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SILICA SCALE PREVENTION TECHNOLOGY USING ORGANIC ADDITIVE, GEOGARD SX

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SUMMARY – A field trial on the application of an organic additive, phosphino carboxylic acid copolymer, was conducted in an actual geothermal system to evaluate its effectiveness in preventing silica deposition from brine containing ultra high silica concentration (1000-1300 ppm). A low concentration of polymer was applied for about five months, and treatment efficiency based on silica concentrations in various sampling points ranged fiom 64-98 %. Treatment efficiency improved over time. Massive silica scaling in the fluid collection and disposal system was minimized, while nominal scaling at the separator vessel and gel deposition occurred at the RI pipeline

1. INTRODUCTION

Scaling due to silica deposition is a worldwide problem in the geothermal industry. It limits the development of geothermal resources for electrical power generation. Operationally, this problem can be avoided by maintaining a high separation pressure and flashing only 20-25 % of the reservoir fluids into steam. In this manner, the brine remains in undersaturated condition, such that the silica saturation index (SSI) is ≤ 1.0. However, this process, requires additional production wells to generate the same amount of power, thus, increasing the development cost.

After separation, most geothermal fluids are 10-30 % oversaturated with respect to silica. This situation leads to silica deposition in the fluid collection and disposal system (FCDS), the reinjection wells and the geothermal reservoir. The silica deposits are usually vitreous to hard porous scales. Cleaning of pipes and injection wells entails substantial cost, which increases the operating and maintenance expenses for power generation.

The Botong sector of the Bacon-Manit0 Geothermal Production Field (BGPF) in Sorsogon, Philippines (Fig. 1) is no stranger to the silica scaling problem. Several brine disposal schemes, including low temperature injection, silica slurry injection, and pH modification of brine were field tested, but all failed (Candelaria et al., 1996).

The scaling problem in Botong was abated with the introduction of Geogard SX (GSX) in the disposal system. GSX, a phosphino carboxylic acid copolymer, is a product of a three-year (1992-95) research cooperation between PNOC-EDC and FMC of U.K. After testing several polymers for silica scale control in local geothermal brine, GSX was designed, formulated, and successfully tested in the field (Garcia et al., 1994).

Baltazar et al. (1997) showed that silica scaling on metal surfaces and in the geologic formation can be successfully prevented in a hot injection experiment using GSX-treated brine. Field test also demonstrated that the polymer can prevent scaling and reduce deposition of soft silica gel in the FCDS and reinjection well.

The application and effectiveness of GSX in the geothermal system can be controlled and measured. At a low concentration, it effectively inhibits silica scaling. The treated brine can also be disposed through low temperature injection. This is a pioneering technology that promises many applications in other geothermal fields, where conditions are similar.

2. THE BOTONG SILICA PROBLEM

In Botong, the brine is undersaturated with silica at the two-phase line. In this area, the silica is in the form of mplecular silicic acid, probably with a negligible amount of silicate anion. At the separator vessel (SV), steam extraction results in a reduction of the mass flow at the RI pipeline and a large drop in brine temperature. In our case, the brine temperature at the SV drops to 165°C and the silica concentration reached –1000-1300 ppm in the separated water. This corresponds to a silica saturation index

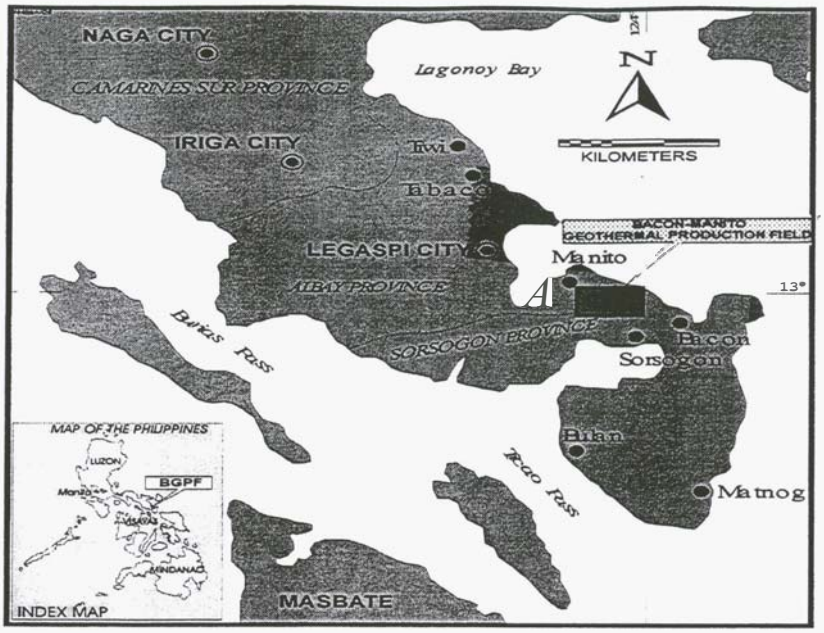


Fig. 1. Location map of Bacon-Manit0 Geothermal Production Field

of 1.5 and excess silica above the saturation of about 400 ppm. The large excess of silica will polymerize and produce hard porous deposits along the FCDS.

