REFORMER AND SHIFT CATALYST EXPERIENCE

FAI / IIChE, Seminar – Delhi, March 2023

COMPANY PROFILE

Incorporated in 1969 at Tuticorin, Tamil Nadu

Commercial Production from 1975

Installed Urea Production Capacity – 512000 MTPA

COMPANY PROFILE

Revamps and Capacity Augmentation in 50 Years

Present Urea Production Capacity – 759200 MTPA

AMMONIA PLANT

Installed Capacity in 1975 - 1100 MTPD (Nap + Steam) / ICI Process

Capacity Augmentation in 1996 to 1998 - 1260 MTPD (Nap + Steam) / Casale Converter

Gas Conversion Revamp in 2021 - 1320 MTPD (NG + Steam) / KBR

Catalyst Upset – Case Study

1. Primary Reformer Catalyst
2. High Temperature Shift Catalyst

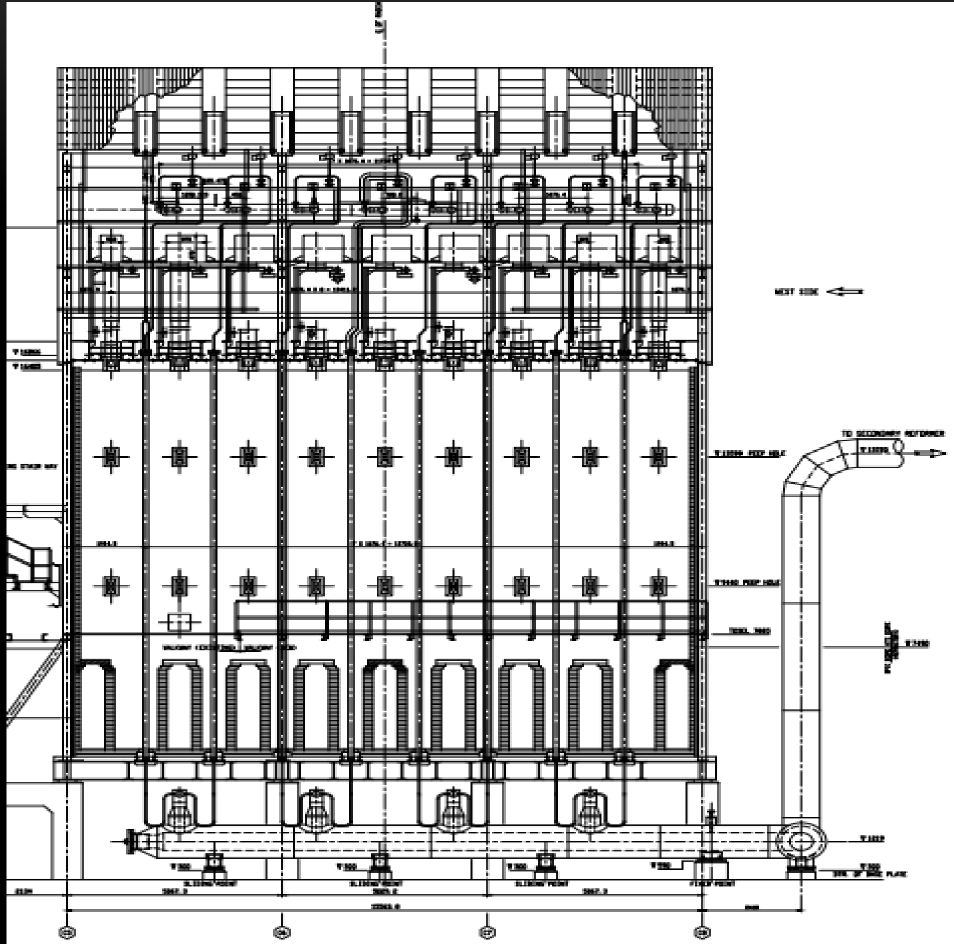
Catalyst Upset – Case Study

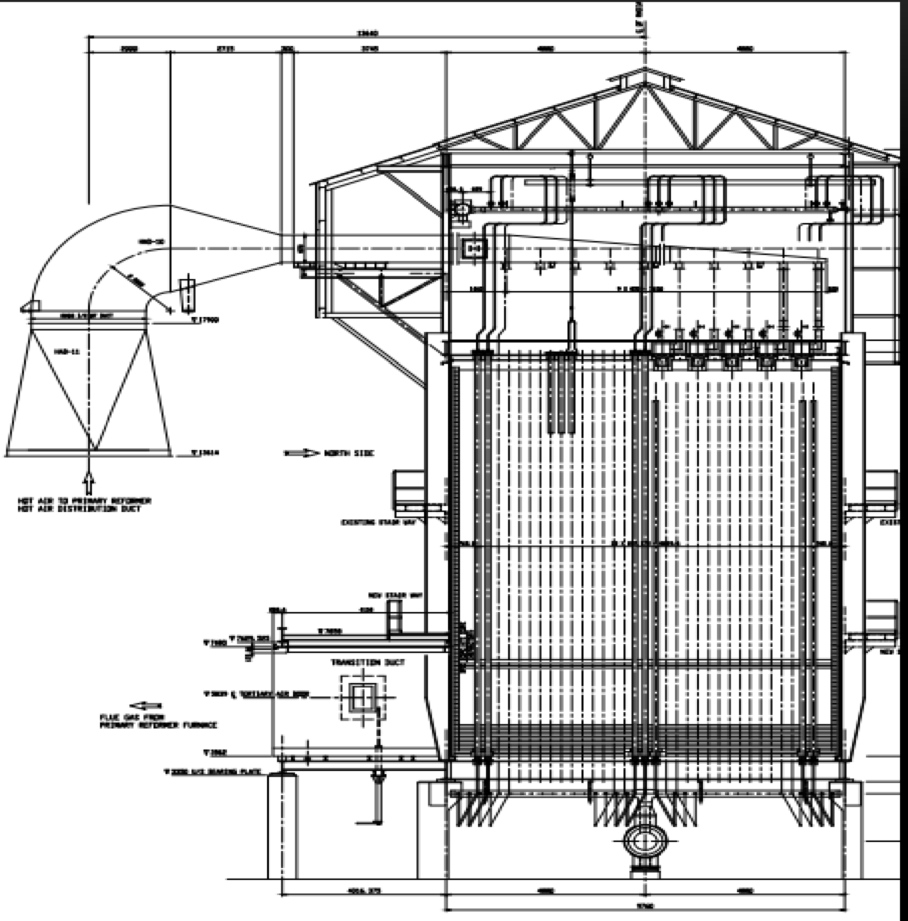
1. Primary Reformer Catalyst
2. High Temperature Shift Catalyst

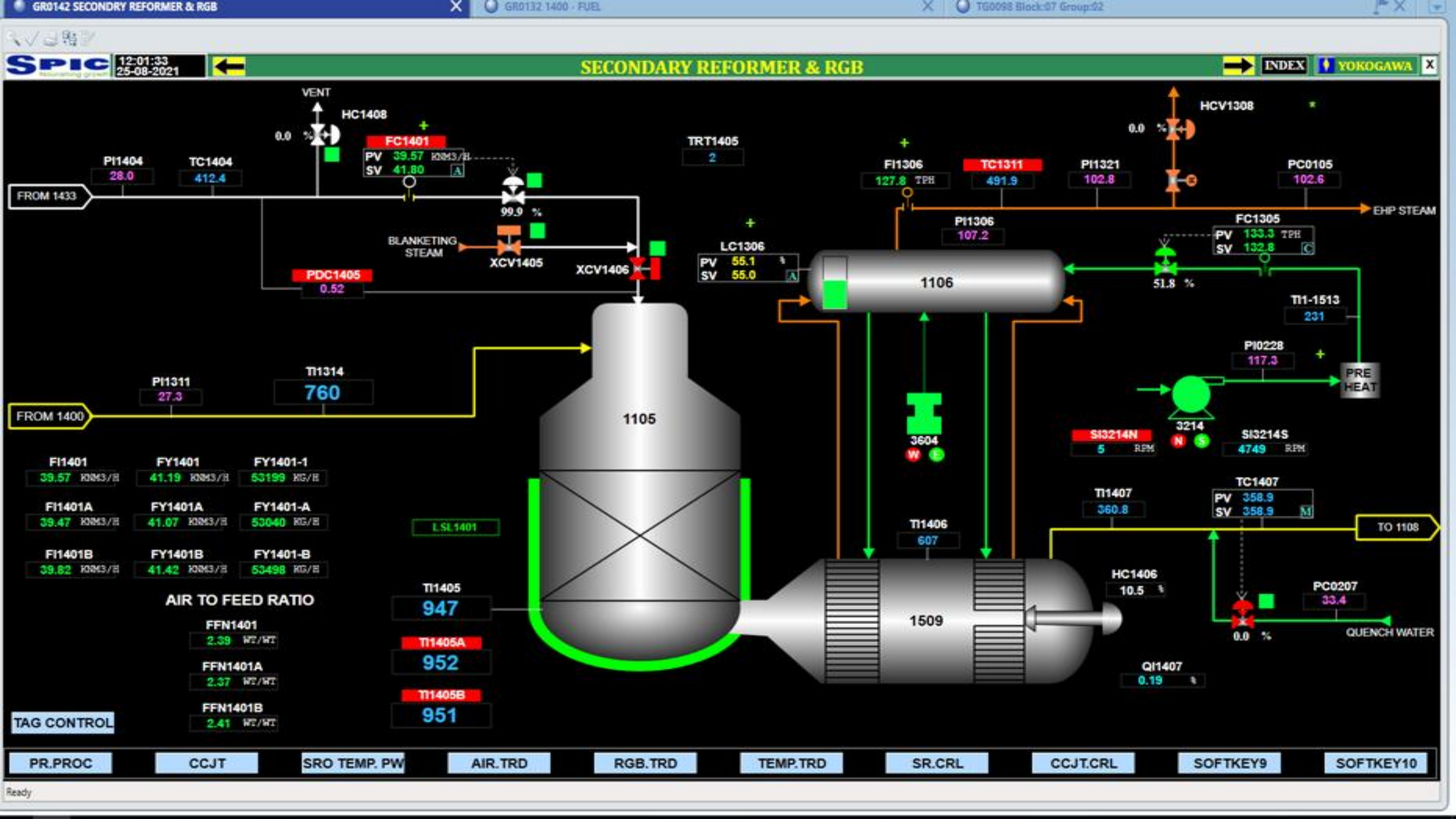
REFORMER – Configuration

1. Top Fired with 90 Guns (10 Rows X 9 Guns)
2. 264 Catalyst Tubes (8 Rows x 33 Tubes) of 4 inches diameter and 13 Mts length
3. Balanced Draft Furnace with design Heat Flux of 75 KW/M^2
4. Furnace operating under – 2 mm WC Pressure
5. Convection Module with Heat Recovery System for Process Steam, Combustion Air and Super Heated Steam

