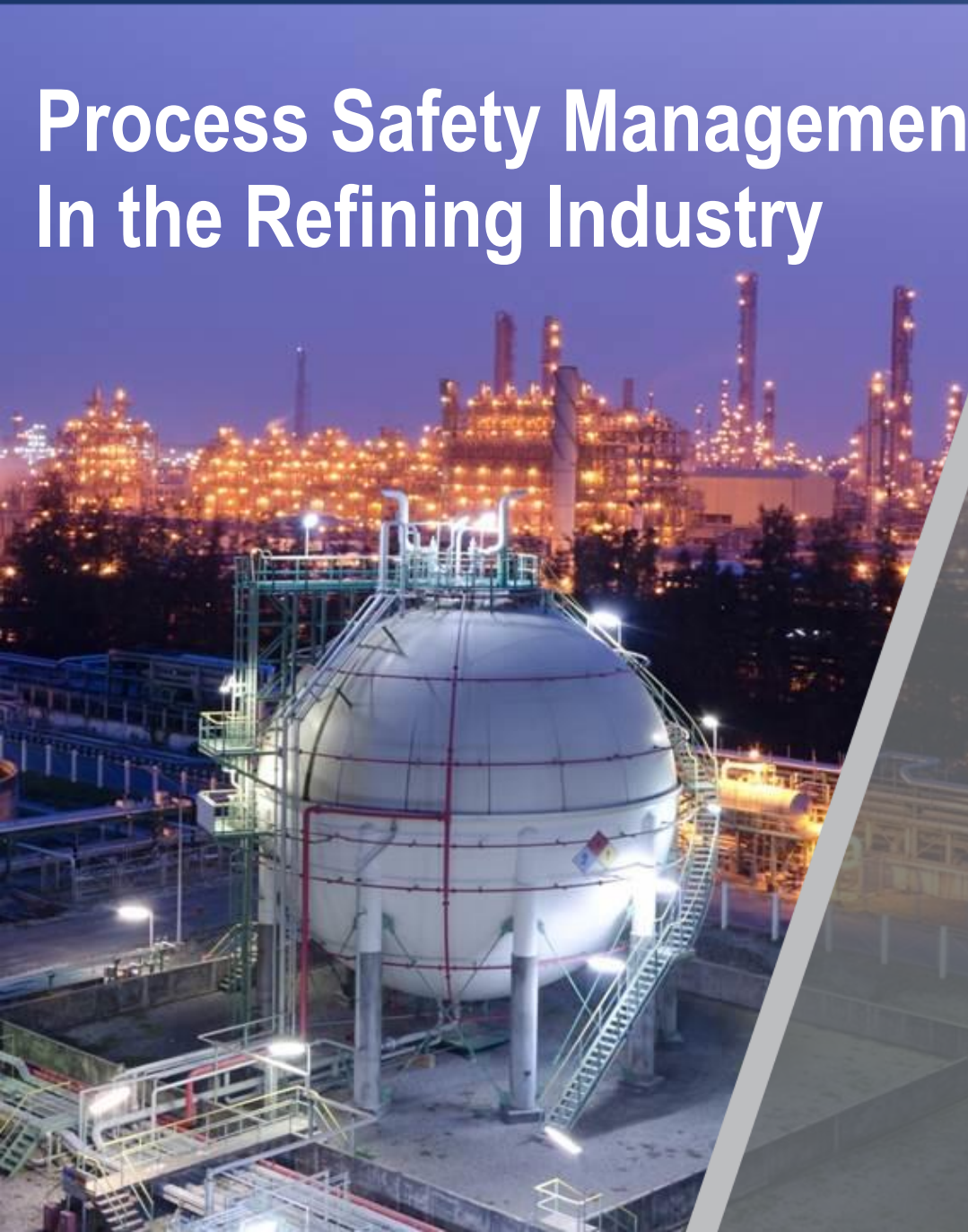
Process Safety Management In the Refining Industry



Presented by

Steve Arendt

VP-Global Oil, Gas & Chemicals

Houston, TX

sarendt@absconsulting.com

ABS Group

Washington State Refiners and Stakeholders Meeting

Wednesday January 6, 2016

Getting Started

- Safety Moment
- Introductions
- Agenda and logistics

Steve Arendt, P.E.

Vice President, ABS Group, Global Oil, Gas, and Chemicals

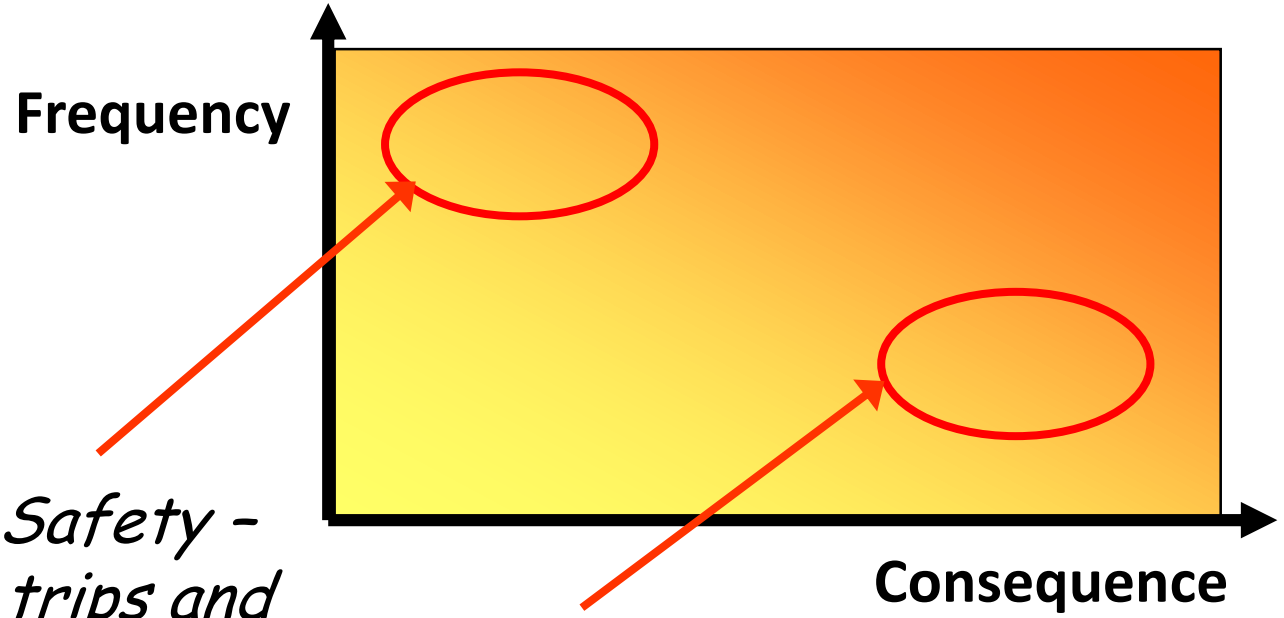
- 35+ years in process safety and risk assessment
- Visited 40+ offshore assets and 200+ onshore facilities
- Conducted 100s of PSM system design/implementations, audits, HAZID/HAZOP/LOPA/QRAs, incident investigations, best practice reviews, and safety culture evaluations – offshore and onshore
- ABS Group manager for the BP-Baker Panel PSM reviews
- 80+ articles and books on PSM and risk management
  - **Guidelines for Risk Based Process Safety**
  - **Implementing PSM, 2nd edition, 4Q2015**
  - **Guidelines for Management of Change**
  - Manager's Guide to Quantitative Risk Assessment
  - Resource Guide to the Process Safety Code of Management Practices
  - Guidelines for Hazard Evaluation Procedures, Second Edition
  - Risk Communication Guide, Chemical Educational Foundation
  - ProSmart - CCPS PSM Performance Metrics System
- Center for Offshore Safety audit and metrics committee member
- Recipient of Mary Kay O'Conner Process Safety Center Merit Award
- Center for Chemical Process Safety Fellow

Discussion Outline

- Important process safety concepts
- Process safety management overview
  - Lessons learned from major accidents
  - Evolution of refinery industry practices
- Industry process safety performance improvement efforts
- Process safety regulatory update
- Keys for sustainable performance improvement

