FALL PROTECTION
Top 10 Misuses & What to Do About Them

By Craig Galecka and Shawn Smith

Fall protection equipment is the most visible aspect of a fall protection program and it can be the most costly. Unfortunately, these investments can be nullified due to equipment misuse or cheating (i.e., using the equipment outside its intended use).

Common fall protection equipment misuse issues are well documented in equipment literature, through standards boards and in safety-related publications. The following 10 examples of misuse were selected based on the authors' personal experience and more than 30 years of observation in their roles as fall protection consultants. Each misuse is explained followed by recommendations for how to rectify it.

1) Rebar Snap Hooks

Rebar snap hooks, also referred to as pelican hooks, large gates or form hooks, are frequently used because they are large and can connect to many objects. Just as with other components, rebar snap hooks are tested and approved for use only in specific configurations. When used outside those configurations a risk of failure exists.

KEY TAKEAWAYS

- **Equipment misuse can jeopardize the often significant investment made in fall protection equipment and systems.**
- **Despite the complex requirements for fall protection anchorage, workers commonly connect to something even when the anchorage strength is in question.**
- **Even seemingly minor damage to fall protection equipment can drastically reduce its capabilities.**

Rebar snap hooks are not tested in the same way they are used. For example, the larger snap hooks are not tested for bending and some manufacturers are now marking certain parts of the hook with "Do Not Load" to illustrate when loading is outside the equipment's intended use. When these snap hooks are attached to vertical members, such as guardrail and scaffolding posts, the potential exists for bending and loading of the area marked as not to be loaded.

This misuse is common for two main reasons:

1) This type of equipment is often preferable because it eliminates the need for an additional anchorage connector. While convenient, this can be dangerous since a worker's anchorage of choice may be of questionable strength or could cause the snap hook to be loaded inappropriately.

2) These snap hooks are designed larger to capture larger structures. However, those structures are not necessarily directly over the worker using the personal fall arrest system (PFAS). Testing has not been performed along any diagonal oblique angles that would commonly occur when using hooks on vertical scaffold members, vertical rebar or ladder side rails. In accordance with Section 4.2 of the consensus standard, these snap hooks are tested to load the major axis of the hook and to load across the gate and down onto the gate (ANSI/ASSE, 2009).

Ideally, to mitigate this misuse issue, the anchorage connector D-ring should be larger than the snap hook to avoid side loading of the snap hook, but this is nearly impossible to achieve. Organizations should consider using a small anchor strap (Photo 1) to achieve better geometry.

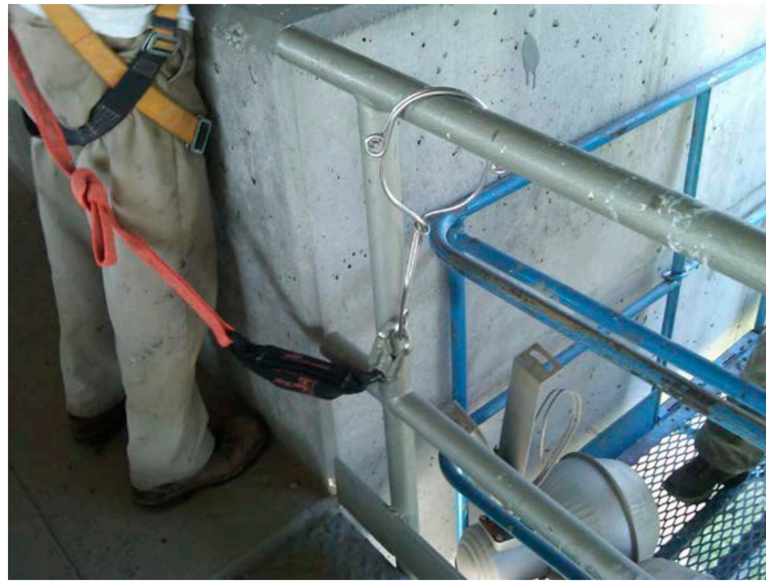
Several factors should be considered if a rebar snap hook will be used. Is it a pre-2009 snap hook with gate strength of 220/350 lb, instead of the upgraded 3,600-lb gate strength? What is the strongest part of the hook? In some configurations, the hooks will have two stress points. Those points should align with the strongest points on the hook. In this manner, the competent person must consider anchor structure, hook configuration and potential load path in the event of a fall.

