BCDMH (Tabs & Granular)
WATER TREATMENT BIOCIDES

Contents

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BCDMH
WATER TREATMENT BIOCIDES

BCDMH BIOCIDES:

- are broad-spectrum halogen-releasing products for the control of algal, bacterial, and fungal populations in industrial water systems,
- are supplied as free-flowing granules **(BCDMH G)** and as tablets **(BCDMH Tab)**, and
- contain bromo-chloro-dimethyl-hydantoin (BCDMH) active ingredient, which slowly releases bromine and chlorine when placed in water.

APPLICATIONS

BCDMH® biocides are recommended for use in the following cooling towers and other related water treatment applications:

- Recirculating cooling towers, flow through filters, and lagoons
- Heat exchange water systems
- Industrial water-scrubbing systems
- Brewery and canning pasteurizers
- Industrial air-washing systems with efficient mist eliminators
- Once-through cooling towers and closed-cycle fresh and sea water cooling systems, cooling ponds. canals, and lagoons
- Ornamental fountains
- Air conditioner condensate

FEATURES AND BENEFITS OF BCDMH BIOCIDES

- Broad-spectrum antimicrobial activity
- Excellent source of bromine
- Effective at very low concentrations
- More effective than chlorine over a broad pH range (6-10)
- More effective than chlorine in the presence of ammonia contamination
- Safer to handle and store than chlorine gas or liquids
- Easy to use solid form
- Especially useful for small to medium size cooling water systems, where handling of chemical additives may be difficult.

CHEMICAL AND PHYSICAL PROPERTIES

(These do not constitute specifications)

Chemically, **BCDMH** biocides contain bromo-chloro-dimethyl-hydantoin (BCDMH).

- CAS Registration No: 32718-18-6
- CAS Index Name: 2,4-Imida-zolidinedione, N,N'-bromo, chloro-5,5-dimethyl-
- Other Synonyms: N,N'-Bromo, chloro-dimethyl hydantoin; 1,3-bromo, chloro-5,5-dimethyl hydantoin: 1,3-bromo, chloro-5,5-dimethyl-2.4- imidazolidinedione.

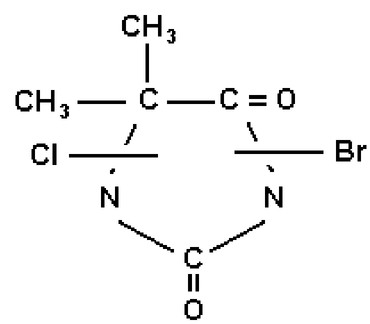
BCDMH biocides contain a mixture of approximately 1:1 of the two BCDMH isomers:

- 1-bromo-3-chloro-5,5-dimethyl hydantoin (CAS # 16079-88-2)
- 3-bromo-1-chloro-5,5-dimethyl hydantoin (CAS # 126-06-7)

Molecular Formula: $C_5H_6BrClN_2O_2$

Formula Molecular Weight: 241.5

Structural Formula:



General Description

	BCDMH G	BCDMH Tab
Appearance	Off-white solid	Off-white solid
Form	Free-flowing powder (granule)	Tablet Diameter~2.5 cm (~l in) Weight~20.5 g (~0.68 oz)
Odor	Faint halogenous	Faint halogenous

Active Ingredient Assay

Typical Values for **BCDMH G** and **BCDMH Tab**

Percent Active Ingredient	98.0
Weight Percent Active Bromine	32.4
Weight Percent Active Chlorine	14.4
Molar Ratio, Bromine : Chlorine	1.0 : 1.2
Percent Total Oxidant, Calc. as Cl_2	58.6 min
Percent inert ingredients	2.0

Solubility: **BCDMH** biocides are soluble in many organic solvents. In water, solubility is approximately 0.2 g/100g @ 25°C. The dissolution rate is dependent on temperature and water flow.

Melting Range: Not applicable. BCDMH starts to decompose at160° C, releasing toxic and irritating, dense fumes.

Specific Gravity: Approx. 1.8 - 2.0.

