Design

Methods for Implementing PTD

By Frank M. Renshaw

Prevention through design (PTD) is grounded in the belief that designing out hazards is the most effective means to prevent occupational injuries, illnesses and fatalities. NIOSH-sponsored research has produced a model to guide organizations in implementing these methods. This article shares those elements.

IN BRIEF

- **Prevention through design (PTD) is grounded in the belief that designing out hazards is the most effective means of preventing work-related injuries, illnesses and fatalities.**
- **While the concept is embraced by most safety professionals, incorporating PTD considerations into new designs and redesign projects on a systematic basis can be a challenge.**
- **NIOSH-sponsored research has produced a model program to help organizations incorporate PTD methods into design/redesign processes.**
- **Each element of this model program is described and supported by examples.**

The first element includes PTD language for SH&E policies and management system standards. The second element provides strategic guidance for integrating PTD into capital project and management of change (MOC) work processes. The third element encompasses tactical guidance in applying hazard analysis and risk assessment tools. Design checklists and an industry case study are discussed as examples of translating safe practices into safe designs. The SH&E professional's role and importance in implementing PTD are reviewed as well.

PTD is a concept grounded in the belief that designing out hazards is the most effective means of preventing occupational injuries, illnesses, fatalities and exposures (NIOSH, 2010). While the concept is familiar to safety professionals, incorporating prevention considerations into new designs and redesign projects on a systematic basis can be daunting.

NIOSH addressed this challenge in 2007 by launching a national initiative (Schulte, Rinehart, Okun, et al., 2008) designed to raise awareness of the need to prevent or reduce work-related injuries, illnesses, fatalities and exposures by including prevention considerations in all designs that affect individuals in an occupational environment. NIOSH expects to accomplish this mission by helping employers apply hazard elimination and risk control methods in the design and redesign of work facilities, processes, equipment, tools, work methods and work organization.

NIOSH (2010) published a detailed plan in 2010 to implement its initiative with defined goals and activities in five major areas: research, education, practice, policy and small business. This article highlights findings from recent research that led to development of a model PTD program (Renshaw, 2011). The model provides PTD language for use in amending policies and standards as well as strategic and tactical guidance to help organizations incorporate PTD methods into their design and redesign process (see "PTD Methods" sidebar).

The model program is designed to support the development of a PTD culture and can be a stand-alone standard or can be integrated within an organization's safety management system. Guidance addresses three key elements associated with program implementation: 1) setting policy and standards; 2) establishing work processes and procedures; and 3) applying tools and practices (Figure 1).

Setting Policy & Standards

Creating awareness of PTD and obtaining management commitment to incorporate PTD methods into safety management systems and work processes are essential in implementing successful PTD programs (NIOSH, 2010, p. 4). This does not mean the awareness and commitment stages of PTD adoption need always start at the highest levels in 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 involves a steady climb up the stairs, whereby key stakeholders such as engineering, manufacturing, procurement and SH&E professionals are familiar with key concepts, benefits and, if possible, success stories. Early 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 top management and key stakeholders are aligned and committed to PTD adoption, that endorsement must be formalized and communicated

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through the organization's SH&E policy statement. The incorporation of PTD as a guiding principle elevates PTD to the same level of importance as other safety principles such as sustainability, continuous improvement and regulatory compliance. The specific language of the sample policy statement in the model program (Renshaw, 2011) is: "We will include prevention considerations in all designs and redesign of facilities, equipment, processes, work methods and products, and will incorporate safe design methods into all phases of hazard and risk mitigation."

PTD Methods

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

Note. *From* Prevention Through Design: Plan for the National Initiative *(p. 6), by NIOSH, 2010, Cincinnati, OH: U.S. Department of Health and Human Services, CDC, Author.*

Management's adoption of PTD also needs to be reflected in the organization's safety management system. Organizations operating within the framework of a formal system such as ANSI Z10 (ANSI/AIHA, 2005; ASSE/AIHA, 2012) will need to insert appropriate PTD wording in their standards that address safety policy, design review and MOC (Section 3.1.2, p. 12; Section 5.1.2, pp. 18, 19). Comparable sections of OHSAS 18001 (BSI, 2007) cover SH&E policy, hazard identification, risk assessment and hazard control (Section 4.2, p. 5; Section 4.3.1, pp. 6, 7).

