I&C FOR SAFETY OF NPP

by

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CONTENTS

- Role of I&C in Safety of NPP
- Safety Life Cycle of Digital I&C

Nuclear Power Plants

- Steady increase in energy requirement to maintain growth rate
- Need to address global warming issues
- Required to have a suitable technology mix
  - Nuclear power must play a significant role as part of the mix
- Impact of Fukushima

Lessons from Fukushima

- Inevitability of Nuclear Events
- Reliable Post Shutdown Cooling
- Essential Safety of Nuclear Power

(Source: IAEA Conference June 2011)

NPP Capacity in India

- PHWR Program
  - 20 in operation, (capacity 4780 MWe)
  - 4 x 700 plants launched 6 under launch
- LWR program (imported)
  - 40,000 MWe planned
- LWR program (indigenous)

NPP – Safety Aspects

- Primary safety functions in NPP are
  - Regulation of reactivity in core and Reactor shutdown
  - Heat removal from fuel core (including decay heat)
  - Containment of radioactivity

Safety-Critical Systems

- A system is safety-critical, if a failure of the system could lead to consequences that are determined to be unacceptable.
  - In general, this implies that the failure of the system may lead to injury or death of human beings.
  - Damage to property can also be a consideration

Safety-Critical Systems Design

- Safety-critical systems need to be designed such that they perform desired function reliably even in harsh environments, are testable and design is verifiable.
- Extent of reliability required is determined by the tolerable rate of failures
  - Higher the damage potential of an event, lower should be the probability of the same

Role of I&C in NPP

- I&C systems monitor and display vital parameters for status of various systems and processes in the plant and carry out automatic control and protection functions
- I&C Systems play key role for actuation and monitoring of safety functions

I&C for Safety

- Designs follow standard techniques including fault tolerance, guard against common cause failures, diversity, use of qualified components, etc.
- Protection systems now use hardwired technologies (earlier some used digital).
- All other systems now use digital I&C

Use of Digital I & C

- Digital I&C systems offer several advantages but also offer challenges to the development and review processes
  - The main challenge is in proving the correctness of software
- Since software failures result from systematic faults, only qualitative analysis can be employed.

Integrity of Digital I&C

- Qualitative Issues
  - Use of rigorous software development process
  - Use of safe subsets of languages
  - Use of good development practices (IEC 60880)
  - Verification of implementation by tracing to requirements
  - Exhaustive documentation

Assessment of Digital I&C

- Safety standards demand definition of an appropriate safety life cycle
- Process has checks and balances to assure safety requirements met
- Demonstration of safety requires evidence that process was followed

Safety Life Cycle Of Dig. I&C

- The safety life cycle consists of activities from defining the requirements through development and installation and commissioning to the operation of the system
- Includes concurrent Verification & Validation activities

Engineering Procedures

- define the work methods for implementing the Safety Life Cycle
- define the documents to be produced at various stages of life cycle (and the nature and structure of information content of the same)

Procedures for Digital I&C

- System Requirements
- Digital I&C Systems
- Pre Developed Systems
- Newly Developed Systems
- Concession Request
- Requirements Change Notice

Regulatory Perspective 1/2

- Nuclear Industry is a heavily regulated industry (in every country)
  - Regulatory permission is required at each stage of design, construction and operation

Regulatory Perspective 2/2

- Defines recommended Safety Life Cycle
- Defines Safety Case and lists Regulatory Requirements
- Describes the Regulatory Review Process

Recommended Safety Life Cycle

- Generation of System Requirements
- Project Planning
- QA and V&V Planning
- Step-wise refinement of design
- System Integration and Testing
- System Safety and Reliability Analysis

Safety Case

- Documentary evidence to demonstrate
  - Compliance to regulatory requirements
  - Subjected to V&V
  - System meets safety and reliability goals

Regulatory Review Process

- Review of System Requirements, Plans
- Review / Audit of Design Outputs
- Review of System Validation
- Review of Analysis Reports

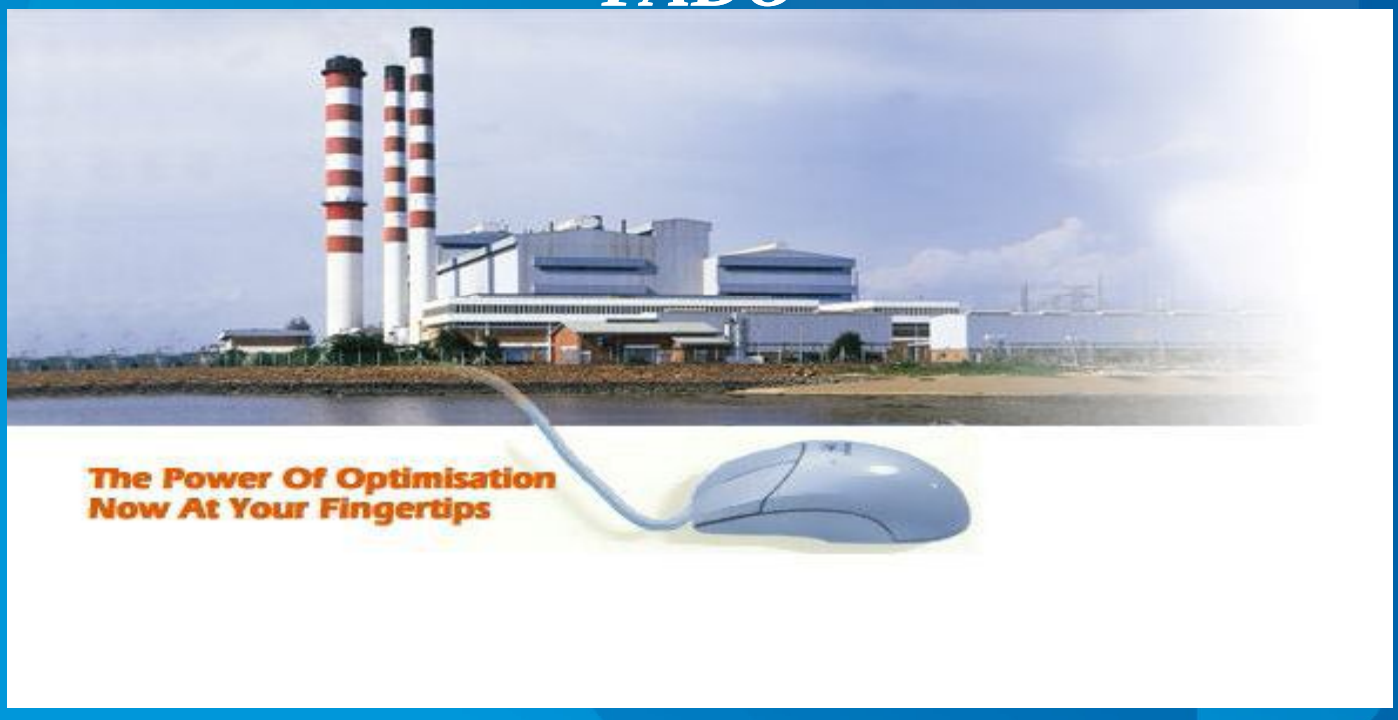
System Safety Analysis

- Confirmation of Safety Function implementation
- Failure Analysis (to meet single failure requirements)
- Analysis for Common Cause Failure

Thank you

Performance Analysis Diagnostics & Optimization

PADO



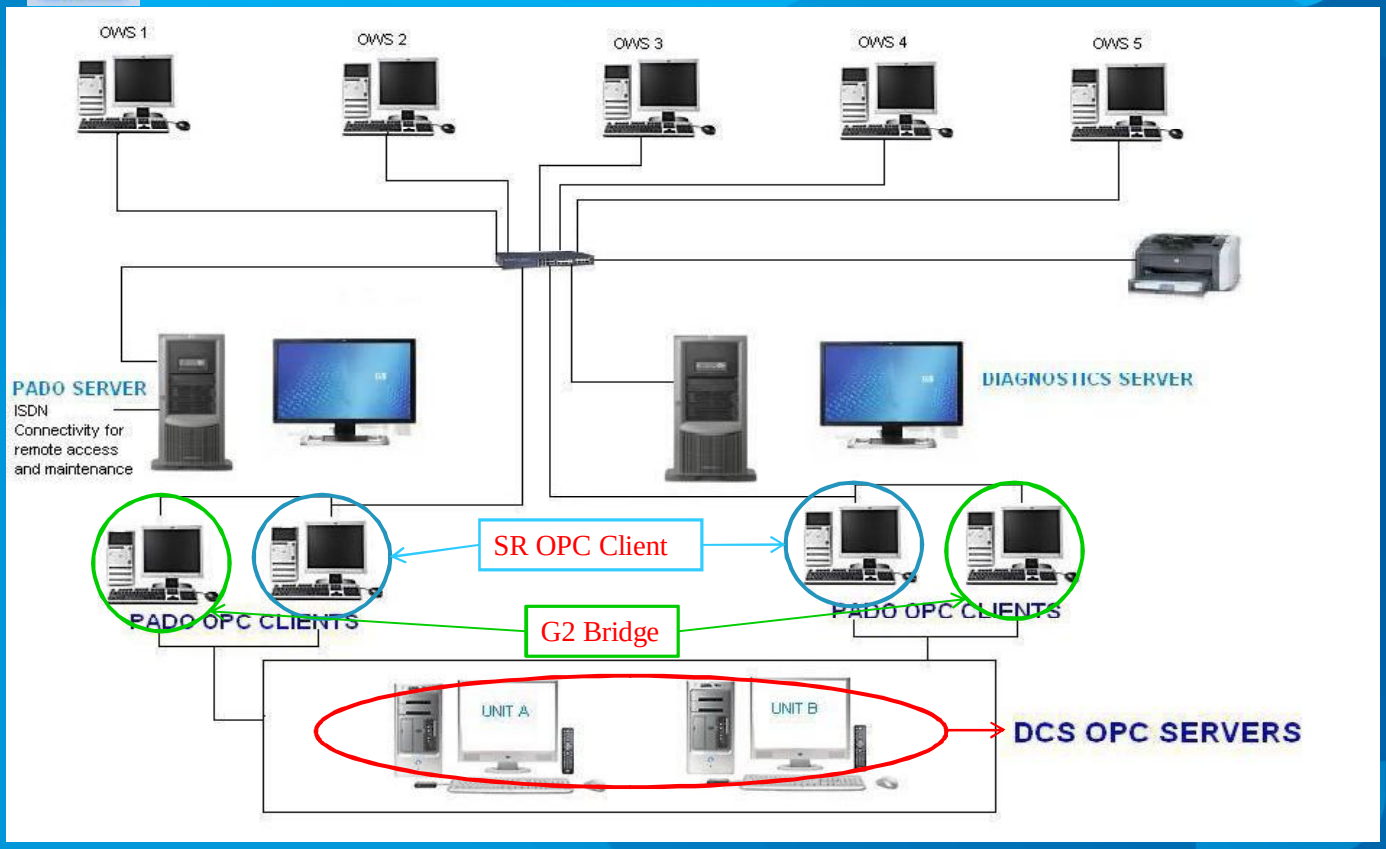
WHAT IS PADO?

- *PADO is a software based optimization and diagnostics system based on client-server architecture.*
- *It's a package rich in intensive information which aids plant operator to run the plant with most optimum efficiency , availability and maintainability.*
- *Massive Computation Engine for monitoring and analysis of Performance Parameters of Power Plant.*

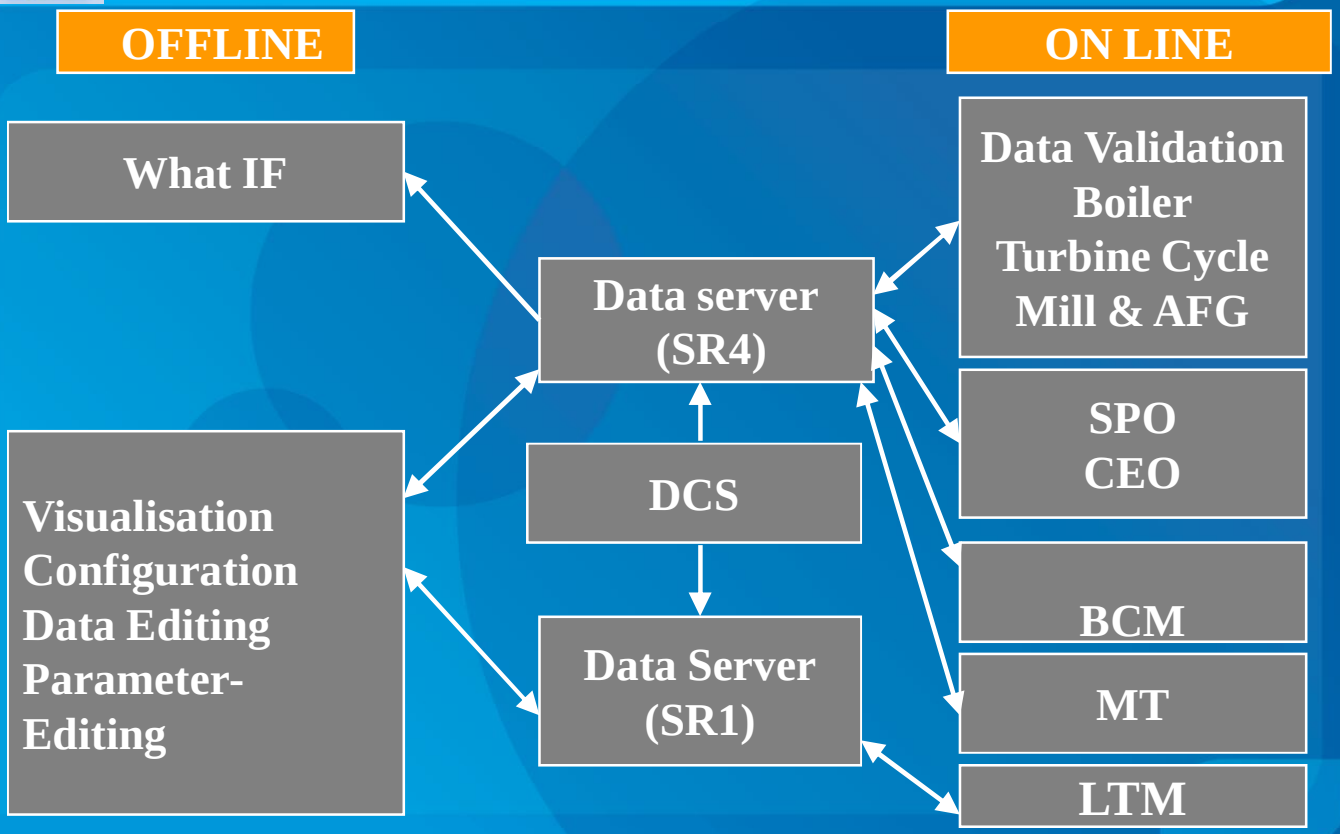
Terminologies Used in Presentation

- *Heat Rate: Ratio of fuel energy input and Gross power generated.*
- *TTD(Terminal Temp Diff): Logarithmic diff value of terminal temperatures.*
- *DCA(Drain Cooler Approach): Diff of drain temp and inlet temp of feed water.*
- *MLP (Multilayer Perception)*
- *SOM (Self Organising Map): Neural Network Techniques.*
- *SPO :Set Point Optimisation*
- *CEO :Combustion Emission Optimisation*
- *MTM :Metal Temperature Measurement*
- *BCM : Boiler Cleaning Module , LTM : Life Time Monitoring*

PADO CONFIGURATION



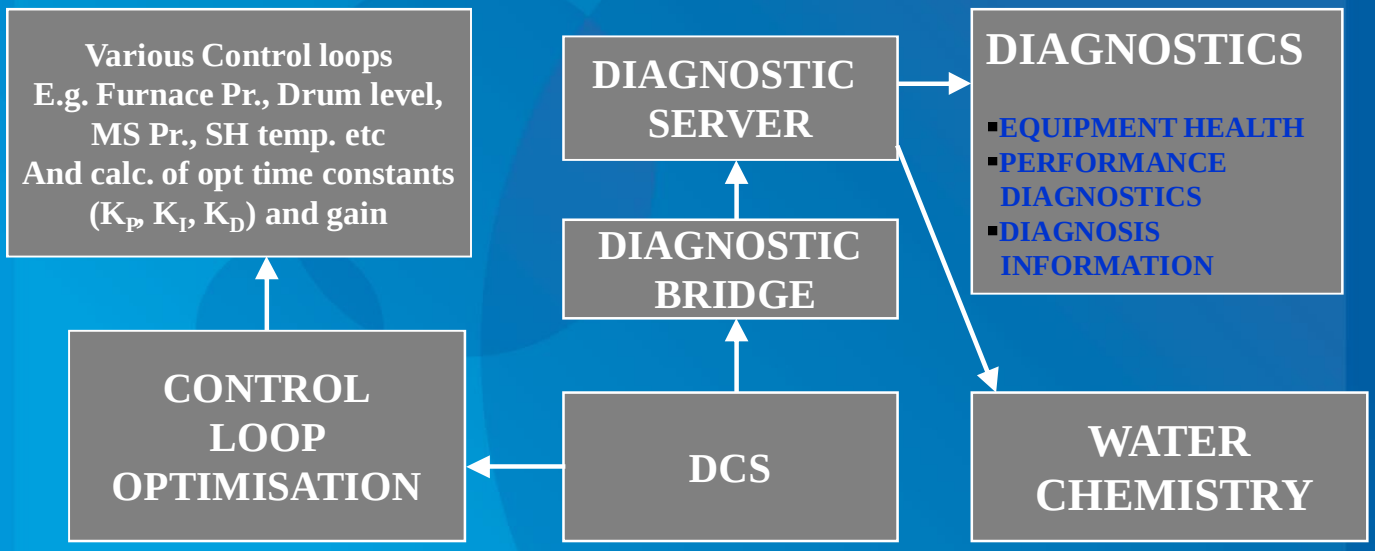
PADO STRUCTURE FOR PERFORMANCE ANALYSIS AND OPTIMISATION



PADO STRUCTURE FOR DIAGNOSTICS

OFFLINE

ON LINE



THE BUILDING BLOCKS (BBs)

- *BB1:PERFORMANCE ANALYSIS & MONITORING MODULE*
- *BB2:SYSTEM & PERFORMANCE OPTIMISATION*
- *BB3:BPOS(BOILER PERFORMANCE OPTIMISATION SYSTEM)*
- *BB4:BOILER STRESS CONDITION ANALYSER*
- *BB5:SYSTEM & PERFORMANCE DIAGNOSIS MODULE*
- *BB6:INTELLIGENT WATER & STEAM CHEM. MGT*

BB-1: PERF. ANALYSIS & MONITORING

PERFORMANCE EVALUATION

- HEAT RATE

  --Net HR, Gross HR, Turbine HR, Unit HR

- EQUIPMENT EFFICIENCY CALCULATIONS
- Controllable losses

  --Throttle Temp. & Pressure

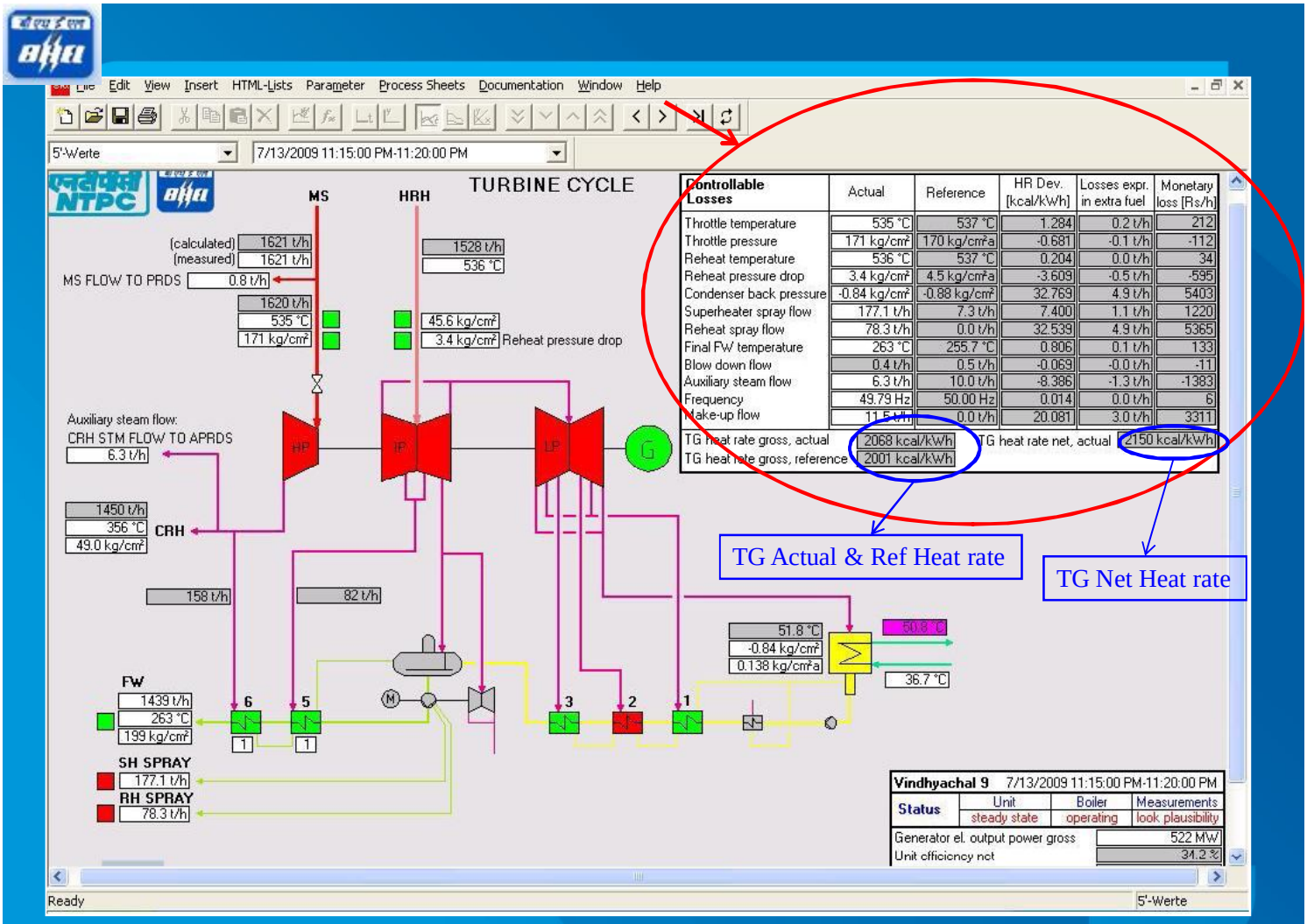
  --RH Temp & Pressure drop

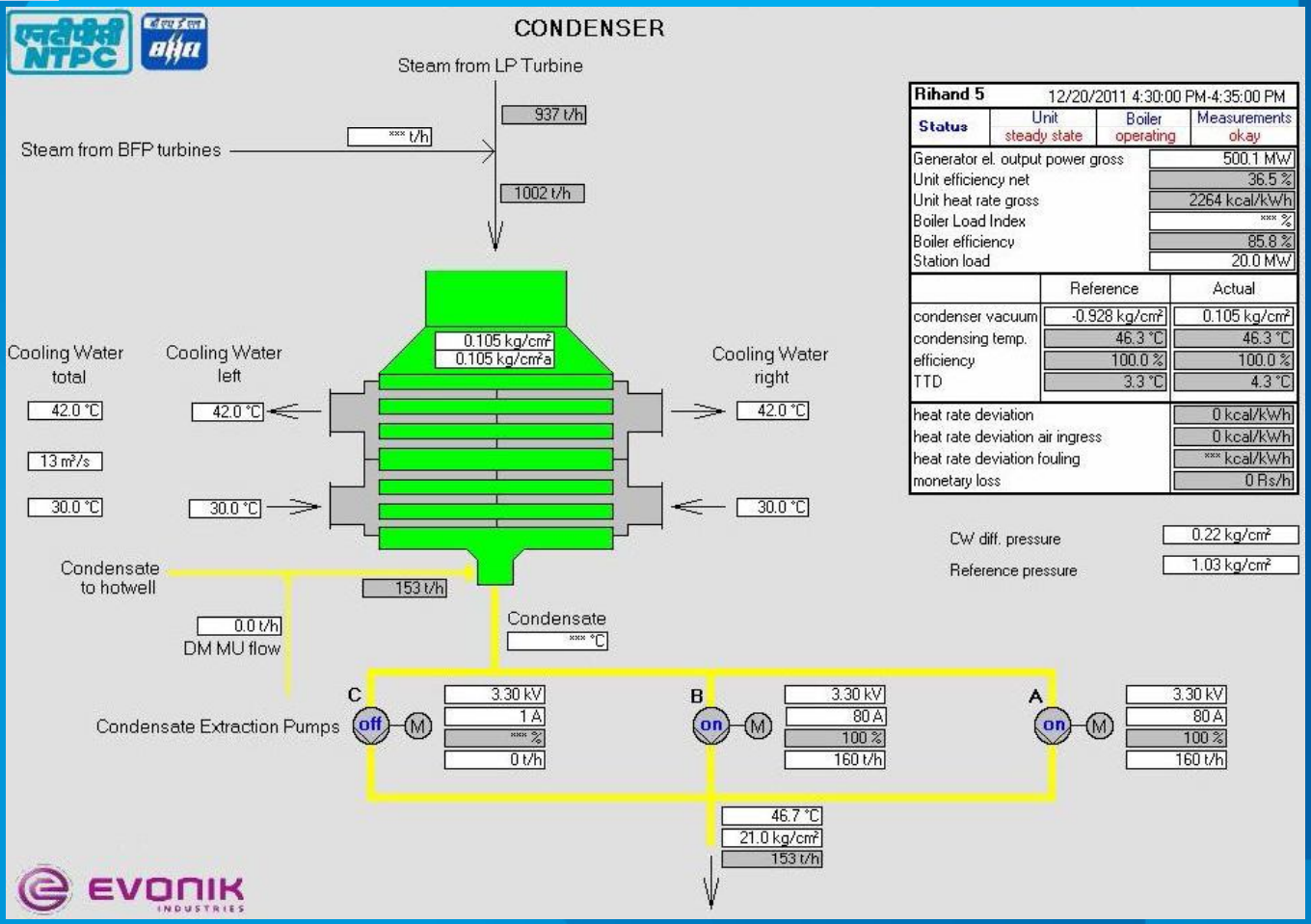
  --Condenser Back Pressure.