Important Process Safety Concepts

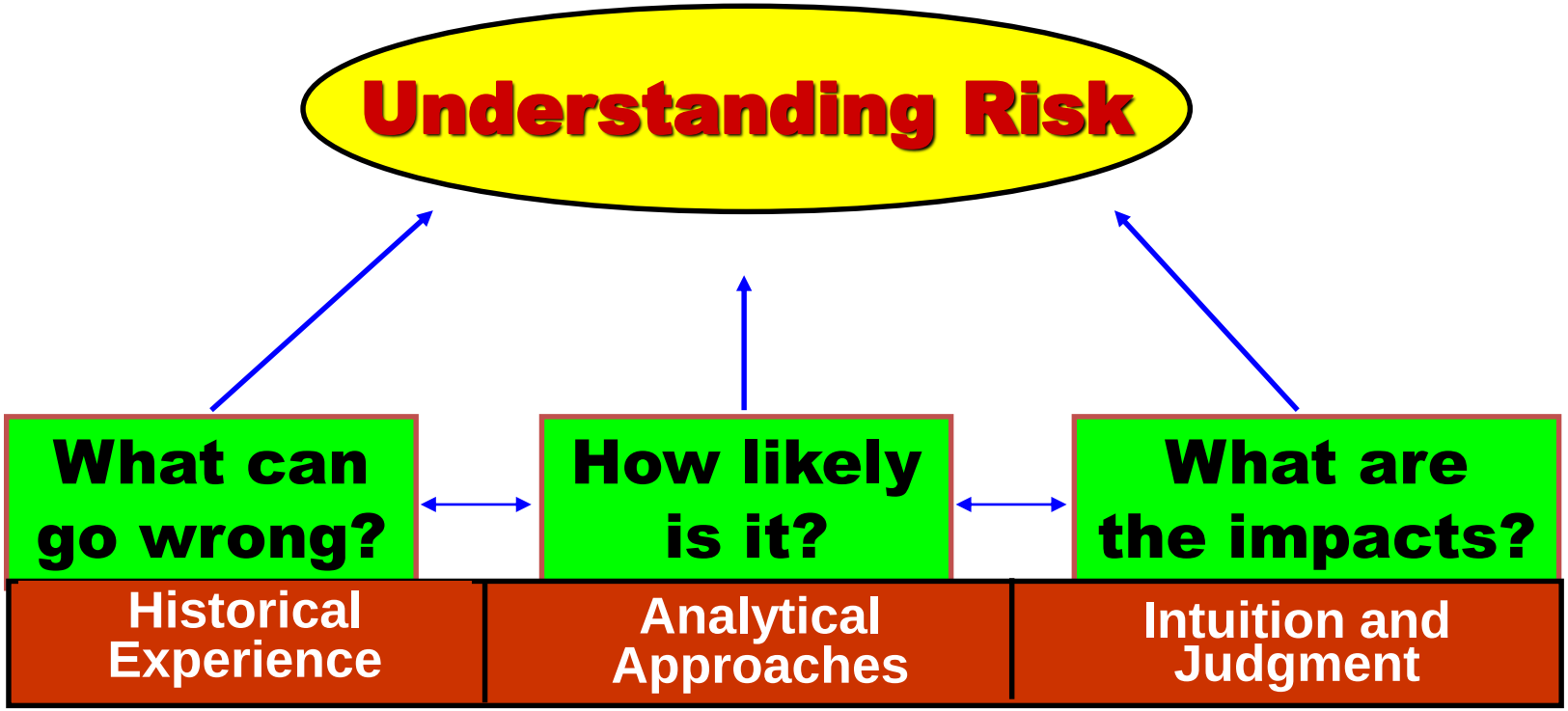
Process Safety vs Occupational/Personal Safety



Personal Safety – e.g. slips, trips and falls

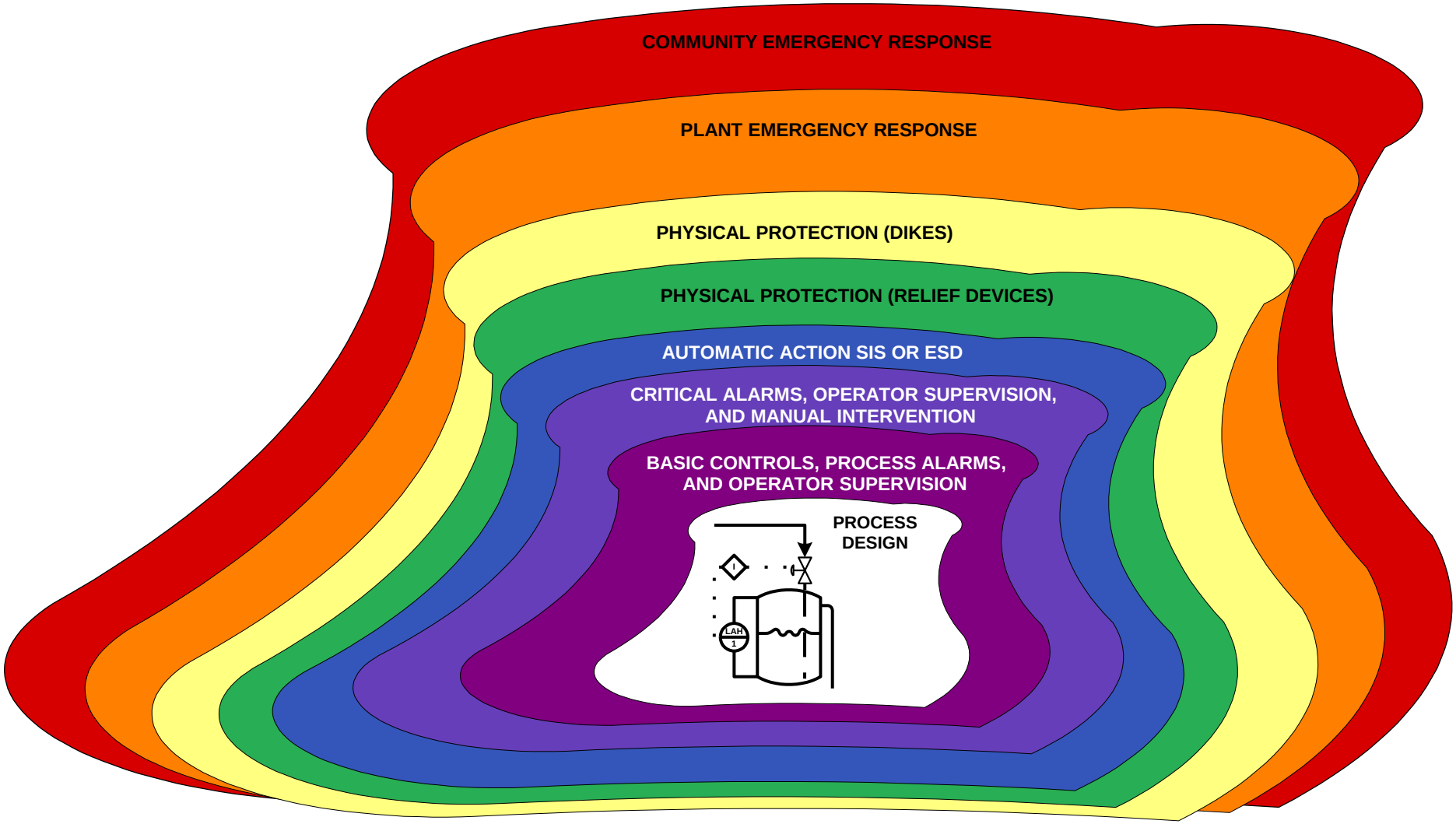
Process Safety -e.g. Fires, Explosions and Toxic Releases

Risk Assessment Concepts



What does it mean and what should you do about it?

Layers of Defense Against a Possible Accident



Inherently Safer Design Concepts

Original IS Concepts

- Substitute - avoid using hazardous materials
- Minimize - use less hazardous materials
- Moderate - use less hazardous conditions
- Simplify – use less complex control strategies
- Be more fault/error tolerant
- Limit effects - choose safer locations

