South African
Cable Yarding Safety and
Operating Handbook

AFESA
FOREST ENGINEERING
SOUTHERN AFRICA

ICFR

2017
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Foreword

During 1997, the need for a South African Cable Yarding Safety and Operating Handbook was identified as being important to the South African Forestry Industry, to help improve the safety and efficiency of local cable yarding operations. A great deal of literature was available at the time from many international sources but no single document satisfied South African specific needs. South Africa has a unique combination of terrain conditions, road spacing, tree sizes, cable yaderer sizes and configurations amongst other variables.


There have been significant advances in cable yarding technology over the last decade or so, necessitating the production of this the third edition of the *Handbook*. This edition has addressed issues such as categorisation of cable yaders, inclusion of guyless yaders, more carriage types, and common guidelines for wire rope selection as well as operational productivity indices. Small changes and improvements were also made throughout the document.

There are a wide range of cable yarding systems and their variations that can be used, making it impossible to discuss every procedure in detail. The *Handbook* should therefore be treated as a general guide, used in conjunction with the original equipment manufacturers (OEM’s) operating and maintenance manual/s. It also does not replace any legislative requirements and occupational health and safety acts or regulations, but rather complements them by providing safe work procedures and protocols. Furthermore, the *Handbook* should also be used in conjunction with other FESA handbooks, such as the following:

- South African Ground Based Harvesting Handbook (2010);
- Guidelines for Forest Engineering Practices in South Africa (2014);
The various editions of the South African Cable Yarding Safety and Operating Handbook have been made possible through the active involvement and contributions of members of the South African Forestry Industry.

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1 Introduction

“Cable Yarding” is a universal term used to describe a timber extraction method, whereby a cable yarder is used to move timber from an infield forest setting to a landing area, using a system of operating cables (lines), rigging and generally a yarding carriage from which the timber is suspended.

The exact manner in which the operating lines and rigging are setup and operated, and the type of carriage that is used on the lines, is determined by the specific “cable yarding system” used. Differing terrain conditions often require the use of a different cable yarding system. Since there is such a wide variety of cable yarding systems and carriages available, a basic knowledge of these components and their terrain capabilities is essential in order to select the correct system and carriage for a given set of circumstances.

An example of a typical cable yarding system used in South Africa (in this case a downhill multi-span skyline system) can be seen in Figure 1.

![Figure 1: Terminology of a typical cable yarding operation](image)

Cable yarding operations are generally more expensive than most ground-based extraction systems, but can be used to extract timber from the most severe terrain. Cable yarding is therefore usually employed in areas in which timber is inaccessible to ground-based extraction equipment, or where ground-based extraction is uneconomical.

These areas are usually steep and often very rocky, which generally presents a hazardous work environment, and the machinery itself is also potentially hazardous. Furthermore, as mentioned above, cable yarding involves a system of cables, which are rigged to trees, stumps and towers, and operated under high tension. This presents even greater hazards. Hence a sound understanding of, and adherence to all the safe work practices and procedures associated with cable yarding, is required to ensure the safety of all personnel involved.

Cable yarding operations often need to run in tandem with ground-based extraction operations to ensure that the overall delivery of timber from the forest is as productive, efficient and cost-effective as possible. This requires sound planning not just of cable yarding operations, but also of the integration between the cable yarding systems and the ground-based systems to ensure overall optimisation. Added to this, correct balancing of the extraction systems with available timber volumes, harvesting operations, transport operations and mill requirements is imperative.
2 Cable yarders

The cable yarding machine is the heart of a cable yarding operation. Cable yarders may be designed to operate a specific cable yarding system, or a number of different systems, and come in a variety of types and sizes. They typically comprise a carrier, power source, drivetrain, winch unit, guy-line drums, a tower and fairlead.

The winch unit will usually have between one and five winch drums, which may be fitted with simple clutch and braking systems or more expensive air-activated, water-cooled components. The number of winch drums and their respective clutching and braking systems and capabilities, will generally determine what cable yarding systems the yarder can be configured to operate.

Larger yarders, and many older medium to smaller yarders, use automatic transmissions, and/or torque converters, and a mechanical gear or chain drivetrain system, to transmit power to the winch drums. Many modern smaller yarders use sophisticated fully hydrostatic drive systems.

Most cable yarders have a tower of sorts, which has an integral fairlead to direct the operating cables over or through the top end of the tower. Towers come in a wide variety of designs and types, constructed of round tube, square section or folded plate, and others are of lattice boom design.

Cable yarders generally have to be stabilised by a number of guy-lines, as determined by the OEM, and therefore also require a number of guy-line winch drums. However, there has been an increasing trend in recent years towards “guyless” cable yarders, which are yarders that do not require guy-lines to stabilise the yarder.

Many of the older type cable yarders described in earlier edition cable yarding handbooks, do not exist anymore, or are so seldom used that it is no longer relevant to mention them. Furthermore, older classifications of cable yarders did not include guyless yarders. Therefore, it has become necessary to re-classify the most commonly used modern-day cable yarders, into the following simple categories:

- Tower yarders;
- Swing yarders;
- Guyless yarders;
- Other yarders.

2.1 Tower yarders

Tower yarders, (Figure 2) that have a tower of fixed in one position while in operation, and are required to have guy-lines to stabilise the tower in the working position.

The tower may be of fixed length or of telescopic design, to shorten the tower for setup and transport purposes. Some telescopic towers can work at one or more different heights, to suit different conditions.

Larger size tower yarders may have towers of up to 36 m tall. Taller towers have the advantage of increased deflection, allowing them to use longer distance single-span yarding systems. In South Africa, cable yarding operations have typically used smaller yarders than most parts of the world, with tower heights usually being between seven and 12 m. Smaller yarder sizes can mainly be attributed to smaller tree sizes, the prevalent convex type terrain, and the inherent contour-type road network systems, necessitating continuous roadside landings and frequent yarder moves.
2.2 Swing yarders

Swing yarders (Figure 3) are typically large powerful yarders that are guyed down, but that have been specifically designed to allow the tower to swing to the side as a load approaches the landing, in order to deck timber to the side of the yarder. Swing yarders can therefore work in more confined spaces than tower yarders, and work efficiently on narrow roads.

Swing yarders usually comprise two towers; namely a leaning main tower, suspended at one end from a centralized guy-line tower, a stationary lower structure and a rotatable upper structure. The centralized guy-line tower is guyed down to support the yarder, but is designed to allow the upper structure and main tower to freely rotate about the centre of the lower structure of the machine, while hauling in a load. This is substantially different to a “tower yarder” that has its tower guyed down and fixed in position whilst in operation.

Modern-day swing yarders have powerful, high-speed interlocked winch drums which enables them to operate highly productive mechanical grapple yarding systems and efficient running skyline systems. They are generally far more expensive than smaller tower yarders and need to be highly productive in order to be cost effective. These yarders are best suited to large piece sizes or terrain where small trees can be pre-bunched, to ensure adequate payloads. As a result, these systems have not been adopted in South Africa as yet.

Figure 2: Terminology for a typical tower yarder

Figure 3: Terminology for a typical Swing Yarde (adapted from Oregon Occupational Safety and Health Services, 2010)
2.3 Guyless yarders

Guyless yarders are “self-stabilised” machines which do not require guy-lines to support the machine while yarding. The most common form of guyless yarder is a tracked construction excavator (typically called Alpine yarder in South Africa) which has been modified into an efficient cable yarder through the addition of a winch unit, a tower and a yarding fairlead.

These excavator-based guyless yarders (Figure 4) are also known as “shovel yarders” in certain parts of the world. Depending on the size of the excavator and the size of the payload, some excavator-based yarders can slew and deck timber to the side, thereby operating in a similar manner to a swing yarder. Some are also capable of running high production grapple yarding systems.

Since these yarders do not require guy-lines, they have several advantages over tower yarders and swing yarders. They are mobile and can be moved during the yarding process to improve the yarding lead around obstacles. They can also cold-deck timber by incrementally moving a few metres down the road as timber piles up in front of the yarder. They are fast to move and set up as there are no anchors to rig. Another major benefit of these machines is improved safety because the risk of poor tower anchoring practices is done away with. They can also be easily moved onto stepped landings and infield landings, should two-stage extraction be required.

Excavator-based guyless yarders are usually configured to operate conventional cable yarding systems and carriages. All the safety and operating guidelines in this handbook, apart from tower rigging requirements, are applicable to these machines. As for all types of yarders, these machines must also be set up and operated according to the manufacturer’s specifications. If the manufacturer requires that guy-lines be used to stabilise the tower of an excavator-based yarder under any particular circumstances, the yarder then becomes classified as a tower yarder, and must be guyed according to the manufacturer’s specifications, and the tower rigging requirements described in this handbook are also applicable to the yarder.

Figure 4: Terminology for a typical Excavator-Based Guyless Yarded (Photo: Andrew McEwan)

Apart from excavator-based guyless yarders, other guyless yarders do exist but at this stage are not available in South Africa. Should these machines become available, they must be operated according to the manufacturer’s specifications.
2.4 Other yarders

All yarders that cannot be categorised into the above sub-sections, fall in the category of “other yarders”. These yarders generally do not make use of an integral steel tower. They may include such yarders as mono-cable winches often used in thinning operations, and sledge-mounted winches used on long distance European-style cableways.
3 Cable yarding carriages

Cable yarding systems generally require an appropriate yarding carriage as an integral part of the system. Most carriages used in cable yarding applications run in skyline yarding systems. Highlead systems, with the exception of the South African highlead, do not require cable yarding carriages.

This section identifies the various types of carriages commonly used in cable yarding. It is important that the carriage matches the yader and the cables on the yader. Various carriages require specific lines for their operation, and therefore the yader should have the correct number and appropriate winch drums to accommodate the carriage. Cable yarding carriages can be classified as indicated in Figure 5.

**Figure 5: Yarding Carriage Classification**

There are different variations of each type of carriage and only the more common types are described in this chapter. The cable yarding system for which the carriage can be used, is listed in a table in every section. Details in these tables include the the number of main drums required on the yader to operate a specific carriage and the need to use a haulback line for downhill or flat terrain yarding. The tables also indicate if the carriage can be used for multi-spanning and whether it has slackpulling capabilities. It is important to note that when yarding downhill or on level terrain, a haulback line is needed to pull the carriage infield, and this is also indicated in the tables. Carriages can be divided into the South African highlead carriage and skyline carriages.
3.1 **South African highlead carriage**

This carriage consists of little more than two lightweight sheaves attached to a frame. It is used with a highlead system, whereby one sheave runs on the haulback line and the mainline passes through the other (Figure 6). The carriage cannot be clamped onto the haulback line and has to be held with the haulback line in order to yard timber laterally to the corridor. The carriage also doesn’t have a locking device.

![Diagram of South African highlead carriage](image)

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**Figure 6:** (a) Highlead and (b) riderblock carriage (c) typical highlead configuration

3.2 **Skyline carriages**

These types of skyline carriages form part of the second grouping of carriages in Figure 5. These include slackpulling, non-slackpulling and motorised dropline carriages. Furthermore, securing the carriage and suspending the load will also be dealt with in this section.

3.2.1 **Slackpulling carriages**

Slackpulling carriages are designed to allow slack in the mainline by running the mainline through the carriage to facilitate lateral yarding. This slack can either be pulled manually through the carriage, or a mechanised carriage can power it out with the use of an engine in the carriage or a slackpulling drum on the yarder. The chokers are attached to the mainline or a skidding line in the carriage.

Slack in the mainline is pulled from the yarder through the carriage. These carriages therefore have lateral yarding capabilities, which can be a significant advantage in both clearfelling and
thinning operations. In clearfelling operations the advantage of lateral yarding means that fewer rack shifts are required as the extraction width of each rack is increased. In thinning operations, slackpulling carriages allow timber off the extraction path to be hauled laterally to the corridor before hauling-in the load along the corridor.

3.2.1.1 Manual slackpulling carriages

Slack in the mainline is pulled manually from the yarder through the carriage by the chokerman. This can be in the form of a mini running skyline carriage with manual slackpulling capabilities or one of several other types skyline carriages with manual slackpulling capabilities. Some of the more common types of these true skyline carriages with manual slackpulling capabilities are discussed below.

a) Basic Carriages

These carriages have no load locking or skyline clamping capabilities. They are simple carriages that need to be held in position during choking and dechoking by stop plates and carriage stops. There is no control of the carriage position on the skyline during breakout, and the load position in relation to the carriage varies during haul-in depending on exerted on the mainline and the terrain conditions. However, the carriage is robust with fewer mechanical parts that could lead to work stopages when breakdowns occur.

b) Fallblock carriages

A fallblock carriage (Figure 7) normally consists of three sheaves; the top two ride on the skyline and the bottom sheave serves as a guide for the mainline. The mainline passes through the carriage, through a fallblock and is then connected back onto the carriage. The fallblock therefore rides in the loop thus created. The doubling of the mainline also has the effect of doubling the break-out force. It is, however, more difficult to manually pull the fallblock from the carriage when choking timber due to the doubling of the mainline. Chokers are attached directly to the fallblock. If a haulback line is used, it is normally attached to the carriage, but it can also be attached to the fallblock.

![Fallblock carriage diagram](image)

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<tr>
<td>Drums required</td>
<td>2 (3 with haulback)</td>
</tr>
<tr>
<td>Lines</td>
<td>Skyline, mainline and (haulback)</td>
</tr>
<tr>
<td>Multi-spanning</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Figure 7: Fallblock carriage
c) Other manual slackpulling carriages

These carriages consist of three sheaves: the top two ride on the skyline, and the bottom sheave serves as a guide for the mainline. The carriage is held in position by one of the methods mentioned in Section 3.2.3.1. Examples of the different carriage configurations are shown in Figures 8 to 10. If the carriage must pass over an intermediate support, it needs to be open sided (no covering on one side of the carriage). Simple carriages can also be used with highlead systems, whereby the top two sheaves run on the haulback line and the bottom sheave guides the skyline.

**Load locking carriage**

<table>
<thead>
<tr>
<th>Slackpulling</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems</td>
<td>Standing skyline</td>
</tr>
<tr>
<td>Drums required</td>
<td>2 (3 with haulback)</td>
</tr>
<tr>
<td>Lines</td>
<td>Skyline, mainline and (haulback)</td>
</tr>
<tr>
<td>Multi-spanning</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Figure 8: Load locking carriage*
3.2.1.2 Mechanical slackpulling (MSP) carriages

Slackpulling can be controlled mechanically either from the yarder or from the carriage. These carriages can also be clamped to the skyline and/or have mainline clamping or load-locking abilities. Common types can include Non-motorised mechanical slackpulling carriages (pulling slack either in the form of the mainline or a dropline), Hydraulic skyline clamping mechanical slackpulling carriages and Motorised mechanical slackpulling carriages.
a) Non-motorised slackpulling carriages (yarder controlled carriage)

Slack is pulled from the yarder by using either the slackpulling line or the haulback line. There are different types of yarder controlled slackpulling carriages. The one is displayed in Figure 11 where the slackpulling line is attached to the mainline which feeds out to the skidding line.

![Diagram of Running skyline configuration]

**Running skyline configuration**

![Diagram of Standing skyline configuration]

**Standing skyline configuration**

The other carriage type contains the skidding line on a drum in the carriage, with drums for the mainline and the slackpulling line on the same shaft (Figure 12).

![Diagram of Yarder controlled carriage (type 2)]

**Yarder controlled carriage (Type 1 & 2)**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Type 1 &amp; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slackpulling</td>
<td>Yes</td>
</tr>
<tr>
<td>Systems</td>
<td>Running skyline, standing skyline</td>
</tr>
<tr>
<td>Drums required</td>
<td>3 (4 with haulback)</td>
</tr>
<tr>
<td>Lines</td>
<td>Skyline, mainline, slackpulling line and (haulback)</td>
</tr>
<tr>
<td>Multi-spanning</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Figure 11: Yarder controlled carriage (type 1)**

**Figure 12: Yarder controlled carriage (type 2)**
b) Motorised slackpulling carriages

 Slack is obtained by a mechanism inside the carriage feeding the mainline. This mechanism could be driven by a small engine inside the carriage or by hydraulic power built up from the carriage running along the skyline. Slackpulling is normally controlled by radio signals. There are two types of carriage-controlled slackpulling carriages. One type powers out the mainline (Figure 13), while the other powers out a skidding line that is contained on a drum in the carriage.

<table>
<thead>
<tr>
<th>Motorised carriage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slackpulling</td>
</tr>
<tr>
<td>Systems</td>
</tr>
<tr>
<td>Drums required</td>
</tr>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>Multi-spanning</td>
</tr>
</tbody>
</table>

**Figure 13: Motorised carriage**

3.2.2 Non-slackpulling carriages

Non-slackpulling carriages (Figure 14) do not have the ability to pull slack and lateral yarding is not possible. The mainline is attached to the carriage, and does not run through the carriage as with slackpulling carriages. The carriage rides on the skyline. The chokers are attached to the carriage and lateral yarding is consequently restricted to the choker length (chokers are approximately 10 m long). To choke timber to the carriage, the skyline is lowered. After the timber has been choked, the skyline is raised again to provide ground clearance. Therefore, slackpulling carriages are usually restricted to live skyline systems. These carriages are usually used for very large logs or trees which could not be broken-out otherwise.

<table>
<thead>
<tr>
<th>Non-slackpulling carriage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slackpulling</td>
</tr>
<tr>
<td>Systems</td>
</tr>
<tr>
<td>Drums required</td>
</tr>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>Multi-spanning</td>
</tr>
</tbody>
</table>

**Figure 14: Non-slackpulling carriage**

These carriages are usually either in the form of Shotgun/Slack line carriages or Grapple carriages.
3.2.3 Safe operating procedure of skyline carriages

Ensuring the safe operation of skyline carriages, methods to secure the carriage at various parts of the span of the skyline must be used. Following this, the load also needs to be raised from ground level and suspended from the carriage.

