**Center for Chemical Process Safety (CCPS)**

**Project P313: Risk Based Process Safety Field Guide**

**Company Name:**

**Submitted by:**

**Submitter Email:**

[ ] **The company name is Confidential. Do not include in the Implementation Guide**

[ ] **The company name can be used in the Implementation Guide**

 **Please note that all Submitter names will be kept Confidential and will not be included in the Implementation Guide. Submitter name and email is required by CCPS so that we can contact the Submitter.**

**RBPS Pillar or Element: Select as many as apply**

[ ] **Pillar 1: Commit to Process Safety**

[x] Process Safety Culture

[x] Compliance with Standards

[ ] Process Safety Competency

[ ] Workforce Involvement

[ ] Stakeholder Outreach

[ ] **Pillar 2:  Understand Hazards and Risk**

[ ] Process Knowledge Management

[ ] Hazard Identification and Risk Analysis

[ ] **Pillar 3:  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

[ ] **Pillar 4:  Learn from Experience**

[ ] Incident Investigation

[ ] Measurement and Metrics

[ ] Auditing

[ ] Management Review and Continuous Improvement

**Company or Facility Demographics**

**Number of Employees**

 [ ] Less than 100

[ ] 100 to 1000

[ ] 1000 to 10,000

[x] More than 10,000

**Industry**

[ ] Advanced Materials

[ ] Bioengineering

[ ] Chemicals – Agricultural

[ ] Chemicals – Commodity

[ ] Chemicals – Fine/Specialty

[ ] Chemicals – Petrochemical

[ ] Consulting

[ ] Consumer Products

[ ] Electronics

[ ] Energy

**Location**

 [ ] Africa

[x] Asia

 [ ] Australia/NZ

[x] Europe

 [ ] Middle East

 [x] North America

 [ ] South America

[ ] Environmental, Health, and Safety

[ ] Foods

[x] Gas Processing

[ ] Mining

[ ] Oil and Gas – Downstream

[ ] Oil and Gas – Midstream

[ ] Oil and Gas - Downstream

[ ] Pharmaceuticals

[ ] Pulp and Paper

[ ] Refining

[ ] Transportation

[ ] Other

**Plant Operation Details**

 [ ] Batch

 [x] Continuous

 [ ] Plant Age: 0-3 years (new)

 [ ] Plant Age: 3-10 years

 [x] Plant Age: 10-20 years

 [x] Plant Age: More than 20 years

**SUCCESS STORY**

Please use the following outline to submit an RBPS Success Story. The outline includes sections for the following topics.

1. Project / Program Description
2. Resources Required
3. Challenges
4. Critical Success Factors
5. Metrics and Sustainability
6. Benefits and Results
7. Advice to other people/companies who want to implement a similar program

Please include photos, tables, graphs, and other visual aids that help tell the story. The story can be as long as needed to convey the relevant information. CCPS will work with all submitters to edit each story as needed.

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1. **Project/Program Description**

*Use this section to describe the program. Provide relevant background information about the reason the program was developed. Every Success Story is based on a problem that has been overcome or an opportunity that was realized. This section can be used to describe the problem or opportunity, but please keep the focus of the discussion on the success story (how the problem was overcome). What was the starting point for the project (such as an incident, system failure, learning from others, etc.)? Use this section to describe the “before” and “after” states.*

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Company XYZ operates approximately 750 production facilities and more than 1800 miles of gas pipelines in over 50 countries. The vast majority of the production facilities and pipelines were also designed and engineered by Company XYZ. For these reasons, Company XYZ has more than 1000 Engineering design standards that cover all aspects of process plant design, and about 200 EHS Standards applicable to plant design and operation. Per internal policy and ISO commitments, each standard is reviewed on a 5-year frequency and either re-confirmed without change or revised as needed.

Company XYZ established a work process for retrofitting Process Safety upgrades into existing facilities. A Retrofit Standard Committee (RSC) was established by the Corporate Risk Council and chartered with the task of deciding whether or not to retroactively apply a new or revised standard or identified requirements from a new or revised standard to existing facilities. Internal corporate standards, industry consensus standards, and regulatory standards are considered.