Secondary IS Concepts

- Passive
- Active
- Administrative/procedural

Swiss Cheese Model for Accident Causation

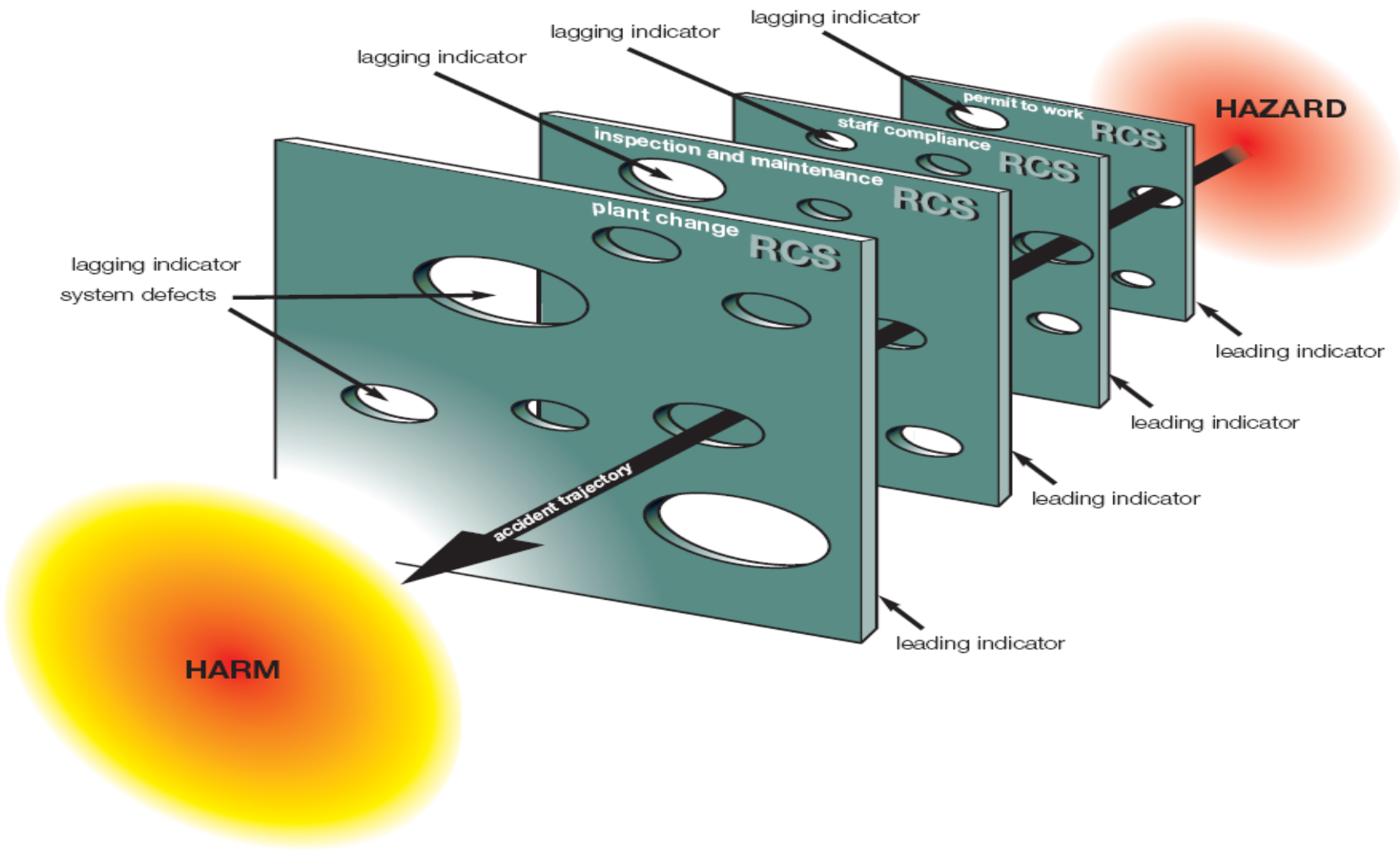
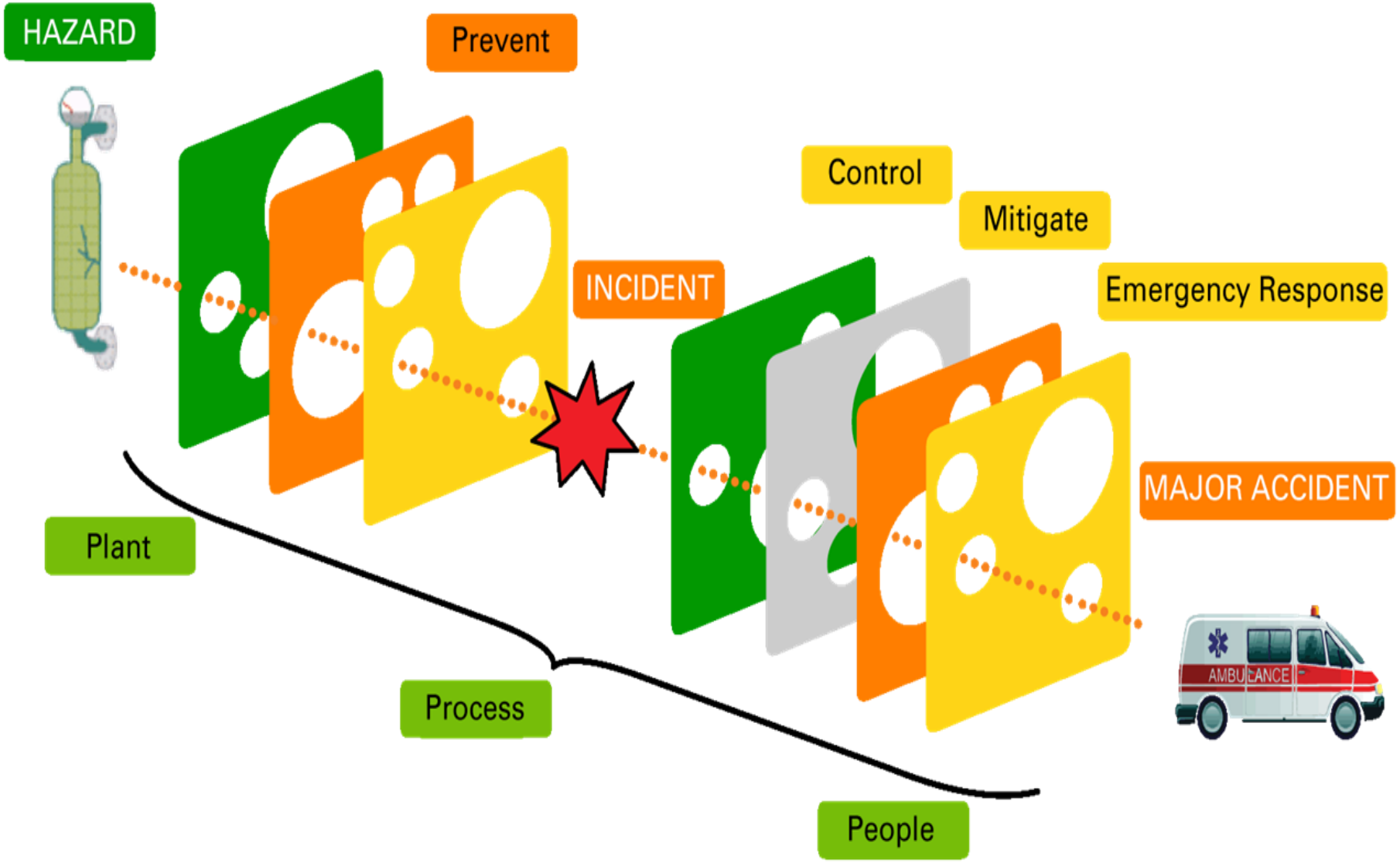


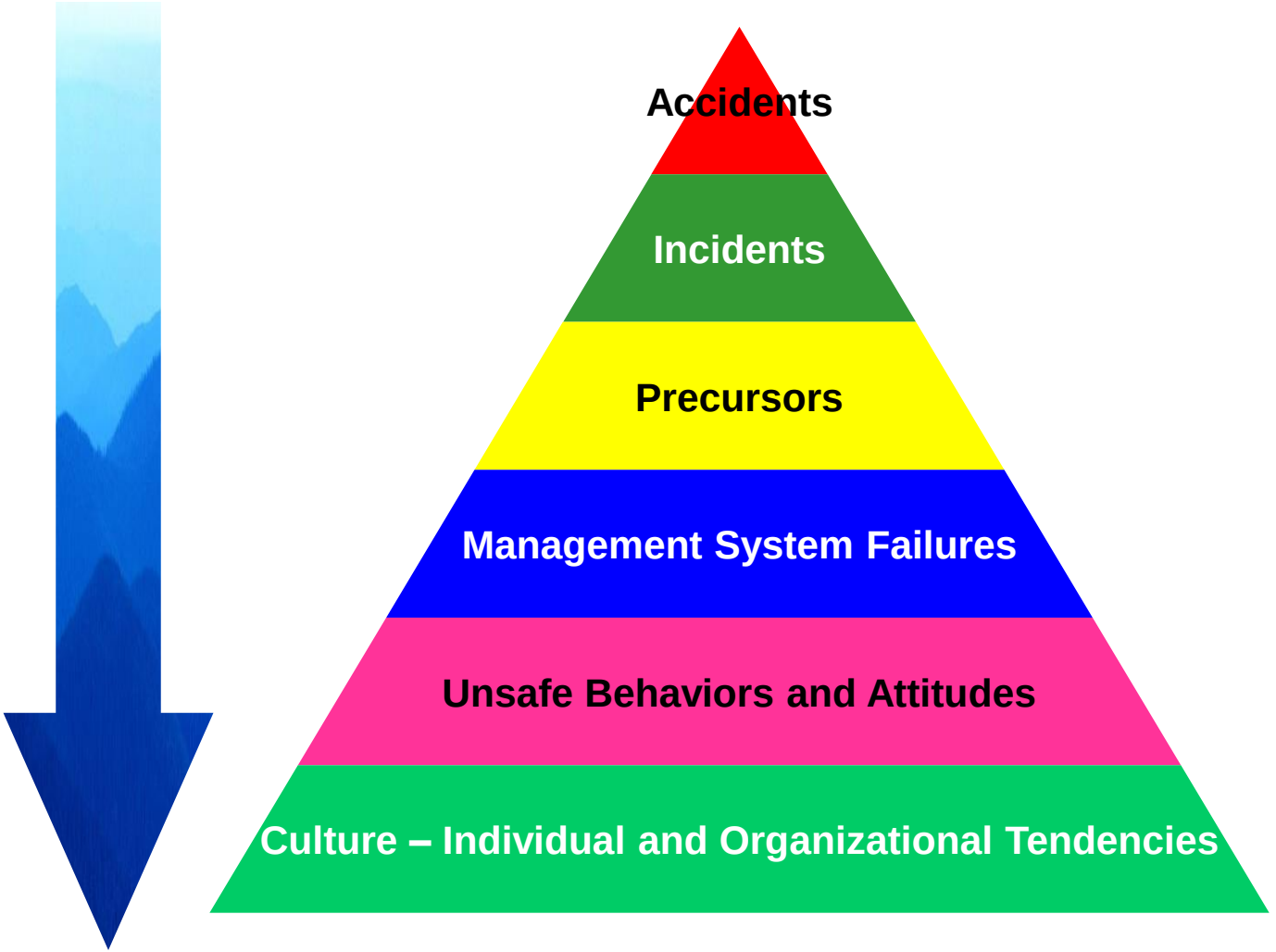
Figure 2 Leading and lagging indicators set to detect defects in important risk control systems