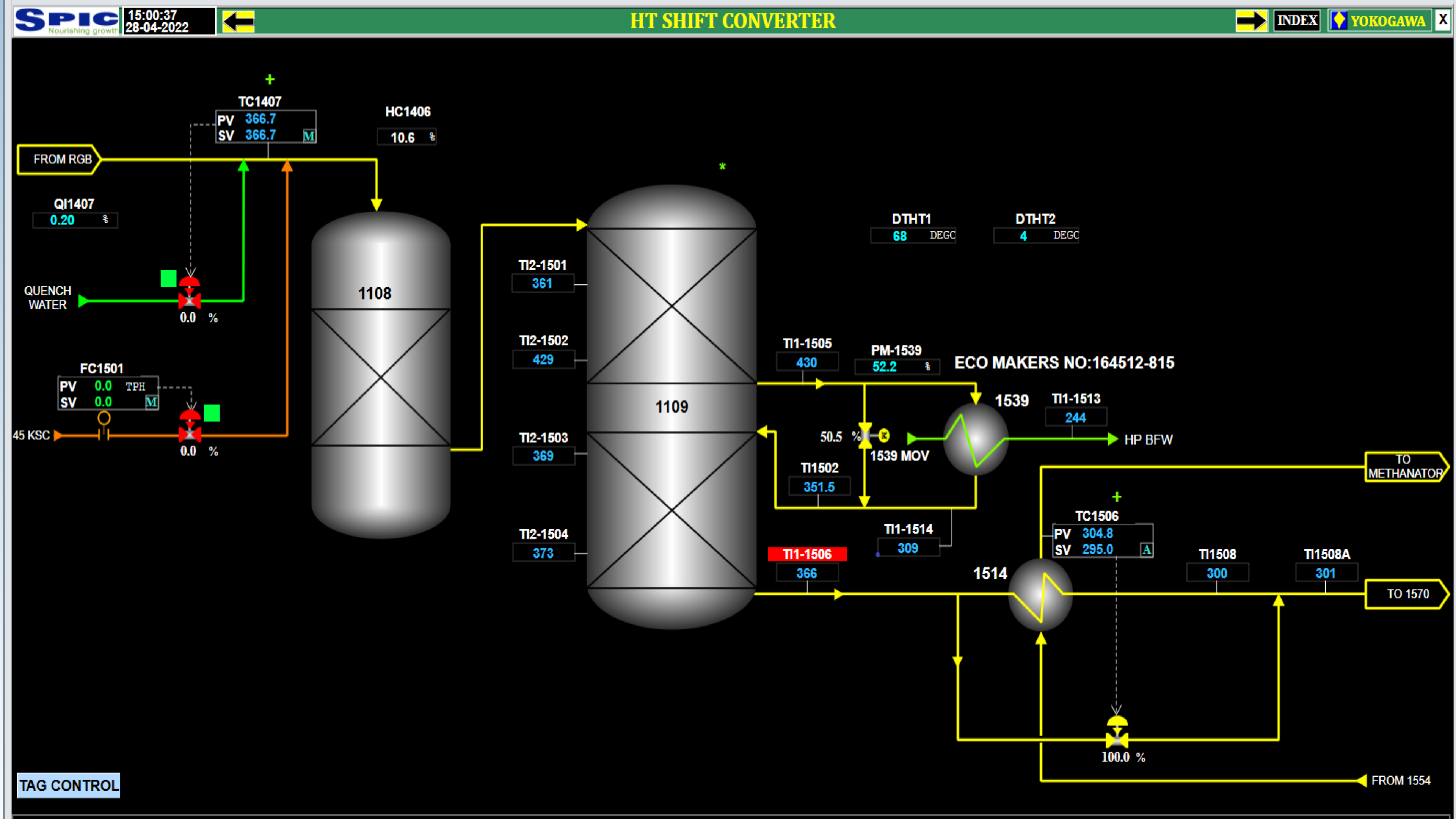
REFORMER – Configuration







GR0142 SECONDRY REFORMER & RGB
GR0132 1400 - FUEL
TG0098 Block:07 Group:02
12:01:33
25-08-2021
SECONDARY REFORMER & RGB
INDEX
YOKOGAWA
VENT
HC1408
0.0 %
FC1401
PV 39.57 KNM3/H
SV 41.80
PI1404
28.0
TC1404
412.4
FROM 1433
99.9 %
BLANKETING STEAM
XCV1405
XCV1406
PDC1405
0.52
TRT1405
2
LC1306
PV 55.1
SV 55.0
FI1306
127.8 TPH
TC1311
491.9
PI1321
102.8
PC0105
102.6
HCV1308
0.0 %
EHP STEAM
PI1306
107.2
FC1305
PV 133.3 TPH
SV 132.8
51.8 %
1106
TI1-1513
231
PI0228
117.3
PRE HEAT
3214
SI3214N
5 RPM
SI3214S
4749 RPM
3604
PI1311
27.3
TI1314
760
FROM 1400
1105
FI1401
39.57 KNM3/H
FY1401
41.19 KNM3/H
FY1401-1
53199 KG/H
FI1401A
39.47 KNM3/H
FY1401A
41.07 KNM3/H
FY1401-A
53040 KG/H
FI1401B
39.82 KNM3/H
FY1401B
41.42 KNM3/H
FY1401-B
53498 KG/H
LSL1401
AIR TO FEED RATIO
FFN1401
2.39 WT/WT
FFN1401A
2.37 WT/WT
FFN1401B
2.41 WT/WT
TI1405
947
TI1405A
952
TI1405B
951
TI1406
607
1509
TI1407
360.8
TC1407
PV 358.9
SV 358.9
TO 1108
HC1406
10.5 %
PC0207
33.4
0.0 %
QUENCH WATER
QI1407
0.19 %
TAG CONTROL
PR.PROC
CCJT
SRO TEMP. PW
AIR.TRD
RGB.TRD
TEMP.TRD
SR.CRL
CCJT.CRL
SOFTKEY9
SOFTKEY10
Ready



SPIC Nourishing growth
15:00:37
28-04-2022
HT SHIFT CONVERTER
INDEX
YOKOGAWA
X
TC1407
PV 366.7
SV 366.7 M
HC1406
10.6 %
FROM RGB
QI1407
0.20 %
QUENCH WATER
0.0 %
1108
FC1501
PV 0.0 TPH
SV 0.0 M
45 KSC
0.0 %
TI2-1501
361
TI2-1502
429
TI2-1503
369
TI2-1504
373
1109
DTHT1
68 DEGC
DTHT2
4 DEGC
TI1-1505
430
PM-1539
52.2 %
ECO MAKERS NO:164512-815
1539
TI1-1513
244
50.5 %
1539 MOV
HP BFW
TI1502
351.5
TO METHANATOR
TC1506
PV 304.8
SV 295.0 A
TI1-1514
309
TI1-1506
366
1514
TI1508
300
TI1508A
301
TO 1570
100.0 %
FROM 1554
TAG CONTROL

REFORMER – CASE STUDY

Catalyst Vessel	Supplier	Quantity (m3)	Charged On	Replaced on	Life (Months)
Primary reformer	A	17.88	Apr-04	Apr-07	36
		11.88			
	B	17.80	Oct-10	Mar-17	78
		11.60			

REFORMER – CASE STUDY

1. After serving for above 6 years, pressure drop of Catalyst in Primary reformer was on increasing trend during end of 2016 and hence it was planned to go for catalyst replacement
2. Availability of NG was foreseen in the next few years, but only 60% of the total quantity was allocated
3. Operation with Mixed Feed of Naphtha + NG was foreseen
4. Supplier – X recommended 3 layer Catalyst for Mixed Feed

REFORMER – 3 Layer Catalyst

1. Top Layer - 23% Ni, 7% K_2O - 40% Volume
2. Middle Layer - 18% Ni, 1.8% K_2O - 20% Volume
3. Bottom Layer - x % Ni, 0 % K_2O - 40% Volume

The above combination of triple decker catalysts has been considered as the plant is expected to operate on natural gas after 3-4 years. This proposed combination of catalyst will allow SPIC to operate the reformer to operate on 100% naphtha, any combination of naphtha and natural gas and 100% natural gas.

Case 1 – 100% naphtha

		S/C@3.6	
Parameters	Unit	SOR	EOR
Exit pressure	kg/cm2g	30.9	30.1
Pressure drop^	kg/cm2	2.4	3.2
Peak heat flux	kW/m^2	120.6	117.6

REFORMER – CASE STUDY

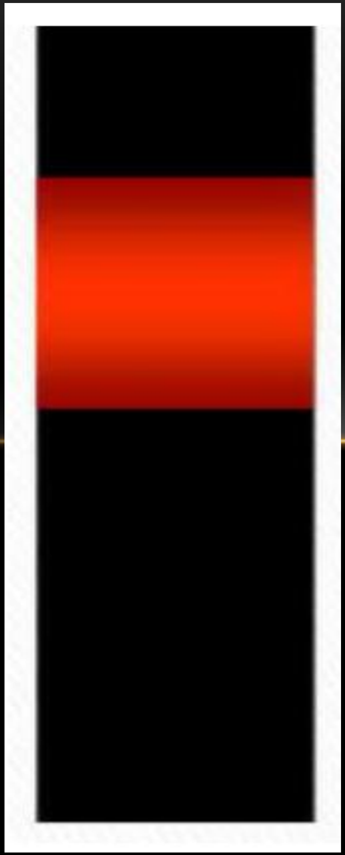
1. Pre dispatch inspection was found normal with respect to Quality
2. Loading done through UNIDENSE mechanism
3. Effective loading was carried out and pressure drop variation was +/- 3%
4. Commissioned on 13th March 2017

REFORMER – Naphtha Feed

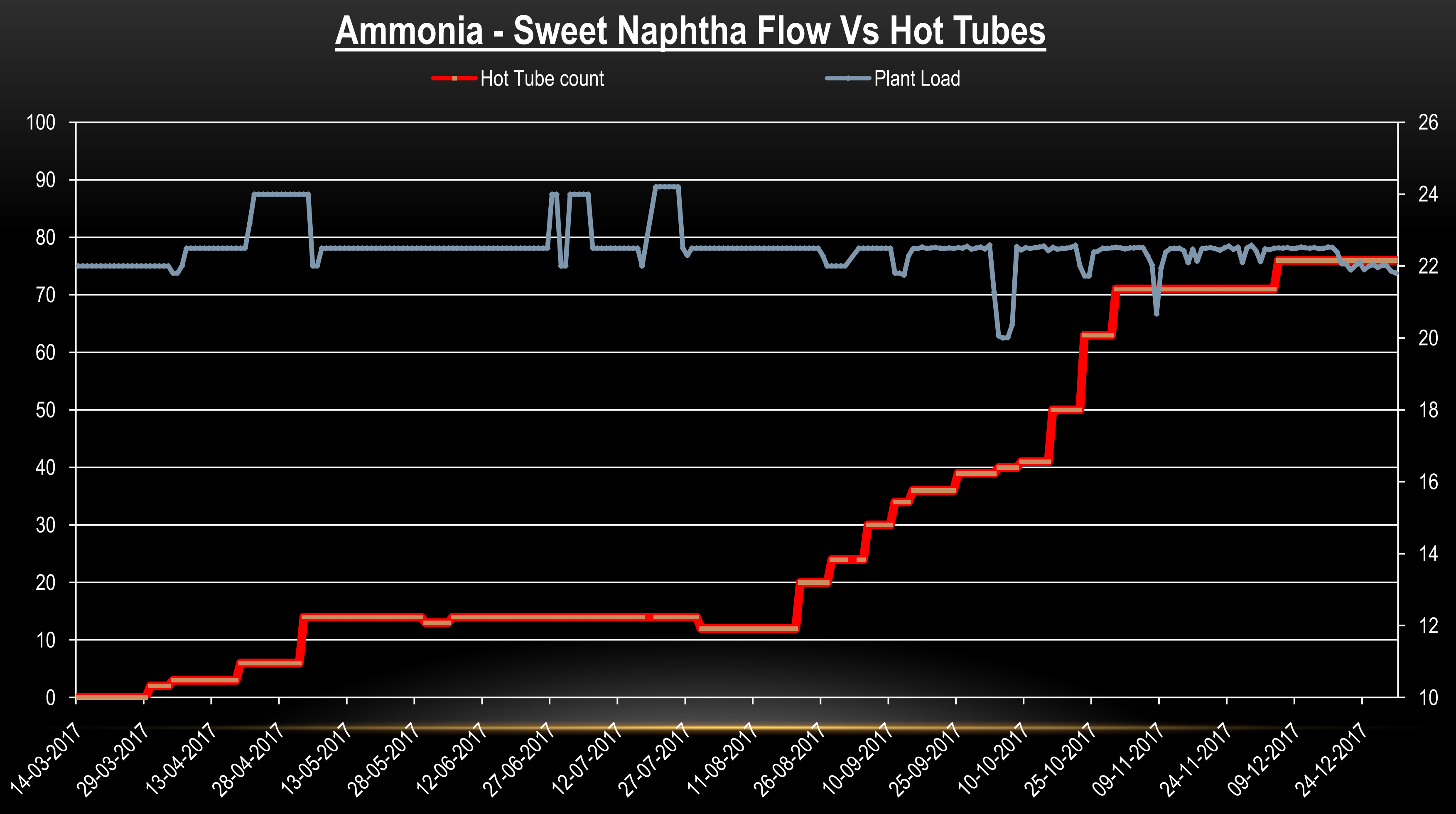
NAPHTHA QUALITY REPORT		
Density @ 15oC	GM/CC	0.685
IBP	DEG C	43.5
10 % v/v		52
50 % v/v		70
90 % v/v		105
FBP		130
Total Sulphur	PPM	143
Olefins	%	0.35
Aromatics	%	6.4
Reid Vapour Pressure (RVP) @ 37.8 Deg. C	Kg/cm2	0.7
Residue on evaporation	mg/100 ml	1.1
Lead	ppb	3
Chloride (In-Organic) ASTM D 4929	ppm	0.3
C/H ratio	-	5.36
Gross Calorific value (IS 1448 Calculation)	Kcals/KG	11414

