Best Practices in Small Wind: Tower Climbing Safety

Please review this document and send your comments and suggestions to: info@windpowerservicesllc.com

For decades, OSHA has dictated standards for workers’ safety in the arenas of Construction and General Industry. More recently, OSHA began exploring safety concerns in large wind turbines — a growing industry in the United States, and AWEA is working with OSHA and other partners to ensure all workers are exposed to the safest conditions possible. But OSHA has not yet addressed issues related to working with small wind energy systems – at least, not directly. In 1992, ANSI published a Best Practices document (Z359) that addresses working safely at height. And NATE has also written best practices pertaining to working with structures like communication towers. This document will attempt to address concerns related directly to small wind energy systems, rated 100 kW or less, and typically installed on towers no taller than 140 feet – which is not directly addressed in any of the aforementioned documents.

Acronyms used throughout this document:
- OSHA – Occupational Safety & Health Administration
- AWEA – American Wind Energy Association
- ANSI – American National Standards Institute
- NATE – National Association of Tower Erectors
- NIOSH – National Institute for Occupational Safety & Health
- NFPA – National Fire Protection Agency

*We need to insert references throughout this document where these standards & codes apply!
**NIOSH says what the equipment is, OSHA sets the limits, and ANSI certifies to that standard

OSHA regulations are written in Codes of Federal Regulation (CFRs) and are enforceable by law. Any employer not adhering to OSHA regulations can be cited, fined, and/or jailed. Workers that erect towers and participate in the construction of small wind energy systems must follow 29 CFR 1926. Those who maintain small wind energy systems (once they are erected and in service) must follow the regulations in 29 CFR 1910.

ANSI standards, on the other hand, are technically not law. They represent best practices for those working in a specific industry where OSHA has not yet addressed particular concerns. Even though the standards in ANSI Z359 pertaining to working safely at height are not yet law, any employer not providing the proper equipment could still be cited for negligence. In essence, the understanding is that if an ANSI standard exists, there isn’t really a good excuse for not following it. This particular topic will be covered more in Section 5 on Personal Fall Protection Equipment.

A job hazard analysis (JHA) or job site analysis (JSA) should be performed with the entire crew before beginning work each day. Sometimes called a “tailgate meeting,” it is an essential part of the job and must not be overlooked or dismissed.

A designated and qualified person (usually the lead installer) should consider himself or herself the site manager, and must be responsible for making sure all workers are fit for duty. This lead person must also ultimately decide what conditions are safe for work, and how to best manage the crew and subcontractors.
This *Best Practices* document is a work in progress, and was compiled with input from a number of small wind energy installers and tower climbing professionals, including:

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- Donny Davol, Ethos Distributed Energy (CO)
- Troy Hewitt, Intertek (NY)
- Brent Hrywkiw, WesTower (CA)
- Joe DiFrancisco, North Coast Energy Systems (PA)
- Gary Harcourt, Great Rock Windpower (MA)
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- Jim Norman, ABS Alaskan, Inc. (AK)
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### Disclaimer:

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Section 1: Environmental Hazards

WEATHER

- **Extreme Heat:**
  Follow reasonable and practicable NIOSH recommendations and make sure all workers are trained to recognize the signs of heat exhaustion and heat stroke. Note that metal surfaces exposed to direct sunlight may be hot enough to cause skin burns.

  **Best practices for working in extreme heat:**
  - Drink plenty of water; stay hydrated
  - Take breaks as needed
  - Avoid heavy foods
  - Dress in light, breathable clothing
  - Use sunscreen, sunglasses, and lip balm when working in direct sunlight
  - Ingest salt tabs or electrolytes for extreme or excessive sweating
  - Avoid working in the extreme heat; if practicable, rearrange climbing schedule
  - Know your limits. Acclimated workers are better suited to work in extreme heat.

- **Extreme Cold:**
  Follow reasonable and practicable NIOSH recommendations and make sure all workers are trained to recognize the signs of hypothermia and frostbite. Note that extremely cold air also tends to be extremely dry air. Dehydration, wind burn and even sunburn can occur rapidly in cold weather.

  **Best practices for working in extreme cold:**
  - Drink plenty of water; stay hydrated. Warm fluids can provide energy, warmth and replace fluids lost during work, but care should be taken to prevent over-consumption of caffeine.
  - Dress in many thin, light layers instead of single-layer, bulky clothes
  - Keep your head covered with a hat to avoid heat loss
  - Avoid excessive sweating & stay dry
  - Use hand-warmers, boot-warmers, and/or portable heaters if necessary
  - Have gloves with good grip for climbing, and bring mittens or thick gloves for keeping fingers warm when not climbing
  - Have extra dry clothes, gloves, and blankets available at the job site
  - Sunglasses are recommended when sunlight is reflecting on ice and snow
  - Use lip balm, sunscreen or petroleum jelly to protect face against wind/sunburn
  - Know your limits. Acclimated workers are better suited to work in extreme cold.

- **Rain and Dew (Moisture):**
  Climbing inside of a monopole structure is not as risky as climbing on an exposed tower in the rain. Surfaces can become very slick, and for that reason, climbing a wet structure is highly discouraged.

  **Best practice:** Never climb a wet tower
• **Mud:**
Along with precipitation comes muddy ground. Mud poses hazards such as: difficult to maneuver (or stuck) machinery, unstable holes and trenches, and dangerous climbing conditions.

