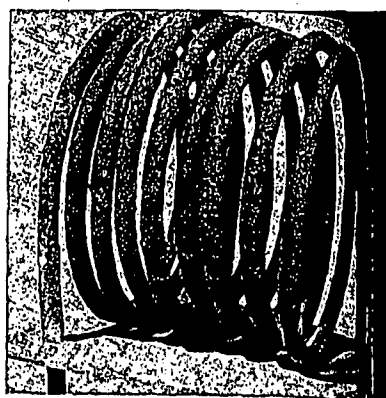


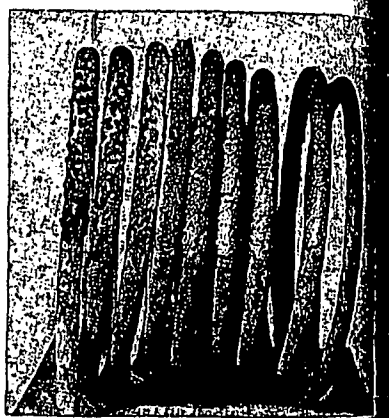
WITHOUT: Typical slag forming on oil superheater tubing with untreated oils is bonded deposit that re-



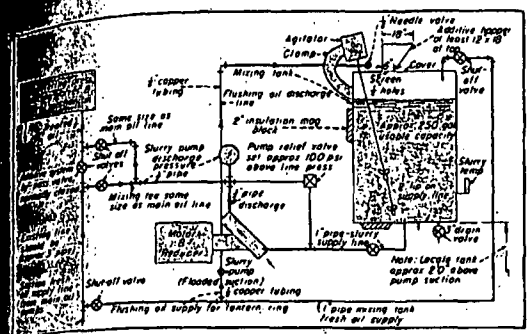
sists ordinary cleaning methods of air, steam soot b
Only sure removal is to shut down, then wash, check ma



WITH: Special additives in plentiful supply to keep them cheap, properly mixed with fuel oil before combustion

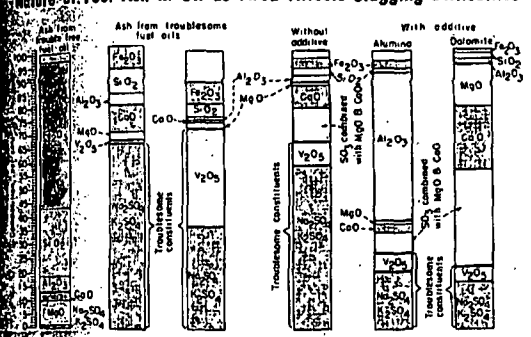


zone produces a slag that can be readily removed by lan
lancing. Exact nature of deposit depended on the additive u



MIXING TANK, 250-gal capacity, contains enough oil-additive material for 8 hr run. It is filled with heated oil from the regular supply at 1 lb to each gallon of oil

Nature of Fuel Ash in Oil as Fired Affects Slagging Difficulties



COMPOSITION OF OIL ASH

CHANGE IN SLAG MAKEUP

STUDIES of fuel-oil ash over a period of years show sharp change in materials

SULFATES, pronounced bonding agents, show up in oils, now coming to market

Superheater Slag Bows to Additives

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Editor's Note: McIlroy, Holler and Lee are co-authors of "The Application of Additives to Fuel Oil and Their Use in Steam-Generating Units," ASME paper No. 52-A-160, New York, annual meeting, Nov 30-Dec 5, 1952.

► THREE MAJOR FACTORS move the problem of slagging and ash build-up in oil-fired furnaces from the ordinary to the critical stage. These factors—progressive deterioration of available fuel oils, higher superheater metal temperatures, a rising frequency of boiler-user complaints—drive home the need for intensive studies backed up by an integrated research program.

Out of one such program comes a solution that reduces cleaning labor and gives good operating efficiencies with present-day oils. What's more, the corrosive qualities of the stack gas are greatly reduced and the flyash nuisance considerably lessened.

The Problem. In a nutshell, the large oil-fired steam generators of recent years are crippled by (1) fluxing of refractory furnace walls (2) slagging of high-temperature superheater surfaces with deposits that resist the ordinary air or steam soot blower (3) fierce attack on steels, including high chromium-content alloys such as superheaters and hangers, when metal temperatures get above 1200 F (4) coating of boiler, economizer and heater surfaces, and (5) plugging and corrosion of cold sections of the heaters.

Superheater slagging is far and away the most serious. It results in lower available, increased draft loss, lowered steam temperatures, an accompanying drop in boiler efficiency. In some plants outages for cleaning occur as often as once a month.

The culprit is easily identified. Early records show oil-ash contents ranging from 0.01% up to 0.1%. Today ash content often runs twice that much, 0.2%, and as a common thing ranges from 0.1 to 0.15 And to really make matters worse the nature of this ash has changed just as drastically. In former days this ash content consisted of iron oxide, silica, lime and magnesia compounds with traces of other materials, bar chart, above. The picture today, though, same chart, shows an ash containing large quantities of alkali sulfates and often considerable vanadium. Source of the vanadium is the crude itself. It runs much heavier in some crudes than in others. Venezuelan fields, for instance, yield crudes notoriously high in vanadium.

Alkali sulfates and vanadium pentoxide, both with low fusing temperatures, prove the principal constituents of troublesome superheater slags, serving as the most active bonding agents. They appear in these slags in far greater proportion than in the oil ash. And their highest concentration shows up in the inner layers of the deposits next to the tube surfaces, becoming progressively less toward outer layers. As you might expect, sintering temperatures of these outer deposit layers get higher and higher with each layer.

New superheaters and those cleaned to bare metal by washing enjoy a period of immunity of several months, when no slagging occurs. Bonding agents in the flue gas do not seem to stick. Once they do start, though, slag deposit is rapid. Mechanical or manual cleaning never completely removes slag and build-up starts apace when the boiler goes back into service.

Various constituents of slag deposits have different melting points and sometimes the surrounding atmosphere affects this temperature too.

Laboratory Investigations. These objectionable ash constituents are present in such small amounts and in such chemical combinations in the crude and fuel oils that you can't remove them economically on a commercial scale. So our move was to see if we could add some material to the oil to raise fusing temperature of the ash. We ran many laboratory tests on alumina, calcium oxide, magnesium oxide, silica, barium oxide and sodium chloride. Alumina, calcium oxide and magnesium oxide raised fusing temperature of ash and slag when mixed in 1 to 1 ratio. Silica worked only with 5 to 1 mix.

Pilot-plant tests followed these chemical investigations. We mixed additive material with the oil before combustion. This gave a thorough mixing with oil-ash solids so the additive particles could (1) serve as nuclei for depositing oil-ash vapors or solids (2) allow maximum time for high-temperature-reaction ash-additive solutions to form.

Deposit was collected on coils in the flue-gas stream. Flue gas passed over these air-cooled coils, photos, p 86, with air flow through the coils regulated to hold the metal temperatures at about the point they would be in a high-temperature superheater. Deposits collected on coils were analyzed following each run. Before testing materials, a trial without additive was made. Material collected on the coils was a hard slag like that from actual superheaters in the field, top photo, p 86.

A wide variety of materials was added