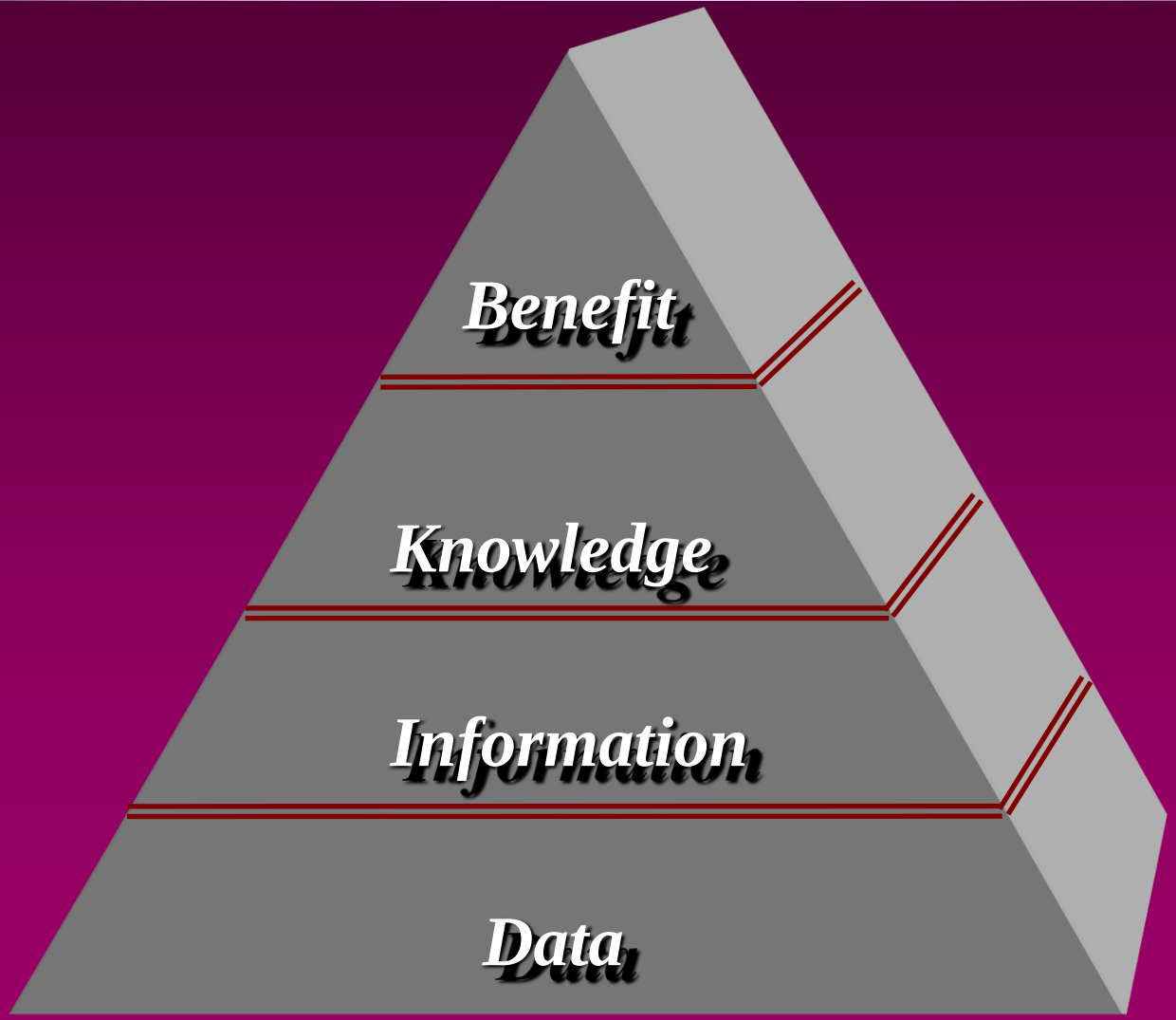
The Application of Process Monitoring and Key Performance Index in Polyethylene Plant

International Innotech, Inc.
Ricky Hsu

Inspiration System, Inc.
Jialin Liu, M. F. Yau

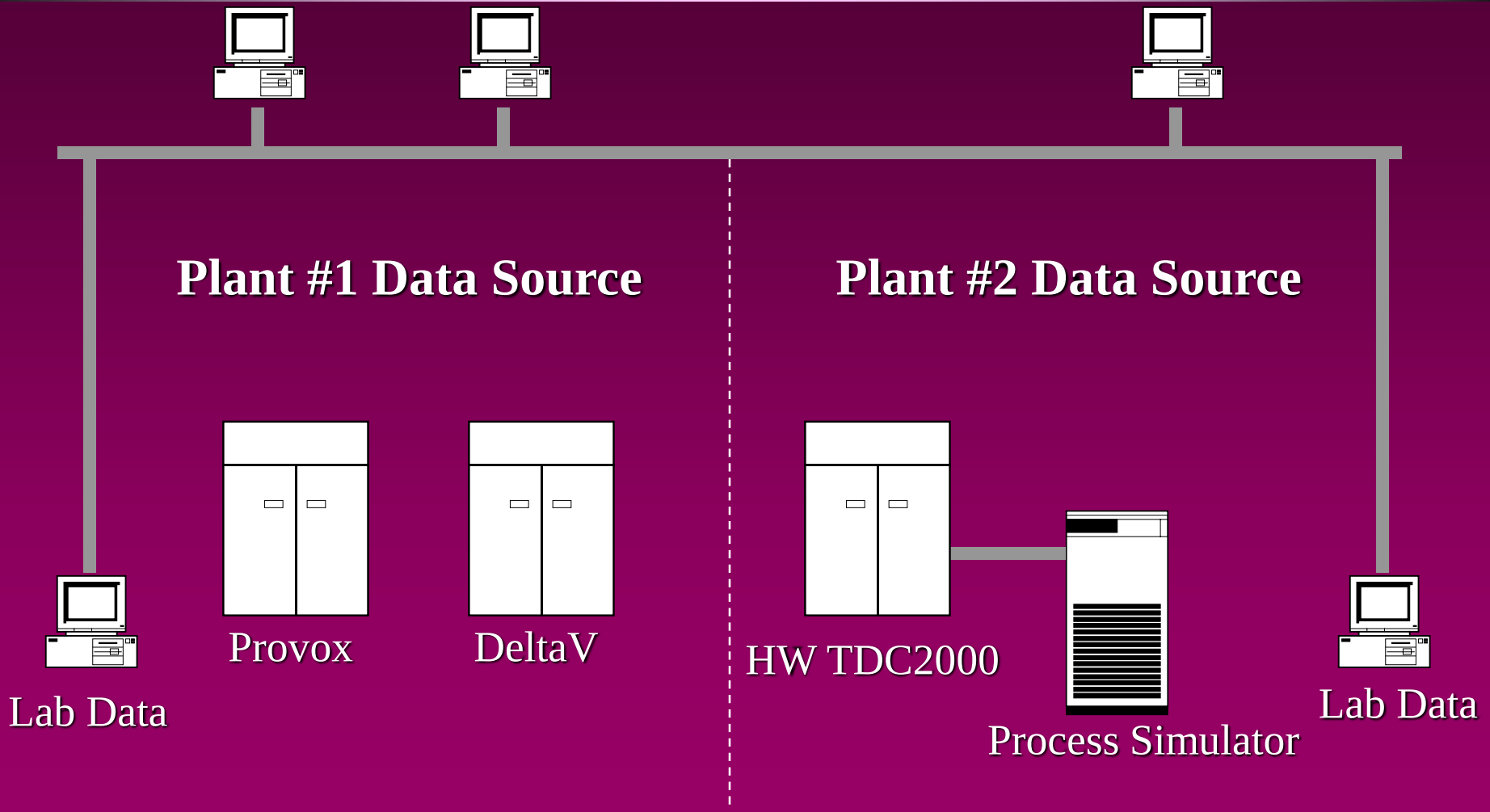
How to Make Your Data Valuable?



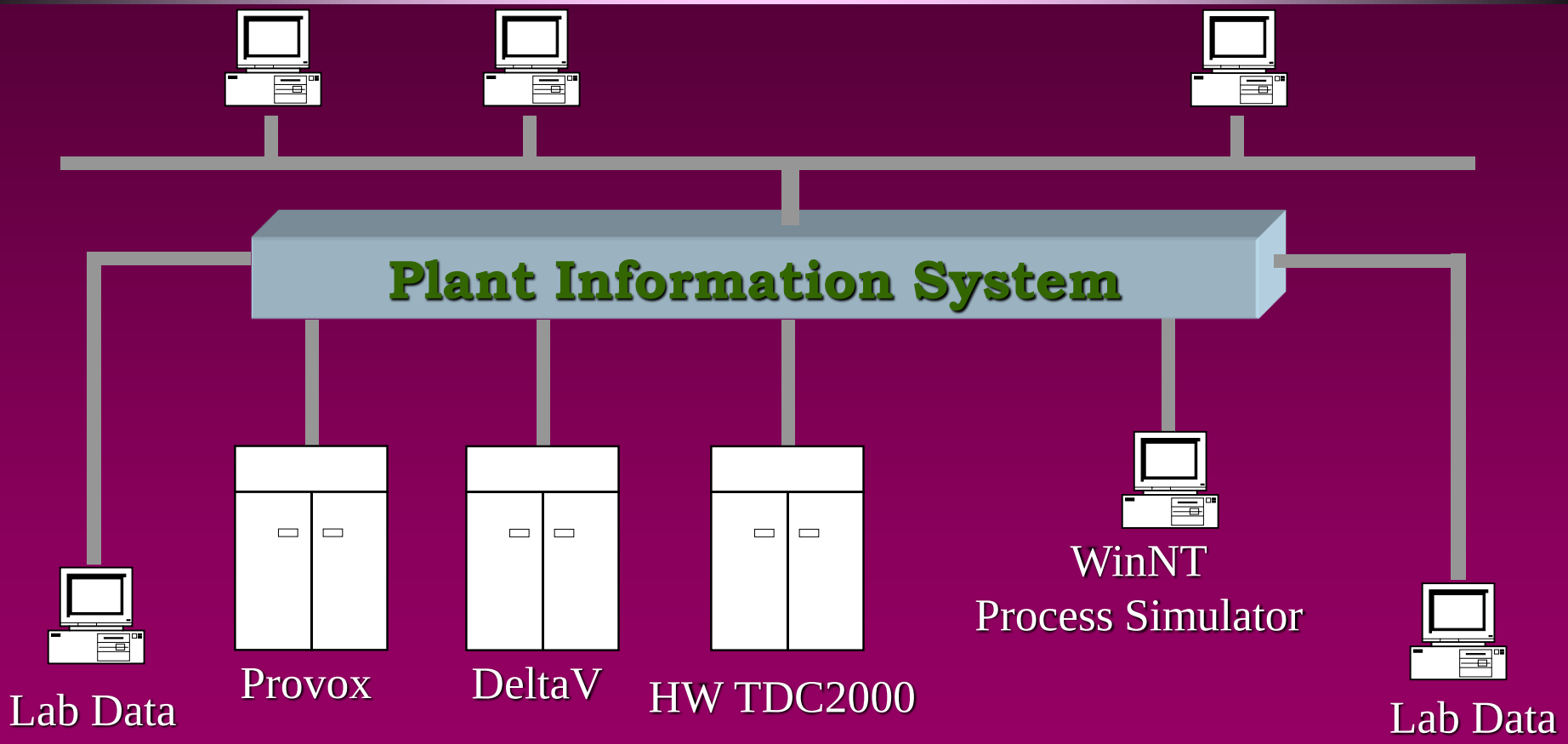
Introduction

- Implement Process Data Infrastructure
  - Integrated HW TDC2000、 Fisher Provox and DeltaV
  - Link Lab QC data
  - Compile the process simulator
- Process Monitoring System
  - Statistical Process Control
  - Multivariate Statistical Process Control
  - Computerize Operator Experience
- Key Performance Index
  - Production Performance Index
  - Operation Performance Index
  - Equipment Performance Index

Platform Backbone (Before)



Platform Backbone (Now)

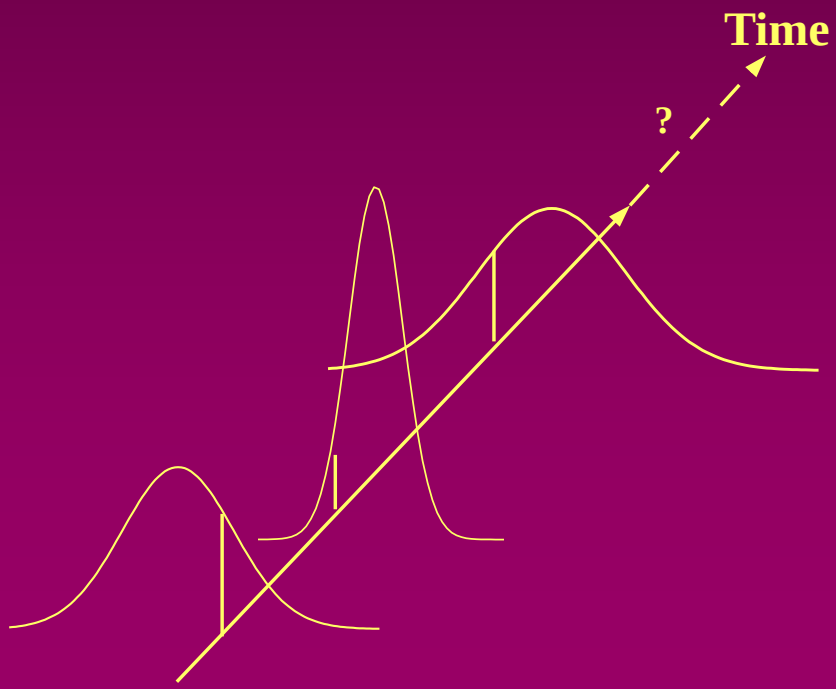


Process Monitoring System

- Statistical Process Control
  - Why Do We Need SPC
  - Cause Effect Diagram, Fishbone Diagram
  - Set up XB/Range control limit
  - On line monitoring
  - Off line analysis
- Multivariate Statistical Process Control
  - Why Do We Need MSPC
  - Set up PCA control limit
  - On line monitoring
  - Contribution plot
- Computerize Operator Experience
  - If - Then architecture
  - Recording symptom and trigger time
  - Display predefined SOP

