Setting the Standard for Automation™

Using ISA-101 & High Performance HMIs for More Effective Operations

(Slide Deck for Distribution)

Speaker: Graham Nasby
Voting member of ISA-101 Committee

Standards
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WEAO Intelligent Wastewater Systems Seminar
Sept 14, 2017 – Canada Centre for Inland Waters – Burlington, Ontario

About the Speaker

Graham Nasby, P.Eng., PMP, CAP

- **Water SCADA & Security Specialist**
- **City of Guelph Water Services**

- 10 years in the consulting sector, followed by 2 years at the city

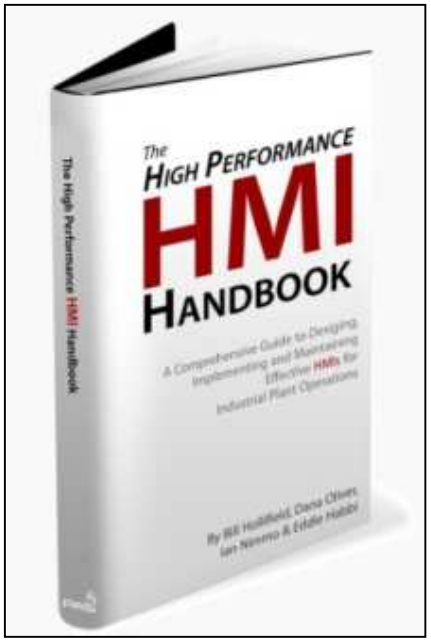
- WEAO and OWWA Member, Member of OWWA Automation Committee
- Co-chair of ISA112 SCADA Systems standards committee
- Voting member of ISA101 HMI Design standards committee
- Voting member of ISA18 Alarm Management standards committee
- Named Canadian Expert on IEC/SCC-TC65 with Standards Council of Canada

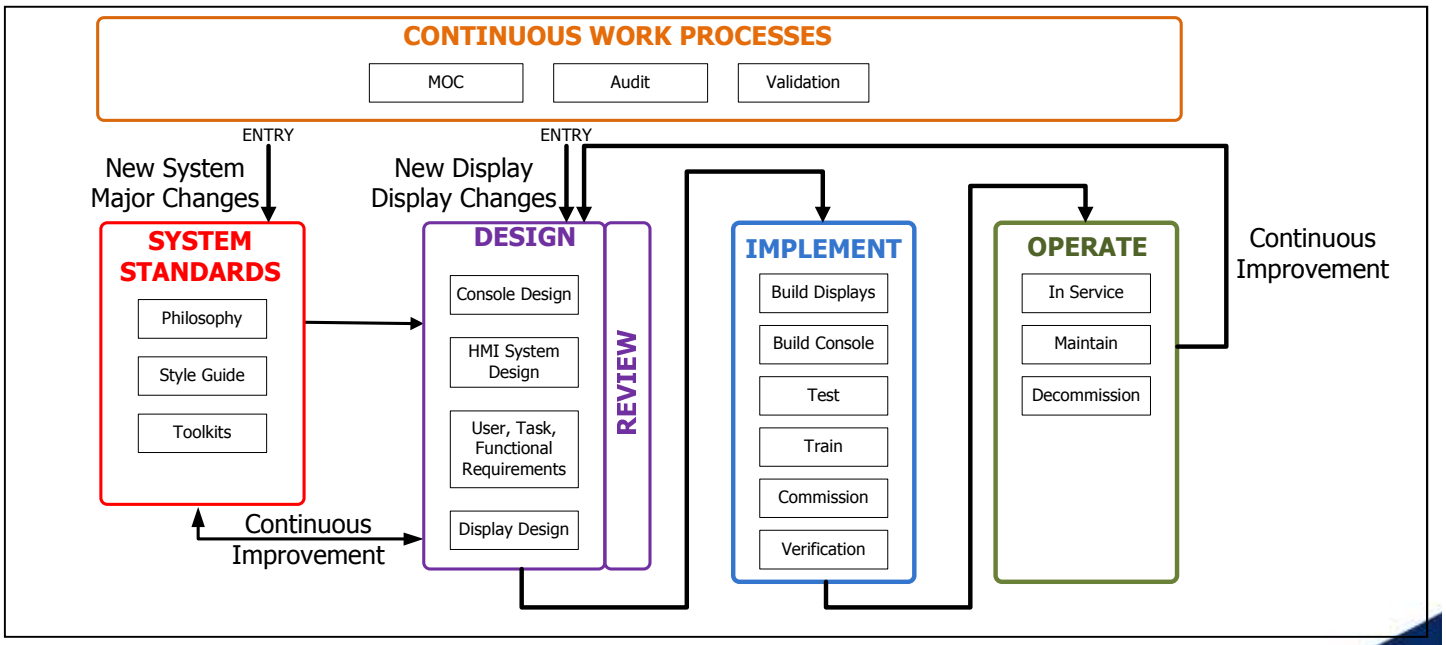
- Has published over 30 papers and articles on automation topics
- Received University of Guelph “Mid Career Achievement Award” in 2014
- Named ISA’s technical division leader of the year award in 2013.

- Contact: graham.nasby@guelph.ca

First a Few Acknowledgements

- Thanks to my fellow members of the ISA-101 committee for contributing several of the graphics in this presentation
- Also special thanks to Bill Hollifield, author of the High Performance HMI Handbook, for kindly letting me use a few of his examples.
- Note: This PowerPoint slide deck is abbreviated version of the slides that were presented on Sept 14, 2017. The original presentation contained some propriety images which were on loan under a "present only" arrangement with the original authors. Thank you for your understanding.





Source: ANSI/ISA-101.01-2015, Human Machine Interfaces for Process Automation Systems

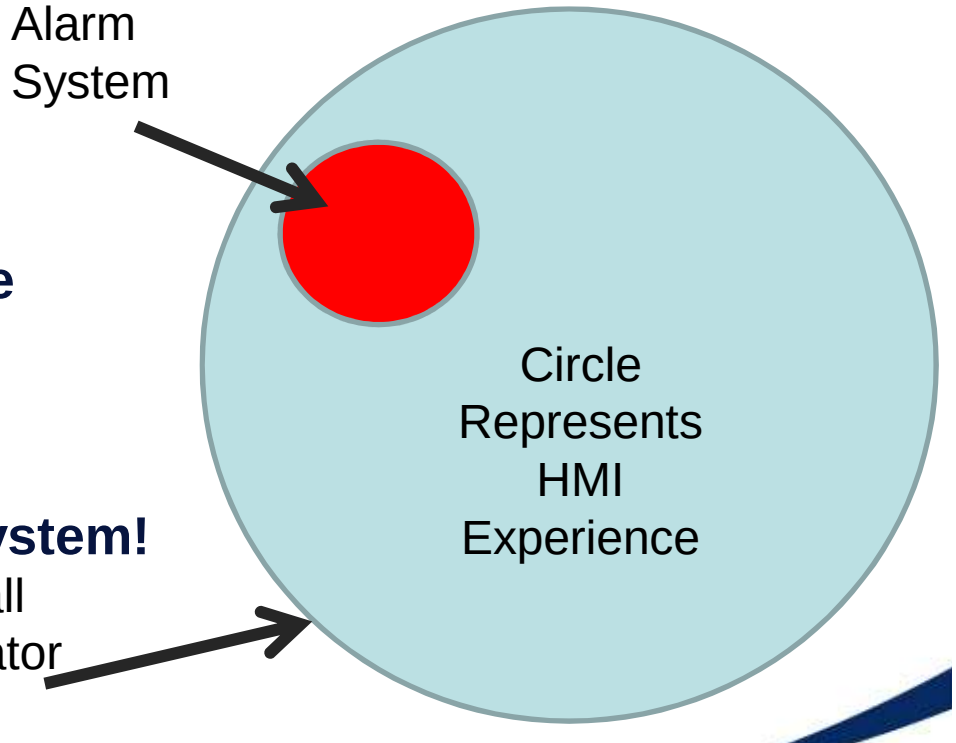
Outline

- Why Do We Care About the HMI?
- Operator Effectiveness for Normal Operations and Abnormal Situation Management
- The History of HMIs in Industry
- Examples Common Problems with HMI Screens
- Justifying the development of High Performance HMIs
- High Performance Graphic Principles and Elements
- High Performance HMI Display Hierarchy & Navigation
- How to apply ISA-101 and High Performance HMIs
- Summary and Questions

Operator Effectiveness:

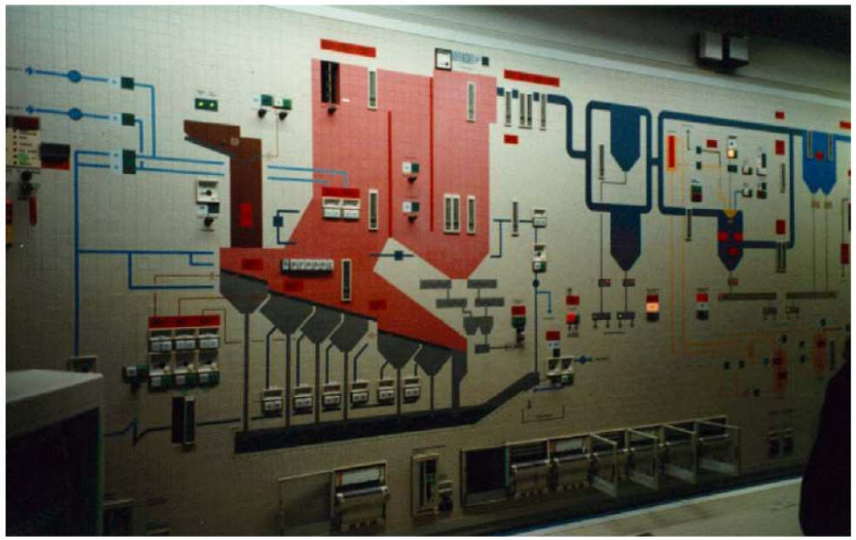
Operations Effectiveness:

- **Effective controls, systems, tools, and training to enable operators to effectively detect and successfully handle BOTH normal operations AND abnormal situations.**
- **The Three Components**
  - Effective Alarm Management
  - Control System Performance
  - **High Performance HMI**
- **Effective Operations Requires all three aspects**
- **Effective Abnormal Situation Management also requires all three**
- **The Alarm System is an essential but <u>small</u> part of the overall HMI!**
- **Operator vigilance involves the ENTIRE HMI – not just the alarm system!**

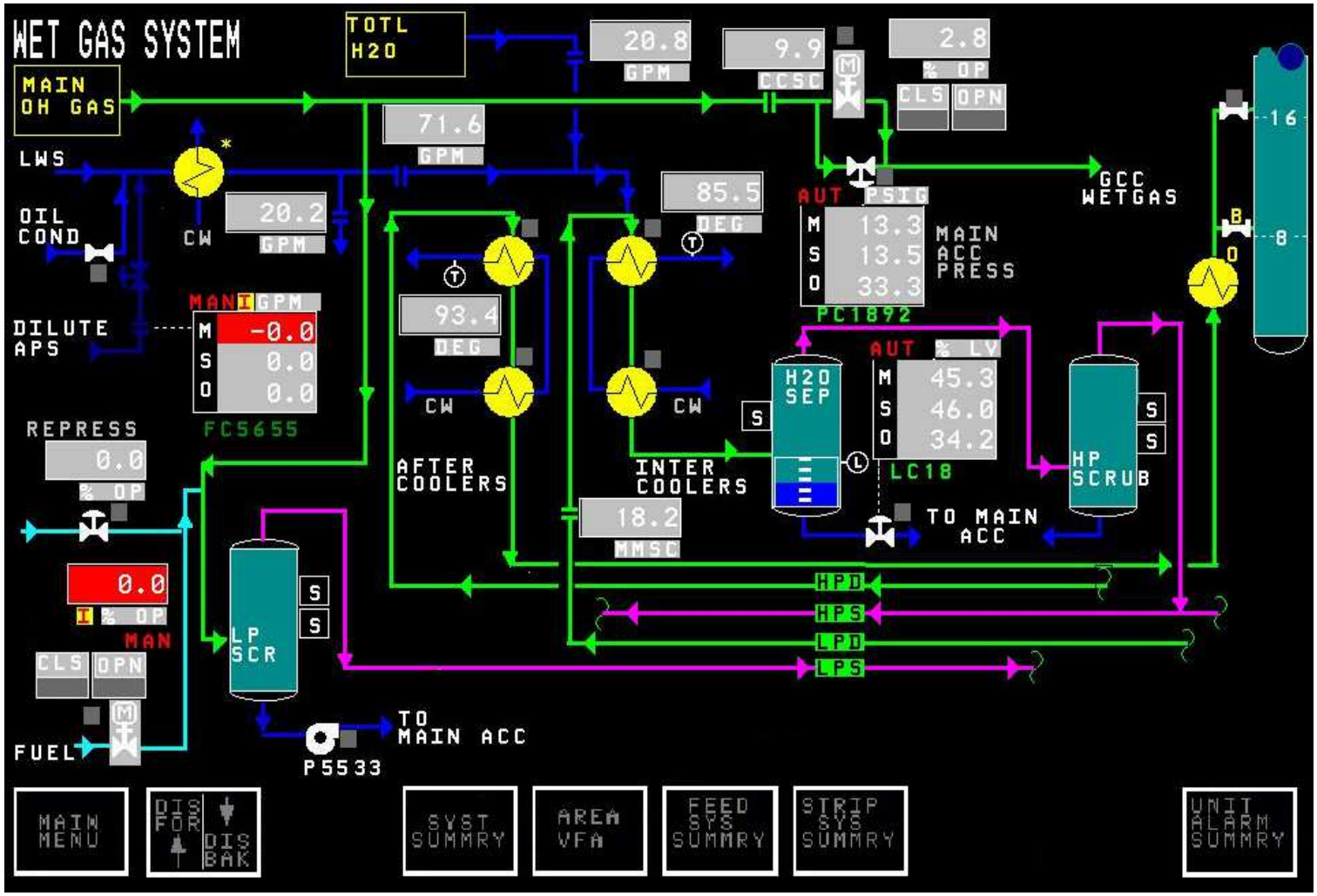


HMIs Past and Present

- Remember the “old days”?
- Provided the “Big Picture”
- Limited Capability
- Many Process Trends
- Status “at-a-glance”
- (but took years to learn)



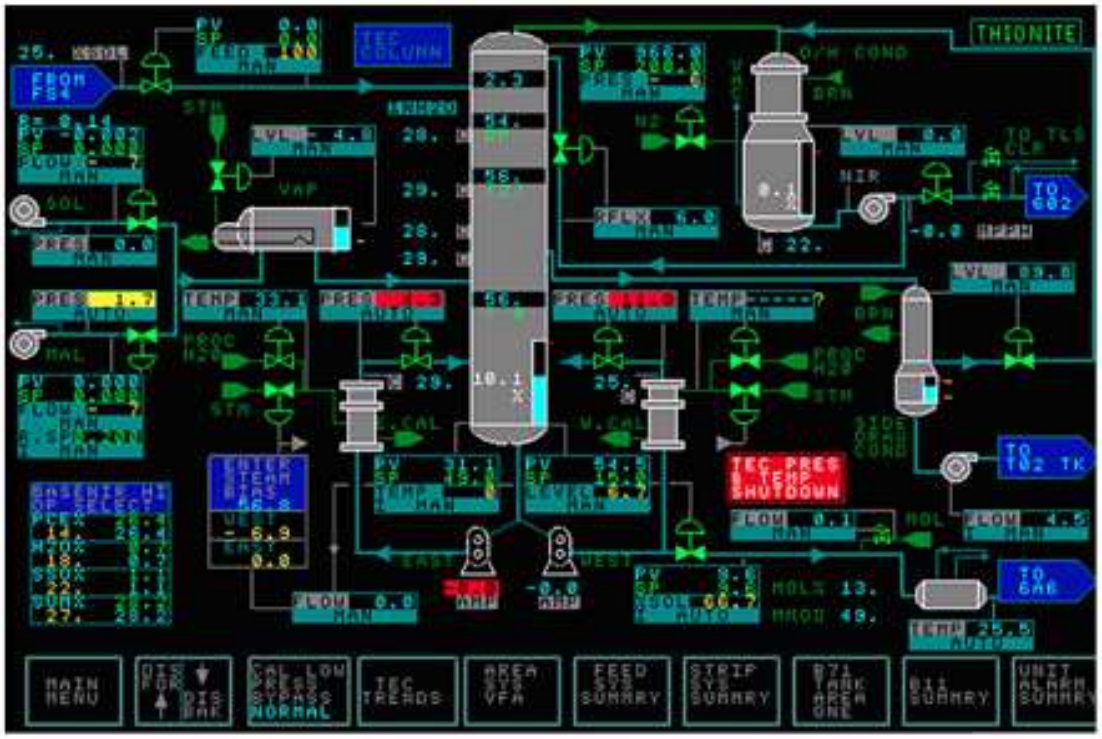
SCADA Graphics Introduced…but no guidelines!



