Water and oilfield biocides
BASF Biocides - protecting the world
The biocide business for Specialty Chemicals, BASF AG

BASF is one of the world’s leading suppliers of specialty biocides. We create products that make life safer, simpler and more comfortable for millions of people worldwide.

Our high performance biocides are used in every aspect of life. From toiletries, to air conditioners used in both industry and home, from Iceland to Ecuador our technology spans the globe in preservation and disinfection. We help to protect the lives of millions of people across the world every day.

Through our product range, marketing expertise, technical and regulatory knowledge, BASF’s innovative biocides approach positions the business at the very forefront of antimicrobial technology. The marketing, technical and research and development headquarters for BASF’s specialty biocide business is located in Nottingham.

Our products are made in ‘state of the art’ manufacturing facilities at Cramlington, England and Ludwigshafen, Germany. In each of our plants, the expert integration of process and energy requirements leads to manufacturing efficiencies and quality production.

To demonstrate our commitment to our customers, we have made significant investment in long term dedicated biocide resources within Europe, Asia Pacific and the USA.

In 2000, we established a direct presence in the USA with a new dedicated marketing and technical centre based at BASF Corporation headquarters in Mount Olive, New Jersey. Product is supplied through an integrated BASF warehousing facility in Charlotte, North Carolina. Our US operation is part of BASF Corporation’s Chemical Division, situated in Mount Olive, New Jersey.

How we work for you
BASF’s biocides are sold through BASF’s established network of sales offices worldwide. In this way, we aim to offer valuable local support and the highest standards of customer excellence.

Working with BASF provides access to many essential regulatory approvals. For example our EPA registrations allow products and customer formulations to be sold in the USA and our approvals ensure supply to the paper industry in the Nordic area. We are also well positioned to support our actives under the European Biocidal Products Directive.

We believe in long-term commitment to our products and customers and this is reflected in our substantial registrations and the data required to obtain them. To this end many of our products are supported with extensive safety and environmental data packages.

In addition, BASF is committed to providing the highest standard of health, safety and environmental protection as part of our commitment to Responsible Care. We continually research and innovate to produce the most advanced products on the market.

At BASF, we are also constantly reviewing ways in which we can improve our products and services to ensure that we keep pace with the rapidly changing developments in information technology. BASF is harnessing these changes and ensuring that we are aligned with our customer’s requirements, making it more efficient and convenient for you to do business with us.

BASF’s specialty biocide products are marketed under the Myacide® and Protectol® trade names.
Introduction to water and oilfield biocides

Microbiological problems in the water and oilfield industries

Industrial systems rely on water as a processing or cooling medium for efficient operation due to its inert character, low cost and safety. In addition, the process chemicals and additives used may have water as a key component. Water provides an ideal environment for the proliferation of micro-organisms and, if uncontrolled, these microbes can cause significant problems that lead to an increase in operating costs.

Water is also used as a heat transfer medium, from large recirculating cooling systems to smaller air conditioning/humidifier units. The problems of biofouling have been recognised for many years in these applications.

Slime-forming organisms can form biofilms that provide ideal conditions for anaerobic bacteria to grow under the surface of the slime. Additionally, given the right physical conditions, a biomass of algae may form which can also be problematic. Biofilms can rapidly become established in pipework and heat exchanger surfaces. Here, they can cause a number of problems including reduction in efficiency, an increase in the flow resistance and, in extreme cases, pipes can become blocked and badly corroded.

In addition to the practical problems associated with microbial contamination, the risk to human health also has to be considered. The presence of potentially pathogenic organisms in air conditioning and humidifier systems, is a cause of concern. * Legionella pneumophila, the bacterium implicated in outbreaks of Legionnaires’ Disease, is only one of a number of organisms which, under the right conditions, cause human infections.

In the oil and gas industry, the development and operation of an oilfield goes through several distinct phases, all of which can be affected by unwanted microbial growth. Microbial contamination can occur during drilling of the well, preparing the well for production (stimulation), construction of the facilities and production itself.

Many operations in the oilfield industry tend to present anaerobic environments, therefore favouring the proliferation of sulphate-reducing bacteria (SRB). The activity of these bacteria results in the production of H₂S, which leads to problems such as reservoir souring, metal corrosion and health hazards.

