MUSTANG

Alarm Management for Control Room Operations in the Natural Gas Industry

Bridget Fitzpatrick

Mustang Automation and Control

People Oriented…Project Driven®

Speaker Bio

Bridget Fitzpatrick is HMI and Abnormal Condition Management Practice Lead for Mustang Engineering in Houston, TX. She has 20 years of experience in process engineering, control engineering, management, consulting, and energy management in the process industry. Her experience includes the chemical, plastics, pharmaceuticals, refining, and power fields.

Prior to joining Mustang Engineering, she was associated with Celanese Chemicals for 15 years.

She is a senior member of ISA. She is active on both the ISA18 (Alarm Management) and ISA101 (HMI) standards and practices committees. She is also on the API1167 (alarm management for pipelines) committee. She is also a member of IEEE, AIChE and ACS.

Bridget is a graduate of MIT with a Bachelors Degree in Chemical Engineering. She also holds a MBA in Technology Management from the University of Phoenix.

She has made multiple presentations and has multiple publications in the areas of HMI and alarm management.

Agenda

- Mustang Overview (1 slide!)
- Why Do Alarm Management?
- AGA Alarm Management White Paper Recap
- Comparison to EEMUA & ISA 18.2
- How to Get Started

Mustang Summary

Mustang is a leading engineering firm, providing complete Engineering, Design, and Project and Construction Management services to the domestic and international petroleum, chemical, and pharmaceutical industries.

Upstream

Midstream

Process Plants

Pipeline

Automation

Process & Industrial

Alarm Management?

- In the most basic terms, alarm management is completing the steps necessary to ensure that the alarm system is an effective tool for operators to manage and prioritize their response to process upsets.

Not rocket science, not even all that hard in most cases.

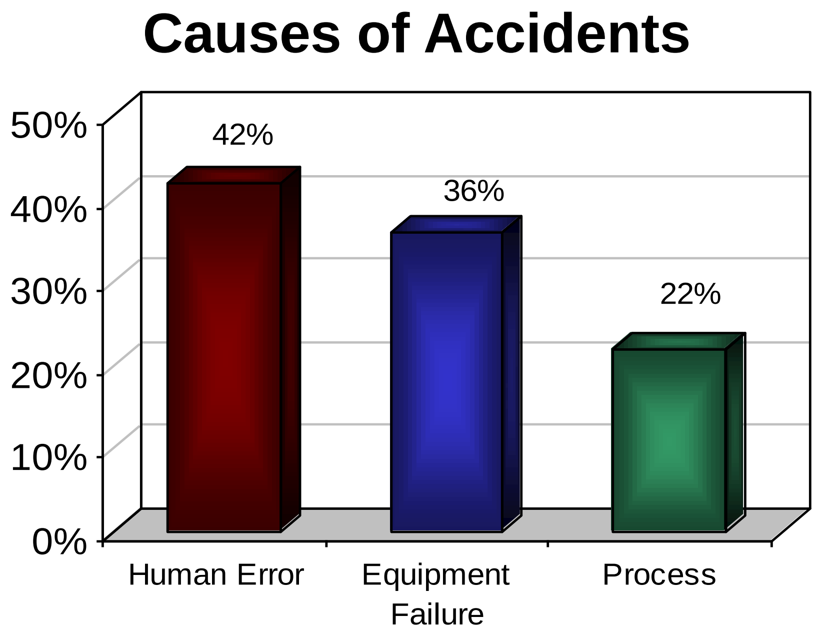
MUSTANG

Why ACM?

- New rule requires it for safety alarms, but also…
- Annual cost of abnormal conditions to US industry: $20B
- From an industrial process control standpoint, an abnormal condition develops when the process conditions deviate significantly from the "normal" acceptable operating range.
- In practical terms, the "abnormal" is a deviation that will lead to injury or financial losses[1].

Causes and Contributing Factors

- Major Contributing Factors to accidents resulting from abnormal conditions[1]:
  - Alarm Management System
  - Operator Interface
  - Information Overflow



Alarm Management Helps?[1]

- Improves operator tools for upsets
  - Decrease trips, downtime.
- Avoids control system overloads during upsets
  - Loss of view of data corruption can be an issue.
- Identifies area for improvement
  - Instruments in need of repair,
  - Areas for process, control or operations improvements.

Other Industry Standards/Guidelines

- Most industrial groups acknowledge the "EEMUA Guide" as a key source of best practices and design information for alarm systems.
  - EEMUA is the Engineering Equipment and Material Users Association.
  - The Guide is Publication 191 or "Alarm Systems - A Guide to Design, Management and Procurement".
- ISA also has a standards committee, ISA18, that recently published a standard.
  - It provides a lifecycle approach to comprehensive alarm management.
  - It is a safety standard much like ISA84 and has requirements and recommendations.
- API is also writing a recommended practice in API1167.
- AGA white paper that we will recap today.

MUSTANG

AGA White Paper²

AGA White Paper Purpose

- The intent of this white paper is to provide guidance for operators developing alarm management plans to address the requirements of the final Control Room Management rule on December 11, 2008.
- This white paper solely addresses the operator's alarm management policies and procedures for pipeline and public safety.
- Alarm management policies and procedures for events that do not affect pipeline and public safety are not covered in this white paper.

AGA White Paper TOC

I. Purpose and Scope
II. General Definitions
III. Alarm Philosophy
IV. Alarm Determination
V. Alarm Audits
   a. Audit Considerations
   b. Performance Metrics
VI. Alarm Resolution
VII. Roles and Responsibilities
VIII. Commissioning new equipment/modified equipment to validate alarm settings
IX. Management of Change
X. Documentation
XI. Notices and Copyright

AGA Alarm Management

- Key concepts:
  - Have an alarm philosophy,
  - Have a process to determine your safety-related alarms,
  - Have audits, which include performance metrics,
  - Have clear roles and responsibilities,
  - Manage change,
  - Document the alarms.

AGA Definitions

- Alarm: An audible or visible means of indicating to the Gas Controller that an equipment or process is outside operator defined safety-related parameters.
  - Remember the scope is limited to safety-related parameters.
- Alert: A notification or event that does not require immediate action. Alerts are always of lower priority than alarms and should never be safety-related.
  - Important concept is that alerts can be safely ignored during an upset.

AGA Alarm Philosophy

- An alarm philosophy defines a consistent process for development, implementation, maintenance and review of an alarm management plan.
- A documented plan includes:
  - Design,
  - Display of alarms,
  - Alarm reviews,
  - Documentation,
  - Gas Controller response to alarms,
  - Training.
- An alarm philosophy covers new, existing and modified systems.
- Consistency across diverse systems key!

AGA Alarm Determination

- The alarm system should be designed, configured, implemented, maintained and managed to ensure appropriate response to alarms.
- Operators will define alarms and alerts according to their unique operating conditions. Operators must specify the Gas Controller response to the alarm.
- **Gas Controllers must be able to quickly identify and respond to alarms.**
- Example operating parameters to consider for alarms include:
  - exceeding MAOP,
  - a gas escape event,
  - fire and,
  - odorization equipment malfunction.

AGA Audit

- Operators should audit the alarm management plan to determine its effectiveness.
- The audit should include consideration of:
  - Compare actual operation to the alarm management plan to identify and address non-compliance,
  - Identify and address safety-related points that have been taken off-scan or that have manual values,
  - Verify alarm settings and descriptions,
  - Review the Gas Controller workload to assure sufficient opportunity to analyze and react to incoming alarms,
  - Identify improvements that can be made to Gas Controller actions or to the overall plan.

The Alarm Management Plan must be kept evergreen.

AGA Performance Metrics

- The operator should develop performance metrics to analyze the effectiveness of the alarm management plan.
- Alarm system analysis should be performed on a periodic basis.
- Common metrics to consider include:
  - Average number of alarms on an hourly basis,
  - Monthly analysis of alarms,
  - Alarm priority distribution profile.

AGA Safety Alarm Resolution

- The Gas Controller should confirm that the cause of the alarm is made safe and document the cause of the alarm and the actions that were taken to allow safe operations to resume.
- The review of the cause of the alarm may include:
  - Verify the legitimacy of the alarm,
  - Take actions necessary to mitigate impacts,
  - Notify persons as per established response procedures,
  - Document the alarming condition, actions taken and persons notified.

AGA Gas Controller R&Rs

- Gas Controller is responsible for promptly responding to alarms, investigating the cause(s) of alarms, taking the appropriate actions and monitoring the situation to resolution, documenting the action taken, analysis performed and communicating any issues with alarms.
- In addition, the Gas Controller is responsible for initiating the needed investigation when an alarm is received. This may include:
  - Checking the log books for ongoing field work,
  - Reviewing historical trends,
  - Calling upstream supplier for assistance,
  - Changing the operational set points and opening or closing valves,
  - Reviewing other portions of the system that are monitored and in close proximity to the location of the alarm for additional information,
  - Contacting the appropriate personnel to verify the source of the problem.

AGA Operator R&Rs

- Each operator should develop a consistent documentation process to record and review the implementation of alarm management processes and procedures.
  - The documentation can be automated, electronic and/or in a written logbook.
- Each operator is responsible for documenting alarms as follows:
  - Document type of alarm and the alarm location;
  - Document, when applicable, the personnel contacted regarding alarm action;
  - Document the action taken by Gas Controller and/or contacted personnel;
  - Document the time that normal operations resumed;
- Each operator should indicate when a Gas Controller should follow up with a resolved alarm.

AGA Commissioning

- Operators should establish communication with Control Room personnel when planning and implementing changes to pipeline equipment or system operation.
- Operators should conduct a point-to point verification between SCADA displays and monitored equipment when changes affect pipeline safety, as defined in the alarm management plan, are made.
- Prior to commissioning, Gas Controllers should be trained sufficiently to obtain a working knowledge of their responsibilities for operation of the new or modified equipment.

AGA MOC

- The objective of management of change is to ensure alarm system changes are communicated, integrated, coordinated, approved and scheduled in an efficient and effective manner.

We all know that unmanaged change can lead to accidents.

AGA MOC

- Change Management in the Control Room
  - The alarm management plan developed by the operator should specify the actions the operator and the Gas Controller must take when alarm system changes are made.
  - These procedures can include:
    - Establishing alarm parameters that are specific to the operations and system composition under the Gas Controller's discretion,
    - Validating alarm parameters for new or modified equipment,
    - Designating the qualified personnel that have the decision-making authority to change the alarm parameters,
    - Train the appropriate personnel that have the decision making authority to ensure they are properly qualified,
    - Documenting any changes to alarm parameters and the reason the changes were made.

AGA MOC

- Change Management with the Field
  - When changes are planned for pipeline operations that can affect alarm limits and the operator's alarm management program, Gas Controllers or their designated representative should be consulted.
- These changes may include:
  - Increasing or decreasing pressure in a system,
  - Operating valves,
  - Installing a new facility,
  - Retiring a facility,
  - Major facility re-build,
  - Maintenance activities that could disrupt or inhibit flow through the pipeline or data received or sent via the SCADA system.

AGA MOC

- Communication related to MOC should include:
  - Reason for required change,
  - Internal/external contact information,
  - Impacted equipment and or pipeline,
  - Impacted customers,
  - Temporary operations or operating procedures to accommodate the planned change,
  - Current status updates,
  - Anticipated return to normal operations,
  - Required follow-up actions.

AGA Documentation

- The alarms received and the manner in which they are addressed should be documented.
- This documentation can be captured through SCADA alarm logs, SCADA event logs or written logs by the Gas Controller.
- Each Control Room must have a written alarm management plan.
- In addition to the alarm log, the event log or written logs, documentation should include:
  - Reports on SCADA points that have been taken off scan or changed,
  - Reports for alarm activity values,
  - Actions taken to resolve identified alarm deficiencies,
  - When appropriate notifications have been made,
  - When necessary, the appropriate regulatory agencies that have been notified,
  - Changes to alarm set points;
  - Verification of alarm parameters for new or modified equipment,
  - Volume of activity being directed to Controllers.

