Following Procedures Can Save Lives!

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The clear path to operational excellence

YOKOGAWA

Dr. Maurice J. Wilkins

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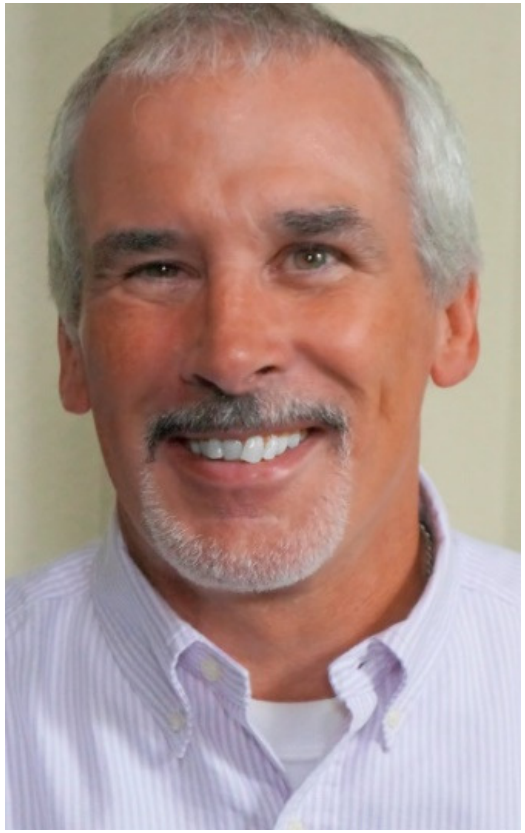
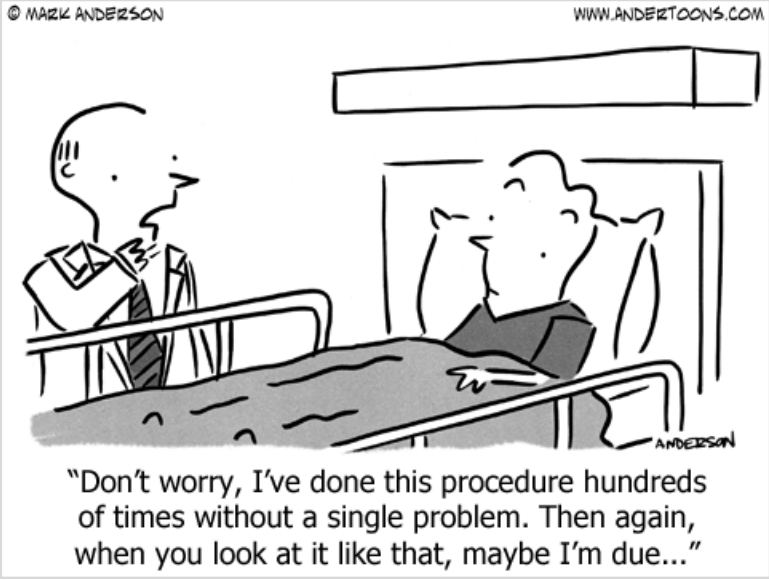
- Fellow of IChemE, InstMC and ISA
- Member of Process Automation Hall of Fame
- Proposer and Managing Director of ISA106
  - Procedure Automation for Continuous Process Operations
- Chair of ISA101 – HMI standard
- VP Elect – ISA Standards and Practices Board



Food for Thought

- Have you ever driven somewhere and not remembered how you got there?

What IS a Procedure?



Definitions

- A particular way of accomplishing something or of acting
- A series of steps followed in a regular definite order
- A set of instructions for a computer that has a name by which it can be called into action
- A traditional or established way of doing things

Examples

- Installing a car battery is a simple *procedure*
- What is the *procedure* for applying for a loan?
- New employees are taught the proper safety *procedures*
- We must follow proper court *procedure*
- An identity check is standard police *procedure*
- The *procedure* for treating a burn
- The *procedure* will take two hours

A History Lesson - Aviation Standards

1935 – Dayton, OH

B-17 Flying Fortress crashed on takeoff

- Too complicated
- Gust lock still engaged

APPROVED B-17F and G CHECKLIST

REVISED 3-1-44

PILOT'S DUTIES IN RED
COPILOT'S DUTIES IN BLACK

BEFORE STARTING
1. Pilot's Preflight—COMPLETE
2. Form 1A—CHECKED
3. Controls and Seats—CHECKED
4. Fuel Transfer Valves & Switch—OFF
5. Intercoolers—Cold
6. Gyros—UNCAGED
7. Fuel Shut-off Switches—OPEN
8. Gear Switch—NEUTRAL
9. Cowl Flaps—Open Right—OPEN LEFT—Locked
10. Turbos—OFF
11. Idle cut-off—CHECKED
12. Throttles—CLOSED
13. High RPM—CHECKED
14. Autopilot—OFF
15. De-icers and Anti-icers, Wing and Prop—OFF
16. Cabin Heat—OFF
17. Generators—OFF

STARTING ENGINES
1. Fire Guard and Call Clear—LEFT Right
2. Master Switch—ON
3. Battery switches and Inverters—ON & CHECKED
4. Parking Brakes—Hydraulic Check—On—CHECKED
5. Booster Pumps—Pressure—ON & CHECKED
6. Carburetor Filters—Open
7. Fuel Quantity—Gallons per tank
8. Start Engines: both magnetos on after one revolution
9. Flight Indicator & Vacuum Pressures CHECKED
10. Radio—On
11. Check Instruments—CHECKED
12. Crew Report
13. Radio Call & Altimeter—SET

ENGINE RUN-UP
1. Brakes—Locked
2. Trim Tabs—SET
3. Exercise Turbos and Props
4. Check Generators—CHECKED & OFF
5. Run up Engines

BEFORE TAKEOFF
1. Tailwheel—Locked
2. Gyro—Set
3. Generators—ON

AFTER TAKEOFF
1. Wheel—PILOT'S SIGNAL
2. Power Reduction
3. Cowl Flaps
4. Wheel Check—OK right—OK LEFT

BEFORE LANDING
1. Radio Call, Altimeter—SET
2. Crew Positions—OK
3. Autopilot—OFF
4. Booster Pumps—On
5. Mixture Controls—AUTO-RICH
6. Intercooler—Set
7. Carburetor Filters—Open
8. Wing De-icers—Off
9. Landing Gear
   a. Visual—Down Right—DOWN LEFT Tailwheel Down, Antenna in, Ball Turret Checked
   b. Light—OK
   c. Switch Off—Neutral
10. Hydraulic Pressure—OK Valve closed
11. RPM 2100—Set
12. Turbos—Set
13. Flaps ½—½ Down

FINAL APPROACH
14. Flaps—PILOT'S SIGNAL
15. RPM 2200—PILOT'S SIGNAL

Test pilots developed checklists

Standard global checklists

- Pre-flight
- In flight
- Landing
- Taxiing

EVERY pilot and plane whether private or commercial now uses checklists

Miracle on the Hudson

Flight 1549 struck a flock of birds minutes after take-off and lost power to both engines

Capt. Chesley “Sully” Sullenberger and First Officer Jeff Skiles ditched the aircraft in the Hudson. All 155 occupants safely evacuated the airliner

“The handling of the emergency and evacuation was text book….To have safely executed this emergency ditching and evacuation with no loss of lives, is heroic….”