Uncontrolled microbial growth will cause different problems and requires different treatment philosophies and biocide use patterns. BASF's biocides has a full range of complementary products for the water and oilfield industry which help to either eradicate or control microbial growth and prevent the build-up of biofilms.

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Myacide® AS and S1/S15 Biocide

The industrial grade of Bronopol (2-Bromo-2-nitropropane-1,3-diol) is supplied as a crystalline solid, Myacide AS biocide, or as liquid formulations, Myacide S1 and S15. This choice provides the end-user with the means of an optimised approach to the treatment of microbiological problems in the water treatment and oilfield application sectors.

Bronopol offers broad-spectrum antibacterial activity against the major slime-forming and spoilage bacteria. It is also extremely effective at controlling the pathogenic Legionella bacteria and the anaerobic SRB.

Myacide AS or the liquid formulations can be used alone, as components in mixtures or as part of an integrated biocide treatment programme.

QUALITY

Myacide AS is an off-white to pale yellow crystalline solid containing a minimum of 98% 2-Bromo-2-nitropropane-1,3-diol. The product, as supplied, is stable for at least 3 years when stored under good conditions.

Myacide AS Plus is marketed only in the USA as an EPA end use product. The technical specification and product quality are the same as Myacide AS.

Liquid Formulations

The liquid formulations allow for ease of handling and are ideal for use in systems where automatic dosing is practised.

Myacide S15 biocide is a 10% (w/w) solution of Bronopol in propylene glycol and water.

Myacide S1 is a 20% (w/v) solution of Bronopol in dipropylene glycol monomethyl ether and water.

Liquid formulations have a shelf life of 2 years.

ANTIMICROBIAL ACTIVITY

Biofouling in cooling-water systems and the spoilage of oilfield additives is largely due to the presence of Gram negative bacteria. In addition anaerobic bacteria can give rise to corrosion and souring problems, particularly in oilfield pipework and reservoirs. The activity profile of Bronopol is ideally suited to treating the adverse effects of microbial contamination.

The Minimum Inhibitory Concentrations (M.I.C.) of Bronopol are typically 12.5 to 25ppm for a wide range of aerobic, water-borne bacteria, including Pseudomonas spp., Staphylococcus spp., Bacillus subtilis and Klebsiella pneumoniae.

Levels of 6.25 to 25ppm control anaerobic sulphate-reducing bacteria (SRB) such as Desulphovibrio vulgaris and D. desulphuricans.

In cooling-water systems, the presence of potentially pathogenic organisms such as Legionella pneumophila is a specific concern. Bronopol has been proven to control this organism with M.I.C. figures of 50ppm.

M.I.C. data have been generated according to in-house methodology.

<table>
<thead>
<tr>
<th>Test Organism</th>
<th>M.I.C. (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus spp.</td>
<td>12.5 - 50</td>
</tr>
<tr>
<td>Bacillus spp.</td>
<td>12.5 - 50</td>
</tr>
<tr>
<td>Desulphovibrio spp.</td>
<td>12.5 - 50</td>
</tr>
<tr>
<td>Pseudomonas spp.</td>
<td>12.5 - 50</td>
</tr>
<tr>
<td>Legionella spp.</td>
<td>50</td>
</tr>
<tr>
<td>Candida spp.</td>
<td>400</td>
</tr>
<tr>
<td>Aspergillus spp.</td>
<td>3200</td>
</tr>
</tbody>
</table>

USAGE RECOMMENDATIONS

Solubility, Stability, Compatibility

Bronopol is readily water-soluble and solutions containing up to 28% w/v are possible at ambient temperature. The compound also shows a high affinity for polar organic solvents (e.g. propylene glycol 50% w/v) which allows a flexible approach to formulating solution concentrates for ease of application.

Bronopol shows optimum stability in the acid pH range with excellent efficacy. At alkaline pH, Bronopol is less stable but still provides effective control. When used to preserve alkaline formulation systems, Bronopol reaches equilibrium with its breakdown products, which are also microbiologically active. This self-stabilisation means efficacy can be maintained over the required shelf-life of the formulation being preserved.
In dynamic, recirculating systems, repeat or shock dosing is the accepted practice. Under these conditions, Bronopol will deliver the required activity while it is present in the system but will then decay sufficiently to pose no threat to any subsequent biological treatment of the waste stream.

