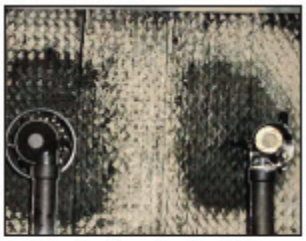
Application Guide for BCP™ 5000 Series

Sulfur Control in Geothermal Power Plant Cooling Systems

BCP™ 5000 Series products are used in geothermal power plant cooling systems to disaggregate and disperse elemental sulfur deposits, and prevent the formation of new sulfur deposits in flowlines, condensers and cooling towers.

Sulfur deposits in geothermal power plant cooling systems reduce cooling efficiency and limit a plant's power production capacity.

Sulfur deposit accumulation in flow-lines.



Sulfur fouling in the fill diverts water flow to less fouled zones.

Sulfur fouling on and in the spray nozzles results in uneven water distribution over the fill.

This document provides general guidelines for the application of BCP™ 5000 Series products for sulfur deposit removal and prevention in direct contact geothermal power plants. Geothermal power plants vary significantly in size, design, operation, steam chemistry and cooling water chemistry, making it possible to provide only general treatment recommendations applicable to most systems in this document. For more detailed discussion of system clean-up and maintenance programs based on BCP™ 5000 Series products, please contact AMSA.

Use

BCP™ 5000 Series products are used in geothermal power plant cooling systems to disaggregate and disperse elemental sulfur deposits, and prevent the formation of new sulfur deposits in flowlines, condensers and cooling towers. Sulphur deposits in geothermal cooling tower water systems form from the chemical and biological oxidization of hydrogen sulfide which is present in the geothermal fluids and enters the cooling water of direct contact geothermal power plants.

Compatibility

BCP™ 5000 products are compatible with most common geothermal cooling water treatment chemicals at end use concentrations. BCP™ 5000 products should not be mixed in concentrated form with other water treatment chemicals, or dosed into a slipstream at the same time as other chemicals. BCP™ 5000 Series products also function as powerful organic deposit dispersants, and are frequently used in conjunction with biocides to control bacterial and algal fouling. Systems with effective biocide programs will be easier to clean, and will be less likely to experience sulfur deposition caused by the microbial oxidation of hydrogen sulfide. Contact AMSA to discuss optimal use of BCP™ 5000 products with biocides.

Dosing

BCP™ 5000 products can be added to geothermal power plant cooling systems as slug doses, or continuously. Clean-up program dosing is always by slug dose, as it is desirable at the beginning of a clean-up program to establish a high concentration of the product in the recirculating cooling water in order to initiate deposit disaggregation. Maintenance program dosing is usually conducted by slug dosing at reduced frequency and concentration compared to clean-up program dosing, but may be applied continuously if experience indicates the rate of refouling in a particular plant is low. The timing and location of BCP™ 5000 product dosing must be coordinated with the dosing programs for all other water treatment chemicals, including biocides and cooling water pH adjustment chemicals. The optimal dosing strategy is plant specific, and must be developed over time as operating experience is gained.

Clean-Up Dosing to Remove Sulfur Deposits from Fouled Systems

BCP™ 5000 products are dosed once to twice per day during the initial phase of the clean-up program. Dosing should be at a concentration of 50 to 200 ppm of BCP™ 5030 (or equivalent) based on total cooling system volume. Once initiation of sulfur deposit removal is evident from monitoring program data, dosing can usually be reduced in concentration and/or frequency by approximately 25% to 50%, depending on refouling rate, for the remainder of the clean-up program.

Maintenance Dosing to Prevent Sulfur Deposition in Clean Systems

Systems which have been cleaned online with BCP™ 5000 products, or which have been mechanically cleaned during system shut-down can be maintained free of sulfur deposits by regular treatment with BCP™ 5000 products. Treatments can be applied either as periodic low concentration slug doses, or as a continuous lower concentration dose. Site-specific factors will determine which mode of dosing will be most cost-effective for each plant. Contact AMSA to discuss optimal maintenance dosing for your system.

Initial recommended maintenance treatments for slug dosing are 25 ppm (based on system volume), 3x per week. Initial recommended maintenance treatment for continuous dosing is 10 ppm (based on system blowdown). These two treatment approaches use approximately equivalent amounts of chemical for a system blowing down 4% to 5% of the system volume per hour. Effective monitoring will determine if these maintenance treatment levels are sufficient, more than required, or insufficient to prevent sulfur deposition in your system.

System pH Adjustment During Slug Dosing

BCP™ 5000 products are most effective in sulfur deposit removal and prevention when applied at alkaline pH. The optimum recirculating cooling water pH for effective treatment is pH 8 to pH 8.5. Recirculating cooling water pH should be adjusted to the optimum range prior to dosing, and should be maintained in the optimum range throughout the system for at least 3 hours, and ideally 4 to 24 hours after dosing. In the absence of effective system microbiological control this will require significant volumes of the chemical used to raise pH, but once effective microbiological control is established, the required volumes of pH-adjusting chemical will be significantly reduced.