Poor Graphics Encourage Poor Operating Practices

Common, Ineffective HMI Depictions

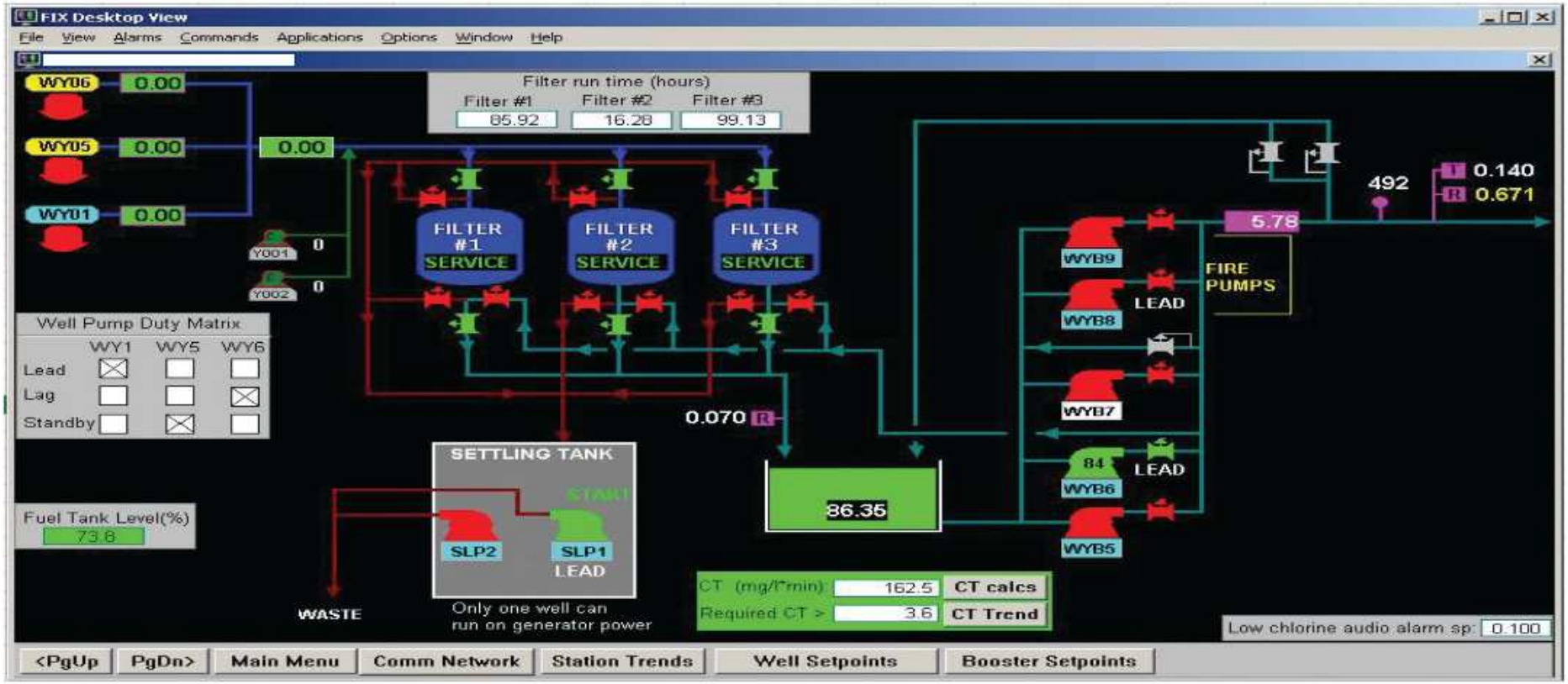
- Common, but ineffective process depictions!
- Numbers sprinkled on a screen
- Inconsistent, improper use of color



- No trends, no condition information
- Are these processes running well?

But the graphics got better over time…

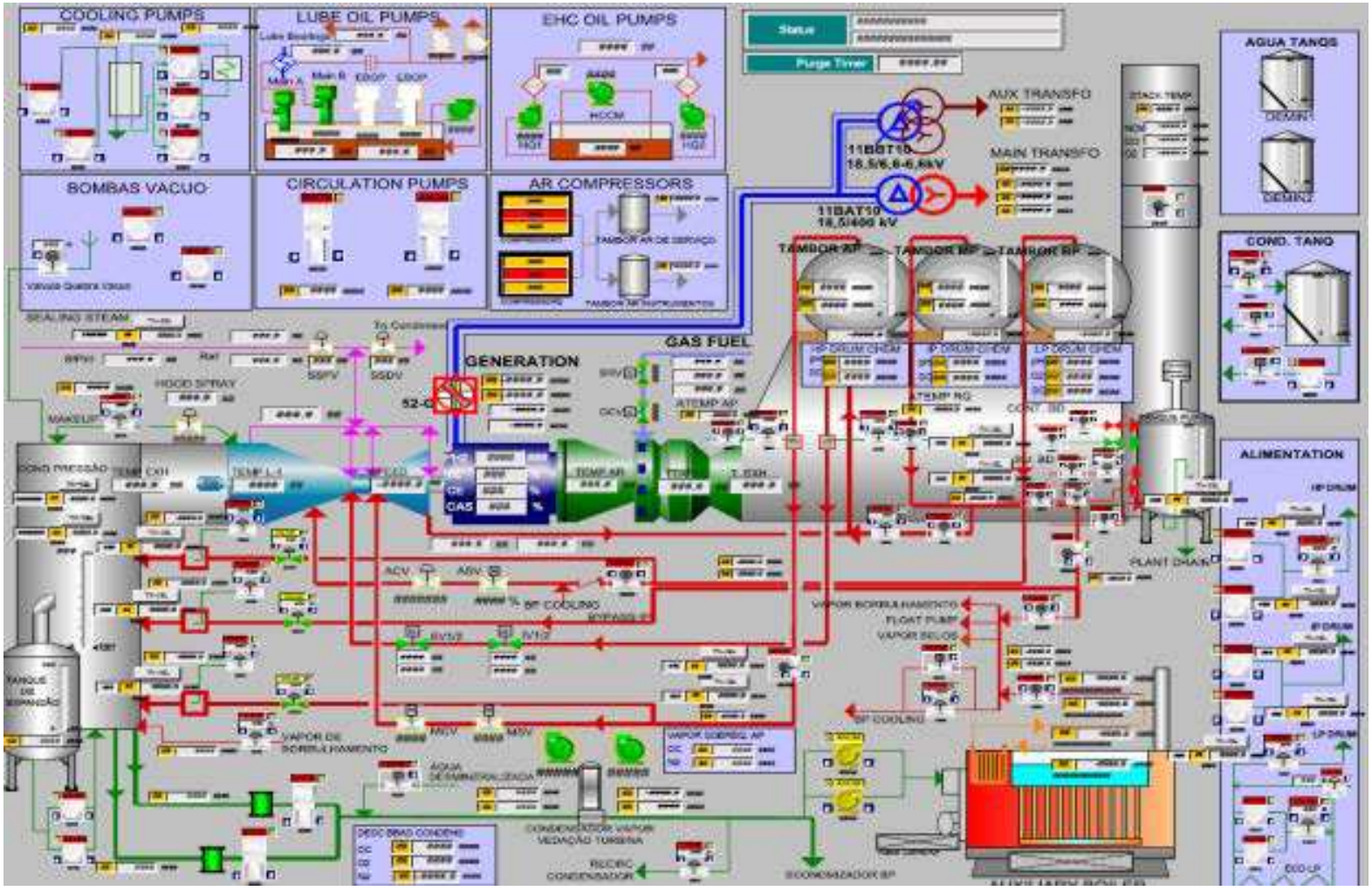
- **"Improved" Graphic Capability doesn't seem to make it any better**
- **At a glance, what can you tell from this screen?**



- What is running?
- Is the process running well?
- Is anything abnormal?
- What if your are colour blind?

One of my favourites…

- **So glad this is not from our industry!**



How do we make better HMIs?

We need to look at what other industries are doing!

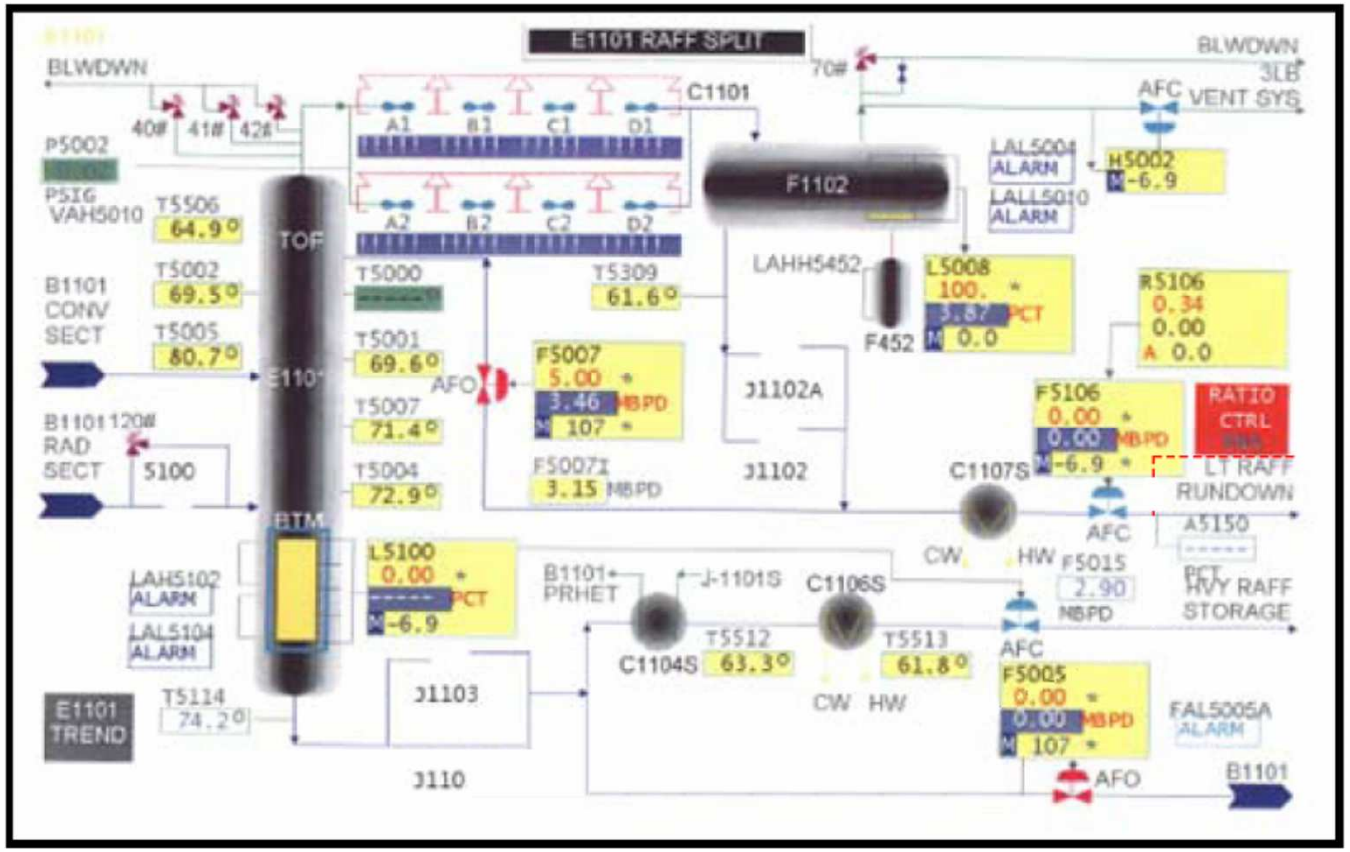
Look at industries where the cost of human error is so high that they have spent the time and energy to develop more effective HMIs

- **Oil Refining Industry**
- **Offshore Platforms**
- **Power Plants**
- **Chemical Industry**
- **Railways**
- **Aviation**
- **Mining**
- **Pulp and Paper**

- **In 2003 a group of end-users from the process industries got together and started working on the ISA-101 HMI Design Standard…. they published it in 2015! ….. It took them 12 years ….**

2015 Texas City Oil Refinery Disaster from www.csb.gov

- **Just a P&ID - no overview, trends, condition information, or material balance**
- **Inconsistent colors and alarms. 15 killed, 180 injured, $1.5 billion damage**



Cited: Poor HMI was significant contributing factor to the fatal accident

Operators could not tell from the HMI that they were continuing to feed fuel into the fire!

Situation Awareness in Aviation

Speed
Altitude
Position
Course
Nearby Airports

Time Enroute
Time to next Waypoint
Time to Destination

Fuel Remaining
Proximity to Ground
Proximity to Rising Terrain

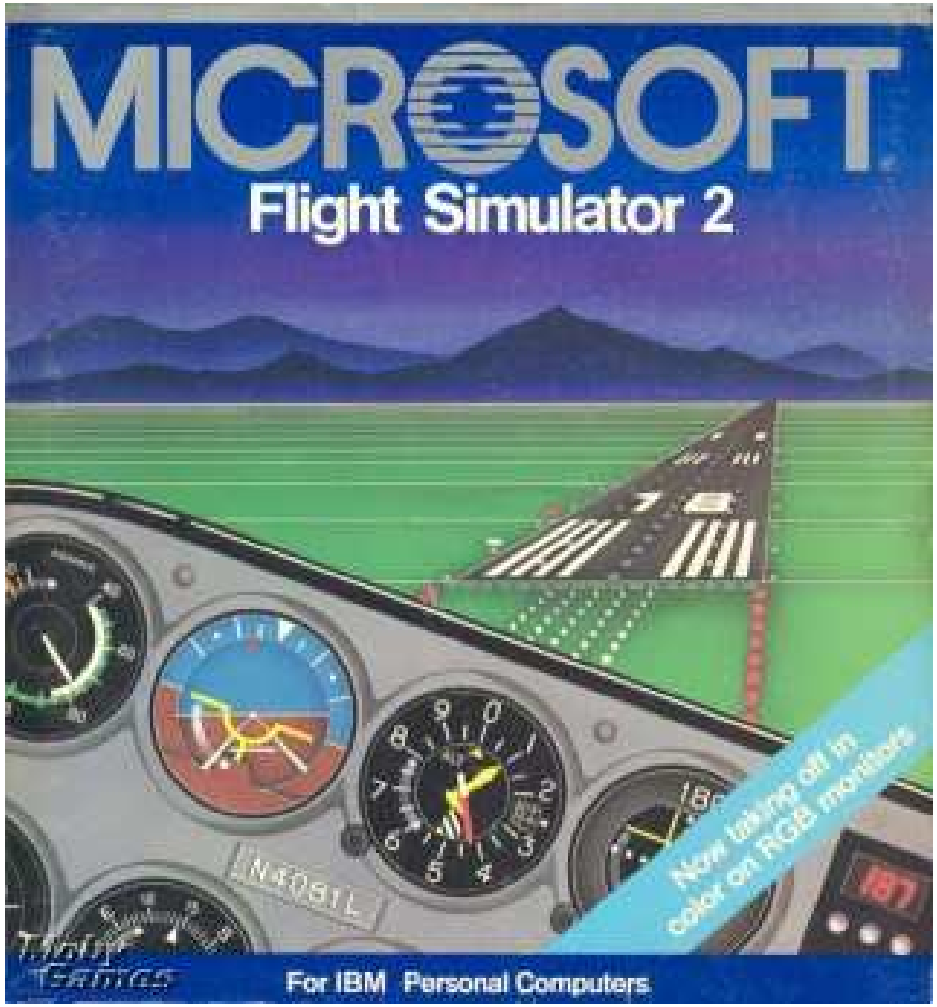
Positions of nearby aircraft
Real-time weather & lightning

Engine diagnostics
Data on Available Services at Airports

Comm & Nav Frequencies
Instrument Approaches
Glide Radius

Example is the Garman GTN-650 small aircraft display system

If we designed heads up displays like old HMIs



Does the fighter jet pilot stand a chance?

