comme dans le cas de la formation du personnel. Enfin, dans la partie 5.1.6, indiquez la date d'achèvement prévue pour chaque mesure prévue.

5.1.1 Mesure prévue : _____

5.1.2 Types de méthodes de prévention de la pollution :

- ☐ Modifications de l'équipement ou du procédé
☐ Prévention des fuites ou des déversements

- ☐ Récupération, réutilisation ou recyclage sur place
☐ Bonnes pratiques d'exploitation ou formation
☐ Autres : _____

5.1.3 Autres types de méthodes de protection de l'environnement :

- ☐ Récupération d'énergie
☐ Recyclage hors site
☐ Traitement des déchets

- ☐ Contrôle de la pollution
☐ Élimination
☐ Autres : _____

5.1.4 Changement(s) prévu(s) : _____

5.1.5 Aucune information n'est requise pour la partie 5.1.5 de cette déclaration

5.1.6 Date d'achèvement prévue (année/mois/jour) : _____

Ceci termine les parties 5.1.1 à 5.1.6 devant être remplies séparément pour chaque mesure prévue dans le plan de prévention de la pollution.

5.2 Aucune information n'est requise pour la partie 5.2 de cette déclaration

5.3 Information détaillée sur les résultats prévus**Résultats totaux prévus pour les chloramines inorganiques et les eaux usées chlorées**

Le tableau ci-dessous résume, pour l'activité identifiée dans la partie 3.0 de cette déclaration, le changement total prévu à la concentration maximale de chlore résiduel total (CRT) dans l'effluent rejeté à l'eau de surface, en mg/L et en pourcentage par rapport à l'année de préparation.

Déclarez le changement total prévu à la suite de la mise en œuvre des mesures prévues décrites dans la partie 5.1 de cette déclaration.

Concentration maximale de CRT dans l'année de préparation (mg/L)	Concentration maximale de CRT prévue dans l'année de la mise en œuvre (mg/L)	Changement* prévu à la concentration maximale (%)

* Indiquez une diminution avec un signe négatif (« - ») et une augmentation avec un signe positif (« + ») devant la quantité déclarée.

6.0 Surveillance et rapport

Pour l'activité identifiée à la partie 3.0 de cette déclaration, décrivez les méthodes de surveillance et de compte rendu qui seront utilisées pour suivre les progrès de l'exécution du plan de prévention de la pollution.

7.0 Objectif de gestion du risque

Décrivez comment le plan de prévention de la pollution, tel qu'il est décrit dans cette déclaration, répond à l'objectif de gestion du risque décrit au paragraphe 4(3) de l'avis pour l'activité identifiée à la partie 3.0 de cette déclaration. Si ce plan ne répond pas à l'objectif de gestion du risque, expliquez pourquoi.

8.0 Facteurs à prendre en considération

Décrivez les mesures prises par les personnes ou catégories de personnes assujetties à l'avis pour tenir compte des « facteurs à prendre en considération » des paragraphes 4.2 et 4.5 de l'avis, sauf pour les facteurs pour lesquels une demande de dérogation a été accordée par le ministre.

9.0 Certification

J'atteste qu'un plan de prévention de la pollution a été élaboré pour les chloramines inorganiques et les eaux usées chlorées et qu'il est en cours d'exécution, et que les renseignements soumis dans la présente déclaration sont véridiques, exacts et complets.

Signature de la(des) personne(s) visée(s) par l'avis ou
représentant(e) autorisé(e)

Date

Nom :

En lettres moulées s.v.p.

Titre/Poste :

En lettres moulées s.v.p.

Note: Please contact the National Office of Pollution Prevention for more information about electronic reporting or the filing of paper forms.

Schedule 2: Request for Waiver of the Requirement to Consider a Factor or Factors – Inorganic Chloramines and Chlorinated Wastewater Effluents (Subsection 56(5) of CEPA 1999)

Notice Reference Code: P2CLMWWE

Please refer to the instruction booklet "Instructions for Completing the Schedules of the *Canada Gazette* Notice Requiring the Preparation and Implementation of Pollution Prevention Plans for Inorganic Chloramines and Chlorinated Wastewater Effluents" for guidance on how to complete this Request.

