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Gasoline HDS Plant

Control Loops Tuning

Advance Report

August 2008

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Preliminary

- For comments -

Summary

This report documents the work done on the Gasoline HDS plant as part of re-tuning all the control loops in the HDS plants.

Loops were tuned to get the best performance to their duty and efforts were done to compare it's functioning prior and after the tuning

Tuning was done by "Ziegler Nichols" approach – namely – finding the ultimate process gain and ultimate process dynamics and setting the controller's parameters accordingly – bearing in mind the controller duty and the characteristics of the expected behavior..

The control performance is calculated and presented using two indices:

1. Process value Standard Deviation (**STD**)

and

2. Process Value Travel Index (**Process travel**)

Table 1 **Summary Table** (Page 3) summarizes the results of the Gasoline HDS plant control loops tuning project which was carried out during the month of August 2008.

The table demonstrates a significant improve in both indices that were calculated.

Those control loops where, apparently, the performance was worsens are loops that were not in control mode prior to our project hence the comparison is irrelevant.

Some control valves are having mechanical problems such as "**Stickness**" which disturbs the smooth operation of the associated control loops and influenced the neighbor control loops as well. In some cases the situation is so bad, that the loops are either untuneable or that we had to use "extreme" measures to overcome the problem (such as, relatively, very high filter factor).

Remarks were introduced for these loops in Table 1 and a detailed list was given to the operation team.

Economical Benefits:

The improvement of temperature control in RTC4007 - E-3 TOP TEMP only, brought savings of nearly 1 Million $/Year by reducing product RVP and savings in steam due to better temperature control and reduction in the reflux.

Table 1:Summary table

Performance Indices

Assessing the performance of control loops is a subject that was discussed elsewhere and we shall only refer here to the relevant aspects to our project.

Calculating an assessment needs using the control loop parameters such as PV, SP and OUTPUT. Normally, only the PV is histories and even this one is undergoing tortures to better use the available memory. These compression techniques make the data recovery process troublesome and some of the accuracy might be lost.

Because references are made to PAST performances we could have used only AVAILABLE parameters E.G. the PV, assuming similar behavior of the "other" parts of the process.

Error Standard Deviation

This assessment calculates the Standard deviation of the Error (=PV-SP) according to the formula

$$\sqrt{\frac{\sum (x-\bar{x})^2}{(n-1)}}$$

where X is the measured PV and $\overline{X}$ is the SP.

Because the values of the SP are not stored in the history, we had used the *average* of the PV as alternate to the SP, assuming this average behaves very close to the way the SP does.

This assessment is referred to as **STD** in this report.

(For more details regarding this calculation, please refer to Appendix B'.)

Valve Travel

Needless excess valve movements are undesired for some reasons:

- It causes process instability;
- It cost us energy to drive the valve;

and

- It causes excess wear of the valve parts.

Calculating this assessment needs knowledge of the controller's OUTPUT which, usually, is NOT available. As an alternate we used the "Process Travel" by summing the absolute changed in the process value – each sample we hade in our historian.

This assessment is referred to as **Process Travel** in this report.

Tuning “Level” controllers

We treated control loops with high Integral action built into the process in a special manner as to make use of their special behavior on one hand and to prevent taking actions that may disturb the system as such.

Processes like liquid level, gas pressure and temperatures in some cases have the characteristics of nearly pure integrators.

In this work, we have tried to tune these controllers, in all those cases where the exact process value (E.G. the level, the pressure or the temperature) has no importance, to "float" between the acceptable high and low limits, to make use of the available freedom in the associated processes, in such a way that the disturbances upstream to these control points are absorbed in these, to minimize the transfer of the disturbances down stream.

In these control loops the process Standard deviation (**STD**) and the “**Process Travel**” does not have the same importance as in other process control loops. “Good” tuning of these loops should result is reduced **STD** and reduced “**Process Travel**” in the process parameters that follow that controller (E.G. the flow that follows a level controller).

Where integrating processes were identified, NO integrating action was built into the PID algorithm. Small action (~50-60 Min/repeat) was left to avoid the theoretical possibility of being stuck with some offset – without causing too much harm.

Loops with problems

The following table summarizes those loops where there are problems:

- valves' Stickness
- Valves' sizing,
- Instrument range setting
- Noisy sensor signal

And

- General instrumentation attention

	Tag	Description	Remarks
1	RFC4006	FEED TO C7-3/4	(Was) Sticky
2	RFC4025	F2 LPG TO AMINE	Instrument Range too Small
3	RFC4055A	J2 MINIMUM FLOW	Sticky
4	RFC4056	F5 FLOW TO E3	Sticky! Check Positioner as well. Flow is not stable in MAN mode. Hi filter essential.
5	RFC4059	LEAN AMINE FLOW TO E-6	Sticky
6	RFC4067	START-UP LINE FLOW	Sticky
7	RLC4007	F-2 LEVEL	Level signal noisy. Needs attention.
8	RLC4013	C-13A LEVEL	Check reason for valve oscilations
9	RPC4003	F-2 PRESSURE	Valve needs attention.
10	RPC4082	B2A EAST F.G PRESSURE	Sticky
11	RPC4126	F-30 PRESSURE	Valve too Small
12	RTC4029	B-2 COIL-B OUTLET TEMP.	Valve too Small

Although – the re-tuning of these loops was successful it will be needed to check its tuning once these problems are resolved.

Results and Conclusions

25 loops were tuned in the Gasoline HDS plant. 8 additional loops had not yet been tuned for administrative reasons.

All the tuned loops show improvement on the assessment as were checked in this case **Process Standard deviation** and **Process Travel** – in comparison to the same indices prior to the tuning.

Specific points:

- RFC4055A - J2 MINIMUM FLOW – besides being tuned, the minimum output limit was reduced. This caused the spill back of J2 to be reduced from 20+ Cum/Hr to some~1 Cum/Hr. A significant energy savings. Can this flow be set to 0?
- RTC4011 - C-11 A/B AVR. OUTLET TEMP. – is a slave to RFMN4012 (E3 Reflux Minimum Flow) and a master to RFC4054 (Steam Flow to C11A/B): while manipulating RTC4011, it was observed that the controller (=the system!) was unable to drive the temperature beyond a certain temperature which is , probably, the boiling temperature of the gasoline in the bottom of E3 in the operating pressure (159º C at 7Barg).
  I suggest that we check the possibility to eliminate TC4011 altogether as a controller and implement the concept of RFMN4012 further to serve as Reflux to Product Ratio controller.

בדיקת תוצאות וחסכונות מוכחים בתוצאה משפור תפקוד הבקרה במה״ד בנזין[1]

חסכון בקיטור
לאחר כשבוע מעקב בו צמצמנו תחזיר למגדל ניתן לסכם הנתונים להלן:

ירידה של כ- 0.4 טון/שעה בחישוב שנתי מדובר בכ- 173,000 דולר (50 דולר/טון קיטור).

RVP
RVP: ירידה של כ- 0.4 PSI.
לפי הנתונים להלן:
ירידה של 0.4 PSI שוות ערך ל**חיסכון** של (בהנחה של התנהגות לינארית):

$$0.16\frac{\$}{Ton}+\left(\frac{0.95\frac{\$}{Ton}-0.16\frac{\$}{Ton}}{0.5psi-0.2psi}\right)\times(0.4psi-0.2psi)=0.6866\frac{\$}{Ton}$$

אם סך הפק הבנזין הוא 100,000 טון לחודש הרי בגין ירידה זאת בלחץ האדים במה״ד נקבל בחישוב שנתי:

$$0.6866\frac{\$}{Ton}\times 100{,}000\frac{Ton}{Month}\times 12\frac{Months}{Year}=0.824\times 10^{6}\frac{\$}{Year}$$

סך חסכון שנתי: 0.997 מיליון $ לשנה!

נתונים מאיתן:

1. בחנתי 3 נקודות עבודה בלחץ אדים של פצ״ק 7.5,7.7,8.0 פס״י
2. 3 ידיות שימשו לתיקון ה-RVP זרם הרפינט, האיזומרט, וה MTBE בכל השאר אי אפשר לגעת.
3. סט המחירים נלקח הרצת LP לספטמבר 2008 (31 לאוגוסט)
4. ניתן לראות כי יש תוספת עלות 0.16$/טון אם עולים ב0.2 פס״י בבנזין פצ״ק ותוספת עלות 0.95$/טון אם עולים ב0.5 פס״י בבנזין פצ״ק
5. היפקי הבנזין המוגמר עומדים על כ-100,000 טון בחודש ולכן תוספת העלות בגין עליה של חצי פס״י עומדת על כ-95,000$ ועקרה יותר תערובת MTBE+RAFF ופחות איזומרט.

[1] החשוב נערך על ידי מהנדסי אגף היצור ביולי 2008 או בסמוך לכך.

Appendices

Appendix A - Control Loops Performance prior and after tuning
Appendix B - Standard Deviation Function
Appendix C - PI Process Flow Diagrams

Appendix A – Control Loops Performance prior and after tuning

This appendix contain the details for the performance of each of the following control loops, which were re-tuned in this project/

For each control loop there are:

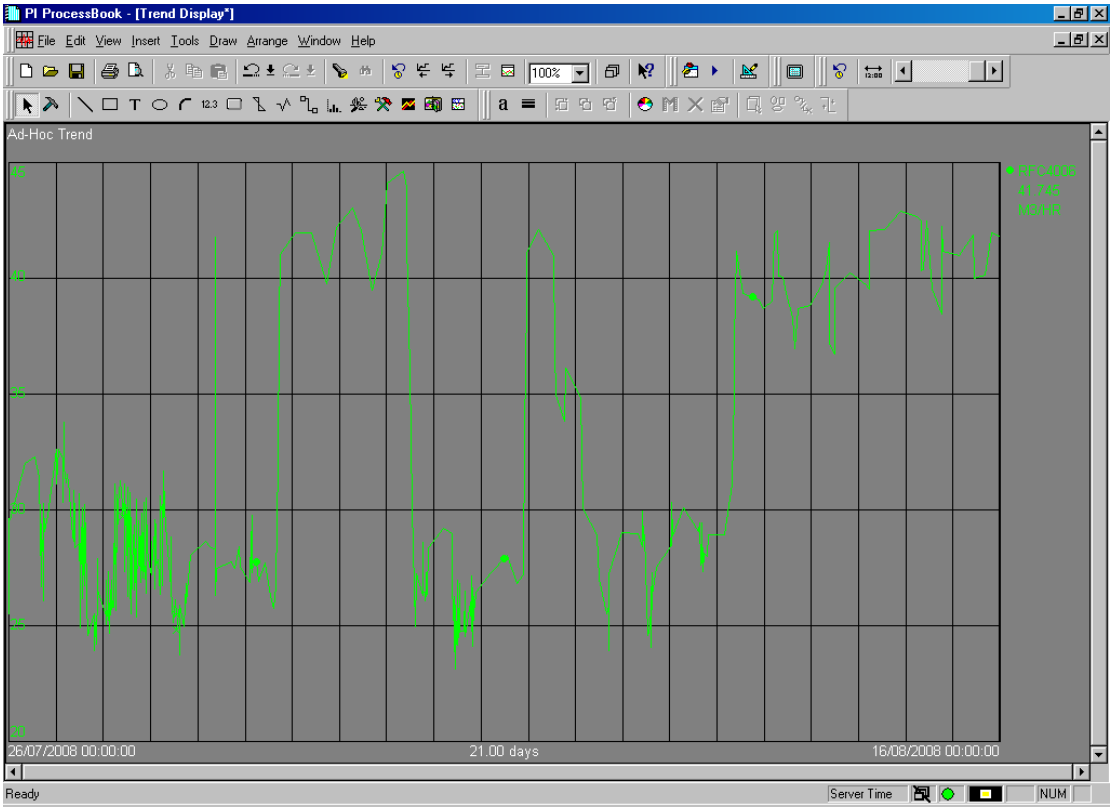
- Basic information regarding the loop such as:
    - master/slave relations
    - reference to which PI display(s) contains this control loop
    - Date(s) of re-tuning
- A table showing its performance indices (E.G. the Process Standard Deviation (STD) and the Process Travel) as was described in a prior section.
- Graphic presentation of these performance indices normalized to have the "before" in blue bar, performance equal "1" for better comparing it to the "after" performance – in red bar.
- Graphic presentation of the sampled process data collected for "before" and "after" to visualize the difference in behavior between the two.

Some specific control loops have some specific additional information

	Tag	Description
1	RFC4006	FEED TO C7-3/4
2	RFC4007	FEED TO C7-5/6
3	RFC4012	E-3 REFLUX
4	RFC4025	F2 LPG TO AMINE
5	RFC4054	STEAM FLOW TO C11A/B
6	RFC4055A	J2 MINIMUM FLOW
7	RFC4056	F5 FLOW TO E3
8	RFC4059	LEAN AMINE FLOW TO E-6
9	RFC4067	START-UP LINE FLOW
10	RLC4006	E-3 LEVEL
11	RLC4007	F-2 LEVEL
12	RLC4013	C-13A LEVEL
13	RLC4036	F-2 WATER LEVEL
14	RLC4040	E-6 LEVEL
15	RLC4053	F-5 LEVEL
16	RPC4003	F-2 PRESSURE
17	RPC4081	B2B WEST F.G PRESSURE
18	RPC4082	B2A EAST F.G PRESSURE
19	RPC4101	B-2 PILOT GAS PRESSURE
20	RPC4126	F-30 PRESSURE
21	RSC4001	JT-14A SPEED
22	RTC4007	E-3 TOP TEMP
23	RTC4011	C-11 A/B AVR. OUTLET TEMP.
24	RTC4027	B-2 COIL-A OUTLET TEMP.
25	RTC4029	B-2 COIL-B OUTLET TEMP.

RFC4006 - FEED TO C7-3/4

Display R90



First Tuning was performed on 29/7/8. Loop was tuned but it was revealed that the valve was sticky.

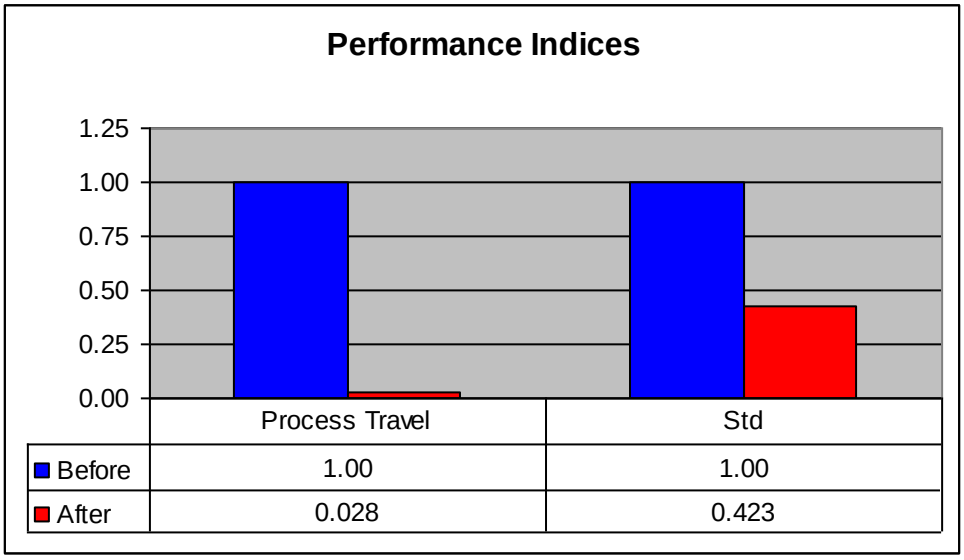
Valve came back from maintenance and was reinstalled on 14/8/8.

The difference in flow behavior before an after tuning is clearly seen.

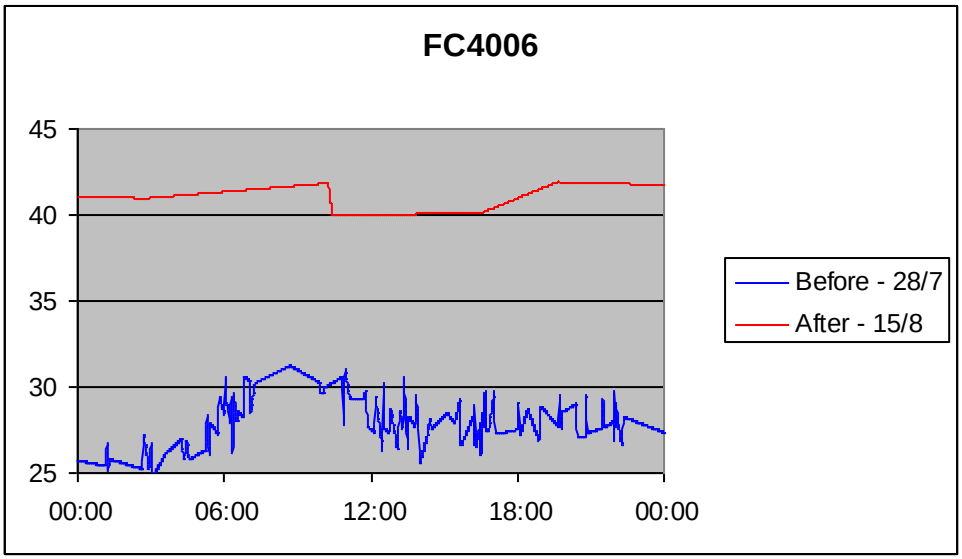
Performance indices:

	Before	After	Factor
Process Travel	103.23	2.89	35.7
Std	1.61	0.68	2.4
	Normalized		
Process Travel	1.00	0.028	
Std	1.00	0.423	

.