EEMUA

Comparison to EEMUA

- As we noted before, most industrial groups acknowledge the "EEMUA Guide" as a key source of best practices and design information for alarm systems.
  - EEMUA is the Engineering Equipment and Material Users Association.
  - The Guide is Publication 191 or "Alarm Systems - A Guide to Design, Management and Procurement".
  - First printing was funded by the ASM Consortium.
- Key strengths
  - Performance metrics,
  - Overall look from alarm system specification to management of a running system.

MUSTANG

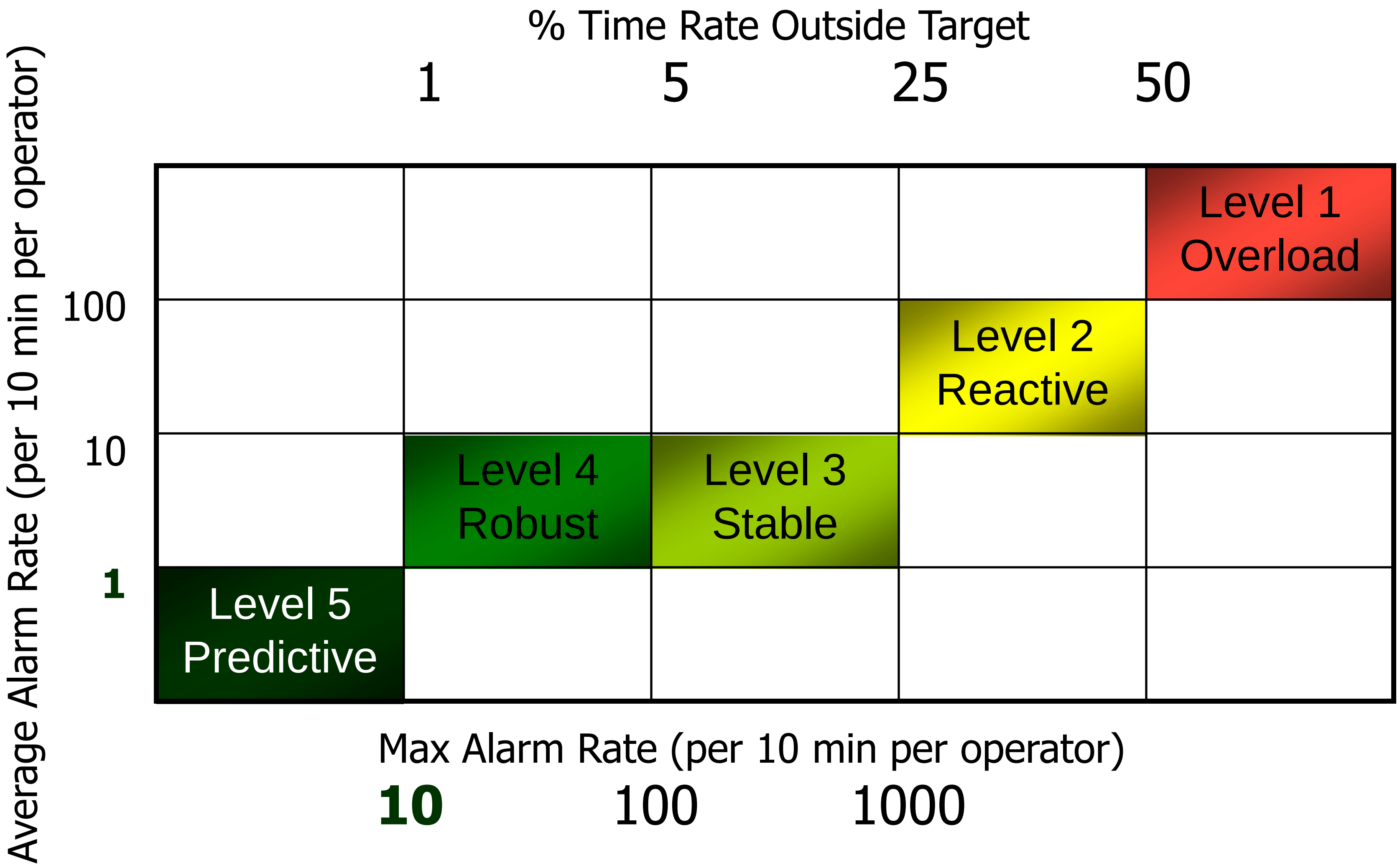
EEMUA Guide[3]

- Four core principles of the guide are:
  - Alarm system should be designed to meet user needs.
  - The alarm system purpose is to protect the safety of people, the environment and the plant equipment.
  - The performance of the alarm system should be assessed.
  - Every alarm is justified and properly engineered.

- EEMUA System metrics:
  - 3 alarms/control valve
  - 1 alarm/analog measurement
  - 0.4 alarms/digital measurement
  - 10% high - 20% medium - 70 % low priority alarm distribution

- EEMUA Usability metrics:
  - average alarm rate <1 per 10 min
  - <10 alarms in 10 minutes after upset
  - <10 standing alarms
  - <30 disabled or inhibited alarms
  - usefulness questionnaire

World-class Performance[3]



EEMUA Level Definitions

- Level 5: Predictive
  - May be cost prohibitive and not justifiable
  - Commonly has adaptive alarm schemes with state detection logic
- Level 4: Robust
  - Average and peak alarm rates at target
  - Dynamic/advanced alarm techniques likely to be extensive
- Level 3: Stable
  - Average alarms rate OK, likely has continuous improvement program
  - Likely has had some rationalization
  - Peak rate not controlled, so a bit of a hindrance during upsets
- Level 2: Reactive
  - Somewhat useful during normal operations
  - Still of essentially no use during upsets
- Level 1: Overloaded
  - Continuously high rate of alarms with high operator stress
  - Deteriorates rapidly during upsets

ISA 18.2[4]

ISA18.2 Scope Overview

- This standard addresses alarm systems for facilities in the process industries.
- Implementation of this standard should consider alarms from all systems presented to the operator, including:
  - basic process control systems,
  - local panels,
  - safety instrumented systems,
  - other emergency response systems.
- The practices in this standard are applicable to continuous, batch, and discrete processes.
- Standard approved by ISA and ANSI in June 2009.
- Key strengths:
  - Extensive definitions, which were built up from a review of existing guidelines and standards from around the world.
  - Strong life-cycle basis, with good consideration of all modes of alarm system operation, from design to operation and maintenance, etc.
  - Strong performance metrics,
  - Good models for understanding alarms and process conditions.

ISA18.2 Definitions

- Absolute alarm
- Acknowledge
- Activate
- Adjustable alarm (Operator-set alarm)
- Advanced alarming
- Alarm
- Alarm attributes (Alarm parameters)
- Alarm class
- Alarm deadband (Alarm hysteresis)
- Alarm flood (Alarm shower)
- Alarm group
- Alarm historian
- Alarm log
- Alarm management
  (Alarm system management)
- Alarm message
- Alarm off-delay (Debounce)
- Alarm on-delay
- Alarm overview indicator
- Alarm philosophy
- Alarm priority
- Alarm setpoint
  (Alarm limit, Alarm trip point)
- Alarm summary
- Alarm system
- Alarm system requirements specification
- Alarm type (Alarm condition)
- Alert
- Allowable response time
- Annunciator
- Bad measurement alarm
- Bit-pattern alarm
- Calculated alarm
- Call-out alarm
- Chattering alarm
- Classification
- Clear
- Clear
- Console
- Control system
- Decommission
- Deviation alarm
- Discrepancy alarm (Mismatch alarm)
- Dynamic alarming
- Enforcement
- First-out alarm (First-up alarm)
- Highly managed alarm
- Implementation
- Instrument diagnostic alarm
- Interim alarm
- Latching alarm
- Manual safety function alarm
  (Safety related alarm)
- Master alarm database
- Nuisance alarm
- Operator (Controller)
- Out-of-service
- Plant state (Plant mode)
- Prioritization
- Rate-of-change alarm
- Rationalization
- Recipe-driven alarm
- Remote alarm
- Reset
- Return to normal
- Re-alarming alarm (Re-triggering alarm)
- Safety alarm
- Safety function alarm
- Shelve
- Silence
- Stale alarm
- Standing alarm
- State-based alarm (Mode-based alarms)
- Station
- Statistical alarm
- Suppress
- Suppressed by Design
- System diagnostic alarm
- Tag (Point)
- Unacknowledged

ISA18.2 Key Definitions

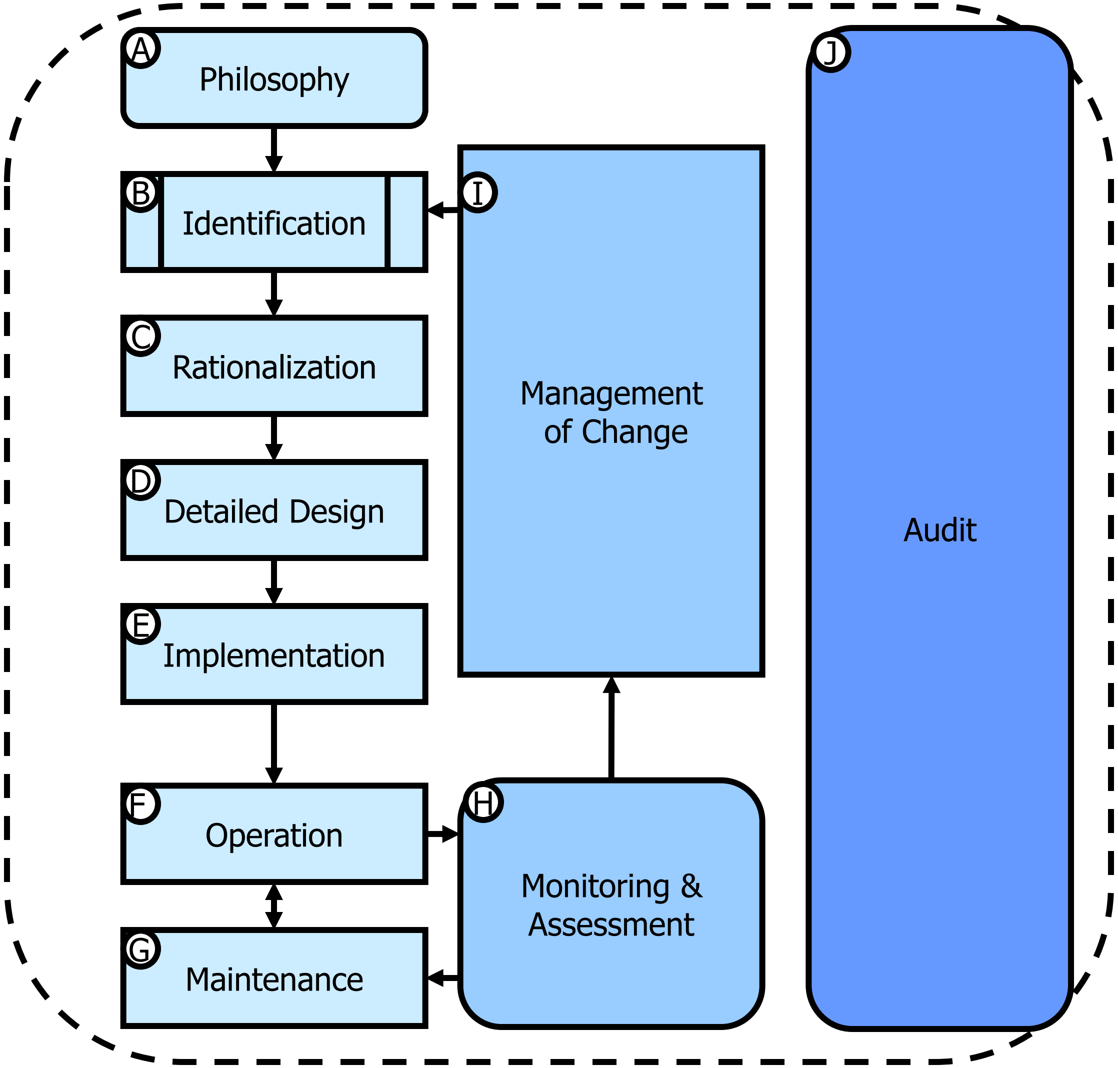
- **ISA Alarm -** An audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a response.
- **AGA Alarm -** An audible or visible means of indicating to the Gas Controller that an equipment or process is outside operator defined safety-related parameters.

