Framework for Process Safety Management
based on Engineering Activity
through Plant Lifecycle

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1. Introduction

**How the Process Safety Management (PSM) should be implemented in chemical processes?**

![Activity Modeling for PSM]

[Goal of this study]

To propose the *practical framework for PSM* for preventing industrial accident.
2. Discussion on PSM

What is PSM?

✓ To discuss about
  - safety-related engineering techniques,
  - scheme of plant risk management and effective disaster prevention for outside communities, etc.

What is practical framework for PSM?
OSHA (Occupational Safety and Health Agency)/PSM

A U.S. regulatory standard that requires use of a 14-elements management system to help prevent or mitigate the effects of catastrophic releases of chemicals or energy from processes covered by the regulation.

14 elements required by OSHA/PSM

√ Process Safety Information √ Employee Participation
√ Process Hazard Analysis √ Operating Procedures
√ Hot Work Permit √ Mechanical Integrity
√ Contractors √ Training
√ Management of Change √ Pre-Startup Safety Review
√ Emergency Planning and Response √ Incident Investigation
√ Compliance Audits √ Trade Secrets
Seveso II Directive

Framework of PSM which aims at the prevention of major accidents which involve dangerous substances, and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the community in a consistent and effective manner.

(COMAH* in UK)
* The Control of Major Accident Hazards Regulations
**AIChE/CCPS Risk Based Process Safety**

**A. Commit to process safety**
- Process safety culture
- Compliance with standards
- Process safety competence
- Workforce involvement
- Stakeholder outreach

**B. Understand hazards and risk**
- Process knowledge management
- Hazard identification and risk analysis

**C. Manage risk**
- Operating procedures
- Safe work practices
- Asset integrity and reliability
- Contractor management
- Training and performance assurance
- Management of change
- Operational readiness
- Conduct of operations
- Emergency management

**D. Learn from experience**
- Incident investigation
- **Measurement and metrics**
- Auditing
- Management review and continuous improvement

Risk-based strategies
Implementation tactics
Subjects on existing PSM system

(1) Existing PSM systems *just give the minimum elements for the safety management*, but they do not mention about concrete management activity.
(2) **Consistency among elements** is not ensured.
(3) **Practical scopes of elements** are different each other.

Subjects on
- Position of PSM in the engineering and production activities
  “How the PSM activity should be executed with routine activities?”
Problem on a legal system in Japan

PSM system as tertiary management system
(Ref. to ISO9000; QMS and ISO14000; EMS)

- 4 major laws concerning safety of chemical process industry; managed under different ministry or agency
- Companies are preoccupied with responses to make enormous documents for each audit.
- No framework to audit whole process plant comprehensively

Difficult to establish the standardization for safety management activity!
Points of agenda

**Activity model for PSM**
- To make precondition, constraint condition, resources, etc to perform PSM activities within PLCE clear.
- To specify what, how, and why to do for activity of each PSM element.
- To summarize glossary table and list of typical tasks of PSM activities

**Practical framework of overall activity of PSM**
- Performance in the form of PDCA (Plan-Do-Check-Act) cycle
- Resource provision

**Position of OSHA/PSM elements**
- Activities of the PLCE
- Relation among each PSM element
Purpose of PSM from PLCE perspective

View from Plant Lifecycle Engineering

Plant Development Stage
- Research and Development
- Design
- Construction

Plant Operation Stage
- Production
- Maintenance

To design safe process plant
To construct safe facility and plant (hardware and/or software)
To maintain process safety of production plant
To handle safely for change of plant condition (MOC)
To maintain integrity of function of facility and plant

View from Process Safety Management
3. Activity model for PSM

**IDEFO (Integrated DEfinition for Functional model)**
- **Box**: Activity means what to do (Verb).
- **Arrow**: Object (information) used by activity (Noun).

**Controls** (constraints on an activity, e.g., procedures, budgets, etc.)

**Inputs**
(what is required before an activity can occur, e.g., purchase order, supervisor’s signature, etc.)

**Function or Activity (Verb Phase)**

**Mechanisms**
(what enables an activity, e.g., equipment, personnel assignments, etc.)

**Outputs**
(what is produced by an activity, e.g., reports, products, etc.)

Activity transfers Input to Output by using Mechanism under Control.
IDEF0 activity model - Hierarchical structure
**Why using IDEF0 format**

To develop *reference model for PSM* which can be used *for various companies commonly*

*Function-based discussion for activity modeling*

vs. Discussion based on each organization framework

**What is needed as function or activity?**

- What kind of PSM activities should be implemented?
- What kind of information, tools or methods is needed for supporting the PSM activities effectively?

