Briefing Paper
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California's Revised Safety Regulations for Oil Refineries
Process Safety Management for Oil Refineries
CCR Title 8, General Industry Safety Orders §5189.1

Prepared for the Office of Governor Jay Inslee
State of Washington

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Executive Summary

Photo courtesy of Richmond Progressive Alliance (2012)

An August 2012 pipe failure and fire at the Richmond, Chevron refinery endangered the lives of 19 workers and caused some 15,000 residents to seek medical attention for symptoms related to smoke exposure. In response, California Governor Jerry Brown launched an interagency refinery working group, which concluded that "improving refinery safety is a goal strongly shared by government, industry, workers, and communities." The group's report recommended that the following regulatory changes "be required as soon as possible" in the state's oil refineries:

- Implement inherently safer systems to the greatest extent feasible;
- Perform periodic safety culture assessments;
- Incorporate damage mechanism hazard reviews into process hazard analyses;
- Conduct root cause analyses after significant accidents or releases;
- Account for human factors and organizational changes;
- Use structured methods, such as layer of protection analysis, to ensure adequate safeguards in process hazard analyses.

Following extensive outreach to industry, refinery workers, community-based organizations and the public, the California Department of Industrial Relations (DIR) translated these recommendations into a revised Process Safety Management (PSM)

standard. The 24-part PSM revision now represents a comprehensive, risk-based, prevention-oriented approach to process safety. It will require greater attention by refinery managers on strategies to *anticipate, analyze* and *prevent* process incidents. It shifts the focus of the California PSM standard from requiring industrial practices that *control* risks to practices that substantially *reduce* risks or *prevent* risks from arising in the first place.

To ensure effectiveness and enforceability, the revision requires worker participation in all PSM elements, with worker representatives selected by the workforce. It includes several measures to improve transparency and accountability in the process safety decisions made by refinery managers.

While the regulation is intended to protect refinery workers and neighboring communities, it will also help ensure the stability and operational integrity of this important industrial sector. A RAND analysis of the costs and benefits of California's PSM revision concluded that maintaining compliance with the revised regulation will cost the state's refineries between $20 and $184 million per year in total, with a point estimate of $58 million per year, spread across 14 refineries. When passed on to consumers, this equates to a price increase of $0.004 per gallon in California.

RAND found that *each* major refinery incident avoided would save a refinery about $220 million, not including the potential costs associated with damage to surrounding communities or worker fatalities and injuries. RAND found that the improvements in process safety would also improve system reliability, the reliability of the state's fuel supply, community relations, labor–management relations, company reputation and public image. Most importantly, RAND concluded that California's PSM revision will substantially lower the risk of death among refinery workers, compared to the existing PSM standard.

Background

Immediately following an August 2012 pipe failure and fire at the Richmond, Chevron refinery, California Governor Jerry Brown convened an Interagency Refinery Safety Working Group, consisting of representatives from 13 state, Federal and local agencies.[(1)] The final report of the Working Group, issued in February 2014, concluded that "improving refinery safety is a goal strongly shared by government, industry, workers, and communities," and it called for changes in three areas to meet this objective: [(2)]

1) Emergency Response and Preparedness
2) Safety and Prevention of Hazardous Events
3) Community Education and Alerts

[1] Interagency Working Group on Refinery Safety members represented the Department of Industrial Relations (DIR), CalOSHA, Cal/EPA Secretary's Office, Air Resources Board (ARB), Governor's Office of Emergency Services (OES), Department of Toxic Substances Control (DTSC), State Water Resources Control Board (SWRCB), California Energy Commission (CEC), California Technology Agency (CTA), Department of Finance (DOF), Department of Public Health (DPH), Office of the State Fire Marshal (OSFM), U.S. EPA and Contra Costa County Health Services Agency.

[2] Governor Edmund G. Brown (February 2014). *Improving Public and Worker Safety at Oil Refineries: Report of the Interagency Working Group on Refinery Safety.* [Available: http://www.dir.ca.gov/dosh/interagency-refinery-task-force.html] (Accessed March 22, 2017) (pp. 24-33).