*Best practices:*
- Take measures to minimize mud at and around the tower base to keep muddy work boots off the tower
- Wear “mud boots” to the work site, then change into clean, dry boots in the clean area maintained at the tower base before climbing

• **Ice and Snow:**
Structures covered in ice are dangerous, as they are of course quite slippery. Additionally, sections of ice may fall to the ground and may be hazardous to people and property.

*Best practices:*
- Never approach an icy tower
- Never climb an icy or snow covered tower
- Wait for ice to melt before attempting to restart a wind energy system
- Keep vehicles parked upwind of the tower and out of the ice and snow “shed zone,” or approximately one half the tower height – where the ice would most likely land

• **Lightning:**
Working on tall towers and being in close proximity to metal structures and electrical equipment poses particular concerns during thunderstorms or lightning events. Refer to the National Lightning Safety Institute for more information and decision trees. (http://lightningsafety.com)

*Best practices for storms and lightning:*
- Get off the tower if you hear thunder or see lightning
- Stay a reasonable distance away from the tower during lightning or thunderstorms
- Continually monitor the local weather radar for storm watches and warnings
- Maintain continuous communication between all members of the tower and ground crews, especially when there is an increased potential (“watch”) for severe weather
- Seek shelter inside a vehicle or building, and away from trees, tall structures, and metal equipment during a storm

• **Excessive Wind:**
It’s ironic, but it’s dangerous to work on a wind turbine in high winds. Many crane operators are hesitant to lift when wind speeds are over 25 mph. Ropes can easily get tangled in tower structure and guy wires. Working in high winds tires climbers more quickly, so accidents are more likely to happen – and rescues or evacuations will be more difficult to execute. Communication becomes difficult in high winds, as typically the only noise one can hear on a radio or phone is the whistling of the wind, and shouting isn’t a good option. Note that high winds combined with cold temperatures can result in wind chill advisories and warnings. Crews should assess the tasks at hand, as there is a varying scale of work that can be done – depending upon the competence and experience of each worker.
**Best practices for working in high winds:**

- Avoid climbing towers when wind speeds are approaching 25 mph or are extremely gusty. *High winds have the potential to damage yaw and rotor locks, door covers, and other equipment and hardware on the tower.*
- Take precautions and measures to ensure ropes won’t get caught and tangled in the structure or with each other.
- Use a thin layer of petroleum jelly on the face & lips to avoid windburn.
- Continually monitor local weather stations for watches and warnings.
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**NOTE:** Add 10°F when protective clothing is worn. Add 10°F when in direct sunlight.

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<td>EXTREME DANGER</td>
<td>Heat stroke imminent!</td>
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<td>DANGER</td>
<td>Heat cramps or exhaustion likely, heat stroke possible if exposure is prolonged and there is physical activity.</td>
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<td>EXTREME CAUTION</td>
<td>Heat cramps and heat exhaustion possible if exposure is prolonged and there is physical activity.</td>
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<td>CAUTION</td>
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<td>Below 80°F</td>
<td>NONE</td>
<td>Little or no danger under normal circumstances.</td>
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# NWS Windchill Chart

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**Frostbite Times**
- Blue - 30 minutes
- Purple - 10 minutes
- Pink - 5 minutes

**Wind Chill (°F) = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})**

Where, T = Air Temperature (°F)  V = Wind Speed (mph)

*Effective 11/01/01*
ANIMALS & INSECTS

Critters can bite and sting. An encounter can be a mild inconvenience or a life-threatening situation. Those allergic to bees or other insects can go into anaphylactic shock, requiring immediate medical attention. Less dramatic but nonetheless a hazard, bird droppings on climbing surfaces are slippery – so watch out for them.

Best practices:
- All workers should be trained in First Aid, and a standard First Aid kit should be on the job site. Note that First Aid kits don’t typically contain EpiPens for stings, as they are sensitive to time and temperature.
- Anyone with a known allergy should bring with him or her the medication needed in case of an emergency, and all workers should know the exact location of the medication and how to administer it.
- All workers should know the location of the nearest hospital emergency room.
- Workers should carry cell phones so that 911 can be called in case of an emergency.
- Be cautious when approaching holes, enclosures, or otherwise sheltered areas – as they may contain animals or insects (especially wasps) ready to defend their home. When in doubt, use a stick or tool to reach in first or tap the cover.
- Always close covers and plug holes on all applicable equipment to discourage infestation.
- Be aware of potential nesting and hiding spots for snakes, birds, rodents, and small mammals.
- Always be aware of potentially dangerous wildlife (bears, moose, cats) on the worksite – depending, of course, upon your geographical location. Talk to the customers and the locals, and heed posted warnings.
- Insect repellant can make the difference between a tolerable and a miserable day on the work site. Best practice is to keep it seasonally available for crew members.

WORK AT NIGHT

Working at night and in the dark morning hours can have its own hazards. Getting to the job site early and leaving late can have detrimental effects on crew members and leaders. The push to complete a job in a timely manner can lead to long hours, and this can affect the decision making abilities of crew members. At night, excavated holes, tower step bolts, and other hazards “disappear,” making even walking through a site hazardous to all. For this reason, working at night or in the dark morning hours is discouraged.

Best practices:
- Plan all work days to start when there is enough light to see the job site and on-site hazards clearly.
- Plan all work days to end before dark. (This includes any housekeeping or site clean-up activities.)
- If working on a tower when dusk is approaching, begin descending the tower at least one half hour before it becomes difficult to see. This should allow enough time to address “typical” or unexpected problems on the way down the tower.
If work must continue after dark, be sure all crew members have hands-free lighting (head lamps and flood lights) and all major hazards are flagged with reflective material that can be seen from all angles of approach.