(Reproduced with permission of Ashgate Publishing Limited, from *Managing the Risks of Organizational Accidents* James Reason 1997 Ashgate Publishing Limited)[6]

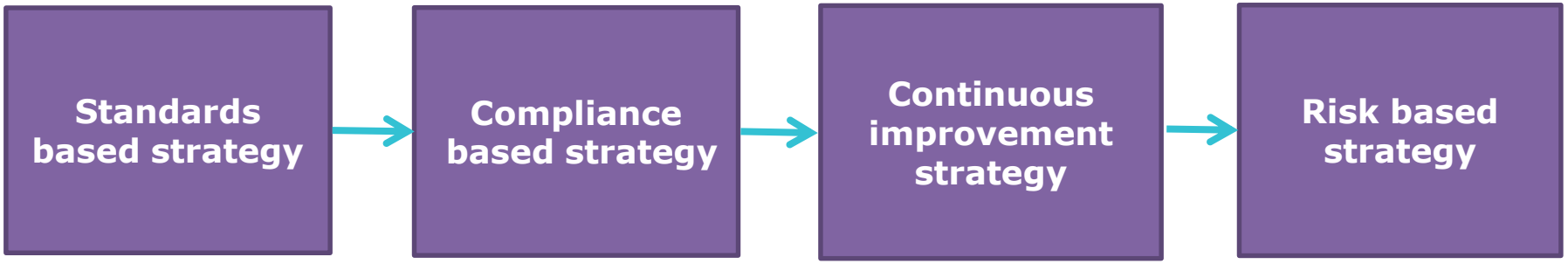
Process Safety Barrier Model



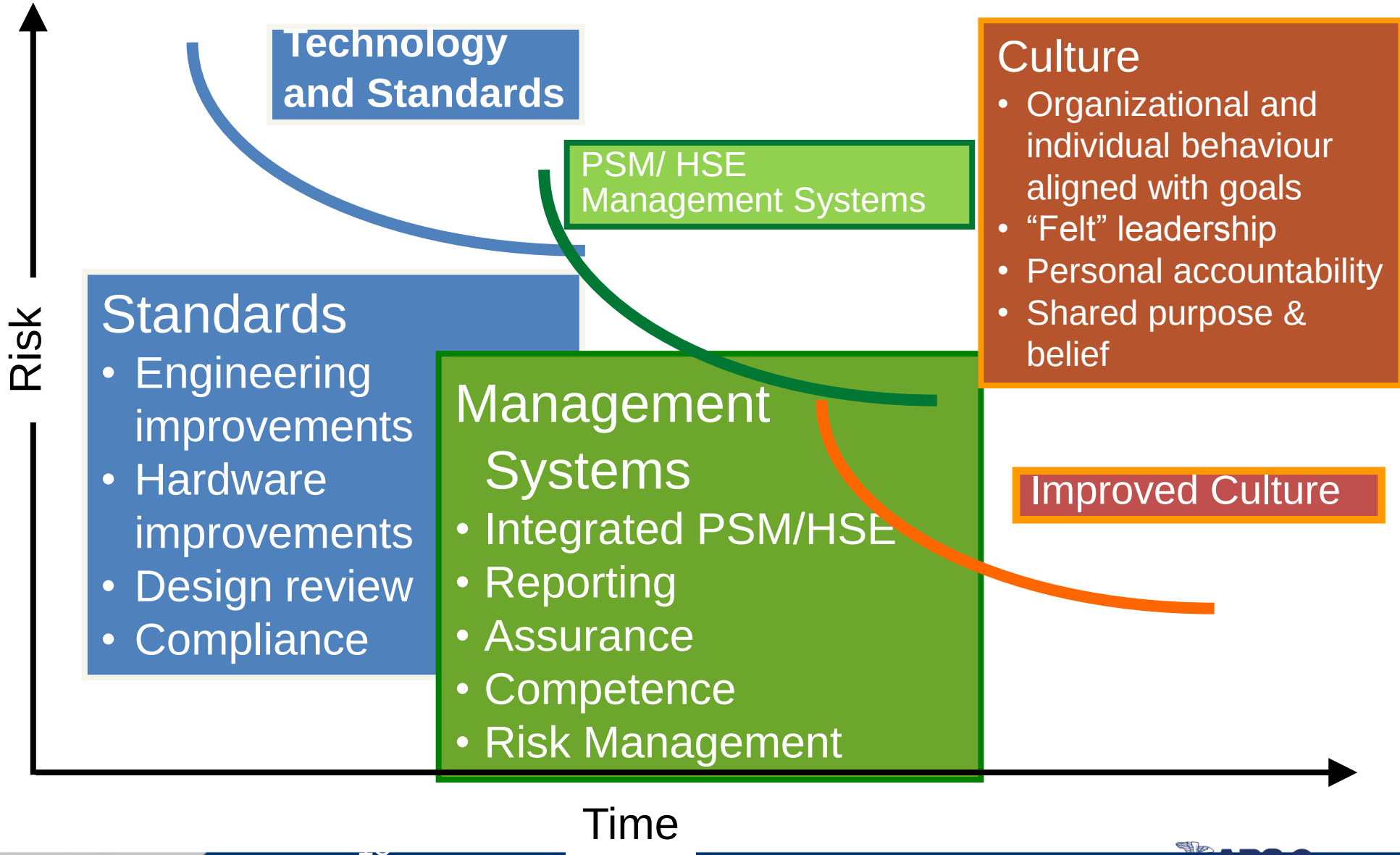
“Learn Lower” on the Pyramid



Strategies for Managing Process Safety



Improvements in Process Safety/HSE



A Management System Is…

- A formal, established set of activities explained in sufficient detail and designed to accomplish a specific goal by the intended users in a consistent fashion over a long time
- Management systems consider the following issues:
  - Purpose and scope
  - Personnel roles and responsibilities
  - Tasks and procedures
  - Necessary inputs and anticipated results
  - Personnel qualifications and training
  - Activity triggers, desired schedule, and deadlines
  - Resources and tools needed
  - Measurement, management review, and continuous improvement
  - Auditing

The Business Case for Process Safety

New Industry Study Shows Four Benefits:

- **Corporate Responsibility**
- **Business Flexibility**
- **Risk Reduction**
- **Sustained Value**

CCPS CENTER FOR CHEMICAL PROCESS SAFETY
An AIChE Industry Technology Alliance

PSM Overview and Evolution of Industry Implementation Practices

PSM Brief History

- 1984 – Bhopal
- 1885 – CCPS formed, CCPA creates RC
- 1986 – CMA creates its RC program
- 1985-88 – OSHA does process safety special emphasis programs in response to accidents
- 1988 - OSHA attempts draft PS standard
- 1988 – ORC creates PSM suggestions
- 1989 – CCPS issues PSM framework
- 1990 – Phillips and ARCO accidents; OSHA spits out draft PSM standard
- 1990 – CMA creates PS Code of Management Practices
- 1992 – OSHA finalizes PSM standard
- 1993-onward – Several states/locals adopt rules
- 1993 Kanawha Valley WCS public meeting
- 1995-98 – Several reactive chemical accidents
- 1998 – EPA finalizes RMP rule

PSM Brief History

- 1998-2000 – RMP facilities hold public meetings to roll out worst-case scenarios; initial RMPlans
- 2001 – ACC creates RCMS and RC-14000
- 2005 – Texas City refinery explosion
- 2007 – BP-Baker Panel report
- 2007-2012 – Several industry initiatives address Baker Panel lessons
  - CCPS ***Risk Based Process Safety Guidelines***
  - Facility siting of temporary structures – API RP 753 and 752 Rev 3
  - CCPS and API RP 754 Metrics
  - API RP 755 Fatigue management
- 2007-10 – OSHA Refining PSM NEP
- 2010 – Macondo-Deepwater Horizon
- 2010 – Significant industry incidents continue
- 2010 – Ongoing OSHA Chemical PSM NEP
- 2013 – EO 13650
- 2014 – Cal Refinery Safety report; DIR and CalARP draft rule changes
- 2014 – OSHA PSM RFI and EPA RMP RFI

OSHA PSM Elements

1. Employee Participation
2. Process Safety Information
3. Process Hazard Analysis
4. Operating Procedures
5. Training
6. Contractors
7. Pre-startup Safety Review
8. Mechanical Integrity
9. Hot Work Permit
10. Management of Change
11. Incident Investigation
12. Emergency Planning and Response
13. Compliance Audits
14. Trade Secrets

PSM Experience

- Most everyone says PSM has been valuable
- Certain industry events and compliance enforcement results have highlighted performance gaps and trends
- Industry process safety practices have evolved and many companies implement PSM in a fashion that goes well beyond minimum compliance
- Some companies still struggle with some aspects of PSM
- The following slides present the basics of PSM compliance requirements
- Discussion will address the range of industry practices

