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Boiler Water Chemistry

Best Practices - A key to success in Super Critical Boilers

By: Team NTPC

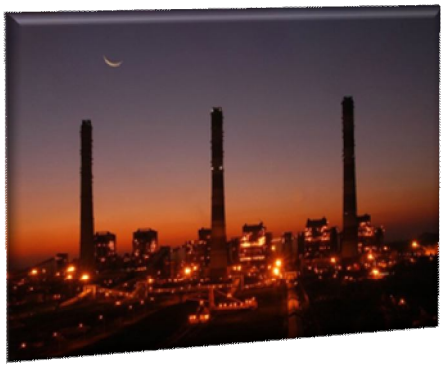
Nov 21, 2013

PRESENTATION OUTLINE

- NTPC Overview
- OT – Introduction
- Oxygen Dosing System Details
- Operation and Control
- AVT v/s OT – Data Comparison
- AVT v/s OT - Benefits
- Results and Conclusion

Our Vision

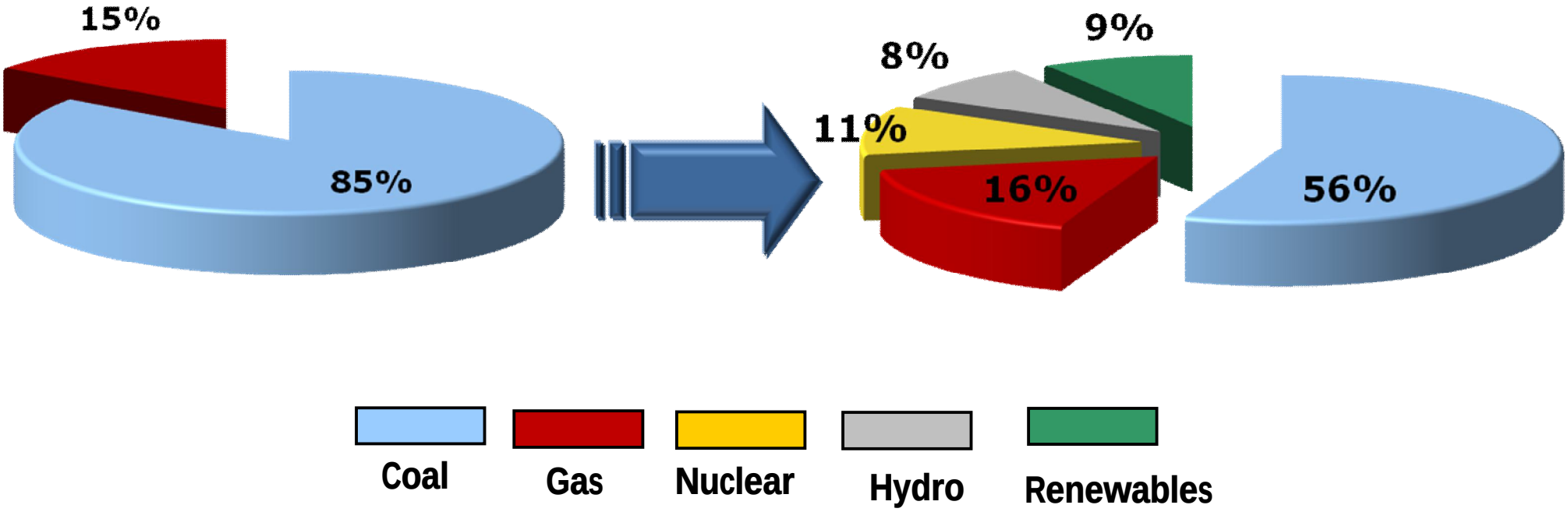
“To be the world’s largest and best power producer, powering India’s growth”



Planning for Accelerated Growth

Today
~41 GW*

2032
~ 128 GW



Capacity under construction: ~20 GW

* 10 MW Solar PV Projects

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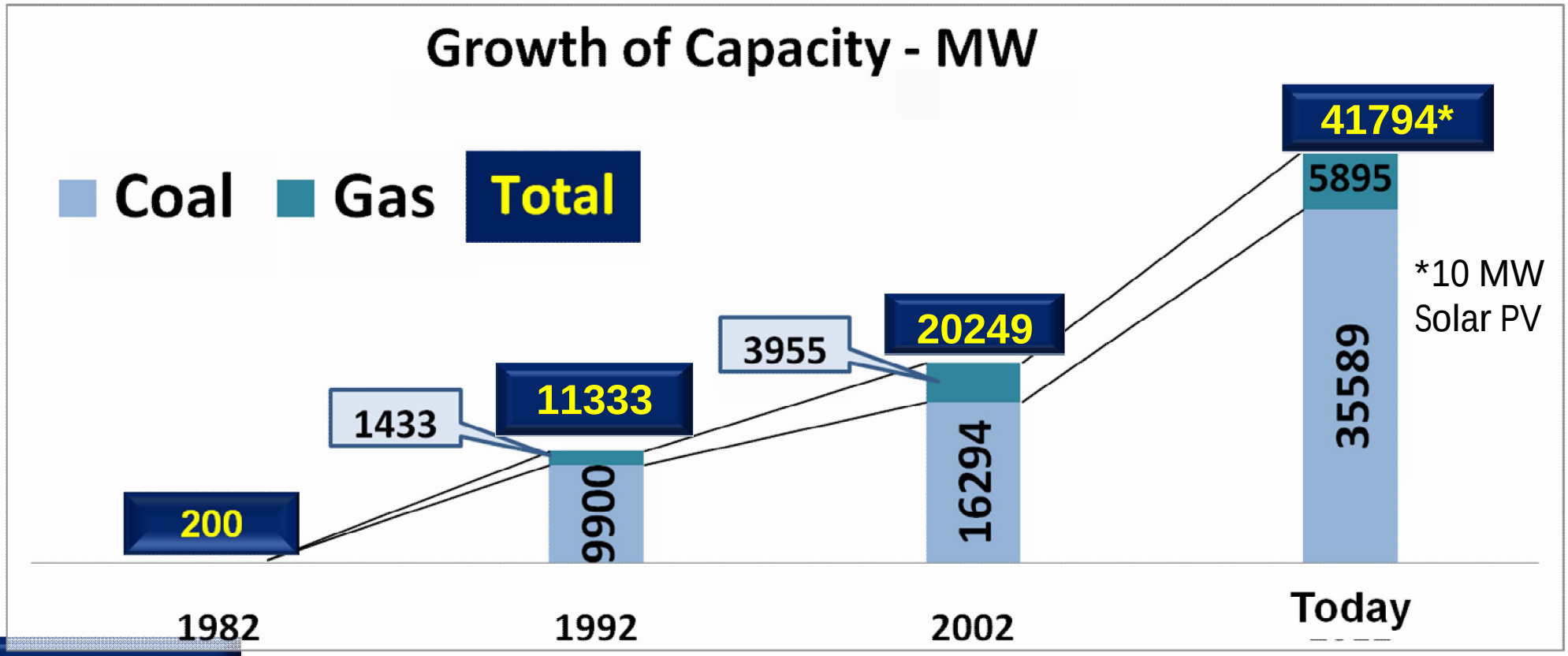
NTPC's Growth Journey

1975	1982	1997	2004	2010	2013
NTPC incorporated	First 200 MW unit commissioned	Became a Navratna Company	Listed on Indian Stock Exchanges (GoI holding 89.5%)	• Became a Maharatna Company • GOI divested 5% equity	• GOI further divested 9.5% equity