3.2.3.1 Securing the carriage in position on the skyline

When operating standing skylines, it is often necessary to secure the carriage onto the skyline during choking and dechoking. Without this, the carriage would be pulled out of control down the slope by gravity during the choking and/or dechoking activities. Furthermore, some carriages require the carriage to be held stationary during breakout in order for the load to be laterally yarded to the carriage. Some carriages need to be held stationary until the load is locked or clamped into the carriage to facilitate load clearance during the haul-in cycle. Other carriages require braking of the haulback line during haul-in to provide load ground clearance. There are various options available to secure the carriage in position which are described in the sections which follow.

a) Use of the haulback line

When carrying out downhill yarding, the haulback line can be used to keep the carriage in position during choking and dechoking.

b) Stop-plate

A stop-plate is a device attached to the skyline to prevent the carriage from moving further down the skyline during choking in up-hill yarding conditions. The yarder operator uses the mainline to slow the carriage down before it hits the stop-plate. The stop-plate is secured in position with a small diameter steel cable attached to a fixed object on the ground, such as a stump. The stop-plate is manually moved further down the slope by pulling it with the stop-plate cable and attaching it to another stump. A stop plate will not keep the carriage stationary on the skyline during breakout.

c) Tyre carriage stopping devices

A tyre and small log are mounted onto the skyline to serve the same function as a stop-plate. The tyre can also be secured in position with a small diameter cable. Once again, the carriage will not be held in position during breakout.

d) Carriage stop

A carriage stop is a device mounted onto the skyline above the landing. It has a small metal arm which raises when the carriage makes contact with the carriage plate during haul-in. Without the carriage stop or another skyline clamping device, the carriage would move back down the slope when the mainline was released at the landing during up-hill yarding operations. The mainline is used to maintain contact between the carriage and the carriage stop until the metal arm drops onto the carriage and secures it. The carriage needs to have a lip on the top side facing the yarder in order for the carriage stop arm to secure it in position. Once it is in position, the mainline is released and the load drops to the ground. When the tree/logs have been detached, the mainline is winched in and the carriage is pulled closer to the carriage plate. This allows the metal arm of the carriage plate to lift, and the carriage may then move down the skyline by gravity towards the choking area. A small diameter steel cable is also used to lift the metal arm if it does not release the carriage.
e) Skyline clamping

The skyline clamping mechanism is a device in the carriage that clamps the carriage onto the skyline. A hydraulic clamp can be engaged either by means of a time switch, remote control or it can be set by a directional change of the carriage. An accumulator powers the skyline clamp, and the accumulator is charged by running gears turned by the carriage sheaves during the haul-in and out-haul.

No stop-plates or carriage stops are required when using skyline clamping, as the carriage maintains its position infield or on the landing during choking and dechoking. An additional advantage is that when used in thinning operations, or when breaking out trees/logs close to intermediate supports, the carriage can be held in position, preventing damage to residual trees or the intermediate supports due to the carriage creeping up the skyline.

3.2.3.2 Suspending the load from the carriage during haul-in

The various methods for suspending a load during haul-in include the following:

a) Braking the haulback cable

Ground clearance can be achieved by pulling on the mainline while simultaneously braking the haulback cable. With smaller cable yarders with simple haulback braking systems, this can only be achieved intermittently by temporarily applying the haulback brake to clear obstacles.

b) Load locking

The load-locking carriage has a lock-up device in the carriage that locks the load in position once it has reached the carriage. A locking mechanism is fitted to the end of the mainline (e.g. locking mushroom) which is locked in place in the carriage. This is done to keep the load in position during haul-in. This is particularly important when extracting valuable timber where maximum lift is required, where full suspension is required, or when uneven terrain or limited clearance could result in excessive contact between the trees and the ground.

c) Mainline clamping

Mainline clamping takes place in the same manner as skyline clamping. With load-locking, the mainline must be pulled right into the carriage in order to lock the load into position. With mainline clamping, the mainline can be clamped into the carriage at any position on the mainline. This allows for flexibility in how close the load is brought to the carriage.

It is possible for carriages to have a combination of skyline clamping, mainline clamping and load-locking mechanisms, depending on the nature of the operation.
4  Yarding systems

There are numerous cable yarding systems in use all over the world and it is not possible to discuss all of them in this handbook. The more common cable yarding systems can be categorised as follows (Figure 15):

![Figure 15: Cable yarding configurations](image)

The cable yarding systems most appropriate for South African conditions are discussed in more detail in this Chapter. Each system is accompanied by an illustration of its layout and a table that provides the information as in Table 1:

**Table 1: General cable yarding diagnostic information**

<table>
<thead>
<tr>
<th>Carriage</th>
<th>The type and number of carriages.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drums</td>
<td>The number of drums required for the system.</td>
</tr>
<tr>
<td>Lines</td>
<td>Lines needed on these drums (SL = skyline, ML = mainline, HBL = haulback line, SPL = slackpulling line).</td>
</tr>
<tr>
<td>Direction</td>
<td>Yarding directions of the system (↑ = uphill; ↓ = downhill).</td>
</tr>
<tr>
<td>Guideline max. distance</td>
<td>The maximum yarding distance which the system will extract at under normal conditions (remember – actual distances will be determined by system configuration, cables used, deflection and yarder power).</td>
</tr>
<tr>
<td>Set-up time</td>
<td>Approximate set-up time required by an experienced team.</td>
</tr>
<tr>
<td>Harvesting type</td>
<td>Whether the system can be used in clearfelling (CF) or thinning (Thin) operations.</td>
</tr>
<tr>
<td>Slackpulling</td>
<td>The slackpulling capabilities of the system.</td>
</tr>
<tr>
<td>Multi-spanning</td>
<td>Whether multi-spanning is possible.</td>
</tr>
</tbody>
</table>

In order to get an idea of the limitations of each system related to terrain, the National Terrain Classification System (TCS) for Forestry (Erasmus, 1994) is used to provide this information (Table 2). The TCS is a handy tool that provides an indication of the physical characteristics and accessibility of an area.
Table 2: Classes of terrain classification components

<table>
<thead>
<tr>
<th>Ground conditions</th>
<th>Ground roughness</th>
<th>Slope (refer to Figure 16 for type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Very good</td>
<td>1. Smooth</td>
<td>1. Level (0-11%)</td>
</tr>
<tr>
<td>2. Good</td>
<td>2. Slightly uneven</td>
<td>2. Gentle (12-20%)</td>
</tr>
<tr>
<td>4. Poor</td>
<td>4. Rough</td>
<td>4. Steep 1 (31-35%)</td>
</tr>
<tr>
<td>5. Very poor</td>
<td>5. Very rough</td>
<td>5. Steep 2 (36-40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Steep 3 (41-50%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Very steep (&gt;50%)</td>
</tr>
</tbody>
</table>

Uphill yarding has the advantage of gravity assisting the carriage to return infield. With standing and live skylines, it could occur that the haulback cable is not required to the return the carriage, as the carriage returns infield by gravity, and its speed is controlled by the mainline (termed “shotgun” in South Africa). However, uphill yarding on undulating, terraced or convex slopes may still require the use of a haulback cable when intermediate supports are used. Downhill yarding always requires a haulback line to return the carriage infield. Types of slope include those in Figure 16.

4.1 Highleads

Highlead systems are the simplest of the multi-drum cable yarding systems. They make use of two working cables, namely the haulback line and the mainline. There are two basic types of highleads that have been employed in South Africa, namely:

- Conventional highleads;
- South African highlead.

4.1.1 Conventional highlead with buttrigging

This system does not use a yarding carriage. Instead, the haulback line is directed through a number of haulback blocks and is joined to the mainline via a buttrigging which consists of a number of swivels, links and chokers as shown in Figure 17. The haulback line is used to pull the buttrigging and mainline back infield. Once the chokers have been attached to the load, the load is hauled in by winding in the mainline cable.
This system provides the least amount of load lift. Partial suspension can be achieved in certain circumstances by applying the haulback brake while hauling in the mainline, but this can result in haulback brakes overheating. Therefore, the load is normally dragged along the ground with little or no lift, braking the haulback line only intermittently to lift the load over obstacles. Because of this, the system is usually restricted to regular and concave slopes. Convex slopes can result in a blind lead that limits timber extraction, results in timber damage and major soil disturbance. Slackpulling is not possible with this system and therefore the width of the extraction corridor is limited to the length of the chokers attached to the buttrigging. Frequent line shifts are thus required. This system generally requires a high-powered yarder in order to run efficiently.

<table>
<thead>
<tr>
<th>Conventional highlead system with buttrigging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carriage</td>
</tr>
<tr>
<td>Drums</td>
</tr>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>Direction (↑↓)</td>
</tr>
<tr>
<td>Guideline max. distance</td>
</tr>
<tr>
<td>Set-up time</td>
</tr>
<tr>
<td>Harvesting type</td>
</tr>
<tr>
<td>Slackpulling</td>
</tr>
<tr>
<td>Multi-spanning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ground conditions</th>
<th>Ground roughness</th>
<th>Slope</th>
<th>Type slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>1-2</td>
<td>3-5</td>
<td>R,V</td>
</tr>
</tbody>
</table>

Figure 17: Conventional Highlead system with buttrigging

4.1.2 South African highlead

This system is typically used on smaller yarders. It uses a simple two-sheave highlead carriage that runs on the haulback line as shown in Figure 18. The mainline runs through the carriage and because light lines are generally used, this system allows for manual slackpulling and therefore lateral yarding. Slack in the mainline cable is manually pulled through the carriage and out to the side of the corridor.
up to approximately 25 m. A T-bar at the end of the mainline can be threaded through any amount of ring sliders attached to choker chains (which are in turn choked to the logs to be extracted). When the mainline is wound in and the haulback brake is applied during break-out, the load is gathered at the T-bar and laterally hauled in towards the carriage. The load is then hauled in towards the yarder by releasing the haulback brake and winding in the mainline cable. Only minimal haulback braking is applied during the haul-in cycle to keep the carriage upright and avoid overspooling of the haulback drum. Once dechoked at the landing, the carriage and empty chokers are hauled back infield by winding in the haulback cable and lightly braking the mainline.

This system appears similar to running skyline systems, but cannot operate as a true running skyline as the smaller yarders generally do not have sufficient mainline power and do not have efficient water cooled haulback braking capability. Hence, the load is also generally dragged along the ground in a similar fashion to the conventional highlead system, also with only limited load lifting ability (achieved by intermittently applying the haulback brake). Therefore, this system is not classified as a running skyline system.

This system is a comparatively cheap and simple yarding system and has therefore been widely adopted by small wood operations in South Africa.

<table>
<thead>
<tr>
<th>South African highlead with highlead carriage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carriage</td>
</tr>
<tr>
<td>Drums</td>
</tr>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>Direction</td>
</tr>
<tr>
<td>Guideline Max. distance</td>
</tr>
<tr>
<td>Set-up time</td>
</tr>
<tr>
<td>Harvesting type</td>
</tr>
<tr>
<td>Slackpulling</td>
</tr>
<tr>
<td>Multi-spanning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ground conditions</th>
<th>Ground roughness</th>
<th>Slope</th>
<th>Type slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>1-4</td>
<td>3-6</td>
<td>R, V</td>
</tr>
</tbody>
</table>

Figure 18: South African highlead with highlead carriage
4.2 **Skylines**

There are three main types of skyline systems, namely:

- Standing skylines;
- Live skylines;
- Running skylines.

Standing skylines and live skylines employ an overhead skyline cable that is wound onto the cable yarder drum at one end and attached to an anchor at the other end. The skyline cable carries the appropriate skyline carriage for the system being used. This differs significantly from the running skyline system. With the running skyline system, the carriage and load are suspended from the haulback cable, and the haulback cable is also used to haul the carriage back to the infield position. Therefore, the haulback cable is moving while supporting the load, which is the reason why this system is referred to as a running skyline.

4.2.1 **Standing skylines**

With standing skyline systems, the skyline cable is raised to its working height and is generally maintained at that height throughout the yarding operation. This system can be used in single span and multi-span operations. The system can be used with carriages with either manual or mechanical slackpulling capabilities.

<table>
<thead>
<tr>
<th>Carriage</th>
<th>Manual slackpulling (except highlead carriage)</th>
<th>Yarder-controlled</th>
<th>Carriage-controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drums</td>
<td>2 (3)</td>
<td>4</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Lines</td>
<td>HL, ML (HBL)</td>
<td>SL, ML, SPL, HBL</td>
<td>SL, ML, (HBL)</td>
</tr>
<tr>
<td>Direction</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
</tr>
<tr>
<td>Guideline Max. distance</td>
<td>500 m</td>
<td>600 m</td>
<td>600 m</td>
</tr>
<tr>
<td>Set-up time</td>
<td>1 hr</td>
<td>2 hr</td>
<td>2 hr</td>
</tr>
<tr>
<td>Harvesting type</td>
<td>CF and thin</td>
<td>CF and thin</td>
<td>CF and thin</td>
</tr>
<tr>
<td>Slackpulling</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Multi-spanning</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
4.2.1.1 Single span skylines

A single span system is used where there is adequate deflection to provide the required lift off the ground for the chosen system, throughout the entire setting. The single span skyline system (Figure 19) can accommodate the widest variety of yarding carriages and consequently the widest variety of yarding systems.

![Diagram of single span skyline system]

**Table: Ground conditions**

<table>
<thead>
<tr>
<th>Ground conditions</th>
<th>Ground roughness</th>
<th>Slope</th>
<th>Type slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>1-5</td>
<td>1-6</td>
<td>R, U, T, V</td>
</tr>
</tbody>
</table>

*Figure 19: Single span skyline system using gravity return carriage*

Typical single span skyline systems and carriages can include:

- Gravity return single span skyline systems (i.e. uphill skyline yarding without the use of a haulback line to haul the carriage back infield):
  - Fallblock carriage with carriage stop, as used in South Africa;
  - Hydraulic skyline clamping and load locking carriages;
  - Motorised slackpulling carriages;
  - Motorised dropline carriages (skycars).

- Single span skyline systems using the haulback line to haul the carriage back infield (generally used for downhill or level terrain skyline yarding, but can also be used for uphill skyline yarding):
  - Basic skyline carriage;
  - Fallblock carriage with carriage stop, as used in South Africa;
  - Mechanically activated load locking or mainline clamping carriages;
  - Skyline clamping load locking carriages;
  - Hydraulic skyline clamping and load locking carriages;
  - Hydraulic skyline clamping slackpulling carriage;
  - Non-motorised slackpulling carriages (MSP mainline and dropline carriages);
  - Motorised slackpulling carriages;
  - Motorised dropline carriages (skycars).
• Single span skyline systems which use the haulback line to facilitate lateral yarding by pulling the buttrigging to the logs (Figure 20):
  ▪ Northbend system;
  ▪ Southbend system;
  ▪ Block-in-the-Bight.

Figure 20: Lateral yarding using buttrigging attached to the haulback line

• Other single span skyline systems:
  ▪ Self-propelled dropline carriages;
  ▪ European-style cableway (the load is moved by gravity from a higher point within the span to a landing at the bottom of the span).

Advantages of a single span system in comparison to multi-span systems:
• Set-up time is quicker;
• Cycle time is faster;
• Not as complex as multi-spanning.

Disadvantages of a single span system:
• The length of a rack is restricted to the distance where the required deflection occurs;
• Yarding is generally restricted to regular and concave slopes with yarders that have short towers.
4.2.1.2 Multi-span skylines

Stands often have areas with little or no deflection, such as convex, undulating and long regular slopes (Figure 21). In such conditions deflection can be provided by installing intermediate supports. The intermediate supports are chosen along the length of the corridor to provide skyline lift where deflection is inadequate. Supports are therefore normally positioned at a change in topography.

The multi-span skyline system cannot accommodate as many carriage types (and therefore yarding systems) as the single span skyline can. Only carriages that are specifically designed to travel over intermediate supports can be used on a multi-span skyline system.

<table>
<thead>
<tr>
<th>Ground conditions</th>
<th>Ground roughness</th>
<th>Slope</th>
<th>Type slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>1-5</td>
<td>1-7</td>
<td>R, U, T, V, X</td>
</tr>
</tbody>
</table>

Figure 21: Multi-span skyline system using gravity return carriage

Typical multi-span skyline systems and carriages can include:
- Gravity return multi-span skyline systems (i.e. uphill skyline yarding without the use of a haulback line to haul the carriage back infield):
  - Fallblock carriage with carriage stop, as used in South Africa;
  - Hydraulic skyline clamping and load locking carriages;
  - Motorised slackpulling carriages.
- Multi-span skyline systems using the haulback line to haul the carriage back infield (generally used for downhill or level terrain skyline yarding, but can also be used for uphill skyline yarding):
  - Fallblock carriage with carriage stop, as used in South Africa;
  - Mechanically activated load locking or mainline clamping carriages;
  - Skyline clamping load locking carriages;
  - Hydraulic skyline clamping and load locking carriages;
  - Hydraulic skyline clamping slackpulling carriage;
  - Non-motorised slackpulling carriages (MSP mainline and dropline carriages), unless specifically designed to go over intermediate supports;
  - Motorised slackpulling carriages.
• Other multi-span skyline systems:
  ▪ European-style cableway (the load is moved by gravity from from a higher point within the setting to a landing at the bottom of the setting).

**Advantages of a multi-span system in comparison to single span systems:**
• Better deflection and clearance on unfavourable terrain:
  ▪ Higher payload;
  ▪ Higher lift;
  ▪ Less yarder wear and tear.
• Yarding distances can be extended;
• Lower road densities due to extended yarding distances;
• Reduced lateral deflection of skyline in thinnings.