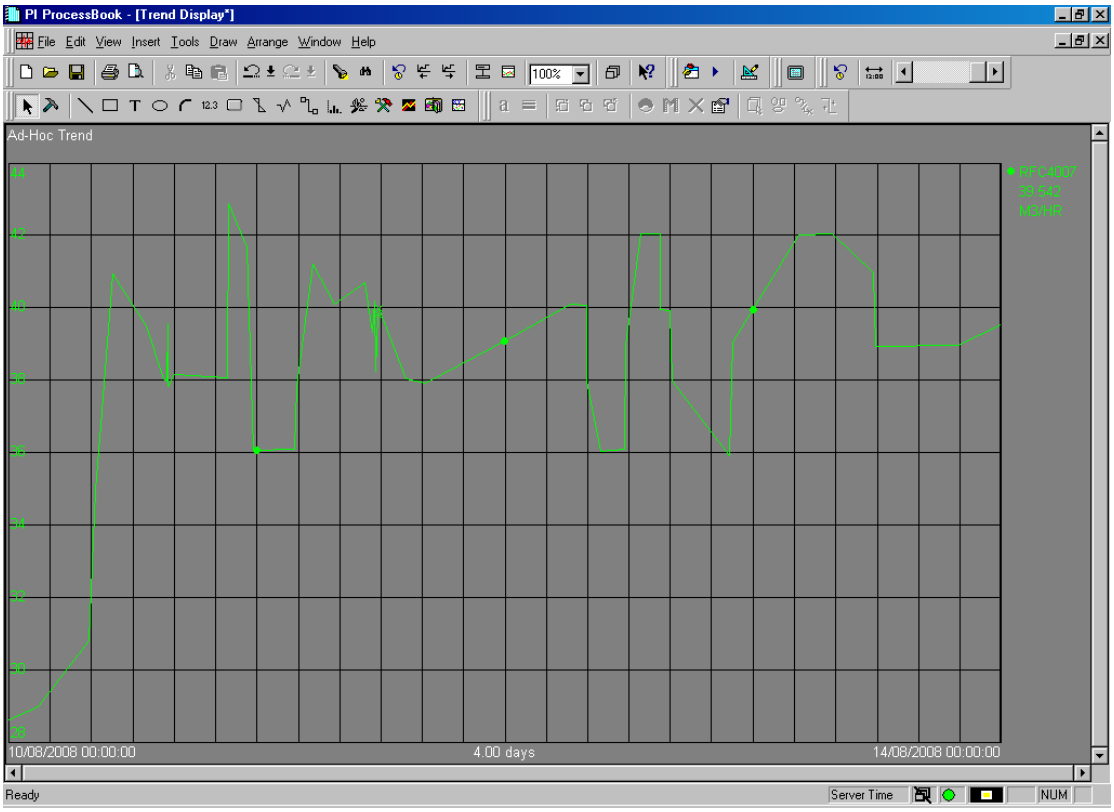


The following is a trend of the data collected from the PI system for dates before and after the tuning



RFC4007 – FEED TO C7-5/6

Display R90

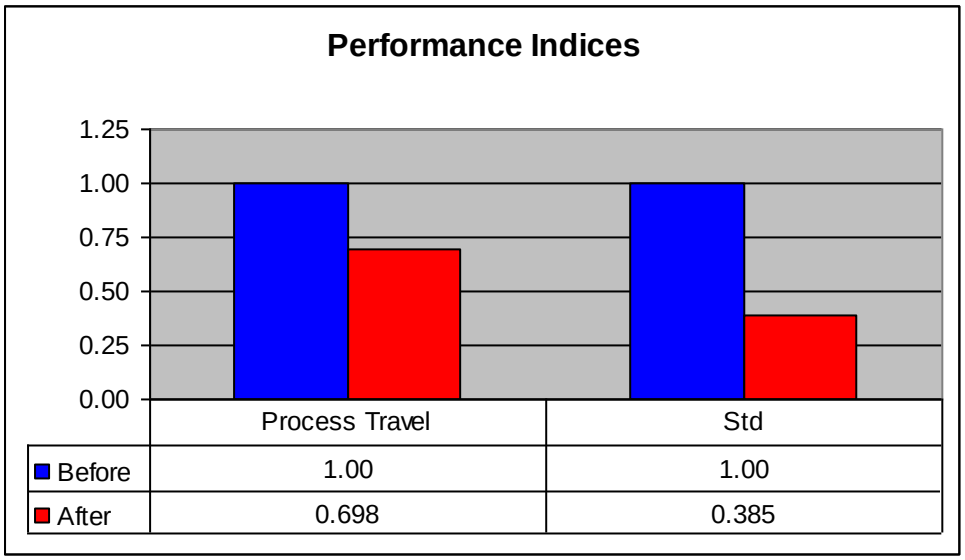


Tuning was performed on 11/8/8

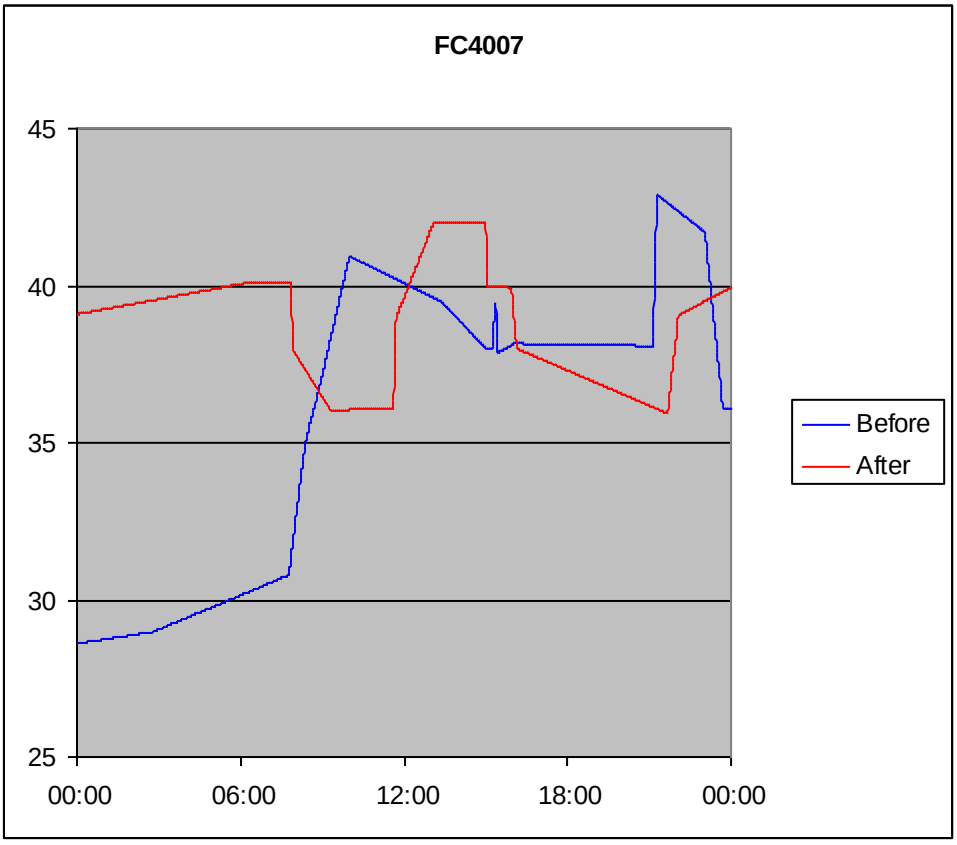
The flow behavior before and after tuning is not clear to the naked eye.

Performance Indices:

	Before	After	Factor
Process Travel	30.37	21.20	1.4
Std	4.70	1.81	2.6
	Normalized		
Process Travel	1.00	0.698	
Std	1.00	0.385	



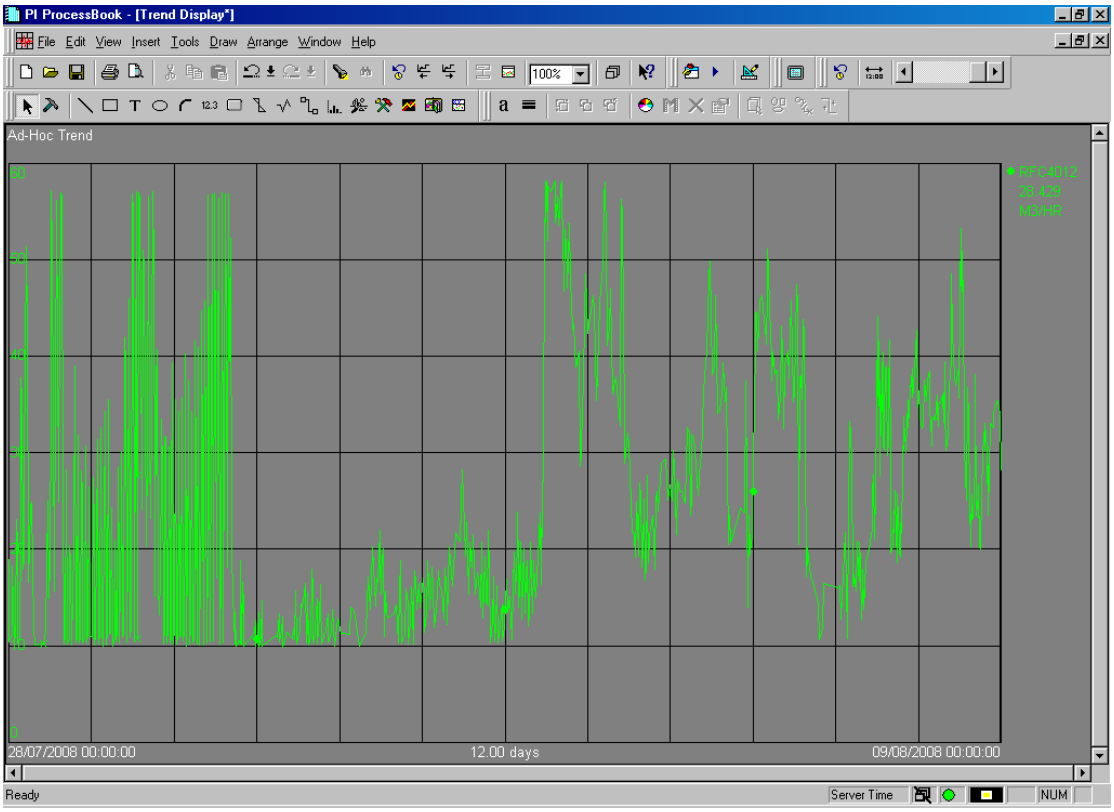
The following is a trend of the data collected from the PI system for dates before and after the tuning.



RFC4012 - E-3 REFLUX

Display R 98

Slave of TC4007



Tuning was performed between 29/7/8 to 7/8/8.

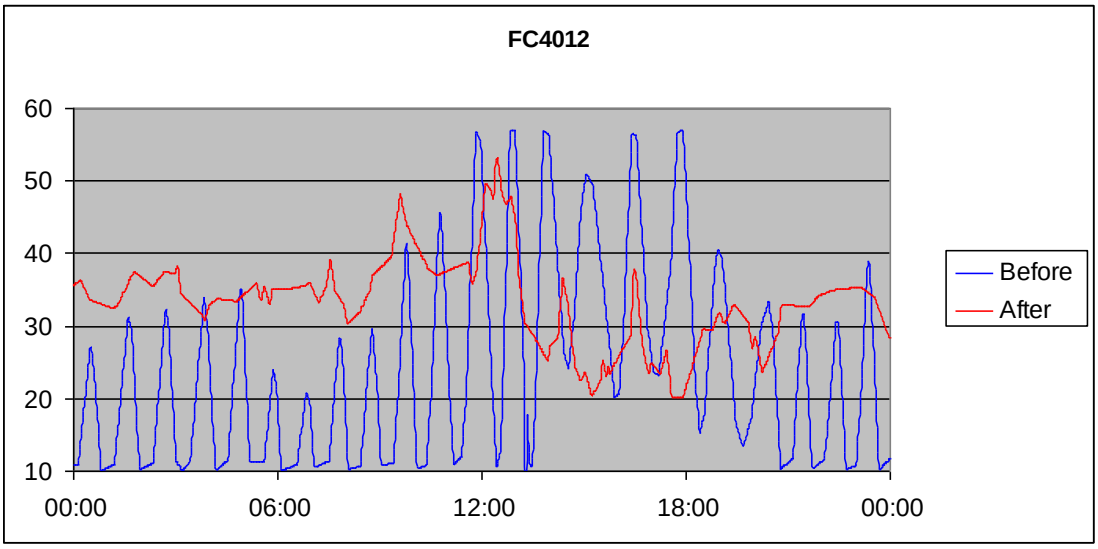
The flow behavior before is much wilder then its behavior after tuning

Performance Indices:

	Before	After	Factor
Process Travel	1170.06	272.20	4.3
Std	13.10	5.96	2.2
	Normalized		
Process Travel	1.00	0.233	
Std	1.00	0.455	

This flow is a "slave" in a cascade loop and hence is supposed to follow demands from a master loop. Its STD is highly influenced by the behavior of its master (**TC4007**).

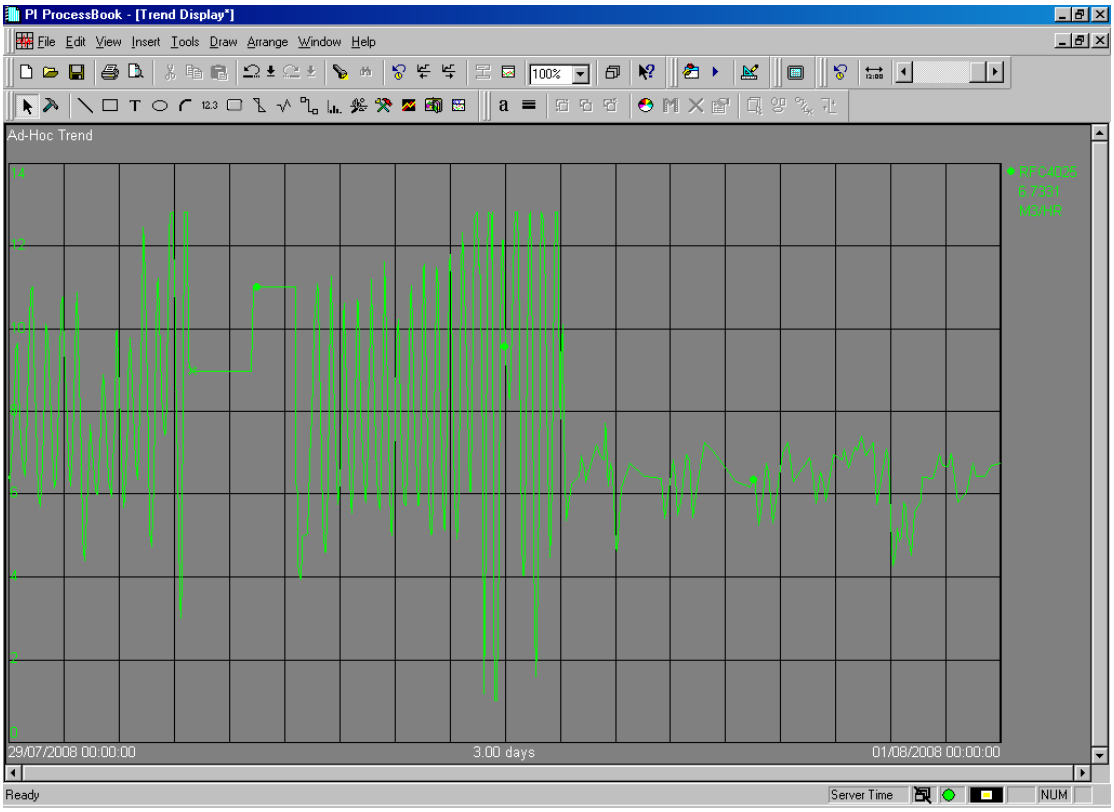
The following is a trend of the data collected from the PI system for dates before and after the tuning.



RFC4025 - F2 LPG TO AMINE

Display R98

Slave of LC4007



Tuning was performed on 30/7/8.

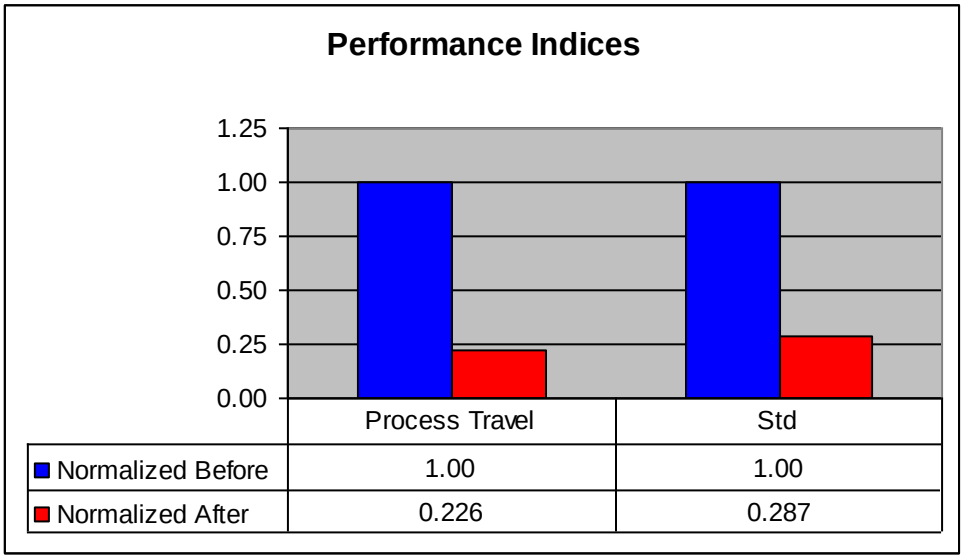
The flow behavior before is much wilder then its behavior after tuning

Performance Indices:

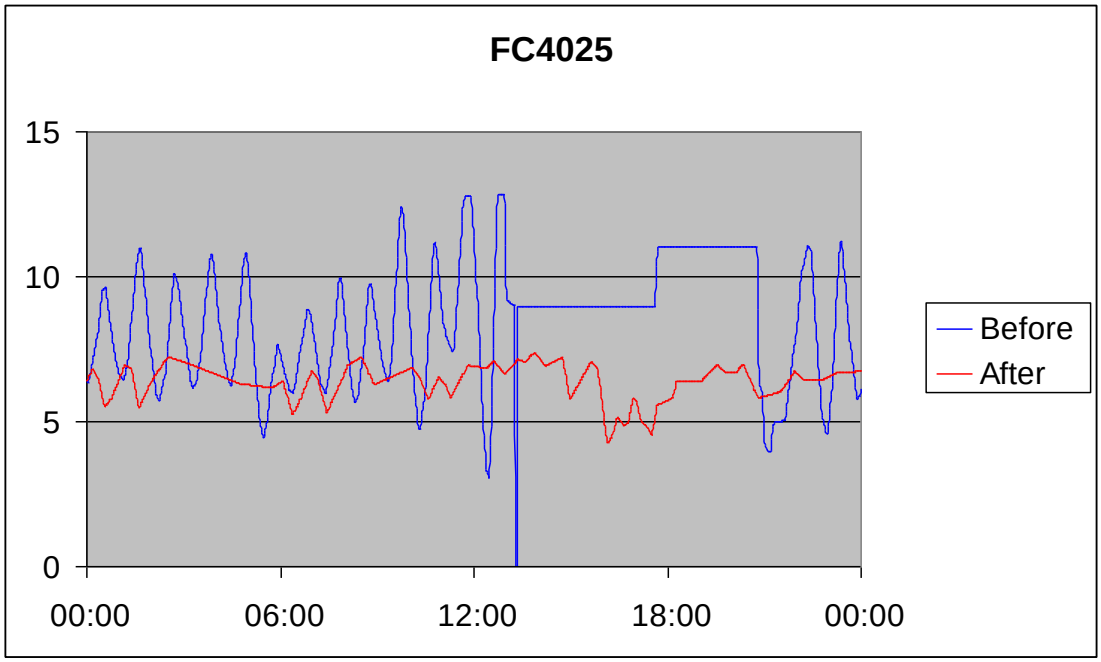
	Before	After	Factor
Process Travel	159.28	36.01	4.4
Std	2.01	0.58	3.5
	Normalized		
	Before	After	
Process Travel	1.00	0.226	
Std	1.00	0.287	

This flow is a "slave" in a cascade loop and hence is supposed to follow demands from a master loop. Its STD is highly influenced on the behavior of its master (**LC4007**) as well.

The flow element is calibrated to the 0-12.5 Cum/hr**. Too small for this service!**



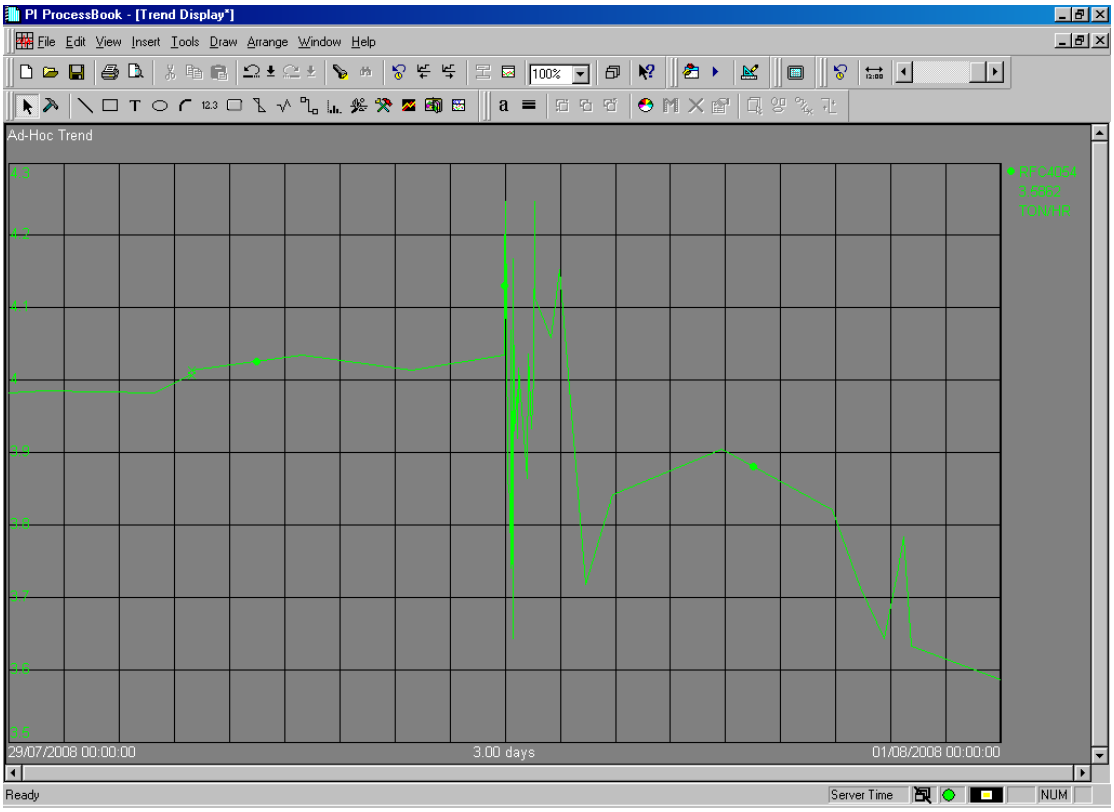
The following is a trend of the data collected from the PI system for dates before and after the tuning:



RFC4054 - STEAM FLOW TO C11A/B

Display R98

Slave of TC4011



Tuning was performed on 30/7/8.

