CCC Overview

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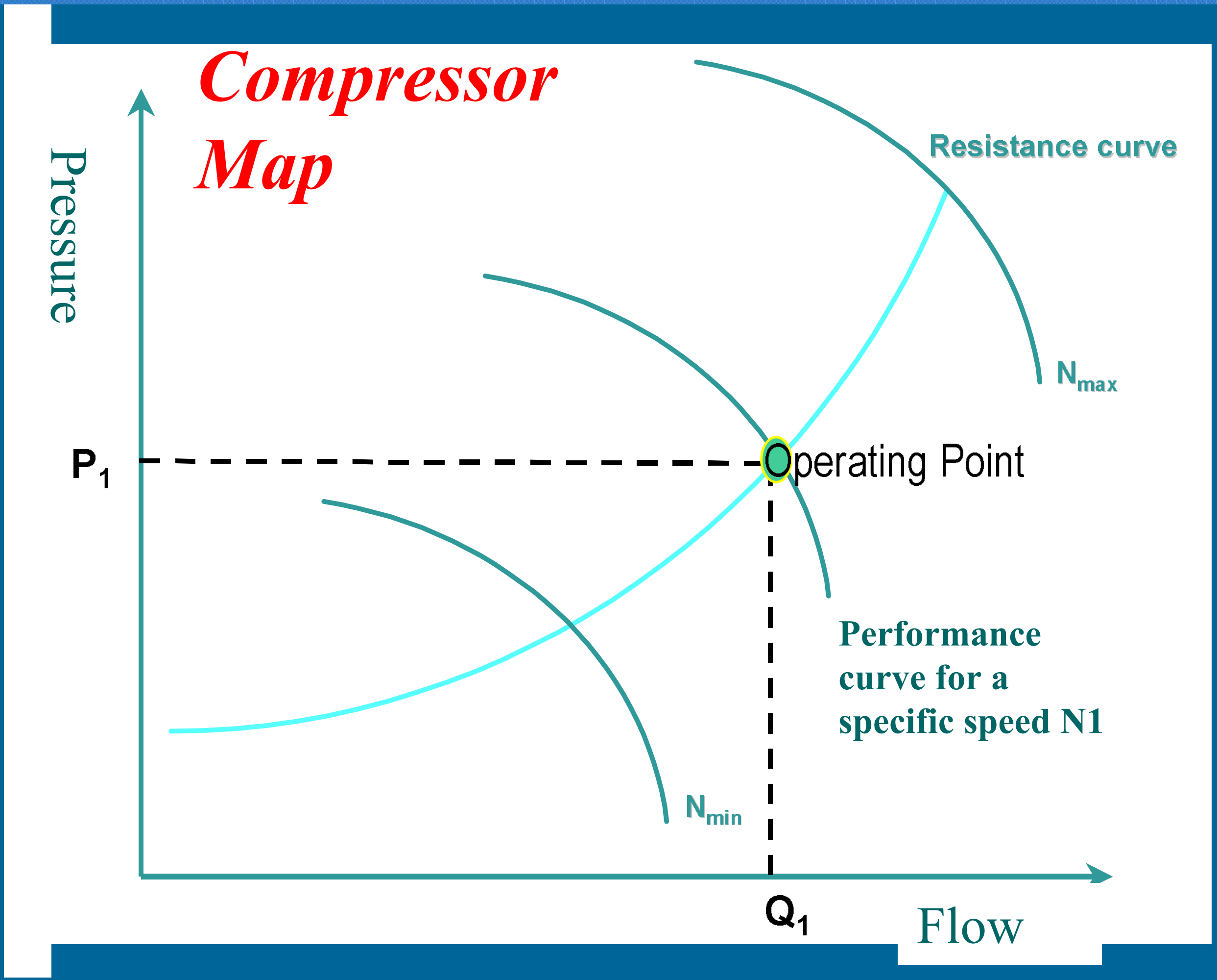
Presentation Overview

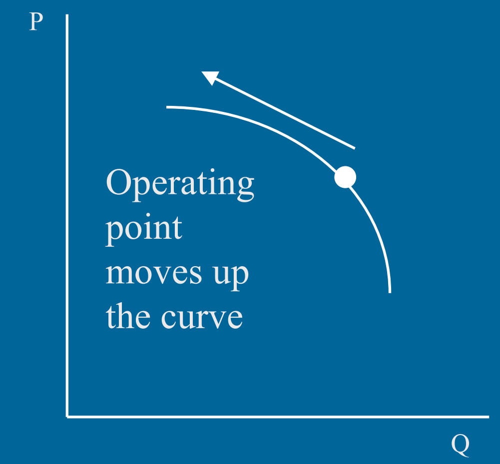
- What is surge?
- How does CCC control surge?
  - Deviation, Recycle Fast & Safety-On
- What is a Performance Controller?
  - Temp track & limit control
- CCC System Alarms

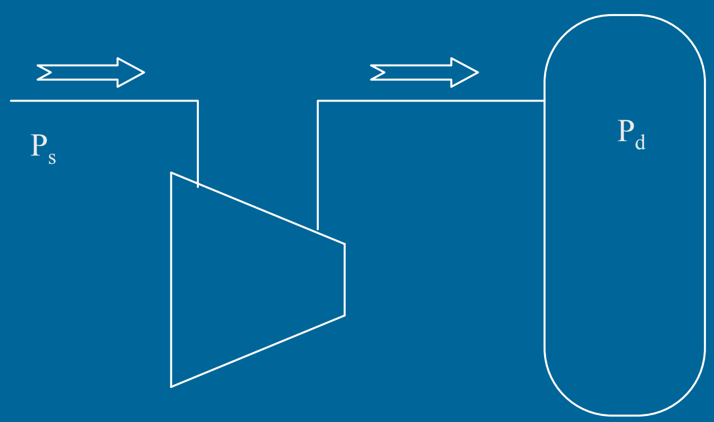
What is surge?



What is surge?