Changes to the state's Process Safety Management (PSM) standard appear in Section Two of the report, *Safety and Prevention of Hazardous Events*. The report recommended that the following changes to the PSM standard "be required as soon as possible:" [3]

1) Implement inherently safer systems to the greatest extent feasible;
2) Perform periodic safety culture assessments;
3) Incorporate damage mechanism hazard reviews into process hazard analyses;
4) Conduct root cause analyses after significant accidents or releases;
5) Account for human factors and organizational changes; and
6) Use structured methods, such as layer of protection analysis, to ensure adequate safeguards in process hazard analyses.

The California Department of Industrial Relations (DIR) translated these recommendations into a substantially revised, 24-part PSM standard for the state's 14 oil refineries, *Process Safety Management for Oil Refineries, GISO* **§***5189.1*. [4]

After nearly five years of effort, the California PSM revision now represents a comprehensive, risk-based, prevention-oriented approach to process safety. It will require greater attention by refinery managers on strategies to *anticipate, analyze* and *prevent* process incidents. It shifts the focus of the California PSM standard from requiring industrial practices that *control* risks to practices that substantially *reduce* risks or *prevent* risks from arising in the first place.

In this way, the California PSM revision reflects the industry's more contemporary, best-practice approach to process safety.

To ensure effectiveness and enforceability, the revision requires worker participation in all PSM elements, with worker representatives selected by the workforce. It includes several measures to improve transparency and accountability in process safety decisions made by refinery managers.

Rather than relying on a rule-based set of requirements, the California revision applies a performance-based approach. This approach is appropriate in a refinery setting, where thousands of potential risks must be identified, evaluated, prioritized and mitigated by applying expert judgment and professional engineering and management practices. The PSM revision acknowledges that judgment is vastly improved by involving the expertise of workers in all phases of process safety decision-making. This performance-based approach is expected to lead to continuing improvement, investment and innovation in process safety performance in California's refineries.

While the regulation is intended to protect refinery workers and neighboring communities, it will also help ensure the stability and operational integrity of this important industrial sector.

Industry, Labor and Public Engagement

In developing the PSM proposal, DIR conducted extensive outreach to industry, refinery workers, community-based organizations and the public. During 2014, DIR convened or participated in 26

[3] Governor Brown (February 2014) *op cit.* p. 21

[4] See the full text of the revised regulation beginning at page 12: http://www.dir.ca.gov/oshsb/documents/Process-Safety-Management-for-Petroleum-Refineries-15day.pdf. A detailed description of the purpose and necessity for each PSM element is provided in DIR's *Initial Statement of Reasons*: http://www.dir.ca.gov/OSHSB/documents/Process-Safety-Management-for-Petroleum-Refineriess-ISOR.pdf.

meetings or hearings pertaining to process safety. At each of these meetings, DIR presented the findings and recommendations of the Governor's report; described DIR's proposed revisions to the PSM standard for refineries; and listened to and recorded the views of meeting participants.

Four of these meetings consisted of DIR's PSM Advisory Committee, made up of invited representatives of labor and industry. All Advisory Committee meetings were open to the public, who were invited to present their views before the Committee.

Regulatory Overview

California's PSM revision meets the recommendations of the Governor's Working Group on Refinery Safety, and it incorporates many of the recommendations of the U.S. Chemical Safety and Hazard Investigation Board (CSB) investigations into the 2012 Chevron, Richmond refinery fire and the 2010 Tesoro, Anacortes explosion.

The PSM revision contains 24 elements that include nine new elements (k, l, r-x) and revisions to the 15 elements in the existing PSM standard (Table 1).