**Disadvantages of a multi-span system:**
• Longer setup times;
• Slower operation;
• Planning is more complex;
• Rigging is more complex;
• Multi-span systems can be more expensive than single span systems (e.g. additional rigging, longer yarding distance).

**4.2.1.3 Systems commonly used in South Africa**

In South Africa, the most commonly used skyline systems are standing skyline systems using simple fallblock carriages with carriage stop for uphill gravity return yarding on single span and multi-span skylines. In downhill single span and multi-span skyline operations, basic carriages (non-skyline clamping and non-load locking) and mechanically activated load locking carriages are most commonly used. However, there are also a number of radio controlled hydraulic skyline clamping load locking carriages in use.

The above-mentioned systems are all manual slackpulling systems using light lines to facilitate lateral yarding and accumulation of small piece sizes. The appropriate operating methods for each carriage type can be found in **Chapter 3**.
4.2.2 Live skylines

The fundamental difference between a live skyline and a standing skyline is that with a live skyline system, the skyline cable is raised and lowered with each yarding cycle. Therefore, the yarder has to be equipped with a powerful skyline drum and efficient skyline brake system. Live skyline systems are generally used on but not limited to single spans.

 Shotgun skyline systems (Figure 22) are live skyline uphill yarding systems in which the carriage is returned infield by gravity. Therefore, they only require two working drums, namely the skyline drum and the mainline drum. The shotgun carriage is normally a very heavy, basic carriage that has long chokers directly attached to it.

<table>
<thead>
<tr>
<th>Shotgun live skyline system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carriage</td>
</tr>
<tr>
<td>Drums</td>
</tr>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>Direction</td>
</tr>
<tr>
<td>Guideline Max. distance</td>
</tr>
<tr>
<td>Set-up time</td>
</tr>
<tr>
<td>Harvesting type</td>
</tr>
<tr>
<td>Slackpulling</td>
</tr>
<tr>
<td>Multi-spanning</td>
</tr>
</tbody>
</table>

The mainline cable is attached directly to the carriage and does not pass through the carriage. As the carriage approaches the timber to be choked, the skyline cable is progressively lowered until the carriage comes to a stop on or near the timber to be choked. Once the timber has been choked, the skyline cable is then raised while the operator simultaneously pulls on the...
mainline cable until the skyline reaches working height. As the carriage and load approaches the landing, the skyline is once again lowered until the timber and carriage are on the landing, ready to be dechoked. The skyline cable is again raised to the working height and the carriage is returned to the infield position when the mainline cable is spooled out.

With live skyline systems, the extraction corridor is limited to the length of the chokers, which necessitates frequent line changes. They are normally robust systems with few working parts leading to generally high mechanical availability. They also have relatively fast set up and cycle times. They are usually used where tree sizes are very large, making the breakout difficult.

4.2.2.1 Motorised and/or hydraulic grapple carriage systems

A number of motorised and/or hydraulically operated grapple carriages which are designed to run on live skyline cables have recently come onto the market. These carriages require the skyline cable to be lowered in order to place the grapple onto the timber to be extracted. Once the grapple arms have clamped the load, the skyline is raised to working height. The mainline then hauls the grapple carriage and load in to the landing. As the grapple carriage approaches the landing with the load, the skyline cable again needs to be lowered in order for the grapple carriage to safely release the load.

4.2.2.2 Other live skyline systems

More sophisticated carriages than the simple carriage have been used in conjunction with a live skyline system. These carriages have slackpulling capabilities which thus extend the lateral yarding capabilities of the live skyline system.
4.2.3 Running skylines

A running skyline (Figure 23) is a cable yarding system where the carriage and the load are suspended from the haulback cable, and the haulback cable is also used to haul the carriage back to the infield position. When the haulback line is tensioned against the mainline during haul in, lift is provided for the carriage and its load. These systems therefore require yoders that have sufficient power, haulback braking capability and/or an interlocked winch drum set to be able to achieve partial or full suspension of the load during haul-in.

Running skyline system using an MSP carriage

<table>
<thead>
<tr>
<th>Carriage</th>
<th>Slackpulling/Non-slackpulling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drums</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Lines</td>
<td>HL, ML (SPL)</td>
</tr>
<tr>
<td>Direction</td>
<td></td>
</tr>
<tr>
<td>Guideline Max. distance</td>
<td>500 m</td>
</tr>
<tr>
<td>Set-up time</td>
<td>30 min</td>
</tr>
<tr>
<td>Harvesting type</td>
<td>CF and thin</td>
</tr>
<tr>
<td>Slackpulling</td>
<td>Yes</td>
</tr>
<tr>
<td>Multi-spanning</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ground conditions</th>
<th>Ground roughness</th>
<th>Slope</th>
<th>Type slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>1-4</td>
<td>1-7</td>
<td>R, V</td>
</tr>
</tbody>
</table>

Figure 23: Running skyline system using an MSP carriage

There are a number of variations of running skyline systems. The most common include the Grabinski (Scab) skyline system, mechanical slackpulling carriage systems and grapple carriage systems. The South African highlead system, when used with a riderblock or highlead carriage, is in fact a very simple running skyline, as the simple carriage runs on the haulback line, and the same operating principles relating to haulback cable and mainline apply.
4.2.3.1 Running skyline system with a mechanical slackpulling carriage (Manual SP)

The running skyline system with a mechanical slackpulling carriage (Manual SP) requires a more sophisticated three-drum winch set with water cooled slipping clutches and brakes. They work best with yarders fitted with interlocked winch sets (generally found on swing yarders).

In a running skyline setup, the Manual SP carriage is supported by the haulback line by means of a riderblock. There are a number of variations of the Manual SP carriage and the rigging of the mainline will differ slightly according to the type of Manual SP carriage. In one type, a slackpulling line is used to pull mainline slack off the yarder to allow for lateral yarding. The mainline is either pulled directly through the carriage and used for lateral yarding, or alternatively a short skidding line is attached to the mainline at the point where the slackpulling line attaches to the mainline, and is used for lateral yarding. In another type, the slackpulling line will turn an internal dropline drum housed in the carriage, which is used for lateral yarding purposes. The mainline cable and the slackpulling line must be reeled in at the same speed during haul-in to prevent the slackpulling line snagging on obstacles.

4.2.3.2 Mechanical grapple carriage system

Mechanical grapple carriage systems, like the Manual SP systems, require sophisticated three-drum winch sets. A mechanical grapple carriage generally comprises a Manual SP carriage with a pair of grapple jaws suspended from the carriage by means of a set of chains. The Manual SP carriage is of the type whereby mainline slack is pulled off the yarder by reeling in the slackpulling line. The skidding line of the Manual SP carriage is replaced by a shorter grapple closing line. When the mainline is wound in, the grapple closing line causes the jaws to close. When the skidding line is wound in, the grapple closing line is slackened, the jaws are lowered and the suspension chains cause the jaws to open.

4.2.3.3 Motorised and/or hydraulic grapple carriage systems

A number of motorised and/or hydraulically operated grapple carriages which are designed to run on two-drum running skyline systems, have recently come onto the market. These carriages require the haulback cable to be lowered in order to place the grapple onto the timber to be extracted. Once the grapple arms have clamped the load, the haulback cable is then raised to working height. The mainline then hauls the grapple carriage and load in to the landing. As the grapple carriage approaches the landing with the load, the haulback cable again needs to be lowered in order for the grapple carriage to safely release the load.
4.3 Monocables

Only one variation of a monocable system is discussed here, although other systems are available. The monocable system (Figure 24) uses an endless loop of wire rope (9-12 mm diameter) that runs through a series of open-sided blocks. Various lengths of wire rope, with eyes at both ends, can be connected to form a continuous line. This makes it easier to adjust the length of the wire rope. The blocks hang from the support trees by straps. A tensioning line can be used to tension the mainline. The trees are selected to support both the wire rope and logs over critical areas (e.g. a break in the slope). A capstan winch, driven by an 8-10 kilowatt diesel engine normally feeds the endless wire rope. Logs are attached to the slow moving monocable by tying or hooking chokers. Baling twine can be used as chokers. The logs therefore travel continuously from hitching locations to the landing.

<table>
<thead>
<tr>
<th>Monocable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carriage</td>
</tr>
<tr>
<td>Drums</td>
</tr>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>Direction</td>
</tr>
<tr>
<td>Guideline Max. distance</td>
</tr>
<tr>
<td>Set-up time</td>
</tr>
<tr>
<td>Harvesting type</td>
</tr>
<tr>
<td>Slackpulling</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ground conditions</th>
<th>Ground roughness</th>
<th>Slope</th>
<th>Type slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>1-4</td>
<td>1-7</td>
<td>R, U, T, V</td>
</tr>
</tbody>
</table>

Figure 24: Monocable
5  **Wire ropes and synthetic ropes**

Rope used in cable yarding operations is divided into wire (traditional) and more recently synthetic rope.

5.1  **Wire rope**

The component parts of wire rope are illustrated below (Figure 25):

![Figure 25: Component parts of a wire rope](image)

When a wire rope is under tension, there are a number of complex forces being exerted on and between the outer strands and the core.

5.1.1  **Description of wire ropes**

A wire rope is described by the following characteristics; diameter, lay, core, configuration of strands and wires, and tensile grade.

5.1.1.1  **Diameter**

All wire ropes are measured by diameter in millimetres (Figure 26). Care should be exercised in determining the diameter of a wire rope. The correct measurement should coincide with the diameter that includes all the strands of the wire rope.

![Figure 26: Measurement of wire rope diameter](image)

5.1.1.2  **Lay**

This term is used to describe the length of pitch or distance along the wire rope that is required for one strand to complete one full turn around the core. It also denotes the direction in which the strands are laid, as well as the relationship between the direction of the wires in the strand and the direction of the strands in the wire rope (Figure 27).

![Figure 27: Wire rope lay – spiral distance](image)
Lang’s lay wire rope is made with the wires of each strand laid in the same direction as the strands in the wire rope. Ordinary lay (regular lay) wire rope is manufactured with the wires in each strand laid in the opposite direction to that of the strands in the wire rope.

Wire ropes used in cable yarding in South Africa are normally right-hand ordinary lay.

**a) Ordinary lay (regular lay) (Figure 28)**

- In left-hand ordinary lay (or left-hand regular lay or crosslay to the left) wire rope, the strands are turned to the left and the wires to the right.
- In right-hand ordinary lay (or right-hand regular lay or crosslay to the right) wire rope, the strands are turned to the right and the wires to the left.

![Figure 28: Ordinary lay (regular lay) wire rope](image)

**b) Lang’s lay (uniform lay)**

- In left-hand Lang’s lay (or uniform lay to the left) wire rope, the wires and strands are turned to the left.
- In right-hand Lang’s lay (or uniform lay to the right) wire rope, the wires and strands are turned to the right.

Lang’s lay (Figure 29) wire rope wears more evenly than ordinary lay wire rope, and its resistance to bending fatigue is better. It is also more abrasion resistant than ordinary lay wire rope. It is however more inclined to kink and unravel than ordinary lay wire rope. Therefore, Lang’s lay wire rope has to be anchored at both ends to prevent it from unravelling (e.g. as a standing skyline).

![Figure 29: Lang’s lay (uniform lay) wire rope](image)
5.1.1.3 Core

The primary function of the core is to support the strands. It also acts as a reservoir for the lubricant that is necessary in a wire rope. The internal lubricant is much more important than later external applications of lubricant.

There are four types of cores:
- F = fibre (e.g. sisal, hemp, etc.)
- P = polypropylene
- IWRC = independent wire rope core
- WMC = wire main core

IWRC is normally used for harvesting purposes because of its higher strength and crush resistance.

5.1.1.4 Configuration of strands and wires

Wire rope is described firstly by the number of strands per wire rope, and then by the number of wires per strand. The number of wires per strand has a direct relationship with flexibility and resistance to abrasion. In general, for a given strand diameter, the more wires per strand, the more flexible the wire rope and the lower its resistance to abrasion. The following table indicates how the wire rope formula is deduced from the wire and strand configuration (Table 3).

Table 3: Wire rope configurations (example)

<table>
<thead>
<tr>
<th>Look at the whole cable</th>
<th>Number of outside strands</th>
<th>6 x 19 (9/9/1)/F</th>
<th>6 x 25 (12/6/6/1) IWRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>Core</td>
<td>F</td>
<td>IWRC</td>
</tr>
<tr>
<td>Look only at one strand</td>
<td>Number of wires in outer layer</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Number of wires in first layer</td>
<td>9</td>
<td>6 (thick wires)</td>
</tr>
<tr>
<td></td>
<td>Number of centre wires</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sum of the wires in the strand</td>
<td></td>
<td>19</td>
<td>25</td>
</tr>
</tbody>
</table>

Therefore, the 6 x 19 wire rope has 9 outer wires per strand compared as to the 6 x 25 wire rope that has 12 outer wires per strand. The 6 x 19 outer wires are thus thicker than the 6 x 25 outer wires, and the rope is therefore more resistant to abrasion than the 6 x 25 wire rope. The 6 x 19 wire rope is, however, not as flexible as the 6 x 25 wire rope.
Common names used for compacted wire ropes

Compact strand

Each strand in the compact strand wire rope (Figure 30) is reduced one size in diameter by drawing it through a die that flattens the outside wires. The strands are then laid up to manufacture the compact strand wire rope. Compact strand wire rope is more flexible than swaged wire rope, but less so than ordinary wire rope. Compact strand wire ropes take longer to manufacture, and are therefore more expensive.

![Figure 30: Compact strand wire rope](image)

Swaged wire rope

Swaged wire rope (Figure 31) is made from ordinary wire rope that has been reduced one size in diameter by a pounding action. It has greater strength compared to ordinary wire rope for the same diameter wire rope. This wire rope looks like normal wire rope that has been evenly worn.

![Figure 31: Swaged wire rope](image)

5.1.1.5 Tensile grade

Tensile grade refers to the strength rating of the steel wire within the ropes. In the wire rope manufacturing process, steel wire is made by drawing a rod of a selected grade of steel through progressively smaller dies until the required diameter is reached. The final steel rope usually has a strength of between 180 and 200 MPa. The recommended tensile grade is therefore between 180 and 200 MPa. Compact strand wire ropes can, however, be made of wire rope with 160 MPa tensile strength, because this type of wire rope is softer. It still conforms to the required strength required because the strand has been compacted and there is more steel per surface area.

Other terms found in literature are IPS and EIPS (or XIP). IPS is an abbreviation for Improved Plough Steel, which is a tough, strong grade of wire developed for use under a wide variety of operating conditions. It has a high carbon and manganese content which makes it hard and abrasion resistant. IPS is similar to 180 MPa tensile strength. EIPS is the abbreviation for Extra Improved Plough Steel and is made of a special grade of steel, containing a very high carbon content, which provides about 15 % greater tensile strength and greater toughness than IPS.
5.1.2 Wire rope limits

When using wire rope it is important to be aware of the safety limitations of this material.

5.1.2.1 Elastic limit

Up to the elastic limit, tension on a steel bar elongates the steel bar very slightly by an amount proportional to the load applied. When the load is removed, the bar returns to its original length. If loaded beyond the elastic limit, the bar no longer returns to its original length and a small permanent extension remains. Wire rope exhibits the same elastic stretch as the steel bar, provided that the load is kept below the elastic limit which, for the commonly used wire rope is about 60% of its ultimate breaking strength. However, the behaviour of wire rope is not entirely the same as a steel bar, since the wire rope also exhibits “constructional stretch”. This is permanent and starts to develop as soon as stress is applied. It is due to wires “bedding-down” into the strands, and the strands into the core. It mostly occurs within the first few days or weeks of operation, depending on the amount of load. For ordinary wire ropes, this stretch will be approximately 0.25% to 1% of the length of the wire rope under load.

5.1.2.2 Endurance limit

Tests have shown that there is another limit, lower than the elastic limit, which is of equal or even greater importance in the life of a wire rope. This limit is approximately 50% of the breaking strength, and is known as the endurance limit. If a wire rope is given repeated pulls or jerks greater than the endurance limit, the life of the wire rope is comparatively short and it will finally break, even though it has never been strained to its breaking strength nor its elastic limit.