Myacide AS is widely compatible with materials used both in general water treatment and the oil and gas industry. These include corrosion inhibitors (nitrates, phosphonates and polyphosphates), scale control agents based on polyacrylates and polycarboxylates, viscosity modifiers (starch, cellulose thickeners, guar and xanthum gums) and other biopolymers.

Myacide AS is also compatible with many other biocides used in water and oilfield applications, including Quatery Ammonium Compounds (QAC), Isothiazolinones (MIT/CMIT), Methylene bishothiocyanate (MBT) and Dibromonitrilopropionamide (DBNPA). Synergistic activity has been observed between Myacide AS and several other biocides, which allows a flexible approach to dealing with biofouling problems through the use of blended formulations or sequential treatment regimes.

In common with many other biocides, strong oxidising or reducing agents such as sulphites and bisulphites that are often used as oxygen scavengers inactivate Myacide AS. In these instances a rotational and sequential programme should be adopted.

**Recommended Dose Rates**

**Recirculating Cooling Water, Air-Conditioning and Humidifying Systems**

Myacide AS should be dosed once or twice weekly at 15 to 100ppm to inhibit the growth of SRB and slime forming bacteria in cooling towers and air-conditioning systems. Shock dosing is preferred to continuous feed. Myacide AS may be dosed either as a stock solution or by adding the crystalline solid directly into the sump or basin at a point where there is adequate flow or turbulence to ensure quick dissolution.
Where significant contamination with *Legionella* spp. has been identified, a twice-weekly dose of Myacide AS at 100ppm is recommended. It is recognised that in these situations, other disinfection regimes may be adopted.

Following decontamination, a lower maintenance dose of 30 to 500ppm twice-weekly should inhibit the growth of *Legionella* bacteria. It must be stressed, however, that Myacide AS should only be used as part of an integrated treatment programme involving scale control, corrosion inhibition and regular cleaning. The use of alternating biocides may also be considered in this context.

Myacide S1, a 20% liquid formulation, should be dosed *pro rata* based on the Bronopol concentrations recommended for Myacide AS. Myacide S1 should therefore be used in the range 75 to 500ppm and Myacide S15 in the range 150 to 1000ppm.

Representative dose rates for Myacide AS are provided in the table below.

<table>
<thead>
<tr>
<th>Application</th>
<th>Bronopol (ppm)</th>
<th>g / 1000 litres</th>
<th>lbs / 1000 gallons (US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recirculating Cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water, Air Conditioners,</td>
<td>15 - 100</td>
<td>15 - 100</td>
<td>0.018 - 0.036</td>
</tr>
<tr>
<td>Humidifiers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Oil and Gas**

*Drilling Muds, Fracturing Fluids, Workover and Completion Fluids etc*

Myacide AS can be used to control the contamination and degradation of a wide range of gels and fluids caused by SRB, cellulolytic and slime-forming bacteria. It may be pre-mixed with the fluid or added directly at the point of use as required. Recommended dose levels are 50 to 100ppm.

For Well-Squeeze Fluids, Myacide AS should be added at 25 to 200ppm depending on the quality of the make-up water.

The liquid formulations, Myacide S1 and S15 should be dosed at a *pro rata* level to deliver the required quantity of Bronopol.

**Flooding, Injection and Produced Water**

Myacide AS should be shock-dosed at levels between 25 and 100ppm to inhibit the growth of slime-forming or corrosion inducing SRB in flooding, injection and produced waters at oil and gas installations. Shock dosing should be applied from once per week to once per month depending on the severity and rapidity of onset of contamination.

As above, the liquid formulations, Myacide S1 and S15 should be dosed to deliver the required *pro rata* level of Bronopol.

**Pipeline and Tank Maintenance**

Myacide AS can be used to control microbial contamination in water-bottoms in crude and refined hydrocarbon storage tanks, piping and transportation systems. Dose levels should be calculated to achieve concentrations of 25 - 200ppm in the aqueous phase. Myacide AS can be injected directly into the water-bottom, pipeline or may be added to the hydrocarbon phase. Treatment can vary from once daily to once every one or two months for both storage and transportation systems.

Representative dose rates for Myacide AS are provided below.

