

## **Incorporating Prevention through Design Methods into the Design/Redesign Process**

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### **Introduction**

“Prevention through Design” (PtD) is a concept that resonates in a very positive way with environmental, health, and safety (EHS) professionals. It is a sensible and useful approach in assessing and addressing workplace hazards and risks. But to move from agreeing in principle with PtD, to implementing it in practice can be a daunting task. This paper offers an approach that will help EHS practitioners to incorporate PtD methods into their organizations’ design and redesign processes. The paper highlights NIOSH’s Plan for the National PtD Initiative and discusses what safety professionals, industrial hygienists and other EHS personnel need to know and understand about PtD methods, the design/redesign process, and key elements for successful PtD implementation.

### **NIOSH Plan for the National PtD Initiative**

NIOSH published a *Prevention through Design Plan for the National Initiative* in 2010. (NIOSH 2010) The mission of the Initiative is: “To prevent or reduce occupationally related injuries, illnesses, fatalities, and exposures by including prevention considerations in all designs that affect individuals in the occupational environment.” (NIOSH 1) The Plan outlines a systematic three-step approach to:

- First, create awareness of PtD in all industrial sectors, in organizations and agencies and at schools and universities, by sharing the benefits of PtD, success stories, and financial returns,
- Second, obtain a commitment from businesses, organizations, and workers to incorporate PtD into work processes and safety and health management systems, and
- Third, monitor the impact of PtD on eliminating hazards and minimizing risks to ensure that appropriate program and process adjustments occur as needed. (NIOSH 4)

### **First Seek to Understand...**

If you were given the task of guaranteeing that PtD methods were incorporated into all of your organization’s capital projects, you would benefit by first acquiring a basic knowledge and understanding of the following three subjects: 1) What are PtD methods, 2) How does the design/redesign process work in your organization, and 3) Who are your key PtD partners?

### What are PtD Methods?

NIOSH has defined the core methodology of PtD through the following three-point strategy to achieve the mission of the National Initiative:

- Eliminate hazards and control risks to workers to an acceptable level *at the source* or as early as possible in the life cycle of equipment, products, or workplaces.
- Include *design, redesign, and retrofit* of new and existing work premises, structures, tools, facilities, equipment, machinery, products, substances, work processes, and organization of work.
- Improve worker safety and health through the inclusion of prevention methods in all designs that impact workers and others on the premises. (NIOSH 6)

### How does the Design/Redesign Process Work in Your Organization?

Another prerequisite for successful PtD implementation is understanding where in your organization the design/redesign process resides, who owns the process, and how it works. Design and redesign are normally at the heart of an organization's capital project delivery process (CPD). This process is the mechanism used by an organization to manage the development and execution of capital projects from idea conception through start-up and process optimization. The CPD process is typically owned by the central engineering/construction function and the manufacturing/operations function, and is normally executed following a stages-and-gates approach. We will return to the CPD process later in the paper as this process provides the framework to incorporate PtD into design and redesign projects.

### Who are Your Key PtD Partners?

It is also essential in implementing PtD to understand who your key partners are, and how you as an EHS professional can work with them to incorporate PtD into the design/redesign process. There could easily be twenty or more internal and external partners. They would include your organization's internal EHS staff, engineering, operations and procurement, and external partners such as design, engineering and construction contractors, regulatory agencies, insurance carriers, and suppliers of equipment, materials, and technology.

### The Path Forward

Once these key aspects of PtD are identified and understood, the EHS professional is well positioned to proceed forward on the path to incorporate PtD into his/her organization's design/redesign process. The path forward involves the following key elements: (Renshaw 50)

1. Setting Policy and Standards
2. Establishing Work Processes and Procedures
3. Applying Tools and Practices

## **Setting Policy & Standards**

The first key element in implementing PtD involves policy and standards setting. Creating awareness of PtD and obtaining management's commitment to incorporate PtD methods into their organization's EHS policy and management systems are key success factors in implementing PtD programs. This does not mean the awareness and commitment stages of PtD adoption need always start at the highest levels within an organization.

Much can be said for an evolutionary rather than a revolutionary approach in creating awareness and gaining commitment to PtD. The evolutionary approach can be depicted as a steady climb up the stairs, whereby key stakeholders such as engineering, manufacturing, procurement and EHS professionals are familiarized with key concepts, benefits and success stories. Early engagement and frequent dialogue with key stakeholders is a critical step in gaining their commitment and support for formal PtD adoption by top management. Without the support of these functions, implementation may at best be delayed and at worst fail as an unsustainable initiative.