REFORMER – Hot Band / Hot Patches

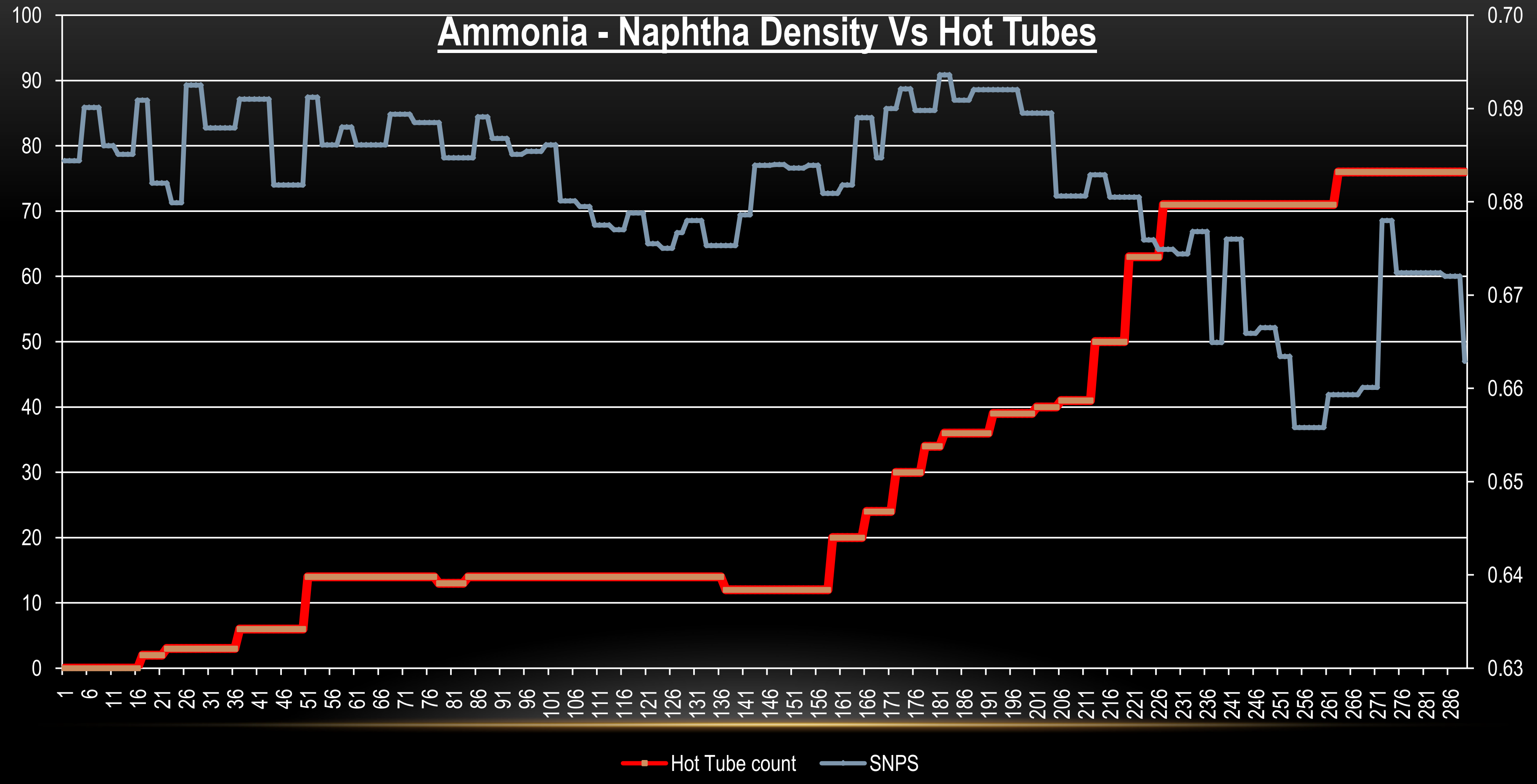
Hot Band

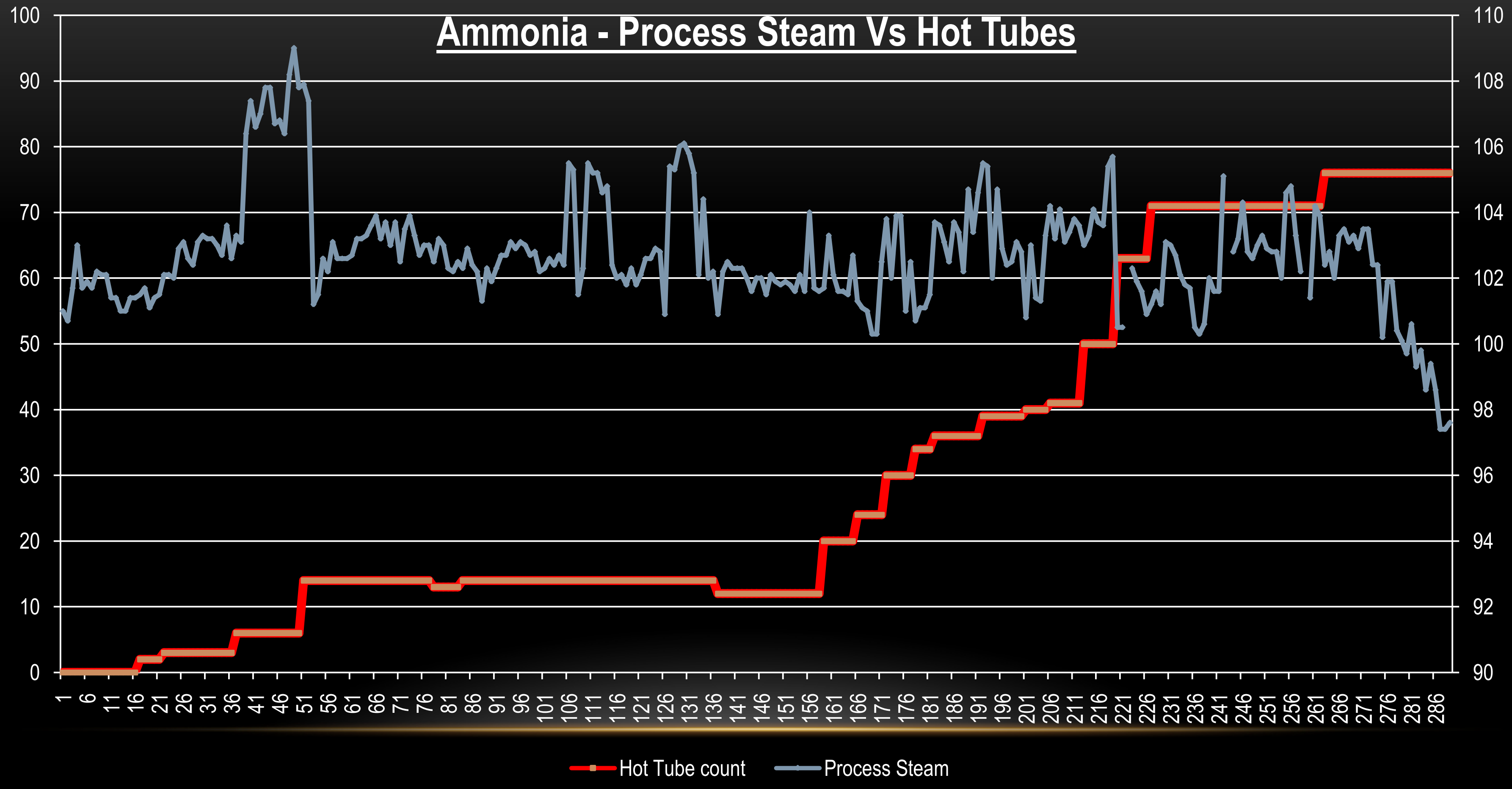


Hot Patches



Ammonia - Sweet Naphtha Flow Vs Hot Tubes
Hot Tube count
Plant Load
100
90
80
70
60
50
40
30
20
10
0
26
24
22
20
18
16
14
12
10
14-03-2017
29-03-2017
13-04-2017
28-04-2017
13-05-2017
28-05-2017
12-06-2017
27-06-2017
12-07-2017
27-07-2017
11-08-2017
26-08-2017
10-09-2017
25-09-2017
10-10-2017
25-10-2017
09-11-2017
24-11-2017
09-12-2017
24-12-2017


Ammonia - Naphtha Density Vs Hot Tubes
100
90
80
70
60
50
40
30
20
10
0
0.70
0.69
0.68
0.67
0.66
0.65
0.64
0.63
1 6 11 16 21 26 31 36 41 46 51 56 61 66 71 76 81 86 91 96 101 106 111 116 121 126 131 136 141 146 151 156 161 166 171 176 181 186 191 196 201 206 211 216 221 226 231 236 241 246 251 256 261 266 271 276 281 286
Hot Tube count
SNPS



