Boiler Water Best Practises

Boiler Water Internal Treatment Technology

Why is Effective Internal Boiler Water Treatment Necessary ?

Effective Internal Boiler Water Treatment

Controls

- Deposition
- Corrosion
- Carryover

and

Enhances System Reliability and Efficiency

- Avoids unscheduled shutdowns
- Helps ensure uninterrupted production
- Reduces maintenance costs
- Reduces operating costs

What Operating Costs are Associated with Boiler Operation ?

Boiler Operating Costs

- Fuel - Gas, Oil, Coal
- Water - Influent and Effluent
- Regenerants - Salt, Acid, Caustic
- Water Treatment

Boiler Operating Costs

- Fuel - Gas, Oil, Coal
- Water - Influent and Effluent
- Regenerants - Salt, Acid, Caustic

- Water Treatment

Boiler Operating Costs

- Need to minimise all operating costs
  Reducing boiler water blowdown gives water, energy and chemical savings

- Need to maximise efficiency
  Maintain clean heat transfer surfaces
  Heat recovery systems

Effective Internal Boiler Water Treatment

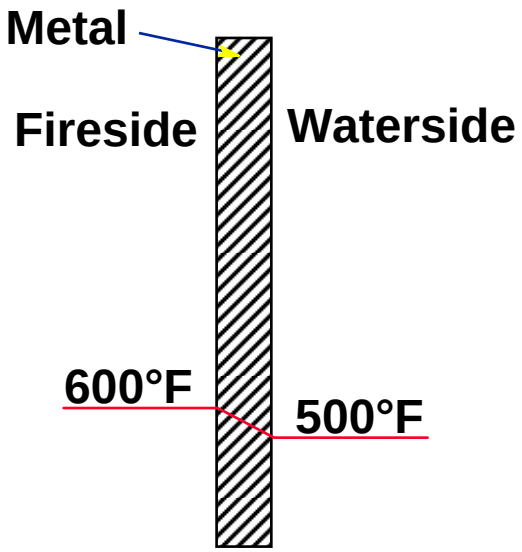
Controls

- Deposition

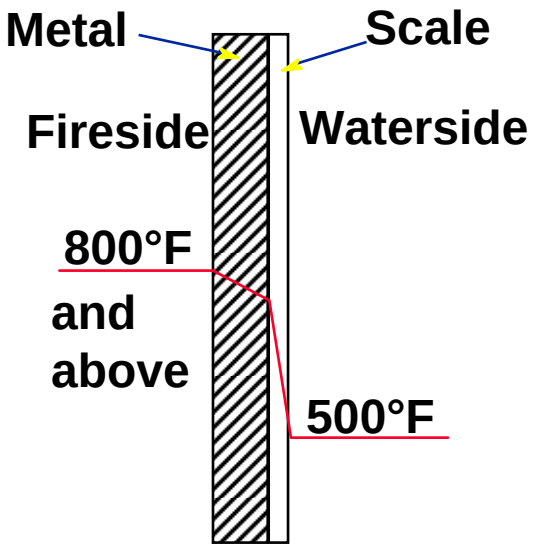
Boiler Water Deposit Control

- Hardness salts
  - Calcium
  - Magnesium
- Metal oxides
  - Iron
  - Copper

Comparison of Heat Transfer Surfaces With and Without Deposits



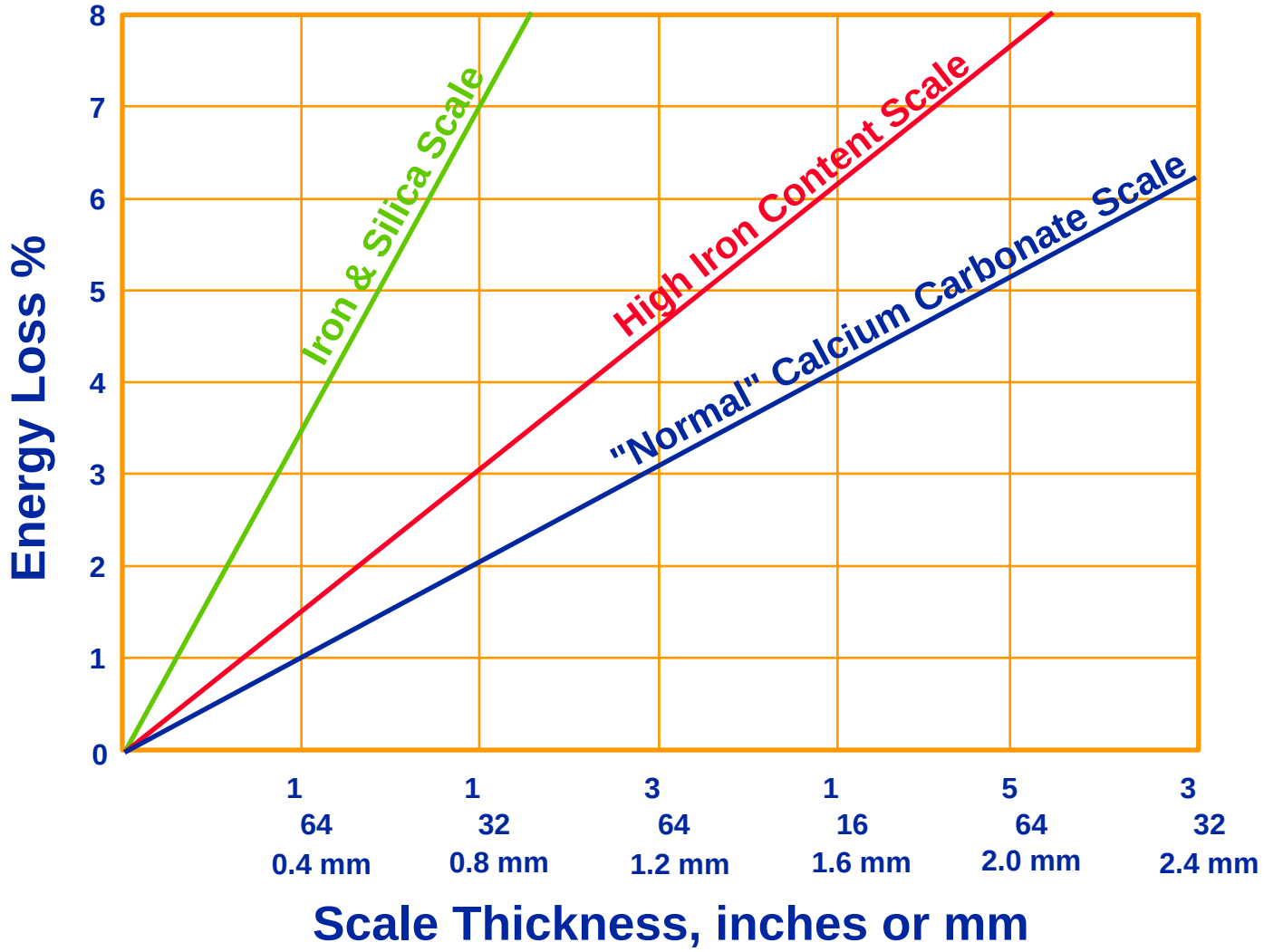
Without deposits



With deposits

Energy Loss from Scale Deposits

(from Energy Conservation Programme Guide for Industry & Commerce)



Long Term Overheating

Boiler Water Deposit Control

- Removal of impurities
  - Pretreatment plant
- Chemical treatment
- Controlled blowdown