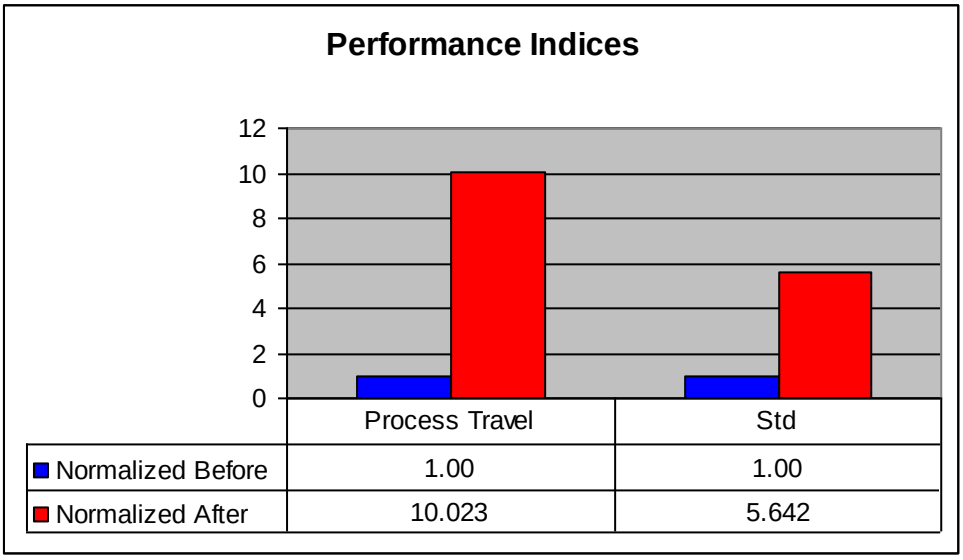
This loop was kept in **Manuel** mode with fix valve opening.

Performance Indices:

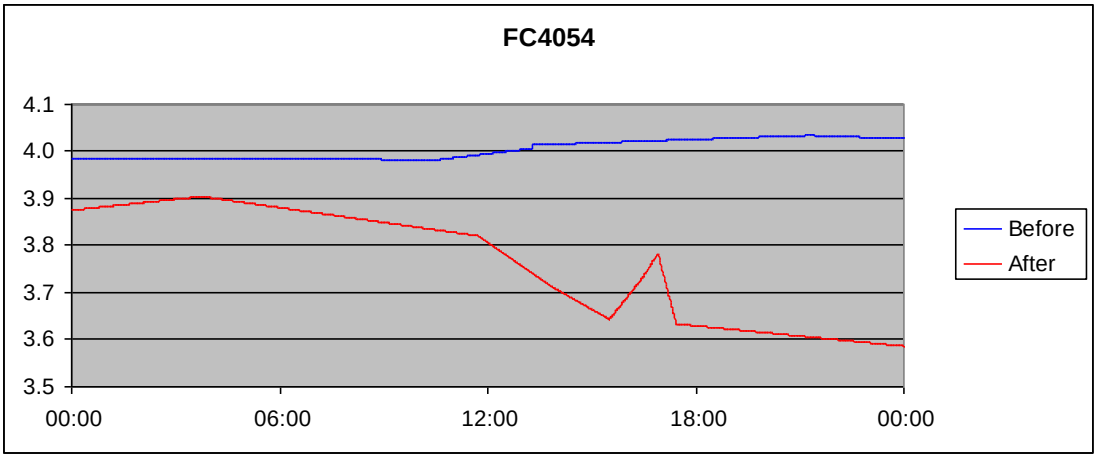
	Before	After	Factor
Process Travel	0.06	0.63	0.1
Std	0.02	0.12	0.2
	Normalized		
Process Travel	1.00	10.023	
Std	1.00	5.642	

As this loop was not in **Auto** mode comparison should be done accordingly. This flow is a "slave" in a cascade loop and hence its performance is part of the "master" loop performance (**TC4011**).

This control loop was in **Auto** and not in **CAS** ; E.G. TC4011 was not in control!

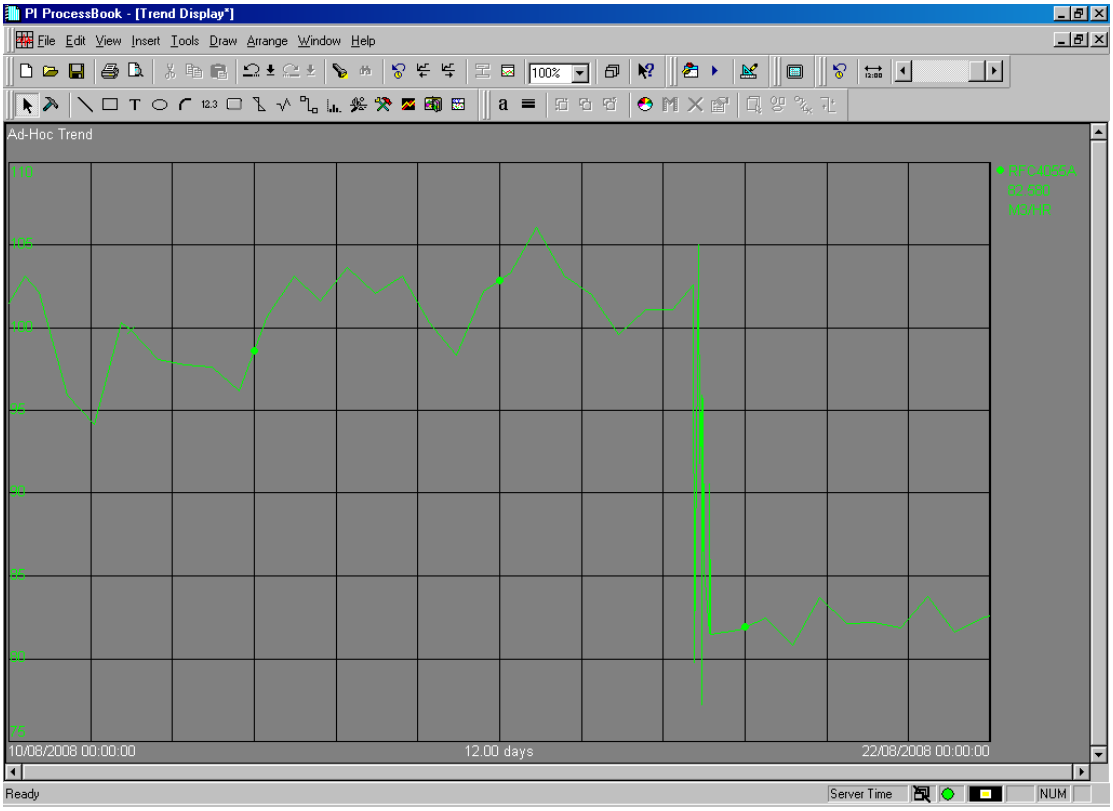


The following is a trend of the data collected from the PI system for dates before and after the tuning



RFC4055A - J2 MINIMUM FLOW

Display R90

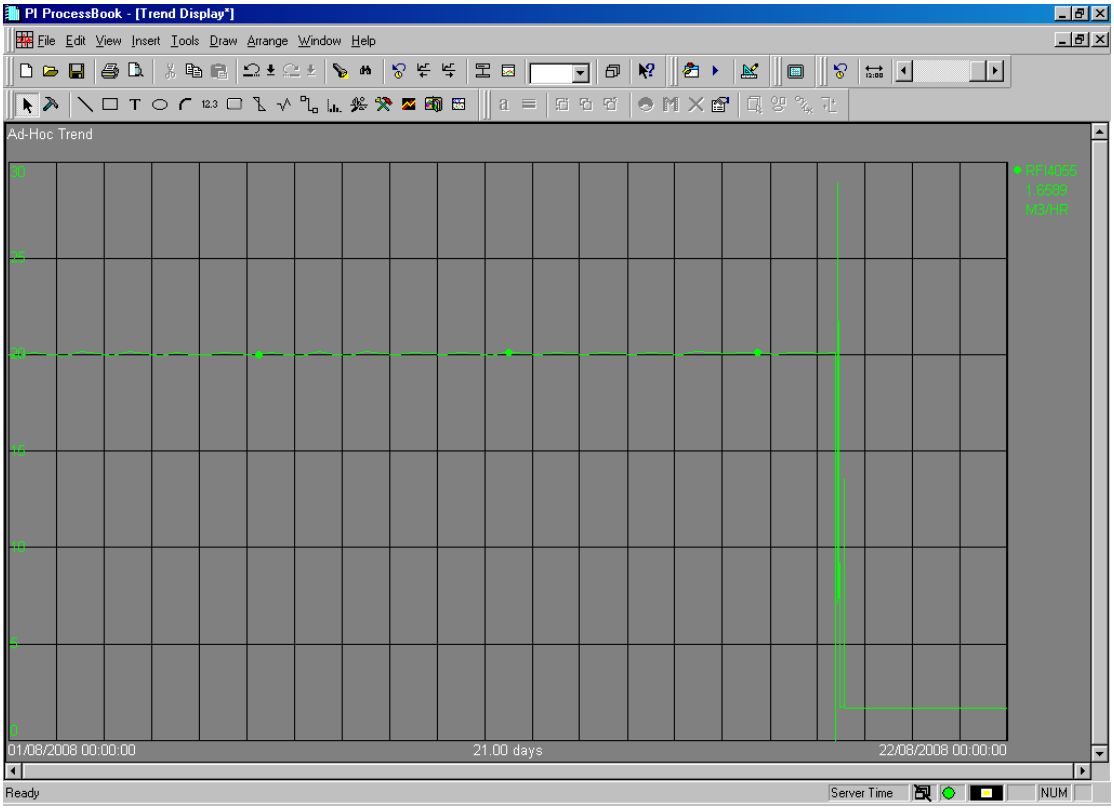


FC4055A is a "Minimum flow" controller designed to protect J2. The controller was actually working with one of the block valves restricted with no possibility to perform any control! Our investigation revealed the situation the problem was resolved and the pump gets the protection available from this setting.

Thanks to setting the minimum output limit to a lower limit a reduction in the total flow is observed. This is a direct saving of pumping energy.

Tuning was performed on 17/8/8.

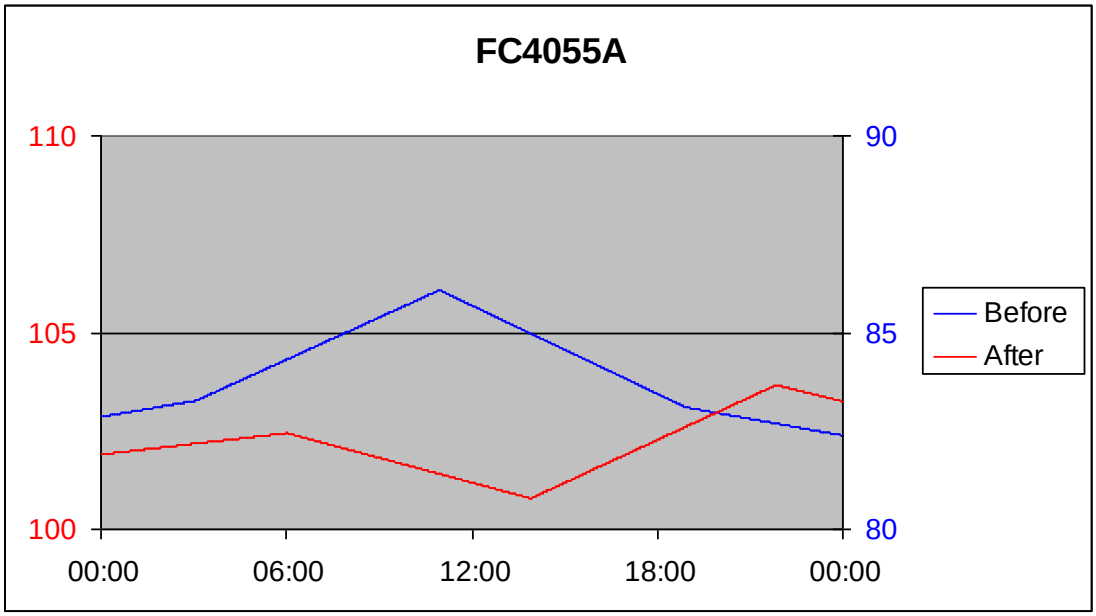
FI4055 is the flow indicator measuring the spill back flow and this flow is directly the out come of this controller's action.



Performance Indices:

	Before	After	Factor
Process Travel	6.91	5.50	1.3
Std	1.09	0.75	1.5
	Normalized		
Process Travel	1.00	0.796	
Std	1.00	0.689	

The following is a trend of the data collected from the PI system for dates before and after the tuning



RFC4056 - F5 Flow to E3

Display R98

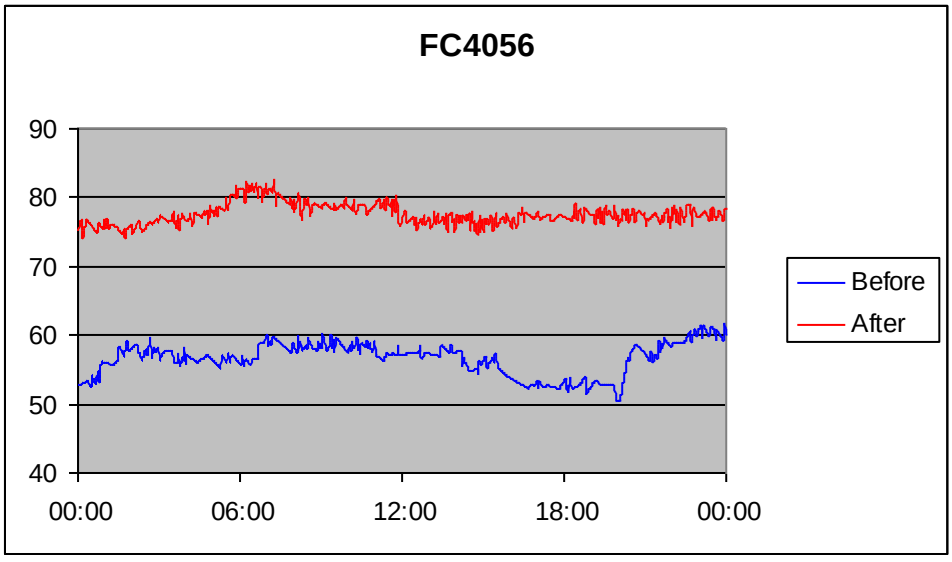
Slave of LC4053

Currently the valve is sticky and hence these results are the best achievable under these conditions.

Performance Indices:

	Before	After	Factor
Process Travel	253.61	408.30	0.6
Std	2.37	1.49	1.6
	Normalized		
Process Travel	1.00	1.610	
Std	1.00	0.631	

The following is a trend of the data collected from the PI system for dates before and after the tuning



FC4059 - LEAN AMINE FLOW TO E-6

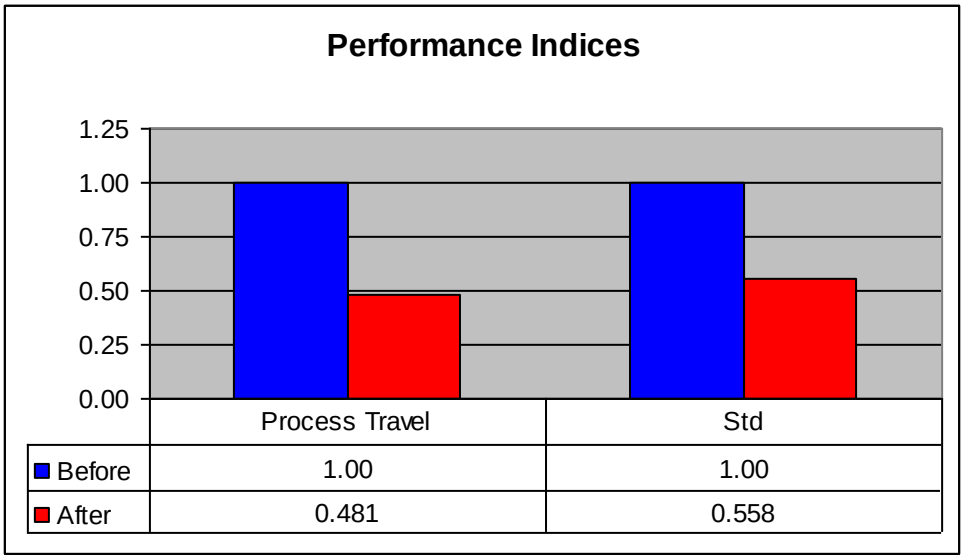
Display R96

Controller was tuned on 17/8.

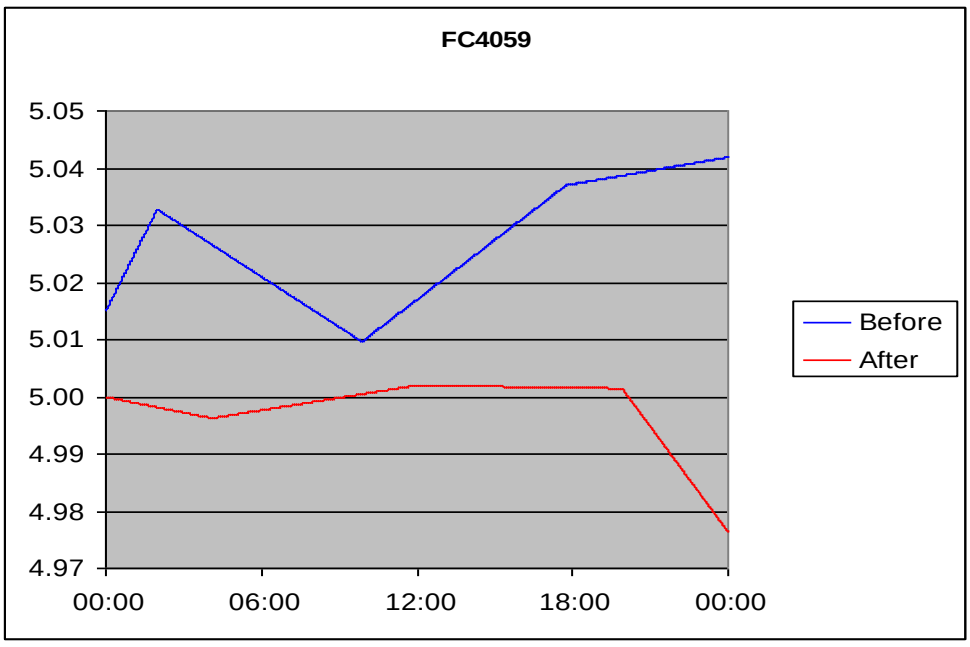
Valve is sticky. To be tuned again after maintaining the valve!