Pan India Presence

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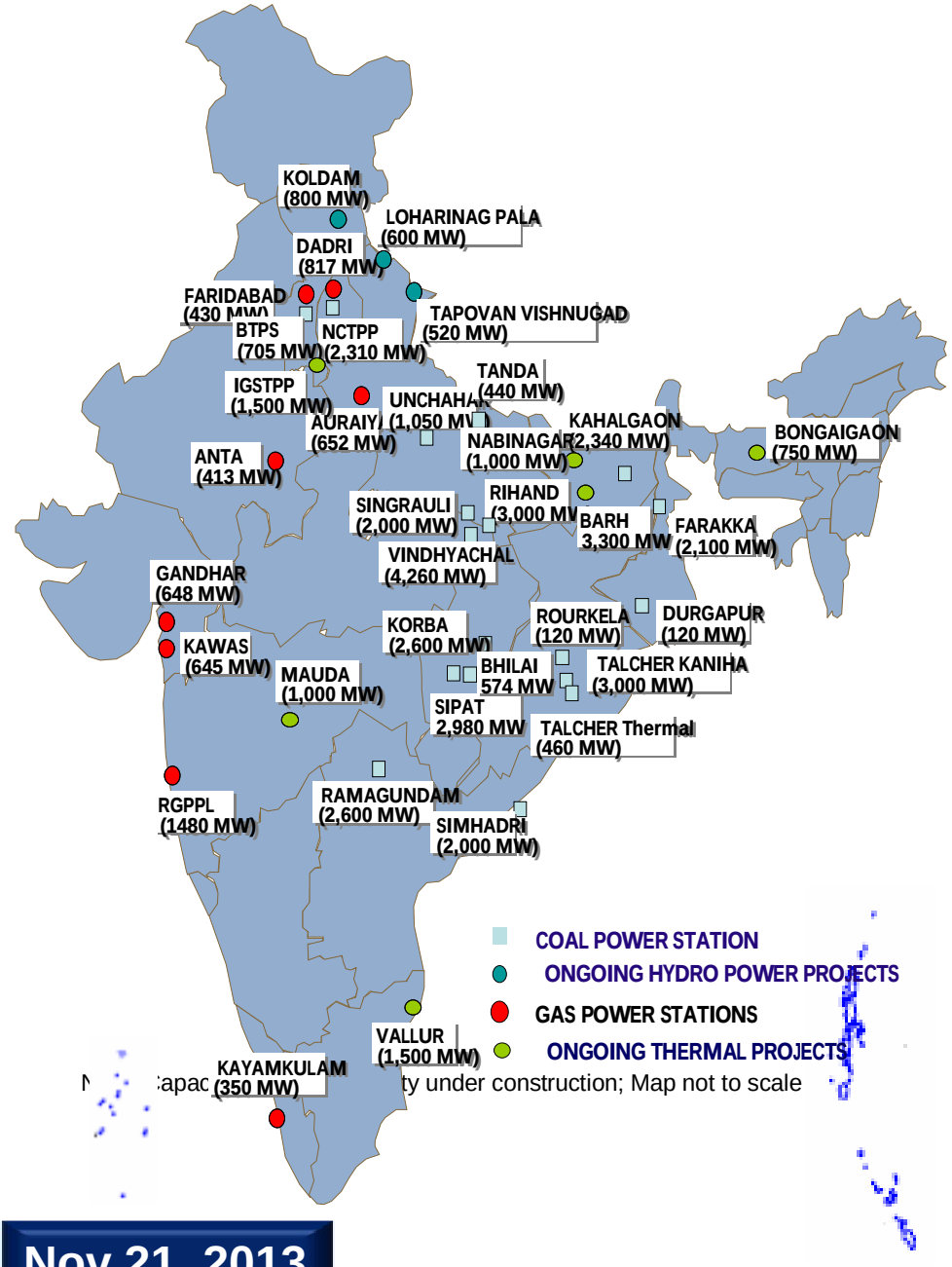
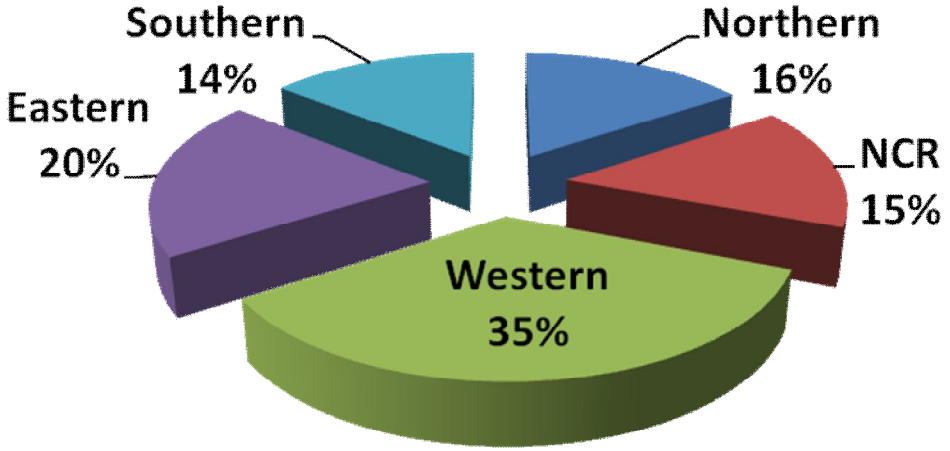


	No. of plants	Capacity MW	Share
NTPC Owned			
Coal	16	32,355	77.42%
Gas/Liquid fuel	7	3955	9.46%
Solar	2	10	0.02 %
Sub-Total	**25**	**36,320**	**86.9%**
Owned by JVs			
Coal	6	3534	8.46%
Gas	1	1940	4.64%
Sub-Total	**7**	**5474**	**13.1%**
Total	**32**	**41,794**	**100%**



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Sustainable Power Development

Implementing high efficiency technology

3x660 MW (1980 MW) - Commissioned at Sipat
14x660 MW (9240MW) - Under construction at Barh, Mouda, Solapur, Meja & Nabinagar
2X660 MW (1320 MW) - Under bidding
7x800 MW (5600 MW) - Under construction at Kudgi, Lara & Gadarwara
2x800 MW (1600 MW) - Under bidding

Hydro, Renewable & Nuclear Energy forays

- 1499 MW hydro capacity under construction
- Developing Wind and Solar capacities – 1000 MW by 2017
- Anushakti Vidhyut Nigam Ltd. - JV company formed with NPCIL for nuclear power development - NTPC(49%) & NPCIL(51%) – 14 GW by 20

Research & Technology Development

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NTPC Energy Technology Research Alliance

NETRA

Focus Areas

- Efficiency & Availability Improvement and Cost Reduction
- Renewables and Alternate Energy
- Climate Change and Environment
- Scientific Support to Stations

- ECBC (Energy Conservation Building Code) compliant building
- ISO/NABL 17025 Certified Labs, CBB certification

Investment of more than 1% of PAT for R&D Activities and Climate Change studies

OXYGENATED TREATMENT (OT)

- Oxygenated treatment – Feed water treatment or conditioning.
- Injection of High purity oxygen gas at CPU & Deaerator outlet
- Conversion of Fe_3O_4 (Magnetite) to hydrated FeOOH and Fe_2O_3 (Hematite).
- Hydrated FeOOH and/or Fe_2O_3 block the pores in the magnetite layer and forms a more adherent protective layer and reduces the migration of iron
- Prevents flow accelerated corrosion (FAC).

FEED WATER SPECIFICATION

S.N	Parameter	Units	Normal Operation		During Start up
			Alkaline water Treatment	Oxygenated Treatment	
1	pH		Min 9.0	8-8.5	Min 9.0
2	ACC, ms/cm	ms/cm	Max 0.2	<0.15	Max 0.5
3	D O	ppb	< 5	30-150	Max 100
4	Iron	ppb	< 2	< 2	< 20
5	Sodium	ppb	< 2	< 2	< 10
6	Silica	ppb	<10	< 10	< 30
7	Turbidity	NTU	<2	< 2	<5

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STEAM PARAMETERS LIMITS

Parameter	Normal	Action 1 (2 weeks per year)	Action 2 (2 days per year)	Action 3 (8 hours per year)	Immediate shut down
ACC, ms/cm	<0.15	>0.2	>0.3	>0.6	>2
Silica, ppb	10	>10	>30	>40	>50
Sodium, ppb	<3	>3	>6	>12	>24
Chloride, ppb	<3	>3	>6	>12	>24

STEAM WATER ANALYSIS SYSTEM (SWAS)