**What to do for PSM?**
Template for activity modeling

- Directive (from upper plane)
- Requirement (from other section)
- Directive to perform execution plan (incl. requirement from other section)
- Requirement to provide resources
- Engineering standard (from upper plane)
- Request to make or change standard

Manage (Act)

Plan

Do

Check

Provide Resources

Output (part of)

- Resource (Info.) (from upper plane)

- Request to perform PDC activities
- Compliant with ES
- Proper provision of resources
- Validity of ES itself

- a) Performance and results for the directive and the plan
- b) Compliance with ES
- c) Sufficient provision of resources
- d) Validity of ES itself

- a) Educated and trained people and organizations
- b) Facilities and equipment, tools and methods for supporting activities
- c) Information to perform PDC activities
- d) Information for progress management
- e) Engineering standards for controlling each activity which are distributed from upper level
Hierarchical structure of PSM activity

Enterprise-level
- E1: Announce corporate philosophy and management policy
- E2: Make basic plan for PLCE-PSM
- E3: Perform PLCE-PSM
- E4: Evaluate result of PLCE-PSM
- E5: Provide resources for PLCE-PSM

Plant-site level
- A1: Manage PLCE-PSM execution
- A2: Make execution plan for PLCE-PSM activities
- A3: Perform PLCE-PSM activities at plant development stage
- A4: Perform PLCE-PSM activities at plant operation stage
- A5: Evaluate performance of PLCE-PSM
- A6: Provide H&O for performing PLCE-PSM
- A7: Provide resources for performing PLCE-PSM

A31, A32, A33, A34, A35, A36, A37, A41, A42, A43, A44, A45, A46

Typical tasks
- PDCA-PR
Top activity model for PSM related with Plant-LCE

Manage (Act)

Plan

Do: Plant-LCE-PSM

Check

Provide Resource & Organization for Plant-LCE-PSM

- Human resources and organization
  (Employee participant, Contractor Management, Education and training)

- Information on result of activity execution and requirement of change
- Information on result of performance evaluation
- Tools and methods
- Engineering standard
Activity model for performing PSM activity at plant development stage
Activity model for performing PSM activity at plant operation stage

- PSM execution plan
- Manage PSM activity at production phase
- Requirement of change for performing PSM at plant operation
- Result of PSM at plant operation
- Requirement of resources needed for PSM at plant operation
- Direction of PSM at plant operation
- Resource for making plan of PSM at plant operation
- Resource for making plan of PSM at plant maintenance
- Resource for PSM at production
- Resource for PSM at maintenance
- Resource for performance evaluation of PSM at plant operation
- H&O for PSM at production
- H&O for PSM at maintenance
- Evaluate performance of PSM at plant operation phase
- Resource for PSM execution at plant operation
- Info. for management of PSM at plant operation
- H&O for performing PSM at plant operation
- Provide resources for performing PSM at plant operation phase
- Result of performance evaluation of PSM at plant operation
- Integrity info. on equipment and facility
- Plan for PSM at plant maintenance
- Plan for PSM at plant operation
- Operating data (information)
- Deteriorated plant
- Requirement of change for performing PSM at production
- Requirement of change for PSM performance at plant operation
- ES for PSM at plant operation
- ES for management of PSM activity at plant operation
- ES for making plan for PSM at plant operation
- ES for making plan for PSM at plant maintenance
- ES for PSM at plant operation
- ES for PSM at production
- ES for performance evaluation of PSM at plant operation
- ES for PSM at plant maintenance
4. Glossaries and typical tasks of PSM Activities

Activity model for PSM:
- position of activities in the form of PDCA cycle
- flow of related information and resources

Explanations of each activity box and arrow are written in fixed phrase,
► User may not understand the meanings of developed activity model and the concrete tasks of activities.

For the easy-to-understand explanation of the activity model for PSM,
- Glossaries of each activity are summarized.
- Typical tasks of each PSM activity are listed.
List of typical tasks of PSM activity
## Typical tasks of PSM activities (format)

| No | Activity                                                   | Glossary                                                                 | Typical tasks                                                                 |
|----|------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|---|
| A---1 | Manage for PSM activity at production stage       | Explanation of activity for ‘manage’ and ‘act’                             | Create basis principle and purpose for PSM activity at production stage        | Request to provide resources needed for performing PSM at production stage    | Revision and/or improvement --- |
| A---2 | Make execution plan for PSM activity at production stage | Make execution plan for PSM at production                                 | ---                                                                           | ---                                                                           |
| A---3 | Perform PSM activity at production stage               | Explanation of activity for ‘plan’                                         | Surveillance and compliance with relevant law and regulation                   | Risk analysis at production stage                                           | Risk reduction strategy for production safety --- |
| A---4 | Evaluate performance of PSM activity at production     | Explanation of activity for ‘check’                                        | Analysis of issue (abnormal situation) (to clear up the problem)               | Check result for execution plan (directive)                                  | Check compliance with ESs --- |
| A---5 | Provide resources for performing PSM activity at production stage | Provide resources for ‘provide resources’                                | [Facility and equipment]                                                      | [ESs (given from activity of upper plane)]                                   | Check provision of ESs --- |
|       |                                                           |                                                                          | [Info.]                                                                       | [HRs (education and training) and organization]                             | Check provision of resources (info.) --- |
|       |                                                           |                                                                          | [Facility and equipment]                                                      | [ESs (created within the plane)]                                             | Check provision of HRS and organization --- |
|       |                                                           |                                                                          | [Info.]                                                                       | [HRs (education and training) and organization]                             | --- |
|       |                                                           |                                                                          | [Info. for progress management for PSM activity at production stage (to transfer to ‘act’ activity)] | [Info. for progress management for PSM activity at production stage (to transfer to ‘act’ activity)] | --- |
5. Framework for Overall PSM