Not a miracle….but good procedure execution?

Training and adhering to procedures allowed the crew, which had never worked together before, to execute emergency protocols flawlessly

Industry Trends Impacting Process Operations

10,000 ‘Baby Boomers’ per day retiring over the next 20 years

400,000 years of experience being lost per day

Preserving Procedural Knowledge

Much “procedural knowledge” is in the heads of the most experienced operators

They have their own tweaks that are often not in the SOPs or are their interpretation of an SOP

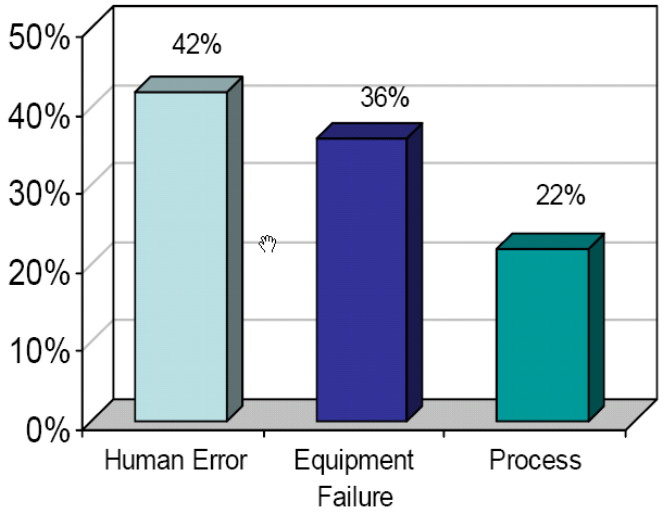
Automated procedures can capture the knowledge of the best operator on his/her best day…every day!

To Err is Human

- Failure in **maintenance procedures** cost airline $150,000 fine
- Engine cover not replaced and test run not done
- Almost cost 189 lives

Single largest factor in plant trips and accidents is human error

Causes of Abnormal Situations



- ASM consortium analysis of 32 incident reports indicated the need to **improve human reliability**
- Majority of procedural operations failures due to execution failures in abnormal conditions
- Over half of the reports included recommendation to **improve procedural content** for abnormal conditions

Transient Operations

- Disproportionate percentage of incidents during **transient operations**
- Conducted **infrequently** during startups, shutdowns and abnormal events
- **10% of time** is spent on transient operations yet they account for over **50% of incidents**
- Deficiencies in **procedures** and training cited

Scott W. Ostrowski & Kelly K. Keim, ExxonMobil Chemical Company
Chemical Processing Magazine, June 2010

Human Factors and Operator Errors

- Errors of *Commission:*
  - Performing correct step on wrong item
  - Performing step incorrectly on right item
  - Performing correct step at wrong time
- Errors of *Omission:*
  - Skipping a necessary step
  - Failing to communicate to a fellow worker (spoken or written)

P. L. Clemens *February 2002*

Procedure Errors & Breakdowns

Root Cause Description	%
Incomplete Coverage	42.7
Procedure NOT Followed	29.0
Flawed Reasoning	13.7
Incorrect Procedure	6.1
Incorrect Use of Procedure	3.8
Inadequate Coordination	3.1
Incorrect Data/Facts	1.5

- 5 Refineries and Petrochem Plants
- 3 year period
- $12 million losses

Root Cause Category	Subcategory	No.	%
Procedure Followed Incorrectly		6	9
	Format Confusing	1	
	Details need improvement	2	
	Check-off Misused	3	
Procedure Wrong		28	40
	Facts Wrong	3	
	Situation Not Covered	25	
Procedure Not Followed		36	51
	Procedure not used	19	
	No procedure	15	
	Procedure not available or inconvenient for use	1	
	Procedure difficult for use	1	

Procedures in Process Operations

- ALL process operations in ALL industries have procedural operations
  - Normal, safe operation
  - Change of state e.g. Start up, Shut down, Transition
    - Fuel source switch, adjusting to market demands, adjust to different operating conditions and running times, meet regulatory compliance

- Procedures may be:
  - Operator Knowledge (Tribal lore)
  - Manual via Written SOP's
  - Semi-Automated
  - Automated

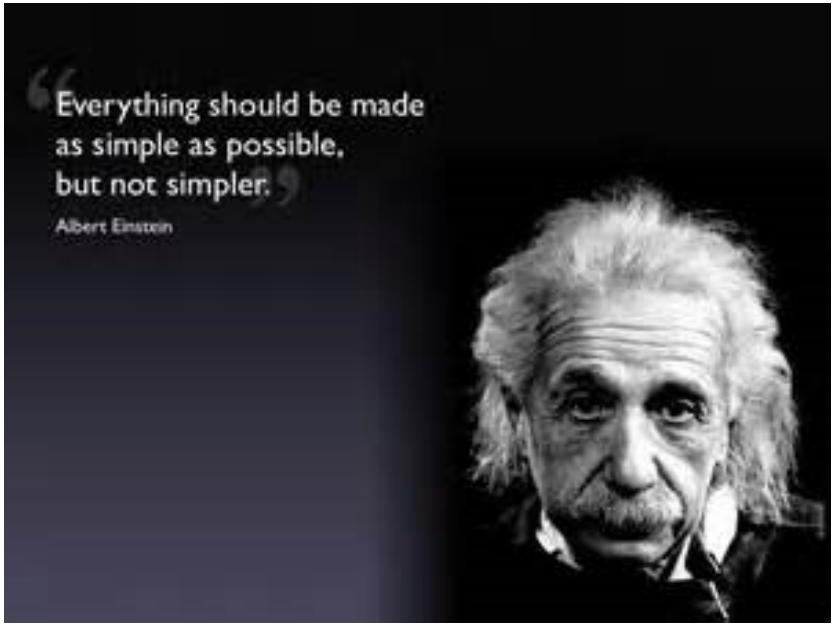
- Procedures vary by industry/company/plant, but they require consistent execution

(SOP – Standard Operating Procedure)

