Setting the Standard for Automation™

ISA Symposium

Alarm Management & High Performance HMI

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League City

Standards
Certification
Education & Training
Publishing
Conferences & Exhibits

Agenda

- About the presenter and PAS
- Human Reliability
- Alarm Management
- High Performance HMI
- Questions

Presenter

- Human Machine Interface experience
- Alarm Management experience
- HMI Product Management
  - Software inception and development
  - Intellectual property
  - Path finding
  - Product integration

About PAS

- Founded in 1993
  - Operations Effectiveness
    - Alarm Management
    - High-Performance HMI
    - Control Loop Performance
  - Automation Effectiveness
    - Automation Systems Integrity
    - Disaster Recovery
    - Knowledge Retention/Collaboration
- Industry Organizations & Strategic Partners
  - Voting Member of the ISA18 committee
  - EPRI, ISA, API, AICHE, NPRA, EEMUA

Why Alarm Management & HP HMI?

To improve *human reliability* and enable *safe production*!

What is *human reliability*?

- Human reliability is related to human factors that help minimize human error and lead to optimum human performance.

How do we do it?

- We achieve this by aggregating, contextualizing and simplifying essential information and making it universally accessible and useful.

What is the benefit?

- Improved safety, reliability, productivity and knowledge retention.

Manufacturing Value

- **Alarms**
- **HMI**
- Control Loop

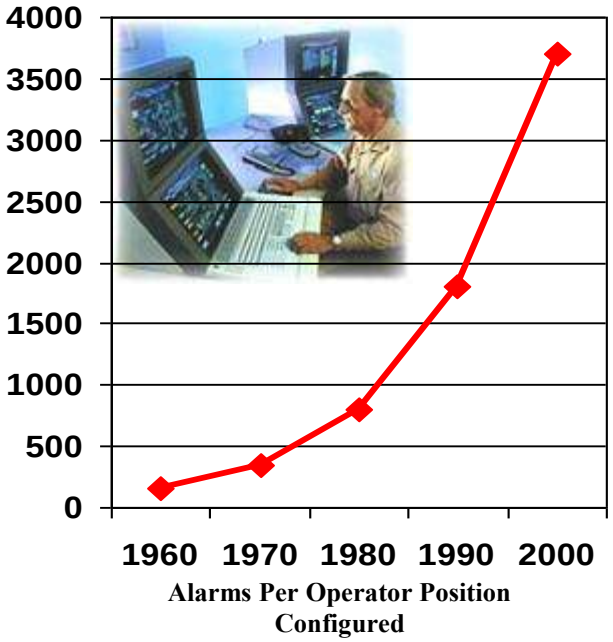
Profit

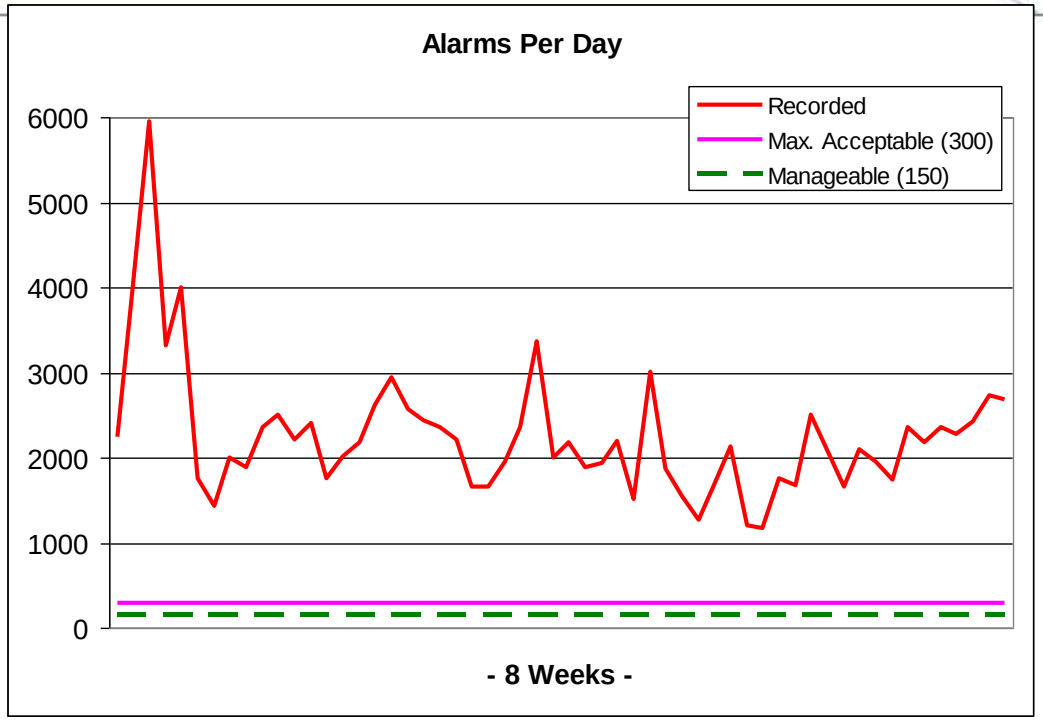
Purchasing → Inbound Logistics → Manufacturing → Outbound Logistics → Order Fulfillment

Outside of R&D, manufacturing is the only segment of a company's supply chain where value is added.

Manufacturing is the largest financial lever under a company's control.

Alarm Management





Thousands of Alarm Events Presented to the Operator!

Human Reliability: Do NOT miss the important alarm

Alarm Management – 7 steps

Step 1: Develop, Adopt and Maintain an Alarm Philosophy

Step 2: Collect Data And Benchmark Your Systems

Step 3: Perform "Bad Actor" Alarm Resolution

Step 4: Perform Alarm Documentation and Rationalization

Step 5: Implement Alarm Audit and Enforcement Technology

Step 6: Implement Real Time Alarm Management

Step 7: Control and Maintain Your Improved System

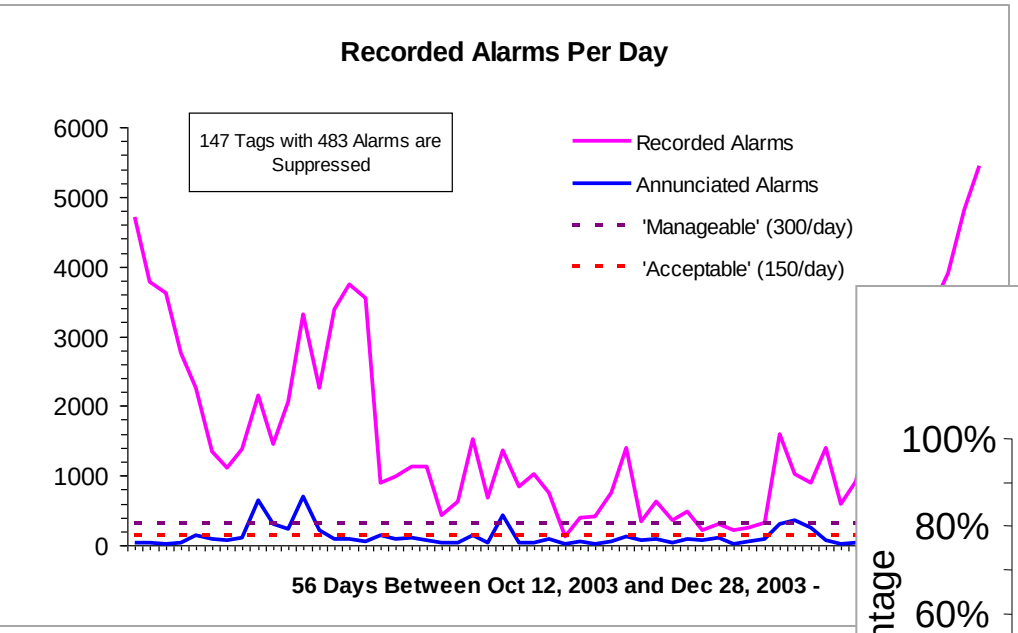
Step 1 – Alarm Philosophy

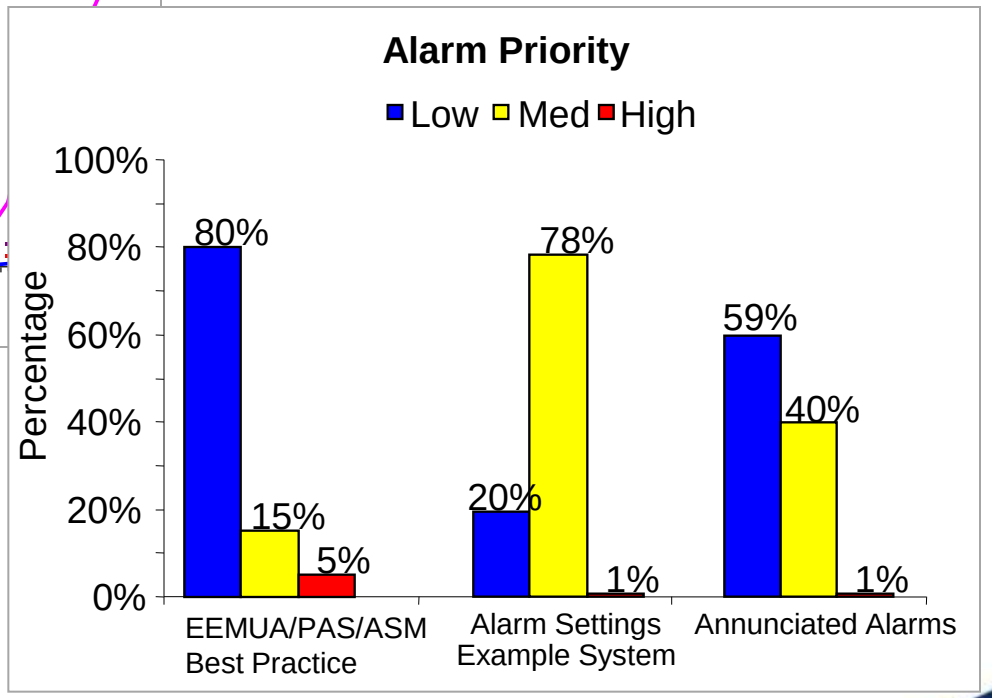
- Alarm Design Guideline Based on Best Practices
  - Alarm Selection – What is an alarm?
  - Priority determination & Distribution - Methodology
  - Configuration
  - KPIs
  - Nuisance Alarm Resolution
  - State Based Alarming
  - Alarm Shelving

Simplify access to accepted best practices

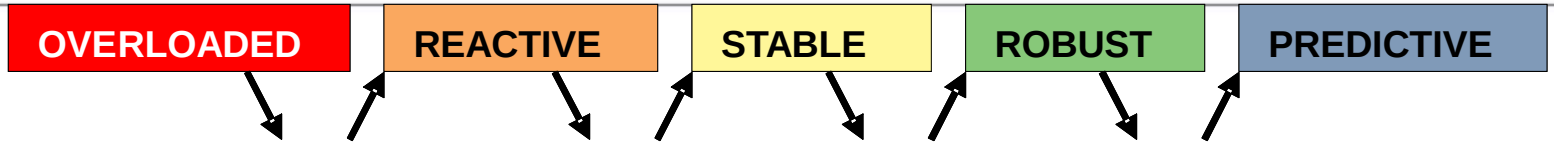
Step 2 - Benchmarking

- Is my Alarm system performing as per accepted best practices?





Benchmarking - Robust



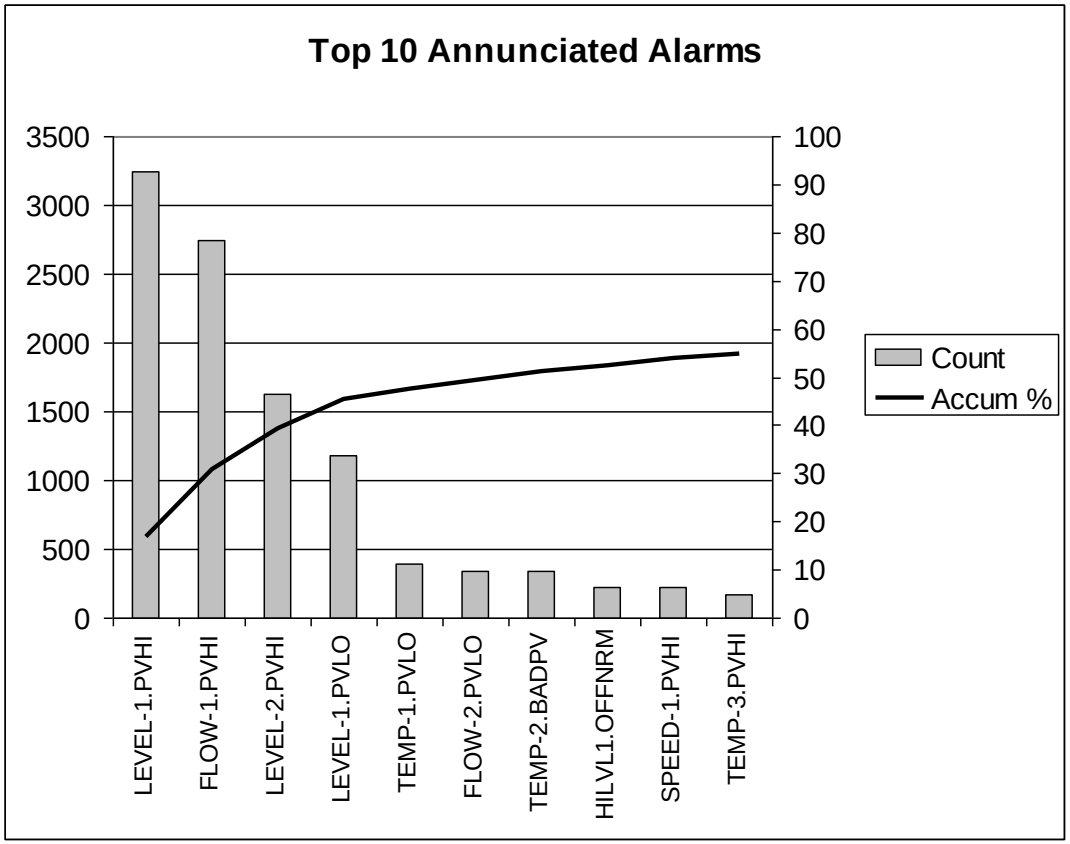
Improvement Plans : Specific Steps to move from each classification to the next.

- ROBUST: Average and the peak alarm rates are under control for foreseeable plant operating scenarios
  - Dynamic and state-based techniques used to improve the real time performance
  - Alarm system is reliable during all plant modes, including normal operation and plant upsets
  - Alarm system configuration is not subject to inadvertent change

Operators have a high degree of confidence in the alarm system, and have time to detect and understand all alarms.