Electronic copies of the Notice, and the instructions for completing the declarations (Schedules 1 to 5), are available from the National Office of Pollution Prevention Web site at www.ec.gc.ca/nopp/p2p/en/p2pnotices.cfm or can be requested by telephone at (819) 994-0186, by facsimile at (819) 953-7970 or by e-mail at CEPAP2Plans@ec.gc.ca.

1.0 Information on the Person or Class of Persons Subject to the Notice

Name of the Person or Class of Persons Subject to the Notice: _____

Facility Name: _____

Street Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

Telephone Number: _____ E-mail (if available): _____
(with area code)

If different from Street Address

Mailing Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

National Pollutant Release Inventory ID (if no ID, leave blank): _____

Six-digit North American Industry Classification System (NAICS) Code: 221320

Facility Technical Contact: _____

E-mail (if available): _____

Telephone Number: _____ Fax Number (if available): _____
(with area code) (with area code)

2.0 Factor(s) for which a Waiver is Requested

Identify exactly for which factor(s) listed in the Notice a waiver is requested.

3.0 Rationale for Request

Explain why it would not be reasonable or practicable to consider each factor for which a waiver is requested.

Explain how the outcome of the P2 plan will be affected if this(these) "factor to consider" is(are) not taken into account.

Explain which, if any, additional factor(s) you propose to consider in preparing the pollution prevention plan (optional).

4.0 Certification

I hereby certify that the information provided in this Request is true, accurate and complete.

Signature of the Person(s) Subject to the Notice
or Duly Authorized Representative

Date

Name: _____
Please Print

Title/Position: _____
Please Print

Note : Veuillez communiquer avec le Bureau national de la prévention de la pollution pour obtenir plus d'information au sujet de la soumission électronique ou du dépôt des formulaires écrits.

Annexe 2 : Demande de dérogation à l'obligation de prendre en considération certains facteurs — Chloramines inorganiques et eaux usées chlorées [paragraphe 56(5) de la LCPE (1999)]

Code de référence de l'avis : P2CLMWWE

Pour plus d'information sur la façon de remplir cette déclaration, consulter la brochure « Directives pour remplir les annexes de l'avis de la Gazette du Canada requérant l'élaboration et l'exécution de plans de prévention de la pollution pour les chloramines inorganiques et les eaux usées chlorées ».

Une copie électronique de cet avis et les instructions pour remplir les déclarations (annexes 1 à 5) sont disponibles sur le site Web du Bureau national de la prévention de la pollution à l'adresse www.ec.gc.ca/nopp/p2p/FR/p2notices.cfm ou peuvent être obtenues par téléphone au (819) 994-0186, par télécopieur au (819) 953-7970 ou par courriel à l'adresse cepap2plans@ec.gc.ca.

1.0 Renseignements sur la(les) personne(s) ou catégorie de personnes visée(s) par l'avis

Nom de la(des) personne(s) ou catégorie de personnes visée(s) par l'avis : _____

Nom de l'installation : _____

Adresse civique de l'installation : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Téléphone : _____ Courriel (si disponible) : _____
(y compris l'indicatif régional)

Adresse postale de l'installation, si différente de l'adresse civique : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Numéro d'identité de l'Inventaire national des rejets de polluants (si aucun, laissez en blanc) : _____

Code à six chiffres du Système de classification des industries de l'Amérique du Nord (SCIAN) : 221320

Responsable des renseignements techniques : _____

Courriel (si disponible) : _____

Téléphone : _____ Télécopieur (si disponible) : _____
(y compris l'indicatif régional) (y compris l'indicatif régional)**2.0 Facteur(s) faisant l'objet d'une demande de dérogation**

Indiquez de façon précise pour quel(s) facteur(s) énuméré(s) dans cet avis une dérogation est demandée.

3.0 Justification de la demande

Expliquez pourquoi il serait déraisonnable ou impossible de prendre en considération chacun des facteurs pour lesquels une dérogation est demandée.