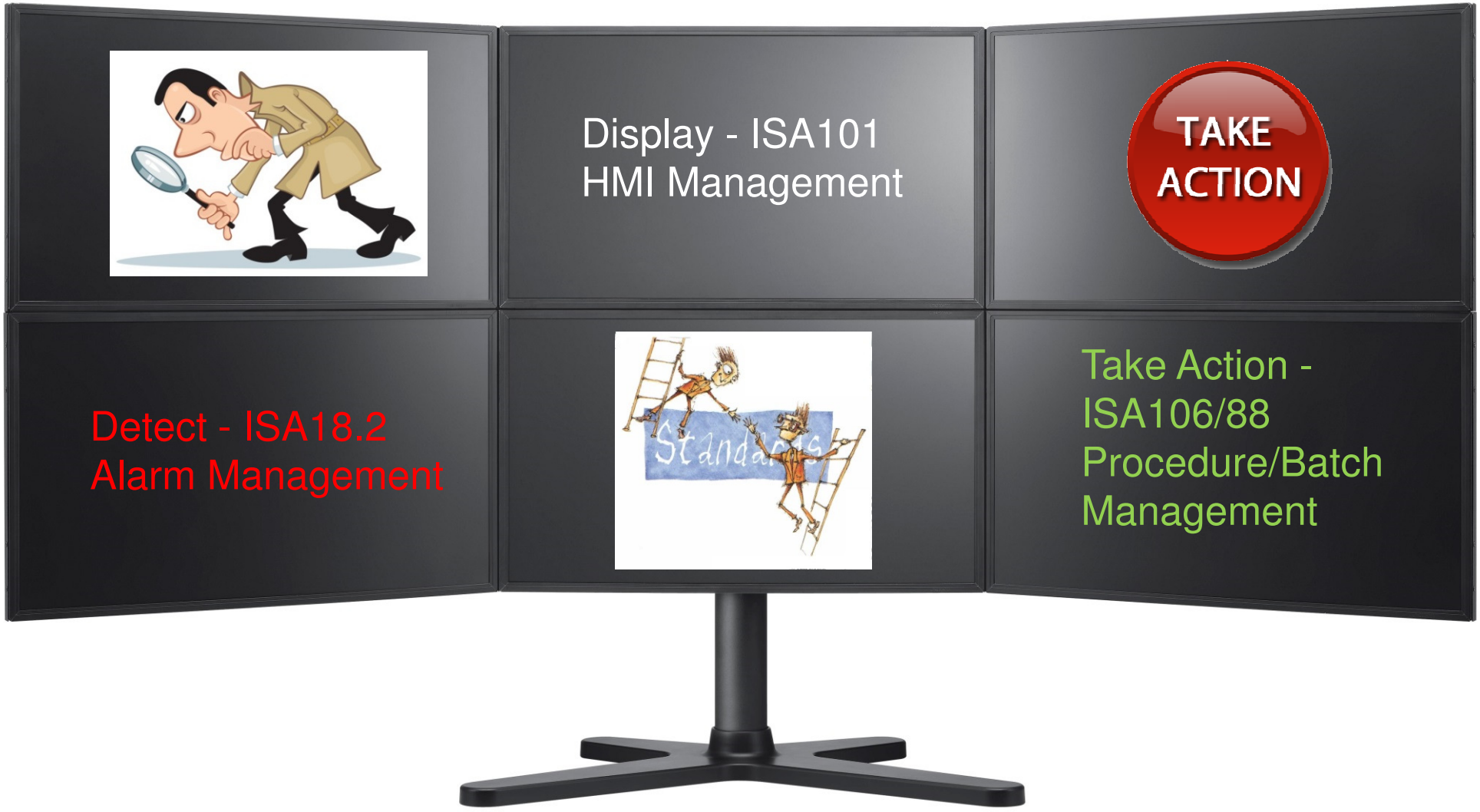
Which Procedures to Automate

No easy answer but ASM Consortium has some suggestions

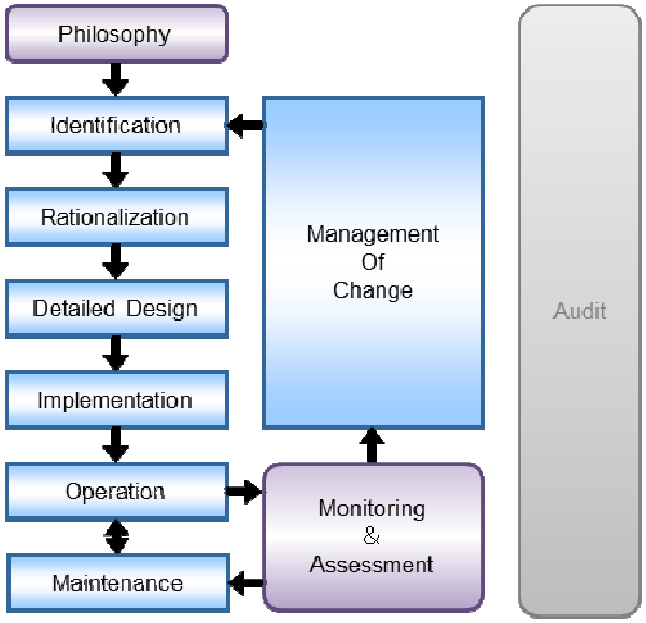
- Critical
  - Low frequency, highly complex, and serious consequences
- Reference
  - Moderate frequency, complexity and consequences
- Guidelines
  - High frequency, low complexity and minor consequences.



Standards Based Decision Support



Comprehensive Alarm Management (ISA18.2)