Effective Internal Boiler Water Treatment

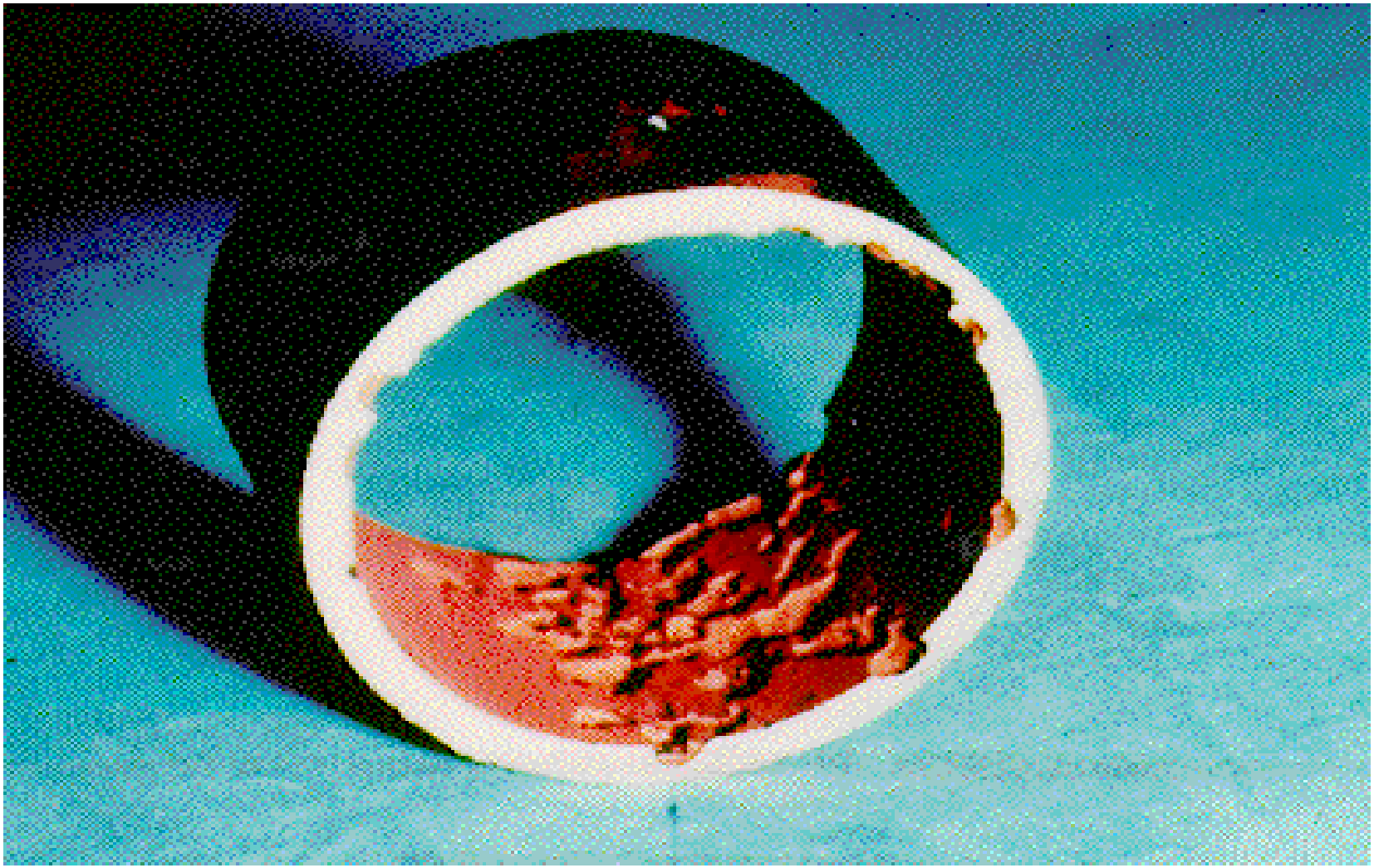
Controls

- Deposition
- Corrosion

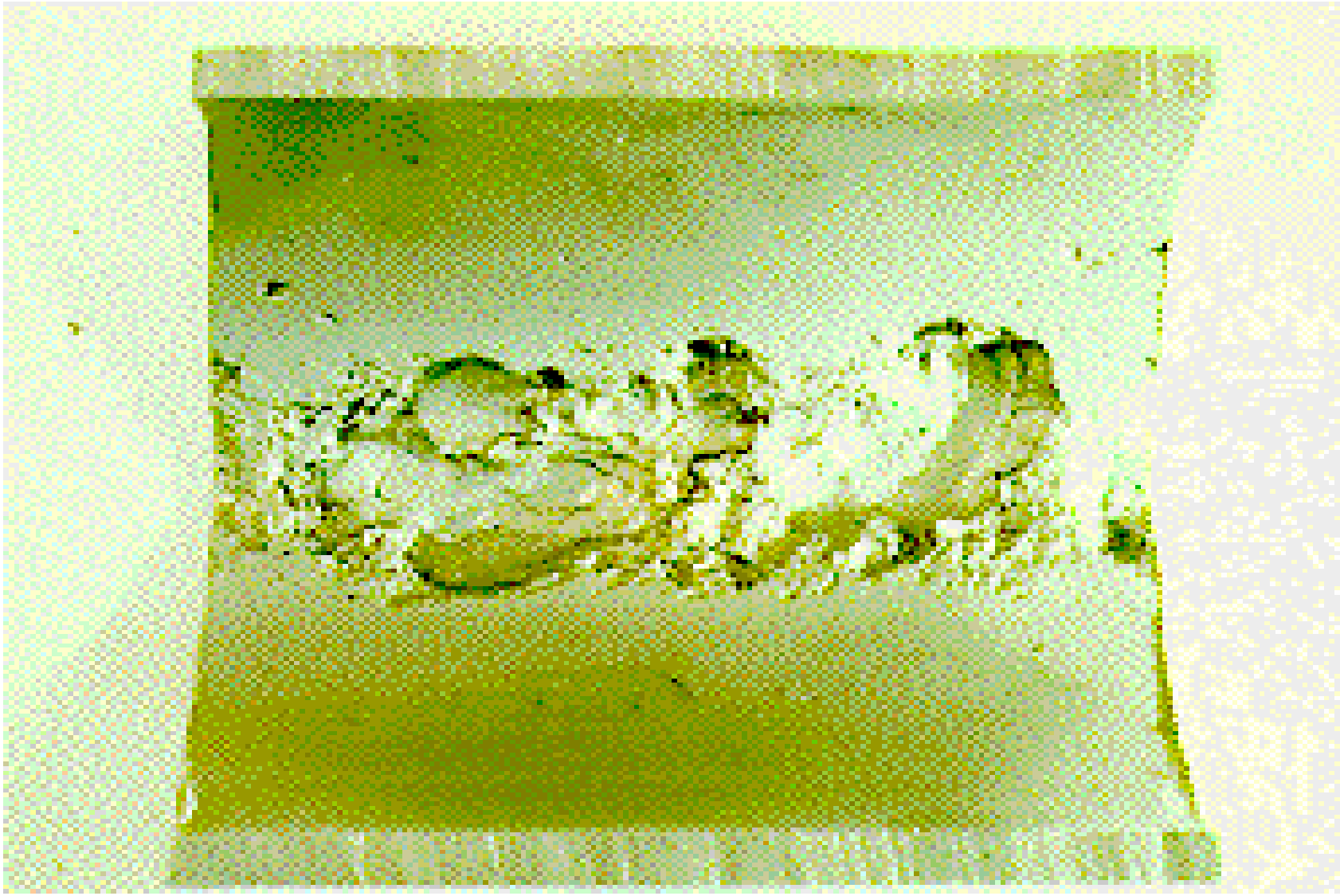
Boiler Water Corrosion Control

- Oxygen pitting
- Caustic corrosion
    - Embrittlement or gouging
- Acidic attack