PSM Compliance Scope

- PSM coverage is based upon the existence of a threshold quantity (TQ) of defined highly hazardous chemicals
  - Toxics
  - Reactives
  - Flammable liquids and gases
- TQs, definitions, exemptions, exclusions, etc. all designed to prevent or minimize the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals
- "Covered processes" must implement the 14 PSM elements
- PSM has been called a "performance-based" regulation – it is a blend a prescriptive and "more flexible" management system/work process-based requirements

Employee Participation

- Develop a written employee participation plan
- Consult with employees and representatives on development of PSM program
- Provide employees and their representatives access to PSM documentation and information

Trade Secrets

- Provide all information necessary to those persons responsible for PSM activities
- May require confidentiality agreements

Process Safety Information (PSI)

- Compile and maintain for the life of the process:
  - Chemical hazards information
  - Process technology information
  - Process equipment information

- Document that equipment complies with recognized and generally accepted good engineering practices (RAGAGEP)

- For existing equipment designed and constructed to out-of-date codes/standards, determine and document that the equipment is designed, maintained, inspected, tested, and operating in a safe manner

Chemical Hazards Information

- Toxicity data
- Permissible exposure limits
- Physical data
- Reactivity data
- Corrosivity data
- Thermal and chemical stability
- Chemical incompatibility

Process Technology Information

- Block flow or process flow diagram
- Process chemistry
- Maximum intended inventories
- Safe operating limits for process parameters
- Consequences of deviations
- Where original technical information no longer exists, it may be developed in conjunction with a PHA in sufficient detail to support the analysis

Process Equipment Information

- Materials of construction
- P&IDs
- Electrical classification
- Relief system design and basis
- Ventilation system design
- Design codes and standards used
- Material and energy balances
- Safety systems (e.g., interlocks, detection or suppression systems)

Process Hazard Analysis (PHA)

- Prioritize/conduct PHAs; revalidate at least every 5 years
- Use method appropriate to hazard and complexity
- Ensure all PSI is accurate and up-to-date
- Use qualified PHA leader and team (engineering, operations, and employees)
- Create system to promptly address findings and track/document corrective actions
- Retain PHA reports for life of process

PHA Should Address Specific Concerns

- Hazards of the process
- Previous incidents
- Engineering and administrative controls and their interrelationships
- Consequences of failure of these controls
- Facility siting
- Human factors
- Qualitative evaluation of a range of the possible safety and health effects on all employees in the workplace

Operating Procedures

- Create written operating procedures that address steps for each operating phase
  - Startup
  - Normal operations
  - Temporary operations
  - Emergency shutdown and operations
- Ensure procedures are accessible to affected employees who work in or maintain a process
- Review procedures as often as necessary to ensure they reflect current operating practices; certify annually that procedures are current and accurate

Written Procedures Should Include

- Operating limits
- Consequences of deviations
- Steps required to correct or avoid deviation
- Safety and health considerations (PPE)
- Safety system descriptions

Training

- Provide initial training on
  - Overview of the process
  - Operating procedures
- Provide refresher training
- Document the means to ensure that the training was understood

Contractors

- Evaluate contractor's safety performance and programs when selecting a contractor
- Inform contract employers of known process and work-related hazards
- Explain applicable parts of the emergency action plan to contract employers
- Implement safe work practices, including safe work practices and control the entrance, presence, and exit of contract employers and employees in process areas
- Periodically evaluate the performance of contract employers in fulfilling their obligations
- Maintain contract employee injury and illness logs related to contractors' work in process areas

Pre-startup Safety Review (PSSR)

- For new facilities and for facilities with modifications that require changes to PSI
- Requirements must be completed before introducing highly hazardous chemicals
- The PSSR must confirm that:
  - Construction and equipment meet design specifications
  - Safety, operating, maintenance, and emergency procedures are in place and adequate
  - PHA has been performed (for new facilities), the recommendations have been resolved or implemented before startup, and modified facilities meet MOC requirements
  - Training of each employee involved in operating process is complete

Mechanical Integrity

- Develop and implement written procedures to maintain the on-going integrity of process equipment
- Provide training to ensure that the employees involved in maintaining the on-going integrity of process equipment can perform their jobs, each employee shall be trained in:
  - an overview of the process
  - the hazards of the process
  - the procedures applicable to the employee's job
- Perform inspections and tests

Mechanical Integrity (cont'd)

- Frequency of inspections and tests of process equipment shall be consistent with:
  - manufacturer's recommendations
  - good engineering practices
  - operating experience, which may dictate that frequencies be increased
- Document each inspection and test performed on process equipment and identify:
  - date of the inspection or test
  - name of the person who performed the inspection or test
  - serial number or other identifier of the equipment tested or inspected
  - description of the inspection or test performed
  - results of the inspection or test

Mechanical Integrity (cont'd)

- Correct equipment deficiencies that are outside acceptable limits (defined by the process safety information) before further use, or in a safe and timely manner when other means are taken to ensure safe operation
- In the construction of new plants and equipment, ensure that fabricated equipment is suitable for the process application
- Perform appropriate checks and inspections to ensure that equipment is installed properly and is consistent with design specifications and manufacturers' instructions
- Ensure that maintenance materials, spare parts, and equipment are suitable for the process application for which they will be used

Safe Work Practices (including Hot Work)

- Develop and implement safe work practices to control hazards including
  - hot work
  - lockout/tagout
  - confined space entry
  - opening process equipment/piping
  - access control for support personnel
- Safe work practices apply to employees and contractors

Management of Change (MOC)

- Develop written procedure to manage changes
  - Equipment
  - Procedures
  - Chemicals
  - Operating and safety limits
  - Personnel and organizational *(interpretation letter)*
- For each change, the review should address:
  - Technical basis for the change
  - Safety and health impacts
  - Time period for change
  - Authorization requirements
- Inform and train operations and maintenance employees and contractors before change is implemented
- Update process safety information and procedures, as necessary

Incident Investigation

- Investigate incidents which resulted in, or could reasonably have resulted in, a catastrophic release of highly hazardous chemical
- As promptly as possible; not later than 48 hours
- The investigation team must include:
  - At least one person knowledgeable in the process involved
  - A contract employee if the incident involved work of the contractor
  - Other persons with appropriate knowledge and experience to thoroughly investigate and analyze the incident

Incident Investigation (cont'd)

- The report shall contain at least the following:
  - Date of incident
  - Date investigation began
  - Description of incident
  - Contributing factors
  - Recommendations
- Establish a system to promptly address and resolve the incident report findings/recommendations
- Document the resolutions and corrective actions
- Review report with all affected personnel whose job tasks are relevant to findings
- Include contract employees when applicable
- Retain incident investigation reports for 5 years

Emergency Planning and Response

- Establish and implement an emergency action plan in accordance with 29 CFR 1910.38(a)
- Develop procedures for handling small releases
- Employers may also be subject to emergency response provisions in 29 CFR 1910.120 (a), (p), or (q)

Compliance Audits

- Certify, at least every 3 years, that PSM compliance has been evaluated and that procedures and practices implementing the PSM standard are adequate and are being followed
- The compliance audit should be conducted by at least one person knowledgeable in the process
- A report of the findings of the compliance audit shall be developed
- Promptly determine and document an appropriate response to each of the findings of the audit
- Document that deficiencies have been corrected

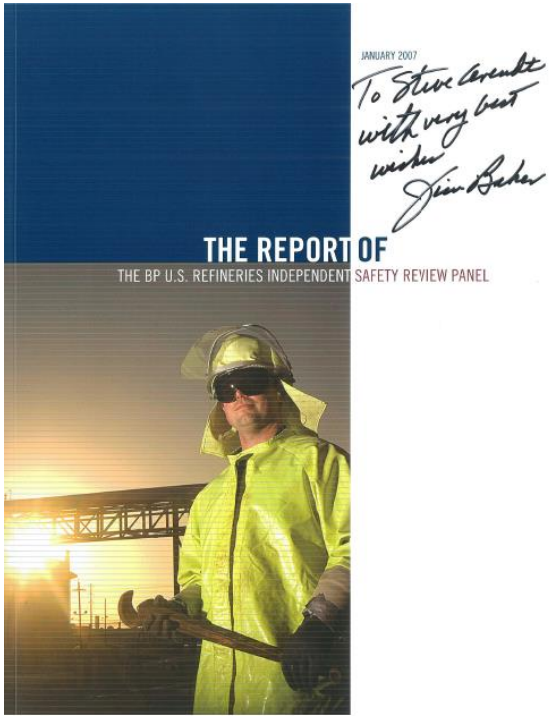
Summary of Federal PSM Enforcement Activities

- Pre-PSM – Chemical Special Emphasis Program following Bhopal
- OSHA PSM
  - Program Quality Verification (PQV) inspection
  - Interpretation letters/enforcement guidance
  - Citations and penalties
- Incident/accidents investigations
- Special emphasis programs – reactives, dust, refineries, chemical plants
- Frequent PSM element violations
  - Mechanical integrity
  - Operating procedures
  - Process safety information
  - Process hazard analysis
  - Management of change
- Perceived current OSHA PSM regulatory/enforcement strategy