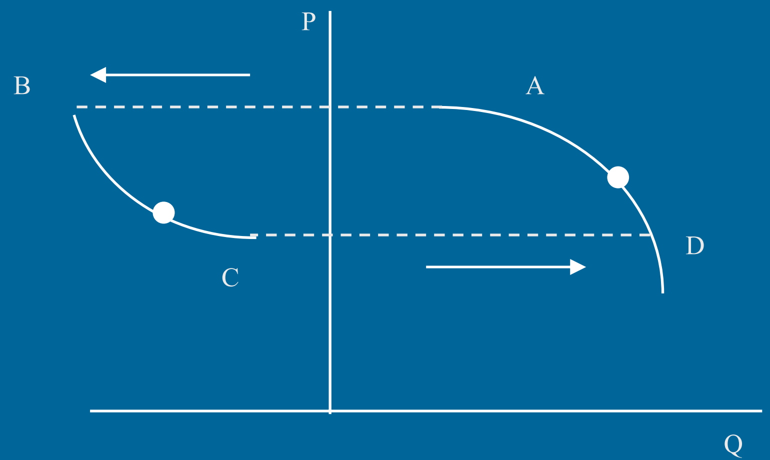
- P_d rises
- delta-P across compressor rises
- Compressor loses ability to make pressure



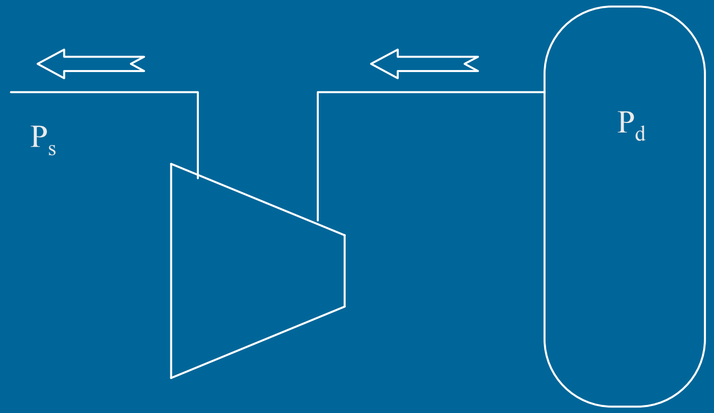


What is surge?

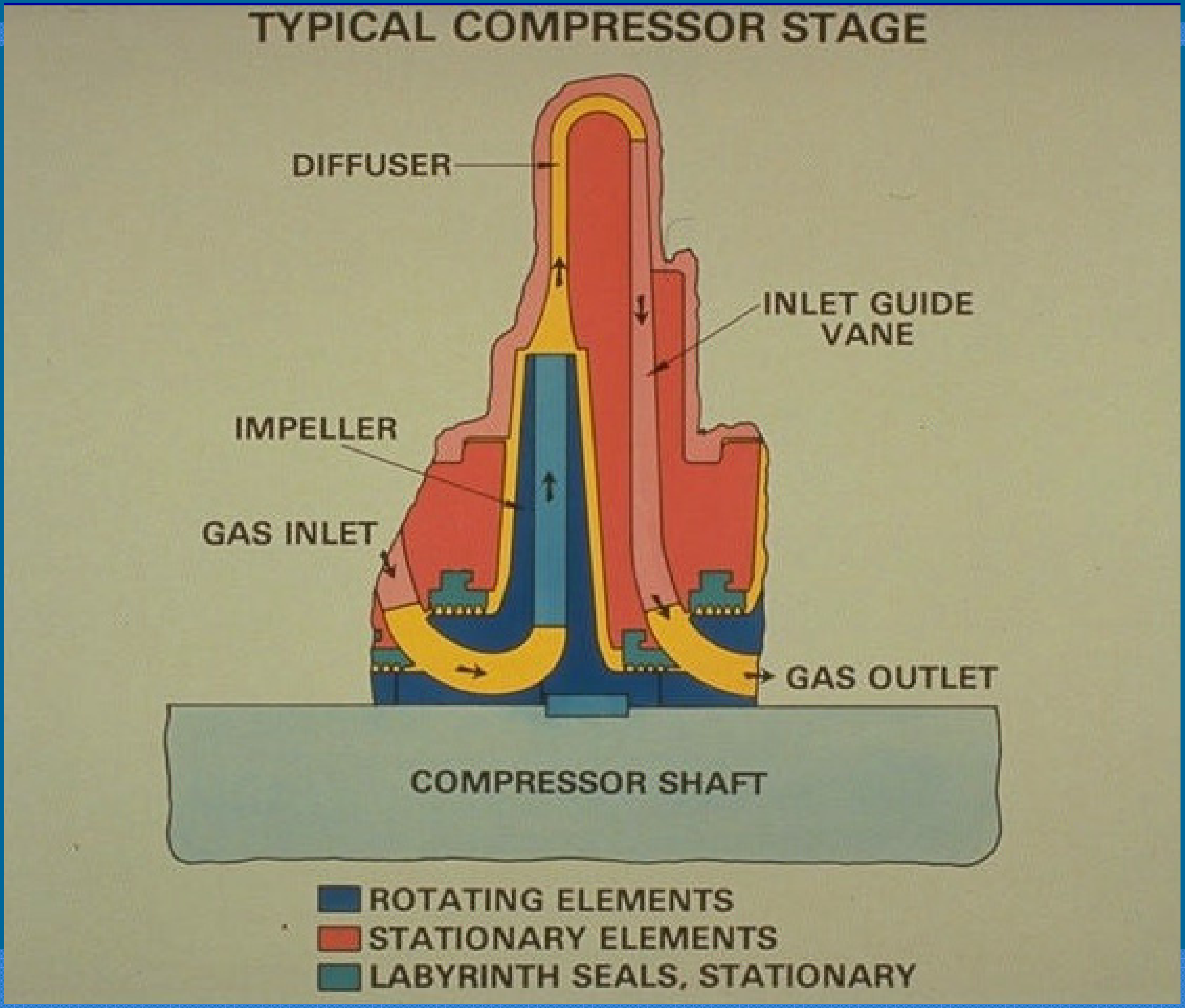
- Flow reverses
- delta-P across compressor drops
- Compressor moves back to stable region
- Cycle starts again...