Further extraction of steam in the second flash vessel (FV) would mean a further increase in the supersaturation of silica. The colloids in this location are relatively bigger and will normally produce brittle to hard and porous scale under high velocity brine flow. At slow flow rate (i. e. in the thermal pond), the colloids form the non-structured gel network which result in the precipitation of soft silica gel. The gel, with time, will form a dense mass of thick, pasty silica at the RI line. At the RI well, this massive silica, will be adsorbed and could cause blockages in the porous formations. The net effect is detrimental reduction in the RI well capacity, or at worst, total loss of permeability of the well and the formations.

3. FIELDSET-UP

The Botong FCDS and injection set-up schematic diagram is shown in Figure **2.** The GSX injection set-up is located near the OP-4D and the 3D combined two-phase line. The combined mass flow of the two wells serves as a vehicle for the chemical. Prior to the separator vessel, the OP-5D and the 6D two-phase lines meet the OP-4D and the 3D lines. Therefore the combined fluids are already treated before they enter the separator vessel. The brine then passes through a second stage flashing unit, using either the silencer or the flash vessel.

Normal operation requires a silencer with a steam trap. The baffles in the silencer weirbox were made lower than usual, so as to have a continuous overflow of fiesh brine. Brine aging inside the silencer can then be prevented. The FV-thermal pond (TP) system serves as a back-up line. The silencer discharge is then delivered to the mini-TP (mTP). The mTP has two functions in the system; 1) to trap cuttings and corrosion products, and **2)** to break the turbulence and cool the brine. Cuttings and corrosion products are major factors in the coagulation and deposition of silica. Once trapped in the mTP, the unnecessary debris can be removed fiom the system.

The turbulent brine flow turns laminar at the mTP. The brine temperature also drops to about 70°C. Thus, flashing inside the RI line is avoided. The mTP is connected to a deaerator pond (DP) by a cemented canal. The DP serves as a catchment or reservoir during high water flow. The brine is then delivered to the RI well through an 8" victualic pipeline.

4. PREDICTED GSX ACTION

Geogard SX is an aqueous solution of organic additive based on phosphino carboxylic acid

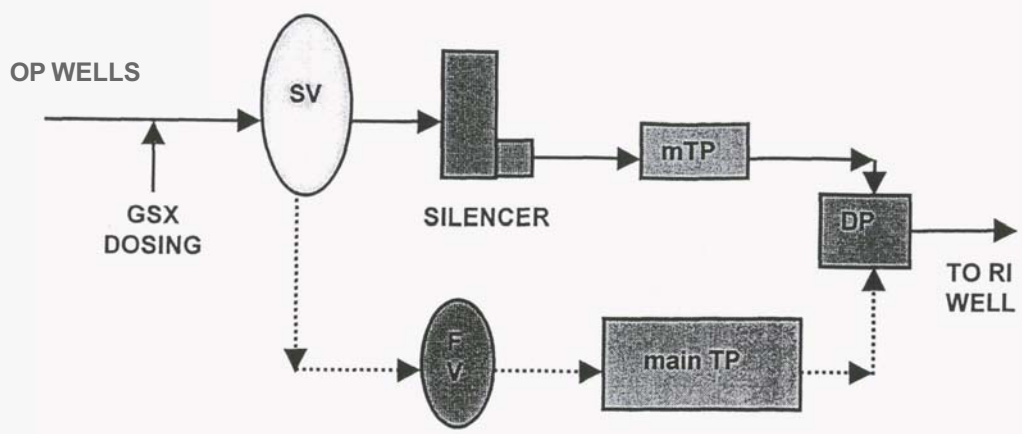


Fig. 2. Botong FCDS Schematic Diagram

copolymer. It is commercially introduced as an antiscalant. It has dispersive effect toward silica colloids and is reactive to iron corrosion products.

Figure 3 illustrates the predicted mechanism of the actions of GSX towards colloidal silica and iron corrosion products. These combined and simultaneous actions make the chemical effective in preventing silica deposition.