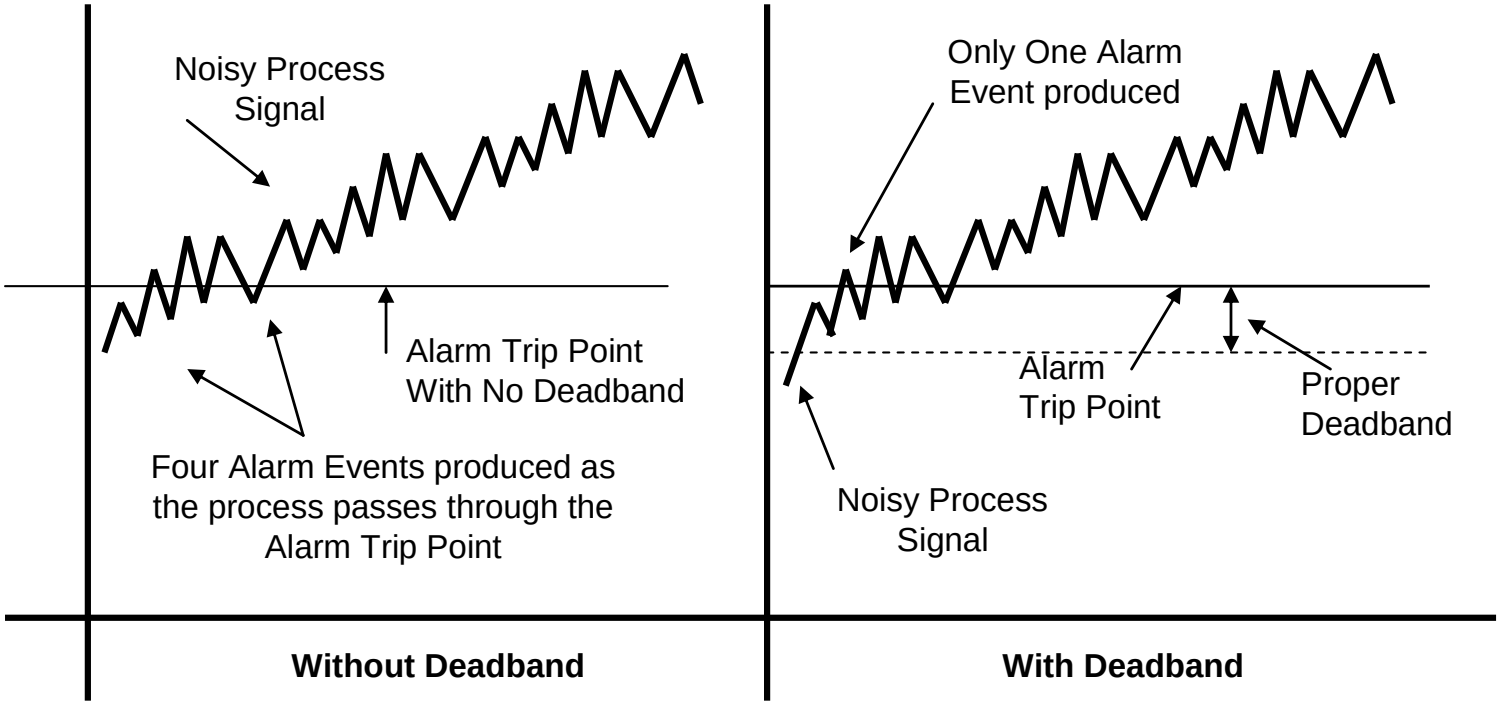
Step 3 – Bad Actor Resolution

- Bad Actor = Nuisance or meaningless alarms
  - Chattering alarms
  - Fleeting alarms
  - Stale alarms
  - Duplicate alarms
  - No Action alarms
- Correction Methods:
  - Dead Band
  - Time-Delay
  - PV Filtering
  - Alarm Shelving



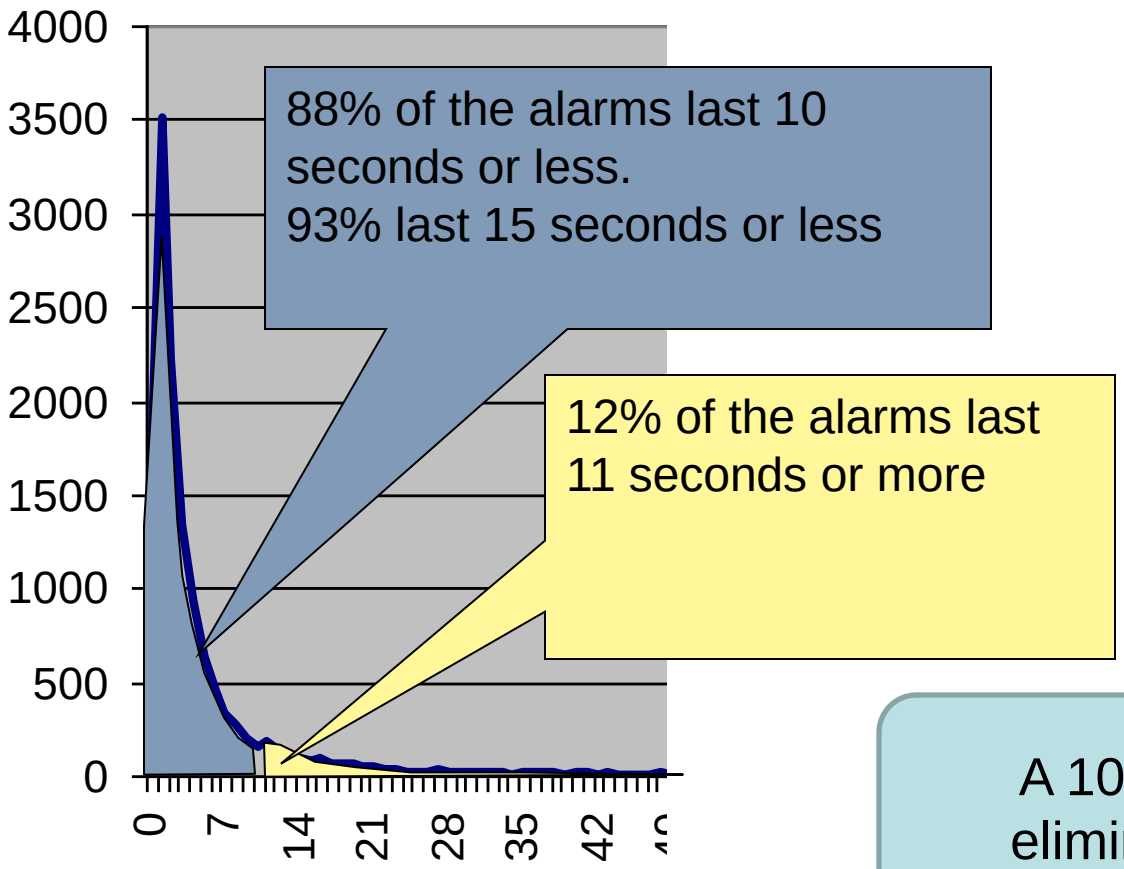
Deadband and Alarms

- EVERY analog alarm needs a deadband or it will chatter. All process signals have noise.



Alarm Reduction- ON-Delay

- The AREA UNDER THE CURVE totals 100% of the alarms:



A 10 second ON-Delay would eliminate 88% of these alarms

Step 4 – Alarm Documentation & Rationalization

- Evaluate Every Possible Alarm To Ensure Compliance with the Alarm Philosophy:
  - All Alarms Require Operator Action
  - Alarms are based on the best indicator of the root cause of an abnormal situation (and not duplicated)
  - All Alarms must be produced upon abnormal situations only, not from normal situations
  - Alarm Settings (not just trip points) are properly designed
  - Alarm Priorities are based on a sound and consistent methodology
  - Eliminate combination alarms

Priority Determination

Typical Grid-Based Priority Determination:

Impact Category	NONE	MINOR	MAJOR	SEVERE
Personnel	No injury or health effect	Alarms where operator action is the primary method by which harm to a person is avoided shall be configured at the highest DCS priority		
Public or Environment	No effect	Minimal exposure. No impact. Does not cross fence line. Contained release. Little, if any, clean up. Source eliminated. Negligible financial consequences.	Exposed to hazards that may cause injury. Hospitalizations and medical first aid possible. Damage Claims. Contamination causes some non-permanent damage.	Uncontained release of hazardous materials with major environmental impact and 3rd party impact. Exposed to life-threatening hazard. Disruption of basic services. Impact involving the community. Catastrophic property damage. Extensive cleanup measures and financial consequences.
Costs or Value of Production Loss	No loss	Event costing <$10,000, notification only at Department Head level	Event costing $10,000 - $100,000, notification at Site Manager level	Event costing >$100,000, notification above Site Manager level

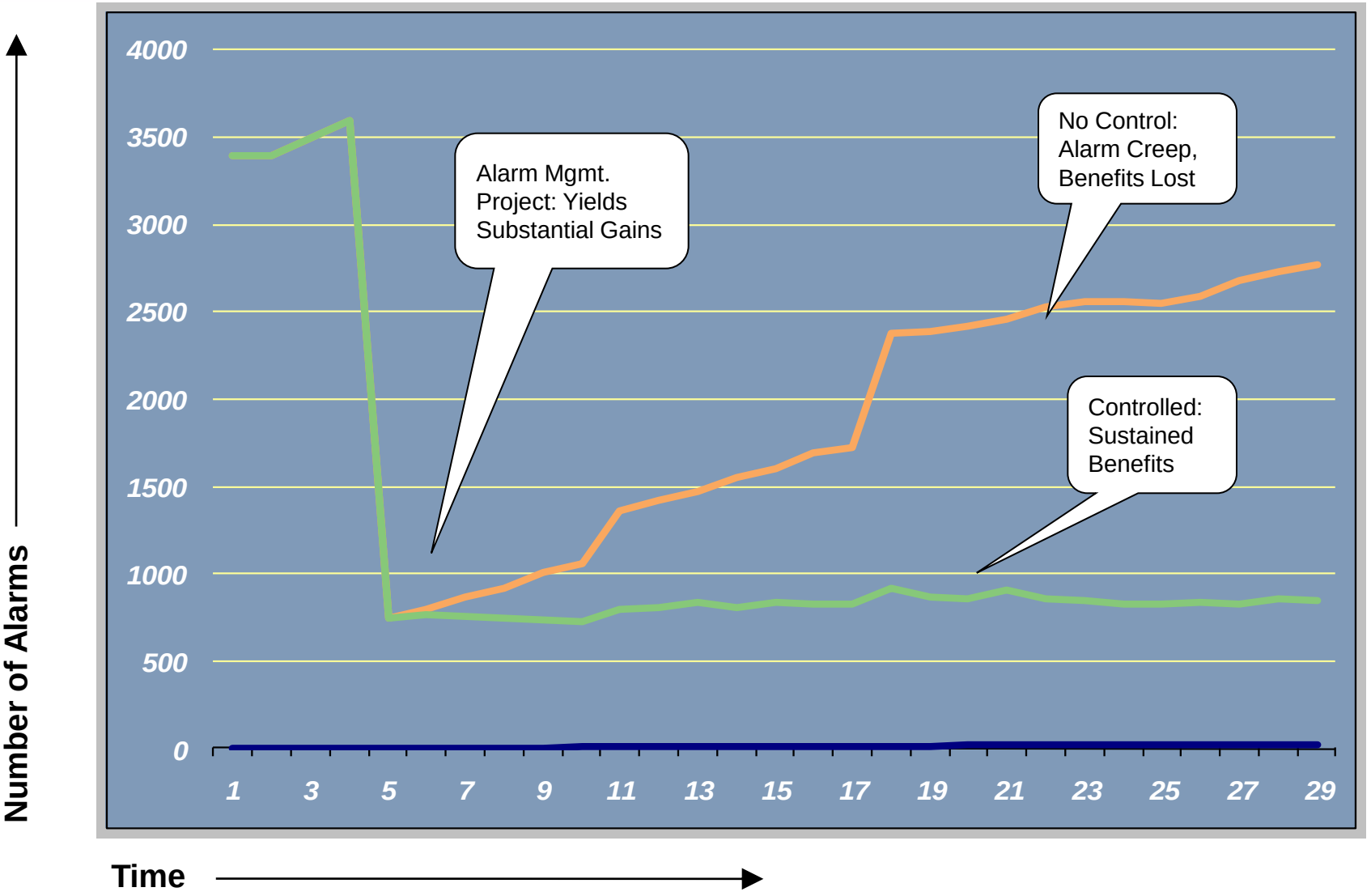
Severity of Consequence, Plus:

Time Available to Respond
> 30 Minutes
10 - 30 Minutes
3 - 10 Minutes
<3 Minutes

Alarm Priority Determination				
	Severity of Consequences			
Time Available	None	Minor	Major	Severe
>30 Min	No Alarm	Re-engineer the Alarm for Urgency		
10-30 Min	No Alarm	LOW	LOW	MED
3-10 Min	No Alarm	LOW	MED	MED
<3 Min	No Alarm	MED	HIGH	HIGH

Determines Alarm Priority

Step 5 – Audit and Enforce



Alarm Audit and Enforce

Master Alarm Database

Alarm Management Server

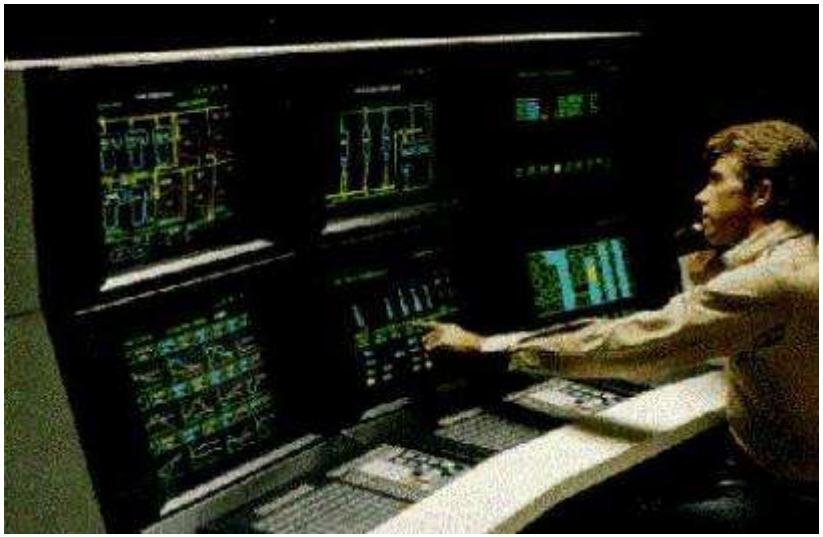
Audit alarm values from DCS, compare to Master Alarm database

Generate Exception Reports

Read

Write

Optional and with Control:
Enforce alarm settings to DCS



Review and approve changes

Step 6 – Real-Time Alarm Management

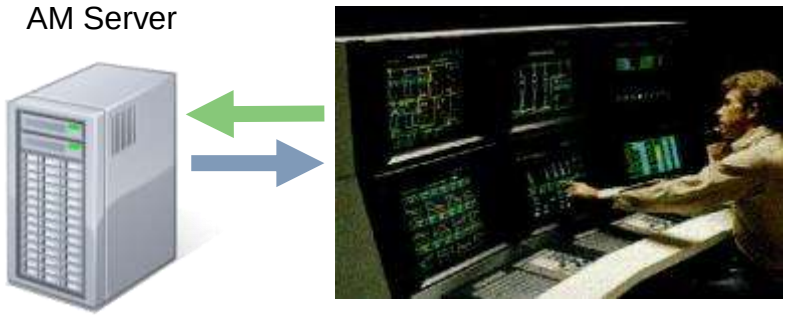
If your process:

- Makes Multiple Products or Grades
- Uses Multiple Differing Feedstocks
- Has Parallel Operating Trains
- Has Different Modes of Operation
- Runs at Different Rates

Then:

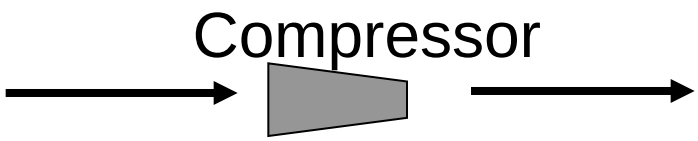
- Don't have only ONE set of unchanging, compromise alarms settings for your alarms.

State-based alarming technology, lets you have multiple alarm settings that are optimum and correct for all your operating conditions.



It is NOT OK to ignore an alarm

Alarm Flood Suppression – Shutdown State



States:
RUNNING (default)
and
SHUTDOWN

When the State is **SHUTDOWN,** suppress the following alarms**:**

- *Low Flow*
- *Low Discharge Pressure*
- *High Suction Pressure*
- *Low Oil Pressure*
- *Low Amps*
- *Low Speed*
- *Several BAD VALUE alarms*

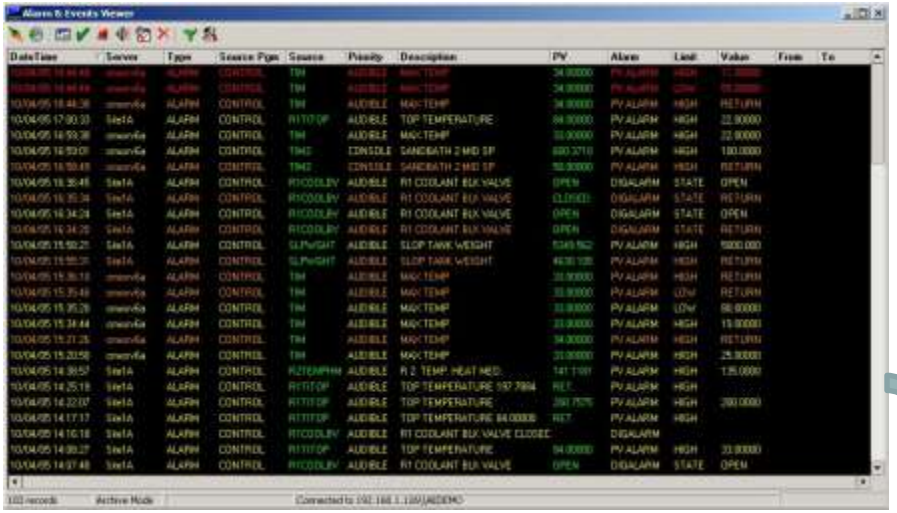
…and so forth – the ***expected diagnostics*** plus closely related, **expected** process alarms.