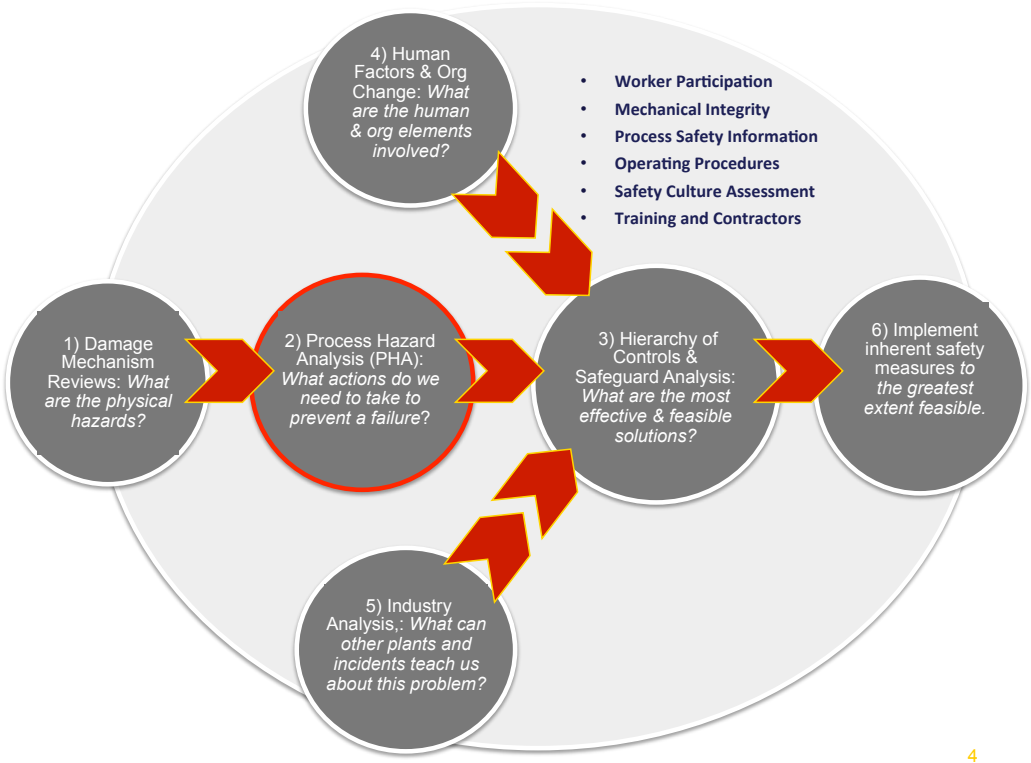
Table 1. Twenty-four elements of California's PSM revision

Section	Title	Page
(a)	Scope and Purpose	1
(b)	Application	1
(c)	Definitions	1
(d)	Process Safety Information	5
(e)	Process Hazard Analysis	7
(f)	Operating Procedures	10
(g)	Training	12
(h)	Contractors	13
(i)	Pre Start-Up Safety Review	14
(j)	Mechanical Integrity	15
(K)	Damage Mechanism Review	17
(l)	Hierarchy of Hazard Controls Analysis	18
(m)	Hot Work	20
(n)	Management of Change	21
(o)	Incident Investigation – Root Cause Analysis	22
(p)	Emergency Planning and Response	24
(q)	Employee Participation	24
(r)	Process Safety Culture Assessment	25
(s)	Human Factors	27
(t)	Management of Organizational Change	28
(u)	Compliance Audits	28
(v)	Process Safety Management Program	29
(w)	Division Access to Documents and Information	29
(x)	Implementation	29

Each of these elements is essential to the function of a comprehensive PSM program, whose primary objective is to establish a best practice, risk-based, prevention-oriented approach to

process safety (Figure 1). Each of the PSM elements functions as part of an integrated engineering and management system. The system is designed to drive continual improvement, investment and innovation in process safety.

Figure 1. Logic Model of the California PSM Revision. Each of the engineering and management elements indicated in spheres are new to the PSM revision, with the exception of the Process Hazard Analysis (PHA). Each of the bulleted elements is integrated into each sphere in various ways. Several PSM elements are not included in the model.



Drawing on Industry Best Practice

California's PSM revision draws from and improves upon the recommendations of the industry's Center for Chemical Process Safety (CCPS) *Guidelines for Risk Based Process Safety (2007)* which "reflect fifteen years of PSM implementation experience and well-established best practices from a variety of industries."[5] The *Guidelines* group 20 recommended elements of an effective PSM program into four foundational areas of practice: (1) commit to process safety; (2) understand hazards and risk; (3) manage risk; (4) learn from experience.

The CCPS developed these areas of practice based on the industry's findings that incident investigations in high hazard process industries "continue to identify inadequate management system performance as a key contributor to the incident," and that "audits reveal a history of repeat findings" that "indicate chronic problems whose symptoms are fixed again and again without effectively addressing the technical and cultural root causes."[6]

[5] Center for Chemical Process Safety (CCPS) (2007). *Guidelines for Risk Based Process Safety*. American Institute of Chemical Engineers (AIChE). Wiley: New Jersey (Preface, p. l).
[6] Center for Chemical Process Safety (CCPS) (2007) *Risk-Based Process Safety.* The RBPS Subcommittee consists of members from Chevron Energy Technology Company, 3M Company, Celanese Chemical, The

Table 2. Each element of the California PSM revision is consistent with the four foundational areas of risk-based process safety, as recommended by the Center for Chemical Process Safety (2007).

