AGREEMENT FOR THE PURCHASE OF GOODS AND SERVICES

THIS AGREEMENT FOR THE PURCHASE OF GOODS AND SERVICES ("Agreement") is made _____, 2015, between UNIVAR USE, INC. ("Contractor"), whose address is 8201 S. 212th Street, Kent WA and telephone number is 253-872-5000 and the City of Stockton, a municipal corporation ("City").

In consideration of the mutual promises set forth in this Agreement, the parties agree as follows:

1. Goods to be provided and services to be performed. Contractor shall provide the goods and perform the services as set forth on the attached Exhibit A incorporated herein by reference Contractor shall begin providing the goods/performing the services by July 1, 2015 and complete providing the goods/performing the services by June 30, 2016; provided, however, the parties may agree to change the beginning or ending date(s).

2. Compensation. For the goods and services under this Agreement, City shall pay Contractor the sum of $0.4685 per gallon for delivery of Sodium Hypochlorite (12.5%).

3. Method of Payment. City shall pay Contractor within 30 days from the date Contractor's invoices are approved by the City Manager. Contractor shall submit monthly invoices.

4. Maintenance. Contractor shall maintain the goods as set forth in Exhibit A at a cost as set forth in Exhibit A. Contractor shall respond to calls for required maintenance from City personnel within 24 hours of the call; required maintenance occurs when the self check system fails to perform any of its functions. If Contractor is unable to resolve routine maintenance issues by phone within 48 hours, Contractor shall provide to City Operations personnel a resolution report indicating how and when the Contractor intends to resolve the issue. Within the period of the maintenance agreement, Contractor shall implement all software and firmware upgrades to the goods identified in Exhibit A at no cost to City. If software and firmware upgrades require a hardware upgrade, Contractor shall provide the upgraded hardware at no cost to the City. City personnel shall review and approve any upgrades prior to their installation.

5. Warranty. Contractor warrants that for one year the goods installed shall be free of defects in materials and workmanship. The one year period shall begin upon the date the City provides in writing to Contractor acceptance of the goods. The warranty under this section shall provide coverage equal to or greater than those warranties that are customary in the industry and, at a minimum, include all parts and labor,

6. Indemnification. Contractor shall indemnify, save and hold harmless from and defend the City, members of the City Council and employees, agents and volunteers, against any and all claims, costs, demands, causes of action, suits, losses, and expense, including attorneys fees, arising from or out of acts or omissions of Contractor, its officials, employees, agents or sub-contractors, in connection with the goods and services that the Contractor is to

provide/perform under this Agreement, except where caused by the active or sole negligence of City, or City's willful misconduct.

7. Insurance. During the term of this Agreement, Contractor shall maintain in full force and effect at its own cost and expense the insurance coverage set forth on the attached Exhibit B and shall otherwise comply with the provisions of Exhibit B.

8. Business License. Prior to its execution of this Agreement, Contractor shall obtain a City business license.

9. Audit. City reserves the right to periodically audit all charges for good and services provided by Contractor.

10. Ownership of Goods. All goods accepted by the City shall be the property of the City.

11. Changes to the Agreement. This Agreement may not be modified except in writing by both parties.

12. Applicable Law. This Agreement shall be governed by the laws of the State of California and venue for any action brought in state court shall be in the Superior Court, County of San Joaquin, Stockton Branch or, for actions brought in federal court, the United States District Court for the Eastern District of California, Sacramento Division.

13. Non-Assignability. Contractor shall not assign or transfer this Agreement or any interest or obligation in this Agreement without the prior written consent of the City and then only upon such terms and conditions as City may set forth in writing.

14. Notices. All notices herein required shall be in writing and shall be sent certified or registered mail, postage prepaid, addressed as follows:

To Contractor:	Univar, USA, Inc Attn:_____ 8201 S. 212th Street Kent, WA 98032	To City:	City Manager City of Stockton 425 N. El Dorado St. Stockton, CA 95202

15. Conformance to Applicable Laws. Contractor shall comply with all applicable Federal, State and Municipal laws, rules and ordinances. Contractor shall not discriminate in the employment of persons or in providing services under this Agreement on the basis of any legally protected classification including race, color, national origin, sex or religion of such person.

16. Miscellaneous Provisions.

a. City may terminate this Agreement at any time by mailing notice to Contractor at the address first stated above. Contractor shall be paid for that portion of goods provided / services provided when notice is received.

b. Contractor shall not assign or transfer this Agreement.

c. In the performance of this Agreement, Contractor, its employees and agents shall have the status of an independent contractor and not as an employee of the City for any purpose.

d. If either City or Contractor waives a breach of this Agreement, such waiver shall not constitute a waiver of other or succeeding breaches of this Agreement.

e. This Agreement constitutes the entire understanding of the parties.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement the date and year first above written.

CITY OF STOCKTON

_____
City Manager

ATTEST:

_____
City Clerk

APPROVED AS TO FORM:

_____
City Attorney

CONTRACTOR

By: _____
Signature

_____
Print name

Title: _____

[If Contractor is a corporation, signatures must comply with Corporations Code §313]

By: _____
Signature

_____
Print name

Title: _____

Attachment E

Univar USA Inc.
8201 S. 212th
Kent, WA 98032-1994
USA

T 253-872-5000
F 253-572-5041
www.univarusa.com

UNIVAR

April 9, 2015

Dublin San Ramon Services District
Attn: Luanne Ivy, Administrative Analyst - Operations
Regional Wastewater Treatment Facility
7399 Johnson Drive
Pleasanton, CA 94588

RE: Bid for 12.5% Sodium Hypochlorite, BACC BID NO. 14-2015

To Whom It May Concern:

Univar USA Inc. is pleased to offer a price quote on your IFB due Tuesday, April 14, 2015 and has done so on the attached required paperwork.

Our contact information for all things bid and contract related, as well as the information for your local branch, is also attached.

We look forward to hearing the results of your request.

Thank you,

Shawnasey McCarthy
Jennifer Perras

Municipal Specialists
Western Region
Univar USA Inc.
muniteam-west@univarusa.com

www.univar.com

Please Note: Seller shall indemnify Buyer for losses to the extent caused by Seller's negligence or breach of contract. Neither party is liable for incidental or consequential damages. Seller's liability is limited to the purchase price of the goods. SELLER MAKES NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

STANDARD AGREEMENT, PAGE 1 OF 2
BAY AREA CHEMICAL CONSORTIUM
BID NO. 14-2015
SUPPLY AND DELIVERY OF 12.5% SODIUM HYPOCHLORITE

Bay Area Chemical Consortium (BACC)
c/o Dublin San Ramon Services District
Regional Wastewater Treatment Facility
7399 Johnson Drive
Pleasanton, CA 94588

Dear Sirs:

I hereby agree to furnish 12.5% sodium hypochlorite identified in the attached bid forms, as solicited by the Bay Area Chemical Consortium (BACC), to one or more of the participating BACC Agencies.

Company: Univar USA Inc.
Address: 9201 S. 212th
City, State, ZIP: Kent, WA 98032
Phone: (253) 872-5000
Email: muniteam-west@univarusa.com
Authorized Representative: Shawnasey McCarthy
Signature: Shawnasey McCarthy
Date: April 9, 2015

WE ACKNOWLEDGE RECEIVING ADDENDUM/ADDENDA NUMBER 0 THROUGH 0.

SPECIFIC DEVIATIONS (if applicable, attach additional sheets if necessary):

* Unless specified in the BACC bid documents as not accepting deviations from the stated regional pricing on pages 68-69, all "short loads" of less than 2,000 gals. will be priced at the stated regional pricing, plus a $250.00 LTL charge.

STANDARD AGREEMENT, PAGE 2 OF 2
BIDDER INFORMATION

1. Legal Name of Bidder:
   Univar USA Inc.

2. Bidder's Street Address:
   8201 S. 212th, Kent, WA 98032

3. Mailing Address:
   Same As Above

4. Business Telephone: (253) 872-5000 Fax Number: (253) 872 - 5041

5. Type of Supplier:
   ☐ Sole Proprietor ☐ Partnership ☑ Corporation
   If Corporation, indicate State where incorporated: Illinois

6. Business License Number issued by the City where the Supplier's principal place of business is located.
   Number: 3641101210 Issuing City: San Jose, CA

7. Supplier Federal Tax Identification Number: 91 - 1347935

8. Emergency Contact: Name: Ryan Amodeo
   Phone Number: (650) 817 - 0140 (cell)

9. Order Contact: Name: Customer Service
   Address: 2256 Junction Ave, San Jose, CA 95131
   Phone Number: 800-659-5928 Fax Number: 408 - 435 - 1735
   Email: custsvs - sanjose@univarusa.com

10. References:

Company/Agency Name	Contact Name	Phone Number
1) Central Coast Water Auth.	Darin Daragtz	(805) 463-2122
2) City of Brawley	Rudalpho Nunez	(760) 344-5800
3) City of LA, DWP	Teresa Reinosa	(213) 367-2199

11. Chemical Manufacturer's name and address (if different from Bidder):
    K2 Pure Solutions - 950 Loveridge Rd., Pittsburg, CA 94565

Non-Collusion Affidavit
To Be Executed By Bidder and Submitted With Bid

State of ~~California~~ Washington)
) ss.
County of King)

Shawnasey McCarthy, being first duly sworn, deposes and says that he or she is
(Contractor's Authorized Representative)

Municipal Business Manager of Univar USA Inc. the party making the
(Title of Representative) (Contractor's Name)

Foregoing bid that the bid is not made in the interest of, or on behalf of, any undisclosed person, partnership, company, association, organization, or corporation; that the bid is genuine and not collusive or sham; that the bidder has not directly or indirectly induced or solicited any other bidder to put in a false or sham bid, and has not directly or indirectly colluded, conspired, connived, or agreed with any bidder or anyone else to put in a sham bid, or that anyone shall refrain from bidding; that the bidder has not in any manner, directly or indirectly, sought by agreement, communication, or conference with anyone to fix the bid price of the bidder or any other bidder, or to fix any overhead, profit, or cost element of the bid price, or of that of any other bid, or to secure any advantage against the public body awarding the contract of anyone interested in the proposed contract; that all statements contained in the bid are true; and, further, that the bidder has not, directly or indirectly, submitted his or her bid price or any breakdown thereof, or the contents thereof, or divulged information or data relative thereto, or paid, and will not pay, any fee to any corporation, partnership, company association, organization, bid depository, or to any member or agent thereof to effectuate a collusive or sham bid.

I declare under penalty of perjury under the laws of the state of California that the foregoing is true and correct.

Shawnasey McCarthy
Signature of: President, Secretary, Manager, Owner, or Representative

Subscribed and sworn to before me this, 7 Day of April, 2015

Signature of Notary Public In and For

The County of King,

State of Washington

NOTARY PUBLIC
STATE OF WASHINGTON
MICHELLE JEANNE WICK
My Appointment Expires March 01, 2019

All Signatures Must Be Witnessed By Notary

BAY AREA CHEMICAL CONSORTIUM
BID FORM FOR BID NO. 14-2015, PAGE 1 OF 3

Sealed bids must be enclosed in an envelope clearly marked:

"BID FOR 12.5% SODIUM HYPOCHLORITE BACC BID NO. 14-2015"

And delivered to:

Louanne Ivy
Administrative Analyst – Operations
Dublin San Ramon Services District
Regional Wastewater Treatment Facility
7399 Johnson Drive
Pleasanton, CA 94588

No later than 9:00 A.M. PDT
Tuesday, April 14, 2015

Business Name: Univar USA Inc.

Business Address
9201 S. 212th
Attn: WER MuniTeam
Kent, WA 98032

Telephone Number: (253) 872-5000

Facsimile Number: (253) 872-5041

Email Address: muniteam-west@univarusa.com

Authorized Representative (Please Print): Shawnasey McCarthy

Date: April 9, 2015

I. **All costs except California State sales tax for the purchase of 12.5% sodium hypochlorite must be included in the amount shown below on this Bid Form, including any and all mill assessments, fees, excise taxes, transportation charges, etc. Any exceptions to the bid must be noted under Specific Deviations on the Standard Agreement. Bidders shall submit bids in $/gallon.**

BACC Agencies: North Bay Locations

Central Contra Costa Sanitary District, Contra Costa Water District, Delta Diablo, Rodeo Sanitary District, Town of Discovery Bay, and West County Wastewater District.

Unit Price for 12.5% Sodium Hypochlorite $0.4015/gallon

OPTIONAL BID ITEM: Ironhouse Sanitary District

Unit Price for 12.5% Sodium Hypochlorite in totes: $1.9933/gallon

BACC Agencies: East Bay Locations

Alameda County Water District, City of Hayward, City of San Leandro, Oro Loma Sanitary District, and Union Sanitary District.

Unit Price for 12.5% Sodium Hypochlorite $0.4111/gallon

BACC Agencies: South Bay Locations

City of San Jose, and Santa Clara Valley Water District.