<table>
<thead>
<tr>
<th>Application</th>
<th>Bronopol (ppm)</th>
<th>g / 1000 litres</th>
<th>lbs / 3000 gallons (US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Muds, Fracturing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluids, Workover &amp; Completion Fluids</td>
<td>50 - 100</td>
<td>50 - 100</td>
<td>0.018 - 0.036</td>
</tr>
<tr>
<td>Well Squeeze Fluids</td>
<td>25 - 200</td>
<td>25 - 200</td>
<td>0.009 - 0.072</td>
</tr>
<tr>
<td>Injection Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produced Water</td>
<td>25 - 100</td>
<td>25 - 100</td>
<td>0.21 - 0.84</td>
</tr>
<tr>
<td>Pipeline and Tank Maintenance</td>
<td>25 - 200</td>
<td>25 - 200</td>
<td>0.21 - 1.68</td>
</tr>
</tbody>
</table>

**CASE STUDY**

A laboratory study was initiated to assess the ability of Myacide AS to control microbial contamination in drilling muds. A typical starch/bentonite mud was formulated at a pH of 9.5 and...
inoculated with a mixture of common aerobic water-borne and cellulolytic bacteria including Pseudomonas spp., Klebsiella pneumoniae, Escherichia coli and Cellulomonas flavigena. The initial inoculum level was 10^4 cfu/ml. Aliquots were dosed with Myacide AS at 40, 60, 80 and 100ppm and monitored over a 6-day period at 25°C. The results are shown in Figure 1 and confirm that Myacide AS was able to clear the contamination at all levels tested. The untreated control showed significant growth over the same period.

SAFETY CHARACTERISTICS
A considerable data package has been assembled on Bronopol to support a wide range of end-use applications, covering both mammalian and environmental toxicity. This provides the information needed to obtain and retain registrations worldwide. Bronopol is moderately toxic by ingestion. In concentrated form it is irritant to the skin but is non-irritant at normal use levels. Bronopol is one of the least sensitising of all commonly used biocides and sensitisation is unlikely to occur in people with normal healthy skin. Both acute and chronic studies have shown Bronopol to be non-carcinogenic, non-mutagenic, non-embryotoxic and non-teratogenic.

Bronopol is toxic to some algal species and is therefore potentially dangerous for the environment. However, its inherent biodegradability, rapid hydrolysis and photolysis in water and low bioaccumulation characteristics indicate that it is unlikely to cause significant, long term adverse effects in the aquatic environment.

In the USA, the EPA have cleared the discharge of waste waters containing up to 25ppm into the Cook Inlet of Alaska, concluding that toxic effects would not occur due to the hydrolytic instability of Bronopol

Bronopol is officially classified under the EU Council Directive - 67/548/EEC as harmful, irritant and dangerous for the environment.

REGISTRATIONS
NORTH AMERICA
USA
BASF’s Bronopol products are approved at the US EPA for use in industrial recirculating water in cooling waters and evaporative condensers, air conditioners, air washers and humidifier systems, oil, gas and industrial process water. State registrations have also been obtained, especially in California.

The USDA Food Safety and Inspection Service has authorised Bronopol for treatment of cooling and retort water in official establishments operating under the Federal meat and poultry products inspection programme.

CANADA
Various BASF Bronopol formulations are approved for use in cooling towers, heat exchangers, pasteurisers, condensers, air washers and oil and gas applications.

EUROPE (EU)
NETHERLANDS
Myacide AS and S1 are registered for recirculating cooling water systems.

UNITED KINGDOM
Drinking Water Inspectorate approved for decontamination of potable water storage tanks and associated pipework.
BASF supply a range of Glutaraldehyde formulations including Protectol GA 50 / GA 24 biocide for cooling water applications and oilfield operations.

QUALITY
These products are clear, colourless aqueous solutions based on Glutaraldehyde as the active ingredient. Protectol GA 50 has an active content of 50% Glutaraldehyde and the GA 24 is based on 24% Glutaraldehyde. Under recommended storage conditions the solutions have a shelf life of at least six months.

ANTIMICROBIAL ACTIVITY
The active ingredient is an extremely potent antimicrobial with a broad spectrum of activity against Gram negative and Gram positive bacteria, SRB, yeasts and fungi. It is particularly effective against those organisms responsible for slime formation and product spoilage. Glutaraldehyde is also active against *Legionella* spp. Representative results using typical organisms are shown below.