EXAMPLE: PROPER LIGHTING FOR GROUND WORK AT NIGHT

HUNTERS & RECREATIONAL SHOOTERS

Be aware of hunters and recreational gun users. Avoid camouflage outerwear during hunting seasons; wear bright colors (like blaze orange or high-visibility green) so you are easily seen and not accidentally mistaken for game. Pay particular attention and report to the customer and the authorities if you see bullet holes in the nacelle or evidence that someone has shot at the tower.
Section 2: Job Site Hazards

What about communication or other equipment on the tower? Climbing around other stuff... antennas

Before beginning any job, the crew must perform an assessment of the hazards on the site and the risks associated with the work. This is often referred to as a Job Safety Analysis (JSA) or Hazard Identification, Risk Assessment and Control (HIRAC). The JSA/HIRAC is a written document that shows due diligence on behalf of the employer to minimize risks, and can serve as a “checklist” for the tower crew before commencing work.

COMMON HAZARDS IN SMALL WIND

- **Construction Equipment:**
  Often, especially during the erection of a tower, construction vehicles will be on the premises. Forklifts, front end loaders, cranes, and other equipment can present hazards to the crew. Stay alert and aware of your surroundings, especially these large pieces of equipment.

  **Best Practices:**
  - Only trained and qualified personnel should operate construction equipment
  - Crew members should wear high visibility clothes when working with or near construction equipment, especially cranes
  - Have a predetermined method of communication between equipment operators and crew members

- **Mechanical Equipment:**
  Small wind turbines are electromechanical systems that use and/or produce electricity and have many moving parts. Special care must be taken to stay safe when working with or near these systems. Pay special attention to the shutdown procedures specified by the manufacturer. Potential hazards include:
  - Rotating equipment
  - Pinch points
  - Springs under tension
  - Hydraulic and pneumatic systems
  - Yaw mechanisms

  **Best practices:**
  - Never climb a tower when the turbine is running or spinning
  - Never try to “catch” a runaway rotor on the tower
  - If necessary and appropriate, use ropes or straps to secure the rotor to the nacelle
  - Never secure the rotor directly to the tower, as blade damage is likely to occur if the machine yaws
  - Follow yaw lock procedures, if the machine has a yaw lock mechanism. If the machine doesn’t have a yaw lock, use necessary precautions (like ropes, straps and knots) to ensure that the rotor will not yaw if the wind switches direction.
  - Be aware of hydraulic and/or pneumatic lines and fittings that may be under pressure in the nacelle as part of the brake or yaw system
- Make sure your lanyards and work positioning belts are not tangled in moving equipment or in a place that damages wind turbine equipment or damages the PFPE (sharp edges/grease/crane lifting points, etc.)

- Electrical Equipment:
  Electricity can be dangerous. Voltage, or difference in electrical potential, is responsible for delivering electrical shocks. If the human body receives a shock and current is present, it can cause serious injuries and even death. For that reason, only qualified and trained personnel should work on electrical equipment.

  NFPA 70E (Arc Flash safe practices) dictates that any voltage over 50 volts is considered dangerous and requires appropriate Personal Protective Equipment. Fire retardant clothing, gloves, and face shields may be necessary for particular electrical tasks. Therefore, anyone not qualified should not open live electrical enclosures or cabinets.

  All climbers should practice “Lockout/Tagout” before climbing any tower – installing (a) padlock(s) on electrical disconnects and power sources whenever practicable. A separate padlock should be used by each worker, and only one key should be in circulation for each lock. Per OSHA regulations, only he or she who applied the lock shall be allowed to remove it. (Note that there are certain conditions that require power be present to test, troubleshoot, or reposition the machine – but when such maneuvers are not underway, the system should be de-energized and put into an electrically safe working condition.)

Best Practices:
- Each employee should be assigned his or her own personal lock and key
- A padlock should be accompanied with a tag with the name of the person who installed the lock
- Each crew should carry a multi-lock device (hasp) so all workers can attach their locks and tags on one disconnect switch or control cabinet
- Each crew should have available arc flash rated equipment and tools if electrical exposure is expected and/or typical
- Only qualified and trained personnel shall perform electrical work
**Falling Objects:**

Working under a tower, especially with climbers above, can be hazardous. Two or more climbers working at different heights can also be risky. Efforts should be made to avoid working directly below other climbers. Note that dropped tools or equipment can also ricochet off a tower section and alter the path of descent. *Never intentionally drop or throw anything off a tower.*

**Best practices:**
- Hardhats or helmets are required at all times for climbers and ground crew
- Avoid working directly under the tower when climbers are on the tower
- Establish a work zone under the tower equal to half the total height, the distance that tools or hardware could fall away from and/or ricochet off the tower
- Establish “exclusion zones” of at least twice the height for onlookers and media
- Climbers should only use buckets, pouches, bags and pockets for tools, parts, and hardware that can be closed, zipped, fastened, or otherwise securely closed
- Use tools and gear fitted with loops or slings so they can be secured with carabiners to the climber, or to the tower
- Keep vehicles parked at least one-half the tower height away from the base of the tower to avoid damage from accidentally dropped tools or equipment
- All haul ropes should be the proper strength and diameter for tools to be used
- Adequate and proper pulley systems and anchor points are essential for lifting and hauling. Progressive capture for rope systems is highly encouraged.
- Tag lines (what about them??)
- Pay attention to weight restrictions for tools and buckets, and use mechanical advantage wherever possible
- Have a code word understood by the entire crew before work begins like “HEADACHE!” that will alert a crew members something has been accidentally dropped and evasive maneuvers (running, ducking or hiding) are immediately necessary.