Unit Price for 12.5% Sodium Hypochlorite $0.4105/gallon

OPTIONAL BID ITEM: City of Gilroy

Unit Price for 12.5% Sodium Hypochlorite in carboys: $2.71 /gallon

OPTIONAL BID ITEM: City of Morgan Hill

Unit Price for 12.5% Sodium Hypochlorite in drums: $1.9186 /gallon

BAY AREA CHEMICAL CONSORTIUM
BID FORM FOR BID NO. 14-2015, PAGE 2 OF 3

BACC Agencies: **Tri-Valley Locations**
City of Livermore, City of Pleasanton, Dublin San Ramon Services District, and Zone 7 Water Agency.
Unit Price for 12.5% Sodium Hypochlorite $0.4025/gallon

BACC Agencies: **Peninsula Locations**
City of Burlingame, City of Daly City/North San Mateo County Sanitation District, City of San Mateo, City of South San Francisco and Silicon Valley Clean Water.
Unit Price for 12.5% Sodium Hypochlorite $0.425 /gallon

BACC Agencies: **Marin-Sonoma-Napa Locations**
Central Marin Sanitation Agency, City of Mill Valley/Sewerage Agency of Southern Marin), Marin Municipal Water District, Napa Sanitation District, North Marin Water District, Sanitary District No. 5 of Marin County, and Sausalito Marin City Sanitary District.
Unit Price for 12.5% Sodium Hypochlorite $0.5210 /gallon

BACC Agencies: **Sacramento Area Locations**
Carmichael Water District, City of Folsom, City of Roseville, El Dorado Irrigation District, Placer County Water Agency, Rancho Murieta Community Services District and Sacramento County Water Agency.
Unit Price for 12.5% Sodium Hypochlorite $0.5210/gallon
OPTIONAL BID ITEM: Placer County Water Agency
Unit Price for 12.5% Sodium Hypochlorite in carboys: $2.71 /gallon

BACC Agencies: **Central Valley Locations**
City of Fresno, City of Merced and City of Stockton.
Unit Price for 12.5% Sodium Hypochlorite $0.4685/gallon

II. **Bidders must submit all of the following, attached to this Bid Form:**

a. An affidavit of compliance to the appropriate American Water Works Association (AWWA) and/or National Sanitation Foundation (NSF) standard is required for all chemicals and polymers being provided for potable water treatment. Bidders must include a statement by the chemical manufacturer, signed by an authorized representative on letterhead stationery, attesting to the affidavit's validity. In lieu of submitting an affidavit of compliance with AWWA/NSF standards and a letter attesting to the affidavit's validity, a current printout from NSF.org is acceptable.
b. A representative analysis of the chemical to be supplied, as prepared by a reputable outside laboratory or Bidder's in-house laboratory if ISO certified.
c. Product Bulletin and Typical Properties.
d. Safety Data Sheet (SDS).

BAY AREA CHEMICAL CONSORTIUM
BID FORM FOR BID NO. 14-2015, PAGE 3 OF 3

e. If applicable, the name, address, and contact information for the third party hauling company as well as an affidavit signed by the Bidder that the third party hauler can and will deliver the chemical to each and every participating BACC Agency.

* Please see page 65 - "Specific Deviations".

** All prices include CA Pesticide (Mill Tax) Fee @ 2.175%.

Attachment E

Univar USA Inc.
2256 Junction Ave.
San Jose, CA 95131-1216

T 408-435-8700
F 408-435-1735
800-659-5908
www.univar.com

UNIVAR

GENERAL INFORMATION

Regular Office Hours during which orders may be placed:

Monday – Friday 7:00 am – 5:00 pm (PST)

In case of an emergency during non-business hours:

For Non-Chemical Emergencies:

After-hours emergency – 24-hour response:
Ryan Amodeo - (650) 817-0140 (cell)
Will Allison - (408) 593-4460 (cell)
Brian Wills- (650) 670-7267
Tom Mendenhall- (650) 280-3726 (cell)

For Chemical Related Emergencies:

ChemTrec: (800) 424-9300

Names, telephone/FAX numbers of those responsible for taking orders and initiating delivery:

Office Phone: (800) 659-5908
Office Fax: (408) 435-1735

Customer Service- custsvs-sanjose@univarusa.com
John Dinh - Dispatcher John.dinh@univarusa.com
Ryan Amodeo- Plant Manager Ryan.Amodeo@univarusa.com

For anything pertaining to bids:

Please send all bid packets/documents to:
(Unless otherwise specified)

Univar USA Inc.
Attn: WER Muni Team
8201 S. 212th
Kent, WA 98032-1994

Contacts: muniteam-west@univarusa.com

Jennifer Perras
Municipal Specialist
Phone: (253) 872-5040
Fax: (253) 872-5041
jennifer.perras@univarusa.com

Roise Holiday
Municipal Specialist
Phone: (253) 872-5068
Fax: (253) 872-5041
roise.holiday@univarusa.com

Michelle Wick
Municipal Specialist
Phone: (53) 872-5084
Fax: (253) 872-5041
michelle.wick@univarusa.com

Shawnasey McCarthy
Municipal Business Manager
Phone: (253) 872-5052
Fax: (253) 872-5041
shawnasey.mccarthy@univarusa.com

Remittance Address:

Univar USA Inc.
File No. 56019
Los Angeles, CA 90074-6019

Standard Payment Terms:

Net 30 days

Attachment E

UNIVAR

UNIVAR USA INC.
AUTHORIZED BID SIGNERS

RESOLUTION

RESOLVED, that the Corporate Secretary shall maintain a list of the agents of this Corporation who are vested with authority to execute in the Corporation's behalf formal, written bids or proposals for the sale of other disposition of products handled by the Corporation. Said list shall be as established initially by the Board of Directors and thereafter, the President, or a Vice President shall have the authority, by written directive to the Corporate Secretary, to add agents to or eliminate agents from said list, and it is further

RESOLVED, that the Corporate Secretary or any Assistant Secretary of the Corporation is authorized to certify this resolution or certify to the name or names of persons on the list maintained by the Corporate Secretary and such certificate will be conclusive evidence of the authority of such person or persons so to act.

END OF RESOLUTION

CERTIFICATION

I, the undersigned, as Corporate Secretary of Univar USA Inc. do hereby certify as follows:

1. That the above resolution was duly adopted by the Board of Directors of said Corporation at a meeting duly held on December 4, 1986, and is in full force and effect.

2. That the list of persons authorized to execute, for an on behalf of this Corporation, written bids or proposals for the sale or other disposition of products handled by this Corporation, as initially established by the Board of Directors and thereafter added to by the President, or a Vice President of this Corporation as follows:

All officers and the following:

Shawnasey McCarthy – Municipal Business Manager
Jennifer Perras – Municipal Specialist
Michelle Wick – Municipal Specialist
Roise Holiday – Municipal Specialist

3. That all of the foregoing persons are authorized to execute bids pursuant to the resolution above referred to.

Dated this 9th day of April, 2015.

UNIVAR USA INC. CORPORATE SEAL 1986 WASHINGTON

Perry T. Kusakabe
Corporate Secretary

Attachment E

The Public Health and Safety Organization

NSF Product and Service Listings

These NSF Official Listings are current as of **Thursday, April 09, 2015** at 12:15 a.m. Eastern Time. Please contact NSF International to confirm the status of any Listing, report errors, or make suggestions.

Alert: NSF is concerned about fraudulent downloading and manipulation of website text. Always confirm this information by clicking on the below link for the most accurate information: http://info.nsf.org/Certified/PwsChemicals/Listings.asp?CompanyName=K2&ChemicalName=Sodium+Hypochlorite&

NSF/ANSI 60
Drinking Water Treatment Chemicals - Health Effects

K2 Pure Solutions NoCal, L.P.
950 Loveridge Road
Pittsburg, CA 94565
United States
925-203-1190
Visit this company's website (http://www.k2pure.com)

Facility : Pittsburg, CA

Sodium Hypochlorite[CL]

Trade Designation	*Product Function*	*Max Use*
Sodium Hypochlorite	Disinfection & Oxidation	84mg/L

[CL] The residual levels of chlorine (hypochlorite ion and hypochlorous acid), chlorine dioxide, chlorate ion, chloramine and disinfection by-products shall be monitored in the finished drinking water to ensure compliance to all applicable regulations.

Number of matching Manufacturers is 1
Number of matching Products is 1
Processing time was 0 seconds

K2 Pure Solutions

Certificate of Analysis

Physical Properties:

Color:	clear greenish yellow color
Odor:	mild chlorine odor
pH:	12.5

Test Results:

	Lower Limit	Upper Limit	Value
Sodium Hypochlorite (as NaOCl, wt. %)	12.5%	15.6%	13.1%
Specific Gravity @ 60 deg F	1.212	1.279	1.224

Characteristic:

	Lower Limit	Upper Limit	Value
Total Alkalinity (as NaOH, wt. %)	0.1%	1.0%	0.6%
Sodium Carbonate (as Na_2CO_3, wt. %)	-	1.0%	0.2%
Iron (Fe, ppm)	-	< 2.0 ppm	<0.2
Nickel (Ni, ppm)	-	0.1 ppm	0.03
Bromate (BrO_3, ppm)	-	< 30 ppm	<30

Environmental Status:

RCRA List:	N/A
SARA 313 List:	N/A
California Prop 65 List:	N/A
EPA Registration Number:	88296-1; 88296-2
DOT Proper Shipping Name:	Hypochlorite Solutions, 8, UN1791, PGIII
	(RQ 100 Lbs) = 80 Gallons 12.5% Soution

Product:

Sodium Hypochlorite 12.5 @	(Circle One): 12.5% 13.0% 13.7%
K2 Order #:	24404
Date:	3/24/2015

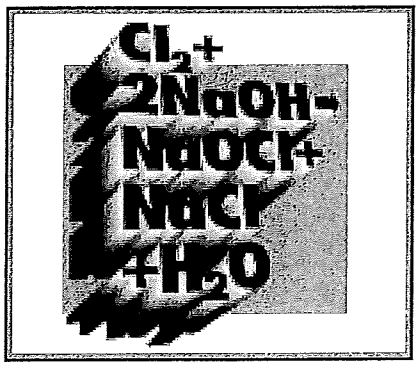
NSF Certified to NSF/ANSI 60

This product has been certified according to NSF/ANSI 60 at a maximum use level in drinking water of 84 mg/L

K2 Pure Solutions, 950 Loveridge Road – Pittsburg, CA 94565 – Phone 925-203-1199

OxyChem Sodium Hypochlorite Handbook

Soda Bleach Solutions Handbook



OxyChem

Foreword

This handbook outlines the methods for handling, storing, preparing and using soda bleach solutions. It includes information on the manufacture, physical properties and analytical methods for testing soda bleach solutions.

Additional information and contacts can be found at www.oxychem.com

Occidental Chemical Corp.
Basic Chemicals Group
Occidental Tower
5005 LBJ Freeway
Dallas, TX 75244

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THE INFORMATION PRESENTED HEREIN WAS PREPARED BY TECHNICAL PERSONNEL AND IS TRUE AND ACCURATE TO THE BEST OF OUR KNOWLEDGE. **OXYCHEM DOES NOT MAKE ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, EXPRESS OR IMPLIED, REGARDING PERFORMANCE, STABILITY OR ANY OTHER CHARACTERISTIC.** THE INFORMATION CONTAINED HEREIN IS NOT TO BE CONSTRUED AS AN EXPRESS WARRANTY CONCERNING THE PERFORMANCE, STABILITY OR ANY OTHER CHARACTERISTIC OF ANY OXYCHEM PRODUCT. THIS INFORMATION IS NOT INTENDED TO BE ALL-INCLUSIVE AS TO MANNER OR CONDITIONS OF USE. HANDLING, STORAGE, DISPOSAL AND OTHER ACTIVITIES MAY INVOLVE OTHER OR ADDITIONAL LEGAL, SAFETY OR PERFORMANCE CONSIDERATIONS. WHILE OUR TECHNICAL PERSONNEL WILL RESPOND TO ANY QUESTIONS REGARDING SAFE HANDLING AND USE PROCEDURES, SAFE HANDLING AND USE REMAINS THE RESPONSIBILITY OF THE CUSTOMER. NO SUGGESTIONS FOR USE ARE INTENDED AS, AND NOTHING HEREIN SHALL BE CONSTRUED AS A RECOMMENDATION TO INFRINGE ANY EXISTING PATENT OR TO VIOLATE ANY FEDERAL, STATE OR LOCAL LAW.

Occidental Chemical Corporation 2000

Introduction

This handbook provides information concerning proper procedures for the manufacture of sodium hypochlorite, or soda bleach, solutions. An attempt has been made to give a relatively comprehensive coverage of the subject. If additional technical information or specific recommendations regarding soda bleach solutions are desired, the Technical Service Group of Occidental Chemical Corporation will be pleased to render assistance. Requests for such information should be made to your local OxyChem representative.

Some safety and handling information has been taken directly from the Chlorine Institute's Pamphlet 96 with the permission of the Chlorine Institute. Pamphlet 96 also contains additional information on sodium hypochlorite.

For further information regarding caustic soda and chlorine, refer to the appropriate OxyChem handbook.

Sodium hypochlorite solutions have attained widespread usage in bleaching operations and as disinfectants, both in the home and in industry. A brief historical sketch may therefore be of interest.

Scheele, a Swedish chemist, is generally credited with discovering chlorine in 1774. During his experiments, he found that a solution of chlorine in water possessed definite bleaching properties. Since the reaction between chlorine and water forms hydrochloric and hypochlorous acids, early textile bleaching experiments were not successful because of damaged cloth.

In 1789, the French chemist Berthollet succeeded in chlorinating a solution of potash, forming a potassium hypochlorite solution. This solution proved to be a more successful bleach for textiles due to the absence of free hydrochloric acid. However, it never gained more than limited usage in the bleaching field, primarily because of the high cost of potash.

