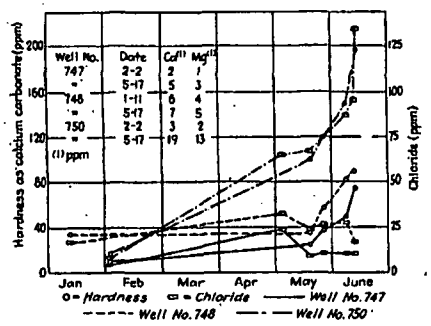
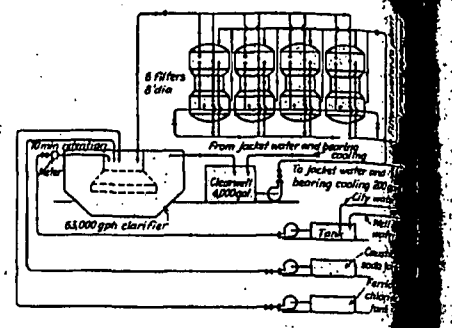
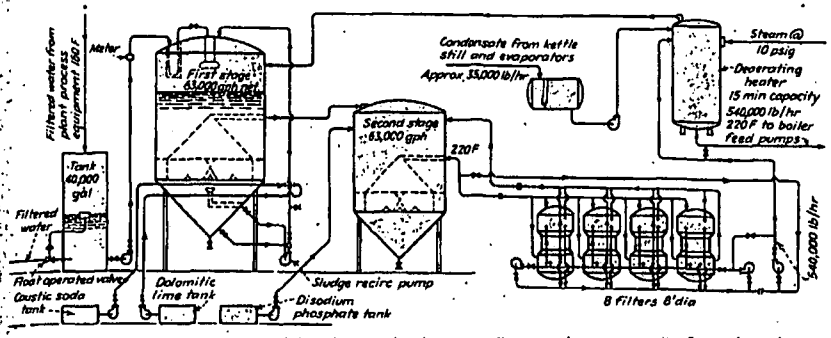


1 Water composition, once the plant got under way in 1935, underwent rapid changes in chlorides and hardness (above)



2 Clarifying equipment includes 40,000-gal tank to collect and mix well and city water. It then goes to the clarifier



3 Filtered water from plant process pumped through metered, inlet-water controller and vent condenser goes to the spray heater on first-stage hot-process unit. Steam from deaerating heater raises the first-stage makeup water to 200 F

Internal Conditions of Old Boilers Guide Water Treatment For New Units

Here's a unique approach in planning treatment for new units: A 10-year experience serves as spadework in producing a sound installation

By J N WELSH, H M RIVERS and C J KILDUFF*

A SPECIALLY DESIGNED feedwater-treatment system represents a major part of the power modernization program at U. S. Industrial Chemicals, Inc, Curtis Bay, Md. plant (POWER, Feb 1948, pp 64-67). Design for this water-treatment plant drew heavily on a 10-year operating record of internal phosphate treatment of raw-water makeup for two 125,000-lb-per-hr 650-psig 645-F steam generators. When plans called for adding to steam generation with two 240,000-lb-per-hr 650-psig 700-F generators (one already in operation) this 10-year experience furnished many influencing factors.

Well-Water Composition. Back in 1935 when the 125,000-lb-per-hr boilers went into service, condensate returns were estimated to run 10 to 30% of feedwater needs. Makeup came from nine wells, as shown in Table I, p. 90.

Water from Well 1326 had 15-ppm calcium and 12-ppm magnesium, making it fairly hard. Water from Wells 747, 750, 1325, 1468 and 1469 ran quite soft. Considering the capacities of all wells, a mixture of water from most, excluding 1326, gave a water as low in hardness as hot-process lime-soda-treated water.

Concentrations of iron, aluminum, dissolved solids and suspended material in the well waters figured in early considerations. The over-all picture in a mixture was not alarming except for Well 1326 water, which was relatively high in iron and dissolved solids, and had a concentration of suspended material of 3 ppm, the maximum found. Aluminum concentration was not more than a trace. As for silica, it was recognized that its concentration was high in relation to other constituents, but back in 1935 silica removal was not understood as it is today. Also, barring localized excessive heat input to the boilers, silica was not expected to be troublesome.

Once the plant got under way water composition changed rapidly for the worse, Fig. 1. As time went on further deleterious changes developed in the water.

Feed-Line Deposits. Table I shows the low pH of the well waters. Also, a substantial part of water hardness was due to magnesium, as the ratio of magnesium to calcium was higher than in most natural waters.

Despite thorough deaeration of feed water, corrosion evidence appeared in feed pumps and regulating valves in the fall of 1935. Some corrosion had been anticipated so it was detected before much damage was done. Arrangements were made to change feeding caustic soda for maintenance of boiler water alkalinity to the alkali chemical would be introduced continuously into the boiler feedwater.