Lessons from Significant Process Safety Accidents

Lessons from BP-Tx City/Baker Panel Review

- **Ineffective PSM system with weak performance evaluation, corrective action, and corporate oversight**
  - Lack of follow-up in ALL areas
  - Huge backlogs in inspections and corrective actions
  - Not following consensus standards – nor their own
  - Poor risk awareness and assessment
  - Superficial audits
  - Inadequate metrics
  - Poor management review at local level
  - Not focused on process safety at corporate level
- **Inadequate corporate safety culture**
  - Lack of effective process safety leadership
  - Inadequate employee empowerment
  - Inadequate resources and positioning of process safety capabilities
  - Ineffective incorporation of process safety into management decision-making
  - Lack of a common, unifying process safety culture



Lessons from Macondo (4/10)

- Process safety management system failures
- Inadequate process safety culture for DH
- Inadequate GOM operating environment culture
- Complex offshore operating environment
- Inadequate GOM regulatory environment

Lessons from Buncefield UK 12/10/05

- Fuel Storage depot near Hemel Hempstead, UK; supplied aviation fuel to Heathrow and Gatwick
- Hazard process was tank filling operations
- Inadequate design
- Inadequate management of tank level alarms
- Tolerance of procedural and equipment deviations
- Inadequate risk awareness by staff
- Contractor competence

Possible Issues from Regional Accidents

- Tesoro Anacortes (4/10)
- Chevron Richmond Refinery (8/12)
- ExxonMobil Torrance (2/15)

Some General Issues that Have Been Mentioned

- Mechanical integrity risk management
- Damage mechanisms
- Inherent safety
- Safety culture

Industry Process Safety Performance Improvement Efforts

PSM Implementation Effective Practices

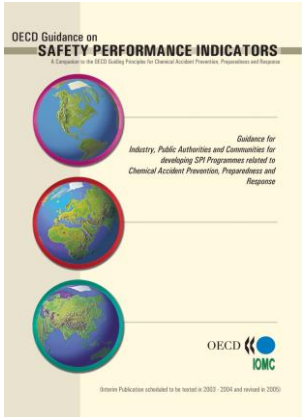
- Pay attention to lessons - incidents and implementation
- Avoid a “compliance-only, minimalistic mindset”
- Provide adequate resources; don’t skimp on rollout
- Create proper ownership; pursue employee engagement
- Grow culture and pursue operational discipline
- Locate leadership/PSM execution in “influencing” spots
- Use PSM networks to leverage competency
- Create fit-for-purpose management systems
- Appropriate use of "generic" procedures and practices
- MR during implementation and beyond
- Use “blended” PSM audit teams
- Know when to “acquire wisdom” for critical PSM activities

Significant Process Safety Improvement Activities

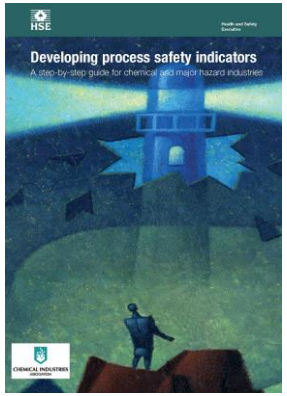
- Evolving and defining recognized and generally accepted good engineering practices (RAGAGEP) and management practices, including internal company guidelines
- ACC RC – Codes of management practices, RCMS, RC-14000
- CCPS – guidelines and conferences
- 100+ CCPS guidelines –Risk Based Process Safety, new/improved techniques for PHA, revalidations, LOPA, metrics, safety culture, etc.
- API standards and RPs – 160+ refining practices, guidelines, and standards
  - API RP 752, 753, 754, 755, 510, 580/581, 584, etc.
- AFPM online process safety networking and educational resources
- API/AFPM benchmarking/practices sharing/networking meetings
- Two examples – process safety metrics and process safety culture

Industry-Published Metrics Efforts and Guidance

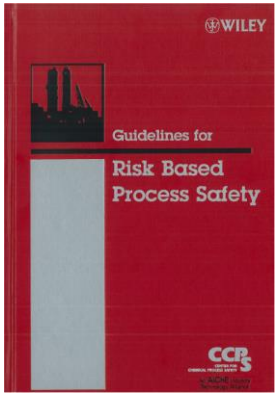
2003



2006

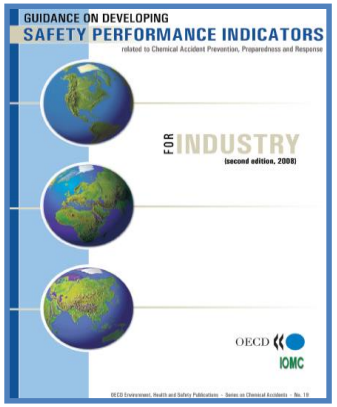


2007

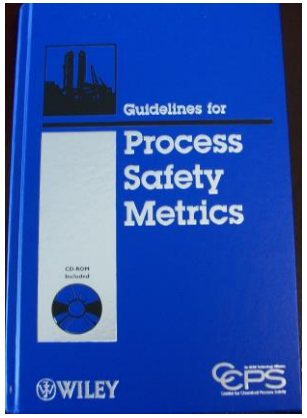


2007

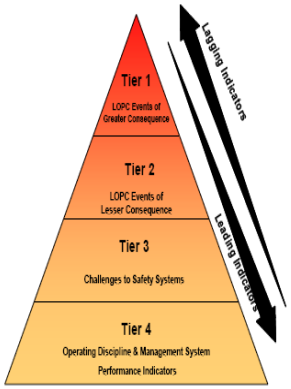
2008



2009

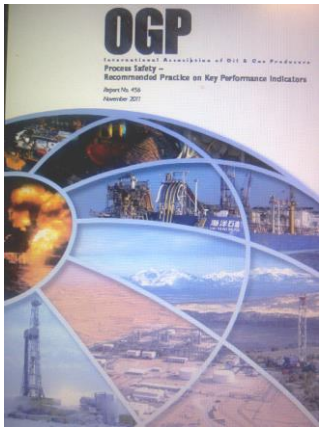


2010

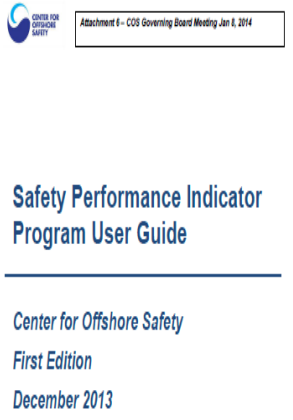


- The count of **Tier 1** process safety events is the most lagging performance indicator and represents incidents with greater consequence resulting from actual losses of containment.
- The count of **Tier 2** process safety events represents loss of primary containment events with a lesser consequence, but may be predictive of future, more significant incidents.
- **Tier 3** events represent challenges to the safety systems. Indicators at this level provide an opportunity to identify and correct weaknesses within the safety system.
- **Tier 4** indicators represent operating discipline and management system performance.

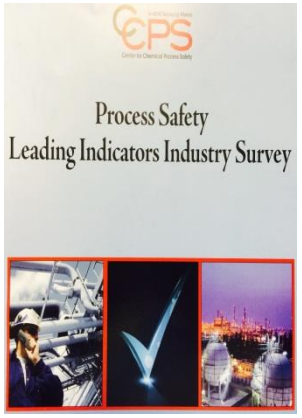
2013



2013



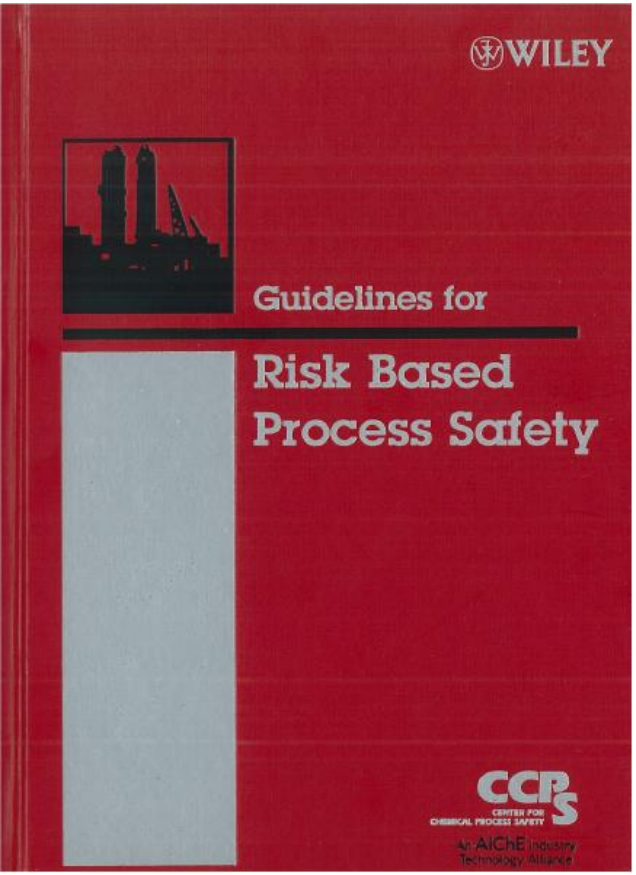
2014



2014-15 Revise RP 754 and Efforts to Harmonize Global Metrics

Center for Chemical Process Safety, 2007

ABS Group Wrote this Guideline



Process Safety Culture Essential Features

1. Establish safety as a core value
2. Provide strong leadership
3. Establish and enforce high standards of performance
4. Formalize the safety culture emphasis/approach
5. Maintain a sense of vulnerability
6. Empower individuals to successfully fulfill their safety responsibilities
7. Defer to expertise
8. Ensure open and effective communications
9. Establish a questioning/learning environment
10. Foster mutual trust
11. Provide timely response to safety issues and concerns
12. Provide continuous monitoring of performance