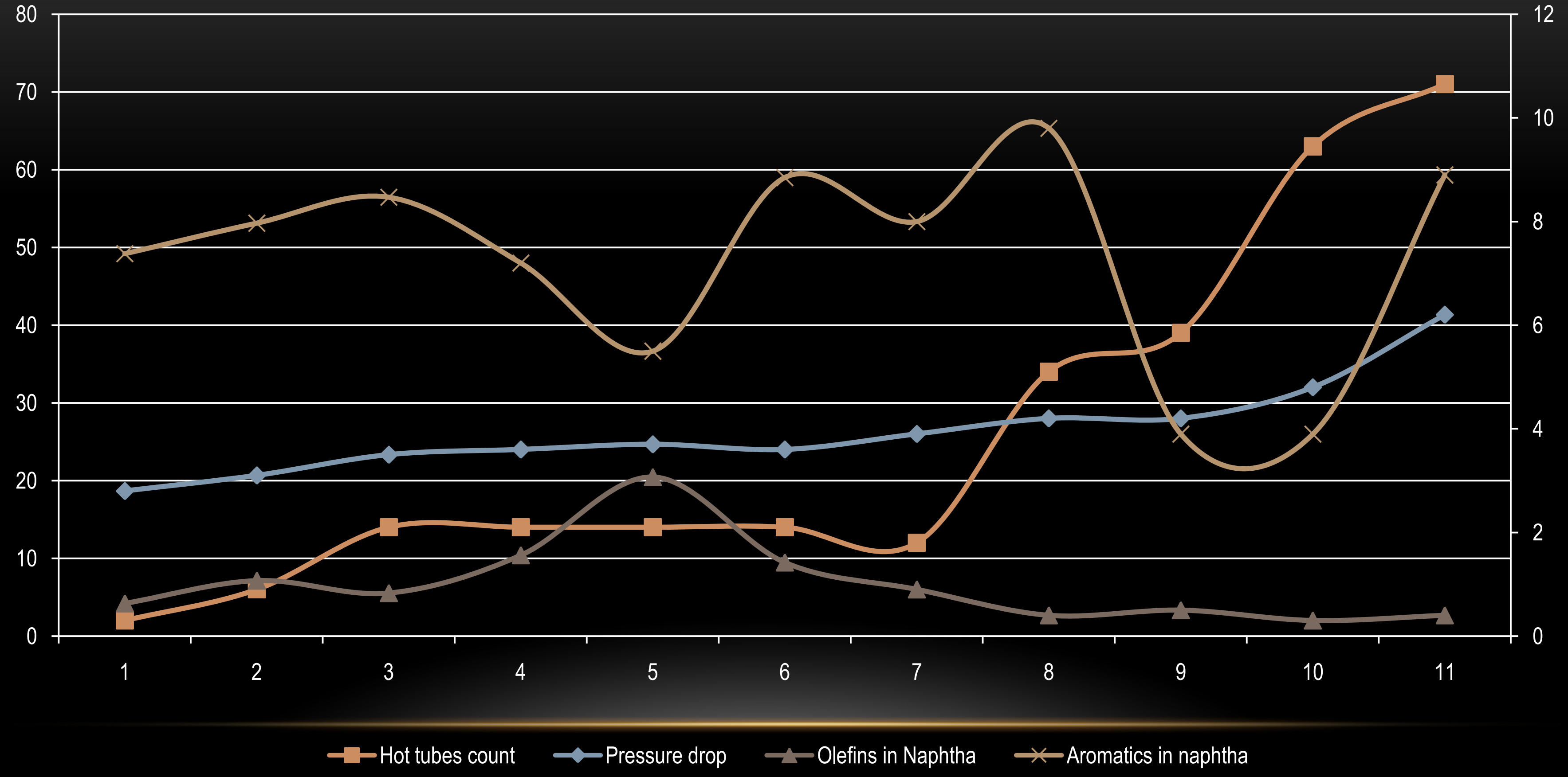
Ammonia - Process Steam Vs Hot Tubes
100
90
80
70
60
50
40
30
20
10
0
110
108
106
104
102
100
98
96
94
92
90
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
116
121
126
131
136
141
146
151
156
161
166
171
176
181
186
191
196
201
206
211
216
221
226
231
236
241
246
251
256
261
266
271
276
281
286
Hot Tube count
Process Steam

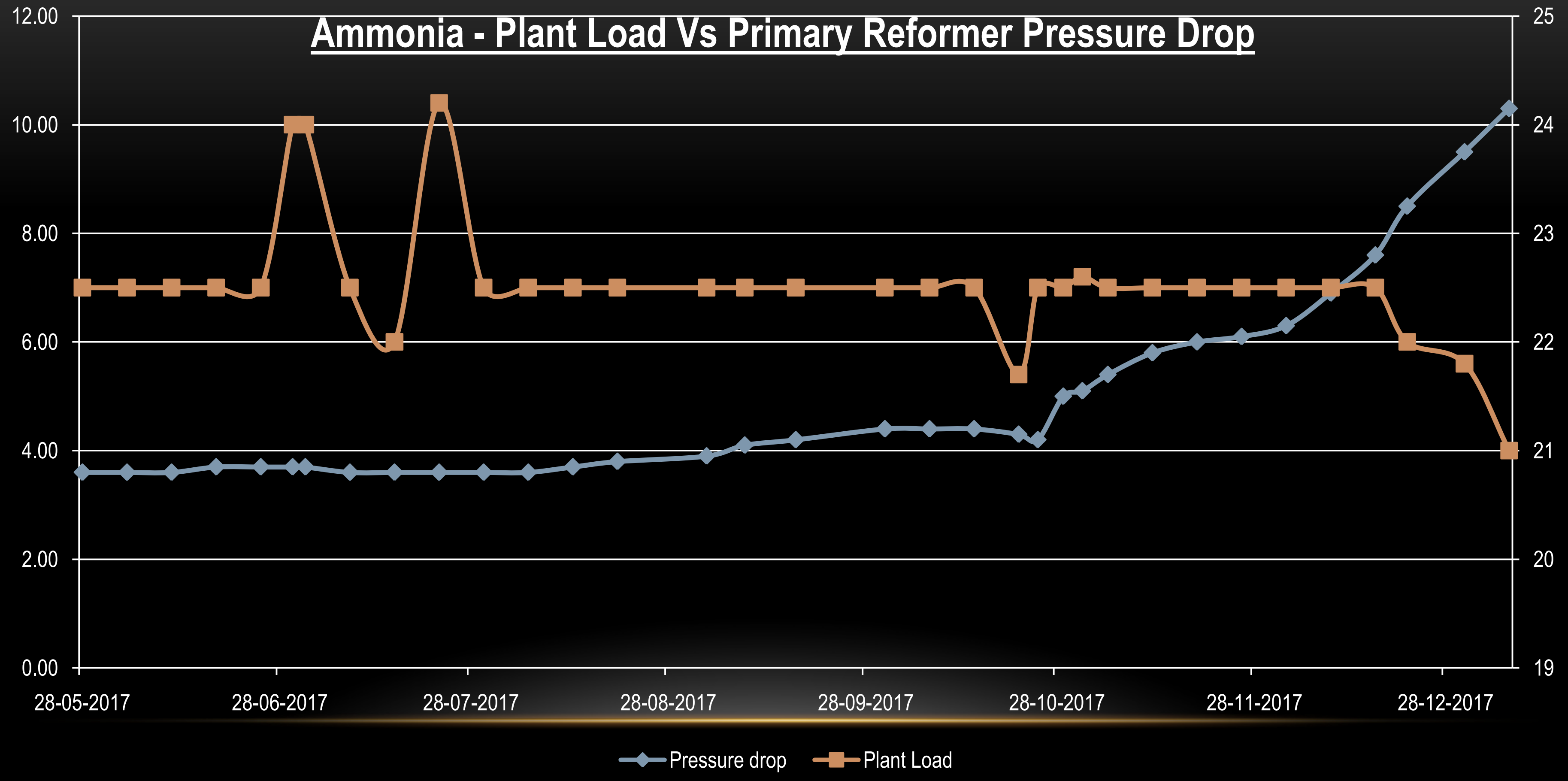
AMMONIA PLANT - REFORMER - BURNER CONDITION on 01st Jan 2018

From North

Br.	A TUBE	Br.	B TUBE	Br.	C TUBE	Br.	D TUBE	Br.	E TUBE	Br.	F TUBE	Br.	G TUBE	Br.	H TUBE	Br.
1	1	11	1		1	31	1	41	1	51	1	61	1	71	1	81
	2		2	21	2		2		2		2		2		2	
	3		3		3		3		3		3		3		3	
	4		4		4		4		4		4		4		4	
2	5	12	5	22	5	32	5	42	5	52	5	62	5	72	5	82
	6		6		6		6		6		6		6		6	
	7		7		7		7		7		7		7		7	
	8		8		8		8		8		8		8		8	
3	9	13	9	23	9	33	9	43	9	53	9	63	9	73	9	83
	10		10		10		10		10		10		10		10	
	11		11		11		11		11		11		11		11	
	12		12		12		12		12		12		12		12	
4	13	14	13	24	13	34	13	44	13	54	13	64	13	74	13	84
	14		14		14		14		14		14		14		14	
	15		15		15		15		15		15		15		15	
5	16	15	16	25	16	35	16	45	16	55	16	65	16	75	16	85
	17		17		17		17		17		17		17		17	
	18		18		18		18		18		18		18		18	
6	19	16	19	26	19	36	19	46	19	56	19	66	19	76	19	86
	20		20		20		20		20		20		20		20	
	21		21		21		21		21		21		21		21	
	22		22		22		22		22		22		22		22	
7	23	17	23	27	23	37	23	47	23	57	23	67	23	77	23	87
	24		24		24		24		24		24		24		24	
	25		25		25		25		25		25		25		25	
8	26	18	26	28	26	38	26	48	26	58	26	68	26	78	26	88
	27		27		27		27		27		27		27		27	
	28		28		28		28		28		28		28		28	
9	29	19	29	29	29	39	29	49	29	59	29	69	29	79	29	89
	30		30		30		30		30		30		30		30	
	31		31		31		31		31		31		31		31	
10	32	20	32	30	32	40	32	50	32	60	32	70	32	80	32	90
	33		33		33		33		33		33		33		33	
Hot tubes			1		3		11		14		25		17		5	

Ammonia - Naphtha Quality Vs Primary Reformer





Ammonia - Plant Load Vs Primary Reformer Pressure Drop
12.00
10.00
8.00
6.00
4.00
2.00
0.00
25
24
23
22
21
20
19
28-05-2017
28-06-2017
28-07-2017
28-08-2017
28-09-2017
28-10-2017
28-11-2017
28-12-2017
Pressure drop
Plant Load

SUMMARY OF OBSERVATIONS

1. Hot tubes started to appear from March 2017 end and it went up to 76 numbers out of 264 in 10 months
2. Pressure drop started at 3.5 Ksc and reached up to 10.5 Ksc. Increase of 7 ksc in 10 months
3. Plant load was 22.5 TPH Naphtha, predominantly
4. Increased inlet pressure due to abnormal pressure drop resulted in limiting the plant load
5. Increased steam consumption to manage the situation resulting in higher energy consumption
6. Hot bands were prevailing in the bottom half where less or non-potash catalyst is present

Action Plan

1. Stopping the plant in January 2018
2. Replacement of catalyst through catalyst loading mechanism
3. Tubes internal & external cleaning
4. Tubes inspection
5. Catalyst inspection and analysis
6. Total duration of 12 days

OBSERVATIONS after Stoppage

- Average pressure drop in each tube before commissioning was 0.936 Ksc and after processing 10 months during removal it was 1.107 Ksc. An increase of 0.1827 Ksc which is about 18%.
- Black colouration over the catalyst layer was noticed in the top layer catalyst up to 2 meters.
- Out of 264 tubes, DP could not be checked in 4 tubes (G33, H31, H32 & H33) as air was backing up.
- Catalyst removal was not easy in many tubes between 3 to 5 meters.