<table>
<thead>
<tr>
<th>Test Organism</th>
<th>M.I.C. (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staphylococcus</em> spp.</td>
<td>50</td>
</tr>
<tr>
<td><em>Bacillus</em> spp.</td>
<td>1250</td>
</tr>
<tr>
<td><em>Desulphovibrio</em> spp.</td>
<td>60</td>
</tr>
<tr>
<td><em>Pseudomonas</em> spp.</td>
<td>150 - 250</td>
</tr>
<tr>
<td><em>Legionella</em> spp.</td>
<td>1250</td>
</tr>
<tr>
<td><em>Candida</em> spp.</td>
<td>1250</td>
</tr>
<tr>
<td><em>Aspergillus</em> spp.</td>
<td>475</td>
</tr>
</tbody>
</table>

M.I.C. data on Protectol GA 50 have been generated using in-house methodology.

It should be noted that due to the influence of media constituents, the M.I.C. results are generally higher than the effective doses required in-use. (See later ASTM data).

USAGE RECOMMENDATIONS
Solubility, Stability, Compatibility
The active ingredient is miscible in all proportions with water and polar organic solvents. It is stable in acid and alkaline pH environments up to pH 7. Above this level, polymerisation and chemical inactivation can occur. The products are compatible with a wide range of additives and auxiliary products including surfactants, flocculants, dispersants, corrosion inhibitors, and other biocides. In common with other non-oxidising biocides, strong reducing and oxidising agents should be avoided.

Recommended Dose Rates
Recirculating Cooling Water and Air-Washer Systems
In recirculating cooling and air-washer systems, microbial contamination can cause significant reductions in efficiency due to slime build-up in heat transfer systems and on other surfaces. In addition, there may be concerns over the safety of open recirculating systems if potentially pathogenic bacteria become established.

Protectol GA 50 offers an ideal treatment strategy for such systems, being easy to handle and dose. Efficacy has been demonstrated using the ASTM E645-91 test procedure. In this test, 25ppm of Protectol GA 50 gave greater than 99% control of a mixed bacterial inoculum after a contact time of 2 hours, while 50ppm controlled the inoculum after a contact time of 1 hour. In another test, 20ppm of Protectol GA 50 demonstrated >99.99% control of two strains of *Legionella pneumophila* after a 1 hour contact time.

For practical situations, Protectol GA 50 must only be used in systems with efficient mist-eliminating facilities. The biocide should be added to the recirculating system at a convenient point to ensure rapid and uniform mixing, such as the water sump close to the outlet pipe.

Protectol GA 50 may be used as part of an intermittent or slug dosing regime or as a continuous dose. Heavily fouled systems should always be cleaned before treatment begins. An initial addition of 100-600ppm is recommended.
and if necessary the blowdown should be discontinued for up to 24 hours. Once control is achieved, dosing can be continued on an intermittent basis at 40-600ppm per day. Alternatively, continuous dosing in the range of 40-200ppm can be recommended.

These dosing recommendations apply equally to the use Protectol GA 50 in other heat transfer systems, such as evaporative condensers, hydrostatic sterilizers and retorts as well as pasteurisers and warmers.

When used for the treatment of *Legionella* contamination, Protectol GA 50 should only be used as part of an integrated management programme involving the use of appropriate scale and corrosion control additives.

The relevant dose rates for individual products should be calculated on a *pro rata* basis related to the Glutaraldehyde content. Representative rates for a 50% formulation are provided in the table below.

<table>
<thead>
<tr>
<th>Application</th>
<th>Glutaraldehyde (ppm)</th>
<th>Protectol GA 50 ppm fl.oz. / 1000 gallons (US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recirculating Cooling</td>
<td>20 - 300</td>
<td>40 - 600 5.1 - 76.3</td>
</tr>
<tr>
<td>Water, Air-Washers etc</td>
<td>20 - 300</td>
<td>40 - 600 5.1 - 76.3</td>
</tr>
</tbody>
</table>
Oil and Gas

Fracturing Fluids / Well Squeeze Fluids / Drilling Muds

For the preservation of drilling muds, workover and completion fluids and other products susceptible to contamination, Protectol GA 50 should be added initially at between 50 and 1000ppm depending on the severity of contamination.

Produced Water, Flooding and Injection Water

For Water Flooding operations Protectol GA 50 should be added initially at 100 to 200ppm and repeated until control is achieved. Subsequent treatment may be continued on a weekly basis, or as required at levels of 20 to 500ppm.