The High Performance HMI

Poor HMIs are cited as contributing factors to major accidents!

Task	With "Traditional" HMI	With High Performance HMI concepts	Improvement
Detecting Abnormal Situations Before Alarms Occur	10% of the time	48% of the time	A 5X increase
Success Rate in Handling Abnormal Situation	70%	96%	37% over base case
Time to Complete Abnormal Situation Tasks	18.1 min	10.6 min	41% reduction

Study by Nova Chemicals and ASM® Consortium

Nova estimated $800,000 per year savings on 1 ethylene plant

PAS-EPRI Study: Similar Results on a Coal-fired power plant

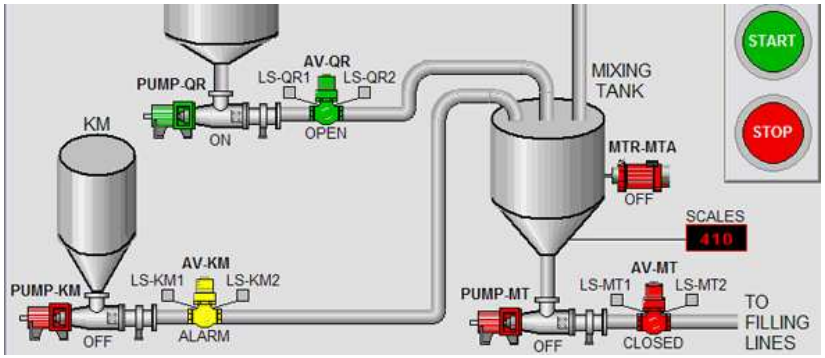
Figures and Graphic courtesy of PAS (www.pas.com)

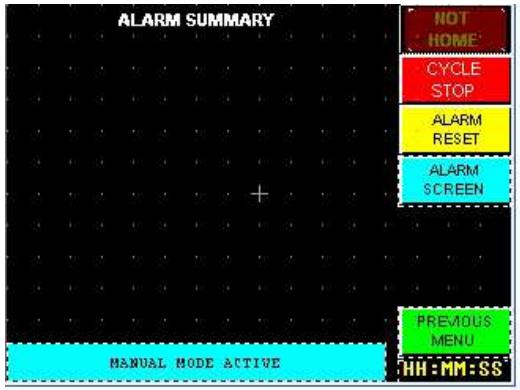
High Performance HMI Concepts

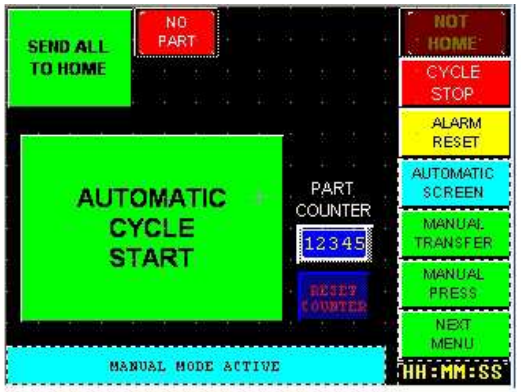
Proper Use of Color

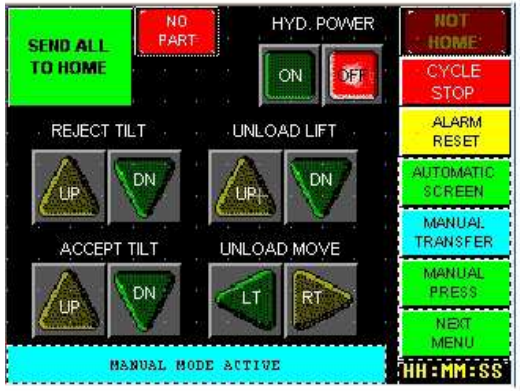
- Color is an attention-getter
- Using Red or Green to indicate normal “running” or “not running” makes problems hard to see

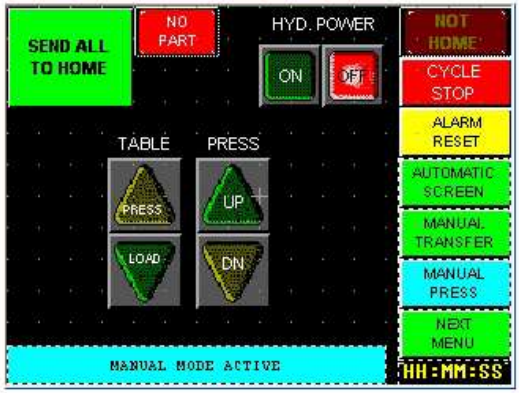
- Use color for the abnormal, not the normal
- Can you quickly tell where the problems are on these screens?





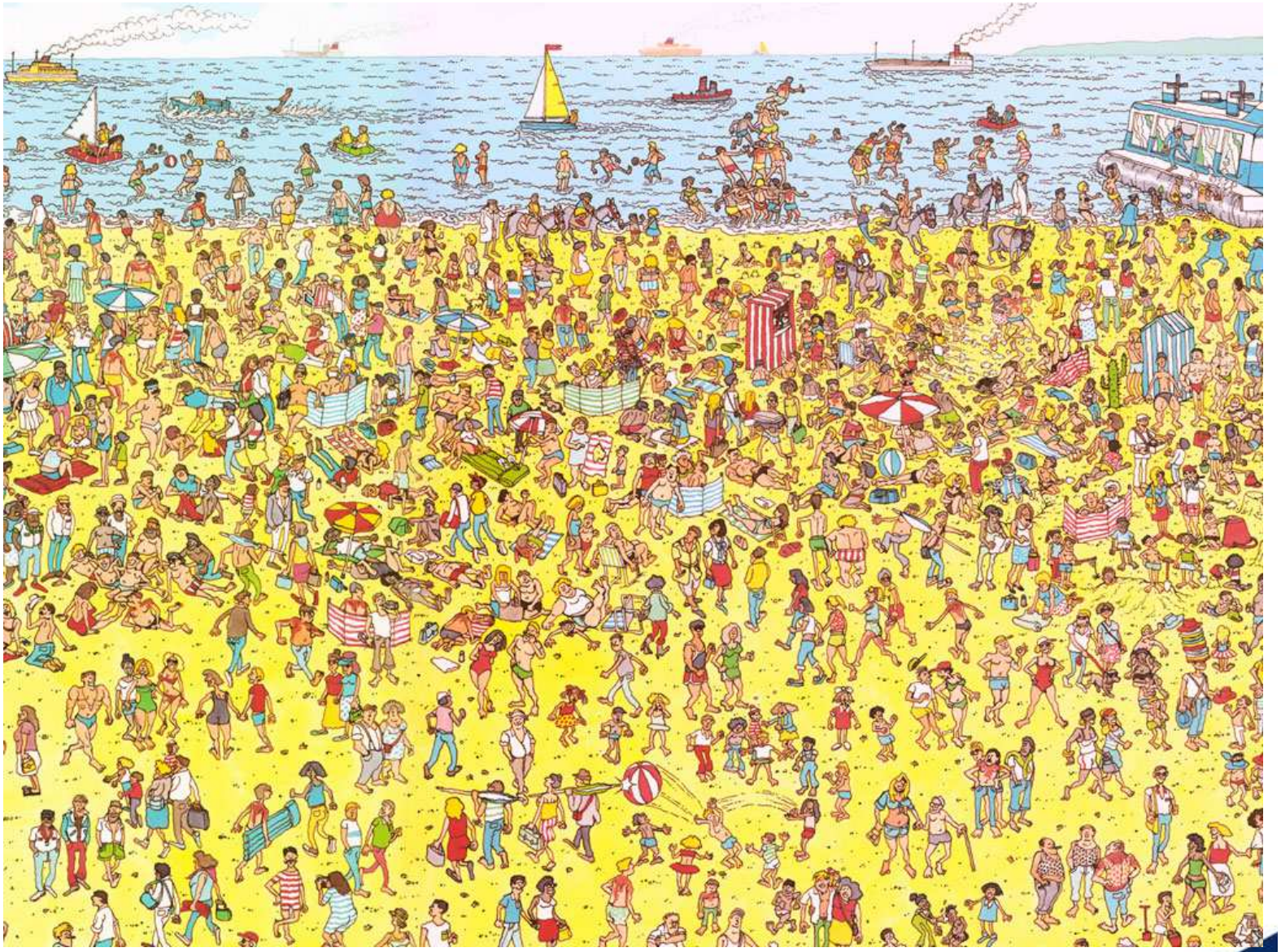






If you overuse red or green, it no longer stands out

Remember these books?

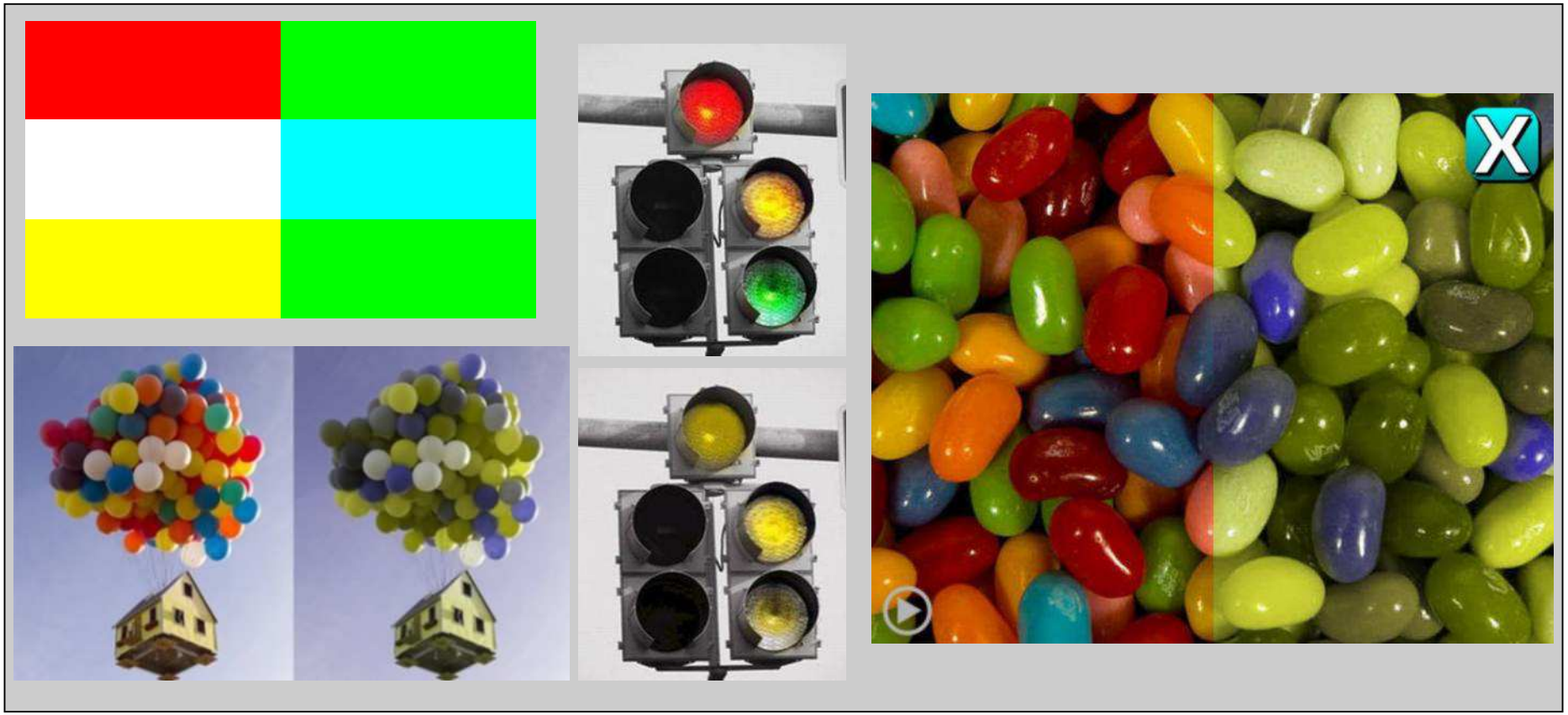


How long did it take to find Waldo?