Catalyst Samples

Table 1: List of samples collected

Reformer spent catalyst Sample details - SPIC

S No	Tube #	Elevation	Category
1	B2	Top	Cold
2	B2	1	Cold
3	B2	2	Cold
4	B2	3	Cold
5	B2	4	Cold
6	B2	5	Cold
7	B2	6	Cold
8	B2	7	Cold
9	B2	8	Cold
10	B2	9	Cold
11	B2	10	Cold
12	B2	11	Cold
13	B2	12	Cold
14	B2	13	Cold

S No	Tube #	Elevation	Category
15	H29	Top	High DIP
16	H29	1	High DIP
17	H29	2	High DIP
18	H29	3	High DIP
19	H29	4	High DIP
20	H29	5	High DIP
21	H29	6	High DIP
22	H29	7	High DIP
23	H29	8	High DIP
24	H29	9	High DIP
25	H29	10	High DIP
26	H29	11	High DIP
27	H29	12	High DIP

S No	Tube #	Elevation	Category
28	F22	Top	Hot
29	F22	1	Hot
30	F22	2	Hot
31	F22	3	Hot
32	F22	4	Hot
33	F22	5	Hot
34	F22	6	Hot
35	F22	7	Hot
36	F22	8	Hot
37	F22	9	Hot
38	F22	10	Hot
39	F22	11	Hot
40	F22	12	Hot
41	F22	Bottom	Hot

S No	Tube #	Elevation	Category
42	H33	Top	High DP
43	H33	1	High DP
44	H33	2	High DP
45	H33	3	High DP
46	H33	4	High DP
47	H33	5	High DP
48	H33	6	High DP
49	H33	7	High DP
50	H33	8	High DP
51	H33	9	High DP
52	H33	10	High DP
53	H33	11	High DP
54	H33	12	High DP
55	H33	Bottom	High DP

S No	Tube #	Elevation	Category
56	G33	Top	Cold
57	G33	2	Cold
58	G33	4	Cold
59	G33	6	Cold
60	G33	8	Cold
61	G33	10	Cold
62	G33	12	Cold
63	G33	Bottom	Cold

S No	Tube #	Elevation	Category
64	D15	Top	Hot
65	D15	2	Hot
66	D15	4	Hot
67	D15	6	Hot
68	D15	8	Hot
69	D15	10	Hot
70	D15	12	Hot
71	D15	Bottom	Hot

S No	Tube #	Elevation	Category
72	Catalyst dust collected during unloading		

Spent Catalyst Analysis Report

Based on the analysis observations, the most likely sequence of events is that, during certain periods, insufficient naphtha conversion has been achieved in the upper 60% of the reformer tube compared with the previous double decker loading. This is likely due to the use of low potash catalyst in the mid-section and further worsened by some slight deviations in naphtha composition and some poisoning of the catalyst at the inlet. The unconverted higher hydrocarbons slipping into the hotter part of the tube (lower 40%) appear to have cracked across the catalyst in the lower part of the tube, forming whisker carbon. This appears to have lifted nickel off the surface of the catalyst, causing deactivation and hot banding on the tubes. It has also likely created the rough service texture left behind, causing some weakening of the pellets and the build of some dust and, consequently, increasing pressure drop.

REFORMER – 2 Layer Catalyst

1. Top Layer - 23% Ni, 7% K_2O - 60% Volume
2. Bottom Layer - 16% Ni, 0 % K_2O - 40% Volume

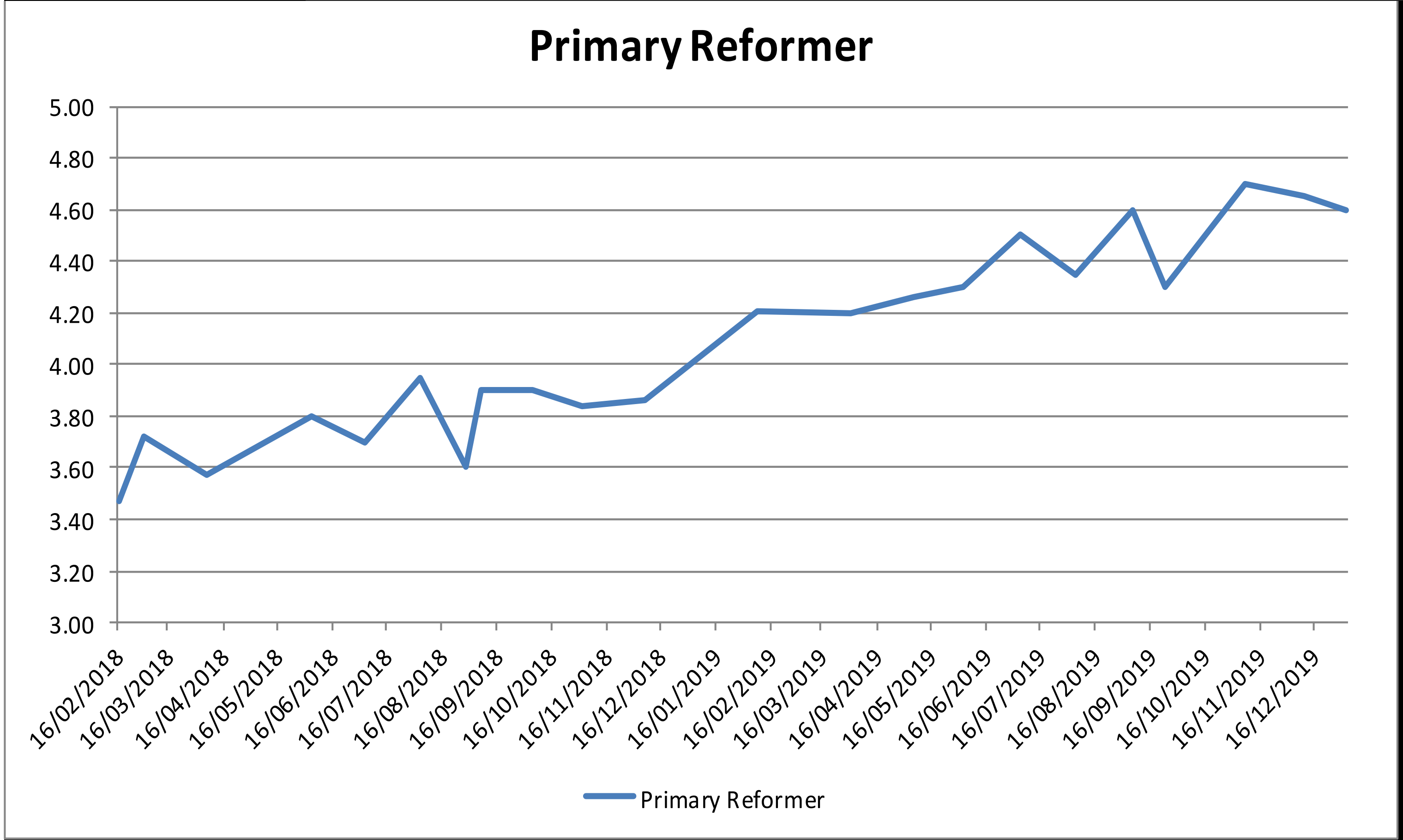
We have considered the following cases to simulate the performance of primary reformer catalysts:

- Case 1 – Plant operates on 100% naphtha from SOR to EOR (5 years)
- Case 2 – Plant operates on naphtha + natural gas. For this case, out of total feedstock flow of 9156 Nm3/hr, we have considered 20% of NG flow (1831 Nm3/hr) + 80% of naphtha (7325 Nm3/hr). The maximum allowable natural gas is 20% of the total feed stock on molar basis i.e., % {natural gas/(natural gas + naphtha)}

For case 2 (naphtha + NG) the inlet, steam to carbon and exit conditions were considered same as case 1.

REFORMER – CASE STUDY

Date	Primary Reformer
16/02/2018	3.47
02/03/2018	3.72
06/04/2018	3.57
04/06/2018	3.80
04/07/2018	3.70
03/08/2018	3.95
29/08/2018	3.60
07/09/2018	3.90
05/10/2018	3.90
02/11/2018	3.84
07/12/2018	3.86
08/02/2019	4.21
01/04/2019	4.20
06/05/2019	4.26
03/06/2019	4.30
05/07/2019	4.50
05/08/2019	4.35
05/09/2019	4.60
24/09/2019	4.30
07/11/2019	4.70
10/12/2019	4.65
03/01/2020	4.60



REFORMER – CASE STUDY

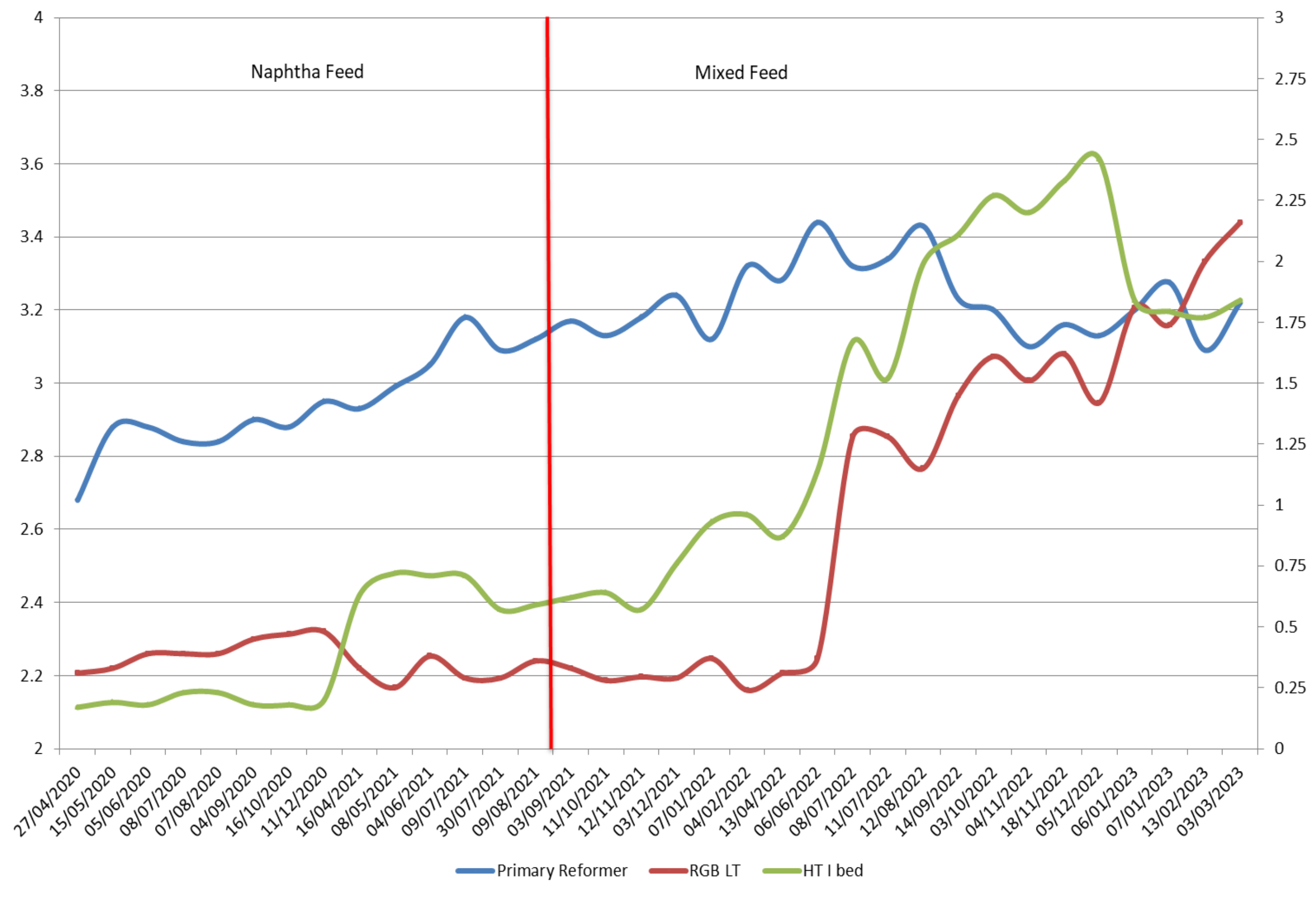
Catalyst Vessel	Supplier	Quantity (m3)	Charged On	Replaced on	Life (Months)
Primary reformer	A	17.88	Apr-04	Apr-07	36
		11.88			
	B	17.80	Oct-10	Mar-17	78
		11.60			
	X	11.20	Mar-17	Jan-18	10
		5.60			
		11.20			
	X	16.80	Jan-18	Apr-20	27
		11.20			