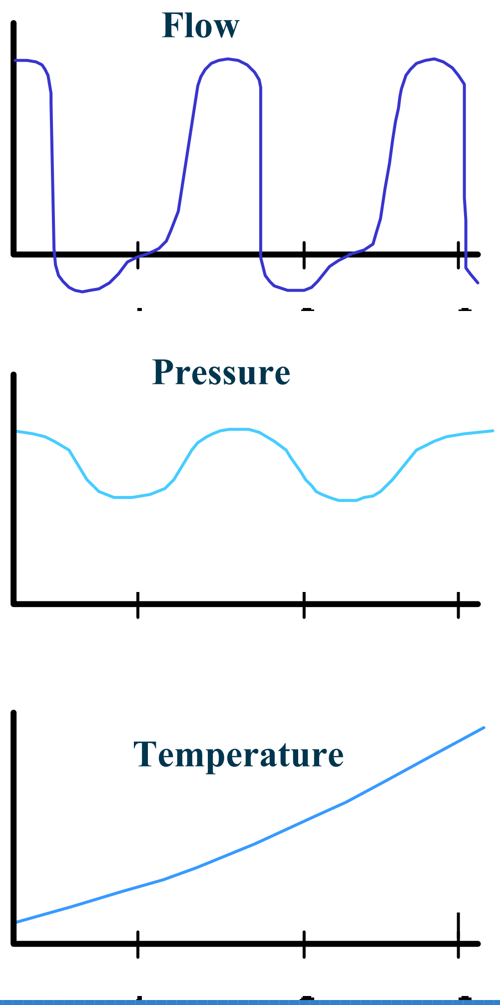
Operating point 'jumps' from +ve and -ve flow



What is surge?



What is surge?



- Rapid flow swings
- Thrust reversals

- Rapid pressure swings & instability

- Rising temps inside compressor

What factors lead to surge?

- Start-up / Shutdown
- Reduced throughput
- Abnormal conditions

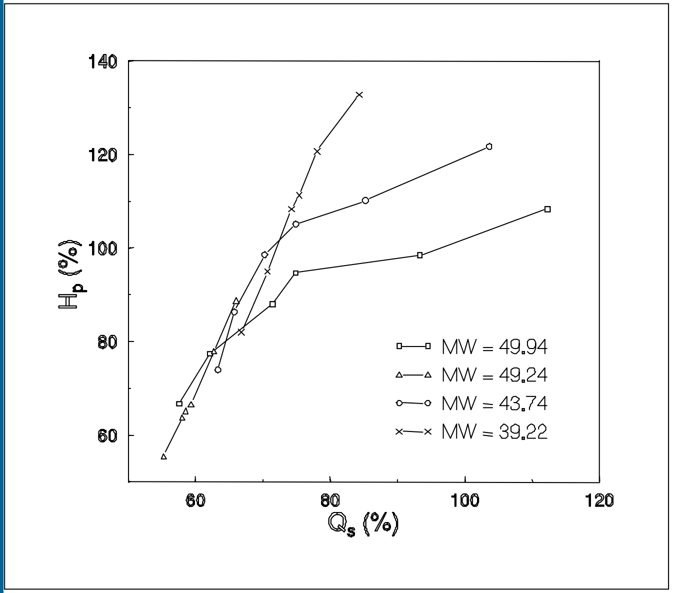
  Trips
  Power loss
  Load changes
  Cooler problems
  Turbine problems
  Operator error
  Process Upsets
  Gas composition changes
  Filter / strainer problems

How does CCC control surge?

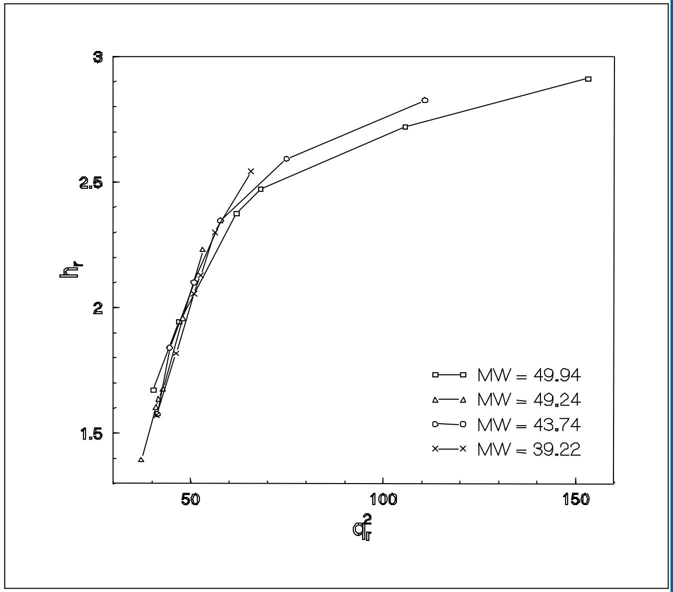
- The Challenge
  - Most efficient operating point is just before you reach surge. How do you measure your proximity to surge accurately so we can run as close as possible to the surge limit?
- The Solution
  - Invent a number called ‘deviation’ that is only dependent on flow / pressure / temperature

How does CCC control surge?

Most OEM head-flow curves are dependent on many factors e.g. Molecular Weight



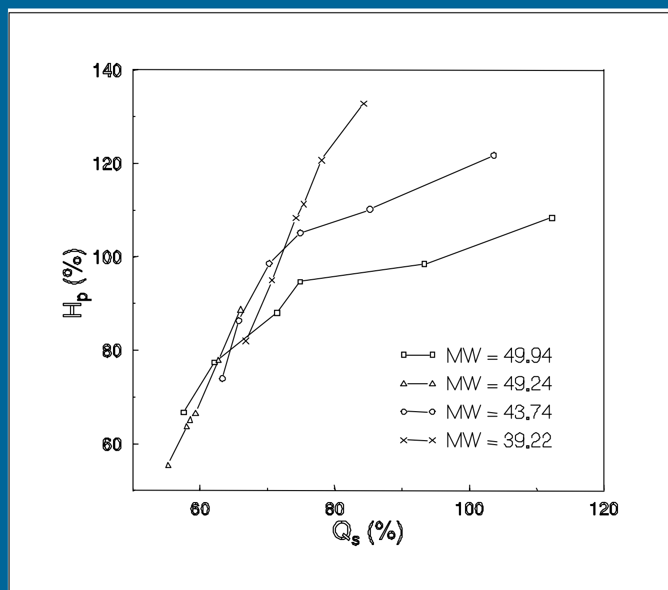
Vendor head-flow curves



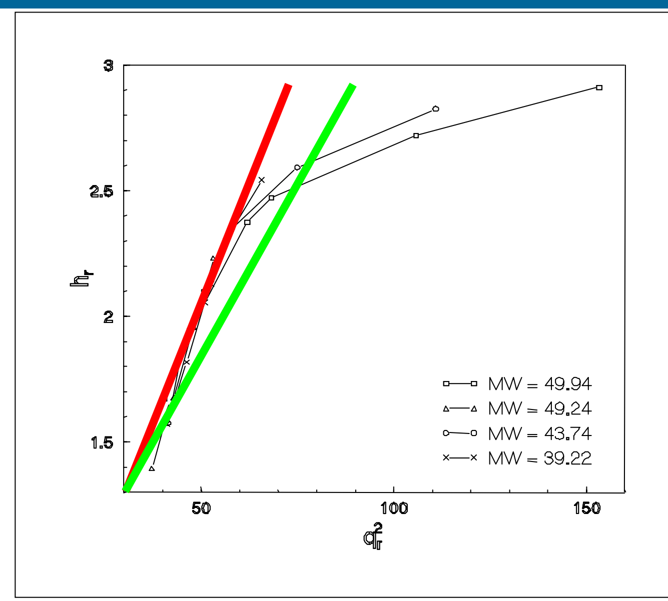
Reduced head-flow curves

How does CCC control surge?

