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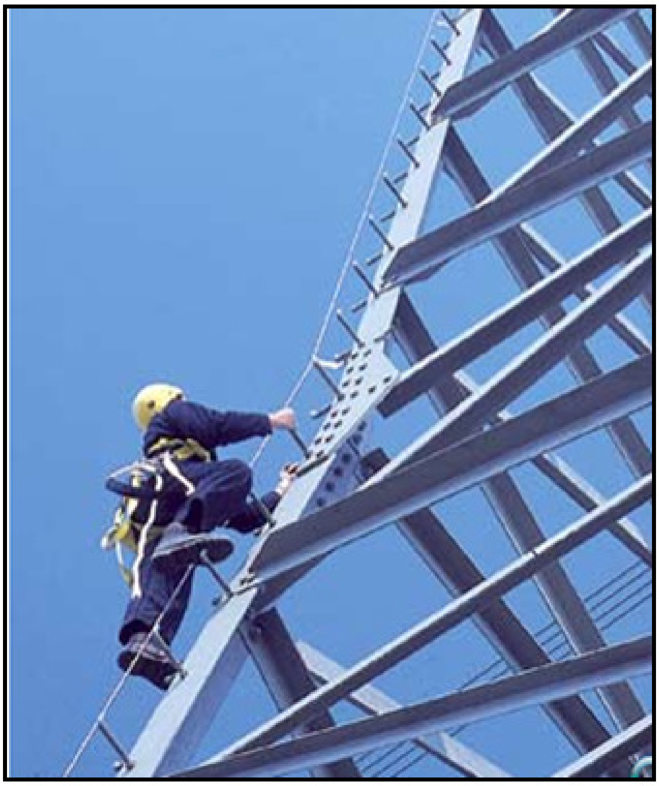
Climbing using Wire Type Fall-Arrest Systems: Why it's the Method of the Future

This paper examines the problems with the dual lanyard attachment method, and explains why permanent wire type fall arrest systems have much better safety outcomes.



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1. Introduction

The power industry has historically used free climbing to access its structures, but over the past decade full attachment has been adopted. This policy has been implemented on towers using “dual lanyards” but in doing so safety and productivity implications have emerged which are difficult to resolve. These include risk of tripping and entanglement, potentially large free fall distances, significant loss of productivity and poor user acceptance resulting in non compliance issues.

These problems are widely recognised internationally, and consequently two significant alternative access options have emerged. One is the increasing use of high lift insulated EWP/bucket trucks. This is option is viable for some work especially for distribution, but its very expensive for transmission. The second viable option is to mount an alternative attachment system to the towers. Several international investigations have demonstrated that the best tower attachment solution involves the installation of permanent wire type fall arrest systems.

With over 100,000 systems already installed on transmission line towers around the world, and extensive use in other industries such as off-shore oil rigs, wind turbine towers and high rise buildings, there is now very good evidence that wire attachment systems represent international best practice.

2. Background

Until 2005, free climbing was the only method used to access transmission towers in NZ. In 1999/2000 in response to OSH concerns about free climbing, Transpower sponsored a major industry study of transmission line falling accidents. This study extracted 60 years of archived accident data and showed that fall incidents during climbing and descending on the climbing leg of towers was very rare as linemen rapidly became highly skilled at this process. However falls were occurring while linemen were moving about on the tower, and while they were at the working position. Consequently free climbing was retained for climb and descend under strictly controlled conditions, with attachment at all other times.

In April 2005 Transpower moved to adopt full attachment during climbing using dual lanyards. There were (and remain) numerous problems with this attachment method. A workshop held by Transpower in 2006 revealed the best alternative by far was wire systems. After a detailed report recommended their adoption, a decision was eventually made by Transpower to start a progressive roll out by installing wire attachment systems on their new 400kV line and at other selected high use locations.

In 2009 a serious fall accident occurred on an SP AusNet training tower in Victoria involving rail type (see para 5c) attachments systems. This resulted in their use being banned and adoption of wire systems after extensive testing and trialing by SP AusNet. The author was tasked by SP AusNet to visit all the other major Australian transmission companies to present a summary of the key facts on tower attachment (as summarised in this paper). The aim was to build an Australia wide industry consensus on the adoption of wire systems.

3. International Studies.

a) Dutch Tower Climbing and Attachment Study 1998-2000

During 1998-2000 Mr Andre Reuver from the Dutch company Arbeidsinspectie, analysed multiple climbing and attachment issues including user friendliness, physical effort, posture, body strain, fatigue, overall efficiency, and fall arrest safety (how well falls were arrested).