REFORMER – CASE STUDY

1. Catalyst received from Supplier – x was in service from 2018 to 2020
2. As bulk of outlet pigtail replacement was planned in 2020, catalyst replacement was needed
3. As the possibility of Mixed Feed operation was still there and considering various other factors Catalyst Procurement was done from Supplier – B instead of Supplier – X
4. Plant started to process NG as feed from end of August 2021
5. Since then till today Plant is being operated with MIXED FEED

REFORMER – CASE STUDY

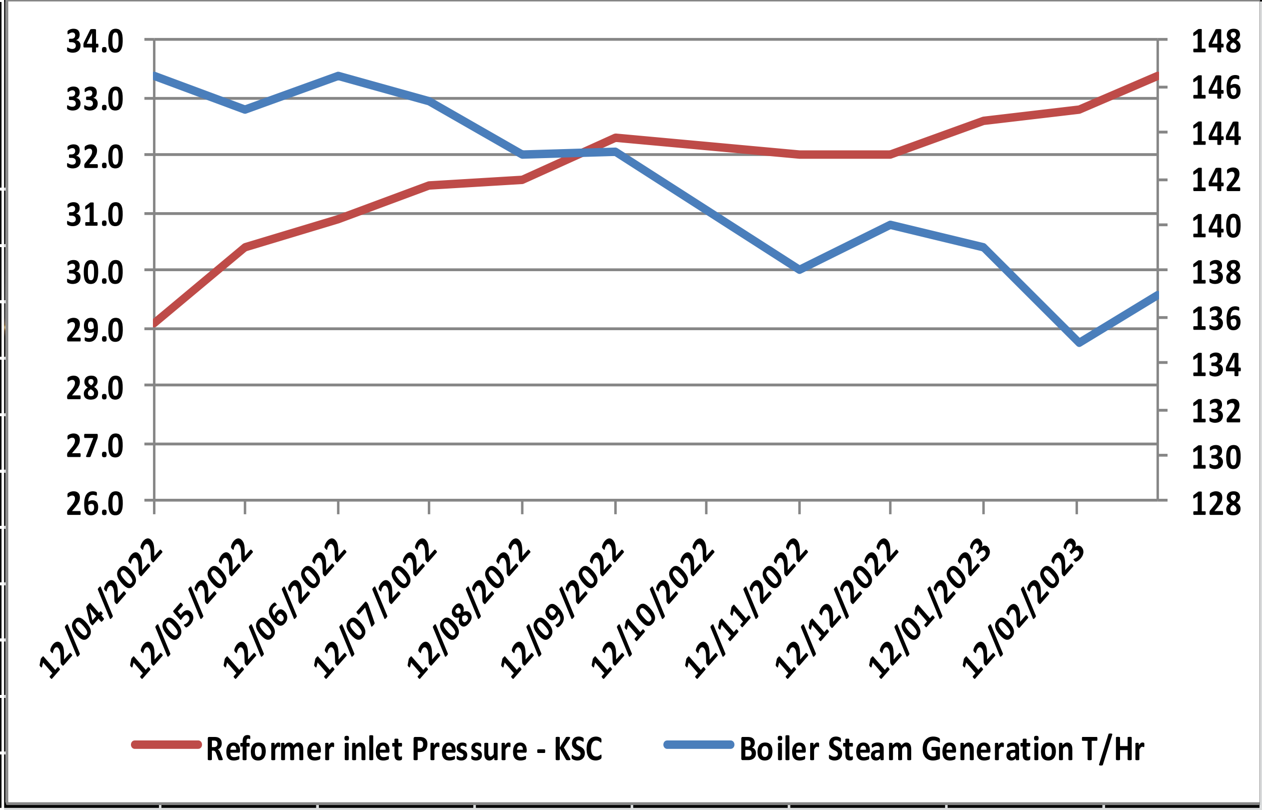
Pressure Drop Data (Kg/cm2)			
Date	Primary Reformer	RGB LT	HT I bed
27/04/2020	2.68	0.31	0.17
15/05/2020	2.88	0.33	0.19
05/06/2020	2.88	0.39	0.18
08/07/2020	2.84	0.39	0.23
07/08/2020	2.84	0.39	0.23
04/09/2020	2.90	0.45	0.18
16/10/2020	2.88	0.47	0.18
11/12/2020	2.95	0.48	0.20
16/04/2021	2.93	0.33	0.63
08/05/2021	2.99	0.25	0.72
04/06/2021	3.05	0.38	0.71
09/07/2021	3.18	0.29	0.71
30/07/2021	3.09	0.29	0.57
09/08/2021	3.12	0.36	0.59
03/09/2021	3.17	0.33	0.62
11/10/2021	3.13	0.28	0.64
12/11/2021	3.18	0.29	0.57
03/12/2021	3.24	0.29	0.76
07/01/2022	3.12	0.37	0.93
04/02/2022	3.32	0.24	0.96
13/04/2022	3.28	0.31	0.87
06/06/2022	3.44	0.37	1.14
08/07/2022	3.32	1.28	1.67
11/07/2022	3.34	1.28	1.52
12/08/2022	3.43	1.15	1.99
14/09/2022	3.23	1.45	2.11
03/10/2022	3.20	1.61	2.27
04/11/2022	3.10	1.51	2.20
18/11/2022	3.16	1.62	2.33
05/12/2022	3.13	1.42	2.42
06/01/2023	3.20	1.81	1.84
07/01/2023	3.28	1.74	1.79
13/02/2023	3.09	2.00	1.77
03/03/2023	3.22	2.16	1.84



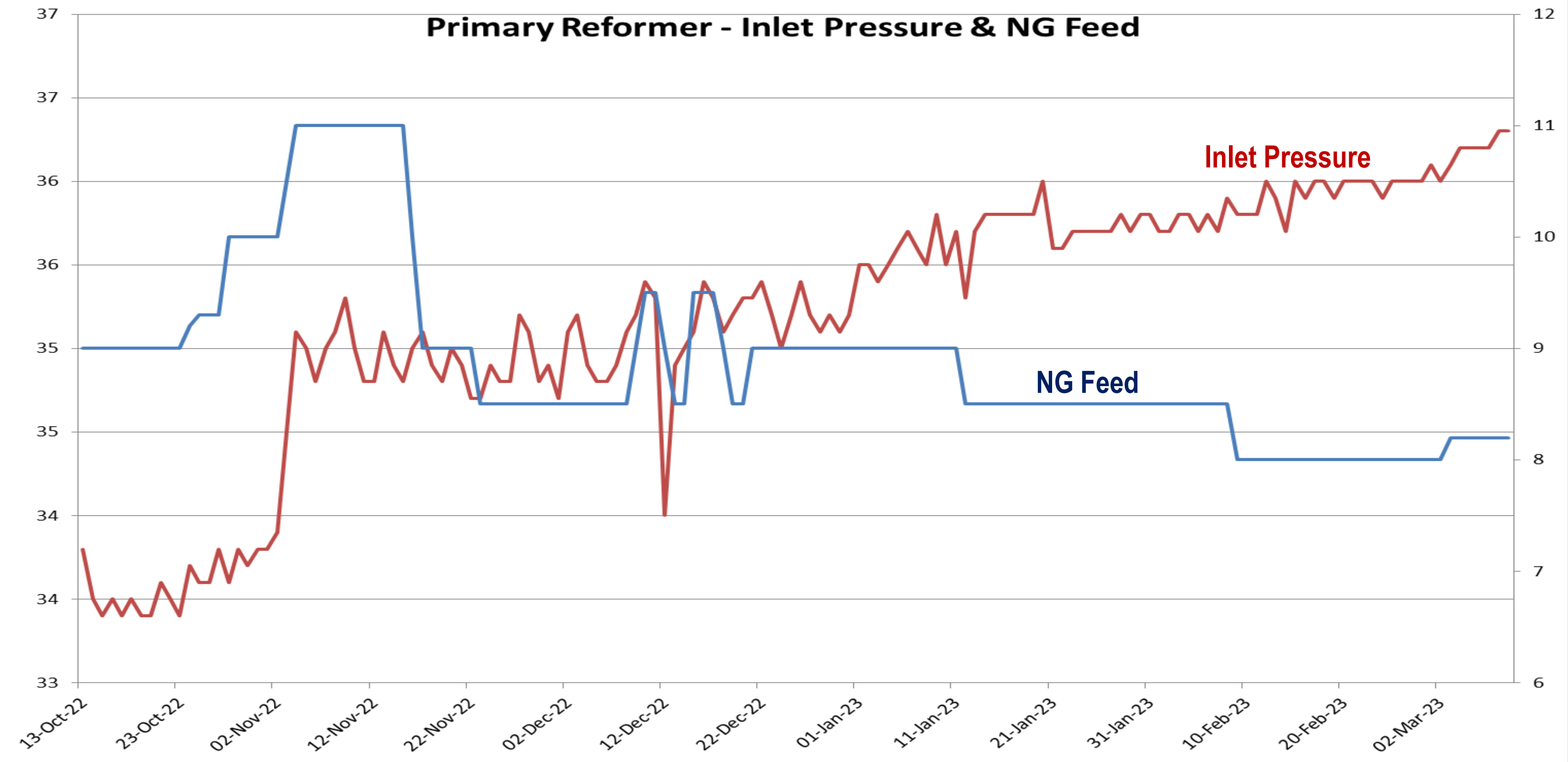
REFORMER – CASE STUDY

Effect of Fouling in RGB and high Pressure Drop in Boiler & HT shift

Date	Boiler Steam Generation T/Hr	Reformer inlet Pressure - KSC
12/04/2022	147	29.1
12/05/2022	145	30.4
12/06/2022	147	30.9
12/07/2022	145	31.5
12/08/2022	143	31.6
12/09/2022	143	32.3
12/11/2022	138	32.0
12/12/2022	140	32.0
12/01/2023	139	32.6
12/02/2023	135	32.8
10/03/2023	137	33.4



REFORMER – CASE STUDY



REFORMER – CASE STUDY

Catalyst Vessel	Supplier	Quantity (m3)	Charged On	Replaced on	Life (Months)
Primary reformer	A	17.88	Apr-04	Apr-07	36
		11.88			
	B	14.80	Apr-07	Mar-17	78
		11.60			
	X	11.20	Mar-17	Jan-18	10
		5.60			
		11.20			
	X	16.80	Jan-18	Apr-20	27
		11.20			
	B	16.80	Apr-20	Mar-23	35
		11.20			