Process Safety Regulatory Update

Addressing Causes of Perceived Industry Process Safety Performance Issues

- Examine performance evidence
  - Incidents – Rate and severity, root causes
  - Enforcement results – PSM citations and RMP NOVs reveal some element weaknesses
  - Current hazard/risk levels – perception
  - Continuous improvement – elective improvement by companies/industries
- Does the evidence present a compelling case for:
  - Improving compliance/enforcement with existing regulations?
  - "Modernizing/increasing" existing regulations?
- **Need + Benefits / Cost + Difficulty/Feasibility – should be used to identify and prioritize "improvements"**

Regulatory Update

- EO 13650 – Improving Chemical Plant Safety & Security
  - Listening sessions and report to the President
  - OSHA PSM RFI – list of 17 RFI topics
  - EPA RMP RFI – List of 19 RFI topics (7 common with OSHA)
  - EPA SBR of possible RMP changes
  - OSHA PSM SBREFA status
- Status for EPA publishing RMP changes – list of 6 change topics
- Cal DIR and Cal ARP – new elements, existing element changes, significant issues

Overview of Proposed Revisions

	P1	P2	P3
Third-party audits (applies to the next scheduled audit after an accident) *		√	√
Incident Root Cause Analysis (only for facilities with accidents/near misses) *		√	√
Safer Alternatives Analysis (applies to a subset of P3 in certain NAICS codes) *			√
Coordinating Emergency Response Program Requirements with Local Responders		√	√
Emergency Response Exercises *		√	√
Information Sharing *	√	√	√

* New Proposed Requirement

PSM for Refineries, Draft 5.0, September 14, 2015

Proposed General Industrial Safety Order 5189.1

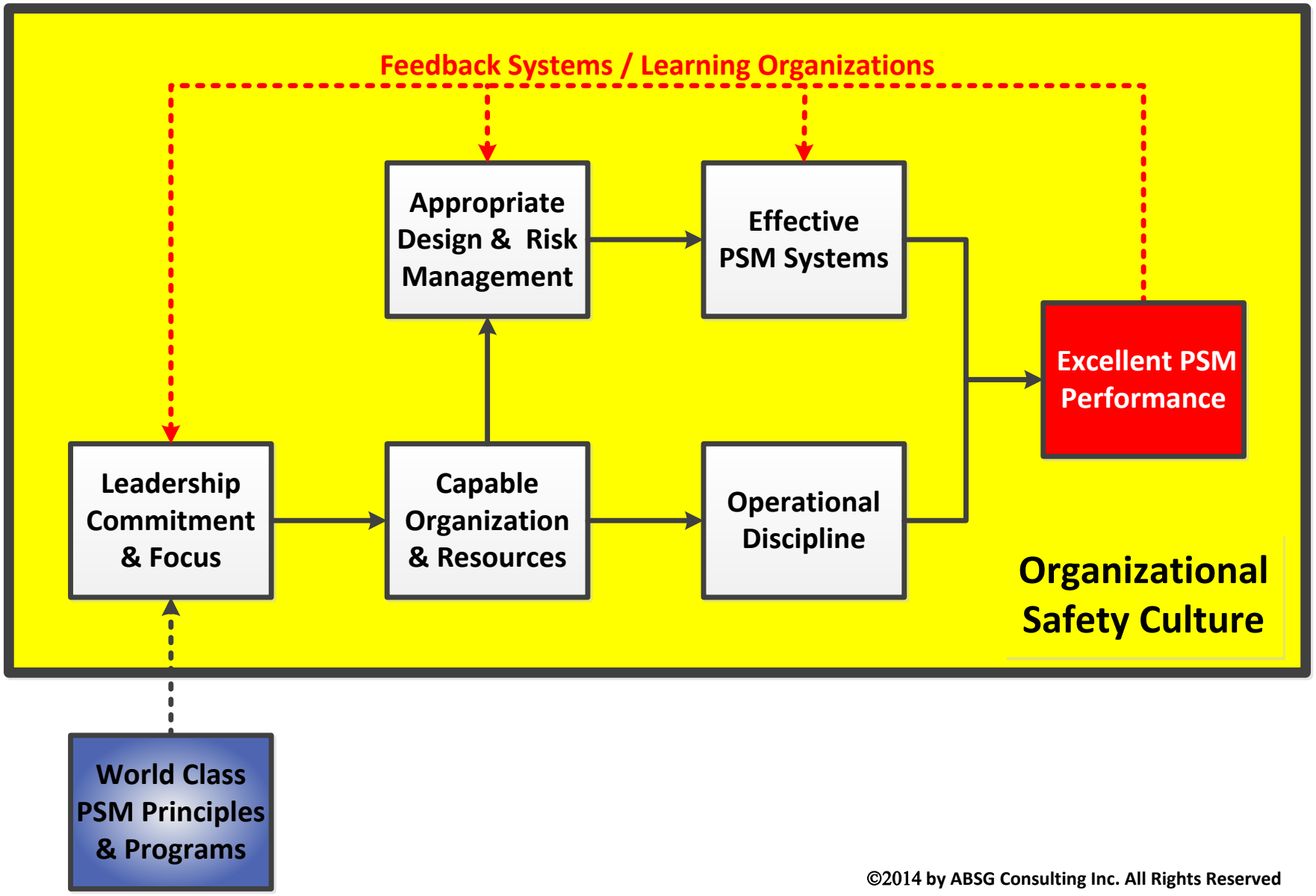
- **(a) Scope and Purpose**
- **(b) Application**
- **(c) Definitions**
- (d) Process Safety information
- (e) Process Hazard Analysis (PHA) **Safeguard Protection Analysis**
- (f) Operating Procedures
- (g) Training
- (h) Contractors
- (i) Pre-start-Up Safety Review
- (j) Mechanical Integrity
- **(k) Damage Mechanism Review (DMR)**
- **(l) Hierarchy of Hazards Control Analysis (HCA)**
- (m) Hot Work
- (n) Management of Change
- (o) Incident Investigation - **Root Cause Analysis**
- (p) Emergency Planning and Response
- (q) Employee Participation
- **(r) Process Safety Culture Assessment (PSCA)**
- **(s) Human Factors**
- **(t) Management of Organizational Change**
- (u) Compliance Audits
- **(v) PSM Program**
- **(w) Division Access to Documents and Information**
- **(x) Implementation**

Keys for Sustainable Performance Improvement

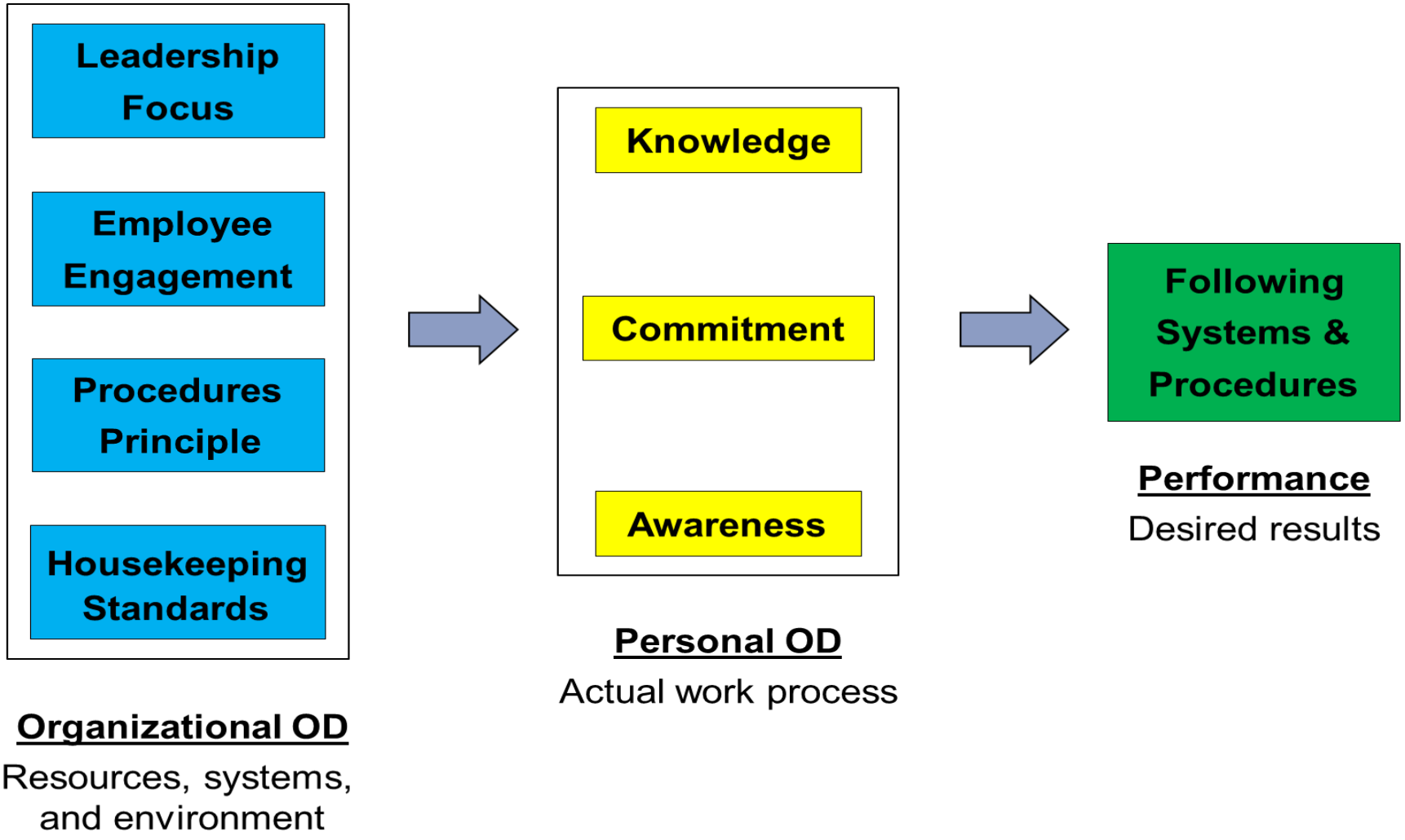
Characteristics of Good Process Safety Companies