  --SH & RH spray Flow

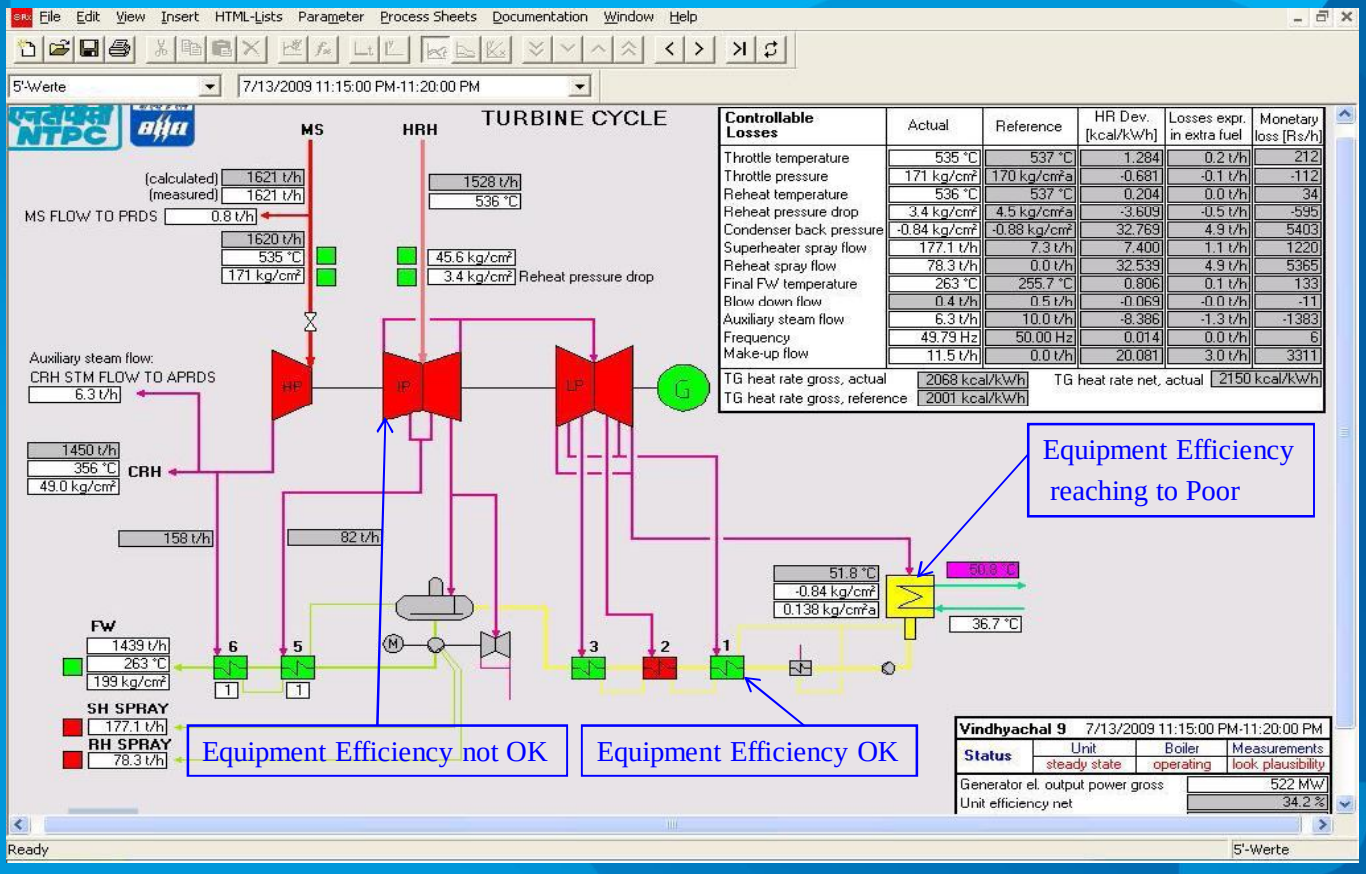
  --Final FW Temp

  --Blow Down, MU Flow, Frequency & Auxiliary Steam Flow


File Edit View Insert HTML-Lists Parameter Process Sheets Documentation Window Help
5'-Werte
7/13/2009 11:15:00 PM-11:20:00 PM
TURBINE CYCLE
MS
HRH
(calculated) 1621 t/h
(measured) 1621 t/h
MS FLOW TO PRDS 0.8 t/h
1620 t/h
535 °C
171 kg/cm²
1528 t/h
536 °C
45.6 kg/cm²
3.4 kg/cm² Reheat pressure drop
Auxiliary steam flow:
CRH STM FLOW TO APRDS
6.3 t/h
HP
IP
LP
G
1450 t/h
356 °C
49.0 kg/cm²
CRH
158 t/h
82 t/h
51.8 °C
-0.84 kg/cm²
0.138 kg/cm²a
50.8 °C
36.7 °C
FW
1439 t/h
263 °C
199 kg/cm²
6
5
3
2
1
SH SPRAY
177.1 t/h
RH SPRAY
78.3 t/h
Controllable Losses | Actual | Reference | HR Dev. [kcal/kWh] | Losses expr. in extra fuel | Monetary loss [Rs/h]
Throttle temperature | 535 °C | 537 °C | 1.284 | 0.2 t/h | 212
Throttle pressure | 171 kg/cm² | 170 kg/cm²a | -0.681 | -0.1 t/h | -112
Reheat temperature | 536 °C | 537 °C | 0.204 | 0.0 t/h | 34
Reheat pressure drop | 3.4 kg/cm² | 4.5 kg/cm²a | -3.609 | -0.5 t/h | -595
Condenser back pressure | -0.84 kg/cm² | -0.88 kg/cm² | 32.769 | 4.9 t/h | 5403
Superheater spray flow | 177.1 t/h | 7.3 t/h | 7.400 | 1.1 t/h | 1220
Reheat spray flow | 78.3 t/h | 0.0 t/h | 32.539 | 4.9 t/h | 5365
Final FW temperature | 263 °C | 255.7 °C | 0.806 | 0.1 t/h | 133
Blow down flow | 0.4 t/h | 0.5 t/h | -0.069 | -0.0 t/h | -11
Auxiliary steam flow | 6.3 t/h | 10.0 t/h | -8.386 | -1.3 t/h | -1383
Frequency | 49.79 Hz | 50.00 Hz | 0.014 | 0.0 t/h | 6
Make-up flow | 11.5 t/h | 0.0 t/h | 20.081 | 3.0 t/h | 3311
TG heat rate gross, actual 2068 kcal/kWh
TG heat rate gross, reference 2001 kcal/kWh
TG heat rate net, actual 2150 kcal/kWh
TG Actual & Ref Heat rate
TG Net Heat rate
Vindhyachal 9 7/13/2009 11:15:00 PM-11:20:00 PM
Status | Unit steady state | Boiler operating | Measurements look plausibility
Generator el. output power gross 522 MW
Unit efficiency net 34.2 %
Ready
5'-Werte


CONDENSER
Steam from LP Turbine
937 t/h
Steam from BFP turbines
*** t/h
1002 t/h
0.105 kg/cm²
0.105 kg/cm²a
Cooling Water total
42.0 °C
13 m³/s
30.0 °C
Cooling Water left
42.0 °C
30.0 °C
Cooling Water right
42.0 °C
30.0 °C
Condensate to hotwell
153 t/h
0.0 t/h
DM MU flow
Condensate
*** °C
Condensate Extraction Pumps
C
off
M
3.30 kV
1 A
*** %
0 t/h
B
on
M
3.30 kV
80 A
100 %
160 t/h
A
on
M
3.30 kV
80 A
100 %
160 t/h
46.7 °C
21.0 kg/cm²
153 t/h
Rihand 5
12/20/2011 4:30:00 PM-4:35:00 PM
Status
Unit steady state
Boiler operating
Measurements okay
Generator el. output power gross 500.1 MW
Unit efficiency net 36.5 %
Unit heat rate gross 2264 kcal/kWh
Boiler Load Index *** %
Boiler efficiency 85.8 %
Station load 20.0 MW
Reference
Actual
condenser vacuum -0.928 kg/cm² 0.105 kg/cm²
condensing temp. 46.3 °C 46.3 °C
efficiency 100.0 % 100.0 %
TTD 3.3 °C 4.3 °C
heat rate deviation 0 kcal/kWh
heat rate deviation air ingress 0 kcal/kWh
heat rate deviation fouling *** kcal/kWh
monetary loss 0 Rs/h
CW diff. pressure 0.22 kg/cm²
Reference pressure 1.03 kg/cm²
EVONIK INDUSTRIES

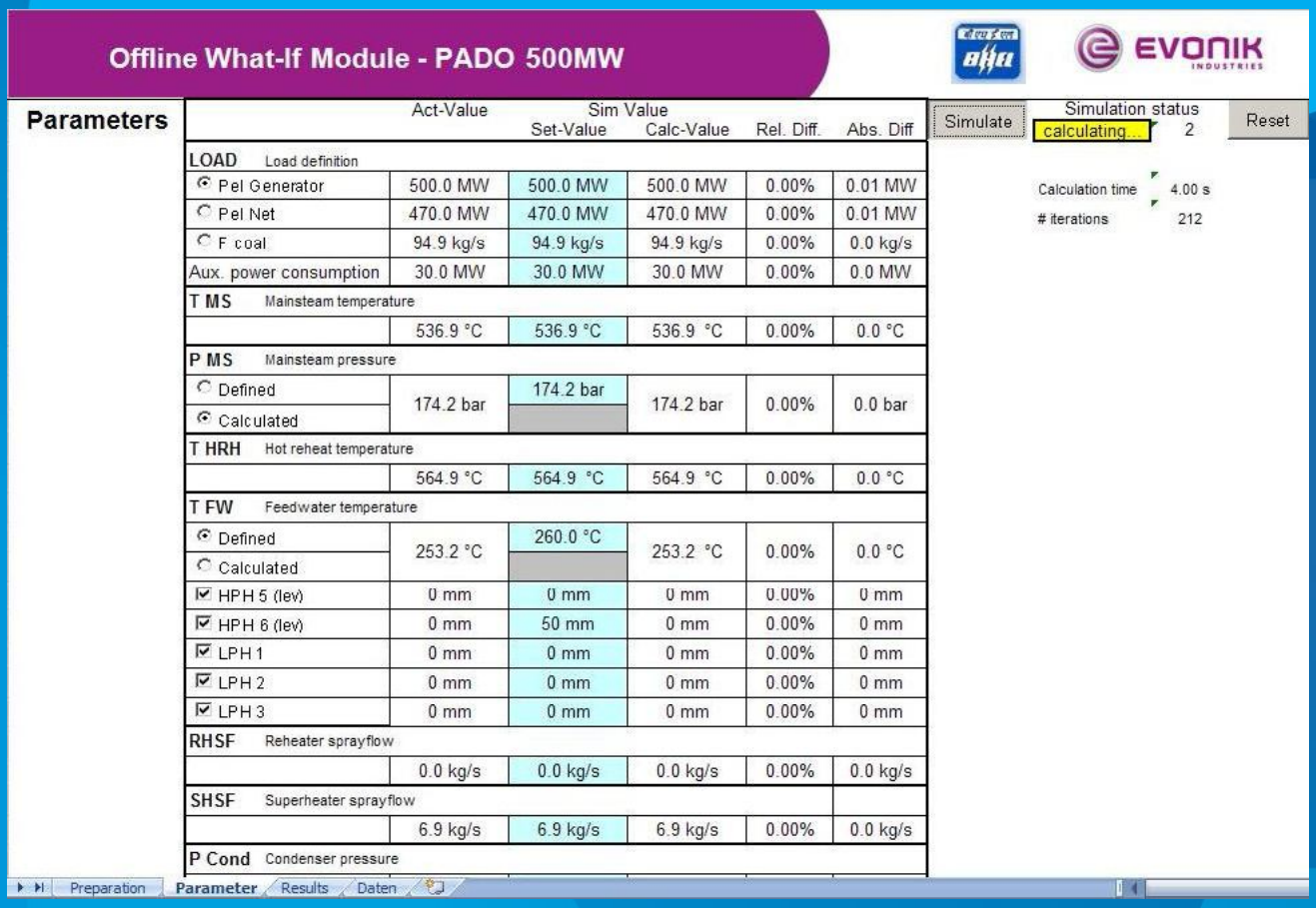
TRAFFIC LIGHT SYSTEM IMPLEMENTED FOR DEGRADATION OF EQUIPMENT



BB-1: PERF. ANALYSIS & MONITORING

PERFORMANCE EVALUATION

- WHAT IF ANALYSIS
  - --MS TEMP
  - --CONDENSER BACK PRESSURE
  - --CW INLET TEMPERATURE
  - --COOLING WATER MASS FLOW
  - --EXCESS AIR
  - --MILL COMBINATION
  - --BURNER TILT



Offline What-If Module - PADO 500MW

EVONIK INDUSTRIES

Parameters

	Act-Value	Sim Value Set-Value	Sim Value Calc-Value	Rel. Diff.	Abs. Diff
LOAD Load definition					
◉ Pel Generator	500.0 MW	500.0 MW	500.0 MW	0.00%	0.01 MW
○ Pel Net	470.0 MW	470.0 MW	470.0 MW	0.00%	0.01 MW
○ F coal	94.9 kg/s	94.9 kg/s	94.9 kg/s	0.00%	0.0 kg/s
Aux. power consumption	30.0 MW	30.0 MW	30.0 MW	0.00%	0.0 MW
T MS Mainsteam temperature					
	536.9 °C	536.9 °C	536.9 °C	0.00%	0.0 °C
P MS Mainsteam pressure					
○ Defined	174.2 bar	174.2 bar	174.2 bar	0.00%	0.0 bar
◉ Calculated					
T HRH Hot reheat temperature					
	564.9 °C	564.9 °C	564.9 °C	0.00%	0.0 °C
T FW Feedwater temperature					
◉ Defined	253.2 °C	260.0 °C	253.2 °C	0.00%	0.0 °C
○ Calculated					
☑ HPH 5 (lev)	0 mm	0 mm	0 mm	0.00%	0 mm
☑ HPH 6 (lev)	0 mm	50 mm	0 mm	0.00%	0 mm
☑ LPH 1	0 mm	0 mm	0 mm	0.00%	0 mm
☑ LPH 2	0 mm	0 mm	0 mm	0.00%	0 mm
☑ LPH 3	0 mm	0 mm	0 mm	0.00%	0 mm
RHSF Reheater sprayflow					
	0.0 kg/s	0.0 kg/s	0.0 kg/s	0.00%	0.0 kg/s
SHSF Superheater sprayflow					
	6.9 kg/s	6.9 kg/s	6.9 kg/s	0.00%	0.0 kg/s
P Cond Condenser pressure					

Simulate | Simulation status: calculating... 2 | Reset

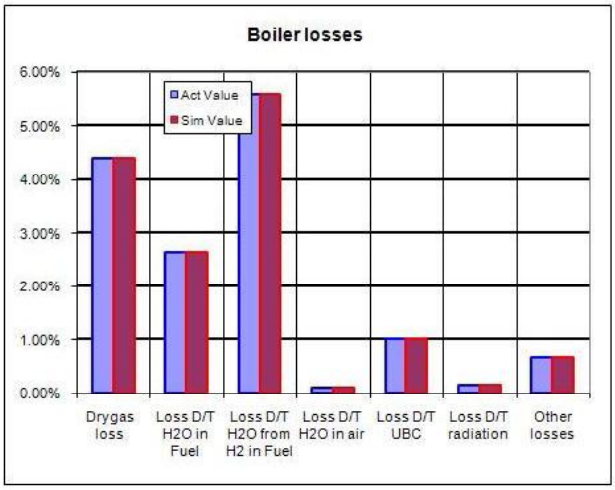
Calculation time 4.00 s

iterations 212

Preparation | Parameter | Results | Daten

Offline What-If Module - PADO 500MW

Results	Act Value	Sim Value	Rel. Diff.	Abs. Diff.
Fluegas temp. aft. AH	125.1 °C	125.2 °C	0.07%	0.1 °C
Boiler				
Boiler efficiency	85.44%	85.43%	-0.01%	-0.01%
Drygas loss	4.40%	4.40%	0.10%	0.00%
Loss D/T H_2O in Fuel	2.64%	2.64%	0.01%	0.00%
Loss D/T H_2O from H_2 in Fuel	5.59%	5.59%	0.01%	0.00%
Loss D/T H_2O in air	0.11%	0.11%	0.03%	0.00%
Loss D/T UBC	1.00%	1.00%	0.00%	0.00%
Loss D/T radiation	0.15%	0.15%	0.00%	0.00%
Other losses	0.67%	0.68%	0.11%	0.00%
Total losses	14.56%	14.57%	0.04%	0.01%
Heatrates				
Unit Gross	2264 kcal/kWh	2260 kcal/kWh	-0.18%	-4 kcal/kWh
Unit Net	2409 kcal/kWh	2404 kcal/kWh	-0.18%	-4 kcal/kWh
Cycle Gross	1934 kcal/kWh	1931 kcal/kWh	-0.19%	-4 kcal/kWh
Cycle Net	2058 kcal/kWh	2054 kcal/kWh	-0.19%	-4 kcal/kWh
Boiler heating surfaces				
Furnace				
Fouling	267.1 %	267.1 %	0.00%	0.0 %
Heat Absorption	416.5 MW	416.4 MW	-0.03%	-0.1 MW
Adiabatic combustion temp.	1736.1 °C	1736.3 °C	0.01%	0.2 °C
Fluegas output temp.	1244.6 °C	1244.1 °C	-0.05%	-0.6 °C
Weater input temp.	361.3 °C	361.4 °C	0.02%	0.1 °C
Water output temp.	360.8 °C	360.9 °C	0.02%	0.1 °C
SHPL				
Fouling	71.1 %	71.1 %	0.00%	0.0 %
Heat Absorption	92.5 MW	94.2 MW	1.81%	1.7 MW
Adiabatic combustion temp.	1075.9 °C	1069.6 °C	-0.59%	-6.3 °C
Fluegas output temp.	957.1 °C	948.3 °C	-0.92%	-8.8 °C
Water input temp.	463.5 °C	462.6 °C	-0.18%	-0.8 °C
Water output temp.	540.0 °C	540.0 °C	0.01%	0.0 °C



Preparation | Parameter | Results | Daten

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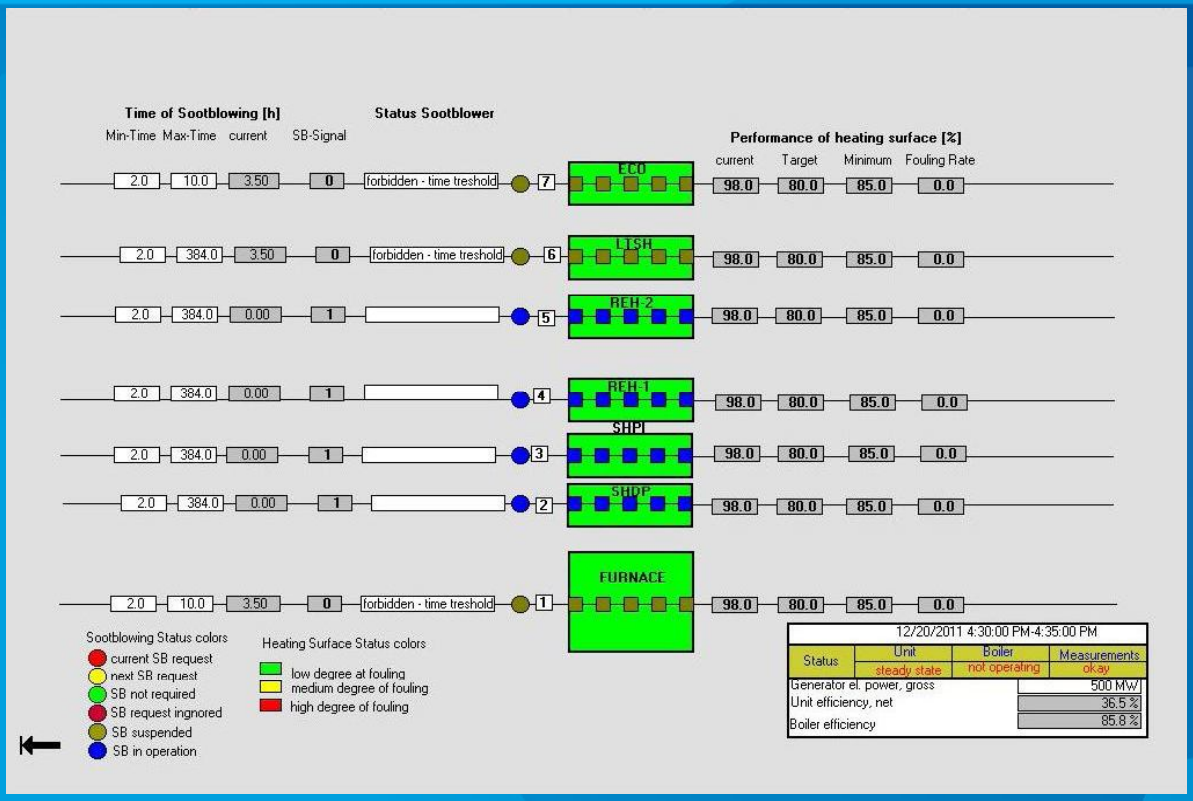
BB-2: SYS & PERF. OPTIMISATION

FEATURES:

- *OPTIMISATION OF BOILER SOOTBLOWING*
- *SET POINT OPTIMISATION*
- *MONITORS EMISSIONS OF SOx, NOx, CO etc.*
- *NOx OPTIMISATION*

SOOT BLOWER OPTIMISATION



SET POINT OPTIMISATION

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Set point optimization

Boiler	Act value	Opt value
O2 at Eco outlet	3.15 %Vol	5.50 %Vol
Burner tilt	0.0 °	3.9 °

Turbine Cycle		
MS temperature	540.00 °C	540.33 °C
MS pressure	173.19 bar	173.00 bar
Reheat temperature	568.00 °C	568.30 °C
Unit Heat Rate gross	2264 kcal/kWh	2266 kcal/kWh
Avg Mill Height FbH1	34 m	35.500 m

Unit Critical Calculated Outputs

Superheater Spray	25.0 t/h
Reheater Spray	0.0 t/h
Furnace Exit Flue Gas Temp	1305 °C
APH-A Leackage	15.758 %
APH-B Leackage	15.758 %
Platten SH Max Metal Temp	573 °C
RH Max Metal Temp	641 °C
HPH-5 Drain O/L Flow	118 t/h
HPH-6 Drain O/L Flow	75 t/h

Mill Recommendations

	Status			Load	
	Maint.	Current	Optimized	Current	Optimized
MILL K	1	0	0	0.00 kg/s	0.00 kg/s
MILL J	1	1	1	46.71 t/h	58.00 t/h
MILL H	1	1	1	46.71 t/h	58.00 t/h
MILL G	1	1	1	46.71 t/h	58.00 t/h
MILL F	1	1	1	46.71 t/h	58.00 t/h
MILL E	1	1	1	46.71 t/h	58.00 t/h
MILL D	1	1	0	46.71 t/h	0.00 t/h
MILL C	1	1	1	46.71 t/h	37.00 t/h
MILL B	1	0	0	0.00 t/h	0.00 t/h
MILL A	1	0	0	0.00 t/h	0.00 t/h

Total consumption of pumps	6610.3 kW	6.610 MW
Total consumption of mills	2136.6 kW	2.137 MW
Total consumption of fans	4797.8 kW	4.798 MW
Total consumption of aux. consumers	13544.7 kW	13.545 MW
Station load	20006.0 kW	20.006 MW

Set point optimization here refers to the heat rate optimization with Nox and metal temperature as a constraint.

