Extreme Industrial Rope Rescue

Preplanning for Success

By Jonathan L. Pennington and Nicole Pennington

Industrial settings have many hazards and present a challenge to those charged with protecting workers to provide practical solutions for safety and health. In early 2007, a contract rescue company was asked to help deliver high-angle rope rescue services for a specialty company that provides coating services to many industries, including the electric power sector. The company had been contracted to apply specialized coatings to the inside of new power plant chimney flues for an energy company located in the Midwest.

The energy company was building several new flue gas desulfurization (FGD) units in several of its powerhouses. FGD is an absorption process used as a means to control sulfur dioxide in flue gas from fossil-fuel power plants. The Clean Air Act includes provisions for sulfur dioxide emission control that caused the energy company to address its FGD units. The stacks or chimneys on FGDs in this case range in height, with many taller than 500 ft and challenged the coatings contractor to provide competent rescue and fall protection options.

The safety director of the coatings contractor was concerned about the time it would take to rescue company employees should the need arise. The energy company's plants were located in fairly remote or rural locations across Illinois. As a point of reference, the safety director used his knowledge of orthostatic intolerance (commonly known as suspension trauma or harness-induced death) and an example of a chimney incident that occurred in Moundsville, WV, on March 5, 2006. Three men were trapped 1,000 ft in the air when an explosion and fire in a flue liner caused their floating scaffolding to become inoperable and ignite.

The men were rescued by personnel on a state police helicopter. The rescue effort took approximately 4 hours, and it was highly technical and dangerous. One worker was lifted off in a basket. When the basket cleared the chimney, it dropped and spun out of control before it was brought safely back to the aircraft. The helicopter pilot later said he thought he had lost the man. One worker was hospitalized, two were treated and released, and a fourth employee who was working in the flue died in the fire.

Plant emergency response teams (ERT) and local public emergency response organizations may find that they are ill-prepared for such rescue efforts if they are not involved in planning and not factored into the comprehensive managed fall protection program. Working at extreme heights while providing emergency response services requires special skills and equipment. Whether the event is medical in nature,

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or related to a fall or mechanical failure, preplanning helps prevent poor performance.

To lower sulfur dioxide emissions as required, power plants across the U.S. are or will be building/retrofitting FGDs, and will likely face the same fall protection issues as this coatings company. This article shares the authors' insight gleaned from their work preparing for the technical rescue and planning process on FGD projects in order to help readers produce solutions to comprehensive managed fall protection program and rescue planning needs. While the article addresses FGDs, the same concepts and planning efforts apply to all at-height projects to some degree.

Fall Injury & Fatality Facts

A review of Bureau of Labor Statistics (BLS) data reveals a major problem associated with working at heights. Nonfatal injuries and illnesses involving falls in private industry totaled 374,831 in 1992; additionally 600 falls from height resulted in deaths in 1992.

Combined, it is safe to say that 375,431 occupational fall events in 1992 resulted in the need for some type of response, rescue or recovery action. This is the first year that the BLS began to track statistics for fall-related occupational injuries, so it serves as a baseline measurement.

In 2007, BLS data indicate that nonfatal injuries and illnesses involving falls in private industry totaled 243,860; in addition, 835 falls from height resulted in deaths. Thus, a total of 244,695 fall incidents in 2007 resulted in a need for some type of response, rescue or recovery action.

Although the number of overall fall events decreased from 1992 to 2007, the number of fatalities due to falls increased by 39% (Figure 1).

Medical Considerations: Falls From Height

In the construction industry, falls are a leading cause of workplace death (Epp, 2007). Falls from height can produce various illnesses and injuries, including strains/sprains, contusions, fractures, cuts, dislocation, back injuries, skeletal injuries, concussion, abrasions, heart attack, dehydration and orthostatic intolerance, as well as other major trauma. Occupational injuries that result from falls are often more severe compared to other types of injuries that occur on construction sites. Such falls usually occur from various heights and surfaces, making prevention challenging.

Current research indicates that younger workers experience higher rates of severe occupational injury from falls, while older workers have higher fatality rates compared to younger counterparts (Grandjean, McMullen, Miller, et al., 2006). The risk for injury increases as people age, get more out of shape, and lose muscle mass, strength, flexibility and bone density. Adults do not heal as quickly nor do the bones continue to strengthen. The stress and fatigue of daily life, improper diet and lack of exercise further compromise bone density, and muscle, tendon and ligament strength in the legs, hips and low back. (Pressley, Barlow, Quitel, et al., 2007).