- **ISA Alert-** An audible and/or visible means of indicating to the operator an equipment or process condition that requires awareness, that is indicated separately from alarm indications, and which does not meet the criteria for an alarm.
- **AGA Alert -** A notification or event that does not require immediate action. Alerts are always of lower priority than alarms and should never be safety-related.

Consistent, main difference AGA scope of safety.

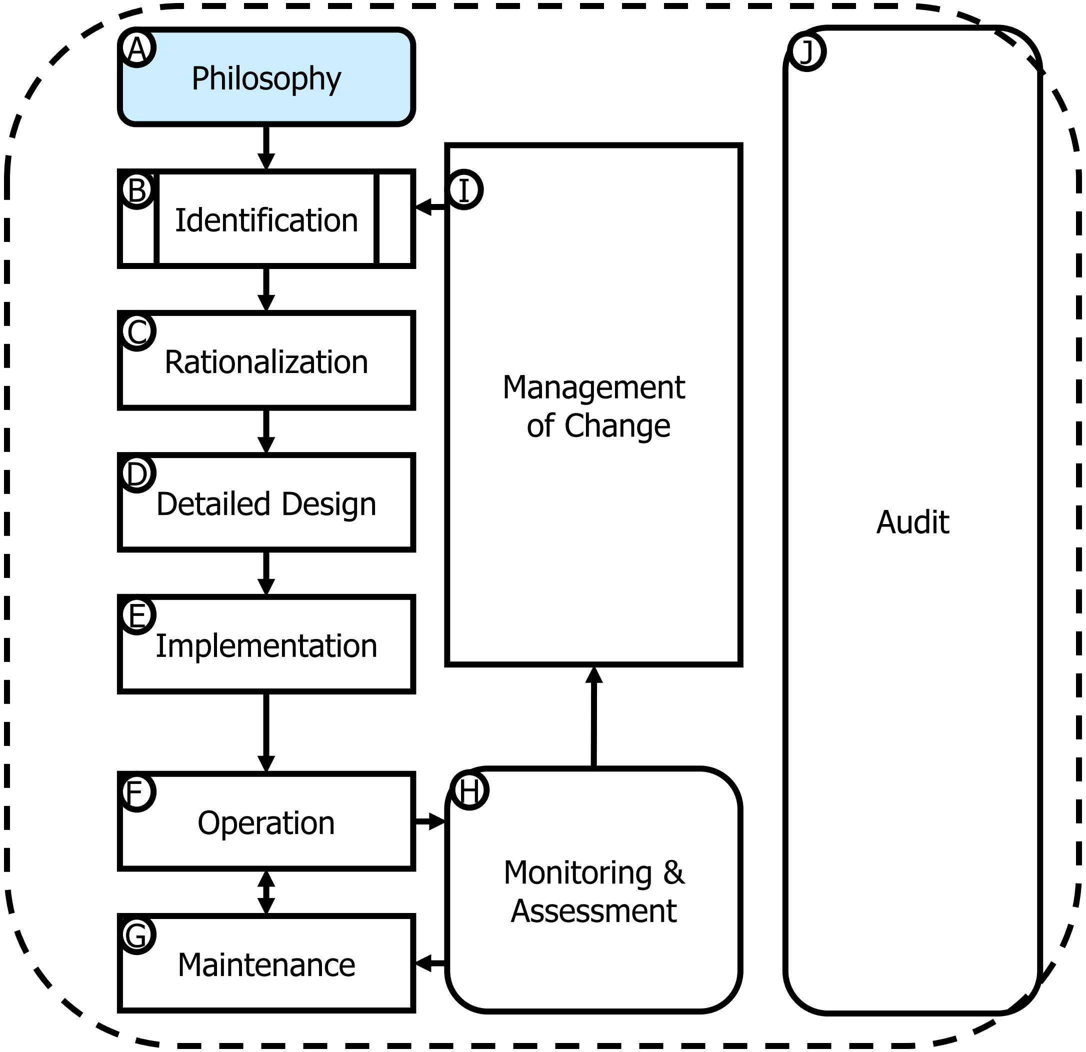
ISA18.2 Lifecycle

- Letter IDs
- Rounded rectangles are entry points (A, H, J)
- Identification is outside the scope of the standard (B)
- 2nd and 3rd columns are simultaneous



A – Alarm Philosophy

- The alarm philosophy documents the objectives of the alarm system and the processes to meet those objectives.
- Includes all the key definitions and principles for the alarm system.
- Includes the HMI alarm details, consistent with the overall HMI design.
  - ISA101 is underway to write a HMI standard.



What is the Philosophy?

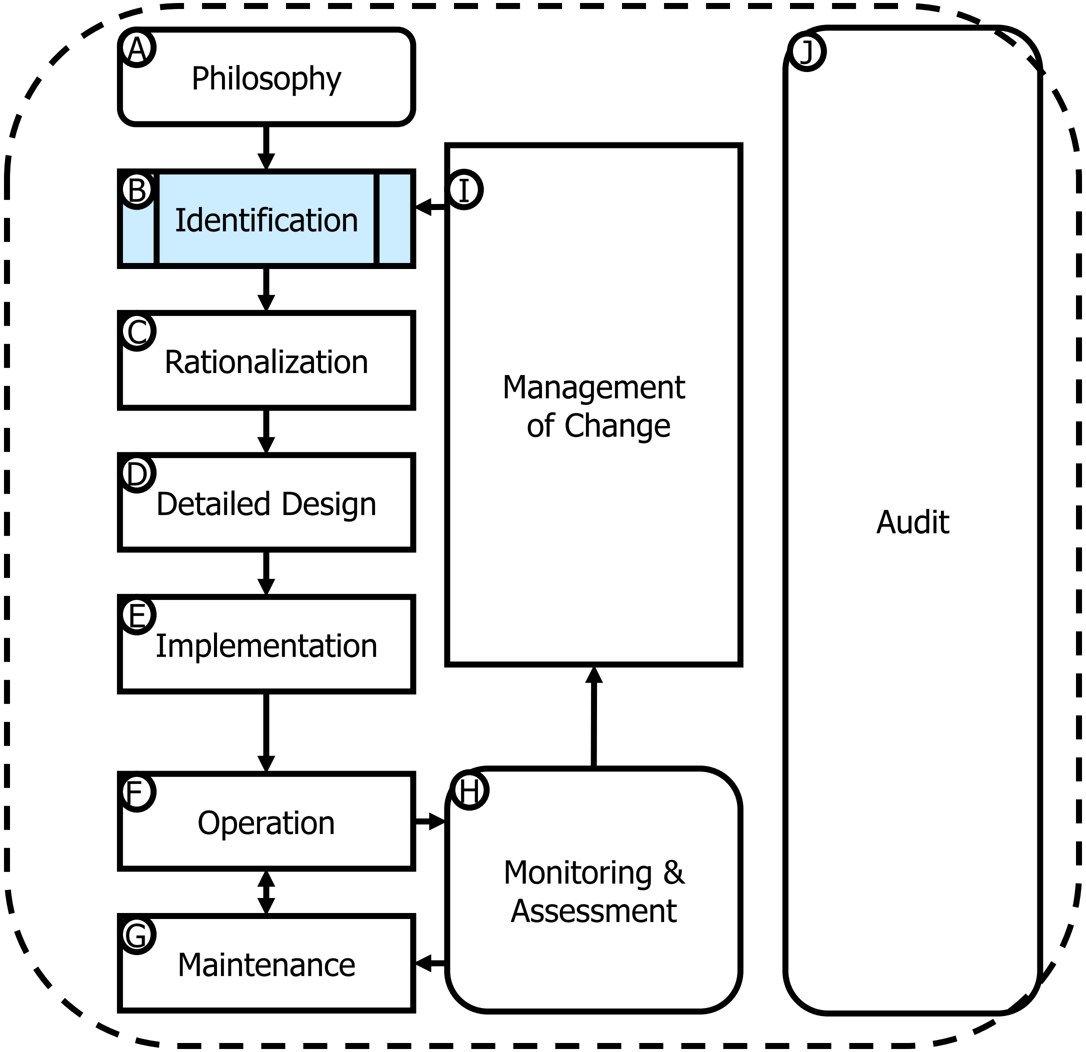
- Basically, the alarm philosophy is a single document that pulls together all of the reasoning and details related to the alarm system.
- It is part specification, part guideline, part documentation.
- If it is not collected, then the true design basis and implementation structure often gets lost.
- **If the alarm system is important, then the document needs to be generated.**

ISA Alarm Philosophy

- Required Elements:
  - Definitions
  - Design principles
  - History preservation
  - HMI design
  - Implementation guidance
  - MOC
  - Prioritization method
  - Purpose
  - Rationalization
  - Roles and responsibilities
  - System maintenance
  - System performance monitoring
  - Testing of alarms
  - Training
- Recommended Elements:
  - Advanced alarm techniques, Alarm documentation, Alarm SP determination, Highly Managed Alarms, References, Related site procedures, Special design considerations

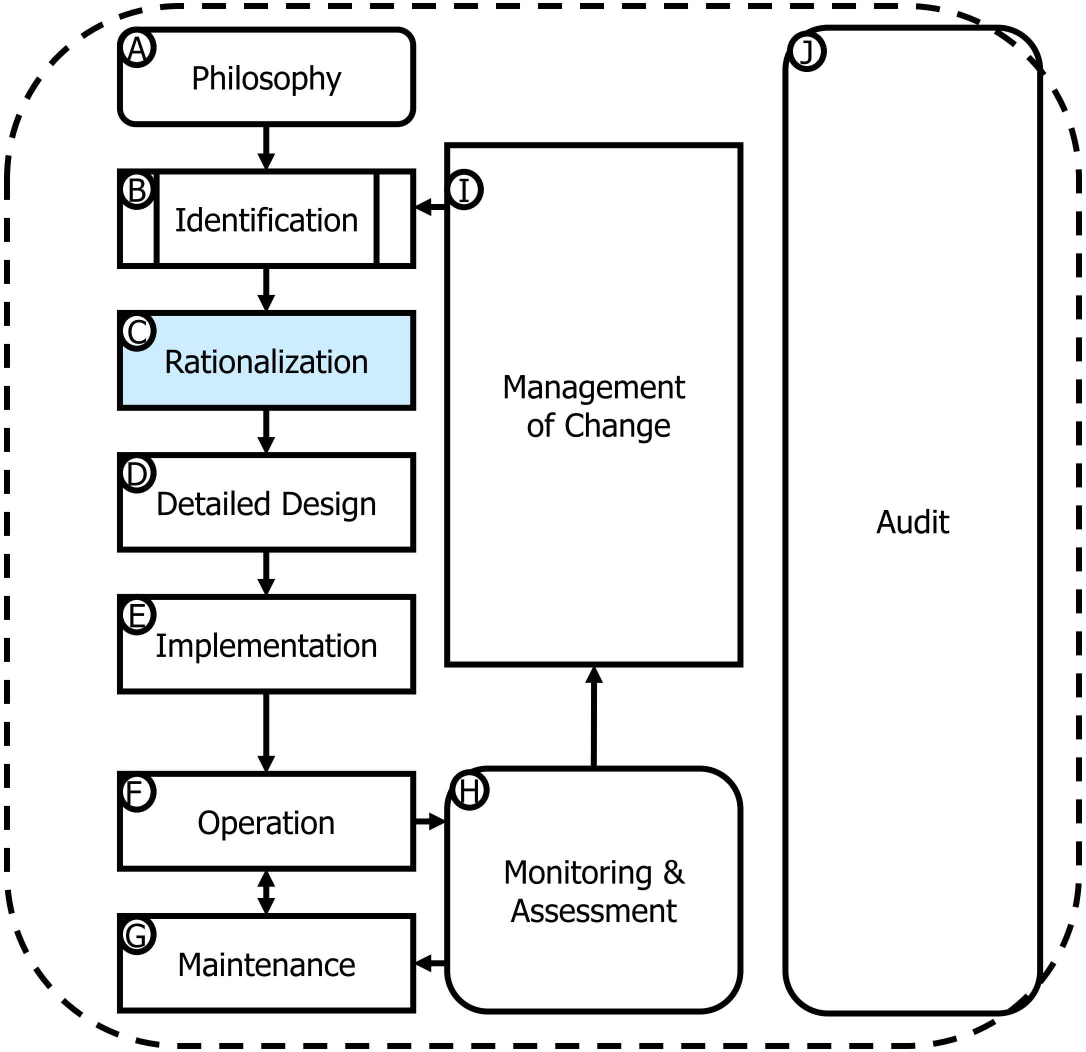
B – Alarm Identification

- The identification stage is outside the scope of the standard.
- There are varied methods for generating potential alarms, including:
  - Process Hazard Analysis,
  - Safety Requirements Specification,
  - Incident investigations,
  - Other regulations,
  - Process tests or trials.
- Commonly alarm changes will be identified from the routine monitoring of alarm system performance.



