

# Reduce Energy & Water Consumption By Using Polyamines/Amines Based All Organic, Phosphate Free Treatment, For Boiler Feed Water

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## ABSTRACT

All organic, phosphate free treatment of boiler water, result in reduction of blow down from boilers thereby saving precious fuel & water. In addition this type of treatment offers several other benefits over traditional treatment. The film forming polyamines create a protective barrier film on all divalent metal surfaces in the pre boiler, boiler and condensate system thus giving a far superior protection against corrosion and scaling. Further the polyamine film is also formed on the internal surfaces of Paper machine dryers which cause drop wise condensation of steam and increases heat transfer rate.

This paper presents the salient features of Polyamine/amine technology and its many benefits, including savings of fuel & water, over traditional treatment using phosphates.

*Key word :- Blow down reduction, Boiler, Turbine, Makeup water, Feed water, Deaerator, Phosphate hideout, AVT, filmity, amine, Monomolecular film layer, distribution ratio, drop wise condensation, Paper machine dryers, LP dosing, etc.*

## Introduction

Rising costs of fuel, water, etc. are leading to development of many new technologies. This is also forcing the Power Plant Managers to constantly think about alternative technologies for boiler feed water treatment to save these resources.

Modern water treatment technologies have significantly improved the quality of makeup water used in boilers and this has reduced the incidences of deposits and scales caused by salts of Calcium, Magnesium & Silica etc.

However generation of corrosion products like iron & copper oxides and their deposition on heat generating surfaces/ turbine blades remain a matter of great concern to Power Plant Managers as these deposits reduce the efficiency of boilers & turbines. In addition to this the problem of "phosphate hideout" and reaction of phosphate with magnetite layer has forced many plants to switch over from traditional phosphate treatment to "phosphate free" All Volatile Treatment (AVT) using a mixture of film forming polyamines, neutralizing amines, dispersants, deoxygenating agents.

Such formulations substantially improve protection against corrosion, scaling and carry over in the steam & condensate systems. Elimination of phosphates leads to reduced solids load on boiler and thus less blow down.

In addition to these benefits there are several additional advantages like only LP dosing, improved heat transfer rates in Paper Machine dryers etc.

The use of film forming amines in boiler water treatment has been practiced since 1950's. Over the years formulations containing filming & neutralizing amines with other synergistic products have been successfully applied in various types of boiler/turbine systems worldwide. This technology has been available in India since late eighties and is presently applied in over 300 boilers all over India with steam pressure ranging from 8 bar to 100 bar in diverse industries like Paper, Sugar, Petroleum, Steel, Power etc.

## Drawbacks of Traditional Approach'

Traditionally, multiple chemicals like phosphates, hydrazine or sulfite, ammonia/neutralizing amines (for raising condensate pH) are used to reduce the corrosion & scaling in the boilers, Some of the major drawbacks of such treatments are:

1. Addition of salts, like TSP, leads to

increased solid load on the boiler (consequently more blow down) and can also cause deposits/under deposit corrosion problems.

2. The protective magnetite layer grows with time leading to reduced heat transfer and incidences of "under deposit corrosion" e.g. caustic attack.
3. The treatment does not provide any protection to condensate system against corrosion by oxygen, ammonia (formed due to decomposition of excess hydrazine).
4. The treatment requires tight monitoring of chemical residuals & pH for its effectiveness.

## Modern "Phosphate Free" Technology Polyamine/ Amine Treatment

The polyamine/amine-based single liquid formulation completely replaces multiple chemicals used in traditional treatment programs and no other chemical is required for BFW treatment. Such products are well established, require only LP dosing and are gaining increasing acceptance worldwide including in India.

Some of the major advantages of Modern technology are:

- **Reduction in blow down levels and savings in boiler operation**

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costs.

- Cleaner boiler, better heat transfer & savings in chemical cleaning costs. Better steam purity & improved turbine performance
- More flexibility in operations.
- Easier dosing, monitoring and control.
- Substantially less corrosion and scaling.

### Salient features of Polyamine /amine treatment;

- i) Functional constituents of Polyamine/amine mixture

The polyamine/amine formulation contains organic components only. It is an eco-friendly and non-toxic blend of the following functional constituents:

- Long chain, aliphatic film forming amines
- Neutralizing and alkalizing amines
- Complexing, and de-oxygenating agents
- Dispersants

### Film forming Polyamines:

The filming amines have a strong affinity to divalent metals and this leads to adsorption of molecules of filming amines on exposed metal surfaces (Chemisorption). The result is formation of an adhesive, largely monomolecular film (with a thickness of about  $10\text{\AA}$ ) on the wetted metal surfaces and this film prevents attack by corrosive impurities in water and also hinders formation of deposit.