Expliquez comment les résultats du plan de prévention de la pollution seront affectés si ce(ces) « facteur(s) à prendre en considération » n'est(ne sont) pas considéré(s).

Si vous proposez d'utiliser un ou des facteurs additionnels lors de l'élaboration du plan de prévention de la pollution, expliquez lequel ou lesquels (optionnel).

4.0 Certification

Par la présente, j'atteste que l'information dans cette demande est véridique, exacte et complète.

Signature de la(des) personne(s) visée(s) par l'avis ou
représentant(e) autorisé(e)_____
Date

Nom : _____

En lettres moulées s.v.p.

Titre/Poste : _____

En lettres moulées s.v.p.

Note: Please contact the National Office of Pollution Prevention for more information about electronic reporting or the filing of paper forms.

**Schedule 3: Request for Time Extension – Inorganic Chloramines and
Chlorinated Wastewater Effluents (Subsection 56(3) of CEPA 1999)**

Notice Reference Code: P2CLMWWE

Please refer to the instruction booklet "Instructions for Completing the Schedules of the *Canada Gazette* Notice Requiring the Preparation and Implementation of Pollution Prevention Plans for Inorganic Chloramines and Chlorinated Wastewater Effluents" for guidance on how to complete this Request.

Electronic copies of the Notice, and the instructions for completing the declarations (Schedules 1 to 5), are available from the National Office of Pollution Prevention Web site at www.ec.gc.ca/nopp/p2p/en/p2notices.cfm or can be requested by telephone at (819) 994-0186, by facsimile at (819) 953-7970 or by e-mail at CEPAP2Plans@ec.gc.ca.

1.0 Information on the Person or Class of Persons Subject to the Notice

Name of the Person or Class of Persons Subject to the Notice: _____

Facility Name: _____

Street Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

Telephone Number: _____ E-mail (if available): _____
(with area code)

If different from Street Address

Mailing Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

National Pollutant Release Inventory ID (if no ID, leave blank): _____

Six-digit North American Industry Classification System (NAICS) Code: 221320

Facility Technical Contact: _____

E-mail (if available): _____

Telephone Number: _____ Fax Number (if available): _____
(with area code) (with area code)

2.0 Request for Time Extension

Identify for which of the following a time extension is requested (choose one):

- ☐ to prepare a pollution prevention plan
- ☐ to submit an Interim Progress Report — Interim Progress Report No. _____ (*not applicable for this Notice*)
- ☐ to implement a pollution prevention plan

For the person(s) identified in Part 1.0, it is requested that the date be extended to _____ (specify exact date – year/month/day)

3.0 Rationale for Request

Explain why further time is necessary to prepare or implement a pollution prevention plan.

4.0 Certification

I hereby certify that the information provided in this Request is true, accurate and complete.

Signature of the Person(s) Subject to the Notice or
Duly Authorized Representative

Date

Name: _____

Please Print

Title/Position: _____

Please Print

Schedule 4: Interim Progress Report – NOT APPLICABLE FOR THIS NOTICE

Note : Veuillez communiquer avec le Bureau national de la prévention de la pollution pour obtenir plus d'information au sujet de la soumission électronique ou du dépôt des formulaires écrits.

**Annexe 3 : Demande de prorogation du délai — Chloramines inorganiques et eaux usées chlorées
[paragraphe 56(3) de la LCPE (1999)]**

Code de référence de l'avis : P2CLMWWE

Pour plus d'information sur la façon de remplir cette déclaration, veuillez consulter la brochure « Directives pour remplir les annexes de l'avis de la *Gazette du Canada* requérant l'élaboration et l'exécution de plans de prévention de la pollution pour les chloramines inorganiques et les eaux usées chlorées ».

Une copie électronique de cet avis et les instructions pour remplir les déclarations (annexes 1 à 5) sont disponibles sur le site Web du Bureau national de la prévention de la pollution à l'adresse www.ec.gc.ca/nopp/p2p/FR/p2notices.cfm ou peuvent être obtenues par téléphone au (819) 994-0186, par télécopieur au (819) 953-7970 ou par courriel à l'adresse cepap2plans@ec.gc.ca.