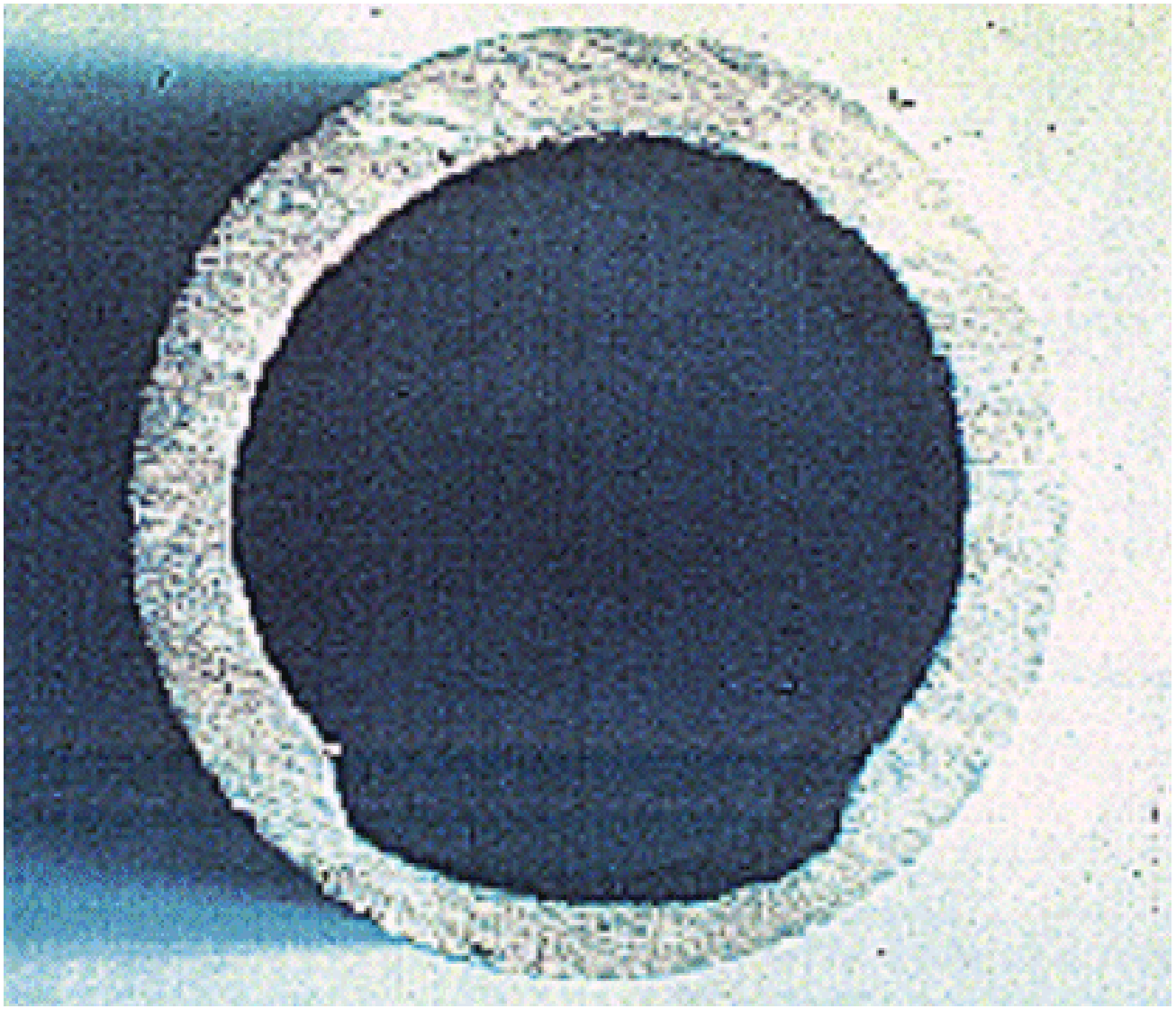
Oxygen Corrosion - Pitting



Caustic Gouging



Acid Corrosion



Effective Internal Boiler Water Treatment

Controls

- Deposition
- Corrosion
- Carryover

Control of Boiler Water Carryover

- Effective mechanical steam separation
- Proper control of boiler water chemistry
- Antifoam, as needed
- Avoid major contaminant ingress
- Proper boiler operating practices

What Types of Internal Boiler Water Treatments are Available ?

Internal Treatment Programmes

General Classifications

- Precipitating
- Solubilising
- Combination

Internal Treatment Programmes

- Phosphate/Polymer
- Phosphonate/Polymer
- Chelant/Polymer
- Phosphate/Chelant/Polymer
- All Polymer
- Coordinated pH/Phosphate/Polymer
- All Volatile Treatment (AVT)

Boiler Water Polymers

are Crucial to the

Success of any

Internal Treatment Programme

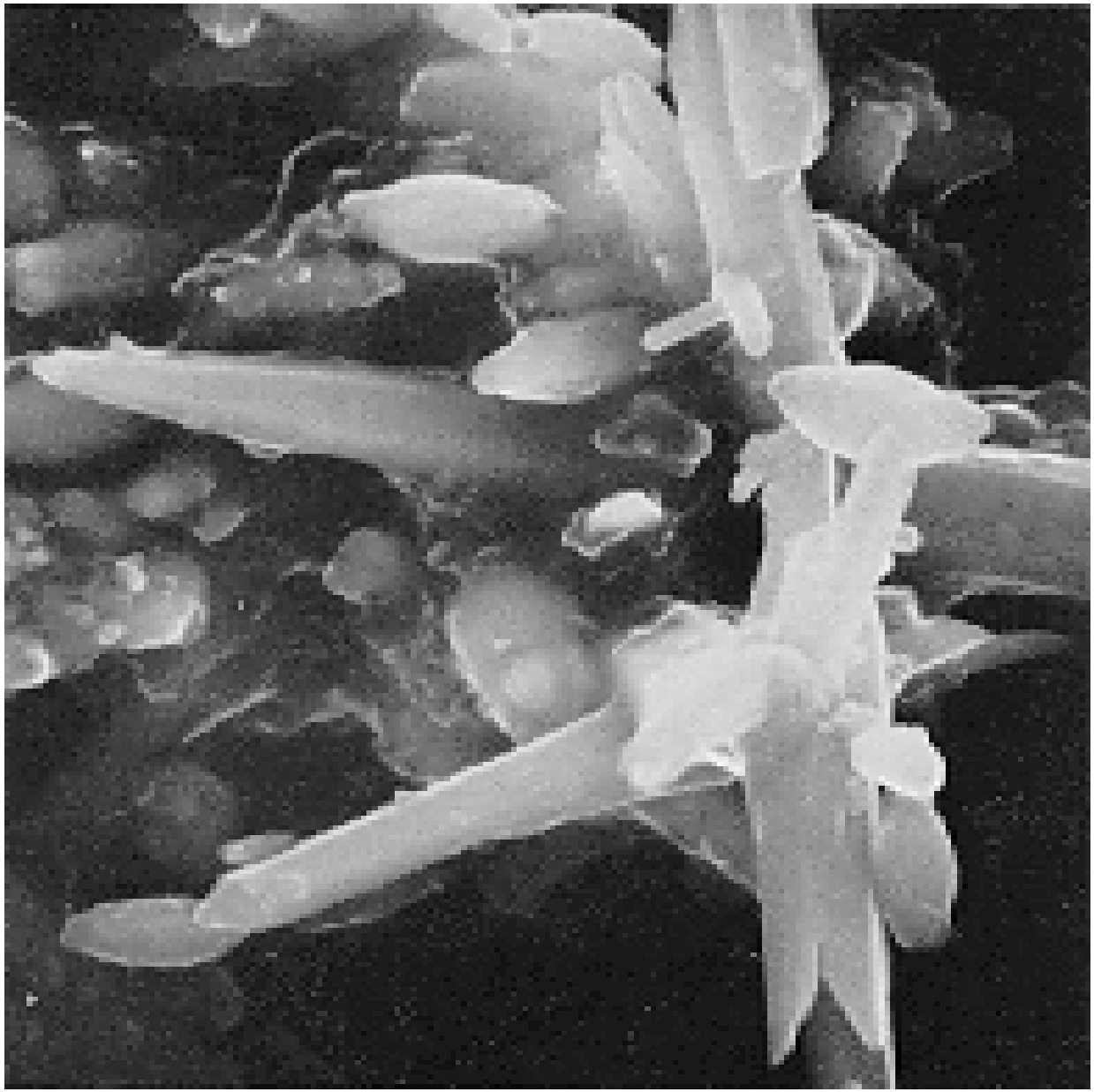
How do Boiler Water Polymers Function ?

Boiler Water Polymers

The mechanisms by which boiler water polymers function are

- Complexation / Solubilisation
- Crystal modification
- Dispersion

Calcium phosphate, magnesium silicate crystals formed in boiler water without dispersant

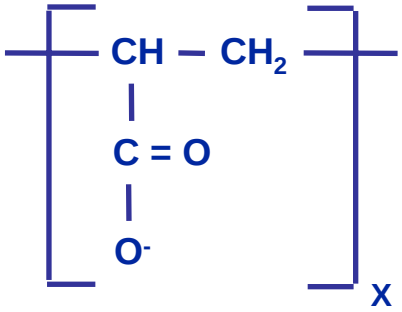


Calcium phosphate, magnesium silicate crystals formed in boiler water in the presence of a sulphonated polymer

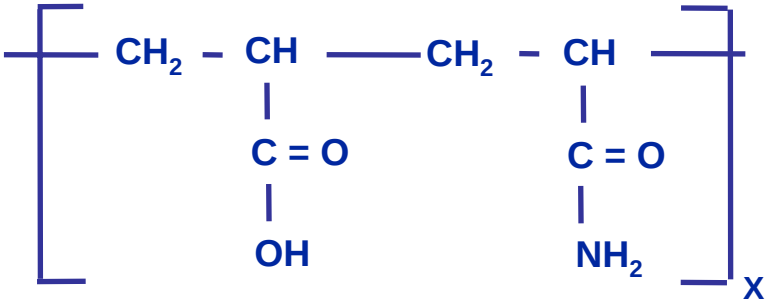
Variables Affecting Polymer Performance

- Functional group
  - carboxylated (SCP/SCCP)
  - sulfonated (SSP)
  - phosphorylated (HTP)
- Polymer backbone
- Molecular weight