Falls from height present a definite injury and death potential. Gravity is indifferent to personal well-being. In combination with fundamental laws of motion, gravity imparts forces that can reach many times body weight. Force is equal to mass times acceleration for the downward fall of the body, and the ground reaction is equal and opposite to the force applied by the body striking the ground (Montante, 2008).

The magnitude of the ground reaction force comes in large part from the combined effects of the total mass-times-acceleration product of all the downward body segments, which is the total of all net muscle forces and the gravitational force. The potential for injury also depends on how a person lands and how the body compresses on landing to absorb the shock. If a person weighs 200 lb, the impact load on the lower body can range from more than 800 lb to 2,400 lb (Montante, 2008).

Suspension trauma can occur when a person falls and is suspended vertically and is motionless, causing the pooling of blood in the legs and other gravitationally dependent regions, and reducing blood flow to the heart. Once a worker's fall has been arrested by a full-body safety harness, the

IN BRIEF

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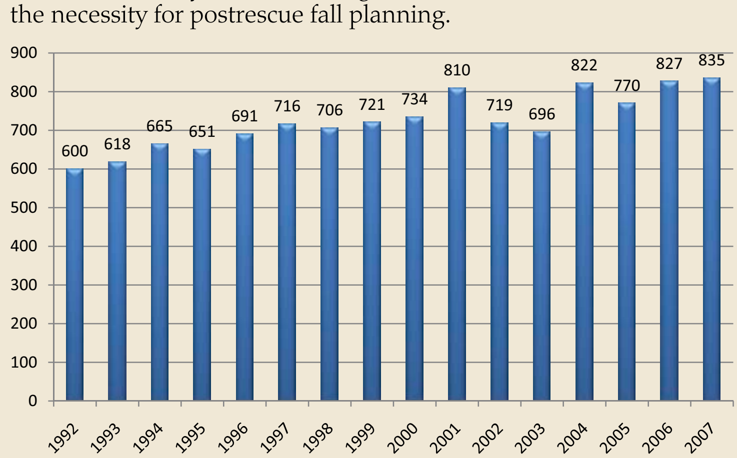
- **Whether the event is medical in nature, or related to a fall or mechanical failure, preplanning helps prevent poor performance.**
- **This article shares insight gleaned from preparing for the technical rescue and planning process on a flue gas desulfurization project. The same concepts and planning efforts apply to all at-height projects to some degree.**

Figure 1

Workplace Fatalities Due to Falls, 1992-2007

Bureau of Labor Statistics data illustrate the fatality rate due to fall incidents for the year 1991 through 2007 and allows one to trend the necessity for postrescue fall planning.



suspended worker must be rescued promptly. If the worker is unconscious or immobilized due to injury, suspension trauma may develop in as few as 5 to 30 minutes. A major cause of orthostatic intolerance is the pooling of blood in the veins of the upper legs and in the abdominal and pelvic regions (Turner, Wassell, Whisler, et al., 2008).

Falls from height can cause other systemic health events. Cardiovascular events can be a physiologic response. The term *myocardial infarction* applies when there is evidence of heart-cell death due to insufficient blood flow. The definition also encompasses cases of sudden death preceded by symptoms that suggest restricted blood flow, as well as heart attacks which can occur as a result of trauma (Harvard Heart Letter, 2009).

Managed Comprehensive Fall Protection Program

In 2007, sections 1 through 4 of the ANSI/ASSE Z359 Fall Protection Code were published, with subcommittee work continuing on several additional sections. To adequately define a managed comprehensive fall protection program, let's use ANSI/ASSE 359.0-2007, Definitions and Nomenclature Used for Fall Protection and Fall Arrest, to define *managed, fall protection* and *program,* while using Merriam-Webster Dictionary to define *comprehensive*.

Merriam-Webster defines comprehensive as "covering completely or broadly or having or exhibiting wide mental grasp." Clearly, this term is used in this context to indicate that a beginning-to-end holistic approach is to be used when developing this type of detailed facility or project program and one would include rescue preplanning in such an overarching program.

Managed would indicate that a single person is in charge of or administers the program. ANSI/ASSE Z359.0-2007, 2.107, defines a *program administrator* as "a person authorized by their employer to be responsible for managing the employer's fall protection program."

ANSI/ASSE Z359.0-2007, 2.61, defines fall protection as "any equipment, device or system that prevents an accidental fall from elevation or that mitigates the effect of such a fall." ANSI Z359.0-2007, E2.61, further clarifies fall protection as "eliminating or controlling hazards, passive fall protection, fall restraint, fall arrest and administrative controls." With this guidance, one understands that the program is not just about a basic fall protection harness and lanyard commonly considered personal fall arrest systems (PFAS); it is about the entire fall protection process.

