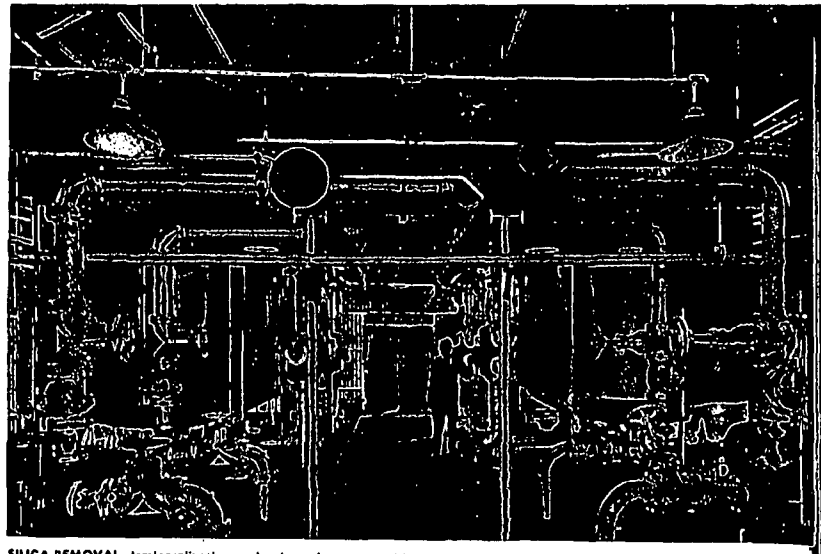

SILICA-REMOVAL demineralization, only about four years old, has made rapid progress in feedwater treatment. Its arrival was none too soon since the latest boiler designs now on the boards call for even higher pressures, and purer feedwater

Demineralization Passes in Review

Here's a fact-crammed summary and comparison of materials, processes to help gage the fast-moving demineralization field

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► THE RAPID PROGRESS of demineralization is mainly due to the need to remove silica for boiler pressures above 500 psi. Above this point, silica distills over in vapor form with steam and, as the steam expands through the turbine, the silica crystallizes out as a glassy deposit on turbine blades. Ultimately the turbine must be shut down to remove this deposit by caustic scouring and, in the meantime, efficiency suffers as the silica deposit builds up.

The one way to prevent this is to reduce silica in the concentrated boiler saline to very low figures. This, in turn, calls for extremely low silica in the feedwater to avoid excessive boiler blowoff.

Limits of silica permissible at various boiler pressures have not been definitely determined, but at a 1951 ASME meeting in Atlantic City, Babcock & Wilcox Co engineers presented their suggested silica tolerances in the concentrated boiler saline, Table I, p 90. From this you can calculate the limits of silica permissible in the entering makeup water to limit boiler blowdown to 5 to 10% of makeup. By dividing the silica figures in Table I by 10 to 20 respectively, we have constructed Table II, p 90, to get these limits.

Various water-treatment methods reduce hardness, alkalinity and silica in addition to demineralizing, but the amount of silica these methods leave in the treated water is: cold-process precipitation, 2 to 3 ppm; hot lime zeolite, 0.5 to 1 ppm; demineralizing, 0.05 to 0.2 ppm.

Table II indicates boiler pressures above 1000 psi require silica in the makeup water to be between 0.25 and 0.5 ppm. This requirement makes demineralizing the only suitable method to avoid excessive boiler blowdown. But demineralizers are serving for boilers operating well under 1000 psi, even down as low as 600 psi, if the water composition and the investment justifies it as compared to other methods. Table III, p 91, shows indicated methods of water treatment for various boiler pressures and various raw-water compositions. From this table you can see boilers with operating pressures of 600 to 1000 psi have two possible choices, demineralizing and hot lime zeolite. Above 1000-psi pressure, though, demineralizing usually proves more economical.

Chemistry. Demineralizing is a 2-step process. First step consists of hydrogen-cation exchange, which converts all the salts dissolved in the water to their corresponding acids; bicarbonates to carbonic acid, sulfates and chlorides to sulfuric and hydrochloric acid, respectively. Fig. 1. The bicarbonates are converted to carbonic acid, which a degasifier or decarbonator liberates; the sulfates and chlorides produce sulfuric and hydrochloric acids. Any nitrates present turn up as nitric acid.