SUMMARY OF FAILURE ANALYSIS

1. 60% of the High Potash and 40% of Non – Potash Catalyst is the ideal combination for processing Naphtha.
2. 2 Layer Catalyst Combination to process Naphtha can handle up to a maximum of 40% NG, however a low potash Catalyst can not handle Naphtha even for a short period of time
3. Potash leaching is suspected and getting deposited in RGB and HT Shift

ACTION PLAN

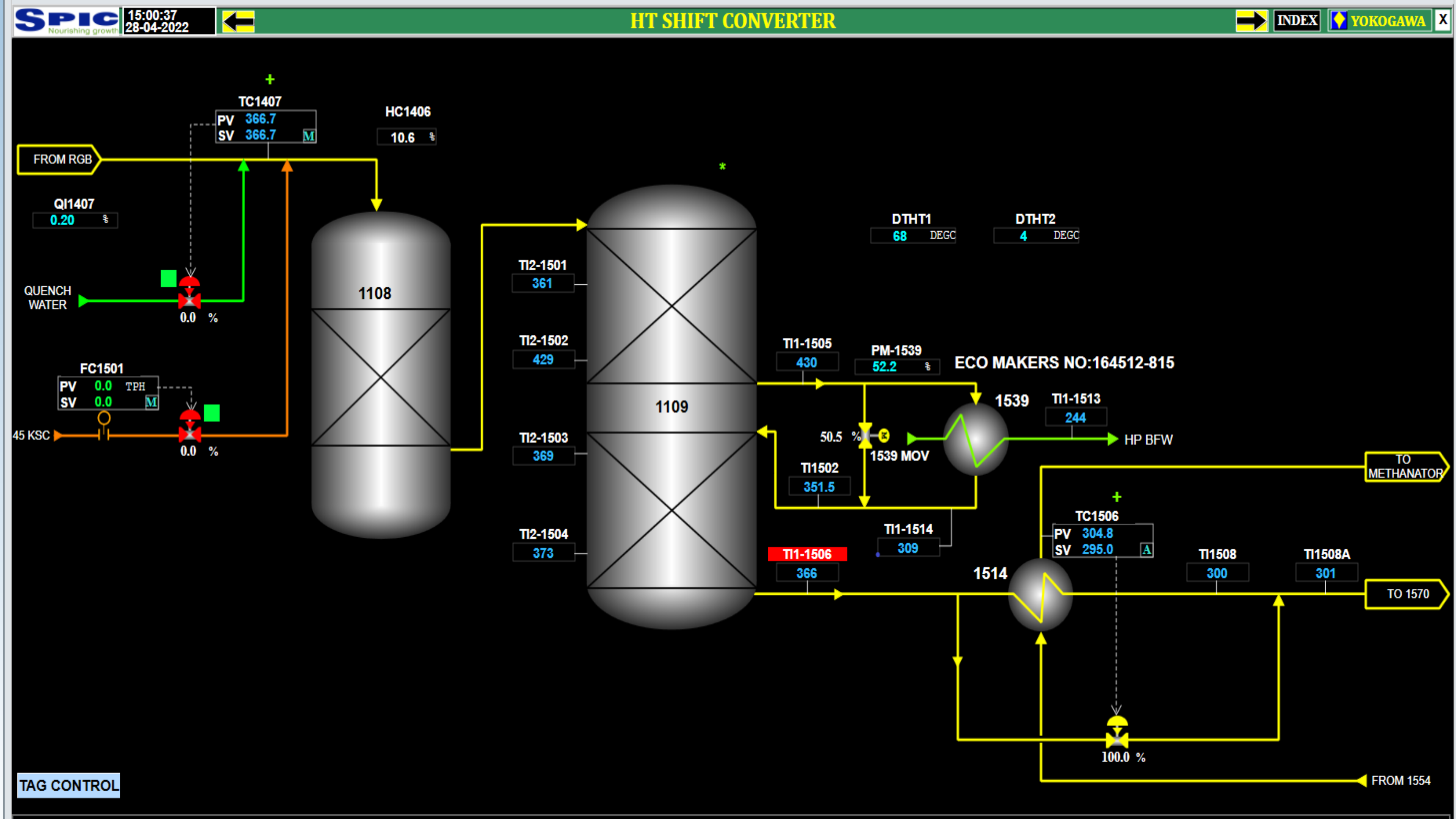
1. Cleaning of tubes to be done for Low Temperature compartment of Reformed Gas Boiler.
2. Catalyst Skimming has to be done in HT – Shift Catalyst in the First Bed

Request to Catalyst Vendors

SPIC is still open to have discussions with Catalyst Vendors who can provide the right combination of Primary Reformer Catalyst than can handle both Naphtha and NG at any proportion without affecting its performance and the downstream sections.

Catalyst Upset – Case Study

1. Primary Reformer Catalyst
2. High Temperature Shift Catalyst



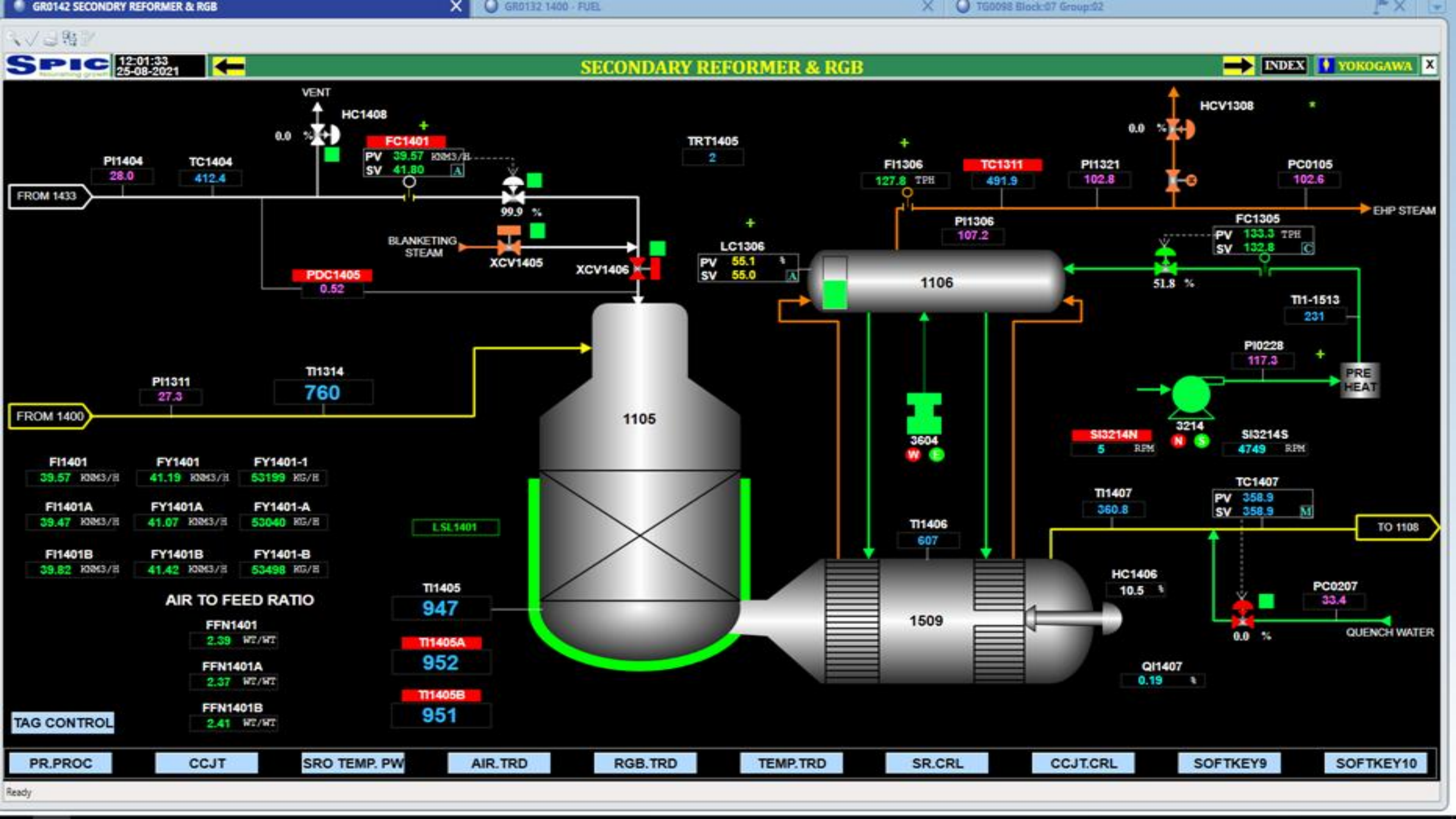
SPIC Nourishing growth
15:00:37
28-04-2022
HT SHIFT CONVERTER
INDEX
YOKOGAWA
X
TC1407
PV 366.7
SV 366.7 M
HC1406
10.6 %
FROM RGB
QI1407
0.20 %
QUENCH WATER
0.0 %
FC1501
PV 0.0 TPH
SV 0.0 M
45 KSC
0.0 %
1108
1109
TI2-1501
361
TI2-1502
429
TI2-1503
369
TI2-1504
373
DTHT1
68 DEGC
DTHT2
4 DEGC
TI1-1505
430
PM-1539
52.2 %
ECO MAKERS NO:164512-815
1539
TI1-1513
244
50.5 %
1539 MOV
HP BFW
TI1502
351.5
TO METHANATOR
TC1506
PV 304.8
SV 295.0 A
TI1-1514
309
TI1-1506
366
1514
TI1508
300
TI1508A
301
TO 1570
100.0 %
FROM 1554
TAG CONTROL

