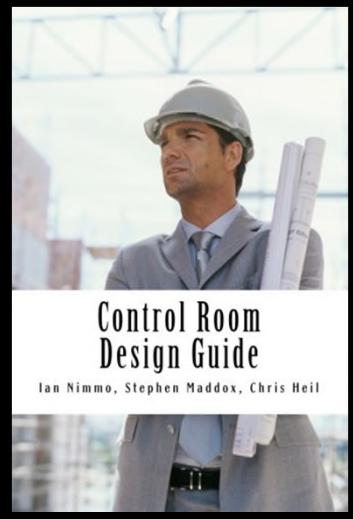
Presentation:
Alarms and Operator Intervention –
A Flawed Safety Layer

By: Stephen Maddox

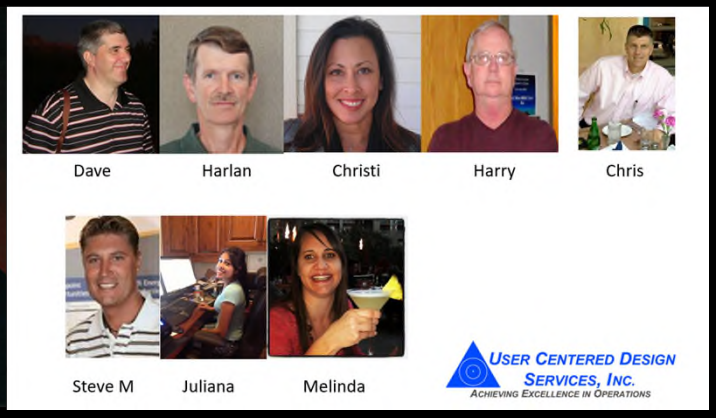
USER CENTERED
DESIGN SERVICES, INC.
ACHIEVING EXCELLENCE IN OPERATIONS

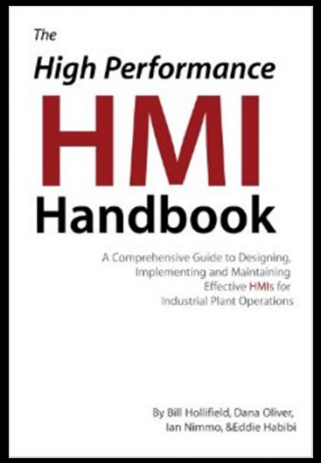
User Centered Design Services

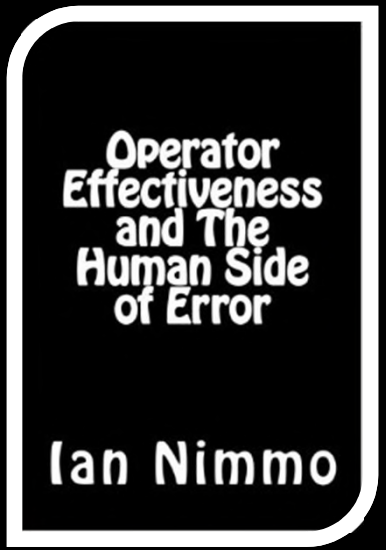
- UCDS was Founded by Ian Nimmo 20 years ago after running the Abnormal Situation Management Consortium.
- Ian set out to help plant managers improve operations by focusing on the control room and the users, the console operators.
- We provide expert training and engineering services that apply human factors and ergonomics to the operators environment, user interfaces, and management systems.
- Our goal is help our customers manage abnormal situations, reduce time in alarm, and prevent the consequences of alarms. To do this you have to go beyond alarm management.



Ian Nimmo

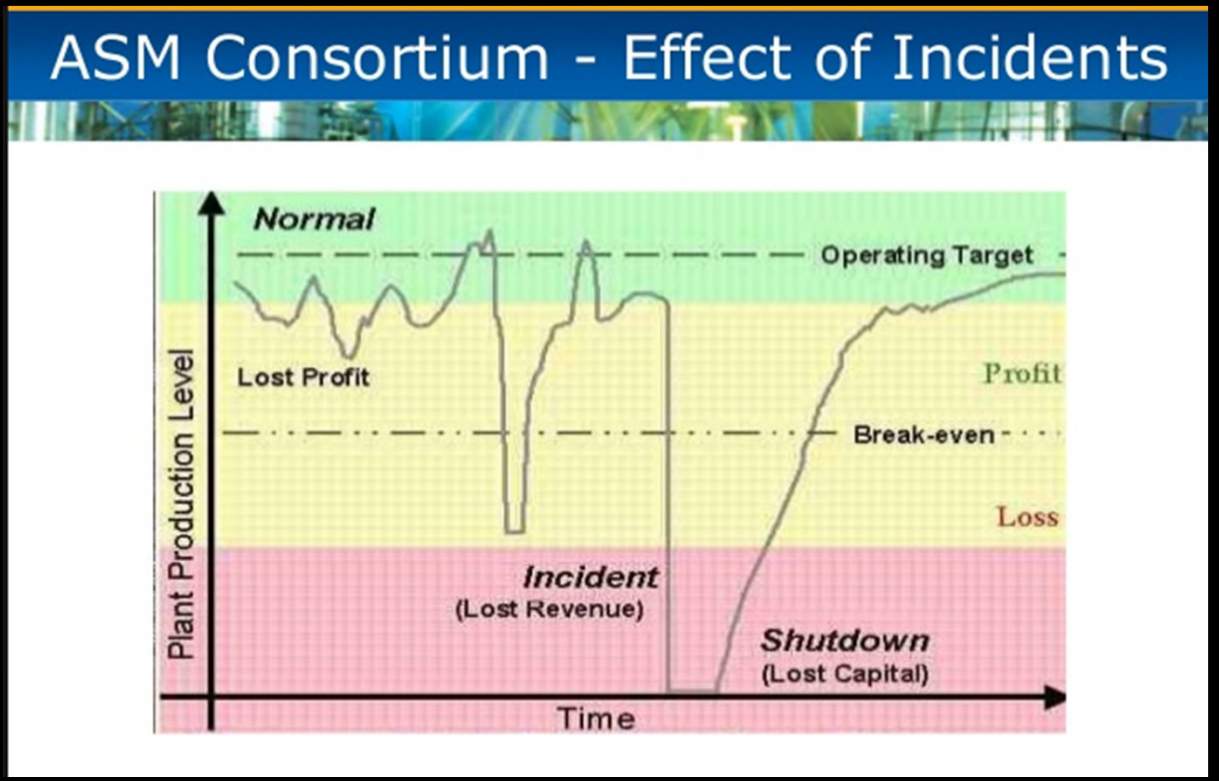






- Many world leading experts from Amoco, Chevron, Exxon, Shell, Texaco, BP, & Nova Chem joined Ian to manage abnormal situations and industrial accidents.
- Ian raised 20 million dollars to fund the research
- The Consensus: Operators can prevent and recover from abnormal situations when human factors are applied and situation awareness is achieved.

20 Billion Dollars in Losses from abnormal situations every year



What makes UCDS unique:

We are experts in process operations and operator performance:

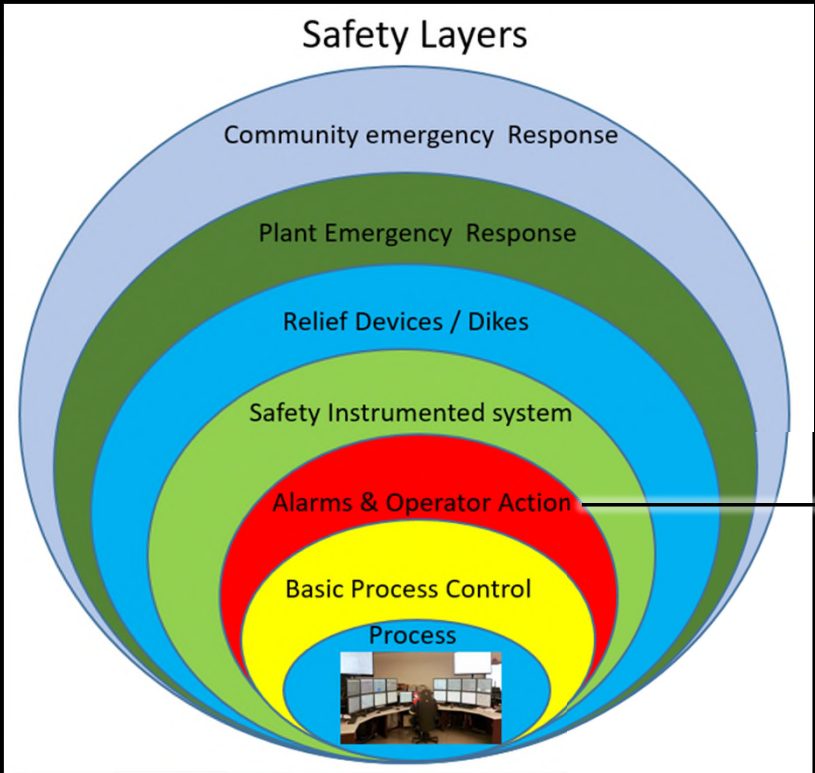
1. Process Engineers – We understand process control and automation
2. Human Factors – We understand human strengths and weaknesses and how to apply this to design
3. Abnormal Situation Management – Experts in the very thing that operators are meant to prevent and manage
4. Operator Performance – We understand operators, how they work, what they need, and what they want – and know how to work with them to so they take ownership of their user interfaces and management systems
5. Situation Awareness – We are experts in “operator” situation awareness - it’s what we do!