The RSC is comprised of senior technical experts at Company XYZ including the Corporate Director of Process Safety (who serves as Chair), the Chief Engineer for Process Technology, the Chief Engineer for Operations, Process Technology Managers from Engineering teams, and the Director of Operations Excellence. There is also a non-voting Secretary position, which is filled by a less-experienced engineer and serves as a developmental role for that person. Taken collectively, the RSC members have revision approval authority for many of the Engineering and EHS Standards that have Process Safety content. Prior to submitting a new or revised standard for approval, the Standard authors indicate whether the standard has Process Safety content and/or a potential retrofit requirement. The authors are made aware of this obligation in the training that they receive, and the categorization as to whether or not the standard has potential for a Process Safety Retrofit is a required step in the submittal and approval process. What this means in practice is that every standard with a potential Process Safety retrofit impact is brought to the attention of the RSC prior to its release.

It is important to note that the default position is to not apply a standard retroactively in existing facilities. This default position then sets the expectation that existing plants will not be continually updated to give them the same features as new plants. It would be impractical to retrofit every new design feature into existing plants and no company could afford to stay in business for long if such a model were followed. Judgement and experience are necessary to provide balance in making retrofit decisions. Once a decision has been made to retrofit a new standard or a new feature from a revised standard to existing facilities, those retrofit decisions are added to a Retrofit Checklist (see below for further detail)

Two additional retrofit drivers are also considered by the RSC. The first driver is plant operating incidents. An incident in an operating plant may result in a fleetwide retrofit. This determination is typically made by the RSC working with the incident investigation team. The corrective actions arising from all Tier 1 and Tier 2 Process Safety incidents at Company XYZ plants are reviewed by the RSC for fleetwide retrofit implications.

The second retrofit driver is the acquisition of operating facilities. In this case, the Retrofit Checklist is used by the technical due diligence teams to determine the number and scope of retrofits required in the asset being examined for acquisition. One of the deliverables from the acquisition due diligence team is a list of the required retrofits and a schedule for their implementation, including items that must be retrofit prior to operation of the plant by Company XYZ personnel.

The RSC focuses on process safety hazards originating *inside the battery limits*involving the processes and equipment operated by Company XYZ. The RSC meets bimonthly and follows typical governance principles for quorum, voting, and record-keeping. As an example, the process for approving a retrofit project requires unanimous approval of the RSC members. In practice, it has not been found that the requirement for unanimous approval hinders the effectiveness of the RSC, and many times has the opposite effect by driving a better retrofit solution. The unanimous approval provides an equal voice for all of the key groups in the process – Process Safety, Engineering, and Operations.

The factors that are considered at Company XYZ when making Process Safety retrofit decisions include the following.

1. Level of risk reduction that will be achieved

2. Ability to install the retrofit

3. Ensuring that the retrofit does not create a larger hazard

Retrofits are managed in two ways. Less complex retrofits are added to a Retrofit checklist. These retrofits tend to be simple and straightforward and can be completed for a nominal cost. The checklist includes information on the scope of the retrofit, the plants to which it applies, and supporting documentation. The checklist is updated twice per year. The additions to the updated checklist are communicated to the regional Operations Directors and Process Safety Teams so that they are aware of new retrofit items. The items on the checklist are to be retrofit at the next plant outage. These retrofits are typically completed by plant Maintenance personnel or plant engineers and are executed within the plant MOC process.

More complex retrofits or those for which timely execution is judged to be more critical by the RSC are executed as a fleet-wide program. In these cases, the RSC assigns subject matter experts (SME) and Plant Operations Project Engineers to develop the scope and cost for each program. The work of the SME includes all the technical work for the program including a HAZOP of the change, P&ID modifications, specification of equipment, and revision of operating instructions (essentially all the technical information required by the MOC process). The SME is familiar with the technology and with the plant or class of plants to which the retrofit is being applied. Typical selections for the SME include Plant Process Engineers, Process Controls Engineers, Pressure Vessel Engineers, or a combination of these jobs depending on the scope and complexity of the retrofit. The role of the Project Engineer is to turn this information into an executable package, including cost and manpower requirements, which can be executed across the fleet of identified plants. Retrofit Programs are typically given a 3-year time window for completion.