The filming amines are large molecules (long chains) having both hydrophilic (water compatible) and hydrophobic (water repellent) ends in their structure. The polyamines are stable over a wide temperature and pressure range up to  $700\text{ deg C}$  and  $160\text{ bar}$  (tested in bomb calorimeter).

### Neutralizing and Alkalizing Amines:

It is essential to use 3-4 types of neutralizing amines with varying distribution ratio (DR), so that the large steam/condensate systems in industries like Paper Mills are well protected against carbonic acid attack.

### Complexing, scale controlling, dispersant and De-oxygenating agents:

While deoxygenating agents provide secondary protection against residual oxygen, other agents arrest crystal

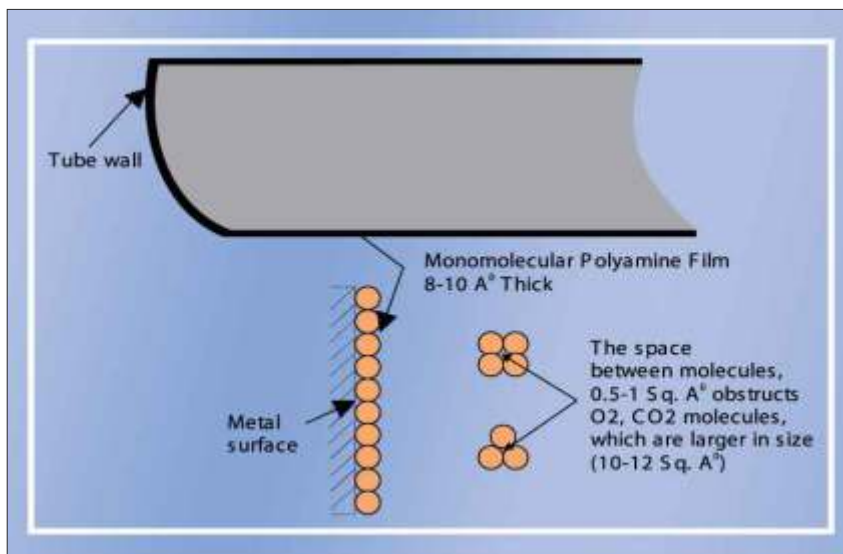


Fig. 1 Polyamine film and protection of metal surfaces.

growth, prevent scale formation, binds silica to water phase and reduce carry over.

- ii) Polyamine film, its properties and protection provided by it

### Polyamine film:

The formation of a non-sticky, continuous polyamine coating/film on the metal surface (specimens from economizer/boiler tubes) had been confirmed by several studies carried out using advance instruments such as Scanning Electron Micrographs (SEM), Electron Spectroscopy (ESCA) and Secondary Ion Mass Spectroscopy (SIMS). Surface coatings on polyamine treated metal surfaces were analyzed and the presence of nitrogen on the surfaces confirmed adsorption of the filming amines on these surfaces.

The film thus formed acts as a physical barrier between impurities in water and the metal surface. The ability of the polyamine to protect against attack by oxygen is very well established and now acknowledged in European Guidelines also. The hydrophobic hydrocarbon chains prevent wetting of the metal surface and protect the boiler tubes from corrosion and scale formation.

Polyamines have the ability to form non-soluble complexes with the fouling layers of oxides, which are then dispersed efficiently by the accompanying organic dispersants. Oxides of hematite variety and almost all the porous magnetite fouling layers are sloughed off till a very dense magnetite layer remains adjacent to the metal surfaces. This dense magnetite layer acts as an extremely good

bonding site for Polyamine molecules. Thus the polyamine film formed includes a thin dense magnetite layer between polyamine molecules and the metal.

### iii) Major Benefits Of Polyamine/Amine Treatment

#### 1. Energy Conservation:

Since no inorganic chemicals like phosphates, sulfites, etc. are used and only organic products are used, the solids input to the boilers is reduced. Thus the recommended TDS levels in boiler water can be maintained with lesser blow down. This saves fuel as well as makeup water. There are many instances where blow down has been reduced by over 50%. Please see Table - 1 reduction in blow down when switching from phosphate to Polyamine/amine treatment.