ERGONOMICS

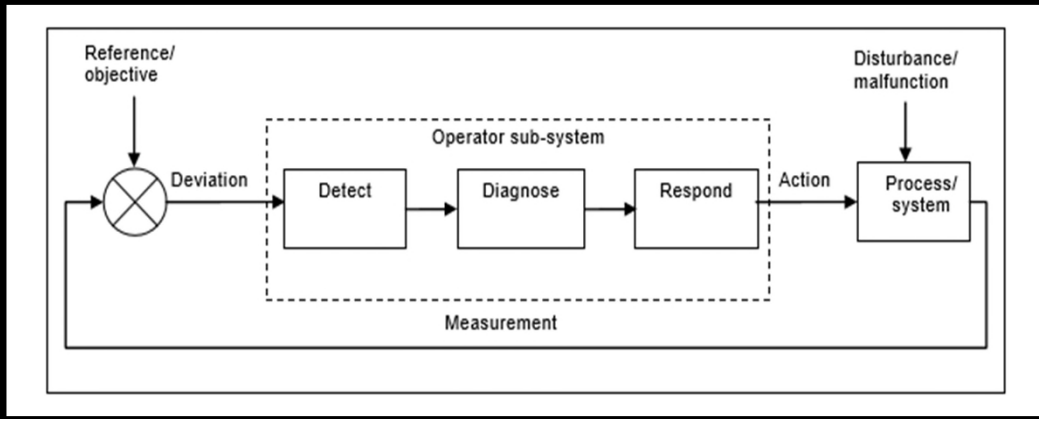
HELPS TO ADAPT JOBS TO THE PEOPLE WHO PERFORM THEM

- The operators job is to keep the process running at optimal capacity
- We are far away from not needing operators
- They effect quality, prevent unplanned downtime, respond to safety critical events, and can provide valuable feedback that can save companies millions of dollars
- Unfortunately, they are under utilized. Most are trying to do their best even though the environment, user interfaces, and management systems are working against them.
- They have just as much responsibility as a pilot but they don't get near the respect

Alarms and Operator Response

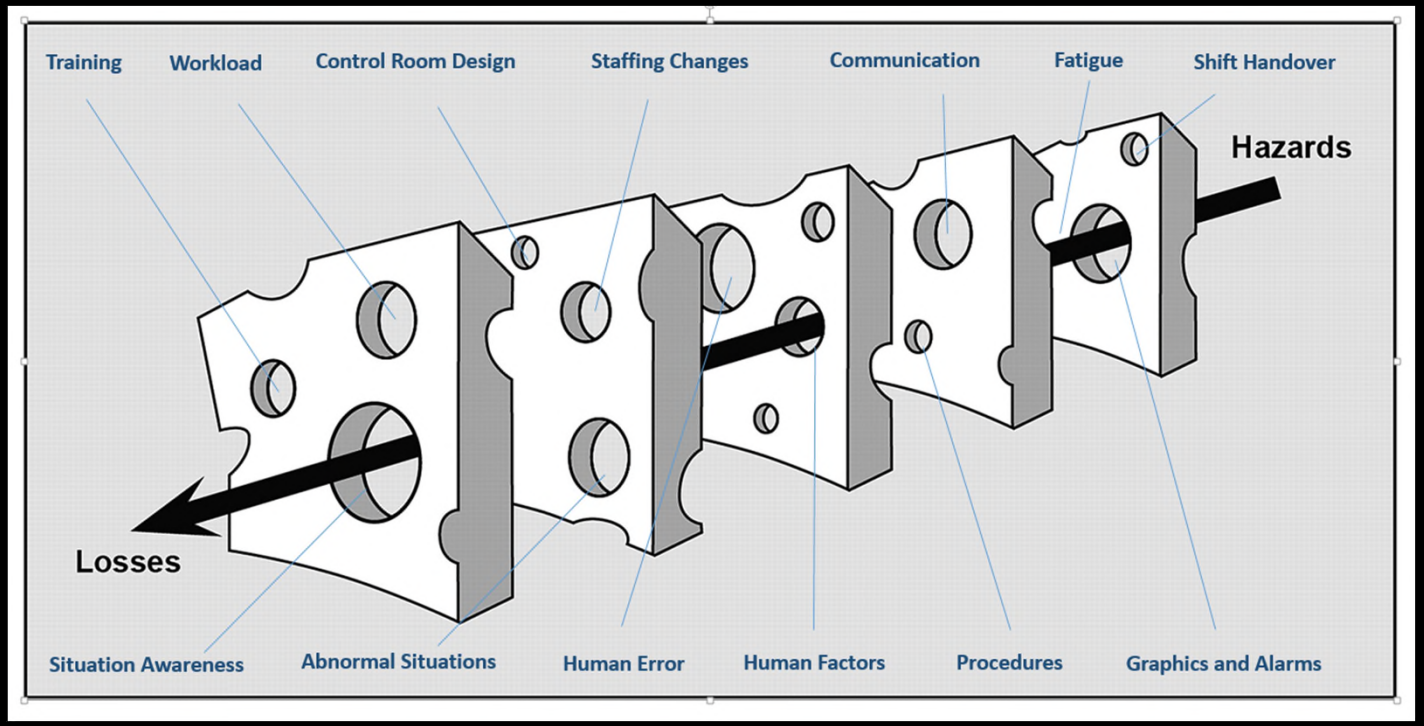


- We rely on operators to be alert, vigilant, and predictive
- To detect, diagnose, and respond when abnormal situations occur
- Operator response is critical, that is why the industry has focused so much attention on alarm management
- However, the industry has not focused on the operators and human limitations specifically on human factors
- Operators have a major impact on the plants assets
- The alarm system is not the safety layer, the operator is the safety layer, alarms are only one of the tools they use for situation awareness



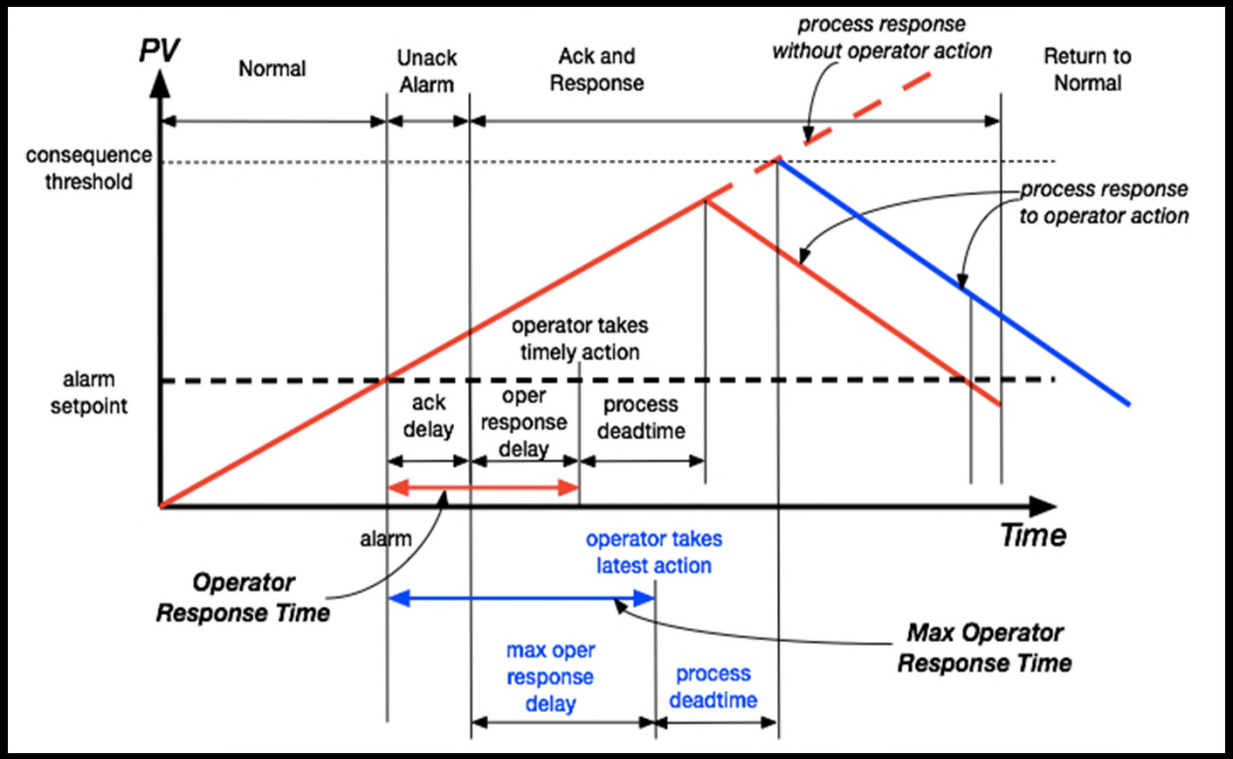
James Reason: Swiss Cheese Model – Major Incident Prevention

- Operator performance is effected by many factors
- When you have holes in your safety layers, the layer becomes weak an ineffective



