Advancements in Boiler Water Internal Treatment Chemistry

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FEBRUARY 10-14 ▲ SHERATON DENVER DOWNTOWN ▲ DENVER, CO

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Agenda

- The Problem of Boiler Waterside Deposition
- A Short History of Boiler Internal Treatments
- Advancements in Boiler Internal Treatment Technology
- A Case Study of Boiler Deposition Control

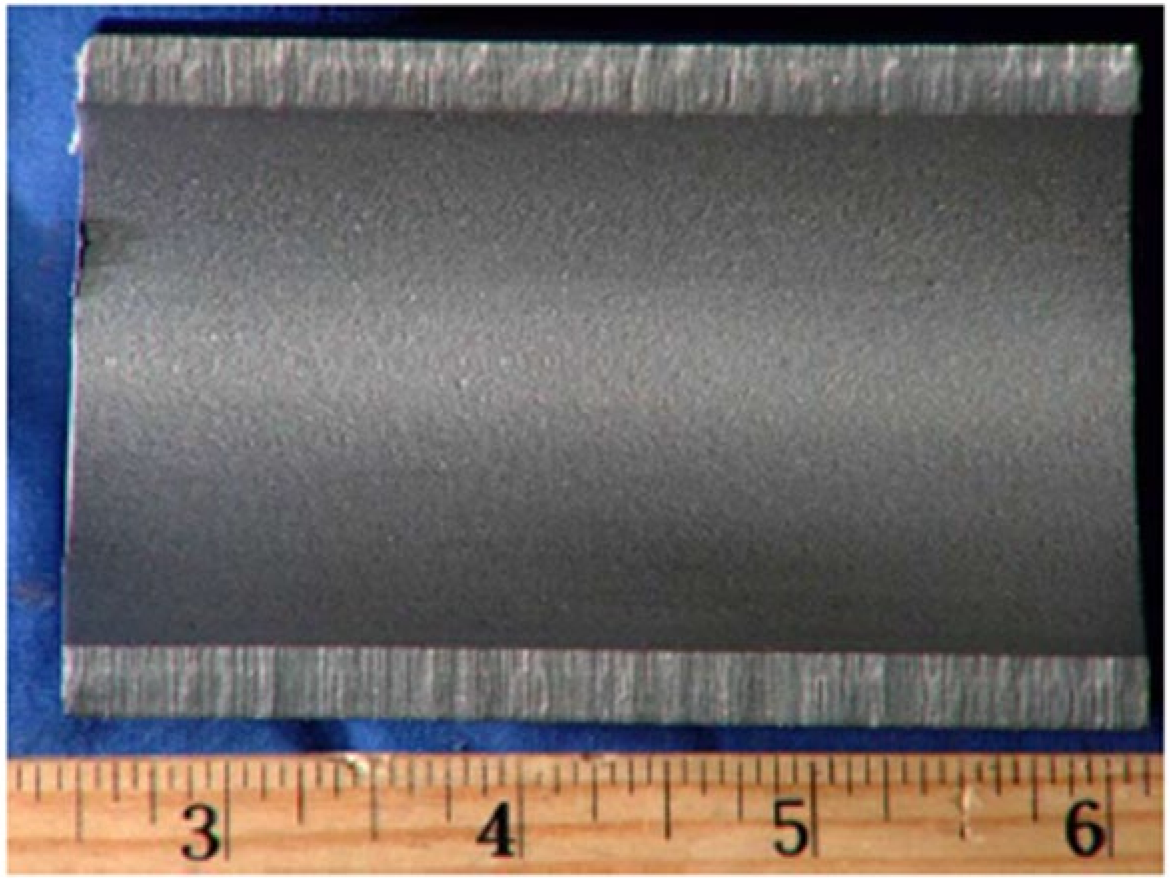
Boiler Waterside Deposition – What Goes in Must Come out!

BFW

1 kg/day of

contaminant

(Ca, Mg, Fe, etc)