HR = f (rhs,egl,mst,rht,msp)

NN € rhs,egl,Nox

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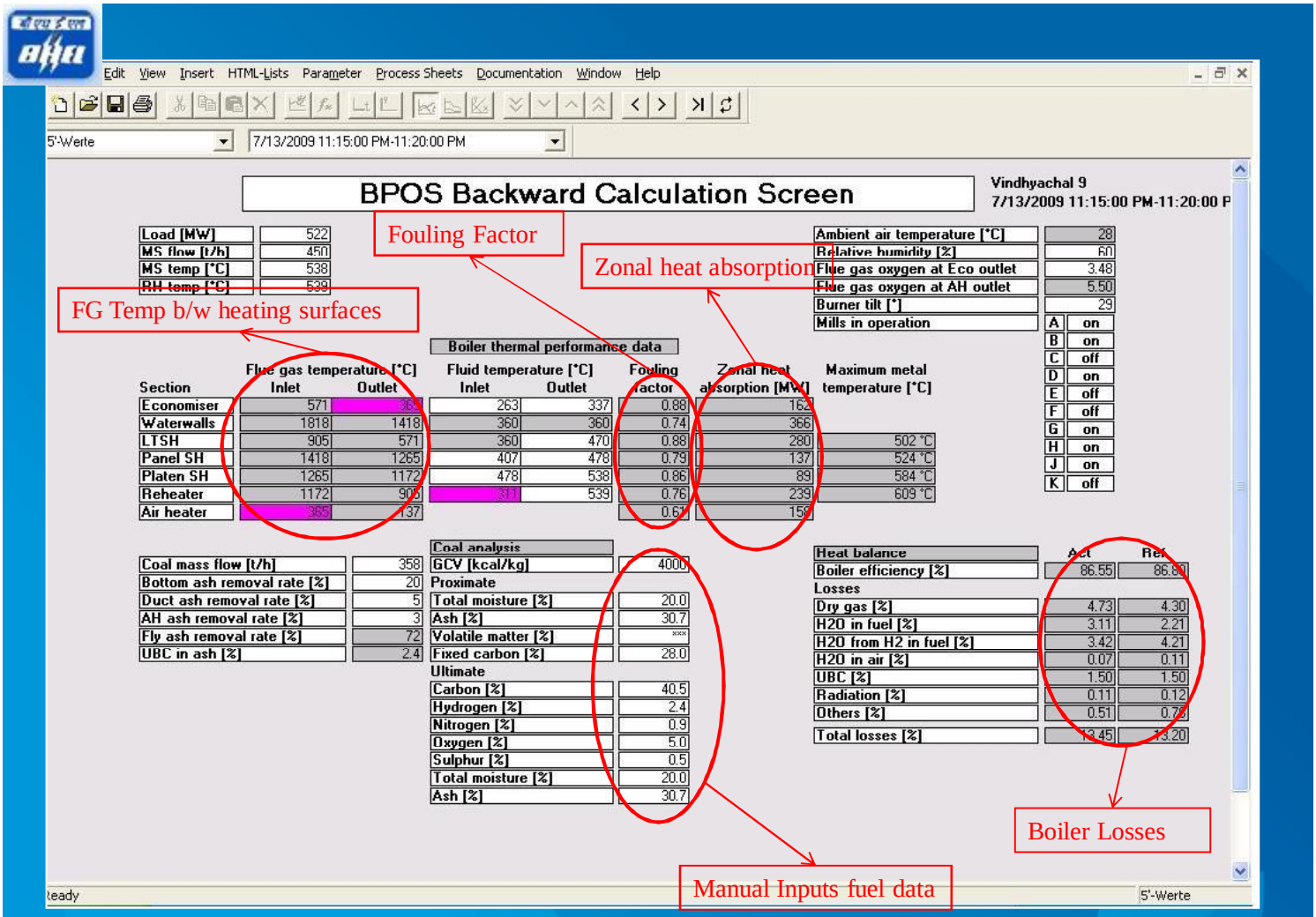
BB-3: BOILER PERFORMANCE OPTIMISATION (BPOS)

FEATURES:

- ***BACKWARD CALCULATIONS***
  - *--ZONAL FG & FLUID TEMPERATURE*
  - *--HEAT BALANCE*
  - *--LOSSES (Dry gas, H2O in fuel, UBC, Radiation, H2O in air)*
- ***FORWARD CALCULATIONS***
  - *--COAL, AIR, SPRAY FLOWS*
  - *--BOILER EFFICIENCY*
- *METAL TEMP. CALCULATION*
- *METAL HOT SPOTS*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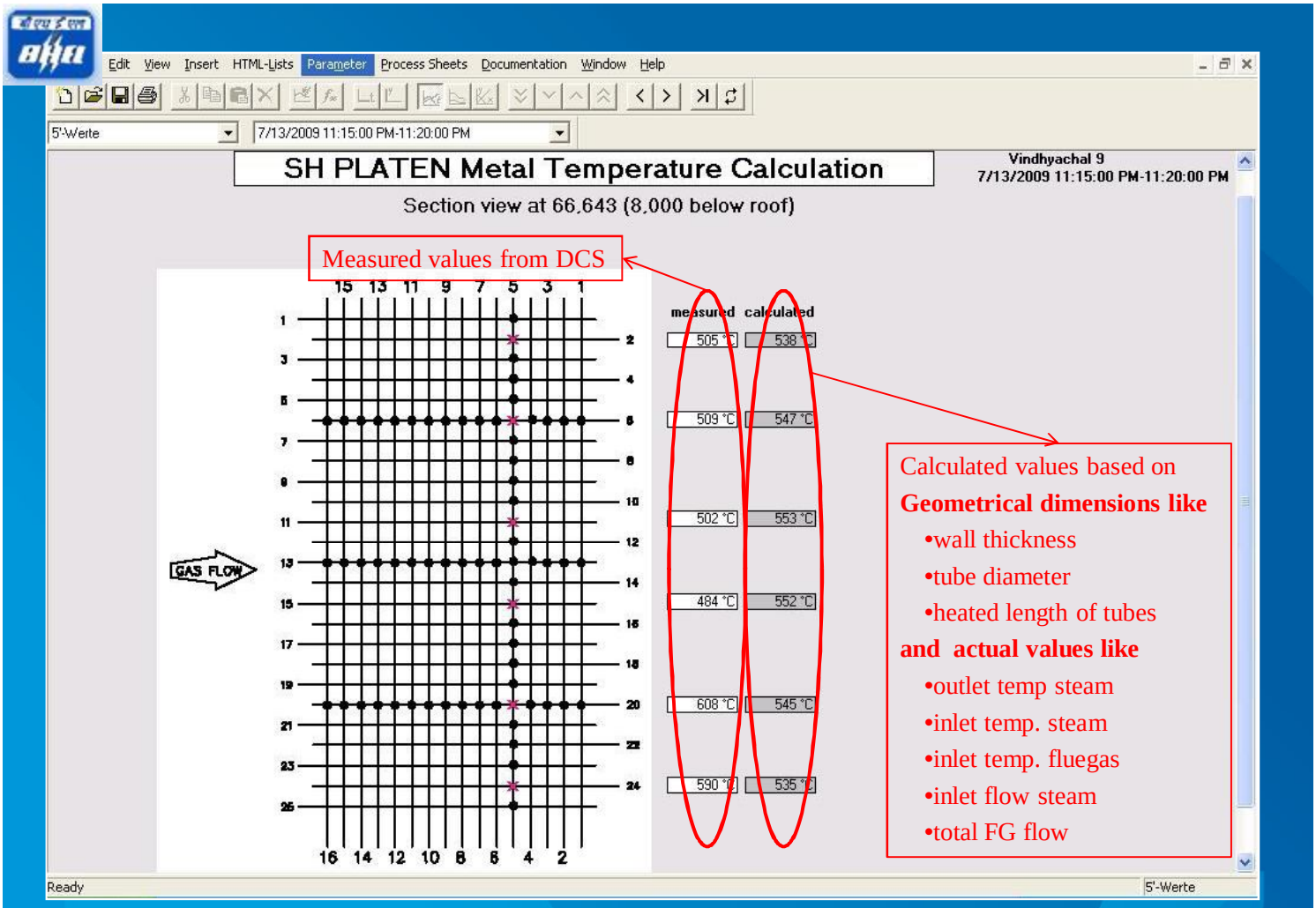
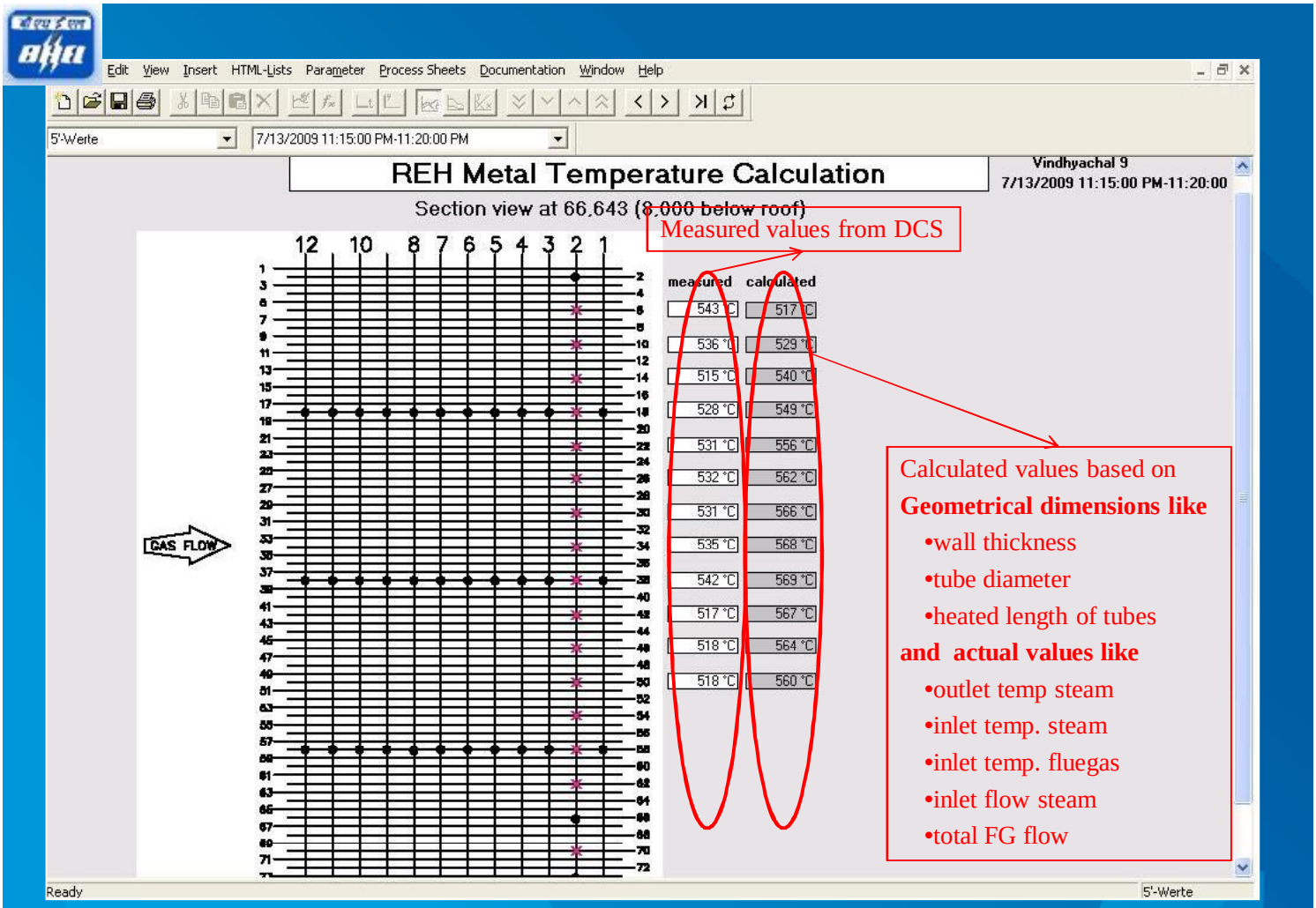
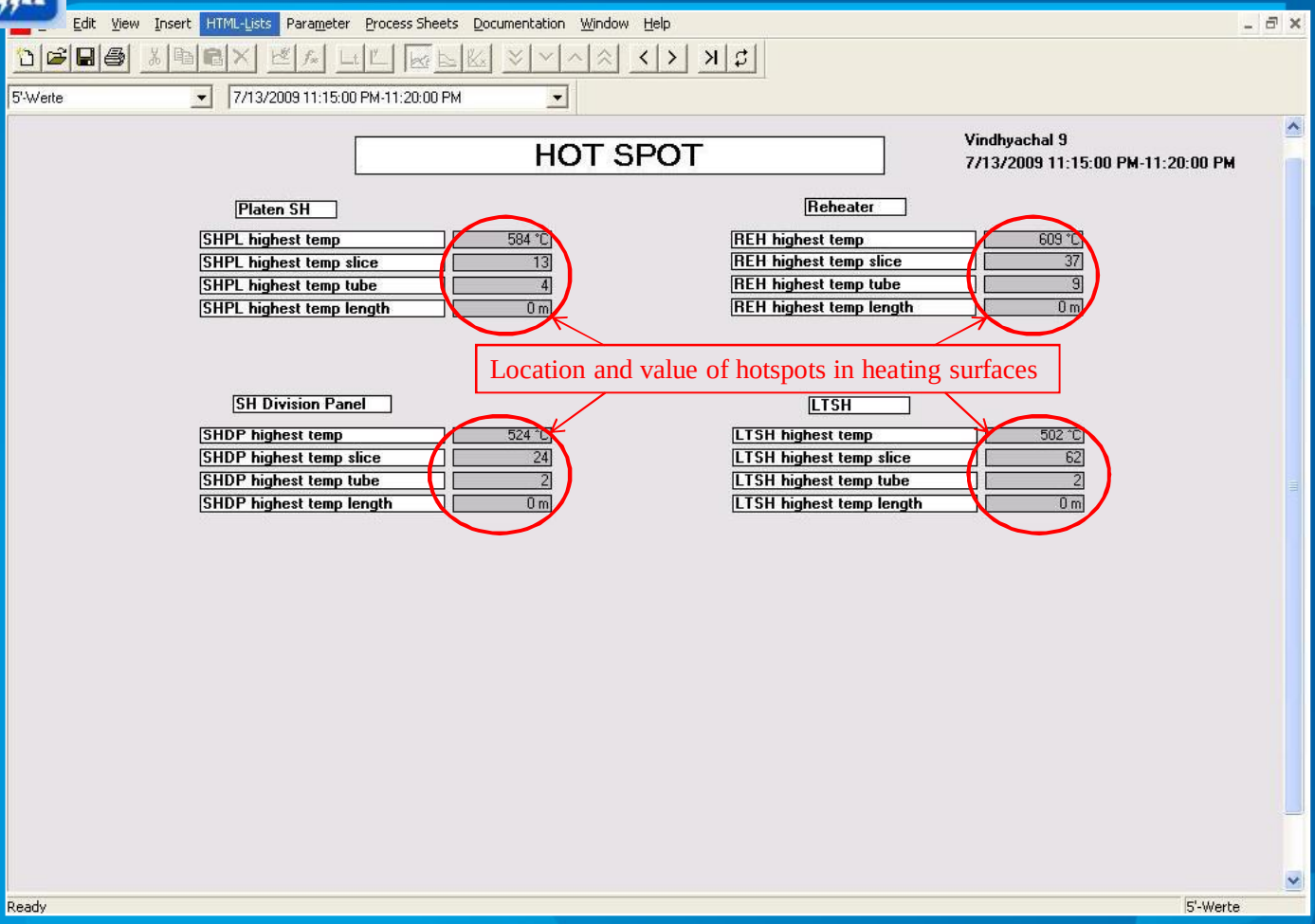
5'-Werte
7/13/2009 11:15:00 PM-11:20:00 PM
BPOS Backward Calculation Screen
Vindhyachal 9
7/13/2009 11:15:00 PM-11:20:00 P
Load [MW] 522
MS flow [t/h] 450
MS temp [°C] 538
RH temp [°C] 539
Ambient air temperature [°C] 28
Relative humidity [%] 60
Flue gas oxygen at Eco outlet 3.48
Flue gas oxygen at AH outlet 5.50
Burner tilt [°] 29
Mills in operation
A on
B on
C off
D on
E off
F off
G on
H on
J on
K off
Boiler thermal performance data
Section
Flue gas temperature [°C] Inlet Outlet
Fluid temperature [°C] Inlet Outlet
Fouling factor
Zonal heat absorption [MW]
Maximum metal temperature [°C]
Economiser 571 263 337 0.88 162
Waterwalls 1818 1418 360 360 0.74 366
LTSH 905 571 360 470 0.88 280 502 °C
Panel SH 1418 1265 407 478 0.79 137 524 °C
Platen SH 1265 1172 478 538 0.86 89 584 °C
Reheater 1172 909 311 539 0.76 239 609 °C
Air heater 365 137 0.61 156
Coal mass flow [t/h] 358
Bottom ash removal rate [%] 20
Duct ash removal rate [%] 5
AH ash removal rate [%] 3
Fly ash removal rate [%] 72
UBC in ash [%] 2.4
Coal analysis
GCV [kcal/kg] 4000
Proximate
Total moisture [%] 20.0
Ash [%] 30.7
Volatile matter [%] ***
Fixed carbon [%] 28.0
Ultimate
Carbon [%] 40.5
Hydrogen [%] 2.4
Nitrogen [%] 0.9
Oxygen [%] 5.0
Sulphur [%] 0.5
Total moisture [%] 20.0
Ash [%] 30.7
Heat balance
Act Ref
Boiler efficiency [%] 86.55 86.80
Losses
Dry gas [%] 4.73 4.30
H2O in fuel [%] 3.11 2.21
H2O from H2 in fuel [%] 3.42 4.21
H2O in air [%] 0.07 0.11
UBC [%] 1.50 1.50
Radiation [%] 0.11 0.12
Others [%] 0.51 0.76
Total losses [%] 13.45 13.20
Fouling Factor
Zonal heat absorption
FG Temp b/w heating surfaces
Boiler Losses
Manual Inputs fuel data
Ready
5'-Werte


Edit View Insert HTML-Lists Parameter Process Sheets Documentation Window Help
5'-Werte
7/13/2009 11:15:00 PM-11:20:00 PM
SH PLATEN Metal Temperature Calculation
Vindhyachal 9
7/13/2009 11:15:00 PM-11:20:00 PM
Section view at 66,643 (8,000 below roof)
Measured values from DCS
15 13 11 9 7 5 3 1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
16 14 12 10 8 6 4 2
GAS FLOW
measured calculated
505 °C 538 °C
509 °C 547 °C
502 °C 553 °C
484 °C 552 °C
608 °C 545 °C
590 °C 535 °C
Calculated values based on
Geometrical dimensions like
•wall thickness
•tube diameter
•heated length of tubes
and actual values like
•outlet temp steam
•inlet temp. steam
•inlet temp. fluegas
•inlet flow steam
•total FG flow
Ready
5'-Werte


Edit View Insert HTML-Lists Parameter Process Sheets Documentation Window Help
5'-Werte
7/13/2009 11:15:00 PM-11:20:00 PM
REH Metal Temperature Calculation
Vindhyachal 9
7/13/2009 11:15:00 PM-11:20:00
Section view at 66.643 (8.000 below roof)
Measured values from DCS
12 10 8 7 6 5 4 3 2 1
GAS FLOW
measured calculated
543 °C 517 °C
536 °C 529 °C
515 °C 540 °C
528 °C 549 °C
531 °C 556 °C
532 °C 562 °C
531 °C 566 °C
535 °C 568 °C
542 °C 569 °C
517 °C 567 °C
518 °C 564 °C
518 °C 560 °C
Calculated values based on
Geometrical dimensions like
•wall thickness
•tube diameter
•heated length of tubes
and actual values like
•outlet temp steam
•inlet temp. steam
•inlet temp. fluegas
•inlet flow steam
•total FG flow
Ready
5'-Werte


Edit View Insert HTML-Lists Parameter Process Sheets Documentation Window Help
5'-Werte
7/13/2009 11:15:00 PM-11:20:00 PM
HOT SPOT
Vindhyachal 9
7/13/2009 11:15:00 PM-11:20:00 PM
Platen SH
SHPL highest temp 584 °C
SHPL highest temp slice 13
SHPL highest temp tube 4
SHPL highest temp length 0 m
Reheater
REH highest temp 609 °C
REH highest temp slice 37
REH highest temp tube 9
REH highest temp length 0 m
Location and value of hotspots in heating surfaces
SH Division Panel
SHDP highest temp 524 °C
SHDP highest temp slice 24
SHDP highest temp tube 2
SHDP highest temp length 0 m
LTSH
LTSH highest temp 502 °C
LTSH highest temp slice 62
LTSH highest temp tube 2
LTSH highest temp length 0 m
Ready
5'-Werte

THE BUILDING BLOCKS (BBs)

- BB 1:PERFORMANCE ANALYSIS & MONITORING MODULE
- BB2:SYSTEM & PERFORMANCE OPTIMISATION
- BB3:BPOS(BOILER PERFORMANCE OPTIMISATION SYSTEM)
- BB4:BOILER STRESS CONDITION ANALYSER
- BB5:SYSTEM & PERFORMANCE DIAGNOSIS MODULE
- BB6:INTELLIGENT WATER & STEAM CHEM. MGT