***Retrofit Program Example***

Company XYZ operates a global fleet of hydrogen production plants which were designed and built by the company’s Engineering team. While each plant was designed according to the internal and external standards that existed at the time the plant was designed, the safety systems were not consistent between plants. This inconsistency occurred because existing standards evolved and new standards were issued as time progressed resulting in gradual changes to safety system design.

Legacy plants did not contain the same safety systems or features embodied in the current plant design. As a result, the fleet of hydrogen plants had a variety of Safety Instrumented Systems (SIS) in operation, ranging from hard-wired trips on older plants to IEC 61511 compliant SIS on newer plants. In addition, identical hazards in different plants were not universally assigned the same Safety Integrity Level (SIL) nor managed in the same way.

The differences in SIS and SIL across the plants in the fleet were recognized by the Plant Process Engineering team. The Director for this team implemented a retrofit project to review SIS and SIL across the global fleet of hydrogen plants. The objective was to standardize the safety systems by upgrading the legacy plants to make their safety systems consistent with current standards. A small team of Plant Process Engineers, Process Safety Engineers and Operators were assigned to develop an upgrade plan.

The upgrade plan was developed in about 6 months and subsequently implemented over the next 3 years at planned maintenance outages. The program had the support of the Global Vice President for the business who recognized the necessity of upgrading the SIS in legacy plants to ensure safe operation. Actions taken during implementation of the upgrade plan included:

1. Replacing hard-wired safety systems with modern IEC61511 compliant SIS.
2. Standardizing SIL levels across all plants for identical hazards and upgrading Safety Instrumented Functions (SIF) to obtain the required SIL level.
3. Separating sensing and control elements in cases where they were shared by the Basic Process Control System (BPCS) and the SIS so that truly independent layers of protection were achieved. This objective was accomplished by retrofitting additional sensing and control elements for the SIS that were separate from the BPCS elements.
4. **Resources Required**

*Use this section to describe the resources required to execute the program. Please include information on the human resources and the financial resources that were needed, including specific skill sets. Discuss whether external technical resources were required. Be as specific as possible (e.g. – the program required 2000 man-hours and had a budget of $350,000). Include information about the project schedule in this section.*

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The successful implementation of the hydrogen plant safety standards retrofit program required a cross-functional team with expertise in Process Design, Plant Operation, and Process Safety. These technical resources were already working within the company but needed to be assigned to the retrofit program. In order to prevent resources from being overloaded, retrofit programs at individual facilities were developed 6-12 months in advance of planned outages so that resources could be assigned in an orderly manner. There were resource shortages in many instances. When shortages of technical resources occurred, the company shifted resources from other areas such as Plant Design and Engineering into Operations to support projects on a short-term basis. A side benefit was the ability to provide Plant Design Engineers with in-plant experience during periods of slow Plant Design workload.

Funding for retrofits is provided by a multi-million dollar fund authorized by the Chairman of the company. The Regional Commercial Directors and Operations Directors are accountable for implementing the approved programs. The RSC Chair reports annually to the Corporate Risk Council. The annual report includes progress updates on all Retrofit Programs, spending on Retrofit Programs, and new Retrofit Programs approved in the past year by the RSC.

Retrofit projects were added to the list of authorized projects at planned maintenance outages and managed as part of the overall outage project list. Managing the safety retrofits in this way assured that resources were assigned to complete the work, that the work was sequenced in the overall outage schedule, and that any required equipment purchases were completed prior to commencement of the retrofit work.

1. **Critical Success Factors**

*Describe Critical Success Factors in this section. Also use this section to comment on the Process Safety Culture that existed before the program was implemented and how it evolved after completion of the program.*

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There were several Critical Success Factors that were crucial to the successful completion of the program.

1. Project Champion: The project champion was the Global Director for Plant Process Engineering, who along with his team of Plant Process Engineers, identified the need for and developed the scope for the project. The project champion secured funding and manpower for the project from the VP for Operations and VP for the Hydrogen Business.