Suggested PTD language for each section is included as proposed amendments in the model (Renshaw, 2011). These amendments formalize an organization's commitment to hazard identification early in the life cycle of facilities and processes, as well as its consideration of the hierarchy of control in eliminating hazards and enacting controls. Organizations that do not have a formal safety management system can incorporate PTD language into specific work processes and procedures.

Establishing Work Processes & Procedures

The second key implementation element involves the establishment of work processes and procedures, or modification of existing ones to include PTD methods. The strategic purpose is to integrate PTD into two key processes associated with design and redesign: the capital project process and MOC.

Capital Project Process

The capital project process (CPP) is a mechanism used to manage the development and execution of capital projects from idea conception through start-up and process optimization. By incorporating PTD into this process—the cornerstones, safety design reviews, hazard analyses and risk assessments—have a high likelihood of being applied on a regular and timely basis to capital projects.

Many companies manage and execute capital projects based on the formal Stage-Gate approach for managing projects in the new product development process (Cooper, 1993). The process involves discrete stages (Figure 2, p. 52) covering the life cycle of a project from stage 1, project initiation, to stage 7, project closeout (Dysert, 2002; Lawson, Wearne & Iles-Smith, 1999).

A key feature of this approach is the definition of critical project execution and design activities called *deliverables,* and specific points of project review and approval called *gate meetings,* normally held at the conclusion of each project stage. These meetings are key checkpoints that ensure that the necessary level of engineering design and documentation has been

Figure 1

Key Elements for Incorporating PTD Methods Into Design & Redesign Processes

Figure 2

Stages of the Capital Project Process

provided; that the required design and technical reviews have occurred; and that the project is viable and ready to proceed to the next stage.

This approach also provides a unique opportunity for an organization to integrate safety-related deliverables, such as design reviews, with the project execution and design deliverables of CPP. To capitalize on this opportunity, the project's safety deliverables must be identified and synchronized with the project execution and design deliverables for each project stage. For example, for stage 1 (initiation), project execution and design deliverables may include development of a project mission, goals, objectives, scope and a project execution strategy.

Corresponding safety deliverables may include a preliminary SH&E project plan, a preliminary regulatory and permit plan, early identification of significant and unique SH&E hazards and risks, and early identification of PTD opportunities. Table 1 lists potential project execution and design deliverables and SH&E deliverables. Identifying and synchronizing safety deliverables with project execution and design deliverables is a critical contribution an SH&E professional can make in implementing PTD methods. Renshaw (2011) provides a sample list of SH&E deliverables for all project stages.

Verifying and documenting the completion of committed SH&E deliverables at the conclusion of each project stage is an important part of CPP. Methods to accomplish this step vary in sophistication among organizations. The template shown in Figure 3 is an example. This template requires that the project manager provide sign-off on each SH&E deliverable. In other cases the sign-off responsibility may reside with the project team member who is accountable for the deliverable in question.

Table 1

Example Project Deliverables for Capital Project Process, Stage 1: Project Initiation

CPP stage 1: Project execution/design deliverables	CPP stage 1: OSH deliverables
Project mission, goals and objectives	Preliminary OSH project plan
Project manager, customer/owner identified	Preliminary regulatory and permit plan
Initial options generated and screened	Early identification of significant and unique OSH hazards and risks
Project execution strategy	Early identification of PTD opportunities
Order of magnitude estimate of cost	Early OSH hazards and risk review

Bender (2011) reported on a sign-off process involving a proprietary Microsoft Access/Visual Basic desktop application. This system requires that SH&E activities such as design reviews have been completed and that specific SH&E-related features have been included in the final designs. Whatever approach is used, completion of the specified safety deliverables is necessary for the project to progress through subsequent stages and, ultimately, to project completion.

Management of Change

An MOC process is normally used to address the effect of major and minor changes on safety. (U.S. establishments covered by OSHA's Process Safety Management Standard and those with Program-3-covered processes under EPA's Risk Management Plan Rule must implement MOC procedures for all changes to facilities, process chemicals, technology, equipment and procedures except *replacement in kind* changes).