Performance Indices:

	Before	After	Factor
Process Travel	0.07	0.04	2.1
Std	0.01	0.01	1.8
	Normalized		
Process Travel	1.00	0.481	
Std	1.00	0.558	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RFC4067 - START-UP LINE FLOW

Display R90, R98

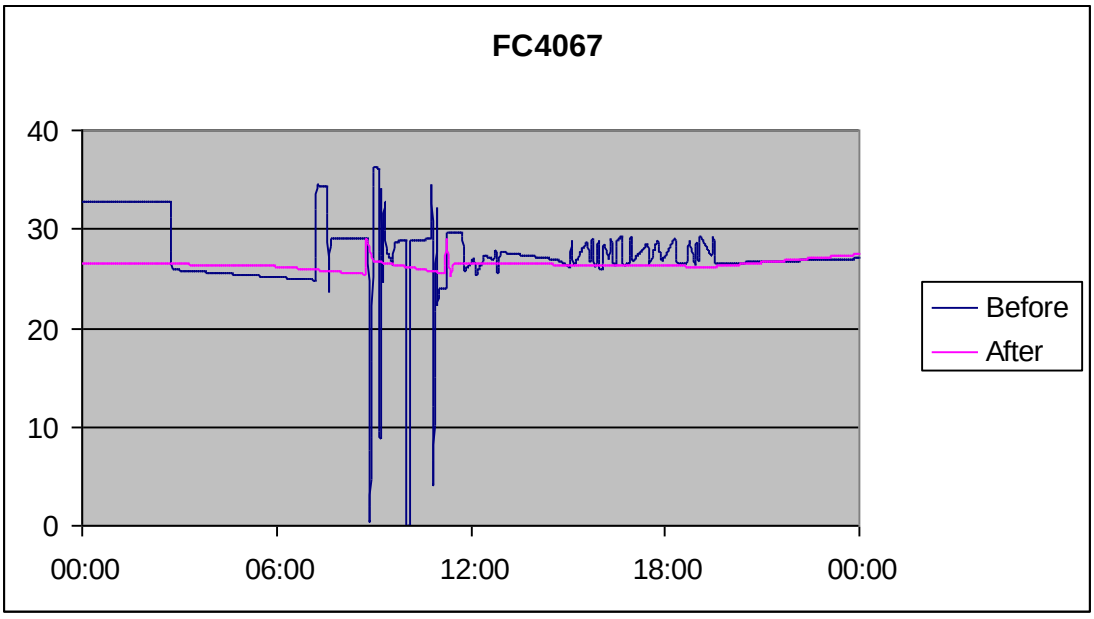
This controller was tuned on the 17/8.

Valve is sticky. To be tuned again after maintaining the valve!

Performance Indices:

	Before	After	Factor
Process Travel	347.56	18.63	18.7
Std	3.14	0.41	7.6
	Normalized		
Process Travel	1.00	0.054	
Std	1.00	0.131	

The following is a trend of the data collected from the PI system for dates before and after the tuning



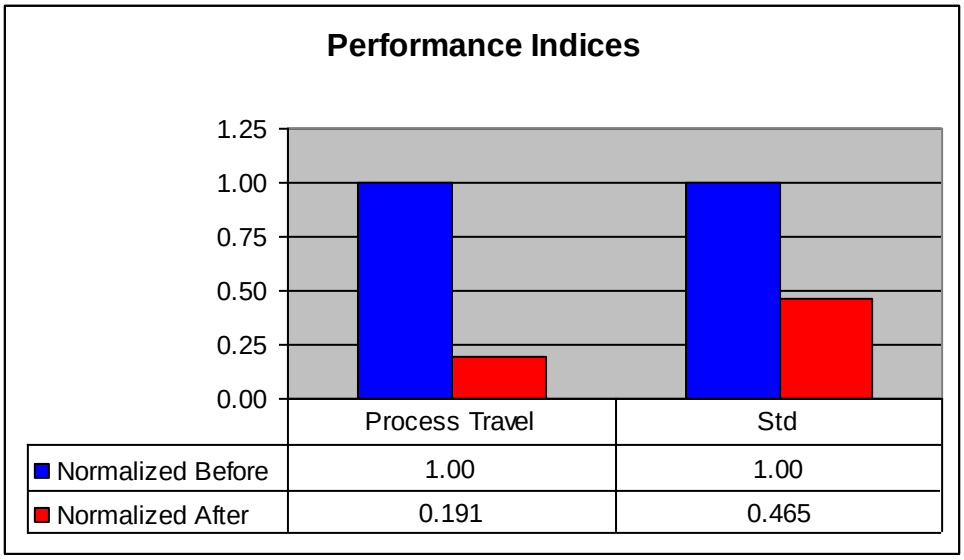
RLC4006 - E-3 LEVEL

Display R98

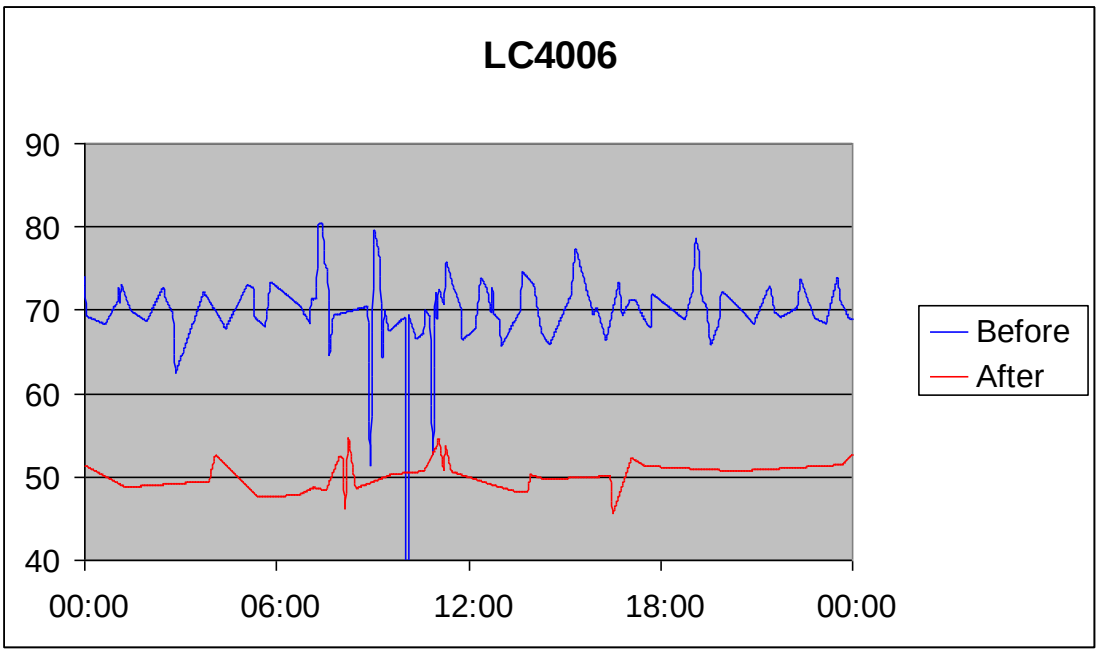
Was tuned between the 29/7 and 18/8.

Performance indices:

	Before	After	Factor
Process Travel	389.47	74.22	5.2
Std	2.85	1.32	2.2
	Normalized		
Process Travel	1.00	0.191	
Std	1.00	0.465	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RLC4007 - F-2 LEVEL

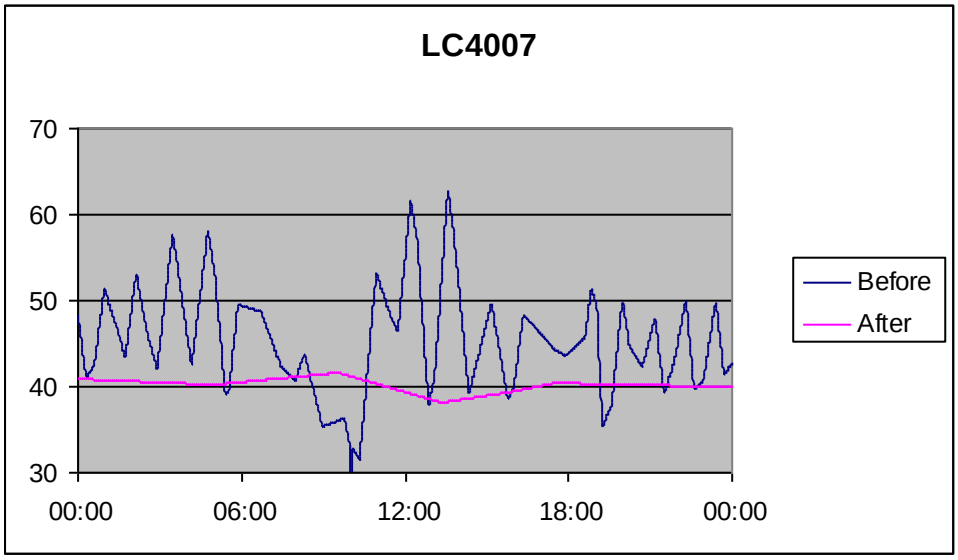
Display R98

Master of LC4025

Was tuned between the 29/7 and the 7/8.

	Before	After	Factor
Process Travel	398.42	8.17	48.8
Std	5.57	0.76	7.3
	Normalized		
Process Travel	1.00	0.020	
Std	1.00	0.137	

The following is a trend of the data collected from the PI system for dates before and after the tuning



RLC4013 - C-13A LEVEL

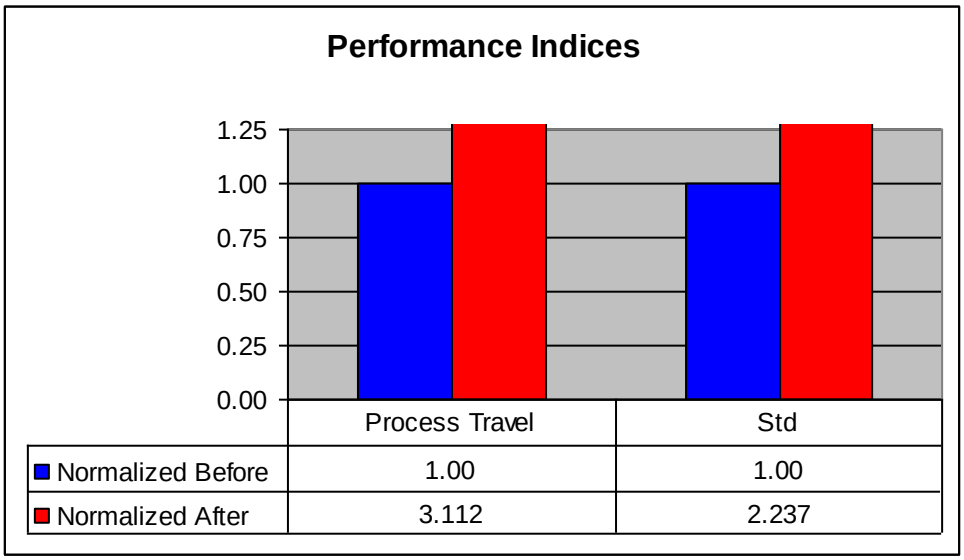
Display R95

Was tuned on the 18/8.

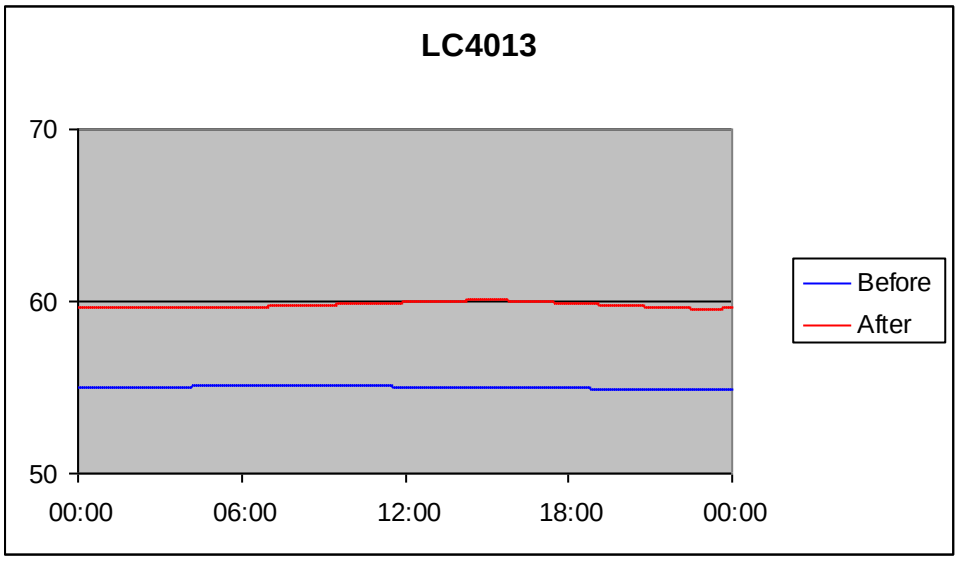
The "performance" is sacrificed to get more relax action. There is no direct parameter to check this loop performance.

Performance Indices:

	Before	After	Factor
Process Travel	0.36	1.13	0.3
Std	0.07	0.16	0.4
	Normalized		
Process Travel	1.00	3.112	
Std	1.00	2.237	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RLC4036 - F-2 WATER LEVEL

Display R98

Was tuned on 8/8.

Boot is located some 10Meters below the F drum (F-2) bottom. Boot is small in size comparing to F-2. the influence of this controller on F-2 Level – is negligible.

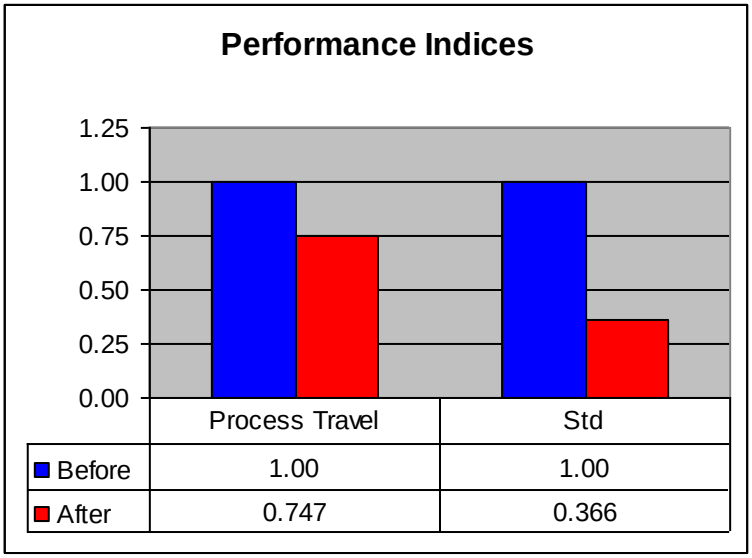
The water Boot

F-2 and the Water Boot.

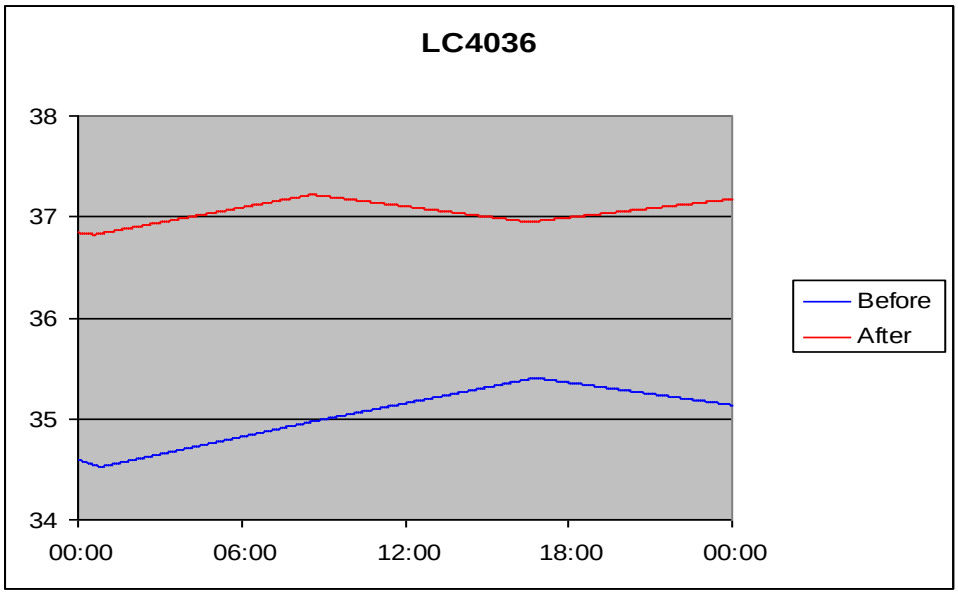
F-2 and the Water Boot.

Performance Indices:

	Before	After	Factor
Process Travel	1.21	0.91	1.3
Std	0.27	0.10	2.7
	Normalized		
Process Travel	1.00	0.747	
Std	1.00	0.366	



The following is a trend of the data collected from the PI system for dates before and after the tuning



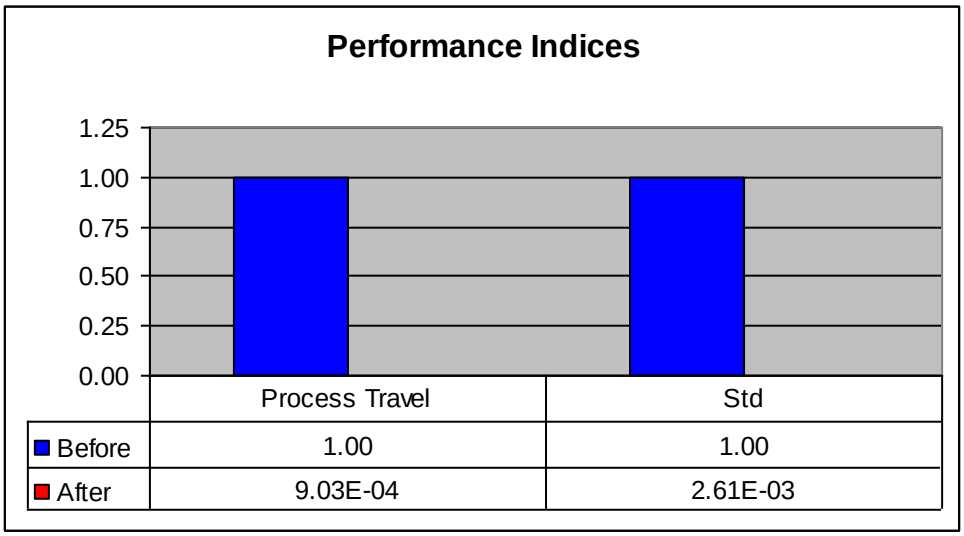
RLC4040 - E-6 LEVEL

Display R94, R95.

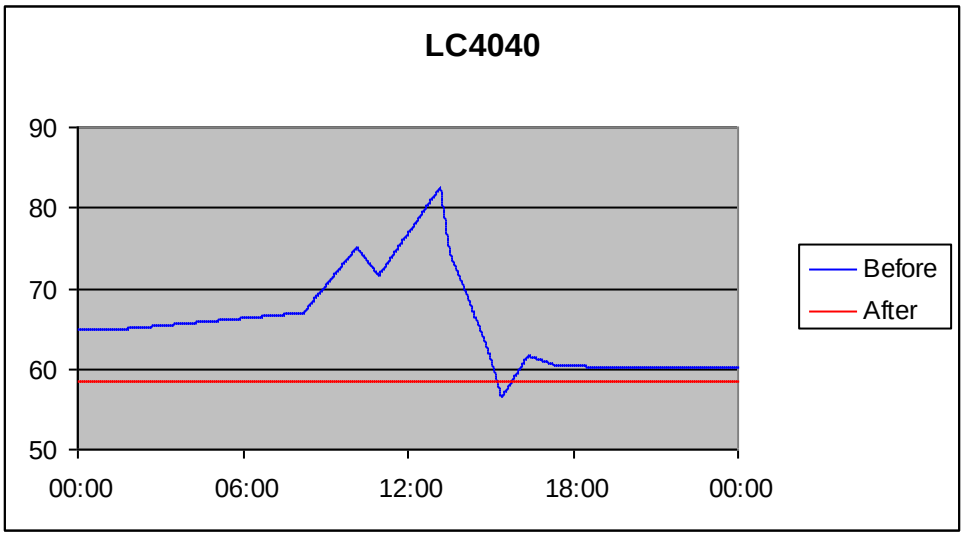
Was tuned on 18/8.