5.1.2.3 Safety limit/safe working load

Wire ropes in a cable yarding operation experience both static and dynamic loading. Static loading occurs when no loads, wire ropes or rigging are moving, i.e. forces in the system are at equilibrium. Engineering mechanics and geometry can fully describe line tensions in this situation. Dynamic loading is experienced whenever a part of the system is in motion, whether it be moving loads, rigging, or even just vibrating wire rope. Little is known in the harvesting industry about the magnitude of dynamic forces. However, experience has shown that if tensions due to static loading are kept below one-third of the breaking strength, there is adequate provision for the combined loading of static and dynamic loads. Therefore, a safety factor of three is typically applied to all wire ropes used in cable yarding:

**Safe working load (SWL) = Breaking strength ÷ 3**

All safety factor calculations should consider wire quality and the type of connector used (if the wire rope is in two or more pieces).
5.1.2.4 Breaking strengths of commonly used wire rope configurations

Table 4 below gives an indication of the minimum breaking load of three different kinds of wire rope:

**NOTE:**
Contact your local supplier/dealer for more specific information about the wire ropes used in your operations.

### Table 4: Breaking load of wire rope

<table>
<thead>
<tr>
<th>Diam. (mm)</th>
<th>Fibre core 6 x 19(9/9/1)/IWRC ROHL*</th>
<th>Wire rope 6 x 19(9/9/1)/IWRC ROHL*</th>
<th>Compact strand wire core 6 x 26C(10/5 + 5/5/1)/IWRC RHOL*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breaking load (kg)</td>
<td>Weight (kg/100 m)</td>
<td>Breaking load (kg)</td>
</tr>
<tr>
<td>8</td>
<td>3863</td>
<td>24.5</td>
<td>1288</td>
</tr>
<tr>
<td>9</td>
<td>4975</td>
<td>31.3</td>
<td>1658</td>
</tr>
<tr>
<td>10</td>
<td>6014</td>
<td>37.7</td>
<td>2005</td>
</tr>
<tr>
<td>11</td>
<td>7360</td>
<td>45.9</td>
<td>2453</td>
</tr>
<tr>
<td>12</td>
<td>8889</td>
<td>55.4</td>
<td>2963</td>
</tr>
<tr>
<td>13</td>
<td>10377</td>
<td>64.8</td>
<td>3459</td>
</tr>
<tr>
<td>14</td>
<td>12059</td>
<td>75.4</td>
<td>4020</td>
</tr>
<tr>
<td>15</td>
<td>15780</td>
<td>98.0</td>
<td>5260</td>
</tr>
<tr>
<td>16</td>
<td>19929</td>
<td>123.4</td>
<td>6643</td>
</tr>
<tr>
<td>17</td>
<td>21620</td>
<td>133.9</td>
<td>7207</td>
</tr>
<tr>
<td>18</td>
<td>24638</td>
<td>152.3</td>
<td>8213</td>
</tr>
<tr>
<td>19</td>
<td>28818</td>
<td>179.0</td>
<td>9606</td>
</tr>
<tr>
<td>20</td>
<td>35464</td>
<td>219.5</td>
<td>11821</td>
</tr>
<tr>
<td>21</td>
<td>40377</td>
<td>250.0</td>
<td>13459</td>
</tr>
</tbody>
</table>

*Right-hand ordinary lay  **Safe working load = Breaking strength (load) ÷ 3

5.1.3 Safety considerations

- Wire rope used in cable yarder extraction should be between 160 and 200 tensile grade;
- No wire rope should be used in any forestry harvesting operation unless the manufacturer or vendor has certified the breaking strength;
- The wire ropes should always be used in accordance with the manufacturer’s instructions.;
- The safe working load (SWL) should not be exceeded;
- All wire ropes should be securely fixed to the cable yarder or winch drum and should be of sufficient length to ensure that there are never less than four complete turns of wire rope on the drum;
- The use of knots in any wire rope in a cable yarding operation is prohibited;
- New wire rope should be run in by extracting smaller loads (for three or four turns) before bigger loads are attempted;
- Wire rope is put under various stresses in a normal working day, and will become fatigued. Such ropes should be replaced. The inspection criteria are discussed in Section 5.1.6;
- Wire rope that has been burned may not be used for yarding.
5.1.4 Recommended wire rope for various lines

Safe operating procedure depends on the correct type of wire rope for various applications.

5.1.4.1 Skyline

The skyline, as used in standing-skyline systems, is a static line. It is recommended preferably using 6 x 19 IWRC, since a 6 x 25 IWRC wire rope is more flexible, but not as resistant to abrasion. Swaged wire rope can also be used with success as it has greater strength compared to ordinary wire rope of the same nominal size. The advantage of using swaged wire rope as a skyline is that a longer length of wire rope of the same strength can be put onto the skyline drum compared to ordinary wire rope. This allows for a longer reach on the skyline. This wire rope does, however, cost more. A Lang’s lay wire rope also performs better than an ordinary lay wire rope in situations where both ends are fixed, such as a standing skyline. This is due to the better resistance of Lang’s lay wire rope to fatigue, and its better wear characteristics compared to ordinary lay.

5.1.4.2 Mainline

The mainline is a working line and is therefore subjected to considerable wear and bending forces. It should therefore not coil up when tension is released on the wire rope, but should only sag. It is recommended preferably using a 6 x 19 IWRC or a 6 x 25 IWRC wire rope. Swaged wire rope can also be used with success as it has greater strength compared to ordinary wire rope of the same nominal size. The advantage of using swaged wire rope as a mainline is that a longer length of wire rope of the same strength can be put on the mainline drum as compared to ordinary wire rope. This allows for a longer reach on the mainline. However, swaged wire rope is more difficult to handle and splice. It also costs more.

5.1.4.3 Haulback line

The haulback line is the longest of the wire ropes. It is used to pull the carriage and mainline infield. The wire rope should therefore be light enough to handle it, but should also be of suitable strength to withstand the forces exerted on it. It is recommended preferably using a 6 x 19 IWRC or a 6 x 25 IWRC wire rope. The haulback line can be heavier if a strawline is used to pull out the lines. Swaged wire rope can also be used for the same reasons as discussed previously.

5.1.4.4 Strawline

The strawline is only used as a rigging line and should therefore be light and flexible. Refer to Section 9.5.6.1. Since the team has to haul the strawline out manually, it should also preferably be galvanised. Galvanised wire ropes do not have any grease on them, which makes them cleaner to work with. Any wire rope can be used, but it is advisable to use a softer wire rope, e.g. a 6 x 25 or 6 x 36 fibre core wire rope.

5.1.5 Typical wire rope sizes on common yarders

Wire ropes must be sized according to manufacturer’s specifications. A basic guide to wire rope sizes used on common yarders in South Africa has been laid out in Table 5 as a guideline. Note this table does NOT replace OEM’s specifications.
Table 5: Typical wire rope sizes used on common yarders (in mm)

<table>
<thead>
<tr>
<th>Yarder</th>
<th>Skyline</th>
<th>Mainline</th>
<th>Haulback line</th>
<th>Staw line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urus I</td>
<td>16</td>
<td>10</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Urus II</td>
<td>20</td>
<td>13</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Howe Line Mk III</td>
<td>20</td>
<td>13</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Howe Line Mk V</td>
<td>22</td>
<td>16</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Alpine Excavator-Based Guyless Yarder (8-ton)</td>
<td>13</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpine Excavator-Based Guyless Yarder (12-ton)</td>
<td>14</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Wheeled Logger Highlead</td>
<td>13</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tower guylines, snaplines and safety straps are sized according to the prescriptions laid out in Chapter 8.

5.1.6 Inspection criteria for wire rope removal

Wire rope shall not be used in cable yarding operations when in any length of eight diameters, the total number of visible broken wires exceed 10% of the total number of wires.

**Example:** 26 mm diameter rope with a 6 x 19 construction

Total wires = 6 x 19 = 114
8 diameters = 26 mm x 8 = 208 mm
10% of 114 = 11.4

Therefore, if in a length of 208 mm there are 12 or more visible broken wires, the wire rope or the damaged section/s, needs to be removed.

NOTE:
Inspect wire ropes at least once every three months. Record such inspections in a Wire Rope Inspection Register.

5.1.7 Causes of wire rope failure

Some causes of wire rope failure are:

- **Corrosion** – caused by exposure to moisture;

- **Excessive crushing** – caused by poor spooling and excessive overloading. If a large amount of wire rope is being put on a drum and then only the top layers are working, the bottom layers should be put on tightly. The care shown in winding on the bottom layers has a critical effect on the life of the wire rope;

- **The use of small sheaves and drums** – causing early breaking of wires due to extreme bending fatigue. Wire rope drums and sheaves should have a diameter of more than approximately 28 times the wire rope diameter. This figure varies with different wire ropes used, and it is advised to consult your wire rope dealer/manufacturer;
• **Incorrect handling** – avoiding kinks, bruises, slipping of the lay or other damage is essential in the handling of wire rope, if good service life is to be expected. The time to avoid a kink is before it starts – don’t pull it out – always unfold it. Unroll and spin out the wire rope if it is supplied in a coil (not on a drum). With every single loop that is unrolled, give the wire rope one spin;

• **Excessive abrasion** – caused by the wire rope rubbing against protruding rocks or against steel or other hard objects;

• **Corrugated sheaves in pinching sheave grooves** – this is a very common cause of early failure;

• **Shock loads** – repeated instantaneous overstrains, such as those occurring during acceleration and deceleration, in starting and stopping loads, or the shocks and overloads encountered in most operations, cause severe unseen damage and shortens the service life of the wire rope. Shock loading should be minimised and avoided through smooth operation;

• **Using the wrong wire rope** – all wire ropes are specially constructed to meet a specific purpose. Using incorrect wire rope in a given situation will lead to premature failure (e.g. using fibre-core wire rope instead of wire-core wire ropes for yarding);

• **Seized sheave** – intense heat is created through friction and this will result in early failure and excessive wear;

• **Improper socketing or splicing** – this causes slackness in strands and wires which will work down a wire rope, resulting in rapid localised wear, and uneven strain on the strands;

• **Reverse bending** – when a wire rope passing over one sheave switches sharply in the opposite direction to pass over a second sheave, reverse bending can be caused in the wire rope, accelerating fatigue failure from bending. If these conditions cannot be avoided, they should be minimised by using a flexible wire rope construction, larger sheaves (if possible), increasing the angle through which the wire rope is turned each time, and/or spacing the sheaves as far apart as possible;

• **Over stretching** – exceeding the safe working load with loads that are too heavy.

### 5.1.8 Splicing wire rope

Splicing techniques are not discussed in this handbook. For detailed information on splicing techniques consult a wire rope manual (e.g. *Splicing Manual of the Workers Compensation Board of British Columbia*) or your wire rope dealer. General splicing principles are:

- Splicing tools should be in a serviceable condition and large enough for the size of the line being spliced;

- When available, and practical to use, a patented wire rope cutter should be used. When using a wire rope axe to cut wire rope, eye protection should be worn;

- Eye-to-eye splices and knots are prohibited in loading ropes, straps used for lifting and guylines;

- Eye splices in all regular lay wire ropes should be tucked at least three times, and four times for Lang’s lay wire rope;

- Splicing of guylines is not acceptable, except to make eye splices;

- Guyline connections should be at least 1.5 times the strength of the guylines.

Recommended splices for various ropes:

- **Skyline, mainline and haulback line**: Long splices, short-long splice (butt-splice);

- **Mainline and haulback line**: Long splices, short-long splice (butt-splice);

- **Guylines**: Guylines should not be spliced lengthways. To extend the length, guylines should be spliced with an approved eye splice (e.g. loggers eye splice, rolled eye splice, married eye splice tucked three times), and joined together with an approved shackle.
5.1.9 **Spooling of wire rope onto drums**

When winding new wire rope onto a drum, care should be taken to wind it correctly. The wire rope should be spooled (Figure 32) onto the yarder drum in the same direction as it is wound off the container drum, as can be seen in the diagrams below.

![Figure 32: Spooling direction of wire ropes onto drums](image)

**Right-lay wire rope (use right hand rule)**

Use the index finger of the right hand to indicate the direction from which the wire rope approaches the drum (Figure 33). The thumb will indicate the direction in which the wire rope should be wound onto the drum.

![Figure 33: Spooling direction of wire ropes onto drums](image)

**Left-lay wire rope (use left hand rule)**

Use the index finger of the left hand to indicate the direction from which the wire rope approaches the drum (Figure 34). The thumb will indicate the direction in which the wire rope should be wound onto the drum.

![Figure 34: Spooling direction of wire ropes onto drums](image)
Calculation of drum capacity with various line sizes

From time to time it may become necessary to change the lines on a drum (Figure 35). To determine the capacity of a drum for a given line diameter, use the following formulas:

A = depth of wire rope
L = length of wire rope
D = diameter of drum
B = width between flanges
C = desired clearance
d = wire rope diameter
H = diameter of flange
K = factor

Where \( A = \frac{(H - D)}{2} - C \); \( K = \frac{0.00314}{d^2} \) and

\[ L = (A + D) \times A \times B \times K \]

**Example:**

Wire rope diameter = 19 mm
Therefore \( C = 19 \) mm
\( A = \frac{(800 \text{ mm} - 400 \text{ mm})}{2} - 19 \text{ mm} = 181 \) mm
\( K = \frac{0.00314}{19^2} = 8.7 \times 10^{-6} \)
\[ L = (181 \text{ mm} + 400 \text{ mm}) \times 181 \text{ mm} \times 500 \text{ mm} \times 8.7 \times 10^{-6} = 457 \text{ m} \]

**Figure 35:** Calculation of drum capacity with various size lines
The following graph (Figure 36) can be used to determine the equivalent drum capacity in length of wire rope resulting from a change in wire rope diameter or to determine the total wire rope weight.

**Figure 36**: Approximate drum capacity in weight and length of wire rope by diameter. (after Studier D. and Binkley V. 1974. In: Kellogg L. Cable Harvest Planning. Draft course manual, British Columbia Institute of Technology)

**Example (drum capacity)**: How much 13 mm wire rope can a drum take that holds 500 m of 16 mm wire rope?

**Answer**: Move vertically from 500 m on the horizontal axis to the intersection with the 16 mm wire rope, then horizontally to the intersection with the 13 mm wire rope, and then down to the horizontal axis again = 800 m.

**Example (wire rope weight)**: How much would 500 m of 16 mm wire rope weigh?

**Answer**: Move vertically from 500 m on the horizontal axis to the intersection with the 16 mm wire rope, then horizontally to the intersection with the vertical axis = 500 kg.
5.2 Synthetic ropes

Webbing belts and slings should be load-rated (with the manufacturer’s safe working load permanently and legibly identified) to ensure that they will withstand the loads exerted upon them (Figure 37). Webbing slings may be tensioned with a ratchet buckle, which should also be load-rated and have a safe working load equal to, or greater than, the webbing sling.

Where synthetic ropes (e.g. webbing belts and slings) are used in lieu of wire ropes as guylines for intermediate supports, tailtrees or as a tieback for tree anchors, it should have the same SWL of the wire rope it replaces, or a combination of synthetic ropes should be used and tensioned appropriately, to achieve the same SWL of the wire rope it replaces.

Where synthetic ropes are used as straps in lieu of wire rope straps it should have the same SWL as the strap it replaces.

Fibre and synthetic ropes can be used as chokers (Figure 38), especially in thinning operations where they cause less damage to standing trees than chain/wire rope chokers. Fibre ropes are damaged more easily by chaffing than wire ropes and consequently have a reduced lifespan. Fibre ropes can be spliced with a hand splice. Contact your local supplier/dealer for splicing instructions.

Figure 37: Webbing sling, belt and ratchet buckle

Figure 38: Fibre/synthetic rope used as a choker
Soft round slings (Figure 39) can be used in thinning operations to anchor guylines to standing trees thereby preventing damage to these trees.

NOTE:

Webbing slings, soft round slings and fibre ropes that have abrasions or tears in the exterior cover or broken fibres in the weaving of braided type straps should be discarded entirely, except if they are repaired and the strength certified.
6 Rigging accessories

Safe rigging of cable yarders depends on the correct application of rigging accessories.

6.1 Cable clamps (crosby clamps)

Cable clamps can be used to fasten wire rope ends to anchor systems and for forming eyes. Cable clamps may not be used to connect two wire ropes together to create a longer wire rope.

When using cable clamps (Figure 40), the clamps should always be attached with the saddle/bridge of the clamp against the longer or live end of the wire rope. The U-bolt goes over the dead end. Tip: Do not saddle a dead horse (don’t put the saddle/bridge over the dead end of the wire rope). Don’t reverse the clamps or stagger them, otherwise the U-bolt will cut into the live wire rope when the load is applied.

![Figure 40: Application of cable clamps](image)

After the wire rope has been used and is under tension, the clamps should again be tensioned to take up any looseness caused by tension that reduced the wire rope diameter. Remember that even when properly applied, a clamp fastening has only about eighty percent of the strength of the wire rope, and far less when it is applied incorrectly.

The correct number of clamps should be used for various wire rope sizes and the clamps should be spaced accordingly (Table 6). Clamps should also be of the same size as the wire rope to which they are attached.

<table>
<thead>
<tr>
<th>Wire rope diameter (mm)</th>
<th>Number of clamps</th>
<th>Minimum spacing between clamps (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>120</td>
</tr>
<tr>
<td>22</td>
<td>5</td>
<td>140</td>
</tr>
<tr>
<td>26</td>
<td>6</td>
<td>160</td>
</tr>
</tbody>
</table>
6.2 Ferrules

A ferrule is a metal sleeve or collar (Figure 41), fastened to the end of a wire rope to prevent it unravelling. It can also fit into a hook or socket to secure the wire rope (e.g. choker hook) (Figure 42).

![Figure 41: Ferrules](image)

A quick ferrule can also be made by inserting a wedge into the wires of an opened up wire rope that has been set in a ferrule.

![Figure 42: Choker hook with ferrule](image)

6.3 Mechanical splices

Pressed metal ferrules are frequently used for making eyes at the end of ropes. Mechanically spliced joints (Figure 43) should be accepted only from authorised workshops.

![Figure 43: Mechanical splices](image)
6.4 Thimbles

Thimbles are used to strengthen an eye at the end of a wire rope (without thimbles the strength of eyes may be considerably reduced because of the flattening of strands). Therefore, thimbles should be used wherever possible (Figure 44).

![Figure 44: Thimble](image)

6.5 Shackles

Shackles are used to join or secure lines (Figure 45). They come in a variety of sizes and shapes, depending on the intended use. Shackles can be fitted with pins, screw pins or with a threaded bolt, nut and split pin.

![Figure 45: Types of shackles](image)

Shackles which are to be used in the rigging or guylines (Figure 46) shall comply with the following requirements:

- Shall be tested and marked with their SWL;
- Shall have a SWL of not less than 1.5 times that of the rope to which they are rigged;
- Shall at all times, other than during rigging or adjusting operations, have their screw threads positively prevented from turning or unscrewing (refer to Section 6.6);
- Shackles shall be rigged with the pin of the shackle through the eye of the guyline. If the shackle is incorrectly rigged, the live section of the wire rope can cause the shackle pin to unscrew. Refer to Section 7.1.3 for additional requirements on how to apply shackles to stump anchors;
- On the tower guyline blocks, a bolt-and-nut type shackle fitted with a safety pin or molly, shall be used to prevent unscrewing.

