EPB 432 - Use of Chemicals in Drinking Water Treatment

Some communities using sodium hypochlorite to treat ammonia-laden water at their water treatment plants are close to or are exceeding the maximum dose of chemical as set in NSF/ANSI Standard 60.

This information sheet is intended to assist the designers, owners, operators, and regulators of waterworks in understanding the evaluation criteria and certification program associated with the Standard and the requirements of the Water Security Agency.

Regulations on Chemical Use in Water Treatment in Saskatchewan

According to Section 27 of *The Waterworks and Sewage Works Regulations*, all chemicals added to drinking water during its treatment, storage and distribution must be certified in accordance with the criteria specified in *NSF International (NSF)/American National Standards Institute (ANSI) Standard 60: Drinking Water Treatment Chemicals – Health Effects*. The dosage of each chemical shall not exceed the dosage specified as Maximum Use of each chemical product in Standard 60, unless otherwise authorized in writing by an Approvals Engineer; and shall be calculated in milligrams of chemical per litre of water (mg/L) by measuring the amount of chemical added in a period not exceeding seven calendar days divided by the total volume of water to which the chemical was added in that time period.

What is NSF/ANSI Standard 60?

NSF/ANSI Standard 60 establishes requirements to evaluate chemicals and the associated impurities added to water for the control of potential adverse human health effects. This Standard was initially developed by a Consortium led by NSF, and has been accredited by the Standards Council of Canada in Canada and the American National Standards Institute in the US. The Standard covers corrosion and scale control chemicals; pH adjustment, softening, precipitation, and sequestering chemicals; coagulation and flocculation chemicals; well-drilling products; disinfection and oxidation chemicals; and miscellaneous and specialty chemicals for treatment of drinking water. Reaction by-products such as the disinfection by-products are not covered by the scope of the Standard.

What are the Criteria of Standard 60?

The principle requirements addressed by Standard 60 are that the chemical is safe at the maximum use level (MUL); and that each impurity (i.e., contaminant) in the chemical product is below the respective single product allowable concentration (SPAC). For the first requirement, the MUL of a chemical product is the maximum amount of a chemical product that can be added to the entire process train per liter of water being treated (unit: mg/L). The Standard also sets up a typical use level (TUL) for each chemical, which is an application level of the chemical which has been used historically and considered safe in water treatment. For most cases, the MUL of a chemical product is proposed by the manufacturer based on the TUL of the respective chemical. An MUL proposed based on a concentration other than the TUL of the chemical may also be acceptable on a case-by-case basis. For the second requirement, the Standard requires a full formulation disclosure of each chemical in ingredient in a product.

For regulated contaminants, the SPAC has a default level not to exceed ten-percent of the regulatory level to provide protection for the consumer in the unlikely event of multiple sources of the contaminant, unless a lower or higher number of sources can be specifically identified. For non-regulated contaminants, SPAC shall be derived after reviewing the available toxicology data for the substance. A testing and certification program for water treatment chemical products was also developed in Standard 60.

How to Find/Identify Certified Chemicals and their limits?

NSF maintains official listings of companies that manufacture and distribute certified treatment products at http://www.nsf.org/Certified/PwsChemicals/. These listings are updated daily and list the products at their allowable maximum use levels. Currently there are at least three entities providing the certification of water treatment chemicals in accordance with the protocol of Standard 60, including NSF, UL (Underwriters Laboratories), and CSA (Canadian Standards Association) International. Certified chemical products should have the logo of the certifier and the MUL on the product packaging (e.g., product label) or documentation shipped with the product (e.g., Material Safety Data Sheet and Product Specifications).

Are repackaged chemicals certified?

No. Using chemicals that have been repackaged by an uncertified chemical supplier could inadvertently contribute contaminants to the product that would render it out of compliance with ANSI/NSF Standard 60. This would make the product ineligible to bear the certification mark. In order for repackaged products to be authorized to bear the certification mark, the repackaging site must be certified and audited by an accredited authority.

It is the responsibility of the waterworks owner to ensure the chemicals used in drinking water treatment are certified. A good practice is to check the certification mark on the package every time receiving the product.

Why does a chemical have varying MULs among different products?