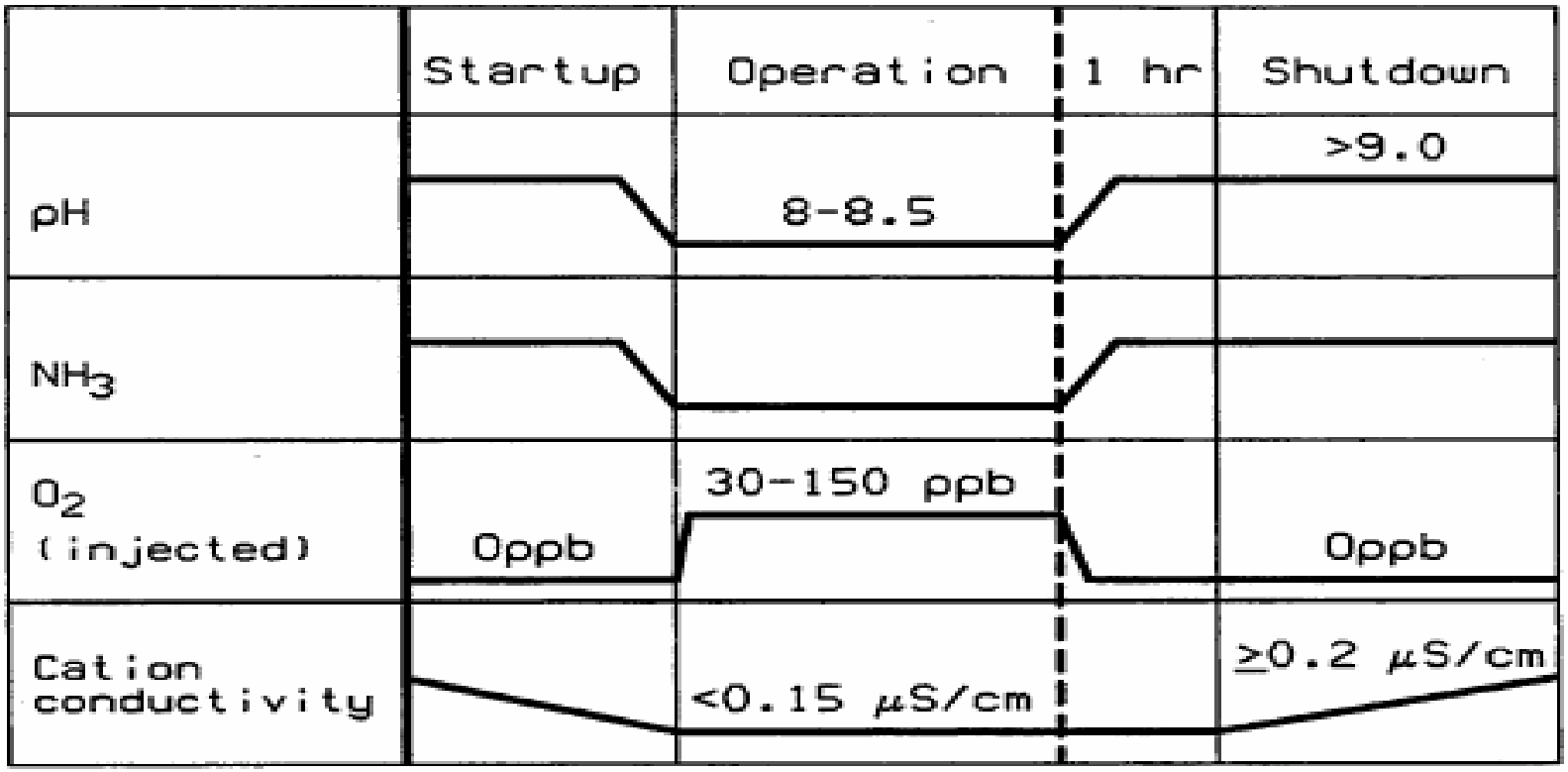
Online Monitors:

S.No	System	Type of measurement
1	Make up DM water	SP.COND., CATION CONDUCTIVITY (ACC)
2	CEP discharge	pH, ACC, Na, DO, SP.COND.,
3	CPU Outlet	pH, ACC, Na, SILICA, SP.COND.,
4	Deaerator outlet	DO
5	Feed water at economizer inlet	pH, ACC, COND., SILICA

STEAM WATER ANALYSIS SYSTEM (SWAS) contd….

S.No	System	Type of measurement
6	Separator outlet steam	ACC, SP.COND., SILICA
7	Main steam	pH, ACC, Na, SILICA, SP.COND.,
8	Water separation storage tank of boiler	Cation conductivity (ACC)
9	Reheated steam	Cation conductivity (ACC)

STARTUP, OPERATION AND SHUTDOWN



- Stop oxygen feed at least one hour before shutdown
- Increase ammonia feed rate to achieve a pH > 9.0
- Open Deaerator vents

CRUD LOAD DURING START UP

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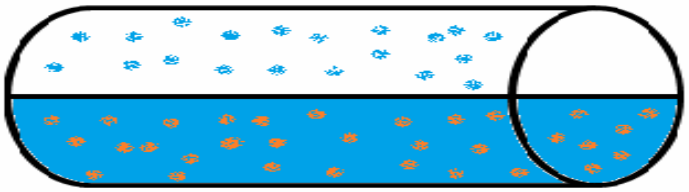
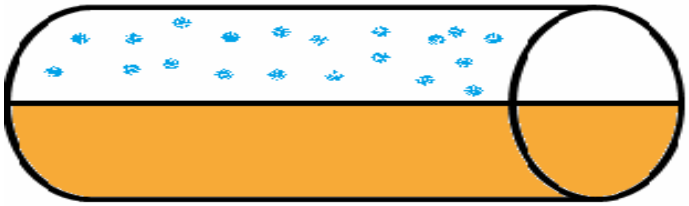
Normal Running condition