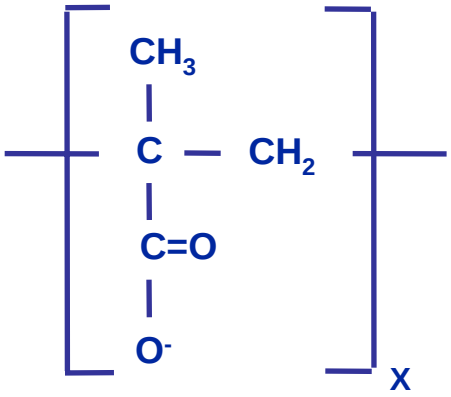
Typical Polymer Structures



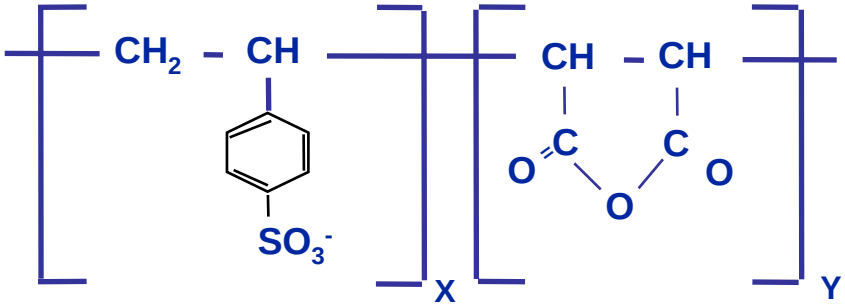
Polyacrylate



Acrylate-Acrylamide Copolymer

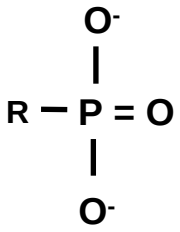


Polymethacrylate

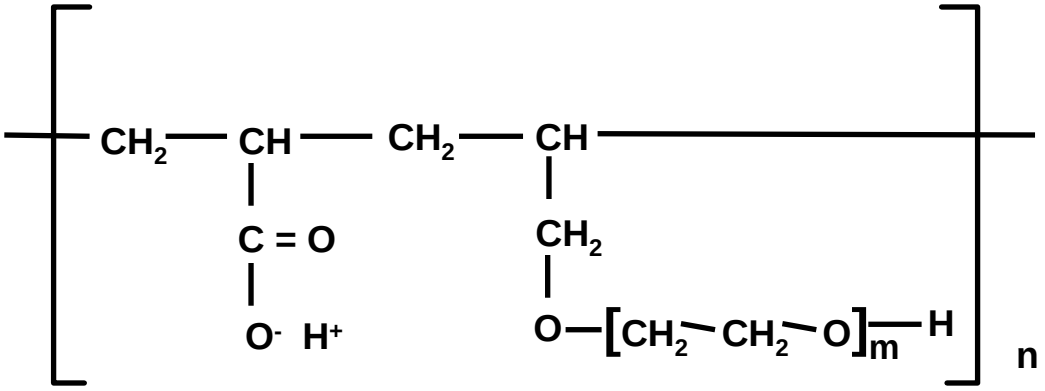


Sulfonated Styrene-Maleic Anhydride Copolymer

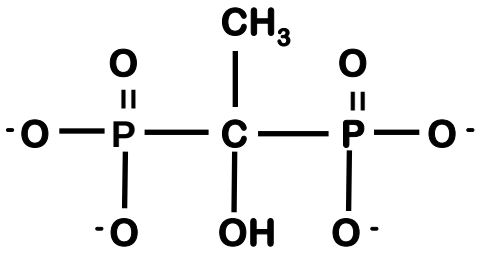
Typical Polymer Structures



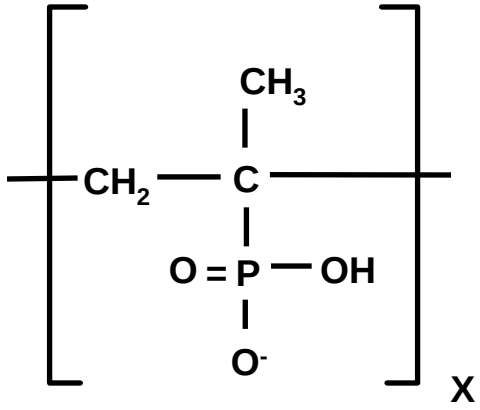
Phosphonate



Polyethylene glycol allyl ether **(PEGAE)**



HEDP



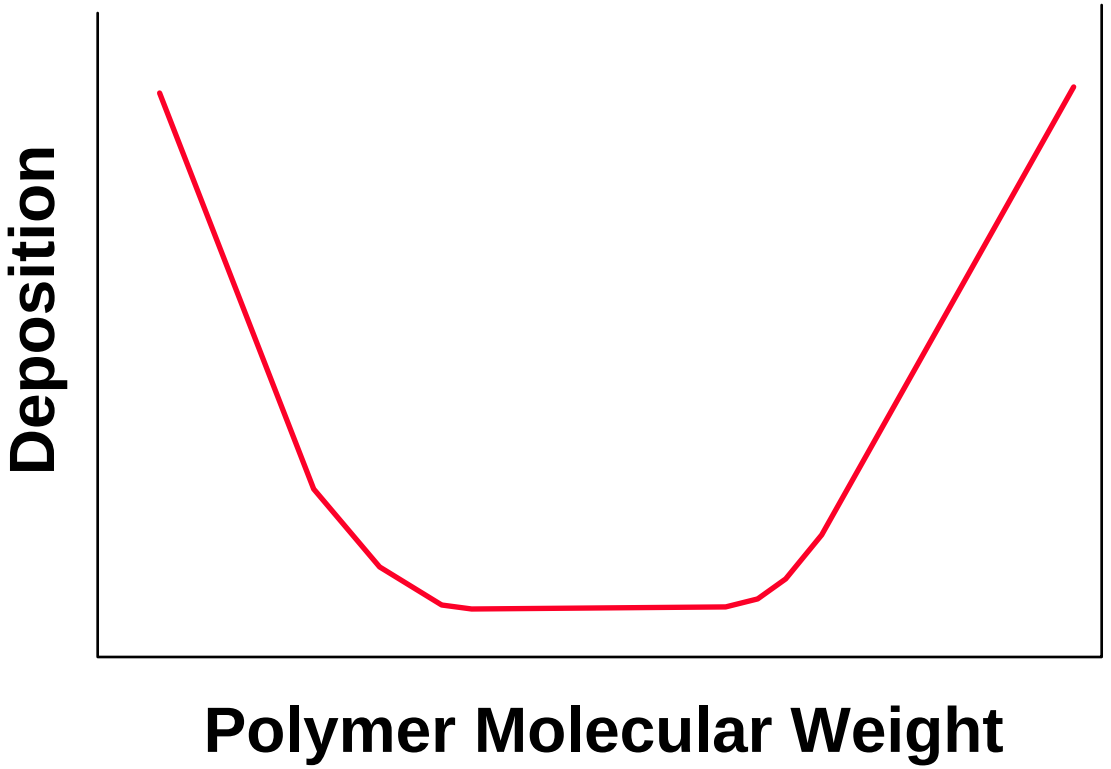
Poly (isopropenyl phosphonic acid)

PIPPA

Polymer Performance

vs

Molecular Weight



Programme Selection Considerations

- Boiler pressure, design
- Pre-treatment plant type
- Feedwater quality
- Hot well, deaerator type
- Steam turbine
- Control capabilities

Chemical Factors

- Total Dissolved Solids (TDS)
- Alkalinity
- Silica
- Suspended Solids

ASME Boiler Feedwater Quality Guidelines for Modern Industrial Water-Tube Boilers

Drum Pressure (kg/cm²)	Iron (ppm Fe)	Copper (ppm Cu)	Hardness (ppm $CaCO_3$)
0 - 21	0.10	0.05	0.30
22 - 31	0.05	0.025	0.30
32 - 42	0.03	0.02	0.20
43 - 52	0.025	0.02	0.20
53 - 63	0.02	0.015	0.10
64 - 70	0.02	0.015	0.05
71 - 105	0.01	0.01	0.0

Internal Treatment Programmes

- Phosphate/Polymer

Phosphate/Polymer Treatment

- **Reactions:**

- $Ca + PO_4 + OH \rightarrow Ca(OH)PO_4$ ↓
- Calcium Phosphate Hydroxide Hydroxyapatite
-

- $Mg + SiO_3 + OH \rightarrow Mg(OH)SiO_3$ ↓
- Magnesium Silica Hydroxide Serpentine

Phosphate/Polymer Treatment

Characteristics

- Hardness controlled by precipitation
- Polymers used to control hardness sludge and metal oxides
- Phosphate residual used for programme control
- Hydroxide alkalinity required (pH : 10.5 - 12)

Phosphate/Polymer Treatment

Boiler Control Parameters

- Phosphate residual as PO_4 depending on hardness in the feedwater
  - usually associated with boiler pressure
  - and environmental legislation
- M alkalinity of 700 ppm as $CaCO_3$ (25 % of TDS)
- Polymer : min 360 ppm as SP8100
- Still the most used method for treating low pressure boilers

Phosphate/Polymer Treatment

Advantages

- **Tolerates a wide range of feedwater hardness**
- **Non corrosive treatment**
- **Suitable for low to medium pressure systems**
- **Easy operator control**