1.0 Renseignements sur la(les) personne(s) ou catégorie de personnes visée(s) par l'avis

Nom de la(des) personne(s) ou catégorie de personnes visée(s) par l'avis : _____

Nom de l'installation : _____

Adresse civique de l'installation : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Téléphone : _____ Courriel (si disponible) : _____

(y compris l'indicatif régional)

Adresse postale de l'installation, si différente de l'adresse civique : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Numéro d'identité de l'Inventaire national des rejets de polluants (si aucun, laissez en blanc) : _____

Code à six chiffres du Système de classification des industries de l'Amérique du Nord (SCIAN) : 221320

Responsable des renseignements techniques : _____

Courriel (si disponible) : _____

Téléphone : _____ Télécopieur (si disponible) : _____

(y compris l'indicatif régional)

(y compris l'indicatif régional)

2.0 Demande de prorogation du délai

Indiquez pour laquelle des raisons suivantes une prorogation du délai est demandée (cochez une case seulement) :

- ☐ pour l'élaboration du plan de prévention de la pollution
☐ pour la présentation d'un rapport provisoire — rapport provisoire n° _____ (ne s'applique pas à cet avis)
☐ pour l'exécution du plan de prévention de la pollution

Pour la(les) personne(s) désignée(s) dans la partie 1.0, il est demandé que le délai soit reporté au : _____ (indiquez la date exacte — année/mois/jour).

3.0 Justification de la demande

Expliquez pourquoi une prorogation de délai est nécessaire pour élaborer ou mettre en œuvre le plan de prévention de la pollution.

4.0 Certification

Par la présente, j'atteste que l'information dans cette demande est véridique, exacte et complète.

Signature de la(des) personne(s) visée(s) par l'avis ou
représentant(e) autorisé(e)

Date

Nom :

En lettres moulées s.v.p.

Titre/Poste :

En lettres moulées s.v.p.

Annexe 4 : Rapport d'étape provisoire — NE S'APPLIQUE PAS À CET AVIS

Note: Please contact the National Office of Pollution Prevention for more information about electronic reporting or the filing of paper forms.

Schedule 5: Declaration That a Pollution Prevention Plan Has Been Implemented -- Inorganic Chloramines and Chlorinated Wastewater Effluents (Subsection 58(2) of CEPA 1999)

Notice Reference Code: P2CLMWWE

Please refer to the instruction booklet "Instructions for Completing the Schedules of the *Canada Gazette* Notice Requiring the Preparation and Implementation of Pollution Prevention Plans for Inorganic Chloramines and Chlorinated Wastewater Effluents" for guidance on how to complete this Declaration.

Electronic copies of the Notice, and the instructions for completing the declarations (Schedules 1 to 5), are available from the National Office of Pollution Prevention Web site at www.ec.gc.ca/nopp/p2p/en/p2notices.cfm or can be requested by telephone at (819) 994-0186, by facsimile at (819) 953-7970, or by e-mail at CEPAP2Plans@ec.gc.ca.

Is this an amendment to a Declaration previously submitted? ☐ Yes ☐ No

If yes, complete Parts 1.0 and 9.0 and any other Parts of this Declaration where previously reported information has become false or misleading. Previously reported information that is unchanged need not be resubmitted.

1.0 Information on the Person or Class of Persons Subject to the Notice

Name of the Person or Class of Persons Subject to the Notice: _____

Facility Name: _____

Street Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

Telephone number: _____ E-mail (if available): _____
(with area code)

If different from Street Address

Mailing Address of Facility: _____

City: _____ Province/Territory: _____ Postal Code: _____

National Pollutant Release Inventory ID (if no ID, leave blank): _____

Six-digit North American Industry Classification System (NAICS) Code: 221320

Facility Technical Contact: _____

E-mail (if available): _____

Telephone Number: _____ Fax Number (if available): _____
(with area code) (with area code)

2.0 No data are required for Part 2.0 of this Declaration

3.0 Substance and Activity

Substance and Activity for which information is required

Inorganic Chloramines and Chlorinated Wastewater Effluents: Persons identified in section 2 of the Notice who are required to prepare and implement a pollution prevention plan for inorganic chloramines and chlorinated wastewater effluents for the use of chlorine or chlorine compounds in wastewater systems and the release of chlorinated effluent to surface water.