Once it is decided at the highest levels in the organization that the PtD approach will be used, this decision should be formalized and communicated in writing by inclusion in the organization's EHS policy statement. Elevating PtD to the level of a "guiding principle" much like sustainability, continuous improvement, and a commitment to full regulatory compliance, lends the necessary visibility and importance to PtD at the policy level.

If the organization operates within an EHS or OHS management system framework such as ANSI/AIHA/ASSE Z-10 or OHSAS 18001, PtD methods need to be hard coded into the sections of these management system standards that cover "Management Leadership – OHS Policy", and the "Operational Elements" sections, which cover "Design Reviews and Management of Change". (ANSI/AIHA/ASSE 10, 18) (BSI 5, 6-7)

## **Establishing Work Processes and Procedures**

The second key element of PtD implementation involves the establishment of work processes and procedures or modification of existing ones such that PtD methods are integrated at a working level with the design/redesign process of the organization. The two work processes which are best suited for integration with PtD methods are Capital Project Delivery (CPD) and Management of Change (MOC). By incorporating PtD into these two processes, the cornerstones of safe designs – hazard analysis and risk assessment – have a high likelihood of being applied on a regular and timely basis.

### Capital Project Delivery (CPD)

The CPD process typically follows a stages-and-gates approach with discreet stages covering each project phase from Stage 1 – Project Initiation through Stage 7 – Project Closeout. The following list of project stages is typical of a well functioning CPD process.

- Stage 1 – Project Initiation
- Stage 2 – Specify and Select Option
- Stage 3 – Detail Option
- Stage 4 – Final Design and Procurement
- Stage 5 – Construction
- Stage 6 – Start-up
- Stage 7 – Project Closeout

A key feature of the stages-and-gates approach is the definition of critical project execution and design activities called *deliverables* at each stage, and specific points of project review and approval called *gate meetings*. These gate meetings are normally held at the conclusion of each project stage. They serve as key checkpoints to ensure that the necessary level of engineering design and documentation has been provided; that the required design and technical reviews have occurred; and that the project is viable and ready to proceed to the next stage.

The stages-and-gates approach offers a unique opportunity for organizations to incorporate PtD methods such as EHS design reviews into their CPD process. In order to capitalize on this opportunity, each project's EHS deliverables must be defined and synchronized with the project's execution and design deliverables for each project stage. This synchronization process is illustrated with a typical list of occupational safety and health (OSH) deliverables for Stage 2 of the CPD process in Table 1.

<b>Stage 2 - Project Execution/Design Deliverables</b>	<b>Stage 2 - OSH Deliverables</b>
Refined goals and objectives	OSH Design Review requirements defined
Select best option	OSH Hazard Analysis & Risk Assessment requirements defined, studies initiated
Preliminary project execution plan & schedule	Regulatory and permitting requirements defined
Preliminary design basis & process description, preliminary P&IDs, PFDs, control philosophy, site plan, raw materials list, preliminary major/critical equipment lists	Insurance assessment complete, fire protection and security requirements finalized
Finalized economic analysis/conceptual cost estimate	Equipment specifications approved, checks and test protocols developed

**Table 1. Example of the synchronization of Project Execution and Design Deliverables with OSH Deliverables for CPD Stage 2 – Specify and Select Option.**

As mentioned earlier, project gate meetings serve as key checkpoints to ensure that the necessary level of engineering design and documentation has been provided and that the required design and technical reviews have occurred. Various recording methods are used to verify and document that all requirements have been addressed. One example is the Planning Template (see Table 2) that lists the deliverables for each project stage and a final sign-off by the project manager or by a representative of the group responsible for the deliverable.

<b>OSH Deliverable</b>	<b>Description</b>	<b>Date Complete (mm/dd/yy)</b>	<b>Deliverable Documented (Y/N)</b>	<b>Action Tracked (Y/N)</b>	<b>Proj Mgr Review (Y/N)</b>
2.2.1	OSH Design Review Requirements Defined				
2.2.2	Hazard Analysis & Risk Assessment Requirements Defined				
2.2.3	Regulatory & Permitting Requirements Defined				
2.2.4	Insurance Assessment Complete, Fire/Security Requirements Defined				
2.2.5	Equipment Specifications Approved, Checks & Test Protocols Developed				