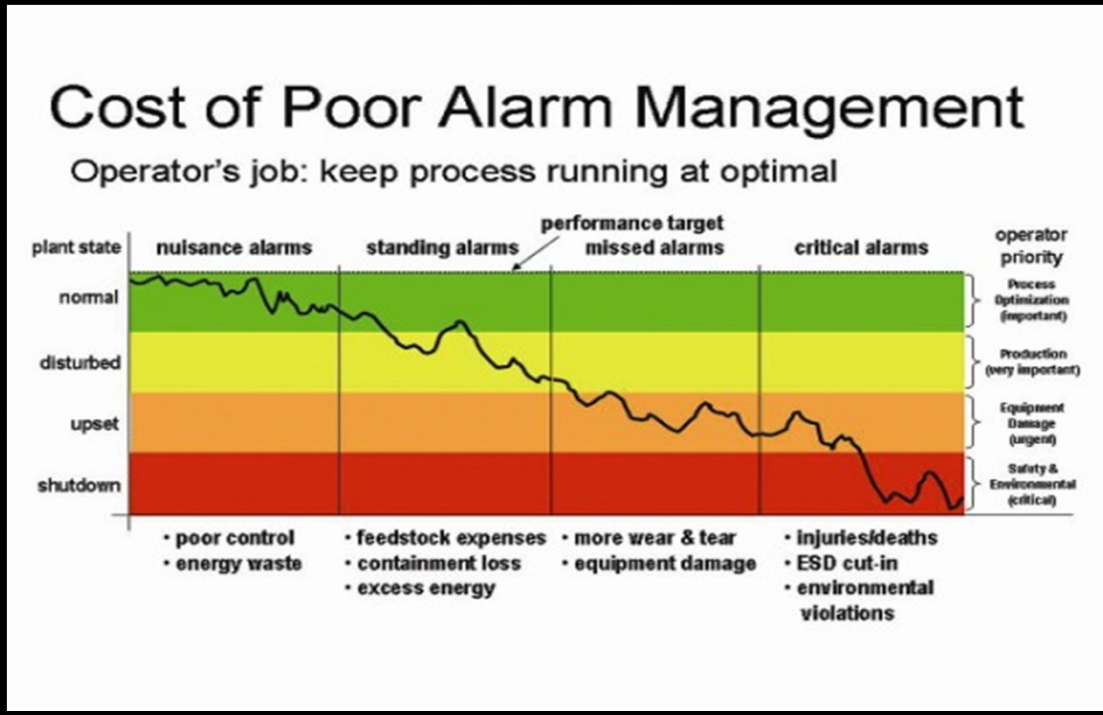
The Biggest Issue with Alarms “Time In Alarm” (SP18.2 and IEC 62682)

- Most of our clients focus on the number of alarms
- We need to focus on the amount of time we are “in alarm”
- Alarms mean you are operating outside the operating limits
- When you are running the process outside the operating limits you are losing money and creeping closer to the consequence of the alarm
- After an alarm management project we almost always find that the alarm limits are not set correctly
- Alarm rationalization does not mean the operators will respond in time



Alarms Cost Money: $1,000 per minute?

- When alarms activate, the operator works to diagnose the problem and return the process back to normal to prevent the consequence of the alarm
- The clock is ticking…
- The longer you are in abnormal the higher the costs
- Costs from: Equipment ware or damage, increased maintenance, waste, quality issues, unplanned down time, length of downtime, major accidents, or regulatory issues
- Each second, each minute in alarm costs money, how much?
- Most managers have not run a report to see how long they run the process in alarm and what that cost them, yet they pay operators a ton of money to intervene when alarms occur. Are they responding in time?



Time in Alarm Cost Money – Time to Respond

- Number 3: Normal Operations: Good!
- Number Two: Abnormal situation occurs, the operator responds quickly - minimizing the amount of time in alarm.
- Number 1: The operator was slow to respond. Most common.

History:

- In the good ole days operators could scan instruments and use pattern recognition to identify when gages were not in the optimal position, they could easily lean in and identify problems before the alarms activated.
- Operators were respected and the control room had rules
- When computers were introduced, the wall went away and hundreds of graphics replaced the instruments. This contributed to the key hole effect.

Key Hole Effect:

- Operators started overlaying graphics, to reduce screens, in an attempt to create an overview of a specific unit.
- This was a poor attempt to recreate the panel wall to help them troubleshoot issues when the alarms activated. Still they relied on alarms and were reactive not proactive.
- Detecting change is impossible!
- The use of color actually made it harder to identify important changes.

More Graphics = More Screens

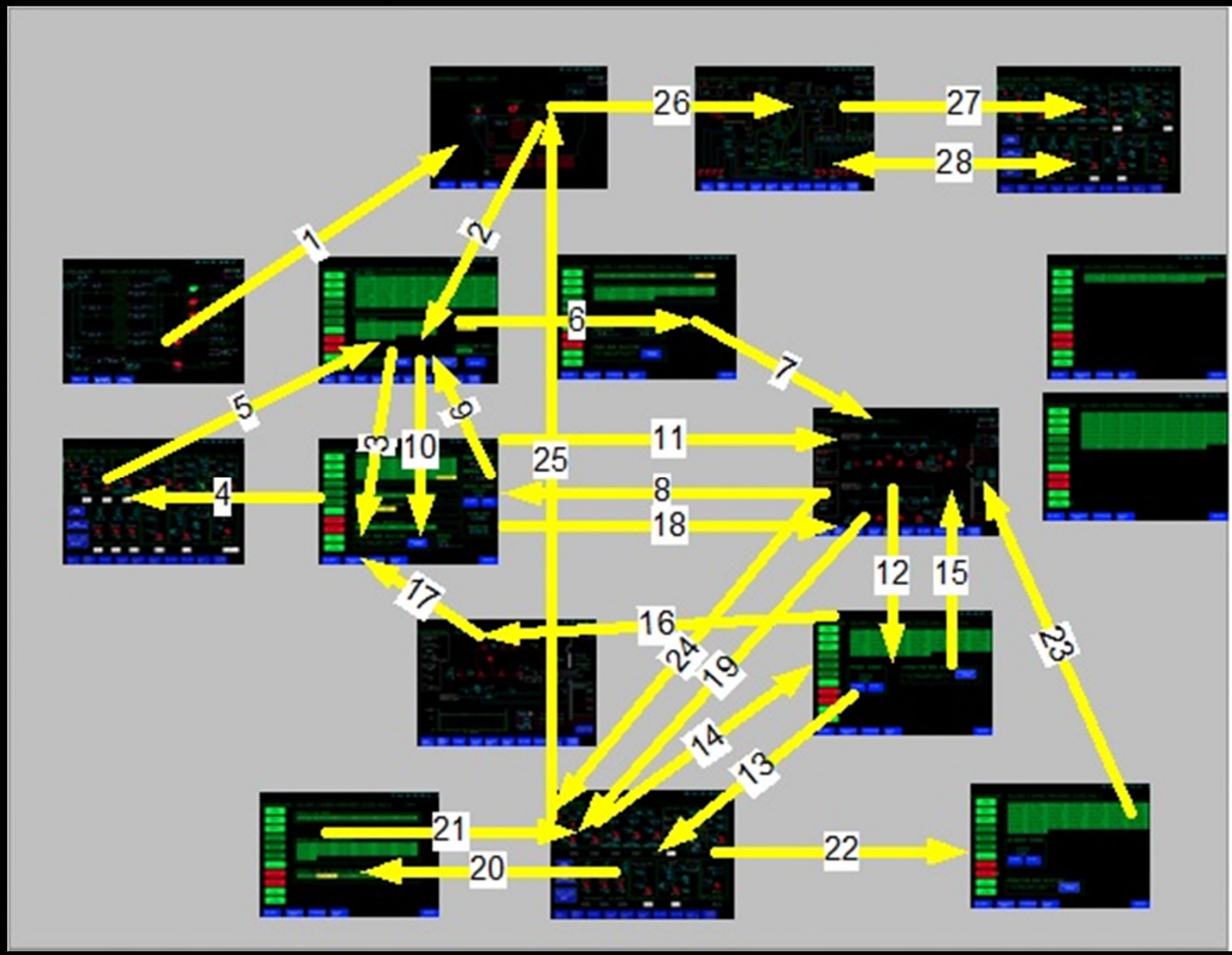
- More and more screens were added
- Operators roll their chairs back and forth from screen to screen
- Overtime they realize they can only monitor a few screens at a time so they have to rely on alarms to alert them when they have a problem.
- The lack of situation awareness forces them to add more and more alarms to let them know what is happening.
- Situation awareness is critical but we did the exact opposite, we un-purposely made it worse

Waiting for an Alarm – Reactive Vs Proactive:

- Over time operators got a bad rap for whining – constantly requesting graphic and alarm changes.
- The culture changed and control rooms became a place to hang out
- Engineers, supervisors, and management began to lose respect for the operators.
- “Operators have it easy, they just sit there, read the paper, take naps, and eat all day”
- When things get bad, they get real bad fast!
- 90% boring and 10% extreme stress