In 1798, Tennant of England prepared a solution of calcium hypochlorite by chlorinating a slurry of relatively inexpensive lime. The following year he patented a process for the manufacture of bleaching powder where chlorine gas was absorbed in a dry lime hydrate.

Labarraque succeeded, in 1820, in preparing sodium hypochlorite by chlorinating a solution of caustic soda. Varying concentrations of this solution have found a multitude of applications so that the general public is now well acquainted with the material. This handbook will discuss sodium hypochlorite solutions.

General Properties of Hypochlorites

The term hypochlorites refers to the salts of hypochlorous acid (HOCl). Since the acid is extremely unstable, most users handle the more stable hypochlorite solutions instead. These salts are prepared by reacting chlorine with an alkali or an alkaline earth hydroxide.

PREPARATION

The common method for making sodium hypochlorite is to react chlorine with a solution of caustic soda. The final concentration of the sodium hypochlorite solution depends on the initial concentration of the starting caustic soda solution. The following equation gives the chemical reaction involved, regardless of concentration:

(1) $Cl_2 + 2\ NaOH \rightarrow NaOCl + NaCl + H_2O$

A more active, but less stable, sodium hypochlorite can be produced by chlorinating a solution of soda ash according to the following equation:

(2) $Cl_2 + 2Na_2CO_3 + H_2O \rightarrow NaOCl + NaCl + 2\ NaHCO_3$

On further chlorination, hypochlorous acid will be produced:

(3) $Cl_2 + Na_2CO_3 + H_2O \rightarrow HOCl + NaCl + NaHCO_3$

Most commercial production processes react chlorine with caustic soda as in equation (1). This handbook addresses that method.

STABILITY

Although more stable than hypochlorous acid, hypochlorites are inherently unstable themselves. They start breaking down when prepared and continue until completely decomposed. With proper care, the rate of decomposition can be controlled to the extent that relatively stable solutions can be prepared.

The stability and shelf life of a hypochlorite solution depends on five major factors:

- Hypochlorite concentration.
- Alkalinity or pH of the solution.
- Temperature of the solution, both in preparation and in storage.
- Concentration of certain impurities which catalyze decomposition.
- Exposure to light.
- Ionic strength of the solution.
- Contact with organic impurities.

Solutions containing low concentrations of hypochlorites decompose more slowly than those at higher concentrations. When stored under adverse conditions, solutions made at high concentrations soon may have a lower concentration than those which were originally made at low concentrations.

The alkalinity or pH has a pronounced effect on the stability of hypochlorite solutions. A pH value between 11.0 and 13.0 gives the most stable solutions. A slight excess of caustic soda also helps protect hypochlorite solutions from the harmful effects of light. To improve control, excess alkalinity should be adjusted based on the strength of bleach solution. Typical targets range from 0.2% excess alkalinity in a 20 grams per liter (gpl) bleach solution to 1.0% excess alkalinity in a 200 gpl bleach solution. There is no evidence that greater concentrations of excess alkalinity have a beneficial effect on the stability of hypochlorite solutions. In fact, excessively high alkalinity may damage textiles and retard the bleaching action of the hypochlorite.

General Properties of Hypochlorites

Temperature during manufacture and storage definitely influences the stability of hypochlorite solutions. Care should be taken to keep solutions away from heat, as higher temperatures will increase the decomposition rate. Although low storage temperatures improve the stability of hypochlorite solutions, freezing should be avoided. Sodium hypochlorite solutions will freeze at different temperatures depending on the concentration of the solution.

The quality and stability of sodium hypochlorite solutions can be affected by the concentration of certain impurities. Trace metals such as nickel, copper and cobalt form insoluble metal oxides, which cause the bleach to catalytically decompose, forming oxygen gas and lowering bleach strength. These trace metals, as well as iron, calcium and magnesium, form sediment and may discolor the bleach solution.

Potential sources for these impurities include raw materials, processing equipment and product storage containers. The most common source for these metals, particularly nickel and copper, is the caustic soda feed. Diaphragm cell caustic soda typically contains a higher concentration of these metal catalysts than do membrane or rayon grades. However, many bleach manufacturers successfully make stable bleach from diaphragm caustic soda.

Some techniques used by bleach producers to minimize the concentration of impurities in the finished product are listed below.

- Polish the finished bleach with a 0.5 to 1 micron filter. This will remove impurities which promote bleach decomposition and/or degrade the visual appearance.
- Use plastic or lined tanks and piping systems to reduce metal pick-up.
- Use soft water for the final dilution step.
- Allow finished bleach to settle until clear and decant before packaging.

The most effective of these, filtration of finished bleach, represents a method for removing insoluble oxides and other particulate matter from the finished bleach.

The type of filtration system required will depend on particulates loading, production rate and other considerations.

Light accelerates the decomposition of hypochlorite solutions. Avoid direct contact with sunlight. Opaque (non-translucent) containers for packaging hypochlorite solutions will reduce decomposition caused by light.

DECOMPOSITION REACTIONS

Hypochlorite solutions decompose in two main ways:
Effect of temperature and time:

(4) $3\ NaOCl \rightarrow NaClO_3 + 2NaCl$

In this reaction the sodium hypochlorite forms sodium chlorate and sodium chloride. The rate increases with increasing temperature. This reaction is not catalytic.

Effect of metal catalysts, temperature and light:

(5) $2\ NaOCl \rightarrow O_2 + 2NaCl$

Trace metals such as nickel, copper and cobalt form insoluble metal oxides, which cause bleach to catalytically decompose to oxygen and sodium chloride. Light also catalyzes this reaction.

As discussed previously, pH has a pronounced effect on the stability of hypochlorite solutions. The breakdown of hypochlorite accelerates according to Reaction 4 as the pH value decreases. In addition, when the bleach solution becomes neutral, hypochlorous acid can form and release chlorine (Cl_2).

Terminology

The strength of soda bleach solutions is usually expressed as either available chlorine or sodium hypochlorite content. The term available chlorine is the amount of chlorine equivalent in oxidizing power to the hypochlorite present. Available chlorine is usually expressed as either percent by weight or grams per liter (gpl).

When describing concentration in terms of sodium hypochlorite content, the standard unit is per cent by weight.

It is important to specify the concentration units whenever describing the strength of bleach solutions. For example, 5.25 wt. % sodium hypochlorite is equivalent to 5.0 wt. % available chlorine, or 5.37 trade percent

Conversions

Weight % available chlorine = $\frac{\text{gpl available chlorine}}{\text{10 x specific gravity of solution}}$

Weight % sodium hypochlorite = **1.05 x wt. % available chlorine**

Weight % sodium hypochlorite = $\frac{\text{1.05 x gpl available chlorine}}{\text{10 x specific gravity of solution}}$

Trade Percent = $\frac{\text{gpl available chlorine}}{10}$

Manufacturing

Sodium hypochlorite (soda bleach) solutions can be prepared by reacting chlorine with solutions of caustic soda, soda ash (sodium carbonate), or a combination of caustic soda and soda ash. Soda ash processes produce less stable sodium hypochlorite solutions. For that reason, only the caustic soda processes will be discussed in this handbook.

Potassium hypochlorite, another bleach product, can be produced with the same equipment for production of soda bleach solutions.

As previously stated, chlorine will react with a caustic soda solution to produce sodium hypochlorite according to the following equation:

	Chlorine	+	Caustic Soda	→	Sodium Hypochlorite		Sodium +Chloride		+Water
Chemical Symbol	Cl_2	+	2 NaOH	→	NaOCl	+	NaCl	+	H_2O
Molecular Wt.	70.91	+	2 (40.00)	→	74.45	+	58.45	+	18.02
Factor	1.00		1.13		1.05		0.82		0.25

From the molecular weights of chemically pure materials, one pound of chlorine plus 1.13 pounds of caustic soda will produce 1.05 pounds of sodium hypochlorite. These calculations do not include any excess alkalinity needed in the resultant hypochlorite solution for stability.

Since commercial materials are not chemically pure, the foregoing calculations must be revised to take that into account. For practical purposes, chlorine can be assumed to be 100% pure. Dry caustic soda is about 98% pure. The value of 1.13 divided by 0.98 gives a factor of 1.15 pounds of commercial caustic soda to react with one pound of chlorine. Since the strength of caustic soda solutions is given as actual concentration of sodium hydroxide content, the theoretical factor 1.13 will apply in calculations with caustic soda solutions.

Manufacturing

The degree of hardness in water for dilution will influence the ratio of chlorine to caustic soda. Some caustic soda will be consumed by reacting with the hardness salts of calcium and magnesium in the water.

The exact ratio of chlorine and caustic soda will depend on the available water quality and the amount of excess caustic soda desired by the bleach manufacturer. The approximate amount of raw materials needed to produce given concentration of bleach solution can be calculated as follows:

Chlorine

(6) Pounds of Cl_2 required = (wt. % available chlorine x specific gravity of bleach x 8.337 x gallons of bleach) ÷ 100.

(7) Pounds of Cl_2 required = gpl available chlorine x 0.008345 x gallons of bleach.

Caustic Soda - Dry

(8) Pounds of dry caustic soda required = (pounds of chlorine x 1.15) + (wt. % excess caustic soda x specific gravity of bleach x 8.337 x gallons of bleach) ÷ 100.

Caustic Soda - Liquid

(9) Pounds of caustic soda solution required = [(pounds of Cl_2x 1.13) + (wt. % excess caustic soda x specific gravity of bleach x 8.337 x gallons of bleach]/ wt. % caustic soda solution.

(10) Gallons of liquid caustic soda required = pounds of liquid caustic soda ÷ (8.337 x specific gravity of caustic soda solution).

Water

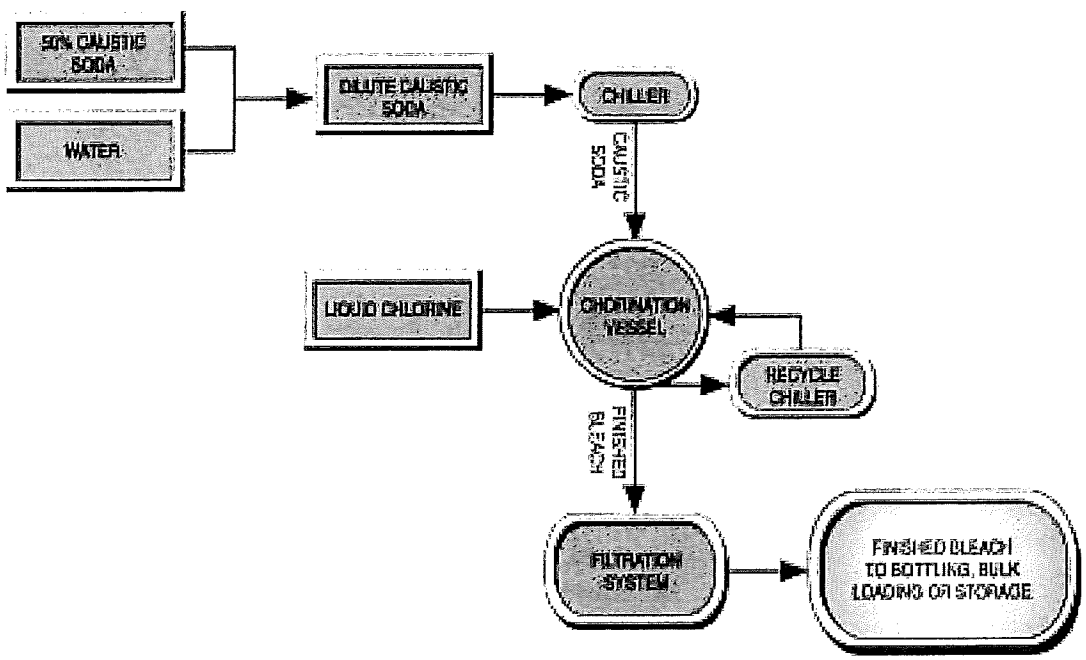
(11) Pounds of water required = (gallons of bleach x 8.337 x specific gravity of bleach) - (pounds of Cl_2+actual pounds of caustic soda).

(12) Gallons of water required=pounds of water ÷ 8.337.

NOTE: All calculations are based on standard conditions at 60° F.

Typical Installation

Figure 1
Sodium Hypochlorite Manufacturing Process



Manufacturing

Tables 1 and 2 list the materials required for making 1000 gallons of bleach solution in concentrations from 10 to 200 gpl available chlorine. Table 1 should be used by those who express bleach concentration as gpl available chlorine. Table 2 will better serve those who express bleach concentrations as per cent by weight available chlorine or sodium hypochlorite.
Tables 1 and 2 use rounded values and will vary slightly from calculated values.

Example:

It is desired to make 1000 gallons of household bleach containing 5.25% sodium hypochlorite by weight. Table 2 provides the following information:

(a) 5.25% sodium hypochlorite = 5.0% available chlorine by weight.
(b) specific gravity = 1.075
(c) desired excess caustic soda = 0.27%

(Reference equations on page 6).

(6) 5.0 x 1.075 x 8.337 x 1000 ÷ 100 = 448 pounds of chlorine required.

(8) (448 x 1.15) + (0.27 x 1.075 x 8.337 x 1000 ÷100) = 539 pounds of dry caustic soda required.

(11) (1000 x 8.337 x 1.075) - (448 + 539) = 7975 pounds of water required.