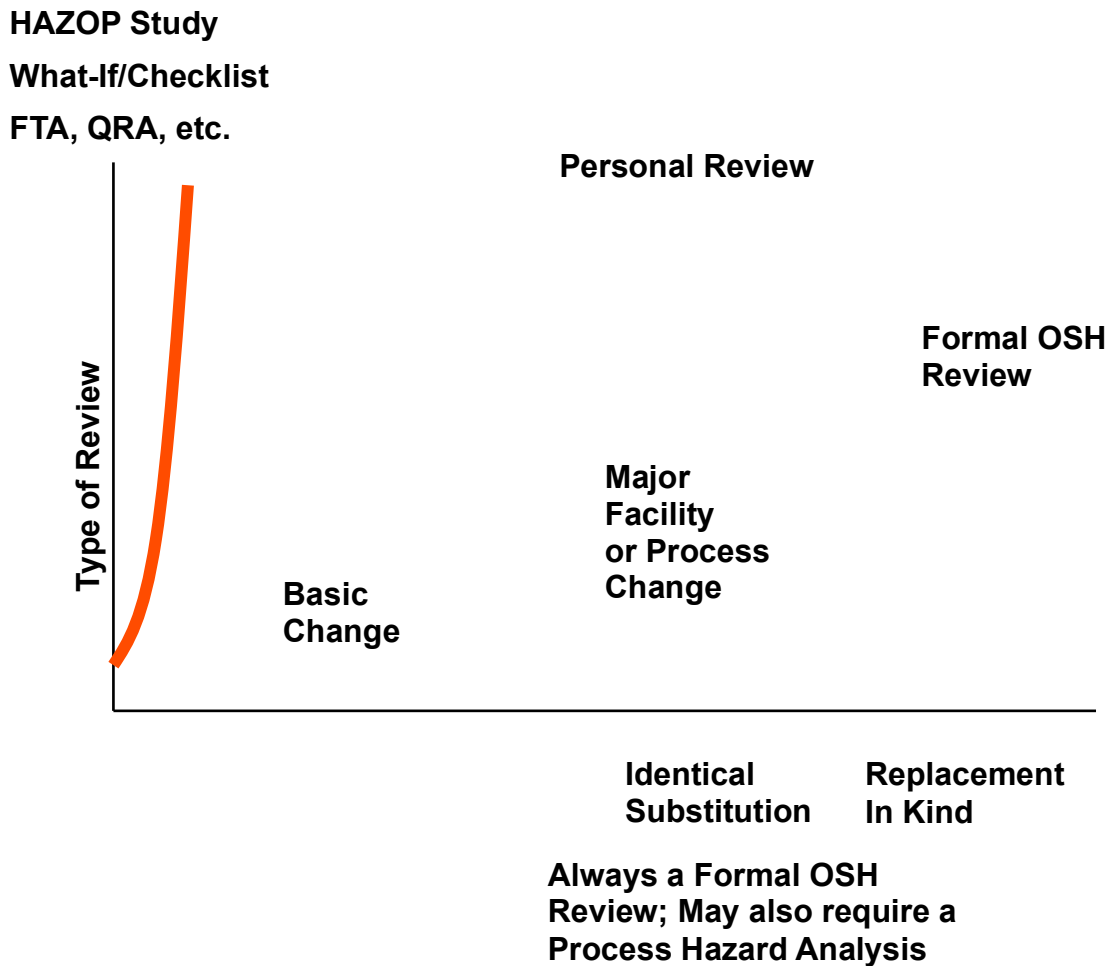
**Table 2. An OSH Deliverables Planning Template is shown for CPD Stage 2 - Specify and Select Option.**

#### Management of Change (MOC)

Management of change (MOC) is the second work process, which needs to be a focal point for PtD integration. The MOC process is defined as a system to assess and address the EHS impact of changes to a process, facilities, or organization before the changes are made. What makes MOC successful is adherence to these key principles:

- Every change must be managed.
- Changes must NOT be made without an appropriate review.
- The type of review should be consistent with the complexity of the change.
- MOC systems should be simple to use.

This first principle underscores the fact that MOC is by no means meant to be restricted for use with major projects. It is intended to be used for projects of all sizes. The second MOC principle calling for review of all changes before the changes are made, aligns well with PtD which calls for the elimination of hazards and control of residual risks at the source or as early as possible in the life cycle of a project. This is best accomplished through the review process, drawing on appropriate hazard analysis and risk assessment methods. The third MOC principle is the mechanism that enables all changes to be properly reviewed. This principle addresses the practicality of reviewing the volume of changes to be encountered by matching the complexity and resource requirements of the review process to the level of change under review. This matching of the level of change to the type of review is illustrated in Figure 1.



**Figure 1. Matching the type of OSH review to the level of change is a critical and enabling part of the management of change process.**

## **Applying Tools and Practices**

The third key element in implementing PtD involves the application of hazard analysis and risk assessment tools, and the translation of established safe practices into safe designs. This is the phase of PtD implementation in which the inputs and outputs of PtD are brought to life.