Injection wells associated with gas storage systems should be treated with sufficient product to give a concentration of 500 to 5000ppm when diluted in the formation water. Any further top-up water should be treated at 200 to 2000ppm.

For hydrostatic systems, the water should be dosed with 100 to 4000ppm depending on the water quality and the duration of the shut-in.

The relevant dose rates for individual products should be calculated on a pro rata basis related to the Glutaraldehyde content of the product in question. Representative rates for a 50% product are provided in the table below.

### SAFETY CHARACTERISTICS

In order to support the safe use of Glutaraldehyde, a wide range of toxicological studies has been carried out. The extensive nature of this database is particularly helpful in supporting product registrations and answering any concerns on product safety. Protectol GA 50 is toxic if swallowed or inhaled and is corrosive to the skin and eyes. It may cause skin sensitisation and has been classed as a respiratory sensitisier in the EU. Protectol GA 50 is not teratogenic or carcinogenic and is not mutagenic in animal studies.

Protectol GA 50 is readily biodegradable in the environment and should not cause problems in sewage treatment plants and surface waters when used as recommended.

### REGISTRATIONS

**NORTH AMERICA**

**USA**

BASF has EPA end-use approval for 50% Glutaraldehyde as a microbicide for controlling slime-forming bacteria, SRB, fungi, yeasts and algae in air washers, recirculating cooling systems and heat transfer systems.

Additionally, BASF has approvals for 25 and 50% Glutaraldehyde solutions for use in controlling SRB in oil and gas well drilling and processing applications.

**CANADA**

Glutaraldehyde is registered as a technical product for use in manufacturing registered microbiocides.

**EUROPE (EU)**

Protectol GA 50.

Formulations based on Protectol GA 50 are approved for use in controlling SRB in oil well drilling and oil field processing applications under the Offshore Chemicals Notification Scheme.

### Application

<table>
<thead>
<tr>
<th>Application</th>
<th>Glutaraldehyde (ppm)</th>
<th>Protectol GAS50 ppm</th>
<th>Protectol GA 50 gallons (US) / 100 barrels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Muds, Fracturing Fluids</td>
<td>25 - 500</td>
<td>50 - 1000</td>
<td>0.21 - 4.2</td>
</tr>
<tr>
<td>Well Squeeze Fluids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood Water Injection Water</td>
<td>50 - 250</td>
<td>100 - 500</td>
<td>0.1 - 0.5</td>
</tr>
<tr>
<td>Produced Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Injection Wells</td>
<td>100 - 2500</td>
<td>200 - 5000</td>
<td>0.2 - 5</td>
</tr>
<tr>
<td>Hydrostatic Systems</td>
<td>50 - 2000</td>
<td>100 - 4000</td>
<td>0.1 - 4</td>
</tr>
</tbody>
</table>

**Protectol® GA 50 / GA 24 Biocide**
Protectol DZ biocide is the trade name for Dazomet, a heterocyclic compound. The product offers broad-spectrum antibacterial activity against major slime-forming and spoilage bacteria and is extremely effective at controlling the pathogenic Legionella bacteria and the anaerobic SRB.

Dazomet can be used on its own or as a part of an integrated biocide treatment programme.

QUALITY
Protectol DZ is a fine granular grade product and Protectol DZ P is a powder form. Both products are off-white in colour and contain a minimum of 99% Tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione.

BASF's Dazomet has a shelf life of at least two years. It should not be stored at temperatures above 40°C.

ANTIMICROBIAL ACTIVITY
Dazomet is extremely effective against biofouling in cooling-water systems and spoilage of oilfield additives. The activity profile of Dazomet is ideally suited to treating the adverse effects of microbial contamination.

In cooling-water systems, the presence of potentially pathogenic organisms such as Legionella pneumonophila is a specific concern. Dazomet has been proven to control this organism. The Minimum Inhibitory Concentrations (M.I.C.) of Dazomet are displayed in the following table:

<table>
<thead>
<tr>
<th>Test Organism</th>
<th>M.I.C. (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacillus cereus</td>
<td>117</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>117</td>
</tr>
<tr>
<td>Desulphovibrio desulphuricans</td>
<td>2</td>
</tr>
<tr>
<td>(Marine species)</td>
<td></td>
</tr>
<tr>
<td>Desulphovibrio desulphuricans</td>
<td>150</td>
</tr>
<tr>
<td>(Freshwater species)</td>
<td></td>
</tr>
<tr>
<td>Saccharomyces cerevisiae</td>
<td>375</td>
</tr>
<tr>
<td>Aspergillus niger</td>
<td>188</td>
</tr>
</tbody>
</table>

M.I.C. data has been generated according to in-house methodology.