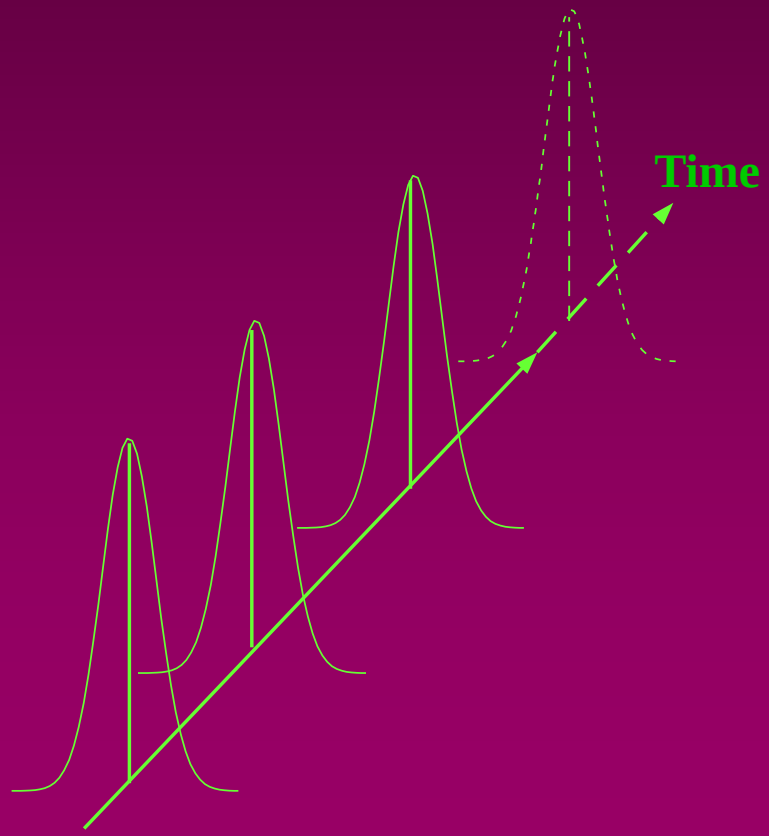
Process Variation

- Uncontrolled Variation

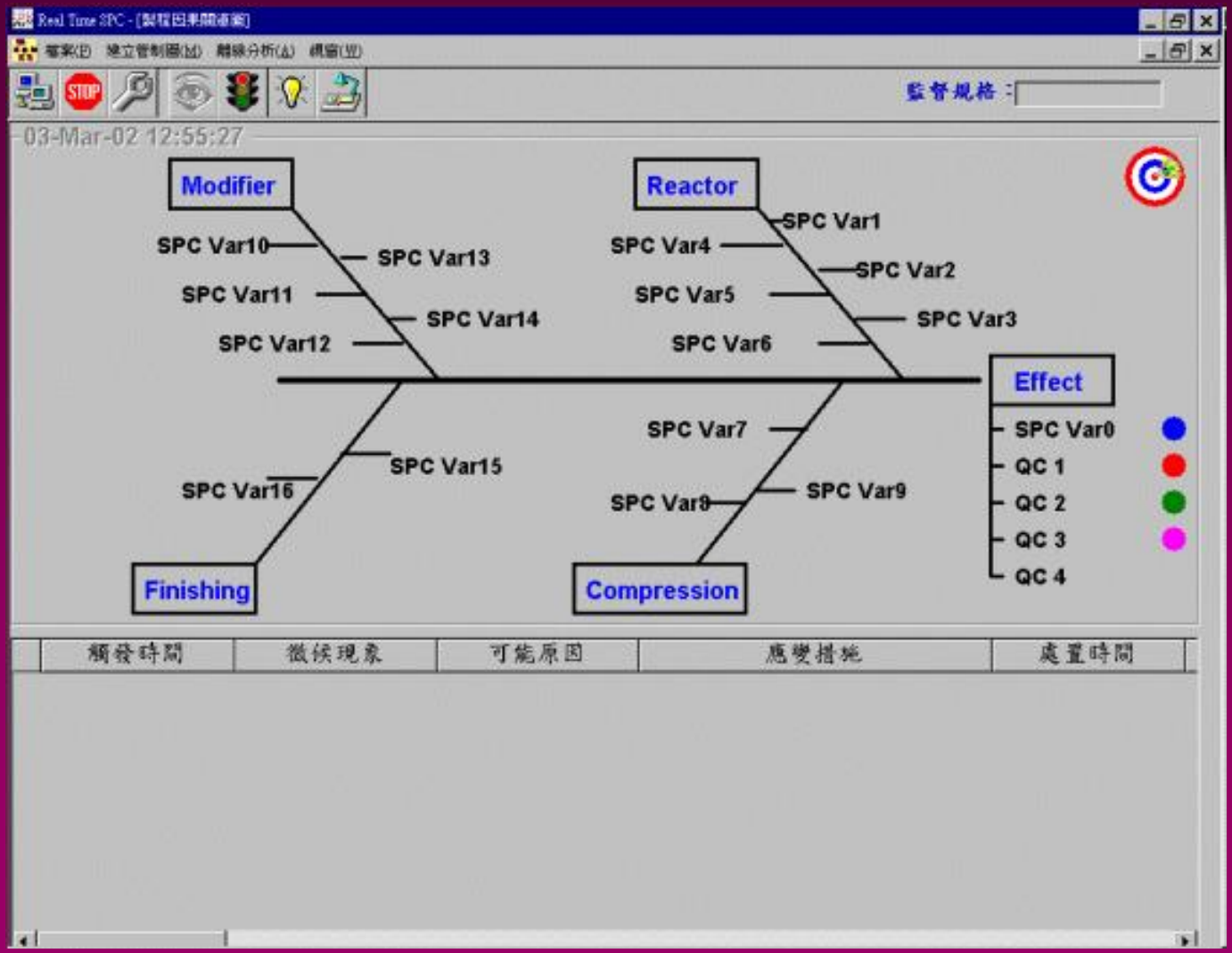


- Controlled Variation

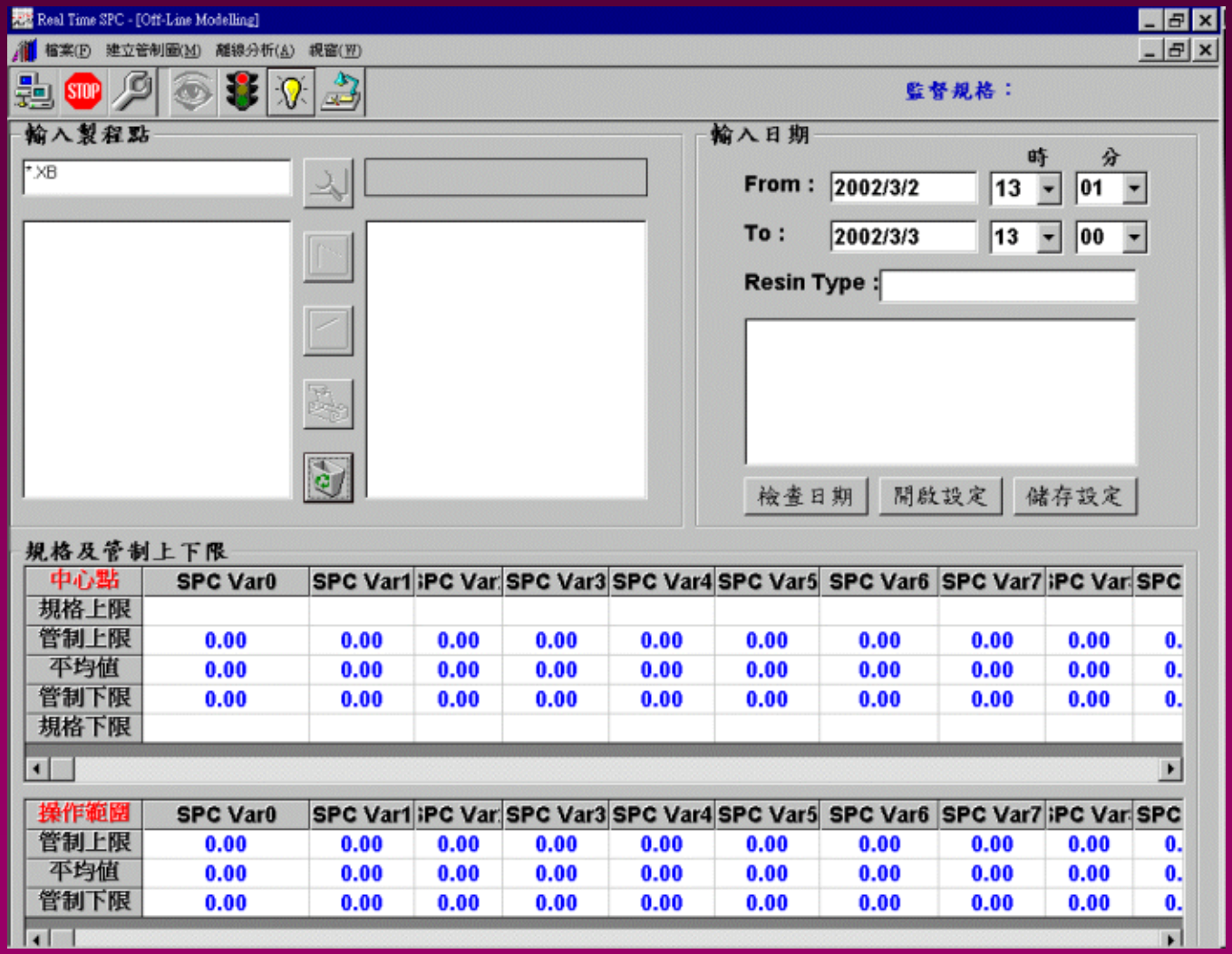
  Predictable Process



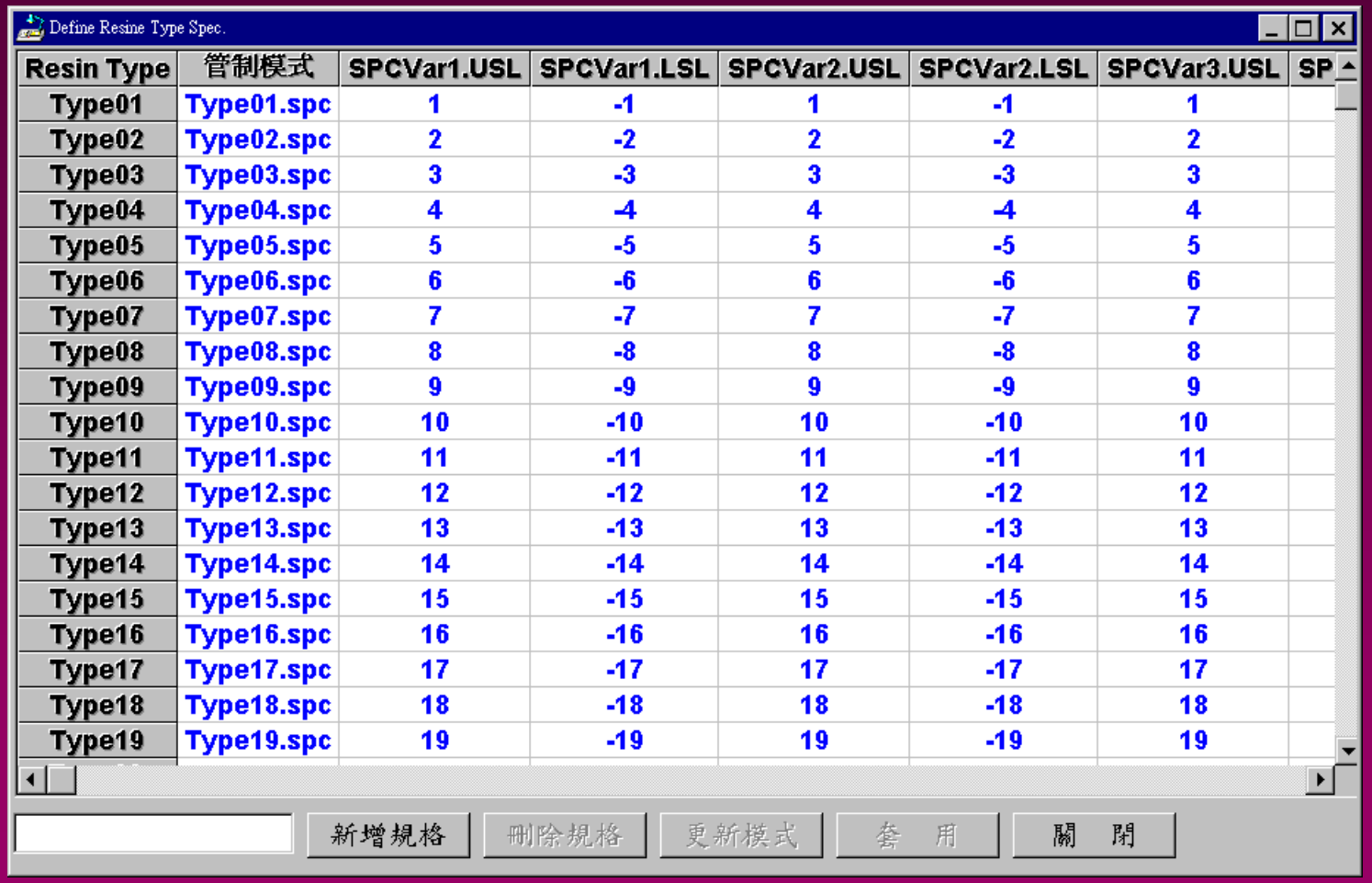