(12) 7975 ÷ 8.337 = 957 gallons of water required.

Starting with 20% caustic soda (specific gravity = 1.223), instead of dry caustic soda, the calculation is:

(9) [(448 x 1.13) + (0.27 x 1.075 x 8.337 x 1000 ÷ 100)] ÷ 0.20 = 2652 pounds of 20% caustic soda solution required.

(10) 2652 ÷ (8.337 x 1.223) = 260 gallons of 20% caustic soda solution required.

(11) (1000 x 8.337 x 1.075) - (448 + 2652) = 5862 pounds of water required.

(12) 5862 ÷ 8.337 = 703 gallons of water required.

Table 1
Materials for Making 1000 Gallons of Bleach Solution

Finished Bleach						Chlorine Required	Caustic Soda Required for Chlorination							Water Addition Required for Diluting Caustic Soda	
Strength												Dilute Caustic Soda Solution For Chlorination			
Available Chlorine															
Grams per Liter *(1)	Weight %	NaOCl Weight %	Specific Gravity	Pounds per Gallon	Excess Caustic NaOH%	Cl_2 Pounds	Stoichiometric NaOH Pounds	Excess NaOH Pounds	TOTAL Pounds	Dry NaOH @ 98% Pounds	50% Liquid NaOH Gallons	Solution Gallons	NaOH%	Dry NaOH Water Gal.	50% Liquid NaOH Water Gal.
10	0.99	1.04	1.014	8.454	0.10	83.5	94.4	8.5	102.8	104.9	16.1	989.4	1.23	991.4	979.1
20	1.95	2.04	1.028	8.570	0.20	166.9	188.6	17.1	205.7	209.9	32.2	980.2	2.45	982.8	958.3
30	2.88	3.02	1.042	8.687	0.21	250.4	283.0	18.2	301.2	307.3	47.1	972.2	3.57	975.1	939.3
40	3.79	3.98	1.056	8.804	0.23	333.8	377.2	20.2	397.4	405.6	62.1	964.4	4.69	967.3	920.1
50	4.67	4.91	1.070	8.921	0.25	417.3	471.5	22.3	493.9	503.9	77.2	956.7	5.81	959.5	900.9
60	5.54	5.81	1.084	9.037	0.33	500.7	565.8	29.8	595.6	607.8	93.1	948.7	6.98	951.0	880.3
70	6.38	6.69	1.098	9.154	0.40	584.2	660.1	36.6	696.8	711.0	109.0	941.2	8.13	942.6	860.0
80	7.19	7.55	1.112	9.271	0.47	667.6	754.4	43.6	798.0	814.2	124.8	933.8	9.28	934.3	839.6
90	7.99	8.39	1.126	9.387	0.54	751.1	848.7	50.7	899.4	917.8	140.6	926.6	10.41	925.8	819.1
100	8.77	9.21	1.140	9.504	0.61	834.5	943.0	58.0	1001.0	1021.4	156.5	919.7	11.55	917.4	798.6
110	9.53	10.01	1.154	9.621	0.65	918.0	1037.3	62.5	1099.9	1122.3	172.0	913.3	12.64	909.3	778.8
120	10.27	10.79	1.168	9.738	0.69	1001.4	1131.6	67.2	1198.8	1223.2	187.5	907.1	13.72	901.2	758.9
130	11.00	11.55	1.182	9.854	0.72	1084.9	1225.9	71.0	1296.9	1323.4	202.8	901.1	14.79	893.1	739.3
140	11.71	12.29	1.196	9.971	0.75	1168.3	1320.2	74.8	1395.0	1423.4	218.1	895.4	15.85	885.1	719.6
150	12.40	13.02	1.210	10.088	0.78	1251.8	1414.5	78.7	1493.2	1523.7	233.5	889.9	16.90	877.1	699.9
160	13.07	13.73	1.224	10.204	0.81	1335.2	1508.8	82.7	1591.4	1623.9	248.9	884.4	17.94	869.1	680.3
170	13.73	14.42	1.238	10.321	0.85	1418.7	1603.1	87.7	1690.9	1725.4	264.4	879.2	18.99	860.9	660.3
180	14.38	15.10	1.252	10.438	0.90	1502.1	1697.4	93.9	1791.3	1827.9	280.1	874.4	20.05	852.6	640.1
190	15.01	15.76	1.266	10.555	0.95	1585.6	1791.7	100.3	1892.0	1930.6	295.9	869.8	21.09	844.2	619.8
200	15.63	16.41	1.280	10.671	1.00	1669.0	1886.0	106.7	1992.7	2033.4	311.6	864.2	22.14	835.9	599.5

Table volumes based on standard conditions @ 60° F

* (1) Trade Percent = $\frac{\text{Grams Per Liter}}{10}$

Manufacturing

Table 2
Materials for Making
1000 Gallons of Bleach Solution

Finished Bleach						Chlorine Required	Caustic Soda Required for Chlorination							Water Addition Required for Diluting Caustic Soda	
Strength												Dilute Caustic Soda Solution for Chlorination			
Available Chlorine															
Weight %	Grams per Liter * (1)	NaOCl Weight %	Specific Gravity	Pounds per Gallon	Excess Caustic NaOH%	Cl2 Pounds	Stoichiometric NaOH Pounds	Excess NaOH Pounds	TOTAL Pounds	Dry NaOH @ 98% Pounds	50% Liquid NaOH Gallons	Solution Gallons	NaOH%	Dry NaOH Water Gal.	50% Liquid NaOH Water Gal.
1.0	10.1	1.05	1.014	8.455	0.10	84.6	95.6	8.5	104.1	106.2	16.3	989.5	1.24	991.3	978.9
2.0	20.6	2.10	1.029	8.577	0.20	171.5	193.8	17.2	210.9	215.3	33.0	980.4	2.51	982.4	957.3
3.0	31.3	3.15	1.044	8.702	0.21	261.1	295.0	18.3	313.3	319.7	49.0	972.7	3.71	974.1	936.9
4.0	42.3	4.20	1.059	8.831	0.25	353.2	399.1	22.1	421.2	429.8	65.9	965.4	4.97	965.4	915.4
5.0	53.7	5.25	1.075	8.964	0.27	448.2	506.5	24.2	530.7	541.5	83.0	958.1	6.23	956.5	893.5
5.25	56.6	5.51	1.079	8.998	0.29	472.4	533.8	26.1	559.9	571.3	87.6	947.5	6.57	954.1	887.6
5.50	59.5	5.78	1.083	9.031	0.31	496.8	561.4	28.0	589.4	601.4	92.2	937.3	6.91	951.6	881.5
5.75	62.5	6.04	1.088	9.066	0.35	521.3	589.1	31.7	620.8	633.5	97.1	927.5	7.26	949.0	875.1
6.0	65.4	6.30	1.092	9.101	0.37	546.0	617.0	33.7	650.7	663.9	101.7	917.9	7.61	946.5	869.0
7.0	77.5	7.35	1.109	9.242	0.45	646.9	731.0	41.6	772.6	788.4	120.8	911.7	8.99	936.3	844.4
8.0	90.0	8.40	1.126	9.387	0.54	751.0	848.6	50.7	899.3	917.7	140.6	906.3	10.41	925.8	818.9
9.0	102.9	9.45	1.144	9.538	0.63	858.4	970.0	60.1	1030.1	1051.1	161.1	901.2	11.87	915.0	792.6
10.0	116.1	10.50	1.163	9.693	0.67	969.3	1095.3	64.9	1160.2	1183.9	181.4	896.3	13.30	904.3	766.5
11.0	129.9	11.55	1.182	9.853	0.72	1083.8	1224.7	70.9	1295.6	1322.1	202.6	892.0	14.78	893.2	739.4
12.0	144.1	12.60	1.202	10.019	0.76	1202.2	1358.5	76.1	1434.6	1463.9	224.3	887.9	16.27	881.9	711.6
13.0	158.7	13.65	1.222	10.189	0.80	1324.7	1496.9	81.5	1578.4	1610.6	246.8	884.0	17.81	870.1	682.8
14.0	173.9	14.70	1.244	10.367	0.87	1451.4	1640.1	90.2	1730.3	1765.6	270.6	880.5	19.41	857.6	652.4
15.0	189.6	15.75	1.266	10.550	0.95	1582.6	1788.3	100.2	1888.6	1927.1	295.3	877.6	21.06	844.5	620.6

Table volumes based on standard conditions @ 60° F

*(1) Trade Percent = $\frac{\text{Grams Per Liter}}{10}$

Manufacturing

Table 3
Amount of Bleach Produced From Standard Chlorine Containers

Occasionally it is desirable to base the size of a batch of bleach on the entire contents of one or more chlorine containers. The volume of bleach produced at various concentrations from a 100-pound cylinder, a 150-pound cylinder or a ton container, may be determined by consulting Table 3 or Table 4.

(1) Trade Percent = gpl/10

Bleach Concentration	Gallons of Bleach Solution Produced with		
gpl Available Chlorine (1)	100 lbs. Chlorine	150 lbs. Chlorine	2000 lbs. Chlorine
10	1198	1796	23952
20	599	899	11983
30	399	599	7987
40	299	449	5992
50	240	359	4793
60	200	300	3994
70	171	257	3423
80	150	225	2996
90	133	200	2663
100	120	180	2397
110	109	163	2179
120	100	150	1997
130	92	138	1843
140	86	128	1712
150	80	120	1598
160	75	112	1498
170	70	106	1410
180	66	100	1331
190	63	95	1261
200	60	90	1198

Manufacturing

Table 4
Amount of Bleach Produced From Standard Chlorine Containers

Bleach Concentration	Gallons of Bleach Solution Produced with		
Wt. % Available Chlorine	100 lbs. Chlorine	150 lbs. Chlorine	2000 lbs. Chlorine
1.0	1182	1773	23641
2.0	583	875	11662
3.0	383	574	7660
4.0	283	425	5663
5.0	223	335	4462
5.25	212	318	4234
5.50	201	302	4026
5.75	192	288	3836
6.0	183	275	3663
7.0	155	232	3092
8.0	133	200	2663
9.0	116	175	2330
10.0	103	155	2063
11.0	92	138	1845
12.0	83	125	1664
13.0	75	113	1510
14.0	69	103	1378
15.0	63	95	1264

Handling and Storage

CAUSTIC SODA

Since metals are detrimental to the stability of bleach, caustic soda for bleach making should be handled to minimize metals dissolving into the solution.

Where 50% caustic soda is added directly into a chlorination tank or a continuous bleach system, the storage vessel should be lined to prevent iron contamination in the bleach.

Where 50% caustic soda is diluted to 25% or less with unsoftened water, then settled or filtered before transfer, the storage or dilution tanks can be plain steel. Any iron dissolved by the caustic soda will precipitate with the calcium and magnesium (hard water salts) after dilution, cooling, and settling or filtration.

Avoid any copper, zinc or aluminum in a caustic soda system. All are readily attacked by caustic soda. In addition, copper is an extremely active catalyst that can accelerate the decomposition of bleach.

Nickel is quickly attacked by bleach and greatly accelerates its decomposition. However, because of the almost total resistance to caustic soda under 300° F, nickel is an excellent material of construction for 50% caustic soda service.

Caustic soda tanks should have two outlet points. The opening for transfer of solution to process should be sufficiently off the bottom to prevent entrainment of sediment. Another outlet should be at the lowest point of the bottom of the tank to allow easy cleaning. Dilution tanks will accumulate a sediment caused by the precipitation of hard water salts and other metals.

A caustic soda dilution tank should be emptied and rinsed out at least annually to prevent sediment from accumulating close to the process solution outlet. Metals and other impurities concentrate in the sediment. A small amount of sediment unintentionally transferred to the chlorination vessel can provide enough contamination to produce poor quality bleach.

Steel tanks in caustic soda service become passivated with a gray-black film forming on the metal. Thereafter, caustic soda at less than 130° F will dissolve very little iron from the tank. The protective film should be preserved whenever practical. Therefore, when sediment is rinsed from a tank, only the bottom should be washed. Caustic Soda solution should then be put into the tank as soon as the washing is finished. Otherwise a soft rust will form and contaminate any future storage.

SODIUM HYPOCHLORITE

GENERAL

Few materials of construction will withstand the highly reactive nature of sodium hypochlorite. Improper selection of those materials may result in damage to the handling system and contamination of the product. As a general rule, no metals (with the exception of titanium and tantalum under certain circumstances) should be allowed to come in contact with this chemical.

STORAGE

Warning - sodium hypochlorite solutions must be stored in vented containers, or in containers equipped with adequate relief devices. If venting rate is exceeded by the decomposition rate, swelling or damage to the container may occur.

BULK STORAGE TANKS

Tank and lining manufacturer's products and processes vary considerably, therefore, selecting an appropriate storage vessel should be given thorough evaluation. Consultation with tank and lining suppliers is recommended.

Rubber Lined Steel

Tanks of this type are generally custom fabricated for a specific process. They may be any size of shape depending on the needs of the user, but are typically closed vertical or horizontal cylindrical vessels from 1,000 to 30,000 gallons capacity.

Fiberglass

The success or failure of this type of tank when used in sodium hypochlorite service depends upon a large number of variables including resin type and additives,type of reinforcement, fabrication technique, storage temperature, environmental exposure and the characteristics of the solution. While many tanks of this type are currently in use, it is advisable to deal only with fabricators having experience with sodium hypochlorite and who are willing to warranty the vessel for the intended applications.