2) Inappropriate Anchorage Connections: Lanyards Wrapped on Themselves

Some lanyards are designed to accommodate being wrapped back upon themselves. The vast majority are not. When using lanyards improperly in this way, users risk equipment failure due to improper gate loading or lanyard material damage due to point loading.

This scenario creates another loading condition that the equipment has not been tested to address. The current ANSI/ASSE Z359.13-2013 standard on lanyards does not include testing for wrap-back lanyards.

Beyond whether the lanyard is rated to be wrapped on itself, it is critical to be aware of what the lanyard is wrapped around. Users must know whether the lanyard is wrapped around piping,



Clockwise from top left:

Photo 1: Using a flexible anchorage connector will help prevent unwanted loading of a snap hook.

Photo 2: Among several equipment misuses shown in this photo, guardrail is typically an inadequate anchorage.

Photo 3: Eyebolts are only rated to be loaded in plane.

ductwork, beams or guardrail, and whether corners, edges or other elements could create a sawing action.

To avoid this misuse concern, focus on the following considerations:

•Maintain unobstructed load path between anchor and potential fall path of worker.

•Use a simple beam strap or beam clamp designed as an anchorage connector to address these concerns.

3) Insufficient Anchorage Strength

Fall protection equipment users are commonly observed attaching to inadequate anchorages such as guardrails (Photo 2), pipe vents or even conduit. Workers must not do this.

Fall protection users often believe that it is better to connect to something than nothing at all, even if the anchorage strength is in question. While the weight of the equipment is easiest to equate to strength (e.g., fans, equipment, pipes), this factor may be deceiving for many materials because protective coatings can conceal the core material.

Eyebolts (Photo 3) are particularly challenging as anchorage connectors because they are rated to be loaded in plane only. When loaded outside of plane, their capacity goes down significantly, which could result in failure (e.g., when loaded 45° out of plane the capacity is 25% of work load limit) (NCCCO, 2014).

It is critical to understand what the eyebolt is attached to and how it is attached to confirm whether it is properly attached. It may appear strong enough but this can be deceiving.

Several methods exist to avoid these misuse issues:

•All competent persons who supervise authorized persons should be trained to identify proper anchorages and be capable of judging that a noncertified anchorage has adequate strength.

•Use certified anchorages that are designed by a qualified person.

•Specify the exact equipment to be used for each system and ensure that the anchorage is designed for the different loading possibilities with 900-lb and 1,350-lb average arresting force lanyards.

Harnesses can be purchased for individuals up to 450 lb. All ANSI/ASSE Z359 equipment is rated for use by individuals between 130 and 310 lb. A person who weighs more than 310 lb could completely pull out an energy absorbing lanyard and increase the average arresting force to more than 900 or 1,350 lb. This force would be transferred to the person's body and to the ultimate anchorage. Therefore, it is of critcal importance to have the anchorage and the overall system designed for the maximum weight of any potential system users.

•Determine the construction of a potential anchor by using a magnet to determine whether it has ferrous content, as would be the case for steel. Tapping the material with metal will also indicate whether the material is an aluminum (metallic echo), fiberglass or composite material (dull sound).

•Users also must be trained to recognize other potential issues that impact anchorage capacity:

1) user weight greater than 310 lb;

2) use of a 12-ft free-fall lanyard, which requires more anchorage capacity than a 6-ft free-fall lanyard.

4) Anchored Below Dorsal D-Ring

When workers anchor below their feet it increases free fall, potentially above the allowable limits of the equipment. This misuse could result in failure of the lanyard or anchorage, or exceed the allowable force on the body, thus increasing the likelihood of serious injury.