Performance Indices:

	Before	After	Factor
Process Travel	56.73	0.05	1108.0
Std	5.78	0.02	383.7
	Normalized		
Process Travel	1.00	9.03E-04	
Std	1.00	2.61E-03	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RLC4053 F-5 LEVEL

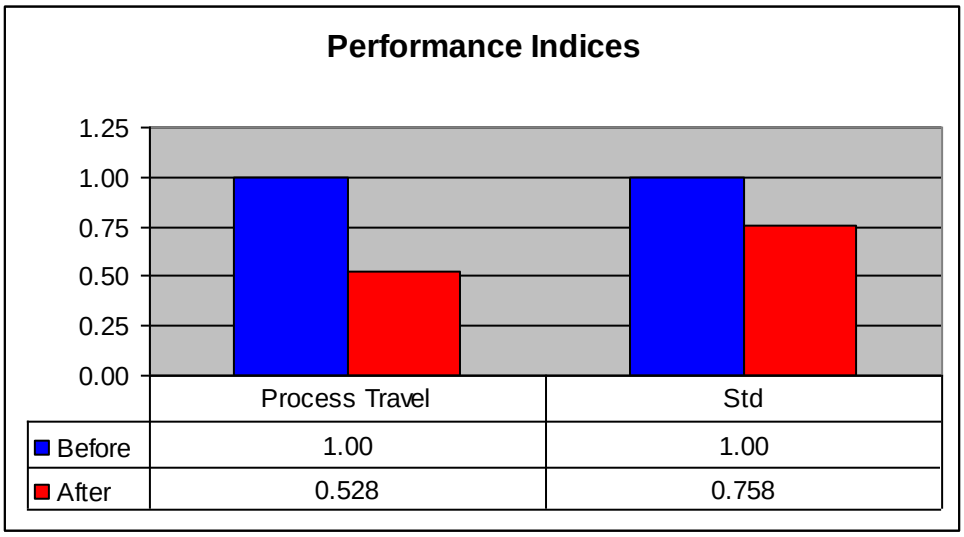
Display R98

Master of FC4056

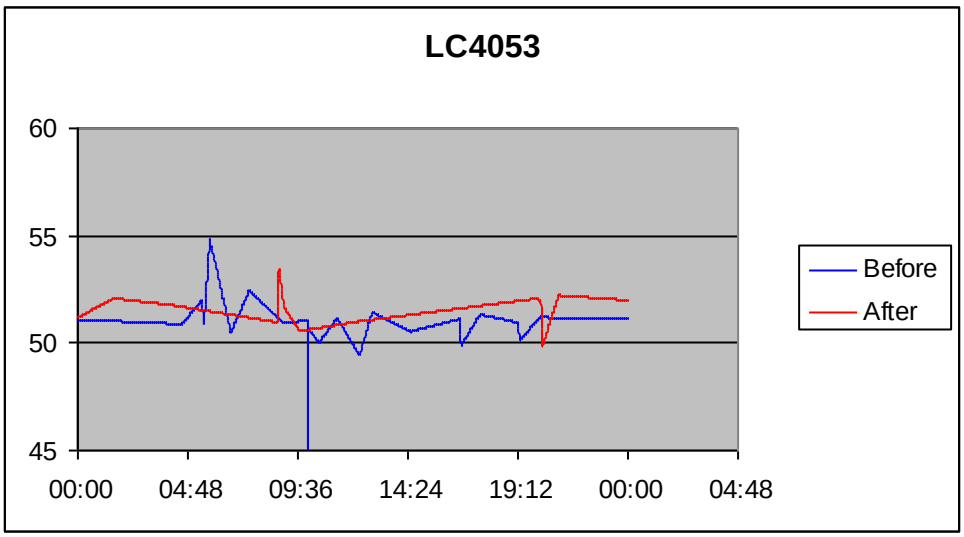
Was tuned on the 29/7.

Performance Indices:

	Before	After	Factor
Process Travel	26.19	13.83	1.9
Std	0.62	0.47	1.3
	Normalized		
Process Travel	1.00	0.528	
Std	1.00	0.758	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RPC4003 - F-2 PRESSURE

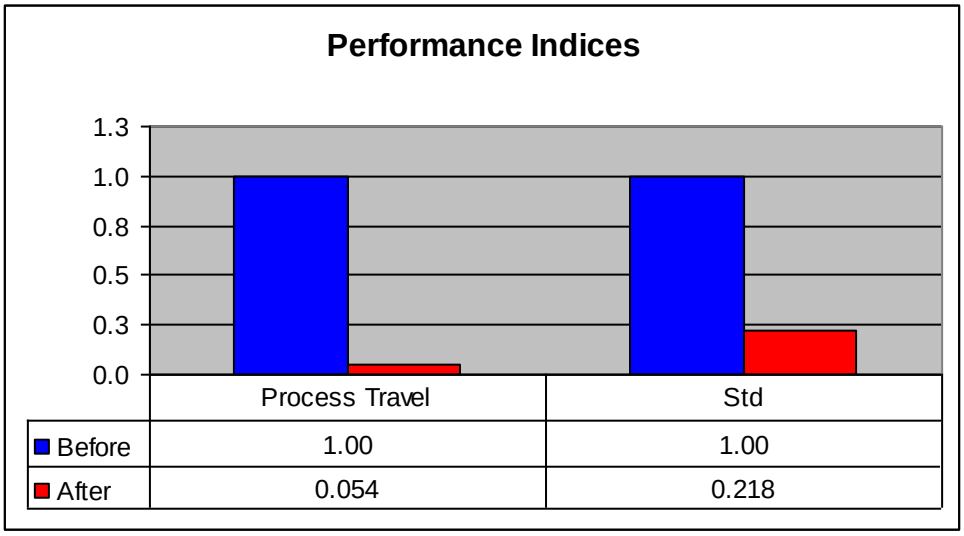
Display R98

Was tuned on the 30/7.

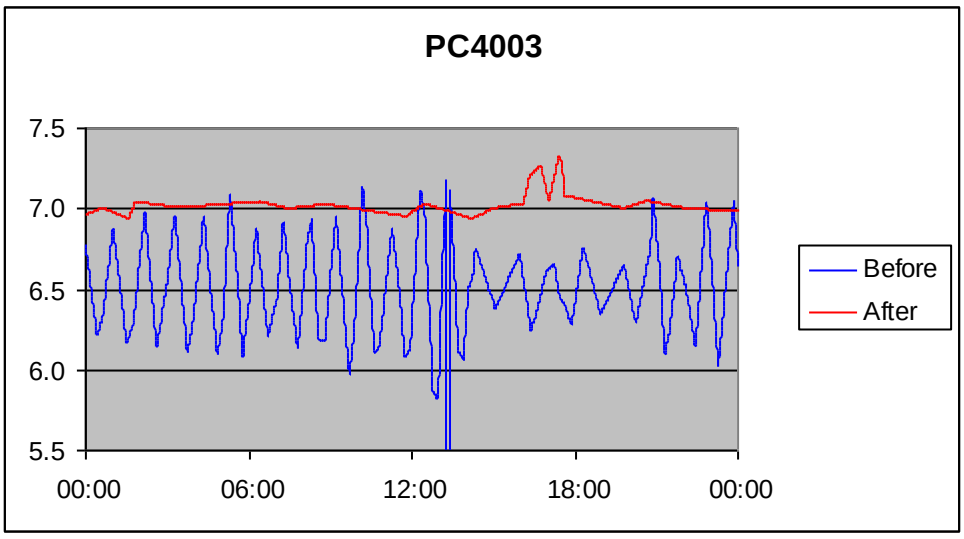
Tuning of this loop stabilized the whole section of E-3.

Performance Indices:

	Before	After	Factor
Process Travel	33.66	1.81	18.6
Std	0.25	0.05	4.6
	Normalized		
Process Travel	1.00	0.054	
Std	1.00	0.218	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RPC4081 B2B WEST F.G PRESSURE

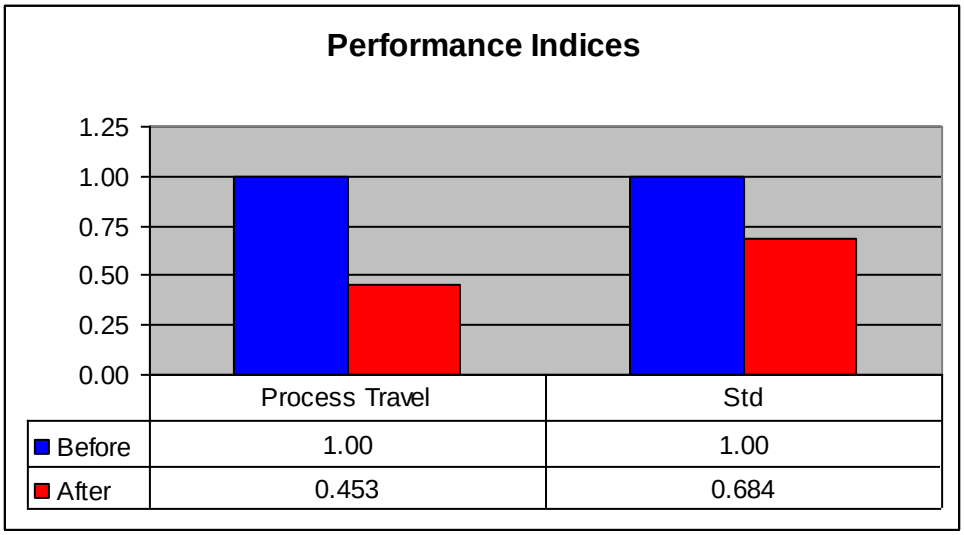
Display R93

Slave of TC4029

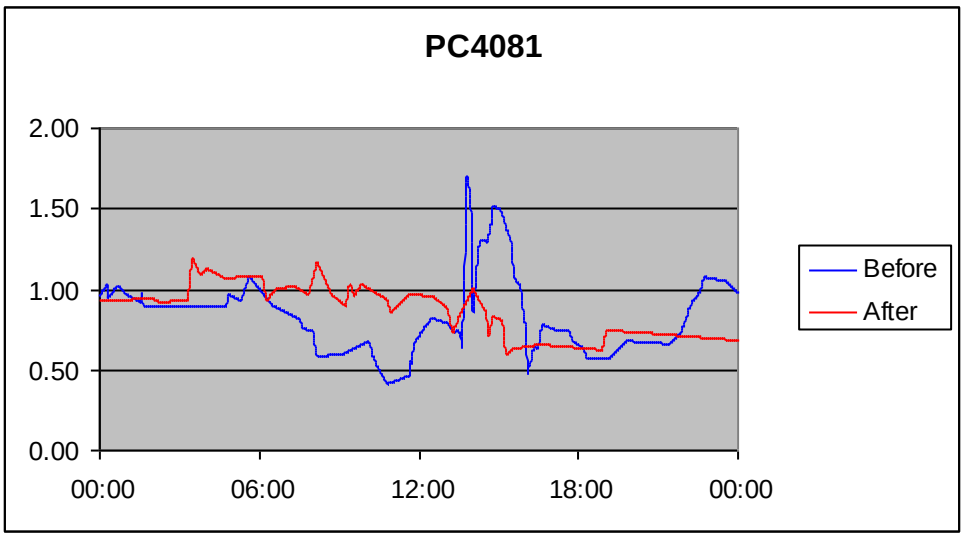
Was tuned on the 13/8.

Performance Indices:

	Before	After	Factor
Process Travel	7.02	3.18	2.2
Std	0.23	0.16	1.5
	Normalized		
Process Travel	1.00	0.453	
Std	1.00	0.684	



The following is a trend of the data collected from the PI system for dates before and after the tuning.



RPC4082 B2A EAST F.G PRESSURE

Display R93

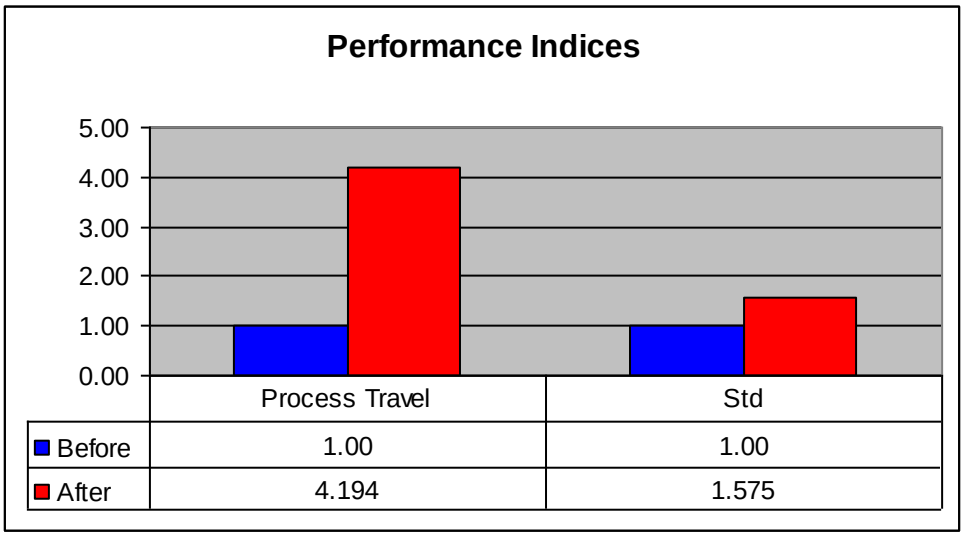
Slave of TC4027

Valve is sticky! Heavy filter in use to compensate for valve's "mis-behavior".

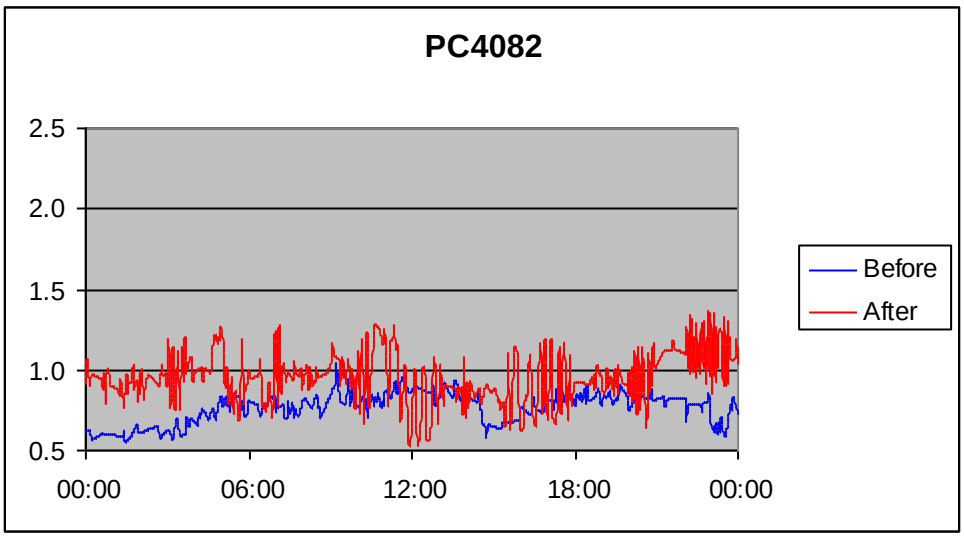
Was tuned on 12/8.

Performance Indices:

	Before	After	Factor
Process Travel	13.44	56.38	0.2
Std	0.09	0.15	0.6
	Normalized		
Process Travel	1.00	4.194	
Std	1.00	1.575	



The following is a trend of the data collected from the PI system for dates before and after the tuning



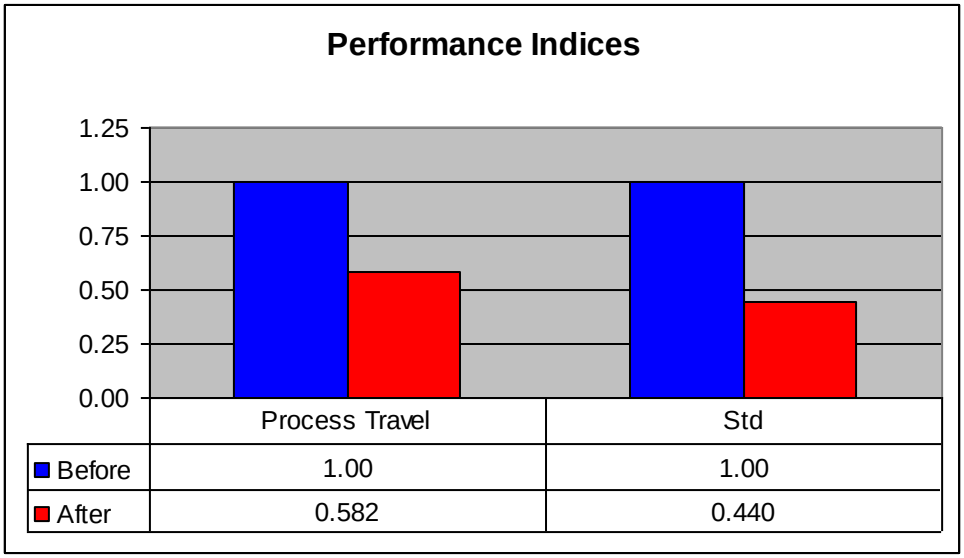
RPC4101 - B-2 PILOT GAS PRESSURE

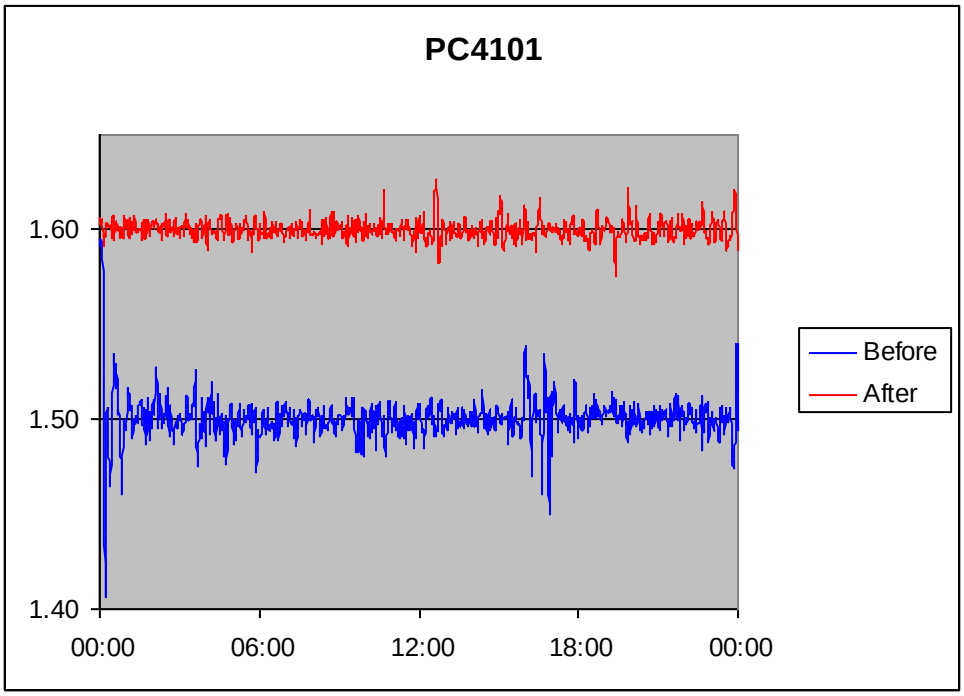
Display R92

Was tuned on 12/8.