Friendly
SCADA Guy

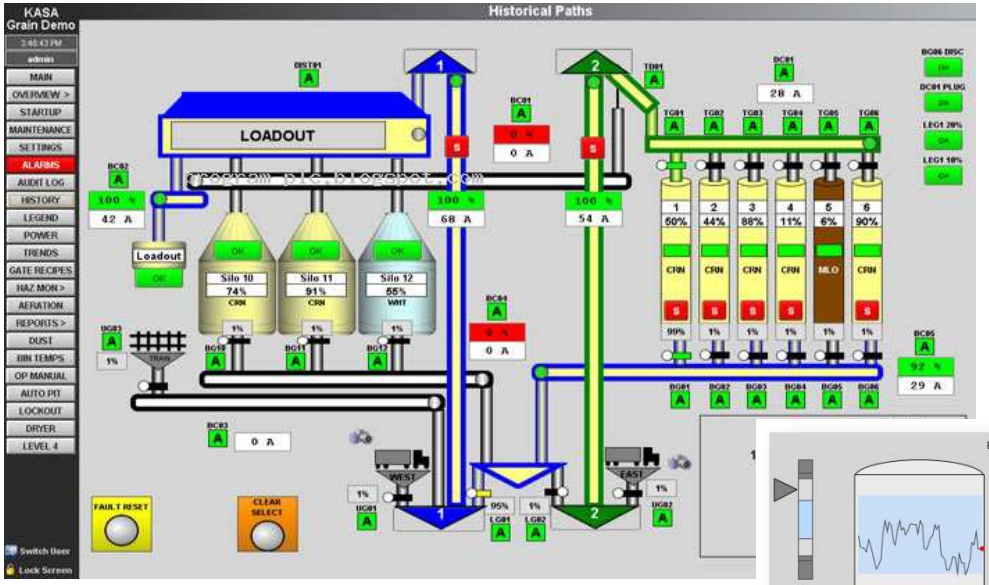
Common Color Blindness or Deficiency

- **Very common, different types**
- **Color change is not detected well in peripheral vision.**
- **<u>Color alone</u> should <u>not</u> used to differentiate an important status!**



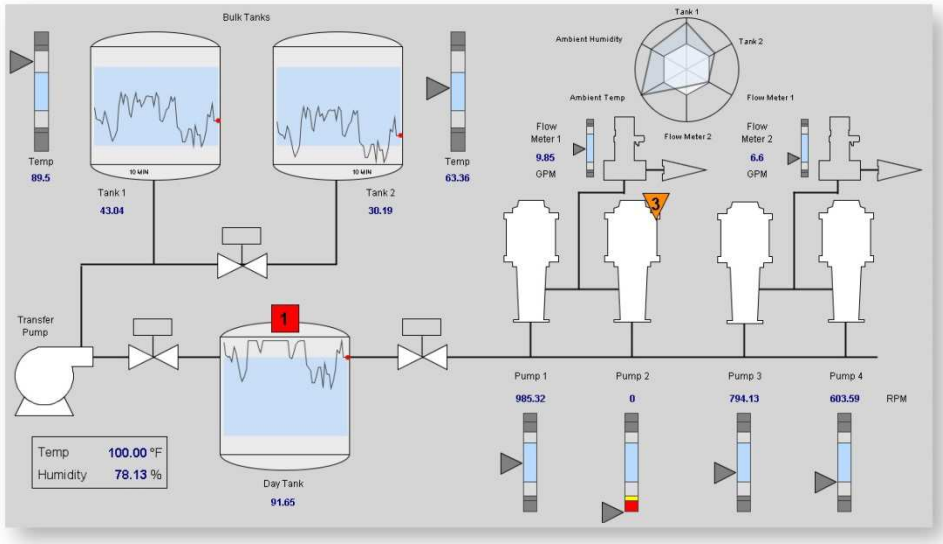
Credit: http://play.google.com/store/apps/details?id=com.givewaygames.colorblind_ads
Credit: http://wearecolorblind.com/wp-content/uploads/general-example-2-types2.jpg
Credit: http://www.personal.psu.edu/afr3/blogs/siowfa12/color_blind_12.jpg

A word about Colour Schemes



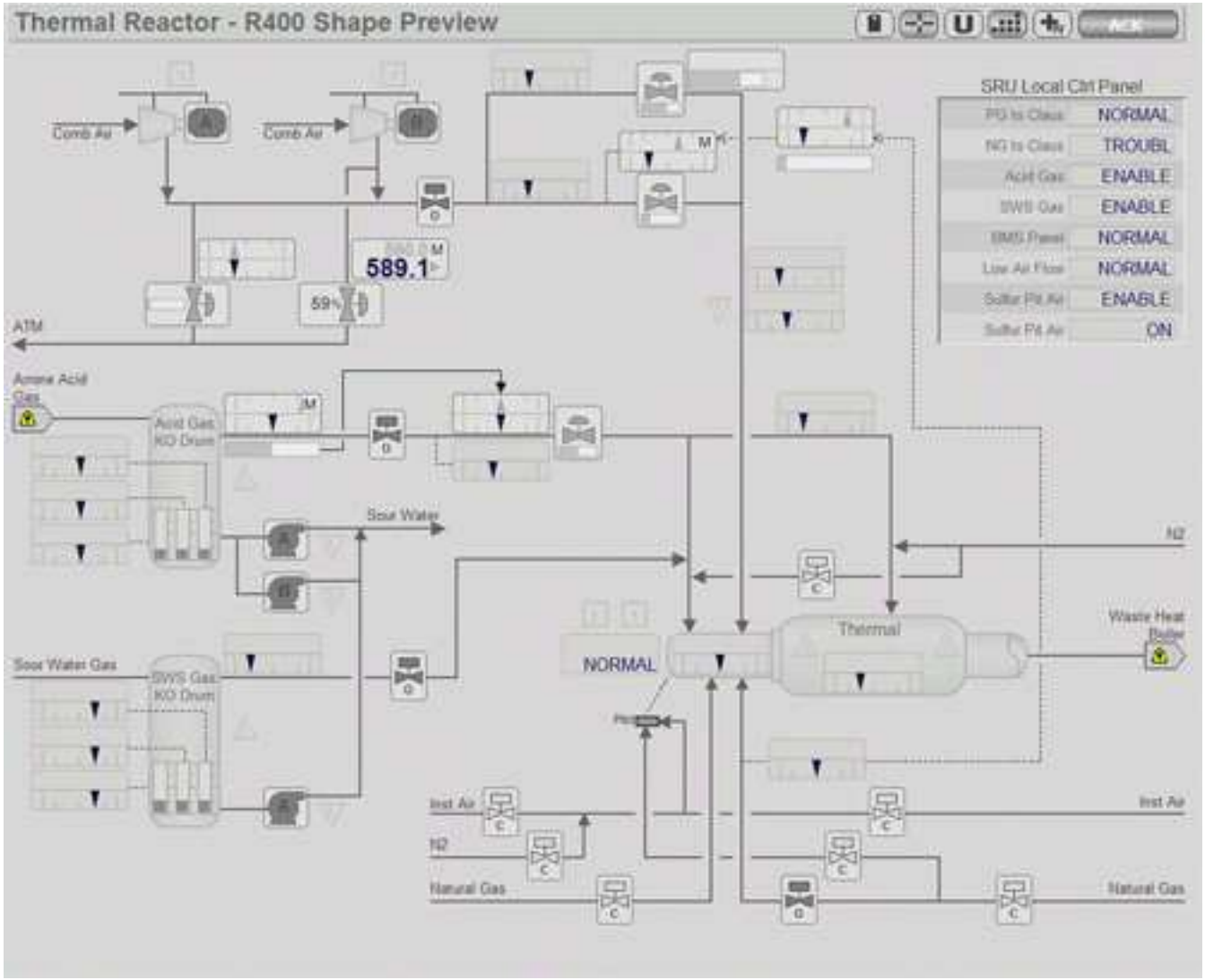
Poor Colour Scheme

Better Colour Scheme



What parts of the screens catch your eye?

You can show a lot of grayscale



In this example, colour is only used to show alarms

HAPPY PLANT = no alarms, no colour

Data is Not Information: Is Spot Sick?

Blood Tests for Spot	
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

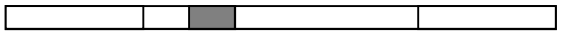
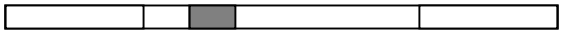
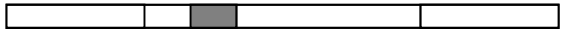
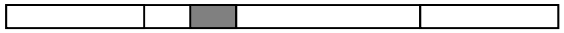
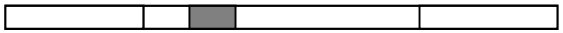
Example adapted from High Performance Handbook

Unless you are vet,
how can you know?

Nice Teeth, eh?

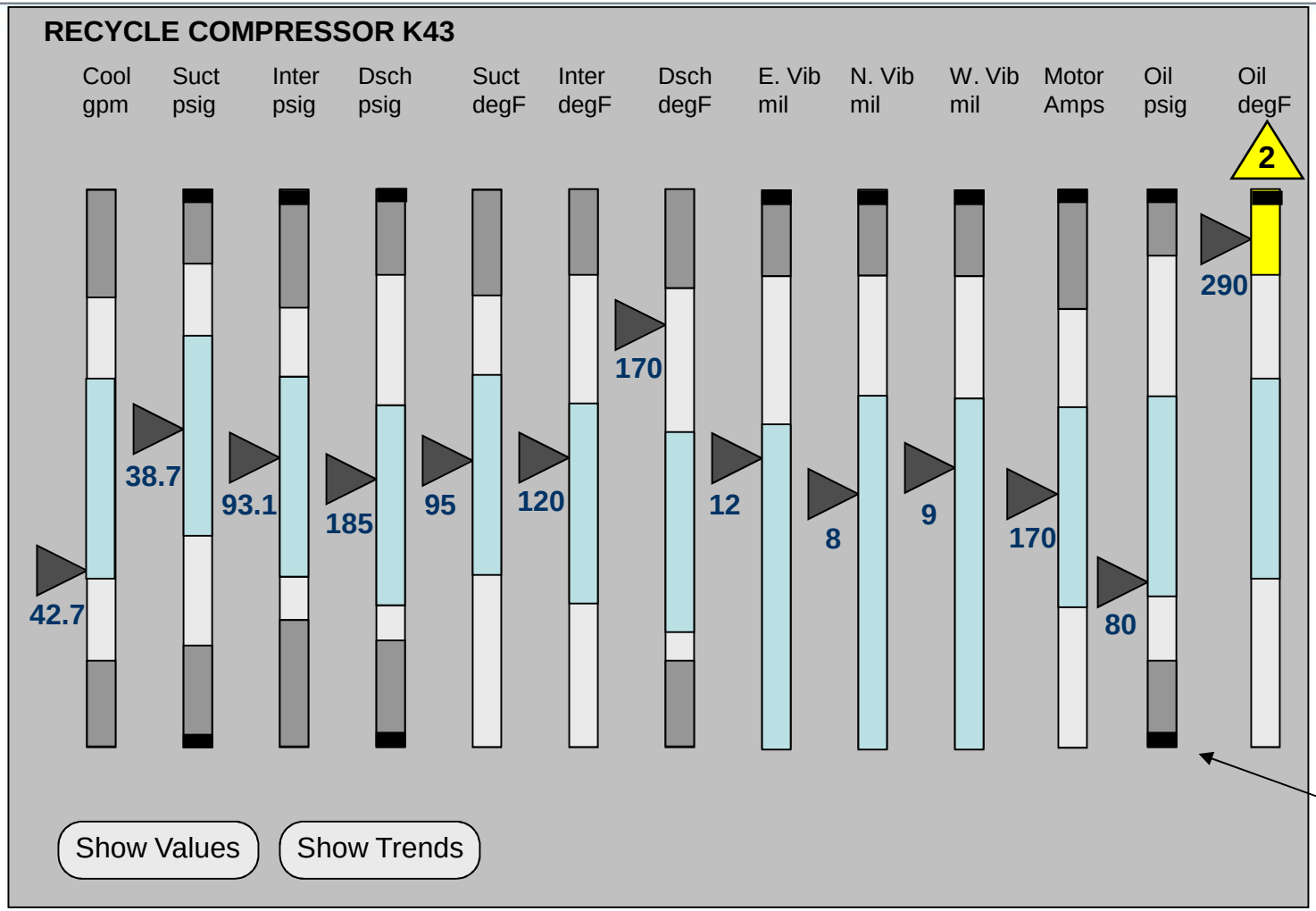
How About Now?

You can tell at a glance

Blood Tests for Spot			
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	

Example adapted from High Performance Handbook

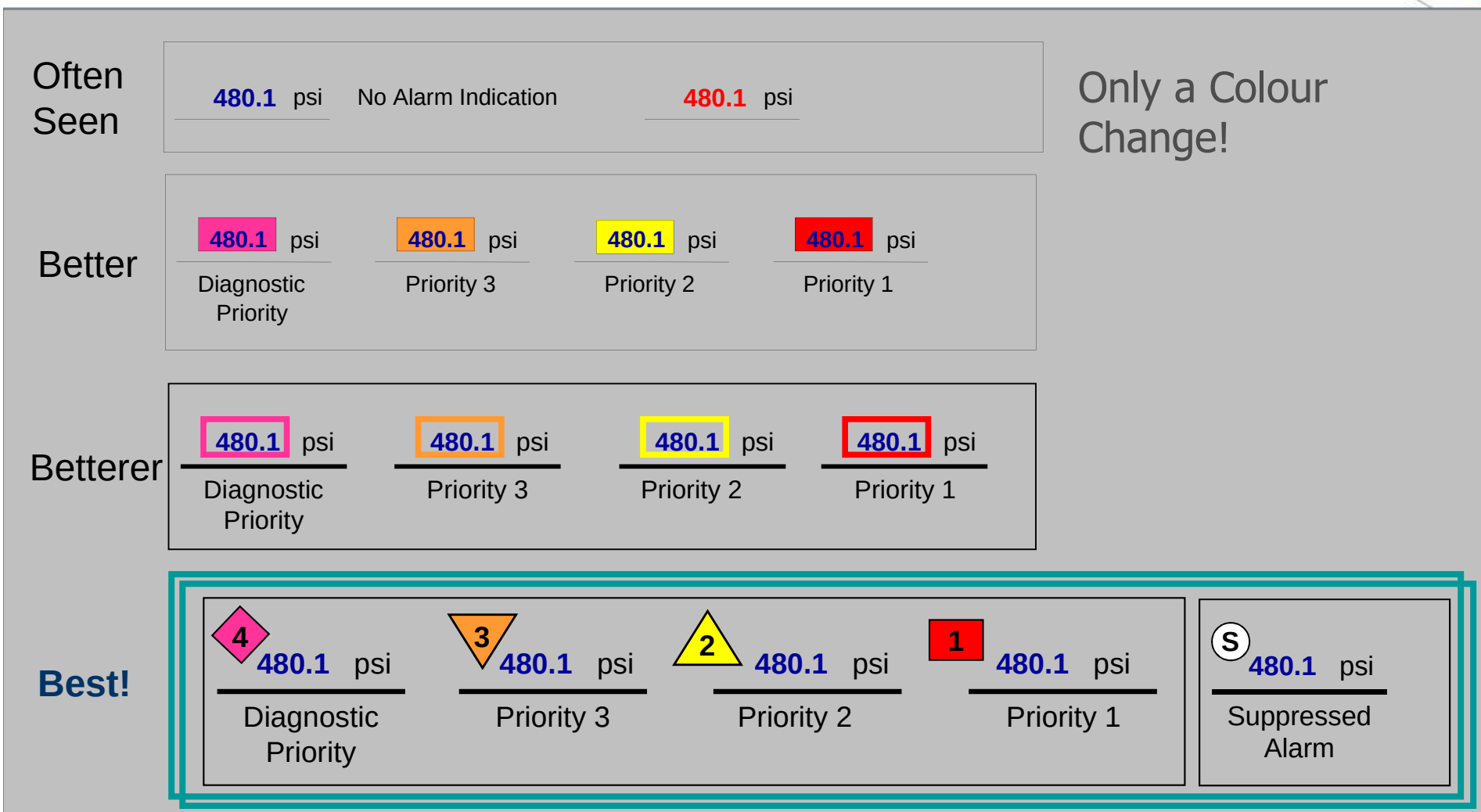
Analog in Industrial Examples



Buttons for additional functionality

Image from High Performance Handbook

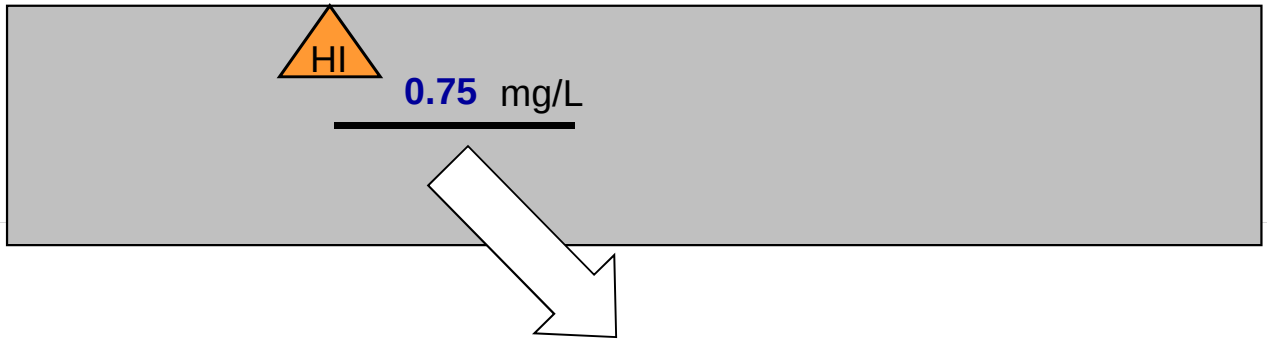
Alarm Indications on Graphics



Show alarms in multiple ways: Colour, Shape, Text ("redundant coding")

Adapted from High Performance Handbook

Embed information into the HMI!