ANSI/ASSE Z359.0-2007, 2.106, defines a program as "an organized, directed effort that uses specified resources to achieve desired objectives." A broad framework of goals to be achieved, serving as a basis to define and plan more specific requirements for meeting those goals.

Thus, the managed comprehensive fall protection program is a dynamic, green document. It changes as the scope of a project changes, facility structures change, new equipment becomes available or when resources once available become unavailable.

A facility's initial fall hazard analysis may reveal that the comprehensive plan need only be a few pages, while other analysis may indicate that a large document requiring a full-time program administrator is needed.

It is important to select the right person as the administrator. S/he must fully understand all concepts related to fall protection, including post-fall rescue. In the authors' experience, program administrators are often least familiar with rescue planning.

Rescue Plans

In 2007, ANSI Z359.2 incorporated guidelines that require rescue after a fall into a comprehensive managed fall protection program for general industry. In Section 2.113, ANSI/ASSE Z359.0-2007 defines a *rescue plan* as "a written process that describes in a general manner how rescue is to be approached under the specified parameters, such as location or circumstances." The code is written specifically for general industry applications and does not address the construction industry.

The construction industry references rescue in 29 CFR 1926.502(d)(20), which states that "the employer shall provide for prompt rescue of employees in the event of a fall or shall assure that employees are able to rescue themselves."

So, just what does this rescue provision require a company to do? Prompt rescue, as required under 1926.502(d)(20), is not defined in the standard. The particular hazard that 1926.502(d)(20) addresses is suspension by the fall arrest system after a fall. While an employee may be safely suspended in a body harness for a longer time than from a body belt, the word *prompt* requires that rescue be performed quickly—in time to prevent serious injury to the worker.

Under 1926.501(b), employees performing construction work at a height of 6 ft or more above lower levels must be protected from falls. However, Subpart M does not require a fall protection plan unless the employer is using alternative fall protection methods to protect employees performing leading-edge work, precast concrete erection or residential construction [1926.501(b)(2)(i), (12) and (13), respectively]. Note that 1926.502(d)(20) does not require that a written rescue plan be prepared or that a preplanning event be held.

The main idea behind a rescue plan is to provide for a successful method to perform a timely rescue. Most will agree that *timely* can only be defined by the expectation or reasonable expectation of an incident, how technical the expected event could be and the possible injuries which could result from the reasonably expected event.

The plan may be designed around the concept that the task is routine and that the rescue team need only be made aware of the work and preposition equipment. Or, the plan may be designed around a technical project, such as FDGs that are 500 ft or more in the air, and may dictate a prerigged and prepositioned full-time rescue team to perform reasonably expected events and reach the victim in a timely manner.

In the authors' experience, based on mock rescues, the timely manner to reach a victim and deliver him/her to the grade level for a prepositioned and prerigged team is the ability to touch the victim in as few as 10 minutes; however, it still may take up to 90 minutes to deliver the victim to the ground depending on the victim's position and the completeness of the chimney's infrastructure (e.g., whether elevators are installed and working).

What Makes for a Successful Plan?

As part of a comprehensive fall protection program, a well-developed rescue plan contains the following elements (although it is not limited to these depending on the nature of the fall hazards):

1) Using the managed comprehensive fall protection program's identification of fall hazards, select hazards that are applicable to the specific work being performed. A comprehensive program should identify workplace hazards (including housekeeping issues that may be caused by the work being conducted), and these hazards should be properly documented in the plan, not only for rescue planning, but also for issues such as equipment selection and employee training. The planner cannot overlook the work platform itself and the hazards that a poorly designed or poorly maintained platform may present.

Once hazards are identified, the program administrator can design the rescue equipment cache (an industry term for the amount of rescue equipment kept on hand), the training program and rescue team requirements for performing rescue, as well as many other required tasks needed in developing a successful rescue plan.

2) Establish a strategy for ensuring that an alert is issued when a fall incident occurs. It is important to not only establish a strategy but also to test that strategy to make sure it works. If portable radios will be the primary contact method, they should be tested to ensure that they will operate in all sections of the work area and are compatible with the work environment. Noise, moisture, flammable atmospheres and vibrations all affect the selected communication strategy.