For a certain chemical, the MUL of Certified Product A may differ from Certified Product B. This is due to factors such as the manufacturer, manufacturing facility, impurity level, solution strength, and way to express solution strength. Although MULs are usually equivalent to TULs (with the solution strength factored in, if applicable), some products may have a MUL which is lower than the TUL in order to meet the purity requirement. For example, the TUL for hypochlorite products is 10 mg Cl_2/L, but a hypochlorite product may only meet the bromate SPAC of 5 ug/L when the MUL is lowered to a concentration at less than 10 mg Cl_2/L. Moreover, MULs for solutions are proposed with the solution strength factored in, and the percentage strengths of a solution may be expressed differently (weight/weight vs. weight/volume vs. trade percents) in the listings database.

Can you provide some calculation examples?

Sodium hypochlorite is used as an example to explain how to determine the proper dosage of NSF/ANSI certified chemicals. MULs for most hypochlorite products are set based upon the "available chlorine" equivalent to 10 mg Cl_2/L as set forth in NSF/ANSI Standard 60. The available chlorine of NaOCl is the ratio of the mass of chlorine to the mass of NaOCl that has the same unit of oxidizing power as chlorine. The available chlorine ratio for NaOCl is 0.95, meaning that NaOCl is 95% effective compared to chlorine. Thus, we have:

Available Chlorine (mg/L) = (% Strength w/w) * (Dose mg/L) * (0.95) (Eq. 1)
Maximum Available Chlorine (mg/L) = (% Strength w/w) * (Maximum Use Level mg/L) * (0.95) (Eq. 2)

For a typical 12.5% w/w solution with an MUL of 84 mg/L (product #1), the available chlorine would be calculated as follows: 0.125 x 84 x 0.95 = 9.975 mg/L available chlorine.

For a 12.5% w/w solution with an MUL of 70 mg/L due to a higher impurity level (product #2), the available chlorine would be calculated as follows: 0.125 x 70 x 0.95 = 8.313 mg/L available chlorine.

For products that are expressed under the w/v percentage as opposed to w/w, the listed MULs will be higher than those based on a w/w percentage. In these cases, a w/w percentage should be first obtained by dividing the percentage in w/v by the specific gravity of the product. For a 12.5% w/v solution with a MUL of 99 mg/L and a specific gravity of 1.175, the available chlorine would be calculated as follows:

$$(0.125/1.175) \times 99 \times 0.95 = 10.005 \text{ mg/L available chlorine}$$

If you are unsure about the MUL, the strength or the specific gravity of a product, please contact the chemical supplier for ensuring accurate calculations. Two more examples for breakpoint chlorination are provided below based on different scenarios:

Community X would like to use groundwater containing 1.5 mg/L of ammonia nitrogen as the source water at their new treatment plant. A site-specific study for breakpoint chlorination has been conducted, which showed that 15 mg/L of chorine should be added to the drinking water to reach the breakpoint. The design engineer found that no sodium hypochlorite solutions could satisfy the chlorination demand considering that their MULs are based on up to 10 mg/L of chlorine. Therefore, Community X gave up using sodium hypochlorite solutions, and turned to consider alternative strategies to treat the ammonia-bearing water.

The source water at the water treatment plant of Community Y contains 0.9 mg/L of ammonia nitrogen. It has been determined by a site-specific study that 9 mg Cl_2/L must be added to achieve breakpoint chlorination. They found that product #1 as described above would work well with a dose of 75.8 mg/L according to Eq. 1, whereas the choice of product #2 would lead to a violation in Standard 60. Community Y thus chose product #1 for their water treatment plant.

What options do I have if the required dose of a chemical is higher than the MUL?

If the required dose of a chemical is higher than the respective max dose set by Standard 60, the following options can be considered:

- Use an alternative chemical. Take chlorine-based disinfectants as an example. When hypochlorite solutions have a MUL of 10 mg Cl_2/L and cannot reach breakpoint chlorination, chlorine gas can be an alternative as using levels up to 30mg Cl_2/L is acceptable. For another example, chlorine dioxide or ozone can replace chlorine-based disinfectants as the primary disinfectant.
- Considering alterations in the treatment process. For example, a treatment unit based on biological nitrification, ion exchange, membrane filtration or air stripping can be added to remove ammonia from raw water. The choice of strategy to be adopted should be based on site-specific technical and economic analyses. For more information on strategies for dealing with source water containing high ammonia levels, please refer to WSA's publication *EPB431 Ammonia Fact Sheet.*

How to use Table 1 to check limits for common water treatment chemicals in Saskatchewan?