Increased fall distance results in increased forces to the body, which can cause severe injury even if the system technically arrests the fall. So, even if it appears that fall risk has been minimized or eliminated, a significant impact risk is still present.

OSHA allows for a maximum of 6 ft of free fall. The only exception is an OSHA (1996) letter of interpretation, which states that it is acceptable to exceed this only if the system can limit the maximum arresting force to 1,800 lb.

It is best not to anchor below one's dorsal D-ring; however, if no alternative exists, it can be done provided the proper equipment is used, namely a 12-ft free-fall energy absorbing lanyard or self-retracting lanyard that is rated for additional free fall. In either case, the average arresting force is more than that of the standard version and, therefore, the anchorage must be designed accordingly.

To avoid this issue:

•Do not stand if it is not necessary to do so.

•Keep the center of gravity low to reduce free fall distance and potential fall energy.

•Use correct equipment for the appropriate application (e.g., use 12-ft free-fall lanyard if the only anchorage option is below the dorsal D-ring).

5) Twin-Leg Energy Absorbing & Self-Retracting Devices

Twin-leg energy absorbing and self-retracting devices are two common pieces of equipment that can be confusing for users because they look similar and are generally used in the same way. However, they are not the same. These devices are tested in different conditions and applications, and they should only be used in the manner in which they are tested. They are not interchangeable.

One of the most common misuses of this equipment is anchoring below the dorsal D-ring. While this is improper use for both types of lanyards, it is especially dangerous with twin-leg energy absorbing lanyards due to the potential for increased forces.

More specifically, if a system has two energy absorbers, as in a twin-leg lanyard, each will begin pulling out at 450 lb and could have an average arresting force of 900 or 1,350 lb. So, a falling worker could experience 900 lb of force even before the twin-leg lanyards begin pulling out. Consequently, after fully pulling out the force could exceed the maximum force allowed and reach up to 2,700 lb.

Following are key tips to avoid misuse of lanyards:

•Ensure that the twin-leg energy absorbing and self-retracting devices are tested in the manner to be used (e.g., tested for additional free fall if attached below dorsal D-ring).

•Do not attach both legs to an anchorage. Always connect unused leg to the non-load-bearing part of the harness via breakaway tab or specific lanyard parking element. Do not attach to a load-bearing part of a harness (Photo 4).

•Do not anchor both legs of lanyard at same height, which may increase arrest forces.

•Have a training self-retracting device unit available that can be disassembled so that users can learn the vulnerabilities and inner workings of the unit.

6) Damaged & Recalled Equipment

Workers are often unaware or not properly trained on what to look for when performing a preuse inspection. For example, UV exposure discoloration, small cuts and corrosives/acid exposure can have serious consequences to equipment use. Employees may not acknowledge that these seemingly minor equipment issues are critical problems for proper functionality.

Clockwise from top left:

Photo 4: Workers should not attach a lanyard leg to a load-bearing part of a harness.

Photos 5 and 6: Both of these pieces of equipment were in active use despite showing significant damage indicating they should be removed from service. The SRL (Photo 5) has significant rust and damage to the extent that equipment labels are no longer readable; the lanyard (Photo 6) shows significant UV deterioration.

Photo 7: This equipment shows significant rust due to improper storage.

These examples highlight the importance of preuse inspection to minimize the risk of equipment misuse or failure. The preuse inspection is a mandatory part of a fall protection program. Workers must be trained to properly inspect equipment with both visual and tactile methods to make sure any imperfections are recognized before using the equipment.

Another way to minimize the risk of damaged equipment is to plan ahead to ensure proper storage. When equipment is stored in a job box or van, the interior can reach an extremely high temperature, which can damage soft goods. In addition, similar damage can occur when equipment is placed into storage while wet and is later exposed to direct sunlight. The self-retracting device shown in Photo 5 had no legible markings, appears severely damaged, yet was in use.