Overview - Cause Effect Diagram



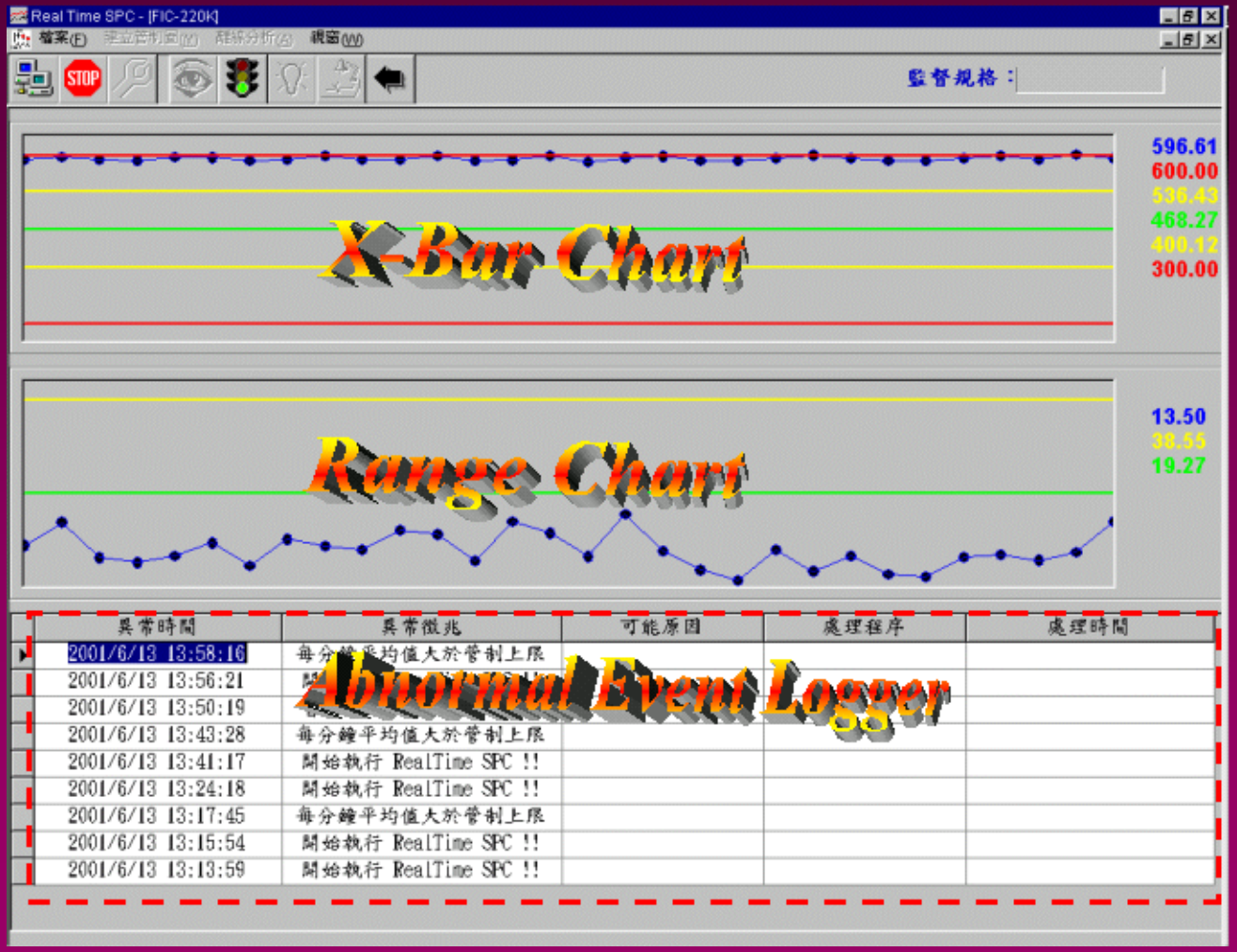
Set Up Control Limit



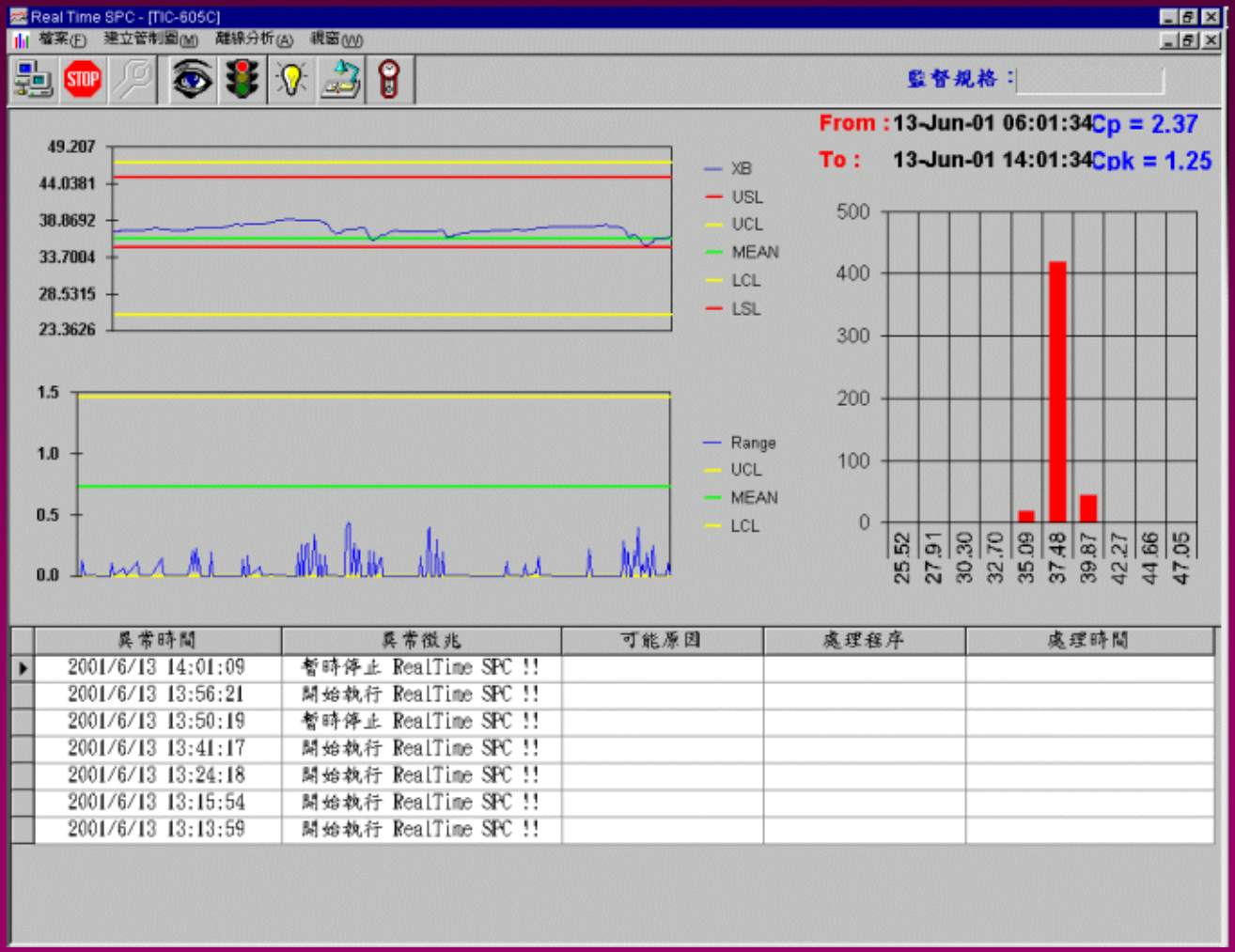
Control Limit Management



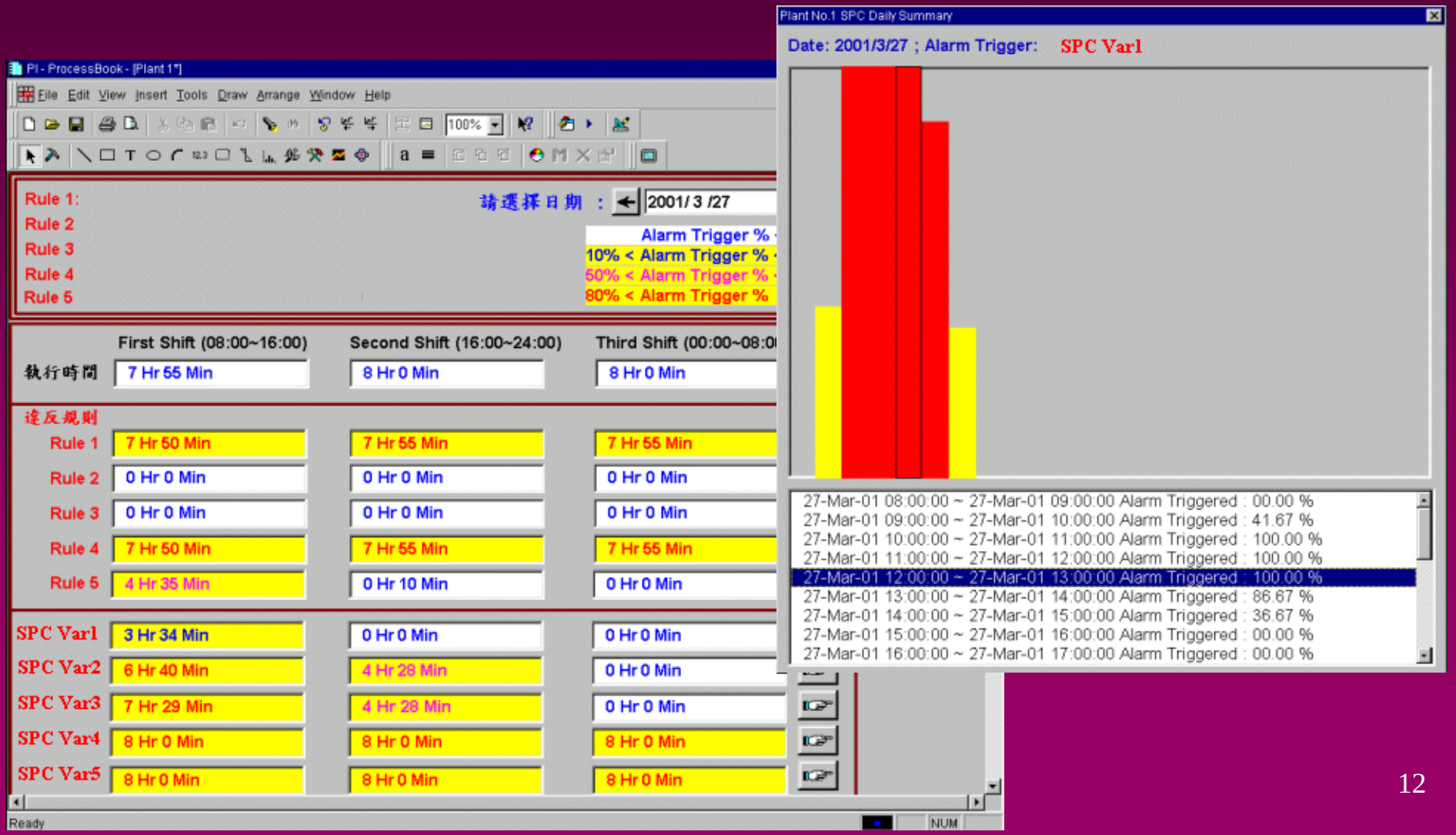
On Line Monitoring (XB/Range)