Table 1 at the end of this fact sheet lists the common chemicals used in Saskatchewan water treatment and their limits. Examining the TUL of each chemical can be a shortcut for designers, owners, operators, and regulators to determine if the use of a chemical complies with Standard 60. **MULs of chemical products sold in Saskatchewan are summarized from the data provided by a major supplier in Saskatchewan, which are thus not exhaustive.** TULs and MULs listed in the table can only be a quick reference for design and compliance check. A close look at the dose, trade name, manufacturer and manufacturing facility of the product is a must to find out the MUL of a treatment chemical and ensure compliance with NSF/ANSI Standard 60.

Are there other requirements on chemical use?

While complying with Standard 60, the following considerations should be taken into account for chemical use in drinking water:

- Chemicals with a lower impurity level as specified on NSF online listings should be considered first whenever possible. Take hypochlorite treatment chemicals as an example. All certified hypochlorite products can meet the bromated SPAC requirement of 0.005 mg/L, but only low-bromate products can have the following statement in the NSF listings: "Based on testing to the requirements of NSF/ANSI 60, use of this product at a dose of [MUL] or less is expected to contribute a bromate residual of 0.001 mg/L or less to the finished drinking water."
- The residual levels of chemicals and by-products shall be monitored in the finished drinking water to ensure compliance to all applicable regulations. For example, compliance concerns over Trihalomethanes (THMs), halogenated acetic acids (HAAs), chlorates, and chlorides are associated with high dosages of chlorine-based disinfectants. The possible concerns over residuals and by-products of common chemicals used in Saskatchewan are listed in Table 1.
- Standard 60 only addresses the human health effects aspects of the products and does not address product efficacy, environmental effects, or other specifications, which are currently addressed in standards established by organizations such as the American Water Works Association, and the American Society for Testing and Materials. It is strongly recommended to use products that also meet the standards of such organizations.

Do we need an approval for using or changing chemicals in water treatment?

Yes. A Permit for Construction of Waterworks must be obtained from the WSA before starting construction or installation of such works. For minor changes in chemical use (e.g., changing from product A to product B for the same chemical), it is the responsibility of the waterworks owner to ensure that chemicals in contact with drinking water are certified in accordance with ANSI/NSF Standards 60 and do not cause health problems. Approvals Engineers and Environmental Project Officers shall be informed in writing for such changes.

Where can I get more information?

Additional information on proper use of water treatment chemicals can be obtained from municipal engineering consultants and chemical suppliers.

Additional information on the regulations concerning chemical use in water treatment is available from Environmental Project Officers (EPOs) and Approvals Engineers of the WSA. To speak to an EPO or an Approvals Engineer, please call 306-787-6504.

The WSA's publications mentioned in this fact sheet are available for download at http://www.saskh20.ca/DWBinder.asp.

Table 1 Summary of NSF Certified Water Treatment Chemical Typical Use Level & Maximum Use Level