Blowdown

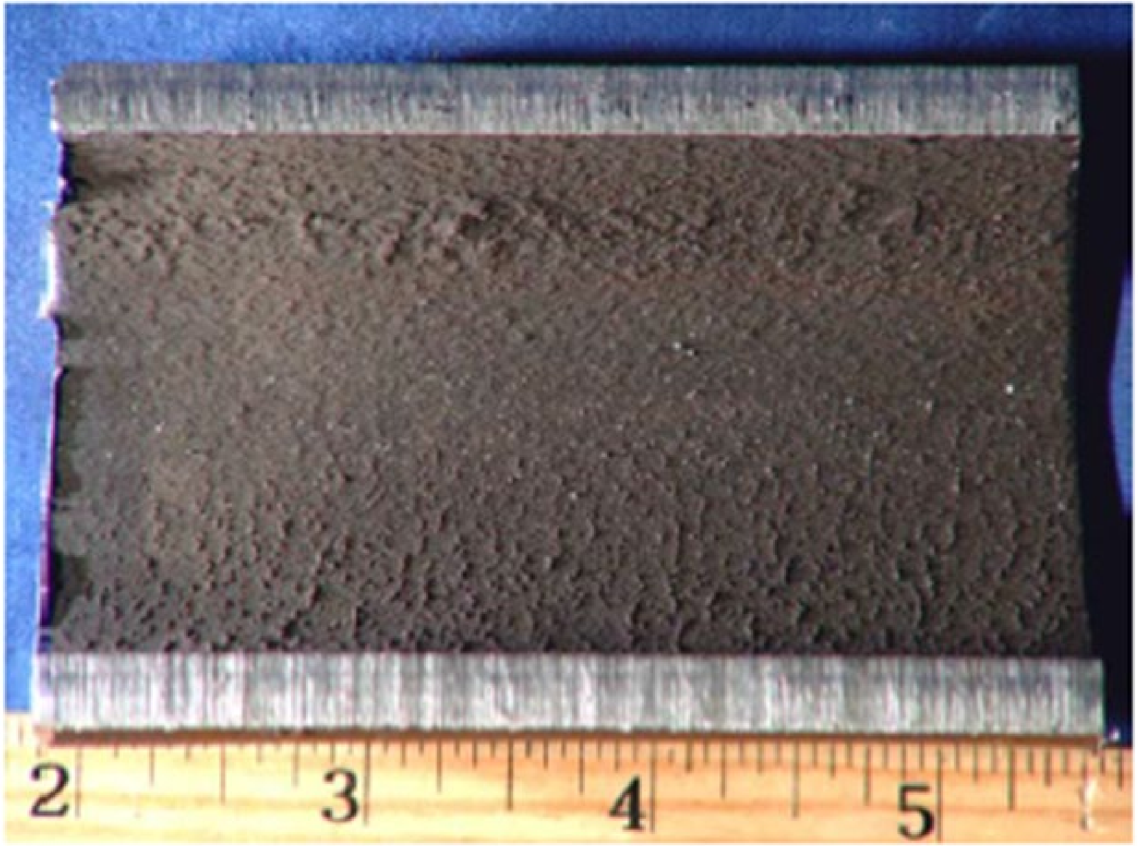
1 kg/day of

contaminant

Boiler Waterside Deposition – Where did the contaminant go?

BFW

10 kg/day of contaminant (Ca, Mg, Fe, etc)

