TECHNIFAX®

Selective silica carryover

SILICA CARRYOVER CAUSES TURBINE DEPOSITS

Most boilers making steam for turbines rarely have excessive carryover of boiler water in the steam. Good operating practices, improved steam separators, and proper chemical control minimize this. Silica deposits in turbines, however, can occur even when boiler water carryover is negligible. The reason: steam selectively "picks up" silica from the boiler water, dissolves it, and carries it to the turbines, where it redeposits. Investigations show that the key to minimizing silica carryover is in keeping the boiler water silica content below certain levels, the concentration depending on operating pressures.

SILICA SOLUBILITY

Research on the solubility of silica in water and steam shows several important points:

- Steam is a solvent for silica
- For any particular steam density and temperature, there is a definite saturation solubility of silica

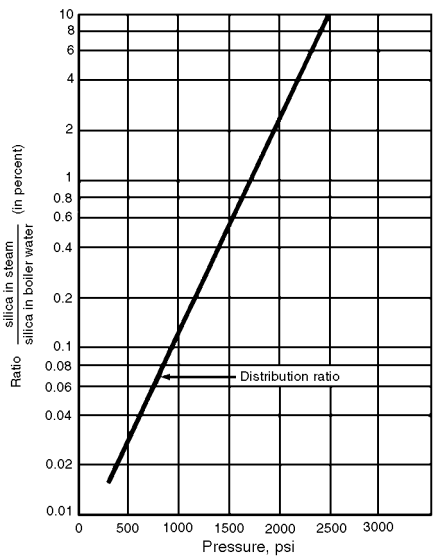

Figure 1 — *Silica distribution ratio*

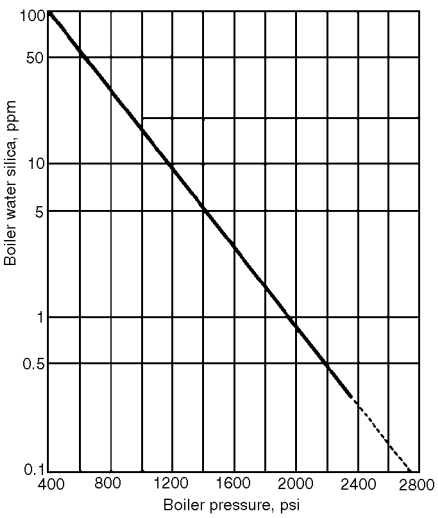

Figure 2 — *Maximum boiler water silica permitted at various pressures to keep steam silica at or below 0.02 ppm*

- The maximum solubility of silica in steam is a direct function of both the steam density and temperature. As steam temperature or density decreases, the silica solubility also decreases.

Since pressure affects steam density and has a bearing on steam temperature, it has an important effect on the solubility of silica in steam.

SILICA CARRYOVER

Investigation of the problem of silica carryover in a laboratory experimental boiler revealed two important facts:

- With constant pressure and boiler water pH, silica carryover is directly proportional to the amount of silica in the boiler water. This was true over a wide range of boiler water silica concentrations.
- The ratio of silica in the steam to silica in the boiler water increases rapidly as boiler pressures increase.

These two points are illustrated by the graph in Figure 1.

Turbine experts and utility operators determined empirically that 0.02 ppm of silica in the steam is a practical maximum limit for boiler water pH >10. With steam silica contents of 0.02 ppm or less, appreciable turbine deposits would not normally occur. A survey of operating experience with utility type boilers confirmed that the 0.02 ppm figure is a valid and realistic maximum limit. Figure 2 shows boiler water silica limits needed to keep steam silica at or below 0.02 ppm.

An extensive study of silica carryover in a laboratory boiler confirmed the results shown in Figures 1 and 2. In addition, the study demonstrated that:

1. The presence of calcium and magnesium sludge, antifoam, organic treatments, and combinations of these do not significantly affect silica carryover.
2. High ratios of hydroxide alkalinity to silica in the boiler water reduce the ratio of silica in the steam to silica in the boiler water, thereby reducing *potential* silica deposits in turbines.
3. These two curves apply to high alkalinity (pH > 10.5) boiler water systems.

Many new boiler installations have high purity makeup systems that allow acceptable boiler water pH control at pH 9–10. Since vaporous silica carryover increases as boiler water pH decreases, Figures 3 and 4 should be used for these high purity systems.