Performance Indices:

	Before	After	Factor
Process Travel	6.03	3.51	1.7
Std	0.01	0.005	2.3
	Normalized		
Process Travel	1.00	0.582	
Std	1.00	0.440	





RPC4126 - F-30 PRESSURE

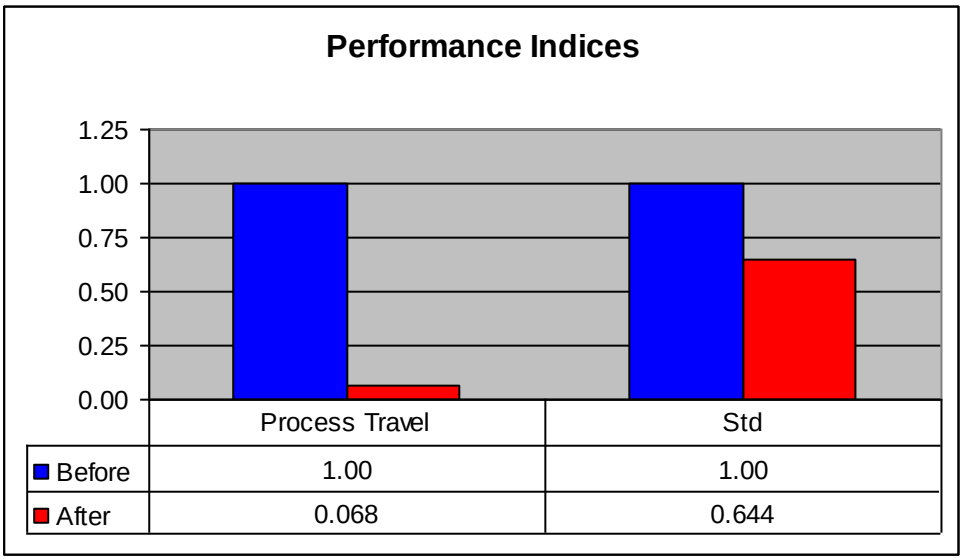
Display R90

Was tuned on 17/8.

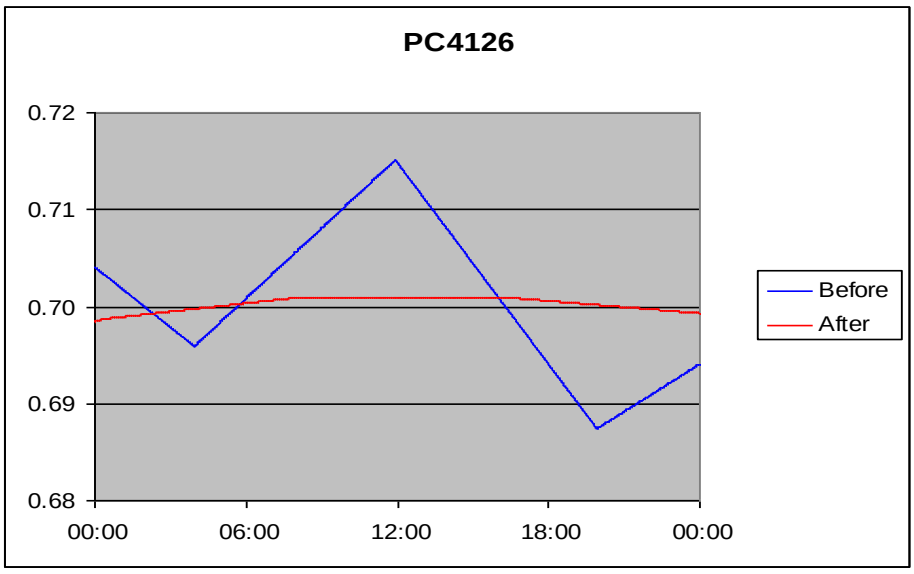
Valve too small!

Performance Indices:

	Before	After	Factor
Process Travel	0.06	0.0042	14.6
Std	0.01	0.0049	1.6
	Normalized		
Process Travel	1.00	0.068	
Std	1.00	0.644	



The following is a trend of the data collected from the PI system for dates before and after the tuning



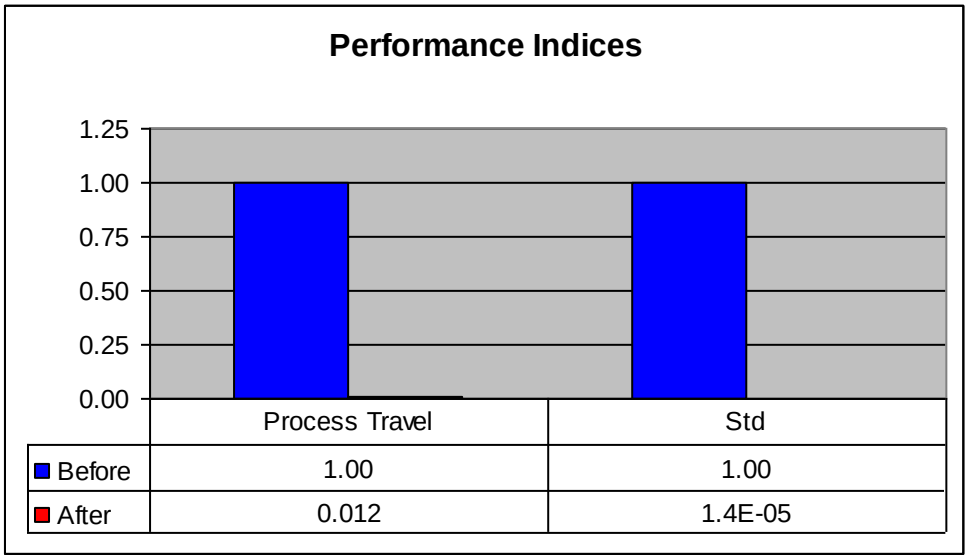
RSC4001 - JT-14A SPEED

Display R94, R95

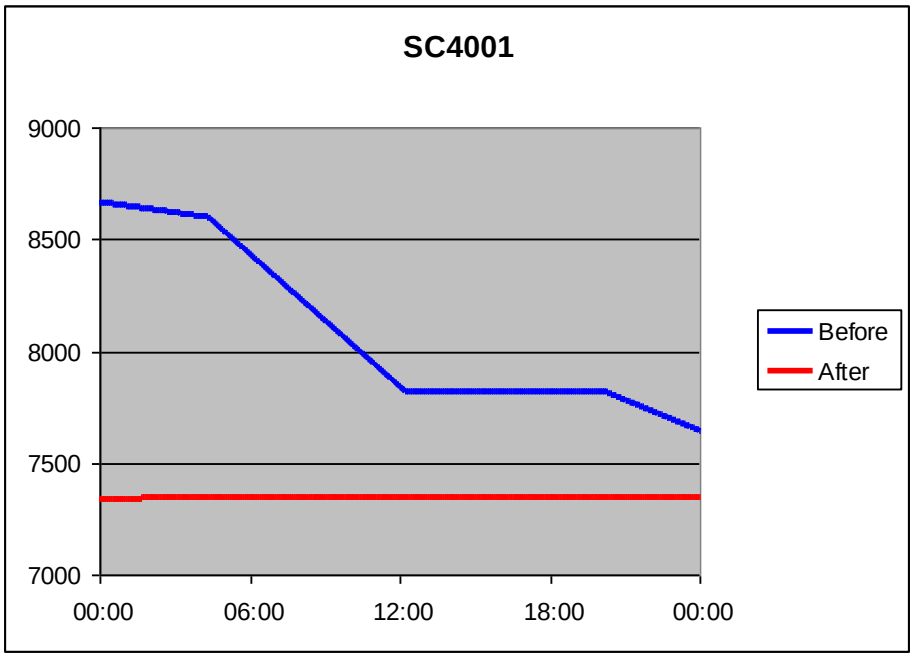
Was tuned on 18/8.

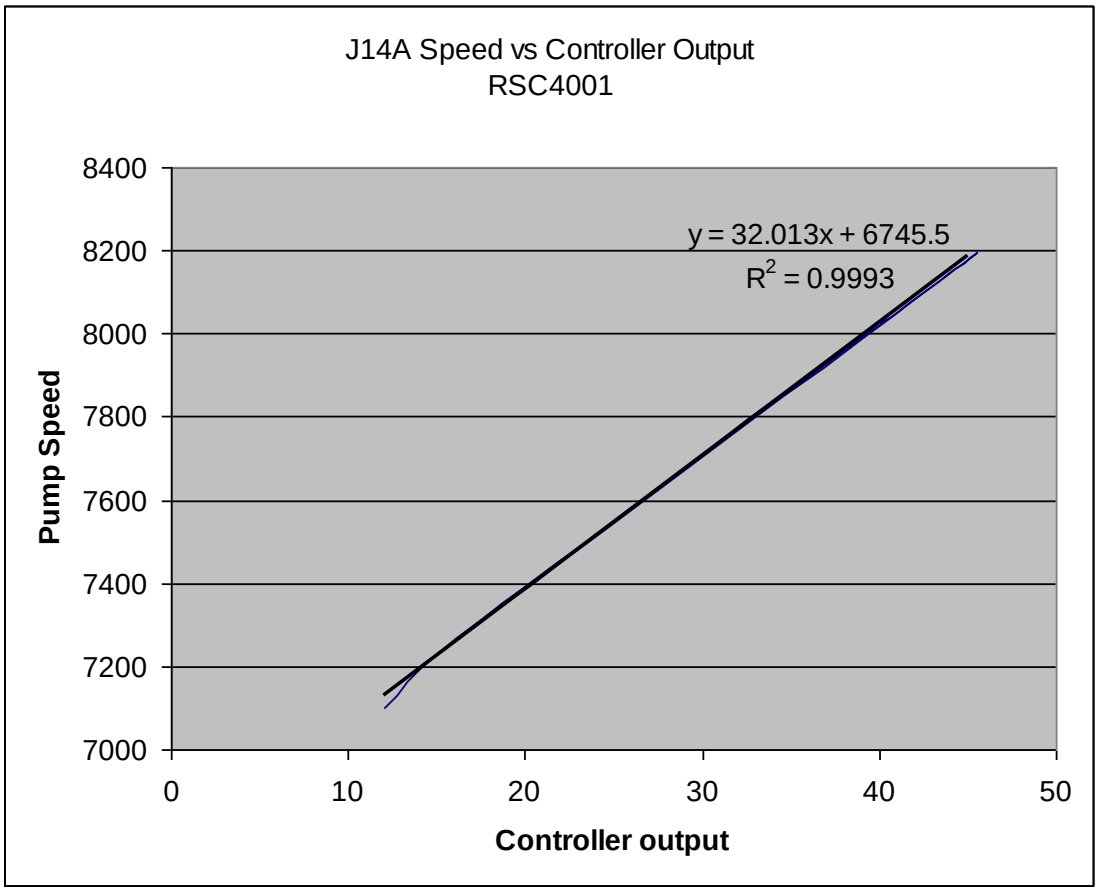
Performance Indices:

	Before	After	Factor
Process Travel	1032.13	11.89	86.8
Std	345.96	0.005	70575.0
	Normalized		
Process Travel	1.00	0.012	
Std	1.00	1.4E-05	



The following is a trend of the data collected from the PI system for dates before and after the tuning


SC4001
9000
8500
8000
7500
7000
00:00
06:00
12:00
18:00
00:00
Before
After


J14A Speed vs Controller Output
RSC4001
y = 32.013x + 6745.5
R2 = 0.9993
Pump Speed
8400
8200
8000
7800
7600
7400
7200
7000
0
10
20
30
40
50
Controller output

RTC4007 - E-3 TOP TEMP

Display R98

Master of FC4012

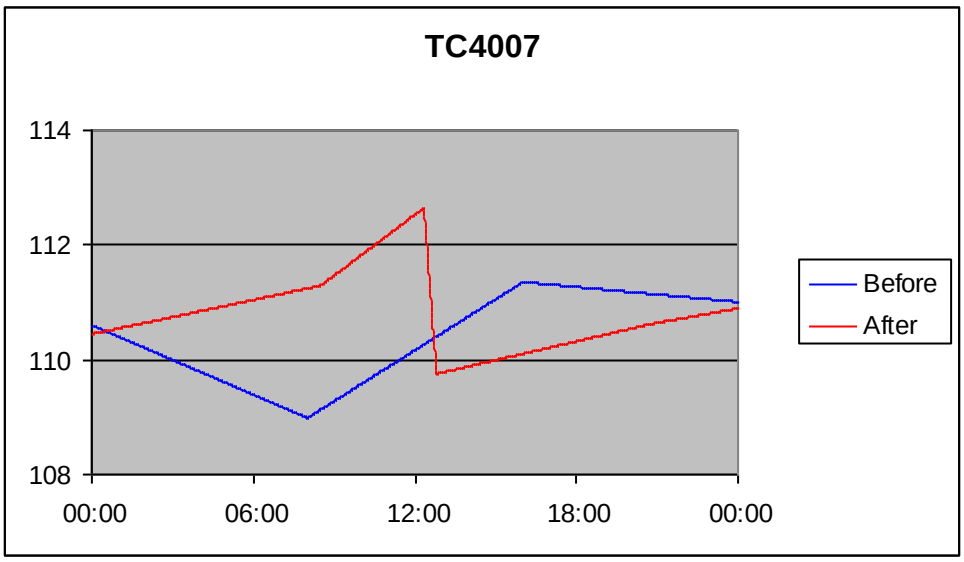
Was tuned on 8/8.

Was not in control!

Performance Indices:

	Before	After	Factor
Process Travel	4.36	6.23	0.7
Std	0.76	0.00	154.9
	Normalized		
Process Travel	1.00	1.430	
Std	1.00	0.006	

The following is a trend of the data collected from the PI system for dates before and after the tuning



RTC4011 - C-11 A/B AVR. OUTLET TEMP.

Display R98

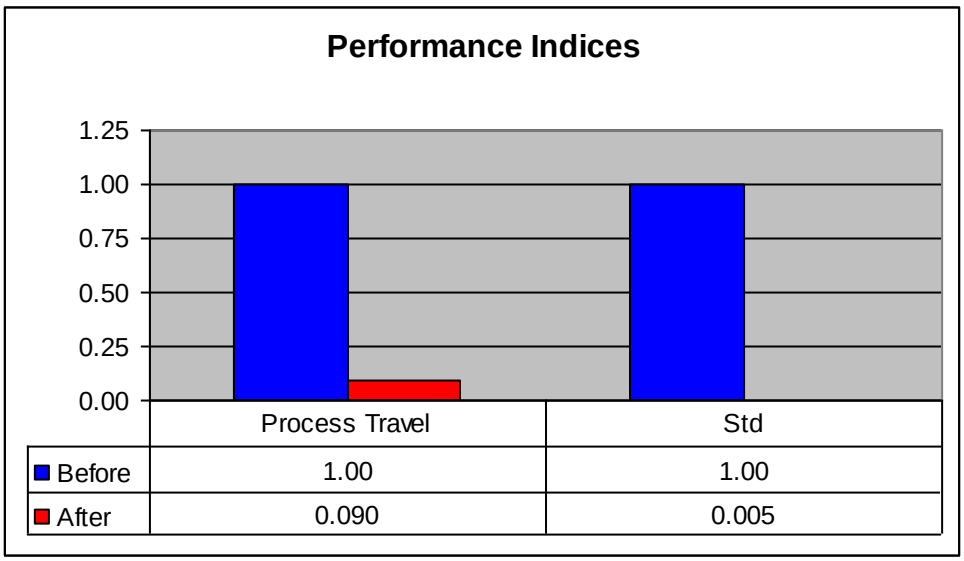
Master of FC4054

Was tuned on 30/7.

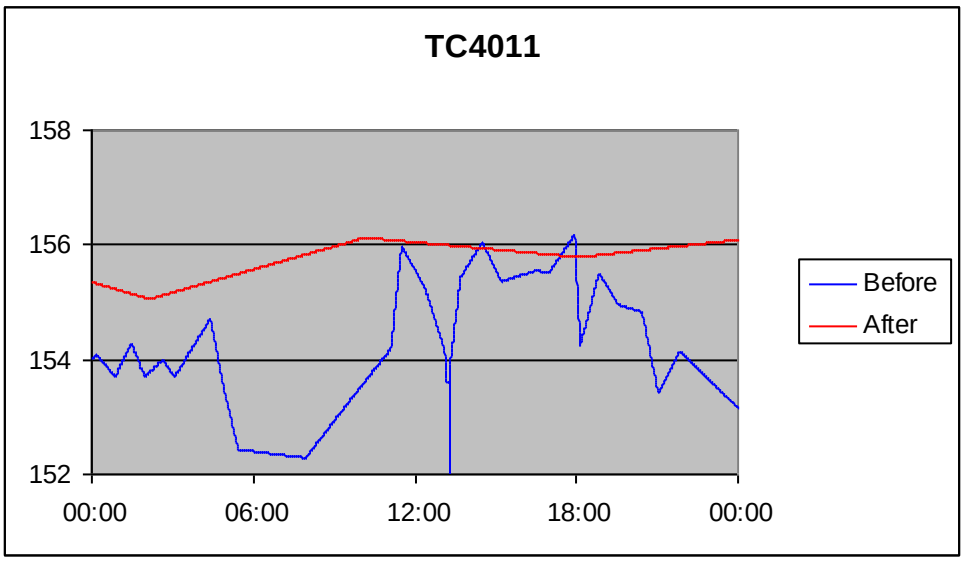
Was not in control.

Performance Indices:

	Before	After	Factor
Process Travel	22.33	2.00	11.2
Std	1.09	0.00	222.0
	Normalized		
Process Travel	1.00	0.090	
Std	1.00	0.005	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RTC4027 - B-2 COIL-A OUTLET TEMP.

Display R93, R94

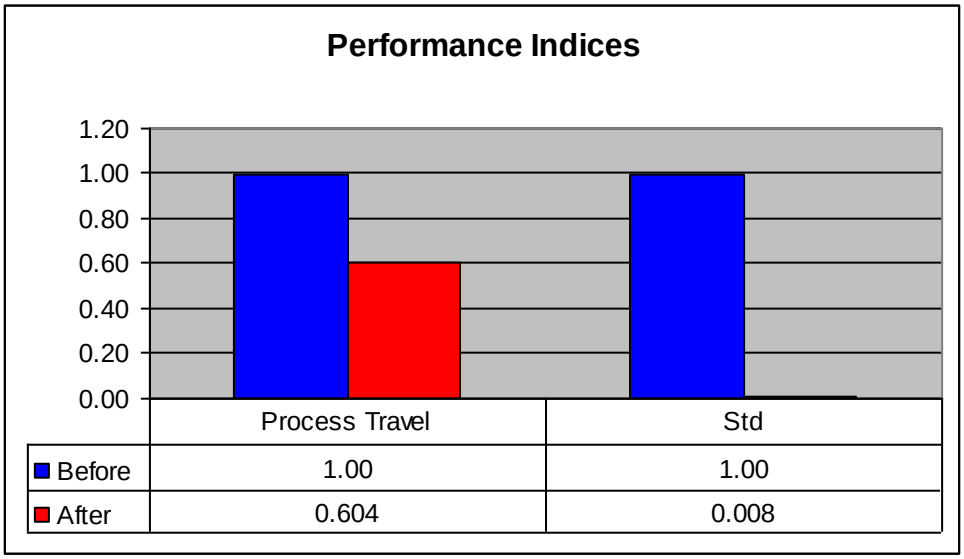
Master of PC4082

Was tuned on 12/8.