Hygroscopicity: The BCDMH in **BCDMH** biocides is hygroscopic and moisture will be absorbed if containers are not kept tightly closed. This moisture can cause the decem-position of the BCDMH, disintegration of the tablets, and lumping of the granules.

Vapor Pressure: Negligible.

Evaporation Rate: Not applicable at standard conditions.

Incompatibility: Incompatible with paints, petroleum, greases (especially mineral lubricants), sawdust and other combustible organic materials, organic and inorganic oxidizers, strong bases, and moisture.

Flammability: Non-flammable. At 160°C, **BCDMH** biocides start to decompose, releasing toxic fumes. In fires around **BCDMH** biocides, do not use water, unless copious amounts can be used. Do not use ammonium phosphate fire extinguishers.

Corrosivity: Not corrosive when used in water at recommended use levels. However, may be corrosive to most metals at high concentrations, such as in metering equipment used in dosing.

Decomposition: The BCDMH in **BCDMH** biocides is a hazard class 5. 1 oxidizing agent and will easily decompose when contaminated with moisture and/or organic matter to produce dense, corrosive fumes that may contain bromine, hydrogen bromide, hydrogen chloride, and nitrogen oxides.

TOXICITY

Skin and Eye Irritant

BCDMH biocides, as supplied, can cause severe irritation of the skin, eyes, and mucous membranes. Prolonged skin contact can cause superficial burns, particularly if skin is wet or damp. Skin contact may cause skin sensitization.

Toxicological Properties

Animal Toxicity Data	**BCDMH G** or **BCDMH Tab** (as supplied)
Oral rat LD50, mg/kg	929
Dermal rabbit LD 50, mg/kg	=>2000
Inhalation rat LC50 mg/1,4 hr	1.11
Skin Irritancy	Severe irritant, may be corrosive
Eye Irritancy	Corrosive
Sensitization, Guinea Pig MK test	May induce sensitization
Genotoxicity	
Ames Mutagenicity	Negative
UDS	No adverse effect
Aquatic and Wildlife Toxicity Data (nominal concentrations)	
96-hr static LC50, mg/l	
Rainbow Trout	0.4
Fathead Minnow	2.25
Bluegill Sunfish	0.46
Grass Shrimp	13
Sheepshead Minnow	20
American Oyster	>640
Daphnia (48 hour)	0.75
Bobwhite Quail Oral LD50, mg/kg	1839
Bobwhite Quail Dietary LC50, ppm	>5620
Mallard Duck Dietary LC50, ppm	>5620

SAFE HANDLING INFORMATION

The BCDMH in **BCDMH** biocides is classified as a hazardous chemical under U.S. DOT and international transportation regulations, due to its properties as a Class 2 oxidizing agent (hazard class 5. 1, oxidizing agent label required) and its characteristics of reactivity when contaminated with moisture or organics to decompose giving off toxic, irritating, and dense fumes. Organic contaminants could cause dangerous over-pressurization when BCDMH is stored in sealed containers, such as could happen in some BCDMH feeder devices not equipped with a pressure relief valve.

BCDMH biocides can be used safely if the recommended safety precautions are observed. These few basic precautions are clearly indicated on each container.

Storage and Handling Precautions

Store in dry, well-ventilated shaded areas between 20°C to 30°C, in tightly closed containers, and away from fire and oxidizable material. Use dry, clean clothing and equipment when handling **BCDMH G** or **BCDMH Tab** biocides. Avoid breathing dust and contact with eyes and skin. Dust masks, chemical safety goggles, rubber gauntlets, boots, and full body covering clothing should be worn while unloading and handling **BCDMH** biocides.

Handling Spills

Sweep up spilled material and place in suitable containers. Wash area of spill with large amounts of water. Wash empty container with water before disposal. Containers should not be reused.

First Aid

Eye Contact: Flush eyes with water for at least 15 minutes. Get prompt medical attention.

Skin Contact: Remove contaminated clothing; wash skin thoroughly with mild soap and plenty of water. Get medical attention if irritation persists. Wash contaminated clothing thoroughly. Do not take clothing home to be laundered.