By using reduced (standardised) values the Surge-Limit-Line and Surge-Control-Line can be defined



Vendor head-flow curves



Reduced head-flow curves

How does CCC control surge?

- DEVIATION
  - Arbitrary number that says how far from the Surge Control Line we are operating
  - Dev = 0 when on the control line
  - Dev = +ve when moving away from surge
  - Dev = -ve when moving towards surge
  - Ranged from -1 to +1

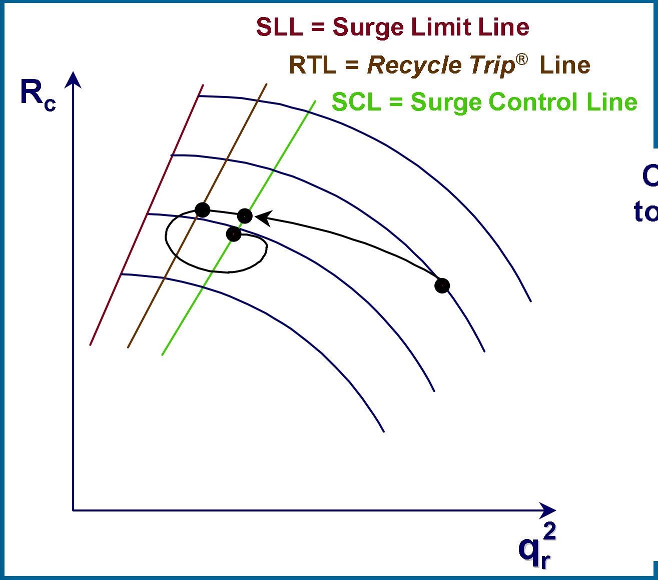
How does CCC control surge?

- Control Scheme
  - If Dev > 0, close recycle valve
  - If Dev < 0, open recycle valve

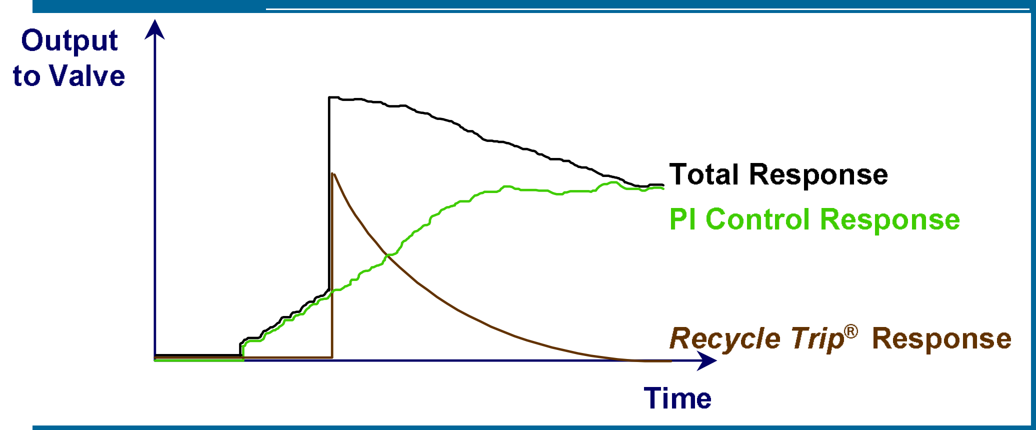
  - Normal PI control, just like any other loop

How does CCC control surge?

- Recycle Fast
  - If deviation moves quickly towards surge, CCC gives the valve a 'kick'

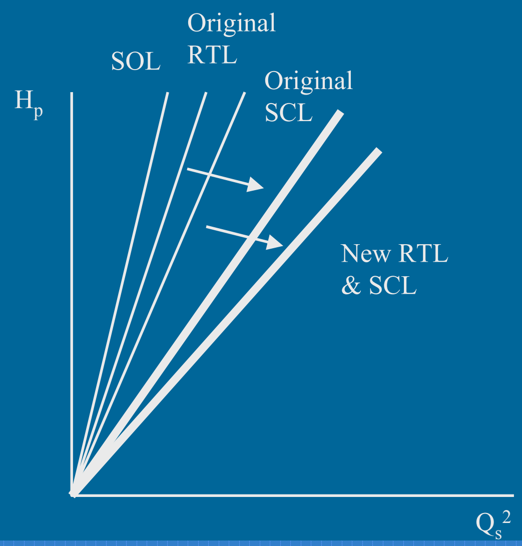


* Holds the last value for 2.5 sec!