Chemical Name	Chemical Formula	Typical Use Level (TUL, mg/L)	Memo for TUL	Maximum Use Level Found in SK (MUL, mg/L)[1]
Coagulants& Flocculants				
Aluminum Sulphate [2]	$Al_2(SO_4)_3 \cdot 14\ H_2O$	156/26.8	The first value is the TUL as indicated by the chemical formula. The second value is the TUL as aluminum oxide for the aluminum salts (aluminum chloride, aluminum sulfate, polyaluminum chloride, and sodium aluminate)	330
Poly-aluminum Chloride [2]	$Al_2(OH)nCl_{6-n}$	-/26.8		250
Sodium Aluminate [2]	$Na_2Al_2O_4$	43/26.8		100
Ferric Chloride	$FeCl_3 \cdot nH_2O$	60.0/20.7 (n = 0) 100.0/20.7 (n = 6)	The first value is the TUL as indicated by the chemical formula. The second value is the typical use level as Fe for the iron salts (ferric chloride, ferric sulfate, ferrous chloride, and ferrous sulfate)	250
Ferric Sulphate	$Fe_2(SO_4)_3$	100/28		600
Ferrous Sulphate	$FeSO_4 \cdot nH_2O$	43.7/16.1 (n = 0) 80.0/16.1 (n = 7)		400
Polyacrylamide (dry)	$(C_3H_5NO)_n$	1	Based on an acrylamide polymer application 1mg/L and an acrylamide monomer level of 0.05% in the polymer, or equivalent for a carryover of not more than 0.5 ppb of acrylamide monomer into the finished water	1
Sodium Silicate	$Na_2O(SiO_2)_n$	7.8		42
Disinfectants & Oxidants				
Ammonia, anhydrous	NH_3	5		5
Ammonium Hydroxide	NH_4OH	10		10
Ammonium Sulphate	$(NH_4)_2SO_4$	25		25
Calcium Hypochlorite [3]	$Ca(OCl)_2$	10	Equivalent to 10mg Cl_2/L, on a dry basis	15
Sodium Hypochlorite ,12% [3]	$NaOCl$	10	Equivalent to 10mg Cl_2/L, on a dry basis. Some hypocholorite products have been restricted to a maximum use level that is less than 10 mg Cl_2/L but more than 2 mg Cl_2/L	87
Chlorine [3]	Cl_2	10	Equivalent to 10mg Cl_2/L, on a dry basis. Use levels up to 30mg Cl_2/L may be acceptable for short-term application such as shock chlorination and disinfection of new installations	30
Dechlorination				
Sodium Bisulfite [4]	$NaHSO_3$	18	Based on chlorine level of 12 mg/L prior to treatment	50
Sodium sulfite	Na_2SO_3	22		22
Sulfur Dioxide	SO_2	10		10
Taste and Odour Control				
Hydrogen Peroxide,35% [5]	H_2O_2	3	For 35% hydrogen peroxide solution	3
Potassium Permanganate [6]	$KMnO_4$	15		50
Algae Control				
Copper Sulphate [7]	$CuSO_4$	1	Based on mg Copper per L water	4

Corrosion & Scale Control, pH Adjustment				
Calcium Carbonate	$CaCO_3$	650		650
Calcium Hydroxide	$Ca(OH)_2$	650		650
Carbon Dioxide	CO_2	200		100
Sodium Hydroxide	NaOH	100		100
Sequestering				
Sodium Polyphosphate, Glassy	$(NaPO_3)n.Na_2O$	10.7-11.9	Equivalent to 10mg PO_4/L, on a dry basis. This typical value is based on potential ecological effects of phosphates at levels exceeding 10mg PO_4/L.	---
Sodium Silicate	$Na_2O(SiO_2)_n$	16		42
Softening				
Calcium Oxide (Quicklime)	CaO	500		500
Sodium Carbonate	Na_2CO_3	100		100
Fluoridation				
Fluosilicic Acid	H_2SiF_6	1.2	Based on mg Fluoride Ion per L water. Total concentration of fluoride ion in finished water may include fluoride occurring naturally in the source water.	6
Sodium Fluoride	NaF	1.2		2.3

(1) Maximum use level (MUL) is not the typical use level for the product, unless specifically stated in Standard 60. The MULs listed here are obtained from the manufactures which are commonly available to Saskatchewan. MUL may vary depending on the manufactures and it is advisable to always confirm the MUL with your own manufacture or distributor before use.

(2) The level of aluminum in the finished water shall not exceed 0.1 mg/L for conventional treatment plants using aluminum-based coagulants and 0.2 mg/L for other types of treatment system.

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

(4) This product contains sulfite. Sulfites have been known to cause potential lethal allergic reaction in sulphite-sensitive individuals. The maximum recommended allowable residual sulphite level in the finished drinking water is 0.1mg/L

(5) Use of this product shall be followed by chlorination to remove levels of hydrogen peroxide. Chlorine residual shall not exceed 4 mg/L, the EPA's proposed maximum residual level.

(6) The finished drinking water shall be monitored to ensure levels of manganese do not exceed 0.05 mg/L.

(7) The use of copper sulphate an algicide may increase the amount of copper present in the finished drinking water. Following use this product, the finished drinking water should be monitored to ensure that levels of copper do not exceed 1.0 mg/L.