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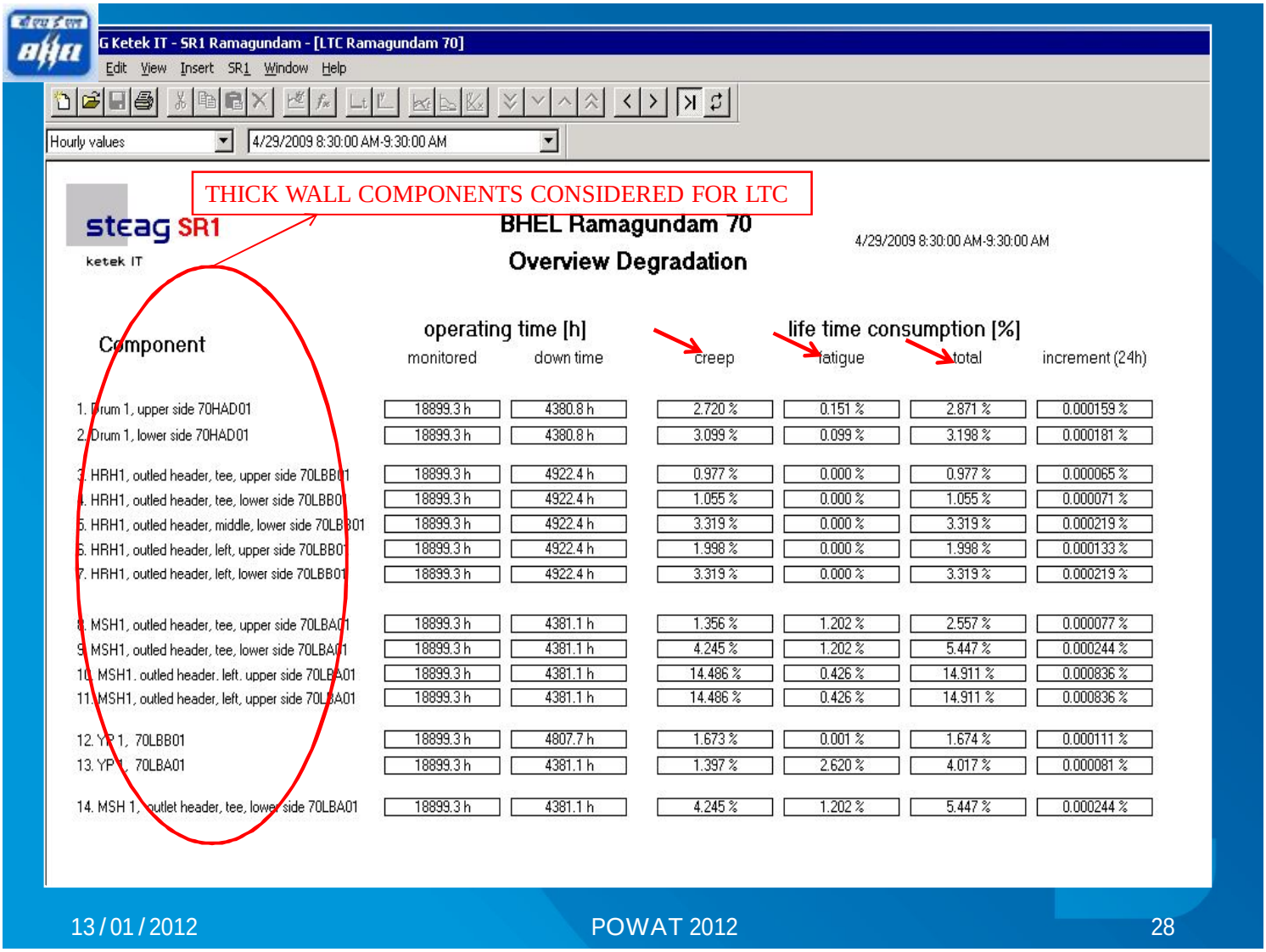
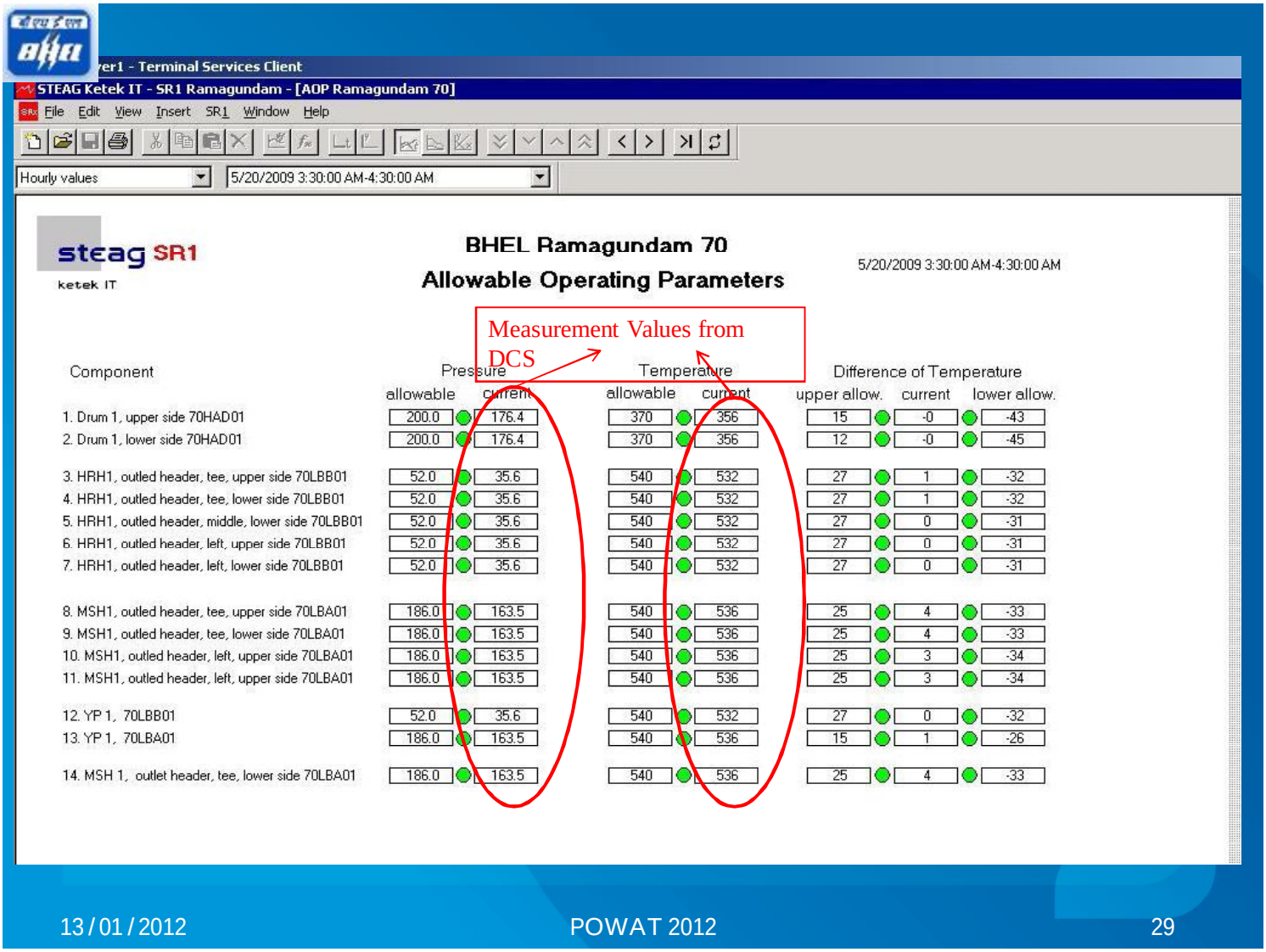
BB-5: BOILER STRESS CONDITION ANALYSER

FEATURES:

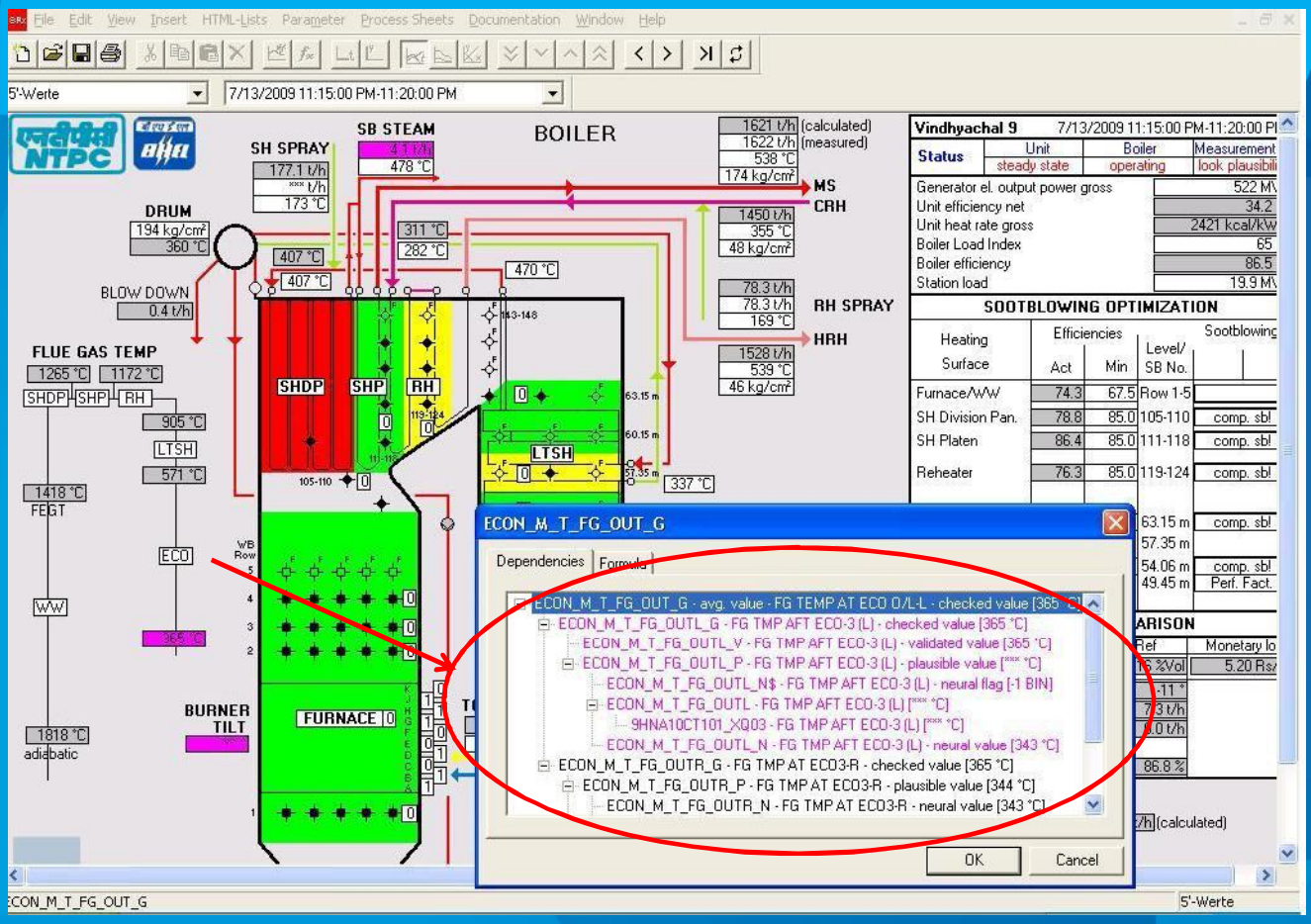
- CALCULATION OF CREEP & FATIGUE
  - --DRUM
  - -- SH O/L HDR
  - -- RH O/L HDR
  - -- Y PIECE IN MS LINE
- REMAINING LIFETIME INDICATION
- LIST OF LARGE LOAD CHANGES
- ALLOWABLE OPERATING PARAMETERS


G Ketek IT - SR1 Ramagundam - [LTC Ramagundam 70]
Edit View Insert SR1 Window Help
Hourly values
4/29/2009 8:30:00 AM-9:30:00 AM
THICK WALL COMPONENTS CONSIDERED FOR LTC
steag SR1
ketek IT
BHEL Ramagundam 70
Overview Degradation
4/29/2009 8:30:00 AM-9:30:00 AM
Component
operating time [h]
monitored
down time
life time consumption [%]
creep
fatigue
total
increment (24h)
1. Drum 1, upper side 70HAD01 18899.3 h 4380.8 h 2.720 % 0.151 % 2.871 % 0.000159 %
2. Drum 1, lower side 70HAD01 18899.3 h 4380.8 h 3.099 % 0.099 % 3.198 % 0.000181 %
3. HRH1, outled header, tee, upper side 70LBB01 18899.3 h 4922.4 h 0.977 % 0.000 % 0.977 % 0.000065 %
4. HRH1, outled header, tee, lower side 70LBB01 18899.3 h 4922.4 h 1.055 % 0.000 % 1.055 % 0.000071 %
5. HRH1, outled header, middle, lower side 70LBB01 18899.3 h 4922.4 h 3.319 % 0.000 % 3.319 % 0.000219 %
6. HRH1, outled header, left, upper side 70LBB01 18899.3 h 4922.4 h 1.998 % 0.000 % 1.998 % 0.000133 %
7. HRH1, outled header, left, lower side 70LBB01 18899.3 h 4922.4 h 3.319 % 0.000 % 3.319 % 0.000219 %
8. MSH1, outled header, tee, upper side 70LBA01 18899.3 h 4381.1 h 1.356 % 1.202 % 2.557 % 0.000077 %
9. MSH1, outled header, tee, lower side 70LBA01 18899.3 h 4381.1 h 4.245 % 1.202 % 5.447 % 0.000244 %
10. MSH1. outled header. left. upper side 70LBA01 18899.3 h 4381.1 h 14.486 % 0.426 % 14.911 % 0.000836 %
11. MSH1, outled header, left, upper side 70LBA01 18899.3 h 4381.1 h 14.486 % 0.426 % 14.911 % 0.000836 %
12. YP 1, 70LBB01 18899.3 h 4807.7 h 1.673 % 0.001 % 1.674 % 0.000111 %
13. YP 1, 70LBA01 18899.3 h 4381.1 h 1.397 % 2.620 % 4.017 % 0.000081 %
14. MSH 1, outlet header, tee, lower side 70LBA01 18899.3 h 4381.1 h 4.245 % 1.202 % 5.447 % 0.000244 %

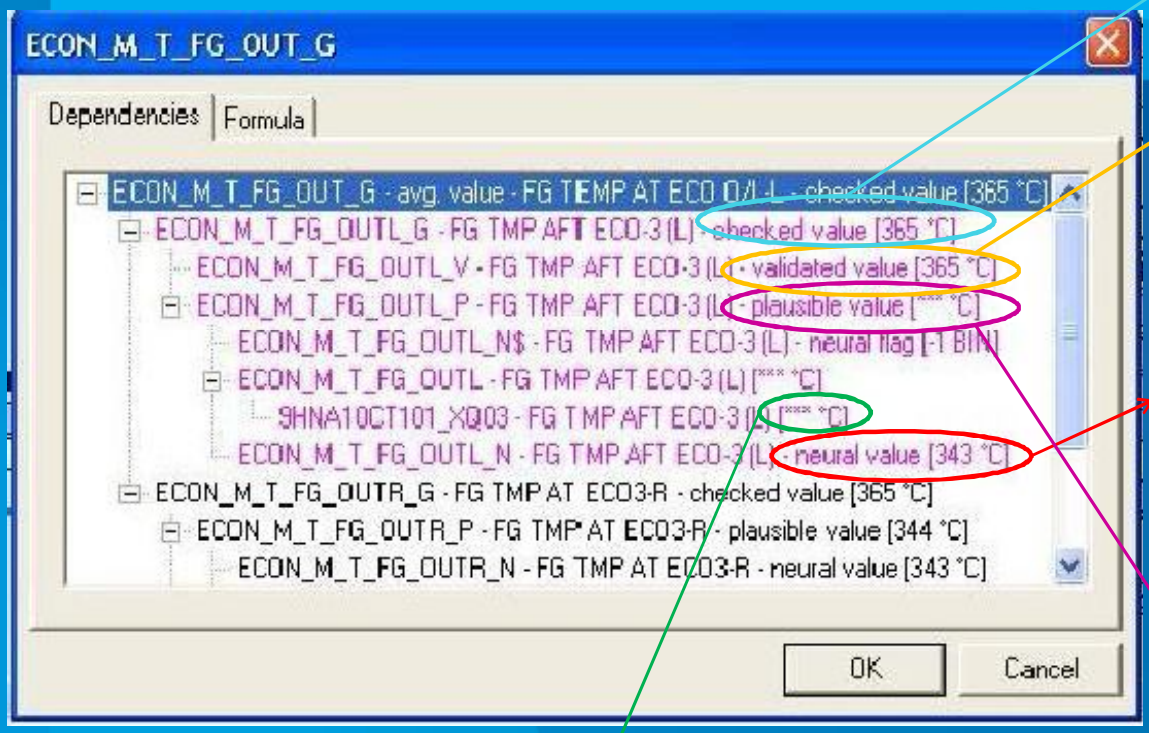


Component	Pressure allowable	Pressure current	Temperature allowable	Temperature current	Difference of Temperature upper allow.	Difference of Temperature current	Difference of Temperature lower allow.
1. Drum 1, upper side 70HAD01	200.0	176.4	370	356	15	-0	-43
2. Drum 1, lower side 70HAD01	200.0	176.4	370	356	12	-0	-45
3. HRH1, outled header, tee, upper side 70LBB01	52.0	35.6	540	532	27	1	-32
4. HRH1, outled header, tee, lower side 70LBB01	52.0	35.6	540	532	27	1	-32
5. HRH1, outled header, middle, lower side 70LBB01	52.0	35.6	540	532	27	0	-31
6. HRH1, outled header, left, upper side 70LBB01	52.0	35.6	540	532	27	0	-31
7. HRH1, outled header, left, lower side 70LBB01	52.0	35.6	540	532	27	0	-31
8. MSH1, outled header, tee, upper side 70LBA01	186.0	163.5	540	536	25	4	-33
9. MSH1, outled header, tee, lower side 70LBA01	186.0	163.5	540	536	25	4	-33
10. MSH1, outled header, left, upper side 70LBA01	186.0	163.5	540	536	25	3	-34
11. MSH1, outled header, left, upper side 70LBA01	186.0	163.5	540	536	25	3	-34
12. YP 1, 70LBB01	52.0	35.6	540	532	27	0	-32
13. YP 1, 70LBA01	186.0	163.5	540	536	15	1	-26
14. MSH 1, outlet header, tee, lower side 70LBA01	186.0	163.5	540	536	25	4	-33

CONCEPT OF DATA VALIDATION



CONCEPT OF DATA VALIDATION



Final Value

Value After Heat Mass Balance

Value from Neural Networ

Value After Range Check

DCS Value

SEAMLESS INTEGRATION OF PADO RESULTS AND RECOMMENDATIONS IN DCS HMI SCREENS

SEAMLESS INTEGRATION OF PADO RESULTS AND RECOMMENDATIONS IN DCS HMI SCREENS

COOLING TOWER CALCULATIONS

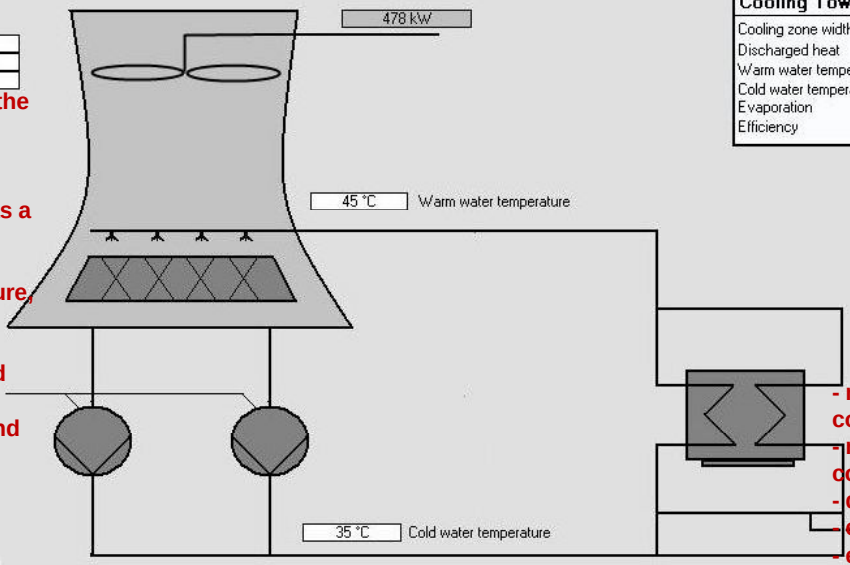
COOLING TOWER

The calculation is made by means of characteristics obtained from design data.

12/20/2011 4:30:00 PM-4:35:00 PM			
Status	Unit	Boiler	Measurements
	steady state	operating	okay
Generator el. output power gross			500 MW
Unit efficiency net			36.5 %
Unit heat rate gross			2264 kcal/kWh
TG heat rate net, actual			2017 kcal/kWh
Boiler efficiency			85.8 %
Station load			20.0 MW

Cooling Tower	Actual	Reference
Cooling zone width	12 K	9 K
Discharged heat	615 MW	
Warm water temperature	45 °C	
Cold water temperature	35 °C	33 °C
Evaporation	854 t/h	
Efficiency	129 %	

The characteristic curve defines the cooling zone width (or the cold-water-temperature) as a function of
- air moisture,
- air temperature,
- load factor (cooling water mass flow) and
- warm water temperature and Cold water temperature



- reference value of cooling zone width
- reference value of cold water temp
- discharged heat
- evaporation
- efficiency

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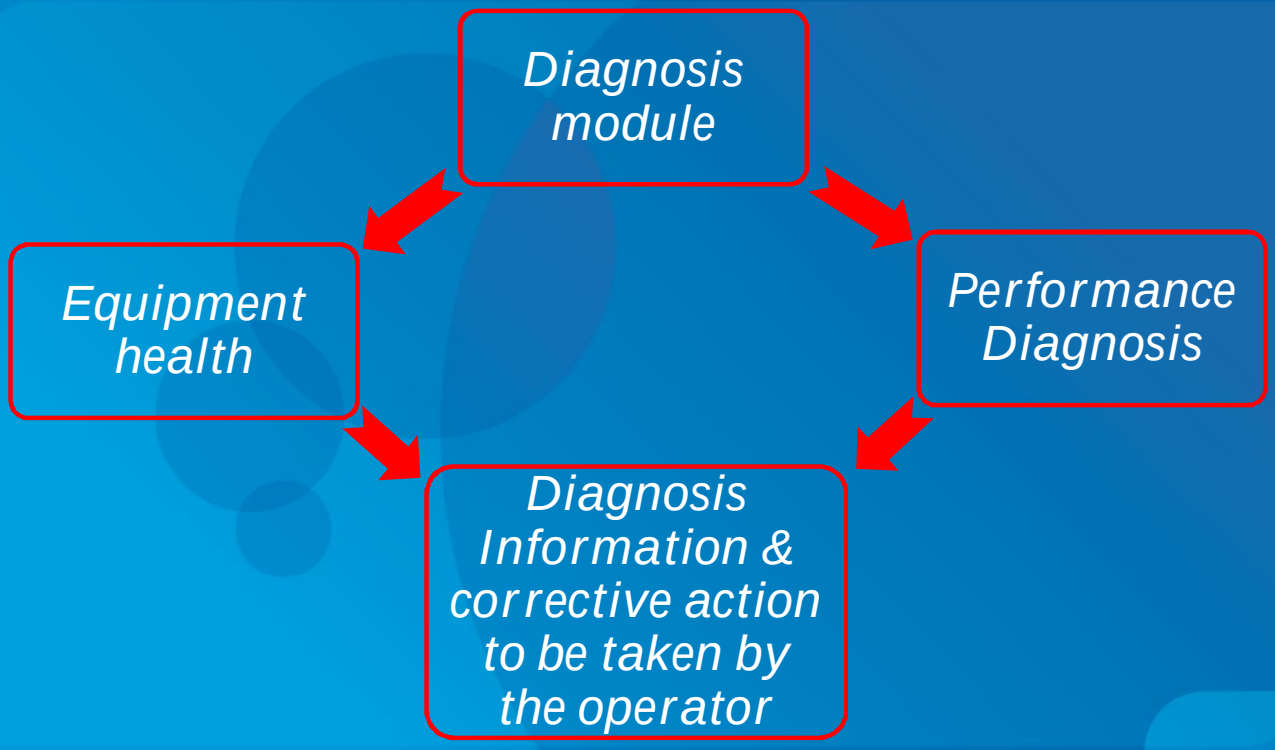
- BB6:SYSTEM & PERFORMANCE DIAGNOSIS MODULE
- BB7:INTELLIGENT WATER & STEAM CHEM. MGT

BB-6: SYS & PERFORMANCE DIAGNOSIS

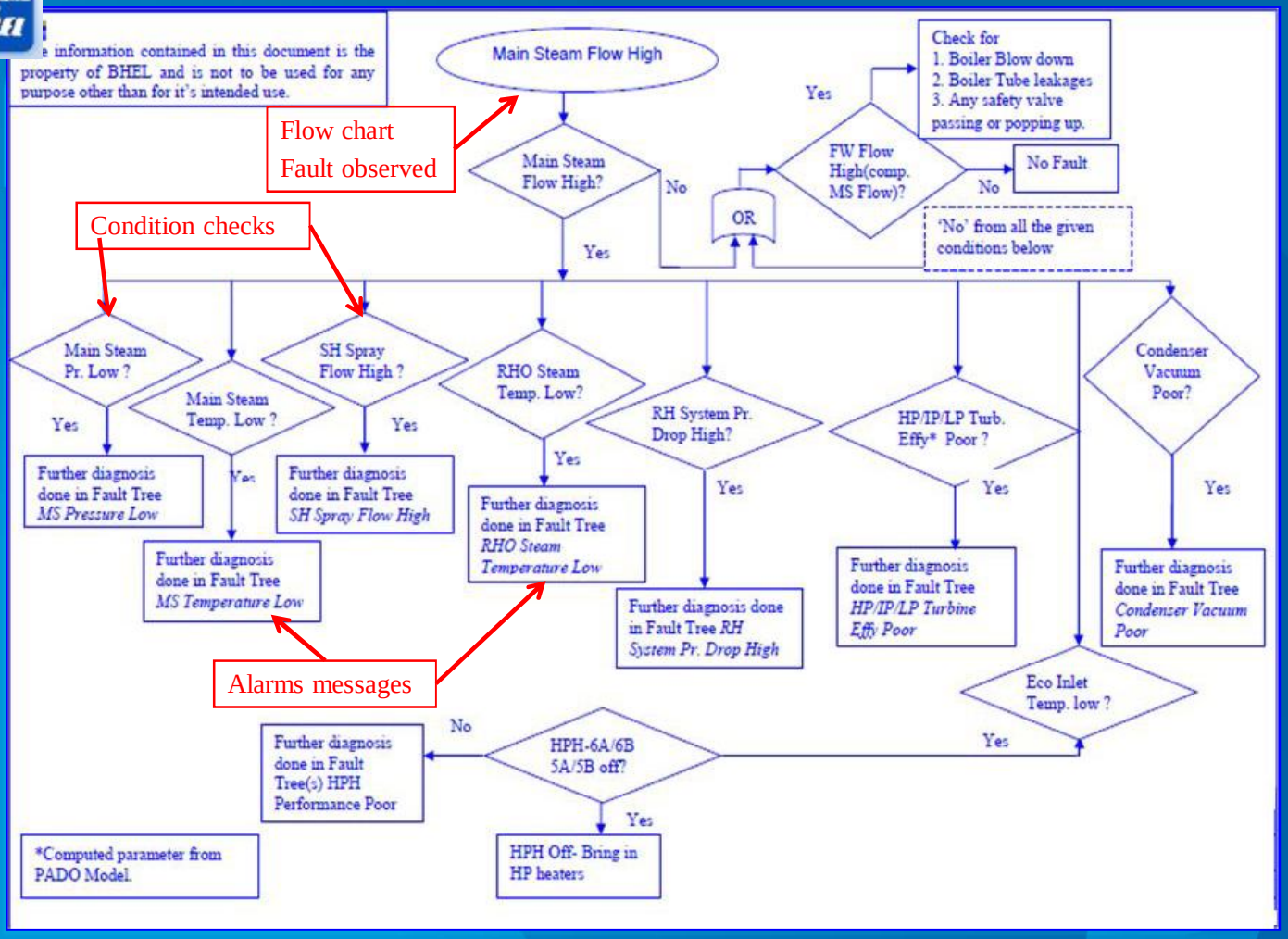
- *A SUPERVISORY MONITORING SYSTEM OVER AND ABOVE THE PLANT PERFORMANCE MONITORING SYSYTEM.*
- *PERFORMS DIAGNOSIS OF SYSTEM & INDIVIDUAL EQUIPMENTS WITH ON-LINE DATA.*
- *THE PURPOSE OF THIS MODULE IS TO PIN-POINT ROOT CAUSE OF ABNORMALITIES EXISTING IN THE PROCESS.*