C – Rationalization

- Rationalization reconciles the identified need for an alarm or alarm change with the principles in the alarm philosophy.
- The product of rationalization is clear **documentation** of the alarm and its **prioritization**.
- Rationalization also includes the activity of classification during which an alarm is assigned to one or more classes to designate requirements (e.g., design, testing, training, or reporting requirements).



Alarm Rationalization Process

- Alarm rationalization is basically the alarm design process.
  - The alarm philosophy spells out the guidelines for the alarm requirements.
  - The rationalization work process defines and justifies or "rationalizes" the alarm existence and priority.
  - Rationalization is generally executed in meetings, similar to a PHA study.
- Document at a minimum of the following:
  - verification that proposed alarm meets the criteria for an alarm,
  - the response action(s) the operator may take,
  - the consequence that will occur if action is not taken or is unsuccessful,
  - the time required between alarm annunciation and the consequence.
- Alarm rationalization should ensure that:
  - the alarm will not become a nuisance or standing alarm,
  - the alarm does not duplicate another alarm that has the same operator actions.

New Best Practices

- Collect and Collate Supporting Documentation BEFORE the meetings:
  - P&IDs or material flow sheets,
  - PHA/HAZOPs reports,
  - cause and effect diagrams,
  - Functional safety documents (SIF, SRS, LOPA verification, etc.),
  - safe operating limits,
  - operating graphics,
  - process and/or alarm history analysis for alarm limit validation,
  - operating procedures,
  - complex loop documentation .

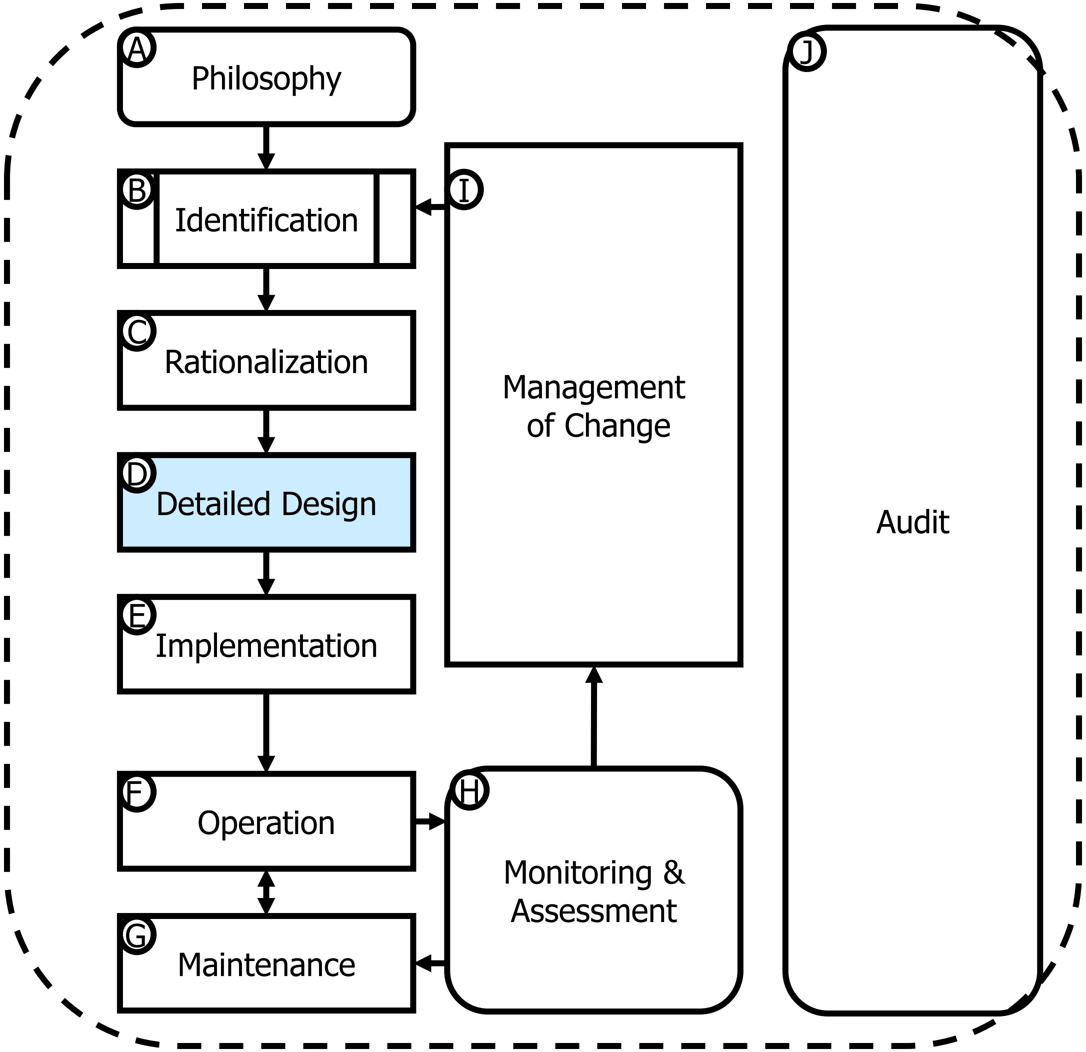
More on Meetings

- It is generally effective to step through the process from the flow of the P&ID drawings, rationalizing all instruments and controls in a given area together.
- It is effective to plan ahead to ensure that you have the correct team members and information ready.
- Define critical quorum and methods to get input from extended team members.
- Quickly common classes of alarms will emerge that can be rationalized in a common manner.
  - It is very effective to pre-document these types of alarms outside of the group meetings.

MUSTANG

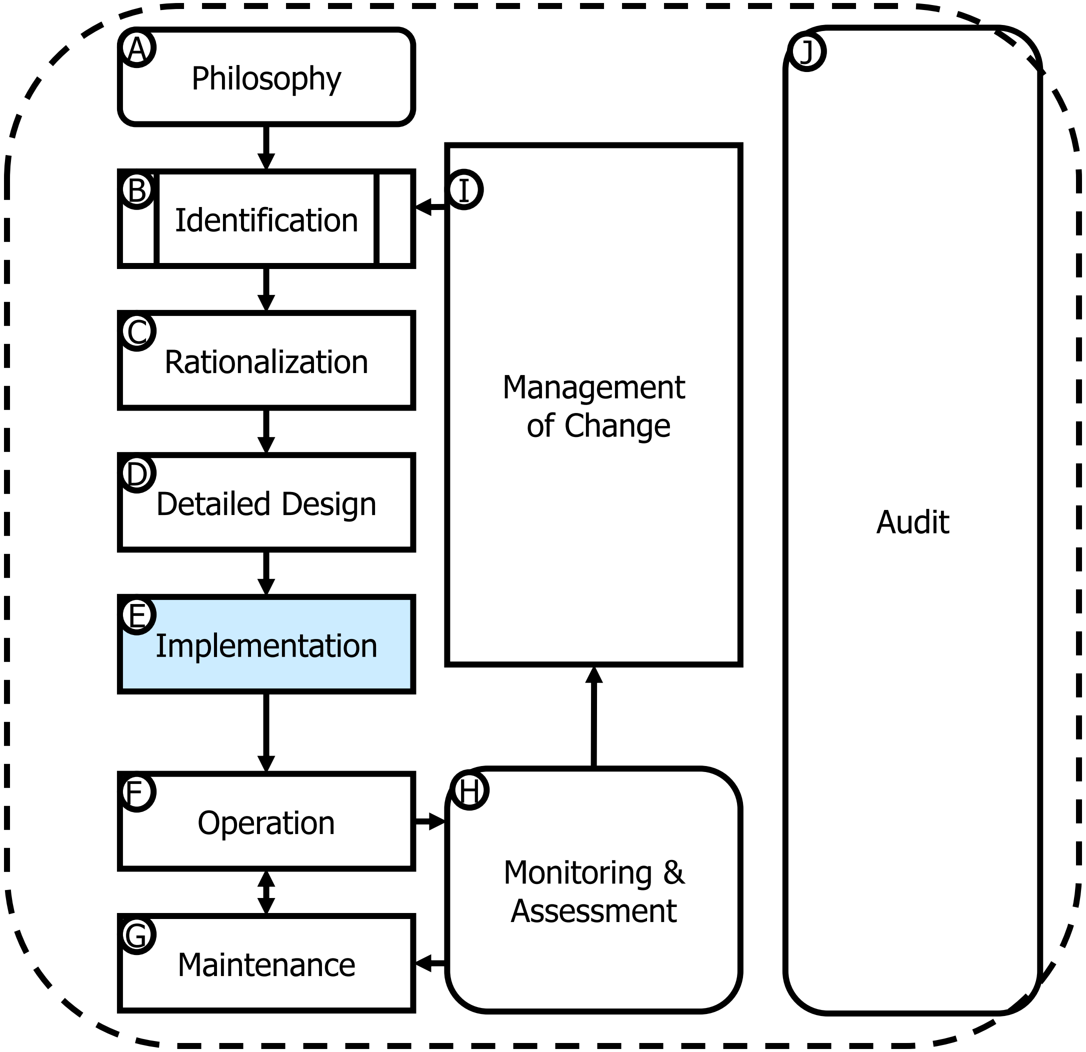
D –Detailed Design

- In the design stage, the alarm attributes are specified and designed based on the requirements determined by rationalization.
- There are three areas of design: basic alarm design, HMI design, and design of advanced alarming techniques.



