Session No. 617

Abating Fall Hazards before They're Created

Steven Gregory, CSP
Owner
Deepwater Energy Loss Control Services
Sugar Land, TX

Nolan Miller, P.E., CSP
Project Manager
LJB Inc.
Lima, OH

Introduction

Although it may be easier to see the hazards in an existing structure, it is safer and more cost effective to implement fall protection before structures or processes are built. This paper focuses specifically on the benefits and process of abating fall hazards before they're created. This is possible when safety measures are evaluated and implemented during the programming and design phases of a project.

This approach to safety has been promoted and applied in different ways. The concept of Safety through Design was introduced in the 1940s, but the design and construction industries did not begin adopting the process until the 1980s. [1] Then in early 2012, a new consensus standard related to this concept, entitled *Prevention through Design*,[2] was made effective by the American National Standards Institute (ANSI). No matter what the concept is called, evaluating and implementing safety measures during the programming and design phases of construction ensures optimal safety for workers—from construction into operations and throughout ongoing maintenance. Besides the obvious enhanced safety benefits, addressing safety concerns early in the design process will significantly reduce the cost of addressing fall protection issues.

In this paper, a sample case study helps explain the basic benefits of incorporating fall protection measures into the design process. While the nuances of every project are different, the basic elements involved in moving these discussions earlier in the project timeline will provide safety, productivity, and cost benefits. To address all the factors, it is essential to gather the right team, including engineering, operations, and maintenance personnel.

The impact to bottom line cost can be dramatic. When considering whether to evaluate fall protection during design, the question should not be how much will it cost if we wait until the

---

[1] Automotive Industry Action Group (AIAG). *Future Trends in Manufacturing Safety Through Design: Past Efforts and Current Crossroads* (retrieved December 8, 2011) (http://*www*.aiag.org/StaticContent/files/FutureTrends.pdf)

[2] American National Standards Institute (ANSI). 2011. *Prevention through Design Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes* (ANSI Z590.3-2011). Des Plaines, IL: American Society of Safety Engineers (ASSE).

end? Instead, the question is: How much can be saved if the hazards are abated now? This is no different from any other engineering discipline, where it is more cost effective to engineer a solution during the design of a project, rather than arriving at a solution and retrofitting during operations.

Benefits

The primary benefits of abating fall hazards during the design phase of a project relate to inherent safety and cost benefit. This proactive approach helps organizations focus on these two critical aspects that help reduce overall safety and financial risk.

Safety

When fall protection is implemented during the design phase, safety can be incorporated at an appropriate stage during the design process. So, the Hierarchy of Control (Exhibit 1) can be optimized, by evaluating each potential solution's effectiveness and defeatability. More effective and safer solutions such as hazard elimination, engineering control strategies, and the general principal to stay toward the top of the Hierarchy of Control can be incorporated into the original design.

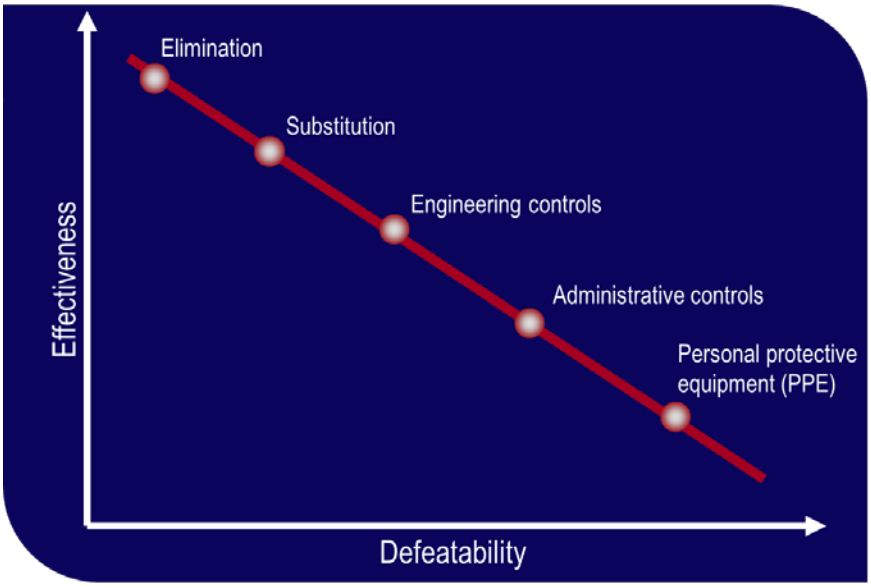

Exhibit 1. This chart shows the Hierarchy of Controls, moving down from most to least acceptable.