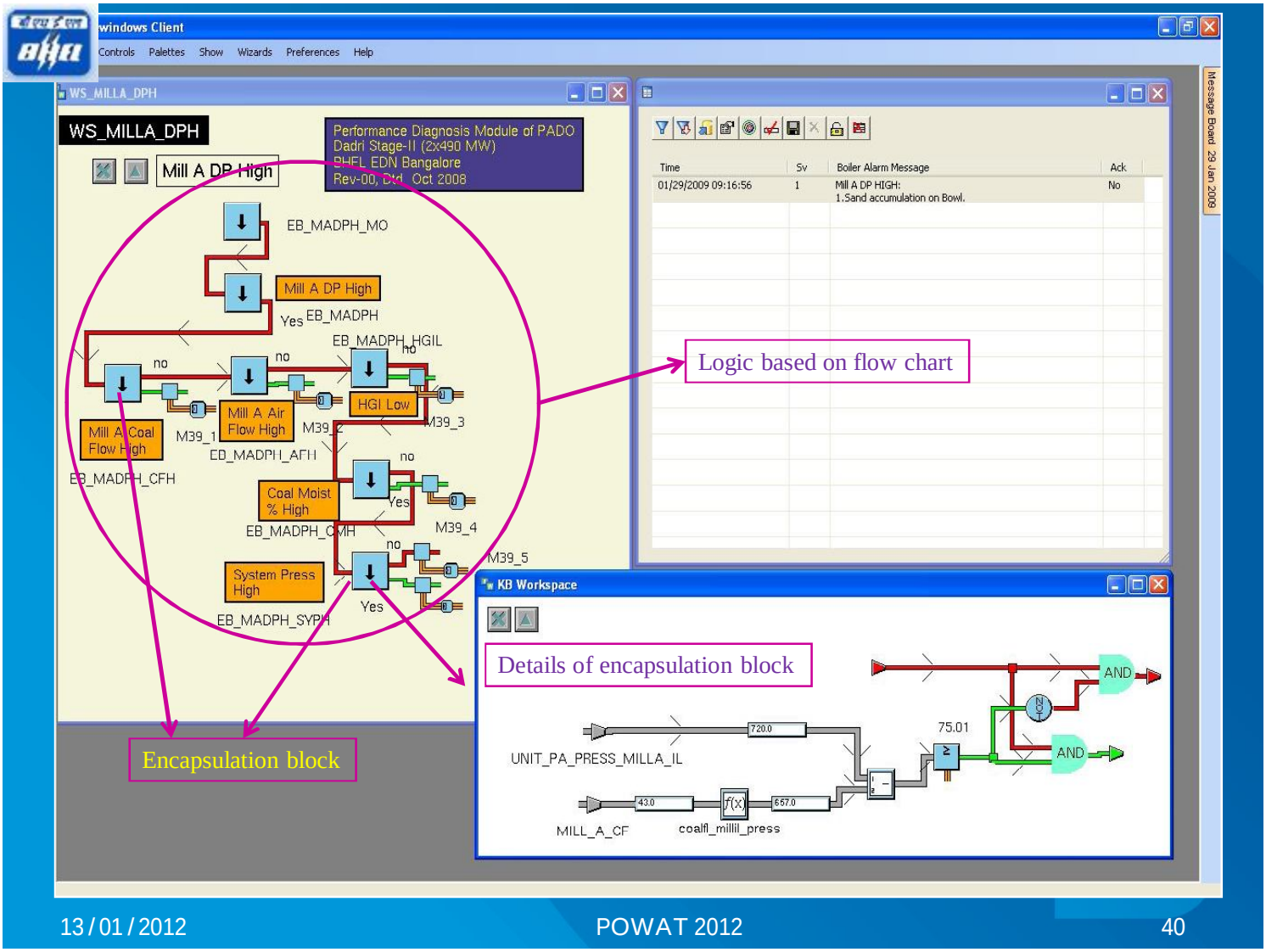
BB-6: SYS & PERFORMANCE DIAGNOSIS

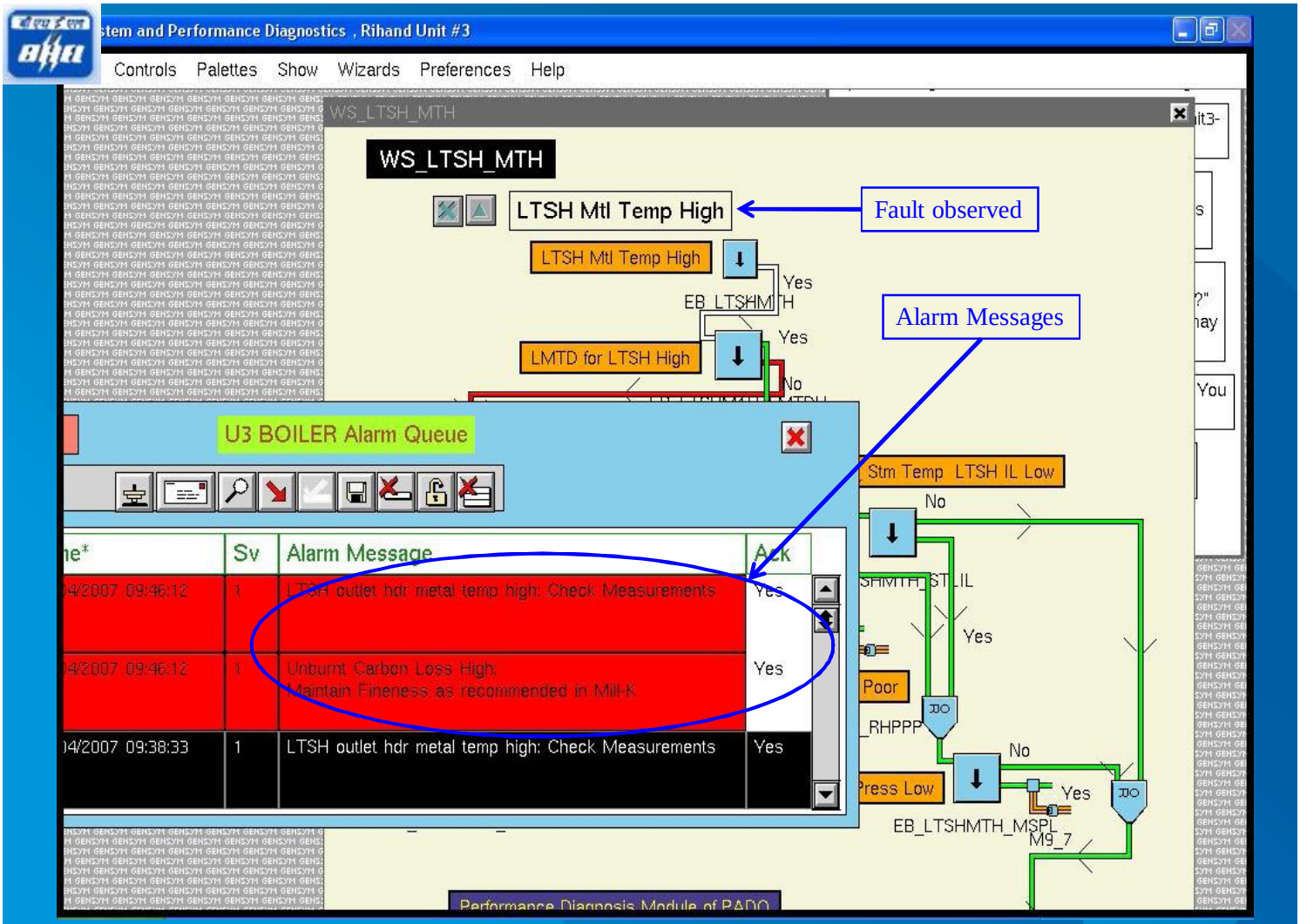


GROUPS OF FAULT DIAGNOSIS TREES

- *Boiler System*
- *Turbine System*
- *Condenser System*
- *Feed Water System*
- *Regenerative Heating System*


e information contained in this document is the property of BHEL and is not to be used for any purpose other than for it's intended use.
Main Steam Flow High
Flow chart
Fault observed
Main Steam Flow High?
No
Yes
OR
FW Flow High(comp. MS Flow)?
Yes
Check for
1. Boiler Blow down
2. Boiler Tube leakages
3. Any safety valve passing or popping up.
No
No Fault
'No' from all the given conditions below
Condition checks
Main Steam Pr. Low ?
Main Steam Temp. Low ?
SH Spray Flow High ?
RHO Steam Temp. Low?
RH System Pr. Drop High?
HP/IP/LP Turb. Effy* Poor ?
Condenser Vacuum Poor?
Yes
Further diagnosis done in Fault Tree MS Pressure Low
Further diagnosis done in Fault Tree MS Temperature Low
Further diagnosis done in Fault Tree SH Spray Flow High
Further diagnosis done in Fault Tree RHO Steam Temperature Low
Further diagnosis done in Fault Tree RH System Pr. Drop High
Further diagnosis done in Fault Tree HP/IP/LP Turbine Effy Poor
Further diagnosis done in Fault Tree Condenser Vacuum Poor
Alarms messages
Eco Inlet Temp. low ?
HPH-6A/6B 5A/5B off?
No
Further diagnosis done in Fault Tree(s) HPH Performance Poor
HPH Off- Bring in HP heaters
*Computed parameter from PADO Model.


windows Client
Controls
Palettes
Show
Wizards
Preferences
Help
WS_MILLA_DPH
Performance Diagnosis Module of PADO
Dadri Stage-II (2x490 MW)
BHEL EDN Bangalore
Rev-00, Dtd Oct 2008
Mill A DP High
EB_MADPH_MO
Yes
EB_MADPH
EB_MADPH_HGIL
no
HGI Low
M39_3
Mill A Air Flow High
M39_2
M39_1
Mill A Coal Flow High
EB_MADPH_CFH
EB_MADPH_AFH
Coal Moist % High
EB_MADPH_CMH
M39_4
M39_5
System Press High
EB_MADPH_SYPH
Time
Sv
Boiler Alarm Message
Ack
01/29/2009 09:16:56
1
Mill A DP HIGH:
1.Sand accumulation on Bowl.
No
Message Board 29 Jan 2009
Logic based on flow chart
KB Workspace
Details of encapsulation block
AND
NOT
AND
75.01
720.0
UNIT_PA_PRESS_MILLA_IL
43.0
MILL_A_CF
f(x)
667.0
coalfl_millil_press
Encapsulation block


stem and Performance Diagnostics , Rihand Unit #3
Controls
Palettes
Show
Wizards
Preferences
Help
WS_LTSH_MTH
LTSH Mtl Temp High
Fault observed
LTSH Mtl Temp High
Yes
EB_LTSHMTH
Alarm Messages
LMTD for LTSH High
Yes
No
U3 BOILER Alarm Queue
Sv
Alarm Message
Ack
LTSH outlet hdr metal temp high: Check Measurements
Yes
Unburnt Carbon Loss High:
Maintain Fineness as recommended in Mill-K
Yes
LTSH outlet hdr metal temp high: Check Measurements
Yes
Stm Temp LTSH IL Low
No
Yes
Poor
No
Yes
EB_LTSHMTH_MSPL
M9_7
Performance Diagnosis Module of RADO

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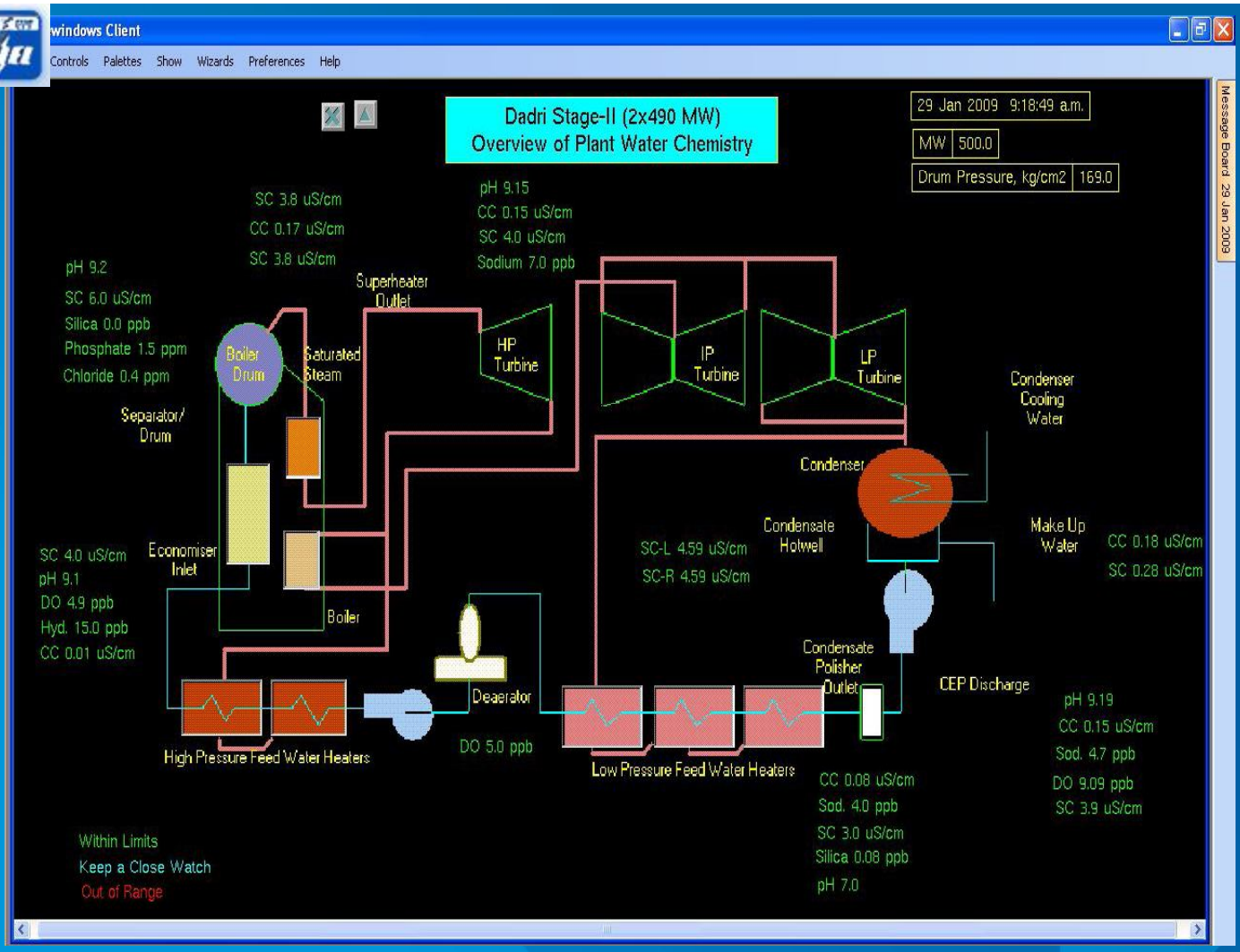
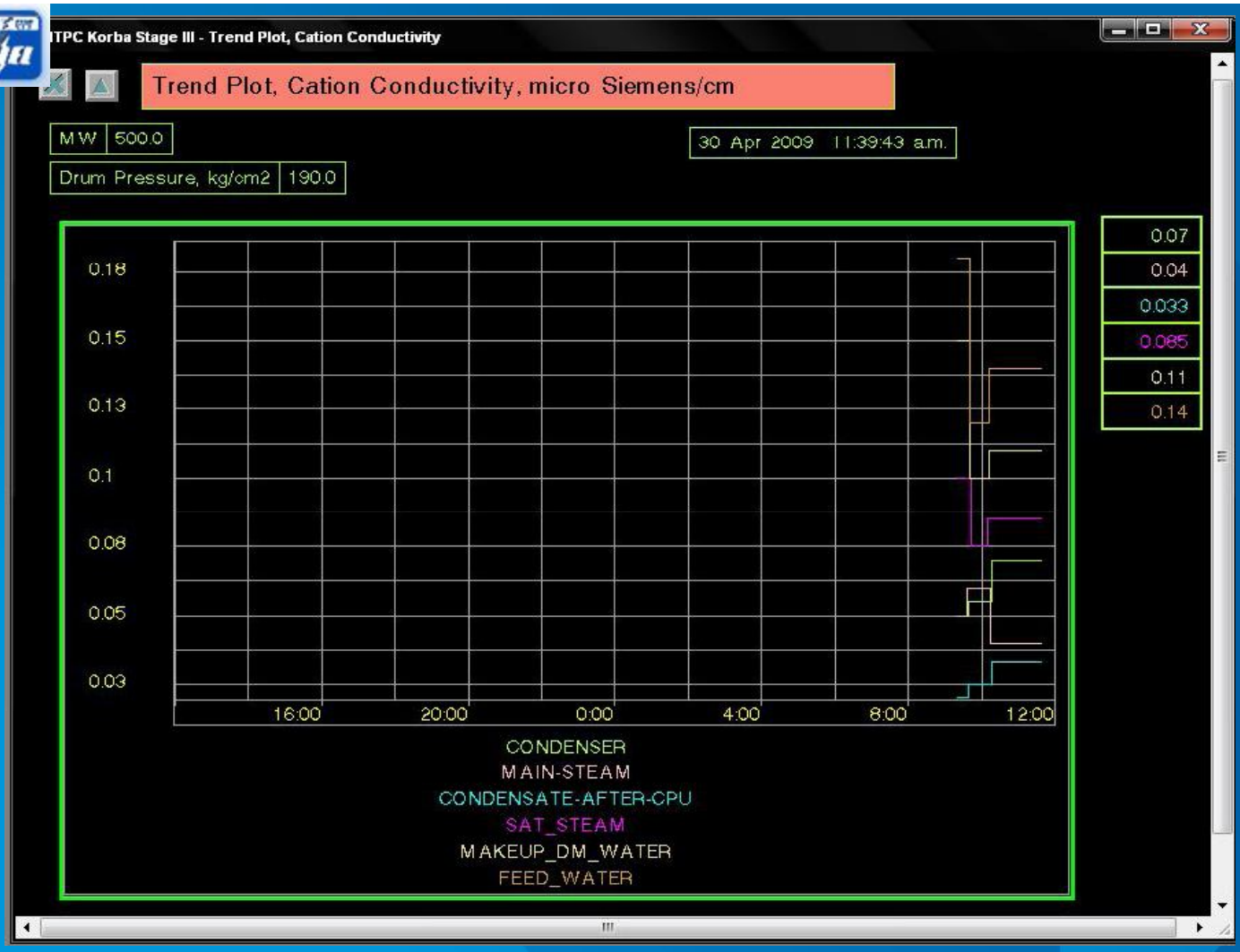
- BB7:INTELLIGENT WATER & STEAM CHEM. MGT

BB-7:INTELLIGENT WATER & STEAM CHEMISTRY MANAGEMENT

Water & Steam Cycle

- *Optimized consumption of dosing chemicals*
- *Reduction in degradation of turbine components*
- *Reduction of boiler tube scale formation*
- *Trending of parameters*


windows Client
Controls
Palettes
Show
Wizards
Preferences
Help
Dadri Stage-II (2x490 MW)
Overview of Plant Water Chemistry
29 Jan 2009 9:18:49 a.m.
MW 500.0
Drum Pressure, kg/cm2 169.0
Message Board 29 Jan 2009
SC 3.8 uS/cm
CC 0.17 uS/cm
SC 3.8 uS/cm
pH 9.15
CC 0.15 uS/cm
SC 4.0 uS/cm
Sodium 7.0 ppb
pH 9.2
SC 6.0 uS/cm
Silica 0.0 ppb
Phosphate 1.5 ppm
Chloride 0.4 ppm
Superheater Outlet
Boiler Drum
Saturated Steam
HP Turbine
IP Turbine
LP Turbine
Separator/ Drum
Condenser Cooling Water
Condenser
Condensate Hotwell
Make Up Water
CC 0.18 uS/cm
SC 0.28 uS/cm
SC-L 4.59 uS/cm
SC-R 4.59 uS/cm
SC 4.0 uS/cm
pH 9.1
DO 4.9 ppb
Hyd. 15.0 ppb
CC 0.01 uS/cm
Economiser Inlet
Boiler
Condensate Polisher Outlet
CEP Discharge
pH 9.19
CC 0.15 uS/cm
Sod. 4.7 ppb
DO 9.09 ppb
SC 3.9 uS/cm
Deaerator
DO 5.0 ppb
High Pressure Feed Water Heaters
Low Pressure Feed Water Heaters
CC 0.08 uS/cm
Sod. 4.0 ppb
SC 3.0 uS/cm
Silica 0.08 ppb
pH 7.0
Within Limits
Keep a Close Watch
Out of Range


TPC Korba Stage III - Trend Plot, Cation Conductivity
Trend Plot, Cation Conductivity, micro Siemens/cm
MW 500.0
Drum Pressure, kg/cm2 190.0
30 Apr 2009 11:39:43 a.m.
0.18
0.15
0.13
0.1
0.08
0.05
0.03
16:00
20:00
0:00
4:00
8:00
12:00
0.07
0.04
0.033
0.085
0.11
0.14
CONDENSER
MAIN-STEAM
CONDENSATE-AFTER-CPU
SAT_STEAM
MAKEUP_DM_WATER
FEED_WATER

Parameters Limits

Parameters for Alarm queue

1. Boiler Water – pH 9.1-9.4
2. Boiler Water - Specific Conductivity < 20.0 micro-siemens/cm
3. Boiler Water - Silica < 100 ppb
4. Boiler Water - Phosphate 1000-2000 ppb
5. Boiler Water - Chloride < 0.5 ppm
6. Deaerator Outlet – Dissolved Oxygen < 7 ppb
7. Feed Water – Hydrazine 10-20 ppb
8. Feed Water – pH 9.0-9.2
9. Feed Water – Specific Conductivity 3-5 micro-siemens/cm
10. Feed Water – Cation Conductivity <0.2 micro-siemens/cm
11. Feed Water – Dissolved oxygen <=5 ppb
12. Main Steam – Specific Conductivity < 5 micro-siemens/cm
13. Main Steam – Cation Conductivity < 0.2 micro-siemens/cm
14. Main Steam – pH 9.0-9.2
15. Main Steam – Sodium < 10.0 ppb
16. Condensate Polisher Outlet – Sodium < 5 ppb
17. Condensate Polisher Outlet – Silica < 5 ppb
18. Condensate Polisher Outlet – Sp. Conductivity < 5 micro-siemens/cm
19. Condensate Polisher Outlet – pH 6.8-9.2
20. Condensate Polisher Outlet –Cation Conductivity <0.1 micro-siemens/cm
21. Hotwell Condensate Left– Sp. Conductivity 3-5 micro-siemens/cm
22. Hotwell Condensate Right– Sp. Conductivity 3-5 micro-siemens/cm
23. CEP Discharge – Cation Conductivity < 0.2 micro-siemens/cm
24. CEP Discharge – Sodium < 5 ppb
25. CEP Discharge – Dissolved Oxygen < 20 ppb
26. CEP Discharge – pH 9.0-9.2
27. CEP Discharge – Sp. Conductivity < 5 micro-siemens/cm
28. Saturated Steam – Sp. Conductivity 3-5 micro-siemens/cm

PADO FUNCTIONS IN PLANT DEPARTMENTS

MANAGEMENT:

- Overview of efficiencies of the plant

EFFICIENCY GROUP:

- Monitoring efficiencies of important plan components

OPERATION GROUP:

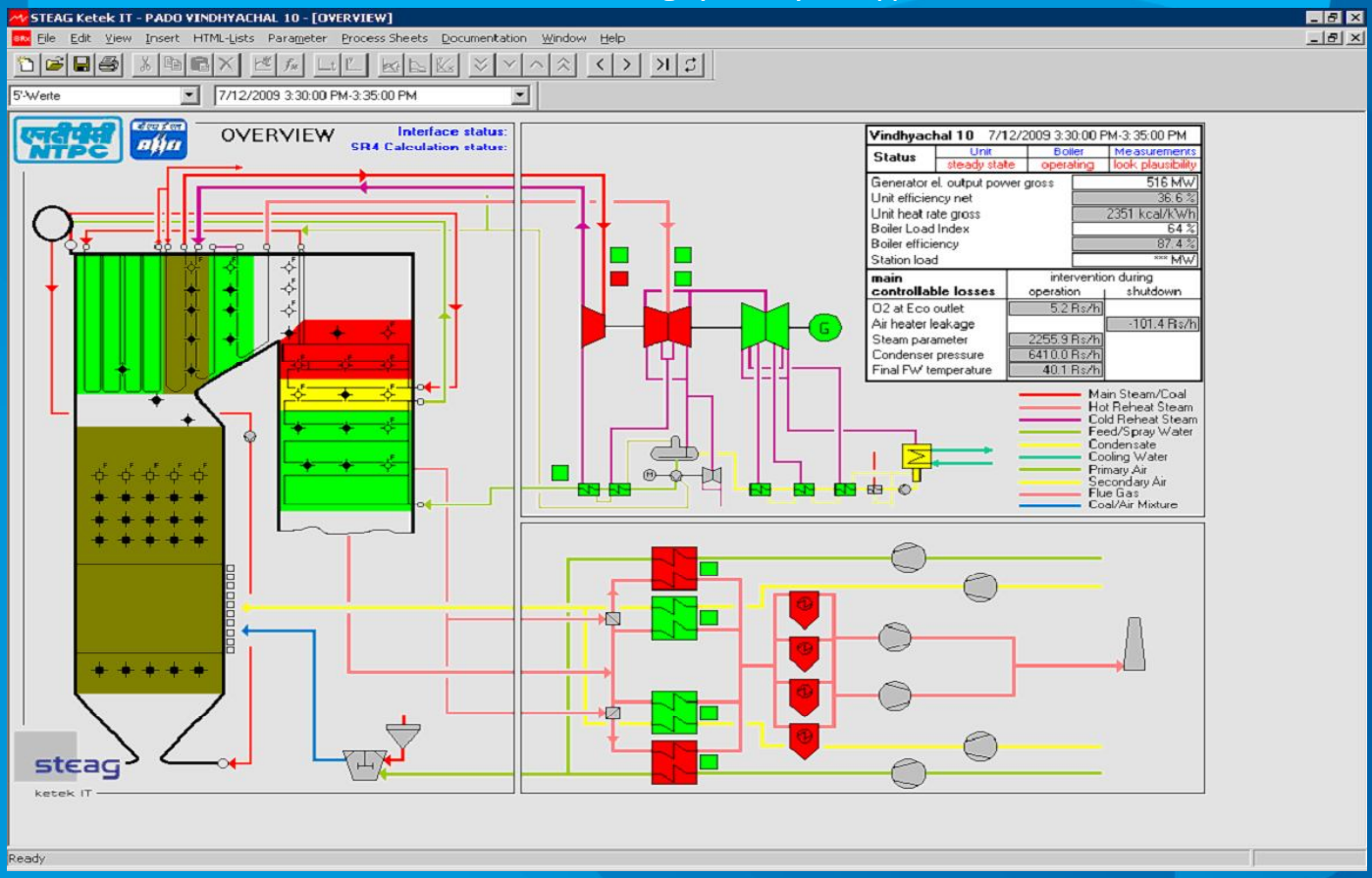
- Following the indication for sootblowing
- Following the set point optimization

MAINTENANCE MECHANICAL AND C&I GROUPS:

- Monitoring of Measurements (Data Reconciliation)

PADO FOR MANAGEMENT

PLANT OVERVIEW



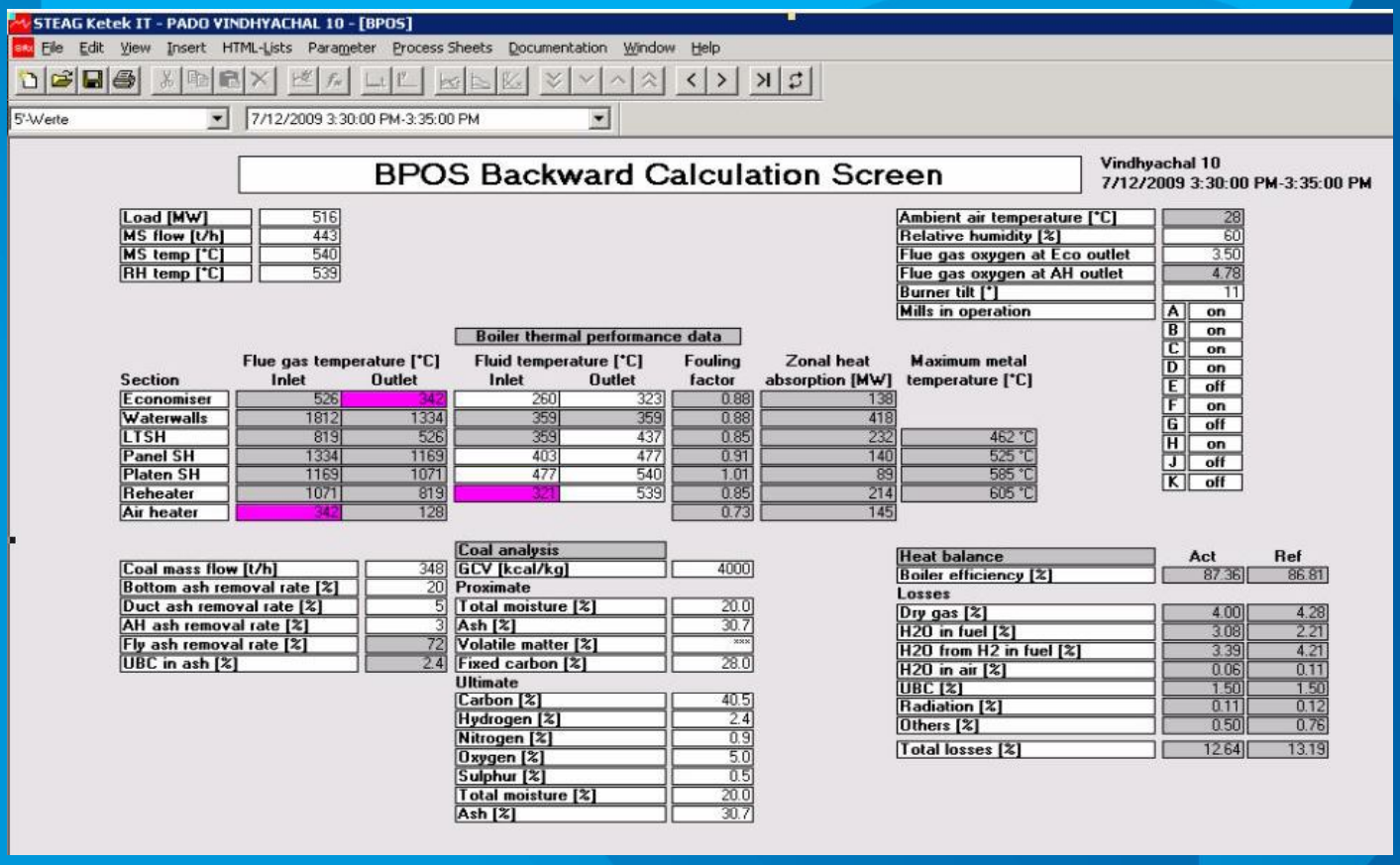
PADO FOR MANAGEMENT

REPORTS

	DAILY REPORT						
	Daily Efficiency Report for Vindhyachal Unit 9						
	Date:	7/12/2009					
	Description	Unit	Availibility (Hr)	No of samples	Average	Min	Max
1	UNIT ACTIVE POWER (AVG) - checked value	GJ/s	24.00	288	516.01	501.81	523.22
2	unit efficiency, net (calc.)	g/kg	21.08	253	33.82	33.21	34.54
3	unit heat rate, gross (calc.)	kcal/kWh	21.08	253	2440.78	2392.55	2481.11
4	boiler efficiency British standard (calc.)	%	21.08	253	83.04	79.73	86.74
5	dry gas loss (calc.)	%	21.08	253	7.76	4.54	10.68
6	loss due to moisture in fuel (calc.)	%	21.08	253	3.28	3.11	3.42
7	loss due to moisture in air (calc.)	%	21.08	253	0.13	0.07	0.17
8	loss due to unburnt carbon (calc.)	%	21.08	253	1.50	1.50	1.50
9	radiation loss (ABMA curve) (calc.)	%	21.08	253	0.11	0.11	0.11
10	other losses (sensible heat of ash etc.) (calc.)	%	21.08	253	0.57	0.50	0.63
11	total losses (calc.)	%	21.08	253	16.96	13.26	20.27
12	gross heat rate, actual (calc.)	kcal/kWh	21.08	253	1998.50	1922.78	2087.91
13	gross heat rate, actual (calc.)	kcal/kWh	21.08	253	2079.47	1995.00	2179.55
14	gross heat rate, reference (calc.)	kcal/kWh	17.92	215	1952.24	1885.83	2009.49

PADO FOR EFFICIENCY GROUP

BOILER EFFICIENCY



PADO FOR EFFICIENCY GROUP

CONTROLLABLE LOSSES

Controllable Losses	Actual	Reference	HR Dev. [kcal/kWh]	Losses expr. in extra fuel	Monetary loss [Rs/h]
Throttle temperature	536 °C	537 °C	0.121	0.0 t/h	19
Throttle pressure	168 kg/cm²	170 kg/cm²a	3.152	0.5 t/h	508
Reheat temperature	536 °C	537 °C	-0.370	-0.1 t/h	-60
Reheat pressure drop	3.5 kg/cm²	4.5 kg/cm²a	-3.462	-0.5 t/h	-558
Condenser back pressure	-0.86 kg/cm²	-0.89 kg/cm²	39.789	5.8 t/h	6410
Superheater spray flow	105.9 t/h	8.3 t/h	4.700	0.7 t/h	757
Reheat spray flow	44.6 t/h	0.0 t/h	14.003	2.1 t/h	2256
Final FW temperature	260 °C	255.1 °C	0.249	0.0 t/h	40
Blow down flow	0.4 t/h	0.5 t/h	-0.047	-0.0 t/h	-8
Auxiliary steam flow	12.0 t/h	10.0 t/h	3.816	0.6 t/h	615
Frequency	49.70 Hz	50.00 Hz	0.021	0.0 t/h	8
Make-up flow	12.8 t/h	0.0 t/h	27.854	4.1 t/h	4487

TG heat rate gross, actual	2026 kcal/kWh	TG heat rate net, actual	*** kcal/kWh
TG heat rate gross, reference	1966 kcal/kWh		

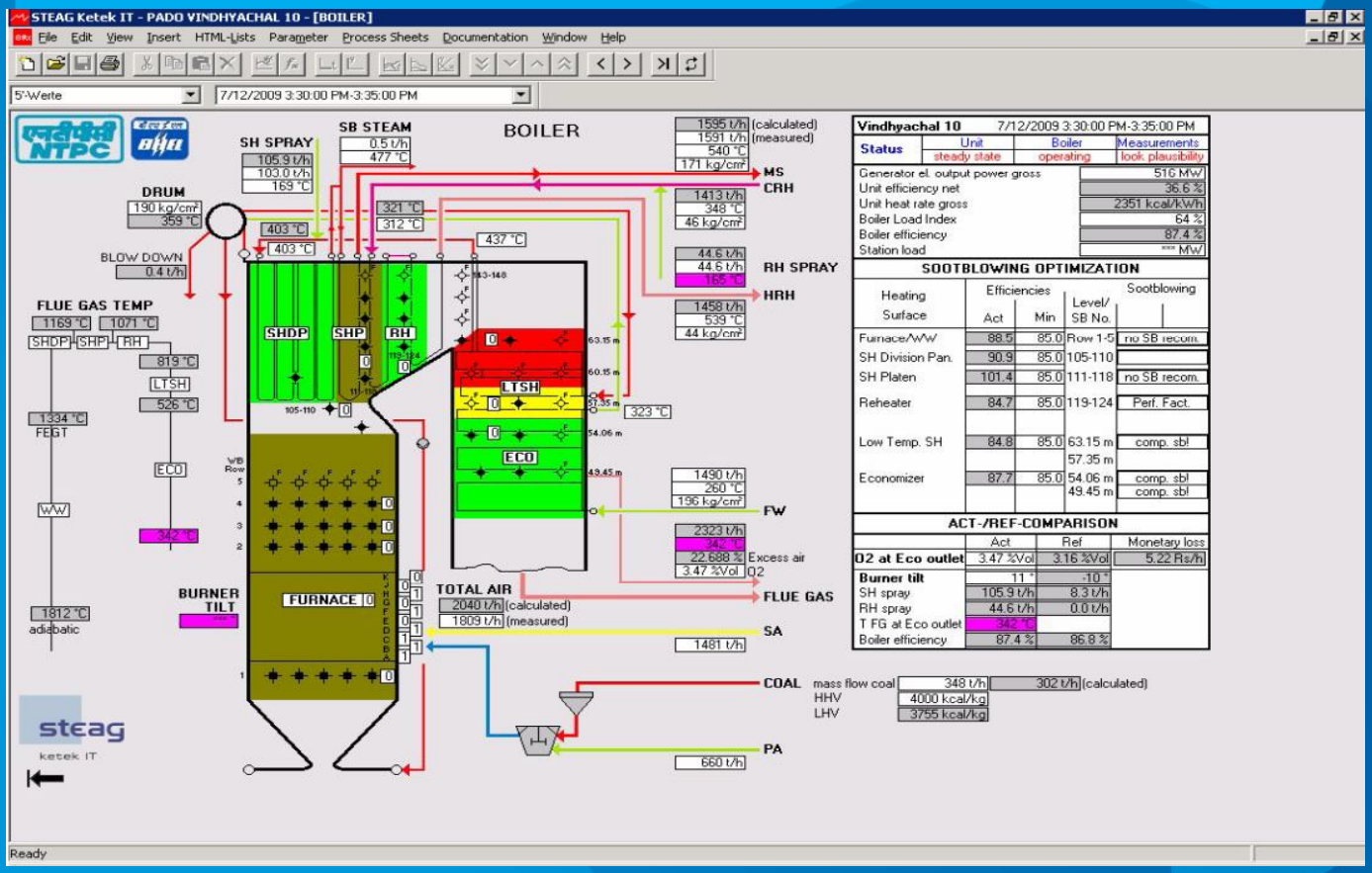
PADO FOR EFFICIENCY GROUP

REPORTS

	DAILY REPORT						
	Daily Efficiency Report for Vindhyachal Unit 9						
	Date:	7/12/2009					
	Description	Unit	Availibility (Hr)	No of samples	Average	Min	Max
1	UNIT ACTIVE POWER (AVG) - checked value	GJ/s	24.00	288	516.01	501.81	523.22
2	unit efficiency, net (calc.)	g/kg	21.08	253	33.82	33.21	34.54
3	unit heat rate, gross (calc.)	kcal/kWh	21.08	253	2440.78	2392.55	2481.11
4	boiler efficiency British standard (calc.)	%	21.08	253	83.04	79.73	86.74
5	dry gas loss (calc.)	%	21.08	253	7.76	4.54	10.68
6	loss due to moisture in fuel (calc.)	%	21.08	253	3.28	3.11	3.42
7	loss due to moisture in air (calc.)	%	21.08	253	0.13	0.07	0.17
8	loss due to unburnt carbon (calc.)	%	21.08	253	1.50	1.50	1.50
9	radiation loss (ABMA curve) (calc.)	%	21.08	253	0.11	0.11	0.11
10	other losses (sensible heat of ash etc.) (calc.)	%	21.08	253	0.57	0.50	0.63
11	total losses (calc.)	%	21.08	253	16.96	13.26	20.27
12	gross heat rate, actual (calc.)	kcal/kWh	21.08	253	1998.50	1922.78	2087.91
13	gross heat rate, actual (calc.)	kcal/kWh	21.08	253	2079.47	1995.00	2179.55
14	gross heat rate, reference (calc.)	kcal/kWh	17.92	215	1952.24	1885.83	2009.49

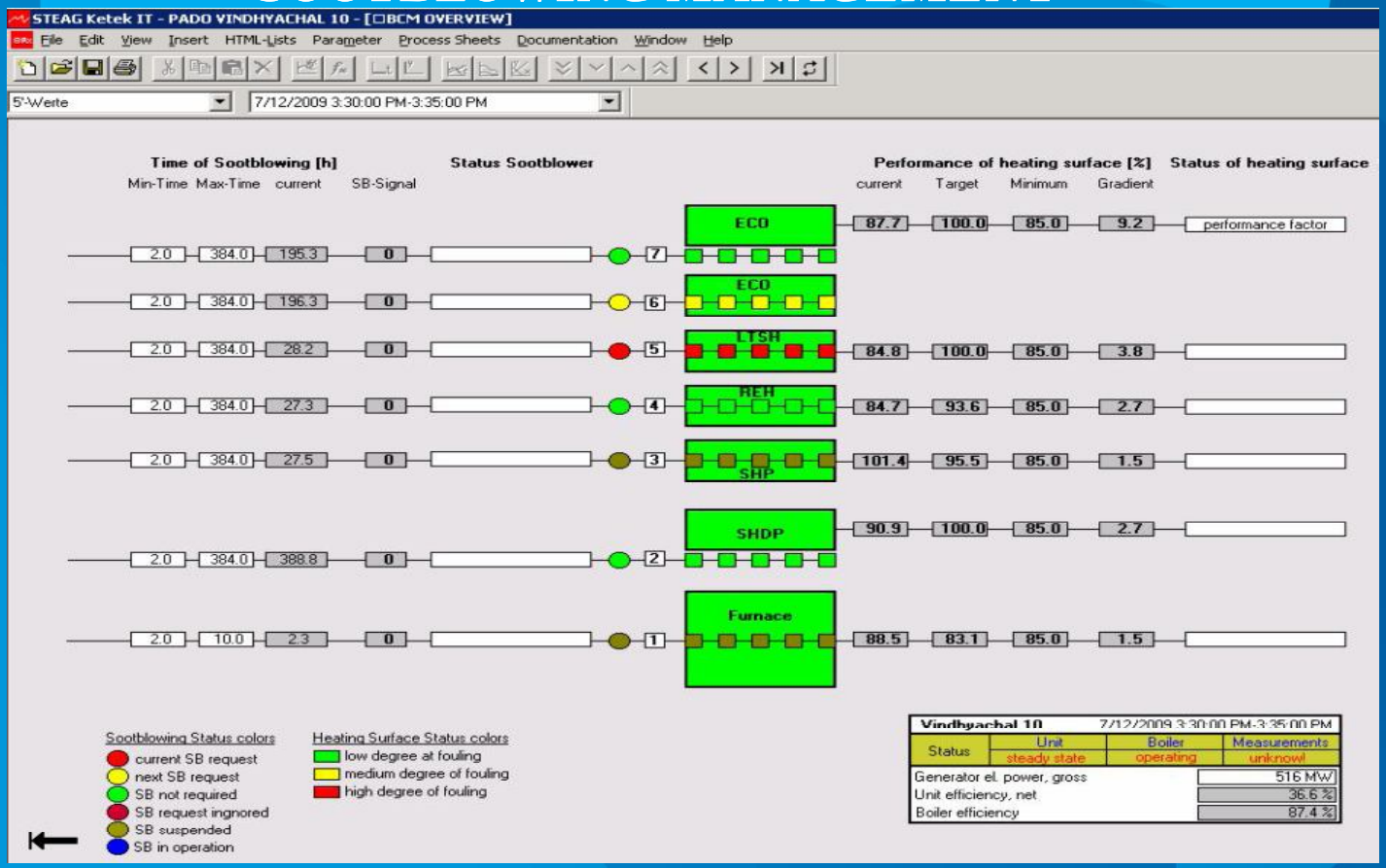
PADO FOR OPERATION GROUP

BOILER



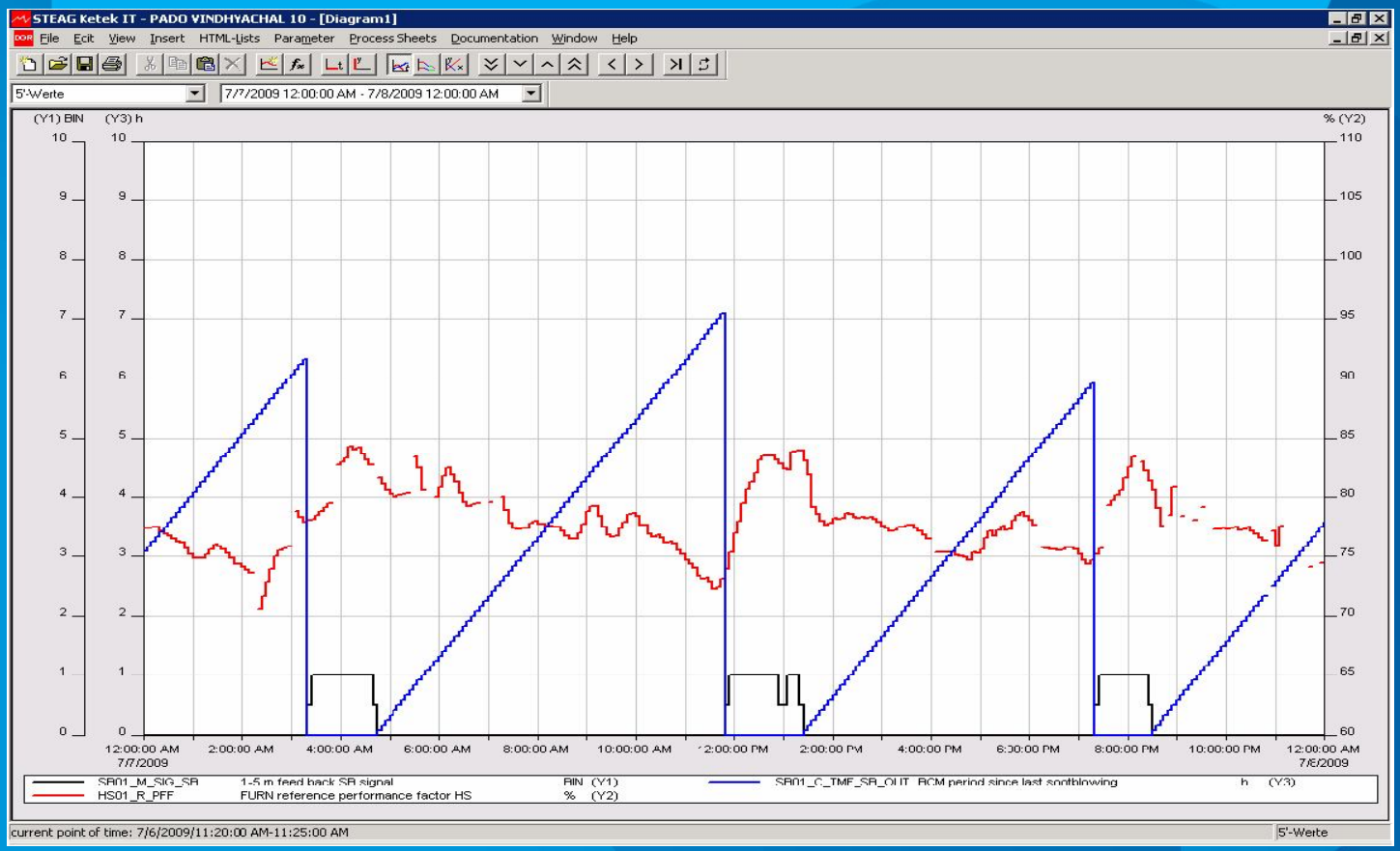
PADO FOR OPERATION GROUP

SOOTBLOWING MANAGEMENT



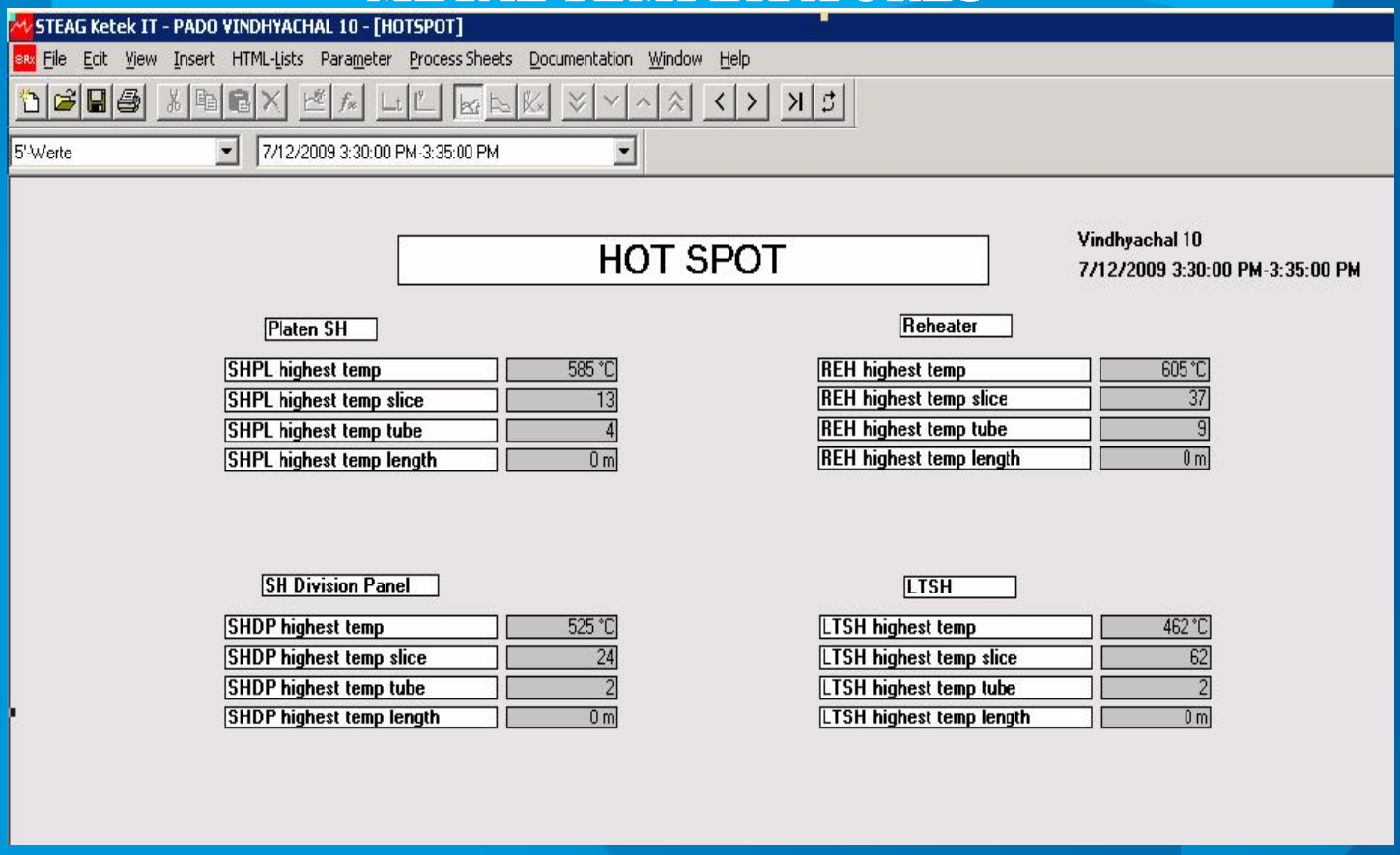
PADO FOR OPERATION GROUP

SOOTBLOWING MONITORING



PADO FOR OPERATION GROUP

METAL TEMPERATURES



PADO FOR OPERATION GROUP

SET POINT OPTIMIZATION

STEAG Ketek IT - PADO VINDHYACHAL 10 - [Set]