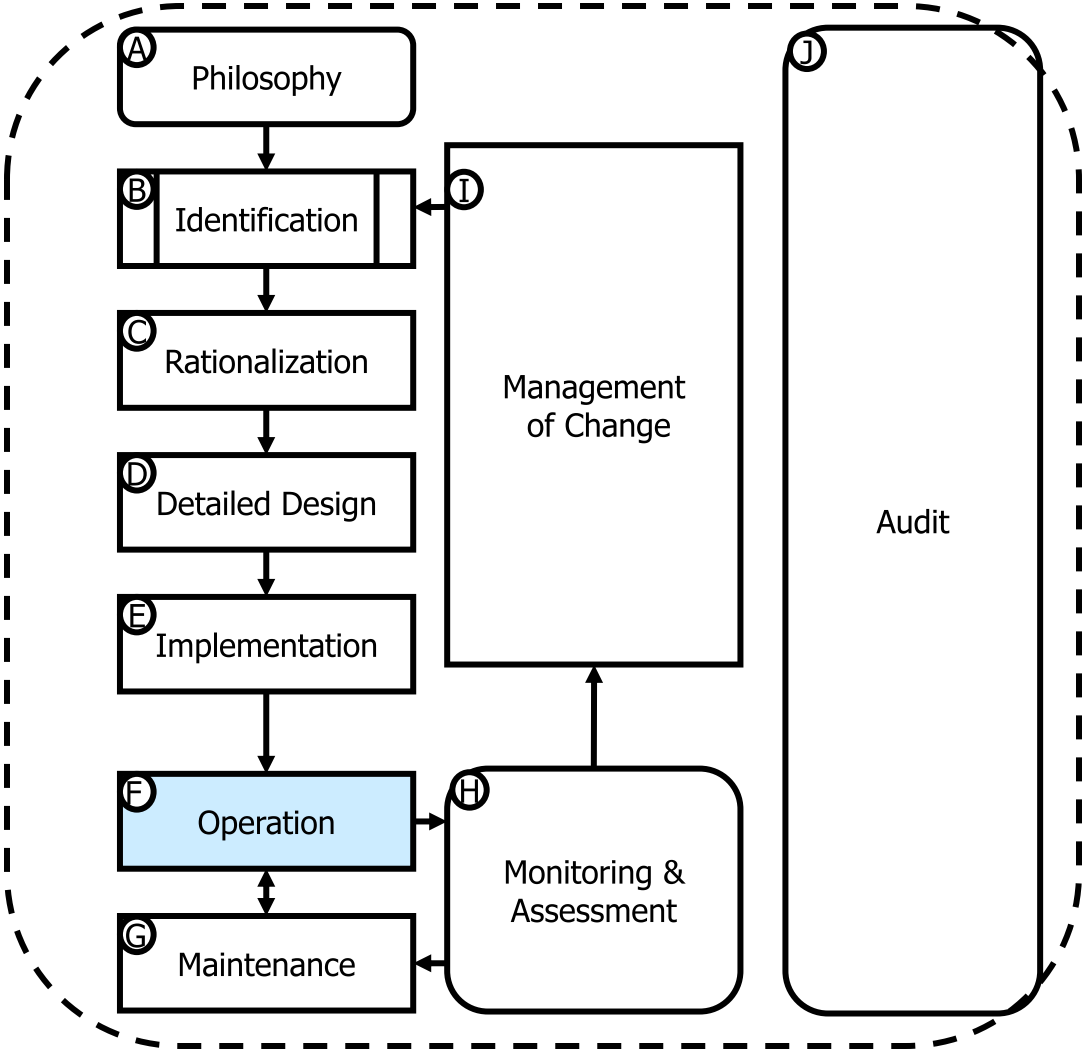
E –Implementation

- Implementation includes the installation and functional verification.
- Operator training is an important activity during implementation.
- Testing of new alarms is often a requirement.



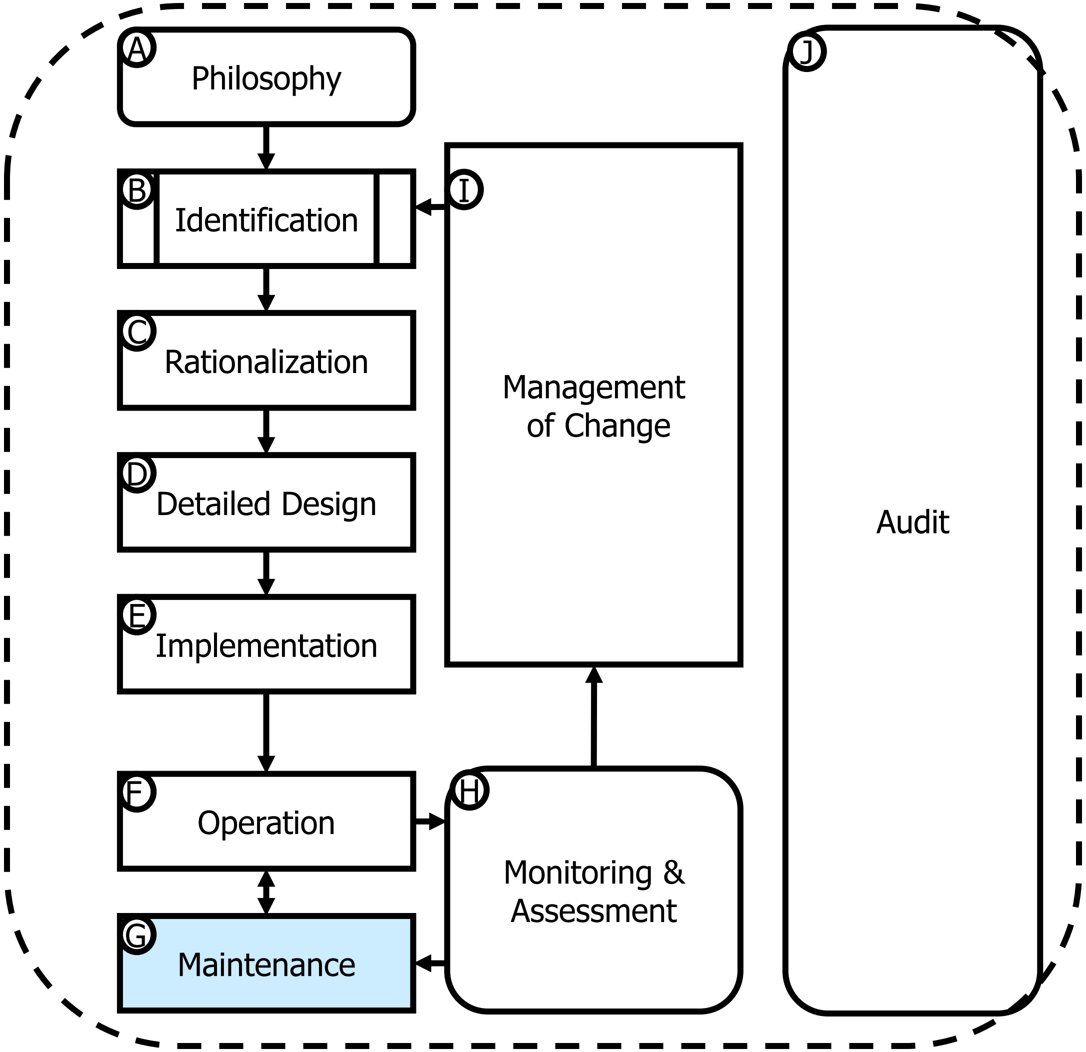
F – Operation

- In the operation stage, the alarm is active and it performs its intended function.
- Refresher training on both the alarm philosophy and the purpose of each alarm is included in this stage.



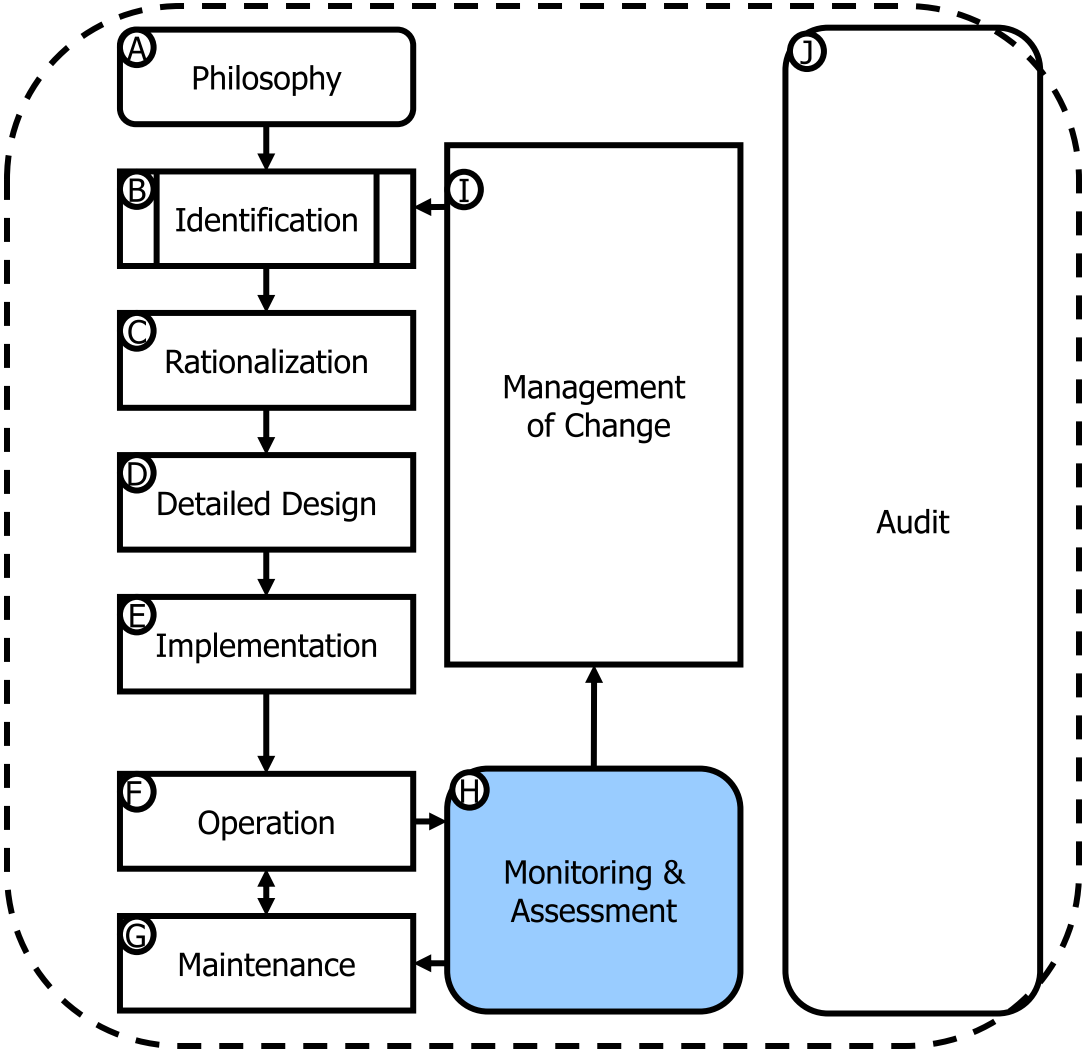
G – Maintenance

- In the maintenance stage, the alarm is not operational but is being tested or repaired.
- Periodic maintenance (e.g., testing of instruments) is necessary to ensure the alarm system functions as designed.