PSM activity should be
- performed under company’s management policy and execution strategy
- integrated with engineering activity to ensure safety and stable production through the plant lifecycle.

A framework for overall PSM is developed as a summary of activity model for PSM.

Integration of flow of things and information on production and human and material resources linked with business management activity.
Framework for PSM at enterprise level

Enterprise Level ➔ PSM at Enterprise Level

Manage (Act)

Plan

Do

PSM Principle

Philosophy

Social Demand ➔ Law/Regulation

CSR Report

Request for Modification/Improvement

PSM Results

Evaluation of PSM

Standards

Evaluation

Resources for PSM

Employee Participation

P.R. Facility

ES Info.

H/O

Resources for PSM

PSM at Plant Site Level through Plant Lifecycle
**Framework for PSM at plant site level**

PSM at Plant Site Level

- **Do**
  - Manage (Act)
  - Direction of Planning
  - Plan
  - Result
  - Check
  - Request for Modification/Improvement

- **Plan**
  - Result
  - Evaluation

- **Result**
  - Guest for PSM

- **Check**
  - Evaluation

- **Request for Modification/Improvement**
  - P.R. Facility
  - ES Info.
  - H/O

- **PSM Principal**
  - Standards

**PSM activities through the plant lifecycle**

**Resources for PSM**

**Employee Participation**
6. Mapping of OSHA/PSM Elements on Proposed PSM Framework

In order to make the role of proposed PSM framework for existing PSM system clear, OSHA/PSM 14-elements have been mapped on it.

<table>
<thead>
<tr>
<th>(a) Applications</th>
<th>(j) Mechanical Integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) Definitions</td>
<td>(k) Hot Work Permit</td>
</tr>
<tr>
<td>(c) Employee Participation</td>
<td>(l) Management of Change</td>
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<tr>
<td>(d) Process Safety Information</td>
<td>(m) Incident Investigation</td>
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<tr>
<td>(e) Process Hazard Analysis</td>
<td>(n) Emergency Planning and Response</td>
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<td>(f) Operating Procedures</td>
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<td>(g) Training</td>
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<td>(h) Contractors</td>
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<tr>
<td>(i) Pre-Startup Safety Review</td>
<td>(p) Trade Secrets</td>
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</tbody>
</table>
Mapping OSHA/PSM elements on the proposed framework
Mapping of OSHA/PSM elements on proposed PSM framework

Enterprise Level

PSM at Enterprise Level

Manage (Act)

Plan

Do

PSM at Plant Site Level

Requirenment for Modification/ Improvement

Resources for PSM

Employee Participation

PSM Results

Evaluation of PSM

Check

Review for Modification/ Improvement

Law/Regulation

Social Demand

CSR Report

Standards

Management/ Improvement Strategy

Do

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Evaluation

Request for Modification/ Improvement

PSM Principle

Enterprise Level

Philosophy

Manage (Act)

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Law/Regulation

CSR

Rt

Report

Manage (Act)

Plan

Do

PSM at Plant Site Level

Requirement for Modification/ Improvement

Resources for PSM

Employee Participation

PSM Results

Evaluation of PSM

Check

Review for Modification/ Improvement

Law/Regulation

Social Demand

CSR Report

Standards

Management/ Improvement Strategy
7. Discussion and Conclusion

(1) Useful for various chemical process companies

(2) Even if some problems happen in the result and performance of PSM activity, they will be corrected by ‘Check’ and ‘Act’ activities.

(3) Resources required for performing the PSM activities can be clearly specified as an activity.
   1) Human resources and organization
      → Education and training, contractor management, etc.
   2) Information, facilities, tools, methods
      → Structure of PSM info. sharing through the PLC
Discussion and conclusion (cont.)

(4) Glossary and list of typical tasks of PSM activities

(5) Purposes of each activity at each stage of plant lifecycle

(6) Proposed PSM framework is not entirely-new system but comprises of existing PSM systems

(7) Proposed PSM framework is build up by process safety culture as underlying fundamental.
Discussion and conclusion (cont.)

(8) Organization of engineering standards as an important activity of PSM

(9) Integration of PSM activity and routine production activities

(10) Improvement of company’s PSM system by comparison to the proposed PSM framework
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Thank you for your attention!