Make certain tank has adequate UV (ultra violet) stabilizer or a gel coat outer layer designed for the area of intended use.

If possible, locate tank in a shaded area.

Handling and Storage

Polyethylene Tanks

Although some sodium hypochlorite users have had success with polyethylene tanks, some suppliers will not certify their tanks for this use.

TRANSFER SYSTEMS

Materials Selection

The following materials are compatible with sodium hypochlorite solutions or as linings for non-compatible materials. Some may not be suitable for use in processes that manufacture sodium hypochlorite. Other materials not listed here may also be suitable.

1. PVDF (fluorinated polyvinylidene)
2. PTFE (polytetrafluoroethylene)
3. Titanium (Warning: titanium must not be used in contact with dry chlorine).
4. Ethylene Propylene Rubber
5. Chlorobutylene Rubber
6. Polypropylene
7. PVC (polyvinyl chloride)
8. CPVC (chlorinated polyvinyl chloride)
9. Tantalum
10. VitonA with a minimum durometer of 70

Piping

The two factors which determine the selection of piping materials for sodium hypochlorite solutions are structural strength and chemical resistance. Where piping systems may be subject to physical stress, lined steel pipe should be selected. Lining types include polypropylene, PVDF, PTFE, or similar thermoplastics. In lighter stress situations, fiberglass and reinforced PVC is suitable. As with the fiberglass tanks, care should be exercised in the selection of the resin for fiberglass piping. Where piping will not be subject to impact, Schedule 80 PVC or CPVC is often used. Conventional support spacing standards should be observed when using this type of piping system. When metal fittings must be used, titanium is the preferred material. Mild steel, stainless steel, and virtually all common metals will corrode rapidly on contact with sodium hypochlorite solutions. Additionally, the resulting corrosion products will contribute to product degradation. Alloy 20 has been reported to corrode in contact with sodium hypochlorite solutions causing product decomposition. Hastalloy C is also not recommended.

Valves

Structural strength of the valve must be considered with respect to its specific application. Valve selection will depend upon the type of piping system being used.

Pumps

Due to the numerous individual components comprising a complete pump, special care should be used when specifying this device. The centrifugal pump is the most common style found in sodium hypochlorite solution transfer systems. Casing and impellers may be of materials previously mentioned as chemically resistant to sodium hypochlorite. Impeller shafts should be made of titanium or protected by another compatible material. Pumps constructed of titanium are available and while more costly than "plastic" pumps will typically provide longer service.

SYSTEM DESIGN

Continuous Reactors For Manufacturing Bleach

Caustic soda and chlorine can be fed continuously into a mixing reactor to form bleach. Instrumentation sensing the oxidation reduction potential (ORP) of the bleach solution automatically controls the chlorination. The reactor should disperse the chlorine sufficiently in the caustic solution to allow total reaction before discharge.

One type of continuous reactor is a vertical column where caustic soda solution enters the top and chlorine enters the bottom. The rate of production can be varied by adjusting the caustic soda feed rate or through a level sensing device in the storage tank. ORP instrumentation controlling chlorine flow is often linked with a warning system to signal the operator if the automatic valve should fail to control the chlorine properly.

Recycling part of the stream through the reactor helps to smooth out the process fluctuations.

Discharge Systems

As previously noted, sodium hypochlorite solutions tend to deteriorate with age, leaving a sediment in the bottom of storage vessels. To avoid transferring this sediment into the process, the primary tank discharge nozzle should be located 1 to 3 feet from the bottom of the tank. An additional discharge nozzle should be located as close to the bottom as possible, (or on the bottom if the tank is elevated), to allow for completed drainage and periodic cleaning.

Handling and Storage

Where product quality is critical, filter systems are available to remove virtually all sediments. In some applications, the process can tolerate this sediment if it is continually transferred out of the storage tank along with the sodium hypochlorite solution. Cone bottom tanks can facilitate removal of the sediment. In other applications the process cannot tolerate this sediment and it cannot be allowed to accumulate.

Venting/Overflow System

The worst case condition for the vent sizing is usually the venting rate required due to decomposition of the contents of the storage vessel. The vent sizing required for discharging or filling is a secondary To eliminate excessive pressure or vacuum build-up when filling or discharging the tank, a venting system must be provided. As a minimum, this system should contain a nozzle at the top of the tank. It should be sized to prevent excessive vacuum or pressure when the tank is discharging or filling. When filling the tank from bulk tank trucks under air pressure, large "air hammers" may occur. Therefore, vent piping should be rigidly secured to prevent vibration. The tank should also have a nozzle on the side near the top. This nozzle should be sized to release the entire filling rate without reaching the tank's vent. Piping should be installed to direct the over flowing solution away from personnel into a containment area.

Gauging Devices

Some tanks are sufficiently translucent to allow for visual gauging from level markers painted on or molded into the side of the tanks. Where lighting conditions or tank construction do not permit this method of gauging, external gauging systems must be provided. Differential pressure systems have been used successfully. Manomometers and sight glass gauges are also used but require additional liquid filled connections, thus potential failure points on the tank. An independent, back up level sensor should be used to prevent tank overflow in the event of a level gauge failure.

Safety in Handling Sodium Hypochlorite

Read the MSDS before use

. Sodium hypochlorite solution is normally a light yellow liquid with a characteristic bleach odor. Sodium hypochlorite is unstable and can release chlorine gas if acidified. To improve the stability of hypochlorite solutions an excess alkalinity is usually maintained. Hypochlorite solutions are corrosive to eyes, skin and mucous membranes.

PRECAUTIONS

- Emergency shower and eyewash facility should be in close proximity to where sodium hypochlorite solution is handled.
- Insure adequate ventilation or use a NIOSH approved respirator with an acid gas cartridge with a dust, fune and mist filter where airborne concentrations are expected to exceed exposure limits or when symptoms have been observed that are indicative of overexposure.
- Avoid breathing fumes.
- Avoid contact with eyes, skin and clothing.
- Wash thoroughly after handling.
- Wear goggles and faceshield, plus chemical resistant gloves made of rubber, neoprene or vinyl. Wear chemical resistant clothing and boots if splashing or contact may occur.
- Do not allow contact with organic materials such as rags, wood fibers, paper, debris, or with reducing chemicals except under controlled conditions.
- Do not discard indiscriminately. A spontaneous combustion fire could result.
- Do no mix with acids, ammonia, heavy metals, ethers or reducing agents. To do so may release hazardous gases.
- Store in corrosion-resistant tanks.

FIRST AID

Eyes:

IMMEDIATELY FLUSH EYES WITH A DIRECTED STREAM OF WATER for at least 15 minutes, forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissue. Washing eyes within several seconds is essential to achieve maximum effectiveness.

Skin:

Flush thoroughly with cool water under shower while removing contaminated clothing and shoes. Discard non-rubber shoes. Wash clothing before reuse.

Inhalation:

Remove to fresh air. If breathing is difficult, have trained person administer oxygen. If respiration stops, have a trained person administer artificial respiration.

Ingestion:

NEVER GIVE ANYTHING TO AN UNCONSCIOUS PERSON. If swallowed, DO NOT INDUCE VOMITING, although it may occur spontaneously. Give large quantities of water. If available, give several glasses of milk. Sodium bicarbonate, which would generate carbon dioxide should not be used. Keep airways clear.

GET MEDICAL ATTENTION IMMEDIATELY.

FIRE

Use water or other extinguishing medium appropriate for surrounding fire. May release toxic fumes under fire conditions. Wear NIOSH/MSHA approved positive pressure self-contained breathing apparatus and full protective clothing.

SPILL

NEVER FLUSH TO SEWER. Contain spill with dike to prevent entry into sewers or waterways. For small spills, absorb with inorganic absorbents. Flush spill area with water ONLY IF water can be collected, and place in appropriate container for proper disposal. For large spills, dike and pump into properly labeled containers for proper disposal.

Report release, if required, to the appropriate local, state and federal agencies.

Note: *For additional information refer to OxyChem Handbooks on Chlorine & Caustic Soda, in addition to the MSDS on Chlorine, Caustic Soda and Sodium Hypochlorite.*

Methods of Analysis

DETERMINATION OF SODIUM HYPOCHLORITE, SODIUM HYDROXIDE AND SODIUM CARBONATE IN CAUSTIC SODA BLEACH SOLUTIONS

PURPOSE

To provide a means for quantifying sodium hypochlorite, sodium hydroxide and sodium carbonate levels in caustic soda bleach solutions.

THEORY

Sodium hypochlorite (NaOCl) is the active agent in caustic soda bleach solutions. Chemically, hypochlorites are the salts of hypochlorous acid (HOCl) and are inherently unstable. The stability of a hypochlorite solution is dependent on five major factors.

1. Hypochlorite concentration.
2. Alkalinity (pH) of the solution.
3. Temperature of the solution, both in production and storage.
4. Concentration of impurities which catalyze decomposition.
5. Exposure to light.

Any one of the above factors or combination of factors can affect the strength of a caustic soda bleach solution. Therefore, reliable methods of quantifying the sodium hypochlorite, sodium hydroxide and sodium carbonate concentrations of a caustic soda bleach solution are necessary.

A) Hypochlorite Determination

Hypochlorite concentration is determined by iodometric titration. In this method, the hypochlorite ion is first reacted with excess I^- in an acidic medium to form an equivalent amount of iodine:

$ClO^- + 2H^+ + 2I^- \rightarrow Cl^- + I_2 + H_2O$ (eq. 1)

Molecular iodine reacts with excess iodide in solution to form tri-iodide via the following reaction:

$I_2\,(aq) + I^- \rightarrow I_3^-$ (eq. 2)

Each mole of tri-iodide is then titrated with two moles of sodium thiosulfate and the concentration of tri-iodide is determined. The percent hypochlorite in the sample can then be calculated from the tri-iodide concentration.

$I^-_3 + 2S_2O_3^{--} \rightarrow 3I^- + S_4O_6^{--}$

B) Sodium Hydroxide and Sodium Carbonate Determination

Sodium hydroxide and sodium carbonate are quantified by a two-step titration with a standardized acid solution. During the first step, the hydroxide is neutralized and the carbonate is converted to bicarbonate simultaneously via the following reactions:

$NaOH + HCl \rightarrow NaCl + HOH$ (eq.3)

$Na_2CO_3 + HCl \rightarrow NaHCO_3^- + NaCl$ (eq. 4)

When both of these reactions (eqs 3 & 4) come to completion, an endpoint is indicated. The solution is then further titrated with acid to convert the bicarbonate to water and carbon dioxide.

$NaHCO_3^- + HCl \rightarrow NaCl + H_2O$ and CO_2 (eq. 5)

A second endpoint is indicated at the completion of this reaction. The volumes of acid used in these two steps are then used to calculate the percent sodium hydroxide and sodium carbonate in the sample.

APPARATUS

Analytical Balance; 200g + 0.0001 (Mettler At-200 or equivalent).
250 ml. Erlenmeyer Flask; (Fisher Scientific #10-090B or equiv.)
Magnetic Stirrer; (Fisher Scientific #14-493-120-S or equiv.)
Magnetic Stirring Bars; (Fisher Scientific #14-511-62 or equiv.)
250 ml. Volumetric Flask; Class A Volumetric, (Fisher Scientific #10-210E or equiv.)
5 ml Pipet; Class A Volumetric, (Fisher Scientific #13-650-2F or equiv.)
10 ml. Pipet; Class A Volumetric, (Fisher Scientific #13-650-2L or equiv.)
20 ml. Pipet; Class A Volumetric, (Fisher Scientific #13-650-2N or equiv.)
25 ml. Pipet; Class A Volumetric, (Fisher Scientific #13-650-2P or equiv.)
50 ml. Pipet; Class A Volumetric, (Fisher Scientific #13-650-2S or equiv.)
50 ml. Pipet; Class A Volumetric, (Fisher Scientific #03-700-2C or equiv.)

REAGENTS

Deionized water
1:1 Acetic Acid; Add 500 ml of ACS reagent grade Glacial Acetic Acid (Fisher Cat# A38 or equiv.) to 500 ml of deionized water.
10% Potassium Iodide solution; Weigh 100.0 grams of KI (Fisher Cat#P412, or equiv.) into a one liter volumetric flask, add deionized water and mix to dissolve. Dilute with deionized water to volume.
0.1 N Sodium Thiosulfate solution;

Methods of Analysis

Weigh 24.8190 grams of $Na_2S_2O_3$ (Fisher Cat#S445, or equiv.) into a one liter volumetric flask, add deionized water and mix to dissolve. Dilute with deionized water to volume. Standardize the solution before use (see Standardization section). Standardized O.1 N $Na_2S_2O_3$ is also commercially available from Fisher Cat. #SS368-1.

Starch Indicator; 1% solution - (Fisher Cat# SS48-1, or equiv.)

Phenolphthalein Indicator solution, 1% - Fisher Cat# SP62-500

Methyl Orange Indicator, 0.1%; (Fisher Cat# SM54-500, or equiv.)

0.1 N Hydrochloric Acid solution; Transfer 8.3 ml of ACS reagent grade concentrated hydrochloric acid (Fisher Cat# A144, or equiv.) into a one liter volumetric containing deionized water, add additional water to bring to volume. Standardize the solution before use (see Standardization section). Standardized O.1 N HCl is also commercially available from Fisher Cat. #SA54-1.