There were two notable outcomes. Firstly the climbing options studied were ranked in a points system, and the overall outcome is shown in Table 1 below. (The more points the better).

Table 1: Overall Results of Dutch Climbing Systems Study.			
Method	Dual Lanyards	Free Climbing	Wire Systems
Total Score	4	6	7.7

The second outcome was that the dual lanyard attachment method was banned by the Dutch OSH as "Outright Dangerous" as its score was lower than free climbing.

b) German Study- RWE-2009

A more recent study was completed by the German Utility RWE in 2009. This study had multiple fall accidents as its origin. The study looked at five climbing options including free climb, slings, twin lanyard, pigtail-steps, and wire systems. It was unique in that it considered in detail the worker stress and energy consumption while climbing. Again wire systems emerged as most preferred method.

4. Difficulties with Dual Lanyards

a) What are dual Lanyards?

There are numerous design variations in use, but essentially they all consist of two lanyards attached to the line workers full-body harness. The photo below shows a large snap hook version for attaching to (or around) tower steel. A small snap hook version is used to attach to climbing steps.

Typical dual lanyard harness assembly: Large Snap Hook Version- Powerlink

b) Safety Concerns: Dual lanyards

If used correctly, dual lanyards will prevent a worker falling. However it also involves numerous less satisfactory safety trade-offs, some of which are:

i) The worker has to hold onto two snap hooks and thus his fundamental ability to hold onto the structure itself, is significantly degraded.
ii) Workers occasionally get tangled up in the lanyards and/or they catch on steel work or tower steps, tripping the climber off balance.
iii) The chances of the equipment itself triggering a fall, is comparatively high.
iv) The constant clipping and unclipping risks distraction from other locational safety hazards such as electrical clearances to phases and climbing route obstructions.
v) Fall distances are generally much larger than ideal as the worker may (at times) only have an attachment point close to his feet. Total fall distances of several metres is possible, exceeding the maximum distances for class 5 equipment in AS/NZS 1891.
vi) Because the process is slow, laborious, and physically tiring, there are very strong incentives for non compliance by workers. (Around 100 connections and disconnections may be required to ascend, and another 100 to descend, a typical 45m tower.)

Note *The dual lanyard process **is** considered satisfactory when used to attach while moving **horizontally** along crossarms or across the tower body. This is because it is inherently much better suited to this work process because the worker is able to clip and unclip far more easily and at a more comfortable working height thus also limiting potential fall distances more effectively.*

c) Impact on Productivity

Because of the slowness of the climb and descend process (reach, clip, climb, stop, bend down, unclip, climb, reach, clip, bend down, etc) it takes linemen appreciably longer to access the work location on a tower for any given job. One estimate for Transpower work suggests this could be as high as 8,000 lost man-hours per year, worth over $1M pa.

5. Other Attachment Options

To overcome the problems with dual lanyards during climbing and descending, alternative attachment systems are available.

a) Bucket trucks / EWP's.
b) Fixed permanent anchorage points installed at, or in conjunction with, climbing steps
c) Permanent ladder + rail systems
d) Permanent tower mounted wire type fall arrest lines.

a) Bucket Trucks / EWP

While distribution size EWP trucks are already used throughout Australia and New Zealand, transmission capable trucks with insulated booms and high lifts demand a full size heavy truck chassis with a long deck. Total weight of the units may exceed 20 tonne, and purchase price from $500,000 to over $1.5M.

Trucks of this size have obvious constraints on accessing many towers, and in addition to the high capital cost, they have considerable ongoing operating and maintenance costs, and specialist dedicated operators are required.

b) Climbing Steps with Anchorage Points

There are both 16 mm and 20mm dia climbing steps used in Australia, and New Zealand Neither size step is capable of arresting a free fall without some potential deformation damage to both the step and to the snap-hook latch, and this is obviously undesirable.

To overcome this, special anchorage points and/or step anchors combinations, have been designed for mounting under or replacing the climbing steps. These shift the fall arrest load from near the outer end of the step back to the tower leg. The step bolts are therefore loaded in shear and not bending. However the worker is still climbing with snap-hooks in at each hand, and this method is only a little faster than the normal dual lanyards attached to tower steel.

c) Climbing Ladder/Rail Systems

This system replaces the existing tower climbing steps with a specially designed ladder with an integral fall arrest "rail" located up the centre. However they are very expensive, costly to install, involve high maintenance costs, and serious problems have emerged with travellers failing to lock during falls in some circumstances. Consequently their use is now banned in an increasing number of countries.

d) Wire Fall Arrest Systems

These have numerous advantages, as described in Section 6 below.

