

# Fall Protection & Rescue: A Systems Approach

*There are significant benefits to understanding fall protection and rescue systems as a whole and designing, planning and purchasing accordingly.*

BY KEVIN DENIS

Over the last few years, several thousand miles, four different countries and more ladders and lifts than one cares to mention, new themes in fall protection and rescue have appeared in the wind industry. Fall protection program administrators have done a good job of acquiring and providing fall protection equipment and training for workers at height on turbines, yet there is still work to be done. As fall protection and rescue issues come to light, a systems approach to designing fall protection and rescue systems needs to occur.

This theme is not dissimilar to other industries and is very common as any industry grows and matures. As issues arise, they are handled on an individual basis. For instance, wind turbines needed an anchorage point, so one was designed, and new regulations required maximum arrest forces to be controlled, so a different energy-absorbing lanyard was purchased. In addition, rescue was an issue, so ropes were purchased with the assumption that the same anchorages can be used.

Over time, the fall protection and rescue system is pieced together by two or three different people, creating a situation that may introduce several issues. A singular focus on each individual part of the fall pro-

tection and rescue system can address fall hazards, but there is significant benefit to understanding the system as a whole and designing, planning and purchasing accordingly. Equipment designers, turbine manufacturers, program administrators and end users must take a systems approach to fall protection.

## **Certified anchorages**

The first systems issue concerns anchorages.

There is a misconception that as long as an anchorage can hold 5,000 pounds, it is acceptable for use. A properly designed fall-arrest system should address location, connected equipment, edges, diameter, thickness, number of workers, aging characteristics, documentation and direction of load before installation. There are many improperly located anchorages on wind turbines. These include anchorages at waist level and nacelle anchors that are at foot level.

Many anchorages do not consider the rope's line-of-sight and the edges it will contact. Since many wind turbines use a single three-eighths-inch nylon rope for rescue and evacuation, an edge combined with a weighted rope can be very dangerous. Many rescue and evacuation locations do not have overhead anchorages at all. Lower anchorages at the waist

or knee height may still be used, but they are very difficult to manage, especially when using automatic descent-control devices. Anchorage designers must consider the whole system, its performance and design criteria rather than being solely focused on strength.

For example, a rigid pipe anchor around the perimeter of the nacelle roof is a popular design. This system is reported as a fall-restraint system, so it has a lower anchorage strength requirement than a fall-arrest system. If both legs of a Y-lanyard are connected to the rigid pipe anchor, the worker achieves fall restraint and is protected adequately. However, there are many situations in which only one leg of the lanyard is connected to the anchor, creating a fall-arrest situation. In fall arrest, rescue becomes a necessity. The number of workers connected to the anchor must also be taken into account, including the rescuer who must connect to an already impacted anchorage.

## **Compatibility**

The second systems issue concerns snap-hook and connector compatibility. An incompatible connection is one that puts pressure on the gate of the snap hook or carabiner.

Turbine personnel use a two-leg lanyard with large snap hooks on each

end to navigate the turbine. These Y-shaped lanyards allow a worker to remain connected to an anchor with one snap hook while traveling to another anchor. By alternating the snap hooks, a worker can move while remaining connected to the structure at all times. This lanyard is a necessary tool for working on the tower ladder, traversing the nacelle roof, traveling from the nose cone into the hub and performing work in other areas on the turbine. The large snap hooks are preferred, and arguably required, because workers can use them to anchor to the side-rails of most ladders.

Anchor designers rarely design or understand compatibility between these large snap hooks and their anchorages. Designers typically focus on anchorage strength without considering the equipment that will be connected to these anchorages. The anchors can withstand 5,000 pounds of force, and that is the singular design requirement and focus. It is not uncommon for designers to certify lifting eyes on electrical motors, gearboxes or framework as acceptable anchors for large snap hooks. Although strong enough, these anchorages are incompatible with the large snap hooks.

In November 2007, the American National Standards Institute (ANSI) released the Z359 Fall Protection Code. This code requires snap-hook manufacturers to design snap hooks and carabiners with gate strengths of 3,600 pounds to combat snap-hook incompatibility and forced rollout. This code is a significant improvement, but it does not eliminate compatibility issues with anchors completely.