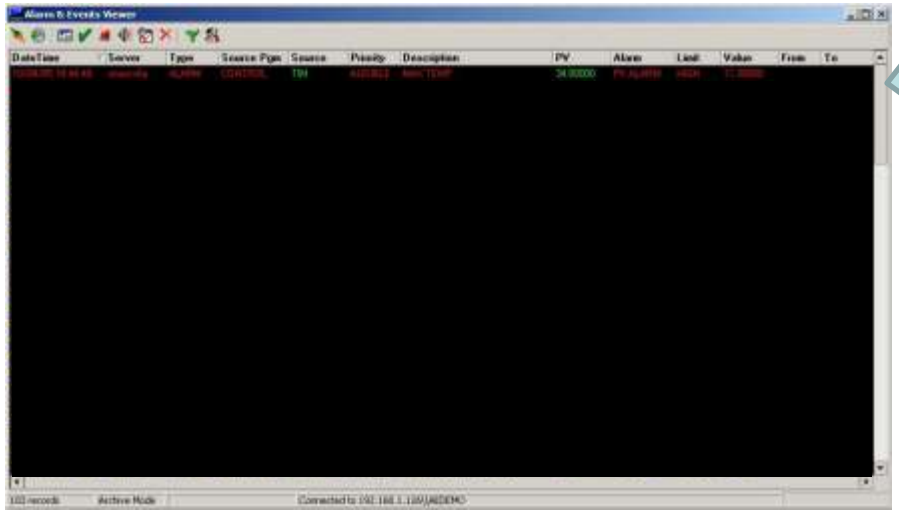
Post-Shutdown, the **important** alarms are from the remainder of the process as it adjusts to the loss of the compressor

Step 7 – Control and Maintain Your System

- The following types of changes to alarms must be controlled:
  - Changes in alarm priority
  - Changes in alarm trip point
  - Creation of new alarms
  - Deletion of existing alarms
  - Change of alarm type
  - Change of alarm description or text message
  - Temporary suppression of alarms (an approved Shelving methodology must be used)
  - Point execution status (turning a sensor “on” or “off”)
  - Changes in alarm presentation on graphics
  - Additions of, modifications to, or updates to alarm handling capabilities such as Alarm Shelving systems or State-Based Alarming configuration
- The following changes should be controlled as well
  - Controller tuning parameters
  - Point ranges
  - Modification of logic points, interlocks, embedded programs, DCS operating system software, and similar functions

Your Alarms are Now Under Control

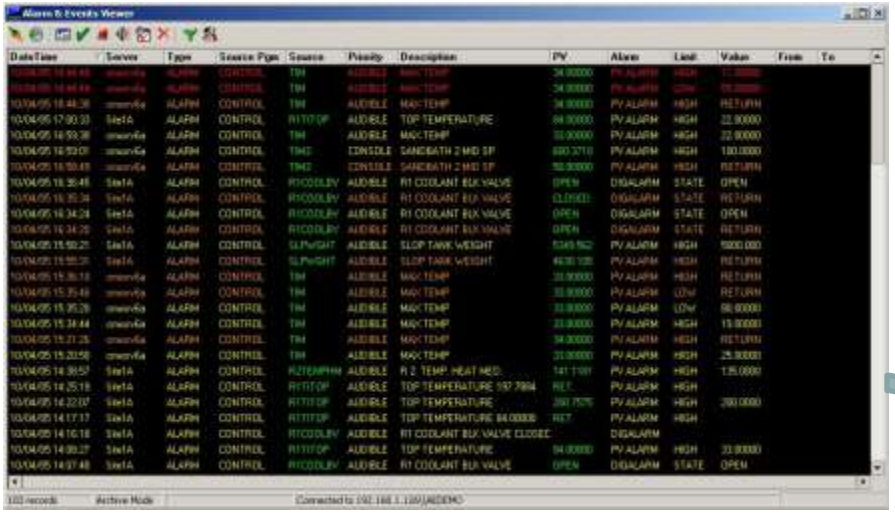


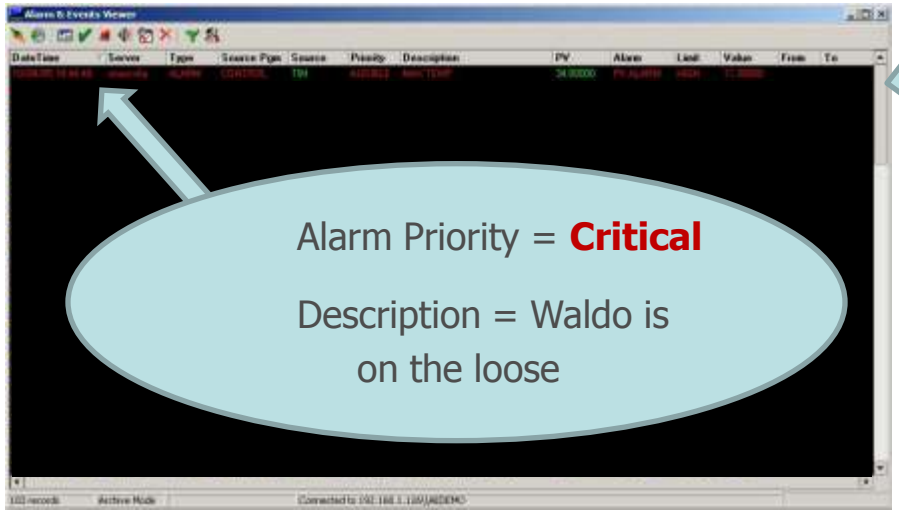


7 Steps of Alarm Management

- Alarm system is reliable during all plant modes
- Operators have a high degree of confidence in the alarm system, and have time to detect all alarms
- Alarm system configuration is not subject to inadvertent change

Your Alarms are Now Under Control



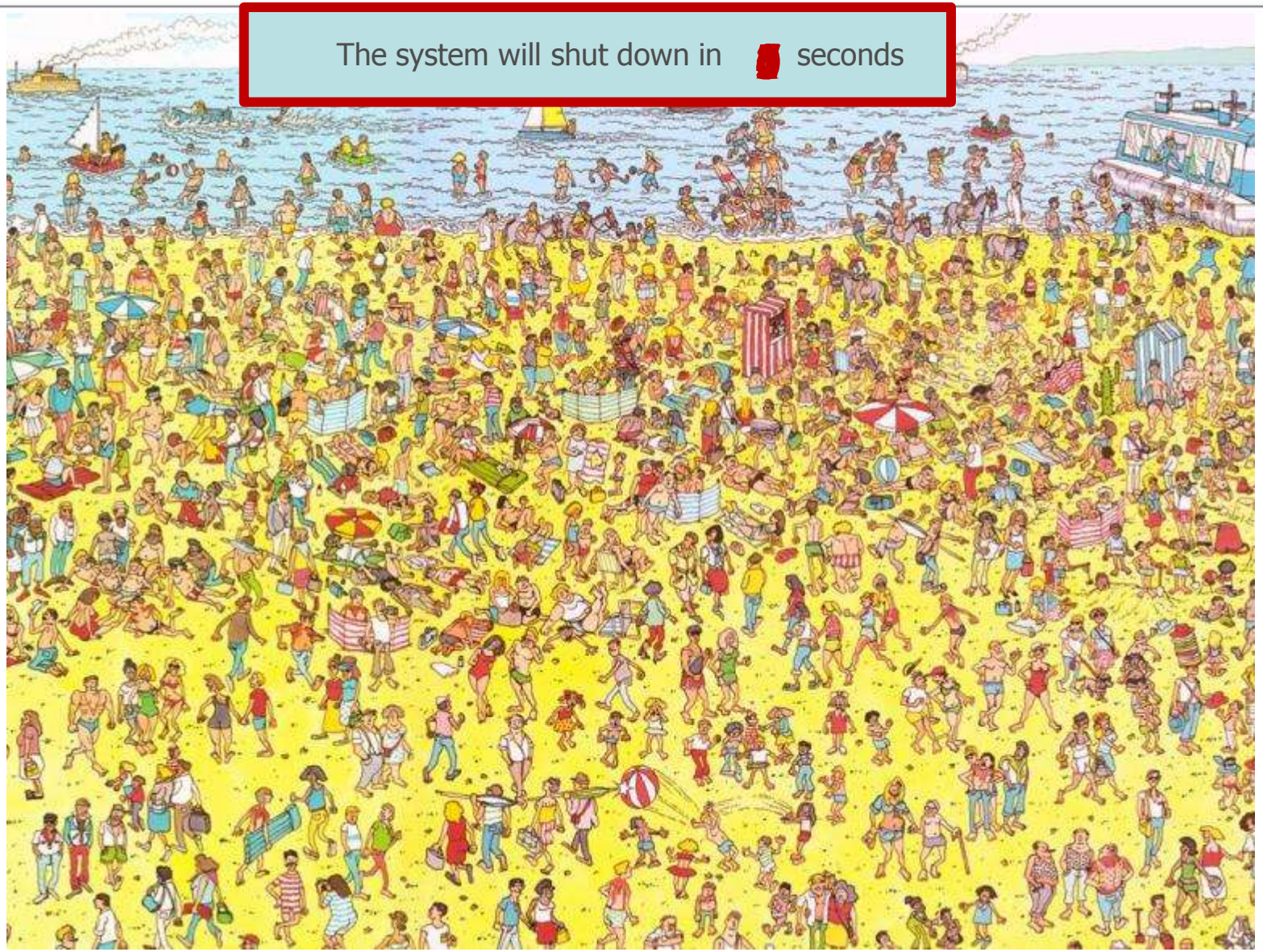


Alarm Management Best Practice:

Critical Alarm = an abnormal event with **SEVERE** consequences requiring **IMMEDIATE** action

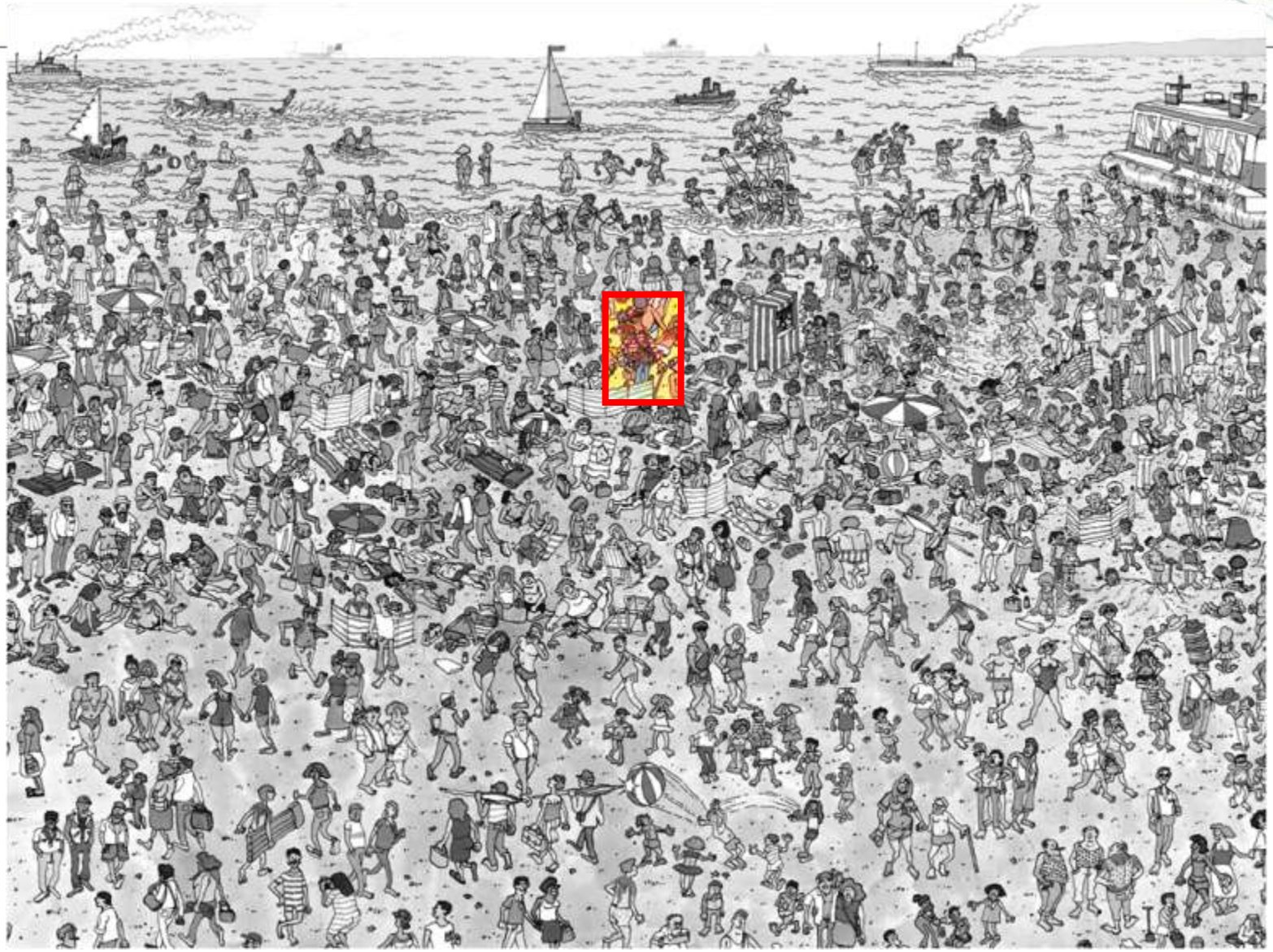
Good luck!

Find Waldo…



Lets Go to Grey Scale…

There he is…

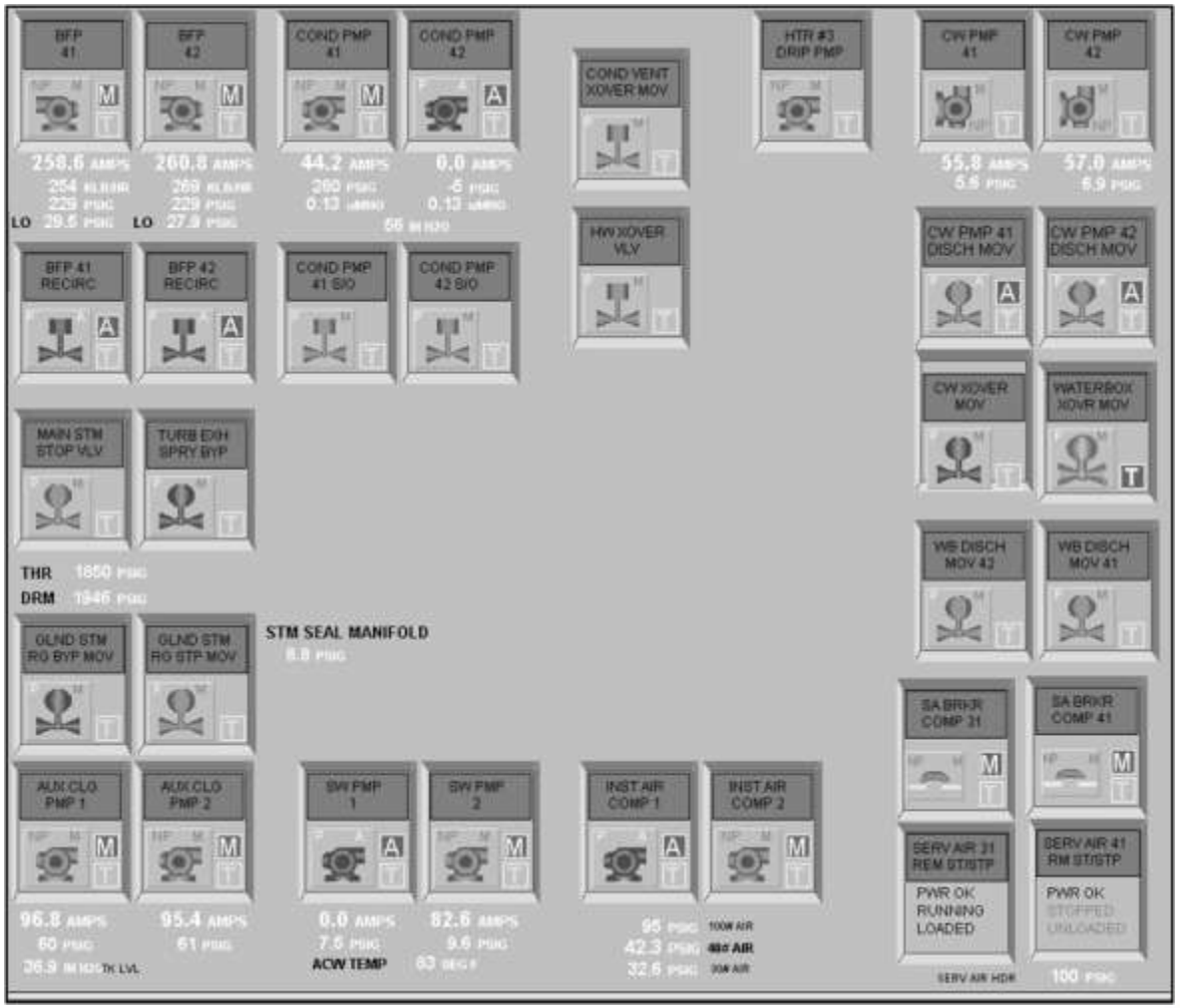


Appropriate use of Color

- Color is an attention getter.
- Use for the abnormal, not the normal.
- Screens should function even if the color is “turned down” – like an old television!