If fall protection measures are not incorporated during design, abatement options are often limited. Essentially, the ability to apply the Hierarchy of Control is compromised due to the lack of pre-planning. Although it can still be considered by evaluating a solution's effectiveness and defeatability, field conditions often dictate how a hazard is abated. In certain cases, the only possible means of protecting employees is through the use of personal protective equipment (PPE), which is in the lowest position on the Hierarchy of Control. PPE is often required due to existing interferences and inability to access the area with appropriate engineering controls unless significant, costly modifications are made. In addition, all interferences, connection details, layout issues and required clearances must be field verified, and details must be developed and

designed to match existing conditions. Additional framing may also be required to work around existing equipment, requiring costly physical modifications to the structure.

Another concern is that fall protection solutions developed in the field are often handled by inexperienced personnel, working under pressure. In these cases, inadequate solutions may be adopted, with over-reliance on PPE.

Cost

A study conducted by an international consumer-goods manufacturer showed that implementing safety measures during the conceptual design phases of a project resulted in substantially lower costs than implementing systems during or after construction.

The following chart (Exhibit 2) summarizes the relative cost required to achieve the same level of safety for a given hazard based on when the hazard is identified and abated during the design and construction process. Incorporating safety during the design stage saves money because designers do not even need to erase lines on their drawings—the safety aspects are simply programmed into the design. Implementing the same solution during operations would be far more costly. Using the optimal solution may not be possible since it cannot be fitted in the field, forcing an inferior alternative to be adopted. In the example portrayed in Exhibit 2, implementing safety during conceptual design represents a base cost ($1) to abate the hazard.

If fall protection measures are implemented after a project is completed, the cost to abate the hazard increases due to the following elements:

- Costs of design
- Production of additional drawings for hazard abatement
- Mobilization of the contractor
- Potentially significant field modifications
- Potentially significant rework of interferences
- Long-term costs of not using the ideal abatement method
    - Costs associated with using a potentially riskier (more easily defeated) means of hazard abatement, such as PPE

Project Phase	Cost Factor
Conceptual Design	$1
Final Drawings	$10
Field Modifications	$100
Start-up and Debugging	$1,000
Post Completion	$10,000

Exhibit 2. This chart compares the costs of implementing fall protection at different project stages.

Short-term and recurring costs, as well as productivity gains and losses, should also be thoroughly considered prior to selecting abatement solutions. A simple example is evaluating engineering controls (such as platforms with guardrails with a fixed ladder) versus a personal fall-arrest system. With an engineering controls solution, short-term costs include design, procurement, and basic employee training. On the other hand, a PPE-based system requires these same costs, plus recurring costs related to time for equipment inspections or modifications, advanced employee training, periodic re-training of personnel, equipment replacement purchases, rescue considerations, and productivity losses. Engineering controls typically allow workers to perform their tasks more quickly, efficiently and safely, while PPE solutions require pre-planning, inspection, donning and doffing, and storage.

Case Study: Process

When companies plan large building projects, there are many factors to consider. Even within the safety category, there are so many different issues to consider, that fall protection is often overlooked. When a petrochemical organization planned the construction of a new offshore platform, they decided to incorporate fall protection considerations into the front end engineering design (FEED) and detailed design stages of the project. From previous experience, the organization's leadership understood the ramifications of incorporating fall protection measures after a platform was operational.

To improve safety for workers and minimize the impact to operations, the project management team invited a fall protection consultant to assist the design team by providing fall protection expertise. The design team and fall protection consultant worked through the following process to incorporate fall protection.

Kick-off meeting with design team: The initial step was a kick-off meeting with the design team so that every team member could better understand the fall protection issues that could be considered during the design process for the project.

Having a fall protection consultant involved helped the entire team better understand the importance of proactive safety approaches and how employees could be best protected from potentially dangerous or fatal situations. At the start of the project, specific concerns related to fall protection emerged through a survey given to operators and members of the design team.

Virtual fall hazard risk assessment: With a baseline of information about the project and the specific fall protection issues, the team moved into hazard identification and risk assessment. Using a 3-D model of the project, the fall protection consultant conducted a "virtual" fall hazard risk assessment of the platform. Essentially, safety professionals who are experienced in fall hazard risk assessments for petrochemical facilities used the model to identify potential fall hazards. Then, they documented these hazards along with possible abatement solutions.