4.1 Reaction of GSX with Silica Colloids

GSX prevents further coagulation of colloidal silica. In this manner, the silica colloids of just the right size remain suspended in a flowing solution, thus inhibiting precipitation reaction with the metal surface. To attain this condition, the chemical is injected at the two-phase line where colloidal silica is relatively absent and GSX could completely disperse in the brine medium. It could approach the growing colloidal particles uniformly and at the desirable size. Having reacted with silica, GSX-colloid particles have different properties compared to the non-reacted silica colloid. Particle repulsion will be the dominant reaction rather than condensation.

4.2 Reaction of GSX with Iron Corrosion Materials.

Corrosion products are essential substances for the agglomeration and deposition of silica. The M-OH layer of the corroded metal surface provides a bonding site for silica depostion, either by monomeric or polymeric silica (Iler, 1979). GSX is predicted to arrest this reaction by slowly removing the M-OH layer. Thereafter, it tends to bind with the metal surface. Once the surface is coated with GSX, a layer of negative charge will be produced causing repulsion of the incoming silica particles.

5. RESULTS AND DISCUSSION

An effective chemical application requires correct injectate concentration and pump calibration. During injection, these parameters are closely monitored and changed with variations in water flow. The total silica concentration was monitored at various sampling points to determine the inhibition efficiency of the treatment.

5.1 Observations in the FCDS

During the field trial, a thin deposit of porous silica was observed inside the SV. This type of scale was produced by colloidal particles (probably the smallest size in the system) at highly turbulent conditions.

Scaling inside the SV is acceptable and the progress of deposition is nominal. Maintaining a water level at the SV could lessen the scale formation due to the descaling action of the treatment. The brine at the SV was normally clear.

Initially, cuttings and corrosion products accumulated at the silencer base. Since GSX is reactive to the solid wastes, cleaning was necessary to avoid reduction in the treatment efficiency. During this situation, dosing concentration of GSX was increased to 20 ppm. Build-up of these materials stopped at a later period. Brine at the silencer is always clear.

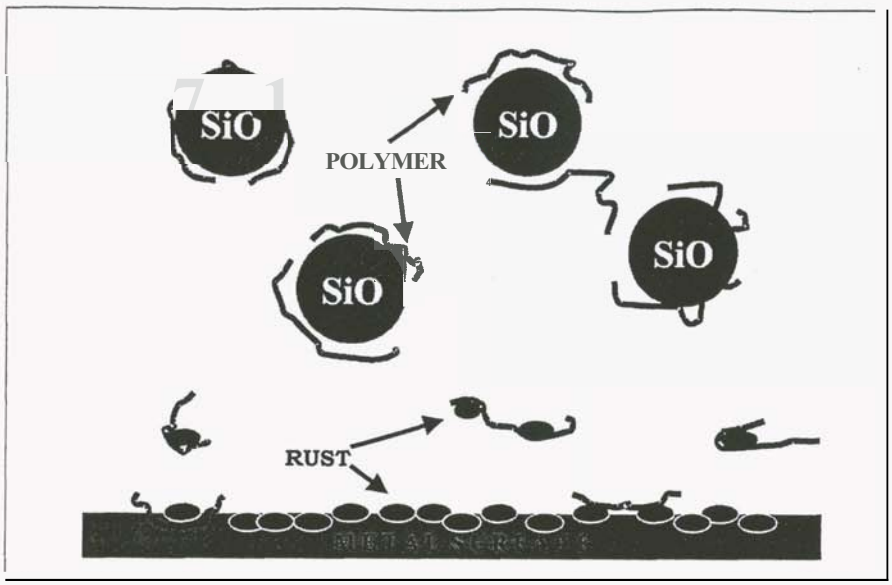


Fig. 3. Illustrated GSX mechanism of action towards silica and iron.

At the weirbox, where turbulence combined with more evaporation occurred, particle growth was observed. A *thin* soft gel deposit was found adsorbed on the metal and cement surface, which can be easily removed by agitation.

The mTP serves as a catchment for the solid wastes. Because of the coprecipitation effect, these materials should also be removed. Further evaporation and cooling occurs in *this* area, which leads to further growth of the particles. The brine is still clear with some visible particles of colloidal silica. Adsorption of silica on the cement wall was observed. However, the build-up is slow and can be easily removed by simple agitation. Simply damming the brine at the mTP and suddenly releasing it at the weir, is sufficient to remove this type of deposit. Brine temperature at the mTP outlet is normally ~70°C.