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Vindhyachal 10
7/12/2009 3:30:00 PM-3:35:00 PM

Set point optimization

	act value	opt value
Boiler		
O2 at Eco outlet	3.47 %	3.00 %Vol
Burner tilt	11 °	11 °
Turbine Cycle		
MS temperature	539.53 °C	545.00 °C
MS pressure	170.62 kg/cm²	170.00 kg/cm²
Reheat temperature	538.85 °C	545.00 °C
Condenser back pressure	-0.86 kg/cm²	-0.89 kg/cm²
Windbox Furn. pressure	79.87 mmWC	89.74 mmWC
PA HDR Pressure	839.16 mmWC	800.05 mmWC
Unit Heat Rate gross	2351 kcal/kWh	2312 kcal/kWh

PADO FOR OPERATION AND EFFICIENCY GROUP

HEAT RATE POTENTIAL

PADO FOR OPERATION/EFFICIENCY GROUP

WHAT-IF

Microsoft Excel - SR4WhatIf.xls

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Offline What-If Calculation Sheet V1.4 01.07.09

DATE 07/7/2009 16:05

NAME	UNIT	LIMITS LO	LIMITS UP	CURRENT VALUE	CASE STUDY	
AUXILIARY POWER	MW	0	0	0.0	0.0	INST_M_PEL_SELF
MS TEMPERATURE	°C	482	569	535.8	540.0	HP1_M_T_MS
MS PRESSURE	kg/cm²	151	184	167.7	167.7	HP1_M_P_MS
RH TEMPERATURE	°C	484	591	537.3	537.3	IP1_M_T_RH
FW INPUT TEMPERATURE	°C	230	281	255	255	WSC0_R_T_FW
HP HEATER 5 STATUS	-	0	1	1.0	1.0	HPH5_I_STA
HP HEATER 6 STATUS	-	0	1	1.0	1.0	HPH6_I_STA
RH SPRAY FLOW	t/h	0	80	68.70	68.70	BOIL_M_FM_SF_RH
SH SPRAY FLOW	t/h	0	60	98.04	98.04	BOIL_M_FM_SF_SH
CW FLOW	m³/h	#####	47542	43220	43220	COND_M_FV_CW
CONDENSER BACK PRESSURE	kg/cm²c	0.02	0.2	0.123	0.123	COND_M_P_2
CW INLET TEMPARATURE	°C	20	40	31.71	31.71	COND_M_T_CW_INP
AMBIENT AIR TEMPERATURE	°C	15	40	26.57	26.57	PAFA_M_T_AR_INP
AMBIENT RELATIVE HUMIDITY	%	10	100	60	60	RHI_P_PSI
O2 AFT ECO	%	2	5	3.28	3.28	BOIL_M_O2W_FG_AVG
O2 AFT PAHA	%	2	10	5.8	5.8	PAHA_M_O2W_FG_OUT
UBC IN % GCV	%	0.1	50	0.71	0.71	BOIL_P_CUC_UC_LOSS
AH ASH REMOVAL RATE	%	1	50	3.00	3.00	BOIL_P_CAA
BOTTOM ASH REMOVAL RATE	%	1	50	20.00	20.00	BOIL_P_CBA
DUCT ASH REMOVAL RATE	%	1	50	5.00	5.00	BOIL_P_CDA
FLY ASH REMOVAL RATE	%	0	100	72.00	72.00	BOIL_C_CFA
GCV	kcal/kg	2500	6000	4393	4393.15	BOIL_P_HHV_CO
ASH	%	0.1	99	37.00	37.00	BOIL_P_CA
TOTAL MOISTURE	%	0.1	99	17.00	17.00	BOIL_P_CWA
CARBON	%	0.1	99	37.60	37.60	BOIL_P_CC
HYDROGEN	%	0.1	99	2.38	2.38	BOIL_P_CH
NITROGEN	%	0.1	99	0.92	0.92	BOIL_P_CN
OXYGEN	%	0.1	99	5.00	5.00	BOIL_P_CO
SULPHUR	%	0.01	99	0.10	0.10	BOIL_P_CS
BURNER TILT	GRAD	-30	30	-3.61	-3.61	BOIL_M_BT
MILL A IN OPERATION	-	0	1	1	1	MLLA_I_STA
MILL B IN OPERATION	-	0	1	1	1	MLLB_I_STA
MILL C IN OPERATION	-	0	1	1	1	MLLC_I_STA
MILL D IN OPERATION	-	0	1	1	1	MLLD_I_STA
MILL E IN OPERATION	-	0	1	1	1	MLLE_I_STA
MILL F IN OPERATION	-	0	1	1	1	MLLF_I_STA
MILL G IN OPERATION	-	0	1	1	1	MLLG_I_STA
MILL H IN OPERATION	-	0	1	0	0	MLLH_I_STA
MILL J IN OPERATION	-	0	1	1	1	MLLJ_I_STA
MILL K IN OPERATION	-	0	1	0	0	MLLK_I_STA
BLOWDOWN FLOW	t/h	1	10	63.27	63.27	BOIL_C_FM_BD
GENERATOR H2 PRESSURE	kg/cm²	1	5	3.45	3.45	GEN0_M_P_H2
FREQUENCY	Hz	47.5	51.5	49.95	49.95	GEN0_M_FQ
AIR HEATER LEAKAGE	t/h	50	400	341.39	341.39	AH00_C_FM_LEAK
HP EFFICIENCY	%	76.3	93.2	84.74	84.74	HP1_C_EFF

EVONIK INDUSTRIES — Evonik Energy Services

Offline What-If Calculation Sheet V1.4 01.07.09

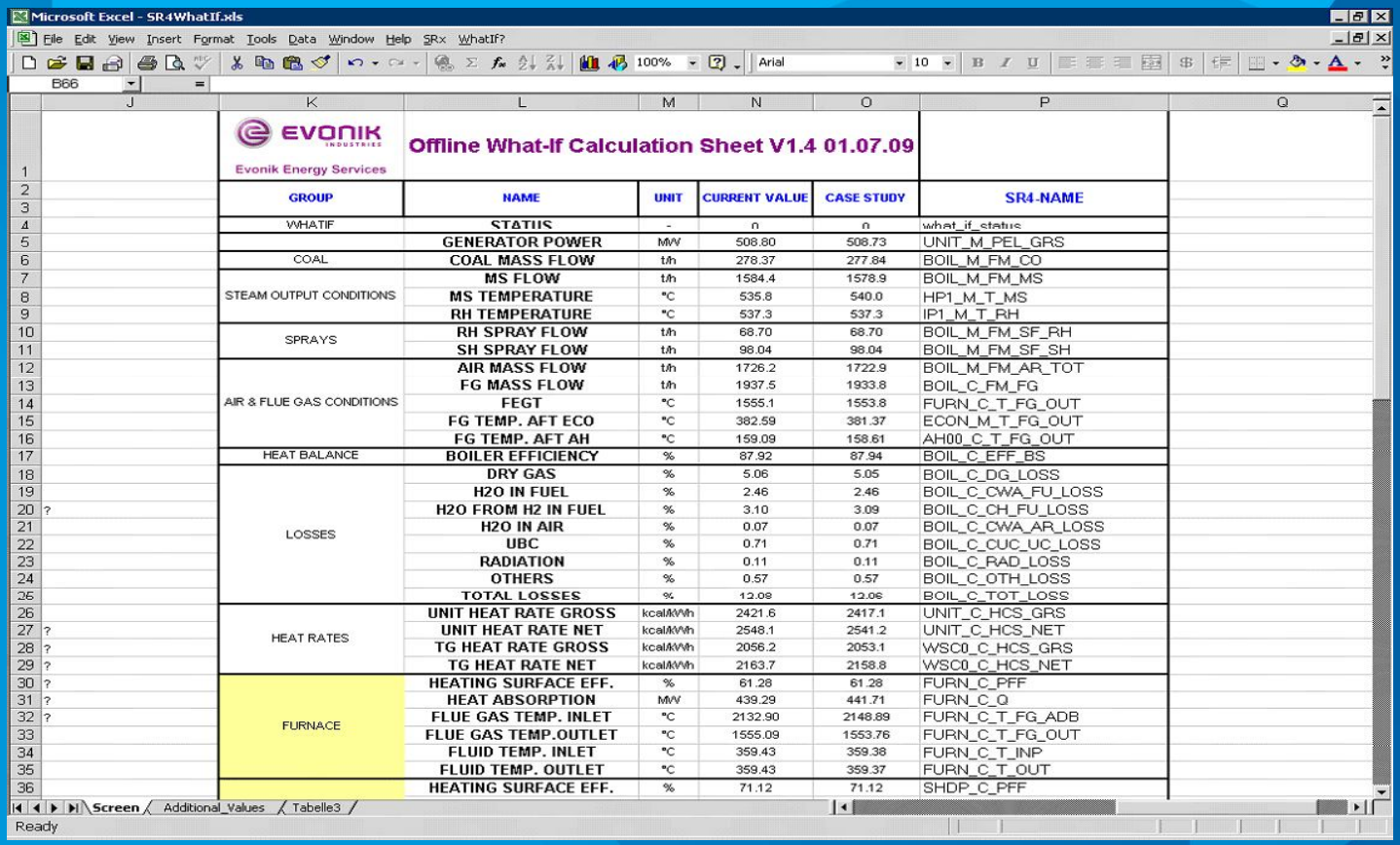
GROUP	NAME	UNIT	CURRENT VALUE	CASE STUDY
WHATIF	STATUS	-	0	0
	GENERATOR POWER	MW	508.80	508.73
COAL	COAL MASS FLOW	t/h	278.37	277.84
STEAM OUTPUT CONDITIONS	MS FLOW	t/h	1584.4	1578.3
	MS TEMPERATURE	°C	535.8	540.0
	RH TEMPERATURE	°C	537.3	537.3
SPRAYS	RH SPRAY FLOW	t/h	68.70	68.70
	SH SPRAY FLOW	t/h	98.04	98.04
AIR & FLUE GAS CONDITIONS	AIR MASS FLOW	t/h	1704.3	1702.9
	FG MASS FLOW	t/h	1937.5	1933.8
	FEGT	°C	1555.1	1553.8
	FG TEMP. AFT ECO	°C	382.59	381.37
	FG TEMP. AFT AH	°C	153.09	158.61
HEAT BALANCE	BOILER EFFICIENCY	%	87.32	87.94
LOSSES	DRY GAS	%	5.06	5.05
	H2O IN FUEL	%	2.46	2.46
	H2O FROM H2 IN FUEL	%	3.10	3.09
	H2O IN AIR	%	0.07	0.07
	UBC	%	0.71	0.71
	RADIATION	%	0.11	0.11
	OTHERS	%	0.57	0.57
	TOTAL LOSSES	%	12.08	12.06
HEAT RATES	UNIT HEAT RATE GROSS	kcal/kWh	2421.6	2417.1
	UNIT HEAT RATE NET	kcal/kWh	2548.1	2541.2
	TG HEAT RATE GROSS	kcal/kWh	2056.2	2053.1
	TG HEAT RATE NET	kcal/kWh	2163.7	2158.8
FURNACE	HEATING SURFACE EFF.	%	61.28	61.28
	HEAT ABSORPTION	MW	439.29	441.71
	FLUE GAS TEMP. INLET	°C	2132.90	2148.89
	FLUE GAS TEMP.OUTLET	°C	1555.09	1553.76
	FLUID TEMP. INLET	°C	353.43	353.38
	FLUID TEMP. OUTLET	°C	353.43	353.37
PANEL SH	HEATING SURFACE EFF.	%	71.12	71.12
	HEAT ABSORPTION	MW	144.92	145.71
	FLUE GAS TEMP. INLET	°C	1555.09	1553.76
	FLUE GAS TEMP.OUTLET	°C	1351.68	1350.41
	FLUID TEMP. INLET	°C	392.97	391.89
	FLUID TEMP. OUTLET	°C	470.80	469.36
PLATEN SH	HEATING SURFACE EFF.	%	65.46	110.01
	HEAT ABSORPTION	MW	96.30	104.26
	FLUE GAS TEMP. INLET	°C	1351.68	1350.41
	FLUE GAS TEMP.OUTLET	°C	1225.45	1212.90
	FLUID TEMP. INLET	°C	470.80	469.36
	FLUID TEMP. OUTLET	°C	541.17	545.41
	HEATING SURFACE EFF.	%	65.24	65.24

Screen / Additional_Values / Tabelle3

Ready

PADO OPERATION/EFFICIENCY GROUPS

WHAT-IF



Microsoft Excel - SR4WhatIf.xls

Evonik Energy Services

Offline What-If Calculation Sheet V1.4 01.07.09

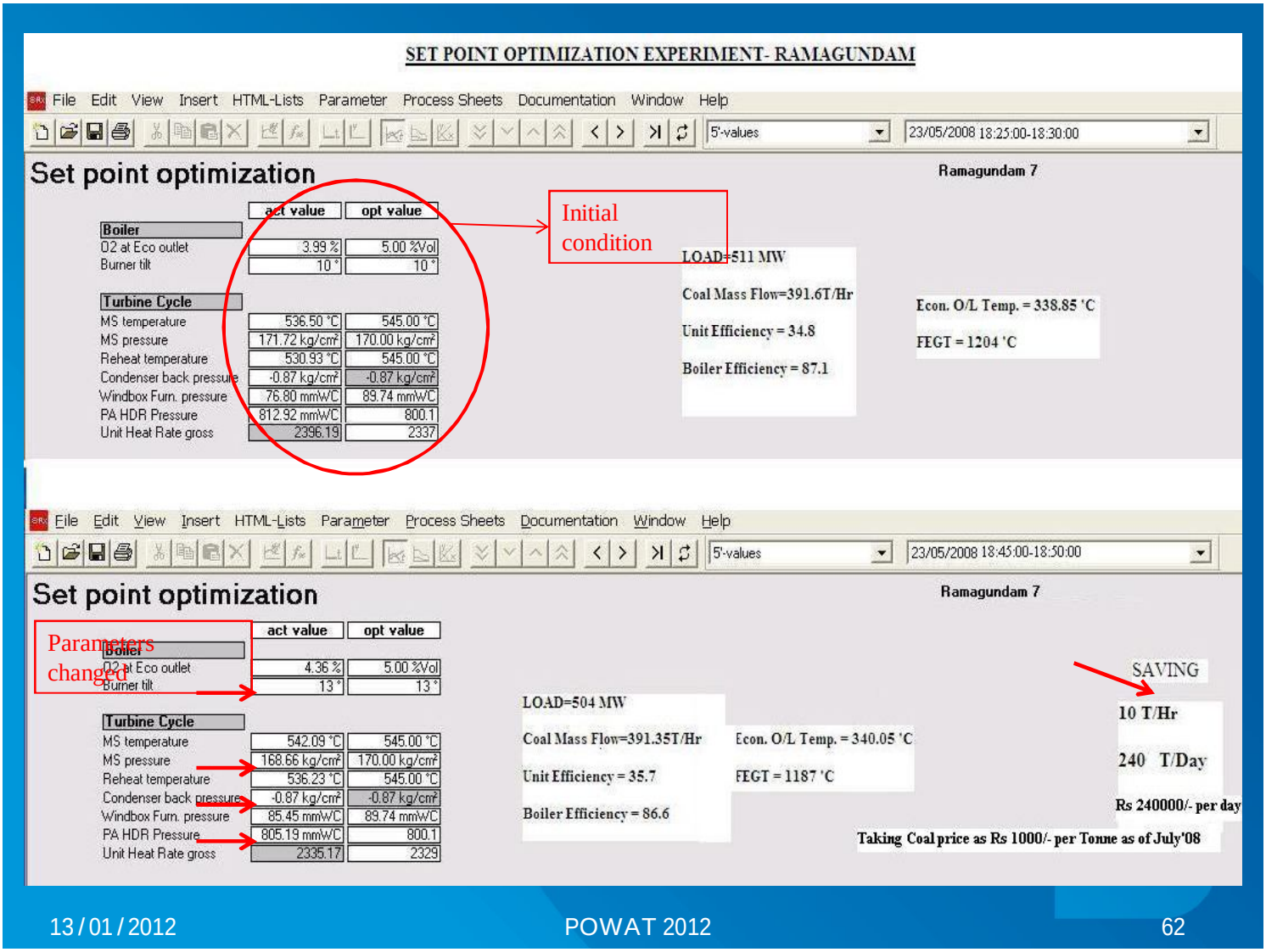
GROUP	NAME	UNIT	CURRENT VALUE	CASE STUDY	SR4-NAME
WHATIF	STATUS	-	0	0	what_if_status
	GENERATOR POWER	MW	508.80	508.73	UNIT_M_PEL_GRS
COAL	COAL MASS FLOW	t/h	278.37	277.84	BOIL_M_FM_CO
STEAM OUTPUT CONDITIONS	MS FLOW	t/h	1584.4	1578.9	BOIL_M_FM_MS
	MS TEMPERATURE	°C	535.8	540.0	HP1_M_T_MS
	RH TEMPERATURE	°C	537.3	537.3	IP1_M_T_RH
SPRAYS	RH SPRAY FLOW	t/h	68.70	68.70	BOIL_M_FM_SF_RH
	SH SPRAY FLOW	t/h	98.04	98.04	BOIL_M_FM_SF_SH
AIR & FLUE GAS CONDITIONS	AIR MASS FLOW	t/h	1726.2	1722.9	BOIL_M_FM_AR_TOT
	FG MASS FLOW	t/h	1937.5	1933.8	BOIL_C_FM_FG
	FEGT	°C	1555.1	1553.8	FURN_C_T_FG_OUT
	FG TEMP. AFT ECO	°C	382.59	381.37	ECON_M_T_FG_OUT
	FG TEMP. AFT AH	°C	159.09	158.61	AH00_C_T_FG_OUT
HEAT BALANCE	BOILER EFFICIENCY	%	87.92	87.94	BOIL_C_EFF_BS
LOSSES	DRY GAS	%	5.06	5.05	BOIL_C_DG_LOSS
	H2O IN FUEL	%	2.46	2.46	BOIL_C_CWA_FU_LOSS
	H2O FROM H2 IN FUEL	%	3.10	3.09	BOIL_C_CH_FU_LOSS
	H2O IN AIR	%	0.07	0.07	BOIL_C_CWA_AR_LOSS
	UBC	%	0.71	0.71	BOIL_C_CUC_UC_LOSS
	RADIATION	%	0.11	0.11	BOIL_C_RAD_LOSS
	OTHERS	%	0.57	0.57	BOIL_C_OTH_LOSS
	TOTAL LOSSES	%	12.06	12.06	BOIL_C_TOT_LOSS
HEAT RATES	UNIT HEAT RATE GROSS	kcal/kWh	2421.6	2417.1	UNIT_C_HCS_GRS
	UNIT HEAT RATE NET	kcal/kWh	2548.1	2541.2	UNIT_C_HCS_NET
	TG HEAT RATE GROSS	kcal/kWh	2056.2	2053.1	WSC0_C_HCS_GRS
	TG HEAT RATE NET	kcal/kWh	2163.7	2158.8	WSC0_C_HCS_NET
FURNACE	HEATING SURFACE EFF.	%	61.28	61.28	FURN_C_PFF
	HEAT ABSORPTION	MW	439.29	441.71	FURN_C_Q
	FLUE GAS TEMP. INLET	°C	2132.90	2148.89	FURN_C_T_FG_ADB
	FLUE GAS TEMP.OUTLET	°C	1555.09	1553.76	FURN_C_T_FG_OUT
	FLUID TEMP. INLET	°C	359.43	359.38	FURN_C_T_INP
	FLUID TEMP. OUTLET	°C	359.43	359.37	FURN_C_T_OUT
	HEATING SURFACE EFF.	%	71.12	71.12	SHDP_C_PFF