Design team workshops: The virtual fall hazard assessment was followed by a workshop for both the topsides and the hull. During the workshops, the team used the 3-D model to "walk through" the structure to review the pre-identified fall hazards. Because the fall protection consultant performed the fall hazard assessment independently, the workshops provided the opportunity to complete the assessment with the input of the stakeholders, who provided additional context to the specific tasks and locations.

In addition, the fall hazards that were identified during the assessment were validated or rejected. Then, the team determined whether the hazard could be eliminated. For the hazards

that could not be eliminated, the team evaluated and selected a fall hazard abatement solution. From this input, the team developed specific action items for each identified hazard (i.e., what are the next steps, who was responsible for the next steps, action required, and due date). Through an iterative process the team was able to account for all hazards that were identified and provide a solution for each.

The workshops involved members of the design team, operations personnel, inspectors, and others who have an interest in the project. Each individual stakeholder provided input from their unique perspective, while the fall protection consultant provided an impartial perspective on the overall project. Again, this collaboration helped to ensure that safety, productivity and cost were all considered.

Specification binder for hazard abatements: The goal of this process was to eliminate hazards or control them with passive fall protection solutions. Some hazards that could not be abated using engineering controls needed further consideration, and the team determined that some hazards would best be controlled with PPE solutions. One example is areas where guardrail must be removed to accomplish the desired task. Another example is ladders in the elevator shaft that exceed length and clearance limitations, which prohibit the installation of a ladder cage and landings.

For these circumstances, a performance specification was provided to allow the construction team to install the required fall restraint or fall arrest systems. This information will also be used by the operations team to help complete the process required for training and certification of these systems.

Follow through during construction process: As construction proceeds, the fall protection consultant will provide review of the constructed platform to ensure that the identified hazards have been abated as planned and that any hazards that were not identified during the design phase are subjected to the same rigorous assessment process.

Using this process allowed each team member could contribute their expertise and specialized knowledge. This collaboration helped account for the needs of all perspectives and stakeholders.

Case Study: Results

Companies who have incorporated safety into the design process have shown that costs are lowered, task performance is improved and life-threatening work hazards are reduced. Learning the critical skill of foreseeing safety hazards before they're created will benefit the organization in the long term.

On this project, the following items were the primary results of incorporating fall protection during design:

Hazards eliminated:

Valves and actuators relocated from near the edge of an elevated platform

Equipment related to lifeboat and fast rescue craft relocated to a safer location

Flame sensors and deluge nozzles relocated to areas that provide safe access, while not compromising the level of protection required for these items

Hazards abated with engineering controls, rather than PPE:

Floor opening covered with grating

Ladders and platforms provided for access inside ballast tanks and voids

-

Processes/products changed to reduce risk

Flare boom stair guardrail posts strengthened to allow them to be used as anchorage points

Light bulbs changed to long-life bulbs to decrease the frequency required for changing bulbs

Fall protection system developed and incorporated for maintenance requirements on top of crane boom.

Some may wonder if incorporating safety into design is cost effective. On this project, project leadership noted that the fees paid to the fall protection consultant would have been spent on a few days' worth of erecting scaffolding to gain access to solve issues after project completion. This is a significant order of magnitude cost savings, not to mention the improvements to worker safety and productivity.

When fall hazards are eliminated or managed through engineering control solutions, there are fewer fall protection issues to contend with through the life of a facility. This translates to less equipment purchases, less training and fewer elements to manage. While it may be difficult to attach a direct cost savings to this, it certainly reduces overall operating costs.

Conclusion

When workers are faced with fall hazards in an existing structure, there are limitations on the potential solutions. Many times, equipment-based solutions are the only choice due to existing operations and interferences. But, when fall hazards are identified and evaluated before facilities are built, fall hazards can be eliminated or controlled in the best possible manner, often with a solution at the high end of the Hierarchy of Control.

Based on the example case study presented in this paper, it is clear that safety can be drastically improved without a major impact on the existing design process. And, it was well worth the cost. As this company found, simply engaging in the process of thinking through fall hazards results in practical, cost-effective safety solutions.

So, when considering whether to evaluate fall protection during design, the question should not be how much will it cost if we wait until the end? Instead, ask: How much can be saved if the hazards are abated now?