![Figure 46: Correct rigging of a shackle](image)
Almost all shackles purchased in South Africa have a safety factor of 5:1 (Figure 47). The safe working load on a shackle is normally indicated by a number, after the letters WLL (Working Load Limit).

**NOTE:**
The Working Load Limit (WLL) is just a different term for the Safe Working Load (SWL).

**Example:** A shackle stamped with WLL 8.5 has a breaking strength of \((5 \times 8.5) = 42.5\) ton.

6.6 **Devices to prevent unscrewing**
The following devices can be used to positively prevent pins from turning or unscrewing (Figure 48):
- A split pin or wire through a hole in the pin;
- A molly through a hole in the pin;
- A piece of wire attached through the eye of the pin to the shank of the shackle.

A molly is made as follows (Figure 49):
- Take a strand of wire rope that would fit the hole in the pin. Make a rough loop with four or five corners, and wrap the strand at least two full loops before threading it through the pin. Pull the strand tight after threading it through the pin, then wrap it at least another one and a half loops.
6.7 Chains, chokers, hammerlocks and attachments

- All chains, sliders and hammerlocks should be of Herc Alloy Grade 600-800 quality or an equivalent. In South Africa, hooks, rings, oblong links, welded or mechanical coupling-links, sliders, hammerlocks, chains, etc. generally have a safety factor of 4:1;
- Chains should only be linked with hammerlocks (Figure 50);

![Figure 50: Hammerlock](image1)

- All hooks, sliders, chains, wire rope straps and hammerlocks used in a choker system should be compatible and of the same SWL;
- Choker chains, wire rope chokers, hooks and hammerlocks attached to the chokers should have a breaking strength of approximately 75% of the breaking strength of the mainline;
- The use of C-hooks (Figure 51) or open hooks (snaplinks) is prohibited for use in cable yarding operations, EXCEPT where they are used in a tagline system on small yarders. It is not allowed on the haulback line or any other part of the rigging;

![Figure 51: C-hook in tagline](image2)

- Where chain is used in lieu of wire rope anywhere in the rigging it shall have the same SWL as the wire rope it replaces.
Table 7 below gives an indication of the safe working load in kilograms of Herc-Alloy 800 chain.

Table 7: Safe Working Load of Herc-Alloy 800 chain (Haggie Rand product catalogue, 1995)

<table>
<thead>
<tr>
<th>Chain size (mm)</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1200</td>
</tr>
<tr>
<td>7</td>
<td>1600</td>
</tr>
<tr>
<td>10</td>
<td>3200</td>
</tr>
<tr>
<td>13</td>
<td>5400</td>
</tr>
<tr>
<td>16</td>
<td>8200</td>
</tr>
</tbody>
</table>

6.8 Blocks, straps and sheaves

6.8.1 Block requirements

- All blocks should be fitted with line guards and be designed and used in a manner that prevents fouling;
- All blocks should be kept in proper alignment when in use;
- All blocks should have sheaves of a size designed for the size of the wire rope used;
- Blocks with cracked or excessively worn sheaves may not be used;
- Block bearings should be kept well lubricated;
- All blocks should be of steel construction or of material of equal or greater strength and hung that they will not strike or interfere with other blocks or rigging;
- All block pins should have their screw threads positively prevented from turning or unscrewing;
- Load bearing blocks should not be used for heavier lines than those for which they are constructed;
- Consult the manufacturer for specifications if uncertain of the size and/or the breaking strength of a block.

6.8.2 Hanging of blocks and strap sizes

Blocks should be hung using one of the following methods:

- **In both eyes of a strap.** The strap used to hang the block should have a breaking strength equal to, or greater than, the breaking strength of the operating rope that passes through the block. If a block is hung from both eyes of a strap using a bow-shackle, the shackle should be rigged with the bow of the shackle through both eyes of the strap. Refer to Figure 52b. If a snatch block is used, hang the block in both eyes of the strap Figure 52a.

![Figure 52](image-url)
In one eye of the strap, provided that the strap is connected back to itself with a shackle and the eyes of the strap are preferably equipped with thimbles. Refer to Figure 53(a). Threading an eye through a soft eye is prohibited. Refer to Figure 53(b). However, threading the strap through a thimbled eye is acceptable. Refer to Figure 53(c). A choker hook (refer to Section 6.2) can also be used to hang blocks. The strap should be sized according to the size of the operating rope that passes through the block. Refer to Table 8.

![Figure 53: The correct way (a, c) an incorrect way (b) to hang a block in one eye of a strap](image)

**Table 8:** Strap size for different size operating ropes (from Oregon Occupational Safety and Health Code)

<table>
<thead>
<tr>
<th>Operating rope size (mm)</th>
<th>Strap size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>24</td>
<td>34</td>
</tr>
</tbody>
</table>
6.8.3 Sheave diameter and bending fatigue

In cable yarding, wire ropes operate over sheaves and around drums. The resultant bending of the wire rope requires a considerable effort. The sharper the bend the greater the force required, and if the bend is too sharp, the wire rope becomes permanently damaged. The passage of a wire rope around a sheave causes increased tension in outer wires and reversed loading on inner wires. This combination of load stress and bending stress is the most common cause of wire rope damage and failure. It is recommended that sheave diameter should be at least 28 times the wire rope diameter. Table 9 gives the strength efficiencies for wire ropes bent around sheaves of a given diameter in comparison to the same wire rope when straight.

Table 9: Strength efficiency of wire ropes bending over a sheave (from Oregon Occupational Safety and Health Code)

<table>
<thead>
<tr>
<th>When sheave diameter is:</th>
<th>Efficiency of wire rope is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 times wire rope diameter</td>
<td>79% of strength of straight wire rope</td>
</tr>
<tr>
<td>12 times wire rope diameter</td>
<td>81% of strength of straight wire rope</td>
</tr>
<tr>
<td>14 times wire rope diameter</td>
<td>86% of strength of straight wire rope</td>
</tr>
<tr>
<td>16 times wire rope diameter</td>
<td>88% of strength of straight wire rope</td>
</tr>
<tr>
<td>18 times wire rope diameter</td>
<td>90% of strength of straight wire rope</td>
</tr>
<tr>
<td>20 times wire rope diameter</td>
<td>91% of strength of straight wire rope</td>
</tr>
<tr>
<td>24 times wire rope diameter</td>
<td>93% of strength of straight wire rope</td>
</tr>
<tr>
<td>30 times wire rope diameter</td>
<td>95% of strength of straight wire rope</td>
</tr>
</tbody>
</table>
7 Anchor systems

Various anchor systems are available for different conditions. Some examples of anchor systems are mentioned below.

- The most common type of anchors are stump anchors because they are readily available. They are also the lowest cost anchors;
- In the absence of appropriate stump anchors, various other types of artificial anchors are available. These include using equipment as anchors (e.g. bulldozers or excavators), using various materials buried in the ground as earth anchors, or using rocks as anchors;
- Standing trees and timber bundles can also be used as anchors, but only under certain circumstances.

7.1 Stump anchors

Due to the nature of forestry, tree stumps have the most potential to be used as anchors.

7.1.1 General rules of thumb

There is no reliable way of predicting the load-bearing capacity of stumps because of variations in root systems which grow differently as soil type, soil moisture, soil density and slope change. There are, however, some general rules of thumb (Figure 54):
• Holding power tends to increase with soil depth.

• Holding power increases approximately proportionate to the square of the size difference stump diameter (i.e. a 40 cm stump will hold approximately four times as much as a 20 cm stump, because its diameter is twice the size so the calculation is $2^2 = 4$ times).

• Stumps have greater holding strength on uphill pulls than on downhill pulls, as there are normally larger roots on the downhill side of the stump.

Holding power tends to increase with soil density.

• Holding power tends to decrease as soil moisture increases.

• The notch in the anchor should be as close to the ground as possible, but preferably above the root buttress. Cutting into the buttress reduces the holding strength of stumps. Comply to the following requirements regarding holding wood:
  ▪ If stump anchors are prepared from standing trees, holding wood of at least 10 cm should be left above the notch (at the place where the least holding wood is left).
  ▪ If stump anchors are prepared from trees that were previously felled, holding wood of at least 5 cm should be left above the notch (at the place where the least holding wood is left).

  ▪ If holding wood of less than 10 cm is present after stump anchors have been prepared from previously felled trees, the first stump anchor should be tied back to at least one more stump anchor, with at least 5 cm of holding wood left on all the stump anchors.

  ▪ Groove depth into solid wood should be deep enough (approximately twice the wire rope diameter) to ensure that the wire rope does not slip over the stump, but should not be so deep as to weaken the strength of the stump. The notch should be sloped so that it is in the lead of the line that will be attached to it (e.g. toward the top of the tower) and then gradually levelled off as it goes around the back of the stump.

Figure 54: Stump anchor rules of thumb
7.1.2 *Stumps to avoid*

Avoid the following stumps (Figure 55):

- Damaged stumps (e.g. damaged by road excavation, etc.);

- The stump of a broken tree;

- Stumps that are situated on rocks or in shallow soil on top of a rock bank;

- Stumps that are badly burned or that show signs of decay. Check for decay when notches are prepared;

- Stumps that are situated at water level (e.g. vlei areas).

*Figure 55: Stumps to avoid*
7.1.3 Attaching lines to stump anchors

- Guylines and skylines should be attached to stump anchors by one of the following methods (Figure 56):
  - **Cable clamps**: The cable should be wrapped at least twice around the stump and the clamps correctly applied. Refer to Figure 56(a). Refer to Section 5.1 on how to apply cable clamps;
  - **D-shackles and bow shackles**: If the cable is attached to only one stump anchor then the cable should be wrapped twice around the stump. Refer to Figure 56(b). If multiple stump anchors (in series) are used, only one wrap around the stumps are required. Refer to Section 7.1.4 on multiple stump anchors and Section 6.5 on how to apply shackles;
  - **Guyline sleeve (wide throat shackle)**: If a guyline sleeve is used to choke the cable to a stump anchor, only one wrap around the stump is required. Refer to Figure 56(c). Refer to Section 6.5 on how to apply shackles.

![Figure 56: Attachment of guyline to a stump: (a) cable clamps (b) D-shackle (c) guyline sleeve](image)

7.1.4 Multiple stump anchors

- Where doubt exists as to the soundness of the stump, such a stump should be tied back to another stump or stumps or other alternative anchors should be considered (Figure 57). Good stump notches are essential to transfer the load between the stumps. Approximately ⅔ of the line pull is transferred to the first stump and approximately ⅓ to the second stump. The angle of pull between these multiple stump anchors should be minimised;

![CORRECT – angle of pull is minimised](image) ![INCORRECT – change in angle of pull too great](image)

Figure 57: Multiple stump anchors – angle of pull
• The horizontal angles should also be minimised as the upward forces can pull the stump out of the ground if angle A is too sharp (Figure 58);

![Figure 58: Multiple stump anchors – horizontal angles](image)

• Where multiple stump anchors are used in series, only one wrap of the line is required around stump 1 and 2. Wrap the line around the stumps as illustrated in Figure 59. Attach the line to the final stump as explained in Section 7.1.3;

![Figure 59: Multiple stump anchors in series](image)

• Where stump anchors are not suitably situated or are not strong enough, the guyline or skyline can be attached to an equaliser block on a single wire rope secured to two stumps (Figure 60). The size of the wire rope (tieback line) should be at least equal to the size of the guyline/skyline. The equaliser block does not necessarily have to be in the middle of the two stumps – it can be offset to either side of the centre;

![Figure 60: Equaliser block in two-stump anchor system](image)
• Where each stump is stable enough to support the full weight of the line tension, the maximum angle between the tieback line should not exceed 120°. The smaller the angle the better (i.e. the closer the stumps are to one another). An equaliser block can be used to get the guyline or skyline in an appropriate guyline/skyline zone. At a 120° angle, the tension in the tieback line would be the same as the tension in the guyline/skyline. Example: If the tension in the guyline/skyline is 4500 kg, the tension on the tieback line will also be 4500 kg;

• Where single stumps are not suitable to hold the full weight of the line tension (e.g. if small trees are used to prepare the stump anchors), the angle between the tieback line may not exceed 90° (Figure 61). The smaller the angle the better. In this case the equaliser block is used to distribute the force between the two weaker stumps.

![Figure 61: Equaliser block with 120° and 90° angles](image)

• The following graph gives an indication of the relationship between the tension in the tieback line and the tension in the guyline/skyline at various angles (Figure 62).

![Figure 62: Relationship between the tension in the tieback line and the guyline/skyline at various angles](image)

Example: If the tieback angle between the two stumps is 90°, the tension in the tieback line would be 70% of the tension in the guyline/skyline.
### 7.2 Equipment anchors

Where a mobile anchor (e.g. bulldozer, excavator or skidder) is used as a guyline anchor or a tailhold, steps should be taken to ensure that the machine is incapable of any movement. The equipment must not be placed on shear rock or unstable ground, and the following conditions need to also apply:

- The angles in **Figure 63** should not exceed 40° from the horizontal;
  - The machine should be equipped with a blade or a bucket. If the machine is equipped with a blade, it should be dug in so that at least 1/2 of the depth of the blade or 700 mm is below the natural ground level, whichever is greater. If the machine is equipped with a bucket, the bucket should be pushed firmly into the ground in the direction of the pull;
  - The guyline, skyline or haulback line block should be attached to the machine and should not pass under the blade. The edges of the blade or other sharp edges that would chafe or cut the line should be smooth, or provision should be made with blocking or excess line size to control the cutting;
- Ensure that the machine is of sufficient size (**Table 10**). The following table gives an indication of the size of the machine required for different line sizes.

![Figure 63: Equipment anchors](image)

<table>
<thead>
<tr>
<th>Safe working load of the line (kg)</th>
<th>Weight of the machine (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5250</td>
<td>7000</td>
</tr>
<tr>
<td>7700</td>
<td>1000</td>
</tr>
<tr>
<td>10400</td>
<td>13500</td>
</tr>
<tr>
<td>13500</td>
<td>18000</td>
</tr>
</tbody>
</table>
7.3 Earth anchors

Earth anchors are achieved by burying the cable attached to an anchor or log in the ground. Holding capacities of earth anchors differ greatly with soil different conditions.

7.3.1 Deadman anchors

If suitable stump anchors are not available a deadman anchor can be used. The deadman consists of a fresh log, buried in the ground, and a deadman anchor strap. It can be used for guyline and skyline anchors, or as a machine tieback. The holding characteristics depend on the soil type, compaction in the front face of the trench, the frontal area (diameter and length) of the log and the amount and type of soil in front of it. Maximum benefit from a deadman is attained when the trench is as narrow as possible while maintaining the recommended depth. The trench should be at right angles to the line pull, with the wall as vertical as possible. To prevent vertical lift of the log, the deadman anchor strap should be angled out of the trench. A short wire rope strap (the deadman anchor strap), as strong as the guyline or skyline, is used to join the deadman to the guyline or skyline.

The deadman anchor can be rigged in various ways, of which the three most common are discussed in this section. The following table provides information concerning the log sizes to be used (Table 11). Care should however be taken, since the holding ability of the deadman anchor depends on the soil type, direction of pull, ground slope, etc.

Table 11: Guidelines for log sizes to be used as deadman anchors, results based on fresh, green logs in dry, good soil (Pestal 1961 in Samset 1985)

<table>
<thead>
<tr>
<th>Wire rope safe working load of less than (kg)</th>
<th>Mid diameter of log (cm)</th>
<th>Length of log (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>3000</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>5000</td>
<td>32</td>
<td>4</td>
</tr>
<tr>
<td>10000</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>15000</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>20000</td>
<td>56</td>
<td>6</td>
</tr>
</tbody>
</table>

Procedure 1:

- Dig a trench with a back hoe/excavator, or by hand. In clay soils the trench should be approximately 1.5 m deep, and in sandy soils more than 2 m. The soil should be placed within easy reach for back filling. Dig another trench at a 45° angle, perpendicular to the first trench in which the deadman anchor strap will be laid;
- Cut a notch in one side of the trench as shown in Figure 64;

Figure 64: Trench for a deadman anchor
• Place the deadman anchor strap in the trench with both ends above the ground. The two ends should face in opposite directions;
• Place the log over the deadman anchor strap on the bottom of the trench;
• Pull the ends of the deadman anchor strap together so that the two eyes are in line. The ends of the deadman anchor strap should project sufficiently from the trench;
• Fill in the trench, taking care that the two ends of the deadman anchor strap remain above ground (Figure 65). Shackle both eyes of the deadman anchor strap securely to the guyline/skyline, and then tighten. The eyes of the deadman anchor straps should be fitted with thimbles to prevent kinking. The guyline/skyline should not be buried. When the anchor is no longer required, the deadman anchor strap can be retrieved by unfastening the one end of the strap and pulling it out of the ground (e.g. with a skidder);

![Figure 65: Deadman anchor with retrievable deadman anchor strap](image1)

**Procedure 2:**

• This procedure differs from the previous one that the deadman anchor strap can’t be retrieved, except if the log is dug out. In this procedure, the deadman anchor strap is shackled back onto itself as indicated in Figure 66;

![Figure 66: Deadman anchor with non-retrievable deadman anchor strap](image2)
Procedure 3:

- Dig the trench as in procedure 1 (Figure 64), except that the notch is not made;
- Place the deadman anchor strap in the trench with both ends above the ground. The two ends should face in opposite directions (Figure 67 a). The ends of the deadman anchor strap should project sufficiently from the trench to allow for the steps below;
- Place one log over the deadman anchor strap on the bottom of the trench (Figure 67 a);
- Pull the two ends of the deadman anchor strap to one side (the side opposite to which it will be attached to the guyline/skyline) (Figure 67 b);

![Figure 67](a): Deadman anchor strap and log in trench (b): Deadman anchor strap pulled to one side

- Place a second log on top of the first log (Figure 68 a);
- Pull the two ends of the deadman anchor strap to the side to which it will be attached to the guyline/skyline. Ensure that the two eyes are in line (Figure 68 b);

![Figure 68](a): Second log placed in trench (b) Deadman anchor strap pulled to one side

- Fill in the trench, taking care that the two ends of the deadman anchor strap remain above the ground. Shackle both eyes of the deadman anchor strap securely to the guyline/skyline, and then tighten. Deadman anchor straps should be fitted with thimbles to prevent kinking. The guyline/skyline should not be buried. When the anchor is no longer required, the deadman anchor strap can be retrieved by unfastening the one end of the strap and pulling it out of the ground (e.g. with a skidder).
7.3.2 Tipping plates

There are three types of tipping plates available; namely the arrowhead, the manta ray and the soil toggle anchor.