4.0 Baseline Information after Implementation of the Pollution Prevention (P2) Plan

This Declaration requires reporting of data for the year of implementation (January 1 to December 31) of the pollution prevention plan, but no later than for the year 2009 (as specified in the Notice or any other year specified to a person who has been granted an extension of time to implement a plan).

Indicate the year of implementation for which the person(s) is(are) reporting: _____ (This will be the Reporting Year throughout this Declaration.)

4.1 - 4.4 No information is required for Parts 4.1 to 4.4 of this Declaration

4.5 Additional Baseline Information**4.5.1 Wastewater System Information**

Describe the changes to your wastewater system since 2004 or 2005, compared to the information provided in Schedule 1: Declaration that a pollution prevention plan has been prepared and is being implemented.

--

4.5.2 Releases to Surface Water**4.5.2.1 Inorganic Chloramines and Chlorinated Wastewater Effluents**

Report in the table below the average flow of wastewater effluent and the maximum Total Residual Chlorine (TRC) concentrations. The average monthly flow should be determined on the basis of daily flow measurements. The maximum total residual chlorine concentration should be determined on the basis of representative sampling.

Implementation Year (Month)	Average Flow of Effluent (m ³ /day)	Maximum Total Residual Chlorine (TRC) Concentration (mg/L as Cl)
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		

5.0 Action(s) Taken and Results Achieved**5.1 Action(s) Taken**

The following section (Parts 5.1.1 through 5.1.6) must be completed separately for each action taken in the P2 plan, i.e. this section will be completed as many times as there are actions taken to report.

In Part 5.1.1, describe, for the activity identified in Part 3.0 of this Declaration, the action taken in implementing the Pollution Prevention Plan. In Parts 5.1.2 and 5.1.3, identify whether the action represents pollution prevention method(s) or other environmental protection method(s) by selecting from the list of options provided below. In Part 5.1.4, report, where possible, the corresponding change to the maximum concentration of total residual chlorine measured in the effluent released to surface water achieved from implementation of that action, in mg/L. Refer to the instructions for specific information on how to report. Indicate a decrease with a negative sign ("−") and an increase with a positive sign ("+") in front of the reported change. Note that estimating a quantitative change for some actions taken, such as training, may not be possible. Finally, in Part 5.1.6, identify the completion date for each action taken.

5.1.1 Action Taken: _____

5.1.2 Type of Pollution Prevention Method(s):

- ☐ Equipment or process modifications
☐ Spill and leak prevention

- ☐ On-site reuse, recycling or recovery
☐ Good operating practices or training
☐ Other: _____

5.1.3 Other Type of Environmental Protection Method(s):

- ☐ Energy recovery
☐ Off-site recycling
☐ Waste treatment

- ☐ Pollution control
☐ Disposal
☐ Other: _____

5.1.4 Results of Actions Taken in 5.1.1: _____

5.1.5 No information is required for Part 5.1.5 of this Declaration

5.1.6 Completion Date (year/month/day): _____

This ends the section (Parts 5.1.1 through 5.1.6) that must be completed separately for each action taken in the P2 plan.

5.2 No information is required for Part 5.2 of this Declaration**5.3 Detailed Results Achieved Information****Total Results Achieved for Inorganic Chloramines and Chlorinated Wastewater Effluents**

The table below summarizes, for the activity identified in Part 3.0 of this Declaration, the achieved change to the maximum concentration of total residual chlorine (TRC) in the effluent released to surface water, in mg/L, and as a percentage relative to the preparation year.

Report the change achieved from all actions taken as a result of implementing the pollution prevention plan.

Maximum Concentration of TRC in the Preparation Year (mg/L)	Achieved Maximum Concentration of TRC in the Implementation Year (mg/L)	Achieved change* in Maximum Concentration (%)

* Indicate a decrease with a negative sign ("−") and an increase with a positive sign ("+") in front of the reported change.