ISA18.2 Lifecycle

Limit alarms to what the operator has time and ability to handle

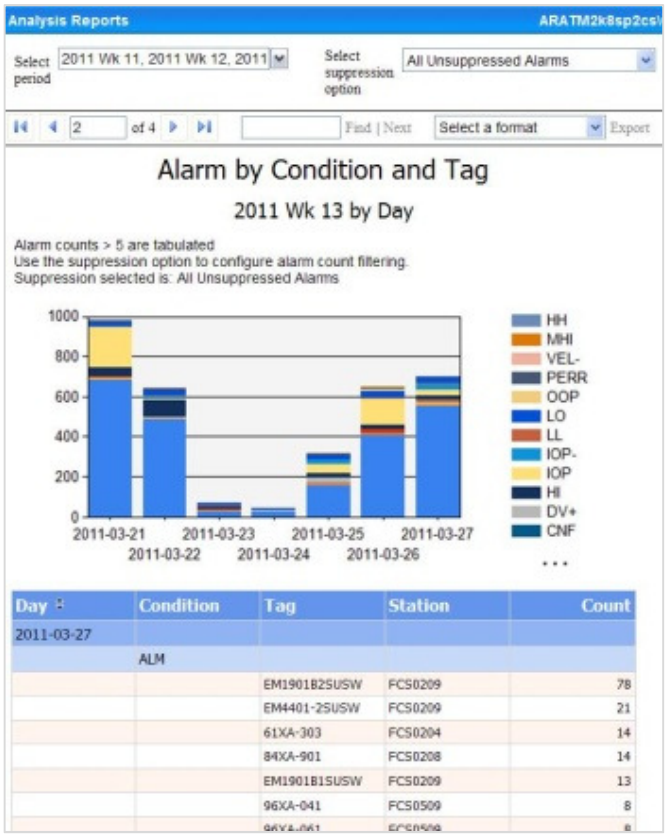
Alarm Philosophy

Alarm Rationalization

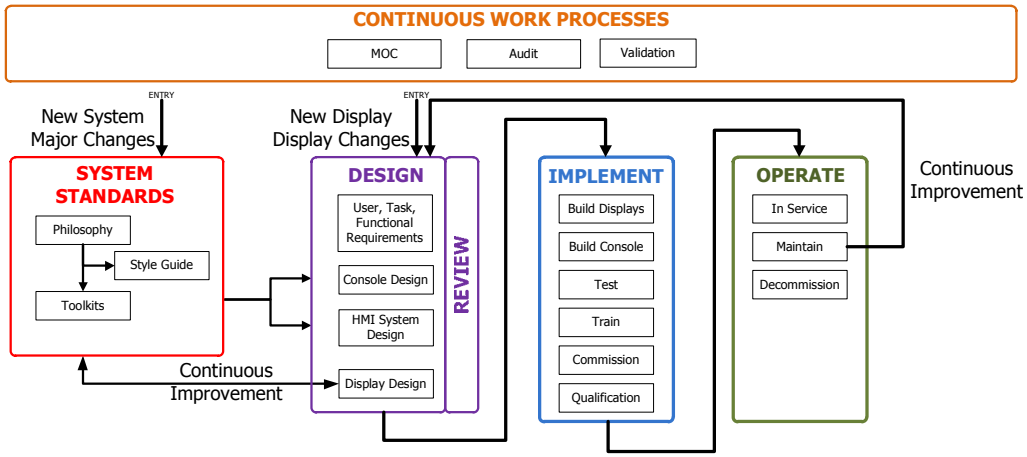
Continuous monitoring and optimization

Ensure the right alarms are detected

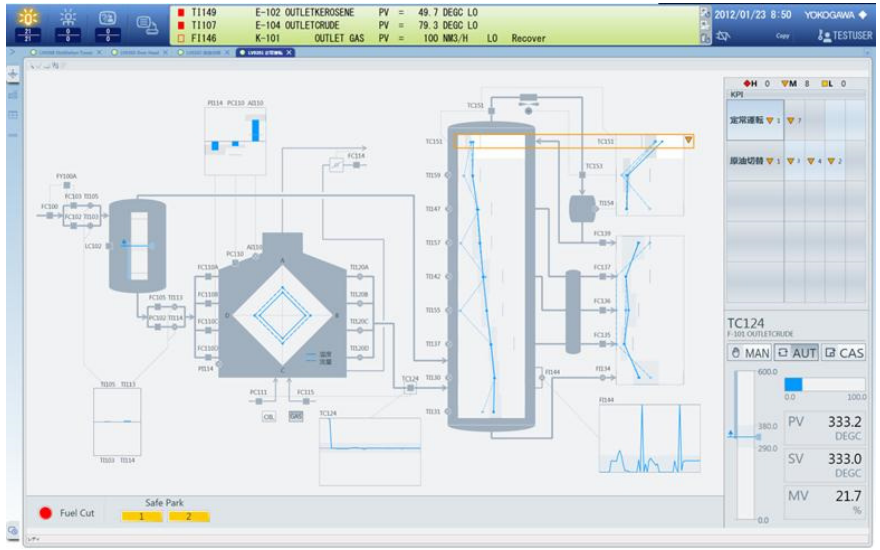
Either the operator or the system can take action



Advanced HMI Management (ISA101)



ISA101 Lifecycle



Design Based on Operator Tasks

Incorporate Human Factors (color, layout, navigation)

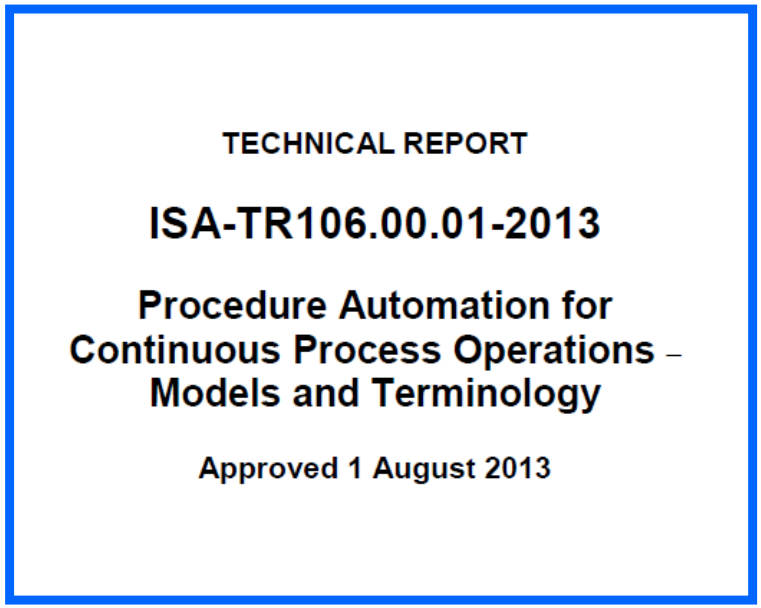
Provide Situation Awareness (trends, profiles)