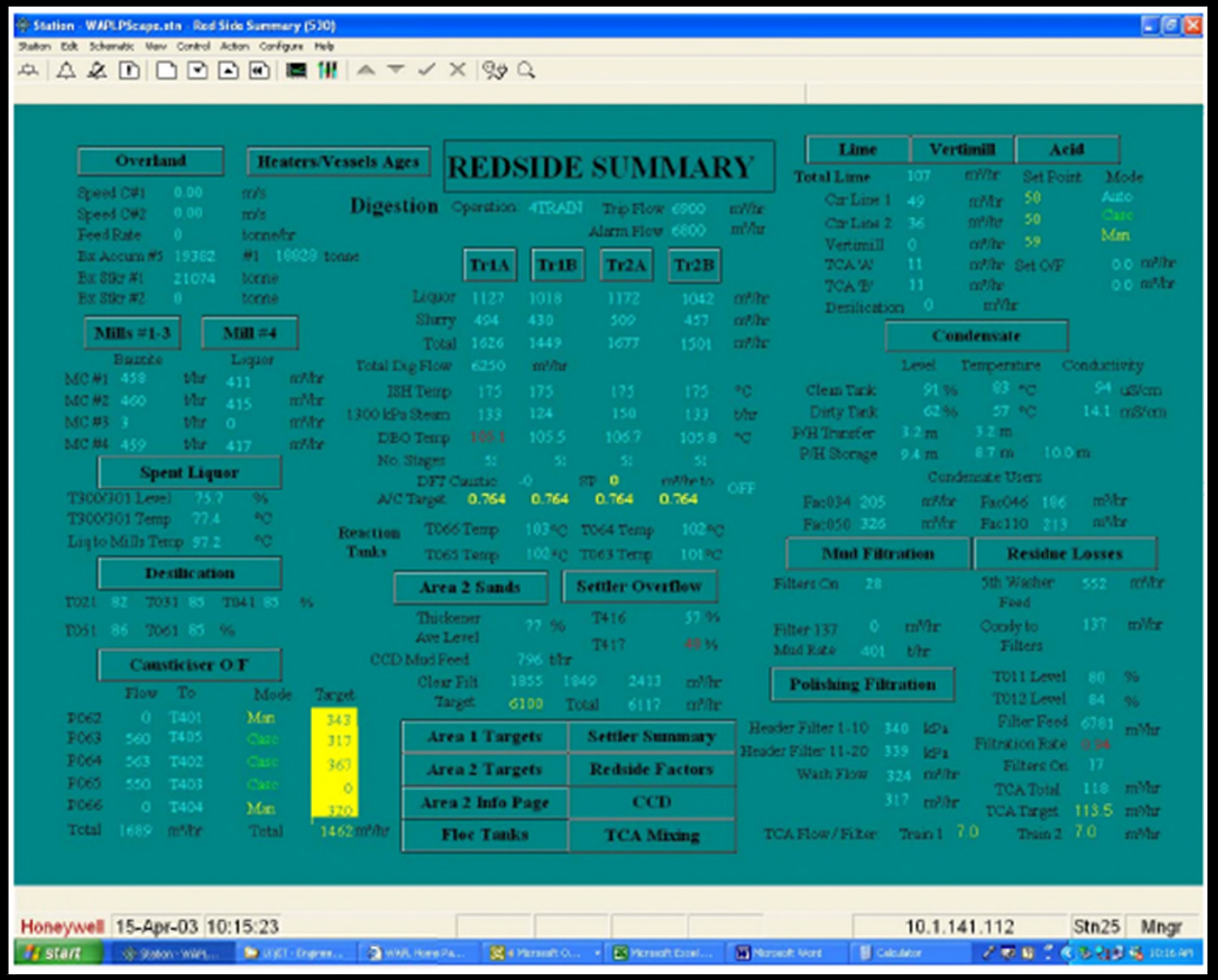
Graphic Navigation increased “time in alarm”

- When alarms activated, the operators struggled to diagnose the problem.
- In this example, the operator clicked and reviewed 28 screens trying to work out the alarms.
- It took 32 minutes to solve the problem.
- The process was in abnormal, running outside the operating limits the whole time.
- This increased maintenance costs from excessive stress on the equipment.



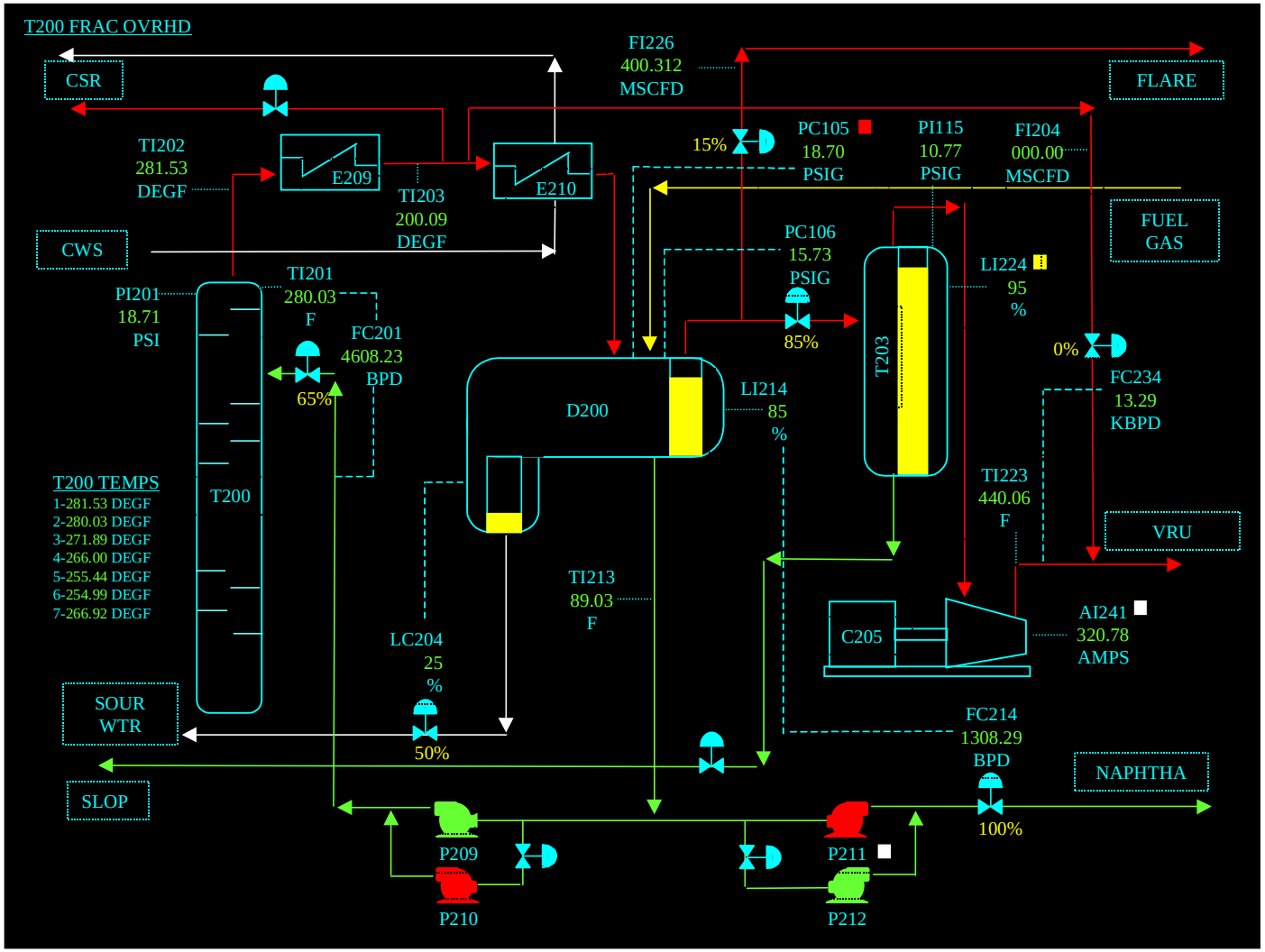
Data Overload: (ISA 101)

- Graphics were covered in data (No gages)
- This forced the operator to mentally calculate ranges to determine if the process was good or bad
- This prolonged time in alarm
- More operators had to be trained and hired to manage the same amount of units
- More alarms were added to tell the operator when things changed, deviation alarms became unmanageable.
- Many alarms were removed during an alarm project but the graphics were not changed to reflect the information that the alarm provided
- Change blindness is a major problem!

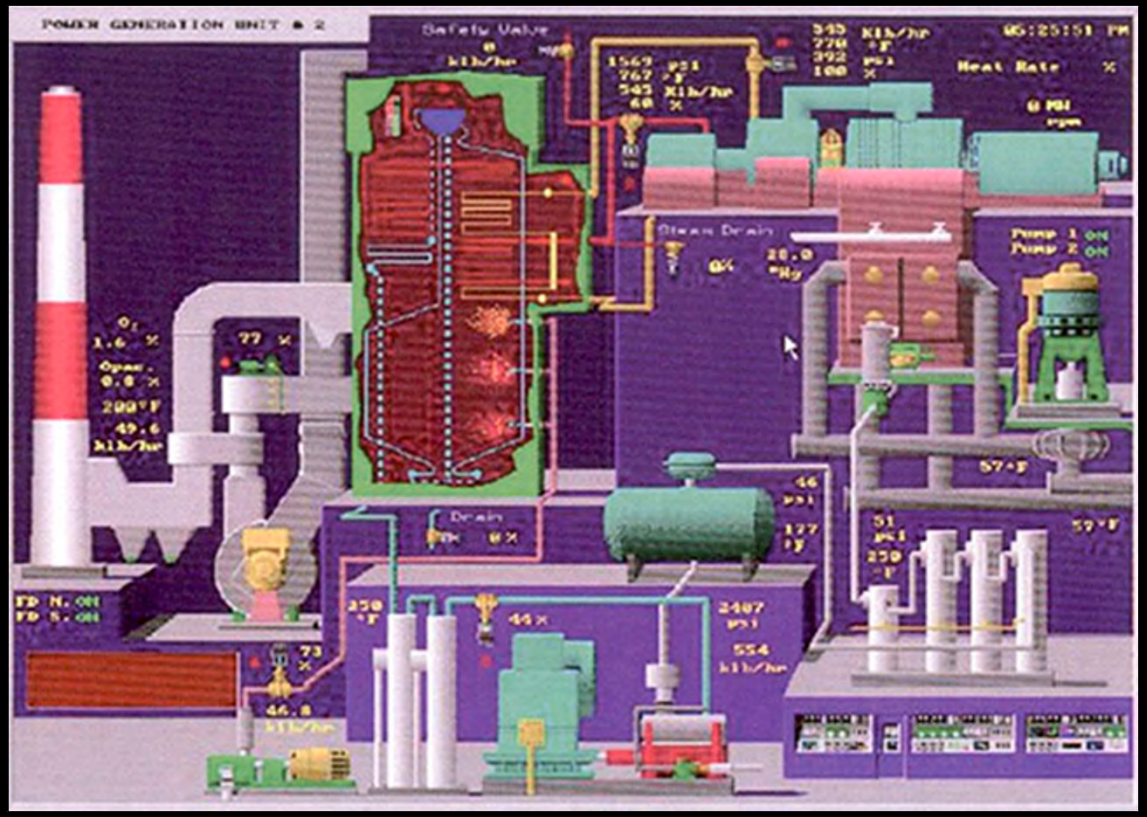


Color Overload (ISA 101)

- Bright colors actually work against the operator
- Operators lost track of what each color meant
- Bright colors jumped off the screen and made it impossible to detect important changes in the data
- This contributed to fatigue, eye strain, darker control rooms, headaches, confusion, and frustration.