Ideally, the anchorage designer will be familiar with the dimensions of the equipment that will be connected to the anchorage and will design the anchor accordingly. The anchorage design will be such that the gate of the connecting member cannot be loaded or forced open by the anchorage. Anchorages with rounded shapes, swivels, large diameters, along with the use of high-quality snap hooks with strong

gates, can help to prevent common incompatibility issues.

### **Impact force**

The third systems issue is impact force.

The Occupational Safety and Health Administration and the ANSI Z359 Fall Protection Code recommend that free-fall distances do not exceed six feet. There are several areas on a turbine where free-fall distances are greater than six feet. Personnel standing on the roof of a nacelle, anchoring to the ladder below the dorsal D-ring, traveling from the nacelle to the nose cone, or working in any other location where they are anchored below the dorsal D-ring, may experience a free fall greater than six feet. This issue is compounded if the user's weight is close to the 310-pound threshold.

In these cases, the personal-energy absorber may fully deploy and create a spike over acceptable limits in the arresting force, exceeding manufacturers' design criteria. This also increases the potential to strike surrounding structures. The worker's weight, the free-fall distance and the type of personal-energy absorber in use will determine the maximum arrest force. It can be argued that a lighter worker will be unharmed, and different energy absorbers can be purchased to prevent this from occurring. However, if a systems approach is taken at the design stage and a properly located anchorage is provided, impact force will not be an issue.

There are personal-energy absorbers available for these applications, but they require more clearance and have a higher maximum arrest force. Solutions to this issue include specifying different lanyards or distributing more than one type of lanyard to the crewmembers. This approach often is met with resistance, because it requires personnel to bring more equipment with them when they climb.

### **Ladder safety systems**

The fourth systems issue concerns fall protection systems on the turbine access ladders.

Many turbine manufacturers install their own ladder-climbing system cables at the time of construction rather than purchasing a complete ladder safety system from a fall protection system manufacturer. The cable installed by turbine manufacturers typically has a three-eighths-inch diameter and is anchored at the top of the access ladder. Climbers will use one of many off-the-shelf cable sleeves – the component that travels up and down the cable and connects to the climber's harness to attach to the cable.

Even though there are many sleeves that are designed for this cable, there are other system considerations that may not have been accounted for by the turbine manufacturer that installed the cable. Different sleeves will have different free-fall distances, a circumstance that affects the maximum impact force on the system. This situation is multiplied by having more than one person on the system. Many of the cable systems include an energy absorber on the top of the system, which is rarely present on the systems provided by the turbine manufacturer.

Liability is another concern, because very few of the sleeve manufacturers recommend or allow their sleeves to be used on any cable other than their supplied systems. It would be similar to putting Ford parts in a GM vehicle. It may work, but it is generally viewed as a bad idea.

Like any fall-arrest system, ladder-climbing systems have a minimum anchorage requirement based on the number of workers specified to use the system at one time. These systems are manufactured according to ANSI 14.3, which allows between two and four workers on the system at one time and a safety factor of five-to-one for most of the components. The system must be tested with a 500-pound rigid weight that is allowed to fall 18 inches – representing only a portion of the testing requirements.

Many systems are connected to a 5,000-pound anchorage at the top of the ladder without prior testing. If

turbine manufacturers install their own cables and use sleeves from a number of different fall protection manufacturers, the system should be tested according to the ANSI 14.3 standard. These tests should be conducted with the maximum number of climbers and all sleeves that may be used on the ladder-climbing system. Anchoring a three-eighths-inch cable to the top of the ladder, certifying the complete system to 5000 pounds and allowing any three-eighths-inch sleeve to be used would not be considered a systems approach to design.

### **Rescue planning**

One of the final systems considerations is rescue.

The term "rescue" has very broad implications and can mean many things to different people who work in and on turbines. A rescue can be quite simple or as complex as removing an incapacitated subject from deep inside the blades with multiple rope systems.

It is important to evaluate the wind farm to determine the scope of rescue when developing rescue plans, writing rescue procedures, purchasing rescue equipment and conducting rescue training. The limitations and conditions found on most wind farms may make it difficult to address life-threatening situations quickly.