- **Disadvantages**
- **Is a precipitation programme (some deposition is normal)**
- **Higher blowdown rates may be required**

Internal Treatment Programmes

- Phosphate/Polymer
- Phosphonate/Polymer

Phosphonate/Polymer

Characteristics

- Organic phosphor donors combined with three synergistic polymers
- Complexes hardness, iron and copper ions in BFW
- Disperses/solubilises contaminants in boiler minimising sludge formation

Phosphonate/Polymer

a) Solubilising

Boiler Control Parameters

- 200 - 300 ppm in blowdown
- (BFW hardness + tot Fe) max 1 ppm for 300 ppm in boiler
- filtered tot. PO_4 min 6 ppm in BD
- Other :
  - conductivity
  - SiO_2
  - M-alk

Phosphonate/Polymer

b) Precipitating

Boiler Control Parameters

- Phosphate residual as PO_4 depending on hardness in the feedwater
- M alkalinity of 700 ppm as $CaCO_3$ (25 % of TDS)

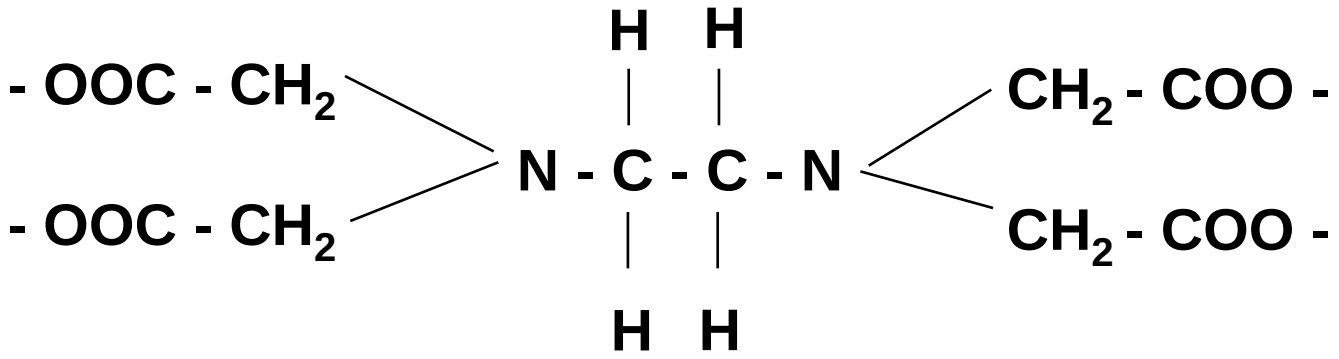
Internal Treatment Programmes

- Phosphate/Polymer
- Phosphonate/Polymer
- Chelant/Polymer

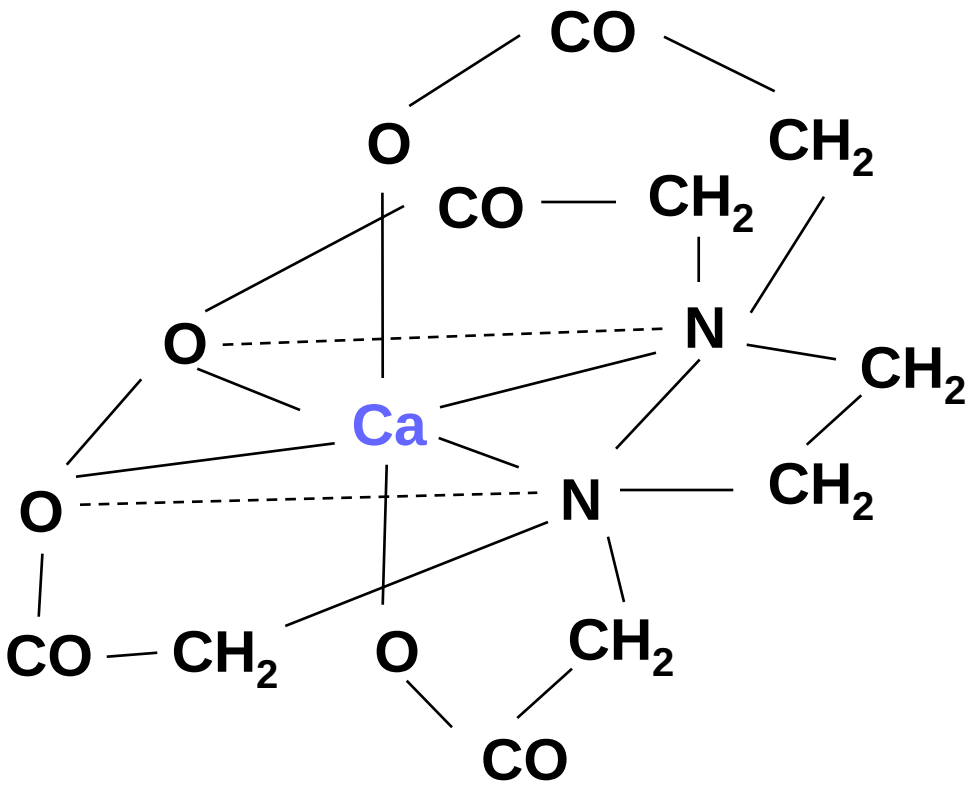
Chelant/Polymer Treatment

- Common Chelating Agents
- EDTA
- NTA

Chemical Structure of EDTA



EDTA/Calcium Complex



Chelant/Polymer Treatment

Characteristics

- Are solubilising treatments
- Chelant complexes hardness and soluble iron / copper
- Polymers used to enhance metal oxide control
- Must be fed to the feedwater line

Chelant/Polymer Treatment

Advantages

- **Solubilising treatment**
- **Effective on hardness and soluble iron**
- **Allow reduced blowdown**
- **Increased reliability and efficiency**
- **Suitable for low to medium pressure systems**

Disadvantages

- **Requires intensive operator control**
- **Potentially corrosive if misapplied**

Internal Treatment Programmes

- Phosphate/Polymer
- Phosphonate/Polymer
- Chelant/Polymer
- Phosphate/Chelant/Polymer

Chelant/Phosphate/Polymer Treatment

Characteristics

- Utilises EDTA chelant (partial chelation)
- Primarily a solubilising programme
- Phosphate provides back-up upset protection
- Residual phosphate test used as programme control
- Polymers used to control metal oxides and other precipitates

Chelant/Phosphate/Polymer Treatment

Advantages

- **Primarily a solubilising treatment**
- **Effective on hardness and iron**
- **May allow reduced blowdown**
- **Increased reliability and efficiency**
- **Easy and accurate control test**
- **Tolerates a wide range of feedwater hardness**
- **Suitable for low to medium pressure systems**

- **Disadvantages**
- **Some precipitation is possible**
- **Potentially corrosive if misapplied**

Internal Treatment Programmes

- Phosphate/Polymer
- Chelant/Polymer
- Phosphate/Chelant/Polymer
- All Polymer

All Polymer Treatment

Characteristics

- Certain polymers can be effective complexing agents
- Principle mechanism is complexation of soluble impurities
- Secondary mechanism is dispersion of particulates
- Fed to the boiler feedwater

Limitations of Polyacrylate Based All Polymer Programmes

- Low tolerance to feedwater quality upsets
- Potential for calcium polyacrylate deposition
- Releases ammonia
- Economiser iron pick-up
- Precise testing for polymers is difficult

Internal Treatment Programmes

- Phosphate/Polymer
- Phosphonate/Polymer
- Chelant/Polymer
- Phosphate/Chelant/Polymer
- All Polymer/OptiSperse AP

What is OptiSperse AP ?