Second step of the demineralizing process consists of an anion exchanger, regenerated with caustic soda so anion resin is in hydroxyl form. Incidentally, the first anion-exchange resins developed were weakbase resins, only capable of adsorbing the strongly ionized acids, such as sulfuric and hydrochloric acid, Fig. 2. But, *these weakly basic exchangers* could not remove weakly dissociated acids, like carbonic or silicic acids and, therefore, were not valuable for boiler-feed application. Fig. 3 shows how the new strongly-basic anion exchangers react to remove CO_2 and silica, and hence make demineralization important in the boiler field.

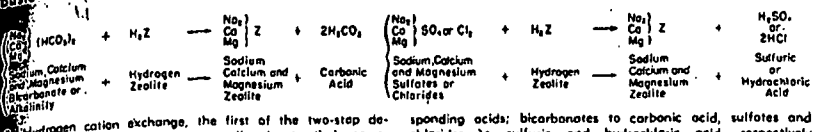
Cation Materials. For the first step, the hydrogen-cation exchange, there are today three successful materials:

1. Sulfonated coal, oldest of the hydrogen zeolites dating back to 1935, has the advantage of easy regeneration. It requires only a single strength of 2% sulfuric acid, introduced rapidly to avoid calcium sulfate crystallization on the exchange material. But its capacity is lower than the other available materials and, therefore, requires larger containers. *Its cost*, though, is lower and this frequently compensates for the larger shell. It is sensitive to high amounts of chlorine, say over 0.3 ppm, which may attack the material. But under the proper conditions and for waters relatively high in percent of alkalinity present, it is a very good material to use.

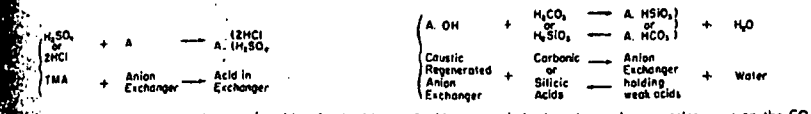
2. Medium-capacity resin, such as that made by Rohm & Haas, as their IR-112, and Nalco-Dow, as their Nalcite MCR, is relatively new, only about a year old. Like sulfonated coal it requires only a single strength of acid in regeneration. It comes as styrene beads but somewhat softer than those of the high-capacity resins to be *described presently*. As a result you may experience higher pressure losses. What's more, the bead particle swells during the hydrogen exchange run and contracts during the regeneration. So you have to allow for these volume changes. Further field experience will eventually determine whether these volume changes affect the long-term stability of the material.

(*Continued on page* 90)

Basic Chemical Reactions in Demineralization, Regeneration Are Straightforward, Easily Understood

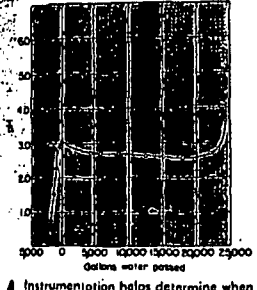


1 Hydrogen cation exchange, the first of the two-step demineralization process, converts all salts to their corresponding acids; bicarbonates to carbonic acid, sulfates and chlorides to sulfuric and hydrochloric acid, respectively

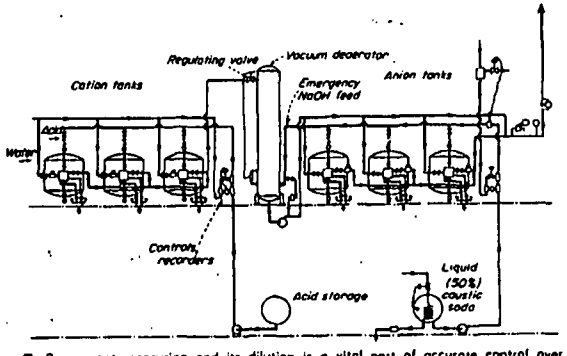


2 Early anion-exchange materials were capable of adsorbing only the strongly ionized salts, and lost the weak ones

3 New strongly-basic anion-exchange resins react on the CO_2 and silica, and hence remove these troublesome weaker acids



4 Instrumentation helps determine when to regenerate and when to end rinses



5 Regenerant measuring and its dilution is a vital part of accurate control over demineralization. Here's a case where ratio-control equipment does a full job