Like CPP, the process provides a strategic opportunity to incorporate PTD methods into design and redesign. Linking PTD methodology to the MOC process helps to ensure that SH&E design reviews, hazard analyses and risk assessments are conducted before a change is made. A well-executed MOC process also ensures that appropriate PTD methods are used to properly classify the level of each change. Figure 4 illustrates how the level of change should drive the type of review.

The model PTD includes a model MOC standard (Renshaw, 2011). It defines the MOC process and provides a flowchart to follow in addressing change; it also contains definitions of the various levels of change and examples of popular SH&E design reviews, hazard analysis and risk assessment techniques. Furthermore, by linking PTD methods to the MOC process, an organization better ensures that prevention methods are carried through to the final designs associated with each change.

Applying Tools & Practices

The third element of PTD implementation involves the application of hazard analysis and risk assessment tools, and the translation of established safe practices into safe designs. The tools of reference include SH&E checklists; hazard analysis methods such as

Figure 3
OSH Deliverables Planning Template

Project:
Manager:
Date:

OSH deliverable	Description	Date complete mm/dd/yy	Deliverable documented (Y/N)	Actions tracked (Y/N)	Project manager reviewed (Y/N)
1.2.1	Preliminary OSH project plan				
1.2.2	Preliminary regulatory and permit plan				
1.2.3	Early identification of significant and unique OSH hazards and risks				
1.2.4	Early identification of PTD opportunities				
1.2.5	Early OSH hazards and risks review				

hazard and operability (HAZOP) studies (Charsley, 1996; Charsley & Brown, 1993) occupational exposure assessment strategies (Ignacio & Bullock, 2006); and risk assessment techniques such as the risk estimation matrix (ANSI/AMT, 2007). ANSI/ASSE Z590.3-2011 reviews and offers guidance on the selection and use of hazard analysis and risk assessment tools. The model PTD program (Renshaw, 2011) also includes a sample listing of tools for use in each stage of CPP.

The PTD practices of reference include design features that eliminate the hazard, or that control residual risks where elimination is not practicable. These practices are typically documented in consensus standards, industry codes of practice and government regulations. PTD supports adoption of hazard control measures according to the traditional hierarchy of controls (Figure 5, p. 54; Schulte & Heidel, 2009).

Application of closed system designs for HazMat handling is an effective application of PTD principles. For example, in a case study involving batch-type specialty chemical operations, retrofitting of process vessels with vapor tight closures and substitution of liquid grades of HazMats in place of solid grades enabled closed system transfers (Renshaw, 2002). Installing materials handling machinery to reduce airborne contaminant hazards and ignition sources due to static electricity also improved safety. Photos 1-3 (p. 55) illustrate the use of PTD technology to replace manual, open-system transfer and charging of small-quantity additives with closed systems that employ remotely controlled transfers directly from the shipping container to the processing vessel.

Compiling safety features from recognized standards and codes into a checklist is another effective means of translating safe practices into safe designs. This approach can be especially useful to small businesses, which may find it burdensome to seek out and interpret safe design requirements for specific hazards. The model PTD program includes a checklist that covers all design features needed to ensure accessibility, reliability and effectiveness of emergency eyewash and shower units (Renshaw, 2011). The checklist captures essential design requirements such as unit location, water flow rates, flow patterns and operability in layperson's terms.

Role of SH&E Professionals in PTD

SH&E professionals serve as a bridge between the science and culture of the function, and an organization's managers, technical staff, supervisors and employees. This role places SH&E professionals in a unique position to facilitate the implementation of PTD. They should serve as champions for the approach and advocate that prevention be considered in all designs that affect workers. They should review capital project plans for SH&E deliverables and advise project managers in the selection, use and resourcing of hazard analysis and risk assessment methods. In addition, SH&E practitioners should make themselves available and participate in project design reviews, hazard analysis and risk studies, and on-site assessments.

SH&E professionals should share their expertise

Figure 4
Management of Change

Matching the type of OSH review to the level of change is a critical part of the management of change process.

