Three Years Experience With Commercial Organic Scale Inhibitors

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In maintaining the efficiency of the evaporators in the sugar factory, the most important factor and the one least subject to control is the fouling of heat transfer surfaces by the formation of scale. Even the best purified and clarified juices in most houses contain salts which precipitate out on the heating surfaces as the juice is concentrated. As these insolubles collect on the tubes, the capacity of the evaporators for any given load decreases, until a point is reached where one or more bodies must be taken out of service and boiled out. The length of run between successive boil-outs varies from as little as three or four days to a full campaign, depending on the composition of the evaporator influent and other local conditions.

From a fuel standpoint alone, scaling of the evaporator heating surfaces is obviously expensive. Added to this is the cost of cleaning chemicals, corrosion of equipment by these chemicals, and lost time and cost of extra labor during boil-outs. There is, therefore, great economic justification for any chemical or combination of chemicals which will prevent or even inhibit such scale formation. However, to expect any treatment to answer all of the problems created by a variety of conditions and juices is foolish. Even in the same set of evaporators, the chemical equilibria are constantly changing as the concentrations of the various substances in the juice increase or decrease during operation. Coupled with the complex physical chemistry of the scaleforming components in the juice is the utter lack of a reliable method of evaluating various scale inhibitors in the laboratory. The only means, therefore, by which the efficiency of evaporator scale inhibitors can at present be estimated is by a full scale factory trial. Even then, economic justification for any treatment must be established independently for each factory, in accordance with its own conditions.

In the last three years, considerable success has been reported in the control of evaporator scale in the cane industry by a combination of polyphosphates and various sequestering colloids. In view of this, during the latter half of the 1947 campaign, two such treatments were tried: one at the Idaho Falls plant, and one at the Garland plant. Both of these factories are Steffen houses and both have severe scaling problems.

The compound used at Idaho Falls was tetra-phospho glucosate (T.P.G.) manufactured by D. W. Haering Co. The T.P.G. was dissolved in hot water and the solution added continuously to the thin juice in the evaporator supply tank ahead of the evaporator preheaters at the rate of 12 p.p.m. of the original chemical based on thin juice. For 27 days of the Idaho Falls campaign, beta glucoside was also added at the rate of 6 p.p.m. based on

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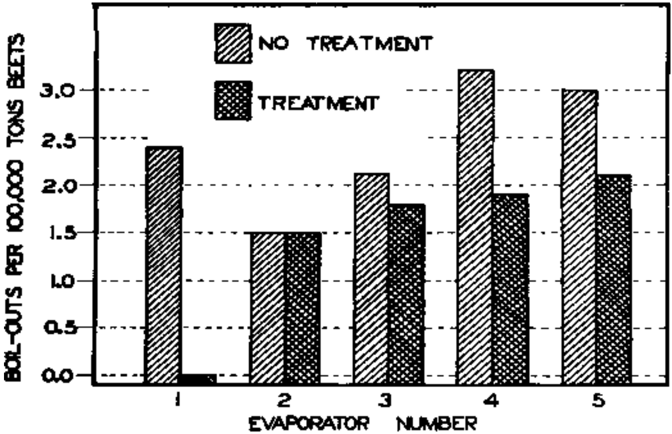
thin juice, but there was no noticeable difference in the rate of scale deposition during this addition, so it was discontinued.

The treatment at Garland consisted of a colloid or mixture of colloids extracted from seaweed and containing an equivalent of 12% sodium alginate. Coupled with this was added a sodium tri-poly-phosphate compound. These materials are termed "Evaporator Concentrate" and "APAM," respectively, by the manufacturer, E. F. Drew Co. A 50-50 mixture by weight of the two was dissolved in water, strained through cheesecloth, and fed into the evaporator supply tank at the rate of 8 p.p.m. based on thin juice.