Commit to Process Safety (a) Scope and Purpose (b) Application (q) Employee Participation (r) Process Safety Culture Assessment (v) Process Safety Management Program	**Understand Hazards and Risk** (c) Definitions (d) Process Safety Information (e) Process Hazard Analysis (k) Damage Mechanism Review (s) Human Factors
Manage Risk (f) Operating Procedures (g) Training (h) Contractors (i) Pre Start-Up Safety Review (j) Mechanical Integrity (l) Hierarchy of Hazard Controls Analysis (m) Hot Work (n) Management of Change (p) Emergency Planning and Response (t) Management of Organizational Change (x) Implementation	**Learn from Experience** (o) Incident Investigation – Root Cause Analysis (u) Compliance Audits (w) Division Access to Documents and Information

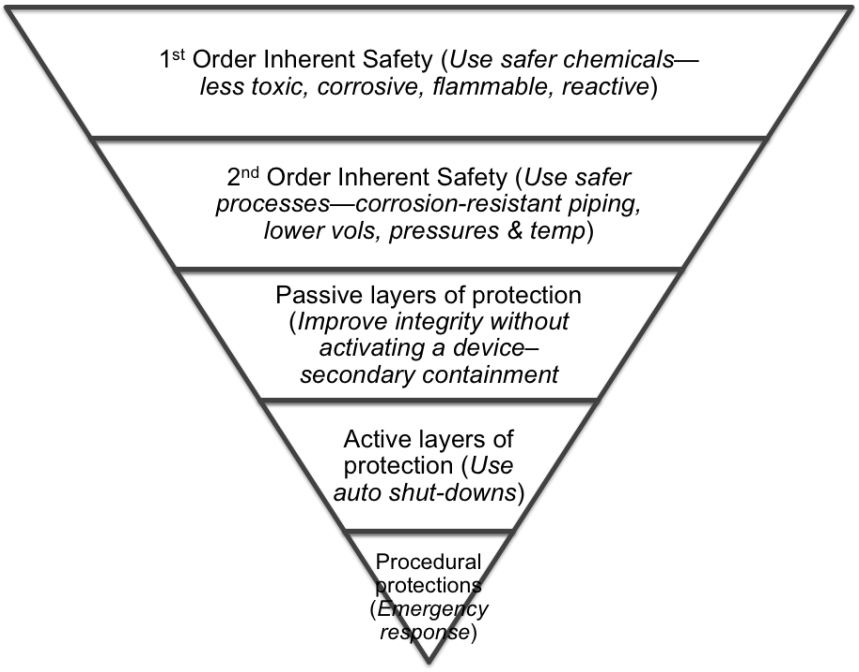
The California PSM revision relies on these same areas of practice, and it updates them by including the "hierarchy of hazard controls" and "inherent safety," as recommended by the CCPS in *Inherently Safety Chemical Processes: A Life Cycle Approach (2009),* which compiles more than a decade of industry experience in the area of inherent safety (Table 2). [(7)]

Consistent with this approach, the "Hierarchy of Hazard Controls Analysis (HCA)" element is a foundation of California's PSM revision. The HCA, combined with the implementation requirements of element (x), requires the refinery to identify, analyze and implement the most effective, feasible and enduring solutions to serious hazards identified in the Process Hazard Analysis (PHA). The HCA requires the refinery to analyze solutions beginning with inherent safety measures, followed by passive safeguards, active safeguards, and procedural protections (Figure 2).

Figure 2. Framework of the California PSM Hierarchy of Hazard Controls Analysis (HCA).

Lubrizol Corporation, Air Products and Chemicals, Inc., Rohm and Haas Company, DuPont, Eastman Chemical Company, Shell Chemical Company, Bayer Material Science BP, Eli Lilly and Company, BP, Monsanto Company, Olin Corporation, INEOS Olefins and Polymers USA, Rhodia, Inc. (p. 1).