Inhalation: Remove the patient to fresh air. Keep patient quiet and warm. Apply artificial respiration if necessary.

Ingestion: If swallowed give large amounts of water (two glasses) to dilute toxicant. If immediately available, demulcents such as milk, vegetable oil or egg whites can be given. **Do not induce vomiting!**

Please refer to **BCDMH MSDS** for further details.

USE DIRECTIONS

The amount of **BCDMH G** or **BCDMH Tab** biocides needed to control biofouling or microorganism level is dependent on many factors, among the most important are:

- characteristics of the system treated
- halogen demand of the water
- system contamination with ammonia, amines and other oxidizable organics and inorganics
- compatibility with other chemical additives
- degree of cleanliness desired

A free halogen residual must be maintained for effectiveness, but the level required and duration of residual maintained will vary widely depending upon the system. In some systems, microorganism levels can be controlled with a free halogen (i.e., bromine) residual of 0.25 ppm or lower, whereas in other systems control may require higher halogen residual levels.

Bromine residual can be determined by measuring the total residual oxidant with a chlorine test kit, such as the diethylphenylaminediamine (DPD) test kit (l), and expressing the results as ppm total residual oxidant, as Cl_2. An iodometric titration method can also be used.

BCDMH G or **BCDMH Tab** biocides may be fed to the system as a shock or intermittent, or continuous dose. A bypass feeder is recommended to achieve best results generally for most systems treated with **BCDMH** biocides.

DOSAGE RECOMMENDATIONS

Initial Dose: Dose to achieve 1 ppm residual bromine to noticeably fouled systems.

Examples of dosaging amounts of **BCDMH** biocides for the corresponding amounts of water to achieve 1 ppm bromine residual are as follows:

Add		To Water in System	
kg or	lbs	m^3 or	gallons
0.24-0.72	0.53-1.6	10.0	2,640
0.91-2.72	2.00-6.0	37.85	10,000

Repeat dosage until a 1 ppm bromine residual is established for at least four hours.

Subsequent Dose: After microbial control is obtained, add **BCDMH** biocides to maintain 1 ppm residual bromine.

Examples of dosaging amounts of **BCDMH** biocides for the corresponding amounts of water to maintain 1 ppm bromine residual are as follows:

Add		To Water in System	
kg or	lbs	m^3 or	gallons
0.12-0.36	0.27-0.8	10.0	2,640
0.46-1.37	1.00-3.0	37.85	10,000

Repeat as needed to maintain 1 ppm residual for at least four hours.

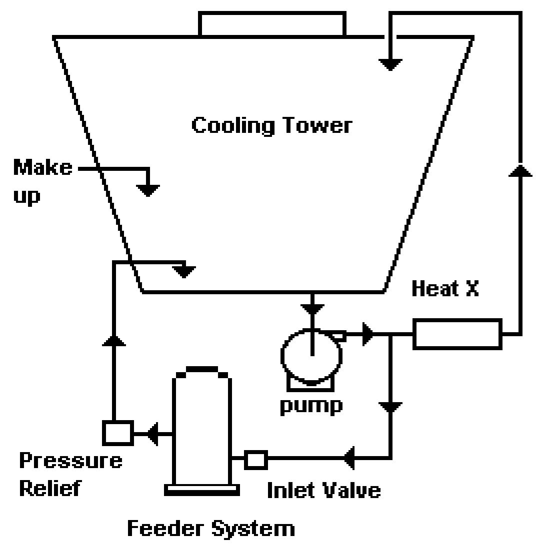
BCDMH FEEDING SYSTEM RECOMMENDATIONS

BCDMH G or **BCDMH Tab** biocides are most readily introduced into the water system by means of a bromine feeder device. It is essential to use a bromine feeder that is of an appropriate size for the dimensions of the specific water system and the chosen dosing regimes. (Suppliers for bromine feeders are available upon request.)