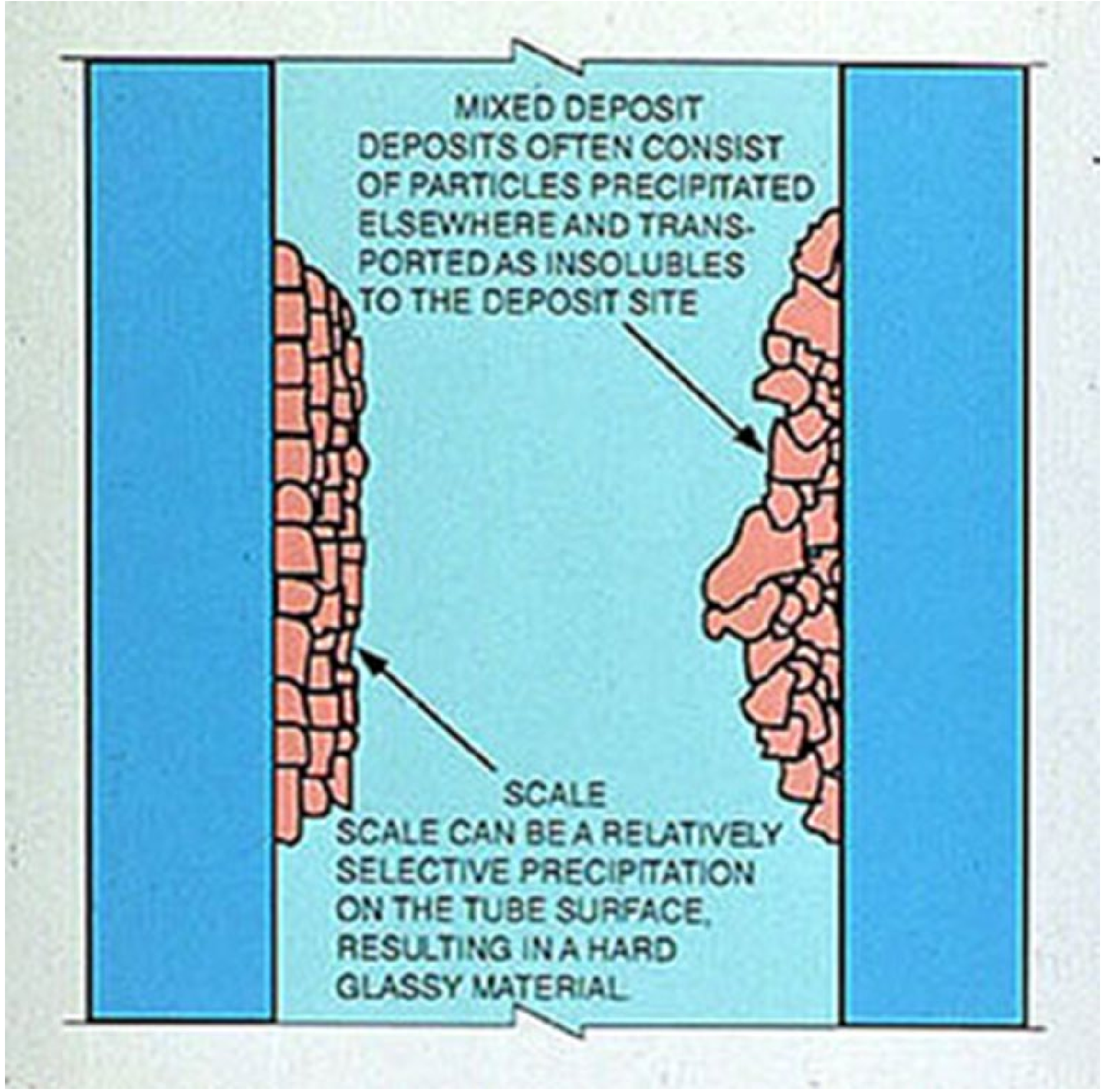


Blowdown

5 kg/day of contaminant

What Creates These Deposits?

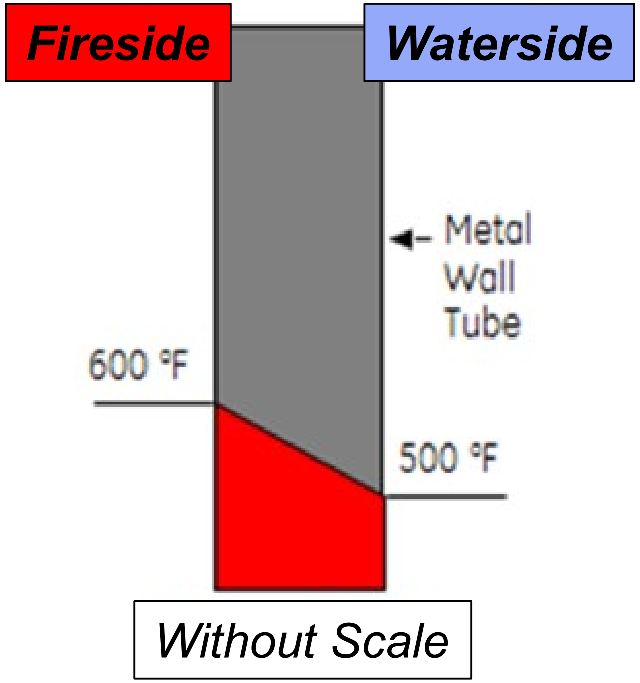
- All deposition can be tracked back to the boiler feedwater (BFW)
- 99% of work needs to be focused on BFW
- Important to understand BFW quality 24/7