Screen / Additional_Values / Tabelle3

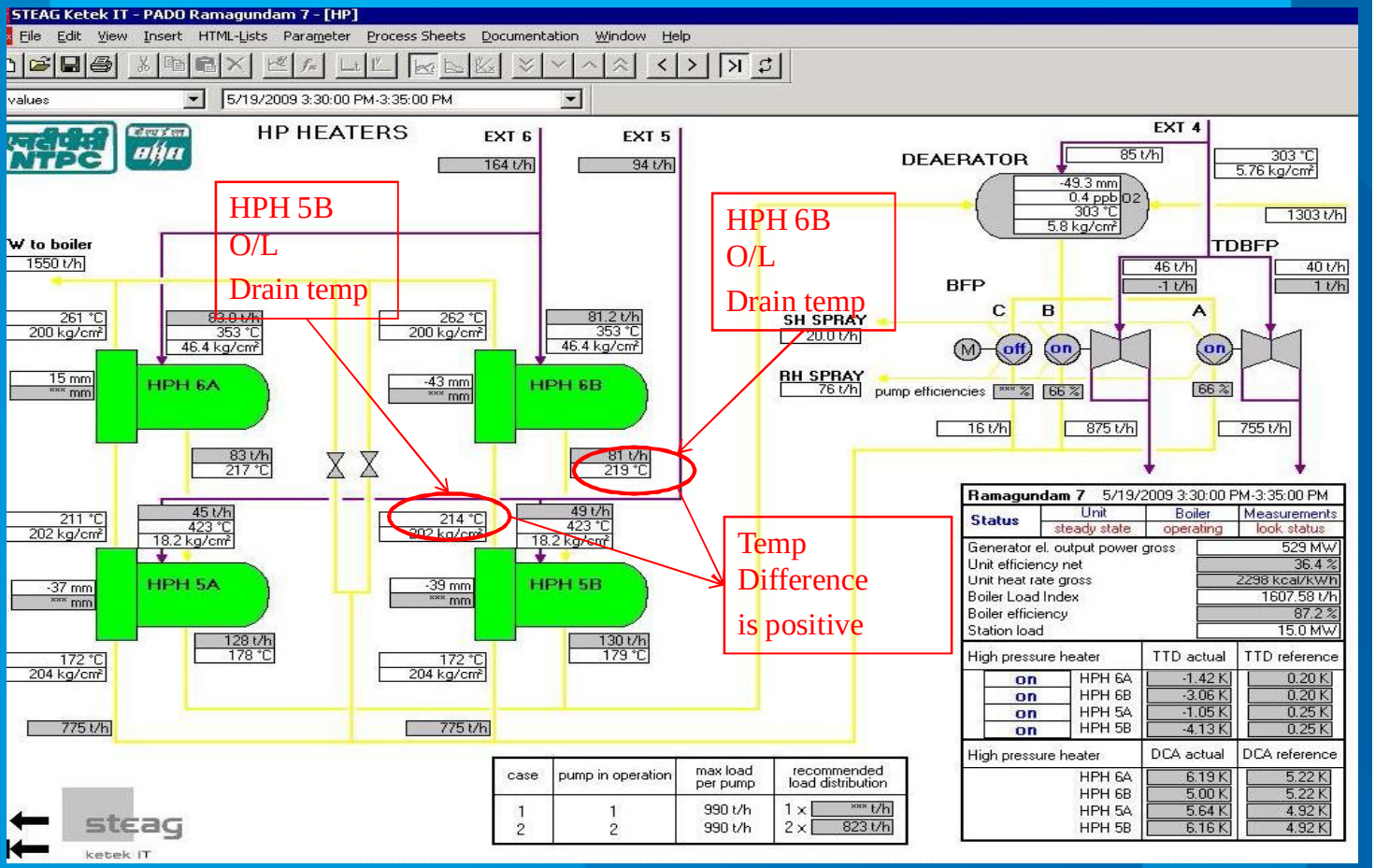
Ready

CASE STUDIES

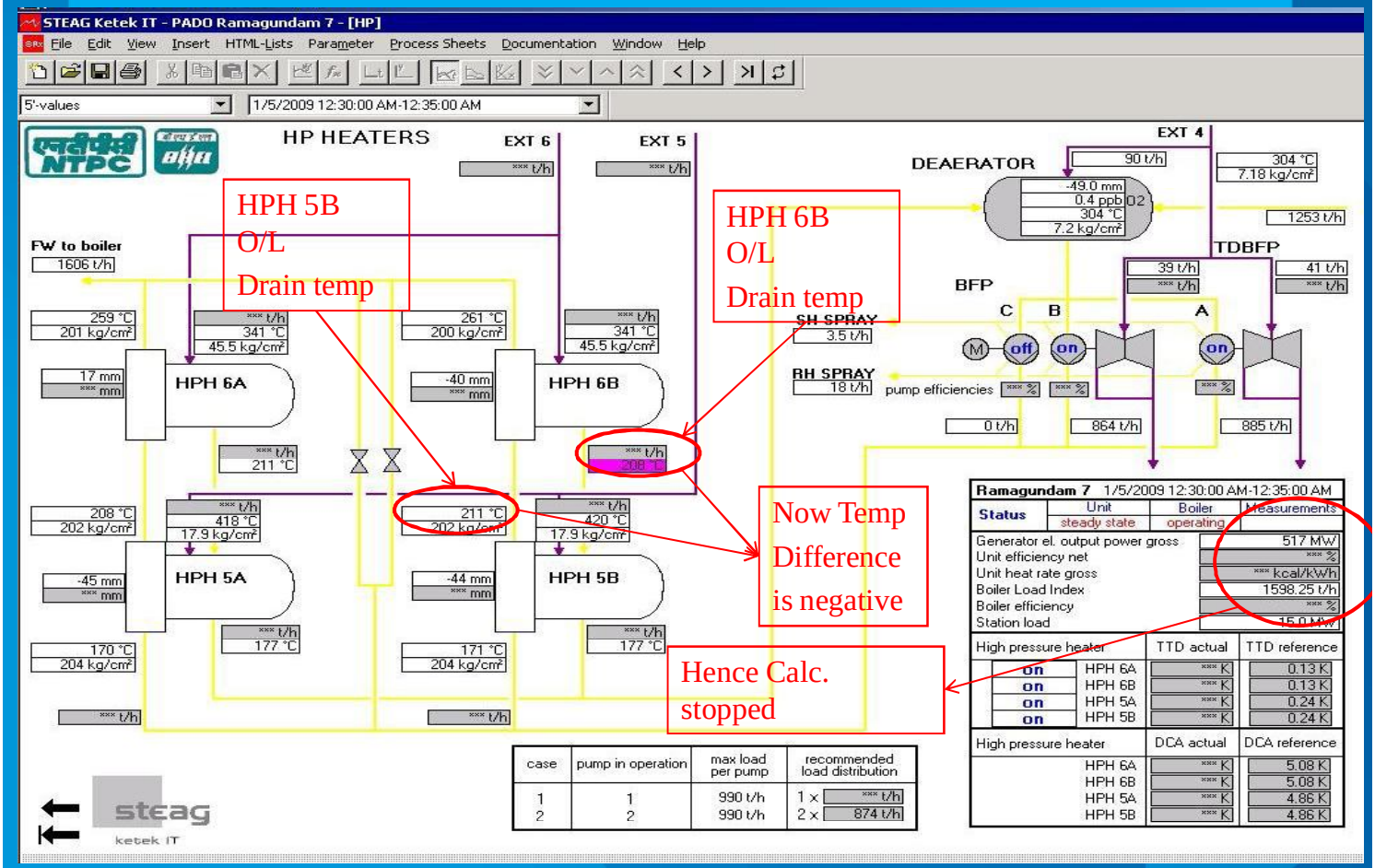
- SET POINT OPTIMIZATION
- HPH DRAIN TEMPERATURE


SET POINT OPTIMIZATION EXPERIMENT- RAMAGUNDAM
File Edit View Insert HTML-Lists Parameter Process Sheets Documentation Window Help
5'-values
23/05/2008 18:25:00-18:30:00
Set point optimization
Ramagundam 7
act value
opt value
Boiler
O2 at Eco outlet 3.99 % 5.00 %Vol
Burner tilt 10 ° 10 °
Turbine Cycle
MS temperature 536.50 °C 545.00 °C
MS pressure 171.72 kg/cm² 170.00 kg/cm²
Reheat temperature 530.93 °C 545.00 °C
Condenser back pressure -0.87 kg/cm² -0.87 kg/cm²
Windbox Furn. pressure 76.80 mmWC 89.74 mmWC
PA HDR Pressure 812.92 mmWC 800.1
Unit Heat Rate gross 2396.19 2337
Initial condition
LOAD=511 MW
Coal Mass Flow=391.6T/Hr
Unit Efficiency = 34.8
Boiler Efficiency = 87.1
Econ. O/L Temp. = 338.85 'C
FEGT = 1204 'C
File Edit View Insert HTML-Lists Parameter Process Sheets Documentation Window Help
5'-values
23/05/2008 18:45:00-18:50:00
Set point optimization
Ramagundam 7
Parameters changed
act value
opt value
Boiler
O2 at Eco outlet 4.36 % 5.00 %Vol
Burner tilt 13 ° 13 °
Turbine Cycle
MS temperature 542.09 °C 545.00 °C
MS pressure 168.66 kg/cm² 170.00 kg/cm²
Reheat temperature 536.23 °C 545.00 °C
Condenser back pressure -0.87 kg/cm² -0.87 kg/cm²
Windbox Furn. pressure 85.45 mmWC 89.74 mmWC
PA HDR Pressure 805.19 mmWC 800.1
Unit Heat Rate gross 2335.17 2329
LOAD=504 MW
Coal Mass Flow=391.35T/Hr
Unit Efficiency = 35.7
Boiler Efficiency = 86.6
Econ. O/L Temp. = 340.05 'C
FEGT = 1187 'C
SAVING
10 T/Hr
240 T/Day
Rs 240000/- per day
Taking Coal price as Rs 1000/- per Tonne as of July'08

CASE STUDY FOR HPH DRAIN TEMPERATURE

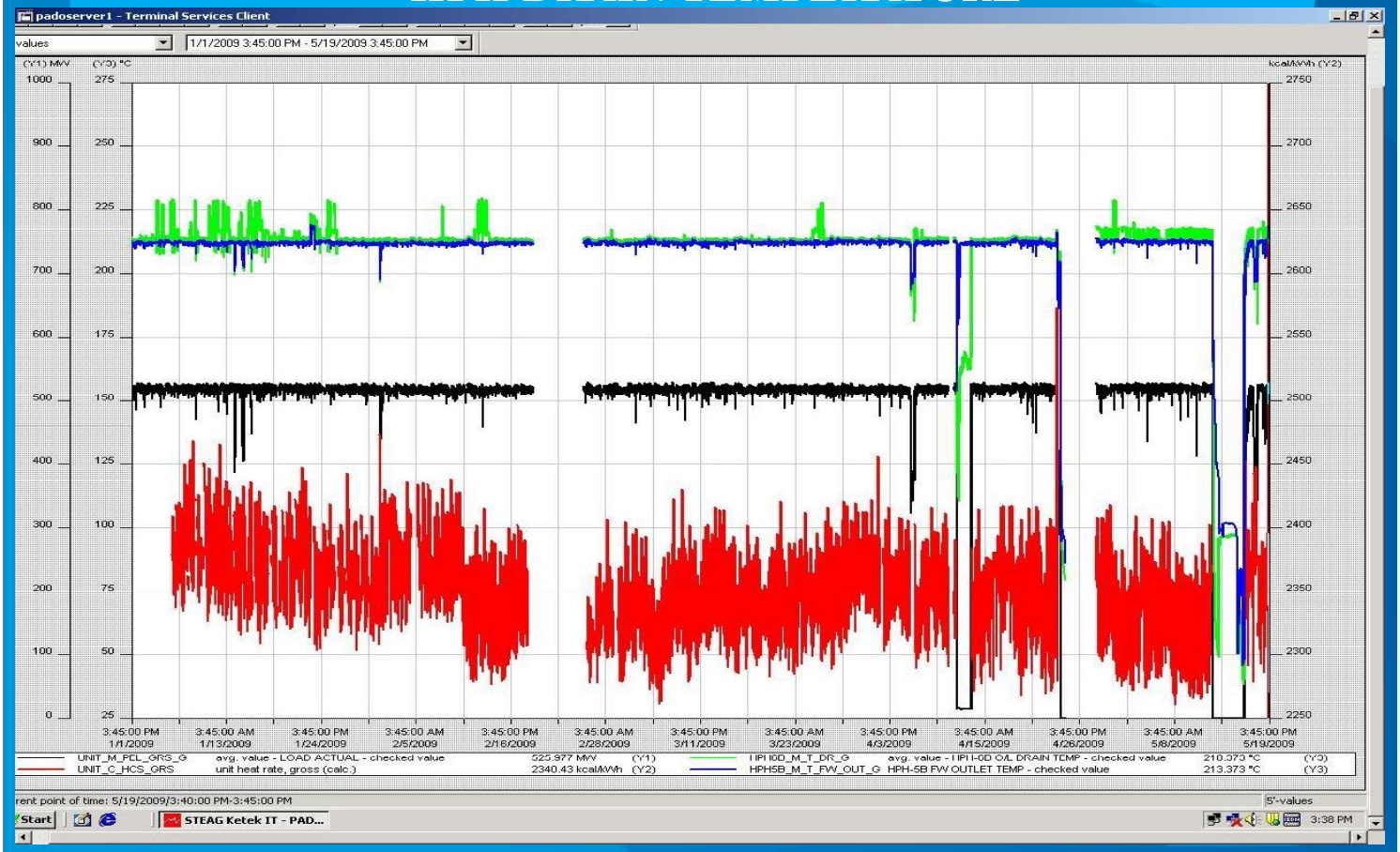


CASE STUDY FOR HPH DRAIN TEMPERATURE



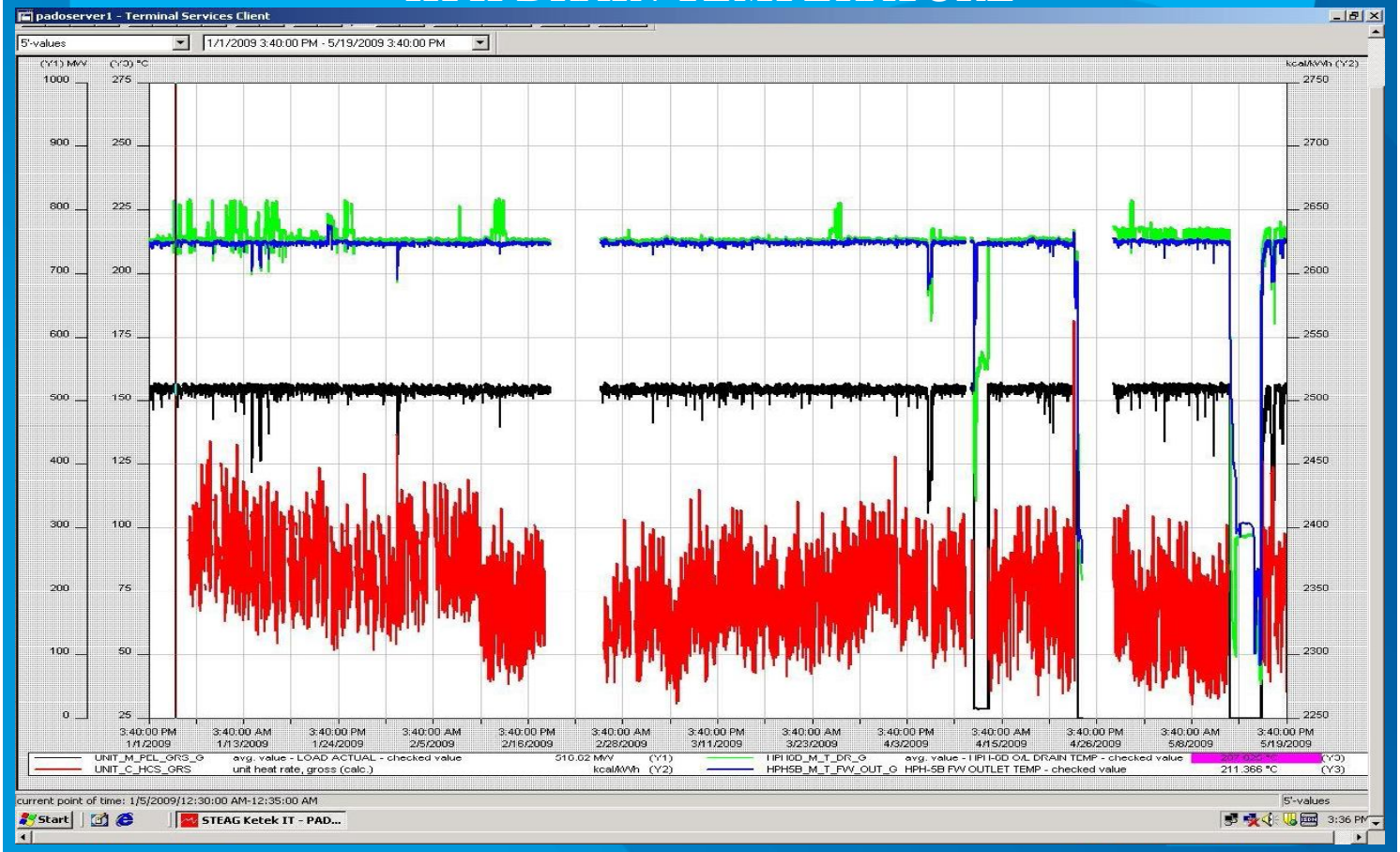
GRAPHICAL PLOT OF THE ABOVE CASE STUDY

HPH DRAIN TEMPERATURE

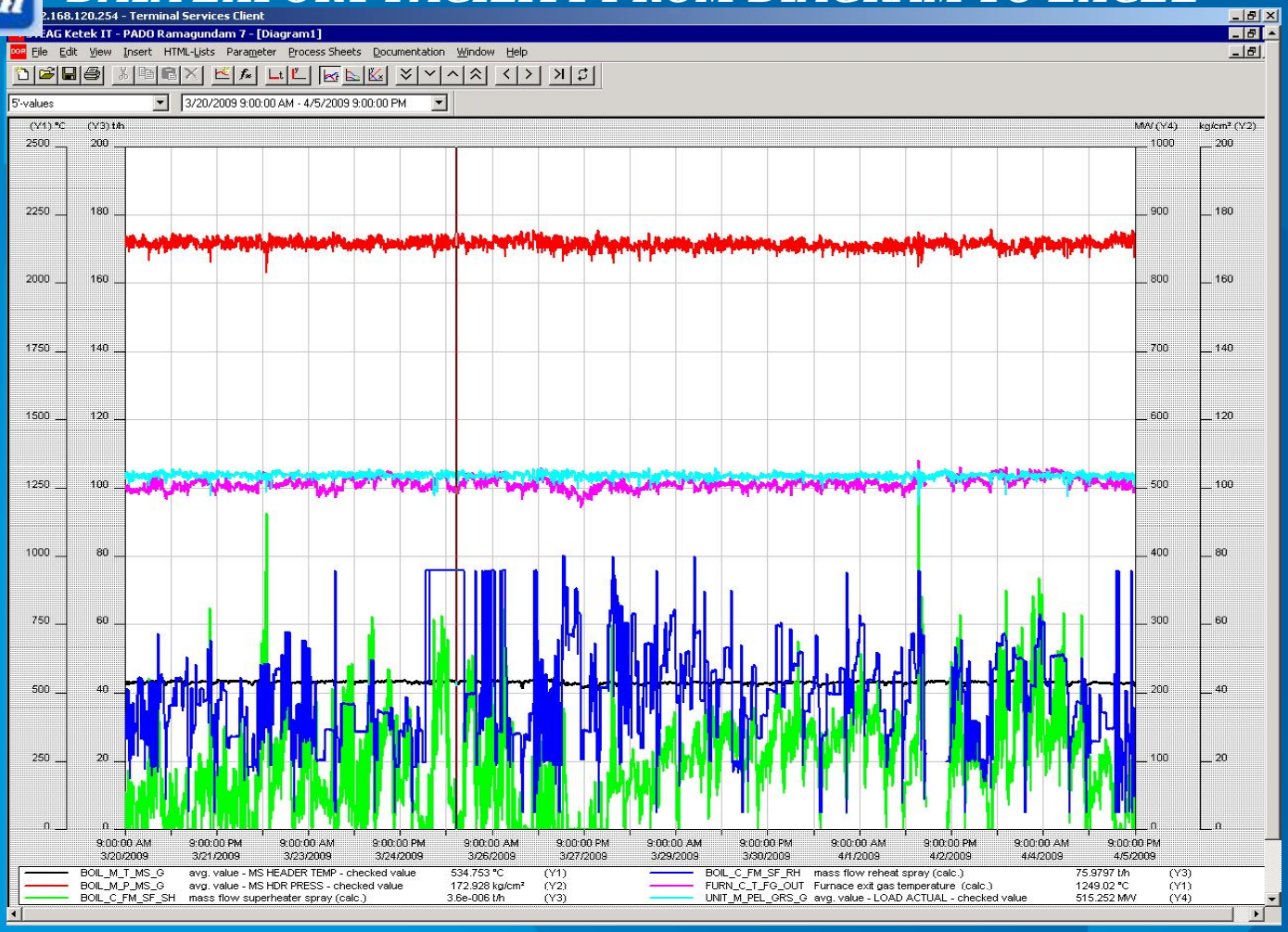


GRAPHICAL PLOT OF THE ABOVE CASE STUDY

HPH DRAIN TEMPERATURE



DATA EXPORT FACILITY FROM DIAGRAM TO EXCEL



DATA EXPORT FACILITY FROM DIAGRAM TO EXCEL

Microsoft Excel - Book1

File Edit View Insert Format Tools Data Window Help

D13 = 14.292977

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1	Time	BOIL_M_T_MS_G	BOIL_M_P_MS_G	BOIL_C_FM_SF_SH	BOIL_C_FM_SF_RH	FURN_C_T_FG_OUT	UNIT_M_PEL_GRS_G
2	3/26/2009 11:15	541.540031	171.737078	0.000007	28.599163	1273.947654	518.038725
3	3/26/2009 11:20	545.98328	171.983408	14.593378	28.667549	1291.655681	519.190588
4	3/26/2009 11:25	540.215661	173.014665	18.065099	28.714936	1284.209713	520.893648
5	3/26/2009 11:30	543.734656	171.100809	13.445369	28.636903	1284.592661	517.205509
6	3/26/2009 11:35	543.652048	171.692085	10.465426	28.579191	1285.32054	517.840951
7	3/26/2009 11:40	543.637352	172.198211	16.781962	28.657268	1293.927173	520.410201
8	3/26/2009 11:45	543.458054	171.790413	6.902958	28.571646	1295.323332	518.401331
9	3/26/2009 11:50	545.432136	170.787374	13.881216	28.367076	1294.29108	517.207353
10	3/26/2009 11:55	542.210936	172.072001	29.415827	28.465363	1301.950066	520.415682
11	3/26/2009 12:00	543.428051	172.136387	22.663056	28.488451	1297.320822	519.481763
12	3/26/2009 12:05	543.820996	171.94005	14.386503	28.508104	1293.857271	518.868278
13	3/26/2009 12:10	546.031558	169.946318	14.292977	75.979686	1281.920383	515.387069
14	3/26/2009 12:15	543.843851	172.08316	42.419206	28.466487	1307.149516	520.679382
15	3/26/2009 12:20	537.797214	173.363604	29.57972	28.637625	1304.251298	521.439368
16	3/26/2009 12:25	540.625729	171.048897	20.411498	28.418703	1294.324915	516.711084
17	3/26/2009 12:30	546.85449	170.896506	29.488038	28.388178	1299.958023	518.857292
18	3/26/2009 12:35	539.683249	173.461177	37.347786	75.979686	1304.983835	521.424723
19	3/26/2009 12:40	541.013951	172.384748	23.732828	75.979686	1291.463019	519.124658
20	3/26/2009 12:45	545.835608	171.812482	2.87457	75.979686	1288.153614	519.071558
21	3/26/2009 12:50	543.354289	170.989558	27.356533	75.979686	1289.126828	517.40695
22	3/26/2009 12:55	546.39116	170.61587	9.356384	75.979686	1288.777811	516.37961
23	3/26/2009 13:00	544.219192	172.440259	25.316578	75.979686	1299.327807	521.01818
24	3/26/2009 13:05	542.755681	173.27977	18.567395	75.979686	1290.047452	520.767293
25	3/26/2009 13:10	544.493187	172.19304	24.155994	75.979686	1288.449522	519.243681
26	3/26/2009 13:15	544.932787	173.547018	29.705701	75.979686	1299.378103	522.349488
27	3/26/2009 13:20	543.106319	173.126972	24.012039	75.979686	1291.551745	519.659391
28	3/26/2009 13:25	545.078117	169.684793	29.373211	75.979686	1285.837594	511.744718
29	3/26/2009 13:30	546.120826	171.826217	51.500223	75.979686	1308.454941	522.173706
30	3/26/2009 13:35	538.498208	171.268256	36.252325	75.979686	1283.515171	519.529374
31	3/26/2009 13:40	545.437092	167.62292	24.947616	75.979686	1270.044194	509.924465
32	3/26/2009 13:45	547.196403	169.363753	33.490689	75.979686	1285.719919	515.301017
33	3/26/2009 13:50	539.0231	171.920639	38.807205	75.979686	1287.141034	521.007194

PADO PROJECTS IMPLEMENTATION BY BHEL

UNIT RATING	NO OF SETS	CUSTOMERS
490/500	46	NTPC, KPCL, MAHAGHENCO, GEB, CSEB
525	4	TATA POWER, HNPL
600	5	TNEB, MPEB, APGENCO
195/250	9	NTPC
660, 700 (Super critical)	3	NTPC, KPCL

PADO REMOTE CONNECTIVITY TO VARIOUS SITES

The Remote Connectivity to sites is through the ISDN line. The PADO Server at the site can be accessed from EDN, Bangalore. Following sites are now remotely connected to EDN, Bangalore:

- SIMHADRI
- RAMAGUNDAM
- RIHAND
- VINDHYACHAL
- TALCHER
- SIPAT
- BELLARY
- DADRI
- KORBA

THANK YOU