Clear Indications – Items That Need Attention

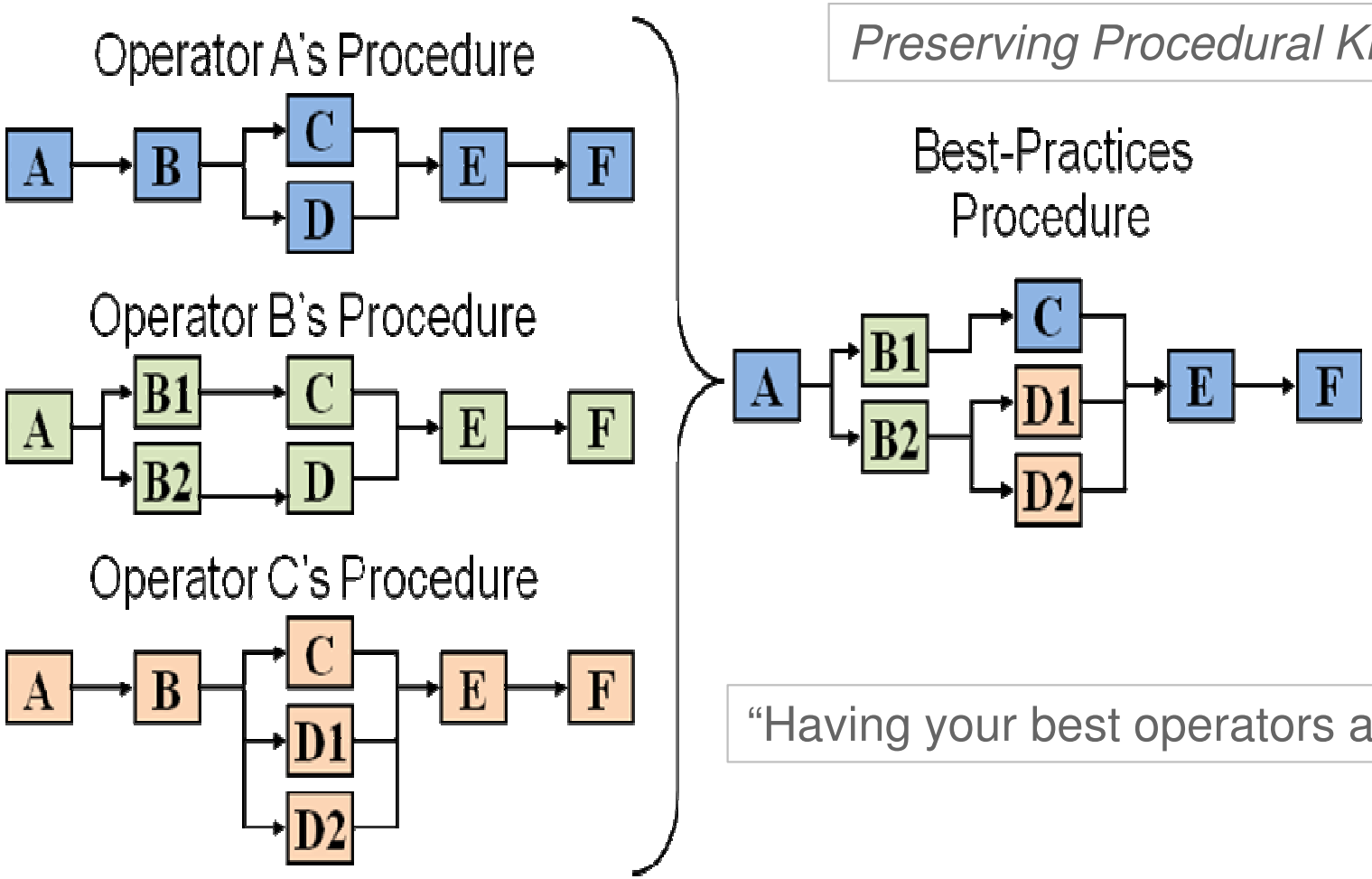
Procedure Automation Standard – ISA106

ISA106 is a committee formed in May 2010 to develop standards, recommended practices, and technical reports on the design and implementation of procedures for automating continuous process operations

- Published 1st Technical Report in 2013
  - Models and Terminology
  - Available in the ISA store at www.isa.org
- Working on the 2nd Technical Report
  - Work Processes
- Work on the Standard is expected to start soon
  - Use industry feedback on the technical reports to create the standard



Procedure Management (ISA106)



Preserving Procedural Knowledge

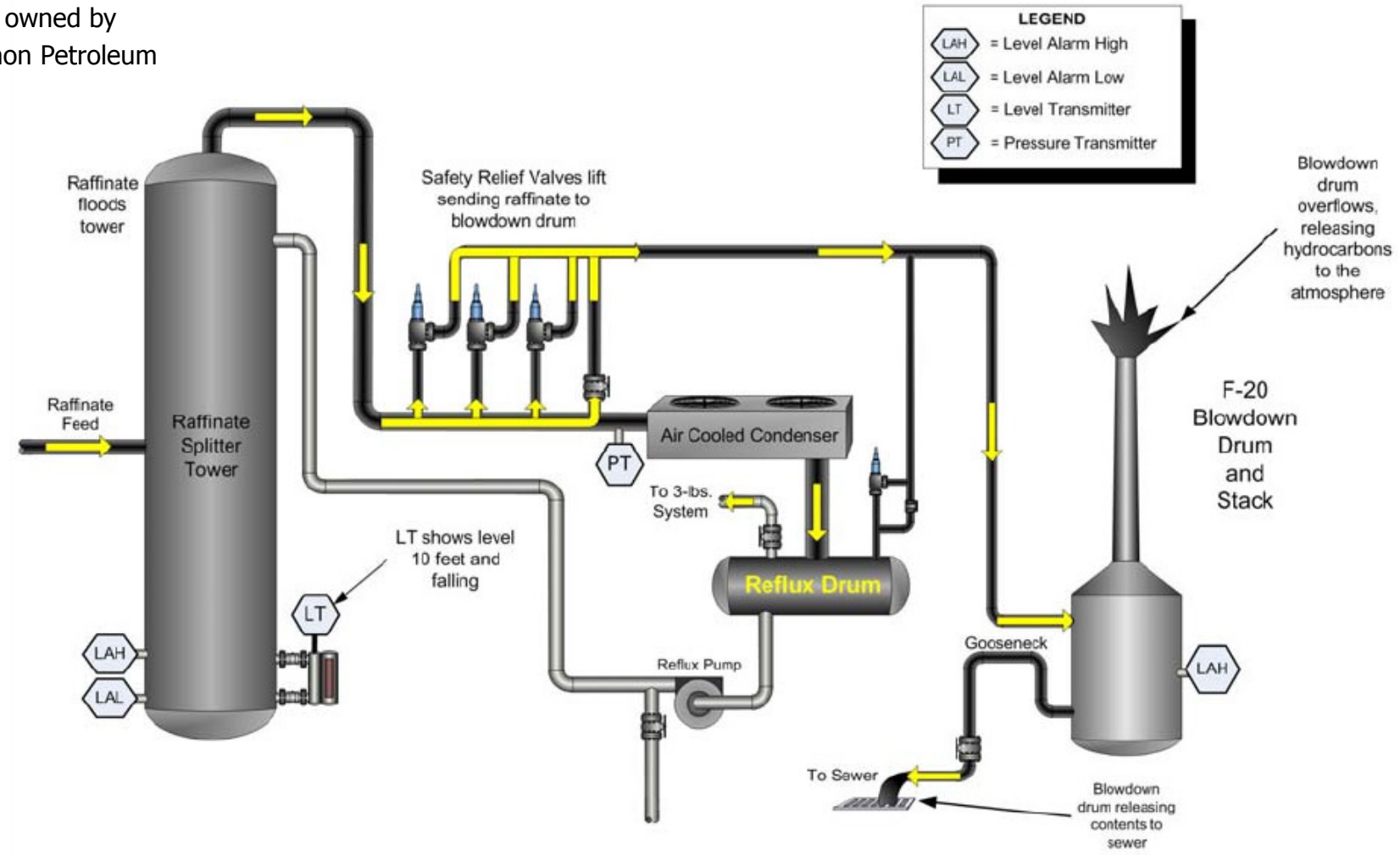
"Having your best operators all day, every day"