**Communication:**

Climbers and the ground crew need to stay in contact with each other. Working with each other, yet separated by distance, can be hazardous if there is difficulty communicating what’s happening at each end. The windier it gets, the harder it is to communicate by shouting. Yelling is not the recommended method for staying in contact with coworkers.

**Best practices:**
- Keep radios or “walkie-talkies” charged and available at the job site
- Carry cell phones for alternate means of communication, and make sure they are charged
- Those working up-tower are generally “in charge” and should direct the ground crew.
  Working on the ground does not offer the same perspective as someone on the tower, where there are generally more hazards and greater risks.
- Use hand signals (crane signals agreed upon by the crane operator and crew before work begins) when your hands are full, if the radios aren’t functioning properly, or you cannot hear well with other means of communication.
- When using radios, do not use foul language. Have a system and language agreed upon by the entire crew before work begins. Standard words and phrases like “copy that” and “over” are encouraged for clarity during tower work.
Section 3: Personal Protective Equipment (PPE)

Like any other skilled trade, tower climbing requires the use of personal protective equipment for nearly all tasks. Workers must protect their eyes, ears, head, hands, and feet.

- **Eyes**: Safety glasses, approved eyeglasses, or sunglasses shall be worn at all times. ([OSHA reference](#)) Goggles are recommended in cold and windy weather.

- **Ears**: Hearing protection shall be worn when decibel levels exceed OSHA limits (e.g., using loud power tools or banging on tower structure) ([OSHA reference](#)).

- **Head**: Helmets or hardhats shall be worn at all times when approaching and/or working on a tower. ([OSHA reference](#))
  - Chin straps on helmets are recommended to stop the helmet from falling off the worker’s head.
  - Helmets shall be top- and side-impact rated for climbers. ([ANSI reference](#)) Top-impact-only rated hardhats are permitted for ground crew members.
  - Helmets shall not be vented if electrical and/or chemical work is typical or routine ([ANSI reference](#)).

- **Hands**: Gloves are highly recommended whenever practicable because working on a metal structure and with ropes has the potential to severely damage the hands. Additionally, foot pegs and ladder rungs are sometimes manufactured or coated with abrasive grips. See Section 1 on Environmental Hazards regarding protection of the hands in cold temperatures.

- **Feet**: Closed-toed shoes are required. Leather, waterproof work boots with ankle support and soles with good grip are recommended. Steel toes are not typically required, since they can be cumbersome when climbing a structure. However, they may be required or recommended by some employers. If working with electricity or in cold temperatures, composite toes are recommended instead of steel toes. Steel shanks are recommended if standing on thin metal structures for long periods of time is typical or routine.

- **Arc Flash Equipment**: Whenever a worker is exposed to 50 volts or more, he or she must be trained in arc flash requirements and wear appropriate Personal Protective Equipment. See **NFPA 70E** for more information regarding arc flash requirements including:
  - Cotton clothing and long sleeves
  - Gloves, face shields, and flash suits
  - Insulated tools
  - Qualified persons and required training

**EXAMPLE: ARC FLASH EQUIPMENT**
Section 4: Personal Fall Protection Equipment (PFPE)

In OSHA 29 CFR 1926 (Construction), a worker is required to be in full fall protection gear when working more than 6 feet off the ground. In 29 CFR 1910 (General Industry), work at 4 feet or higher requires fall protection. To be safe (and consistent), the best practice is to be in complete fall arrest gear when working 4 feet off the ground.

**OSHA Requirements:** (insert references)
- A worker shall never be exposed to more than a 6 foot free fall
- A full body harness shall be used; lineman, arborist, or other climbing “belts” are not acceptable
- Twin arm lanyards or two single lanyards shall be attached to the back D-ring of the full body harness. When not in use, these lanyards are stored on the climber’s side D-rings.
- Energy absorbers in the twin arm lanyards should limit the forces on the body to **1800 pounds** in the event of a fall
- Climbers shall always be “100% tied off” to the tower or a safe climb system. Never shall a worker be without fall protection. Absolutely no “free climbing” is allowed.
- Anchor points used for personal fall arrest systems shall be capable of holding **5000 pounds**. (Ask yourself – Would this anchor point support a full-size **pick-up truck**?)
- Work positioning belts, when used, must be in conjunction with fall arrest. Work positioning lanyards are not part of a personal fall arrest system.

**ANSI Z359 Standards:** (insert references)
- **Fall Factor 1** twin arm lanyards should be used when attaching to an anchor point at or above the rear D-ring of the harness, and should limit the forces on the body to **900 pounds**
- **Fall Factor 2** twin arm lanyards should be used when attaching to an anchor point below the rear D-ring of the harness, and should limit the forces on the body to **1350 pounds**
- Lanyards will deploy properly when the total weight of the person in the harness (with all equipment and tools) is between **130 and 310 pounds**
- These ANSI standards are the reason why climbers no longer use straight-nylon or rope-type lanyards with no Personal Energy Absorber. The forces generated during a fall without a PEA would likely exceed the OSHA-mandated 1800 pound maximum and cause serious harm.
- **Local codes & restrictions (CA – 4”lanyards)**