Arrowhead anchor

Arrowhead anchors (Figure 69) are cast from ductile iron and vary in size from 50 mm to 300 mm. The actual size is determined by the measurement across the back (the side opposite the point) of the arrow. A 200 mm arrowhead anchor would therefore be one that measures 200 mm across the back.

![Figure 69: Arrowhead anchor](image)

Manta ray anchor

The manta ray anchor (Figure 70) is approximately 130 mm wide and 300 mm long and is made of mild steel.

![Figure 70: Manta ray anchor](image)

The arrowhead and the manta ray anchors are driven edgewise into the ground with a drive rod and with the wire rope attached to the plate. This is done by using a sledgehammer on smaller anchors and impact hammers (e.g. hydraulic, pneumatic, petrol) on larger anchors (Figure 71). Alternatively, a pilot hole can be drilled before the anchor is driven in to serve as a guide. The anchor should be set at a minimum depth of 1.5 m. The drive rod should then be removed. As the wire rope is tensioned, the plate turns to present a large resistance area when pulling on the anchor.

![Figure 71: Tipping plate anchors set in soil](image)
The soil toggle anchor (Figure 72) is a metal plate that has a wing on each end, one blunt and the other sharp. Soil toggle anchors vary in size from 140 mm x 350 mm to 190 mm x 400 mm.

The soil toggle anchor is installed by dropping it, blunt end first, down an augured hole. The smaller soil toggle anchor requires a hole of approximately 150 mm in diameter, and the larger soil toggle, a 200 mm diameter hole. The anchor is set after the hole has been filled and compacted. The anchor should be set at a minimum depth of 2 m. The pointed wing at the top will dig into the side of the hole and cause the anchor to rotate to its load-holding position.

Always angle the direction of pull away from the direction of placement. In most cases, more than one anchor is needed per guyline to achieve the required holding capacity. This requires tying multiple anchors (Figure 73) together (e.g. by using an equaliser block). For detailed information on anchor design and installation procedures, refer to Copstead et al. 1993.

Figure 72: Soil toggle anchor

Figure 73: Multiple anchors
7.3.3 **Pickets**

This type of anchor consists of a single steel picket that is driven into the ground at an angle. The guyline is attached to the picket at ground level. A picket anchor can be reinforced by driving one or more additional pickets into the ground behind the first picket and then attaching them to each other as shown in the Figure 74.

![Figure 74: Picket anchors](image1)

7.3.4 **Screw-in anchors**

A screw-in anchor consists of a single steel shaft with two to four helical blades attached to it, one above the other (Figure 75). These anchors are most often used in sandy soils, and should be screwed into the ground as deep as possible.

![Figure 75: Screw-in anchor](image2)


7.4 Rock anchors

Rock anchors offer another possibility for anchoring guylines, but they are seldom used in South Africa. This is due to it being difficult to assess how deep a protruding rock is embedded in the soil; and the bearing capacity of rocks. A hole should be drilled into large rocks or rock formations, and a torqued bolt positioned in the hole to serve as an anchor (Figure 76). The anchor should be stronger than the safe working load of the guyline used.

WARNING:
The use of rock anchors could be dangerous. A specialist should inspect the anchor before it is used.

7.5 Tree anchors

As a general rule, skylines, guylines and haulback line blocks should not be anchored to standing trees if these trees could be pulled into the work area (Figure 77). However, in exceptional circumstances, standing trees may be used as anchors under the following conditions:

- The standing tree is alive, sound, upright and has an undisturbed root system AND
- The skyline/guyline is attached to the base of the anchor tree at a height not greater than 30 cm; AND
- The tieback line has a breaking strength of at least 50% of the mainline; AND
- The point of attachment of the tieback line to the anchor tree is not less than 3 m above the adjacent ground line if the anchor tree is 35 m or less. If the anchor tree is greater than 35 m in height, the tieback line should be attached at least 5 m above the adjacent ground line; AND
- An appropriate size tieback tree, which is approximately in-line with the anchor tree, should be used; AND
- The guyline angle to the standing tree and the angle between the anchor tree and the tieback tree should not exceed 45°; AND
- Standing trees used as guyline anchors should not have dead tops or lean towards the landing.
• In a **skyline system**, standing trees may be used to anchor the **tower** if:
  - The anchor tree has a dbh of at least 20 cm; **AND**
  - The skyline has a diameter equal to, or smaller than 20 mm; **AND**
  - The anchor tree is tied back.

• In a **highlead system**, standing trees may be used to anchor the **tower** if:
  - The anchor tree has a dbh of at least 20 cm; **AND**
  - The mainline has a diameter equal to, or smaller than 14 mm; **AND**
  - The anchor tree is tied back.

• Standing trees may be used to anchor **intermediate support trees and tailtrees** if:
  - The anchor tree has a dbh of at least 20 cm; **AND**
  - All workers are 1.5 tree lengths from the anchor tree when lines are under tension; **AND**
  - The anchor tree is tied back.

**OR**

  - The anchor tree has a dbh of at least 20 cm; **AND**
  - The anchor tree is outside the work area (the standing tree need not be tied back).

• Standing trees may be used as a **tailhold** for the skyline and to secure blocks for the **haulback line** if:
  - The anchor tree has a dbh of at least 20 cm; **AND**
  - All workers are 1.5 tree lengths from the anchor tree when lines are under tension; **AND**
  - The anchor tree is tied back.
OR

- The anchor tree has a dbh of at least 20 cm; **AND**
- The anchor tree is outside the work area (the standing tree need not be tied back).

**NOTE:**
Outside the work area is defined as the area where no workers will perform any task and there is no danger of workers being struck by trees being pulled over or sliding towards them.

## 7.6 Bundle anchors

South African forestry plantations often consist of relatively small compartments of various ages. This often results in a cable yarder working in a particular compartment, anchoring to stumps in an adjacent compartment. If the trees in the adjacent compartment are either too small to act as anchors, or have been felled more than approximately 1.5 years previously (and are thus too old to act as stump anchors due to decay) an alternative anchoring system should be used.

Deadman anchors are commonly used as alternative anchors for large to medium sized yarders. However, in South Africa, smaller sized yarders are almost exclusively used, with small landings and continuous roadside landings being common practice. It is therefore often difficult to dig deadman anchors above or below the road as this (particularly in steep terrain) could result in soil disturbances and adverse environmental impacts. In certain circumstances it is also impractical, and sometimes impossible, to dig deadman anchors due to shallow rock or shale beds.

This resulted in cable yarder contractors in South Africa developing the bundle anchor system (**Figure 78**). The approach is to use a number of logs/tree lengths tied together in a bundle as an anchor.

![Figure 78: Guylines attached to a bundle anchor (Photo: Ian Conradi)](image)

Each guyline can be attached to a separate bundle or more than one guyline can be attached to a single bundle.
7.6.1 Bundle building procedure

- Lay a strap on the ground. The strap should have the same breaking strength as the
guyline to which it is attached. Guyline angles, as stipulated in Sections 8.2.3 and 8.2.4,
should be adhered to;
- Stack the logs on the strap until the required bundle size is achieved.
  - Stack the logs with the thin and thick ends in alternate directions to enhance bundle
stability (Figure 79);
- Minimum acceptable log length to be used is 4.8 m;
- Pull the dead end of the strap over the pile of logs and attach it back onto itself using an
appropriately sized shackle to choke the bundle as shown in Figure 80;
- Attach the guyline or skyline to the live end of the anchor strap using an appropriately
sized shackle.

![Figure 79: Stack logs with thin and thick ends in alternate directions](image)

- Before final tensioning of the guyline/skyline cable, adjust the strap around the bundle
if necessary to ensure minimal bending of the cable at the point of choking.

![Figure 80: A bundle attached to a guyline with a strap](image)

The guyline itself can also be used instead of the strap described above. In such a case, the
guyline is attached back onto itself with a shackle. Refer to Figure 81. The eye of the guyline
should be fitted with a thimble. The shackle should be sized according to the lines to which
they are attached. Refer to Section 6.5.

![Figure 81: A bundle attached directly to a guyline (without a separate strap)](image)
7.6.2 Safety procedures

**WARNING:**
Bundle anchors are only allowed in a skyline system if the skyline is equal to, or less than 20 mm. In a highlead system, the mainline should be equal to, or less than 14 mm.

At least two guylines share the load equally at all times;
- Where possible, stumps should be cut high and bundles placed behind these stumps to further improve the holding capacity of the bundles;
- The bundle system can only be used on level ground or ground sloped away from the yarder (Figure 82);
- No persons are allowed to enter the danger zone between the bundle and the tower;
- If the bundle moves, then the operation should be stopped immediately and the bundle size increased.

![Figure 82: Safe positioning of bundles used as anchors (a + b) and incorrect (c)](image)

7.6.3 Bundle sizes

There are two schools of thought regarding the method for determining minimum allowable bundle sizes. One involves calculating minimum allowable bundle size based on the Safe Working Load (SWL) of the guyline or skyline which is attached to the bundle, since the SWL on the cables should never be exceeded. This method is defended on the basis that it is more desirable that a bundle moves (which the operator could feel and re-tension the lines), rather than having a cable snap (which could result in more sudden, catastrophic failure). For added safety reasons, however, a safety factor of 1.4 is applied to the SWL to account for possible spikes in cable tension during the work cycle. The other method involves a similar calculation, but is based on the Breaking Strain (BS) of the cables rather than the SWL. In this case, no additional safety factor is applied.
The recommended bundle sizes (the volume of timber in the bundle, not the volume of the bundle itself) for various SWL/BS of lines are given in Figure 36. The values were determined for 6 weeks dry pine timber. If Eucalyptus bundles are used, the bundle sizes should be adjusted accordingly. Figure 83 is used to determine the bundle sizes referred in Sections 7.6.3.1, 7.6.3.2 and 7.6.3.3.

**Figure 83:** The relationship between SWL/BS and bundle size on level terrain. The equation for the straight line, as indicated in the graph, is $y=1.418299x$.

### 7.6.3.1 Bundle sizes for guylines: One guyline attached to a single bundle

In this system one guyline is attached to a single bundle anchor. The other guylines may be attached to other bundles or any other acceptable anchoring system. The bundle should preferably be positioned at an approximate right angle to the incoming guyline (Figure 84). However, it can be positioned longitudinally, if required (e.g. due to space constraints).

**Figure 84:** One guyline attached to a single bundle (top view)
**WARNING:**

The SWL of the mainline (in a highlead system) and the skyline (in a skyline system) is used to determine the bundle size based on SWL. If the possibility exists that the SWL of the above-mentioned lines may be exceeded, the bundle size based on the SWL should be increased. This is especially true if lateral yarding takes place and if the SWL is exceeded during break-out. The BS of the mainline (in a highlead system) and skyline (in a skyline system) can be used to determine the bundle size based on BS (i.e. three times the bundle size based on SWL).

Refer to the following examples to determine the minimum and maximum bundle sizes for highlead and skyline systems:

**Example 1:** Highlead with a 13 mm IWRC mainline.

**Bundle size based on Breaking Strength:**

The size of the bundle is determined by the BS of the mainline, multiplied by a correlation coefficient of 1.42. The BS of the guyline should be at least equal to the BS of the mainline.

Minimum guyline size required = 13 mm IWRC

Breaking strength of 13 mm IWRC = 11.285 t *(refer to Table 4, Section 5.1.2.4)*

Read off from the graph what size bundle is required for a BS of 11.285t = 16 m³

The bundle size can also be determined by multiplying 11.285t by 1.418299 = 16.01 m³

**Example 2:** Skyline with a 20 mm IWRC skyline.

**Bundle size based on SWL (i.e. the minimum allowable bundle size):**

When calculating the minimum allowable bundle size, the size of the bundle is determined by the SWL of the mainline multiplied by the correlation coefficient 1.42. The SWL of the guyline should be at least equal to the SWL of the mainline.

Minimum guyline size required = 20 mm IWRC

Safe Working Load of 20 mm IWRC = 8.943 t *(refer to Table 4, Section 5.1.2.4)*

Read off from the graph what size bundle is required for a SWL of 8.943t = 13 m³

The bundle size can also be determined by multiplying t by 1.418299 = 12.68 m³

### 7.6.3.2 Bundle sizes for guylines: Multiple guylines attached to a single bundle

In this system multiple guylines are attached to a single bundle anchor. Position the bundle at an approximate right angle to the skyline/mainline *(Figure 85).*
**7.6.3.3 Bundle sizes for tailholds**

A bundle can be used as a tailhold in a highlead and skyline system. However, since all the forces are exerted onto only one bundle, the BS (not the SWL) should be used to determine the size of the bundle.

Refer to the following examples to determine the bundle size.

**Example 1**: Highlead with a 13 mm IWRC mainline and a 10 mm haulback line.

**Bundle size:**

The size of the bundle is determined by the combined BS of the mainline and the haulback line.

- BS of 13 mm IWRC mainline = 11.285 t (refer to Table 4, Section 5.1.2.4)
- BS of 10 mm IWRC haulback line = 6.568 t
- Combined breaking strength = 17.853 t

Read off from the graph what size bundle is required for a BS of 17.853 t = 25.5 m³

The bundle size can also be determined by multiplying 17.835 t by 1.418299 = 25.32 m³
Example 2: Skyline with a 20 mm IWRC skyline.

Bundle size:

The size of the bundle is determined by the BS of the skyline.

Breaking strength of 20 mm IWRC = 26.830 t (refer to Table 4, Section 5.1.2.4)

Read off from the graph what size bundle is required for a BS of 26.830 t = 38 m³

The bundle size can also be determined by multiplying 26.830 t by 1.418299 = 38.05
8 Rigging requirements

The angles at which the guylines are placed are critically important to ensure the safety of workers, to prevent damage to equipment, and to ensure efficient and productive operations. These angles are discussed in detail in this Chapter. Sketches are included to indicate the areas where guylines can be placed (guylines zones). Both the horizontal (as viewed from the top) and vertical angles (as viewed from the side) should be taken into account during rigging. The size of guylines and rigging accessories are also addressed.

8.1 Rigging requirements for the tower

Refer to Section 10.5 for the safe working procedures on how to rig a tower.

8.1.1 Size of guylines and rigging accessories

- The guylines on the tower in a highlead system should be equal to, or stronger than, the breaking strength of the mainline.
- The guylines on the tower in a skyline system should be equal to, or stronger than, the breaking strength of the skyline.
- Some towers require one or more snaplines in the portion in front (front hemisphere) of the tower to prevent the tower from toppling backwards should one of the working ropes break. These snaplines should be sized and rigged according to OEM prescriptions.
- Shackles and cable clamps, to attach the guylines to the anchors, should be sized according to the cables to which they are attached (refer to Chapter 6).

8.1.2 Safety straps on the tower

Tower guyline blocks should have a safety strap passing through the blocks or beneath a closed block to grab any guyline in case of tower guyline block failure (Figure 86). The safety strap should have the same safe working load as the guylines.

Figure 86: Safety strap to hold guyline blocks
8.1.3 Horizontal angles

- Towers shall be rigged in accordance with the manufacturer’s instructions,
  OR
- If these instructions are not available, refer to the guidelines below.

A corridor of approximately 8 m wide is kept open in front of the yarder where the load will pass. Front guylines and snaplines may not be rigged within this corridor as they would interfere with incoming loads and/or removal of timber from the landing chute.

**Guideline 1: Cable yarders with four guylines.**

At least three guylines should be used in the back hemisphere (behind the yarder), and at least one snapline in the front hemisphere (*Figure 87*).

![Figure 87: Cable yarders with four guylines (three in the back hemisphere, one in the front hemisphere)](image1.png)

**Guideline 2: Cable yarders with five guylines**

At least four guylines should be used in the back hemisphere, and one snapline in the front hemisphere (*Figure 88*).

![Figure 88: Cable yarders with five guylines (four in the back hemisphere, one in the front hemisphere)](image2.png)
8.1.4 Vertical angles

Tension in the guylines increases significantly with an increase in the guyline angle (refer to the example below).

Example: If the tension in the skyline is 10 tonnes and the total tension is transferred to only one guyline, the tension in that guyline at various angles is described in Table 12 and Figure 89.

Table 12: Tension in a guyline at various angles

<table>
<thead>
<tr>
<th>Angle of guyline</th>
<th>Tension in guyline (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 degrees</td>
<td>10.0</td>
</tr>
<tr>
<td>30 degrees</td>
<td>11.6</td>
</tr>
<tr>
<td>45 degrees</td>
<td>14.1</td>
</tr>
<tr>
<td>60 degrees</td>
<td>20.0</td>
</tr>
</tbody>
</table>

Figure 89: Tension in a guyline at various angles

The guyline angle should therefore be less than 45° (measured from the horizontal). Anchors could be pulled out of the ground and the tension in the guylines may exceed the safe working load if 45° is exceeded. If suitable anchors are not available or the terrain is so steep that the guyline angle exceeds 45°, an additional guyline/s should be added to oppose the force (Figure 90).