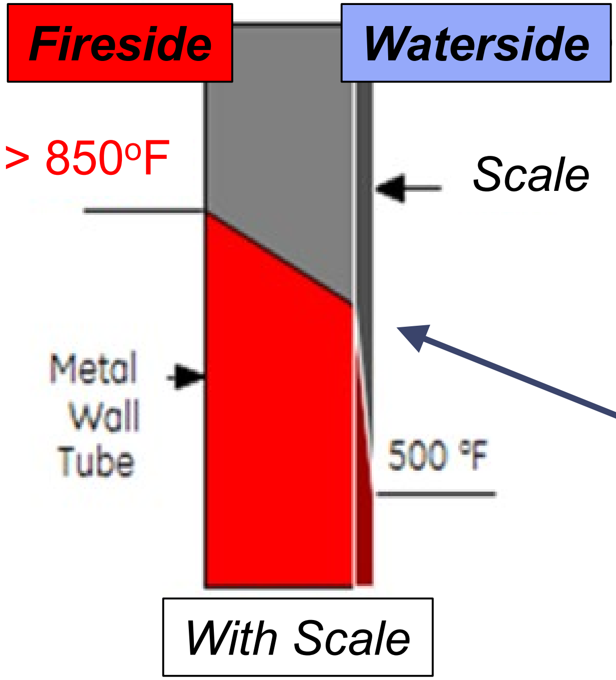


Boiler Feedwater Contamination

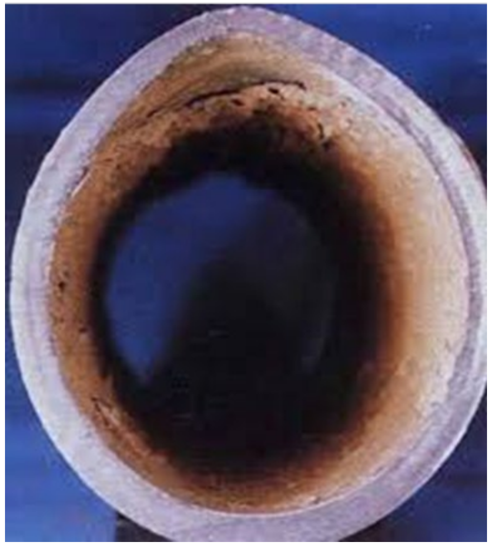
- We rarely, if ever, have zero contaminants in the feedwater
- How do we get this contaminant to transport thru?
  - Bottom Blowdown
  - Continuous Blowdown
  - Chemical Treatment
- Last resort….
  - Aqua blasting
  - Chemical Cleaning

Impacts of Boiler Waterside Deposition





Alloy	Composition	Maximum Recommended Service Temperature
SA-178, SA-210	Carbon Steel	850 F
SA-209 T1	0.5% Mo	900 F
SA-213 T11	1.25% Cr, 0.5% Mo	1025 F
SA-213 T22	2.25% Cr, 1.0% Mo	1075 - 1100 F



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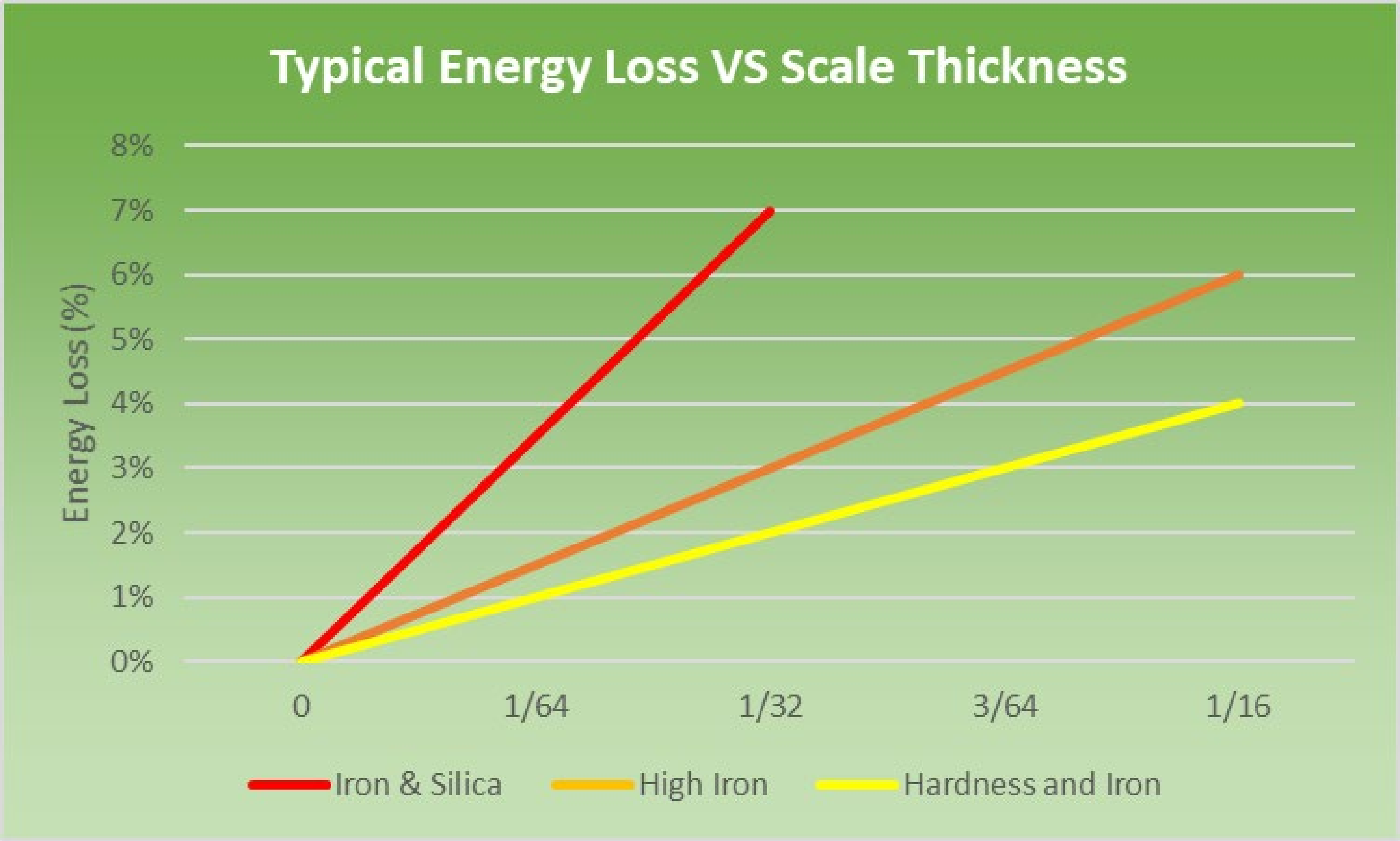
Impacts of Boiler Waterside Deposition