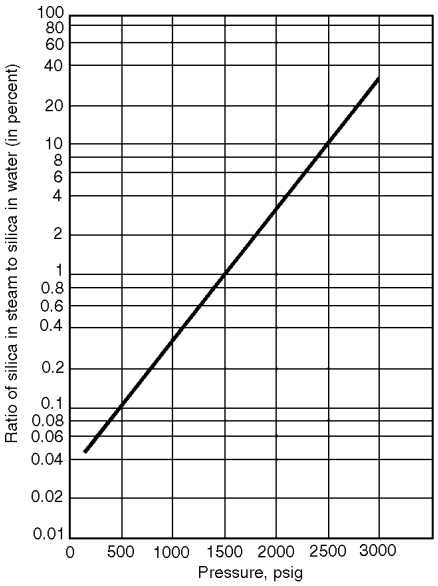

Figure 3 — *Ratio of silica in steam to silica in water vs boiler pressure*

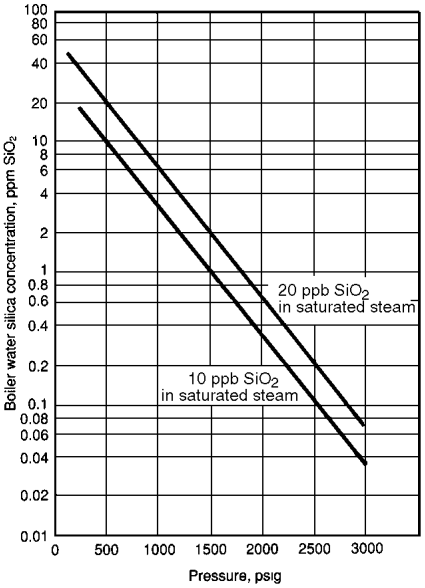

Figure 4 — *Boiler water silica concentration vs boiler pressure*

In addition, some new turbine installations require a silica in steam limitation of 10 ppb as opposed to the traditional 20 ppb limit. This control curve (10 ppb) is also shown in Figure 4.

CORRELATING SILICA SOLUBILITY AND CARRYOVER

The conditions under which silica carryover occurs had been thoroughly investigated and documented. What was needed at this point was a means of determining the conditions under which silica is redeposited in the turbines. To determine this experimentally would be difficult. Reasonably valid calculations could be made, however, based on the prior investigations of silica solubility and silica carryover.

Researchers have calculated the approximate relationship between boiler pressure, boiler water silica, silica carryover, and silica solubility in saturated and superheated steam. These relationships are combined in Figure 5.

INTERPRETING BOILER WATER AND STEAM SILICA VALUES

In Figure 5, silica in the steam is plotted against boiler pressure. Each diagonal line represents a particular silica concentration in the boiler water. The amount of silica expected in the steam from a particular boiler is shown by the intersection of the boiler pressure line and boiler water silica line. For example, a boiler operating at 1400 psi with 10 ppm silica in the boiler water would show about 0.04 ppm in the steam.

The solid curved line in Figure 5 represents the calculated maximum solubility of silica in saturated steam. If the steam containing 0.04 ppm silica in the above example is allowed to expand without being superheated, the graph shows that silica will start to precipitate out when the pressure drops below 300 psi.

This point is found by following the 0.04 ppm line from the boiler pressure and boiler water silica intersection across until it intersects the silica solubility line.

The dotted lines in Figure 5 indicate calculated maximum solubility of silica in superheated steam. To illustrate how these superheat lines are used, suppose the steam containing 0.04 ppm silica has 100°F superheat. Following the 0.04 line across until it intersects the 100°F superheat line indicates that silica will start to precipitate out as the pressure is reduced to about 200 psi.

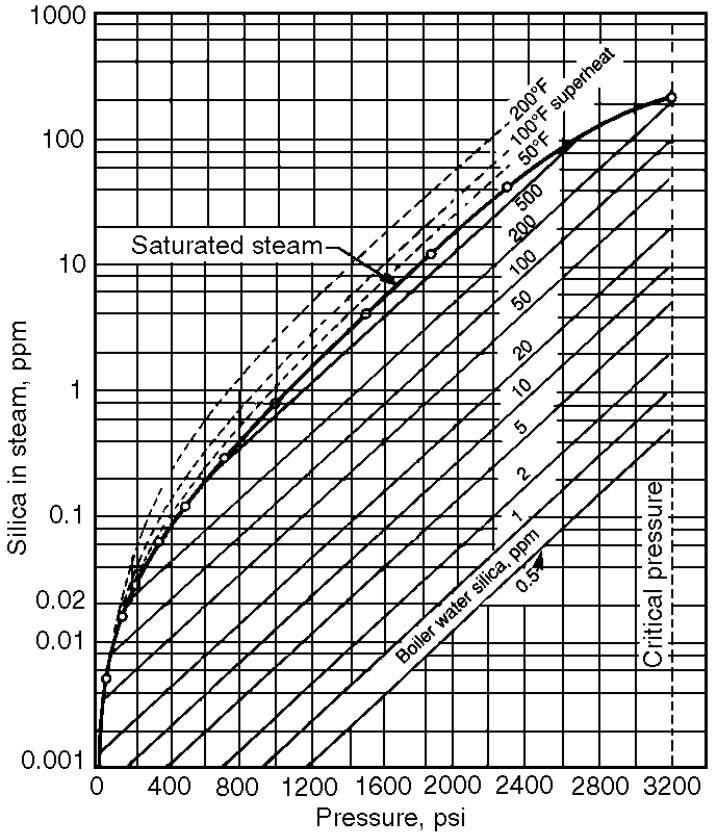

Figure 5 — *Silica in steam vs boiler pressure for pH = 11.3*

ENHANCING CUSTOMER

SATISFACTION THROUGH QUALITY

Nalco Chemical Company's mission is to enhance the profitability of our customers' business by providing programs and services that add value to their operations and enhance their return on investment.

We are committed to a quality management philosophy that strives for continuous improvement. Every employee is expected to do his or her part to ensure our programs and services lead to increased customer satisfaction.