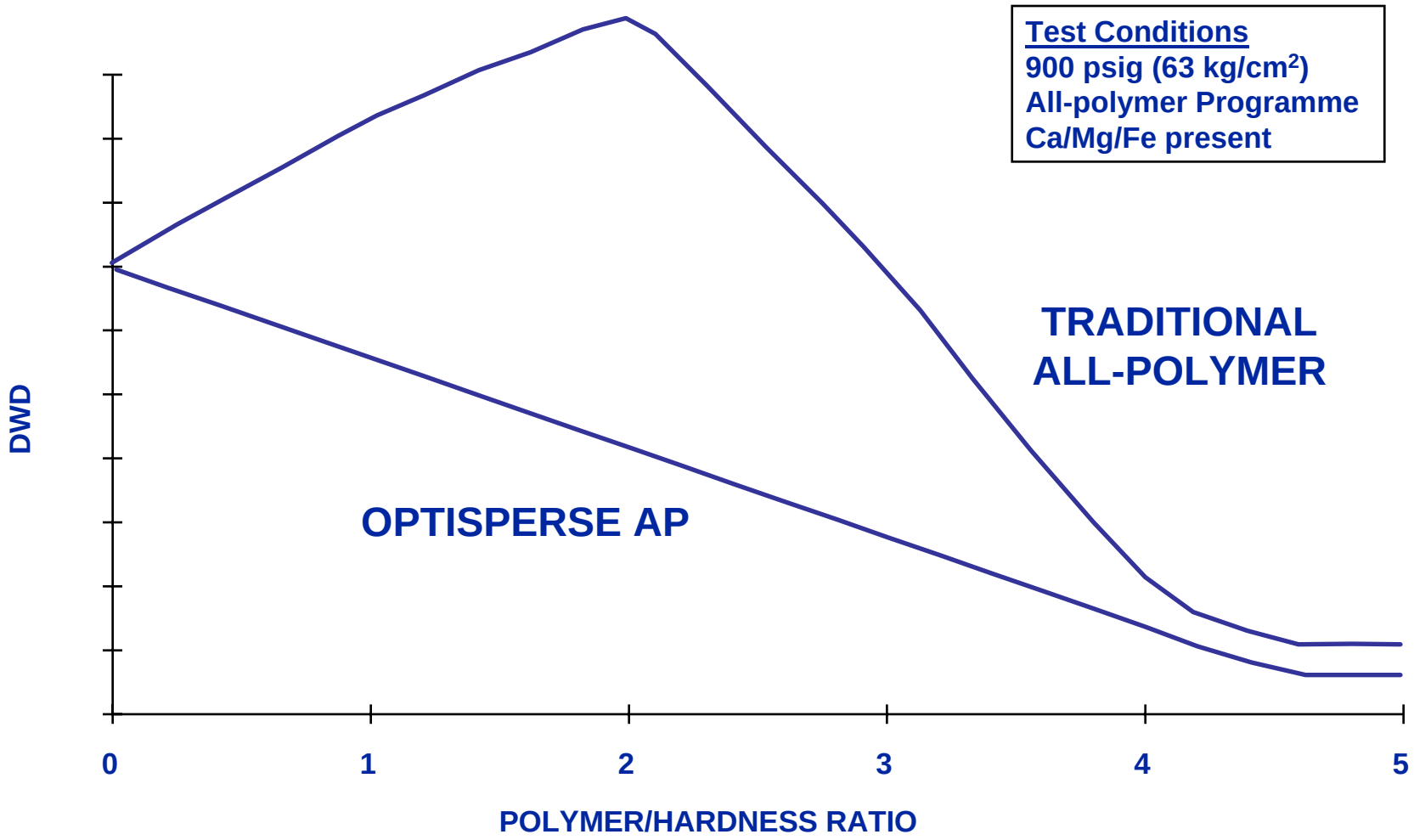
- A new, revolutionary programme using patented co-polymer technology

- A stand-alone all polymer / all organic boiler internal treatment programme which provides superior control over hardness and iron deposition

OptiSPerse AP Treatment vs. Traditional All Polymer

- Traditional All Polymer Programme
  - Generates ammonia
  - Forms calcium-polymer deposits with BFW hardness excursions or underfeed
  - Overfeed may cause foaming
  - Corrosive to economiser surfaces
  - Must be fed downstream of copper alloys
- OptiSperse AP Programme
  - No ammonia generated
  - No treatment related deposition
  - No steam purity problems
  - Not corrosive to preboiler circuit
  - May be fed ahead of copper alloys in BFW

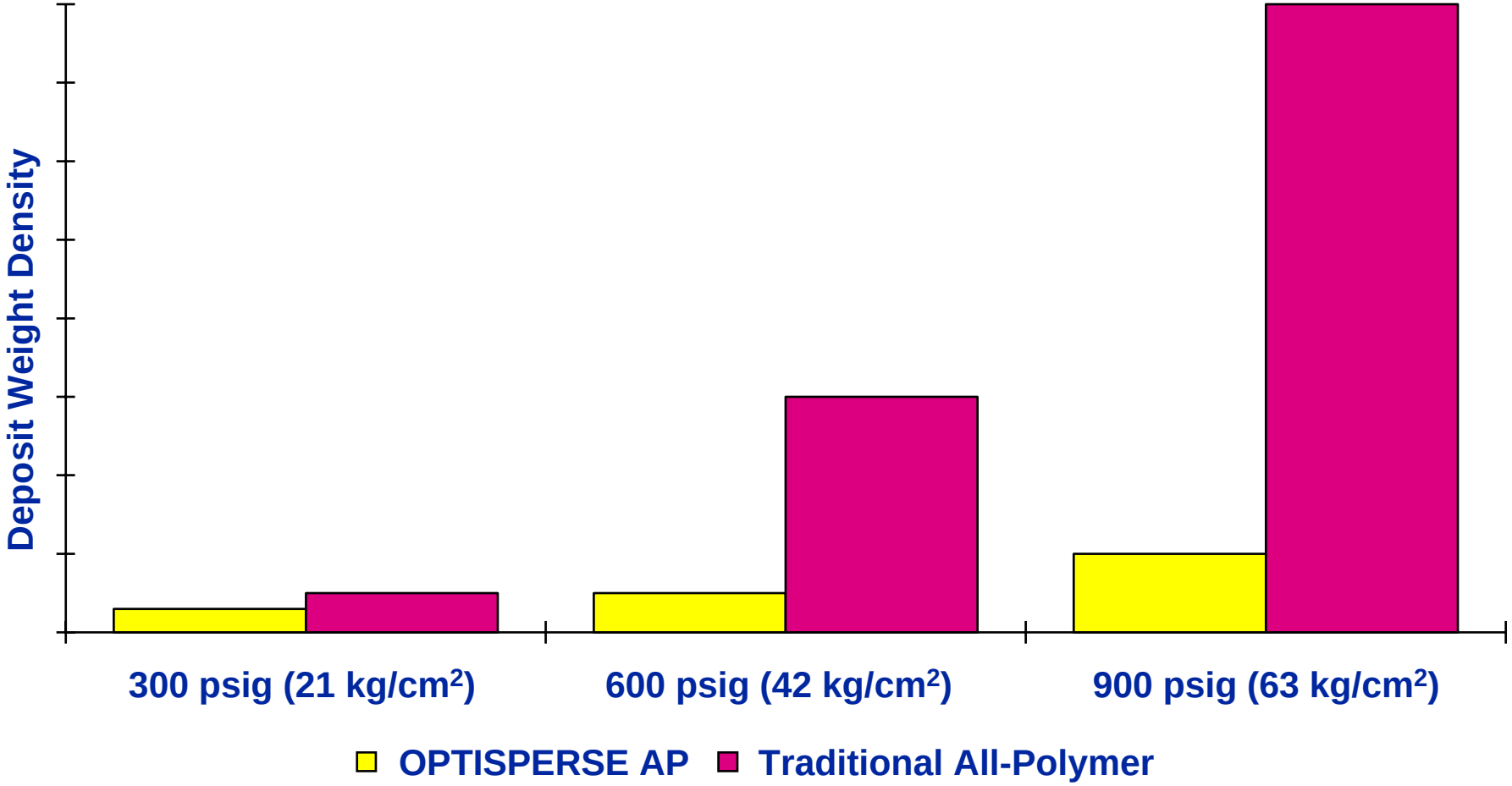
Research Boiler Studies Under Fouling Conditions



Research Boiler Studies

Under Potential Fouling Conditions

(Equal Polymer Actives)



Internal Treatment Programmes

- Phosphate/Polymer
- Phosphonate/Polymer
- Chelant/Polymer
- Phosphate/Chelant/Polymer
- All Polymer
- Coordinated