- Not blind or arrogant – willing to look into the mirror
- Safe questioning/learning environment
- Proper safety ownership, leadership, and accountability throughout the organization
- Fosters a better culture
- Collaborative labor-management relationship
- Authentic, consistent workforce participation in PSM
- Effective, fit-for-purpose management systems
- Implementation of process safety work processes earlier in project life-cycles
- Disciplined in execution - low/decreasing backlogs
- High quality incident investigations
- Learns lessons cheaply taught from all sources - avoids repeat teaching
- Effective action - prevention, not just correction
- Action at multiple levels of the pyramid
- Pursues effective continuous improvement – seeks out better practices
- Proper process safety metrics and discerning audits
- Effective management review

PSM Performance Model to Pursue Excellence



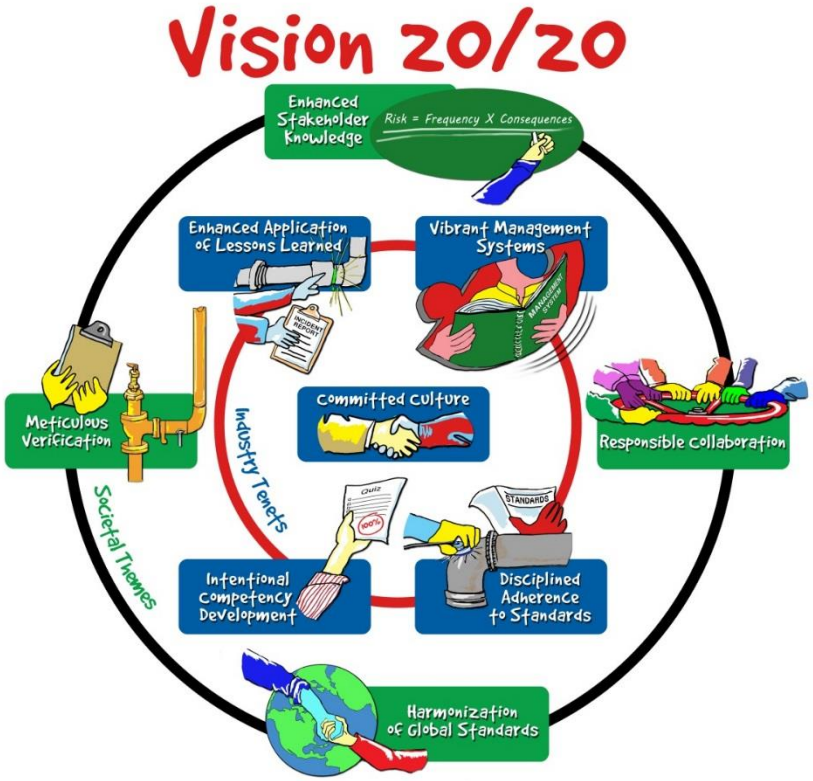
Operational Discipline



Klein and Vaughen, Process Safety: Key Concepts and Practical Applications, CRC Press, 2016

Industry Tenets

- Committed culture
- Vibrant management systems
- Disciplined adherence to standards
- Intentional competency development
- Enhanced application and sharing of lessons learned



Societal Themes

- Enhanced Stakeholder Knowledge
- Responsible Collaboration
- Harmonization of Standards
- Meticulous Verification

Assessment Tool

Vision 20/20, developed by the Center for Chemical Process Safety (CCPS), looks into the not-too-distant future to describe how great process safety is delivered when it is collectively and fervently supported by industry, regulators, academia, and the community worldwide; driven by the five industry tenets; and enhanced by the four global societal themes.

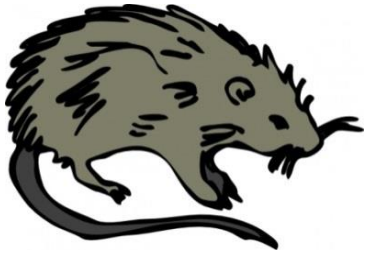
VISION 20/20 | An AIChE Technology Alliance CCPS Center for Chemical Process Safety

Implementing the Industry Tenets…

Prepare	Assess	Plan	Perform	***Achieve***	Sustain
Present V20/20 to PSM Colleagues and Management	Complete the V20/20 Assessment Tool	Reinforce and Use Strong Elements as Building Blocks	Implement Action Plans	Complete Action Plans	Verify Management System Improvements
Make V20/20 a Regular Topic at PSM-Related Meetings	Identify Weak and Strong Sub-Elements (<2.5 or >3.5 Respectively)	Identify the Specific Improvements Needed	Monitor Status of Action Plan Implementation	Re-Assess V20/20 Implementation Status with the Assessment Tool	Develop Action Plans for Weak Sub-Elements and Individual Items
"Sprinkle" V20/20 into PSM Conversations	Report Results; Management Commits to Improve	Research Options to Improve (Reference Industry Documents)	Evaluate Effectiveness of Actions	Report & Celebrate Improvements	Implement Action Plans and Monitor Performance
Use V20/20 Logo on Internal Communications	Communicate Results Within Organization	Develop Specific Action Plans to Address Weak Areas	Capture & Communicate Learnings	Identify New Weak Sub-Elements and Weak Individual Items (<2)	Continual Improvement… Continue the Journey!

Today → *2020*

Need to Exterminate Poor Culture Rats



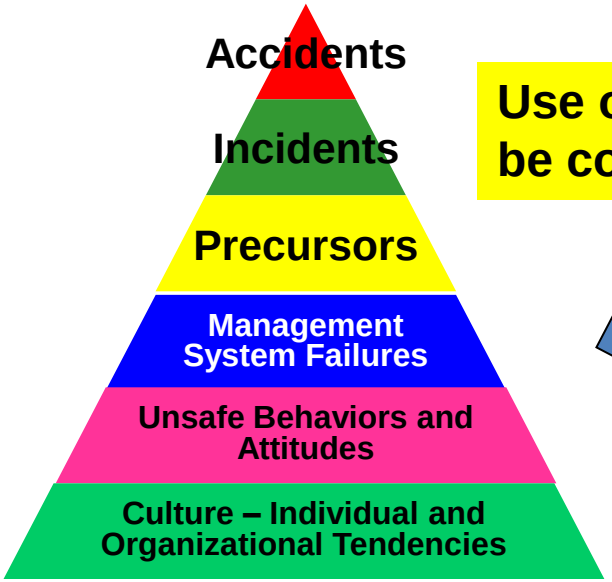
© Can Stock Photo - csp6101735

Figure 2 Leading and lagging indicators set to detect defects in important risk control systems

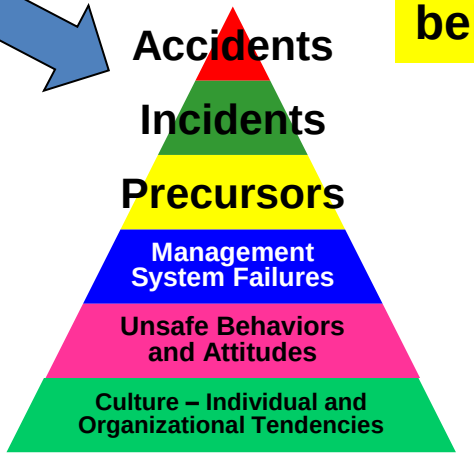
(Reproduced with permission of Ashgate Publishing Limited, from *Managing the Risks of Organizational Accidents* James Reason 1997 Ashgate Publishing Limited)[6]

Continuous, Sustainable Improvement in Process Safety Performance Demands…

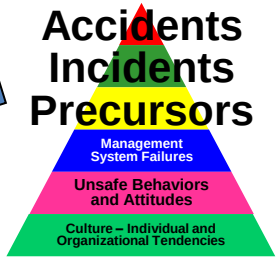
Effective RCA and corrective action creates improvement



Use of leading indicators to be continuous



Addressing culture and behaviors to be sustainable



Time for Questions