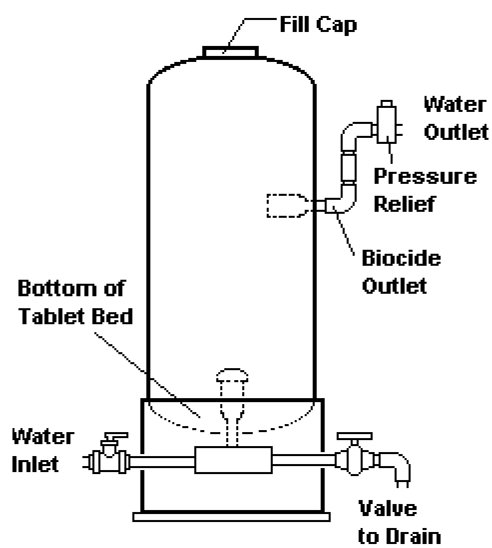
The feeder facilitates controlled release of the active bromine by controlling the water flow through it. The amount of active halogen released depends on the flow rate through the BCDMH reservoir in the bromine feeder and on the water temperature. The flow rate is adjusted by a control valve.

Chemical additives, such as organic biocides or any other incompatible substance, should not be mixed-in with the BCDMH in the bromine feeder. Under certain conditions, a reaction with an incompatible substance could result in excessive pressure development and possible explosion. A pressure relief valve should be installed in the bromine feeder device, as a precautionary measure.

FEEDER INSTALLATION



Typical Feeder Design



BCDMH CHEMISTRY

The chemical reactions of the BCDMH in the **BCDMH** biocides have been reported in the scientific literature (2). These reactions, which are described in the following paragraphs, show why BCDMH biocides are considered as primarily bromine releasers (2).

BCDMH hydrolyzes in water to release bromine and chlorine, as hypobromous and hypochlorous acids, as shown in reactions I and II below. However, the bromine is released almost immediately, whereas the chlorine release reaction is slow.

I. Bromochloro DMH + H_2O $\rightleftharpoons$ (Rapid) HOBr + Monochloro DMH*

II. Bromochloro DMH + H_2O $\rightleftharpoons$ (Slow) HOCl + Monobromo DMH

The monohalo-DMH products from reaction I or II also can hydrolyze. The monobromo-DMH hydrolyzes much faster to release hypobromous acid (reaction III) than does the corresponding hydrolysis of the monochloro-DMH (reaction IV), as shown below.
The hypobromous acid released in reactions I and III can dissociate to the biocidally low active hypobromite ion (reaction V), but this reaction is much slower than the corresponding dissociation of the hypochlorous acid, especially in alkaline water, to form the biocidally low active hypochlorite ion (reaction VI).

III. Monobromo DMH + H_2O $\rightleftharpoons$ (Rapid) HOBr + DMH

IV. Monochloro DMH + H_2O $\rightleftharpoons$ (Slow) HOCl + DMH

V. HOBr $\rightleftharpoons$ (Slow) OBr^- $\rightleftharpoons$ (Rapid) Br^-

VI. HOCl $\rightleftharpoons$ (Rapid @ pH>7.5) OCl^- $\rightleftharpoons$ (Slow) Cl^-

The reverse is true in the decomposition of the dissociated hypohalites, The hypobromite reacts rapidly to form bromide ion (V), whereas the hypochlorite ion reacts slowly to form the inactive chloride ion (VI).

*DMH = dimethylhydantoin

One final, but very important set of reactions is that of bromide ion with hypochlorous acid or hypochlorite ion produced in some of the reactions. Bromide reacts rapidly with these chlorine compounds to form more of the biocidally active hypobromous acid (reactions VII and VIII).

VII.	**$HOCl + Br^-$**	$\rightleftharpoons$ (Rapid)	**$HOBr$**
VIII.	**$OCl^- + Br^-$**	$\rightleftharpoons$ (Rapid)	**$HOBr$**

These reactions show that:

- bromine is the major active ingredient most rapidly available for killing microorganisms, and that
- bromine production is favored over that of chlorine in the various other reactions.

In terms of biocidal activity, the **BCDMH** biocides are therefore primarily bromine releasers, having the efficacy advantages of bromine. These advantages are summarized in the sections that follow.