FIGUPE I
GAPLAND



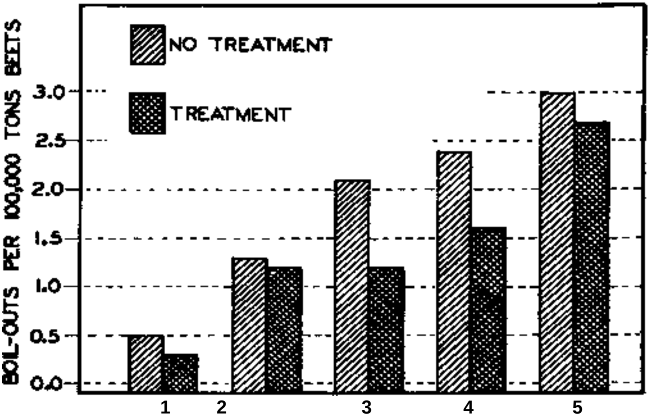
Both the tetra-phospho-glucosate and the Evaporator Concentrate are what are known as "protective colloids." They tend to prevent the formation of anything but a colloidal precipitate. Protective colloids will exhibit this property when in their absence a crystalline precipitate would be formed. This effect is due to the formation of a stabilizing envelope about the particles, which results in the formation of suspensoids preventing the precipitation as an adherent scale.

The role of the phosphate is undoubtedly twofold. Polyphosphates, while they remain as such, form soluble compounds with scale-forming elements, which apparently have the property of keeping far more than an equivalent amount of scale former from precipitating. In addition to this, the phosphate undoubtedly acts as a peptizing agent for the colloid. However, these polyphosphates must be used judiciously, because they have the property of reverting to orthophosphate in solutoin, reversion being slow at ordinary temperatures, but much accelerated by rise in temperature. These orthophosphates form insoluble calcium and magnesium orthophosphates which are prone to precipitate in the white pan, with resultant high turbidity of the final granulated.

Results of 1947 Trials

During the 1947 trial, both Idaho Falls and Garland ran the first part of campaign without treatment and the last half with treatment. The T.P.G.

***FIGURE* 2**
TOPPENISH

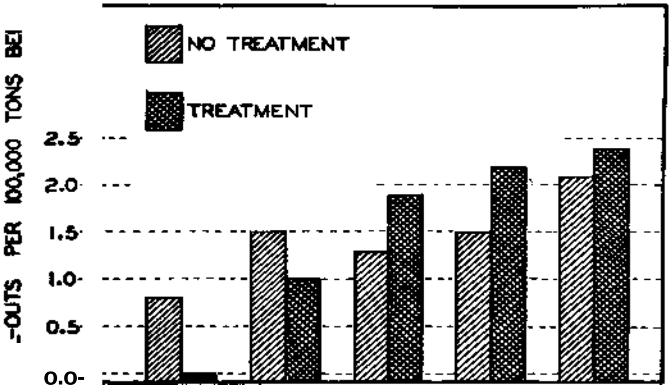


treatment at Idaho Falls did not decrease the number of evaporators boiled out. On the other hand, the algin treatment at Garland effected a 45% decrease in boiling out requirements. At both plants, however, one significant fact was observed. Both treatments completely inhibited scale formation in the thin juice heaters and in No. 1 effect. Only very light scale deposition was observed in No. 2, but the colloid seemed to let go of the scale in No. 3 where the deposition was heavier than in No. 4. This was evidenced by the fact that No. 3 was boiled more times than No. 4, yet when inspected at the end of campaign the deposit was heavier in No. 3. This delayed precipitation is a phenomenon which has often been observed in working with protective colloids.

From previous experience in operating sugar factories, we are all aware that conclusions on any experiment such as the above when based on a one-year trial are very apt to be faulty and misleading. However, results obtained this first year were encouraging enough to warrant continuation of the experiment. So, in the campaigns of 1948 and 1949 the algin-APA-M treatment was added at Toppenish. T.P.G. was continued at Idaho Falls, and Garland continued using the algin.

During these two campaigns, two changes were made in the treatment. First, because of the delayed precipitation effect in No. 3 evaporator, the

FIGURE 3
IDAHO FALLS



EVAPORATOR NUMBER

5050 mixture of algin and APA-M was split; two-thirds of the treatment was fed to the evaporator supply tank, and one-third added directly to No. 3 evaporator. Second, the dosage of the Drew treatment was increased to 10 p.p.m. based on thin juice.

The results for the three-year treatment at Garland and Idaho Falls and for two years at Toppenish are shown in Table 1. These results are compared with the four previous years at the respective plants when no treatment was used.