6.0 Monitoring and Reporting

For the activity identified in Part 3.0 of this Declaration, describe the monitoring and reporting used to track progress in implementing the Pollution Prevention Plan.

7.0 Risk Management Objective

For the activity identified in Part 3.0 of this Declaration, describe how the Pollution Prevention Plan outlined in this Declaration met the risk management objective identified in subsection 4(3) of the Notice. If this plan did not meet the risk management objective, explain why.

8.0 No information is required for Part 8.0 of this Declaration**9.0 Certification**

I hereby certify that a pollution prevention plan has been implemented for inorganic chloramines and chlorinated wastewater effluents and that the information provided in this Declaration is true, accurate and complete.

Signature of the Person(s) Subject to the Notice or
Duly Authorized Representative

Date

Name:

Please Print

Title/Position:

Please Print

Note : Veuillez communiquer avec le Bureau national de la prévention de la pollution pour obtenir plus d'information au sujet de la soumission électronique ou du dépôt des formulaires écrits.

[49-1-o]

Annexe 5 : Déclaration confirmant l'exécution d'un plan de prévention de la pollution — Chloramines inorganiques et eaux usées chlorées [paragraphe 58(2) de la LCPE (1999)]

Code de référence de l'avis : P2CLMWWE

Pour plus d'information sur la façon de remplir cette déclaration, consulter la brochure « Directives pour remplir les annexes de l'avis de la *Gazette du Canada* requérant l'élaboration et l'exécution de plans de prévention de la pollution pour les chloramines inorganiques et les eaux usées chlorées ».

Une copie électronique de cet avis et les instructions pour remplir les déclarations (annexes 1 à 5) sont disponibles sur le site Web du Bureau national de la prévention de la pollution à l'adresse www.ec.gc.ca/nopp/p2p/FR/p2notices.cfm ou peuvent être obtenues par téléphone au (819) 994-0186, par télécopieur au (819) 953-7970, ou par courriel à l'adresse cepap2plans@ec.gc.ca.

La présente déclaration apporte-t-elle une modification à une déclaration déjà présentée? ☐ Oui ☐ Non

Si vous avez coché « oui », remplissez les parties 1.0 et 9.0, et toute autre partie de cette déclaration pour laquelle des renseignements déjà déclarés sont maintenant faux ou trompeurs. Il n'est pas nécessaire de soumettre les informations inchangées se trouvant dans des déclarations précédentes.

1.0 Renseignements sur la(les) personne(s) ou catégorie de personnes visée(s) par l'avis

Nom de la(des) personne(s) ou catégorie de personnes visée(s) par l'avis : _____

Nom de l'installation : _____

Adresse civique de l'installation : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Téléphone : _____ Courriel (si disponible) : _____
(y compris l'indicatif régional)

Adresse postale de l'installation, si différente de l'adresse civique : _____

Ville : _____ Province/Territoire : _____ Code postal : _____

Numéro d'identité de l'Inventaire national des rejets de polluants (si aucun, laissez en blanc) : _____

Code à six chiffres du Système de classification des industries de l'Amérique du Nord (SCIAN) : 221320

Responsable des renseignements techniques : _____

Courriel (si disponible) : _____

Téléphone : _____ Télécopieur (si disponible) : _____
(y compris l'indicatif régional) (y compris l'indicatif régional)**2.0 Il n'est pas nécessaire de fournir de données pour la partie 2.0 de cette déclaration****3.0 Substance et activité****Substance et activité pour lesquels certaines informations sont requises**

Chloramines inorganiques et eaux usées chlorées : Personnes identifiées dans l'article 2 de l'avis, qui doivent élaborer et exécuter un plan de prévention de la pollution pour les chloramines inorganiques et les eaux usées chlorées liées à l'usage du chlore ou de composés chlorés dans les réseaux d'assainissement et le rejet d'eaux usées chlorées dans les eaux de surface.