AIT01-HI Chlorine Treatment High Residual Alarm		
Alarm: HIGH	**Setting: 120 deg C**	**Priority: 3**
Class: OPERATIONAL	**Response Time: <15 min**	
Alarm Consequences:	**Alarm Causes:**	**Corrective Actions:**
High Hypo Usage	Hypo Pump Problem	Check dosing rate
High Dechlor Usage	Pump in Manual	Adjust dosing rate. See. ***SOP 26***
	Problem with Feed Valve	Visit site and inspect pump
	Bad load of Hypo	Go to site and do manual hand sample
	Problem with Analyzer	

Alarm Information Record from the SCADA System's Master Alarm Database – see the ISA18 alarm management standard

The Importance Of Trends

Embedded “always visible” trends on process displays are always better.

Don’t’ rely on “trending on demand”, “trend pop-ups” or “trend screens” – in practice they don’t’ work very well.

Best Practice:
Embed Trends on HMIs

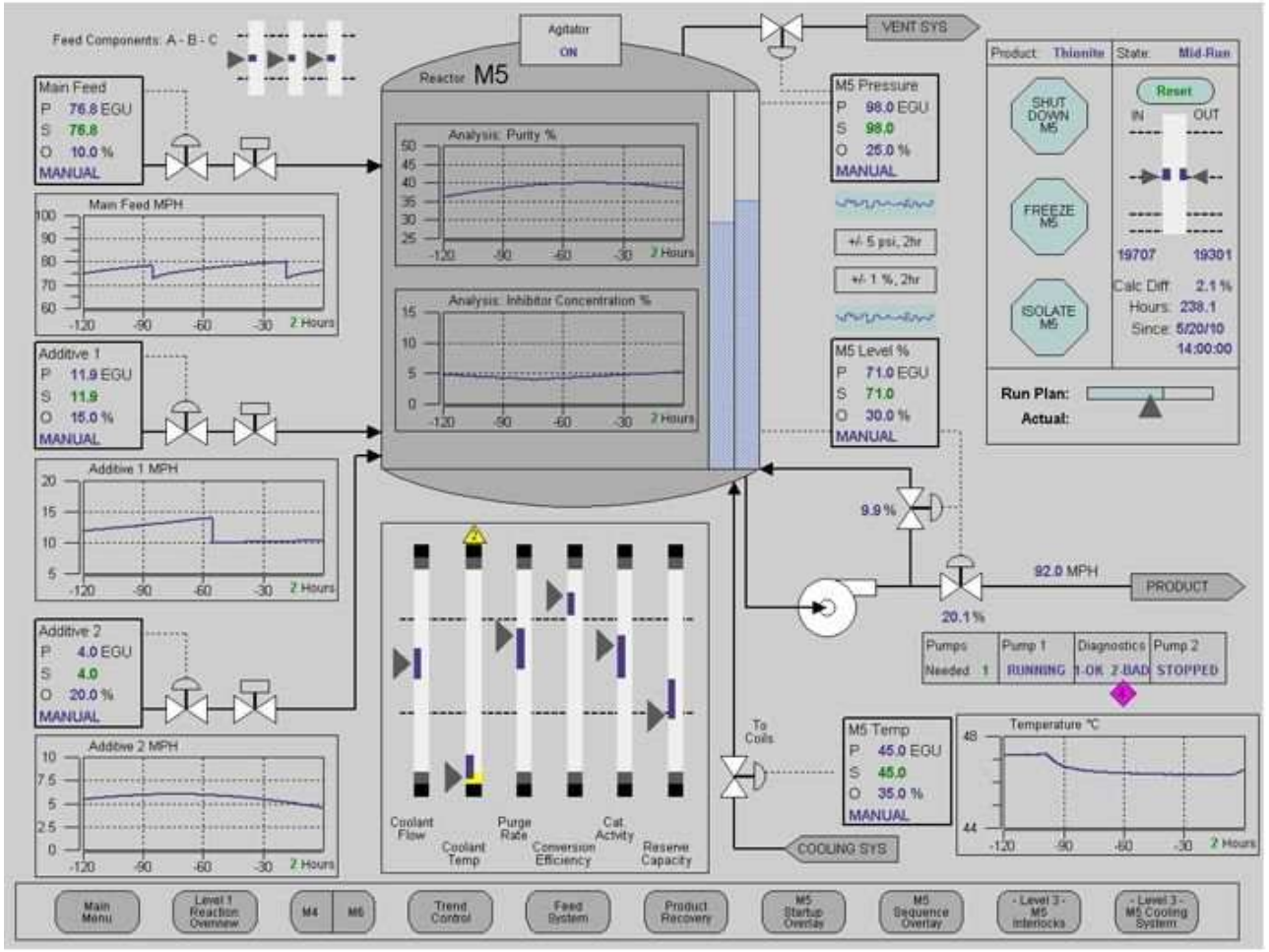
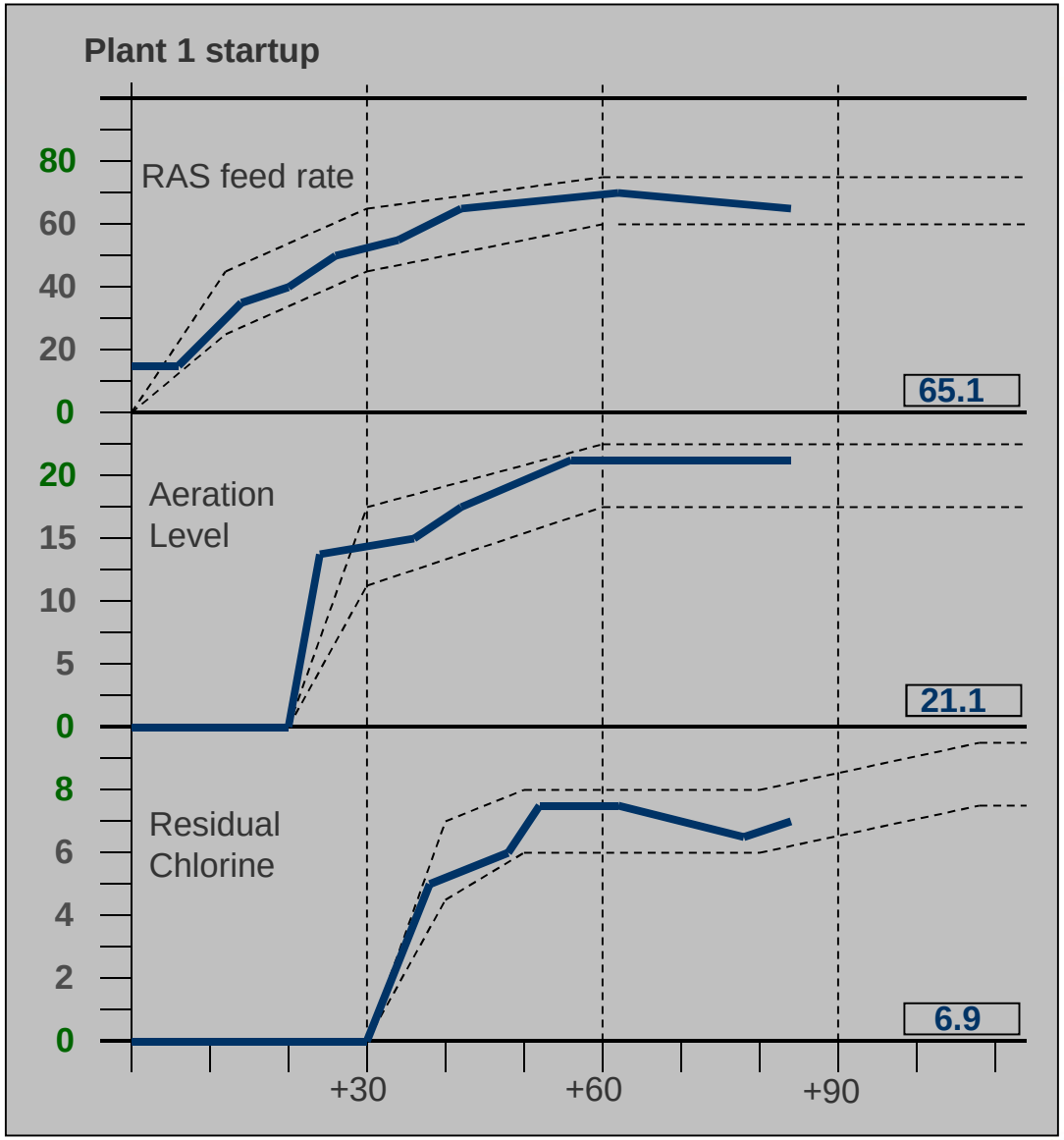


Image from High Performance Handbook

More concepts with Trending

- **Would these graphs help start up your plant?**



Adapted from image courtesy of PAS (www.pas.com)