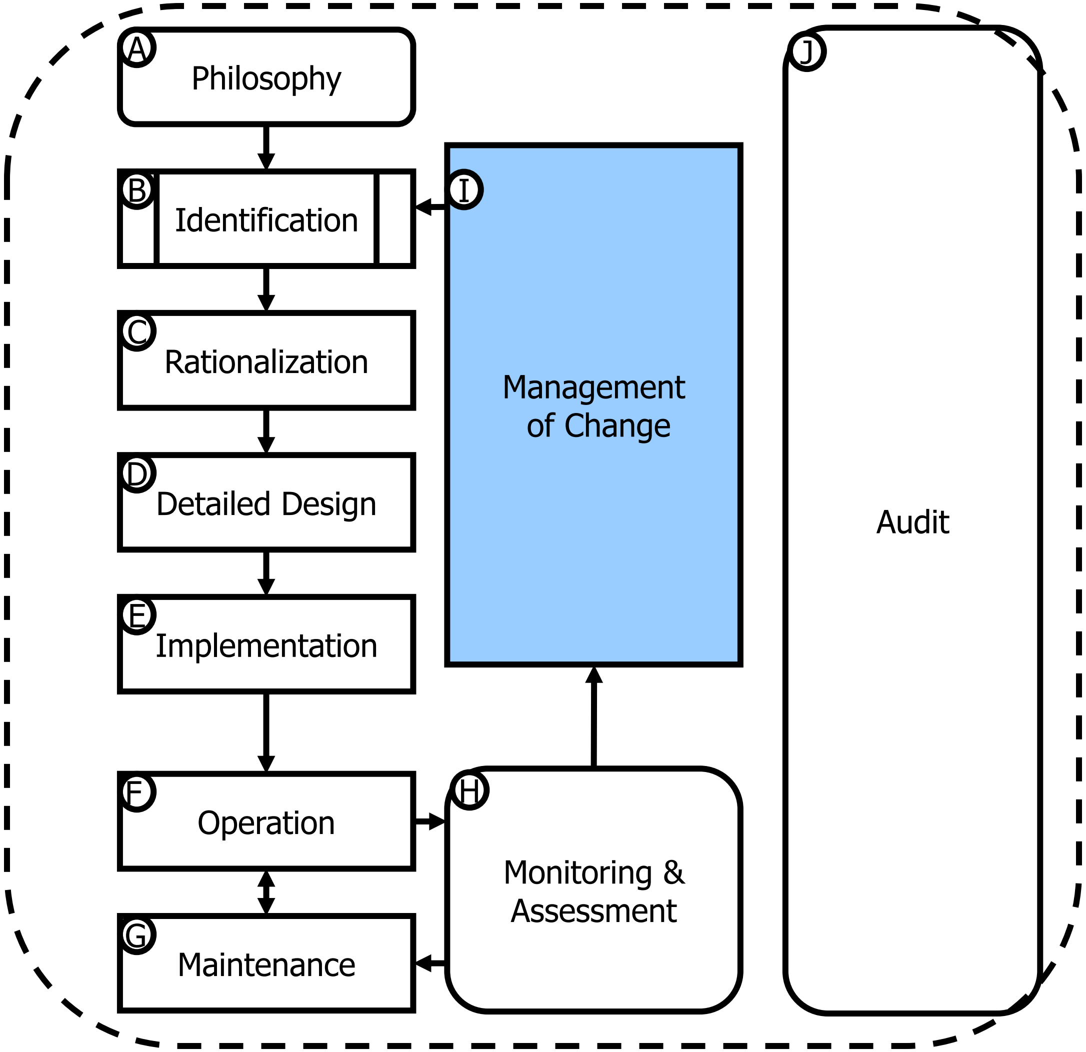
H – Monitoring and Assessment

- In the monitoring and assessment, the overall performance of the alarm system is continuously monitored against the performance goals stated in the alarm philosophy.
- This may trigger maintenance work or identify the need for changes to the alarm system or procedures.
- Without monitoring an alarm system is likely to degrade.



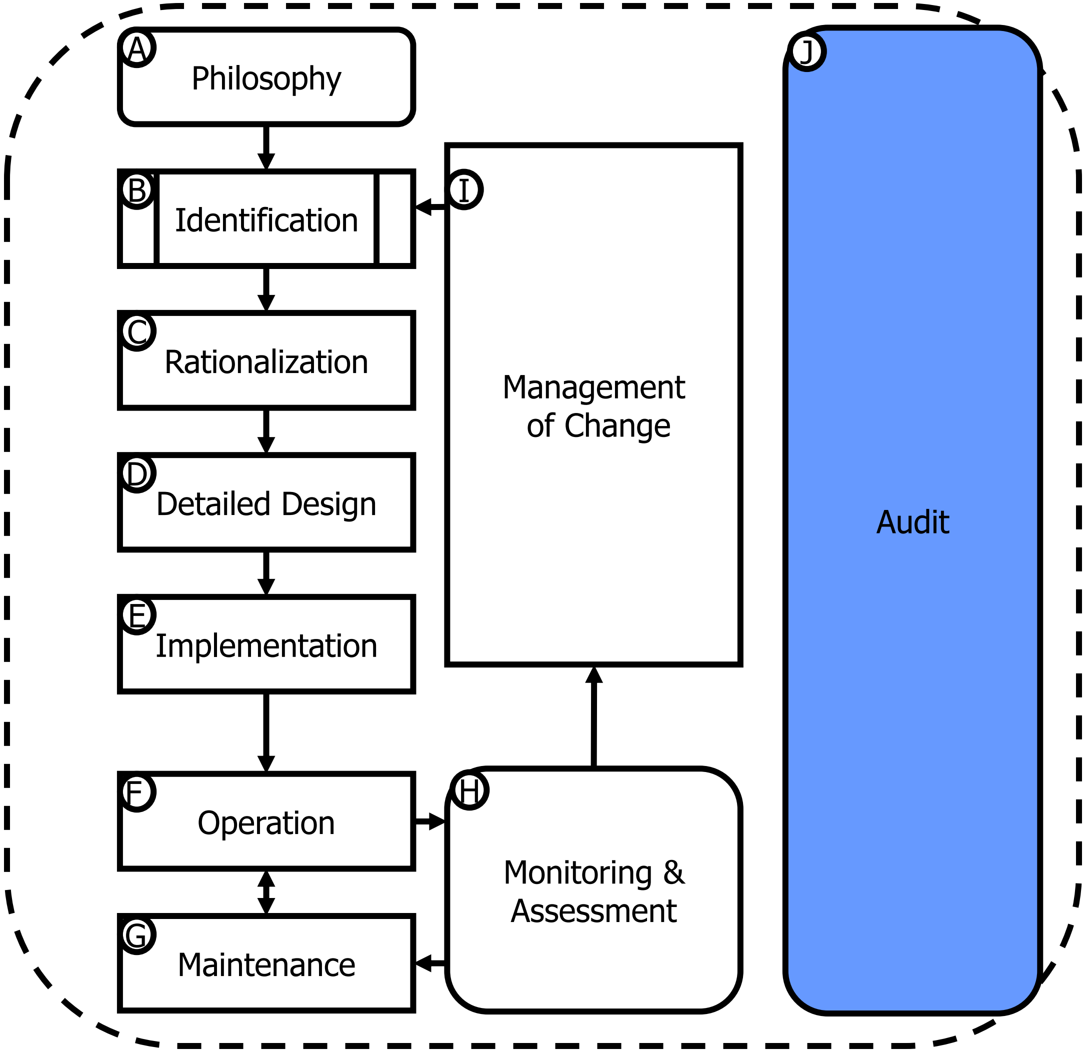
I – Management of Change

- In the management of change, modifications to the alarm system are proposed and approved.
- The change process should follow each of the lifecycle stages from identification to implementation.
- The philosophy will dictate the thresholds for MOC paperwork. It is likely important to modify MOC checklists to reflect the principles in the philosophy.



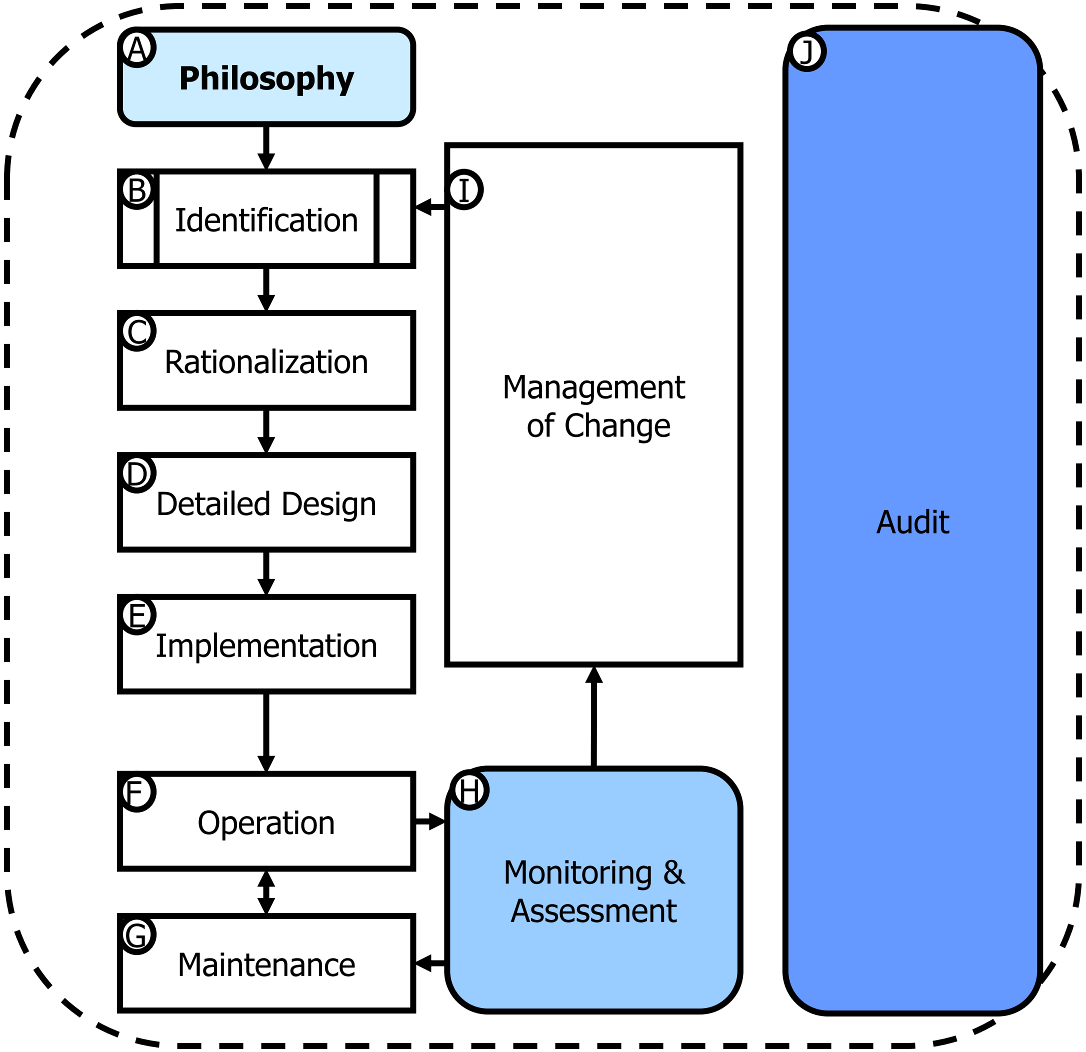
J – Audit

- In the audit, reviews are conducted to maintain the integrity of the alarm system.
- Execution against the alarm philosophy is audited to identify system improvements, including modifications to the philosophy.



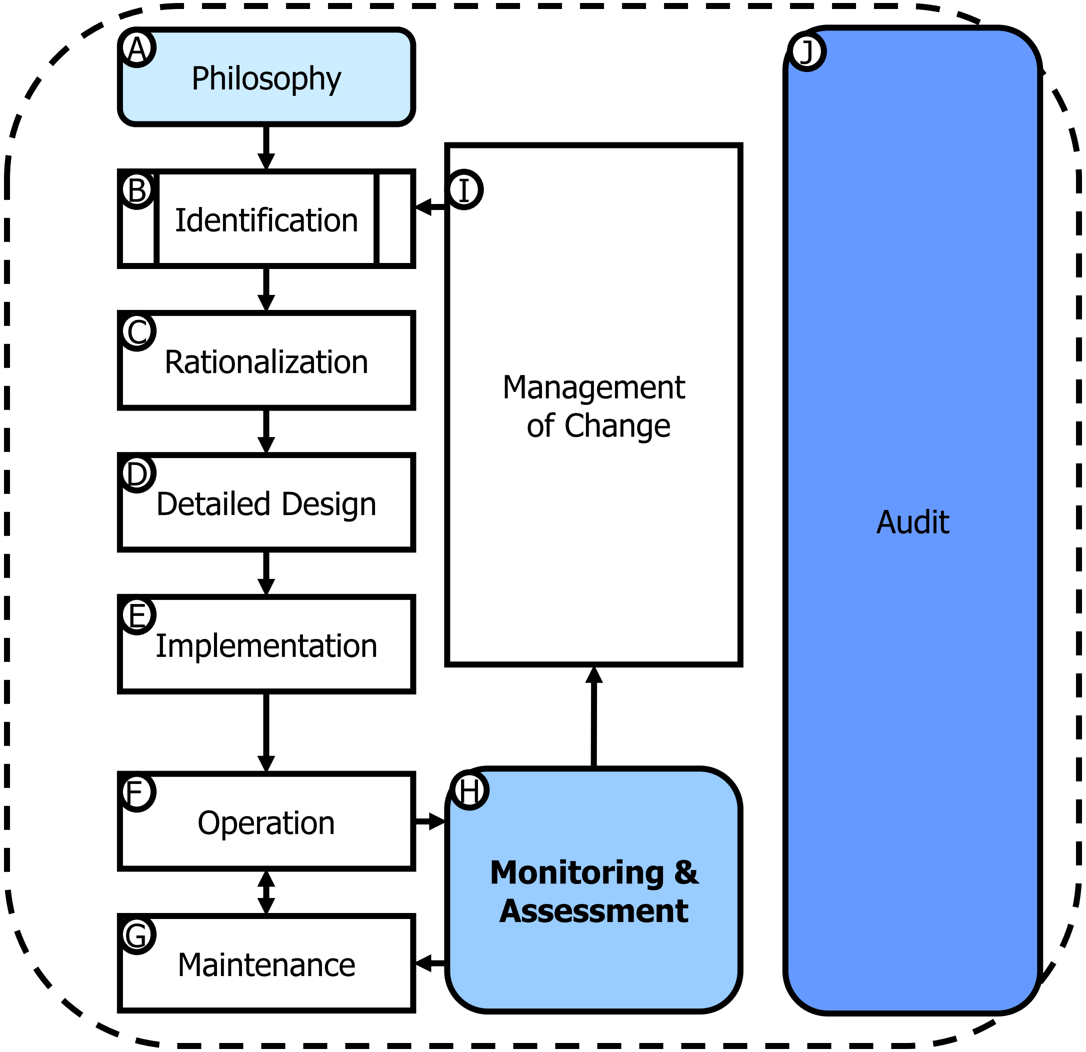
Alarm Lifecycle Entry Points

- **Alarm Philosophy (A)**
  - This is the lifecycle entry point for new installations.
  - Commonly the basis of the alarm system requirements specification is set as part of developing the philosophy.