It is important to maintain as much environmental control as possible to avoid allowing soft goods to be exposed to hazardous materials, chemicals or UV lighting. The original color of the lanyard shown in Photo 6 was bright red. This is obviously UV degradation, but the lanyard was still actively being used. On naval ships, fall protection equipment has been found in paint lockers where paint is mixed, which increases risk of equipment damage.

There are several ways to avoid these misuse issues:

•Ensure that competent persons conduct detailed, comprehensive formal equipment inspections at least annually.

•Register the products to be made aware in the event of a product recall or advisory. If products are not registered, ensure

Photos 8 and 9: Improper harness fit. Photo 8 (left) shows the harness dorsal D-ring more than halfway down the person's back, while it should be between the shoulder blades. Photo 9 (right) shows a chest strap positioned too high, which could cause a choking hazard in the event of fall.

that the competent person annual equipment inspection includes reviewing product inventory against product recalls.

•Develop and maintain a relationship with a manufacturer, distributor, training entity or consultant organization to remain current on advisories and advances in technology.

•Store equipment in an environment that is as protected as possible.

One example that showcases the impact of ostensibly insignificant damage is the testing conducted by Murdock Webbing Co. Inc. According to its research, a 10% center cut decreases the original capacity of the webbing material by more than 23% (Golz, 2010).

Another example illustrates how a pencil-sized discoloration on a harness strap proved to be a significant safety concern. When the competent person who was conducting the formal equipment inspection noticed this, he pulled on the leg strap and it actually broke. The cause of this discoloration and ultimate failure of the equipment was exposure to battery acid. Photo 7 shows significant rusting due to storage of the lanyard in a cabinet with corrosive chemicals.

7) Improper Fit of Equipment

When workers wear harnesses that are not properly fitted and hang loose on their bodies, serious injury can result during a fall. When equipment is hanging loose more potential energy is introduced, which becomes kinetic energy in the event of a fall.

If a dorsal D-ring is too high, it could hit the back of the head during a fall. If it is too low, an individual who falls may be facing the ground after the fall is arrested, increasing the probability of suspension trauma (Photo 8). If a chest retainer strap is too high, it can choke the worker (Photo 9). If it is too low, it could pull apart and allow a worker to fall out of the harness.

When discussing proper equipment fit, people typically think of harness adjustment. However, another significant aspect of proper fit is matching the workers to the task, taking into consideration health and physical factors that impact the risk profile.

When considering personnel assignment to tasks that require the use of PFAS, several factors should be considered, including weight, height, underlying medical conditions such as hypertension, back injuries, vertigo and medication side effects.

The weight range according to ANSI/ASSE Z359.11 is 130 to 310 lb (ANSI/ASSE, 2014a). This is not necessarily an effective range. According to an analysis of the 2010 Anthropometric Survey of U.S. Marine Corps Personnel, approximately 39% of females weigh less than 130 lb (Gordon, Blackwell, Bradtmiller, et al., 2013). This indicates that a sizeable percentage of the population is not supported under the current standard. A significant population of workers also exceed the 310-lb limit, especially when using heavy tools, leading to a significant number of models on the market, covering from 310 to 450 lb.

Following are recommendations to avoid improper harness usage:

•Perform five-point fit check:

1) one dorsal D-ring between shoulder blades;

2) two shoulder straps that cannot be pulled off the shoulders outward;

3) subpelvic strap under buttocks;

4) four fingers between leg straps and leg (but not able to pull away from leg);

5) general observation of harness fit, looking for potential issues such as twisted straps and loose leg straps to ensure symmetry.

•Engage medical personnel in establishing a medical clearance process for PFAS users to properly control and mitigate medical risks.

•Train all authorized persons in the proper fit of their harness.

•Suspend authorized persons in their harnesses to demonstrate how it feels to be suspended. This exercise has proven to impact worker behavior, as they have personally felt the effects of misuse.

8) Leading Edge Self-Retracting Device

Only self-retracting lifelines (SRLs) that are designed for leading edge work or that are edge rated should be used in a horizontal arrangement, otherwise the result can be equipment failure due to point loading of the lanyard.

