

(2) Internal treatment : In this process (also called *sequestration*), an ion is prohibited to exhibit its original character by '*complexing*' or converting it into other more soluble by adding appropriate reagent. An internal treatment is accomplished by adding a particular chemical to the boiler water either : (a) to precipitate the scale forming impurities in the form of sludges, which can be removed by blow-down operation, or (b) to convert them into compounds which will stay in dissolved form in water and thus do not cause any harm.

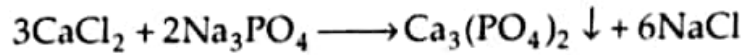
Notes : (i) *Blow down operation* is partial removal of hard water through top at the bottom of boiler when extent of hardness in the boiler becomes alarmingly high.

(ii) '*Make up*' water is addition of fresh softened water to boiler after blow down operation.

Internal treatments methods are, generally, followed by '*blow-down operation*' that accumulated sludge is removed. Important internal conditioning/treatment methods are :

(i) **Colloidal conditioning** : In low-pressure boilers, scale formation can be avoided by adding organic substances like kerosene, tannin, agar-agar (a gel), etc., which get coated over the scale forming precipitates, thereby yielding non-sticky and loose deposits, which can easily be removed by pre-determined blow-down operations.

(ii) **Phosphate conditioning** : In high-pressure boilers, scale formation can be avoided by adding sodium phosphate, which reacts with hardness of water forming non-adherent and easily removable, soft sludge of calcium and magnesium phosphates, which can be removed by blow-down operation, e.g.



The main phosphates employed are : (a) NaH_2PO_4 , sodium dihydrogen phosphate (acidic); (b) Na_2HPO_4 , disodium hydrogen phosphate (weakly alkaline) ; (c) Na_3PO_4 , trisodium phosphate (alkaline).

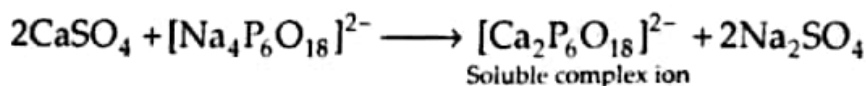
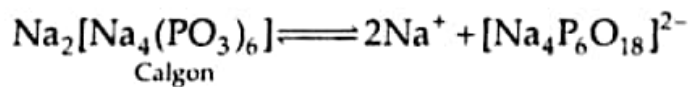
Note : The choice of salt depends upon the alkalinity of the boiler-feed water. Calcium cannot be precipitated properly below a pH of 9.5, so select a phosphate that adjusts pH to optimum value (9.5–10.5). Trisodium phosphate is most suitable for treatment, when the alkalinity of boiler water is low, as it is most alkaline in nature. If boiler water's alkalinity is sufficient, then disodium phosphate is more preferred. But if the alkalinity of boiler water is too high and requires to be reduced, then monosodium phosphate, being acidic in nature, is preferred.

(iii) **Carbonate conditioning** : In low-pressure boilers, scale-formation can be avoided by adding sodium carbonate to boiler water, when CaSO_4 is converted into calcium carbonate in equilibrium.

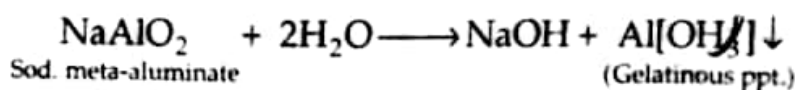


Consequently, deposition of CaSO_4 as scale does not take place and calcium is precipitated as loose sludge of CaCO_3 , which can be removed by blow-down operation.

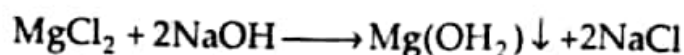
(iv) **Calgon conditioning** : Involves in adding calgon [sodium hexa meta phosphate $\text{Na}_6\text{P}_6\text{O}_{18}$] to boiler water. It prevents the scale and sludge formation by forming soluble complex compound with CaSO_4 .



(v) **Treatment with sodium aluminate (NaAlO_2)** : Sodium aluminate gets hydrolysed yielding NaOH and a gelatinous precipitate of aluminium hydroxide. Thus :



The sodium hydroxide, so-formed, precipitates some of the magnesium as $\text{Mg}(\text{OH})_2$,



The flocculent precipitate of $Mg(OH)_2$ plus $Al(OH)_3$, produced inside the boiler, finely suspended and colloidal impurities, including oil drops and silica precipitate can be removed by pre-determined blow-down operation.

Note : Sodium aluminate in thick solution form is available in plenty and at a cheap price from bauxite refining units and this can be used as such for boiler-water treatment.

(vi) **Electrical conditioning :** Sealed glass bulbs, containing mercury connected to a circuit, are rotating in the boiler. When water boils, mercury bulbs emit electrical discharges, which are forming particles to adhere/stick together to form scale.

(vii) **Radioactive conditioning :** Tablets containing radioactive salts are placed inside the boiler water at a few points. The energy radiations emitted by these salts prevent scale formation.

(viii) **Complexometric method** involves adding 1.5% alkaline (pH = 8.5) solution of EDTA to the feed-water. The EDTA binds the scale-forming cations to form stable and soluble complex. As a result, sludge and scale formation in boiler is prevented. Moreover, this treatment : (i) prevents the formation of iron oxides in the boiler, (ii) reduces the carry over of oxides with steam, and (iii) protects the boiler units from corrosion by wet steam (steam containing liquid water).