6. Wire Attachment Systems

a) What are they?

Wire attachment systems for towers retain the existing tower climbing steps but add an 8 mm dia stainless steel wire to the outside of the tower climbing leg. The top of the steel wire is attached to a specially designed energy absorbing top anchorage point, and the wire is retained at intervals down the tower with intermediate supports. The lower end is terminated in a bracket which is spring loaded to retain wire tension. The brackets typically mount under the existing climbing step bolts, and position the wire close to the climber's chest (See pictures on the cover page, and last page).

A removable traveller runs on the wire and is attached to the front of the climbers harness with a very short energy absorbing lanyard. Because the wire is flexible it can easily follow angle changes and obstacles on the climbing route.

These systems are simple and quick to install (1-2 hrs per tower), extremely easy to use, relatively inexpensive and allow only very small fall distances. Modern systems are used (for example) for tourists on the Sydney and Auckland labour bridge tour routes.

b) How are they fitted?

Installation involves inserting the mounting and location brackets under the existing climbing steps. The selected steps only have to be loosened a couple of turns so the brackets can be inserted (approximately 3-4m spacing up the leg). Only the top step bolt is replaced because that bolt takes the majority of the fall arrest load and needs to be of reliable known strength.

c) How are they used?

The climber attaches a traveller to the front of his harness and then onto the wire (a one handed operation), and climbs normally. The traveller passes freely over the intermediate supports. During a fall the traveller immediately locks onto the wire. The climber can attach and detach at any point in the climb. More than one worker can use the system at once.

d) **What about testing, inspection and maintenance**?

The position adopted in most companies / countries is that the systems are treated as a permanent structural addition to the tower, and not a separate safety system as such. Thus they are treated the same as the existing tower climbing steps for example.

AS 1891 Part 4 (2009) requires fall arrest steel rope or anchor systems to be inspected in accordance with the manufacturer's recommendations or on a maximum 5 yearly rotation. Most wire system brands made of stainless steel have a manufactures recommended inspection time of 10 years or more. Therefore to comply with AS 1891.4 all that is required is that the tower is climbed at least once every 5 years and the system is inspected as the climb progresses. With rare exceptions, the normal power system maintenance and condition assessment cycles will result in at least one climb within each 5 year time frame.

One item that does need regular (6 monthly) checks is the traveller. However this is easily incorporated into the existing inspections already conducted on all safety harnesses, lanyards, anchorages and similar safety equipment.

e) What about wind vibration damage?

One of the more popular brands (Latchways) tested the vibration modes of their cable system when loaded to the tensions used on their system. This established that depending on site wind speeds, an intermediate support every 3-4 m was adequate to prevent vibration fatigue.

f) **How long will they last?**

Wire systems are available manufactured of galvanised steel or stainless steel. Stainless units, appropriately specified and made of matching materials are expected to last indefinitely even in a coastal exposure environment.

7. What are the Transmission Companies Doing?

a) Australia and New Zealand

The current position of Australian and New Zealand transmission companies was collected by the author during personal visits to Transpower, SP AusNet, Powerlink, Transgrid, Western Power, ETSA, ElectraNet, and Transend.

While overall Australia and New Zealand still have a current practice of using dual lanyards, acceptance that wire systems offer a better safety outcome is clearly growing. Several companies have proceeded with trial installs of wire systems to familarise their staff, and more are planned. In addition, volume installs began with 200 towers in Victoria during 2010, (SP Ausnet) and they have called now tenders to complete a further 1500 towers. Installs will start by Powerlink during 2011/12 on their 500kV towers.

Transpower are currently fitting wire systems on their new 400kV towers, and installs on other high work load project towers are planned on a rolling basis.

b) International

The international situation is set out in Table 2 below.