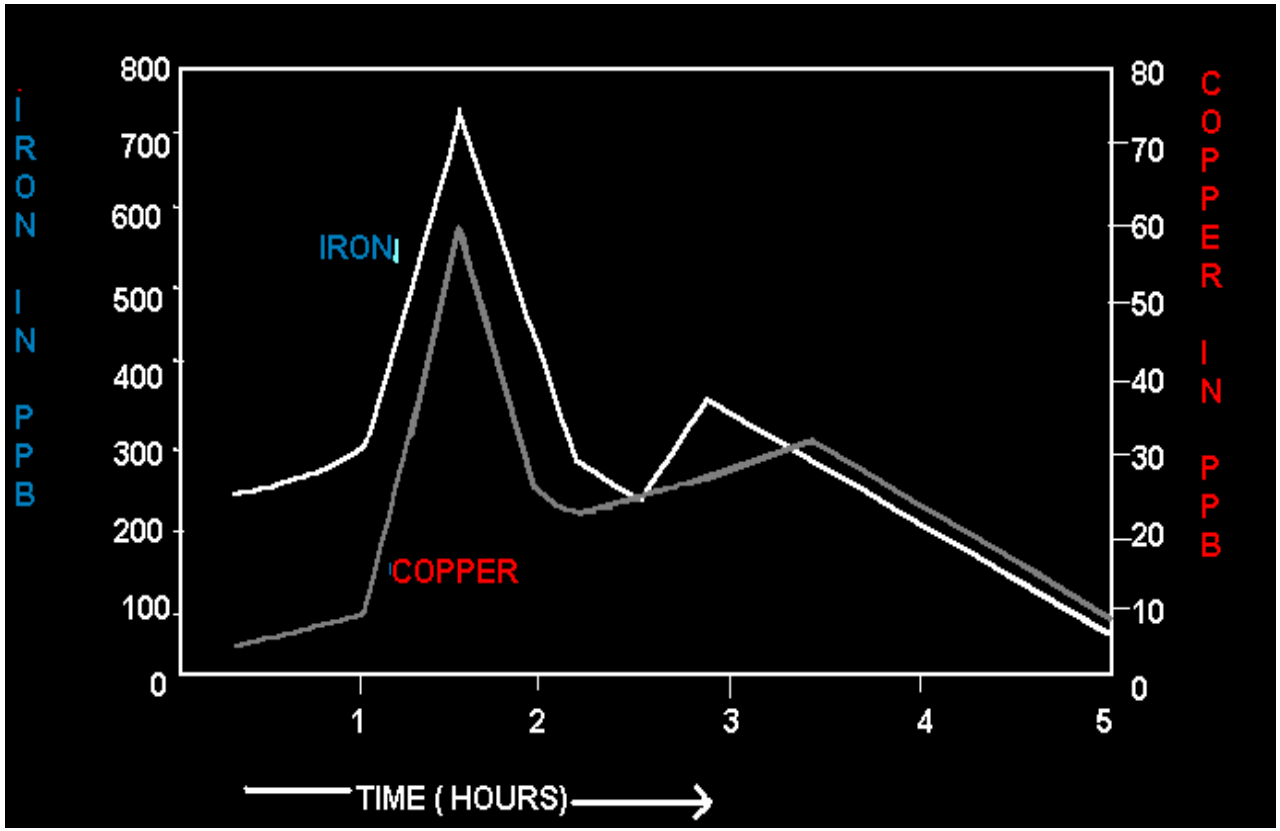


During shut down
Ammonia vaporise to upper layer



During shut down
Dissolution of iron in low pH water

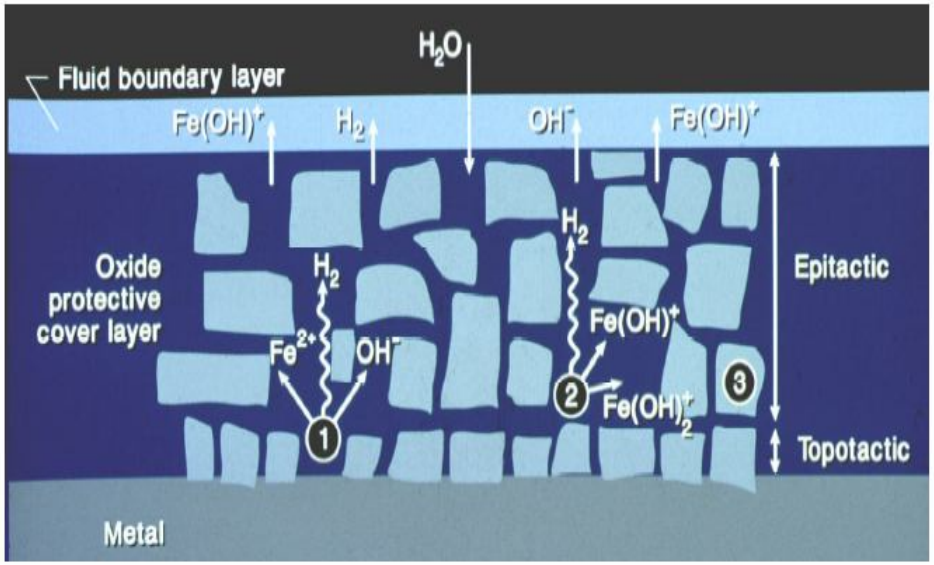
Crud load during start up



Water wall tube deposits from feed iron transport

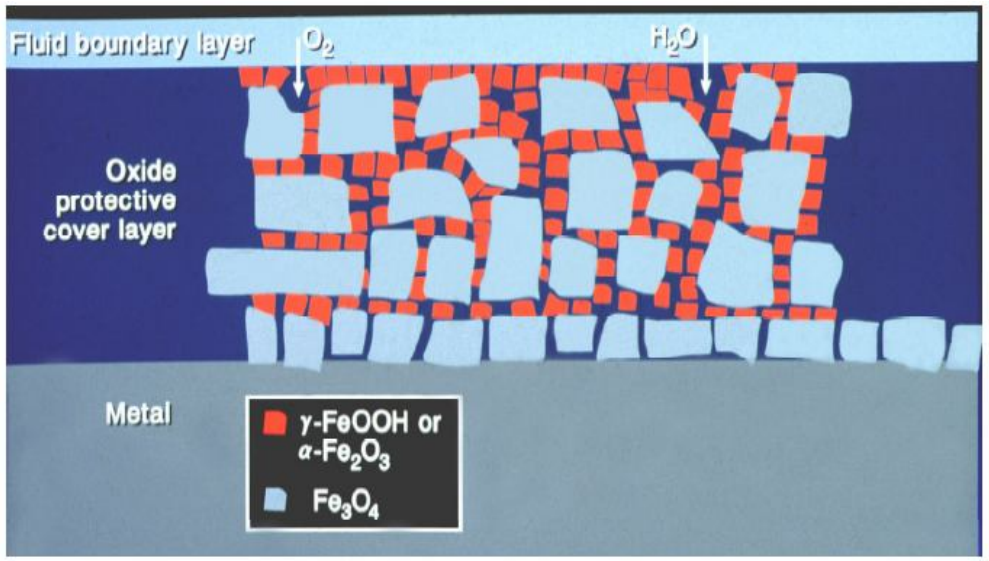
BOILER PROTECTIVE LAYER

AVT

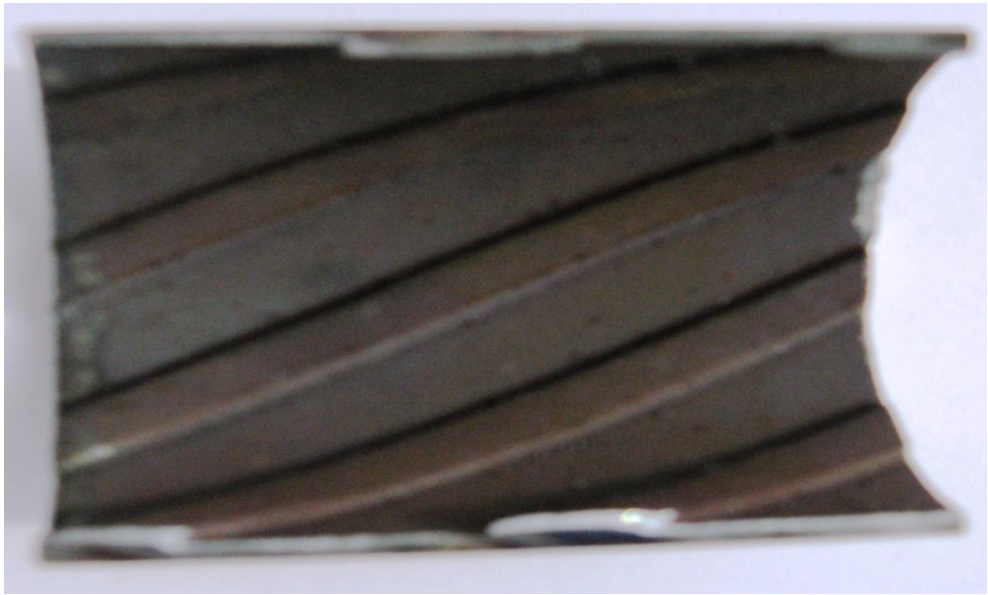


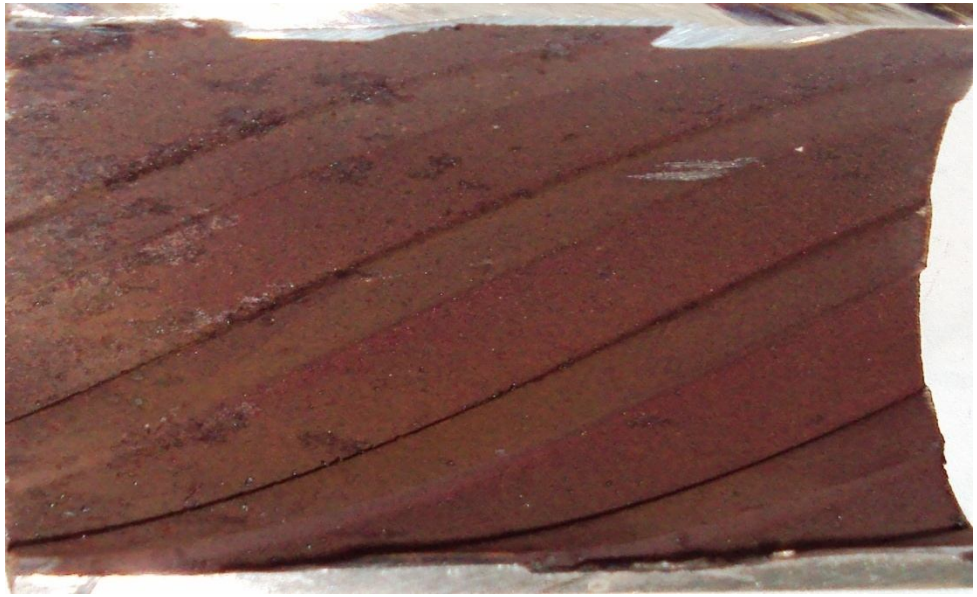
Migration of Fe^{2+} to fluid boundary layer