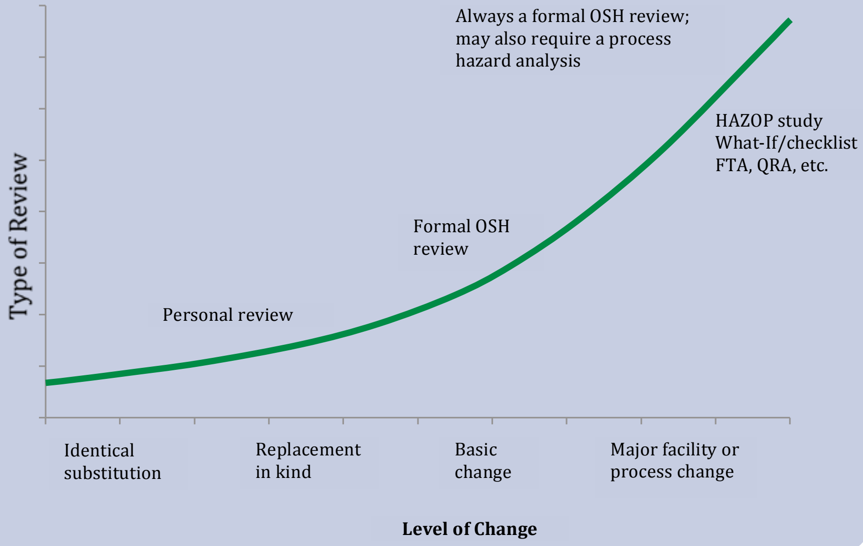

Figure 5
Traditional Hierarchy of Controls

and knowledge of safe designs through frequent interactions with capital project team members.

However, in some cases, the offering of design solutions should be restrained. Most hazard elimination and risk control solutions are grounded in engineering and physical sciences, and are documented in technically oriented regulations and industry practices. Therefore, this body of knowledge and its proper application may be beyond the competencies of many SH&E professionals. Codes of professional conduct require SH&E practitioners to recognize the limitations of their professional ability and provide services only when qualified by education and experience in the specific technical fields involved (ABIH, 2007; ASSE, 2012; BCSP, 2002). These codes also obligate SH&E professionals to continually strengthen their knowledge, skills, competencies and awareness of new developments that should include topics related to PTD.

SH&E professionals should be mindful of their role as verifiers on design and redesign projects. Selecting and designing hazard elimination and risk control solutions may be outside the scope of an SH&E professional's ability and experience as noted. However, verifying that committed hazard elimination and risk control measures are carried through to project completion and are effective is a legitimate role for safety professionals.

Conclusion

NIOSH's PTD initiative has focused the SH&E community's attention on hazard elimination and risk control as the most effective way to address worker safety and health. Capturing the attention of industrial sectors and organizations regarding the PTD approach and benefits is a work in progress.

The PTD model presented is designed to help businesses and organizations incorporate PTD methods into their design and redesign process. It can be a standalone element or incorporated into an organization's safety management system. Organizations with well-developed safety management systems should be able to adapt their policies, work processes, tools and practices to include the recommended methods. Small organizations may be more challenged to adopt PTD due to limited resources focused largely on conformance with external and internal standards.

Organizations can benefit from the PTD model by selectively adopting aspects that meet their greatest needs. For example, a small chemical manufacturer may adopt an internal standard to control/eliminate open systems. A metal fabricator might adopt an internal machine safety standard that includes the risk assessment and engineering control provisions of ANSI B11.0 (ANSI/AMT, 2010a) and ANSI B11.19 (ANSI/AMT, 2010b). Such an approach would bring both businesses into closer alignment with PTD.

The model presented leverages the CPP and MOC work process as key steps in integrating PTD with design and redesign. These two processes provide the best opportunity for organizations to sustain a PTD approach. SH&E professionals must ensure that safety deliverables are synchronized with project execution and CPP design deliverables. In addition, SH&E professionals must work with management to define the levels of change in an organization and ensure that appropriate hazard and risk reviews are completed before changes are made.

While some SH&E professionals may feel their knowledge and experience are too limited to recommend specific hazard analysis or design solutions, they should still participate in the CPP and MOC process. Doing so helps verify that safe designs are carried through to the final, as-built installation. **PS**

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(From top): Use of PTD methods to replace open-system transfer of hazardous raw materials in small quantities (Photo 1) with automated closed-system transfers (Photos 2 and 3).

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