USAGE RECOMMENDATIONS

Solubility, Stability and Compatibility
Dazomet has relatively low water solubility (max 0.3%) but is sufficiently soluble to act effectively in water-based systems. The solubility of the active may be increased by the use of organic solvents (e.g. Dimethylformamide, N-Methylpyrrolidone) or by formation of solium salts at high pH. Solutions of >20% w/w are possible in NaOH. It is also possible to formulate suspension concentrates containing 30% active ingredient.

Dazomet is compatible with a range of additives used in the paper processing industry including flocculants, retention aids, dispersants and mineral slurries.

Recommended Dose Rates

Oil and Gas
Fracturing Fluids, Well Squeeze Fluids and Drilling Muds

Protectol DZ can be used to control the contamination and degradation of a wide range of gels and fluids caused by SRB, cellulolytic and slime forming bacteria in both terrestrial and offshore drilling muds and packer fluids including fracturing, enhances oil recovery, injection drilling workover and completion fluids. It may be pre-mixed with the fluid or added directly at the point of use as required.

Recommended dosage levels are between 200 – 1000ppm. The dose level should be varied according to the mud or fluid composition and the levels of bacterial contamination. To aid dispersion it is recommended that Dazomet is added in a thin stream while the drilling mud/packer fluid is being circulated.

Flooding, Injection and Produced Water

Protectol DZ should be shock-dosed at levels between 150 - 200ppm to inhibit the growth of slime forming bacteria. Shock dosing should also be applied from once a week to once a month depending of the severity and the rapidity of onset of contamination.
Pipeline and Tank Maintenance

Dazomet can be used to control microbial contamination in water-bottoms in crude and refined hydrocarbon storage tanks, piping and transportation systems. Protectol DZ should be injected directly into the water bottom or pipeline, or added to the hydrocarbon phase.

Treatment can vary from once daily for pipeline maintenance to once every one or two months for both storage and transportation systems. Protectol DZ should be applied to achieve 200-500ppm in the aqueous phase but higher concentrations to the hydrocarbon phase are essential. The latter will result in longer-term protection by gradual diffusion into the water phase. The dose will depend on the volume of crude or oil and the expected water fraction.

<table>
<thead>
<tr>
<th>Application</th>
<th>Dazomet g / 1000 litres</th>
<th>lbs / barrel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Muds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracturing Fluids, Workover and</td>
<td>200 - 200</td>
<td>0.07 - 0.35</td>
</tr>
<tr>
<td>Completion Fluids</td>
<td>1000</td>
<td>1.67</td>
</tr>
<tr>
<td>Flood Water</td>
<td>200</td>
<td>1.67</td>
</tr>
<tr>
<td>Injection Water Produced Water</td>
<td>200 - 500</td>
<td>1.67 - 4.2</td>
</tr>
<tr>
<td>Pipeline and Tank Maintenance</td>
<td>200 - 500</td>
<td>1.67 - 4.2</td>
</tr>
</tbody>
</table>

SAFETY CHARACTERISTICS

Protectol DZ has an extensive toxicity data package due to its use in the agricultural industry. As supplied, Protectol DZ has a moderate acute oral toxicity and is an eye irritant but is neither irritant nor sensitising to the skin. Protectol DZ is also not carcinogenic, mutagenic or teratogenic.

Protectol DZ is ultimately biodegradable in the environment and should not cause problems in sewage treatment plants and surface waters when used as directed.

REGISTRATIONS

NORTH AMERICA

USA

BASF’s Dazomet is EPA approved for the manufacture of antimicrobial products. It also has end use EPA approvals for oilfield uses, process water systems and mill additive preservation.

Dazomet is on the chemical register of Japan (MITI), Australia (AICS), Korea and Philippines.

The information submitted in this publication is based on our current knowledge and experience. In the view of many factors that may affect processing and application, this data does not relieve processors of the responsibility of carrying out their own tests and experiments: neither do they imply that any legally binding assurance of certain properties or of a suitability for a specific purpose. It is the responsibility of those to whom we supply our products to ensure that any proprietary rights and existing laws and legislation are observed.