Element	Weight Percent
Calcium	51.2
Phosphate	21.6
Iron	13.6
Silicon	3
Copper	2.9
Manganese	2.3
Aluminum	2.2
Sulfur	1.2
Sodium	1.1

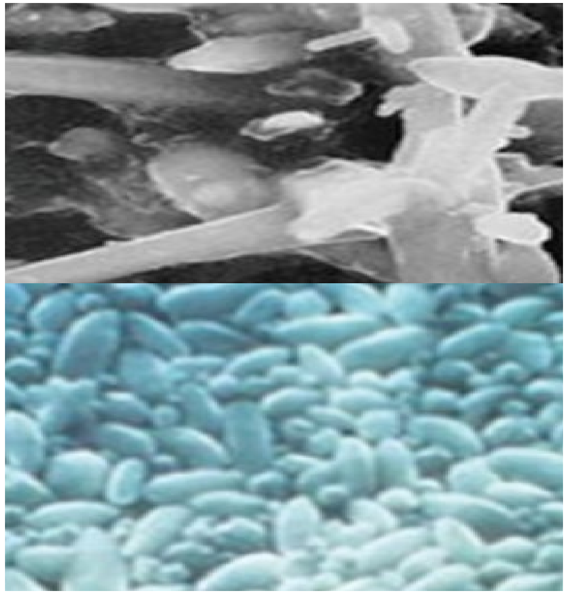
DWD Section	DWD (g/ft^2)	Internal Surface Deposit Thickness		Wall Thickness		Internal Pit Depth – Max. (in.)
		Min. (in.)	Max. (in.)	Min. (in.)	Max. (in.)	
Side I	194	0.016	0.028	0.135	0.137	0.002
Side II	197	0.023	0.033	0.132	0.139	0.002

Impacts of Boiler Waterside Deposition

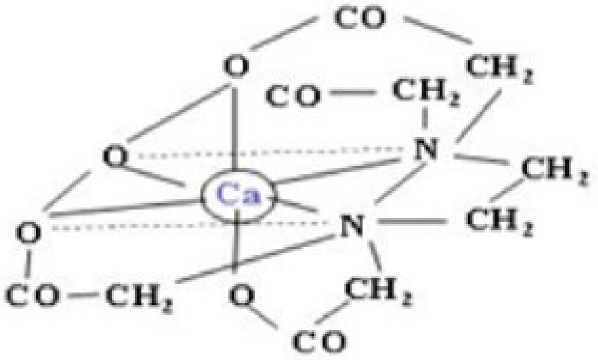


Internal Treatment Chemistry Advancements

- Polymer components make the backbone of today's internal treatment
- Prior to 2000's, many boiler systems were treated using other treatment strategies:
  - Sludge conditioning
    - Carbonate cycle (1900's)
    - Phosphate precipitation (1920's)
  - Complexation
    - Chelants (1950's)
  - First generation synthetic polymers (1970's)