OT



$FeOOH/Fe_2O_3$ block pores lowering Fe^{2+} migration

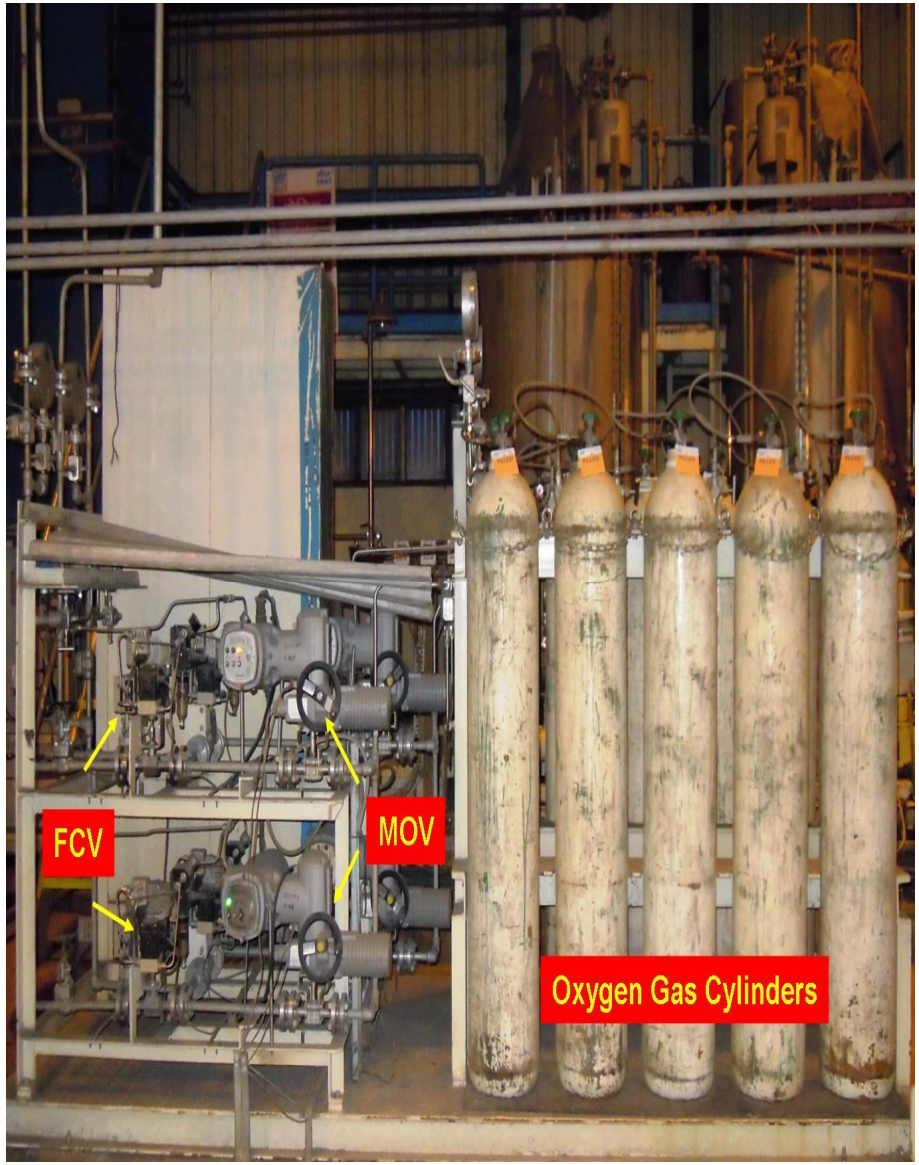




OXYGEN DOSING SYSTEM

The piping material is of SS 316

- Pressure Regulating Valve
- Flow Control Valves
- Gas Cylinders
- Motorised Valves



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OPERATION AND CONTROL

- Five gas cylinders charge at once at regulated pressure 42 ksc
- The safety valve operates, if gas pressure is >50ksc.
- Four dosing lines - two each at D/A and CPU outlet
- Dosing line with one Motorised (MOV) and one Flow control valve (FCV)
- The MOV is fully opened and gas flow is controlled by FCV.

OXYGEN DOSING OPERATION

The injection control is automatically adjusted by Condensate water flow and Feed DO.

CONVERSION TO OT - ACTIVITIES

Pre OT Activities

- Instruments Installation – DO meter, ACC
- Install Sampling lines – ACC, pH, K at each CPU Vessel
- Replacement of De-aerator O/L sample line by Feed water line to analyzer for round the clock monitoring of Feed DO.

PORTABLE D.O. METER

PORTABLE A.C.C. METER

OT CONVERSION - ACTIVITIES

CPU Availability

- 100% CPU availability
- Formal training to Shift –Chemist regarding CPU operation.

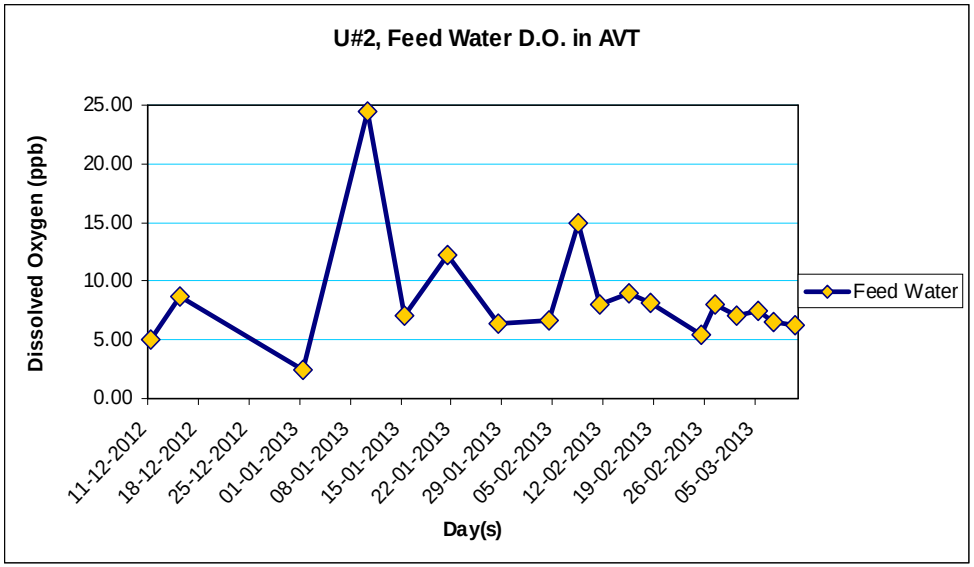
Training Session

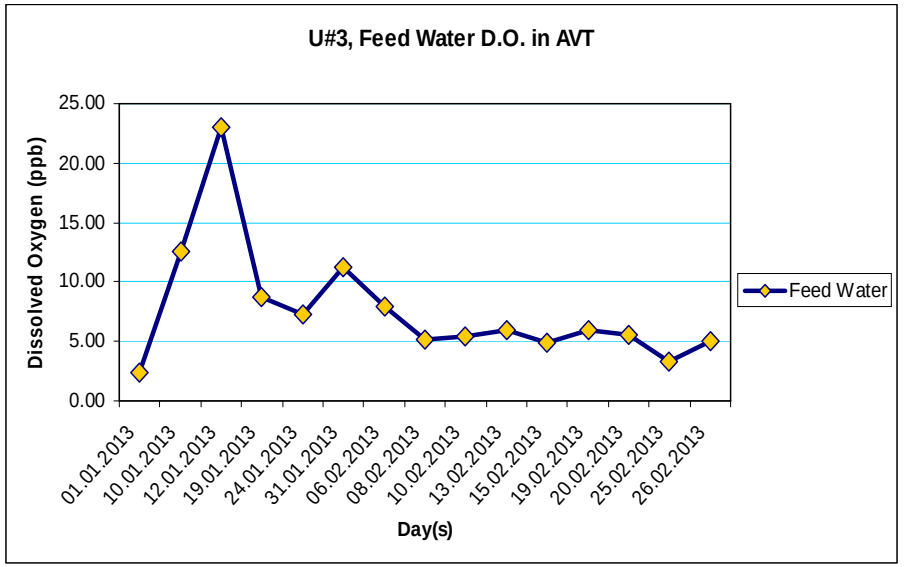
- The training session for operators regarding OT &
- Actions to be taken during start-up, shut-down and in normal operation.