1. Financial support from the executive level: The project spanned three years and had a budget in the range of $1-$5 million US dollars. Financial support was absolutely necessary for the project to proceed and succeed.
2. Education: An element of the plan was an explanation of why each identified improvement was required. These justifications were shared with the operating staff at each plant so that they would understand the reasons for the upgrades. In addition to the written explanations, a training program was developed for Operators to ensure that they understood the changes to plant operation (and shutdown) resulting from the Process Safety Retrofit and for the Maintenance teams so that they understood the requirements for maintaining functionality of the SIFs.
3. Well-established Process Safety culture in existence at start of project: The company had a well-established Process Safety culture and this culture facilitated acceptance and approval of the project. The culture was an enabler. Following completion of the project, the Culture was reinforced as the resources expended to complete the project brought about the anticipated benefits.
4. Variable compensation for company employees tied to safety performance of operating facilities: A portion of each employee’s variable compensation was tied to the safety performance of the company, which included Process Safety incidents at operating facilities. Employees were required and expected to improve safety every year. A way to do this was to identify opportunities for improvement and develop programs specifically tailored to deliver improvement in safety performance.
5. **Challenges**

*Describe the challenges overcome. Provide information about the strategies and practices that were successful in overcoming challenges. Types of challenges include financial, lack of human resources, lack of needed technical skills, culture, and change management. Did you have to make any “course corrections” as the program was being implemented?*

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The main challenge was explaining the benefits of the program to the various stakeholders. The primary program benefit was improved safety performance in plant operations – with a stated goal to achieve a reduction in Tier 1 and Tier 2 process safety incidents. Plant Managers and Maintenance Managers were wary of adding safety retrofits to already-crowded project lists and planned outages. Engineering team managers had concerns about availability of engineers and other technical resources to work on the retrofits. The human and financial resources required were significant, with the main benefit being an improvement to an already good safety record in plant operations.

The challenge was overcome through a variety of means. Benefits beyond an improvement in process safety performance were identified and included in the program. Program champions realized that the retrofit program could reduce the number of spurious plant trips resulting from aging safety systems. This increased reliability would be realized as increased revenue from production and on-stream bonuses. By standardizing safety systems across the fleet, the engineering resources assigned to support the fleet could support a greater number of plants as the variability in safety system design across different plants was reduced or eliminated.

1. **Metrics and Sustainability**

*Use this section to describe any metrics that were implemented or tracked to determine the success of the program. Discuss actions taken to ensure that the program is sustained and continues to deliver benefits going forward. Discuss any Lessons Learned that could be helpful to other companies interested in starting a similar program.*

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The overall objective of the program was to update process safety systems installed in operating facilities to realize a reduction in the number of Tier 1 and Tier 2 incidents. For this reason, the number and severity of Tier 1 and Tier 2 incidents before and after program completion were tracked and compared. Another metric that was tracked was plant reliability/availability, before and after program completion.

1. **Benefits and Results**

*Use this section to describe the specific benefits obtained. Be as specific as possible (e.g. – employee injuries decreased by 37% as a result of the program). Were any unexpected benefits realized? Include any “soft benefits”, such as a culture change, that were realized.*

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Tier 1 and Tier 2 Process Safety incidents in the hydrogen-producing facilities decreased following the completion of the program. The added benefits of fewer spurious trips leading to increased on-stream time, increased production, and increased reliability bonuses were also realized. Specific details cannot be provided as this information is considered Company Confidential.

1. **Advice to other people/companies who want to implement a similar program**

Start small. Pick a specific facility or unit operation for a safety retrofit program. Assign experienced technical resources to develop the scope of the project. Be cautious to limit the scope to the amount of work that can be accomplished in the planned maintenance outage timeframe. Incorporated the program within the overall maintenance outage schedule, rather than attempting to run the safety retrofit program as a standalone project during the planned outage. After the first program has been implemented, audit the work process to determine which aspects went well and which aspects could be improved. Realize that the benefits will not be evident on Day One or even in Year One but will manifest over time and accrue for the remainder of the operating lifetime of the facility.