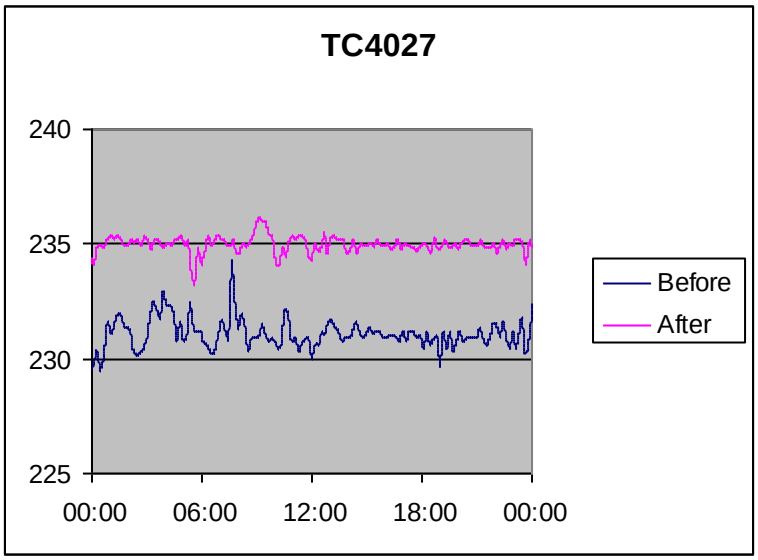
Was not in control.

Performance Indices:

	Before	After	Factor
Process Travel	68.51	41.36	1.7
Std	0.60	0.005	122.7
	Normalized		
Process Travel	1.00	0.604	
Std	1.00	0.008	



The following is a trend of the data collected from the PI system for dates before and after the tuning



RTC4029 - B-2 COIL-B OUTLET TEMP.

Display R93

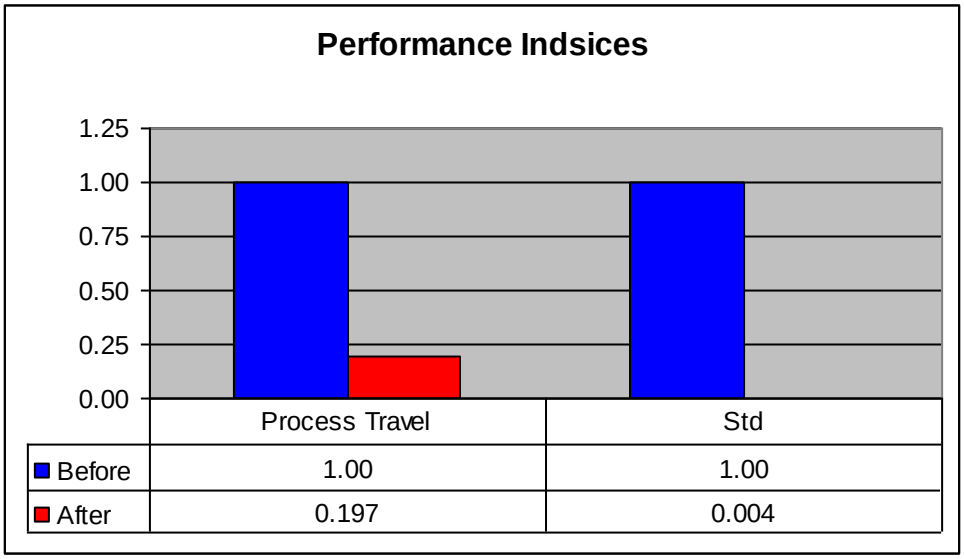
Master of PC4081

Was tuned on 13/8.

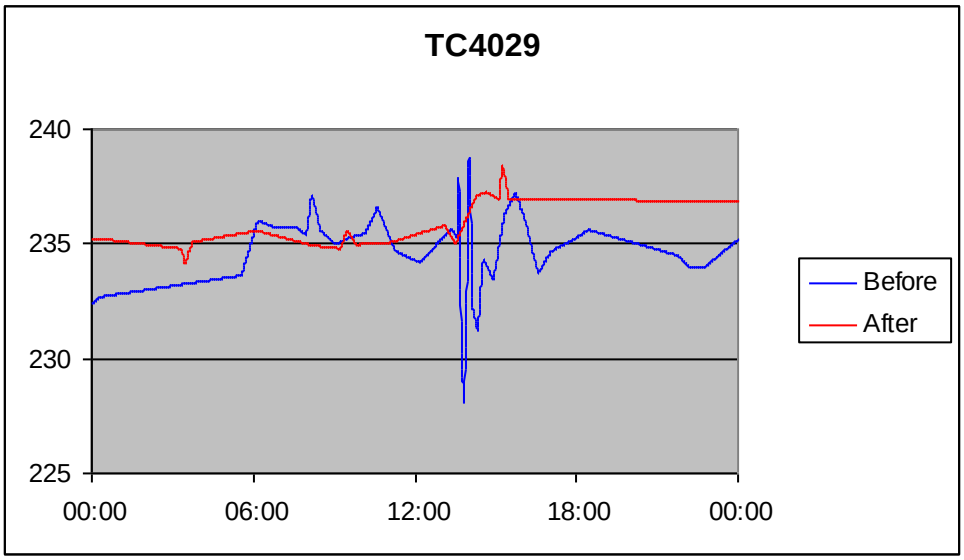
Valve is too small!

Performance Indices:

	Before	After	Factor
Process Travel	60.85	12.01	5.1
Std	1.23	0.005	251.0
	Normalized		
Process Travel	1.00	0.197	
Std	1.00	0.004	



The following is a trend of the data collected from the PI system for dates before and after the tuning



Appendix B – Standard Deviation Function

In the calculation of the Standard Deviation we used the EXCEL's built in function

STDEV

and here is the EXCEl's description for this function:

Estimates standard deviation based on a sample. The standard deviation is a measure of how widely values are dispersed from the average value (the mean).

Syntax

STDEV(**number1**,number2,...)

Number1, number2, ... are 1 to 30 number arguments corresponding to a sample of a population. You can also use a single array or a reference to an array instead of arguments separated by commas.

Remarks

- STDEV assumes that its arguments are a sample of the population. If your data represents the entire population, then compute the standard deviation using STDEVP.
- The standard deviation is calculated using the "unbiased" or "n-1" method.
- STDEV uses the following formula:

$$\sqrt{\frac{\sum (x-\bar{x})^2}{(n-1)}}$$

where x is the sample mean AVERAGE(number1,number2,…) and n is the sample size.

- Logical values such as TRUE and FALSE and text are ignored. If logical values and text must not be ignored, use the STDEVA worksheet function.

Example

Suppose 10 tools stamped from the same machine during a production run are collected as a random sample and measured for breaking strength.

The example may be easier to understand if you copy it to a blank worksheet.

Appendix C – PI Process Flow Diagrams

R90

R92

R93

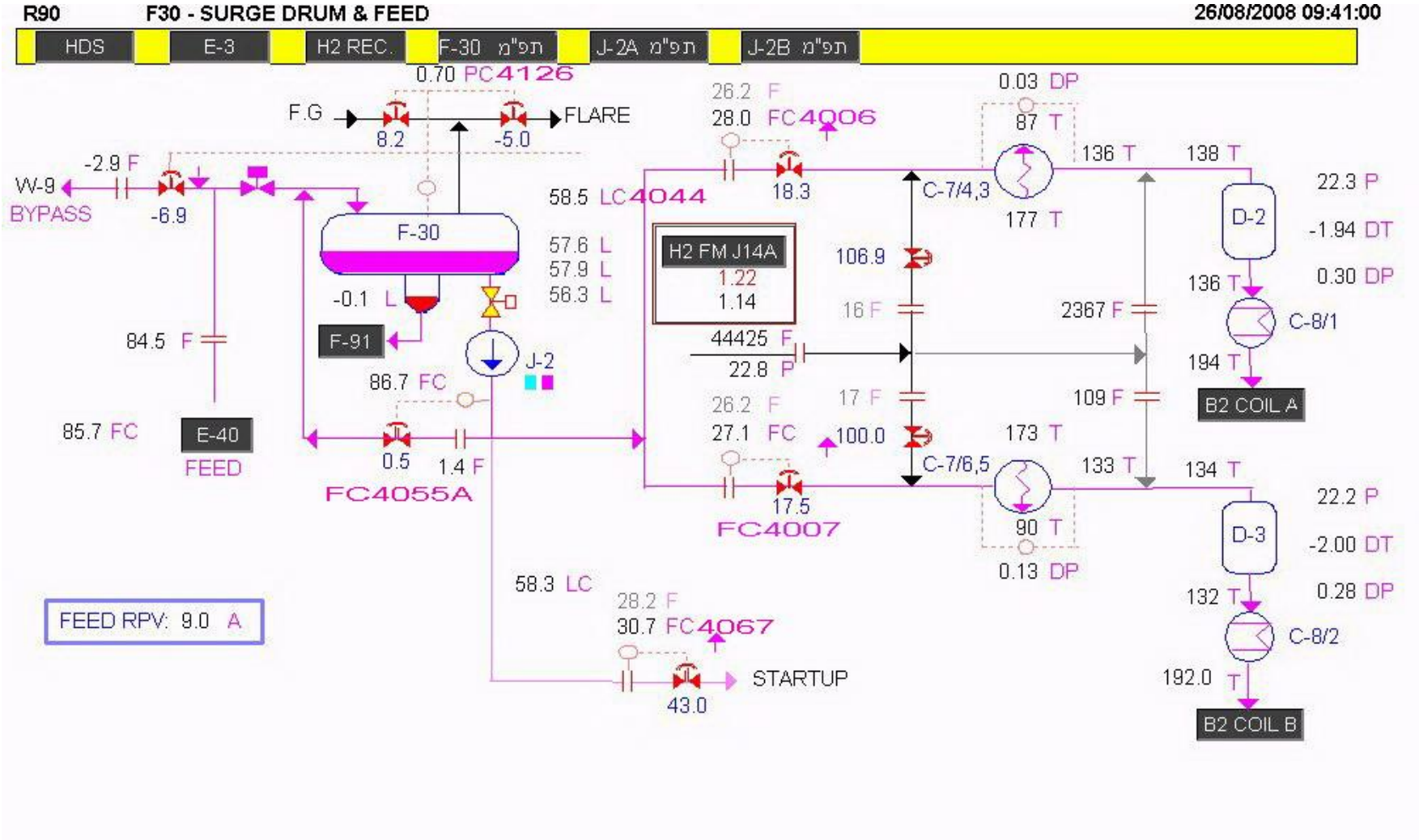
R94

R95

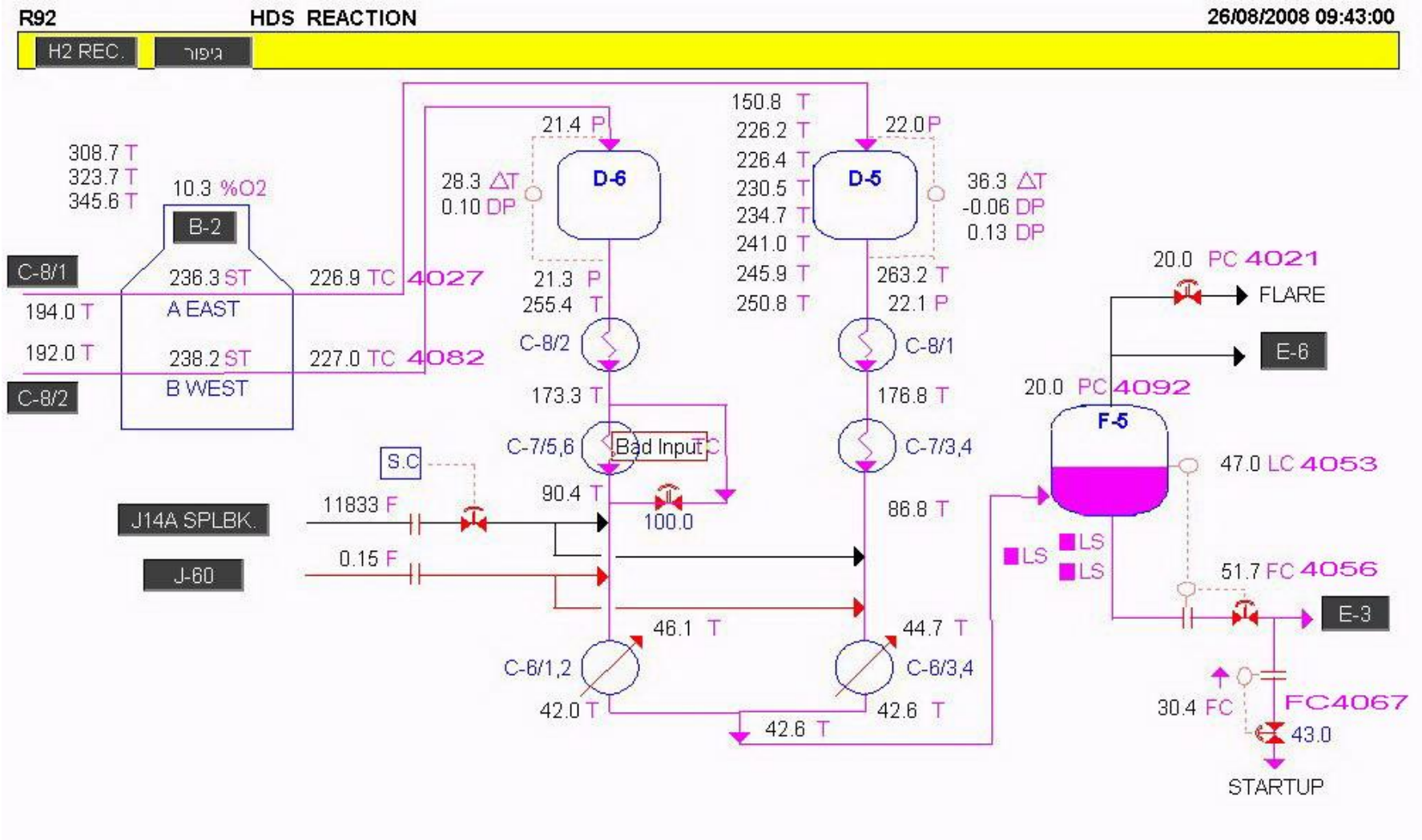
R96

R98

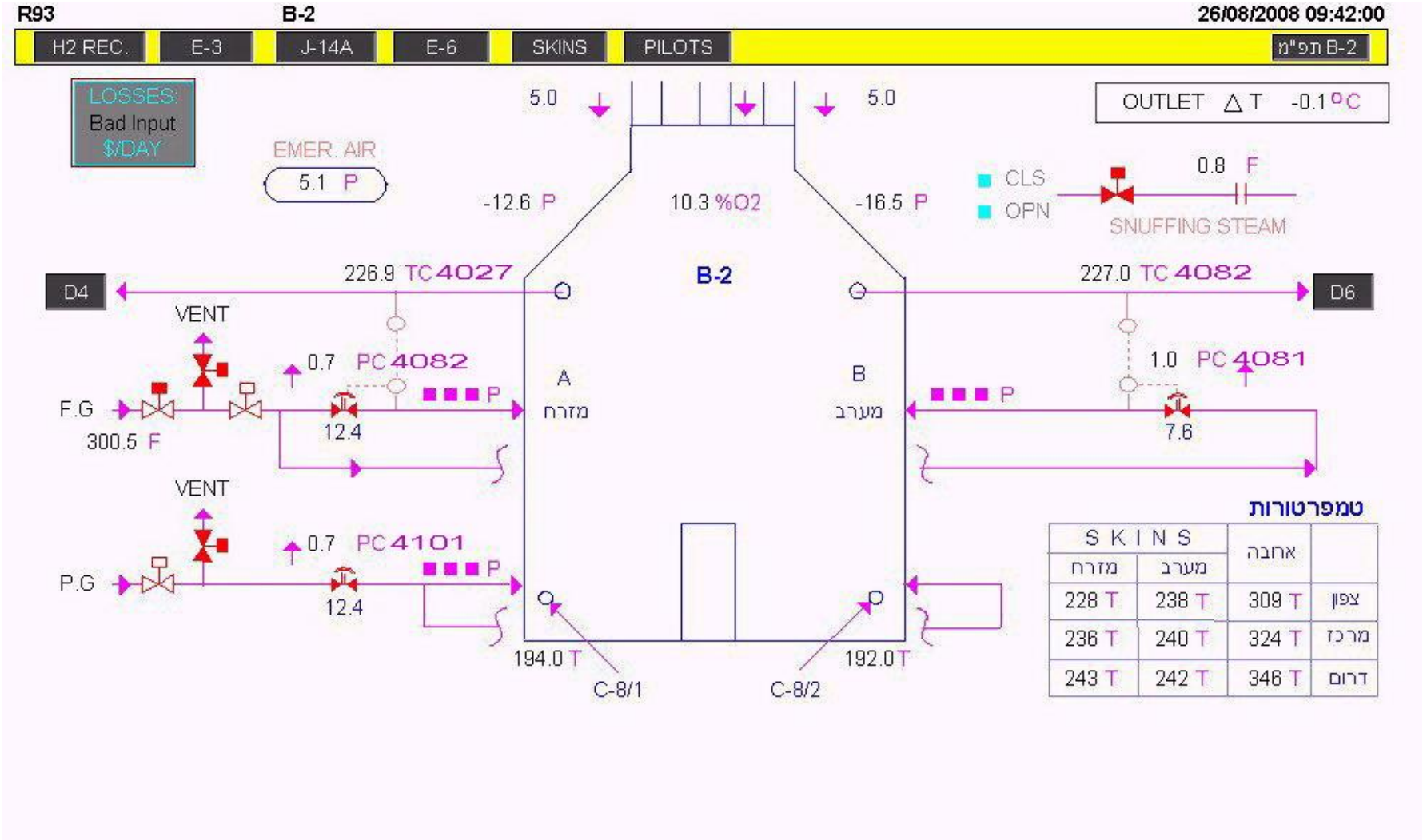
R90


R90
F30 - SURGE DRUM & FEED
26/08/2008 09:41:00
HDS
E-3
H2 REC.
F-30 תפ"מ
J-2A תפ"מ
J-2B תפ"מ
0.70 PC4126
F.G
8.2
-5.0
FLARE
26.2 F
28.0 FC4006
0.03 DP
87 T
-2.9 F
W-9
BYPASS
-6.9
58.5 LC4044
18.3
C-7/4,3
177 T
136 T
138 T
22.3 P
-1.94 DT
0.30 DP
D-2
F-30
57.6 L
57.9 L
56.3 L
-0.1 L
H2 FM J14A
1.22
1.14
106.9
16 F
2367 F
136 T
C-8/1
84.5 F
F-91
J-2
44425 F
22.8 P
194 T
B2 COIL A
86.7 FC
26.2 F
17 F
109 F
85.7 FC
E-40
FEED
0.5
1.4 F
FC4055A
27.1 FC
100.0
173 T
C-7/6,5
133 T
134 T
22.2 P
-2.00 DT
0.28 DP
17.5
FC4007
90 T
0.13 DP
D-3
58.3 LC
28.2 F
30.7 FC4067
132 T
C-8/2
FEED RPV: 9.0 A
STARTUP
43.0
192.0 T
B2 COIL B