The brine at the DP and mTP were similar. At normal conditions, brine continuously flows in the canal built inside the DP. During airlock conditions or silica gel build-up in the RI line, water level at the DP rises. At times where the wells are at full discharge, particle growth and precipitation were the dominant processes inside the DP. Massive type of gel normally build-up in this area. The gel, however, can be completely dispersed once disturbed during injection. Initially, gel built-up inside the RI line, this is the worst problem in the process. However, this problem is reduced once the application attains its maximum efficiency, that is when the cuttings and corrosion products are eliminated.

As experienced, deposition in the RI line near OP-2RD and the well itself was never a problem. Once the brine enters the wellbore, further heating will occur, and dissolution of silica will dominate the process. This condition is expected to promote the prolonged use of the RI well.

The same condition at the silencer-mTP is expected to happen at the FV-main TP system. Build-up of cuttings and corrosion products in the FV, however, will not occur due to a continuous discharge at the main-TP.

5.2 GSX Treatment Efficiency

The efficiency of GSX treatment was evaluated based on the silica concentrations at various points of the FCDS. Daily samples were collected and analyzed for total SiO_2, using the yellow molybdate method.

Figure 4 shows the total SiO_2 data during a period of five months. The total SiO_2 at the silencer weirbox was stable and averaged about 1240 ppm. Initially, for about a week, the efficiency was low primarily due to the large amount of cuttings and corrosion products that accompanied the discharge. These materials reacted with the polymer and enhanced deposition. However, as these materials were reduced and the brine flow rate stabilized, the

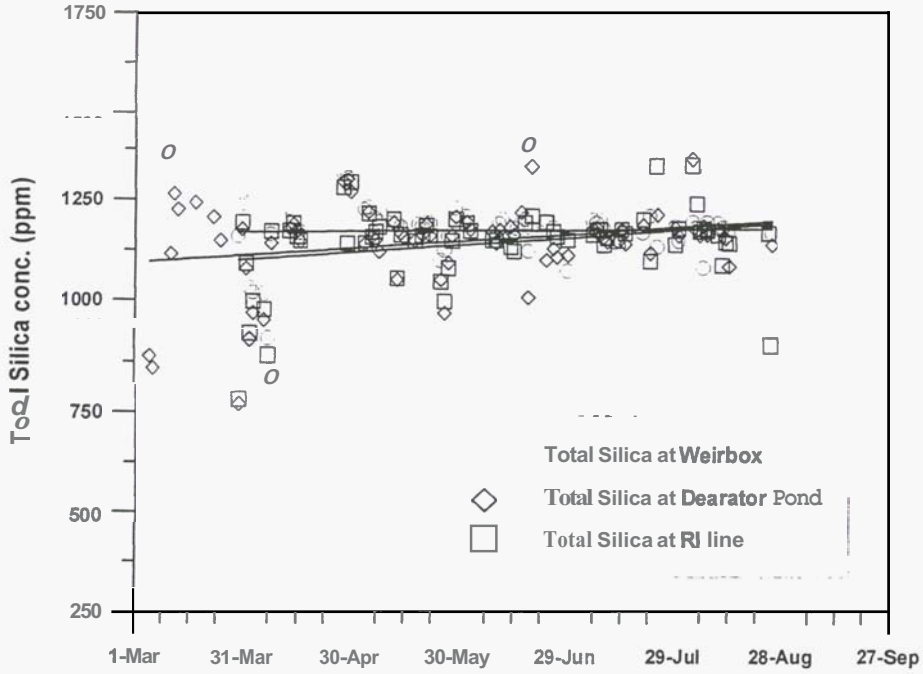


Fig. 4. Total silica data for the five-month period of GSX application

inhibition efficiency improved. Recorded treatment efficiency based on the total SiO_2 ranged from 64-98 %.

6. CONCLUSION

GSX is an effective antiscalant chemical that prevents silica deposition. The Botong power plant is now operating with an output of 20 MWe while the brine is treated with a low concentration of the chemical inhibitor.

The technique is new, sensitive, and in its final development stage. Further process optimization is necessary, and the best working conditions can be determined during actual field application. If used in other silica scaling related problems, the technology could provide the following benefits.

1. Utilization of silica rich geothermal resources
2. Reduced FCDS maintenance cost,
3. Zero waste disposal to the environment,
4. Additional power generation using second flash brine,
5. Antiscalant for power plants with low silica concentrations, and
6. Direct utilization of excess heat in geothermal wastewater.

7. ACKNOWLEDGEMENTS

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