Here again it may be noted that T.P.G. did not reduce the total number of boil-outs at Idaho Falls, but that the algin gave a substantial reduction at Garland and Toppenish. However, while T.P.G. did not decrease the total boilouts, the evaporator heating surfaces were kept in a very much cleaner condition than before. Ev6n more important than this was the fact that since the treatment was started it has been unnecessary to clean No. 1, and only about two-thirds as many cleanings have been necessary on No. 2.

The various necessary boil-outs for the individual bodies during the two periods shown in Table 1 are pictured graphically in Figs. 1, 2, and 3.

The cost of boiling out an evaporator has been estimated by the superintendents at these three plants, and these estimates will, of course, vary with the cleaning chemicals used, the thickness of the scale, and the body which is being cleaned. On the average, however, cost of cleaning chemicals

TABLE I

FACTORY	TREATMENT	AVERAGE TONS BEETS PER YEAR	BOIL-OUTS PER 100,000 TONS BEETS
IDAHO FALLS	NONE	120029	7.2
	T.P.G	142911	7.5
GARLAND	NONE	125842	12.2
	ALGIN	123166	7.3
TOPPENISH	NONE	281932	9.3
	ALGIN	285524	7.0

is very close to 3115.00 per evaporator. Tn addition to this cost, and particularly where automatic evaporator controls are being used, at least 8 man-hours of labor must be charged. This gives a total material and labor cost of approximately $125.00 per evaporator boiled out. Other costs, perhaps more important, but difficult to evaluate, are corrosion effects, increased steam consumption, and loss of capacity. These costs are, of course, very much greater when frequent boilings of Nos. 1 and 2 are necessary. Steam consumption is increased, regardless of which body is boiled out. However, sufficient steam is available to boil out Nos. 3, 4, and 5 without capacity loss. This is not true of Nos. 1 and 2. When they are boiled out, loss of capacity usually results.

The combination of algin and phosphate costs 26i/^ cents per pound. At 8 p.p.m. based on thin juice, the cost of evaporator treatment at Garland is $594 per 100,000 tons of beets, and at Toppenish is $510 per 100,000 tons of beets. Considering only the cost of materials and labor for boiling out, Garland has more than saved the expense of the treatment, while Toppenish has saved about 56% of the expense.

In addition to the savings which have already been mentioned, we have observed that in those factories using the treatment evaporators were kept constantly cleaner, resulting in lower back-pressures and higher evaporator and boiler efficiencies.

Conclusions

Treatment of evaporator influent with an algin colloid-phosphate combination at two beet sugar plants over a period of three years has definitely decreased scaling of the evaporator heating surfaces, when compared with four years previous operation.

Treatment of evaporator influent with tetra-phospho-glucosate at another plant for a three-year period did not decrease the total amount of boil-outs, but the scale was nearly all deposited in evaporators 3, 4, and 5.

Algin-Phosphate Treatment

A treatment of 8 p.p.m. based on thin juice seems to be about the optimum dosage. Less than this produces less effect. Ten p.p.m. did not result in a comparable decrease in scale deposition.

Splitting the addition, two-thirds to the evaporator influent and one-third to No. 3 body, did not decrease the heavy deposition in No. 3. In fact, the entire dosage fed to the evaporator supply tank seemed to be somewhat more effective.

The addition of the chemical must be steady and continuous throughout the entire campaign.

Evaporator heating surfaces must be kept relatively clean. Once the heating surfaces have become fouled, thorough cleaning by one of the conventional methods is essential before the treatment can again be fully effective.

It was necessary to discontinue the treatment for short periods while processing spoiled beets. The colloid increased the foaming characteristics of an already foamy juice to a point where it could not be handled in the evaporators.

Poor filtration of the thin juice which leaves in suspension a small amount of second carbonation mud uses up the colloid immediately, and its beneficial effects are noticeably absent.

No abnormal effects were detected either in the white pans or in the final granulated. Apparently the treating chemicals and their occluded salts remain in suspension throughout and are eliminated in the molasses.

Trials of one and two years duration at two of our other factories have not shown beneficial results. This emphasizes the fact that economic justification for a treatment of this type must be established independently for each factory, in accordance with its own conditions.