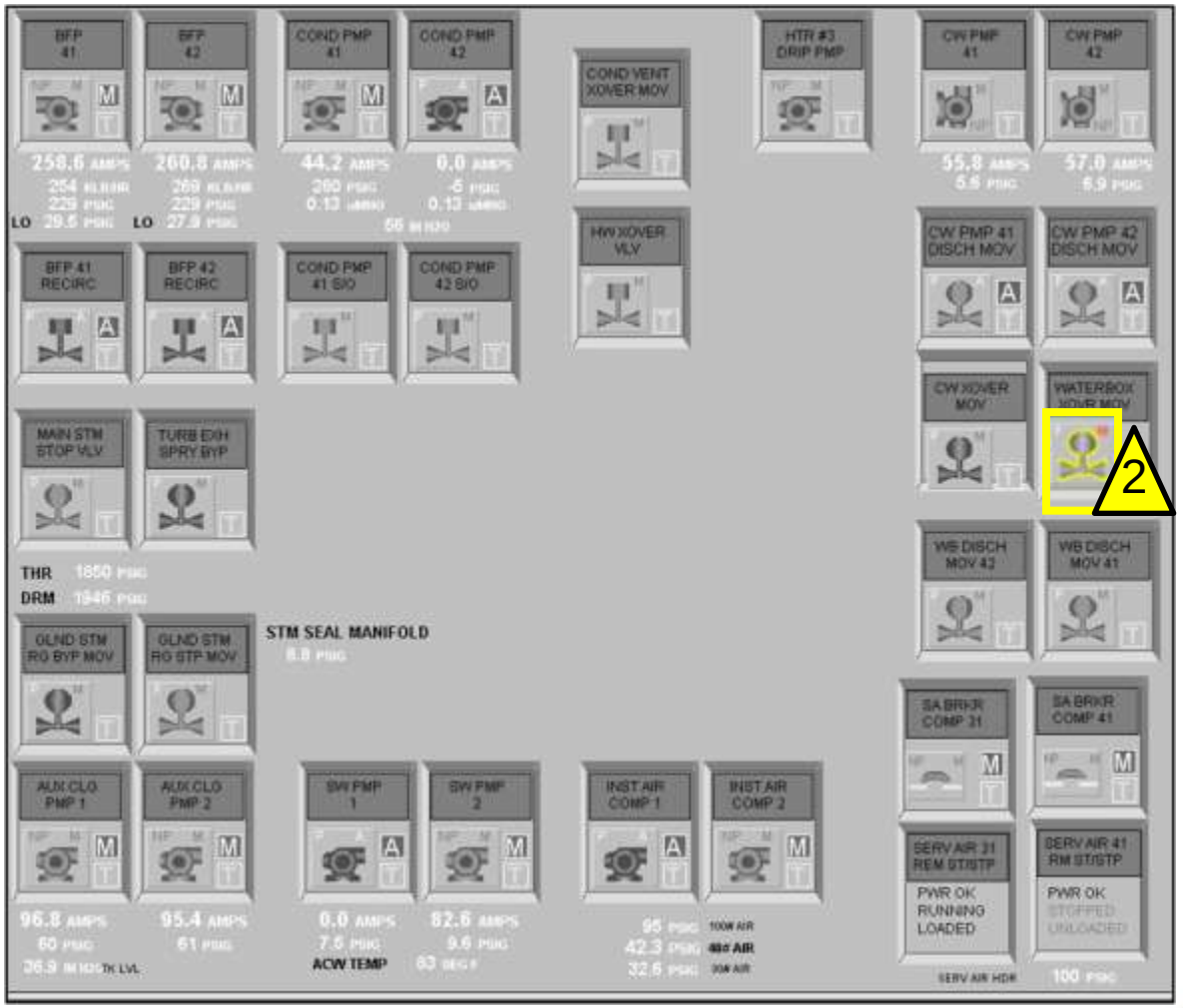
Lets Go to Grey Scale

- This is what the screen would look like for a color blind person
- About 6% of males in the US have certain amount of color blindness
- Can you tell which valves are open/closed in this display? Color blind people cannot tell the difference between red/green



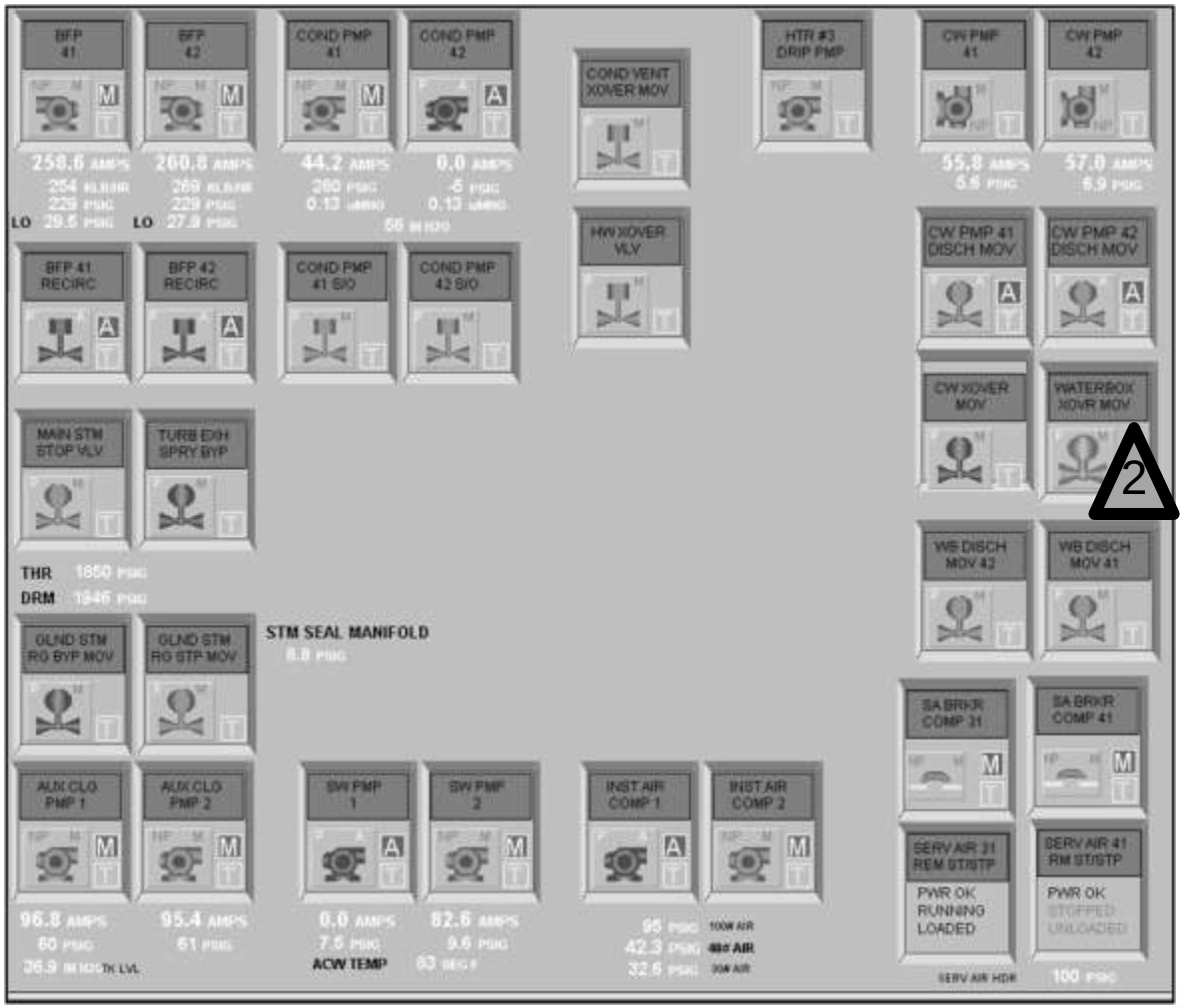
I See Waldo

- Can you tell which valves are open/closed in this display? Color blind people cannot tell the difference between red/green
- Moral of the Story:
  - 1) Reserve bright colors for abnormal situations.
  - 2) Do NOT rely solely on color to depict important status indications– for alarms use Shape/Text and color (triple coding)



I See Waldo

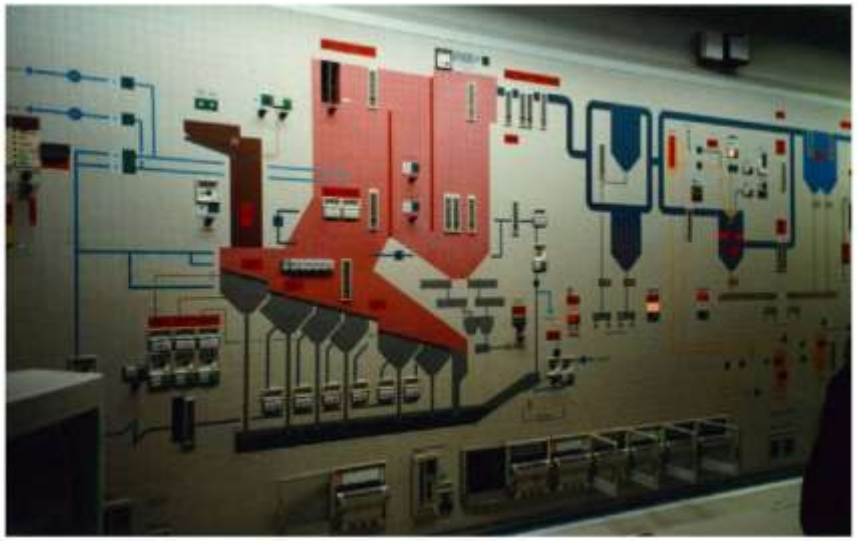
- Moral of the story:
  - **SIMPLIFY**
    - **Appropriate use of color**
    - **Animation for abnormal only**



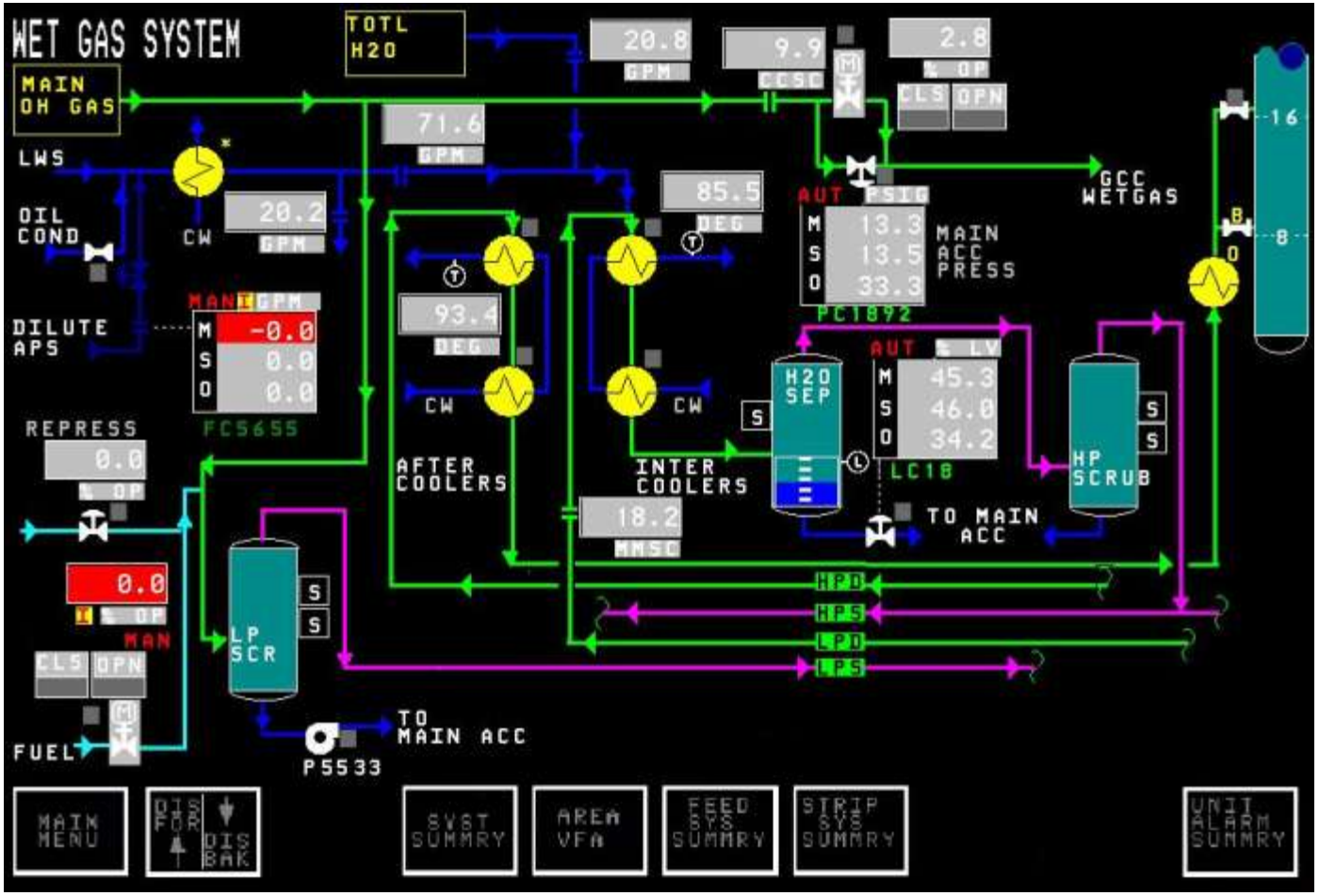
The High Performance HMI

HMIs Past and Present

- Provided the “Big Picture”
- Limited Capability
- Many Process Trends
- Status “at-a-glance”



DCS Graphics Introduced – but no guidelines!