<table>
<thead>
<tr>
<th>Twin Arm Lanyards</th>
<th>Twin Arm Lanyards without PEA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>With Personal Energy Absorber (PEA)</strong></td>
<td><strong>VIOLATION:</strong></td>
</tr>
<tr>
<td>Fall Factor 1 = 900 lb max force on body</td>
<td>May not limit max force on body to 1800 lb</td>
</tr>
<tr>
<td>Fall Factor 2 = 1350 lb max force on body</td>
<td></td>
</tr>
</tbody>
</table>
We need to add calculating total fall distances!
Lanyards deploy (FF1/2 – harness stretch, etc…)

Best Practices with regard to PFPE:

Equipment Inspections:
- A complete fall arrest system must be used with every climb
- Annual written and recorded inspections by qualified and competent and trained workers are required. Each piece of PFPE inspected shall be appropriately marked on designated manufacturer tags, including the name or initials of the inspector and the date.
- Get a “buddy check” from a coworker before climbing the tower and commencing work
- Check all equipment for damage before each climb. Before each climb, look for:
  - Worn or frayed stitching
  - Cuts, rips, tears, burns, or mold
  - Discoloration (UV or chemical degradation)
  - Proper activation & seating of snap hooks and carabiners
  - Signs of deployment (stitching/tags)
  - False connections (snap hooks accidentally connected to nylon from the harness, clothing, ropes, or other equipment)
  - Proper harness fit
  - Twists in the harness fabric
  - Proper placement of all equipment and tools

Equipment Care & Storage:
- Store all PFPE in a dry place, and out of direct sunlight
- Never put wet equipment into storage
- Clean equipment as needed with water and mild soap. Air dry only; never use forced heat.

Snap Hooks and Carabiners:
- Only use double- or triple-activation snap hooks and carabiners. Single-action snap hooks can experience “roll-out” – especially when the hook is under pressure and not loaded along its major axis. (The gate on snap hooks and carabiners are rated far less than along the major axis.)
Components of a Personal Fall Arrest System:

- **Full Body Harness:**
  The purpose of the harness is to catch a worker when he/she falls, keep the body in an upright position, and evenly distribute the hanging weight. Waist bands or built-in “belts” are optional. The harness should have a minimum of 4 D-rings:
  - Front (sternum) – for limited fall arrest (climbing cable) systems
  - Back – for twin arm lanyards
  - Sides (2) – for attaching lanyard snap hooks when not in use, work positioning belts, tools, rope, and rescue equipment

**Best Practices:**
- The harness should fit well and be relatively snug – with only two fingers of wiggle room between the leg straps and the body of the worker. If the harness is loose, it can seriously hurt the climber in the case of a fall (especially male climbers)
- V-style harnesses are recommended for female climbers
- One should have full range of motion while wearing a full body harness. There are many styles harnesses available; the climber should wear what fits and works best.

**EXAMPLES: FULL BODY HARNESS (DBI SALA)**
- **Twin Arm Lanyards:**
  Shock absorbers for the twin arm lanyards will either be stitched directly into the nylon of each arm (Partially Oriented Yarn – POY), or a single Personal Energy Absorber (PEA) will be attached to the two static arms.

  **EXAMPLES:**
  - Single lanyard with PEA (below) and Twin arm lanyards with POY (right)

  Both styles are acceptable, and the lanyards will deploy properly if only ONE is attached and the total weight of the worker is between 130 and 310 pounds. Connecting BOTH arms of a twin arm lanyard will result in only half the forces normally present during a fall (since the weight is evenly distributed between both arms), and the PEA may therefore not deploy as designed. This can result in excessive forces on the body.

  The exception to this rule is when a person is climbing a structure by using twin arm lanyards as fall protection. Remember the “100% tie off” rule – a worker can never be without fall protection. If a worker is climbing a structure that does not have a safe climb (cable) system, he or she must attach the second arm of the lanyard before removing the first – and repeat this process all the way up and down the tower. While transitioning, it will be necessary to have both lanyards attached. When not in motion, the worker should have only one lanyard attached to an anchor point.

  Whenever possible, attach the lanyards directly above you – not off to the side. If a fall occurs, the climber will experience a “swing fall” and could sustain greater injuries by striking objects while swinging.

  **Best Practices:**
  - Wear Fall Factor 1 lanyards when attaching to anchor points level with or above the back D-ring of the harness
  - Wear Fall Factor 2 lanyards when attaching to anchor points below the back D-ring of the harness
  - Keep lanyards connected directly above the body, not off to the side (whenever possible)
  - When not transitioning, have only one lanyard attached so PEA will properly deploy
• **Limited Fall Arrest Systems:**
  Some small wind energy system towers have a steel cable that allows the climber to ascend and descend the ladder or foot pegs without having to use the twin arm lanyards. When this is the case, a limited fall arrest system must be attached from the cable to the front D-ring of the full body harness. The most common limited fall arrest systems in small wind are the Lad-Saf® (DBI Sala®) and the Tuf-Tug®. Safe climb systems that use cables and limited fall arrest are highly recommended over the lanyard-by-lanyard process described in the previous section.

Per ANSI Z359 standards, the maximum free fall distance allowed on a limited fall arrest system is **2 feet**. The maximum allowable distance between the steel climbing cable and the front D-ring is **9 inches**, so don’t swap the carabiners with larger ones, or use equipment that doesn’t come standard with these devices.