Sludge conditioning



Complexation by chelant

Internal Treatment Chemistry Advancements

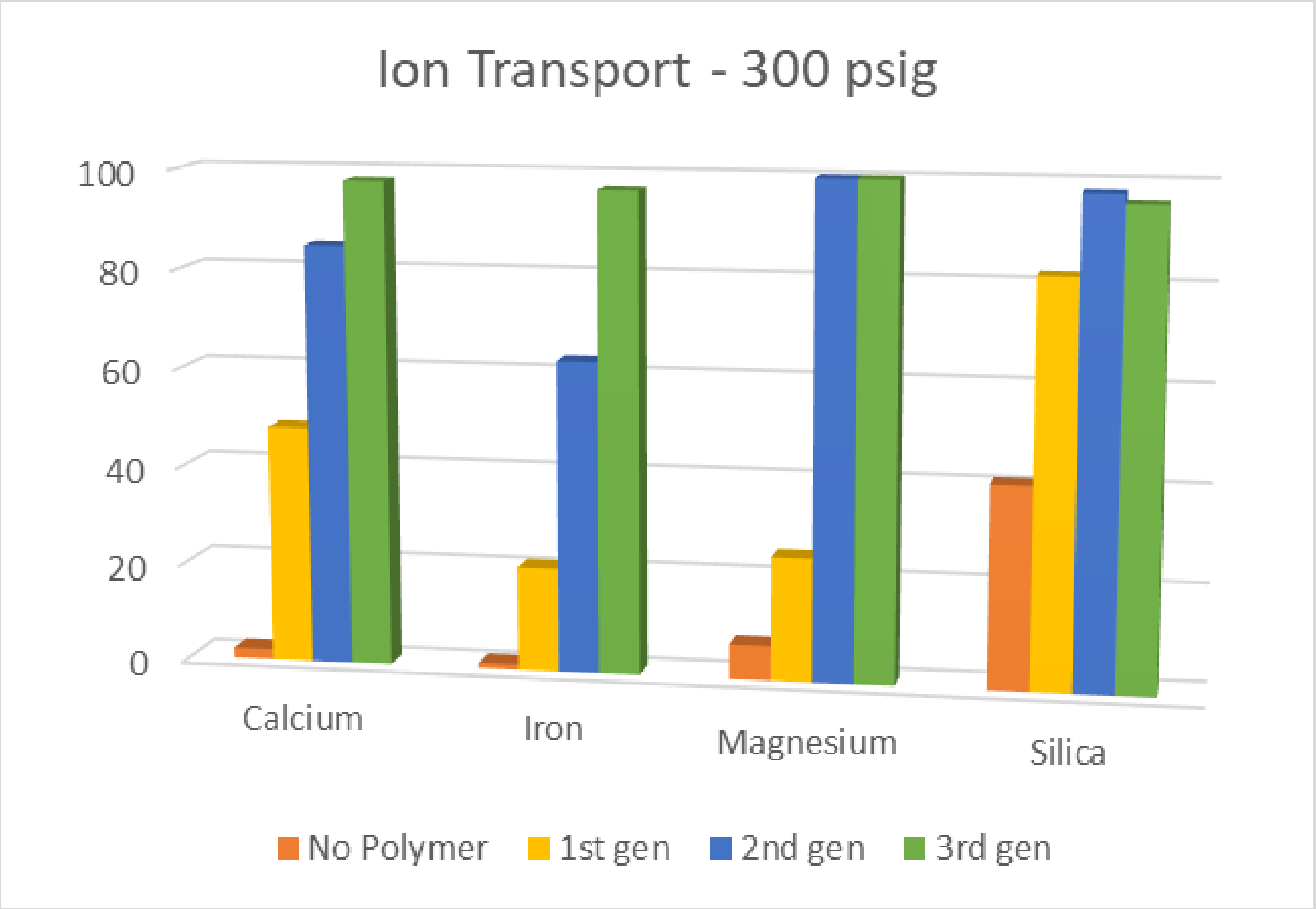
- Today's industry has refined 3rd generation boiler polymers
- The latest internal treatment programs are:
  - Performant and easy to use
  - Cost effective
  - Safe… to the users, the metallurgy and the environment !

Previous treatment

3rd generation treatment

Internal Treatment Chemistry Advancements

- Performance:
  - Cleaner surfaces
  - Better heat transfer
  - Lower fuel consumption
  - Lower risk of failure
  - Less maintenance (reactive and planned)



Internal Treatment Chemistry Advancements

- Ease of use:
  - Safe for the user
  - Can be fed to any part of the system
  - Works without constant proportional injection

SUEZ Research Boiler
On-line deposit removal evaluation
300 psig/magnesium silicate-dominated deposit

Deposit formed under upset conditions without treatment

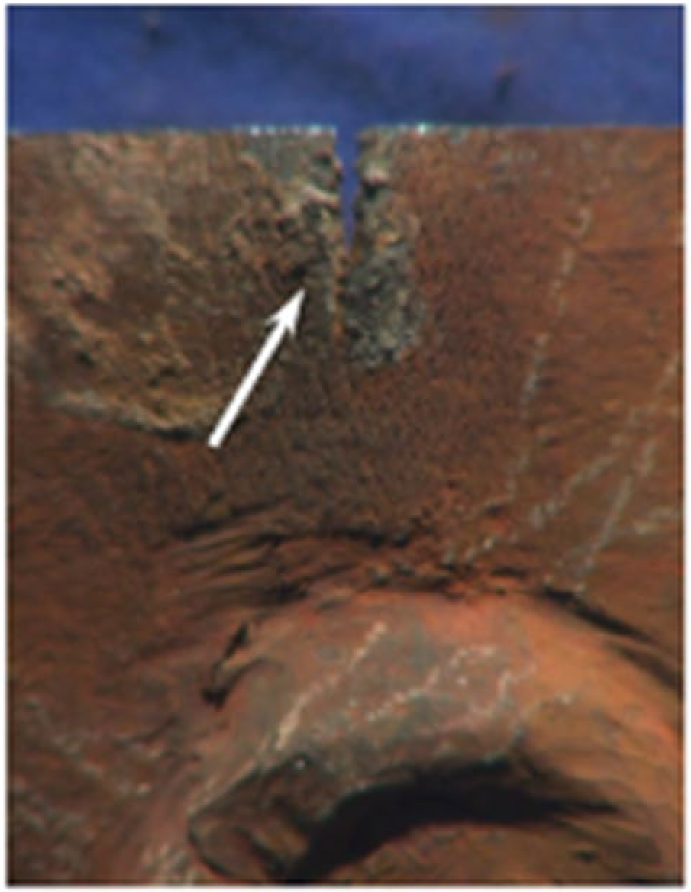
– Same tube as above –
After 3rd generation polymer applied (upset recovery)