Following this change deposits formed in the feed lines and regulating valves. Although magnesium hydroxide, ferric-iron oxide and ignition loss were substantial in amount, magnesium silicate was the main deposit constituent. This compound separates solid phase from high-temperature feedwater containing a fair amount of magnesium and silicate if pH is in excess of about 8.0.

Subsequent adjustments of alkali chemical feed indicated deposition could be prevented by holding pH at 7.5, and from mid-1941 on the problem was no longer serious. But changes in raw-water composition made close control of pH difficult. A reduction in magnesium concentration in the feed water was desirable.

Analcite Scale. Analcite (sodium aluminum silicate) first appeared in the boilers in Sept. 1935. From then until pretreating equipment was installed a constant battle was waged to stop formation of this complex silicate scale. Attempts were made to return more condensate, but contamination from slop evaporators ruled this out. Magnesium sulphate was fed to one boiler to reduce silica concentration, but magnesium precipitated as magnesium phosphate, and phosphate consumption increased too greatly.

Even tannin-feeding was instituted. It did not affect rate of scale formation but it did seem to render deposits more brittle and hence more easily turbined from tubes. After several years its continued use did not seem justified.

Some relief from analcite deposits was gained by (1) discontinuing use of water from some wells (2) increasing capacity of others by rehabilitation (3) installing new pumps (4) making up net loss in water with city water, Table I.

Analcite scale cannot form if aluminum does not get into the boiler water. Because aluminum did not appear in filtered makeup-water samples its source was recognized to be suspended material. In Sept 1944, Well 3700 water became heavily laden with suspended matter and demonstrated the soundness of this thinking. Boiler tubes failed from analcite-scale formation after a boiler had generated only 100 million lb of steam.

For several years boiler tubes had had to be turbined after every 125 to 150 million lb of steam to avoid overheating because of analcite-scale formation. But, improvements in makeup quality had extended runs to 400 to 500 million lb of steam between 1940 and 1944. Then came the 1944 experience.

Analyses of raw-water samples in Oct 1944 (Table I) showed less suspended mater in Well 3700 water than was present on occasions in Sept. Nevertheless the 74 ppm of suspended material was sufficient to add 2 ppm of aluminum and 33 ppm of silica to the water. The other well waters contained less but far from insignificant amounts when silica and aluminum concentrations of filtered samples are compared with total concentrations of these constituents. Even city water had a substantial amount of suspended solids containing silica and aluminum.

X-ray examination identified aluminum silicate as sillimanite in the suspended matter of Well 3700 water. The boiler feedwater must have carried considerable suspended matter at the time showed because the scale formed aluminum silicate in relatively small amounts. This would not normally remain as such very long in high-temperature, alkaline boiler water unless it was there in considerable amount.

Pretreatment Found Necessary. Rapid changes in well-water composition indicated the need for pretreating equipment. Removal of suspended material was considered in 1937. Always the hope that further contemplated water-supply changes would obviate the need for pretreatment delayed action.

Hope was abandoned in 1944, and a decision made to install suitable equipment for two reasons: (1) Abnormal contamination of Well 3700 water with suspended material demonstrates the need for clarification. (2) The new 240,000-lb-per-hr steam generator was to be installed, and troublefree operation demanded the best possible water.

Selection of Equipment. The wealth of experience gained in ten years' operation of the 125,000-lb-per-hr boilers simplified selection of equipment. Burns and Roe, Inc, consulting engineers, Hall Laboratories, Inc., consultants on water, and engineers and chemists of *U. S. Industrial Chemicals, Inc* cooperated in reaching conclusions.

Except for less suspended solids in water from Well 3700 as the result of strainer repairs, Table I, 1944 listing, shows representative analyses on which conclusions were based. Total capacity of Wells 1323 and 1326 was 125 gpm at the time as compared with 300 gpm each for 3700 and 4241. Thus the mixture to be treated would be mainly water from the last two wells plus city water.

Well 3929 water was not to be used but its inclusion was necessary in all considerations because of (1) possible failure of other wells (2) radical change in water composition.

Table I indicated much of the silica and all the aluminum could be removed from well waters and city water by removal of suspended material. If base-exchange softening was to be considered this suspended matter had to be removed if only to prevent fouling exchange materials. With hot-process pretreatment silica removal might be satisfactory. But the high pH, hot

* J N Welsh, director of engineering service, Hall Laboratories, Inc; H M Rivers, engineering service, Hall Laboratories, Inc; C J Kilduff, power engineer, U. S. Industrial Chemicals, Inc, Curtis Bay Plant.