In addition, if the equipment does not have an energy absorber between the edge point and the worker, the worker could receive the full impact of the fall without the benefit of an energy absorber.

A video of SRLs tested in a horizontal arrangement illustrates the dire consequences of using equipment in this way (Honeywell Safety, 2013). Based on this and other research studies, ANSI/ASSE Z359.14-2014 now includes a requirement that SRLs that are tested for use in this arrangement receive special indication as edge rated (ANSI/ASSE, 2014b).

To avoid failure at a leading edge:

•Ensure that equipment that could go over an edge is rated for that type of use (e.g., SRL-LE).

•Use an edge protector to minimize the potential damage on lanyards going over an edge.

•Ensure that there is an energy absorber at the worker's body to minimize the potential for additional forces on the body.

9) Warning Line Systems

Guidelines for warning line systems (Photo 10, p. 56), exclusion zones and handrail systems are all direct; yet, it is still common to find a combination of systems that neither provides protection nor meets requirements.

According to OSHA (2016a) in 1910.29(d)(2), warning line systems must meet the following requirements:

•located 34 to 39 in. off the surface (roof) and visible from 25 ft away;

•flagged every 6 ft;

•tensile strength of 500 lb;

•tip over force of 16 lb.

Tips to minimize misuse of a warning line system:

•Ensure that the roofing company understands the complete requirements of warning line systems.

•Use parachute or 550 cord for the warning line.

•Label it "Warning line system in use."

10) Horizontal Lifelines

Horizontal lifeline (HLL) systems are perceived as low cost, simple, aesthetically pleasing solutions; they are touted for their ability to span long distances without overhead structure. However, they always require a qualified person's involvement due to the energy equations involved to properly design them. If the system is not designed properly, the end anchorage structure may be overloaded or cause an individual who has fallen to hit the ground due to the increase in anchorage system displacement.

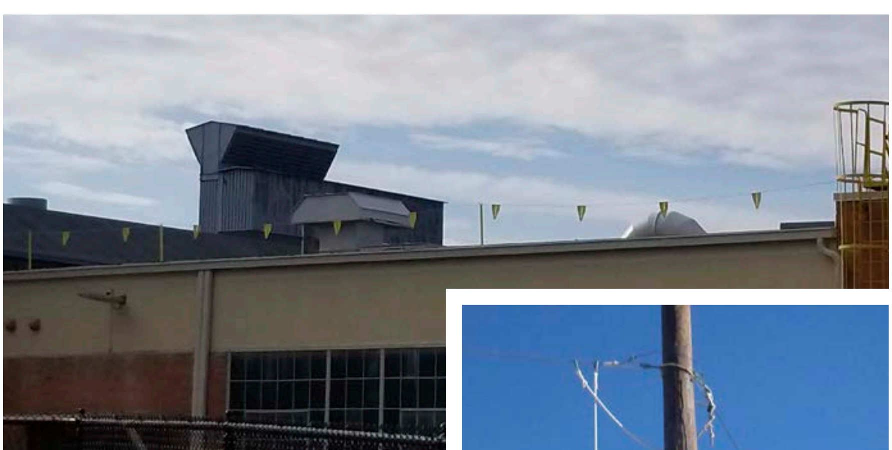
End anchorage forces can easily exceed 5,000 lb. Fall clearance requirements can also be high with these systems. Changing parameters such as number of users, span length, intermediate anchorages and presence of an in-line energy absorber can greatly affect end anchorage forces and fall clearances. Because of this, it is critical to not make adjustments in the field without oversight by a qualified person.

These systems can also be misused due to poor installation (e.g., wire rope clips installed incorrectly) and improper intermediate anchorages that could result in point loading and failure of the cable. Photo 11 shows a questionable end anchorage and noncompliant anchorage connectors.

Some other considerations related to HLLs: Workers should not attach a snap hook directly to an HLL. This can cause damage to both the HLL and the snap hook. Also, while HLLs can be inexpensive, they can be expensive if a system requires pass-through devices.