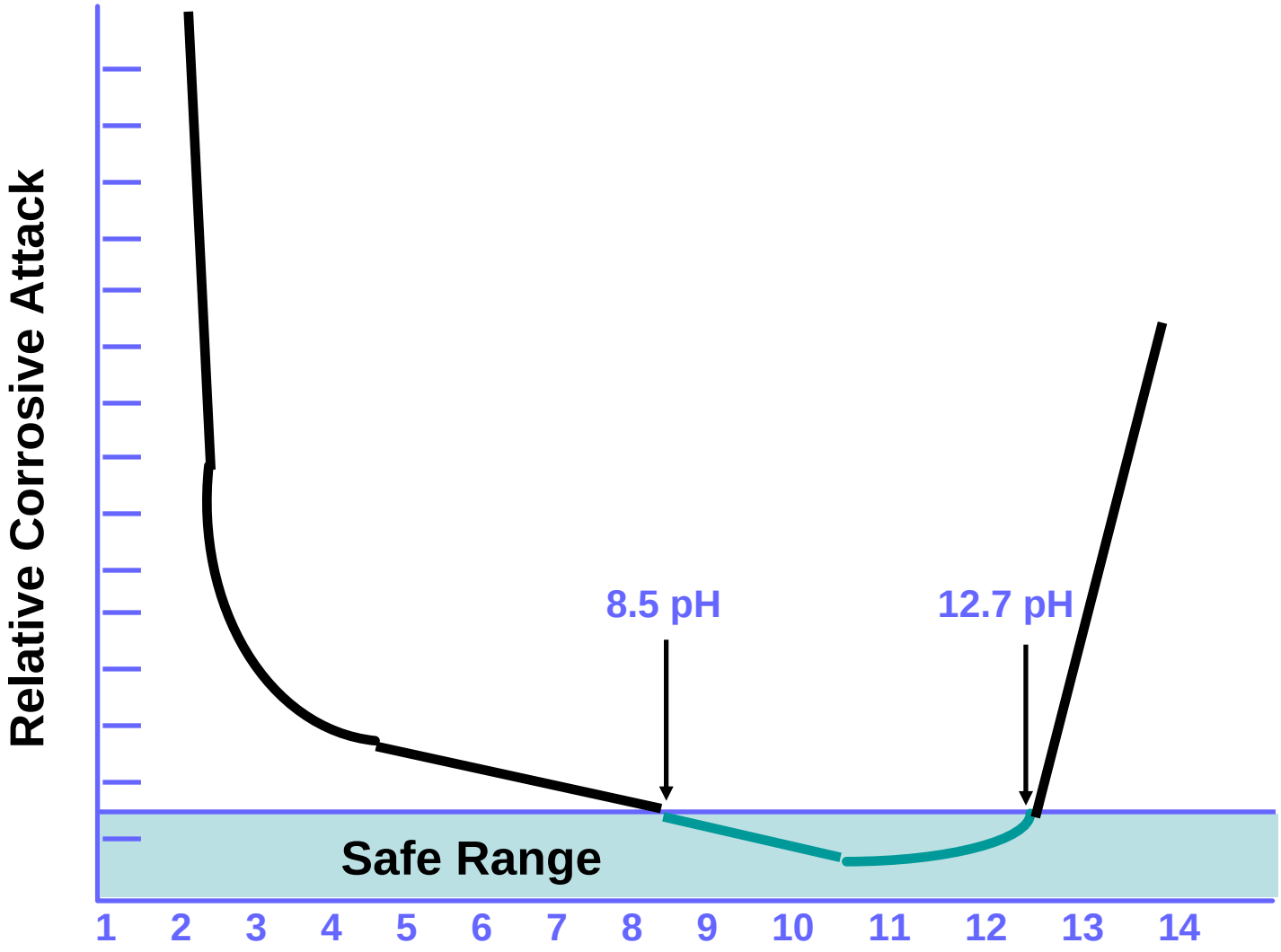
  pH/Phosphate/Polymer

Coordinated pH/Phosphate Polymer Treatment

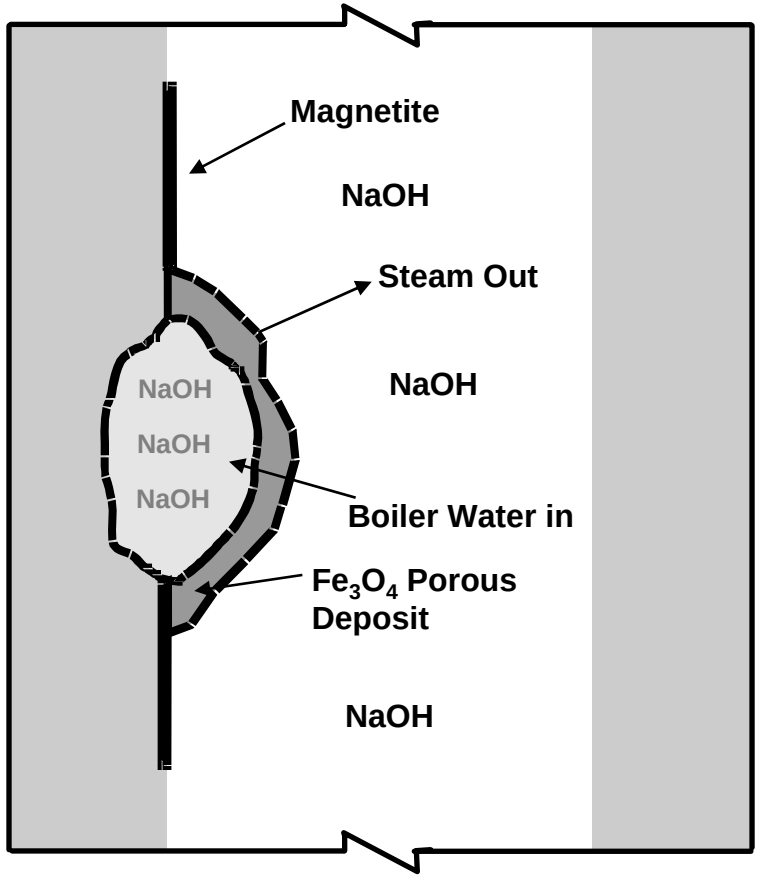
Characteristics

- Primarily for high purity/high pressure systems
- Mainly a corrosion control programme
- Phosphate used to control pH and neutralise excess caustic
- Polymers used to control deposition