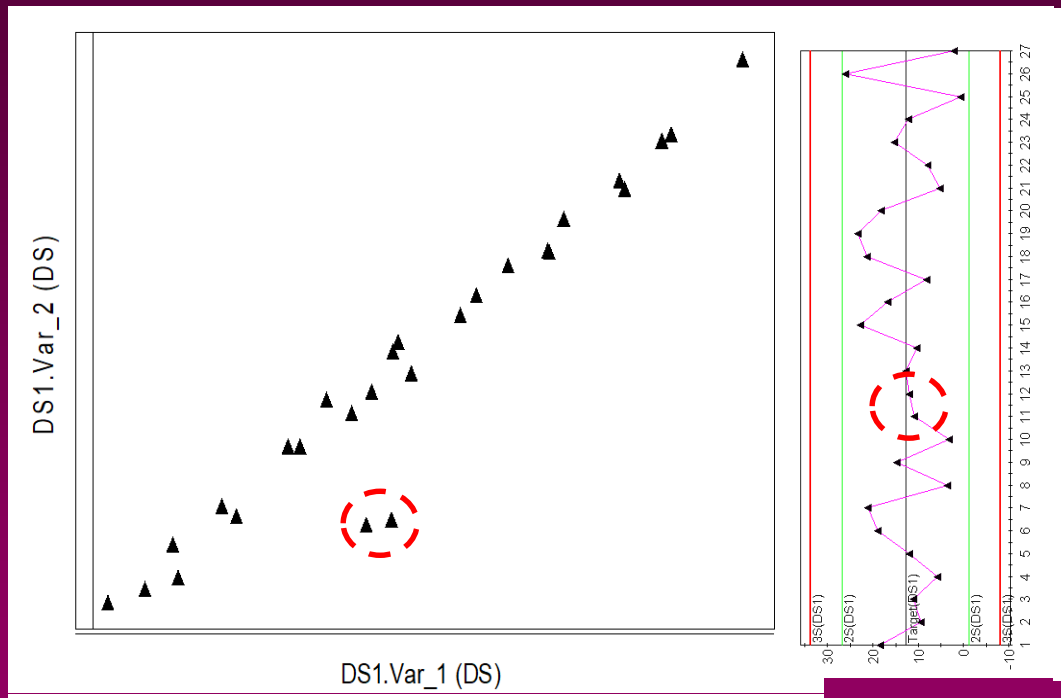
Offline Analysis

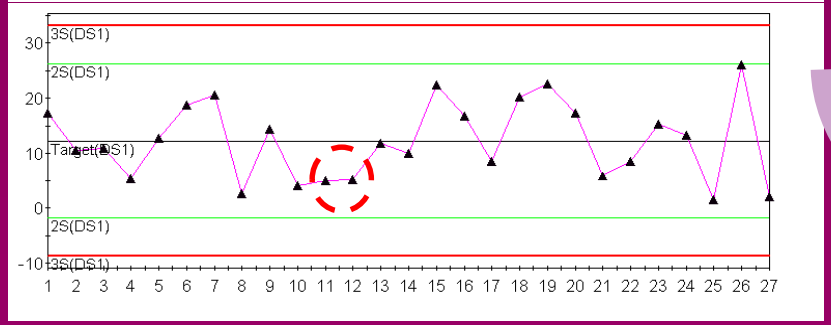


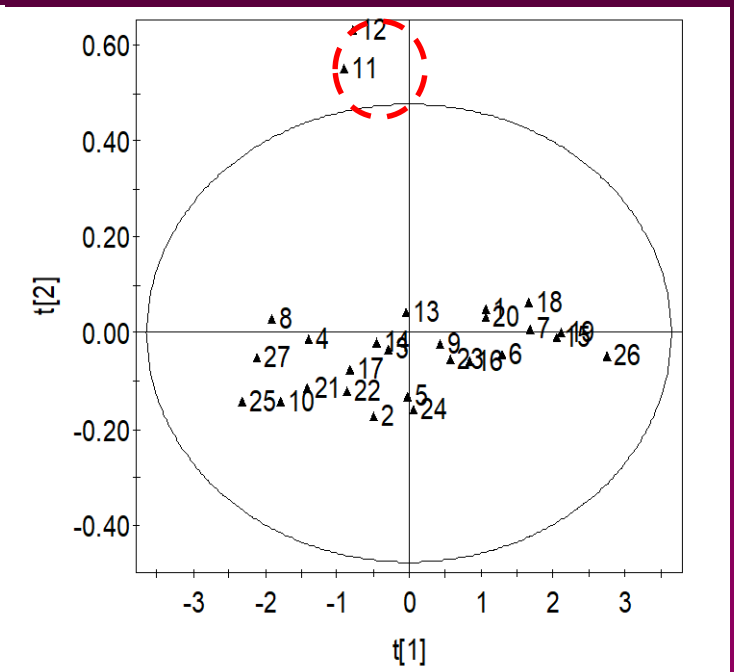
SPC Summary


PI - ProcessBook - [Plant 1*]
File Edit View Insert Tools Draw Arrange Window Help
Rule 1:
Rule 2
Rule 3
Rule 4
Rule 5
請選擇日期 ：
2001/ 3 /27
Alarm Trigger %
10% < Alarm Trigger %
50% < Alarm Trigger %
80% < Alarm Trigger %
First Shift (08:00~16:00)
Second Shift (16:00~24:00)
Third Shift (00:00~08:0
執行時間
7 Hr 55 Min
8 Hr 0 Min
8 Hr 0 Min
違反規則
Rule 1 7 Hr 50 Min 7 Hr 55 Min 7 Hr 55 Min
Rule 2 0 Hr 0 Min 0 Hr 0 Min 0 Hr 0 Min
Rule 3 0 Hr 0 Min 0 Hr 0 Min 0 Hr 0 Min
Rule 4 7 Hr 50 Min 7 Hr 55 Min 7 Hr 55 Min
Rule 5 4 Hr 35 Min 0 Hr 10 Min 0 Hr 0 Min
SPC Var1 3 Hr 34 Min 0 Hr 0 Min 0 Hr 0 Min
SPC Var2 6 Hr 40 Min 4 Hr 28 Min 0 Hr 0 Min
SPC Var3 7 Hr 29 Min 4 Hr 28 Min 0 Hr 0 Min
SPC Var4 8 Hr 0 Min 8 Hr 0 Min 8 Hr 0 Min
SPC Var5 8 Hr 0 Min 8 Hr 0 Min 8 Hr 0 Min
Ready
NUM
Plant No.1 SPC Daily Summary
Date: 2001/3/27 ; Alarm Trigger: SPC Var1
27-Mar-01 08:00:00 ~ 27-Mar-01 09:00:00 Alarm Triggered : 00.00 %
27-Mar-01 09:00:00 ~ 27-Mar-01 10:00:00 Alarm Triggered : 41.67 %
27-Mar-01 10:00:00 ~ 27-Mar-01 11:00:00 Alarm Triggered : 100.00 %
27-Mar-01 11:00:00 ~ 27-Mar-01 12:00:00 Alarm Triggered : 100.00 %
27-Mar-01 12:00:00 ~ 27-Mar-01 13:00:00 Alarm Triggered : 100.00 %
27-Mar-01 13:00:00 ~ 27-Mar-01 14:00:00 Alarm Triggered : 86.67 %
27-Mar-01 14:00:00 ~ 27-Mar-01 15:00:00 Alarm Triggered : 36.67 %
27-Mar-01 15:00:00 ~ 27-Mar-01 16:00:00 Alarm Triggered : 00.00 %
27-Mar-01 16:00:00 ~ 27-Mar-01 17:00:00 Alarm Triggered : 00.00 %

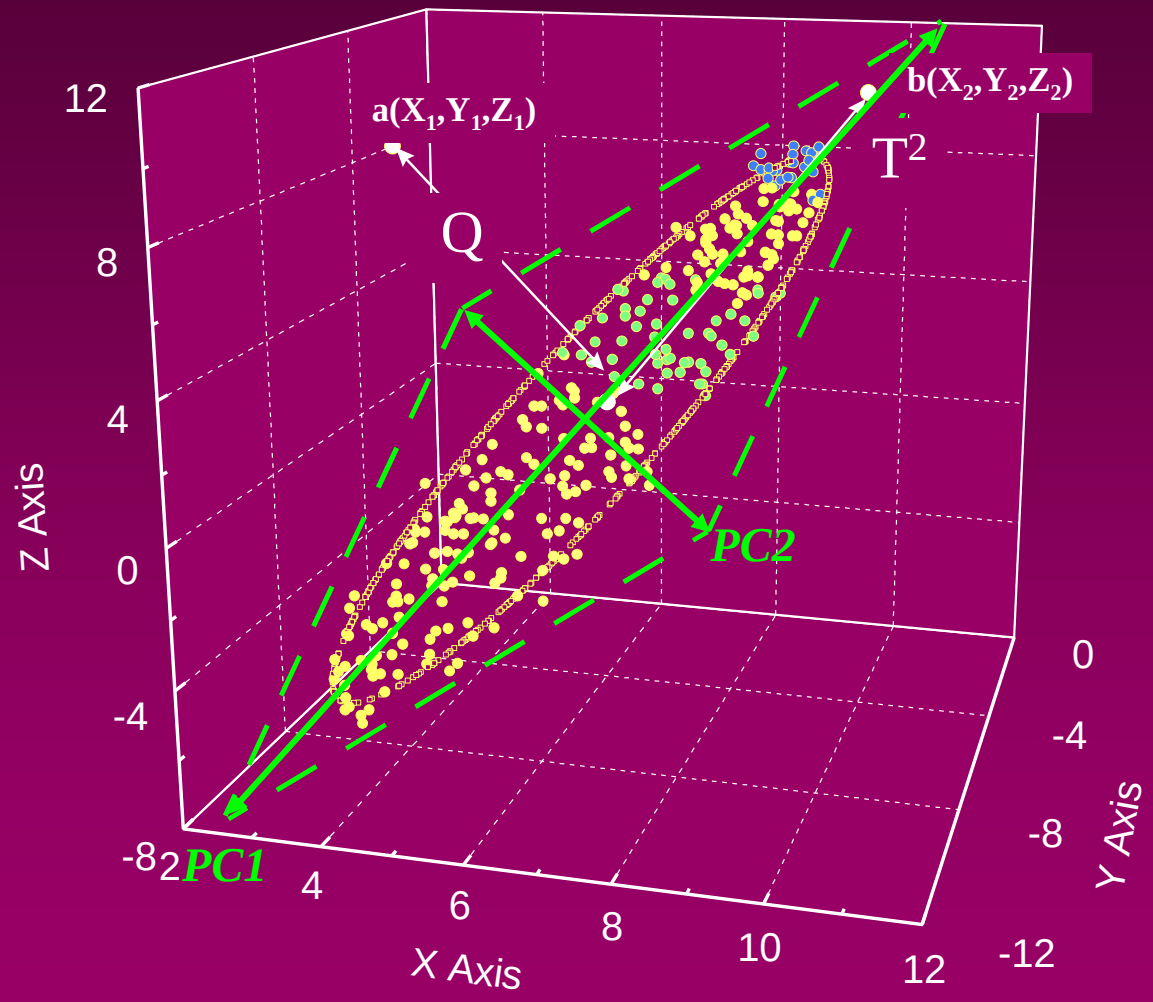
Why Do We Need MSPC?