The limited fall arrest device acts much like a seatbelt mechanism, and allows the climber to ascend and descend at a normal rate – but will lock if the climber falls 6 inches. These devices can also lock when attempting to descend a tower, which can be a bit of a nuisance. To stop the device from unnecessarily locking, make sure it rides low on the cable (at the navel), and keep your body close to the cable. (Don’t lean back too far, or it will probably lock.)

**EXAMPLES: LIMITED FALL ARREST SYSTEMS**

![DBI SALA LAD-SAF](image1.png) ![TUF-TUG](image2.png)

**Best Practices:**
- Inspect the safe climb system and cable before climbing
- Attach the limited fall arrest device to the cable and test for proper operation before proceeding with climb
- When transitioning from a limited fall arrest system to lanyards, take the device with you. Do not leave it hanging on the cable.
- Use only manufacturer-specified limited fall arrest systems, based on the size of the cable.
- Do not use rope-grabs with steel cables, and do not use cable-grabs with ropes
Section 5: Emergency & Rescue Planning

If a climber gets hurt on a structure, the local first responders are not likely trained to execute a rescue. Much like a lineman working on overhead power lines, the emergency response team will need the person lowered to the ground before emergency care can begin. Small wind installers and maintenance personnel must plan for emergencies and rescue procedures. A person hanging in suspension trauma in a harness typically has less than 30 minutes before falling unconscious, and the window for rescuing an unconscious person is even less – only 5 minutes! Therefore a rescue plan is absolutely necessary.

Best Practices:
- Have a First Aid kit on site at all times
- Know the availability of 911 service (cell phone reception)
- Make sure all workers know the number to call (if other than 911) for emergencies – and have that number posted or saved in cell phones
- Keep an “In Case of Emergency, Contact” log for all crew members
- Have all crew members trained to perform an aerial rescue
- Do not depend on local rescue services to be trained in aerial rescue. Call ahead to locate nearest rescue team trained in aerial rescue.
- Know the approximate distance to the nearest hospital or response time of a rescue team
- Make sure all workers know the address/location of the job site, and have it posted so the rescue team can find you
- Never work alone
- Have rescue gear on site and available at all times:
  - Rope long enough to reach the ground from the top of the tower
  - Controlled rate descent device
  - Anchor slings or straps
  - Edge protectors for rope (rolling or wrap-around/Velcro type)
  - Extra carabiners
- Never use rescue gear or rope for missions other than rescue
- Have all workers keep trauma straps on their harnesses. In case of a fall and hanging in suspension trauma, the person (if conscious) can deploy the straps, connect the two ends to form a loop, then stand in the loop to lessen discomfort, restore blood flow to the lower half of the body, and lengthen the time needed for the rescue team to respond.

EXAMPLE: TRAUMA STRAPS (DBI SALA)
Some of the rescue gear used in the large wind energy field can be used in small wind as well. One essential piece of gear to have is a **controlled rate descent device** that can be used to rescue a coworker, or as an evacuation device to get yourself out of danger quickly. The purpose of the controlled rate descent device is the ability to raise a person if needed (to relieve the strain on the climber’s fall arrest system), and then to lower him or her to the ground at a controlled speed.

**EXAMPLES: CONTROLLED RATE DESCENT DEVICES**

Anchor points used for rescue equipment must be rated for at least **3100 pounds** per ANSI Z359. Anchor points can be made with nylon straps, ropes, and carabiners.

**Best Practices:**
- Have rescue gear on site at all times
- Make sure all workers are trained in rescue and potential emergency situations
- Have an appointed and qualified person inspect rescue gear and rope annually
- Train workers to tie basic knots for ropes and anchor points. Refer to [www.animatedknots.com](http://www.animatedknots.com).
  - Alpine Butterfly (Lineman’s knot), for anchor points
  - Figure 8 and Double Figure 8 on a bight, for anchor points
  - Munter Hitch, for emergency belay
  - Klemheist and Prusik knots, for attachment (anchor) points on ropes and lanyards
ALPINE BUTTERFLY

FIGURE 8 ON A BIGHT

DOUBLE FIGURE 8 ON A BIGHT

MUNTER HITCH

KLEMHEIST

PRUSIK
Section 6: Health & Fitness

Climbing a tower is a highly physical activity that requires general good health. There is no reason to be an incredibly fast climber under normal circumstances, and it’s actually best to keep a steady pace and get into a climbing “rhythm.” It’s not a good idea to let yourself become exhausted, as you may need strength to attend to an unexpected situation or emergency. Continually monitor the condition of your climbing partner(s). In most cases, you are likely to be up-tower for a long time, so be prepared.

Best practices:
- Be well rested and in good general health
- Avoid excessive caffeine, sugar, or other “energy products”
- Have enough food in your body and on the worksite for the day. You will burn many calories if you’re climbing and will need adequate “fuel.”
- Never climb under the influence of alcohol or drugs
- Rest as needed
- Stretch before climbing to avoid strains and sprains. Do each exercise or hold each stretch a minimum of 10 seconds.
  - Neck rolls
  - Arm circles (for shoulders)
  - Forearms
  - Groin
  - Hamstrings
  - Ankles
  - Hips & Gluteus
- Share with your coworkers information about any injuries you have or medications you’re taking that may interfere with your ability to climb or perform safely
- Never climb if you’re feeling ill, weak, or light-headed
- Keep your body close to the tower and focus on climbing mostly with your legs, not your arms
- Try to maintain “three points of contact” – only one limb off the tower at a time (or two limbs when using a limited fall arrest system attached to the front D-ring on a full body harness)
Section 7: Tower & Foundation Inspection

VISUAL CHECKS:

- **Vertical alignment of tower:**
  Stand at the base of the tower and look up each face. Attempt to obtain a view of the tower legs from the base to the top of the tower. You are looking for visible deviation from plumb in the structure or legs, or visible deviation of the legs between guy stations. For an accurate indication of the actual field condition of the tower, a transit should be used to check the plumb.