Traditional Graphics Encourage Poor Operating Practices

The High Performance HMI

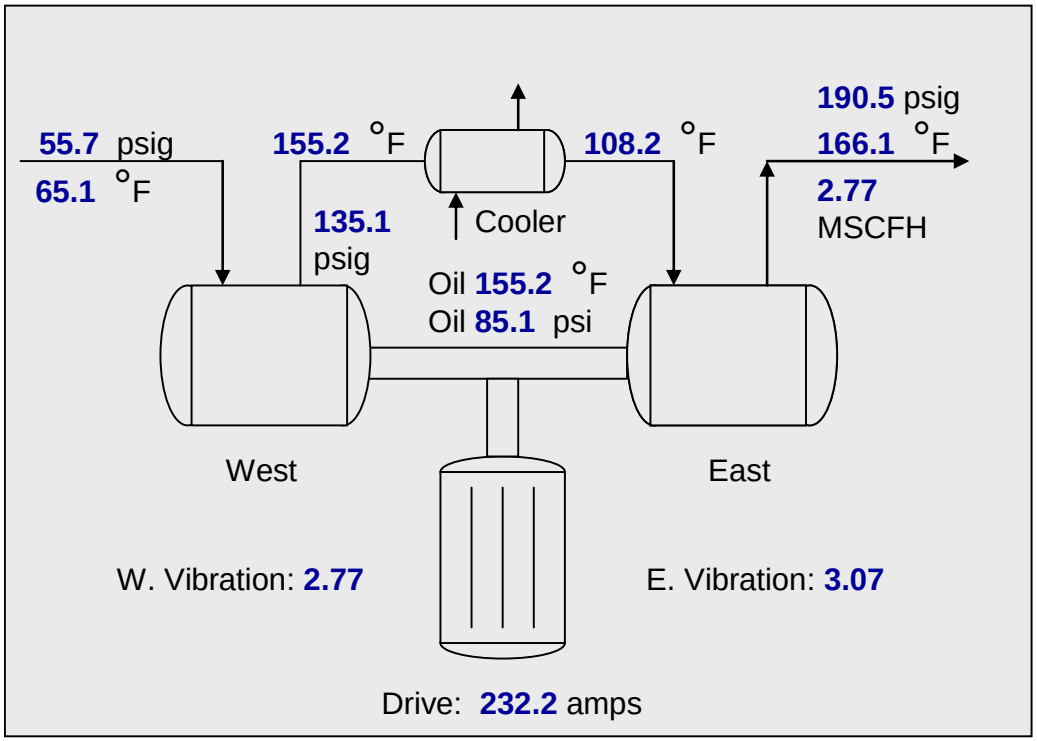
- Time after time, poor HMIs are cited as contributing factors to major accidents
- $800,000 per year savings anticipated on 1 ethylene plant
- Similar results for a PAS-EPRI study of a coal-fired power plant

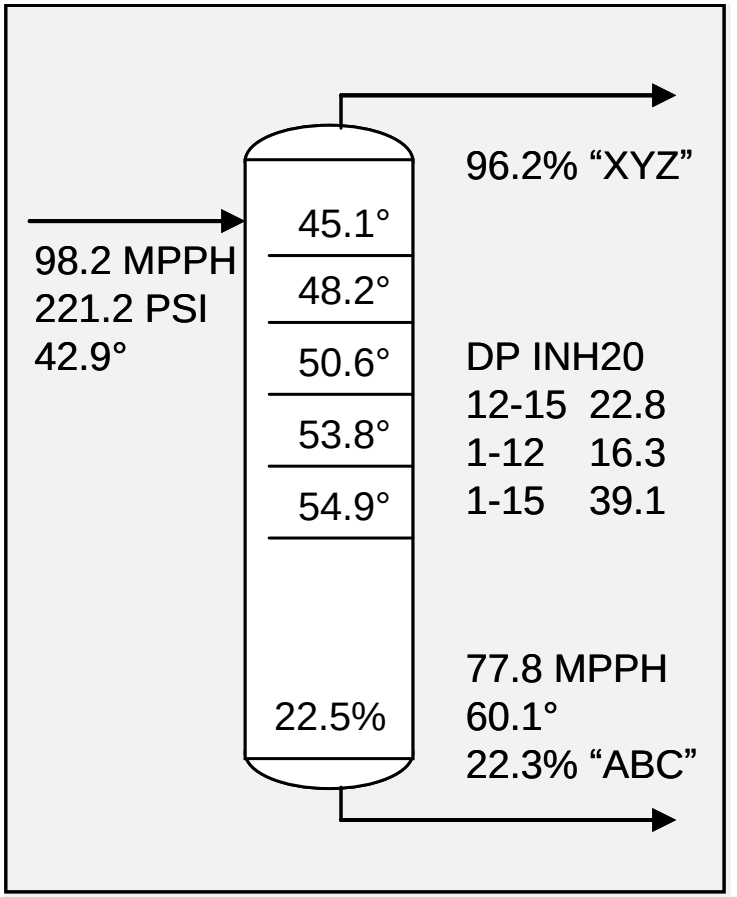
Task	Improvement
Detecting Abnormal Situations Before Alarms Occur	**A 5X increase**
Success Rate in Handling Abnormal Situation	**37% over base case**
Time to Complete Abnormal Situation Tasks	**41% reduction**

Study by Nova Chemicals and ASM® Consortium

Data is Not Information

- Lots of Data but Not Much Information!
- Poor Presentation
- High Mental Workload to Decipher





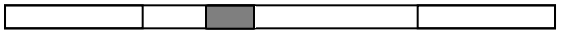
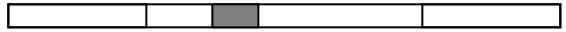
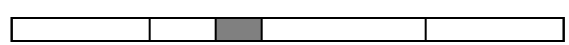
P&IDs are NOT HMIs

Data is Not Information: Is Fluffy Sick?

Blood Tests for Fluffy -1	
Test	**Results**
HCT	31.7%
HGB	10.2 g/dl
MCHC	32.2 6/dl
WBC	9.2 $x10^9$ /L
GRANS	6.5 $x10^9$ /L
L/M	2.7 $x10^9$ /L
PLT	310 $x10^9$ /L

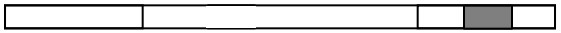
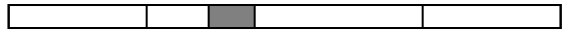
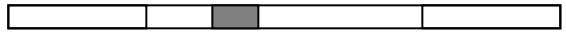
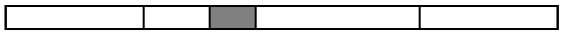
Answer: Unless you are a veterinarian, how can you know?

How About Now?

Blood Tests for Fluffy -3			
Test	**Results**	**Range**	**Indicator Low – Normal - High**
HCT	31.7%	24.0 – 45.0	
HGB	10.2 g/dl	8.0 – 15.0	
MCHC	32.2 6/dl	30.0 - 36.9	
WBC	9.2 $x10^9$ /L	5.0 – 18.9	
GRANS	6.5 $x10^9$ /L	2.5 – 12.5	
L/M	2.7 $x10^9$ /L	1.5 – 7.8	
PLT	310 $x10^9$ /L	175 - 500	

Contextualize information

How About Now?

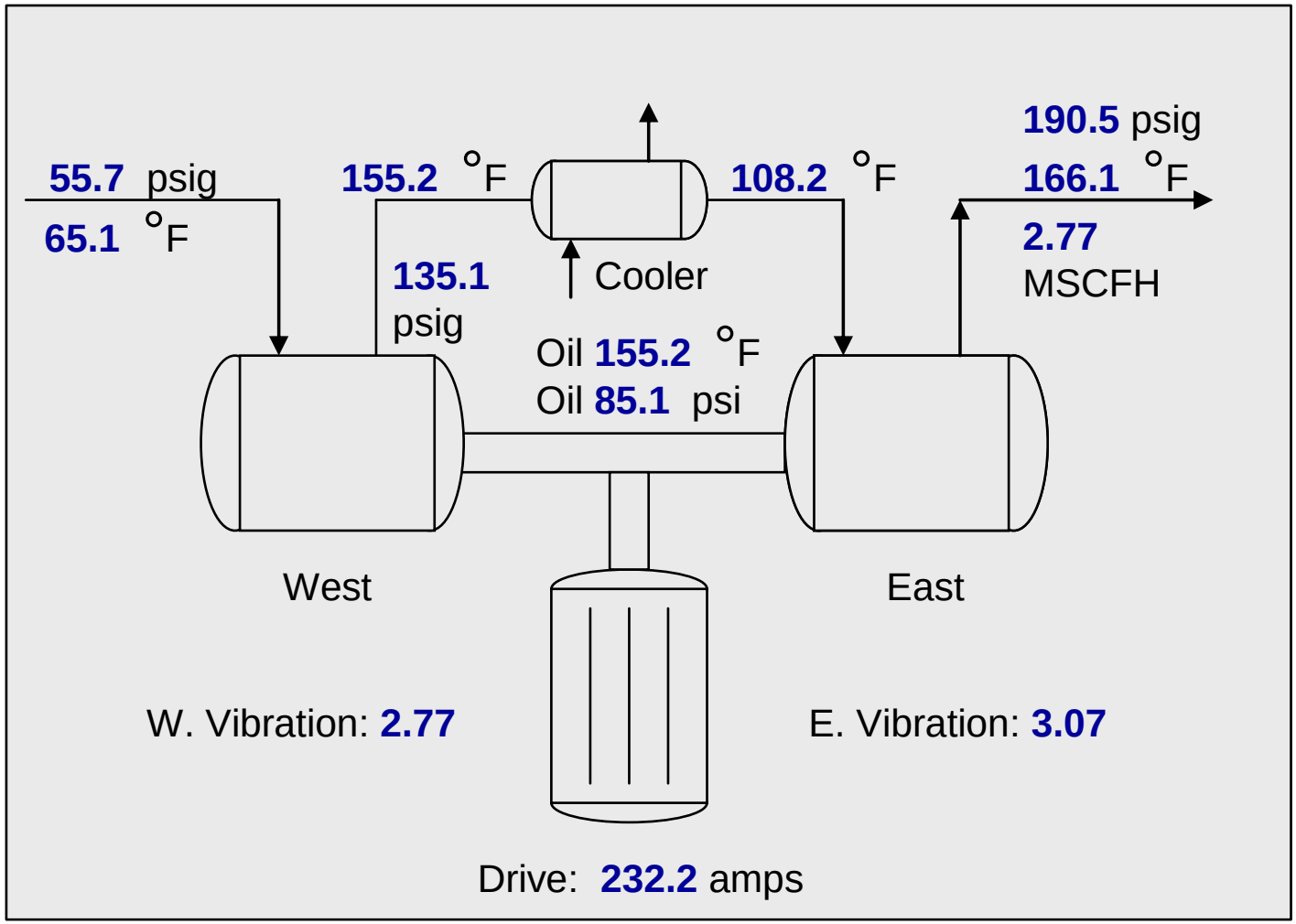
Blood Tests for Fluffy -3			
Test	**Results**	**Range**	**Indicator Low – Normal - High**
HCT	31.7%	24.0 – 45.0	
			
			
			
			
			
PLT	310 x10^9 /L	175 - 500	

Tag = HCT Alarm = PVHI
The hematocrit (HCT) is the proportion, by volume, of the blood that consists of red blood cells

Causes	Corrective Actions
Temporary dehydration	Drink water
Lung Disease	Lung exam
Bone marrow disorder	Bone marrow exam

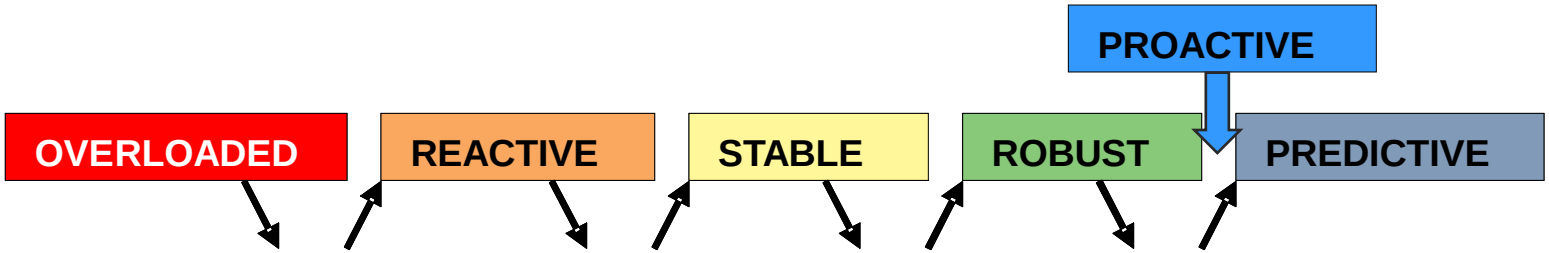
Aggregate information into the HMI

Analog in Industrial Examples



Is this compressor running OK?

From Robust to Proactive



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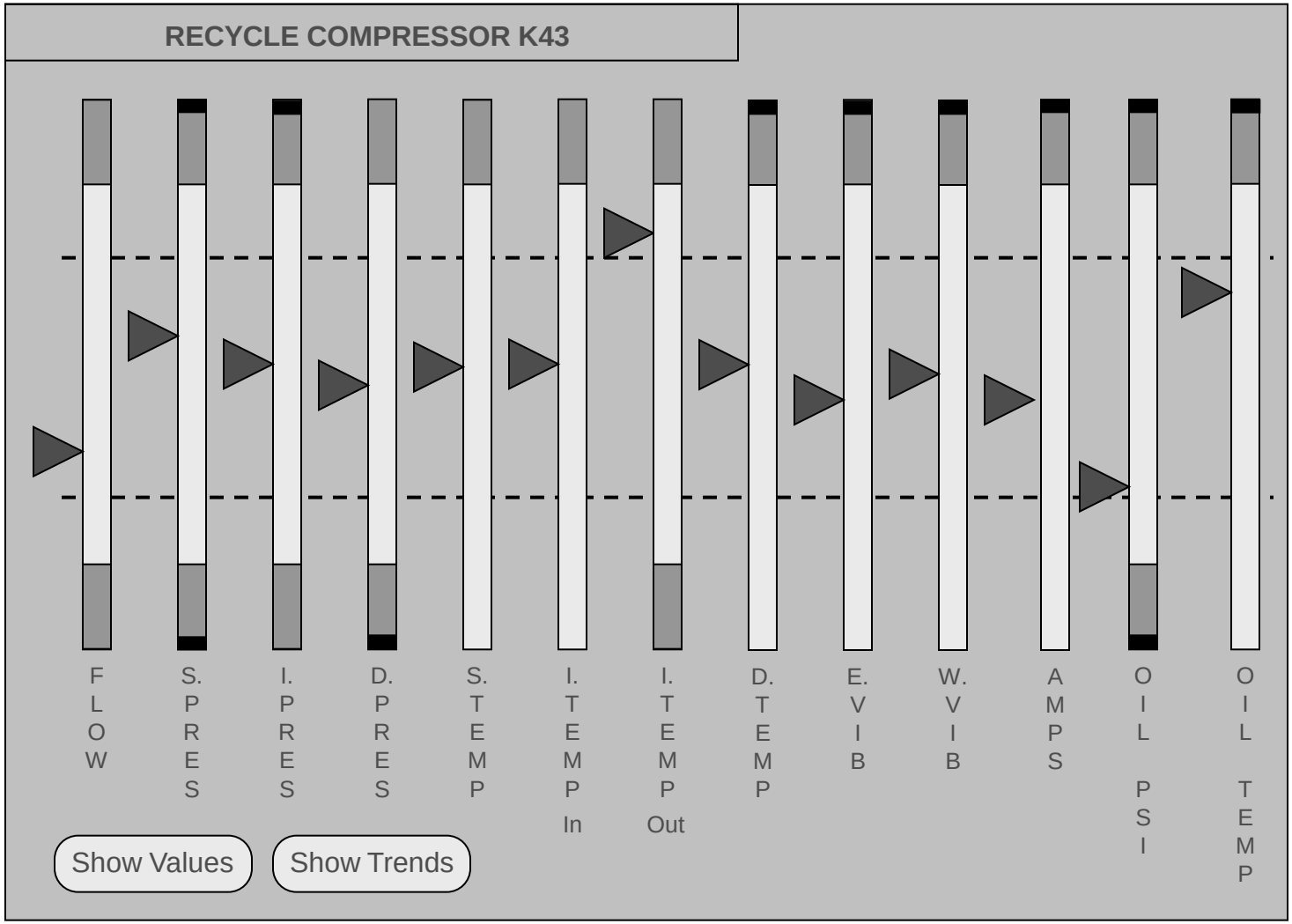
Next Step: Enabling Operators to be Proactive