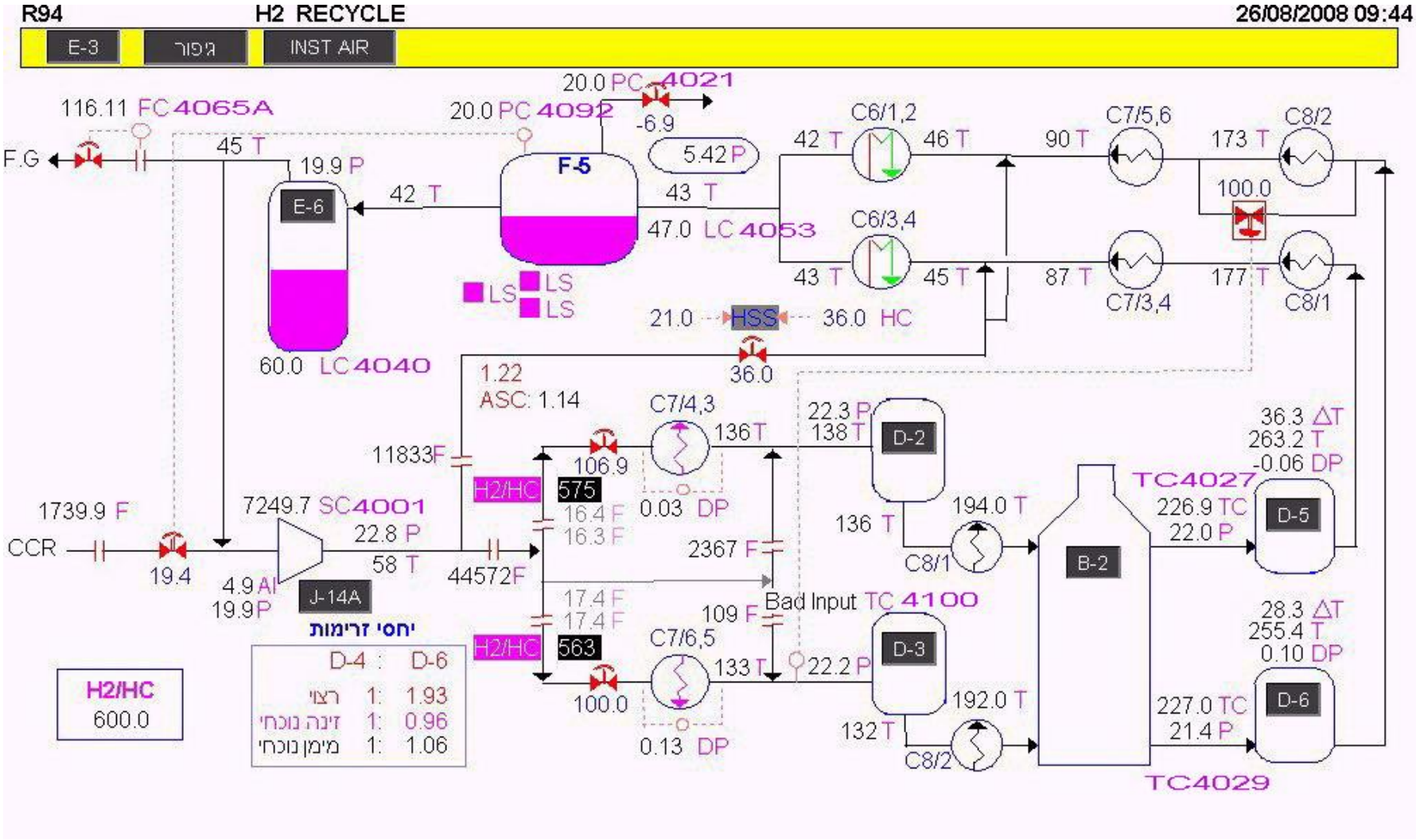
R92


R92
HDS REACTION
26/08/2008 09:43:00
H2 REC.
308.7 T
323.7 T
345.6 T
10.3 %O2
B-2
C-8/1
236.3 ST
226.9 TC 4027
194.0 T
A EAST
192.0 T
238.2 ST
227.0 TC 4082
C-8/2
B WEST
21.4 P
28.3 ΔT
0.10 DP
D-6
21.3 P
255.4 T
C-8/2
173.3 T
C-7/5,6
Bad Input
S.C
90.4 T
100.0
J14A SPLBK.
11833 F
0.15 F
J-60
46.1 T
C-6/1,2
42.0 T
150.8 T
226.2 T
226.4 T
230.5 T
234.7 T
241.0 T
245.9 T
250.8 T
22.0 P
D-5
36.3 ΔT
-0.06 DP
0.13 DP
263.2 T
22.1 P
C-8/1
176.8 T
C-7/3,4
86.8 T
44.7 T
C-6/3,4
42.6 T
42.6 T
20.0 PC 4021
FLARE
E-6
20.0 PC 4092
F-5
47.0 LC 4053
LS
LS
LS
51.7 FC 4056
E-3
30.4 FC
FC4067
43.0
STARTUP

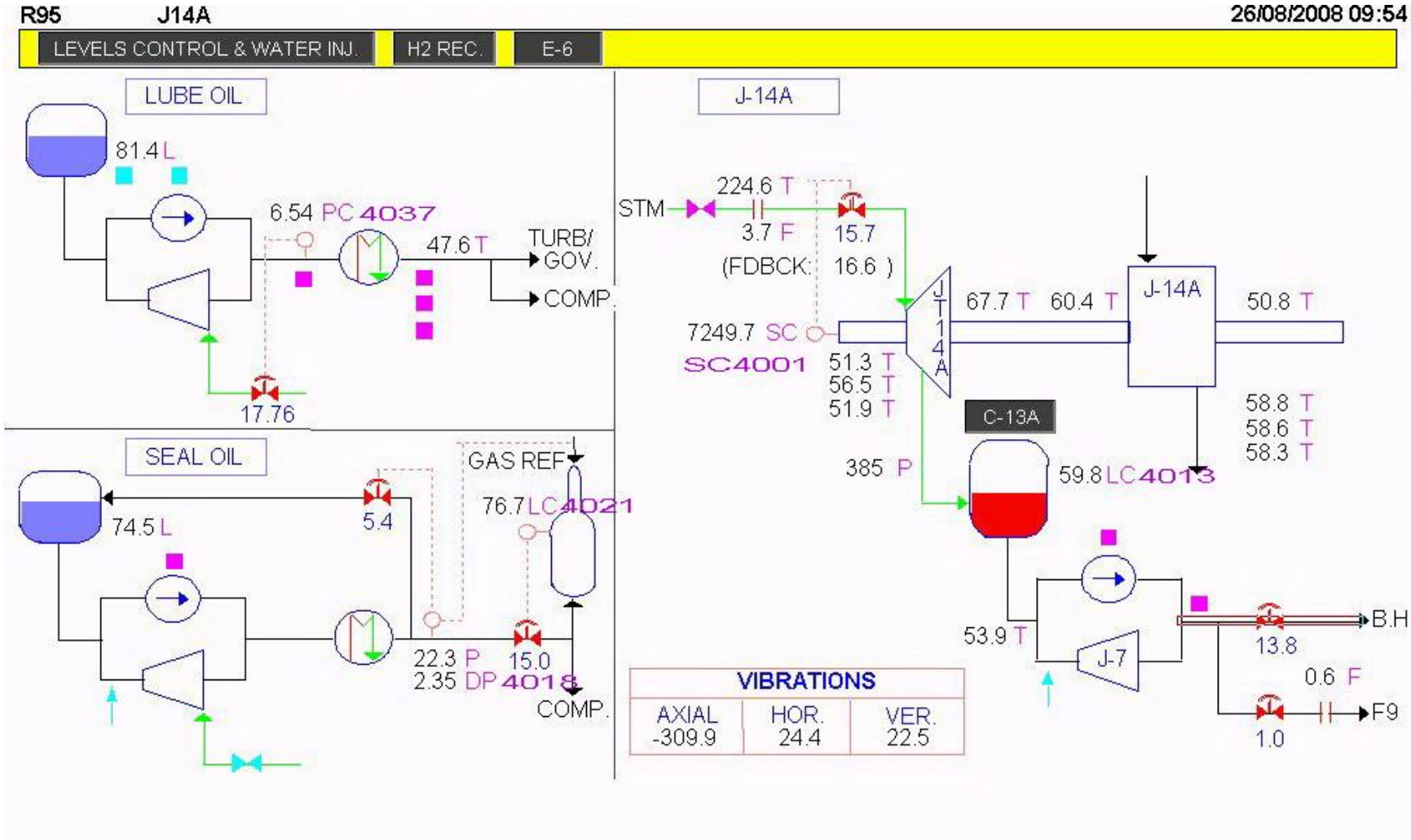
R93


R93
B-2
26/08/2008 09:42:00
H2 REC.
E-3
J-14A
E-6
SKINS
PILOTS
B-2 תפ"מ
LOSSES:
Bad Input
$/DAY
EMER. AIR
5.1 P
5.0
5.0
OUTLET △T -0.1°C
-12.6 P
10.3 %O2
-16.5 P
CLS
OPN
0.8 F
SNUFFING STEAM
D4
226.9 TC4027
B-2
227.0 TC4082
D6
VENT
0.7 PC4082
A
מזרח
B
מערב
1.0 PC4081
F.G
300.5 F
12.4
P
7.6
VENT
0.7 PC4101
P.G
12.4
194.0 T
192.0 T
C-8/1
C-8/2
טמפרטורות
SKINS
מזרח
מערב
אחורה
צפון 309 T 346 T 243 T
מרכז 324 T 240 T 236 T
דרום 346 T 242 T 228 T

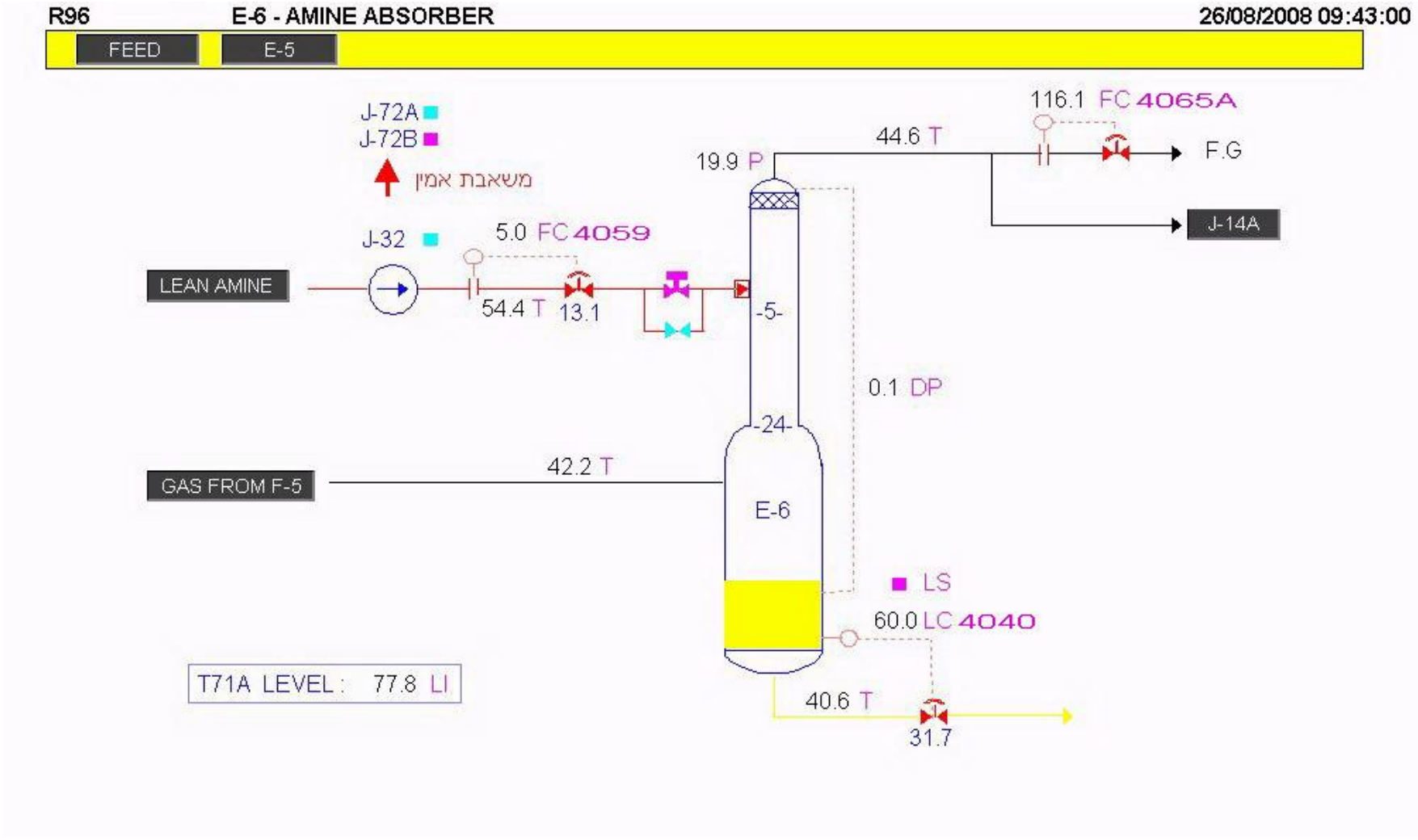
R94


R94
H2 RECYCLE
26/08/2008 09:44
E-3
INST AIR
20.0 PC 4021
116.11 FC 4065A
20.0 PC 4092
-6.9
F.G
45 T
19.9 P
F-5
5.42 P
42 T
C6/1,2
46 T
90 T
C7/5,6
173 T
C8/2
E-6
43 T
100.0
47.0 LC 4053
C6/3,4
43 T
45 T
87 T
C7/3,4
177 T
C8/1
LS
LS
LS
21.0
HSS
36.0 HC
60.0 LC 4040
36.0
1.22
ASC: 1.14
C7/4,3
22.3 P
138 T
D-2
36.3 ΔT
263.2 T
-0.06 DP
11833F
106.9
136T
H2/HC
575
16.4 F
16.3 F
0.03 DP
TC4027
226.9 TC
22.0 P
D-5
1739.9 F
7249.7 SC4001
22.8 P
58 T
194.0 T
136 T
CCR
19.4
4.9 AI
19.9P
J-14A
44572F
2367 F
C8/1
B-2
יחסי זרימות
17.4 F
17.4 F
Bad Input TC 4100
109 F
28.3 ΔT
255.4 T
0.10 DP
H2/HC
563
C7/6,5
D-4 : D-6
D-3
22.2 P
רצוי 1: 1.93
זינה נוכחי 1: 0.96
מימן נוכחי 1: 1.06
H2/HC
600.0
100.0
133 T
192.0 T
227.0 TC
21.4 P
D-6
0.13 DP
132 T
C8/2
TC4029

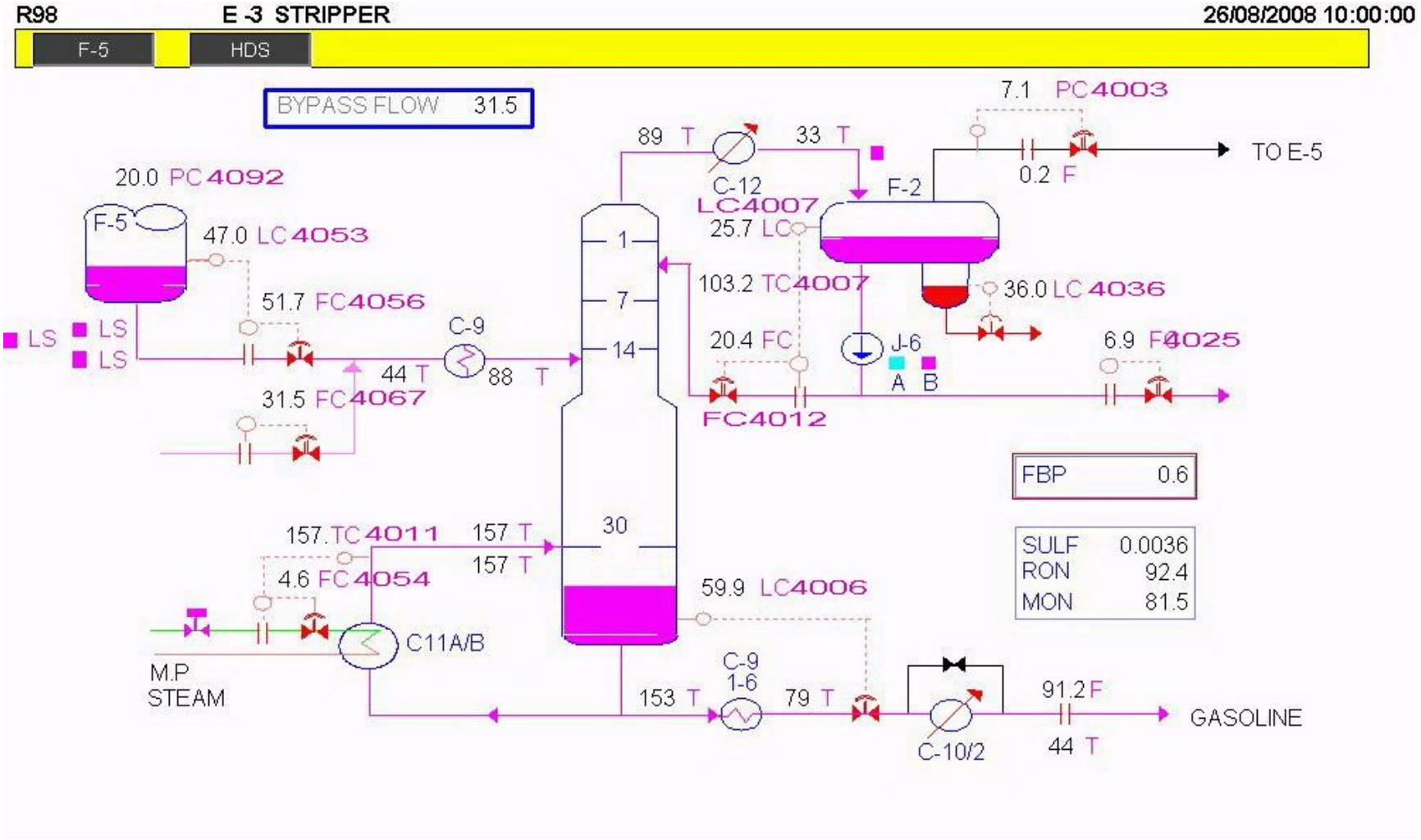
R95


R95
J14A
26/08/2008 09:54
LEVELS CONTROL & WATER INJ.
H2 REC.
E-6
LUBE OIL
81.4 L
6.54 PC 4037
47.6 T
TURB/
GOV.
COMP.
17.76
SEAL OIL
74.5 L
5.4
GAS REF
76.7 LC 4021
22.3 P
2.35 DP 4018
15.0
COMP.
J-14A
224.6 T
STM
3.7 F
15.7
(FDBCK: 16.6)
7249.7 SC
SC4001
51.3 T
56.5 T
51.9 T
J T 14 A
67.7 T
60.4 T
J-14A
50.8 T
58.8 T
58.6 T
58.3 T
C-13A
385 P
59.8 LC 4013
53.9 T
J-7
B.H
13.8
0.6 F
F9
1.0
VIBRATIONS
AXIAL
-309.9
HOR.
24.4
VER.
22.5

R96


R96
E-6 - AMINE ABSORBER
26/08/2008 09:43:00
FEED
E-5
J-72A
J-72B
משאבת אמין
J-32
LEAN AMINE
5.0 FC 4059
54.4 T
13.1
19.9 P
44.6 T
116.1 FC 4065A
F.G
J-14A
-5-
0.1 DP
-24-
42.2 T
GAS FROM F-5
E-6
LS
60.0 LC 4040
T71A LEVEL : 77.8 LI
40.6 T
31.7

R98


R98
E -3 STRIPPER
26/08/2008 10:00:00
F-5
HDS
BYPASS FLOW 31.5
7.1 PC4003
TO E-5
0.2 F
89 T
33 T
C-12
LC4007
25.7 LC
F-2
20.0 PC4092
F-5
47.0 LC4053
1
7
14
103.2 TC4007
36.0 LC 4036
51.7 FC4056
C-9
LS
LS
LS
44 T
88 T
20.4 FC
J-6
A B
6.9 FC4025
31.5 FC4067
FC4012
FBP 0.6
157.TC4011
157 T
157 T
30
SULF 0.0036
RON 92.4
MON 81.5
4.6 FC4054
59.9 LC4006
C11A/B
M.P
STEAM
C-9
1-6
153 T
79 T
91.2 F
GASOLINE
C-10/2
44 T