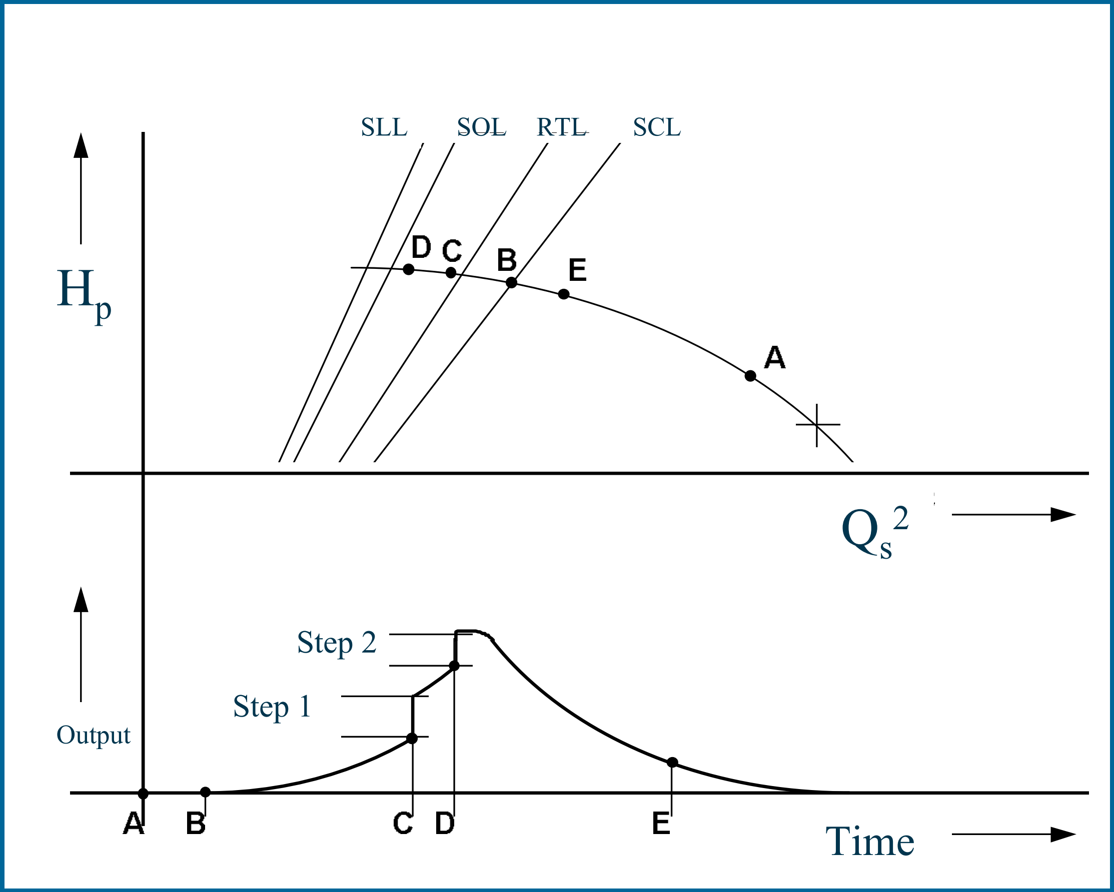
How does CCC control surge?

- Safety-On
  - Compressor has surged or a very low deviation
  - *No additional valve response*
  - Moves the Surge Control Line further to the right

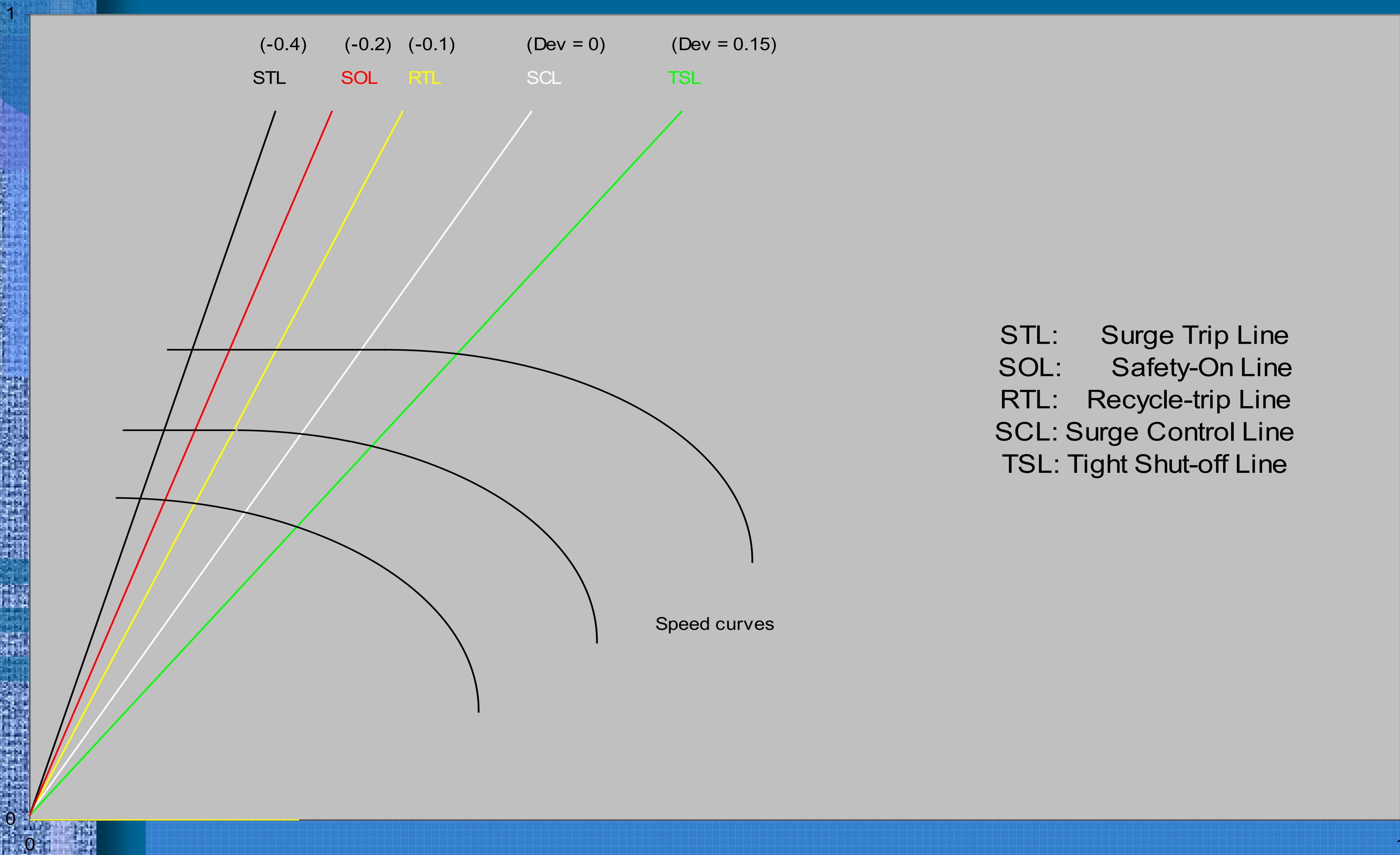


How does CCC control surge?