#### 2. Improved heat transfer:

The thickness of the polyamine film is only in Angstrom while magnetite layer can grow up to few millimeters. Further the thermal conductivity of iron oxide layer is  $1.5\text{ BTU/hr/sq. ft}^{\circ}\text{F/inch}$  is much more than of polyamine film is in the range of  $2000 - 14000\text{ BTU/hr/sq. ft}^{\circ}\text{F/inch}$ . This improves the heat transfer rate. Further due to the non wetttable nature of the film, drop wise condensation occurs in dryers of paper machine which reduces the chances of formation of condensate film inside the rotating dryer. As the thermal resistance of the polyamine film is less than that of normal condensate film, an increase in heat transfer is achieved.

**Table :-1 Potential Saving in Blow Down in a Typical Paper Mill**

Boiler operating data	Before	After
Superheated Steam Pressure, Bar (G)	42	42
Superheated Steam Temp., Deg. C	370	370
Average steam generation, TPD	2400	2400
Average Blow down, TPD	48 (2%)	24 (1%)
Condensate return, TPD	1440 (60%)	1440
Makeup water, TPD	1008	984
Sensible heat of Blow Down water, Kcal/Kg	264	264
GCV of coal, Kcal/Kg	3200	3200
<b>Overall Savings with Eloguard treatment</b>		
Saving in coal due to reduced blow down	660 TPY	
Saving in water due to reduced blow down	7920 TPY	

### 3. Single product, Easy to prepare & dose:

It is replacement for the antiscalant/sludge conditioners, oxygen scavenger. The formulation is completely miscible in water and only LP dosing is required. Thus HP dosing required with phosphates is eliminated.

### 4. Improved Protection:

Nonstick film and adsorption ability of dispersants prevents growth of scale and formation of hard crystalline deposits on metal surfaces. Film formation on wetted low-pressure side of turbine provides protection against deposition and improves efficiency. Keeps the boiler system completely clean and thus better heat transfer rates are maintained and at the same time the boilers become self cleaning (Ref. 1).

### 5. Improved Silica Management:

Binding silica to water phase enhances silica tolerance in boiler water. Further substantial reduction in sodium in boiler water reduces the chances of glass like deposits (silicates of sodium) on turbine blades.

### 6. Improved steam purity and Turbine efficiency:

Boilers operated on phosphate treatment necessarily have high TDS levels in boiler water as a residual of phosphates has to be maintained. Since no inorganic chemicals are used in this treatment the boiler water TDS reduces substantially and this results in improved steam purity. Needless to say the availability & efficiency of turbines also sees a significant improvement.

### vi) Dosing Method And Program Monitoring

#### Dosage

The product should be added continuously as a diluted solution (dilution with DM water/condensate), using a positive displacement metering pump preferably to the out let of the deaerator or in the feed tank where deaerators are not used. The dosage rate should be optimized based on the makeup water quantity & quality and is generally between 12-20 ppm on makeup water. The chemical supplier's recommendation should be followed for such products. .

#### Monitoring parameters

It is sufficient to monitor pH, Conductivity and Silica in Feed, Steam, Drum water and condensate on a regular basis. Iron in feed and boiler drum water may be checked once a week or as and when required. In addition to these parameters, chlorides and hardness need to be checked in makeup (DM) water & feed water. Testing of residual of oxygen scavenger in Feed water and phosphate in boiler water is not required.

#### Regulation of dosage

The dosage is regulated by monitoring the pH of the return condensate. The dosage should be adequate to ensure a condensate pH of 8.3 - 8.8 as this ensures that there is residual amine present to ensure protection to the after boiler/condensate system against low pH corrosion.

#### Conclusion

Application of mixtures of filming &

neutralizing amines with other synergistic chemicals results in savings of fuel & water with better protection to the steam & power generating systems in Paper Industries as well as many other industries.

This is evident from the fact that more than 50 Paper mills in India have adopted this technology and many of them are practicing it for over 15 years continuously.

In n nut shell the following benefits are obtained with such treatments:

- Savings of fuel and water
- Improved heat transfer in boiler and also in dryers in Paper machine.
- Superior protection against scaling & corrosion by the polyamine.
- Dispersion of precipitation products.
- Improved boiler & turbine efficiency.
- Simple handling

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