The primary way to mitigate issues with HLLs is to involve a qualified person in design, inspection and use. This involvement is required by OSHA (2016b) in 1910.140(c)(11)(i) and is truly critical for such complex systems. In addition, qualified persons should:

- Specify all equipment components used in an HLL system, including intermediate anchorages, pass through devices and anchorage connectors.
- Develop detailed use and rescue procedures that provide design basis (e.g., number of users, maximum weight, clearance requirements, inspection requirements) to ensure that systems are not used outside the manner in which they were designed.



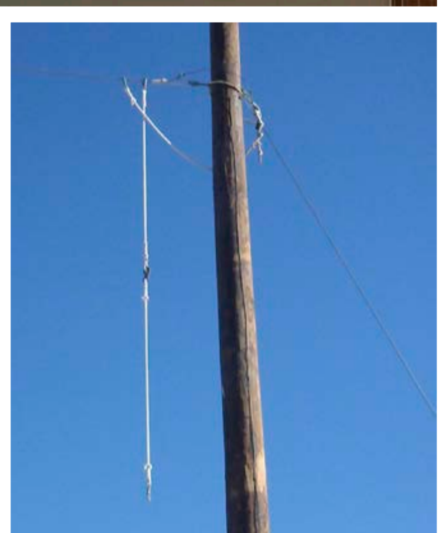


Photo 10 (top): A good example of a warning line system.

Photo 11 (bottom): A questionable end anchorage and noncompliant anchorage connectors on a horizontal lifeline.

Conclusion

Organizations should always strive to avoid putting workers in fall protection systems. When no other practical alternative exists and fall arrest systems are chosen, the residual risk is high due to the prevalence of misuse. Improper equipment use can often be avoided with quality training, active supervision and continuous improvement. PSJ

Craig Galecka, P.E., CSP, is principal and project manager with LJB Inc. He specializes in safety and environmental compliance, and has extensive experience with fall hazard surveys, confined space audits, fall protection system design and fall protection training.

Shawn Smith, CSP, is senior safety specialist at Naval Facilities Engineering Command, and mishap prevention hazard abatement program manager for the U.S. Navy. He has extensive experience in fall hazard surveys, fall protection training and fall protection policies and processes.

References

ANSI/ASSE. (2009). Connecting components for personal fall arrest systems (ANSI/ASSE Z359.12-2009). Des Plaines, IL: ASSE.

ANSI/ASSE. (2013). Personal energy absorbers and energy absorbing lanyards (ANSI/ASSE Z359.13-2013). Des Plaines, IL: ASSE.

ANSI/ASSE. (2014a). Safety requirements for full body harnesses (ANSI/ASSE Z359.11-2014). Des Plaines, IL: ASSE.

ANSI/ASSE. (2014b). Safety requirements for self-retracting devices for personal fall arrest and rescue systems (ANSI/ASSE Z359.14-2014). Des Plaines, IL: ASSE.

Golz, R. (2010, April 6). Considerations in determining service life of webbing products used in the fall restraint industry (Presentation). Murdock Webbing Co. Inc. Presented at ANSI Z359 Committee meeting.

Gordon, C., Blackwell, C., Bradtmiller, B., et al. (2013). 2010 anthropometric survey of U.S. Marine Corps personnel: Methods and summary statistics. Natick, MA: U.S. Army Natick Soldier Research, Development & Engineering Center.

Honeywell Safety. (2013, Aug. 2) Miller edge-tested fall protection solutions (Video). Retrieved from https://youtu.be/3xXYhIFyT3c

National Commission for the Certification of Crane Operators (NCCCO). (2014). Rigger reference manual. Fairfax, VA: Author.

OSHA. (1996, Dec. 4). Standard interpretation: Letter to Lynn A. Warren, Cottrell. Retrieved from www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=interpretations&p_id=22308

OSHA. (2016a). Fall protection systems and falling object protection—criteria and practices (29 CFR Part 1910.29). Retrieved from www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9721

OSHA. (2016b). Personal fall protection systems (29 CFR Part 1910.140). Retrieved from www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=1291