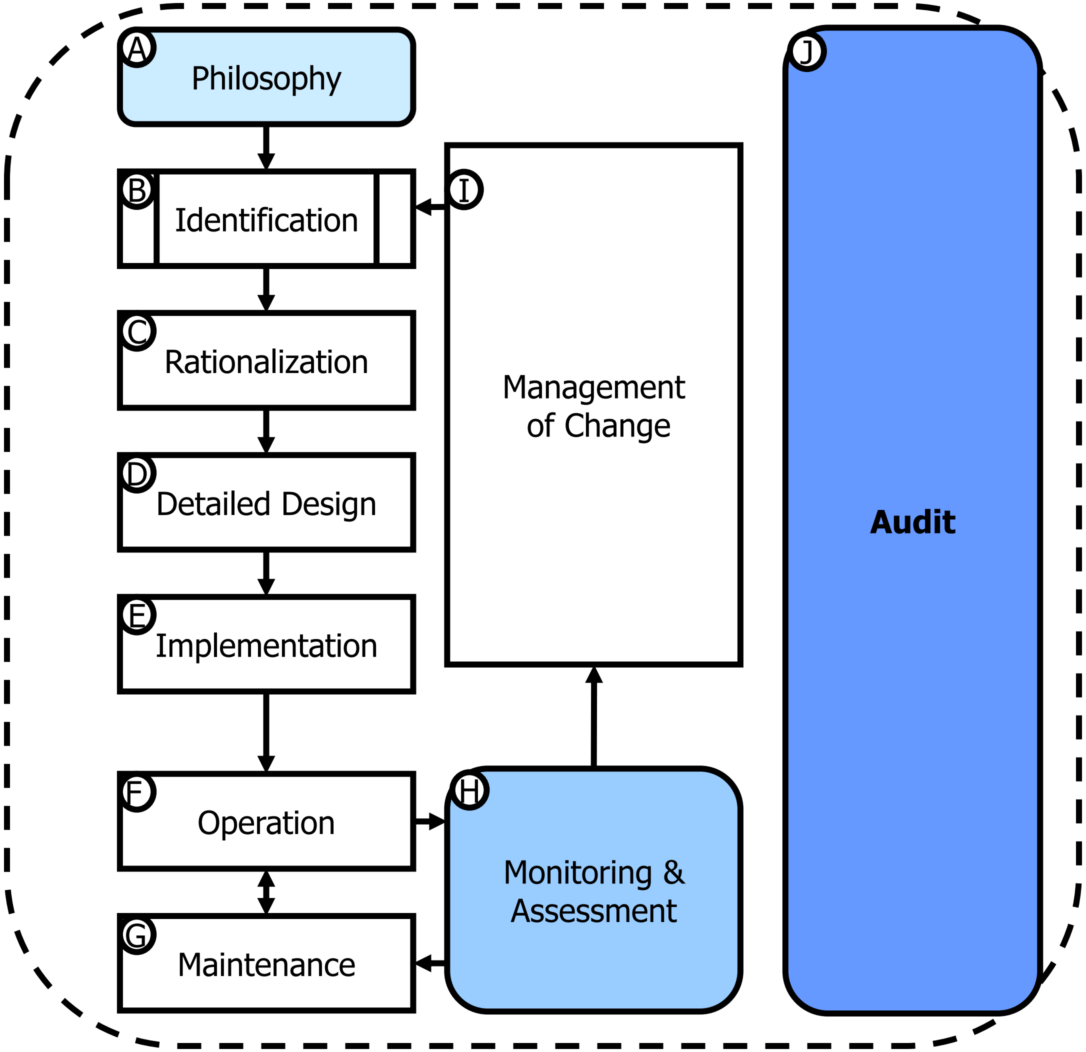
Alarm Lifecycle Entry Points

- **Monitoring and Assessment (H)**
  - This is a common approach for established systems, jump in and find ways to improve the system.
  - Problems can be identified and addressed through maintenance or management of change.



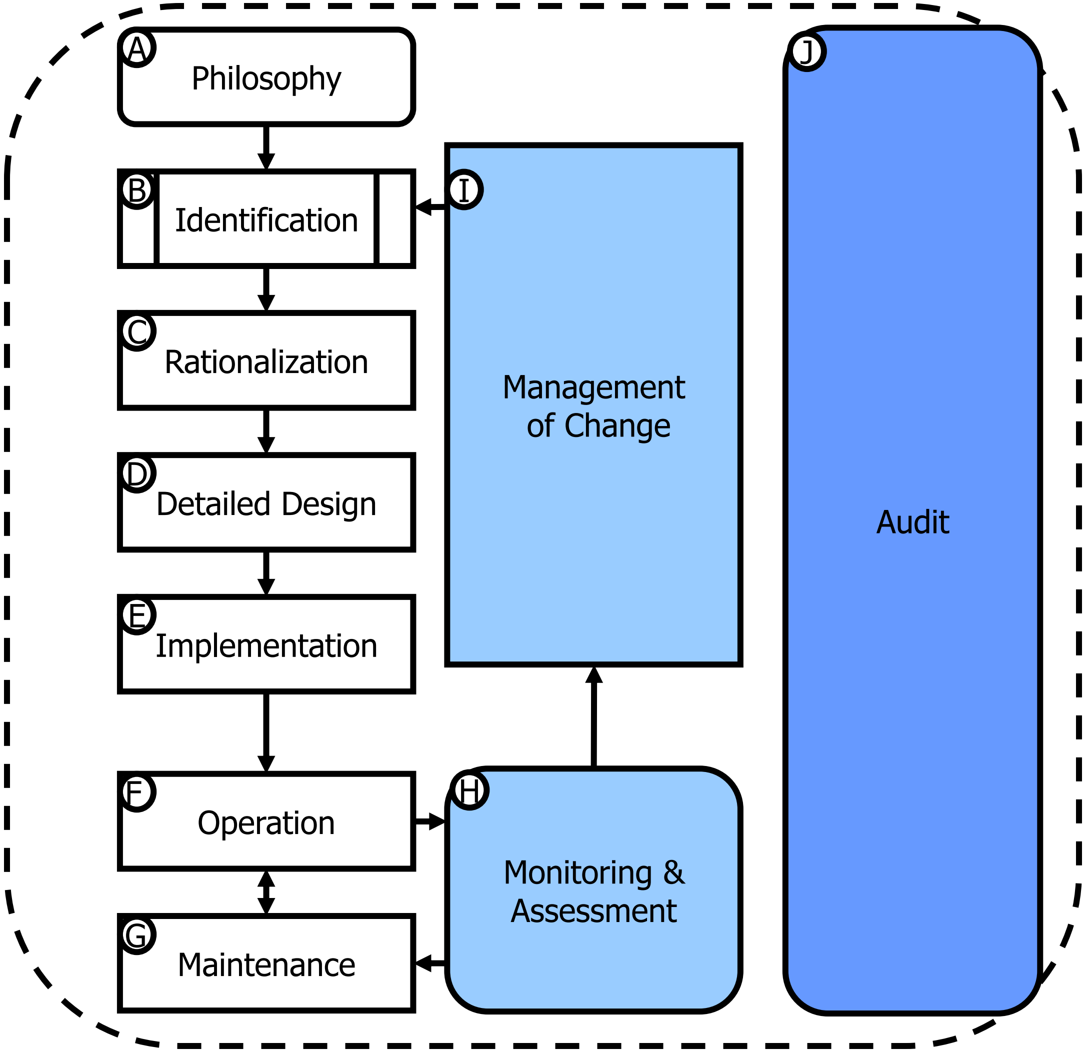
Alarm Lifecycle Entry Points

- **Audit (J)**
  - This last approach is with an initial audit, or benchmark, of all aspects of alarm management against a set of documented practices, such as those listed in this standard.



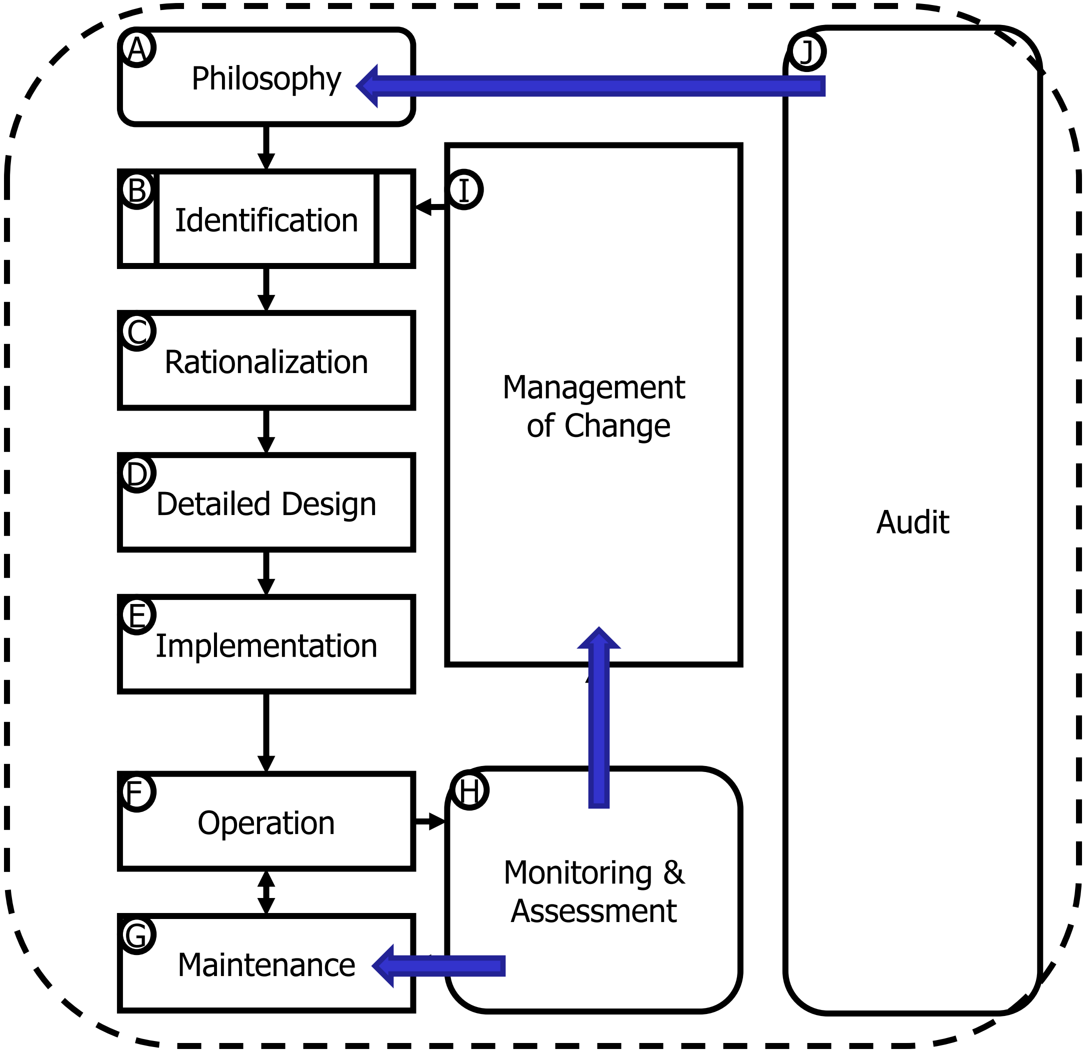
Simultaneous Stages

- The monitoring and assessment (H) is simultaneous to the operation and maintenance.
- MOC (I) represents the initiation of the change process through which all appropriate stages of the lifecycle are authorized and completed.
- Audit (J) can occur at any point in the lifecycle and includes a review of the activities of the other stages.