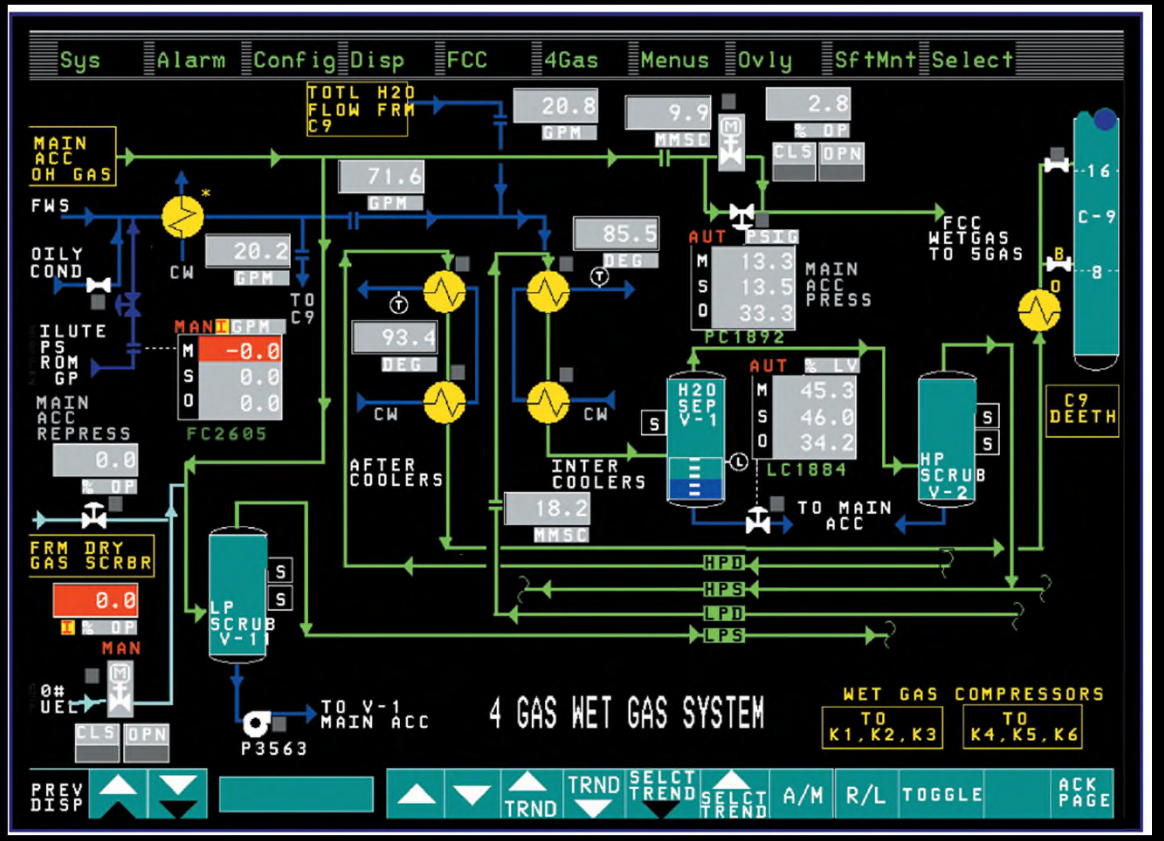


Graphic Designers Got 3-D Fancy but the important information was lost in the background



The Lack of Situation Awareness (ISA 101)

- Everything the operator needed to know became an alarm. The most important alarms got lost in the flood of alarms. The operators have no way to know what they should do first, making it almost impossible to prevent the SIS from taking over and shutting down the unit.



Control Room Design: ISO 11064, API 755, NERC, PHMSA Regulations)

- Most control rooms are dark and promote a disconnected, sleepy, unresponsive mentality.
- Glare is a major issue from poor lighting, small fonts, and color overload on the graphics.
- Some control room's are treated as a break room.
- Some supervisors spend much of their time trying to catch operators sleeping – they should be working on fatigue management and human performance to prevent fatigue instead of baby sitting.

Poor Ergonomics (ISO 11064 / NERC)

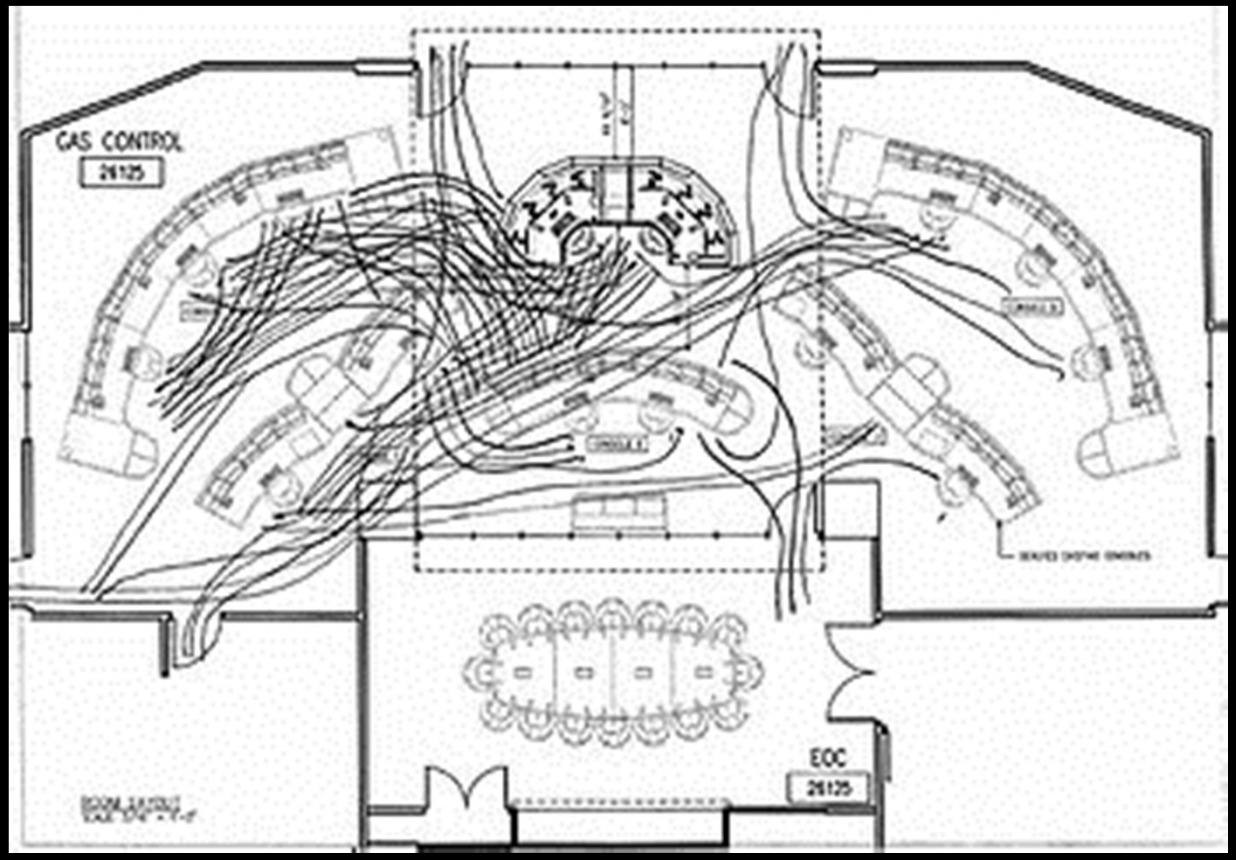
- Poor ergonomics, contributes to low moral, poor situation awareness, and stress.
- Absenteeism increased
- Finding new employees to work in a poor environment is an issue we need to address
- ISO 11064 -we have a standard to follow

Traffic Flow: ISO 11064

- More and more people begin to visit the control room for:
  - Work permits
  - A break from the field
  - To see what the guys are cooking
  - To talk to supervisors
  - Meetings

The lack of respect for the operators job has hit rock bottom.

- The moral has changed.
- Distractions are high.
- Alarms last longer than normal and maintenance / equipment replacement costs go up
- Unplanned downtime is at all time high
- Slow/dangerous start ups



Just a Few Design Considerations for a New Control Room:
User Centered Design Services: Your Human Factors Engineering Company

Are we following ISO 11064?

How big should the room be? Future growth?

Ceiling height? Will we be using large screens

What technology options are best for video walls?

How do we handle contrast from the video wall and background

How many screens should each operator have, size, type, height, etc.

Do we need a console spec to determine what each operator needs for equipment

What about windows or cameras, and monitor locations?

How many people do we need per console, start up? Shut down?

How do make sure glare is not an issue? Do we need a fatigue management plan?

Who communicates with who, should we change the layout of the consoles

Should we create a control room standard, for rules and guidelines?

Are the consoles ergonomic and based on industry standards?

Do we need a lighting study?

What types of chairs do we need?

Where do we put the meeting room? Restrooms? Supervisor station?

Is there enough room to move around quickly during an emergency?

What about traffic flow, permitting, training, and eliminating distractions?

What about power, cables, hardware, do we put hardware in a separate room?

Have we measured site lines, can everyone see without stress?

Do we need an acoustics study?