Analog in Industrial Examples

Compressor Status Showing Alarm/Shutdown Limits



Analog in Industrial Examples

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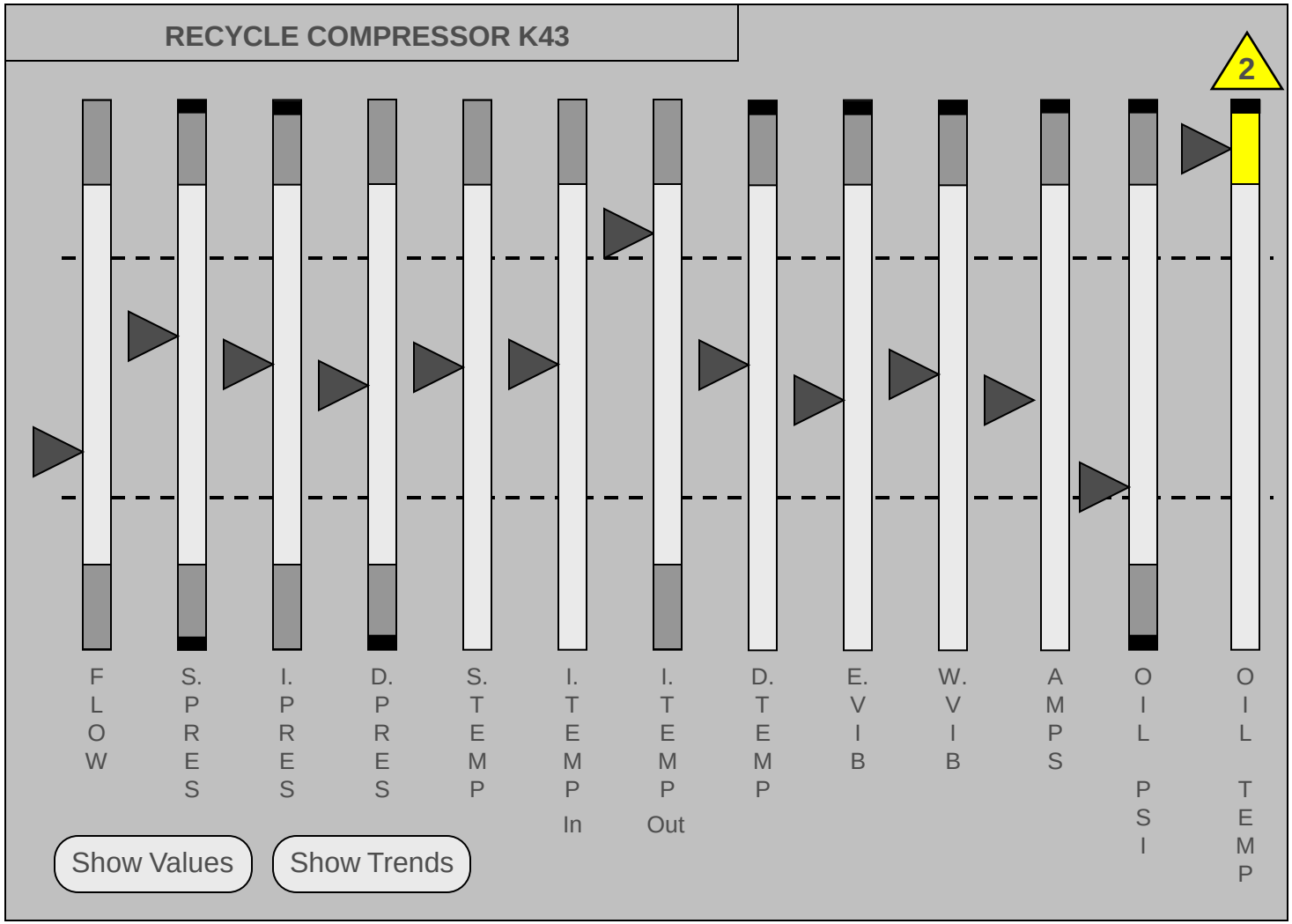
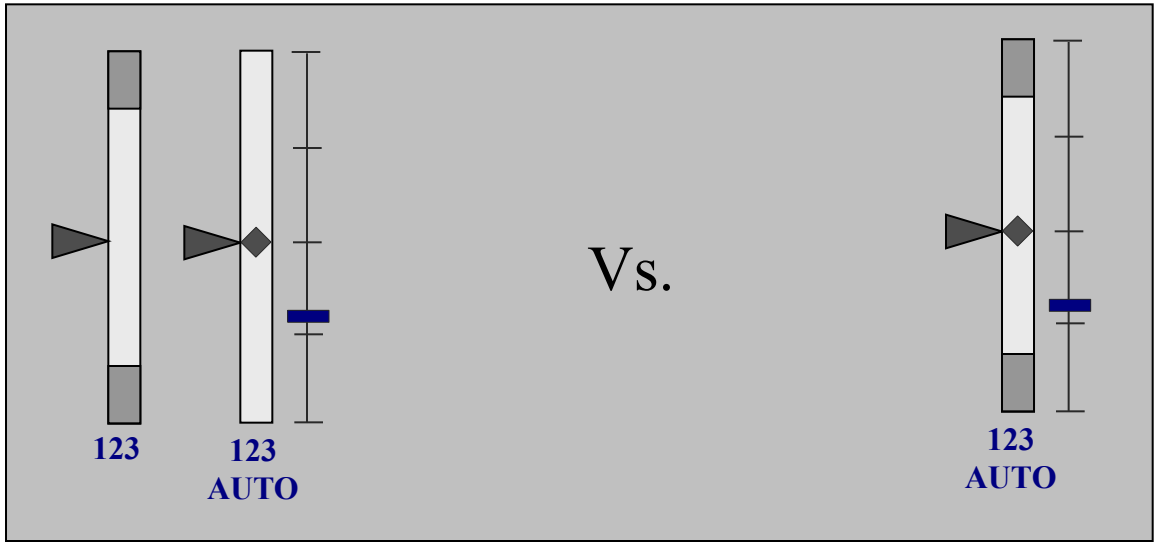


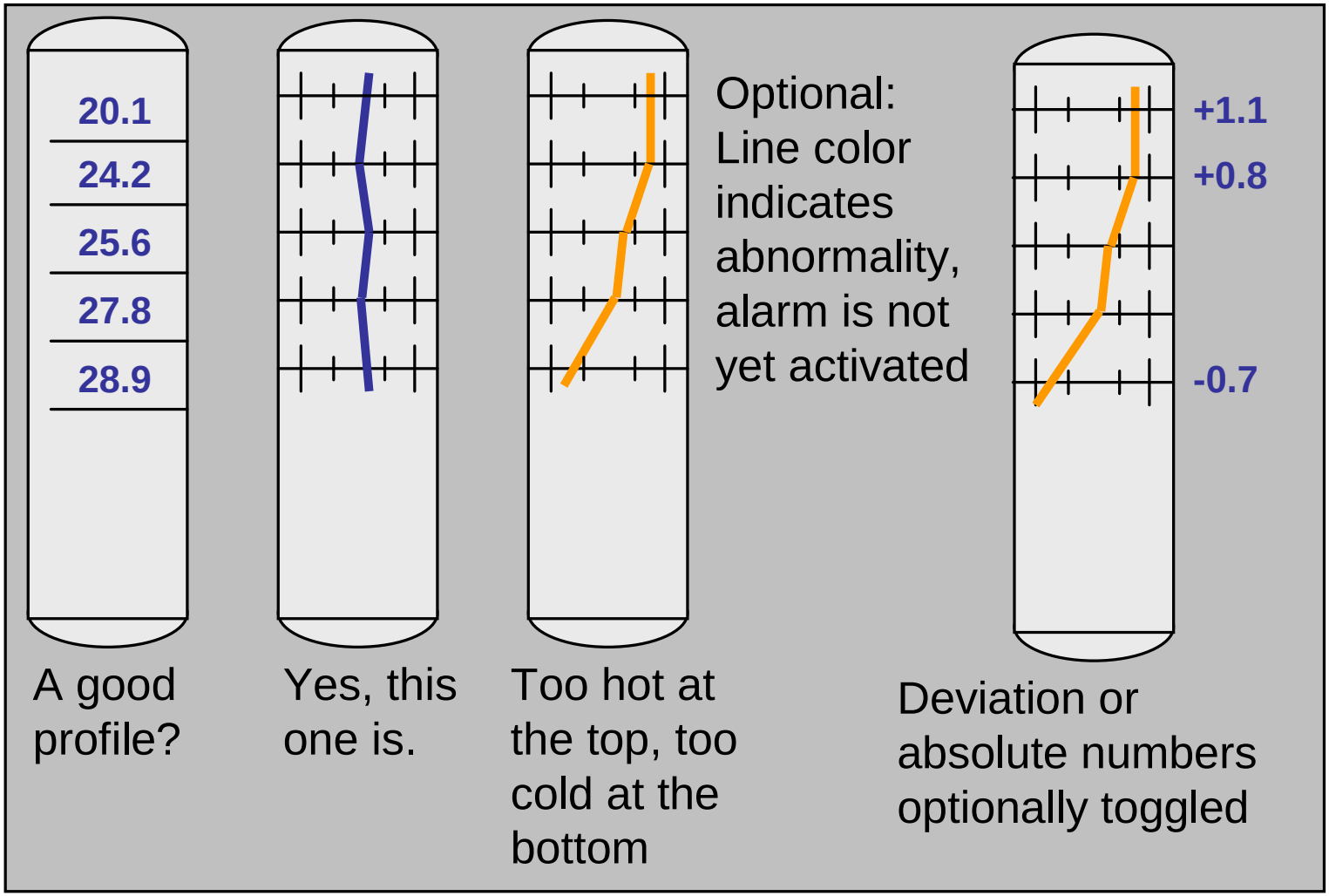
HMI & Alarm Management

- Alarm management Best practice:
  - When indicators and controllers are available for one measurement, place alarms on controllers
- Effect on HMI:
  - Real Estate



Proper Alarm Management Simplifies Graphics Design

Analog in Industrial Examples



A Column Temperature Profile

Alarm Indications on Graphics

Worst

480.1 psi No Alarm Indication 480.1 psi

Only a Color Change!

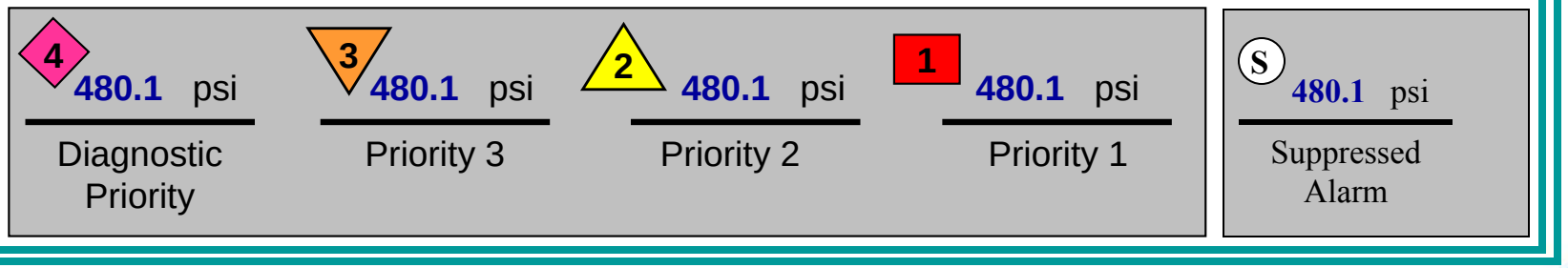
Poor

480.1 psi Diagnostic Priority | 480.1 psi Priority 3 | 480.1 psi Priority 2 | 480.1 psi Priority 1

Poor

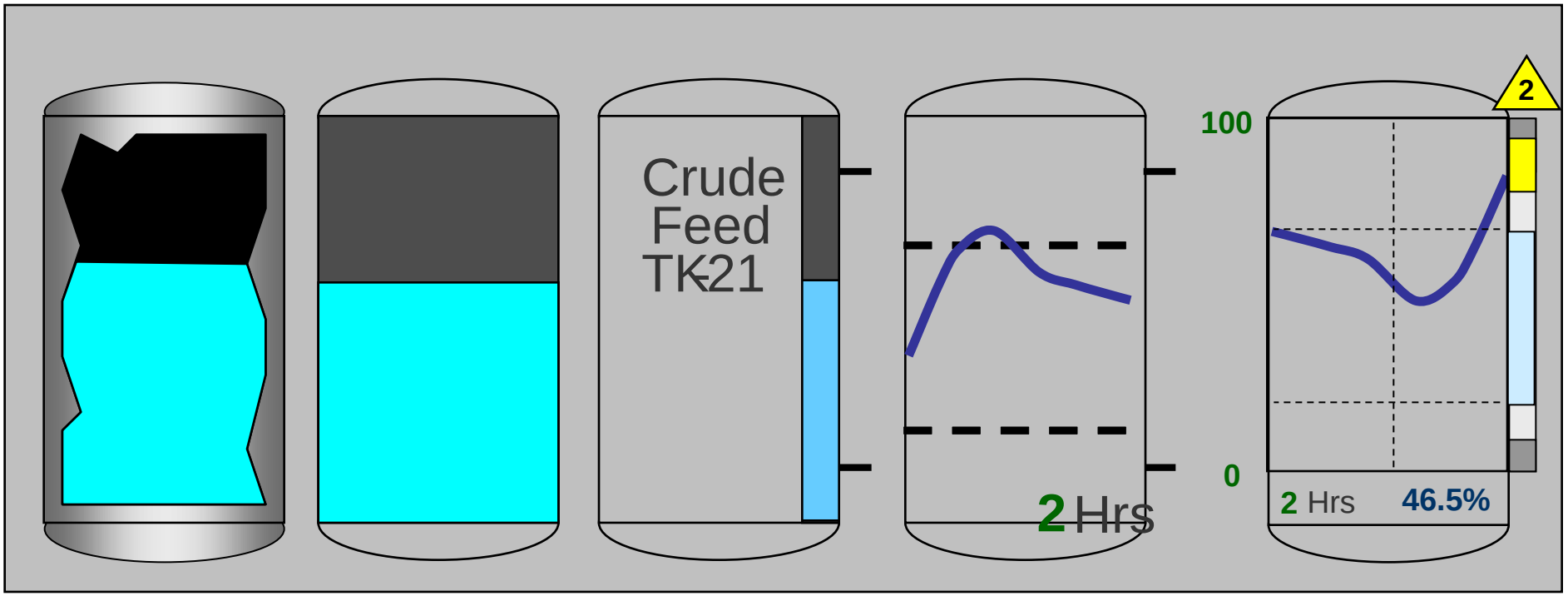
480.1 psi Diagnostic Priority | 480.1 psi Priority 3 | 480.1 psi Priority 2 | 480.1 psi Priority 1

Best!