3% Hydrogen Peroxide solution; (Fisher Cat# H312-500, or equiv.)

SAFETY

Refer to the MSDS for the proper handling procedures for all chemicals being analyzed by this method.

Caustic soda bleach solutions are irritating to the eyes and skin. Potassium iodide is toxic and sodium thiosulfate is an irritant, both should be handled with care. Acetic acid and hydrochloric acid are extremely corrosive. If any of these chemicals comes in contact with the eyes or skin, the affected area should be flushed with plenty of clean water for a minimum of 15 minutes. **Seek medical attention immediately.**

PROCEDURE

Sodium Hypochlorite Determination

1. Pipet 25 ml. of caustic soda bleach solution into a 250 ml. volumetric flask. Record the sample weight to the nearest 0.01 g. Add deionized water to the 250 ml. mark and mix thoroughly. This sample solution will be used as a stock solution for the determination of %NaOCl, % NaOH and % Na_2CO_3.
   Note 1: Sample sizes recommended in this method are for commercial strength bleach solutions (approximately 5.25% NaOCl). For samples of bleach with solution strengths different from commercial grade products, adjustments to sample size or aliquot size may be necessary.
2. Pipet a 10 ml aliquot of the stock solution into a 250 ml. Erlenmeyer flask containing 50 ml. of deionized water.
3. Add 25 ml. of 10% potassium iodide solution. The sample solution will change from clear to an intense yellow color.
4. Add 10 ml. of 1:1 acetic acid. Addition of acetic acid to a solution containing iodide liberates iodine which results in a further color change to amber brown.
5. Place the mixture on a magnetic stirring apparatus and gently stir.
6. Titrate using 0.1 N sodium thiosulfate to a straw yellow color, taking care to not over-titrate the sample to clear.
7. Add 5 ml. of starch indicator and continue the titration until the blue color disappears. Starch indicator reacts with iodine to form a very intense blue/purple color complex, which is visible at very low concentrations of iodine (2×10^{-5} M).
8. Record the volume (ml). of 0.1 N sodium thiosulfate used. This volume will be used to calculate the % NaOCl in the sample.

Sodium Hydroxide and Sodium Carbonate Determination

1. Pipet a 50 ml. aliquot of the sample stock solution (see Step 1 of sodium hypochlorite determination) into 250 ml. Erlenmeyer flask containing 50 ml. of deionized water.
2. Add 20 ml. of neutral 3% hydrogen peroxide solution and cool the sample to 0° to 5° C. The addition of peroxide is necessary to neutralize the sodium hypochlorite in the sample aliquot.
3. Add 3 drops of phenolphthalein indicator and titrate with 0.1 hydrochloric acid solution until the pink color disappears.
4. Record the volume of acid used to the nearest 0.02 ml. This volume will be used to determine the percent sodium hydroxide present in the sample solution.
5. Add 3 drops of methyl orange indicator to the same sample solution and continue to titrate with 0.1 N hydrochloric acid solution until the yellow color changes to red. Take care to titrate slowly since very little acid will be required to produce the second endpoint.
6. Record the volume of acid used to the nearest 0.02 ml. This volume will be used to determine the percent sodium carbonate present in the sample solution.

CALCULATIONS

A) % Sodium Hypochlorite

Let:

W=Weight (g) of original sample.

V=Volume (ml) of 0.1 N sodium thiosulfate solution

N=Normality of the sodium thiosulfate solution

10/250=Dilution factor from stock solution, i.e. - 10 ml aliquot taken from 250 ml stock

0.03723=milliequivalent weight of NaOCl

0.03545=milliequivalent weight of Cl_2

The sodium hypochlorite content can be calculated as wt% NaOCl or as wt% Available Chlorine

$$\%NaOCl = \frac{(V)(N)(0.03722)(100)}{10/250 \times W}$$

$$\%Available\ Chlorine = \frac{(v)(N0(0.03545)(100)}{10/250 \times W}$$

B) % Sodium Hydroxide and Sodium Carbonate Determination

Let:

W_1=Weight (g) of original sample.

V_1=Volume (ml) of 0.1 N HCl needed to reach the phenolphthalein endpoint

V_2=Volume (ml) of 0.1 N HCl needed to reach the methyl orange endpoint

N=Normality of the hydrochloric

0.040= The milliequivalent weight of NaOH

0.053= The milliequivalent weight of Na_2CO_3

50/250=Dilution factor from stock solution, i.e - 50 ml aliquot taken from 250ml stock

V_1 is the amount of acid required to neutralize the hydroxide and convert the carbonate to bicarbonate as shown in equations 3 and 4.

V2-V1 is the additional volume of acid required to convert the bicarbonate to carbon dioxide and water. The overall titration of sodium carbonate with hydrochloric acid requires two moles of HCl for each mole of Na_2CO_3 since one mole is needed to convert Na_2CO_3 to $NaHCO_3$ and another mole is required to convert the $NaHCO_3$ to CO_2.

therefore

$2 \times (V_2-V_1)$= Volume of acid that reacted with Na_2CO_3 in the sample

and

$V_2 - [2 \times V_2-V_1]$= Volume of acid that reacted with the NaOH in the sample

$$\%NaOH=\frac{(V_1)-[2(V_2-V_1)](N)(0.040)(100)}{50/250 \times W}$$

$$\%Na2CO3=\frac{2(V2-V1)](N)(053)(100)}{50/250 \times W}$$

QUALITY ASSURANCE

Clean all apparatus before use to eliminate contamination.

Duplicate analysis should be performed on a minimum of 10% of samples analyzed. Results should be reproducible within 0.025%.

Concentrations of sodium hypochlorite, sodium hydroxide, and sodium carbonate found in samples should be compared with the manufacturers specifications (if available) to ensure the product meets these standards.

Hydrochloric acid and sodium thiosulfate solutions should be standardized at least monthly.

REFERENCES

1. ASTM Volume 15.04, D 2022 (with Modifications)

2. Vogel, Arthur I., A Textbook of Qualitative Inorganic Analysis, 3rd edition, 1961

STANDARDIZATION OF 0.1N HYDROCHLORIC ACID USING SODIUM CARBONATE AND MODIFIED METHYL ORANGE INDICATOR

APPARATUS

Buret: 100ml, Class A, Fischer Cat# 03-700-22D or equiv.

Erlenmeyer Flasks; 250ml, Fischer Cat# 10-090B or equiv

Weighing Dish; disposable, Fischer Cat# 02-202A or equiv.

Stirring Bars; 38mm x 8 mm, Fischer Cat# 14-511-64 or equiv.

Analytical Balance; Mettler AT 200 or equiv.

REAGENTS

0.1N Hydrochloric Acid; measure 8.3mL of concentrated hydrochloric acid (sp.gr. 1.19) into a graduated cylinder and transfer it to a 1L volumetric flask. Dilute to the mark with water, mix well and store in a tightly closed container. A prepared solution of 0.1N HCl can also be purchased (Fischer Scientific Cat# SA54-1 or equiv.)

Sodium Carbonate; anhydrous, volumetric standard grade, EM Science Cat# 6394-2. Dry at 250° C in a platinum or porcelain crucible for 4 hrs.

Water, Deionized; this water should be carbon dioxide free - freshly boiled and cooled or purged with nitrogen for two hours.

Modified Methyl Orange Indicator; dissolve 0.14 gm of methyl orange and 0.12 gm of Xylene Cyanole FF in water and dilute to 100 ml.

SAFETY

Refer to MSDS for the proper handling procedures for each of the chemicals listed in this procedure.

Hydrochloric acid is a strong acid, it is corrosive to body tissue and can cause immediate and severe burns to eyes. Wear proper gloves, proper eye protection and other protective clothing when handling.

When handling sodium carbonate, avoid inhalation or contact with skin.

Xylene Cyanole is a flammable solid. Use proper ventilation, avoid prolonged breathing of vapors or prolonged or repeated contact with skin.

STANDARDIZATION PROCEDURE

Weigh 1.0 grams of sodium carbonate to the nearest 0.0001 grams into a weighing dish. Carefully transfer this material to an Erlenmeyer flask, add 75 ml of deionized water and swirl to dissolve. Add 3 drops of the modified orange indicator and titrate with the HCl solution to a magenta color change.

Repeat the above titration procedure on at least three more solutions of sodium carbonate.

CALCULATIONS

The following is the formula used to calculate the normality of the hydrochloric acid.

Let:

N = Normality of HCl

W = Weight (in grams) of Na_2CO_3 used

V = Volume of HCl required

Milliequivalent wt. of Na_2CO_3 = 0.053

$$N = \frac{W}{(V) \times (0.053)}$$

Calculate the average the normality of hydrochloric acid from the individual values. Also calculate the standard deviation and percent relative standard deviation (%RSD) for the standardization procedure.

STABILITY

Restandardize monthly or sooner.

STANDARDIZATION OF 0.1N SODIUM THIOSULFATE WITH POTASSIUM IODATE

THEORY

A solution of sodium thiosulfate can be standardized by titrating it into an acid solution containing a known amount of potassium iodate and a starch indicator. The acid reacts with the iodate to form iodine. The iodine is stoichiometrically reduced by the thiosulfate. The endpoint of the reaction is indicated when the solution changes from a blue color to colorless. 6 moles of $Na_2S_20_3$ are required to react with 1 mole of $KI0_3$

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_20$$

$$2Na_2S_20_3 + I_2 \rightarrow Na_4S_40_6\ 2NaI$$

APPARATUS

Analytical Balance; 200g±0.0001 (Mettler At-200 or equiv.)
250 ml. Erlenmeyer Flask; wide mouth, (Fisher Cat#: 10-090B or equiv.)
Magnetic Stirrer; (Fisher Cat#: 14-493-120MR or equiv.)
Magnetic Stirring Bar; 1 1/2' x 5/16' dia, (Fisher Cat#: 14-511-64 or equiv.)
250 ml. Volumetric Flask; Class A Volumetric, Fisher Cat#: 10-210E or equiv.)
2 ml. Pipet; Class A Volumetric, (Fisher Cat;# 13-650-2C or equiv.)
5 ml Pipet; Class A Volumetric, (Fisher Cat: #: 13-650-2F or equiv.)
50 ml. Buret; Class A Volumetric, (Fisher Cat; #: 03-700-2C or equiv.)

REAGENTS

Deionized water
0.1 N Sodium Thiosulfate solution: Weigh 25 grams of $Na_2S_20_3\ 5H_20$ (Fisher Cat:#: S445 or equiv.) into a one liter volumetric flask, add deionized water and mix to dissolve. Dilute with deionized water to volume. Store the solution in a tightly capped amber bottle.
Potassium Iodide; iodate free (Fisher Cat:#: P410-500, or equiv.)
Potassium Iodate; dried at 120° C for at least one hour (Fisher Cat;#: P253-500, or equiv.)
2 N Sulfuric Acid solution; Weigh 55.6 of ACS reagent grade concentrated sulfuric acid (Fisher Cat:#: A300-212, or equiv.) into a one liter volumetric flask containing 500 ml of deionized water, mix, allow to cool and diluted to volume with deionized water.
Starch Indicator - 1% solution; (Fisher Cat:#: SS408-1, or equiv.)
Phenolphthalein Indicator - 1% solution; (Fisher Cat:#: SP62-500
Methyl Orange Indicator; (Fisher Cat:#: SM54-500, or equiv.)

SAFETY

Refer to the MSDS for the proper handling procedures for all chemicals being analyzed by this method.

Methods of Analysis

Potassium iodate is an oxidizer and should be handled accordingly. Potassium iodide is toxic and sodium thiosulfate is an irritant, both should be handled with care. Sulfuric acid is extremely corrosive. If any of these chemicals comes in contact with the eyes or skin, the affected area should be flushed with plenty of clean water for a minimum of 15 minutes. **Seek medical attention immediately.**

PROCEDURE

1. Weigh 0.14 - 0.15 grams of dried potassium iodate to the nearest 0.0001 grams, transfer to a 250 Erlenmeyer flask and dissolve in 50 ml. of deionized water.
2. Add 2.0 grams of iodate free potassium iodide and 5 ml. of 2N sulfuric acid.
   Note: To determine if the KI is iodate free, dissolve a small portion of the reagent in 2N sulfuric acid. No immediate yellow color should be observed. Add 1-2 ml of starch indicator, if no immediate blue color is produced, the potassium iodide is iodate free.
3. Place the mixture on a magnetic stirring apparatus and gently stir.
4. Titrate using 0.1 N sodium thiosulfate to a straw-yellow color, taking care to not over-titrate the sample to clear.
5. Add approximately 100 ml. of deionized water and 2.0 ml. of starch indicator and continue the titration until the blue color disappears. To achieve accurate results, the addition of the sodium thiosulfate titrant should be done very slowly. The endpoint of the titration is very sharp (color changes from dark blue or purple to clear) and dropwise addition is recommended. Record the volume of sodium thiosulfate used to the nearest 0.02 ml.
6. Repeat the titration with two more accurately weighted portions of potassium iodate and record the volume of sodium thiosulfate used to the nearest 0.02 ml. for each portion.

CALCULATIONS

The following formula is used to calculate the normality of the sodium thiosulfate.
Let:
N=Normality of the sodium thiosulfate solution.
W=Weight (g) of potassium iodate
V=Volume (ml) of 0.1 N sodium thiosulfate needed to reach the clear endpoint 0.03567 = milliequivalent weight of KIO_3.

$$N = \frac{W}{V \times 003567}$$

Average the values obtained from the three titration and also calculate the standard deviation and percent relative standard deviation (% RSD) of the standardization procedure.