Wind farms can be remote and have limited workforce availability. Conditions may include extreme temperatures, and workers may be confined. Rescues involving an injury require an advanced knowledge of emergency care, as well as high-angle rescue equipment and skills. The rescuer must determine if a rescue subject can be moved, how they can be moved and the appropriate equipment for rescue.

Workers often have limited emergency medical training. Given these circumstances, it may be unrealistic to develop a rescue plan in which untrained workers are expected to immobilize a rescue subject on a spine board using advanced immobi-

lization practices, administer oxygen, package the person into a suspension litter, and evacuate the person from the blade, roof, hub and nose cone.

Addressing every possible emergency situation would require expanding workforce availability, advanced first aid or medical training, advanced knowledge of high-angle rescue techniques, and a commitment to have trained rescue personnel and appropriate equipment present at every job. Communication tower workers, crane operators, miners and window cleaners face these challenges as well, because the nature of the work makes it extremely difficult to manage life-threatening emergencies effectively.

Rescue plans should consider the abilities of the rescue personnel. It is not unrealistic to equip turbine technicians with simple tools and techniques to assist in the removal of a worker from the blade when non-life-threatening conditions exist. In fact, most workplace rescue plans address evacuation in non-life-threatening situations in which coworkers can effectively manage the situation and safely evacuate the rescue subject.

Since managing a life-threatening emergency is difficult, equal emphasis should be placed on prevention and rescue. The following preparation and fall prevention policies should be included in every rescue plan as part of the complete solution to wind farm rescue challenges.

■ Two workers should be in communication with each other and the wind farm office when ascending the turbine. It is recommended that the second worker be present at the wind turbine for single-climb jobs.

■ Rescue equipment should be brought up to the turbine when both workers are on the turbine. Some companies have low-duration tasks where they have deemed it acceptable for one worker to climb and the other to remain on the ground. In these situations, the rescue equipment, at a minimum, should be with the worker on the ground.

■ Local emergency phone numbers should be provided and easily

accessible (e.g., in vehicles, turbines or main office) to call for assistance.

■ Oil-resistant, non-slip footwear should be required.

■ A hard-hat with a three-point suspension bed should be worn by workers at all times. This requirement is not intended to protect workers from falling objects, but to make every effort to minimize injuries and maintain consciousness if a slip occurs inside the nacelle, yaw deck, hub or blades, because it is much easier to rescue a conscious subject than an unconscious one.

■ A full-body harness should be worn at all times. In the event of a rescue, it is very difficult to put a harness on a semi-conscious or incapacitated worker.

■ Formal or on-the-job training that addresses the best way to navi-



**Anchorage on wind turbines often are improperly located.**

Photo by Chris Wingfield

gate the nacelle, nose cone, decks, hub and blades should be required. This training should identify acceptable locations for personnel to hold or place their feet, as well as how a worker should move around to reduce the likelihood of a slip or trip that could lead to injury.

■ Preventive maintenance should be required to keep walking surfaces free of oil and debris or any condition that may lead to a slip or trip.

### **The future**

Although many of these systems issues may seem trivial and the probability of an accident is arguably low, it is difficult to ignore their sum.

The wind industry is striving to do a better job at protecting workers from falls. Workers recognize fall risks and understand how to use fall protection equipment. Administrators are working toward improving their fall protection and rescue programs. While certain issues remain,

there is a collective movement by individual companies, owners and industry associations to reduce risk.

To begin, every organization should have a fall protection program administrator with a fundamental understanding of fall protection basics. Designers should take a systems approach instead of focusing on a singular anchor or cable. Designers of fall protection systems – like engineers and turbine manufacturers who certify fall-arrest anchorages or specify ladder cables – need to have a deeper understanding of fall protection equipment, compatibility, free-fall distances and rescue plans in addition to their knowledge of structural integrity.

Over time, design changes will eliminate many of these issues as the wind energy industry becomes more familiar with fall protection and recognizes the limitless design potential for equipment. Imagine anchorages on the roof of the nacelle where a res-

cue rope could be connected from the inside, the anchor released and the whole system lowered to the ground. The industry currently accepts existing designs and tries to address fall hazards by purchasing traditional personal fall protection equipment rather than designing equipment specific to the task.

Understandably, there are thousands of existing turbines for which retrofitting anchors or making changes will be difficult, but it makes sense to change and improve the systems for future turbines. **SNP**

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