Multiple Coding: Color, Shape, Text

Level Depiction



Very Poor Vessel Level Indication

Poor Vessel Level Indication

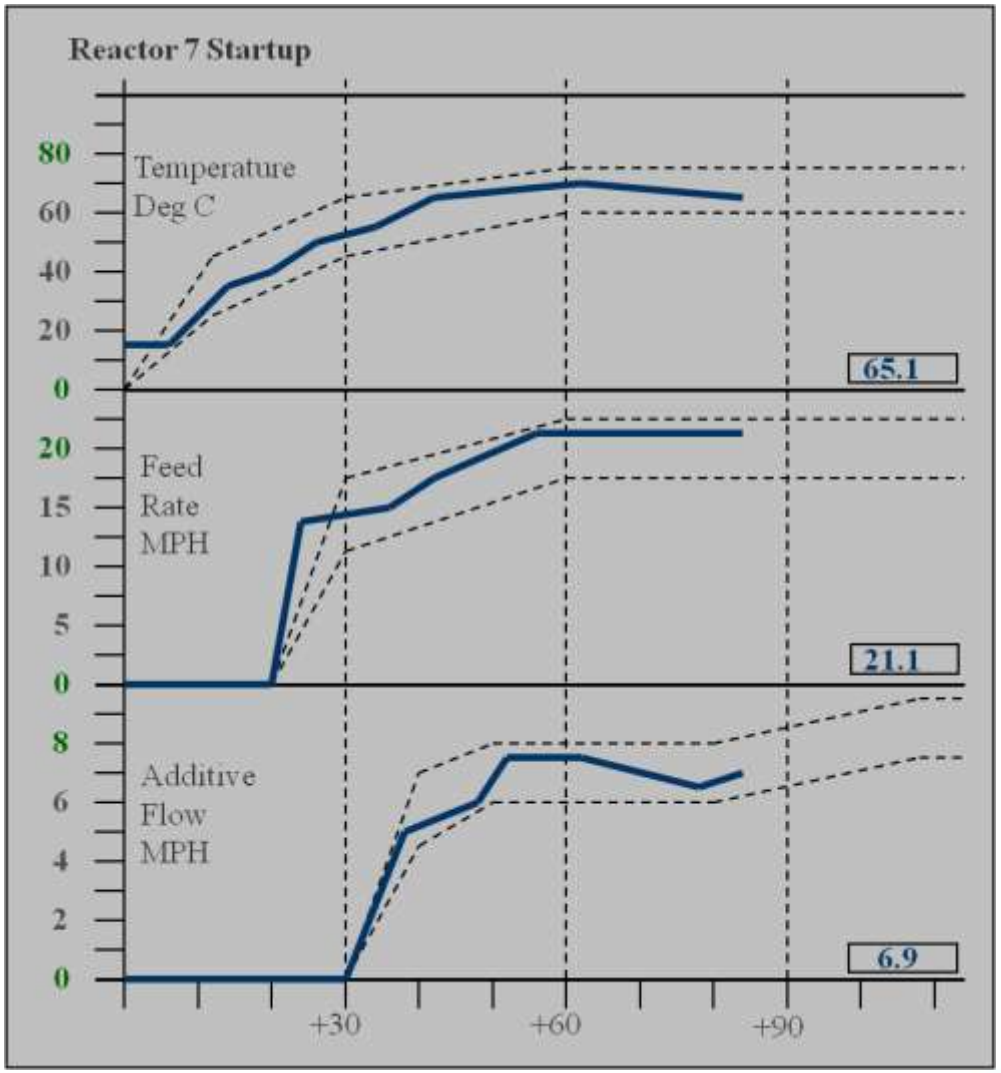
Better Vessel Level Indication

Trend Vessel Level Indication

Combination Vessel Level Indication

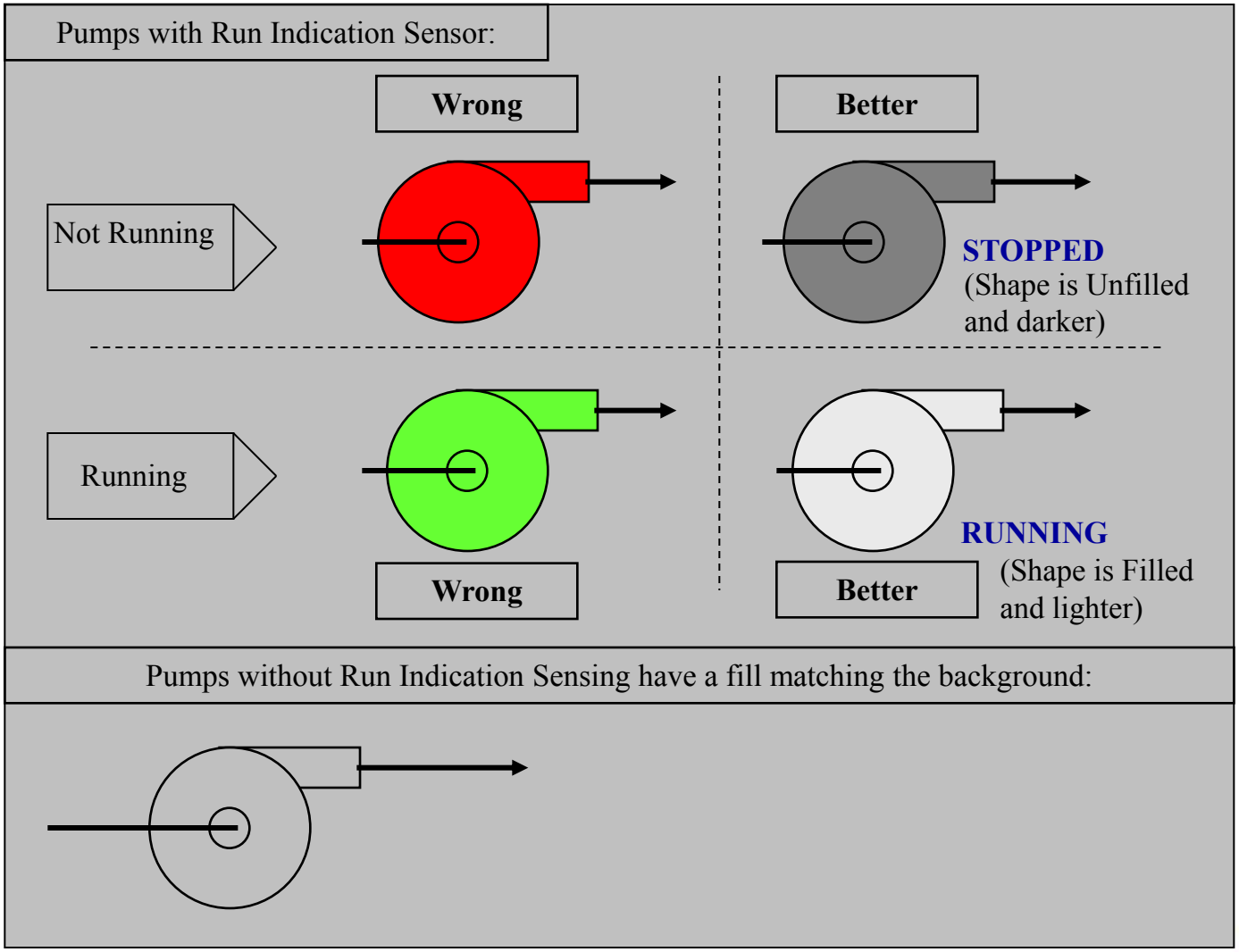
Custom Elements for Startups

- Always try to clearly depict:
  - "Where am I?"
  - "How am I doing vs. what is "good?"



Status Depiction

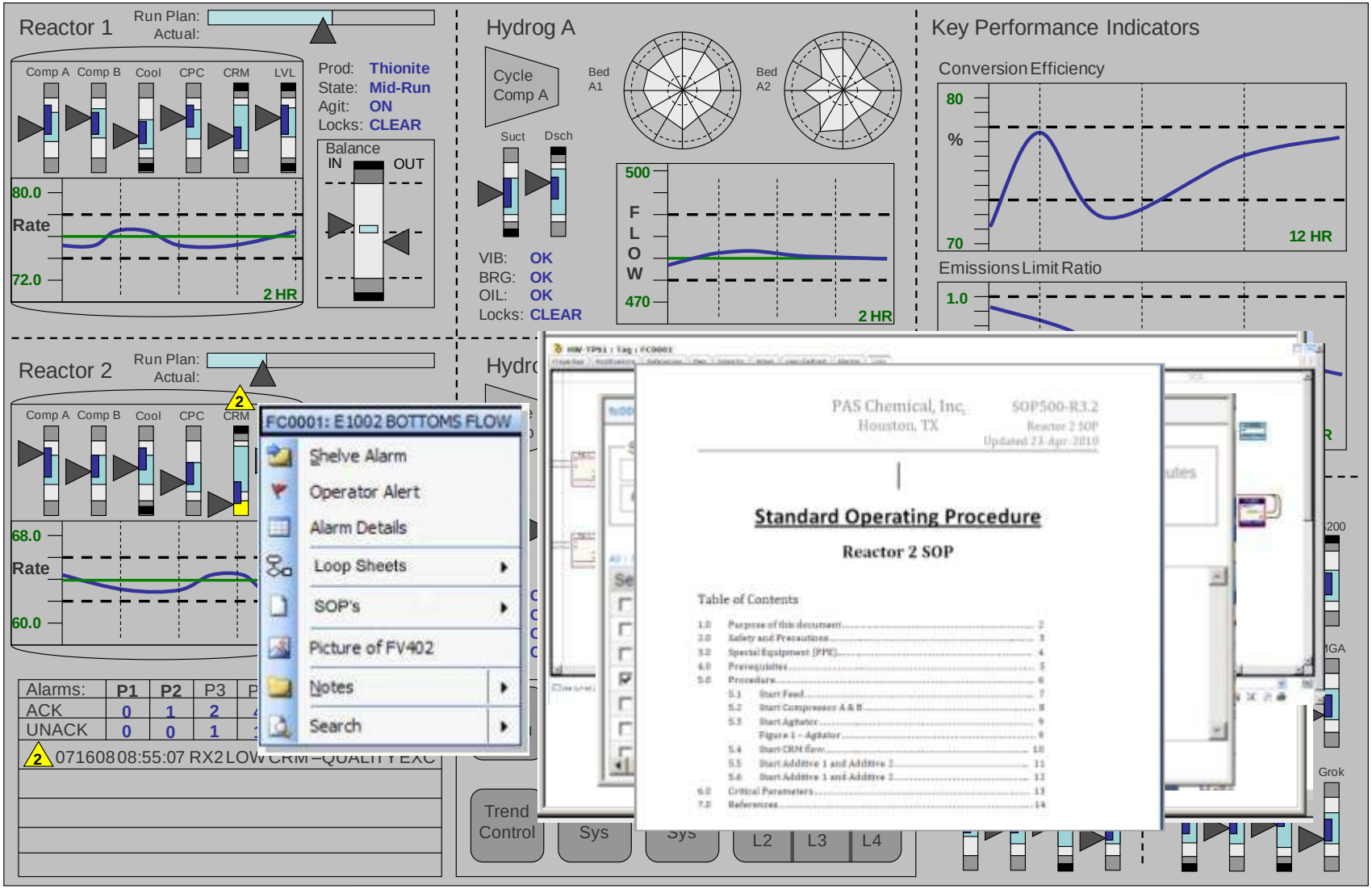
- **Bright color is used to indicate abnormal situations only**



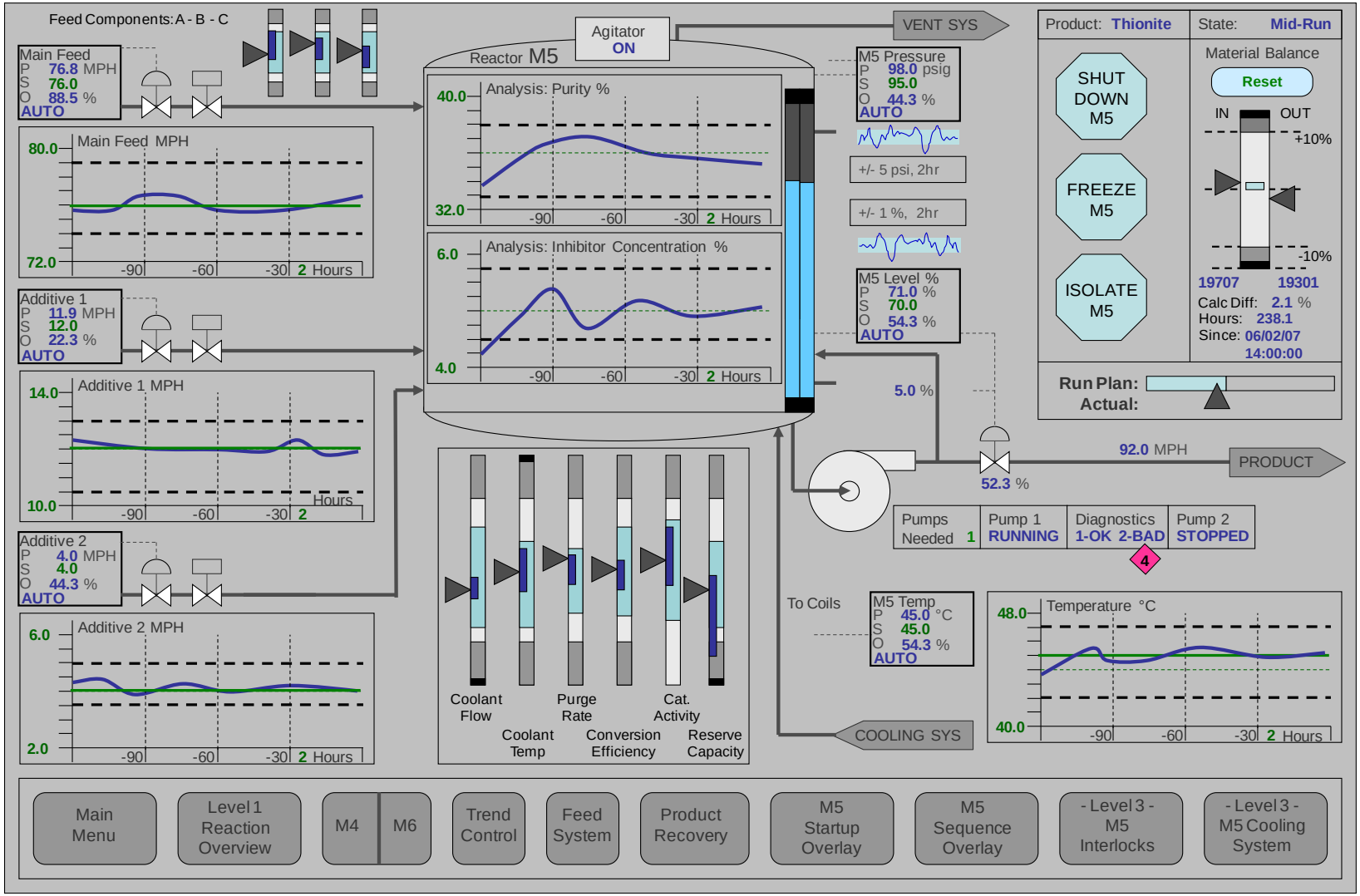
Proper Hierarchy for Displays

- HIERARCHY for Displays:
- Level 1 – Process Area Overview
  - Entire Operator Span of Control. “Single-Glance”
- Level 2 – Process Unit Control
  - Sub-unit controlled by operator
- Level 3 – Process Unit Detail
  - Equipment or controller
- Level 4 – Process Unit Support and Diagnostic Displays
  - Interlocks, ESDs, diagnostic screens, etc.