STABILITY

Sodium thiosulfate solutions are relatively stable, but do decompose over time. Exposure to air (especially carbon dioxide), light and airborne bacteria will accelerate the decomposition reaction. Therefore, restandardization should be performed on monthly basis or sooner.

REFERENCES

1. ASTM 15.04 D 2022 (With Modifications)
2. Vogel, Arthur I., A Textbook of Qualitative Inorganic Analysis, 3rd edition, 1961.

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SAFETY DATA SHEET

This Safety Data Sheet conforms to ANSI Z400.5, and to the format requirements and the International Chemical Safety Cards of the Global Harmonizing System.
THIS SDS COMPLIES WITH 29 CFR 1910.1200 (HAZARD COMMUNICATION STANDARD)
IMPORTANT: Read this SDS before handling & disposing of this product.
Pass this information on to employees, customers, & users of this product.

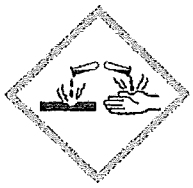
SECTION 1. IDENTIFICATION OF THE SUBSTANCE OR MIXTURE AND OF THE SUPPLIER

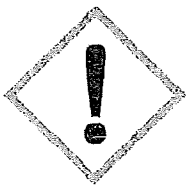
PRODUCT IDENTITY: Liquichlor 10-16% (Sodium Hypochlorite 10-16%)
SDS NUMBER: OX76685
NEW MSDS DATE: 12/21/2011
COMPANY IDENTITY: Univar
COMPANY ADDRESS: 17425 NE Union Hill Road
COMPANY CITY: Redmond, WA 98052
COMPANY PHONE: 1-425-889-3400
EMERGENCY PHONES: CHEMTREC: 1-800-424-9300 (USA)
CANUTEC: 1-613-996-6666 (CANADA)

SECTION 2. HAZARDS IDENTIFICATION

DANGER!!

EXPOSURE PREVENTION: STRICT HYGIENE! AVOID ALL CONTACT!





RISK STATEMENTS:
- R35 Causes severe burns.
- R50 Very toxic to aquatic organisms.

SAFETY STATEMENTS:
- S1/2 Keep locked up and out of the reach of children.
- S24/25 Avoid contact with skin and eyes.
- S36/37/39 Wear suitable protective clothing, gloves and eye/face protection.
- S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
- S28 After contact with skin, wash immediately with plenty of water.
- S45 In case of accident, or if you feel unwell, seek medical advice immediately. (Show the label where possible).
- S61 Avoid release to the environment. Refer to special instructions/safety data sheet.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

MATERIAL	CAS#	EINECS#	WT %
Water	7732-18-5	231-791-2	84-98
Sodium Hypochlorite	7681-52-9	-	< 16
Sodium Hydroxide	1310-73-2	-	<= 1.75

Trace components: Trace ingredients (if any) are present in < 1% concentration, (< 0.1% for potential carcinogens, reproductive toxins, respiratory tract mutagens, and sensitizers). None of the trace ingredients contribute significant additional hazards at the concentrations present in this product. All pertinent hazard information has been provided in this document, per the requirements of the Federal Occupational Safety and Health Administration Standard (29 CFR 1910.1200), U.S. State equivalents, and Canadian Hazardous Materials Identification System Standard (CPR 4).

SEE SECTIONS 8, 11 & 12 FOR TOXICOLOGICAL INFORMATION.

SECTION 4. FIRST AID MEASURES

EYE CONTACT:
If this product enters the eyes, open eyes while under gently running water. Use sufficient force to open eyelids. "Roll" eyes to expose more surface. Minimum flushing is for 15 minutes. Seek immediate medical attention.

SKIN CONTACT:
If the product contaminates the skin, immediately begin decontamination with running water. Minimum flushing is for 15 minutes. Remove contaminated clothing, taking care not to contaminate eyes. If skin becomes irritated and irritation persists, medical attention may be necessary. Wash contaminated clothing before reuse, discard contaminated shoes.

INHALATION:
After high vapor exposure, remove to fresh air. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. Keep person warm and at rest. breathing is difficult, give oxygen. If breathing has stopped, trained personnel should immediately begin artificial respiration. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. If the heart has stopped, trained personnel should immediately begin cardiopulmonary resuscitation (CPR). Seek immediate medical attention. In case of inhalation of decomposition products in a fire, symptoms may be delayed.The exposed person may need to be kept under medical surveillance for 48 hours.

SWALLOWING:
If swallowed, CALL PHYSICIAN OR POISON CONTROL CENTER FOR MOST CURRENT INFORMATION. If professional advice is not available, give two glasses of water to drink. DO NOT INDUCE VOMITING. Never induce vomiting or give liquids to someone who is unconscious, having convulsions, or unable to swallow. Seek immediate medical attention.

NOTES TO PHYSICIAN:
There is no specific antidote. Treatment of overexposure should be directed at the control of symptoms and the clinical condition of the patient. Any material aspirated during vomiting may cause lung injury. Therefore, emesis should not be induced mechanically or pharmacologically. If it is considered necessary to evacuate the stomach contents, this should be done by means least likely to cause aspiration (such as: Gastric lavage after endotracheal intubation).

Victims of chemical exposure must be taken for medical attention. Rescuers should be taken for medical attention, if necessary. Take a copy of label and SDS to physician or health professional with victim.

SECTION 5. FIRE FIGHTING MEASURES

FIRE & EXPLOSION PREVENTIVE MEASURES
Not Applicable.

EXTINGUISHING MEDIA
Use dry powder, foam, carbon dioxide, water spray, halon, or any "ABC" Class extinguisher.

SPECIAL FIRE FIGHTING PROCEDURES
Water spray may be ineffective on fire but can protect fire-fighters
& cool closed containers. Use fog nozzles if water is used.
Do not enter confined fire-space without full bunker gear.
(Helmet with face shield, bunker coats, gloves & rubber boots).
Use NIOSH approved positive-pressure self-contained breathing apparatus.

UNUSUAL EXPLOSION AND FIRE PROCEDURES
Noncombustible.
Isolate from reducers, acids, wood, organic materials, and most metals.
Oxidizer fumes damage lungs. Symptoms may be delayed. Do not breathe fumes.

SECTION 6. ACCIDENTAL RELEASE MEASURES

SPILL AND LEAK RESPONSE AND ENVIRONMENTAL PRECAUTIONS:
Uncontrolled releases should be responded to by trained personnel using pre-planned procedures. Proper protective equipment should be used. In case of a spill, clear the affected area, protect people, and respond with trained personnel.

PERSONAL PROTECTIVE EQUIPMENT
The proper personal protective equipment for incidental releases (such as: 1 Liter of the product released in a well-ventilated area), use impermeable gloves (triple-gloves (rubber gloves and nitrile gloves, over latex gloves), goggles, face shield, and appropriate body protection. In the event of a large release, use impermeable gloves, specific for the material handled, chemically resistant suit and boots, and hard hat. Self-Contained Breathing Apparatus or respirator may be required where engineering controls are not adequate or conditions for potential exposure exist. When respirators are required, select NIOSH/MSHA approved based on actual or potential airborne concentrations in accordance with latest OSHA and/or ANSI recommendations.

ENVIRONMENTAL PRECAUTIONS:
Stop spill at source. Construct temporary dikes of dirt, sand, or any appropriate readily available material to prevent spreading of the material. Close or cap valves and/or block or plug hole in leaking container and transfer to another container. Keep from entering storm sewers and ditches which lead to waterways, and if necessary, call the local fire or police department for immediate emergency assistance.

CONTAINMENT AND CLEAN-UP MEASURES:
Absorb spilled liquid with polypads or other suitable absorbent materials. If necessary, neutralize using suitable buffering material, (acid with soda ash or base with phosphoric acid), and test area with litmus paper to confirm neutralization. Clean up with non-combustible absorbent (such as: sand, soil, and so on). Shovel up and place all spill residue in suitable containers. dispose of at an appropriate waste disposal facility according to current applicable laws and regulations and product characteristics at time of disposal (see Section 13 - Disposal Considerations).

SECTION 7. HANDLING AND STORAGE

HANDLING
Use only with adequate ventilation. Do not get in eyes, on skin or clothing.
Wear OSHA Standard full face shield. Consult Safety Equipment Supplier. Wear goggles, face shield, gloves, apron & footwear impervious to material. Wash clothing before reuse. NEVER pour water into this substance. When dissolving or diluting, always add it slowly to the water.
To minimize static discharge when transferring, ensure electrical continuity by bonding and grounding all equipment. Use an inlet line diameter of at least 3.5 inches (8.9 centimeters) with a maximum flow rate of 1 meter/second.

STORAGE
Keep separated from strong oxidants, strong acids, combustible & reducing substances, metals, food & feedstuffs. Keep cool. Keep dry. Keep in the dark. See: Section 10, <Materials to Avoid>. Do not store above 49 C/120 F. Keep container tightly closed & upright when not in use to prevent leakage.
Wear full face shield, gloves & full protective clothing when opening or handling.
When empty, drain completely, replace bungs securely.

NONBULK: CONTAINERS:
Store containers in a cool, dry location, away from direct sunlight, sources of intense heat, or where freezing is possible. Material should be stored in secondary containers or in a diked area, as appropriate. Store containers away from incompatible chemicals (see Section 10, Stability and Reactivity). Post warning and "NO SMOKING" signs in storage and use areas, as appropriate. Empty containers should be handled with care. Never store food, feed, or drinking water in containers which held this product.

BULK CONTAINERS:
All tanks and pipelines which contain this material must be labeled. Perform routine maintenance on tanks or pipelines which contain this product. Report all leaks immediately to the proper personnel.

SECTION 7. HANDLING AND STORAGE (CONTINUED)

TANK CAR SHIPMENTS:
Tank cars carrying this product should be loaded and unloaded in strict accordance with tank-car manufacturer's recommendation and all established on-site safety procedures. Appropriate personal protective equipment must be used (see Section 8, Engineering Controls and Personal Protective Equipment.). All loading and unloading equipment must be inspected, prior to each use. Loading and unloading operations must be attended, at all times. Tank cares must be level, brakes must be set or wheels must be locked or blocked prior to loading or unloading. Tank car (for loading) or storage tanks (for unloading) must be verified to be correct for receiving this product and be properly prepared, prior to starting the transfer operations. Hoses must be verified to be in the correct positions, before starting transfer operations. A sample (if required) must be taken and verified (if required) prior to starting transfer operations. All lines must be blown-down and purged before disconnecting them from the tank car or vessel.

PROTECTIVE PRACTICES DURING MAINTENANCE OF CONTAMINATED EQUIPMENT:
Follow practices indicated in Section 6 (Accidental Release Measures). Make certain application equipment is locked and tagged-out safely. Always use this product in areas where adequate ventilation is provided. Collect all rinsates and dispose of according to applicable Federal, State, or local procedures.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

MATERIAL	CAS#	EINECS#	TWA (OSHA)	TLV (ACGIH)
Water	7732-18-5	231-791-2	None Known	None Known
Sodium Hydroxide	1310-73-2	-	2 mg/m3	None Known
Sodium Hypochlorite	7681-52-9	-	None Known	None Known

MATERIAL	CAS#	EINECS#	CEILING	STEL(OSHA/ACGIH)	HAP
Sodium Hydroxide	1310-73-2	-	2 mg/m3	None Known	No

This product contains no EPA Hazardous Air Pollutants (HAP) in amounts > 0.1%.

RESPIRATORY EXPOSURE CONTROLS
Maintain airborne contaminant concentrations below exposure limits given above. If respiratory protection is needed, use only protection authorized in 29 CFR 1910.134, European Standard EN 149, or applicable State regulations. If adequate ventilation is not available or there is potential for airborne exposure above the exposure limits, a respirator may be worn up to the respirator exposure limitations, check with respirator equipment manufacturer's recommendations/limitations. For a higher level of protection, use positive pressure supplied air respiration protection or Self Contained Breathing Apparatus or if oxygen levels are below 19.5% or are unknown.

EMERGENCY OR PLANNED ENTRY INTO UNKNOWN CONCENTRATIONS OR IDLH CONDITIONS
Positive pressure, full-face piece Self Contained Breathing Apparatus; or positive pressure, full-face piece Salf Contained Breathing Apparatus with an auxilliary positive pressure Self Contained Breathing Apparatus.

VENTILATION
LOCAL EXHAUST: Necessary MECHANICAL (GENERAL): Necessary
SPECIAL: None OTHER: None
Please refer to ACGIH document, "Industrial Ventilation, A Manual of Recommended Practices", most recent edition, for details.

EYE PROTECTION:
Splash goggles or safety glasses. Face-shields are recommended when the operation can generate splashes, sprays or mists.

HAND PROTECTION:
Wear appropriate impervious gloves for routine industrial use. Use impervious gloves for spill response, as stated in Section 6 of this SDS (Accidental Release Measures).

SECTION 10. STABILITY & REACTIVITY (CONTINUED)

HAZARDOUS DECOMPOSITION PRODUCTS
Hydrogen Chloride, Phosgene, Sodium Oxide & Hydroxide from heating.

HAZARDOUS POLYMERIZATION
Will not occur.