HT Shift Catalyst

1.	Chromic Oxide	- 8.0%
2.	Copper Oxide	- 1.8%
3.	Ferric Oxide	- Balance
4.	Shape	- Tablet
5.	Volume	- 36 Kilo Liters

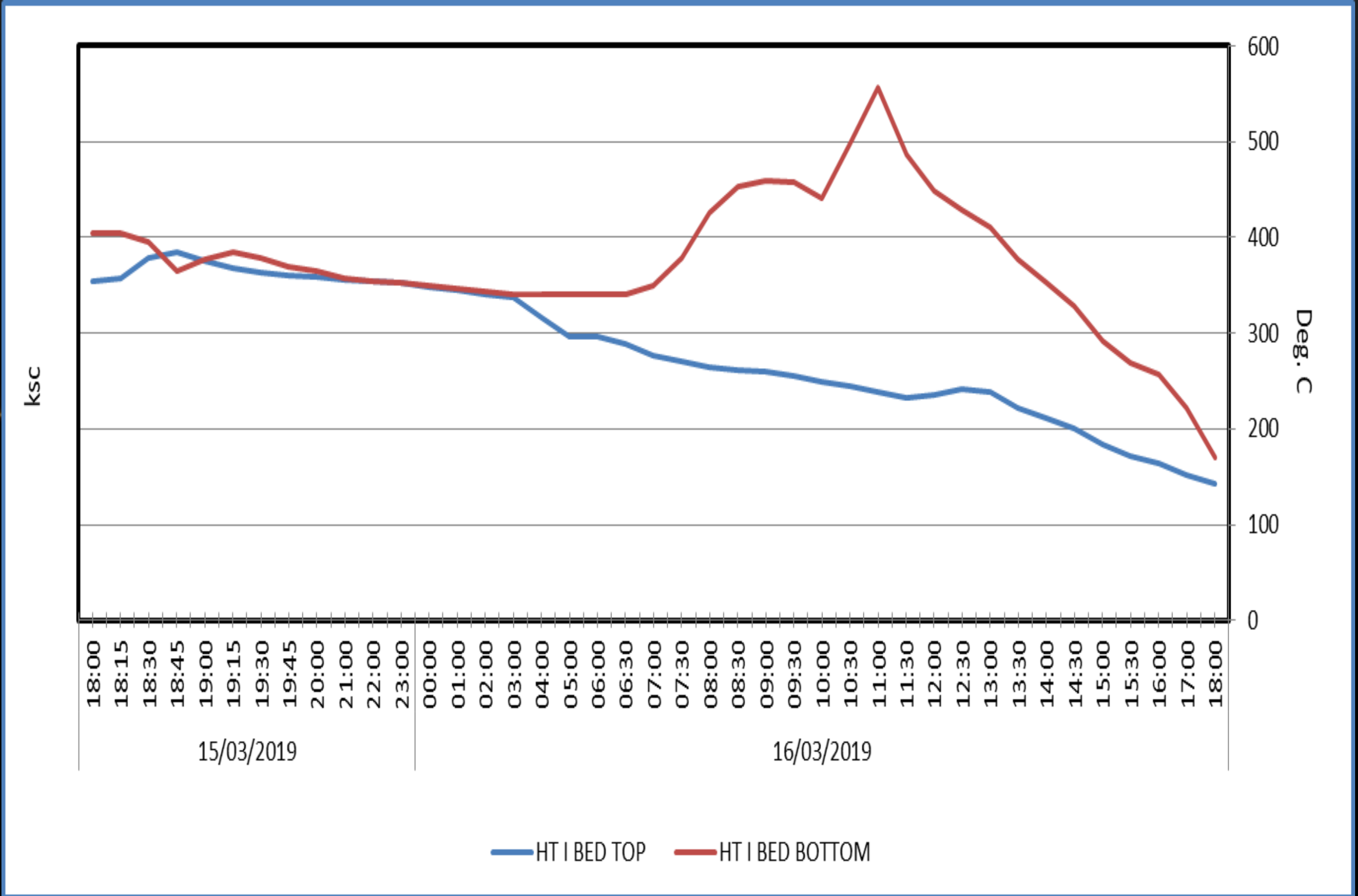
Case Study - Sequence of Events

1. Plant had to be stopped on Emergency due to vibration in Synthesis Gas Compressor on 15th March 2019
2. Reformer Loop purging was completed with Steaming till all the Hydrocarbon and gases are removed
3. Next step was to carryout cooling down operation with Nitrogen Circulation
4. Nitrogen Compressor was lined up and Steam was isolated
5. It is a conventional procedure to keep the Process Air Compressor running for Instrument Air Service and it is charged up to inlet of Process Air Heater.

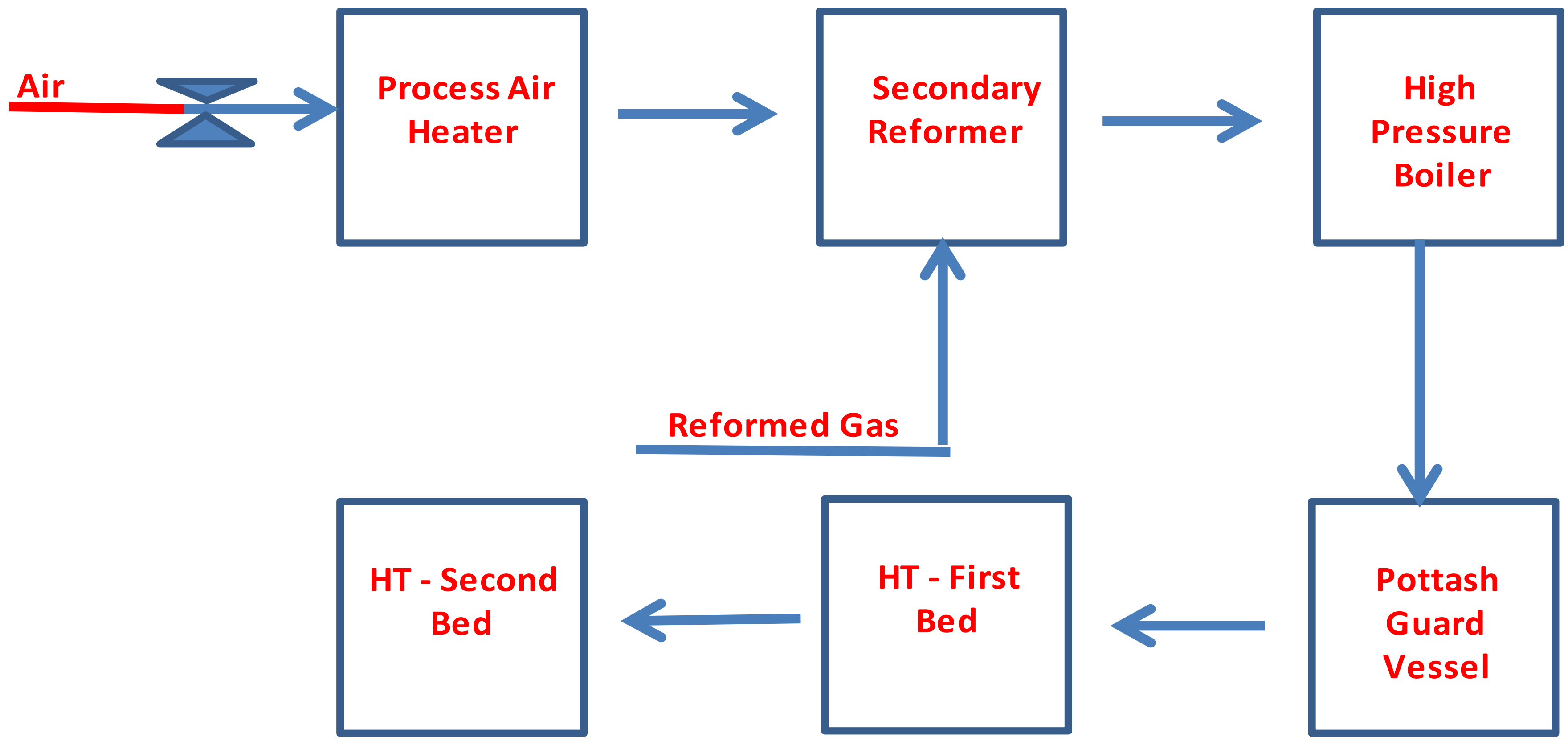

GR0142 SECONDRY REFORMER & RGB
GR0132 1400 - FUEL
TG0098 Block:07 Group:02
SPIC
12:01:33
25-08-2021
SECONDARY REFORMER & RGB
INDEX
YOKOGAWA
VENT
HC1408
0.0 %
FC1401
PV 39.57 KNM3/H
SV 41.80 A
PI1404
28.0
TC1404
412.4
FROM 1433
99.9 %
BLANKETING STEAM
XCV1405
XCV1406
PDC1405
0.52
TRT1405
2
LC1306
PV 55.1 %
SV 55.0 A
FI1306
127.8 TPH
TC1311
491.9
PI1321
102.8
PC0105
102.6
HCV1308
0.0 %
EHP STEAM
PI1306
107.2
FC1305
PV 133.3 TPH
SV 132.8 C
51.8 %
1106
TI1-1513
231
PI0228
117.3
PRE HEAT
3214
N S
SI3214N
5 RPM
SI3214S
4749 RPM
3604
W E
PI1311
27.3
TI1314
760
FROM 1400
1105
FI1401
39.57 KNM3/H
FY1401
41.19 KNM3/H
FY1401-1
53199 KG/H
FI1401A
39.47 KNM3/H
FY1401A
41.07 KNM3/H
FY1401-A
53040 KG/H
FI1401B
39.82 KNM3/H
FY1401B
41.42 KNM3/H
FY1401-B
53498 KG/H
LSL1401
AIR TO FEED RATIO
FFN1401
2.39 WT/WT
FFN1401A
2.37 WT/WT
FFN1401B
2.41 WT/WT
TI1405
947
TI1405A
952
TI1405B
951
TI1406
607
1509
TI1407
360.8
TC1407
PV 358.9
SV 358.9 M
TO 1108
HC1406
10.5 %
PC0207
33.4
0.0 %
QUENCH WATER
QI1407
0.19 %
TAG CONTROL
PR.PROC
CCJT
SRO TEMP. PW
AIR.TRD
RGB.TRD
TEMP.TRD
SR.CRL
CCJT.CRL
SOFTKEY9
SOFTKEY10
Ready

Run Away Reaction

TIME	HT-I-TOP	HT-I-BOT
00:00	348	349
01:00	345	346
02:00	341	343
03:00	338	340
04:00	316	340
05:00	297	340
06:00	297	340
06:30	289	341
07:00	277	349
07:30	270	378
08:00	265	426
08:30	262	453
09:00	260	459
09:30	255	457
10:00	249	441
10:30	244	499
11:00	239	556
11:30	233	487
12:00	236	448
12:30	241	428
13:00	238	410
13:30	221	377
14:00	211	352
14:30	200	329
15:00	183	292



RCA


Air
Process Air Heater
Secondary Reformer
High Pressure Boiler
Reformed Gas
HT - Second Bed
HT - First Bed
Pottash Guard Vessel

Consequence of Upset

1. Catalyst activity had reduced by rapid oxidation
2. Inlet Temperature had to be maintained above 375 deg C to sustain the reaction
3. Loading had shifted from First Bed to Second Bed.
4. However the pressure drop was normal
5. Plant had to be operated at optimum load till the next catalyst charge was made ready by Oct 2019
6. Lost the Catalyst life of about 5 years

Consequence of Upset

HISTORICAL HTS CATALYST PERFORMANCE -SPIC									
Date	7/5/12	04/03/15	12/10/16	05/06/17	03/02/18	02/07/18	18/02/19	01/04/19	05/07/19
MOS	1	31	74	82	1	6	13	15	18
REPORTED									
Production Rate	1125	1127	1150	1008	1035	1035	1035	1039	1044
HTS Inlet Temp	360	361	364	370	340	342	345	376	376
HTS Outlet Temp	426	420	424	429	406	405	406	436	436
DT Measured, Deg C	66	59	60	59	66	63	61	60	60
DT Calculated, Deg C	65.3	61	53.8	86.9	69.5	66	60.9	61.2	59.2
HTS CO Slip	2.82	3.90	3.83	4.14	2.4	2.62	3.72	3.88	4.13
Delta P HTS	0.54	0.88	0.77	0.72	0.19	0.14	0.67	0.32	0.5
ATE, Deg C	21	65.2	76.9	(-)0.9	16.3	30.5	79.7	51.0	60.6

Catalyst Replacement History

HT SHIFT CONVERSION					
Catalyst Vessel	Supplier	Quantity (m3)	Charged On	Replaced on	Life (Months)
HT 1ST bed	B	42.23	Apr-01	Apr-07	72
	B	36.4	Apr-07	Feb-18	89
	B	36	Feb-18	Oct-19	20
	B	36	Oct-19	Mar-23	41

Learning & Outcome

1. Minor Mistakes during a shutdown and startup of an Ammonia Plant can become very costly
2. SOP was modified in such a way that similar mistake do not happen again
3. The Case Study was communicated to the Operation and Maintenance Team for awareness

Catalyst Replacement History

Catalytic Vessel	Volume - KL	From	To	Service - Months
Secondary Reformer	26.2	Apr-96	Mar-23	283
Methanator	36.5	Aug-90	Mar-23	351
Converter	54.81	Apr-96	Mar-22	270

Conclusion

Life of the Catalyst depends on maintaining better operating conditions and exposure to less process upsets with respect to its parameters outside the limits and eliminating poisonous substance

THANKS