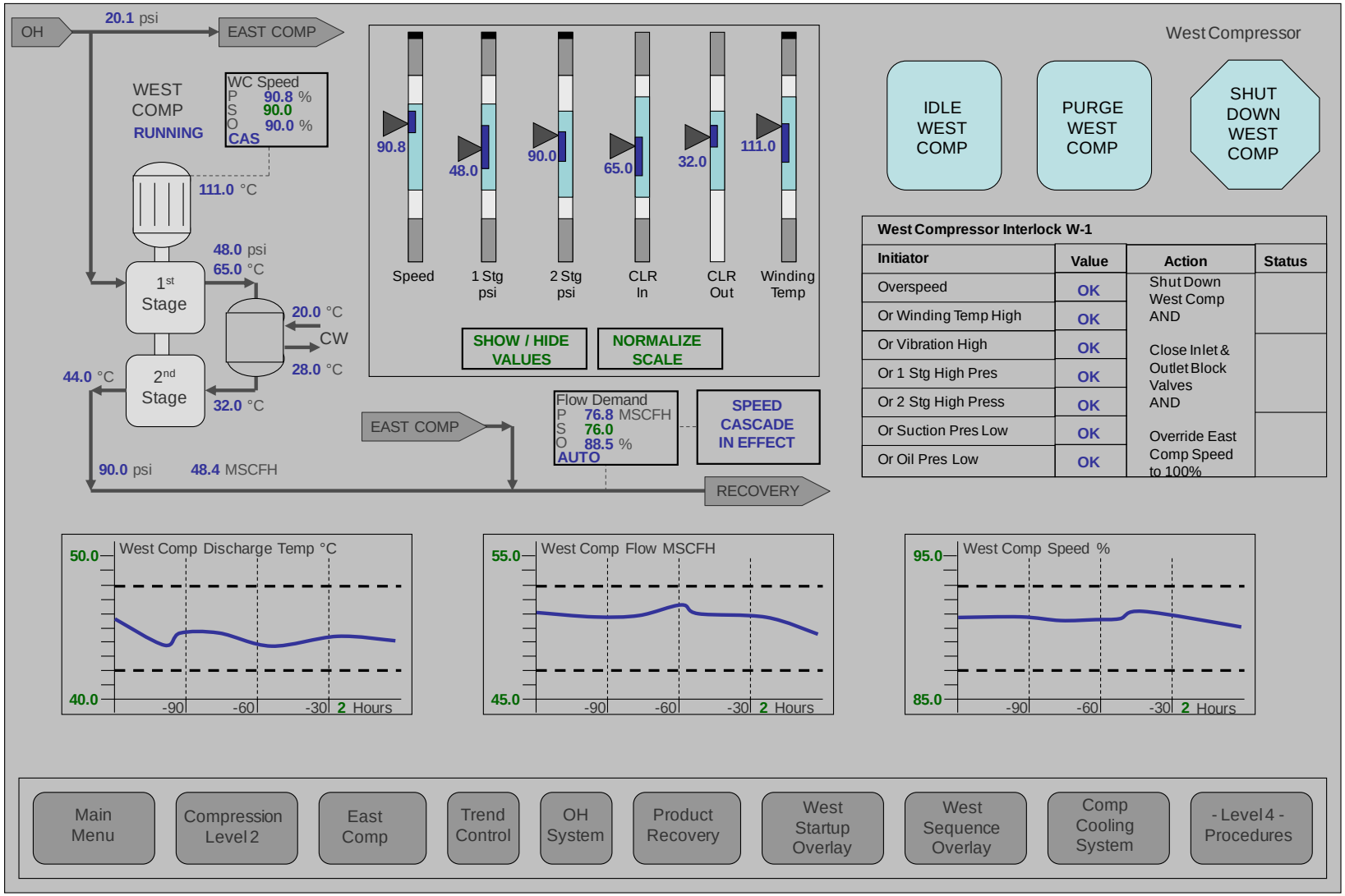
Level 1 Overview



Level 2


Feed Components: A - B - C
Main Feed
P 76.8 MPH
S 76.0
O 88.5 %
AUTO
Main Feed MPH
80.0
72.0
-90 -60 -30 2 Hours
Additive 1
P 11.9 MPH
S 12.0
O 22.3 %
AUTO
Additive 1 MPH
14.0
10.0
-90 -60 -30 2 Hours
Additive 2
P 4.0 MPH
S 4.0
O 44.3 %
AUTO
Additive 2 MPH
6.0
2.0
-90 -60 -30 2 Hours
Agitator
ON
Reactor M5
Analysis: Purity %
40.0
32.0
-90 -60 -30 2 Hours
Analysis: Inhibitor Concentration %
6.0
4.0
-90 -60 -30 2 Hours
Coolant Flow
Coolant Temp
Purge Rate
Conversion Efficiency
Cat. Activity
Reserve Capacity
VENT SYS
M5 Pressure
P 98.0 psig
S 95.0
O 44.3 %
AUTO
+/- 5 psi, 2hr
+/- 1 %, 2hr
M5 Level %
P 71.0 %
S 70.0
O 54.3 %
AUTO
5.0 %
52.3 %
92.0 MPH
PRODUCT
Product: Thionite
State: Mid-Run
SHUT DOWN M5
FREEZE M5
ISOLATE M5
Material Balance
Reset
IN
OUT
+10%
-10%
19707
19301
Calc Diff: 2.1 %
Hours: 238.1
Since: 06/02/07 14:00:00
Run Plan:
Actual:
Pumps Needed 1
Pump 1 RUNNING
Diagnostics 1-OK 2-BAD
Pump 2 STOPPED
4
To Coils
M5 Temp
P 45.0 °C
S 45.0
O 54.3 %
AUTO
Temperature °C
48.0
40.0
-90 -60 -30 2 Hours
COOLING SYS
Main Menu
Level 1 Reaction Overview
M4
M6
Trend Control
Feed System
Product Recovery
M5 Startup Overlay
M5 Sequence Overlay
- Level 3 - M5 Interlocks
- Level 3 - M5 Cooling System

Level 3

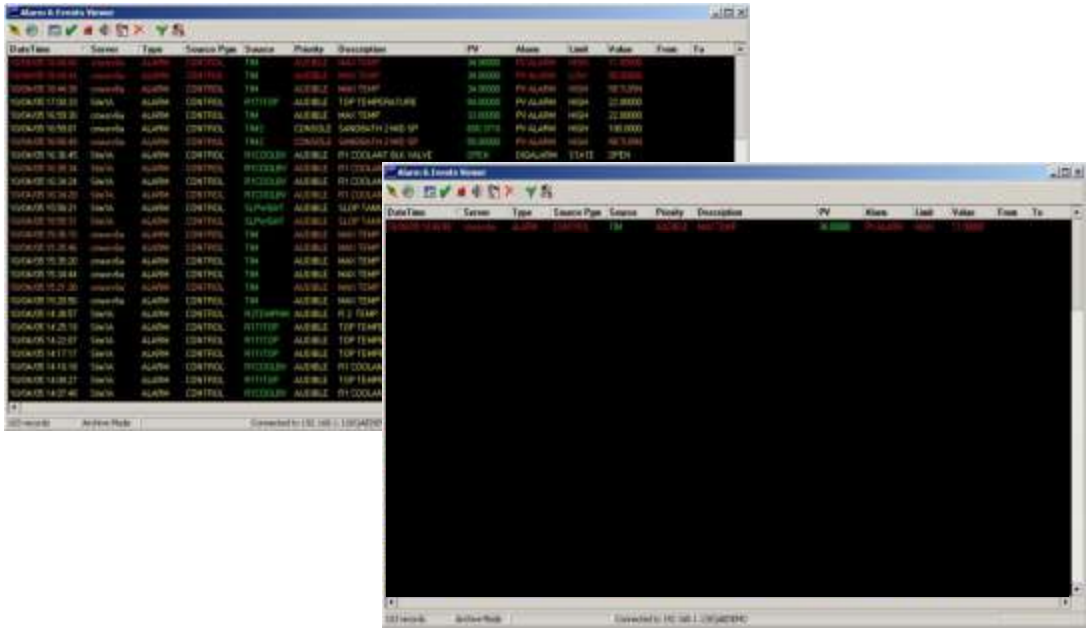

OH
20.1 psi
EAST COMP
WEST COMP
RUNNING
WC Speed
P 90.8 %
S 90.0
O 90.0 %
CAS
111.0 °C
48.0 psi
65.0 °C
1st Stage
20.0 °C
CW
28.0 °C
44.0 °C
2nd Stage
32.0 °C
90.0 psi
48.4 MSCFH
RECOVERY
EAST COMP
Flow Demand
P 76.8 MSCFH
S 76.0
O 88.5 %
AUTO
SPEED CASCADE IN EFFECT
90.8
48.0
90.0
65.0
32.0
111.0
Speed
1 Stg psi
2 Stg psi
CLR In
CLR Out
Winding Temp
SHOW / HIDE VALUES
NORMALIZE SCALE
West Compressor
IDLE WEST COMP
PURGE WEST COMP
SHUT DOWN WEST COMP
West Compressor Interlock W-1
Initiator
Value
Action
Status
Overspeed
OK
Shut Down West Comp AND
Or Winding Temp High
OK
Or Vibration High
OK
Close Inlet & Outlet Block Valves AND
Or 1 Stg High Pres
OK
Or 2 Stg High Press
OK
Or Suction Pres Low
OK
Override East Comp Speed to 100%
Or Oil Pres Low
OK
West Comp Discharge Temp °C
50.0
40.0
-90
-60
-30
2 Hours
West Comp Flow MSCFH
55.0
45.0
-90
-60
-30
2 Hours
West Comp Speed %
95.0
85.0
-90
-60
-30
2 Hours
Main Menu
Compression Level 2
East Comp
Trend Control
OH System
Product Recovery
West Startup Overlay
West Sequence Overlay
Comp Cooling System
- Level 4 - Procedures

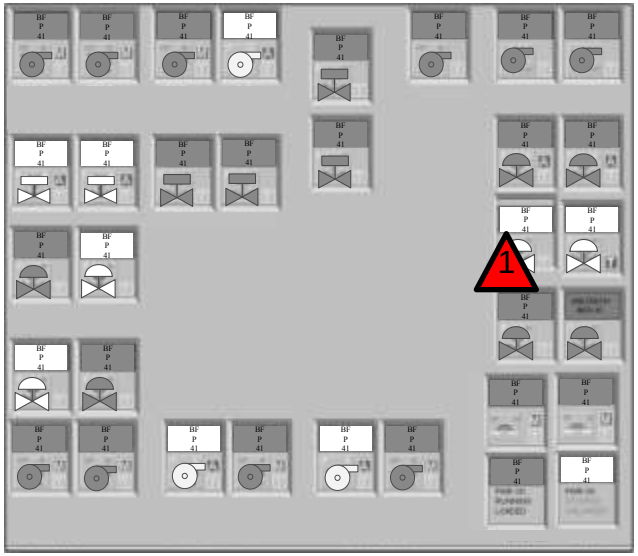
7 Steps for Creating High Performance Displays

1. Adopt a High Performance HMI Philosophy and Style Guide
2. Assess and benchmark existing graphics against the HMI Philosophy
3. Determine specific performance and goal objectives for the control of the process, for all modes of operation
4. Perform task analysis to determine the control manipulations needed to achieve the performance and goal objectives
5. Design and build high performance graphics, using the design principles in the HMI Philosophy and elements from the Style Guide, to address the identified tasks
6. Install, commission, and provide training on the new HMI
7. Control, maintain, and periodically reassess the HMI performance

Conclusion

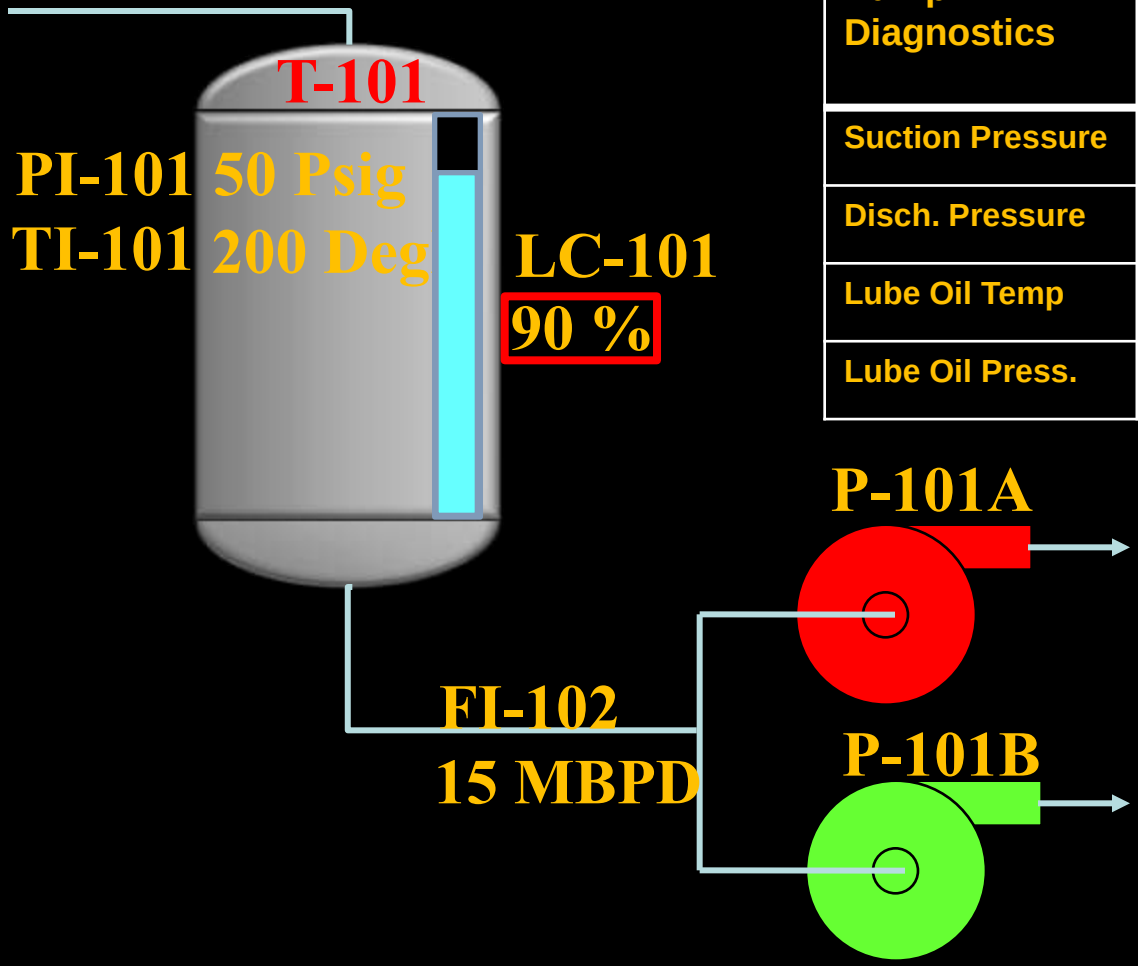
- Alarm management is only one of the tools needed by console operators
- High Performance HMI enables operators to be proactive
- Best practices have been published on how to design effective HMIs
- Alarm Management best practices simplify HMI design
- It is now practical and achievable to enable operators with a solution that augments their human reliability





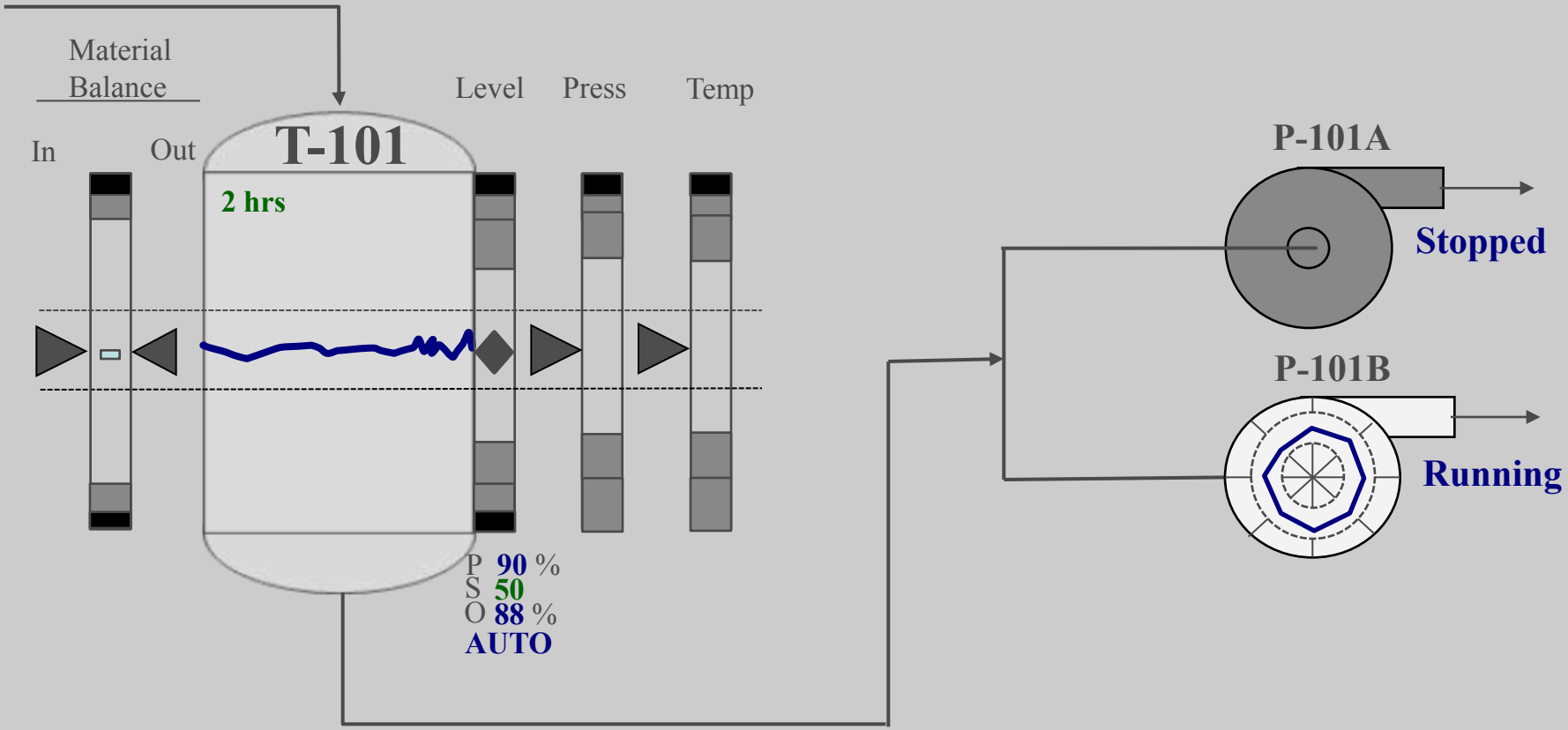
Questions

HP HMI 7 Steps Example



Pump Diagnostics	P-101 A	P-101B
Suction Pressure	60 PISG	40 PSIG
Disch. Pressure	1 PSIG	60 PSIG
Lube Oil Temp	120 DegF	120 DegF
Lube Oil Press.	20 PSIG	20 PSIG

HP HMI 7 Steps Example



HP HMI 7 Steps Example