It should be noted that sulfur disaggregation, dispersion and prevention can be achieved when dosing at less alkaline pH, but the effectiveness of BCP™ 5000 products is proportionately reduced. Consequently, the duration of clean-up programs will be increased, and the concentration and/or frequency of dosing in maintenance programs will be increased when treatments are applied at less alkaline pH.

Dosing Program Considerations

Soft deposits and deposit stability

Sulfur deposits vary considerably in hardness and structural stability. System operators must consider whether a sudden rapid release of deposits following chemical treatment may cause operational problems. For systems where deposits are known to be soft and/or unstable, operators should test the impact of a moderate dose of BCP™ 5000 product (25 to 50 ppm) on system operations prior to the start of aggressive clean-up dosing.

Removal of biofouling deposits, and demand for BCP 5000

BCP™ 5000 products are powerful and effective organic deposit dispersants. In cooling systems with significant levels of bacterial and algal biofouling, BCP™ 5000 products will interact aggressively with these biofouling deposits, resulting in their removal from equipment surfaces, dispersion into the recirculating cooling water, and removal from the cooling system with blowdown. The interaction of BCP™ 5000 products with biofouling deposits represents a “demand” which reduces the amount of the chemical available for sulfur removal. Effective biocide treatments will have the effect of reducing biofouling, and the consequent demand for BCP™ 5000 products, allowing them to be fully effective in their role of sulfur deposit removal and prevention.

Equipment or instrumentation sensitive to cooling water foaming

Systems with extensive biofouling often produce substantial foaming during the first several days of a clean-up program. Dispersed biomass will be evident in the creamy foam that is generated. Direct contact condensers, in particular, can be very sensitive to foaming, and should be monitored closely during initial treatments. Have silicone-based antifoam such as Dow Corning H-10 (or equivalent) available in case initial foaming is significant. Once biofouling is removed from the cooling system, foam generation will be greatly reduced, and antifoam treatments likely will no longer be necessary.

Equipment or instrumentation sensitive to high TSS (Total Suspended Solids)

BCP™ 5000 product users must be aware that the effect of treatments is to *disaggregate* and *disperse* existing sulfur deposits, and prevent the formation of new sulfur deposits. The result of treatments is the dispersion of inorganic sulfur in solid form, *not dissolution of sulfur deposits*. Consequently, sulfur solids ranging from 10’s of micrometers to several centimeters in length/width will be released from deposits into the cooling system. Larger pieces will settle in low flow areas of the system, while smaller particles will remain suspended in the flowing cooling water, eventually leaving the system with blowdown. System operators should consider all equipment which may be impacted by the presence of suspended and settled solids. More frequent blocking and cleaning of cooling tower screens should be expected.

Reinjection or disposal water wells sensitive to high TSS

Systems which reinject condensate via cooling tower blowdown or dispose of excess condensate in dedicated disposal wells should be monitored during clean-up treatments to assure that dispersed particulate sulfur solids will not damage the system’s injection wells.

Monitoring Effectiveness of Treatments to Control Sulfur Deposition

System clean-up takes place in two phases. Initially, biofouling deposits will be removed from the system. This phase of the clean-up program will be expedited if an effective biocide program is also applied. Biofouling deposit removal is visually evident as biomass entrained in the foam generated as a result biofouling deposit removal and dispersion. The increase in dispersed biomass is also evident in measurements of cooling water turbidity and TSS, and can be confirmed by ATP (Adenosine Triphosphate) monitoring. Bacterial viable count monitoring may also be used to document biofouling deposit removal, depending on when samples are collected in relation to system biocide treatments.

Once biofouling deposits are eliminated from the cooling system, sulfur deposit removal and dispersion, the second phase of the clean-up program, will be evident visually as tan to pale yellow solids entrained in foam on the surface of the water in the cooling tower basin. Dispersed sulfur-based solids suspended in the recirculating cooling water will result in increased turbidity and TSS of the cooling water. Unfortunately, there is currently no simple, on-site analytical procedure to confirm the composition of the dispersed solids. Laboratory techniques to determine solids composition are, however, widely available.

Progress of the clean-up program should be documented with photographs of fouled equipment during pre-program, intra-program and post-program inspections. Intra-program inspections not requiring full system shut-down are critical, and must be carefully planned based on the lay-out of equipment in each plant. In-line stainless steel strainers used to protect auxiliary equipment pumps and processes, and monitoring equipment such as plexiglass “bioboxes” and removable test spools have been shown to be of value in some systems. In systems equipped with online cooling tower basin cleaning systems, quantification of solids removed from the basin can be used to monitor removal of larger solids through the course of the clean-up program.

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