MICROBIOCIDAL PERFORMANCE

Performance in High pH and Ammonia- Contaminated Water

Hypobromous (HOBr) and hypochlorous (HOCl) acids are the biocidally active forms of bromine and chlorine, respectively, regardless of the source (1,2,3). These hypohalous acids dissociate to the less efficacious hypobromite or hypochlorite forms. **BCDMH** biocides can be more efficacious than chlorine at higher pH (pH > 7.0) because the HOBr that is released has greater persistence at higher pH than the corresponding HOCl released from chlorine. HOBr has a higher pK value than HOCl and, consequently, with **BCDMH** biocides dosing, the concentration of HOBr is greater with increasing alkaline pH than that of HOCl when dosing with chlorine. The effect of pH on the concentrations of hypobromous and hypochlorous acids is shown in the dissociation curves in figure 1 below (4).

Figure 1: Dissociation Curves of Hypobromous and Hypochlorous Acids

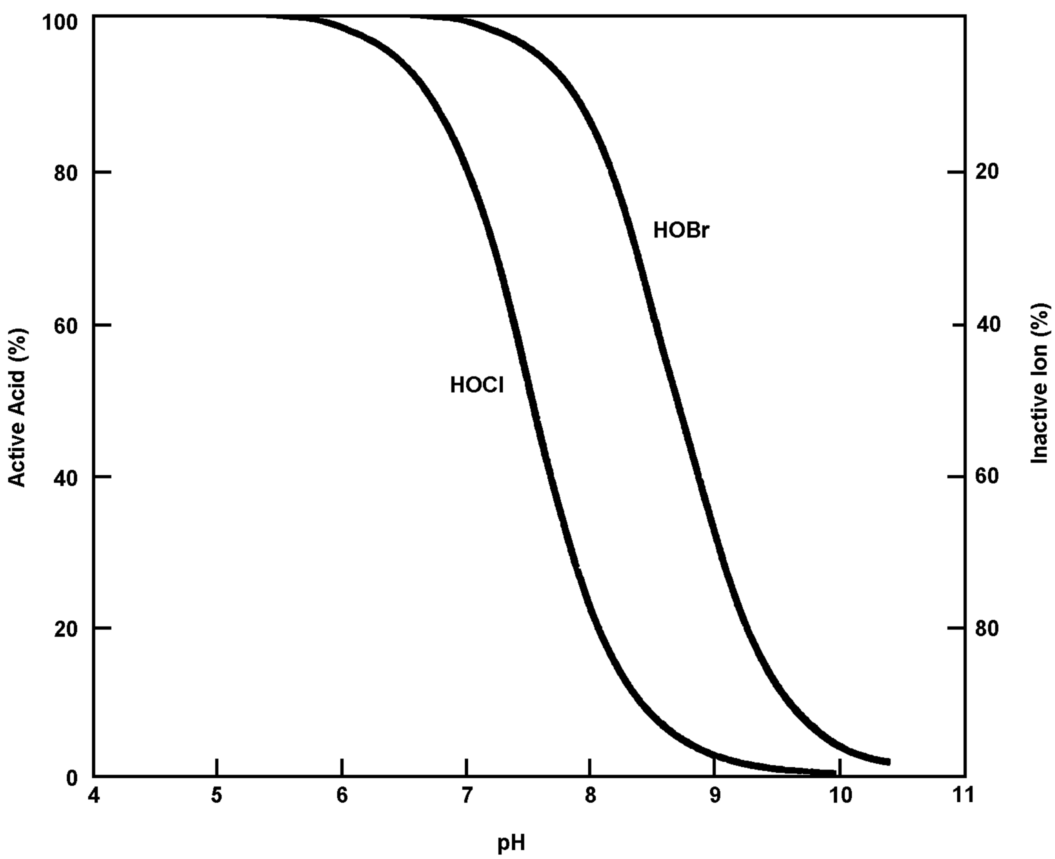
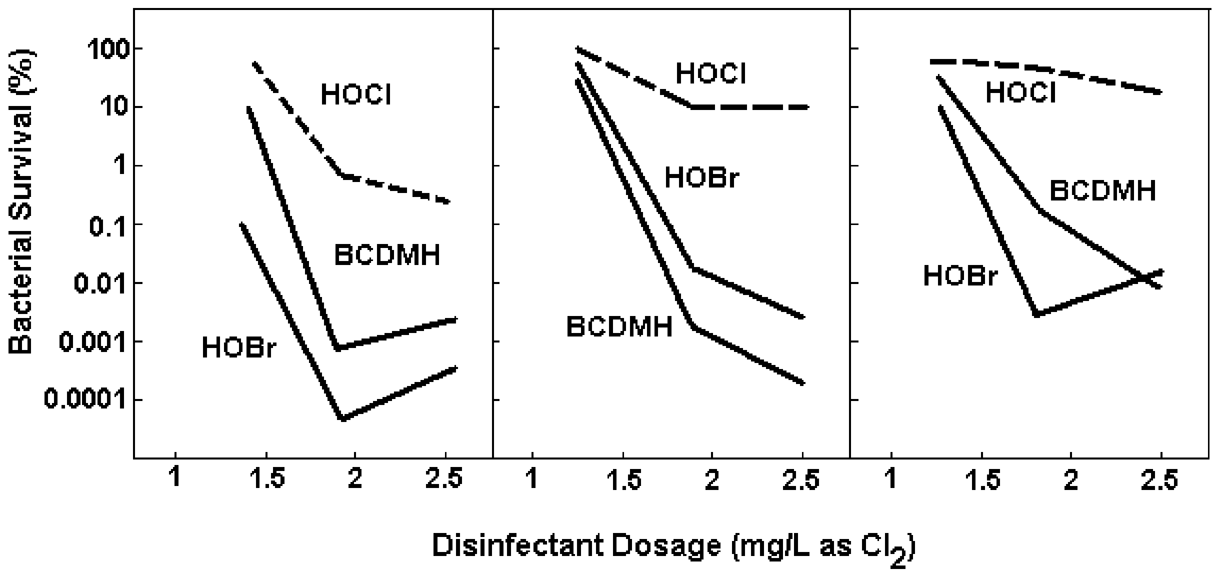
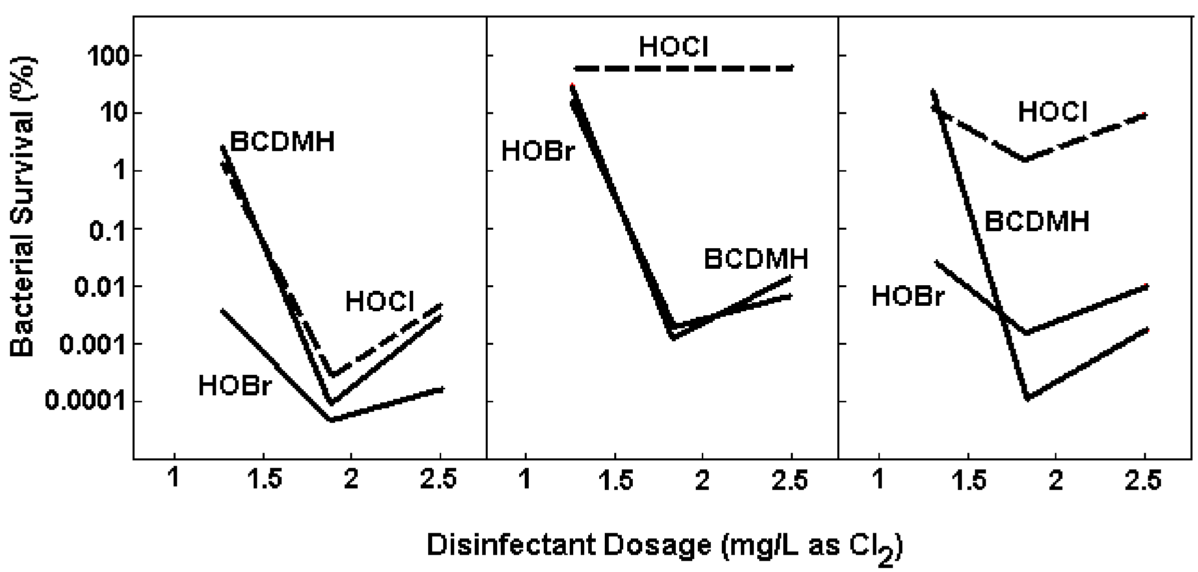