3) Develop procedures to ensure that victims are contacted in a timely manner. The primary concern is rescuer safety, followed quickly by the need to reach the victim in a timely manner. All avenues should be studied to make sure the proper equipment is immediately available to provide for the rescuer's timely arrival to the victim.

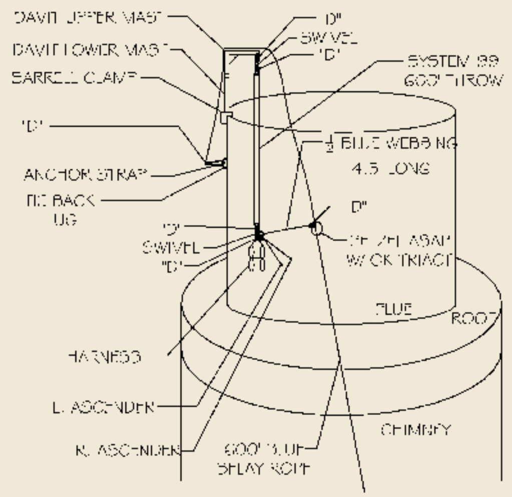
Upon reaching the victim, the rescuer must deliver basic first aid, addressing airway, breathing and circulation. It also is important to remember the ever-present hazards associated with hanging in a harness and orthostatic intolerance.

4) Establish written actions for self-rescue of both victims and rescue team members. Employees should be trained how to properly hang in a harness to reduce exposure to the onset of suspension

Figure 2

Rescue System

CAD drawing of a sample chimney rescue system that was used during an equipment mock-up planning phase.



In this situation, one of the authors had to study the blueprints, visit the locations and work with vendors to provide design solutions to address the vertical high point or anchor needs.

trauma and if possible to use provided equipment for self-rescue. Having a team prepared and ready but never needing to use it is always the safest approach. Self-rescue is not always an option, but it should be built into the rescue plan and should be part of fall protection training.

Rescuers also must receive self-rescue training and be provided with equipment to assist in this endeavor. Many things can happen while attempting to perform a rescue. The author has experienced equipment malfunctions, wind gusts of up to 70 mph, rain and other occurrences that cannot always be factored into the initial rescue plan. Build redundancy into rescue procedures, and remember to provide for rescuer personal rescue procedures.

5) Develop procedures for summoning the designated rescue team and the use of a specified incident management system (IMS) with common terminology. As noted, a work task may be fairly minor and those involved may decide that the rescue team should prerig the job and review the rescue plan, then return to normal work duties at the facility.

It is important to designate a method for alerting the rescue team that an emergency exists and for team members to be able to promptly return to the incident location. Likewise, a more technical work task may require the rescue team to prerig the job, review the rescue plan and stage at the job location. In either case, the authors advocate prerigging every job with the appropriate rescue equipment and the use of a uniform IMS.

The program administrator should coordinate the use of an IMS between plant/company personnel and local emergency responders who will be involved in any on-site event. It does not matter what type of system is used. It could be the fire ground command system pioneered by the Phoenix, AZ, Fire Department, the incident command

Photo 1

Initial meeting with a fall protection equipment vendor to determine the design criteria of equipment based on field and engineering surveys of the jobsite.

system that came out of California in the 1970s or the incident management system that is a hybrid between these systems. What is important is that plain language is used and that all parties involved are familiar with the system.

6) Write clear goals and objectives with general tactics for rescuer team members to perform rescue and maintain a state of readiness. These include:

•Identification of qualified rescue personnel who will respond to a fall incident. These personnel may be part of a plant/company emergency response team, a third-party professional rope rescue team, a municipal response team or a hybrid team consisting of members from all or some of these organizations. The selection process should ensure that rescuers are selected for their ability to perform rope rescue skills under pressure and for their physical fitness to perform the skills under pressure.

•Identification of proper anchor and high points to be used for the job task being performed. Returning to the FGD units example, the chimneys that were being serviced range in height, but all are extreme environments from which to perform rope rescue. When selecting anchorages, the program administrator must understand the design of the structures that will be the rescue platform. In the case of FGD chimneys, they do not have a decent high point anchor to work with that allows one to stay within the OSHA requirements for a vertical anchor point.

When coating work is taking place inside the flues, as was the case in these projects, the top can (upper most section of the flue) is covered with a tarp to keep water out. The top of the flue is 20 ft or more above the chimney roof and scaffolding must be used to reach the top.

In this situation, one of the authors had to study the blueprints, visit the locations and work with vendors to provide design solutions to address the vertical high point or anchor needs (Figure 2, p. 59). One cannot simply call a vendor and say, "This is the issue, fix it." It is important to discuss the work with the vendor, the type of rescue systems that will be used and the environmental limitations that will be present during the actual working phase of the project (Photo 1).