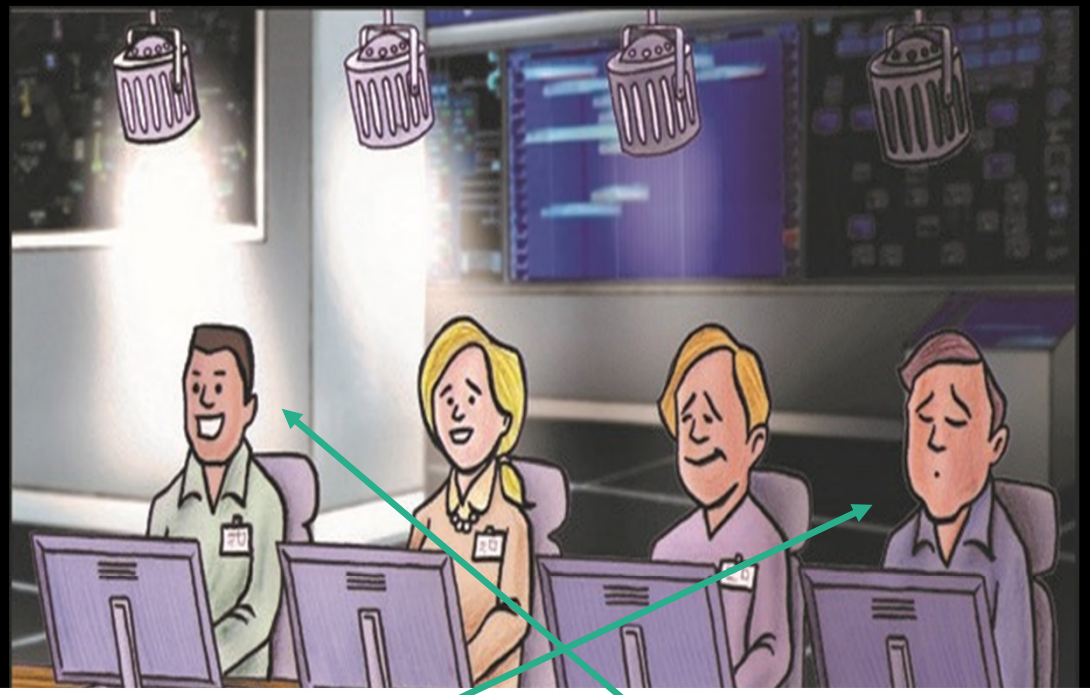
How many operators do we need in the room and the field?

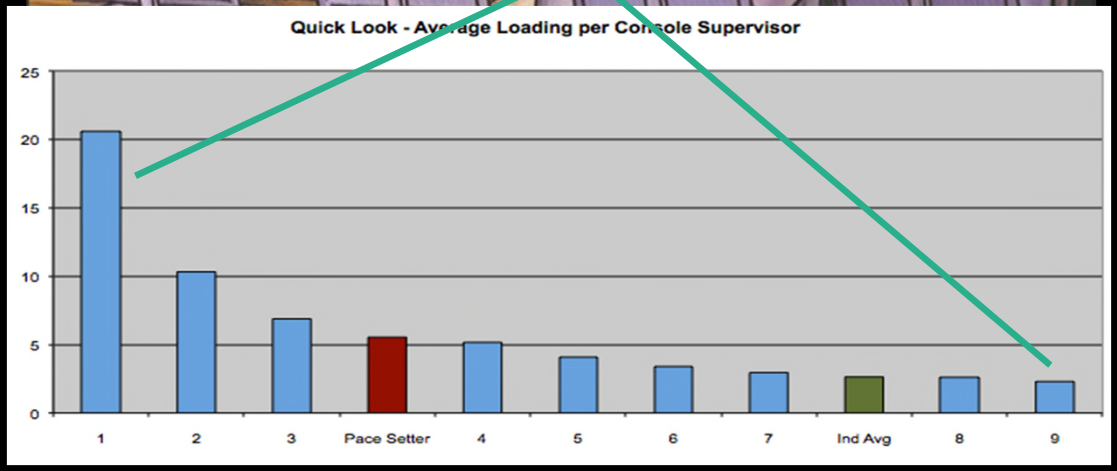
Carpet? Types, differences, no carpet?

Who has the best sit and stand furniture?

Staffing & Workload:

- Most control room have too many or not enough operators – most don't know
- Technology changes, the equipment changes, the automation system changes, this all has an effect on the operator workload
- The workload between most operators is unbalanced (over worked / underworked
- A staffing study will not only allow you to see the workload score for each position but it will also allow you to compare the workload against your industry.
- A workload study also determines what can be done to reduce workload and improve situation awareness
- Staffing should be the fist thing you get right, looking at normal operations and the workload during abnormal, start up, shut down, and maintenance modes.
- Then you design the room to support them



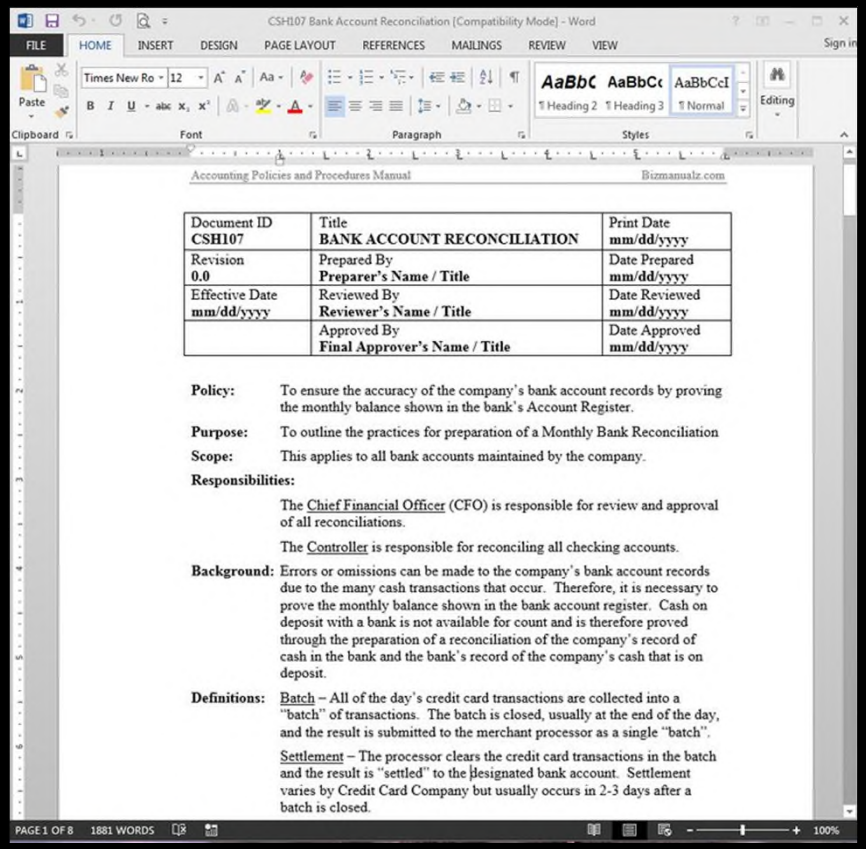


Procedures:

- Procedure performance (culture)
- Operators take short cuts
- Some procedures are out of date or not valid
- Some can not be found
- They are not automated
- They are poorly written
- Hard to follow
- They don’t contain check lists
- Some cultures accept bad practices
- How would you rank yourself on how procedures are used, managed, updated, and amended?

SOP

Standard Operating Procedures



CSH107 Bank Account Reconciliation [Compatibility Mode] - Word

Accounting Policies and Procedures Manual — Bizmanualz.com

Document ID **CSH107**	Title **BANK ACCOUNT RECONCILIATION**	Print Date **mm/dd/yyyy**
Revision **0.0**	Prepared By **Preparer’s Name / Title**	Date Prepared **mm/dd/yyyy**
Effective Date **mm/dd/yyyy**	Reviewed By **Reviewer’s Name / Title**	Date Reviewed **mm/dd/yyyy**
	Approved By **Final Approver’s Name / Title**	Date Approved **mm/dd/yyyy**

Policy: To ensure the accuracy of the company’s bank account records by proving the monthly balance shown in the bank’s Account Register.

Purpose: To outline the practices for preparation of a Monthly Bank Reconciliation

Scope: This applies to all bank accounts maintained by the company.

Responsibilities:

The Chief Financial Officer (CFO) is responsible for review and approval of all reconciliations.

The Controller is responsible for reconciling all checking accounts.

Background: Errors or omissions can be made to the company’s bank account records due to the many cash transactions that occur. Therefore, it is necessary to prove the monthly balance shown in the bank account register. Cash on deposit with a bank is not available for count and is therefore proved through the preparation of a reconciliation of the company’s record of cash in the bank and the bank’s record of the company’s cash that is on deposit.

Definitions: Batch – All of the day’s credit card transactions are collected into a “batch” of transactions. The batch is closed, usually at the end of the day, and the result is submitted to the merchant processor as a single “batch”.

Settlement – The processor clears the credit card transactions in the batch and the result is “settled” to the designated bank account. Settlement varies by Credit Card Company but usually occurs in 2-3 days after a batch is closed.