[7] Center for Chemical Process Safety (CCPS) (2007) *op cit.*



For example, under the requirements of the revision, a refinery PSM team will need to consider all five approaches to addressing risks posed by a hazardous chemical, as follows:

1) First order inherent safety: Can the hazardous chemical be replaced with a safer alternative? Does the safer alternative introduce new risks at the plant or elsewhere up or down the supply chain? Can these risks be prevented or mitigated?

2) Second order inherent safety: Can the hazardous chemical be used in smaller quantities and/or under ambient temperatures and pressures?

3) Passive safeguards: Can the hazardous chemical be contained in piping and equipment that are more resistant to the corrosive effects of the chemical?

4) Active safeguards: Can devices be installed that automatically close a transfer line (from a truck to a tank) in the event of a line failure? Can automatic water deluge systems be installed to suppress hazardous chemical vapors?

5) Procedural actions: Is it feasible for employees to activate a device, such as a valve or fire monitor, to prevent a hazardous chemical leak from spreading and worsening?

Under the implementation requirements, it would not be permissible for the PSM team to rely primarily on chemical release alarms, for example, or on procedures activated by employees. While the PSM revisions would allow these approaches to *augment* inherent safety measures or passive safeguards, they would not—in and of themselves—constitute an acceptable "corrective action" under the revised regulation.

Responding to a Persistent Problem

Incidents in the refinery sector demonstrate that improvements in process safety management continue to be needed. In 2014, the U.S. Chemical Safety Board (CSB) concluded that there is "a considerable problem with significant and deadly incidents at petroleum refineries over the last

decade." In 2012, the CSB tracked 125 significant process safety incidents at U.S. petroleum refineries, 17 (14%) of which took place in California.[8]

An examination of reports submitted between 2007 and 2014 by petroleum refineries to the U.S. Department of Energy shows that the industry continues to experience serious process safety incidents on a regular basis.[9]

The regulations governing refineries have not been updated since the early 1990s, when the PSM regulations were first adopted in response to the 1984 industrial disaster in Bhopal, India, where a late-night leak of methyl isocyanate at the Union Carbide pesticide manufacturing plant killed thousands of people—most of whom were sleeping at the time. In the intervening 25 years, PSM expertise by leading companies has advanced significantly, but the regulation has remained static.

The RAND Economic Analysis

A RAND economic analysis of California's PSM revision concluded that implementing and maintaining compliance with the revised regulation will cost the state's refiners between $20 and $184 million per year in total, with a point estimate of $58 million per year, spread across 14 refineries.[10] When passed on to consumers, this equates to a price increase of about $0.004 per gallon in California.[11]

RAND found that *each* major refinery incident avoided (as a result of improved PSM practices required by the new regulation) would be expected to save a refinery about $220 million, not including the potential costs associated with damage to surrounding communities or worker fatalities and injuries. RAND found that the improvements in process safety would also improve "system reliability, community relations, labor–management relations, and company reputation and public image."

In RAND's analysis, the largest potential economic benefit of the PSM revision would be the improved reliability of California's fuel supply. RAND found that the first six months following the ExxonMobil Torrance Refinery explosion cost California drivers nearly $2.4 billion in the form of a $0.40 per gallon increase in gasoline prices. The disrupted fuel supply associated with this incident reduced the size of the California economy by $6.9 billion in the first six months.

Finally, RAND found that a refinery worker dies in many refinery incidents, and that in a few such incidents, multiple refinery workers die. The analysis concluded that California's PSM revision will bring about a substantially lower death rate among refinery workers compared to the existing PSM standard.

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[8] U.S. Chemical Safety and Hazard Investigation Board (2014). *Regulatory Report: Chevron Richmond Refinery Pipe Rupture and Fire.* Report No. 2012-03-I-CA (October 2014). p. 11.
[9] U.S. Department of Energy, Office of Electricity Delivery and Energy Relability. *Energy Assurance Daily*. [Available: http://www.oe.netl.doe.gov/ead.aspx] (Accessed March, 2017). (Note: For weekly summaries, go to *Download EADs* and scroll to *Petroleum*.)
[10] Gonzales D, Gulden T, Strong A, Hoyle W (2016). *Cost-Benefit Analysis of Proposed California Oil and Gas Regulations.* The RAND Corporation. Santa Monica, CA. [Available: http://www.rand.org/pubs/research_reports/RR1421.html] (Accessed March 22, 2017).
[11] Based on California's 2014 gasoline consumption rate of 14.5 billion gallons per year.