- **Condition of concrete base (foundation):**
  Inspect the visible concrete at the tower base. You are looking for visible signs of:
  - Deterioration (cracking or spalling)
  - Improper installation (uneven surfaces, lack of grout, rebar showing)
  - Settling of concrete (bent tower legs, soil on top of concrete, or non-level concrete surface)
  These conditions are warning signs, and when combined with other conditions of concern, can indicate a problem in need of further attention.

- **Condition of concrete at guy anchors (if visible):**
  Inspect the visible concrete at each guy anchor. This may or may not be applicable at any given site, depending upon anchor designs. In most cases, dead man anchors are designed with soil over the top of the concrete, so the concrete will not be visible or accessible. If visible, you are looking for the condition of the concrete as stated above (deterioration, improper installation, and settling of concrete).

  INSERT PICTURE – DEAD MAN ANCHOR

- **Condition of anchor shafts and anchor head (above grade):**
  Inspect the anchor shaft and anchor head at each guy anchor. Look for corrosion on shaft and anchor head, bent rods, plates, etc. Light corrosion or surface rust with no scaling is not serious enough to warrant an emergency, but should be noted for future inspections.

- **Visual signs of anchor shaft movement in the soil:**
  Inspect the condition of the soil around the anchor shaft where it enters the ground. This is called the “daylight point.” This location can give clues to anchor movement and anchor corrosion. If there is evidence of anchor movement, it may manifest at this location in the form of voids in the soil. Voids under the shaft can indicate that the anchor shaft is not properly aligned with the tower.

- **Alignment of guy anchor shafts to the tower leg:**
  A transit should be incorporated to determine any actual deviation of the anchor from the specified heading. A visual check can be made in the field to roughly gauge the alignment of the anchor. Standing behind the anchor and looking towards the tower, site down the anchor shaft to site the heading. As a general rule, the anchor should point directly at the leg to which its guy wires are attached.
- **Sag in the guy wires:**
  Excessive sag in the guy wires of a tower can be an indication of improperly adjusted guy wires, damage to the tower, or an anchor that is moving. Testing the tension on the guy wires using mechanical, sighting, or pulse methods is the only accurate way to gauge the tension of guy wires. All guy wires will have some sag in them as designed. The manufacturer of the tower should be able to provide tension specifications. Guy wires should not be lying on the ground nor have “excessive” sag.

- **Condition of guy wire terminations:**
The guy wire terminations you will most likely encounter are two main mechanical means: Preformed Dead End grips or metal clamps. The metal clamps will either be designated fist grips or cable clamps. If cable clamps are indicated, look for loose clamps on both ends of all wires. The manufacturer of the tower should have included specifications for quantity of clamps, distance between clamps, and torque. Use these specifications to spot problem clamps, and remember to “never saddle a dead horse.” Look for improperly placed clamps; problems here could be a sign of installer concerns.

  *Never saddle a dead horse*

- **Condition of turnbuckles:**
  Look for excessive corrosion and scaling on turnbuckles. Check the size of the turnbuckle with the size specified by the manufacturer. Check that turnbuckles are installed directly to the anchor head or approved mounting bracket or “splitter,” where torque arms are concerned. Turnbuckles should be attached to the anchor heads with the pins and a cotter pin retainer included with the turnbuckles - and not bolts. The tower end of the turnbuckles should have a thimble installed one size larger than the guy wire being used. The performed or guy wire wraps around the thimble, and should be seated completely in the thimble. Cracked, bent, or otherwise broken or deformed turnbuckles should be replaced before climbing.
- **Condition of turnbuckles – Available threads:**
  Turnbuckles should have been installed at the completion of tower construction with slightly fewer threads on the interior of the turnbuckle body than on the outside, while both ends are even with each other. This allows for tightening of the turnbuckles without the shafts contacting each other. As a general rule, turnbuckle shafts should not touch each other on the inside of the turnbuckle body, and there should not be less than 2 inches of visible threads sticking out of each body toward the inside. If there are less than two threads showing, do not climb the tower.

- **Condition of turnbuckles – Existence and condition of safeties:**
  “Safeties” on turnbuckles should be installed at the completion of tower construction in as close to a figure-eight pattern as possible. Safeties are usually constructed out of small guy wire, ¼” or 5/16”, and cable clamps. They are designed to keep turnbuckles from turning out with the twist of the guy wires. Safeties should be looped through the thimble or turnbuckle eye/jaw on the upper end of the turnbuckle and the turnbuckle body. They should also be looped through the anchor head end of the turnbuckle eye/jaw. If there are no safeties installed, do not proceed climbing this tower.

  **INSERT PICTURE – FIGURE 8 SAFETIES**

- **Check hollow leg towers “weep holes”:** Hollow leg Self Supports and Guyed towers have “weep Holes” at the base of the legs to permit condensation drainage of inside of the legs. These need to be clear of debris to allow proper drainage. Plugged “weep holes” can cause excessive rust and corrosion problems along with possible fractures in the leg from freezing water.

- **Check for missing bolts or bent members on the tower.** Bolts should have been installed pointing up and out to make visual detection easier from the ground. The use of binoculars can be very helpful for ground level inspections.