PAGE 1 OF 8 1881 WORDS 100%

Shift Handover:

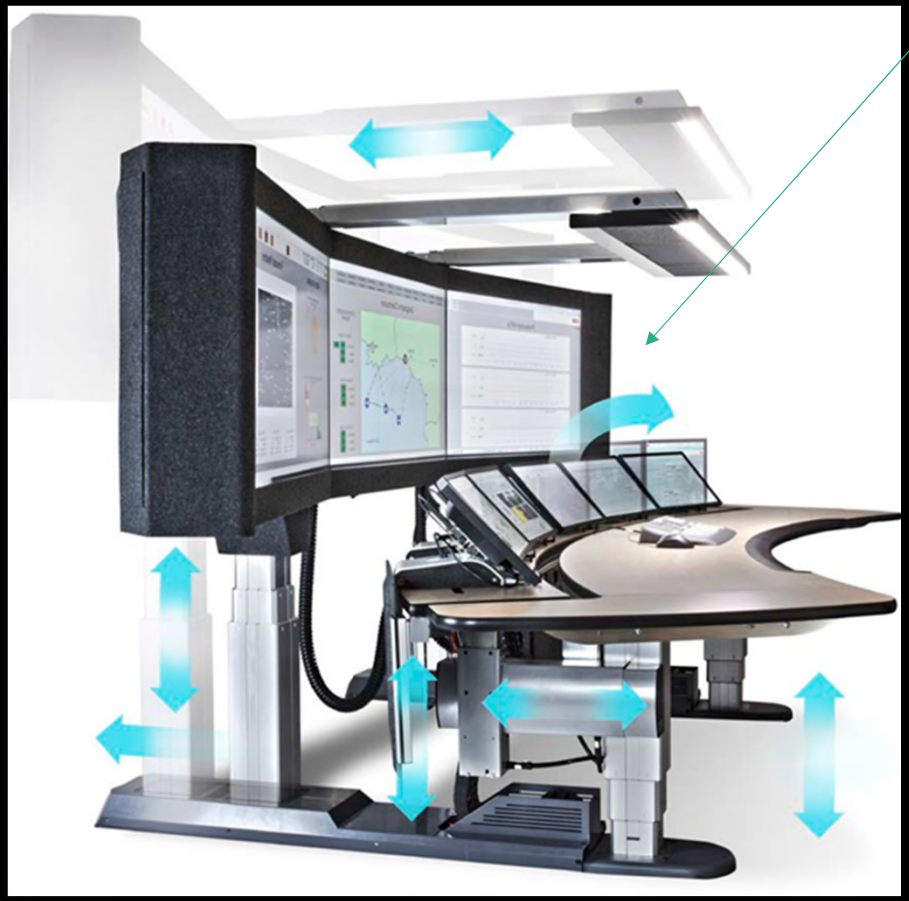
- A shift handover is not a high five in the parking lot
- It should be formal process with check lists, sign offs, and management supervision
- Alarms, operator changes, and maintenance activities should always be reviewed
- Any disabled alarms should be discussed or automatically reenabled
- If you have operators nearing retirement, your procedures should be examined and updated before they hit the road

Training:

- We find that most console operators were taught on the job and written materials were not part of the curriculum
- By incorporating graphic screen shots, with procedures, and providing exercises with testing, operators feel more confident and are more likely to out perform even veteran operators.
- Training materials should be up to date, provide testing, and instructors should have PowerPoint presentations that align with the written materials

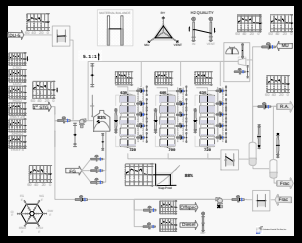
Ergonomic Consoles:

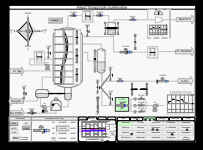
Overview Display: Situation Awareness Screen

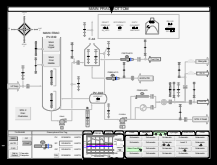


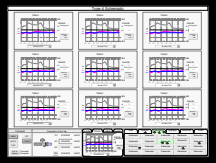
Large displays are used to alert the operator when important changes occur, using pattern recognition, color, and shapes for important events. The idea is to make important details pop off the screen. Smaller screens are used to drill into detailed information.

Scenario-Based Displays Improve Situation Awareness









- Level 1 – Process Area Overview (for situation awareness and problem detection)
- Level 2 – Process Unit Control (for ongoing process manipulation)
- Level 3 – Process Unit Detail (for close, detailed examination)
- Level 4 – Process Unit Support and Diagnostic Displays (for troubleshooting)

Overview Displays Improve Situation Awareness and Combat Change Blindness:

- We see a lot of data on graphics but no visible image that says if things are good or bad
- Graphics are copies of P&ID's
- Operators scan values and calculate ranges mentally
- Changes in data go unnoticed until the alarm activates
- Some operators have hundreds of graphics, multiple screens, and are never on the right screen when a problem occurs

Good or Bad?

HCT	=	31.7 %
HGB	=	10.2 g/dl
MCHC	=	32.2 g/dl
WBC	=	9.2 x10⁹/L
GRANS	=	6.5 x10⁹/L
%GRANS	=	71 %
L/M	=	2.7 x10⁹/L
%L/M	=	29 %
PLT	=	310 x10⁹/L

Data is not always the best way to give information

- Some graphics provide a range, this adds more data and clutter making changes even harder to notice
- You can now determine if the process is normal or not, but mental calculations take time
- It's still very difficult to really know what's happening

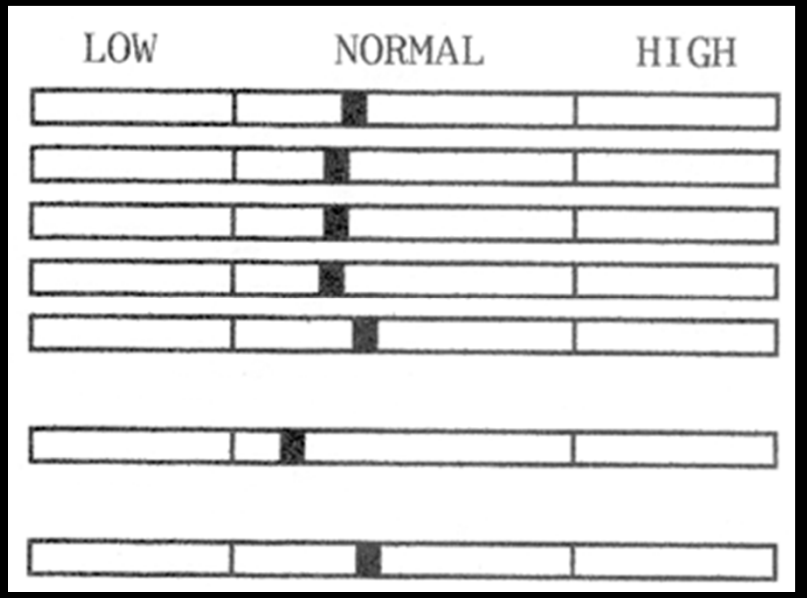
Good or Bad?

HCT	=	31.7 %	24.0 - 45.0
HGB	=	10.2 g/dl	8.0 - 15.0
MCHC	=	32.2 g/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
%GRANS	=	71 %	
L/M	=	2.7 $x10^9$/L	1.5 - 7.8
%L/M	=	29 %	
PLT	=	310 $x10^9$/L	175 - 500

Graphical interpretation is usually better:

- A picture is worth a thousand words
- Overview displays are designed based on this concept
- You can easily see in a split second that things are normal
- You can also see where some things are not perfectly lined up, where you might need to focus your attention
- The idea is to provide real information so that operators can prevent alarms from occurring

Good!



High Performance Graphics Allow an Operator to Identify Potential Problems:

- Level One: Overview screens are designed based on the operators most important alarms and important changes that effect the process
- Pattern recognition makes it easy to detect changes in the process
- Trends tell you where you were, where you are and where you are going
- Color demands attention and action

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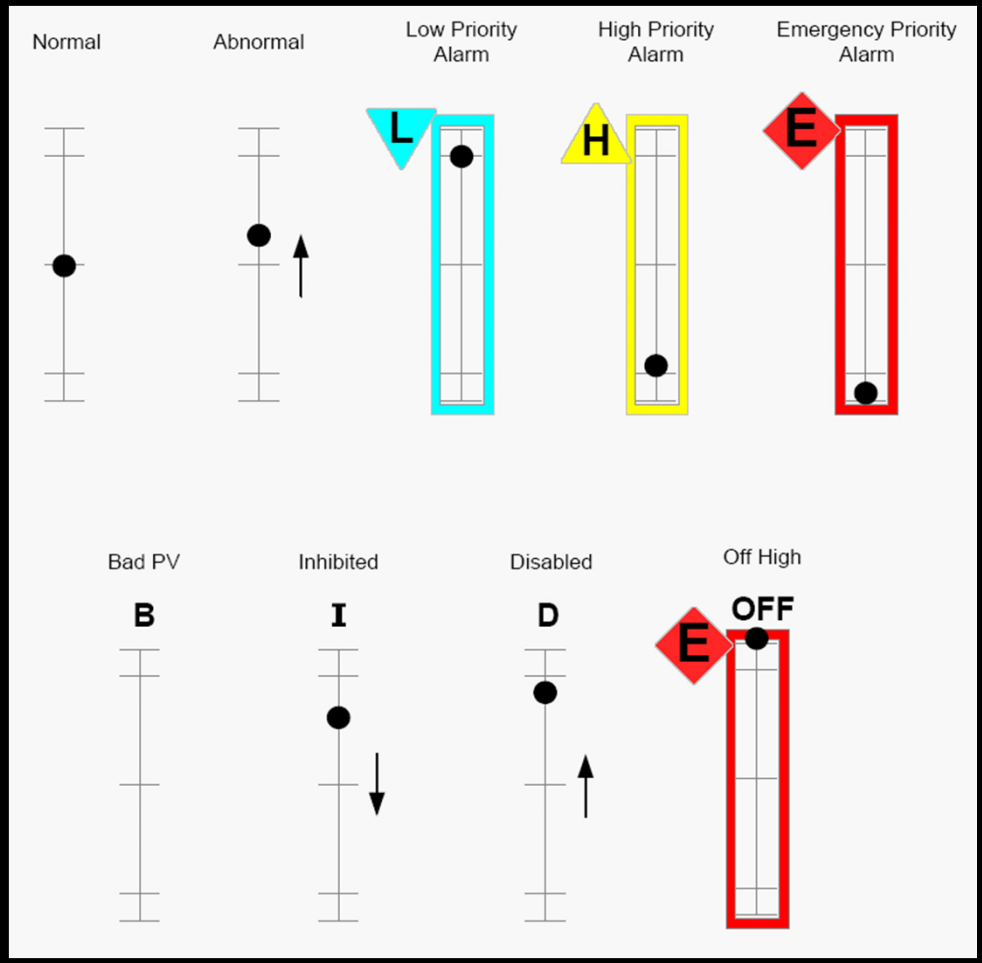
THE VISUAL NETWORK™