Figure 90: Vertical angles for guylines on the tower
In certain situations (i.e. if guyline anchors are located on a steep bank above the top of the tower and the skyline is situated in the area as shown in Figure 91 or angle A is less than angle B) the resultant force on the tower would be upward. If the resultant force is sufficient to lift the yarder or make it unstable, an alternative landing should be used.

![Figure 91: Guylines higher than the top of the tower](image)

8.1.5 Tension in guylines

- The guylines should, in so far as practical, be tensioned in proportion to their lengths:
  - If all guylines are approximately the same length, the tension in each should be the same;
  - If some guylines are significantly longer than others, these should be tensioned more before being loaded.
- Where three guylines are used, the middle one should have a tension slightly less than the two side guylines in order to equalise the tension in the guylines when the yarder is under load.
8.2  **Rigging requirements for intermediate supports**  
Always make sure that if intermediate supports are needed, they are marked out and rigged appropriately.

8.2.1  **Location of intermediate support trees**  
Intermediate support trees are used to gain lift in skyline systems when little or no deflection is available. Refer to [Section 9.4](#). The use of intermediate supports requires carriages that are designed to pass over such supports. The location of intermediate support trees can be determined by measuring the profile of the proposed rack. If felling takes place well in advance of yarding, it is recommended to leave two rows of trees at a crest ([Figure 92](#)) or other similar changes in profile (especially during the windy season when support trees may be blown over).

![Figure 92: Two rows of trees left at a change in profile](image)

8.2.2  **Criteria for the selection of intermediate support trees**  
The following factors are important in the selection of intermediate supports:

- These trees should be examined carefully for defects before being selected. Such trees should be firmly rooted, alive, sound, straight and be of sufficient diameter to withstand the maximum stress likely to be exerted at the point where the block is attached. Trees having evident defects may not be used for intermediate support trees. An indication of tree size is given in [Table 13](#);
- Anchors should be available to which guylines can be secured.

**Table 13:**  Tree size* required for double-tree intermediate supports (from Oregon Occupational Safety and Health Code)

<table>
<thead>
<tr>
<th>Load size (kg)</th>
<th>Minimum DBH (cm) of tree required for support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rigging height &lt; 9 m</td>
</tr>
<tr>
<td>0 – 2200</td>
<td>28</td>
</tr>
<tr>
<td>2200 – 2700</td>
<td>31</td>
</tr>
<tr>
<td>2700 – 3600</td>
<td>32</td>
</tr>
<tr>
<td>3600 – 4500</td>
<td>33</td>
</tr>
<tr>
<td>4500 – 6300</td>
<td>36</td>
</tr>
</tbody>
</table>

*This table has been developed for Douglas fir (*Pseudotsuga menziesii*).

**SUGGESTION:**  
The support tree should be as large as the largest trees yarded.
8.2.3 Maximum horizontal deviation of the skyline

If the offset between the intermediate support and the tailtree is too great, the carriage might climb off the skyline as it passes over the support jack. An approximate rule of thumb is that the change in offset between two spans, at the intermediate support jack, should be less than 8°, but preferably as close to zero degrees as possible (Figure 93).

Figure 93: Maximum horizontal deviation of the skyline

8.2.4 Maximum vertical deviation of the skyline

If the change in the chord slope between the intermediate support tree and the tailtree is too steep, the carriage might not pass over the support jack, which could result in the support tree being pulled over (Figure 94). An approximate rule of thumb is that the change in chord slope between two spans, at the intermediate support jack, should be less than 20° (i.e. less than 36.4% slope).

Figure 94: Maximum vertical deviation of a skyline
8.2.5 Single-tree support: Riderblock method

Refer to Section 10.5.2.1 for the safe working procedures on how to rig a single-tree support using the riderblock method (Figure 95).

The riderblock single-tree support is rigged with a load-bearing guyline, a strap and at least two support guylines. The load-bearing line passes through the support jack and a block that is attached by a strap to the support tree. The load-bearing line is then secured onto the support jack. The support guylines are attached to the support tree just above the strap.

![Figure 95: Single-tree support: Riderblock method](image)

8.2.5.1 Size of lines and rigging accessories

- The load-bearing guyline should be equal to, or stronger than, the breaking strength of the mainline;
- The support guylines should be equal to, or stronger than, the breaking strength of the mainline;
- The strap should be equal to, or stronger than, the breaking strength of the skyline;
- The shackles, blocks and cable clamps should be sized according to the cables to which they are attached (refer to Chapter 6).

8.2.5.2 Horizontal angles

The load-bearing guyline is rigged on one side of the support tree with the two support guylines positioned on the other side of the tree to oppose the forces on the support jack. The support jack should not hang closer than 700 mm and no further than 2 m from the support tree in order to reduce the forces on the support tree.
**Uphill yarding:**

- See Figure 96 for guidelines on where the guylines should be positioned. The guyline zones are indicated in the figure;
- The steeper the chord slope change, the further downhill the load-bearing guyline and the lower support guyline should be positioned within the indicated guyline zones;
- Add a third support guyline positioned at approximately 225° (if required).

![Figure 96: Guyline angle zones for the riderblock single-tree support in uphill yarding](image)

**Downhill and level terrain yarding:**

- See Figure 97 for guidelines on where the guylines should be positioned. The guyline zones are indicated in the figure;

![Figure 97: Guyline angle zones for the riderblock single-tree support in downhill and level terrain yarding](image)
8.2.5.3 Vertical angles

The angle between the guylines and the horizontal should be less than 45°. Refer to Figure 95 (the angles A).

8.2.6 Single-tree support: Centre-block method

Refer to Section 10.5.2.2 for the safe working procedures on how to rig a single-tree support using the centre-block method (Figure 98).

The centre-block single-tree support is rigged with a load-bearing guyline, a strap and at least two support guylines. The load-bearing line passes through a block that is attached by a strap to the support tree. The load-bearing line is then secured onto the support jack. The support guylines are attached to the support tree just above the strap.

![Figure 98: Single-tree support: Centre-block method](image)

8.2.6.1 Size of lines and rigging accessories

- The load-bearing guyline should be equal to, or stronger than, the breaking strength of a line 3 mm thicker than the mainline;
- The support guylines should be equal to, or stronger than, the breaking strength of the mainline;
- The strap should be equal to, or stronger than, the breaking strength of the skyline;
- The shackles, blocks and cable clamps should be sized according to the cables to which they are attached (refer to Chapter 6).

8.2.6.2 Horizontal angles

The load-bearing guyline is rigged on one side of the support tree with the two support guylines positioned on the opposite side of the tree to oppose the forces on the support jack. The support jack should not hang closer than 700 mm and no further than 2 m from the support tree in order to reduce the forces on the support tree.
Uphill yarding:
- See Figure 99 for guidelines on where the guylines should be positioned. The guyline zones are indicated in the figure;
- The steeper the chord slope change, the further downhill the load-bearing guyline and the lower support guyline should be positioned within the indicated guyline zones;
- Add a third support guyline positioned at approximately 225° (if required).

![Figure 99: Guyline angle zones for the centre-block single-tree support in uphill yarding](image)

Downhill and level terrain yarding:
- See Figure 100 for guidelines on where the guylines should be positioned. The guyline zones are indicated in the figure.

![Figure 100: Guyline angle zones for the centre-block single-tree support in downhill and level terrain yarding](image)
8.2.6.3 Vertical angles

The angle between the guylines and the horizontal should be less than 45°. Refer to Figure 98 (the angles A).

8.2.7 Double-tree support (M-support)

Refer to Section 10.5.2.3 for the safe working procedures on how to rig a double-tree support (Figure 101).

The double-tree support is rigged with a single continuous load-bearing guyline. This line runs from the first anchor over a block in the first tree, then through the support jack and finally through a block in the second tree to the second anchor.

8.2.7.1 Size of lines and rigging accessories

- The load-bearing guyline should be equal to, or stronger than, the breaking strength of the mainline;
- The additional support guylines should be equal to, or stronger than, the breaking strength of the mainline (if required);
- The straps should be equal to, or stronger than, the breaking strength of the skyline;
- The shackles, blocks and cable clamps should be sized according to the cables to which they are attached (refer to Chapter 6).
8.2.7.2 Horizontal angles

- In both uphill and downhill yarding, the anchors and guylines should be on the downhill side of the support tree. In downhill yarding this may seem to be the wrong side to have the anchors, but the reason for this is that in almost all cases where intermediate supports are used in downhill yarding, the lower span (span A) of the intermediate support system is steeper than the upper span (span B). Refer to Figure 102. Because the support jack acts as a frictionless block, the resulting force on the support jack (force F) halves the angle between the two spans. This resultant force will be on the uphill side of the support tree. To counter this force, the anchors and guylines have to be positioned on the downhill side of the support tree.

![Figure 102: Resultant force on a double-tree support](image)

- Uphill, downhill and level terrain yarding:
  - See Figure 100 for guidelines on where the guylines should be positioned. The guyline zones are indicated in the figure;
  - The steeper the chord slope change, the further downhill the load-bearing guyline should be positioned within the indicated guyline zones;
  - If doubt exists regarding the stability of the support trees, additional support guylines can be placed as indicated in Figure 103, depending on the particular situation.

![Figure 103: Guylines zones for double-tree support](image)
8.2.7.3 Vertical angles

(Refer to Figure 101 for the angles and measurements referred to below.)
- The angle between the load-bearing guyline and the horizontal should be less than 45° (angle E);
- The angles formed by the guyline and the trees (angles A & B and angles C & D), when viewing the double-tree support from the front, should be the same (A = B and C = D). The angles A and B don’t need to be the same as angles C and D (A & B is not equal to C & D);
- The following formulas give an indication of where the support jack should hang below the support blocks:
  - Maximum distance: \( d = 0.5 \times L \)
  - Minimum distance: \( d = 0.25 \times L \)
- The loaded support tree should not lean more than 15° from vertical at the point of block or wire rope attachment (Figure 104).

![Figure 104: Allowable lean of an intermediate support tree](image)

8.3 Rigging requirements for tailtrees

Refer to Section 10.5.3 for the safe working procedures on how to rig a tailtree.

A tailtree is a tree rigged at the back end to provided lift for a skyline (Figure 105).

A tailtree is rigged with the skyline running through a block, which is tied to a strap in the tailtree. (A tailtree support jack can also be used in certain circumstances). A tail tree support jack supports the tree where the skyline is attached if it has a lean or is becoming unstable. The skyline is attached to an anchor. At least two guylines are attached to the tailtree just above the strap.

![Figure 105: Tailtree](image)
Tailtrees should be positioned approximately 10 to 20 m from the end of the compartment to provide for anchors behind the tailtree.

8.3.2 Criteria for the selection of tailtrees

After the critical points have been identified, an infield reconnaissance should be done to determine if suitable tailtrees are available. The following factors are important in the selection of tailtrees:

- These trees should be examined carefully for defects before being selected. Such trees should be firmly rooted, alive, sound, straight and be of sufficient diameter to withstand the maximum stress likely to be exerted at the point where the block is attached. It should also be the largest tree available in the immediate area. Trees having evident defects may not be used as tailtrees;

SUGGESTION:

The tailtree should be as large as the largest trees yarded.

Anchors should be available to which guylines can be secured.

8.3.3 Size of lines and rigging accessories

- The guylines should be equal to, or stronger than, the breaking strength of the mainline;
- The strap should be equal to, or stronger than, the breaking strength of the skyline;
- The shackles, blocks and cable clamps should be sized according to the cables to which they are attached (refer to Chapter 6).

8.3.4 Vertical angles

- The angle between the guylines/skyline, as measured from the horizontal, should be less than 45° as anchors can otherwise be pulled out if the angle is greater than 45°. Refer to Figure 105 (angles A). If suitable anchors are not available or the terrain so steep that these angles exceed 45°, an additional guyline should be added to oppose the pull;

- In most situations, the angle between the skyline and the horizontal as it comes into the tailtree (angle A) is less than the angle between the skyline and the horizontal as it leaves the tailtree (angle B). Refer to Figure 106. In this situation the guylines would be placed BEHIND the tailtree. Should it however happen that the angle between the skyline and the horizontal as it comes into the tailtree (angle A) is greater than the angle between the skyline and the horizontal as it leaves the tailtree (angle B), the support lines should be positioned IN FRONT of the tailtree because of the direction of the resultant force.
8.3.5 Horizontal angles

- The offset between the tailtree and the anchor for the skyline should be less than 8°, but preferably as close to zero as possible (Figure 107);
• If angle B is greater than angle A (Figure 106) place the guylines behind the tailtree as indicated in Figure 108. The guyline zones are indicated in the figure. If doubt exists regarding the stability of the tailtree, additional guylines can be placed as indicated;

![Figure 108: Guyline anchor zone for a tailtree](image)

• If angle B is smaller than angle A (Figure 106) place the guylines in front of the tailtree as indicated in Figure 109. The guyline zones are indicated in the figure. If doubt exists regarding the stability of the tailtree, additional guylines can be placed as indicated;

![Figure 109: Guyline anchor zone for a tailtree](image)

• A minimum of two guylines should be used where the rigging is placed at a height greater that five times the tree diameter at breast height (e.g. 30 cm dbh x 5 = 1.5 m, therefore
if the rigging is placed higher than 1.5 m at least two guylines should be used). If doubt exists regarding the stability of the tailtree, additional guylines should be rigged. Refer to Figures 108 and 109:

• If the rigging is placed lower than five times the dbh and the tailtree will not fall into the work area, no guylines are required. However, at least two guylines are required if the tailtree can fall into the work area;

• When using a running skyline system, the tail block is sometimes tied in a tree. The haulback line passes through the tail block, and then back to the carriage (Figure 23). The horizontal forces caused by the haulback line exert great forces on the tailtree. In this situation the tailtree should also be supported by at least two guylines.
9 Planning and productivity

Planning of operations should be approached holistically, analysing all activities within the forestry value chain (including silviculture and forest engineering). The ultimate aim in forest planning is to ensure that viable, sustainable and safe operations are established and maintained within the business’s framework.

It is also very important to conduct Hazard Identification Risk Assessments (HIRA) for all operations before they are started. This allows for timeous identification of all factors that can lead to or cause injury or damage to labour or equipment.

9.1 Stages of planning

Planning cannot always be divided into definite time frames, as it is a continuous process in which one stage of planning may merge into another. However there are definite sequences within planning, based on the level at which the planning is carried out. Generally speaking, the following levels of planning can be identified:

- Strategic planning;
- Tactical planning;
- Annual planning;
- Operational planning.

9.1.1 Strategic planning

Continuous monitoring of both the external and the internal environment is required to ensure that the company can continuously adapt to change in order to remain competitive. This mainly takes place at senior management level. Plans usually cover a time frame equal to the rotation length of the timber being grown and harvested.

Strategic decisions will be based on a thorough evaluation of various contributory factors, including:

- Market trends in the timber industry;
- Whether to use own operations or to outsource;
- The company’s social policy and responsibilities will have a marked effect on the decision to choose either manual or mechanised systems;
- The company’s environmental, health and safety policies will also affect the decision on which systems to use;
- Available technologies and appropriate harvesting systems;
  - Social political and other legal or legislation issues.
- International trends.

9.1.2 Tactical planning

The focus of tactical planning is to identify the harvesting systems required over a three- to five-year period based on the stand and site conditions. The following parameters should be considered when deciding on the type and size of equipment to be purchased:

- Infrastructure network;
- Potential harvesting and transport systems;
- Seasonal and weather conditions;
- Piece sizes;
- Total volume available;
• Geographic consolidation of volume source, synergies;
• Product dimensions and definitions.

The particular harvesting system chosen should be appropriate for the terrain, the stands, the nature of the road networks, the transport methods utilised and commercial factors (such as costs and profitability).

Depending on the availability and type of harvesting systems, ground conditions and other factors, a rule of thumb is that cable yarding becomes economically viable on slopes greater than 40%. However accurate costings by a trained professional are required to determine the exact threshold for each situation.

9.1.3 Annual planning

Annual planning produces the Annual Plan of Operations (APO), which covers a forecasted period of one year. It details the roadworks, areas to be harvested and corresponding harvesting equipment and transport plans and routes for the harvested fibre to be moved along. It forms the basis for the annual budget and comprises the following:

• Scheduling of roadworks to be carried out within the course of the year;
• Scheduling of compartments to be harvested and corresponding equipment/systems to carry out the harvesting (considering road networks, market requirements, weather conditions, equipment capabilities, etc.);
• Scheduling of the extraction, extended primary transport, secondary intermediate transport and/or secondary transport operations associated with the fibre to be removed from each compartment.

9.1.4 Operational planning

During operational planning, each compartment is planned in detail. The basis of such planning is a detailed map of the terrain and infrastructure detail combined with details from an infield reconnaissance. An operational plan also provides for the refinement of volumes, operational sequence and costs involved in harvesting the compartment. It is critical that the harvesting forester should complete the operational plan together with the team supervisor/production foreman. As the operational team implements the operational plan on a daily basis, detailed daily feedback will ensure that the operation progresses as planned, deviations are recorded and the necessary adaptations are made to the original plan where required.

9.2 Planning for cable yarding operations

Over and above the planning steps highlighted in Section 9.1 (which should be carried out for any harvesting operation), there are other planning steps which are specific to cable yarding operations. Such steps include detailed landing and exact corridor planning, such as:

• Mark out the corridor including all tailtrees, intermediate supports and the accompanying anchors (Section 9.4, Section 8.3 and Section 8.2). Where visibility is restricted, a compass or GPS can be used to identify the corridor;
• Mark the position of the yarder on the landing and determine the landing size (Section 9.3);
• Mark anchor trees for the tower (Section 8.1);
• Survey at least one critical profile from each landing (Section 9.4) and verify the physical constraints of the yarder (e.g. the length of the mainline).

