SCALE BUILD-UP, uncontrolled, in a firetube boiler, can lead to bagging and bulging like the extreme case above. Once a bulge like this one lets go, it touches off a violent explosion. Today, proper water treatment tools can positively prevent it.

DANGER! Boiler Scale At Work

► MUCH OF YOUR ABILITY to acquire and maintain the best possible internal conditions for your boiler depends on how successful you are in staving off scale formation. First, you need to be familiar with how scale forms, and specifically how it pertains to your particular boiler design and operation. And what is even more important, you must *then conscientiously enforce the proper* steps to prevent scale formation.

Rarely ever do hit-or-miss schemes produce a satisfying or lasting solution. Nor can slipshod supervision insure favorable results. In fact, the less you leave to mere chance and the more you set up controls over the physical and chemical factors governing scale deposits, the surer you are of preventing scale build-up. But let's get down to cases.

What are these factors? How do they influence scale formation? What effect do they have on boiler operation? What must you do to remove scale? Here are the pertinent answers, whose details will follow in later articles.

Factors. Hardness bestows the scale-forming property on water. It consists of the calcium and magnesium compounds contained in a water. Except for *falling rain, all natural waters possess* hardness to some degree. And rain water in making its course over and through the soil absorbs mineral salts to give it hardness. The amount of solids it absorbs depends on (1) chemical composition of the earth's strata in any one particular locale (2) ease with which its constituents are apt to enter into solution. As a rule, the longer water remains in intimate contact with the ground, the more minerals it dissolves. Subterranean waters, therefore, generally carry more dissolved solids than surface waters. Since calcium and magnesium salts are quite soluble, it follows that underground waters usually possess higher hardness content than surface waters.

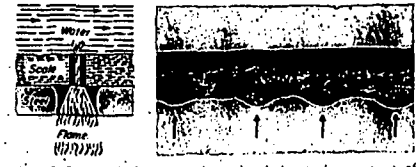
We can roughly classify mountain streams as having from a little below 10 ppm to 60 ppm of hardness (as $CaCO_3$). *Surface supplies fall within a* 50-180 ppm range, and well waters from 150 on to nearly 2000 parts. Sea water, having hardnesses that run well up into the thousands, is ruled out as not feasible for boiler feedwater use.

Calcium is most always the largest single mineral element found in natural waters. It usually predominates over magnesium by 2 or 3 to 1. Together, as total hardness, they constitute the bigger group of dissolved solids in natural waters. They appear most frequently

CAUSTIC EMBRITTLEMENT, long-time crippler of riveted boiler surfaces, is now understood and is effectively controlled

How Scale Formation Ruptures Metal

CLEAN BOILER SURFACE, *left,* absorbs little heat, passes most on to water. As scale builds up, *right,* picture changes



SCALE COATING forces steel to absorb increasing amount of heat, and so tube metal weakens and softens under temperature

RUPTURE OF METAL from too high a local temperature, above, represents the final stage in damage from uncontrolled scale

Sensible, lasting control of boiler scale requires a background of causes, cures. Here's first of 3-part series to give you these data

By PAUL BRINDISI, *Chemical Engineer, Calco Laboratories*

in the form of bicarbonates, sulfates and chlorides, and generally in this order of greatness. A fair amount of similar sodium salts will also be included. A small to a goodly portion of silica will most always be present. Other dissolved solids, such as the nitrates of calcium and magnesium along with compounds of iron and manganese as well as alumina, normally appear in much lesser proportions. Still more minerals are contained, but their minute quantities bear no influence on scale development.

Scale Formation. Your raw water may look crystal clear and be quite good for drinking and other purposes. Yet with the above-mentioned mineral impurities it is sure to be far from ideal for your boiler. Why so? Because your boiler is of itself helpless to cope with the disposal of these chemicals. While the water is distilling off as virtually a pure vapor, some dissolved solids are continually precipitating out of solution. Left untreated, they go on to accumulate to damaging proportions, photos, right. Unless aided by chemical means, no amount of blowdown will dislodge these deposits once they attach themselves on the boiler metal.

This scale-forming process occurring in a boiler can be likened to a snowfall. The crystals first alight sparsely, then with greater number and become interlinked, soon to blanket the whole of the affected area, and eventually pack into a thick layer. With scale, however, the result more often is a dense, hard, very adherent incrustation that defies either mechanical or chemical removal.

While these physical traits are typical of scale in general, the chemical composition differs with each case. All chemical components of scale are poor conductors of heat. Their relative proportions, and hence the texture of the composite, determine how much resistance the scale offers to the transfer of furnace heat to the water. The silicates, for example, have a greater insulating effect than the sulfates, and the sulfates more than the carbonates.

Operating Troubles. By far the worst damage scale inflicts is the rupture of boiler tubes, photos right, with the heavy loss of production, time, labor and money their replacement entails. Let us consider a segment of boiler tube, and with the aid of the three sketches, see how its failure occurs.

Just like any other heating utensil, the metal tube acts as a container only. It merely serves as a medium of transfer. It won't be victimized by the heat applied as long as it can pass the heat