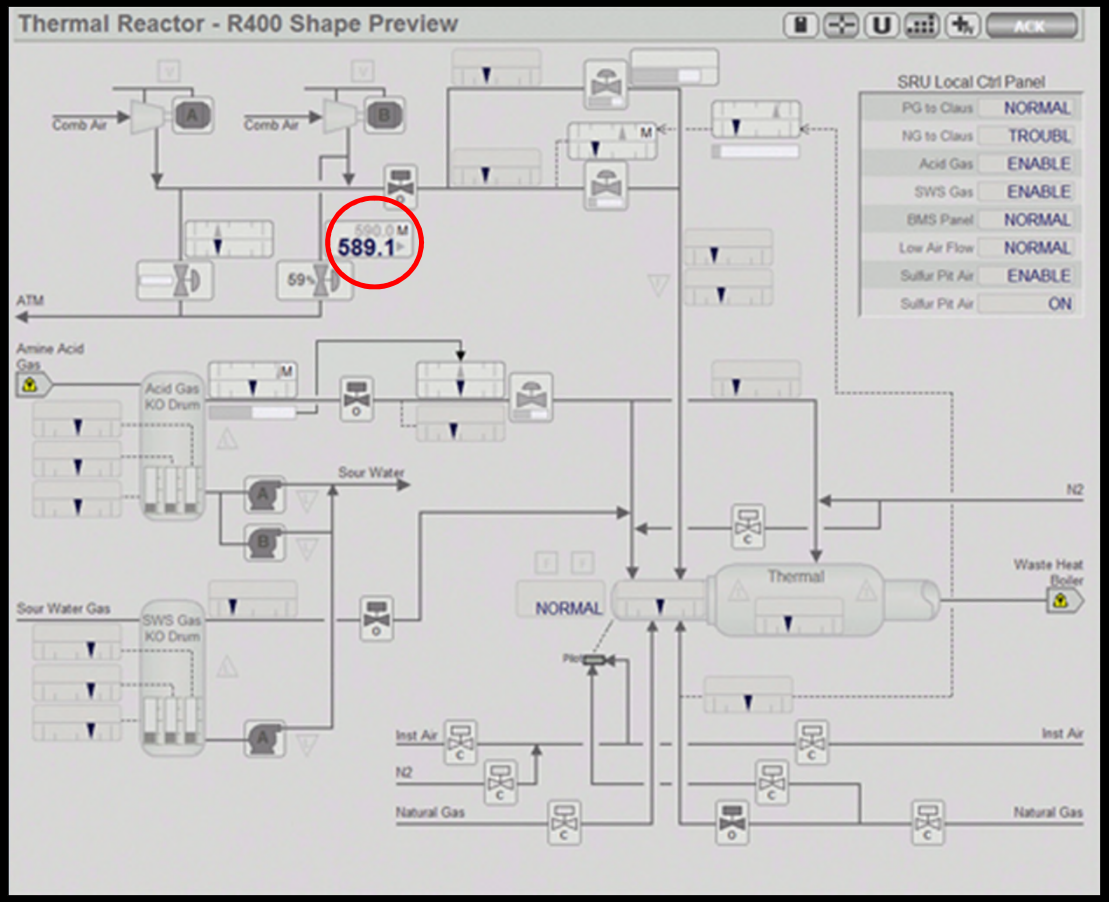
A Level 1 Overview display

High Performance Graphics Use Objects That Provide Information:

- If everything is good, no color
- You can easily see alarm limits and the desired operating limits
- Alarm priorities are obvious, this allows an operator to work on the biggest issues first
- Different colors mean different things but no more than 7 colors are ever used
- Arrows and text can auto appear when important changes occur
- Operators learn quicker when they use pattern recognition

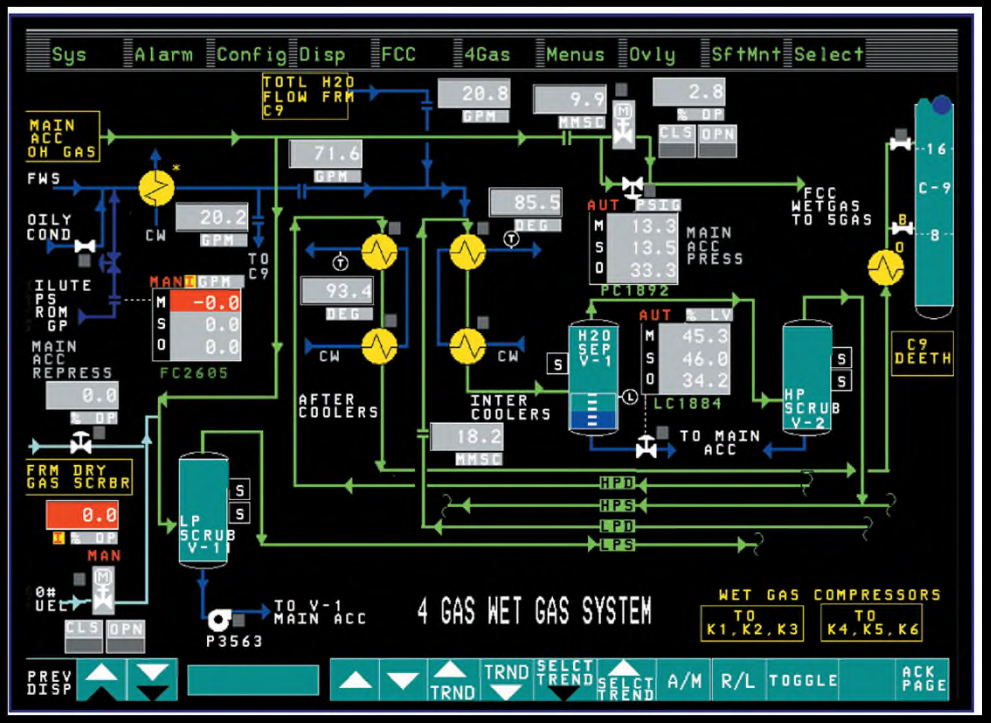


When you need the operator to pay attention use color, shape, and text – just like a stop sign

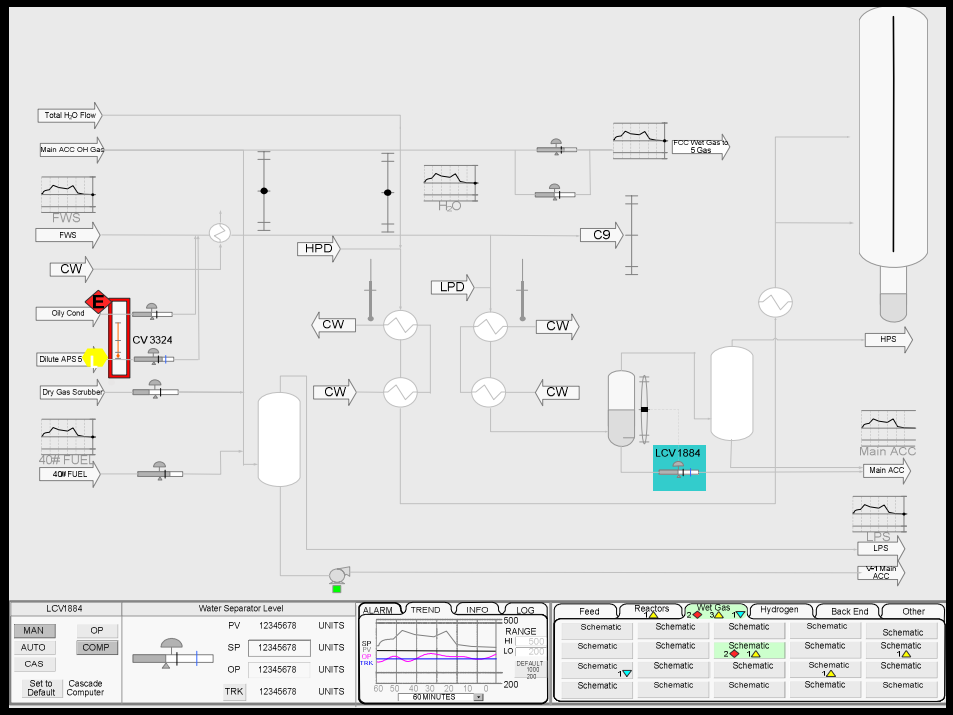


Same Graphic – but only one turns data into real information:

Is everything good?



Now it's obvious we have a problem



High Performance Graphics (The Results)

Task	With "Traditional" HMI	With High Performance HMI	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

We have to change the culture in the control room and Improve Operator Performance

- Operator's make decisions and process changes that have an impact on the business and safety
- They deserve to work in an environment that supports their tasks and objectives
- They must be trained to follow procedures
- Procedures must be accurate and well written
- They must not rely on alarms
- They should be proactive and predictive
- Complete Situation awareness should be the theme
- Human factors should be the focus
- The control room should have respect, rules, and structure
- Graphics and alarms should be evaluated and designed for high performance
- Staffing the room and field should be based on work complexity and measured for accuracy
- The work team design (managers and supervisors) should support operational goals

This is User Centered Design

Operators are the pilots of the process – so we give them wings

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Where do you need the most help?

1. Operator workload unbalanced
2. Operator response (slow response) near misses
3. Alarm problems – alarm floods
4. Operator training (need formal written material with testing)
5. Procedures out of date or operators not using them
6. Graphic design- too many graphics / data overload
7. Situation awareness screen does not exist or is not being used
8. Old control room, needs ergonomic furniture and new lighting
9. Fatigue – No fatigue management in place