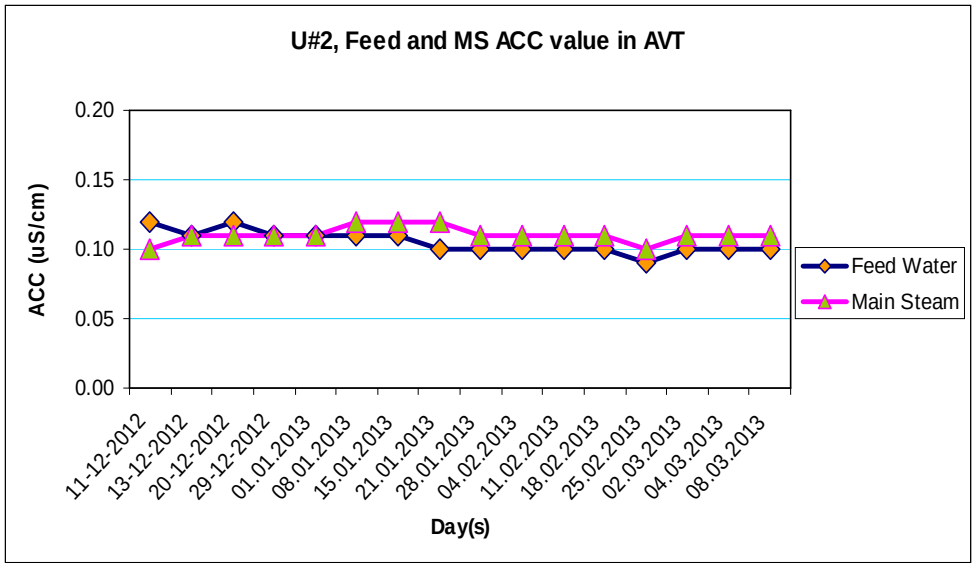
Database

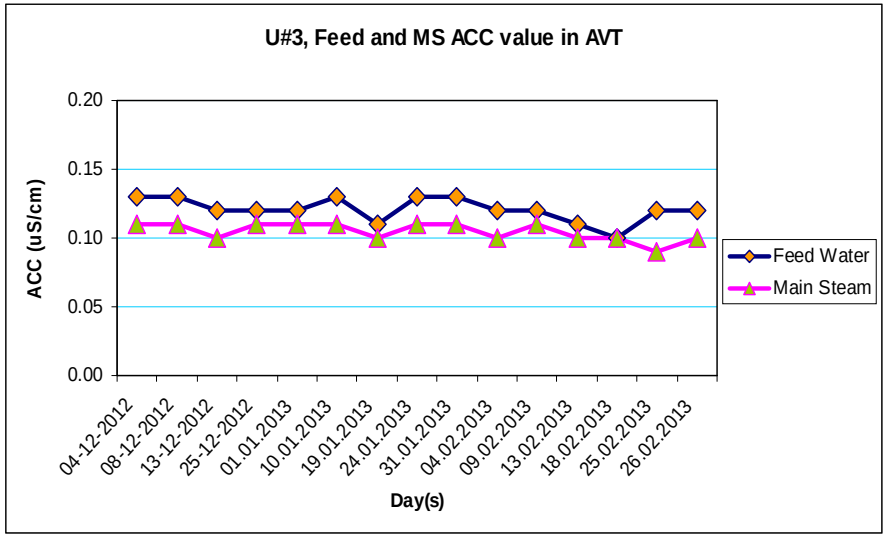
- Recording and observing parameters for three months before start comprising Feed & CEP DO
- Monitoring of ACC of cycle chemistry under AVT condition to ensure the readiness of boilers for conversion to OT.

DO/ACC DATA TREND BEFORE OT









COMMISSIONING ACTIVITIES.

Instrument Checking

- Calibration of all pressure gauges and transmitters
- Checking of following for protection of FCV.
  - Pressure regulating valve & set at 42ksc
  - Pressure safety valve & set at 50ksc.

Valve Operation

- Checking of all MOVs and FCVs for local and remote operation.

Leak Detection Test

- Pressurizing of dosing lines
- Checking for any gas leakage at every weld-joint.

GAS FLOW MEASUREMENT & FCV SETTING

- Most important activity as dosing of oxygen gas with in limit is dependent on FCV setting.
- Measurement of gas flow using Balloons (spherical and cylindrical) and a connector

CONVERSION TO OT - GUIDELINES

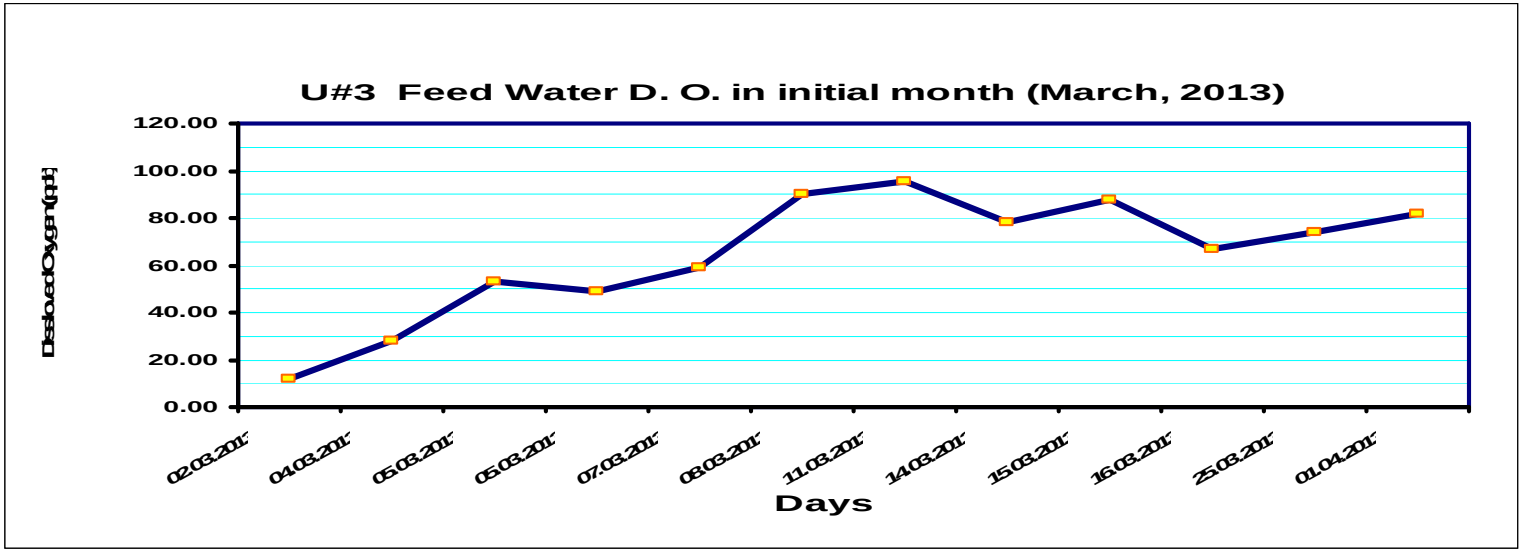
- Based on DO data of different units, decision to start OT first in one unit.
- Steady rate of passivation, [target value of DO is set max. 80 ppb (range 30 -150 ppb)].
- Initially operation at 9.0 to 9.2 pH and then slowly and steadily convert to lower value by monitoring Feed ACC.
- Afterwards operate DO level at 80 -110 ppb range.

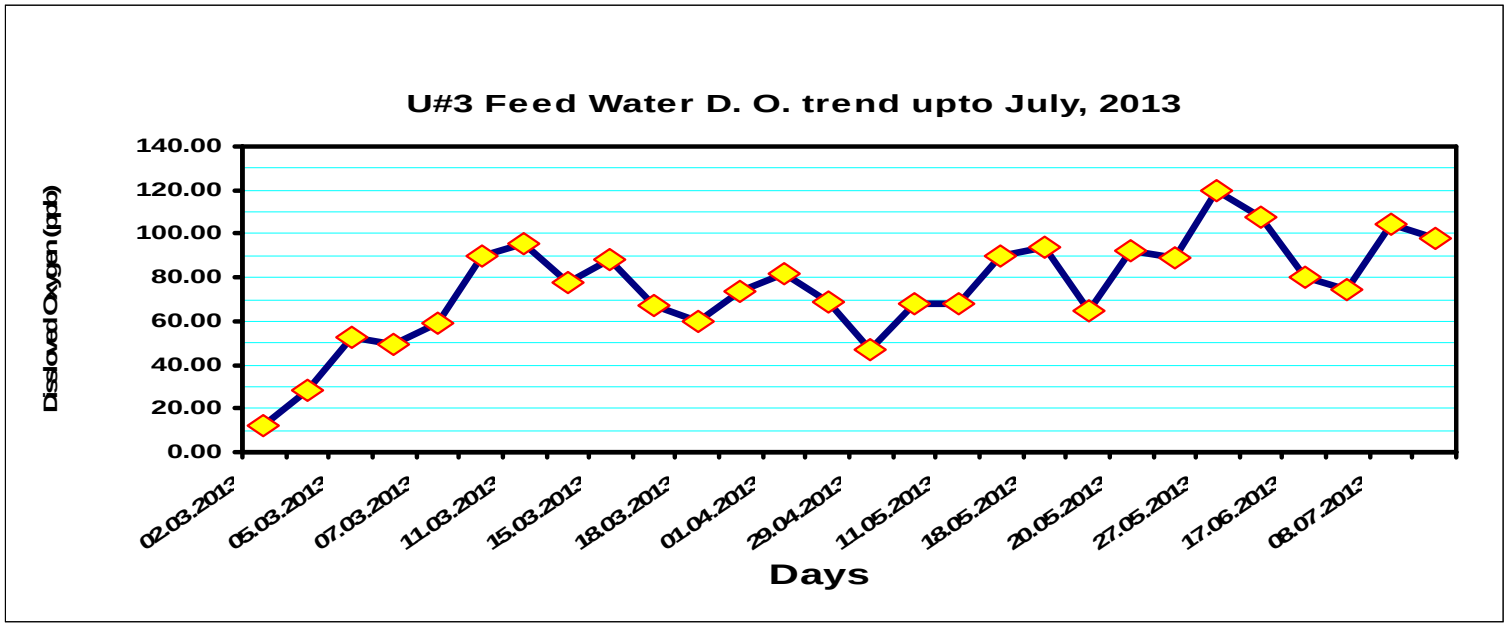
CONVERSION TO OT – Case study

Case study 1:

- Oxygen dosing started
- The D/A vents fully closed and oxygen dosed at CPU O/L.
- Feed DO started increasing from 6.8 ppb to 20 ppb within 10hrs
- After two days, Feed DO attained 20-40 ppb range only
- Additionally the dosing carried out at D/A O/L as minor passing was observed from D/A vent.
- After that, DO increased to 65-80 ppb.
- The target value achieved within 5days of start of OT.
- In the second phase, operation started at DO level of 80-110 ppb.