Capturing Best Practices Procedures

When Things Go Wrong

Texas City Refinery – 2005

The Texas City Refinery is now owned by Marathon Petroleum

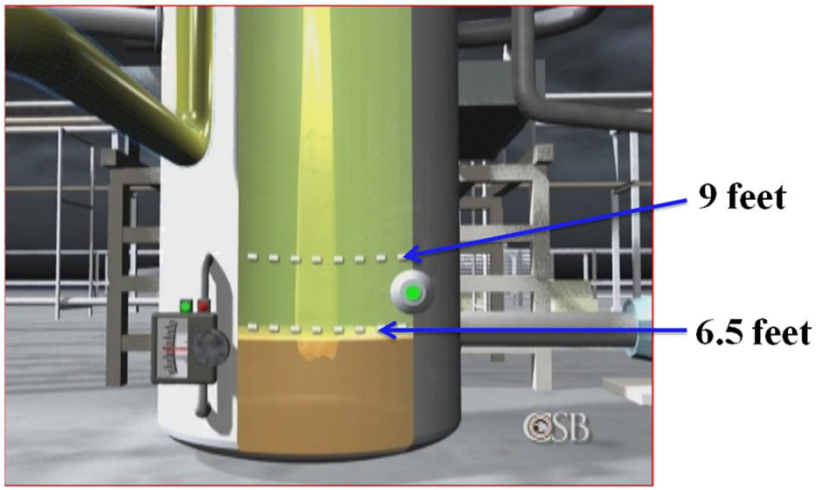


Procedures not followed – why?

Operator distraction, inexperience or overload?

Lack of Procedures in Texas City?

- Faulty hard wired alarm not repaired (no work order)
- DCS high level alarm acknowledged and ignored
- Liquid was over the top level tap at start up
- Control valve was closed in ‘Manual’
- Start up procedure required the valve to be 50% open and in ‘Auto’
- During early start up SOP indicated this is the only way to control splitter level
- Burners turned on prior to establishing rundown
- Heat up ramp rate 50% higher than in SOP



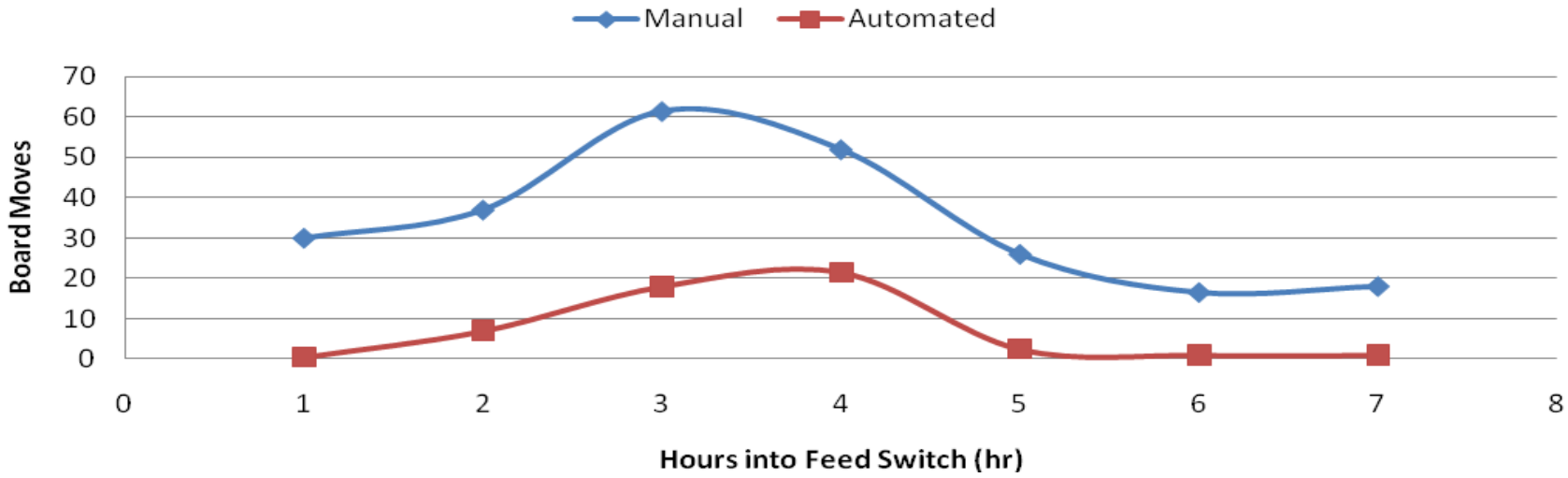
Mogford Report cited 4 critical factors including:

Raffinate splitter startup **procedures** and application of knowledge and skills

When Things Go Right

Refinery Feed Switch

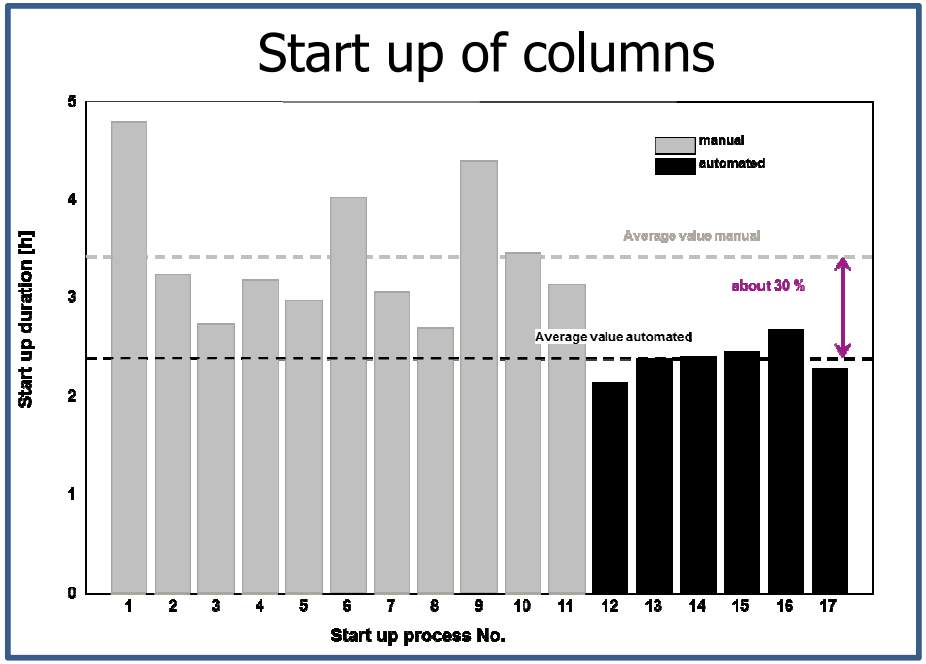
- A refinery operations team recognized there was a large optimization opportunity to automate a feed switch.
- Benefits in automating the feed switch procedure were:
  - Operator workload reduced by 60%
  - A 42% reduction in product yield loss
  - Increased feed throughput during transition by 18%
  - Reduced feed switch transition time by 36%