With the spray application of flue linings, one must consider the sandblasting that occurs during the preparation phase and the overspray that occurs during the priming and finish coating phases. Such environmental factors can destroy improperly selected equipment. In all phases of anchor selection and specialized equipment design, a professional engineer who specializes in fall protection system design must be used to ensure that proper safety factors are met.

•Complete instructions for performing each identified type of rescue scenario. The instructions must be general enough to allow well-trained rescuers to modify them to fit the specific needs of the actual rescue. Rescuers must be trained well enough to be able to make changes as needed to enact a rescue. Planning will assist in the rescue success, but each rescuer must be confident enough in his/her skills that when an unexpected situation occurs, s/he can make necessary adjustments.

The rescue procedures must be practiced in a mock drill (Photos 2 and 3). Often, procedures will need to be modified to increase efficiency. It does not mean that the team is poorly qualified if it must perform more than one mock rescue to perfect these procedures. This is the only way to take theory and make it fact, and should be explained fully to all management personnel before the mock rescue is performed.

•Data for equipment—selection criteria, care of equipment, inspection documentation and frequency, maintenance of equipment based on manufacturer's recommendations and proper storage needs. This is critical information to the rescue plan and the planning process. All involved parties should know the performance criteria of the equipment and its proper application during a rescue.

Equipment strengths and weaknesses also must be understood in order to prevent hazards such as gate or triloading a carabiner (industry terms that indicate improper rigging or angles of attachment, and placing a load on a carabiner in a manner that the device was not designed to withstand) or overloading a 12 mm static-kernmantle rescue rope (specialty rope commonly used in the rope rescue/access industry).

All equipment used for rope rescue work should be selected with the knowledge that rescue efforts place extreme demands on equipment. All equipment selected should be certified for use as a rescue system component and rated for a two-person load when possible.

Photo 2

A professional third-party rescue team performing a successful mock rescue from the top of a 600 ft Powerhouse Chimney.

The authors recommend referencing applicable standards such as ANSI/ASSE Z359.6-2009, Safety Requirements for Fall Arresters for Personal Fall Arrest Systems (PFAS), and NFPA 1983, Standard on Life Safety Rope and Equipment for Emergency for such certification criteria.

•Documentation of training that qualifies a rescue team member as a competent rescuer and skills refresher training plans that will allow the rescuer to maintain his/her established competency. A rescue team, whether municipal, plant/company personnel or a third-party professional team, must have proper training that meets a nationally accepted standard.

The authors recommend NFPA 1006, Standard for Technical Rescuer Professional Qualifications, for guidance. This document's scope is defined in section 1.1, which says that the standard establishes the minimum job performance requirements necessary for fire service and other emergency response personnel who perform technical rescue operations.

Chapter 6 of NFPA 1006 specifically deals with high-angle rope rescue skills and training. Initial training should be documented properly and this documentation requirement should be listed in every rescue plan written at the facility. Take into consideration that other elements such as respiratory protection training, hazardous materials, firefighting and other topics may need to be mastered by a team in order to operate safely in the potential rescue environment.

Refresher training is essential and should be performed as frequently as necessary to maintain the rescuers' skills. The authors suggest quarterly training (even though most will state that the minimum requirements are every 12 months, a practice the authors do not support).

Conclusion

At this time, ASSE reports that at no government agencies cite the Fall Protection Code. However, the Society notes that the standards in the Code are referenced and recognized by many government agencies, both nationally and internationally.

Z359-2007 was developed for general industry application, but it has crossover application in all industries. OSHA's construction regulations address rescues after a fall and mention rescue plans for special circumstances. It is important to protect workers while they perform their duties at height and the Fall Protection Code provides an excellent source for doing so.

Having a managed comprehensive fall protection program involves the development of appropriate rescue plans. Rescue plans cannot be made with a cookie-cutter approach, and each specific fall hazard location must be viewed as a new opportunity to succeed as a rescue planner.

Before an incident occurs, the program administrator must evaluate potential rescue teams to ensure that team members have the proper training, equipment and availability to reach a victim in a timely manner. This must be true for a facility's least hazardous working-at-height location to its most hazardous.

Photo 3

A rescue team member performing refresher training.

It all starts with proper planning and ends well because of this effort. The goal is to be ready and able to rescue a worker who has fallen without ever needing to because the managed comprehensive fall protection program prevented an event from occurring. **PS**

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