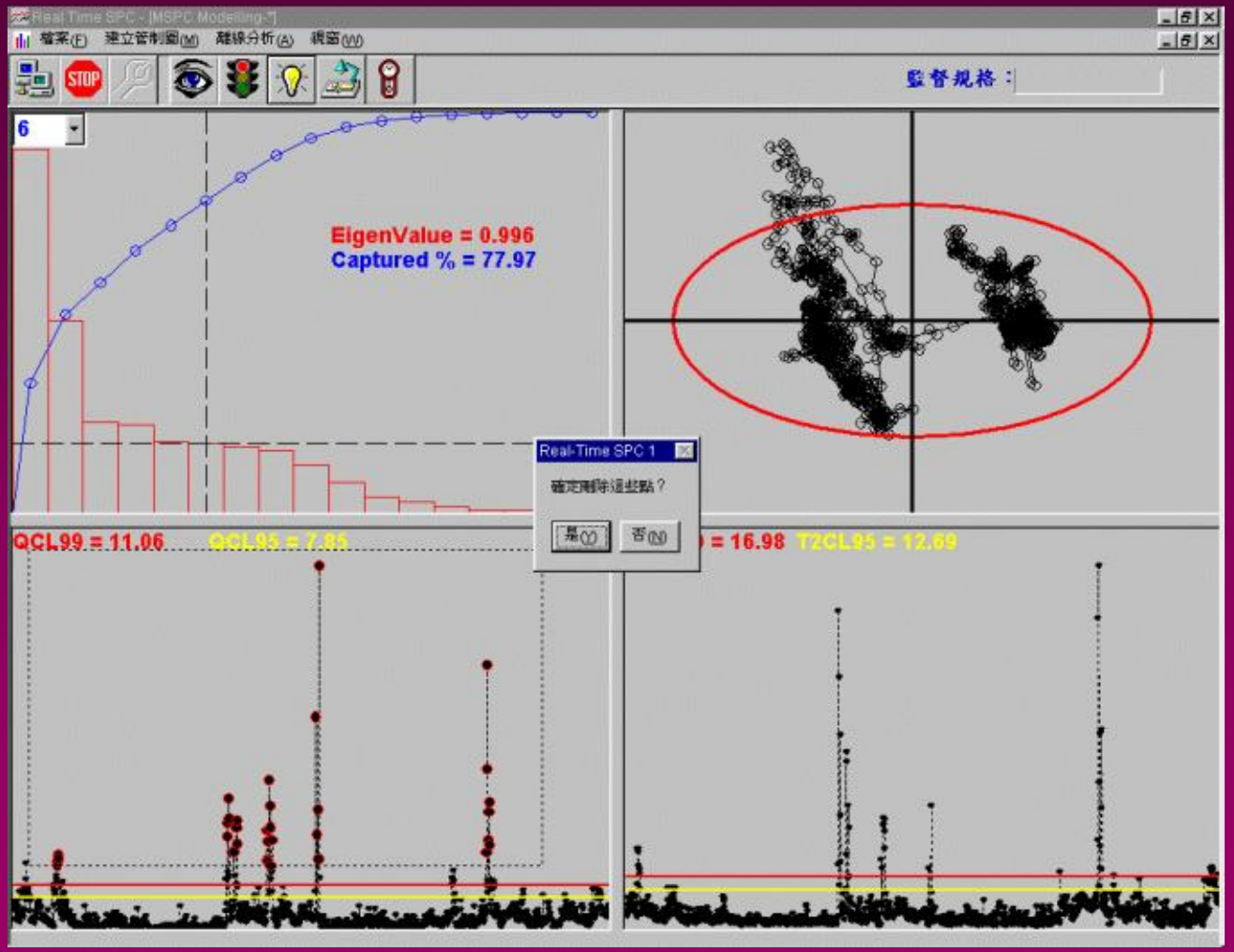




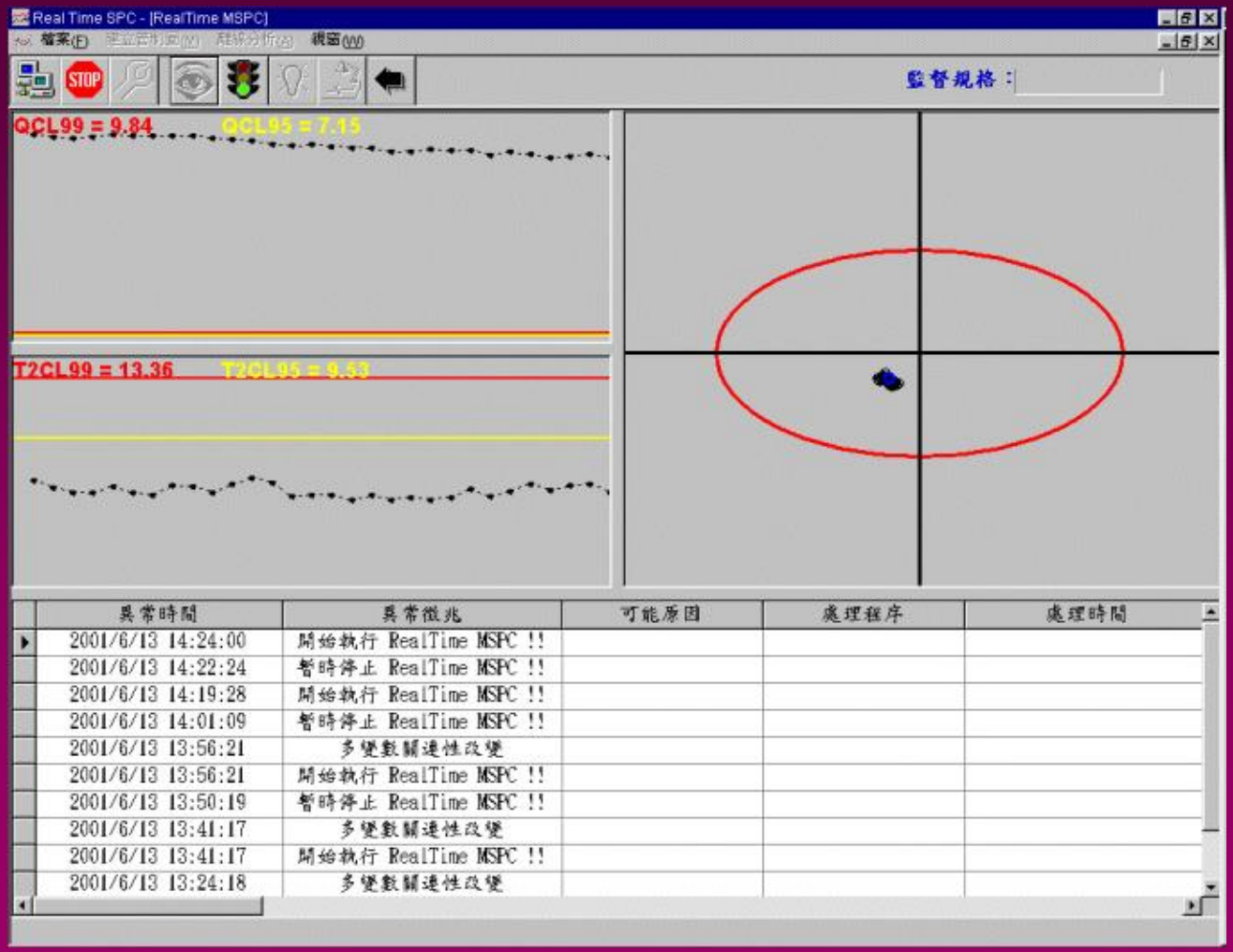
Principal Component Analysis



Set Up MSPC Control Limit

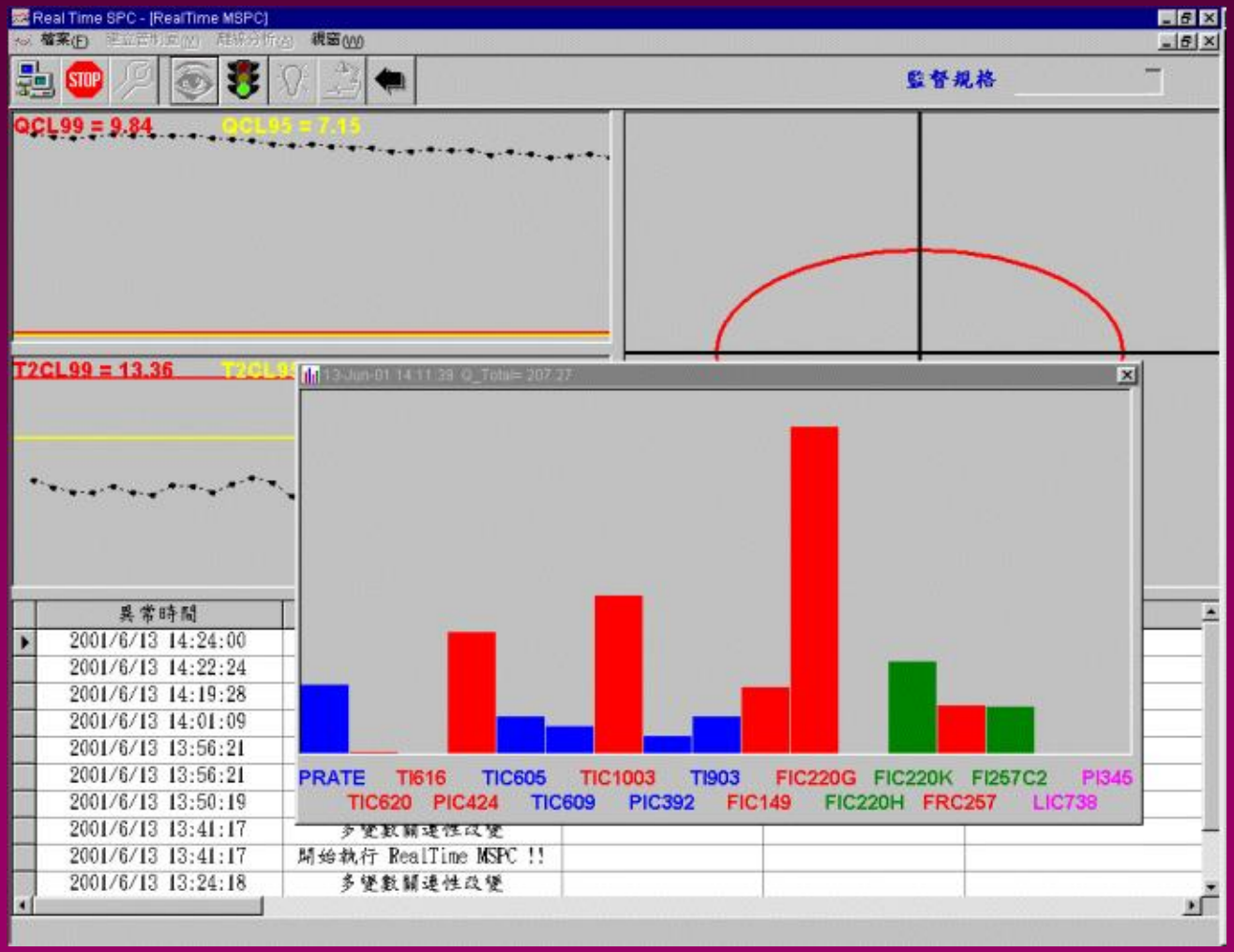


Real Time MSPC



異常時間	異常徵兆	可能原因	處理程序	處理時間
2001/6/13 14:24:00	開始執行 RealTime MSPC !!			
2001/6/13 14:22:24	暫時停止 RealTime MSPC !!			
2001/6/13 14:19:28	開始執行 RealTime MSPC !!			
2001/6/13 14:01:09	暫時停止 RealTime MSPC !!			
2001/6/13 13:56:21	多變數關連性改變			
2001/6/13 13:56:21	開始執行 RealTime MSPC !!			
2001/6/13 13:50:19	暫時停止 RealTime MSPC !!			
2001/6/13 13:41:17	多變數關連性改變			
2001/6/13 13:41:17	開始執行 RealTime MSPC !!			
2001/6/13 13:24:18	多變數關連性改變			

Contribution Plot



Computerize Operator Experience

For Example:

If (cooling water outlet temperature less than 55 degC)

Then (step 1…

step 2…

:)

Trigger Time

Symptom

Possible Cause

Standard Operated Procedure

	觸發時間	徵候現象	可能原因	應變措施
▶	2001/6/13 13:49:41	最末 Cooler 出口水溫小	Cooler效率過低	1) 定期沖洗水側汙泥物 2) 熱交換器酸洗或
	2001/6/13 13:49:41	第一個 Cooler 進出氣體	HX1 Fouling	1) 若 Recycle Cooler正常Fouling，則轉換備用

Key Performance Index

- **Production Performance Index**
  - **Productivity Index**
  - **Raw Material Index**
  - **Utility Index**
  - **Production Rate Analysis**
- Operation Performance Index
  - Real Time ISO Spec Monitoring
  - ISO Daily Report
  - Integrated ISO & SPC
- Equipment Performance Index
  - Critical Equipment Operated Time
  - Compressor Performance
  - Heat Exchanger Performance