Console Operator Moves per Hour Comparison from paper "Improving Refinery Unit Transitions Using Process Automation Technology in a base Oil Hydroprocessing Facility. AIChE Spring 2011 Robert M. Tsai, Chevron, Richmond, CA

Acrylic Acid Plant

- Issue
  - Complex acrylic acid plant
  - Startups, load changes and other operational challenges required highly skilled workers
  - Operators needed to adjust 70 process parameters in parallel and monitor another 200 for reactors
  - Operators needed to adjust 15 process parameters in parallel for columns
    - Start up time and quality depended on operator skill
  - Evonik decided to automate its startup processes
- Results
  - Start up of columns: 30% reduction
  - Start up of reactors: 40% reduction



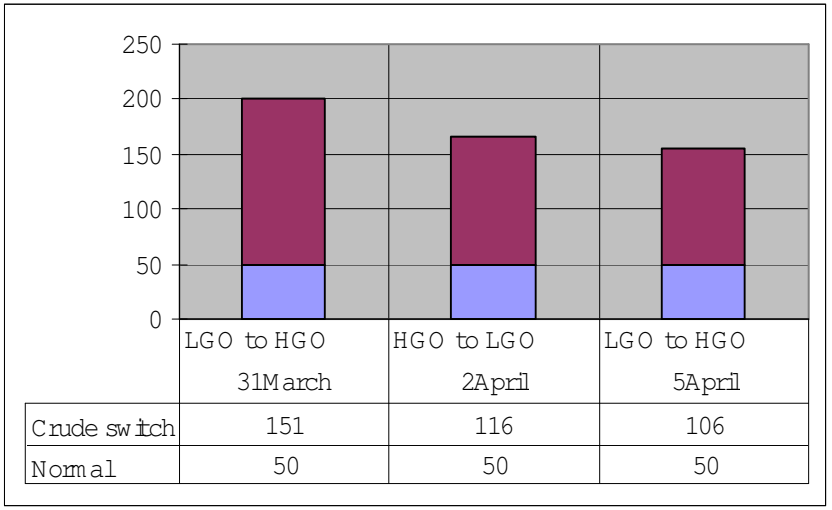
Evonik

Crude Switch

- Japanese Oil Refinery
- Crude switch 2-3 times a week
- Efficiency very dependent on the experience and skill of the board operator
  - Skilled operator: time to reach steady state was typically 5 hours
  - Junior operator: could take over 8 hours to reach steady state
- Long transition times had an impact on:
  - Product quality and production efficiency
  - Inefficient use of utilities such as fuel gas, power, and cooling
- With junior or less experienced operators there was a higher incident of operational errors resulting in abnormal conditions and “off-spec” product

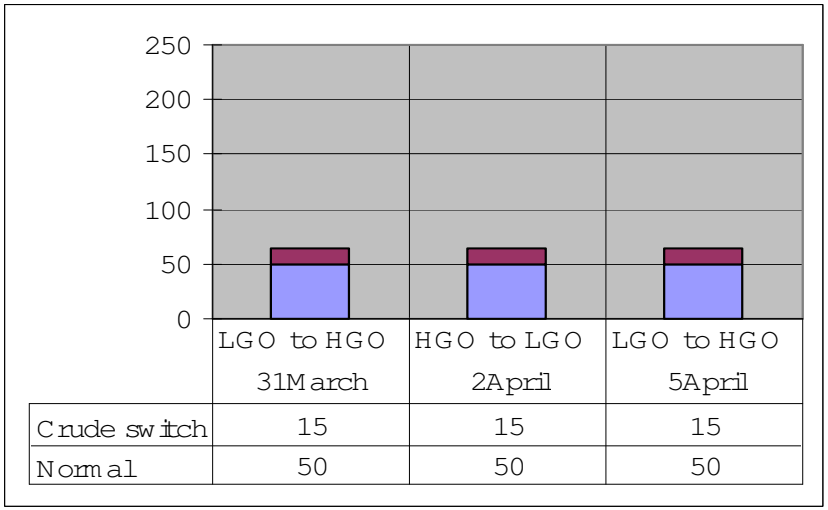
Crude Switch

- Interviewed board operators from different shifts
  - Junior operators would typically ramp feed temperatures at a linear rate throughout the temperature zones
  - Veterans changed the temperature ramp depending on temperature zones
- Operators typically had to make over 100 adjustments to the process in addition to responding to false alarms set for normal operating conditions
- Procedure automation implementation
  - Switchover time to very predictable 2 ½ hrs regardless of operator on shift
  - Control system adjustments reduced to 10 and process alarms adjusted to operating conditions
  - Increased process knowledge sharing, reduction in operator errors, and reduced operator training



	LGO to HGO 31March	HGO to LGO 2April	LGO to HGO 5April
Crude switch	151	116	106
Normal	50	50	50

Operator

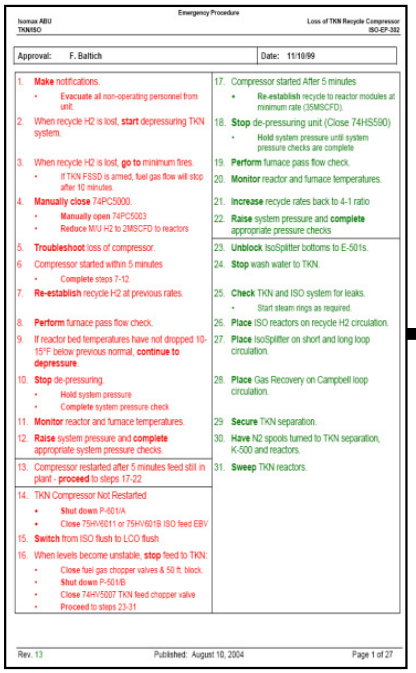


	LGO to HGO 31March	HGO to LGO 2April	LGO to HGO 5April
Crude switch	15	15	15
Normal	50	50	50

Application

Procedure Automation – Major GOM Operator

- Improve safety and reliability of the platform by reducing the likelihood and impact of procedure related incidents
  - Inadequate Procedures or Safe Work Practices are a leading cause of incidents on a facility
- Improve overall performance through consistent execution, leading to higher utilization, production optimization, and extended equipment life
  - Manual procedure effectiveness is mainly dependent on human performance
  - Less than optimal manual execution of procedures may result in an incident, unplanned downtime, and/or slower, rougher transitions