CONVERSION TO OT – Case Study



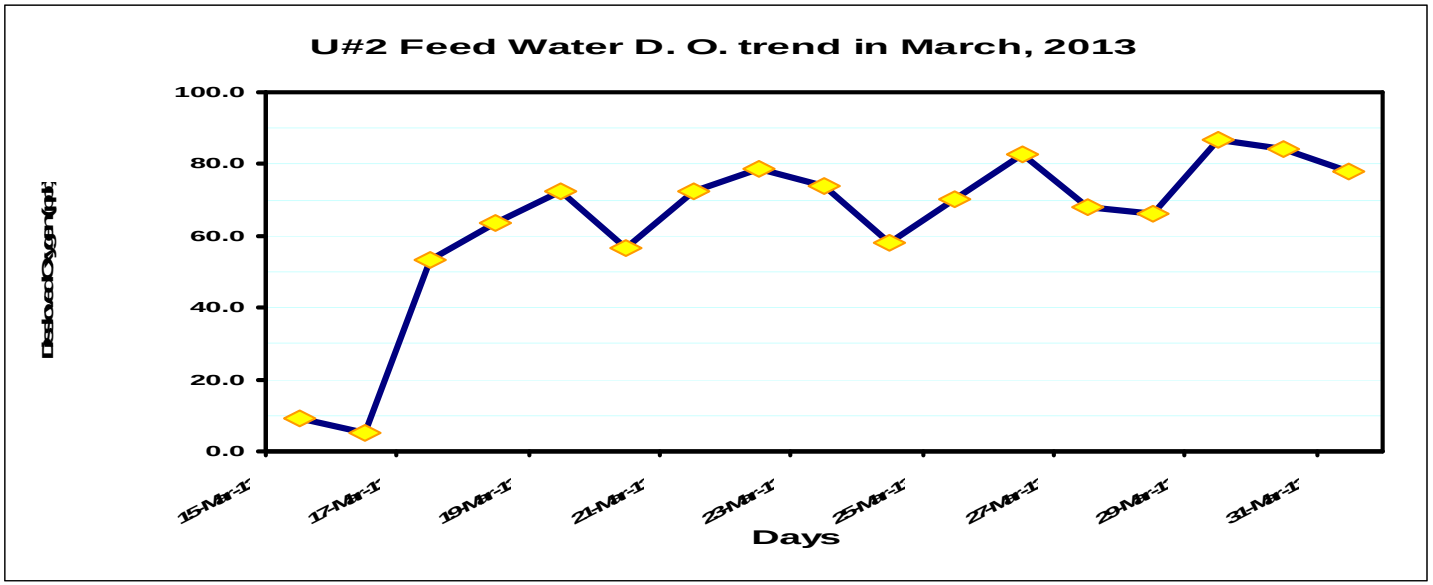


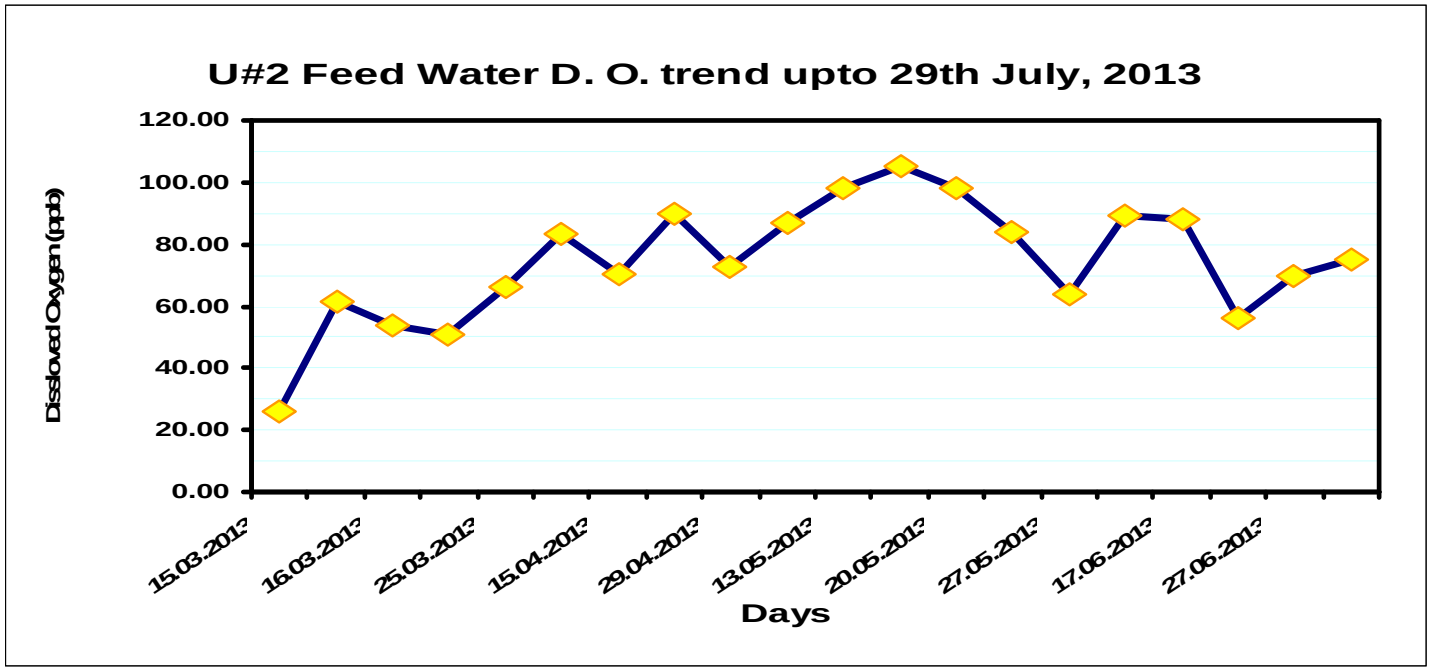
CONVERSION TO OT – Case Study

Case study 2:

- Oxygen dosing started
- The D/A vents fully closed
- Oxygen dosed at CPU O/L & D/A outlet simultaneously
- Feed DO started increasing from 9.2 ppb to 40 ppb within 48 hrs
- After three days, Feed DO attained 50 ppb range
- The target value achieved within 5days of start of OT.
- In the second phase, operation started at DO level of 80-110 ppb.