Productivity Index

USIFE's Data

Raw Material Index / Standard Consumption

USIFE's Data

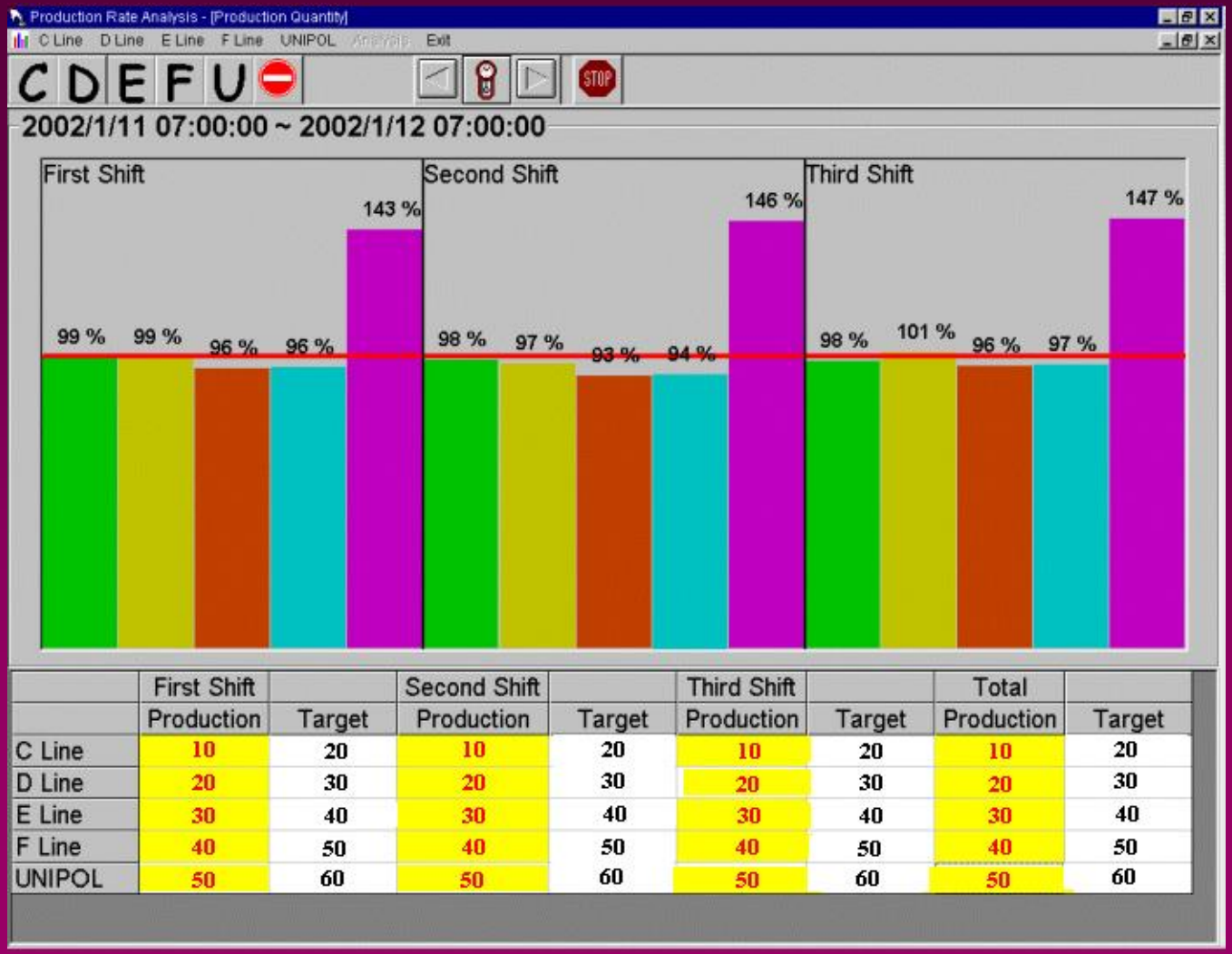
Raw Material Index / Unit Cost

USIFE's Data

KPI Daily Report

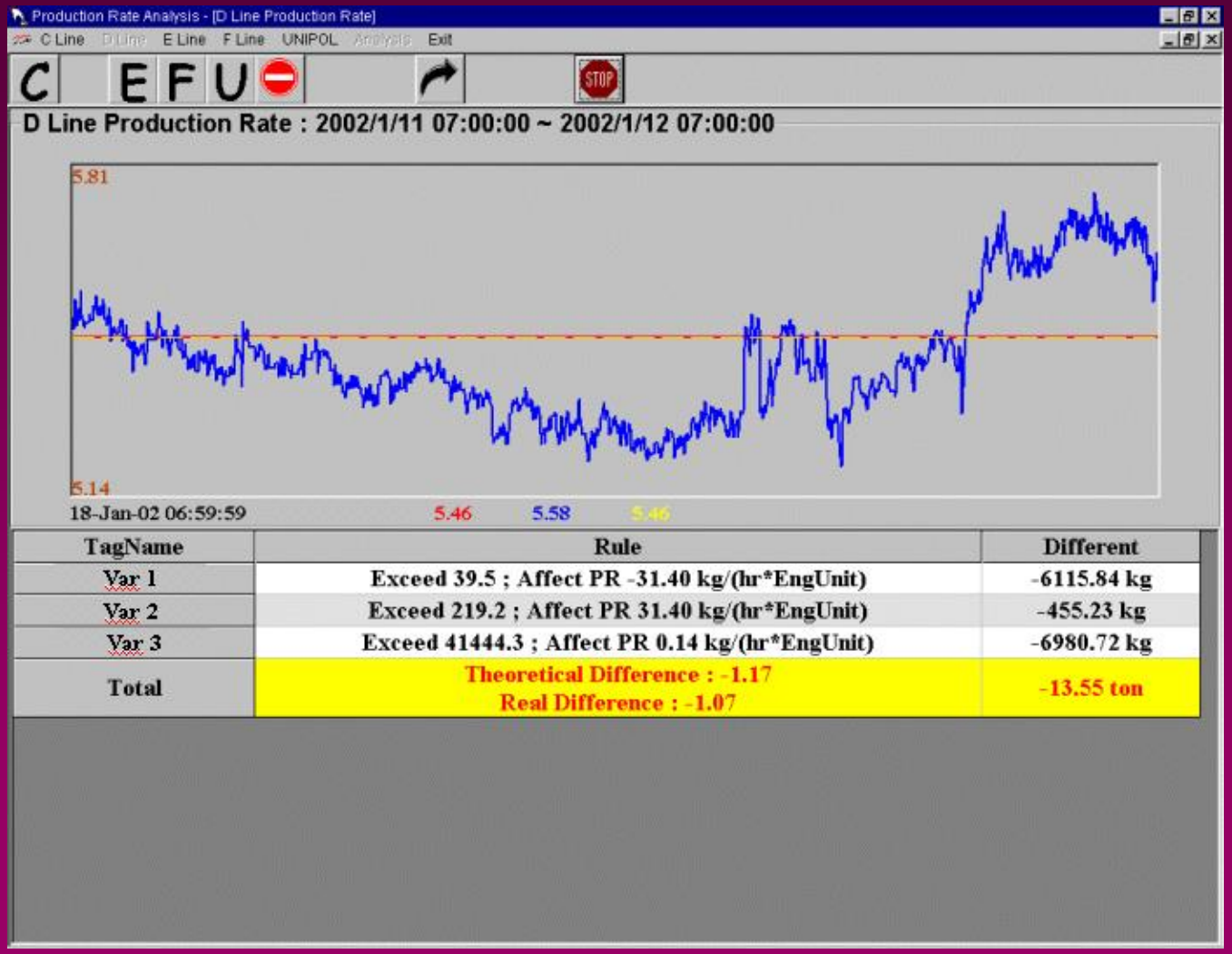
USIFE's Data

Production Rate Analysis Tool



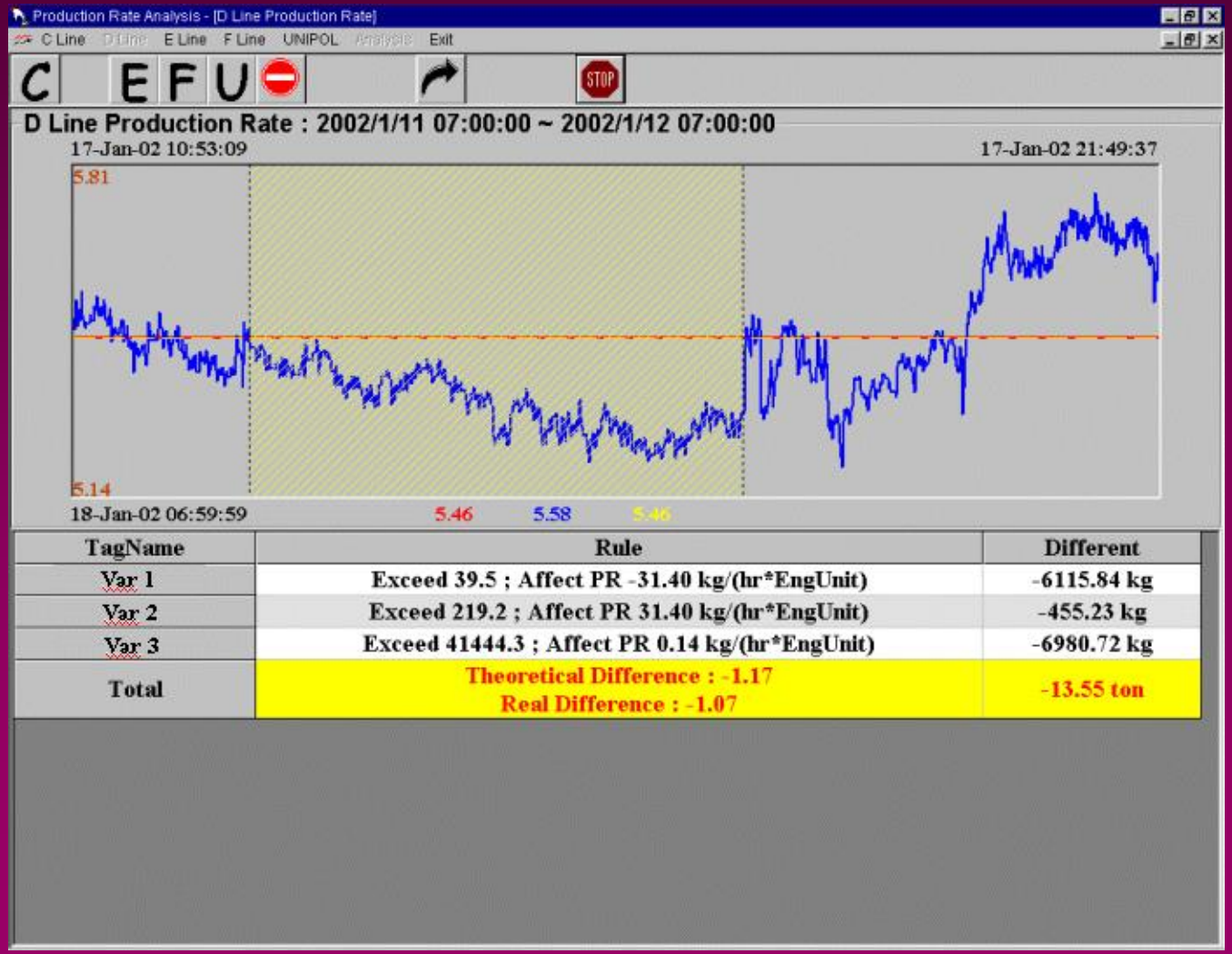
	First Shift		Second Shift		Third Shift		Total	
	Production	Target	Production	Target	Production	Target	Production	Target
C Line	10	20	10	20	10	20	10	20
D Line	20	30	20	30	20	30	20	30
E Line	30	40	30	40	30	40	30	40
F Line	40	50	40	50	40	50	40	50
UNIPOL	50	60	50	60	50	60	50	60

Calculated and Standard Production Rate



TagName	Rule	Different
Var 1	Exceed 39.5 ; Affect PR -31.40 kg/(hr*EngUnit)	-6115.84 kg
Var 2	Exceed 219.2 ; Affect PR 31.40 kg/(hr*EngUnit)	-455.23 kg
Var 3	Exceed 41444.3 ; Affect PR 0.14 kg/(hr*EngUnit)	-6980.72 kg
Total	Theoretical Difference : -1.17 Real Difference : -1.07	-13.55 ton

Selected Time Range for Analyzing



TagName	Rule	Different
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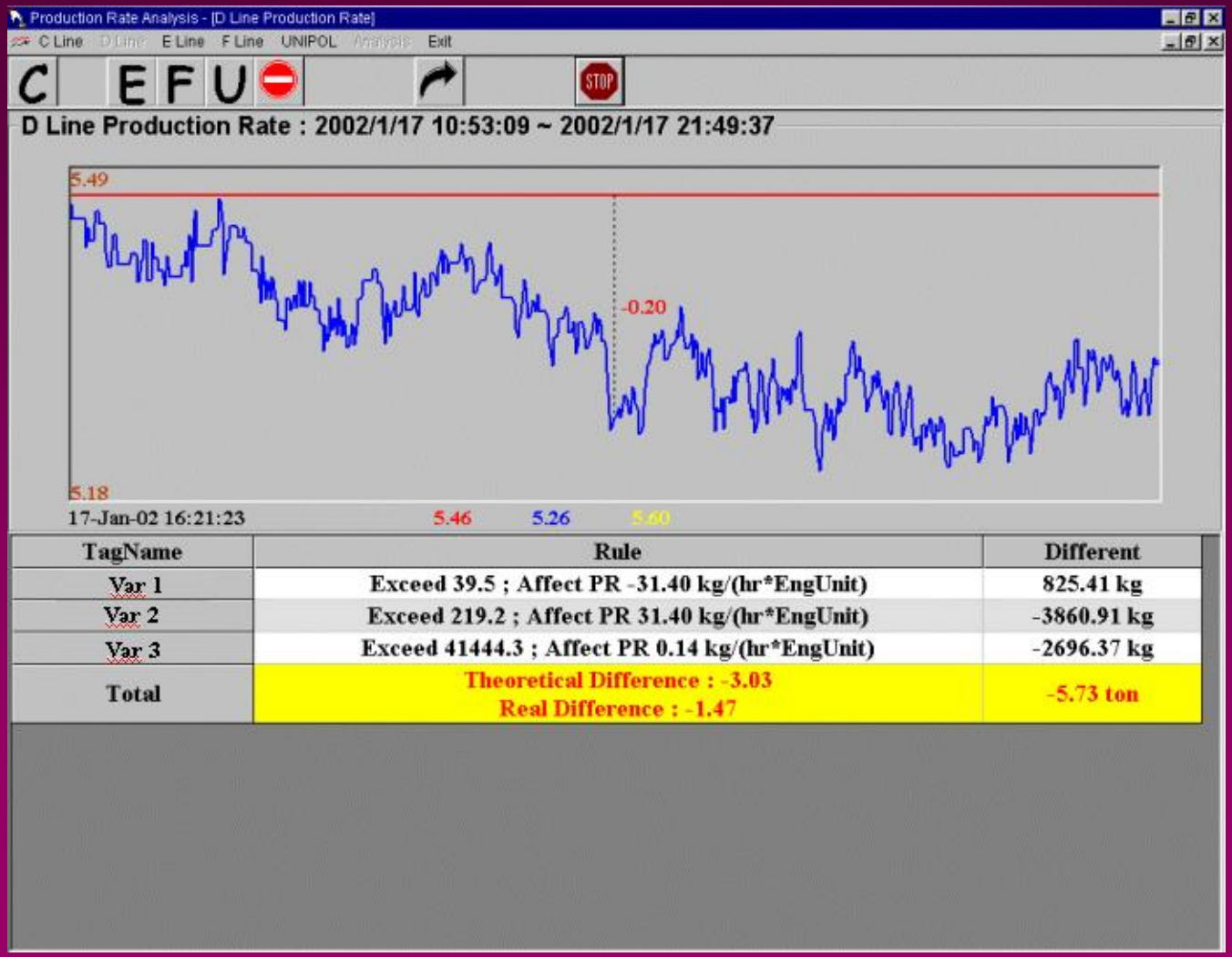
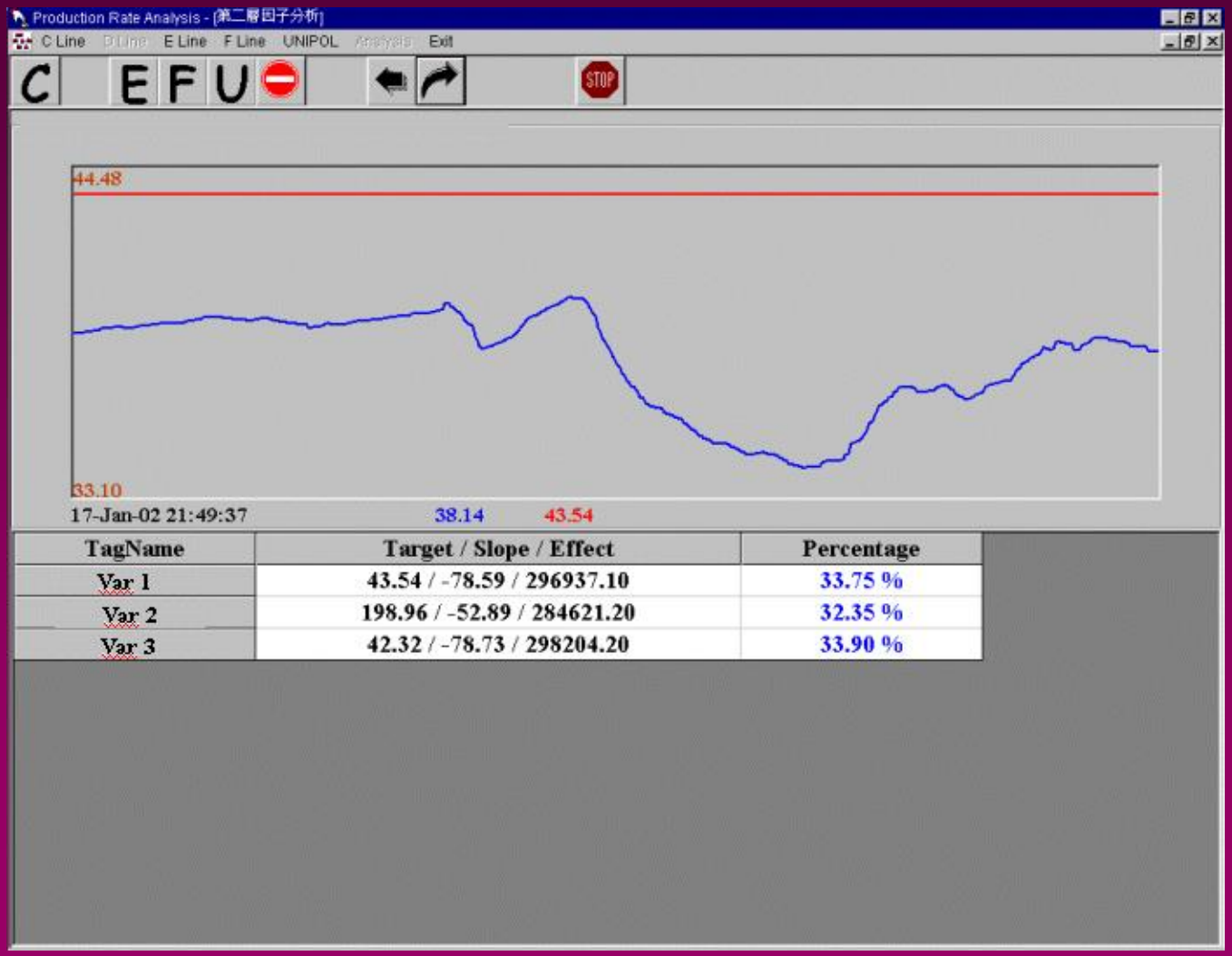
First Level Effect