FIGURE 2: Disinfection Performance High pH (8.2) & Ammonia (2 mg/L)



The biological data in the two figures above and below show that the halogen released from BCDMH is considerably more effective than chlorine and almost as effective as bromine in microbiocidal performance versus pure cultures of bacteria at 2 minutes contact time in water with 2 ppm ammonia and at pH 8.2 (figure 2) and even at pH 7.2 (figure 3). Figures 2 and 3 are from reference #4.

FIGURE 3: Disinfection Performance High pH (7.2) & Ammonia (2 mg/L)



Other investigators (2) concluded that BCDMH was 3-4 times more effective than chlorine at pH 8.5, and was 20 times more effective than chlorine alone in the presence of ammonia nitrogen at pH 7.0. At low pH (6.5) and in demand-free water these investigators found that BCDMH had microbicidal efficiency slightly lower than chlorine at 1 minute exposure, but, at 2 minutes exposure, BCDMH was equal to chlorine in the low pH demand-free water (2).

Performance in Cooling Towers

The performance of the BCDMH active in **BCDMH** biocides in cooling tower systems has been well documented in the scientific literature (references 5-10). **BCDMH** biocides can be used effectively and economically in all types of cooling towers. **BCDMH** biocides can be used alone or in combination with chlorine as a means to reduce total residual oxidant level of effluent discharge in regulatory compliance or merely to reduce the adverse effects of chlorine on equipment, personnel, and environment. **BCDMH** biocides are especially useful in water where chlorine overdosing is required to maintain control, such as in those systems where the water pH is high and/or the chlorine demand is high (e.g., contamination with organic matter, ammonia, etc.).

In a report (5) of seven case studies, the author concluded that BCDMH was effective, economical, and easy to use in field applications. BCDMH was evaluated in three large and four medium to small cooling tower systems for oil refining, chemical processing, chemical packaging, gas processing, and centrifugal chillers. Details of these case studies are provided in the authors report (5). The author concluded the following:

BCDMH was not only effective in all seven case studies, it was the only biocide found to work in four of the case studies where the towers had a history of heavy biofouling and contamination from plant processes. BCDMH was also cost-effective when compared with chlorine gas. Cost calculations were made for one of the case studies, which showed that the total cost for using chlorine gas was $8.44 (US)/day, whereas when BCDMH was used the cost was only $7.60 (US)/day.

BCDMH corrosion of metals was shown to be comparable to chlorine when used with an appropriate water treatment system.

BCDMH BIOCIDES CAN BE USED WITH CHLORINE TO REDUCE TOTAL RESIDUAL OXIDANT LEVELS

In recirculating cooling tower water field studies (6), effective biofouling control was achieved and maintained for at least 90 days with a BCDMH /chlorine combination dosing (1:10 weight ratio) to maintain a halogen residual of 0.45 ppm, measured as chlorine. The system was characterized as having a high organic matter content (~500 ppm), high pH (pH 7.6-7.8), and prior biofouling problems that could not be solved by use of chlorine alone or chlorine plus non-oxidizing biocides combinations. Heat transfer data from a side-stream biofouling monitor and surface condenser vacuum data correlated with biofouling control, but not the data of bacterial counts in bulk water samples (i.e., the planktonic bacteria). Counts

were not made on the bacteria in the

biofilm (i.e.,the sessile bacteria), which would have been expected to have better correlation with visual and physical estimates of surface biofouling than the bacteria dispersed in the water. Another investigator (7) reported that BCDMH was an effective biocide in combination with chlorine and non-oxidizing biocides in controlling biofouling and corrosion problems in a combined power / chemical process cooling system in the southeast U.S. Biofouling monitors were used in these studies in combination with other monitoring methods. BCDMH contributed to reducing chemical treatment requirements, as well as to maximizing energy use efficiency, and to protection of plant investment.

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