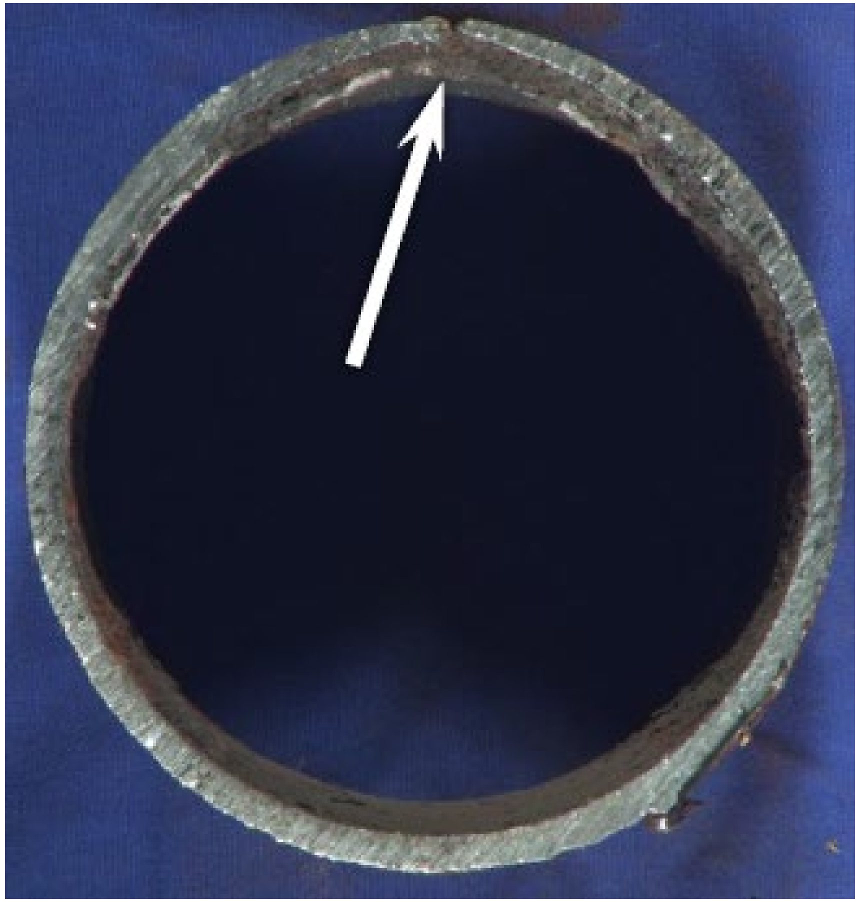
Case Study – 3rd generation polymer field application

- Heavy industrial facility @ 650 PSIG steam (4 boilers)
- Zeolite Softener Pretreatment - Hardness leakage in BFW
  - <50% Hardness transport
- One tube failure per month on average
  - Overheating and/or under deposit corrosion
- Phosphate precipitating internal treatment program

Ca	+	PO_4	+	OH	→	$Ca(OH)PO_4$
Calcium		Phosphate		Hydroxide		Hydroxyapatite

Case Study – 3rd generation polymer field application





Case Study – 3rd generation polymer field application

Element	Top ID Deposit (wt %)	Bottom ID Deposit (wt %)
Na	3.2	5.2
Mg	11.4	4.5
Al	3.2	1.1
Si	13.1	9.9
P	9.0	1.3
S	1.9	-
K	6.4	1.1
Ca	20.5	2.2
Fe	31.3	74.7

Case Study Problem Example

Parameter	DA 2	Boiler 4	Cycles	% Transport
Sulfur	3.3	53	16	100%
Silica	2	34	17	106%
Hardness	0.3	3.1	10	65%
Calcium	0.16	1.9	12	74%
Magnesium	0.14	1.2	9	54%
Chloride	1.9	32	17	105%
Iron	0.02	0.21	11	66%
Phosphate		16.9		

$$\%\,Ion\,Transport = \frac{(ppm\ \ ion\ \ in\ Boiler\ \ blowdown\ )}{(ppm\ \ in\ Feedwater\ \ \ X\,Cycles\ \ of\ \ Concentration\ )}\ \ \text{x } 100$$