- **Verify existence and proper operation of safety climb device**

- **Condition of welds and members at the tower base and above**

- **Corrosion on guy wires or broken strands**
Section 8: Ground Crew

Once a climber is on the tower, he or she may be less able to anticipate or identify certain hazards, especially those occurring on the ground. From good communication to the hoisting of tools, it is important that all members of the ground crew are clear about their roles and responsibilities. Ground crew members should be physically and mentally equipped to perform their own tasks, and should also be aware of, and able to perform, the tasks of other crew members. They are the eyes and ears for the climbers and each other, and they play a significant role in the safe completion of a job.

Best Practices for Establishing a Safe, Effective Ground Crew:

- Have a brief meeting at the beginning of each work day
- Assign tasks based on skill level, physical and mental capability, training, certifications and comfort level of crew members
- Make sure crew is adequately sized for the number, type and duration of required tasks
- Make sure all members understand their roles and the roles of their teammates
- Make sure all members know where First Aid kits, emergency numbers and other important information is located (see more in section xx on safety)
- Establish clear methods of communication (refer to sections xx and xx for more on communication)
- Remove distractions such as cell phones and radios (other than those necessary for crew communication)
- Enforce pre-established perimeters (i.e. control bystanders). Once climbers are on the tower, they have little or no ability to manage what happens on the ground.
- Wear hardhats and avoid standing directly beneath climbers where they could be struck by dropped objects
- Keep a watchful eye on the climber(s) – watch for signs of fatigue, observe safe climbing methods and check in at pre-arranged regular intervals (verbally or w/hand signals...i.e. thumbs-up, thumbs-down, etc.)
- Keep a watchful eye on other ground crew members. For example, if someone running a tag line becomes fatigued and releases a tag line, injuries to the climber(s) and/or damage to equipment can occur.
- Be mindful of approaching and/or changing weather; assist climbers in determining how much time they need in order to descend the tower safely and avoid hazardous weather.
Section 8: Working with Cranes

*Wear bright-colored or high-visibility clothing so the crane operator can easily see you.*

CONSIDERATIONS

- **Correct size for application:**
  - Necessary “stick” (boom height)
  - Size (in tons) needed to pick weight to required height
  - Have crane company walk site before contracting them, so there are no surprises
  - Use a reputable crane company, and have crane company supply all rigging, operator and assistant

- **Staging crane and tower assembly:**
  - Layout crane and tower/generator/blade assembly, so there are no conflicts when the crane arrives
  - Conduct a pre-pick meeting with the crane operator and anyone that will be on-site to review how pick will take place
  - Other equipment to walk bottom of tower in toward crane if necessary
  - If possible never position yourself under a load that is being picked

- **Attachment:**
  - Rigging
  - Straps
  - Spreader bar
  - Clevis hooks

  INSERT PICTURES – Basic rigging, spreader bar, clevis hooks

- **Communication:**
  - Radios – Quality radios are needed for good communication. Verify [radios are working and have fully-charged batteries prior to using them](#). Everyone working on site should have a radio. **Extra batteries and charging stations are a best practice.**
  - Review crane hand signals in case radio doesn’t work
  - Only one experienced person on the ground should direct the crane operator (has a cell phone and the crane operator’s cell number for backup use if needed). It is important that only one person is “in charge” of the crane operator. However, anyone on-site has the authority to stop a pick if he or she sees something happening incorrectly. All other cell phones are shut off or stored away; distractions cause accidents.

- **Setting tower:**
  - Never position yourself under a load. Keep body, fingers and toes clear.
  - Good communication is key to everyone’s safety when setting a tower
  - Install tag lines to control tower
  - Secure base to pre-leveled anchor bolts/nuts
  - Clear flanges from any dirt or debris that make get caught during the initial pick
- **Detachment:**
  - Make sure base is secured before climbing tower
  - Take tension off from crane slowly and stay alert
  - Remove and clear straps, spreader bar, etc.
  - Person on tower is “in charge”

### CRANE SIGNALS

<table>
<thead>
<tr>
<th>Main Hoist</th>
<th>Auxiliary Hoist</th>
<th>Hoist Load</th>
<th>Hoist Load Slowly</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raise Boom</td>
<td>Raise Boom &amp; Lower Load</td>
<td>Lower Load</td>
<td>Lower Load Slowly</td>
<td>Emergency Stop</td>
</tr>
<tr>
<td>Lower Boom</td>
<td>Lower Boom &amp; Raise Load</td>
<td>Swing Boom</td>
<td>Swing Boom Slowly</td>
<td>Travel (mobile eqpt)</td>
</tr>
<tr>
<td>Retract Boom 2 hands</td>
<td>Retract Boom 1 hand</td>
<td>Extend Boom 2 hands</td>
<td>Extend Boom 1 hand</td>
<td>Dog Everything</td>
</tr>
</tbody>
</table>
OLD RIGGING KNOTS

Sight of rope  Overhand Knot  Figure-8 Knot  Double Overhand Knot  Bowline

Square or Reef Knot  Sheet Bend or Weaver's Knot  Sheet Bend with a toggle

Carick Bend  Stevedore Knot

Slip Knot  Flemish Loop  Chain Knot with toggle


Blackwell Hitch  Round Turn and Half-Hitch  Will Knot (end splice)

Fisherman's Bend

Eye Splice

from "Structural Engineers Handbook," Milo S. Ketchum, 1924.
(MOUSING)