Emergency Procedure

Ivanhoe ABU
TKN/ISO

Loss of TKN Recycle Compressor
ISO-EP-332

Approval: F. Baltich

Date: 11/10/99

1. **Make** notifications.
   - **Evacuate** all non-operating personnel from unit.
2. When recycle H2 is lost, **start** depressuring TKN system.
3. When recycle H2 is lost, **go to** minimum fires.
   - If TKN FSSD is armed, fuel gas flow will stop after 10 minutes.
4. **Manually close** 74PC5000.
   - **Manually open** 74PC5003
   - **Reduce** MIU H2 to 2MSCFD to reactors
5. **Troubleshoot** loss of compressor.
6. Compressor started within 5 minutes
   - **Complete** steps 7-12.
7. **Re-establish** recycle H2 at previous rates.
8. **Perform** furnace pass flow check.
9. If reactor bed temperatures have not dropped 10-15°F below previous normal, **continue to depressure**.
10. **Stop** de-pressuring.
    - **Hold** system pressure
    - **Complete** system pressure check
11. **Monitor** reactor and furnace temperatures.
12. **Raise** system pressure and **complete** appropriate system pressure checks.
13. Compressor restarted after 5 minutes feed still in plant - **proceed** to steps 17-22
14. TKN Compressor Not Restarted
    - **Shut down** P-601A
    - Close 75HV6011 or 75HV601B ISO feed EBV
15. **Switch** from ISO flush to LCO flush
16. When levels become unstable, **stop** feed to TKN:
    - Close fuel gas chopper valves & 50 ft. block.
    - **Shut down** P-501B
    - Close 74HV5007 TKN feed chopper valve
    - **Proceed** to steps 23-31
17. Compressor started After 5 minutes
    - **Re-establish** recycle to reactor modules at minimum rate (35MSCFD).
18. **Stop** de-pressuring unit (Close 74HS580)
    - **Hold** system pressure until system pressure checks are complete
19. **Perform** furnace pass flow check.
20. **Monitor** reactor and furnace temperatures.
21. **Increase** recycle rates back to 4-1 ratio
22. **Raise** system pressure and **complete** appropriate pressure checks
23. **Unblock** IsoSplitter bottoms to E-501s.
24. **Stop** wash water to TKN.
25. **Check** TKN and ISO system for leaks.
    - Start steam rings as required.
26. **Place** ISO reactors on recycle H2 circulation.
27. **Place** IsoSplitter on short and long loop circulation.
28. **Place** Gas Recovery on Campbell loop circulation.
29. **Secure** TKN separation.
30. **Have** N2 spools turned to TKN separation, K-500 and reactors.
31. **Sweep** TKN reactors.

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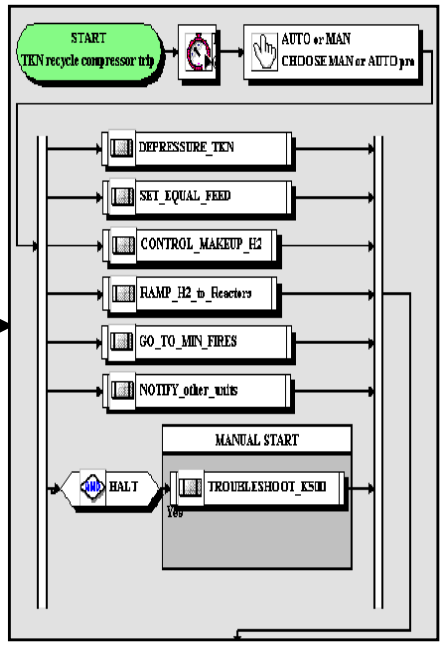
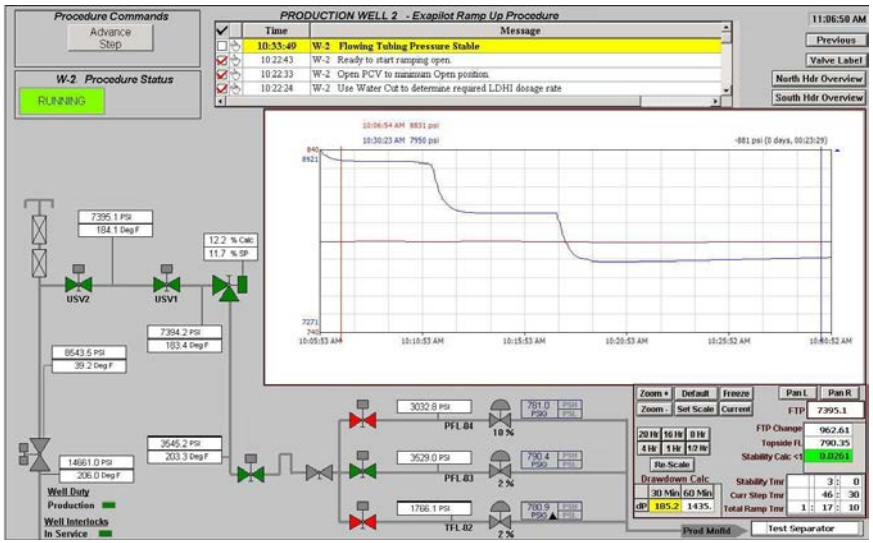


Using a Procedure Automation Application

- Benefits of a Procedure Automation Application
  - Supports and drives the consistent use of SOPs
  - Leverages and institutionalizes the knowledge of experienced operators.
  - Automate steps in the SOP to increase **reliability** and **safety** without decreasing the importance of the operator's role in execution
- Applications
  - In use at existing deep water facilities in Gulf of Mexico. Applications include compliance testing, manifold valve alignment, equipment swapping, platform startup
  - Procedure Automation is being incorporated into the control system design for future major capital projects



Well Ramp Up Example of Operator Screen for Drill Center Overview

Texas City Revisited

Possible Automated Startup Procedure

- First capture the knowledge of experienced operators
- Provide visual indication of procedure progress in a flowchart – makes hand-over to next shift easier
- Include steps for manual field checks prior to startup
- Add steps to verify instruments are working properly
- Warning text that if the level indicator is maxed-out, liquid may be present at higher levels
- Procedure should have an abnormal handling branch
- Step for automatic control valve move to 50% and Auto, with message to operator
- Warning to the operator to establish rundown before being able to start the burners
- Automated step to start heat-up ramping with ramp rate limited

Benefits of Using Procedure Automation

- Standardize and Automate Procedures
  - Capture and implement operating know-how of experienced operators
  - Implement plants predefined Standard Operating Procedures
  - Execute automatically for increased operating efficiency
- Improve Plant Operating Efficiency
  - Increase productivity by reducing the time that operators take during manual operation
  - Reduce costs by reducing usage of energy, utilities, and materials during manual operation
  - Reduce alarms and events to allow operator to concentrate on other activities.
- Improve Safety of Plant Operations
  - Operate plant exactly as defined by the stored operating procedures
  - Reduce operational errors and omissions
  - Ensure optimum operating efficiency and safe operation can be maintained
  - Document stored operating procedures

Conclusion

- Successful execution and management of procedures is important to safe and efficient operation of continuous process operations
- ISA106 committee has released a technical report to document best practices in continuous process applications and is close to releasing one on procedure management work practices
- Concepts of ISA 106 can and should be applied to automating procedures in continuous process applications

Thanks – Questions?