Keep it simple

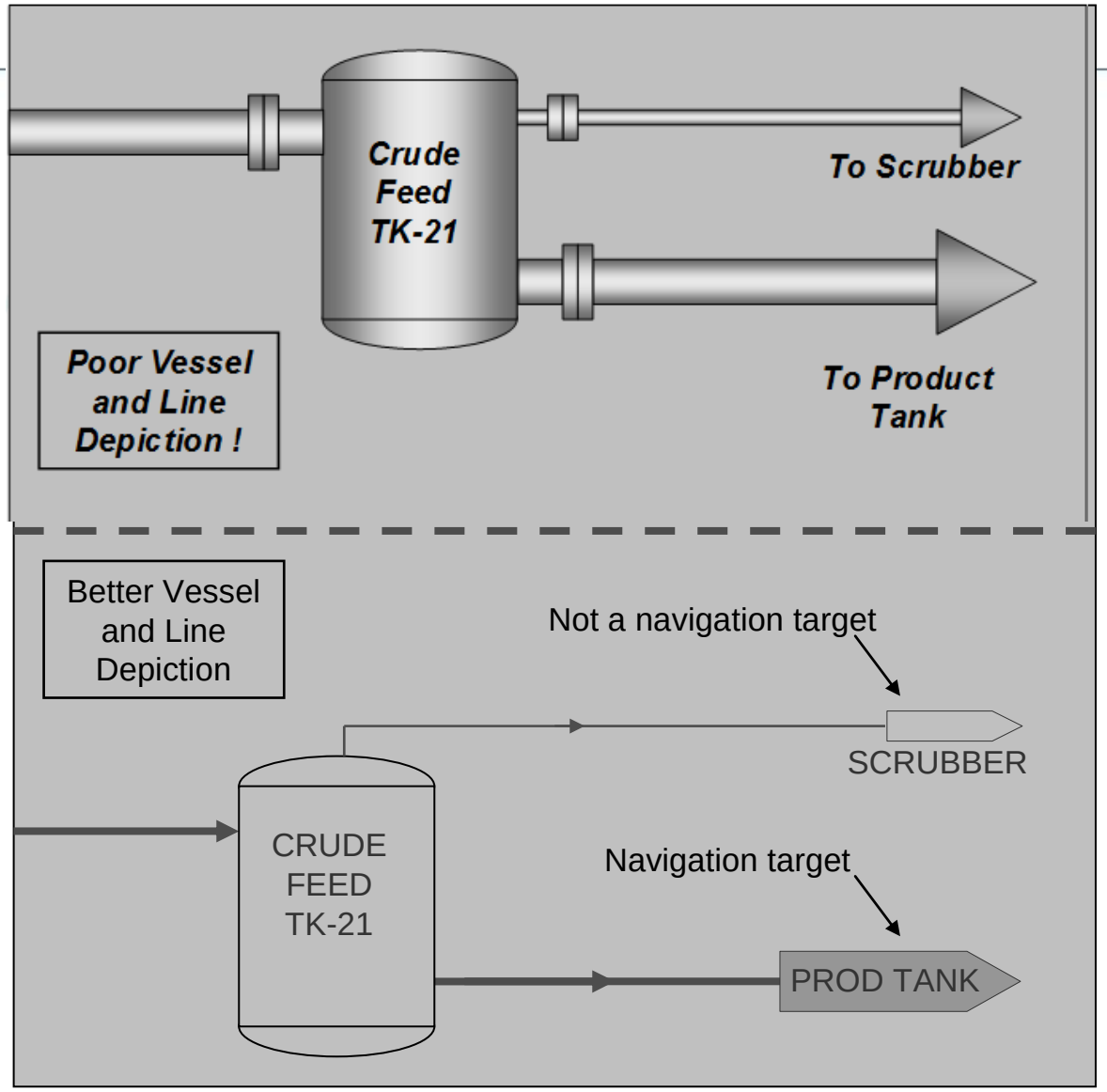


Image from High Performance Handbook

Level Depiction

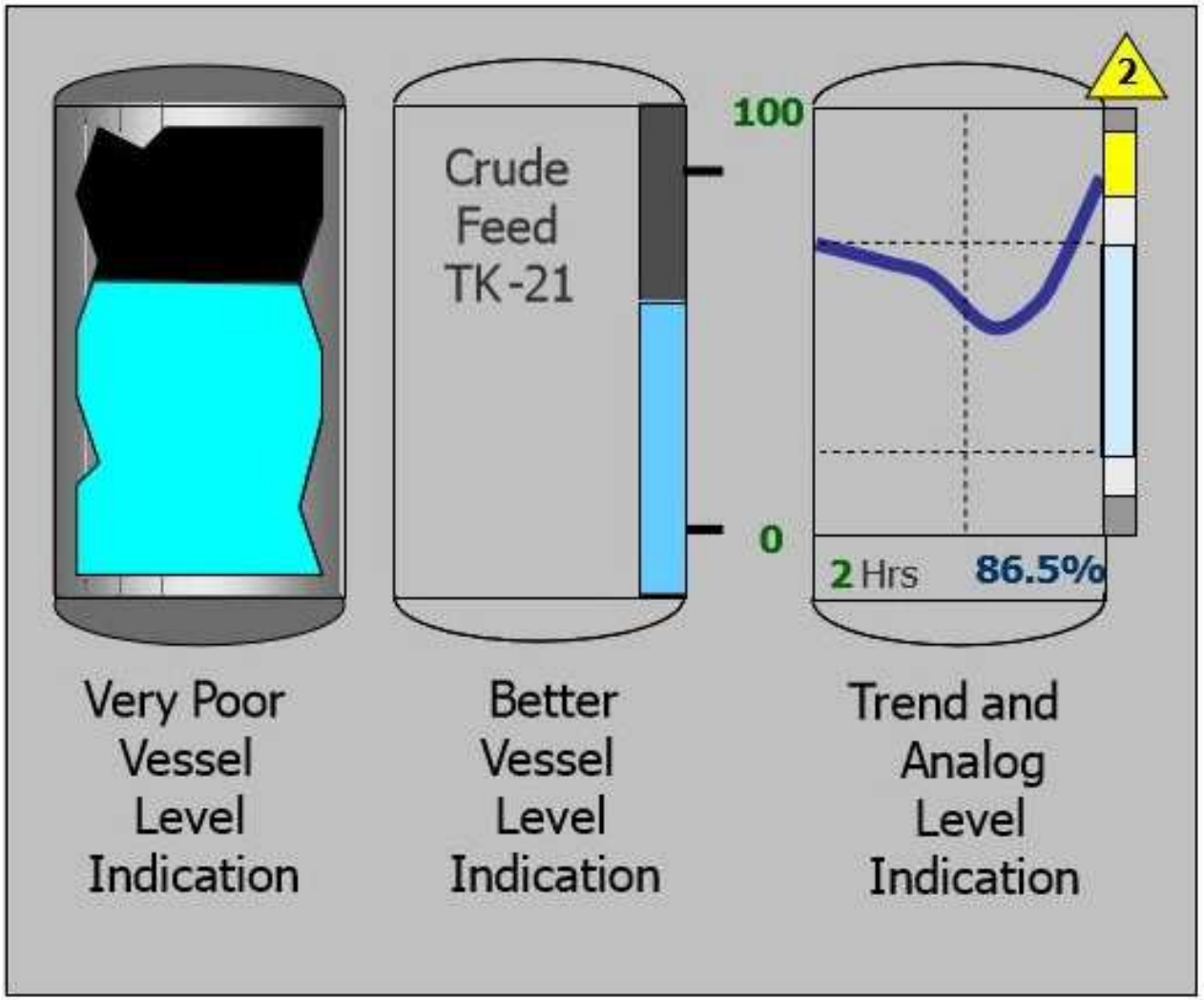


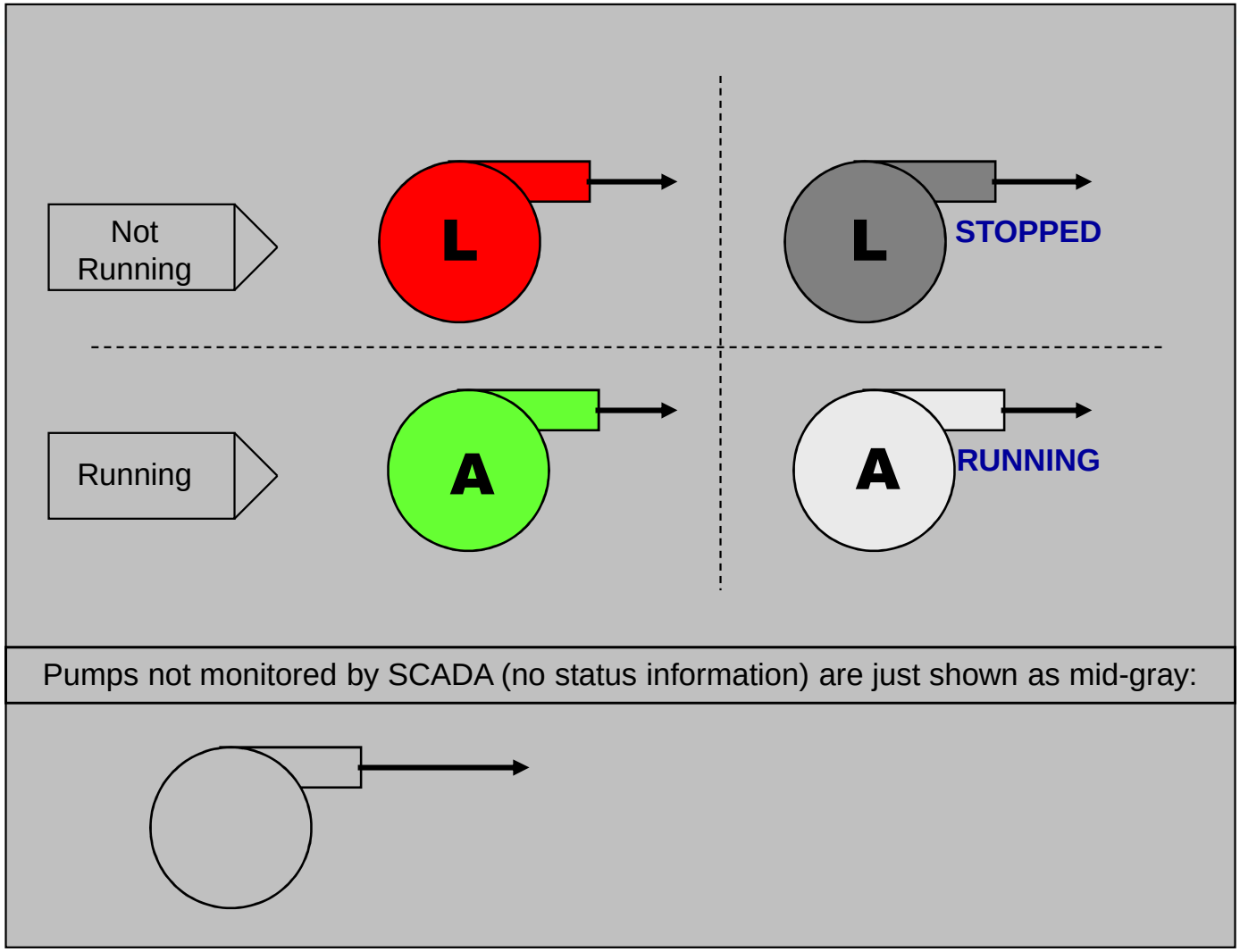
Image from High Performance Handbook

Status Depiction

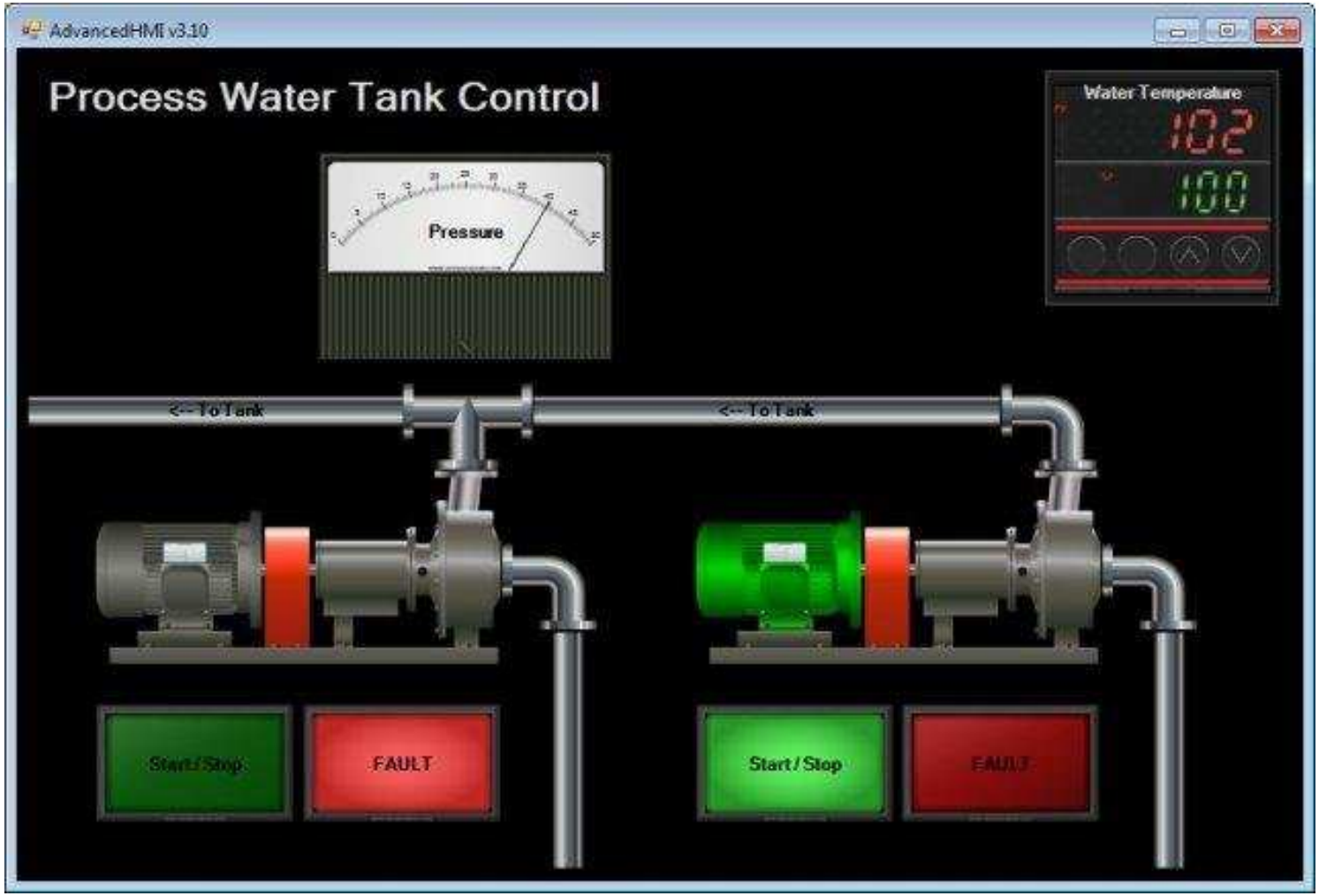
Red/Green for status

vs.

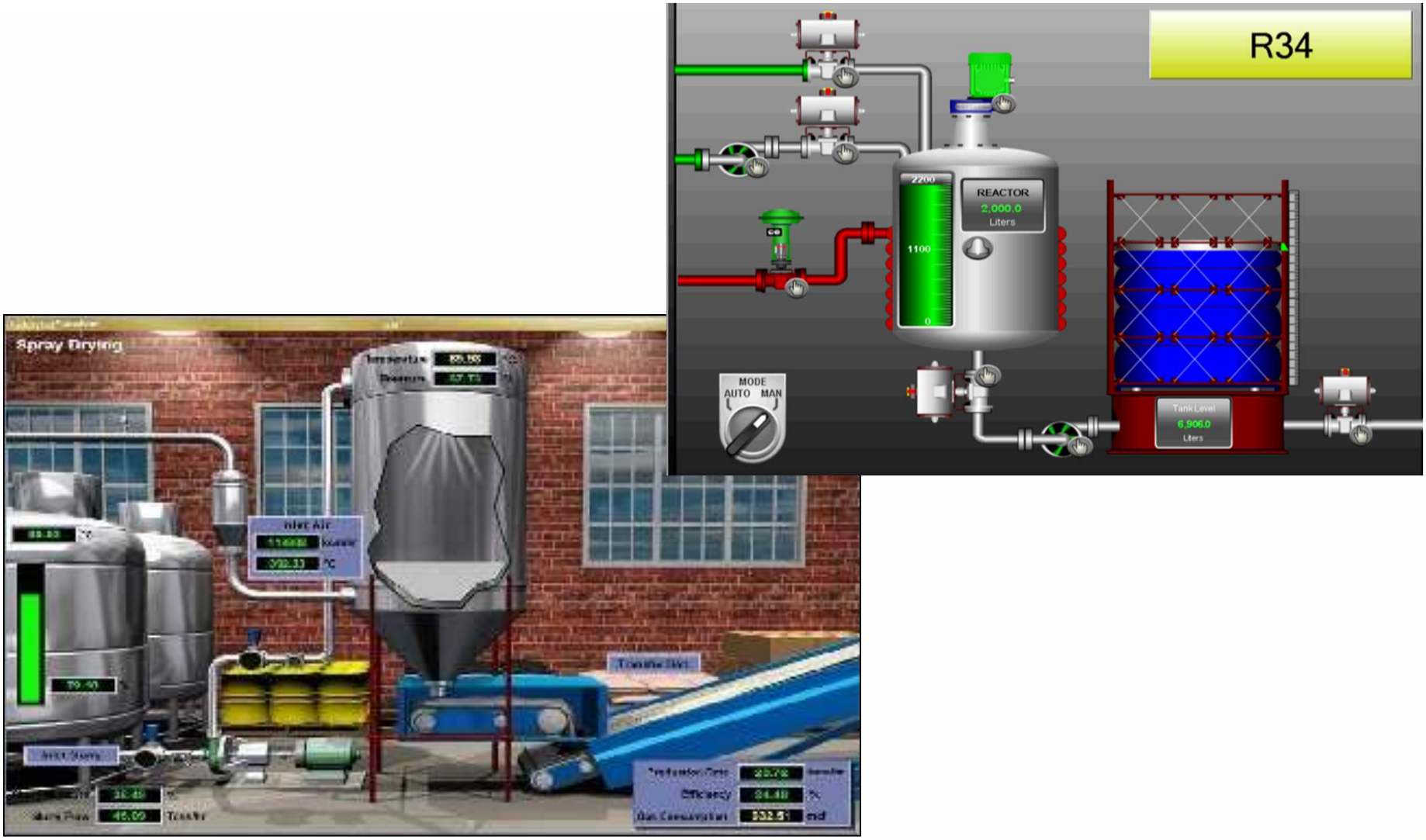
Greyscale & redundant coding



Don’t do this


AdvancedHMI v3.10
Process Water Tank Control
Pressure
Water Temperature
102
100
<-- To Tank
<-- To Tank
Start / Stop
FAULT
Start / Stop
FAULT

Or this…


R34
REACTOR
2,000.0
Liters
2200
1100
0
MODE
AUTO MAN
Tank Level
6,906.0
Liters
Spray Drying
Inlet Air
Efficiency

Or this..