4.0 Information de base suivant l'exécution du plan de prévention de la pollution (P2)

Cette déclaration requiert la présentation des données pour l'année d'exécution (du 1^{er} janvier au 31 décembre) du plan de prévention de la pollution, qui se trouve au plus tard pour l'année 2009 (tel qu'il est précisé dans l'avis, ou toute autre année spécifiée à une personne qui a obtenu une prorogation du délai pour l'exécution d'un plan).

Indiquez l'année d'exécution pour laquelle la(les) personne(s) doit(doivent) soumettre son(leur) rapport : _____ (Cette nouvelle année sera considérée comme l'année pour laquelle le rapport doit être fait, aux fins de cette déclaration.)

4.1 - 4.4 Aucune information n'est requise pour les parties 4.1 à 4.4 de cette déclaration**4.5 Information de base additionnelle****4.5.1 Information sur le réseau d'assainissement**

Décrivez les changements à votre réseau d'assainissement depuis 2004 ou 2005, en comparaison à l'information fournie à l'annexe 1 : Déclaration confirmant qu'un plan de prévention de la pollution a été élaboré et qu'il est en cours d'exécution.

--

4.5.2 Rejets dans un plan d'eau de surface**4.5.2.1 Chloramines inorganiques et eaux usées chlorées**

Déclarez dans le tableau ci-dessous le débit moyen de l'effluent d'eaux usées et les concentrations maximales de chlore résiduel total (CRT). Le débit moyen mensuel devrait être calculé en fonction des mesures du débit quotidien. La concentration maximale de chlore résiduel total devrait être déterminée en fonction d'un échantillon représentatif.

Année d'exécution (mois)	Débit moyen de l'effluent (m ³ /jour)	Concentration maximale de chlore résiduel total (CRT) (mg/L en Cl ⁻)
Janvier		
Février		
Mars		
Avril		
Mai		
Juin		
Juillet		
Août		
Septembre		
Octobre		
Novembre		
Décembre		

5.0 Mesure(s) mise(s) en œuvre et résultat(s) obtenu(s)**5.1 Mesure(s) mise(s) en œuvre**

Les parties suivantes de la présente déclaration (parties 5.1.1 à 5.1.6) doivent être remplies séparément pour chaque mesure prévue indiquée dans le plan de prévention de la pollution, c'est-à-dire que cette section doit être remplie autant de fois qu'il y a de mesures à déclarer.

Dans la partie 5.1.1, décrivez pour l'activité identifiée à la partie 3.0 de la présente déclaration la mesure mise en œuvre pour exécuter le plan de prévention de la pollution. Dans les parties 5.1.2 et 5.1.3, indiquez si cette mesure représente une mesure de prévention de la pollution ou toute autre mesure de protection de l'environnement, en choisissant l'une des options fournies ci-dessous. Dans la partie 5.1.4, inscrivez, le cas échéant, le changement à la concentration maximale de chlore résiduel total mesuré dans l'effluent rejeté à l'eau de surface, en mg/L, résultant de la mise en œuvre de la mesure. Pour obtenir des informations spécifiques sur la façon de compléter cette section, référez-vous aux instructions. Indiquez une diminution par le signe « - » et une augmentation par le signe « + » devant la quantité indiquée. Notez que dans certains cas il peut s'avérer impossible d'estimer un changement quantitatif pour certaines mesures mises en œuvre, par exemple la formation du personnel. Enfin, dans la partie 5.1.6, indiquez la date d'achèvement prévue pour chaque mesure prévue.

5.1.1 Mesure mise en œuvre : _____

5.1.2 Types de méthodes de prévention de la pollution :

- ☐ Modifications de l'équipement ou du procédé
☐ Prévention des fuites ou des déversements

- ☐ Récupération, réutilisation ou recyclage sur place
☐ Bonnes pratiques d'exploitation ou formation
☐ Autres : _____

5.1.3 Autres types de méthodes de protection de l'environnement :

- ☐ Récupération d'énergie
☐ Recyclage hors site
☐ Traitement des déchets

- ☐ Contrôle de la pollution
☐ Élimination
☐ Autres : _____

5.1.4 Résultats des mesures mises en œuvre en 5.1.1 : _____

5.1.5 Aucune information n'est requise pour la partie 5.1.5 de cette déclaration

5.1.6 Date d'achèvement (année/mois/jour) : _____

Ici se termine la section (parties 5.1.1 à 5.1.6) devant être remplie séparément pour chaque mesure mise en œuvre dans le plan de prévention de la pollution.