Table 2: International Practice	
Country/Company	**Comment**
UK: National Grid (Transco)	Use of dual lanyards currently. Wire system approved and many installations completed. Last known plan was to install two systems per tower (each tower has two climbing legs), onto 22,000 towers x 2, spread over 8 years. (5,500 towers per year).
UK: Scottish and Southern Electric Power .	Wire systems being installed on all new build incl 400kV and being progressively retrofitted on existing transmission at a rate of 1000 systems per year with plans to increase this rate.
UK: Western Power	Installing a number of wire systems each year. Quantity varies.
UK: Eon Central Networks West	Wire systems now installed on all their 6000 towers.
UK: Eon Central Networks East	Wire systems being installed on their entire network of 10,000 towers over 10 years.
Netherlands: AMEC SPIE Tennet, Eneco.	50,000 wire systems installed system wide over 7 years at two per tower over all 8 companies.
Belgium: Elia	20,000 towers having wire systems installed over 10 years at two systems per tower. Currently in year 8 of the programme.
France: EDF	EDF have chosen to use an early "pigtail" type climbing step system. (Each climbing step has a loop into which the climber inserts a fall arrest rope). EDF are currently evaluating wire systems with a view to replacing their pigtails)
Switzerland: Atel	Installing wire systems since 2001. Programme to fit 900 towers

	completed.
USA	Primarily dual lanyards onto tower steel, but increasing use of high reach (50m) bucket trucks. Some wire systems being introduced.
Canada	Generally similar to American practice.
Eskom South Africa	Eskom have installed several thousand wire systems on new lines and are retrofitting existing towers.
Spain. REE Red Electrica Espana	Copied the EDF pig tail system. Indications they are considering changing to wire systems.
Germany Vattenfall	Installation of systems on several different tower types in November 2007. Monitoring the installations and trialling the systems. Bulk installs beginning.
RWE Germany	Suffered recent accidents. Trialed wire systems and bulk installs underway.

8. Other Structures

Brackets to install wire systems onto wood steel and concrete poles are readily available, and so retro fitting to these structures presents no particular problems.

Substations with lattice steel structures and masts can be considered a similar case to lattice transmission towers. Climbing steps or ladders are provided in most cases, but no particular fall arrest provision has been made in the vast majority of cases. Of note however is that the climbers ascending these structures are in general far less experienced (c/w professional linemen) and therefore potentially at greater risk of falling.

Substation structures have also been constructed of wood, steel or concrete poles. Many have no provision for climbing or fall arrest provided, and currently access may only be possible by ladder or bucket truck.

Where substation structures need to be climbed, and where the provision of alternative access such as hoists, bucket trucks and cranes is impractical or uneconomic, wire fall arrest systems could be considered. They can be installed horizontally as well as vertically and attached to any surface including to building walls and roofs. Therefore fall arrest coverage for horizontal gantries can be achieved with the same equipment, and potentially without the need to unclip and reattach at the top of the climb.

Many communication structures already have caged ladders and some have older “Lad Safe” wire type fall arrest systems installed. These older systems are crudely designed in that the intermediate support brackets cannot pass the traveller so the climber must pause at each bracket and pull the wire out of the rubber support to continue. On the descent the wire is supposed to be pushed back into the support, but experience has shown this is often not done (or the rubber cushions have deteriorated and are no longer capable of holding the wire secure). Wind chaffing and other damage to the wire soon results.

Over time as these older fall arrest systems need repair or replacement, or new structures are installed, conversion to the more modern stainless steel wire system with pass though intermediate supports will ensure that all installations are safe and standardised.

9. Summary

a) The dual lanyard attachment method has numerous significant safety and productivity shortcomings (for climb and descend) including large potential fall distances. These shortcomings are not applicable to horizontal movement around the tower or along crossarms where the method is more satisfactory.

b) Worker acceptance of dual lanyards for climbing is poor, and thus compliance is less than 100%.

c) Climbing step type anchorages are simple and moderately priced, but do not have as good safety outcomes as wire systems.

d) EWP's have some advantages for distribution work and for major transmission work such as strain string replacements, but their high capital and operating costs, plus serious site access constraints mean they cannot replace the need for climbing.

e) Wire type fall arrest systems installed onto the climbing legs of towers are the most cost effective and viable long term solution to fall arrest when climbing and descending towers.

f) There is excellent worker acceptance of wire fall arrest systems, thus a very low non compliance risk.

g) Internationally many transmission companies, recognising the problems with dual lanyards, have (and are) installing wire type fall arrest systems. (100,000 + systems installed).

h) There is rapidly growing acceptance though Australian and NZ transmission companies that wire systems offer the best attachment solution, and they are either underway with evaluations pricing/planning installs or beginning installations.

i) The cost of purchasing and installing a wire type fall arrest system on a typical 30-40m tower is expected to be in the region of NZ$4,000.

j) There are no ongoing inspection and maintenance costs associated with stainless steel wire type fall arrest systems.

Photos show workers climbing using wire type attachment systems.