- Typical response:



CCC Control Points



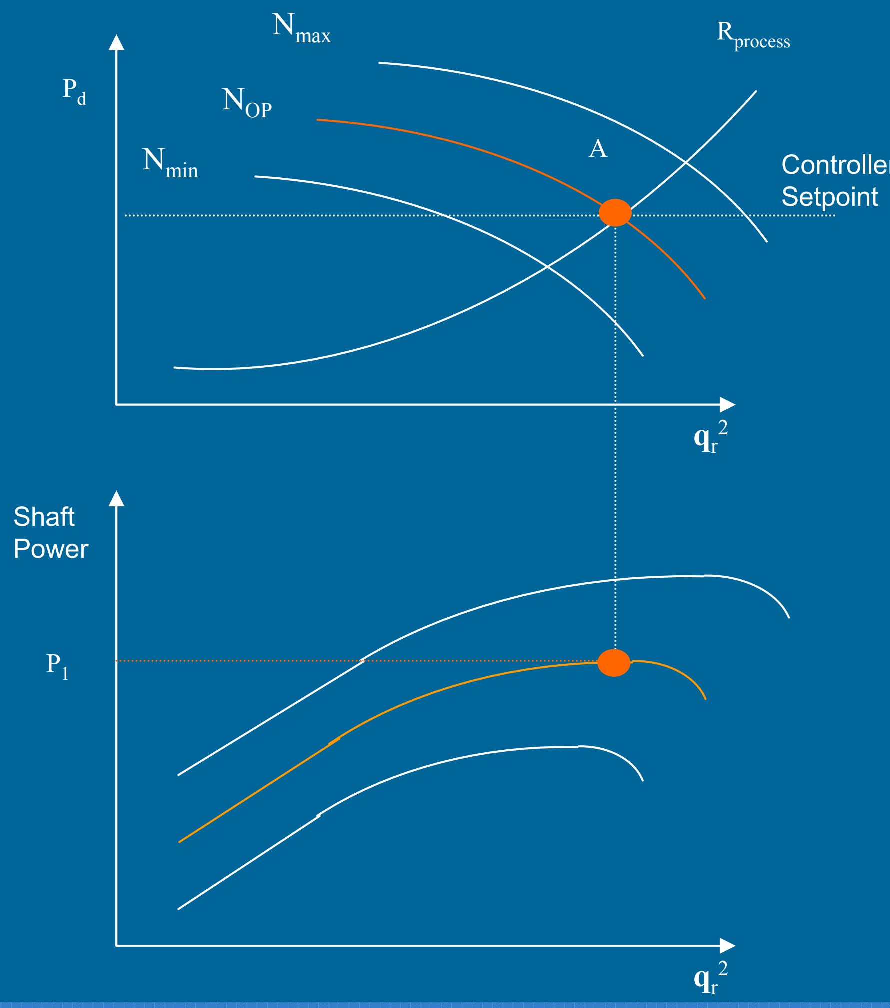
CCC Control - Summary

- Tight-shutoff line (Dev ~ 0.15)
  - Valve is clamped down onto seat, low risk of surge
- Surge-Control line (Dev = 0)
  - PID control of valve at dev = 0
- Recycle-trip line (Dev ~ -0.1)
  - Steps open valve about 10 - 15%
  - Holds the valve for about 2.5s
  - Poor response of valve can lead to trip!!
- Safety-On line (Dev ~ -0.2)
  - Moves all lines to the right & increments surge count
  - Valve steps open due to PID response
- Surge Trip line (Dev ~ -0.4)
  - Would expect compressor to be surging
  - 3 surges in 6 seconds will trip compressor

Performance Controller

- Used to control compressor throughput
  - blow-off
    - used more for plant air systems
  - discharge throttling
    - inefficient
  - suction throttling
    - often used on electric-drive compressors
  - compressor guide-vane control
    - efficient
  - speed variation
    - Used in Domgas & LNG

Performance Controller

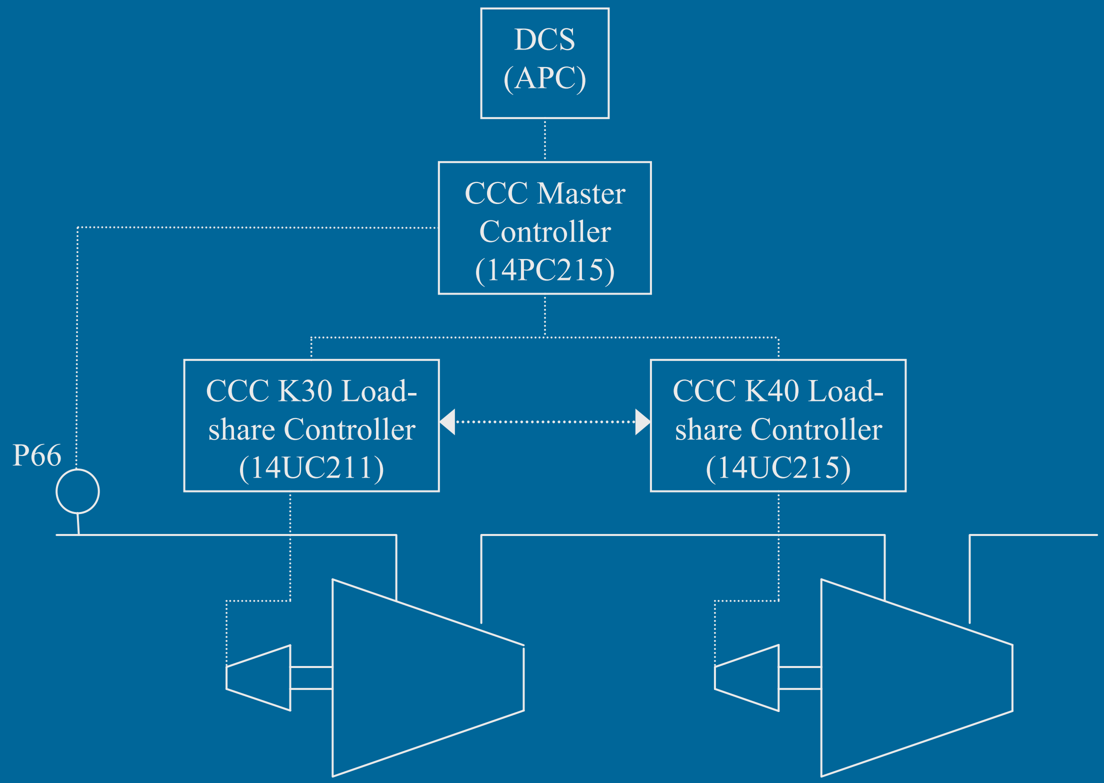


Performance Controller

- Limit Control
  - Ensures a physical constraint is not exceeded. E.g:
    - Pd max of 2350kPa on K1440 discharge
- Temp tracking:
  - Mark IV or V may limit on EGT
  - CCC designed to 'track' speed
    - provides bumpless transfer back to CCC control
  - Historically, has provided problems
    - Incorrectly tuned