Lvl_EF.SH001.Q031
Lvl_EF.SH001.Q032
Lvl_EF.SH001.Q033
Lvl_EF.SH001.Q034
Lvl_EF.SH001.Q035
Performance | 4073180 Triangles | 171132220 tri/sec | @ 42 Frames/sec | Texture Memory | 299892736
Time
Event
25/8/2010 6:50:57 AM
Caller: Database Reader > Internal Database is empty
25/8/2010 6:51:42 AM
Caller: BinaryGeometryLoader() > 25/8/2010 6:51:42 AM Scene sucesfully loaded in 33 Sec
25/8/2010 7:02:44 AM
Caller: CheckMeshCollision() > Geometry Mesh_0 picked! Selected: True
25/8/2010 7:12:55 AM
Caller: CheckMeshCollision() > Geometry Mesh_0 picked! Selected: True
25/8/2010 7:12:59 AM
Caller: CheckMeshCollision() > Geometry Mesh_0 picked! Selected: True
25/8/2010 8:22:05 AM
Caller: CheckMeshCollision() > Geometry Mesh_0 picked! Selected: True
Ready

Proper Hierarchy for Displays

- **HIERARCHY for Displays:**
- **Level 1 – Plant or Entire System Overview**
  - Entire Operator Span of Control. “Single-Glance”
- **Level 2 – Sub-Process Overview**
  - More details than a Level 1 display, smaller area
- **Level 3 – Equipment or Details Screen**
  - Specific details about part of the process or control
- **Level 4 – Specific Task or Diagnostic Screen**
  - Very detailed screen, only used for diagnostics

Level 1 Overview

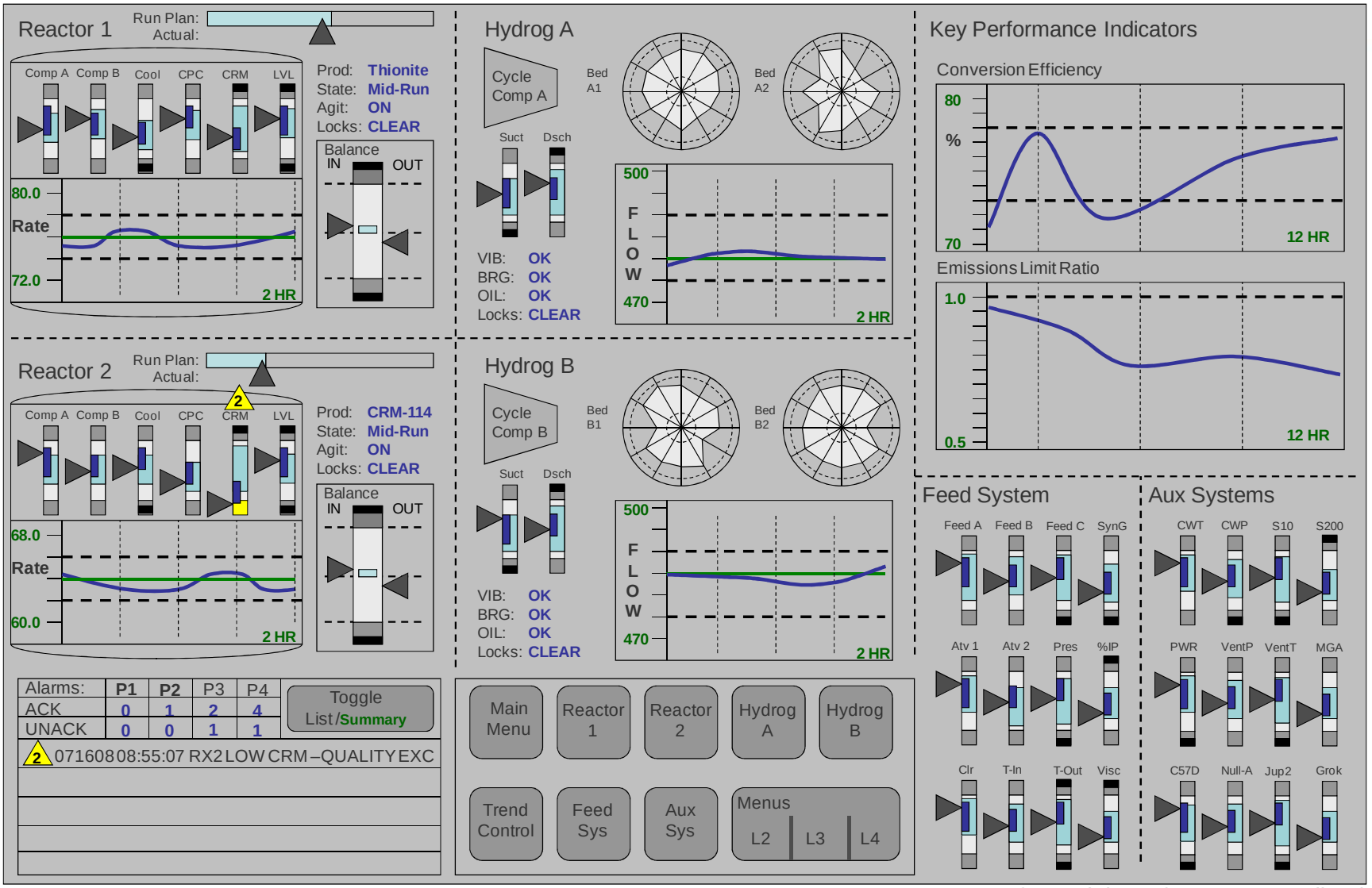


Image from High Performance Handbook

Level 2: Control of a Process Sub-Part

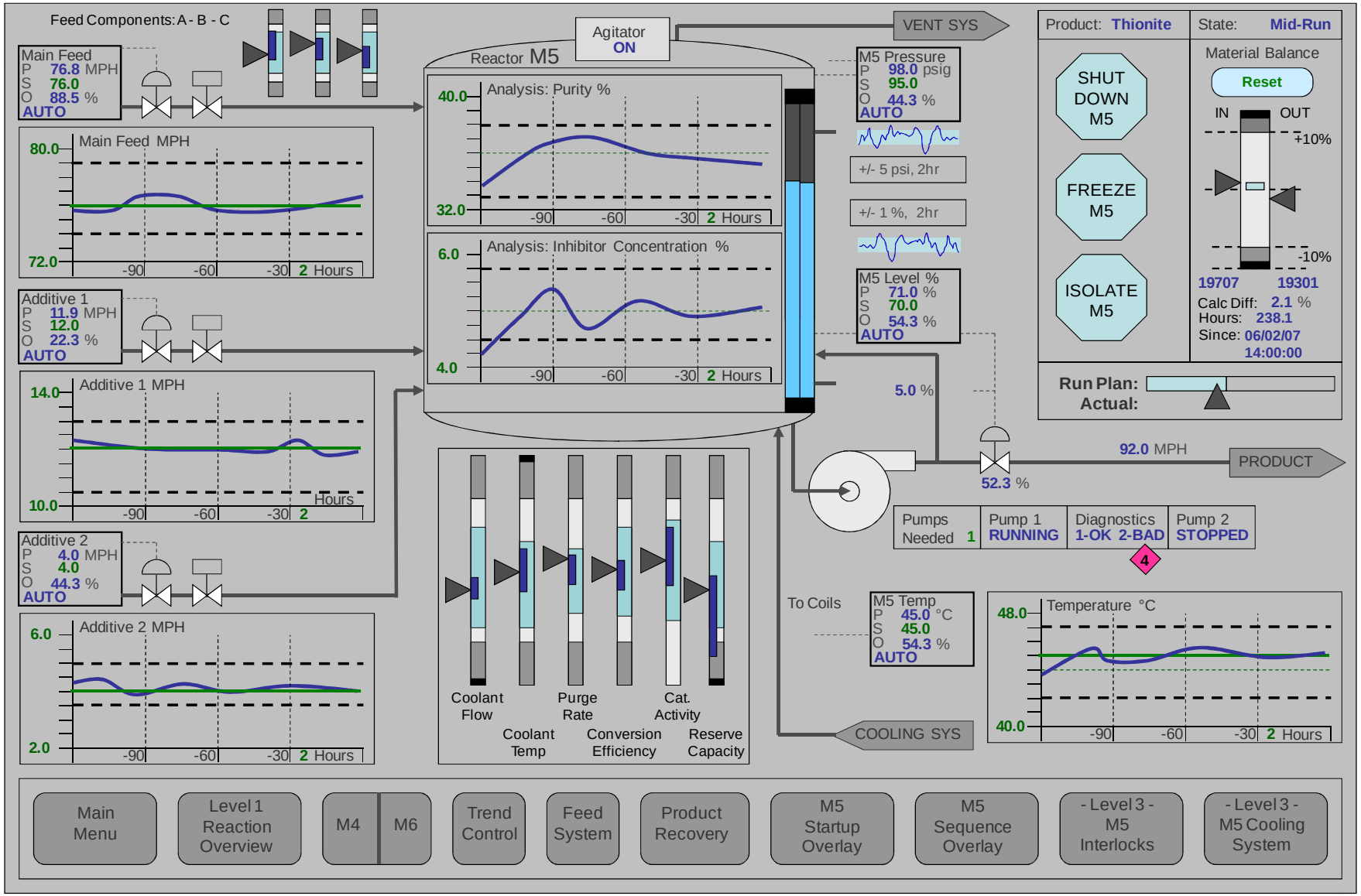


Image from High Performance Handbook

Level 3

Most of what you already have is probably Level 3

We are out of time!

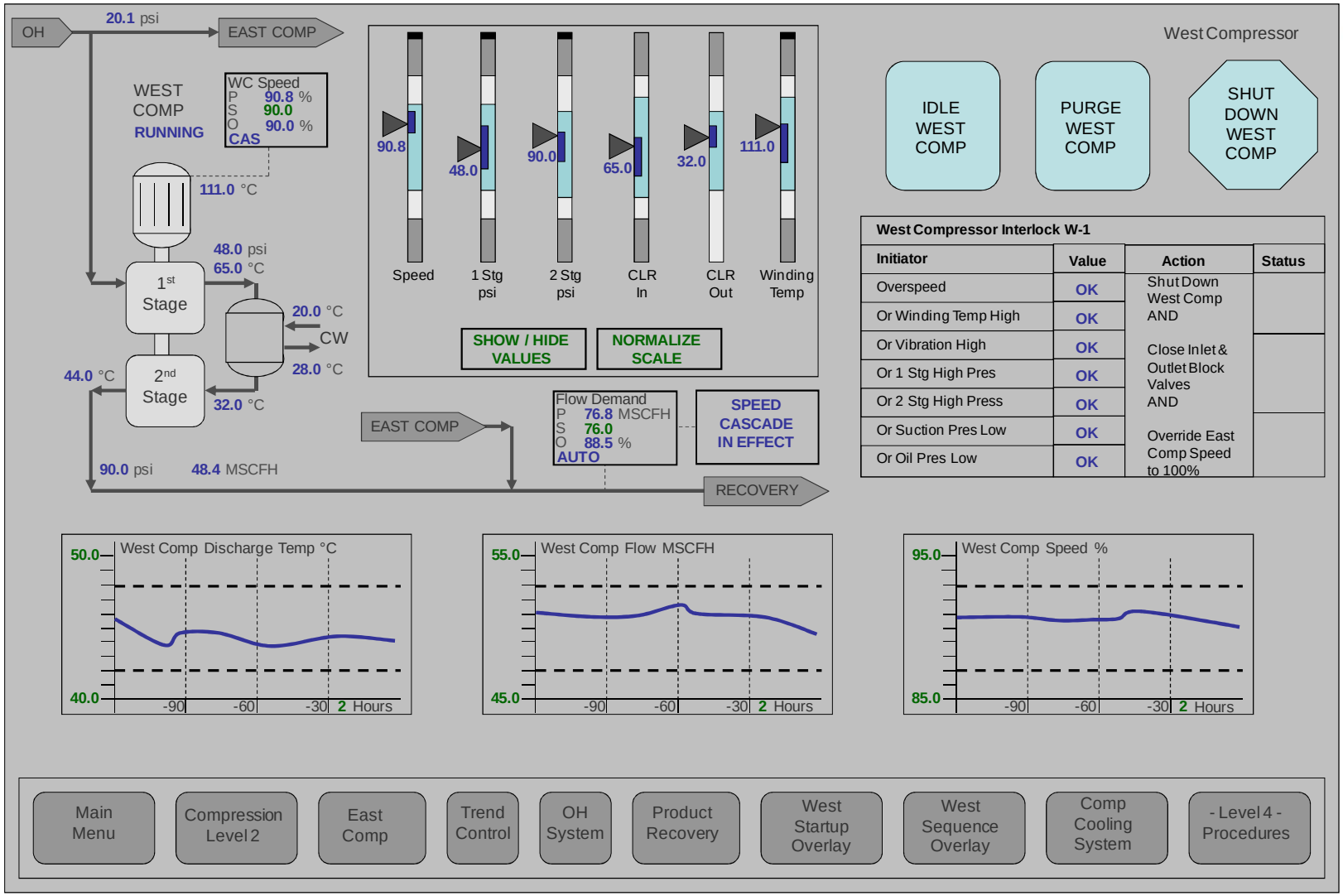


Image from High Performance Handbook

Back to Level 1 –
How many values/indicators are on this screen?

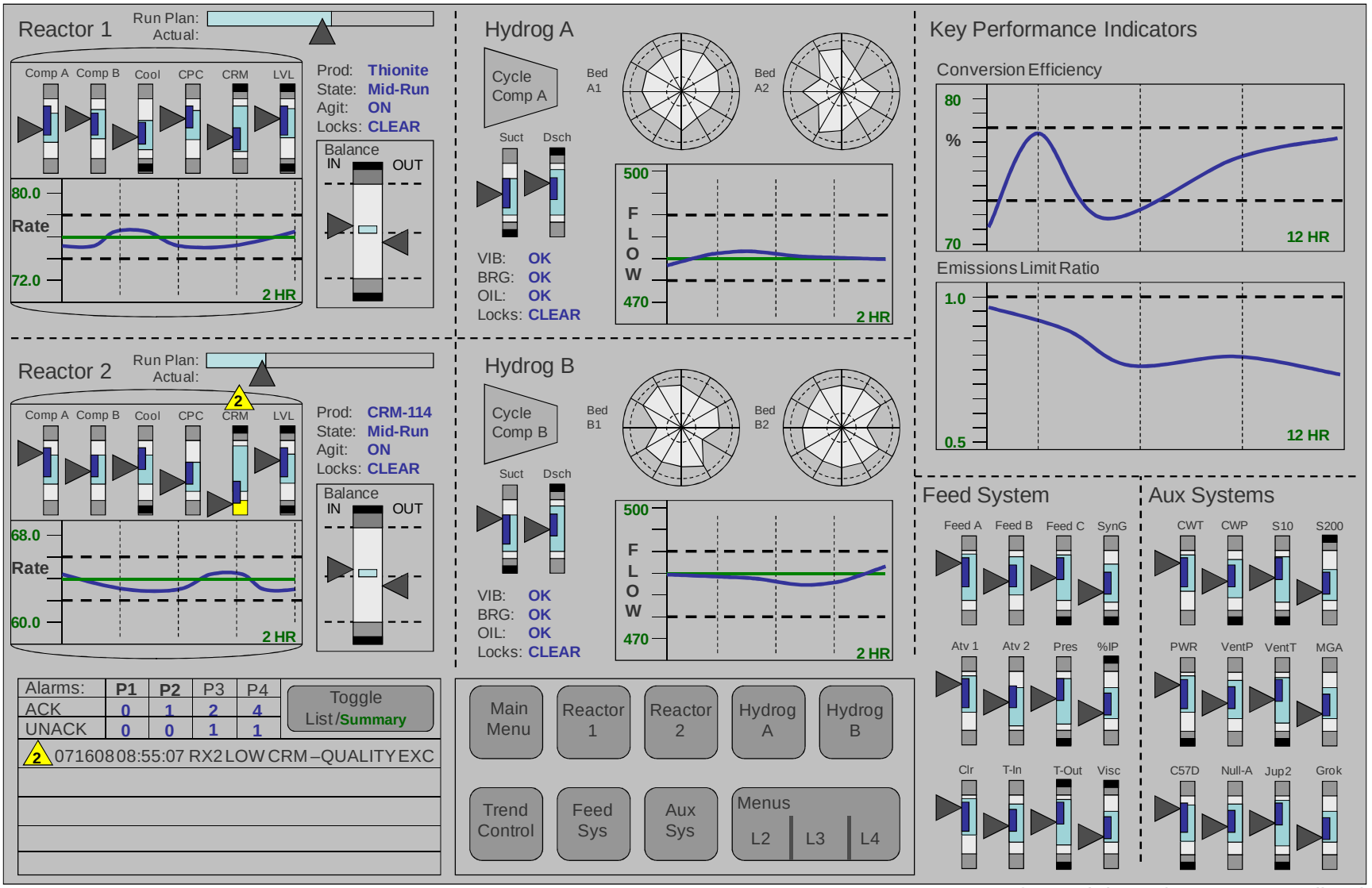


Image from High Performance Handbook

How to show a piping system

Show:

- Topology, not Geography
- Important Status Conditions and Alarms
- Significant highway, railway and river crossing
- Residential areas near pipelines
- Important boundaries (i.e. state lines)
- Moving Analog Indicators indicating performance.
- Direction and content indicators
- Key process values
- Important trends
- Other ideas???

Pipeline Overview Screen

You could show it this way….