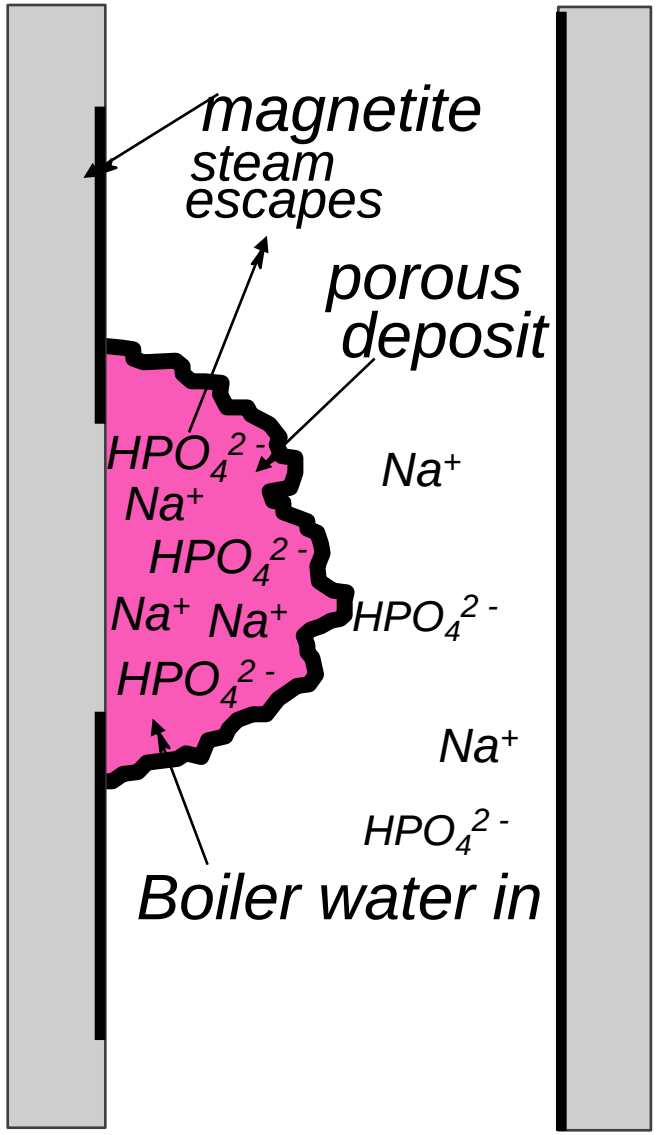
Corrosion of Mild Steel vs. pH



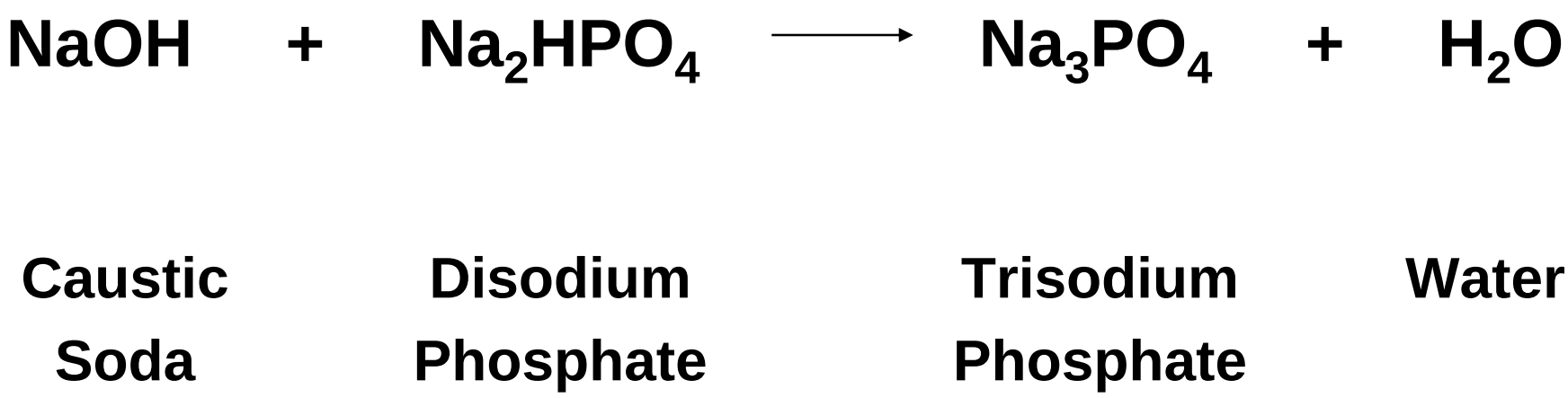
Caustic Concentration Mechanism



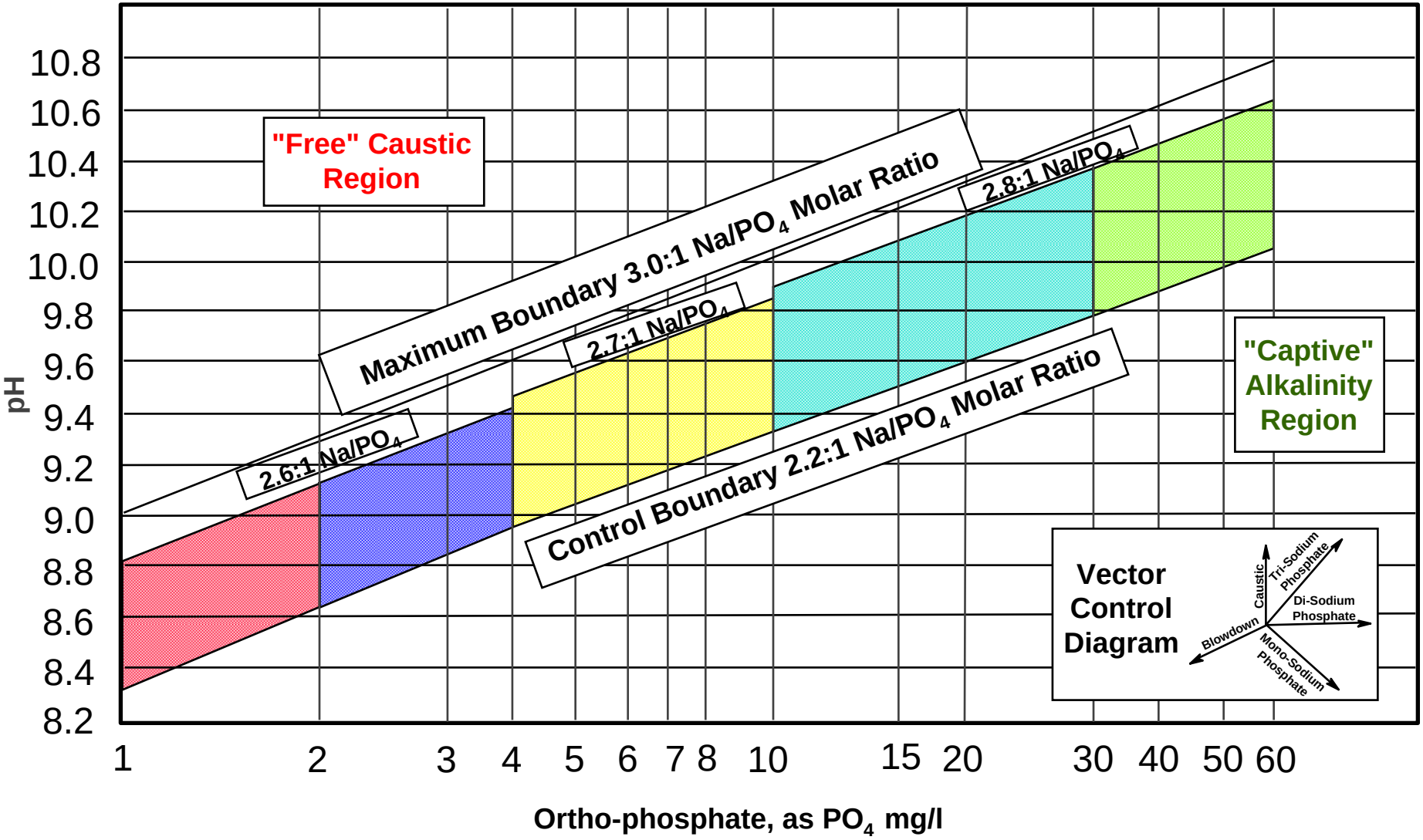
Prevention


magnetite
steam escapes
porous deposit
HPO_4^{2-}
Na^+
Na^+
HPO_4^{2-}
Na^+ Na^+
HPO_4^{2-}
HPO_4^{2-}
Na^+
HPO_4^{2-}
Boiler water in

Minimising Caustic Concentration and Corrosion using Phosphate



Co-ordinated Congruent Phosphate/pH Control Chart



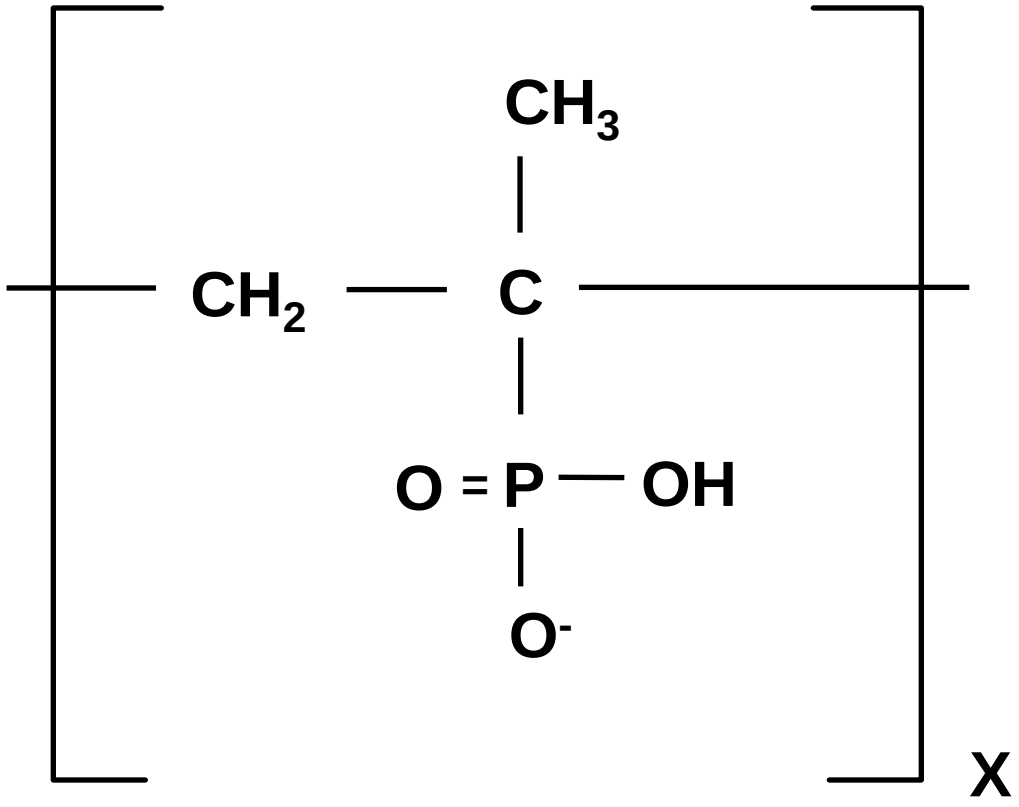
Internal Treatment Programmes

- Phosphate/Polymer
- Phosphonate/Polymer
- Chelant/Polymer
- Phosphate/Chelant/Polymer
- All Polymer
- Coordinated pH/Phosphate/Polymer OptiSperse HTP

Characteristics of HTP-2

- A unique new phosphorylated boiler polymer
- Particularly effective on iron
- Demonstrated clean-up ability
- Designed for high purity/high cycles systems
- Suitable for use up to 125 kg/cm^2

HTP-2 Polymer Structure



Poly (isopropenyl phosphonic acid) . . . PIPPA

Internal Treatment Programmes

- Phosphate/Polymer - OptiSperse PO, OptiGuard MCP
- Phosphonate/Polymer - OptiSperse PQ
- Chelant/Polymer - OptiSperse CL
- Phosphate/Chelant/Polymer - OptiSperse CP
- All Polymer - OptiSperse AP, OptiGuard MCA
- Coordinated pH/Phosphate/Polymer - OptiSperse HTP
- All Volatile Treatment (AVT)

COMPLETED