Load Sharing

- Regulate capacity & maximise efficiency
- Provides control of a network



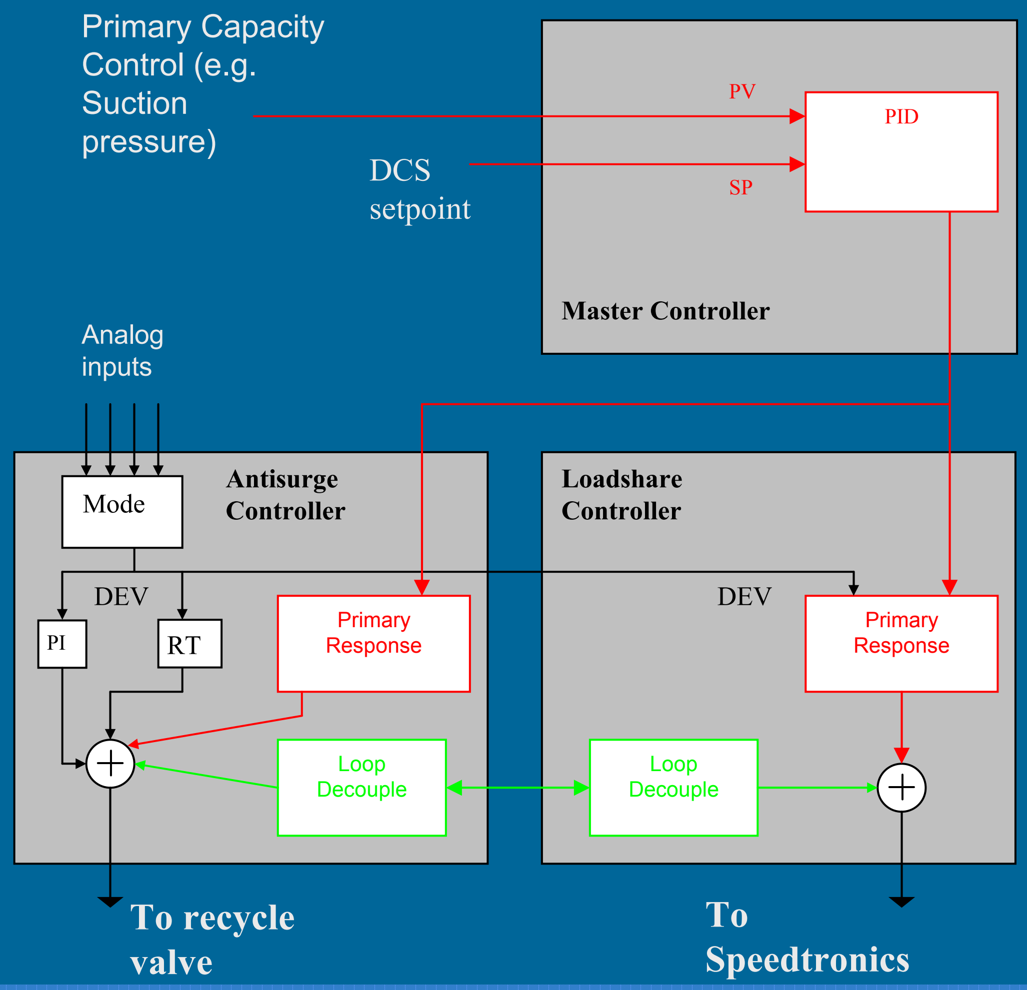
Load Sharing

- Comprises of two types of response:
  - Primary Capacity Control
    - Manipulates a variable by adjusting speed / recycle
      - e.g. Suction pressure on K30
    - ‘visible’ load-sharing response
  - Load-balancing
    - Ensures both compressors operate in the same region
      - I.e. minimise un-necessary recycle
    - De-couples response of the anti-surge & performance controllers

Load Balancing

- Equidistant control
  - Compressors in series
    - Equalise normalised compression ratio
    - Used on LNG MR and C3 circuits
  - Compressors in parallel
    - Equalise recycle deviation
    - Used on Domgas K30
    - Note: Domgas K20 load-sharing performed in DCS

Loadsharing control scheme



CCC System Alarms

- Historically, not much information available on DCS
  - Application faults & hardware faults only
- New alarms utilise graphics to display origin of a fault
  - Any CCC alarm should be referred back to the graphic

CCC System Alarms

- Tag convention

XCC 04 1 1 A

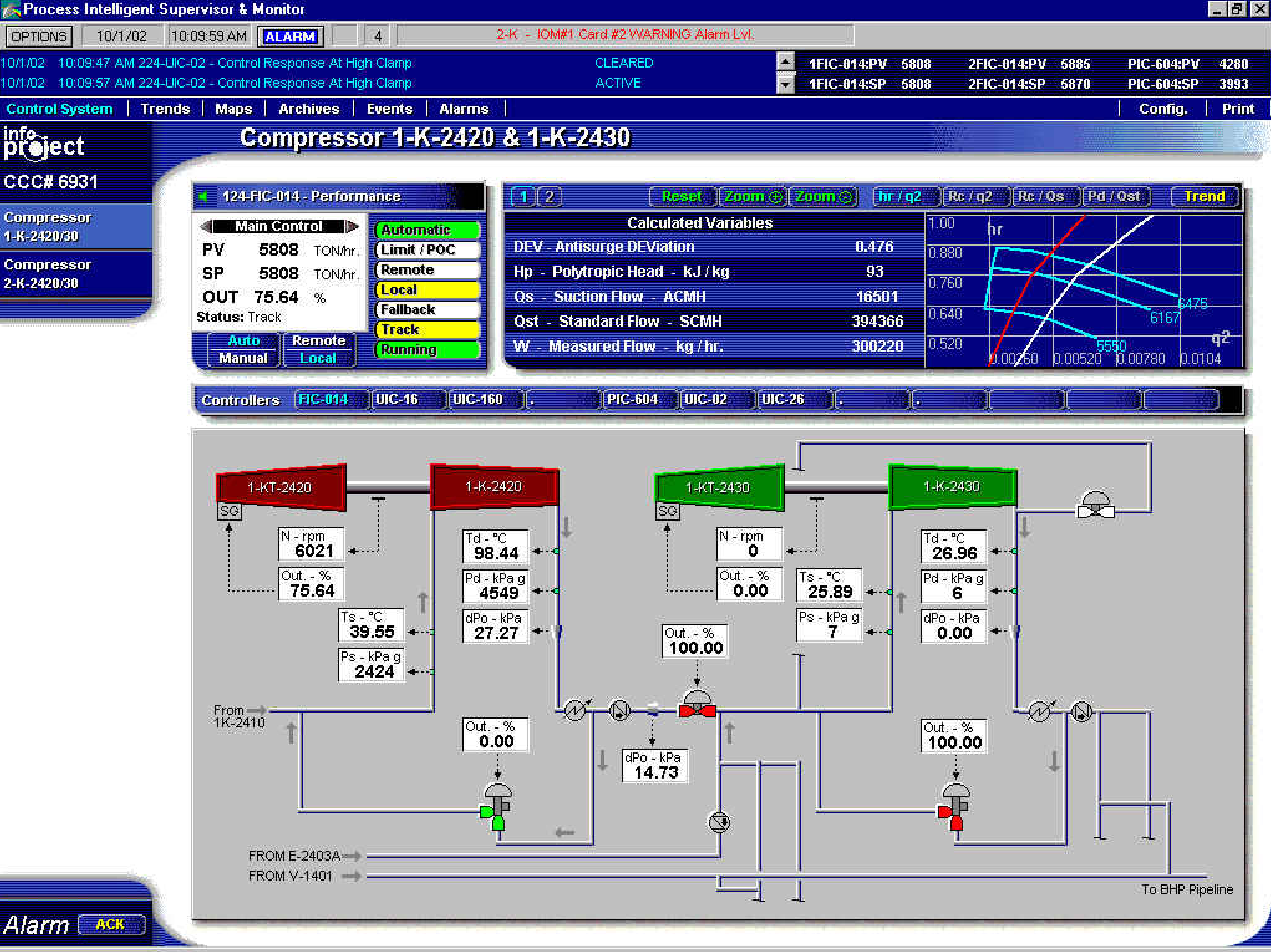
- **XCC** – CCC System Alarm
- **04** – FAR #
- **1** – Cabinet #
- **1** – Card #
- **A** – Tag Type descriptor