SECTION 11. TOXICOLOGICAL INFORMATION

ACUTE HAZARDS

EYE & SKIN CONTACT:
Severe burns to skin, defatting, dermatitis.
Severe burns to eyes, redness, tearing, blurred vision.
Liquid can cause severe skin & eye burns. Wash thoroughly after handling.

INHALATION:
Severe respiratory tract irritation may occur. Vapor harmful. The applicable occupational exposure limit value should not be exceeded during any part of the working exposure.

SWALLOWING:
Harmful or fatal if swallowed.

SUBCHRONIC HAZARDS/CONDITIONS AGGRAVATED

CONDITIONS AGGRAVATED:
Sodiumn Hypochlorite, a component of this product, is a sensitizer. Prolonged or repeated skin contact can result in the development of rashes, welts, and other allergy-like symptoms.

CHRONIC HAZARDS

CANCER, REPRODUCTIVE & OTHER CHRONIC HAZARDS:
This product has no carcinogens listed by IARC, NTP, NIOSH, OSHA or ACGIH, as of this date, greater or equal to 0.1%.

MUTAGENICITY: This product is not reported to produce mutagenic effects in humans.
Human mutation data are available for Sodium Hypochlorite (a component of this product); these data were obtained during clinical studies involving specific tissues exposed to relatively high concentrations of this substance. Mutation data, obtained during clinical studies on test animal tissues or micro-organisms are available for Potassium Hydroxide.

EMBRYOTOXICITY: This product is not reported to produce embryotoxic effects in humans.

TERATOGENICITY: This product is not reported to produce teratogenic effects in humans.

REPRODUCTIVE TOXICITY: This product is not reported to cause reproductive effects in humans.

A mutagen is a chemical which causes permanent changes to genetic material (DNA) such that the changes will propagate through generational lines. An embryotoxin is a chemical which causes damage to a developing embryo (such as: within the eight weeks of pregnancy in humans), but the damage does not propagate across generational lines. A teratogen is a chemical which causes damage to a developing fetus, but the damage does not propagate across generational lines. A reproductive toxin is any substance which interferes in any way with the reproductive process.

MAMMALIAN TOXICITY INFORMATION

SODIUM HYDROXIDE:

Eye irritancy (monkey):	1%, 24 hours (severe)
Eye irritancy (rabbit):	500 ml, 24 hours (severe)
Eye irritancy (rabbit):	1% solution (severe)
Eye irritancy (rabbit):	1 mg, 24 hours (severe)
Cytogenic analysis system (grasshopper parenteral):	20 mg
LD50 (interperoneal, mouse):	40 mg/kg
LDLo (oral, rabbit):	500 mg/kg

SECTION 11. TOXICOLOGICAL INFORMATION (CONTINUED)

MAMMALIAN TOXICITY INFORMATION (CONTINUED)

SODIUM HYPOCHLORITE:
Eye effects (Adult Rabbit): Moderate irritation effects
Microsomal Mutageniticity Assay (Salmonella typhimunium): 1 mg/plate
Cytogenetic Analysis (Human): Lymphocyte, 100 ppm/24 hours.
TDLo, Oral (Woman): 1 g/kg, Central nervous system effects, blood pressure effects
TDLo, Intravenous (Man): 45 mg/kg, Pulmonary system , LD50 (Oral, Mouse): 5800 mg/kg

SECTION 12. ECOLOGICAL INFORMATION

ALL WORK PRACTICES MUST BE AIMED AT ELIMINATING ENVIRONMENTAL CONTAMINATION.

EFFECT OF MATERIAL ON PLANTS OR ANIMALS:
This product may be harmful or fatal to plant and animal life if released into the environment. Refer to Section 11 (Toxicological Information) for further data on the effects of this product's components on test animals.

EFFECT OF MATERIAL ON AQUATIC LIFE:

LC50 (Bluegill sunfish):	2.90 mg/L/96 hours
LC50 (Pimephales promelas):	1.40 mg/L/96 hours
LC50 (Oncorhynchus mykiss):	0.90 mg/L/0.5 hours

The substance is toxic to aquatic organisms.
The substance may be hazardous in the environment.
Special attention should be given to water organisms.

MOBILITY IN SOIL
Mobility of this material has not been determined.

DEGRADABILITY
This product is completely biodegradable.

ACCUMULATION
Bioaccumulation of this product has not been determined.

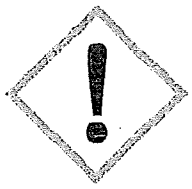
SECTION 13. DISPOSAL CONSIDERATIONS

Processing, use or contamination may change the waste management options. Recycle / dispose of observing national, regional, state, provincial and local health, safety & pollution laws. If in doubt, contact appropriate agencies.

SECTION 14. TRANSPORT INFORMATION

IF > 625 LB / 284 KG OF THIS PRODUCT IN 1 CONTAINER,
IT EXCEEDS THE "RQ" OF SODIUM HYPOCHLORITE.

DOT SHIPPING NAME: UN1791, Hypochlorite Solutions, 8, PG-III
DRUM LABEL: (CORROSIVE)
EMERGENCY RESPONSE GUIDEBOOK NUMBER: 154



SECTION 15. REGULATORY INFORMATION

EPA REGULATION:
SARA SECTION 311/312 HAZARDS: Acute Health

All components of this product are on the TSCA list.
This material contains no known products restricted under SARA Title III, Section 313 in amounts greater or equal to 1%.

SARA TITLE III INGREDIENTS	CAS#	EINECS#	WT%	(REG.SECTION)	RQ(LBS)
Sodium Hypochlorite	7681-52-9	-	< 16	(311,312)	100
Sodium Hydroxide	1310-73-2	-	<= 1.75	(311,312)	1000

> 625 LB / 284 KG OF THIS PRODUCT IN 1 CONTAINER EXCEEDS THE "RQ" OF SODIUM HYPOCHLORITE.
Any release equal to or exceeding the RQ must be reported to the National Response Center (800-424-8802) and appropriate state and local regulatory agencies as described in 40 CFR 302.6 and 40 CFR 355.40 respectively.
Failure to report may result in substantial civil and criminal penalties.
State & local regulations may be more restrictive than federal regulations.

STATE REGULATIONS:
CALIFORNIA PROPOSITION 65: This product contains no chemicals known to the State of California to cause cancer & reproductive toxicity.

U.S. STATE REGULATED COMPONENTS: (HAZARDOUS SUBSTANCE LISTS):

COMPONENT	AK	CA	FL	IL	KS	MA	MI	MN
Sodium Hypochlorite	No	No	No	Yes	No	No	No	No
Sodium Hydroxide	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

COMPONENT	MO	NJ	ND	PA	RI	TX	WV	WI
Sodium Hypochlorite	No	Yes	Yes	No	No	No	No	No
Sodium Hydroxide	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

INTERNATIONAL REGULATIONS
The components of this product are listed on the chemical inventories of the following countries:
Australia (AICS), Canada (DSL, NDSL), China (IECSC), Europe (EINECS, ELINCS), Japan (METI/CSCL, MHLW/ISHL), South Korea (KECI), New Zealand (NZIoC), Philippines (PICCS), Switzerland (SWISS), Taiwan (NECSI), USA (TSCA).

CANADA: WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)
C: Oxidizing Material.
D2B: Irritating to skin / eyes.
E: Corrosive Material.

SECTION 16. OTHER INFORMATION

HAZARD RATINGS:
HEALTH (NFPA): 3, HEALTH (HMIS): 3, FLAMMABILITY: 0, REACTIVITY: 1
(Personal Protection Rating to be supplied by user based on use conditions.)
This information is intended solely for the use of individuals trained in the NFPA & HMIS hazard rating systems.

EMPLOYEE TRAINING
See Section 2 for Risk & Safety Statements. Employees should be made aware of all hazards of this material (as stated in this SDS) before handling it.

Exhibit B:
Insurance Requirements
(Sodium Hypochlorite - Chemical Vendor)

Contractor shall procure and maintain for the duration of the contract insurance against claims for injuries to persons or damages to property which may arise from or in connection with the performance of the work hereunder and the results of that work by the Contractor, their agents, representatives, employees or subcontractors.

MINIMUM SCOPE AND LIMIT OF INSURANCE

Coverage shall be at least as broad as:

1. **Commercial General Liability** (CGL): Insurance Services Office Form CG 00 01 covering CGL on an "occurrence" basis, including products and completed operations, property damage, bodily injury and personal & advertising injury with limits no less than **$3,000,000** per occurrence. If a general aggregate limit applies, either the general aggregate limit shall apply separately to this project/location or the general aggregate limit shall be twice the required occurrence limit.
2. **Automobile Liability** (AL): ISO Form Number CA 00 01 covering any auto (Code 1) with combined single limits of liability of no less than **$1,000,000** per accident for bodily injury and property damage, including **MCS90** endorsement form.
3. **Workers' Compensation:** as required by the State of California, with Statutory Limits, and Employer's Liability Insurance with limit of no less than **$1,000,000** per accident for bodily injury or disease.
4. **Environmental Impairment/Contractors' Pollution Legal Liability** with limits no less than **$1,000,000** per occurrence or claim, to include liability for Groundwater contamination, Explosion, Sudden and Accidental and Environmental cleanup, etc.

If the contractor maintains higher limits than the minimums shown above, the City of Stockton requires and shall be entitled to coverage for the higher limits maintained by the contractor. Any available insurance proceeds in excess of the specified minimum limits of insurance and coverage shall be available to the City of Stockton.

Other Insurance Provisions
The insurance policies are to contain, or be endorsed to contain, the following provisions:

- ***Additional Insured Status***
  The *City of Stockton, its Mayor, Council, officers, representatives, agents, employees and volunteers* are to be covered as additional insureds on the CGL and AL policy with respect to liability arising out of work or operations performed

by or on behalf of the Contractor including materials, parts, or equipment furnished in connection with such work or operations. General liability coverage can be provided in the form of an endorsement to the Contractor's insurance (**at least as broad as** ISO Form CG 20 10 11 85 or if not available, through the addition of both CG 20 10 and CG 20 37 if a later edition is used).

- ***Primary Coverage***
  For any claims related to this contract, the Contractor's insurance coverage shall be primary insurance as respects the *City of Stockton, its Mayor, Council, officers, representatives, agents, employees and volunteers*. Any insurance or self-insurance maintained by the *City of Stockton, its Mayor, Council, officers, representatives, agents, employees and volunteers* shall be excess of the Contractor's insurance and shall not contribute with it. The City of Stockton does not accept primary endorsements limiting the Contractor's insurance coverage to sole negligence.

- ***Notice of Cancellation***
  Each insurance policy required above shall provide that coverage shall not be canceled, except with notice to the City of Stockton.

- ***Waiver of Subrogation***
  Contractor hereby grants to the City of Stockton a waiver of any right to subrogation which any insurer of said Contractor may acquire against the City of Stockton by virtue of the payment of any loss under such insurance. Contractor agrees to obtain any endorsement that may be necessary to affect this waiver of subrogation, but this provision applies regardless of whether or not the City of Stockton has received a waiver of subrogation endorsement from the insurer.

- ***Deductibles and Self-Insured Retentions***
  Any deductibles or self-insured retentions must be declared to and approved by the City of Stockton Risk Services. The City of Stockton may require the Contractor to purchase coverage with a lower deductible or retention or provide proof of ability to pay losses and related investigations, claim administration, and defense expenses within the retention.

- ***Acceptability of Insurers***
  Insurance is to be placed with insurers with a current A.M. Best's rating of no less than A:VII if admitted to do business in the State of California; If not admitted to do business in the State of California, insurance is to be placed with insurers with a current A.M. Best's rating of no less than A+:X.

- ***Claims Made Policies***

  If any of the required policies provide claims-made coverage:

- The Retroactive Date must be shown, and must be before the date of the contract or the beginning of contract work.

- If Claims Made policy form is used, a three (3) year discovery and reporting tail period of coverage is required after completion of work.

- ***Verification of Coverage***
  Contractor shall furnish the City of Stockton with original certificates and amendatory endorsements required by this clause. All certificates and endorsements are to be received and approved by the City of Stockton Risk Services before work commences. Failure to obtain the required documents prior to the work beginning shall not waive the Contractor's obligation to provide them. The City of Stockton reserves the right to require complete, certified copies of all required insurance policies, including endorsements required by these specifications, at any time, for any reason or no reason.

- ***Special Risks or Circumstances***
  The City of Stockton reserves the right to modify these requirements, including limits, based on the nature of the risk, prior experience, insurer, coverage, or other circumstances.

- ***Certificate holder address***
  Proper address for mailing certificates, endorsements and notices shall be:

  - City of Stockton
  - Attention: Risk Services
  - 425 N. El Dorado Street
  - Stockton, CA 95202

  City of Stockton Risk Services Phone: 209-937-5037
  City of Stockton Risk Services Fax: 209-937-8558

- ***Maintenance of Insurance***
  If at any time during the life of the Contract or any extension, the Contractor fails to maintain the required insurance in full force and effect, all work under the Contract shall be discontinued immediately. Any failure to maintain the required insurance shall be sufficient cause for the CITY to terminate this Contract.

- ***Subcontractors***
  If the Contractor should subcontract all or any portion of the work to be performed in this contract, the Contractor shall cover the sub-contractor, and/or require each sub-contractor to adhere to all subparagraphs of these Insurance Requirements section. Similarly, any cancellation, lapse, reduction or change of sub-contractor's insurance shall have the same impact as described above.