### Applying Hazard Analysis and Risk Assessment Tools

The selection and use of hazard analysis and risk assessment tools such as EHS design reviews, process hazard analyses, and industrial hygiene exposure assessments dominate this step in PtD implementation. The choice of which tools to use and at which stage in the CPD process is a determination that needs to be made by each organization based on its operations, experience, and past success. There are many excellent tools and sources of guidance in their use such as ASSE's standard, ANSI/ASSE Z590.3 – 2011: Prevention through Design, Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes. (ANSI/ASSE 2011) The Center for Chemical Process Safety (CCPS) is another important source of guidance in the use of process hazard analysis (PHA) methods and management of change. (CCPS 2008) The CCPS

tools are especially well suited to process safety hazards involving fire, explosions, and toxic vapor cloud releases. The American Industrial Hygiene Association offers excellent guidance in conducting exposure assessments through their “Strategy for Assessing and Managing Occupational Exposures”. (Ignacio 2006)

### Translating Safe Practices into Safe Designs

Safe practices, like hazard and risk assessment tools, need to be identified, validated and translated into safe designs by each organization. These practices are typically documented in consensus standards, external and internal industry codes of practice, and government regulations. Adherence to the core PtD concept, “Hierarchy of Controls”, as illustrated in Figure 2, is a critical success factor in implementing PtD. (Schulte & Heidel 2) ASSE’s guidance in their latest PtD standard is an excellent resource in applying the hierarchy as a governing strategy in eliminating hazards and controlling residual risks at the design stage. (ANSI/ASSE 24)



**Figure 2. Following the traditional hierarchy of controls is a critical success factor for PtD.**

### Attributes of PtD Tools and Practices

While there are many PtD tools and practices to choose from, and much diversity in operations and design constraints across the business sectors, the tools and practices of greatest value in implementing PtD have the following features in common:

- Robustness
- Synchronization with CPD

- Applied Properly and Consistently
- By Competent People
- Working Together
- Straightforward and Simple

*Robust* tools are fundamentally strong, validated, and capable of performing without failure under a wide range of conditions. Process hazard analysis tools such as Hazard and Operability studies (HAZOP), Failure Mode and Effects Analysis (FMEA), and Fault Tree Analysis (FTA) exemplify this attribute and are widely used in the field of process safety. The use of top unloading versus bottom unloading designs for railcar and tank truck transfer stations is illustrative of a robust practice for hazardous materials handling.

*Synchronization* refers to the application of hazard analysis and risk assessment tools at the right stage in the CPD process. There can easily be twenty or more hazard analysis and risk assessment tools in use for personal and process safety hazards alone, not to mention the tools needed for industrial hygiene, environmental, and security risks on a project. Initiating the necessary assessments at the optimum time in the life of a capital project, and delivering the results in time to meet the designers' needs, contributes greatly to the success of a capital project.

*Proper and consistent application* is another common feature of the best PtD tools and practices. Use of standard designs is one of the best ways to ensure proper selection and installation of local exhaust ventilation over general mechanical dilution ventilation for the control of hazardous air contaminants. *Competency* in design and a commitment to *working together* are also important attributes of project team members. These attributes are necessary to maintain consistency in use of standard designs, and to maintain flexibility where issues of technical and economic feasibility call for alternative design approaches.

*Straightforward and simple* are attributes that can also contribute to successful application of PtD tools and practices. While some safety-related design issues, such as machine guarding and emergency pressure relief of vessels are by their nature complex, others such as the design and installation of emergency eyewash and shower units are good candidates for simplification. The use of checklists which are developed for specific safety devices such as eyewash/shower units, and edited to focus primarily on design-build-maintain requirements, can greatly simplify and satisfy the needs of the project design team.

## Summary

NIOSH's dissemination of a National PtD Initiative has focused the EHS community's attention on the elimination of hazards and control of residual risks at the source as the most effective way to address worker safety and health. The first step in implementing the PtD approach is to understand PtD methods, the design/redesign process, and key PtD partners within your organization. The path forward in implementing PtD involves three key elements: 1) setting policy and standards, 2) developing work processes and procedures, and 3) applying tools and practices. The two work processes which are best suited for integration with PtD methods are Capital Project Delivery (CPD) and Management of Change (MOC). By incorporating PtD into these two processes, the cornerstones of safe designs – hazard analysis, and risk assessment – have a high likelihood of being applied on a regular and timely basis. Successful implementation of PtD methods in your organization's design/redesign process will help ensure that prevention considerations are included in all designs that affect individuals in the work environment.



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