How does CCC send alarms?

- Any event causes an alarm
  - Each alarm has a criticality and location
  - Hit the 'acknowledge' target on the graphic
    - If the alarm goes away, the fault has cleared
    - The criticality will remain until an Inlec has investigated
      - Most alarms require no further action apart from a workorder
    - New faults will now be able to initiate the alarm
  - Application faults have a 'look-up' table
  - Refer to the Control Instructions for more info!

Fallback Alarm

- This alarm means CCC has lost the ability to control
  - e.g. lost both flow transmitters
- Response:
  - Recycle valve opened in manual to approx 50%
    - exact amount depends on the controller setting
      - minimum flow required to stay out of surge for all conditions
  - Performance controller goes to manual at last OP


Process Intelligent Supervisor & Monitor
OPTIONS
10/1/02
10:09:59 AM
ALARM
4
2-K - IOM#1 Card #2 WARNING Alarm Lvl.
10/1/02 10:09:47 AM 224-UIC-02 - Control Response At High Clamp CLEARED
10/1/02 10:09:57 AM 224-UIC-02 - Control Response At High Clamp ACTIVE
1FIC-014:PV 5808
1FIC-014:SP 5808
2FIC-014:PV 5885
2FIC-014:SP 5870
PIC-604:PV 4280
PIC-604:SP 3993
Control System
Trends
Maps
Archives
Events
Alarms
Config.
Print
info project
CCC# 6931
Compressor 1-K-2420/30
Compressor 2-K-2420/30
Compressor 1-K-2420 & 1-K-2430
124-FIC-014 - Performance
Main Control
PV 5808 TON/hr.
SP 5808 TON/hr.
OUT 75.64 %
Status: Track
Auto
Manual
Remote
Local
Automatic
Limit / POC
Remote
Local
Fallback
Track
Running
1
2
Reset
Zoom
Zoom
hr / q2
Rc / q2
Rc / Qs
Pd / Qst
Trend
Calculated Variables
DEV - Antisurge DEViation 0.476
Hp - Polytropic Head - kJ / kg 93
Qs - Suction Flow - ACMH 16501
Qst - Standard Flow - SCMH 394366
W - Measured Flow - kg / hr. 300220
1.00
0.880
0.760
0.640
0.520
hr
6475
6167
5550
q2
0.00260
0.00520
0.00780
0.0104
Controllers
FIC-014
UIC-16
UIC-160
PIC-604
UIC-02
UIC-26
1-KT-2420
1-K-2420
1-KT-2430
1-K-2430
SG
SG
N - rpm 6021
Out. - % 75.64
Ts - °C 39.55
Ps - kPa g 2424
Td - °C 98.44
Pd - kPa g 4549
dPo - kPa 27.27
Out. - % 0.00
From 1K-2410
N - rpm 0
Out. - % 0.00
Out. - % 100.00
dPo - kPa 14.73
Ts - °C 25.89
Ps - kPa g 7
Td - °C 26.96
Pd - kPa g 6
dPo - kPa 0.00
Out. - % 100.00
FROM E-2403A
FROM V-1401
To BHP Pipeline
Alarm
ACK

Process Intelligent Supervisor & Monitor

OPTIONS | 10/1/02 | 10:09:04 AM | ALARM | | 4 | 2-K - IOM#1 Card #2 WARNING Alarm Lvl.

10/1/02 10:08:54 AM 124-FIC-014 - Performance Controller Status TRACKING
10/1/02 10:08:56 AM 224-UIC-02 - Control Response At High Clamp ACTIVE

1FIC-014:PV	5797	2FIC-014:PV	5892	PIC-604:PV	4285
1FIC-014:SP	5797	2FIC-014:SP	5870	PIC-604:SP	3993

Control System | Trends | Maps | Archives | Events | Alarms | Config. | Print

info project

CCC# 6931

Alarm Summary

1-K-2420, 1-K-2430, 2-K-2420, and 2-K-2430 - Summary Alarms

Down | Up | PrintAll | PrintVis | PrintSel

Date	Time	Status	Alarm Description	High Set	Low Set	Value	Prior	Ackn
9/17/02	2:22:29 PM		1-K - IOM#1 Card #1 WARNING Alarm Lvl.				4	2:22:35 PM
9/17/02	2:22:29 PM		1-K - IOM#1 Card #2 WARNING Alarm Lvl.				4	2:22:35 PM
9/19/02	9:44:38 AM		2-K - IOM#1 Card #1 WARNING Alarm Lvl.				4	2:21:53 PM
9/19/02	9:44:38 AM		2-K - IOM#1 Card #2 WARNING Alarm Lvl.				4	2:21:53 PM

Potential Active | Ackn | View | Param | Sort | Note | Close | ✔ Scroll

Alarm ACK