TagName	Rule	Different
Var 1	Exceed 39.5 ; Affect PR -31.40 kg/(hr*EngUnit)	825.41 kg
Var 2	Exceed 219.2 ; Affect PR 31.40 kg/(hr*EngUnit)	-3860.91 kg
Var 3	Exceed 41444.3 ; Affect PR 0.14 kg/(hr*EngUnit)	-2696.37 kg
Total	Theoretical Difference : -3.03 Real Difference : -1.47	-5.73 ton

Second Level Effect



TagName	Target / Slope / Effect	Percentage
Var 1	43.54 / -78.59 / 296937.10	33.75 %
Var 2	198.96 / -52.89 / 284621.20	32.35 %
Var 3	42.32 / -78.73 / 298204.20	33.90 %

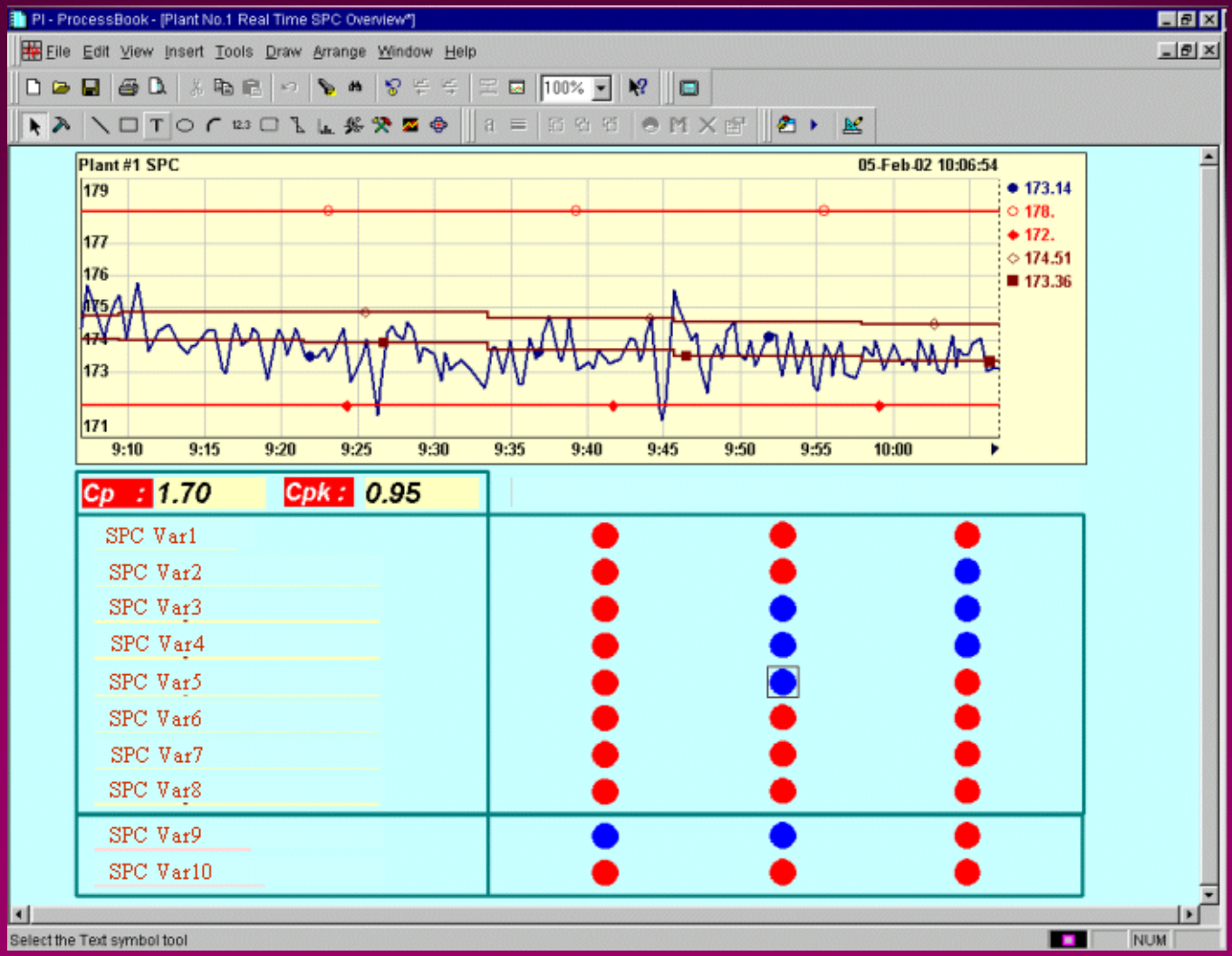
Key Performance Index

- Production Performance Index
  - Productivity Index
  - Raw Material Index
  - Utility Index
  - Production Rate Analysis
- **Operation Performance Index**
  - **Real Time ISO Spec Monitoring**
  - **ISO Daily Report**
  - **Integrated ISO & SPC**
- Equipment Performance Index
  - Critical Equipment Operated Time
  - Compressor Performance
  - Heat Exchanger Performance