Case Study Problem Example

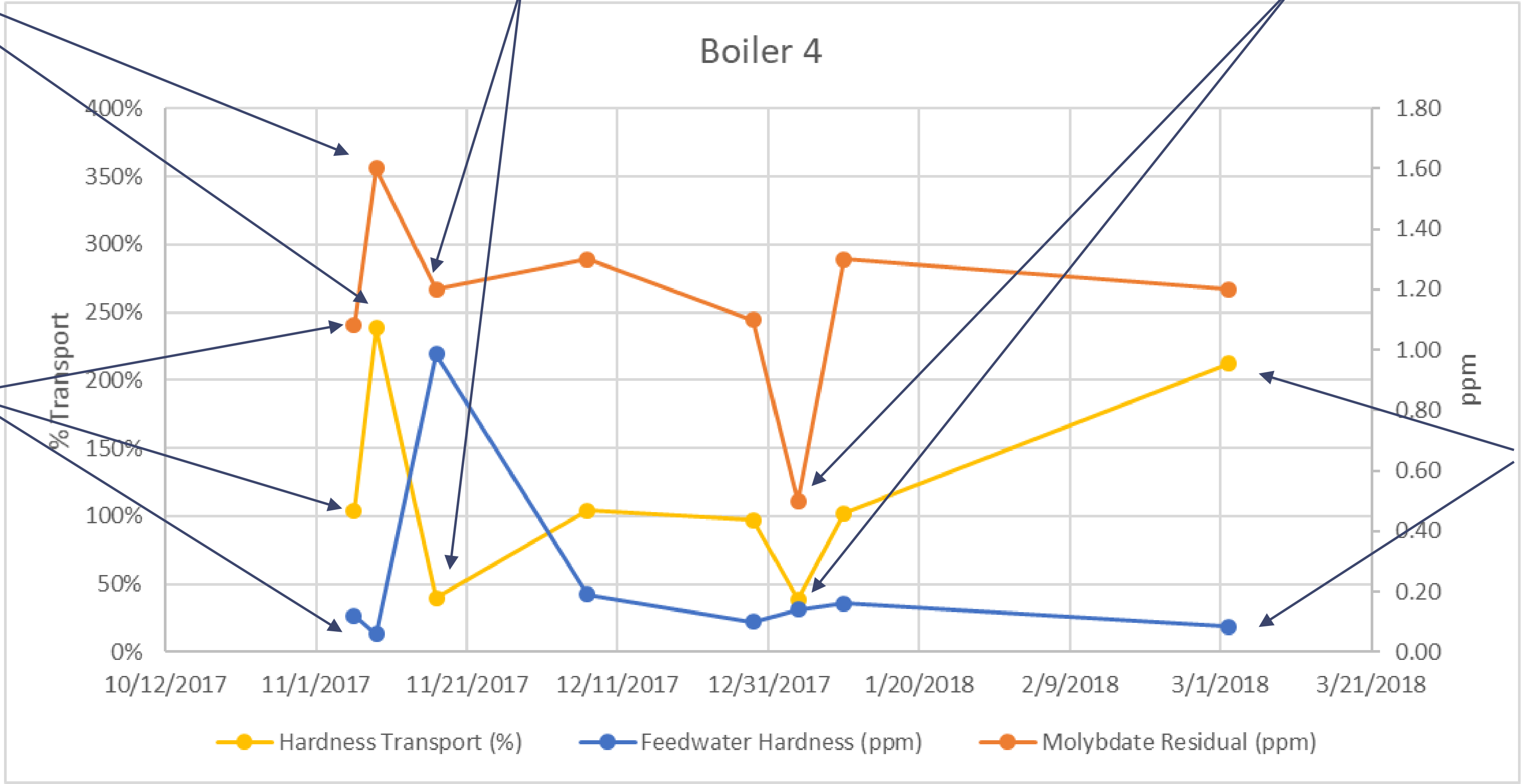
↓ BFW TH and ↑ Treatment = 100+% Transport

↑ Hardness = ↑ Treatment required

Treatment underfeed = <50% Transport

Applied Treatment adequate for Hardness in BFW

↓ BFW TH = >100% Transport



Case Study Problem Example

2015 Inspection – Mud Drum

2018 Inspection – Mud Drum

Case Study Problem Example

2015 Inspection - Mud Drum Third Row Tube

2018 Inspection - Mud Drum Third Row Tube

Case Study Problem Conclusions

- Hardness recovery from <50% to 120%
- Complete elimination of monthly boiler tube failures
- Greatly improved boiler waterside cleanliness
  - Heat transfer efficiency gain

Case Study Problem – Lessons Learned

- Treatment significantly outperforms dated phosphate/polymer chemistry
  - From <50% to 120% Hardness Transport
- Treatment must be fed proportional to contaminant load to maintain 100% contaminant transport
- Treatment exhibits forgiving capabilities
  - Ability to recover from hardness excursion and disperse existing scale

QUESTIONS?

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