CONVERSION TO OT – Case Study

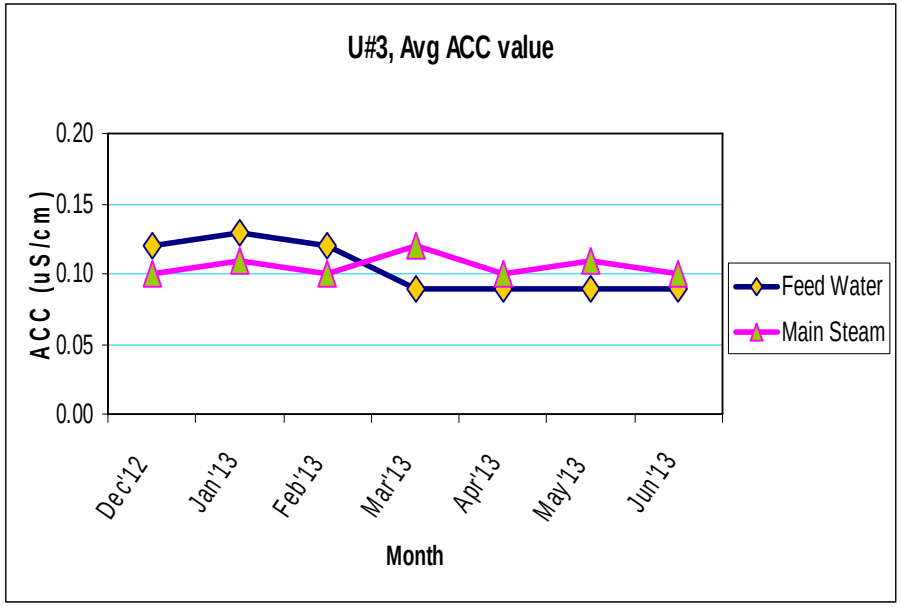


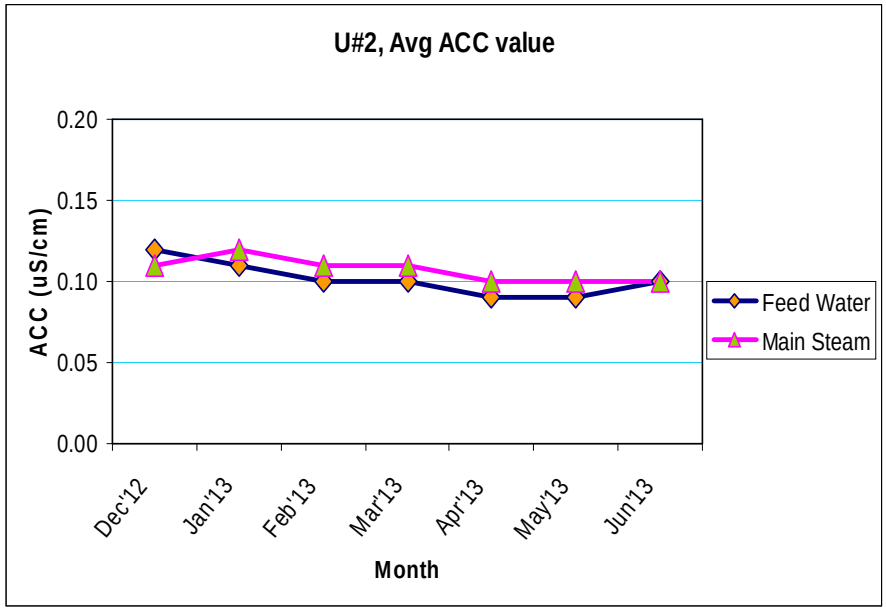


AVT v/s OT – DATA COMPARISON

Feed and Main Steam ACC

- The Feed and MS A.C.C. values of OT - almost stable (0.09-0.10 µS/cm)
- Values are less in comparison to AVT (0.2 µS/cm)

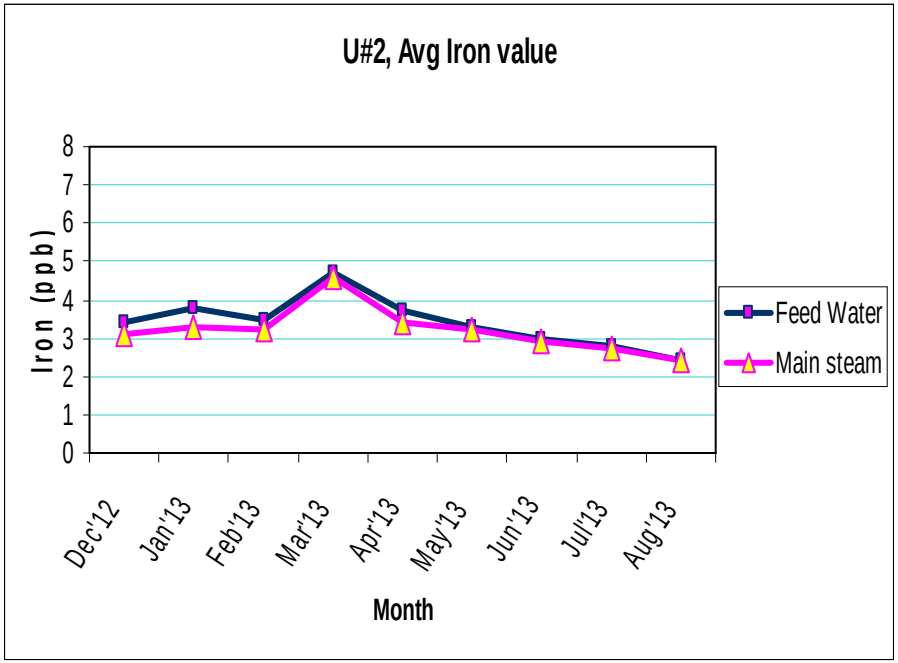


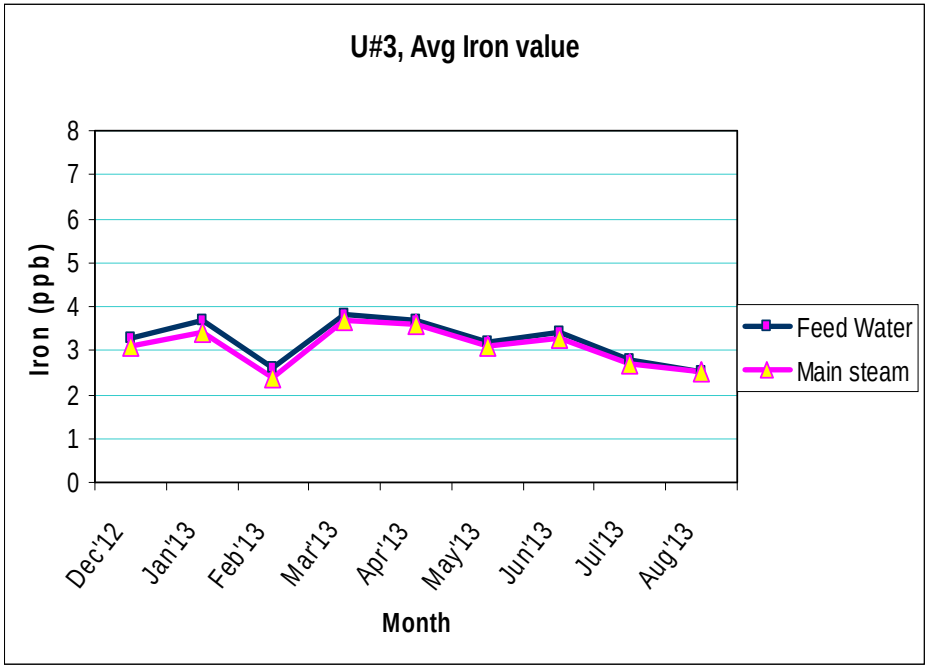


AVT V/S OT – DATA COMPARISON

Feed and Main Steam Iron values

- Rise in Feed and MS iron values of OT at the start (3-4 ppb) and decrease afterwards (2-3 ppb)
- Values lesser in comparison to AVT (more than 5 ppb).





BENEFITS of OT over AVT

50% increase in CPU load

- AVT - 240000 M3 load
- OT - 360000 M3 load

Environmental benefits and Safety

- Increase in CPU loading results decrease in regeneration frequency.
- Reduction in spent regenerant waste. Environmental benefit.
- Reduction in Ammonia consumption by 64%

Reduction in DM Makeup (Cyclic)

- Cyclic make up reduction (less than 1%)

AVT- D/A vents open; OT - close/throttle the vent

BENEFITS of OT over AVT

Reduction of chemical cost :

Chemical	Consumption (Ltr)		Cost (in Rs)	
	AVT	OT	AVT	OT
Ammonia	1100	400	39600	14400
Oxygen (No. of Cyl.)	--	15	--	1950
	Total Cost (in Rs)		39600	16350

MONTHLY SAVINGS (in Rs): 39600-16350 = 23250/-

(monthly average values of chemicals consumed is taken, and current price is considered)

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BENEFITS of OT over AVT

CPU- Regeneration

Reduction in monthly consumption of HCl & NaOH as CPU loading is increased by 50%.

Chemical	CONSUMPTION (Ltr) AVT	CONSUMPTION (Ltr) OT	Cost (in Rs) AVT	Cost (in Rs) OT
ACID (HCl)	31 MT	20 MT	48050/-	31000/-
ALKALI (NaOH)	8 MT	5 MT	210224/-	131390/-
TOTAL COST (in Rs)			258274/-	162390/-

Total monthly savings (in Rs.) = 23250.00 + 95884.00 = Rs. *119134/-.*

* Cost of HCl is taken as Rs.1550/MT and Alkali as Rs. 26278/mt. thus monthly savings of Rs. 95884/-

RESULTS AND CONCLUSIONS

- The judicious and efficient CPU operation helps to maintain stringent Feed -water quality.
- Increase in the Feed DO range to 80-110ppb, and maintaining ACC in the range of 0.09-0.11 μS/cm.
- Stabilization of steam water cycle chemistry - evident from the analytical parameters & CPU cleaning process (hematite layer conversion)
- Success factor of conversion to OT will be more promising after physical inspection of boiler components

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TRANSFORMING LIVES