This is probably a lot easier to use

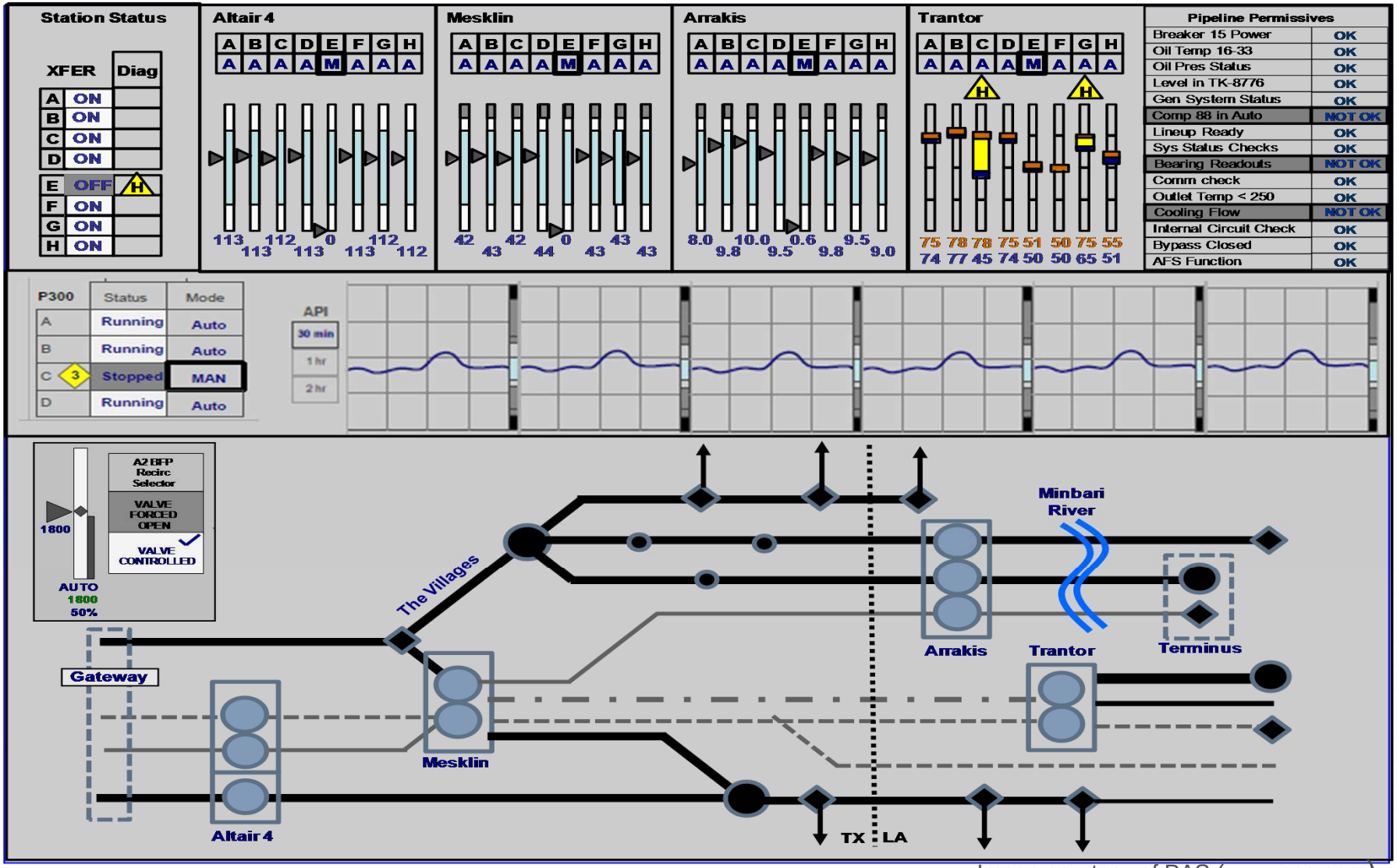
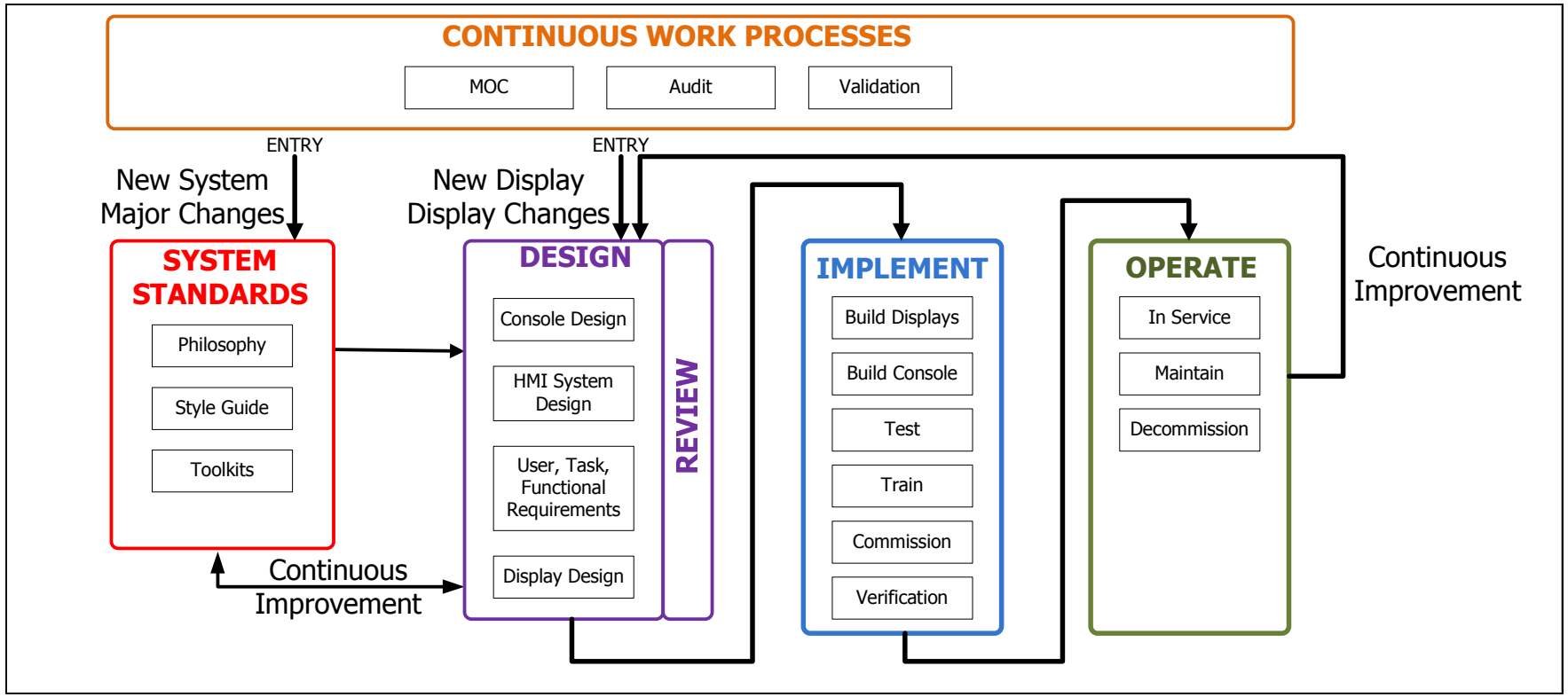


Image courtesy of PAS (www.pas.com)

High Performance HMIs

How do we design and manage our HMI in order to use these concepts?

Introducing the ISA-101 HMI Design Standard



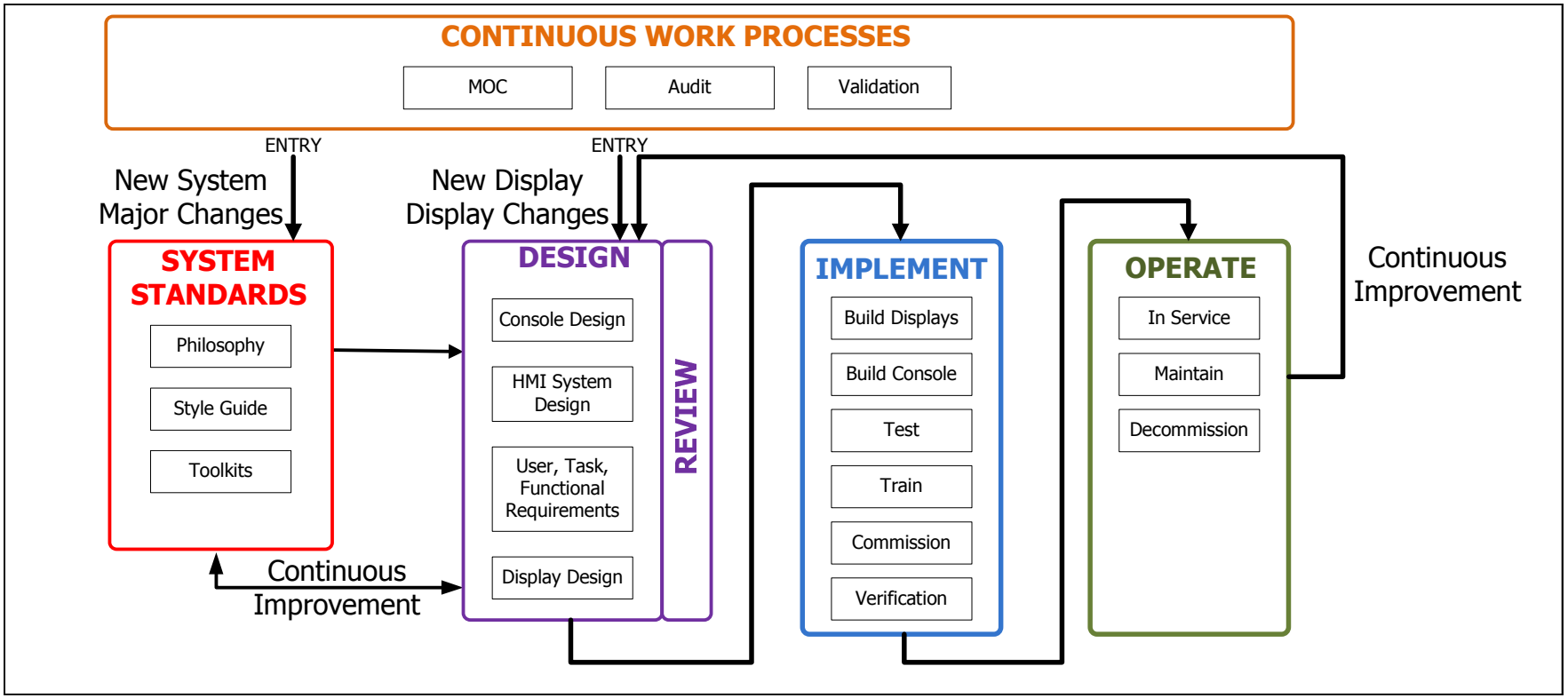
HMI Lifecycle from ANSI/ISA-101-2015

ISA-101 – in a nutshell

- **Actual ISA-101 standard is only 64 pages**
- **Overall design guidance provided in the actual standard, details are in ISA-101 Technical Reports (soon to be available from ISA)**
- **Has a very robust workflow for developing and managing HMI systems, including a strong Change Management Process**
- **Focus is on creating screens for situational awareness and operator tasks. Users must be trained on use to use HMIs.**
- **Facility owners must develop a clear HMI philosophy document and HMI style guide for their HMI system, and couple this reusable software toolkits of screen elements. Without these it is impossible to develop an effective HMI.**

Take another look at the workflow

The ISA-101 standard is important because it is the first international standard to state minimum requirements for HMI displays, including their design, documentation, and management of change.



How to get started?

Understand and document what you have

Add some Level 1 and Level 2 displays to give your operators visibility of your entire process for situational awareness

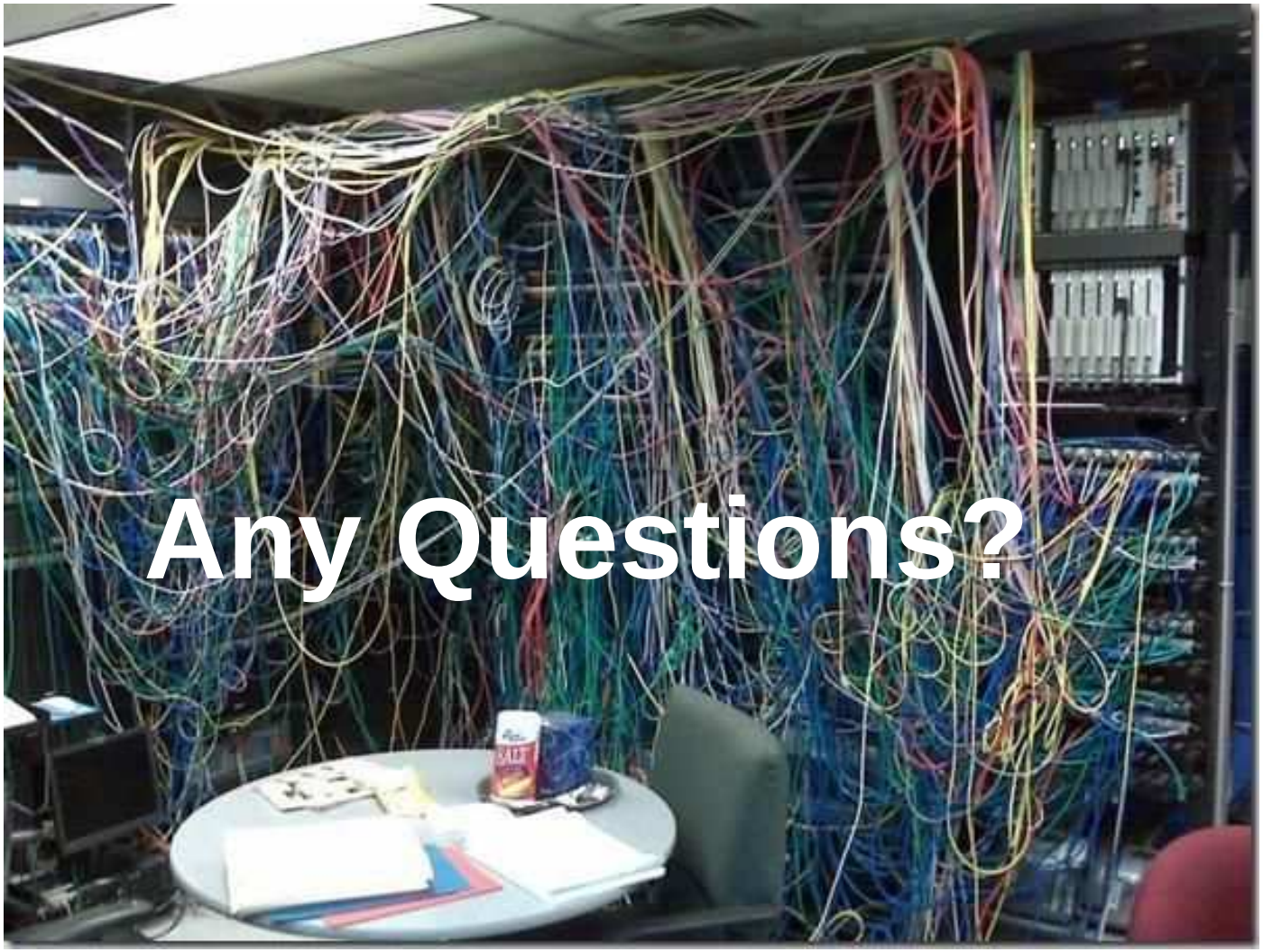
Add some task screens to help with start-up, shutdown or maintenance tasks that are difficult for operators to run

Start developing your HMI Philosophy document and Style Guide to define what you want your system

Start using Revision Control to track changes to your SCADA system's programming. Implement a Management of Change procedure, so changes are controlled and documented.

Do a pilot project of a few new HMI screens to see how they work.

Talk to your operations team.



* Not a High Performance HMI