5.2 Aucune information n'est requise pour la partie 5.2 de cette déclaration

5.3 Information détaillée sur les résultats obtenus**Résultats totaux obtenus pour les chloramines inorganiques et les eaux usées chlorées**

Le tableau ci-dessous résume, pour l'activité identifiée dans la partie 3.0 de cette déclaration, le changement obtenu à la concentration maximale du chlore résiduel total (CRT) dans l'effluent rejeté dans l'eau de surface, en mg/L, et en pourcentage par rapport à l'année de préparation.

Déclarez le changement obtenu à la suite de toutes les mesures mises en œuvre découlant de l'exécution du plan de prévention de la pollution.

Concentration maximale de CRT dans l'année de préparation (mg/L)	Concentration maximale de CRT atteinte dans l'année de la mise en œuvre (mg/L)	Changement* obtenu à la concentration maximale (%)

* Indiquez une diminution avec un signe négatif (« - ») et une augmentation avec un signe positif (« + ») devant la quantité déclarée.

6.0 Surveillance et rapport

Pour l'activité identifiée à la partie 3.0 de cette déclaration, décrivez les méthodes de surveillance et de compte rendu utilisées pour suivre les progrès de l'exécution du plan de prévention de la pollution.

7.0 Objectif de gestion du risque

Pour l'activité identifiée à la partie 3.0 de cette déclaration, décrivez comment le plan de prévention de la pollution, tel qu'il est décrit dans cette déclaration, a répondu à l'objectif de gestion du risque décrit au paragraphe 4(3) de l'avis. Si ce plan n'a pas répondu à l'objectif de gestion du risque, expliquez pourquoi.

8.0 Aucune information n'est requise pour la partie 8.0 de cette déclaration**9.0 Certification**

J'atteste qu'un plan de prévention de la pollution a été exécuté pour les chloramines inorganiques et les eaux usées chlorées et que les renseignements soumis dans la présente déclaration sont véridiques, exacts et complets.

Signature de la(des) personne(s) visée(s) par l'avis
ou représentant(e) autorisé(e)

Date

Nom :

En lettres moulées s.v.p.

Titre/Poste :

En lettres moulées s.v.p.



The printing processes used in producing this document conform to environmental performance standards established by the Government of Canada under Canada's *National Guidelines on Lithographic Printing Services*. These standards aim to ensure the environmental integrity of printing processes through reductions in toxic emissions to the environment, reductions in loading of wastewater, reductions in the quantity of material sent to landfills, and the implementation of resource conservation procedures.

The paper used in the interior of this document conforms to Canada's *National Printing and Writing Paper Guideline* and/or *Uncoated Mechanical Printing Paper Guideline*. These guidelines set environmental performance standards for fibre-use efficiency, chemical oxygen demand, energy use, global warming potential, acidification potential, and solid waste.

The printing processes and the paper used in the interior of this document are fully certified under Canada's sole ecolabelling program – the *Environmental Choice[®] Program* (ECP). The Program's official symbol of certification – the EcoLogo[®] – features three stylized doves intertwined to form a maple leaf, representing consumers, industry and government working together to improve Canada's environment.

For more information about the *Environmental Choice[®] Program*, please visit the ECP website at www.environmentalchoice.com or telephone (613) 247-1900.

Environment Canada's Technology Outreach Section is proud to support environmental and quality performance standards, and the use of Environmental Choice[®] certified papers and environmentally responsible products and printing processes, throughout its development and distribution of information products. To obtain a copy of the catalogue *Environment Canada: Selected Publications and Websites*, please contact us toll-free at 1 800 734-3232, or (819) 953-5750; by facsimile at (819) 994-5629; or by e-mail at epspubs@ec.gc.ca.

For additional information on Environment Canada, visit the departmental website at www.ec.gc.ca.