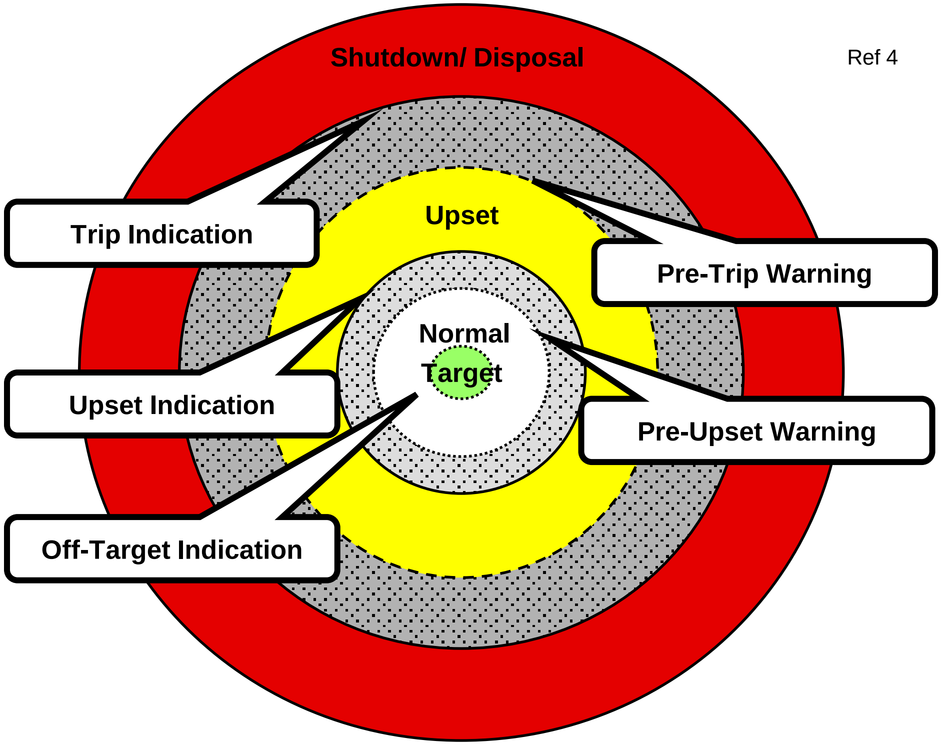
Lifecycle Loops

- The standard identifies 3 critical loops in the lifecycle:
  - Monitoring and Maintenance Loop
  - Monitoring and Management of Change Loop
  - Audit and Philosophy Loop



Process Condition Model

- Clause 5 of the standard includes several useful models of the alarm system, alarm states and the process condition model shown here.
- It is important to understand what type of alarm are you designing:
  - Off target?
  - Upset?
  - Pre-trip?
- Ensure that your team thinks about what the alarm intent is and ensures appropriate response time.
  - If you are not providing time to respond, what are you providing beyond stress on the operator?



Time to Respond?

- Varied studies have repeatedly shown that the less time that there is available to respond, the less likely the correct response will be found.[5]

Time Available, mins	Probability of Failure, %
1	~100%
10	50%
20	10%
30	1%
60	0.01%

Provide enough time to respond on all alarms.

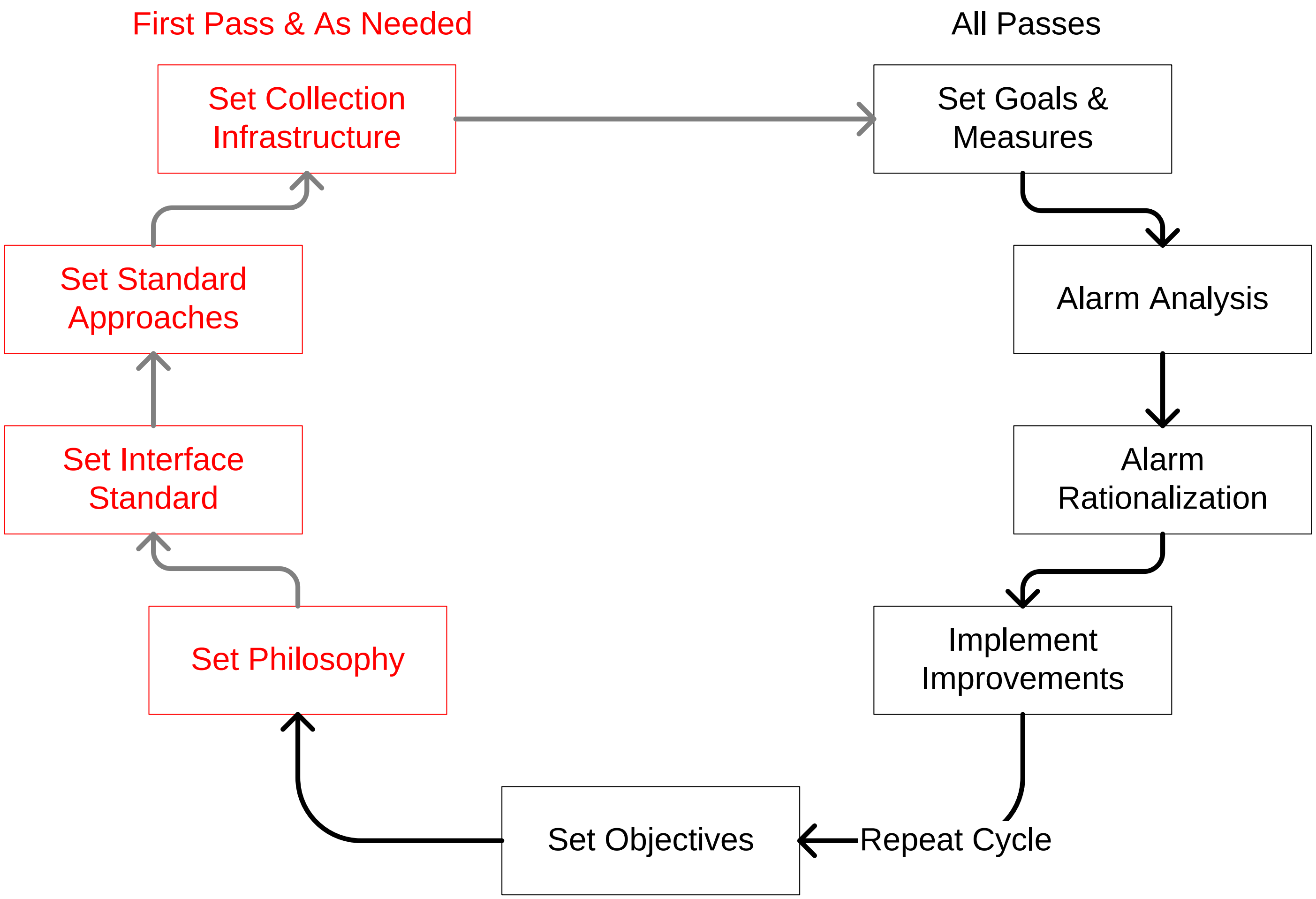
How to Get Started?

- Draft the Alarm Management Plan & Philosophy
  - Determine the desired end product before you start changing things
    - More likely to get to the end state in one major effort
- "Outside" Audit of Current Work Processes Against Expectations
- Perform Monitoring & Assessment of Current Performance Against Best Practices

Alarm Management Improvement

- Like any other improvement process, must have goals, metrics and management support.
- Key items to start with:
  1. Alarm Philosophy
     - Key tenets and work processes
  2. Alarm Interface Standard
     - Look and sounds for alarms
  3. Alarm Engineering Standards
     - Engineering methods for simple and advanced techniques
  4. Collection Infrastructure
     - Make sure alarm history is collecting and KPIs (metrics) auto-generating.
  5. Plans for Alarm Improvement Project or Program
     - Maintain or improve performance plans…

Mustang Alarm Management[1]



Key Considerations

- Alarm Changes (and other process changes),
- Critical Devices Off scan,
- Critical Devices with Manual Values,
- Gas Controller Work Load,
- Key Performance Metrics.

Other Advice for Getting Started

- Do not target Level 1 to Level 5 improvement in 1 month
  - Be reasonable with expectations
- Set a final end state target
  - Decide what level of EEMUA or other end state target is acceptable and a timeframe for getting there
- Define the principles and work practices in enough detail to ensure new employees can clearly understand expectations
- Keep it as simple as is practical
  - Too much complexity will make adhering to the Alarm System Management Plan harder to manage
- Include details on how compliance with the plan will be managed

ISA18 Current and Future

- ISA18.1 – WG to revise "Annunciator Sequences and Specifications"
  - Beth Vail, Beth.Vail@wsms.com
- WG1 – Alarm Philosophy
  - Lokesk Kalra, kalra@chevron.com
  - Nicholas Sands, nicholas.p.sands@usa.dupont.com
- WG2 – Alarm Identification and Rationalization
  - John Campbell, john.campbell@conocophillips.com
  - David Strobhar, dstrobhar@beville.com
- WG3 - Basic Alarm Design
  - Pat O'Donnell, patrick.o'donnell@bp.com
  - Todd Stauffer, tstauffer@exida.com
- WG4 – Enhanced and Advanced Alarm Methods
  - Doug Metzger, doug.metzger@cox.net
  - John Huhman, john.huhman@shell.com
- WG5 – Alarm Monitoring, Assessment, and Audit
  - Donald Dunn, donald.dunn@aramcoservices.com
  - Bill Hollifield, Bhollifield@pas.com
- WG6 - Alarm Design for Batch and Discrete Processes
  - Joseph Alford, jmalford5@earthlink.net
  - Bridget Fitzpatrick, bridget.fitzpatrick@mustangeng.com

Deliverables in Design for ACM

- Design for ACM Assessment Studies,
- Design for ACM Standards/Specifications,
- Alarm Philosophy Development,
- Alarm System Analysis,
- Alarm Rationalization Services,
- User Interface Navigation Development,
- User Interface Toolkit Development,
- Design for ACM Project Implementation,
- Design for ACM Training Services,
- Operator Training Program Development,
- Simulator Development Services.

References

1. Fitzpatrick, B. A. (2005). Section 4.11: Management of abnormal conditions. In B. Liptak (Ed.), *Instrument Engineers' Handbook: Process Control* (pp. 706-718). Stamford, CT: CRC Press.
2. AGA, *AGA: Alarm Management for Control Room Operations in the Natural Gas Industry* , November 2009.
3. Alarm Systems; A Guide to Design, Management and Procurement, Engineering Equipment and Materials Users Association (EEMUA) Publication No. 191; 2007.
4. ANSI/ISA, *ANSI/ISA–18.2–2009, Management of Alarm Systems for the Process Industries* , June 2009.
5. Swain, A. and Guttman, H., *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications (Final Report)*, Washington, DC: United States Nuclear Regulatory Commission, 1983.