Real Time ISO Spec Monitoring

USIFE's Data

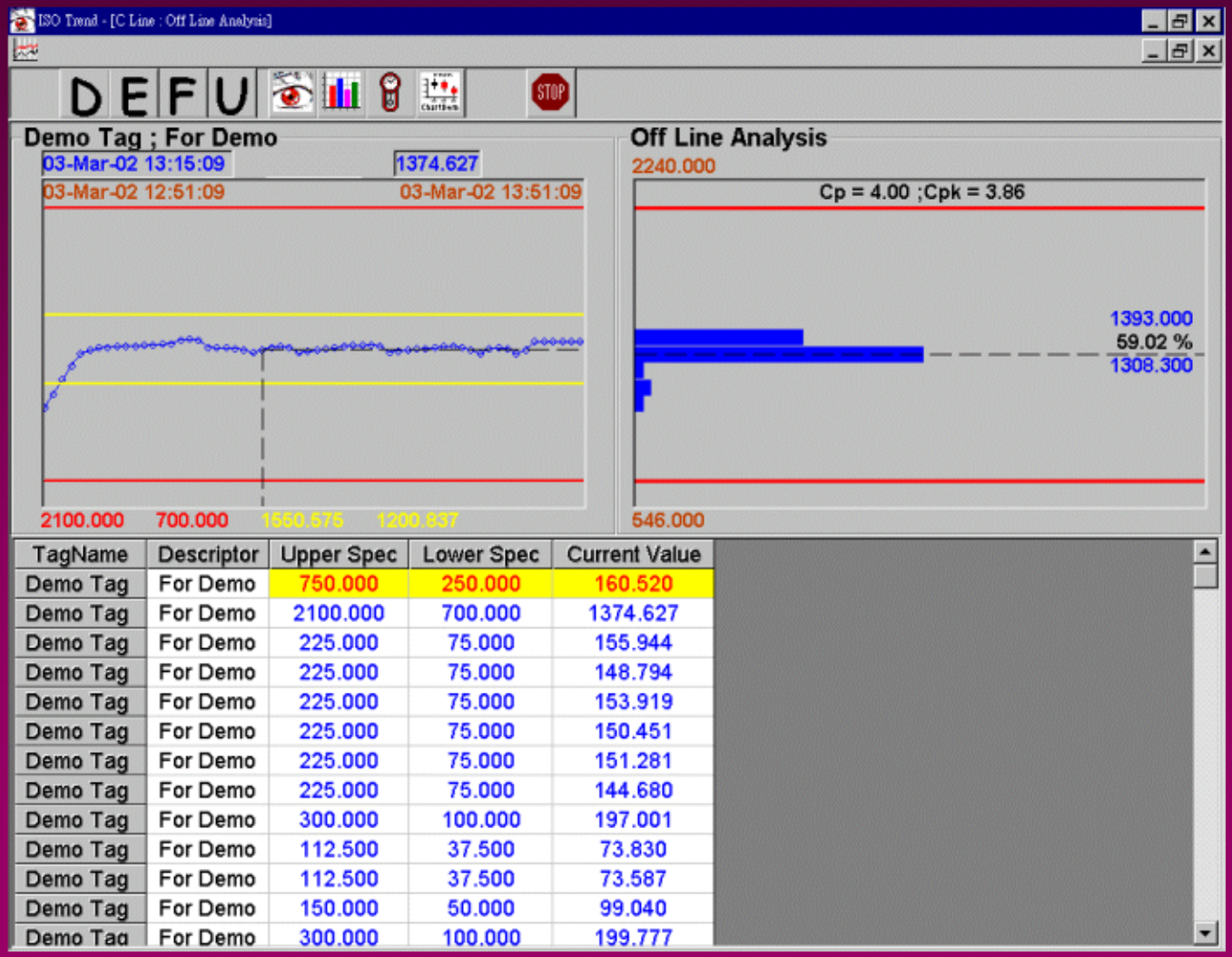
Real-Time SPC for Operator



ISO Daily Report

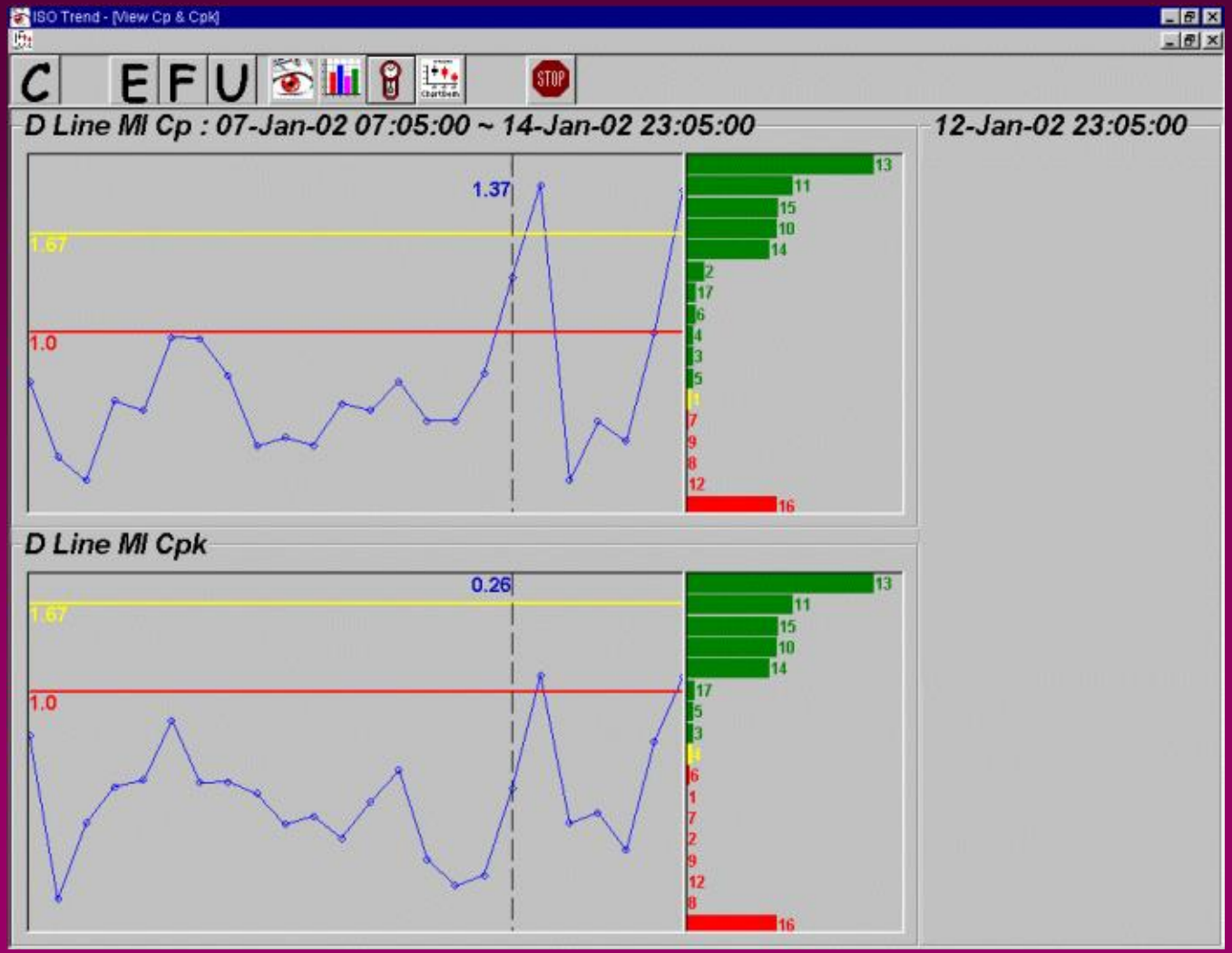
USIFE's Data

Integrated ISO & SPC

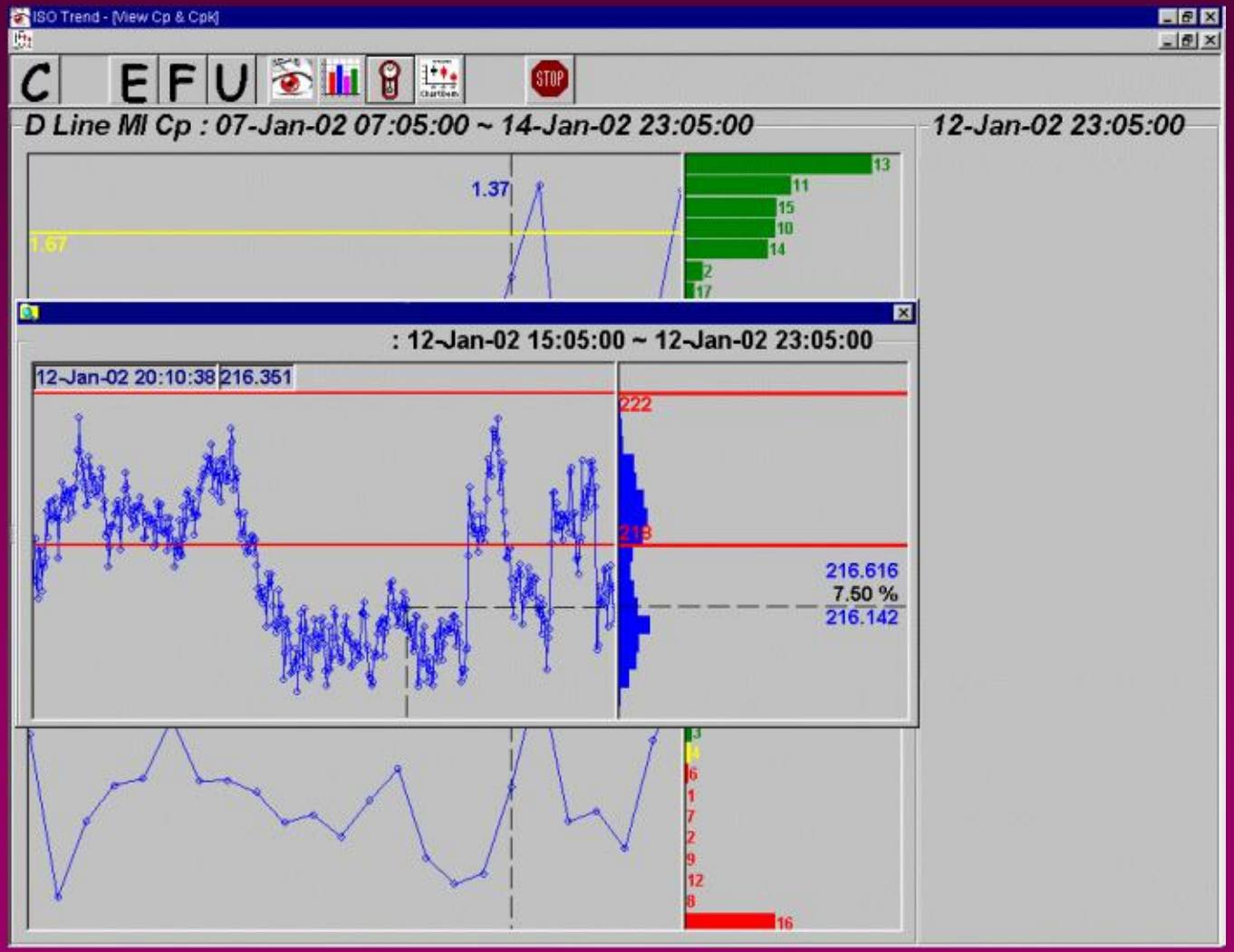


TagName	Descriptor	Upper Spec	Lower Spec	Current Value
Demo Tag	For Demo	750.000	250.000	160.520
Demo Tag	For Demo	2100.000	700.000	1374.627
Demo Tag	For Demo	225.000	75.000	155.944
Demo Tag	For Demo	225.000	75.000	148.794
Demo Tag	For Demo	225.000	75.000	153.919
Demo Tag	For Demo	225.000	75.000	150.451
Demo Tag	For Demo	225.000	75.000	151.281
Demo Tag	For Demo	225.000	75.000	144.680
Demo Tag	For Demo	300.000	100.000	197.001
Demo Tag	For Demo	112.500	37.500	73.830
Demo Tag	For Demo	112.500	37.500	73.587
Demo Tag	For Demo	150.000	50.000	99.040
Demo Tag	For Demo	300.000	100.000	199.777

Analyzing Process Capacity



Analyzing Process Capacity



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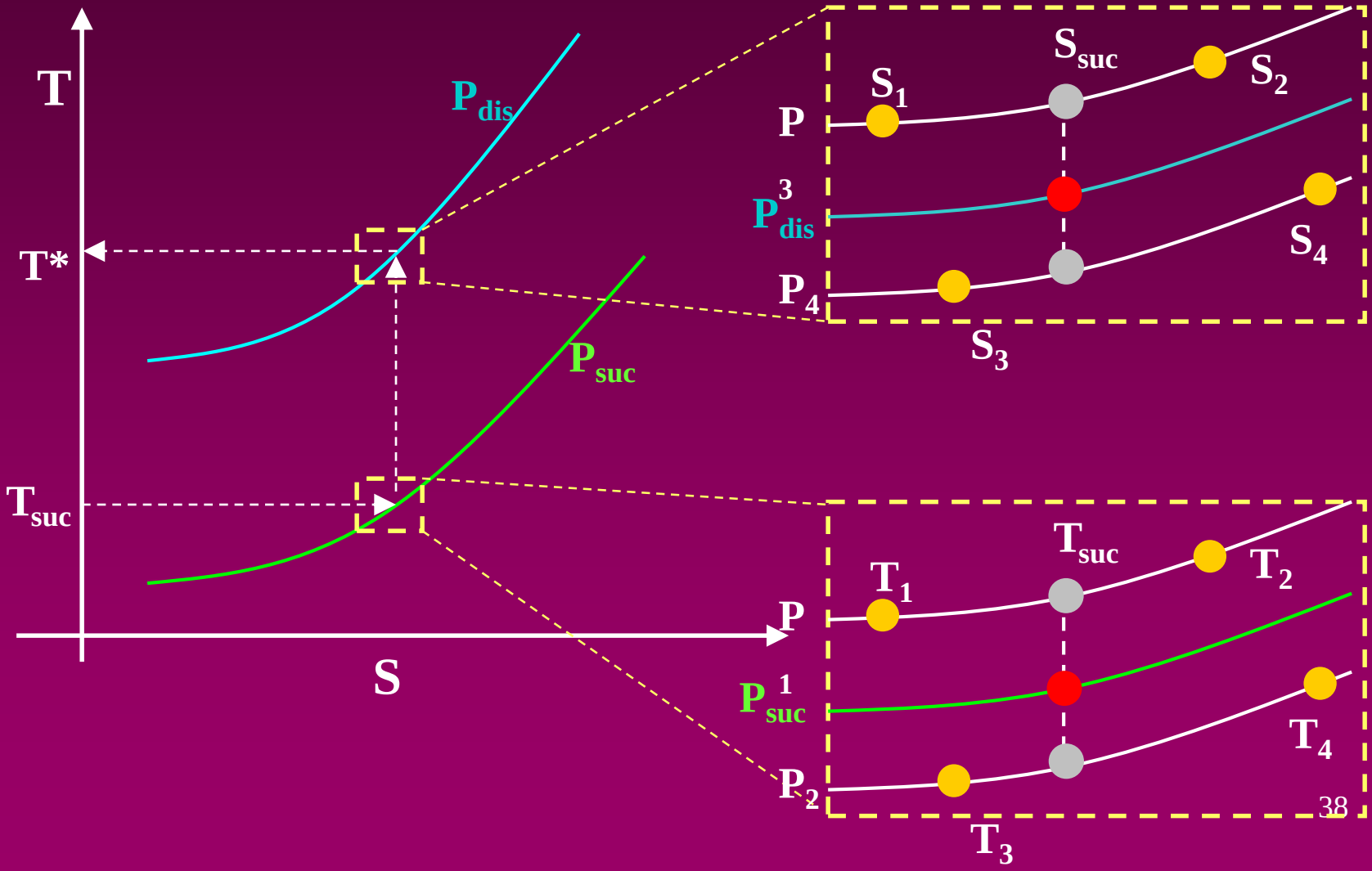
- **Equipment Performance Index**
  - **Critical Equipment Operated Time**
  - **Compressor Performance**
  - **Heat Exchanger Performance**

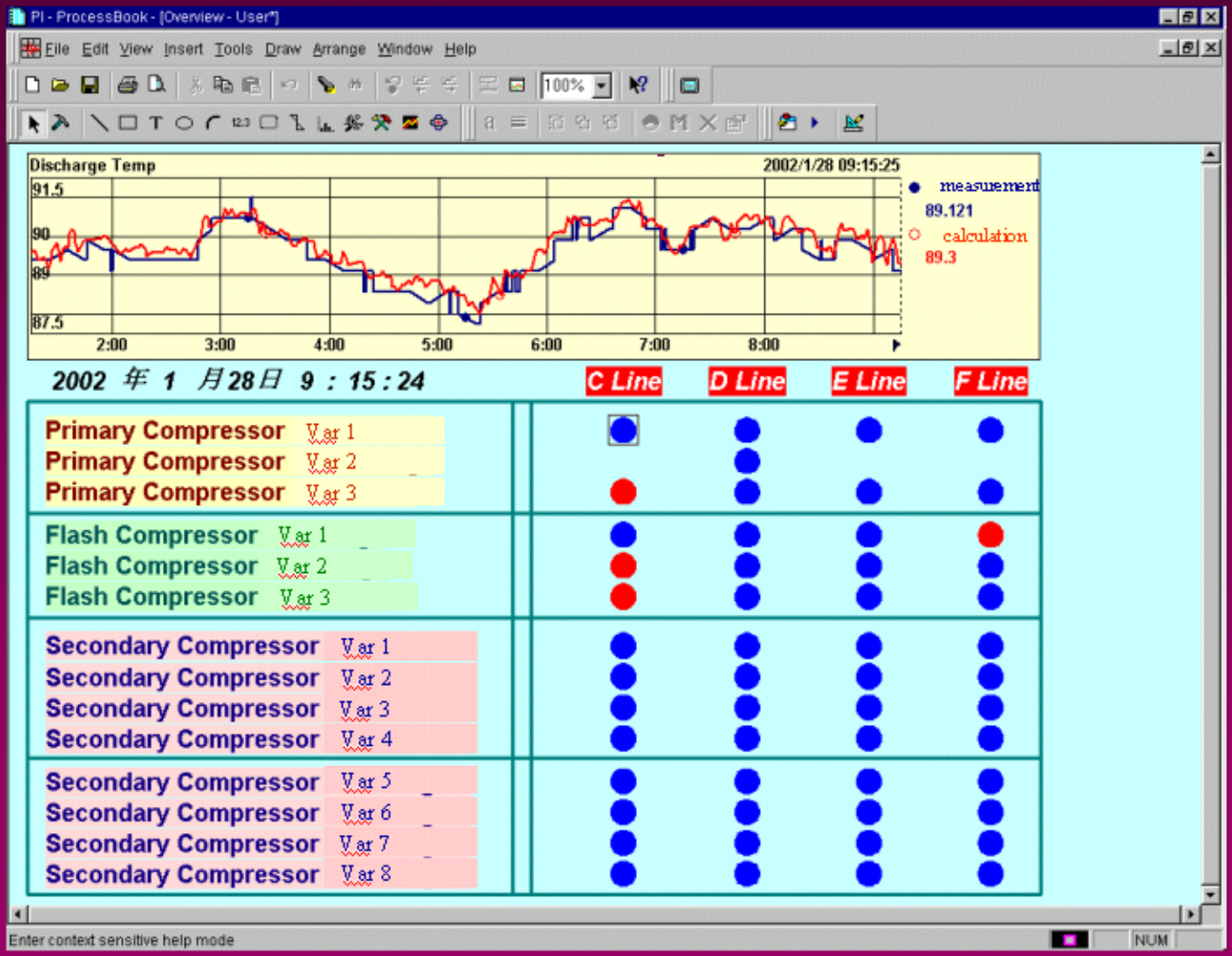
Critical Equipment Operated Time

USIFE's Data

Adiabatic & Reversible Process



Compressor Performance Display



Calibrating Bias

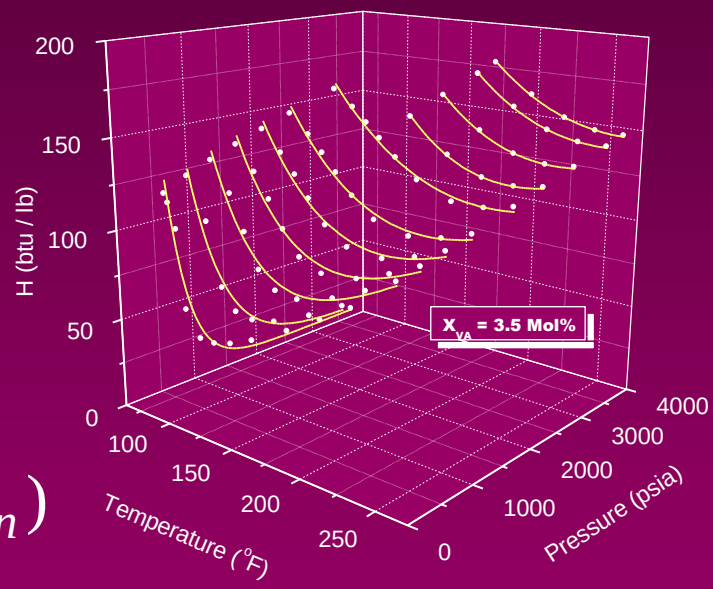
USIFE's Data

Heat Transfer Coefficient

Reactant Stream Temperature Known

$$q = UA(LMTD) = (H_{C2,out} - H_{C2,in})$$

$$UA = \frac{(H_{C2,out} - H_{C2,in})}{(LMTD)}$$



Cooling Water Temperature Known

$$q = UA(LMTD) = (H_{Water,out} - H_{Water,in})$$

$$UA = \frac{(H_{Water,out} - H_{Water,in})}{(LMTD)}$$

Heat Exchanger Performance

USIFE's Data

Summary

- Data infrastructure provide the powerful management tool for supervisor.
- Operator have to concern not only “Safety Alarm”, but also “Quality Alarm”.
- When the performance can be defined and evaluated, there is some way to control it.

Any Question ?