Production targets should also be set and the sequence of harvesting defined (e.g. where and when felling will commence and end).
9.3 **Landings**

Identifying landing locations is one of the first steps in the harvest planning process. There is often a tendency not to do adequate planning for landing location and design. This can be a crucial mistake as the economic and environmental effectiveness of cable yarder extraction often depends on the landing location and the layout of operations on the landing.

This section describes different types of landings and specific factors to evaluate when locating landings. In addition, it covers landing size in relation to equipment, harvesting system and safety. The number of different activities on a landing and the way that these activities are organised affects landing size.

The functions of a landing are the following:
- Create space for landing the extracted timber;
- Concentrate timber to facilitate loading and transport operations;
- Products are prepared and sorted;
- Improved safety and yarding efficiency;
- During extraction, less interference with transport is caused.

### 9.3.1 Types of landings

Landings are typically divided into two main types; centralised and continuous roadside landings (Figure 110). Both landing types are commonly used. The harvest planner should know the inherent characteristics of each landing type, along with the relevant advantages and disadvantages so that an appropriate type of landing is used for the prevailing situation. Typical characteristics and advantages of both landing types are summarised in Table 14 (from Kellogg, L. Cable Harvest Planning. Draft course manual, British Columbia Institute of Technology).

![Centralised landing and Continuous roadside landing](image)

*Figure 110: Centralised landing with fan-shaped skyline corridor pattern and a continuous roadside landing with a parallel skyline corridor pattern*
Table 14: Characteristics and advantages of centralised and continuous roadside landings

<table>
<thead>
<tr>
<th>Centralised landing</th>
<th>Continuous roadside landing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan-shaped corridor pattern.</td>
<td>Parallel corridor pattern (the area yarded from each corridor is larger than with a fan shaped pattern).</td>
</tr>
<tr>
<td>Corridor changes do not involve a yarder move.</td>
<td>The yarder should be moved with every corridor change (adequate guylines anchors should be available along the road).</td>
</tr>
<tr>
<td>Relatively large landing size (advantageous when there are a lot of activities and/or equipment on the width of roads.</td>
<td>Relatively small landing size. This limits the operations to be done e.g. whole-tree debranching and bunching, many log sorts).</td>
</tr>
<tr>
<td>More commonly used in clearfelling applications, especially when many corridors converge at a landing.</td>
<td>Used in clearfelling applications as well as in thinnings.</td>
</tr>
<tr>
<td>More commonly used with large yarders.</td>
<td>More commonly used with small yarders.</td>
</tr>
</tbody>
</table>

An additional type of landing variation is the split-level landing (Figure 111). On steep terrain, split-level landings may be the best solution for creating a safe timber landing area. When creating a split-level landing, a short road for yarder access is built above the transport road. The yarder is positioned at the top of the short road, and timber is landed on the transport road below. Additional indirect advantages are reduced landing excavation and a higher yarder location that can provide additional deflection.

Figure 111: Split-level landing

9.3.2 Landing location

Identifying landing locations is one of the initial steps in the harvest planning process. The information in this section will help to decide under what circumstances it is best to use centralised or continuous roadside landings. A harvest plan will often consist of a mixture of both types of landings. For each specific landing location, consider the potential construction cost, environmental impacts and safety. The landing location should facilitate safe and productive cable yarding. Therefore, the harvest planner should think past the specific activities that will occur on the landing and evaluate the potential effectiveness of yarding timber to the specific landing location. The following factors should be considered when deciding on a landing location:
9.3.2.1 Terrain

The area should be as level as possible and big enough to ensure that timber will not slide downhill when dechoking takes place. The soil type and its capability for being used as fill material in constructing the landing should also be considered. Certain soils are difficult to compact, and would fail under pressure, making it unsuitable for fill material. If fill material is used in the construction of the landing, the foundation should be appropriately strengthened to ensure that the cable yarder would remain stable for the duration of harvesting at that site.

9.3.2.2 Availability of guyline anchors

The proposed landing site should have suitable anchor stumps available to anchor the yarder. If stump anchors are not available, alternative anchors can be used, provided the terrain surrounding the landing allows for the use of such anchors (refer to Chapter 7).

9.3.2.3 Size of the landing

Landings should be of sufficient size to safely accommodate the intended timber buffer between extraction and transport. At least two-thirds of timber should rest on the ground or other substantial material when landed. The size of the landing will depend on the following factors:

- Equipment that will be used on the landing (refer to Section 9.3.3.4);
- Dimensions of the timber to be yarded;
- Requirements of other road users that need an unobstructed passage past the landing;
- The preparation area required for activities such as debranching, crosscutting and log marking;
- Stacking area to accommodate all log types – the number of timber trucks available will affect timber storage quantities at the landing. Provide sufficient space between stacks to ensure safe and unobstructed movement between them;
- Provision for handling unmarketable timber yarded to the landing as well as other debris that accumulates on the landing (e.g. slash);
- Terrain conditions and road constraints.

9.3.2.4 Yarding and transport operations

The location, size and type of landing to be used are determined by the system (e.g. cut-to-length versus tree-length) and equipment on the landing (yarder, processor, loader, timber trucks, etc.). There should be sufficient space to accommodate all the required equipment, ensuring adequate safety distances between equipment and obstacles such as timber stacks and cut banks.

a) Yarder

Most yarders in South Africa have drums that are orientated to lead off the side of the yarder and are thus well designed to yard timber to roadside landings. When yarding several racks to a centralised landing, the machine should be repositioned frequently on the landing so that the yarding lead remains at, or close to a straight lead. Certain large yarders are however capable of yarding several racks to one yarder location because the sheaves at the top of the tower are capable of pivoting and have a wider coverage of guylines. These machines can yard from straight lead to square lead positions.
**b) Loader**

Most loaders used on cable yarder landings in South Africa are still of the three-wheeled type but excavator type loaders with grabs are becoming more popular.

The three-wheeled loader removes the timber from in front of the yarder, stacks logs, assists with other aspects of the yarding operation and loads timber trucks. The advantages of these loaders are that they are more mobile than tracked loaders.

The excavator type loader should be positioned close to the yarder in order to remove timber from the landing chute. They can also assist with other aspects of the yarding operation as required. In addition, these loaders should be able to sort logs, stack them as close to the yarder as possible and load timber trucks. These loaders can handle longer size timber than three-wheeled loaders and stack timber much higher, but are less mobile.

Adequate space is required for a loader to carry out these operations. With three-wheeled loaders, this requires a clearance with a radius equivalent to the distance from the end of the heeled log in the grab to the centre-point of the axis between the drive wheels. Also bear in mind that the three-wheeled loader will move back some distance while turning around. With excavator type loaders, this requires a clearance with a radius equivalent to the distance from the end of the heeled log to the centre of the loader rotation. The log length, boom configuration and loader design need to be taken in account. The radius length can be approximated by the sum of the log length and boom length.

**WARNING:**

It is important to note that the whole area around a working loader is dangerous and should be treated with caution.

An excavator loader’s tail or counterweight requires swing with approximately one metre clearance between it and the yarder, cut bank, timber stacks and other objects. The loader should be positioned on the side of the yarder toward the haulage direction. The landing layout (position of yarder, loader, timber stacks, etc.) often changes as the yarding direction changes on a landing. Cut-to-length systems require smaller loaders than tree-length systems.

c) Transport

The type of transport used will also determine the location, size and type of landing. Shorter rigid trucks require less space to turn than a rigid truck with a trailer. If a stinger-steer type transport system is used, provision should be made for an offloading area for the trailer. Cut-to-length operations need a smaller landing than tree-length systems.

The gradient from the landing to connecting roads should facilitate transport.

d) Disposal of accumulated slash

The type of operation will determine the amount of slash on the landing. The disposal of accumulated slash will therefore also play an important role in deciding on the location of the landing.

**9.3.2.5 Environmental impacts**

Landings should be selected at locations where it can be constructed to an adequate size with minimal environmental impact. The landings should be situated away from streamside...
management zones (e.g. riparian zones) and buffer strips, and should be planned in such a way that eroded material does not enter watercourses. Landing locations should meet the objectives of soil, water quality and visual management.

Drainage is important for maintaining a suitable landing surface. Landings should be gently sloped (3% to 6%) to facilitate drainage. Water approaching the landing should be diverted into surrounding vegetation and silt traps, and not directly into watercourse. The drainage of landings built in sensitive areas requires special attention.

The season during which the landing will be used also plays an important role in the construction of the landing.

9.3.2.6 Infield ground profile

The location of the landing will also be determined by the infield profile (Section 9.4).

9.3.2.7 Safety

Landing locations should be selected so that an appropriate landing can be constructed to perform safe and efficient operations with adequate space and layout for all landing operations. When yarding downhill, the yarder should be rigged so that it pulls down at an angle (Figure 112), unless the slope flattens out sufficiently in front of the yarder, as this will prevent dislodged rocks and/or timber rolling down the slope towards the yarder.

![Figure 112: Angle of downhill yarding](image)

9.3.2.8 General

Prior to making landing location decisions, the harvest planner should have a clear understanding of other important objectives (e.g. avoid using firebreaks as landings during the fire season). A summary of these steps and planning and layout of landings are shown in Table 15.
### 9.3.3 Summary of Steps: Planning and Layout of landings (Table 15)

**Table 15:** A flow chart of activities for locating and verifying landings for cable harvesting (from Kellogg, L. Cable Harvest Planning. Draft course manual, British Columbia Institute of Technology)

<table>
<thead>
<tr>
<th>Field location of potential landing sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadside versus centralised landing</td>
</tr>
<tr>
<td>Existing landings or roadway versus new construction</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Evaluation of harvesting feasibility, safety and environmental impacts</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Yarding effectiveness from landing location and environmental impacts</td>
</tr>
<tr>
<td>Run deflection lines and critical points.</td>
</tr>
<tr>
<td>Determine yarding distance.</td>
</tr>
<tr>
<td>Evaluate visual, soil and other impacts.</td>
</tr>
<tr>
<td>Sidehill yarding problems?</td>
</tr>
<tr>
<td>Downhill yarding problems?</td>
</tr>
<tr>
<td>Etc.</td>
</tr>
<tr>
<td>Accommodate necessary equipment.</td>
</tr>
<tr>
<td>Evaluate length and slope steepness of timber landing area.</td>
</tr>
<tr>
<td>Identify stacking space.</td>
</tr>
<tr>
<td>Locate truck road access to landing and turnaround.</td>
</tr>
<tr>
<td>Etc.</td>
</tr>
<tr>
<td>Determine guyline zones.</td>
</tr>
<tr>
<td>Evaluate guyline steepness and cable length.</td>
</tr>
<tr>
<td>Etc.</td>
</tr>
</tbody>
</table>

*It is helpful to use the operational plan map to draw a plan view of the landing layout that incorporates all the factors necessary for a safe and efficient operation.*

### 9.4 Deflection and line tension

The infield ground profile plays an important role in determining the location of the landing and each rack as it influences deflection, ground clearance and line tension. This in turn influences the payload that can be extracted from each rack and therefore the possible production rate.

The following relationships exist (they are explained in the subsequent sections):
- An inverse relationship between deflection and line tension; the higher the tension in the skyline, the lower the deflection;
- An inverse relationship between line tension and the load-bearing capacity of a skyline system; the higher the line tension, the lower the load-bearing capacity;
- The amount of ground clearance at critical points in the ground profile can be increased by decreasing the deflection (increasing the line tension) in the skyline.

One of the most important aspects of harvest planning for skyline systems is therefore tension in the lines and the related load-bearing capacities. Skyline payload analysis (e.g., *Chain and Board* or *Logger PC*) is used to determine deflection, line tensions, ground clearance and maximum payloads. It is also a useful tool to help harvest planners make the right decisions regarding the following:
- Selection of yarding equipment and skyline systems to be used;
- Feasible yarding distance limit;
- Location of yarder set-up boundaries;
- Need for tailtrees and intermediate supports, and their appropriate rigging heights.

Information on skyline payload analysis is available from recognised cable yarder training providers.
9.4.1 Deflection

An essential feature in any skyline system is deflection (Figure 113). Deflection is the vertical distance between the chord and the skyline at midspan. Midspan is the total horizontal span divided by two. The chord is a straight line between the points of support of the skyline. Percentage deflection is the midspan deflection expressed as a percentage of the horizontal span length.

![Figure 113: Deflection in a skyline system](image)

A rule to keep in mind is that the capacity of a skyline to support a load generally increases with an increase in deflection. A skyline with no deflection has no load-bearing capacity, but such a situation cannot exist because the weight of the wire rope causes some deflection. However, deflection cannot be too great or the load would not be lifted off the ground at all. Therefore, a compromise should be reached between load-bearing capacity and ground clearance. The height of the tower and the tailtree, the ground profile and the extraction distance all play an important role in the deflection attained.

During the haul-in cycle the load can be either partially or fully suspended (Figure 114). Full suspension would be required in environmentally sensitive areas (e.g. when crossing streams, indigenous forests, sensitive soils, etc.). In most South African cable yarding operations, loads are partially suspended. As a rule of thumb, a load size of approximately 50% heavier can be extracted with the load partially suspended as opposed to when fully suspended, thereby decreasing operational costs. However, partial suspension may cause gullies, which could require rehabilitation afterwards.

![Figure 114: Partial vs. full suspension](image)
To avoid exceeding the safe working load of a skyline, adequate deflection should be allowed or payloads should be decreased (Figure 115). Payload tension and deflection analysis should be calculated using one of many techniques, including *Chain and Board* and *Logger PC*. The following example indicates the significant effect deflection has on payload.

**Example: Deflection**

<table>
<thead>
<tr>
<th>Description</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal length:</td>
<td>200 m</td>
<td></td>
</tr>
<tr>
<td>19 mm skyline:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breaking strength:</td>
<td>23 040 kg</td>
<td></td>
</tr>
<tr>
<td>Weight:</td>
<td>1.55 kg/m</td>
<td></td>
</tr>
<tr>
<td>Slope of span:</td>
<td>40 %</td>
<td></td>
</tr>
<tr>
<td>Vertical elevation:</td>
<td>80 m</td>
<td></td>
</tr>
<tr>
<td>Safe working load:</td>
<td>7 680 kg</td>
<td></td>
</tr>
<tr>
<td>Weight of carriage:</td>
<td>200 kg</td>
<td></td>
</tr>
<tr>
<td>Calculated payload*</td>
<td>236 kg</td>
<td>2581 kg</td>
</tr>
</tbody>
</table>

* Calculated with *Logger PC*.

**Figure 115:** The effect of deflection on payload
9.4.2 Line tension

High deflection in the skyline will lead to less ground clearance (Figure 116). Tensioning the skyline would reduce this deflection. However, a reduction in deflection also causes a reduction in available payload. The maximum allowable tension in the skyline should not exceed the safe working load of the skyline. The following example indicates the correlation between line tension and deflection.

### Example: Line tension

<table>
<thead>
<tr>
<th>Horizontal length:</th>
<th>400 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 mm skyline:</td>
<td>Weight = 1.44 kg/m</td>
</tr>
<tr>
<td>Nominal strength of skyline:</td>
<td>23 200 kg</td>
</tr>
<tr>
<td>Safe working load:</td>
<td>7 733 kg</td>
</tr>
<tr>
<td>Vertical elevation:</td>
<td>100 m</td>
</tr>
<tr>
<td>Load:</td>
<td>1 tonne (1000 kg) at midspan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deflection</th>
<th>Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>3440 kg</td>
</tr>
<tr>
<td>6%</td>
<td>5825 kg</td>
</tr>
<tr>
<td>4%</td>
<td>8590 kg</td>
</tr>
<tr>
<td>2%</td>
<td>16900 kg</td>
</tr>
</tbody>
</table>

**Figure 116:** The effect of deflection on line tension

With an increase in deflection, there is a significant decrease in line tension. The remaining tension is therefore available for timber extraction.

9.4.3 Selection of support trees

Intermediate support trees are used to gain lift in skyline systems when little or no deflection is available. The location of intermediate support trees can be determined by measuring the profile of the proposed rack. A clinometer and a measuring tape can be used. The critical points in the slope can be determined by using various techniques (e.g. Chain and Board or Logger PC), or by plotting the information on graph paper.

After the critical points have been identified, an infield reconnaissance should be done to determine if suitable support trees are available. Refer to Sections 8.2 and 8.3 for the criteria used to select intermediate support trees and tailtrees.
9.5 Felling

Felling of trees for cable yarding extraction can be done motor-manually (chainsaw) or with a mechanised system (e.g. feller bunchers or harvesters). It is of vital importance that all safety aspects related to chainsaw felling are strictly adhered to. A special consideration in steep area felling operations is the danger of rolling or sliding trees or logs. This requires a strict rule, that felling operators should work on the same level on the slope. If they do need to work on different levels, adequate lateral safety distances need to be determined. This distance is a factor of the following considerations (amongst others):

- The standard applicable safety distance (2 tree-lengths);
- The steepness of the terrain – the steeper the terrain, the lower the chance of lateral rolling or sliding;
- Rockiness – this will increase lateral deflection;
- Ground conditions – wet soils offer less resistance to sliding and are therefore more unsafe;
- The length and size of the trees being felled – the bigger (heavier) and the taller the trees, the bigger the safety distances need to be.

In steep areas all dangers are more severe and special precautions may be needed.

In South Africa, motor-manual felling is the most commonly used felling method for the extraction of timber by yarders. A chainsaw operator can fell trees in virtually any type of terrain. However, chainsaw felling is more strenuous, it is more difficult to directionally fell the trees and trees can’t be bunched as with mechanised felling. Refer to FESA’s *South African Chainsaw Safety and Operating Handbook* for more information.

**Felling procedure**

One of the first decisions to be made is where to open up the rack. Make sure where the rack centre line or skyline corridor is located and that the tailtree and intermediate support trees are marked before trees are felled. Safety trees should also be left in the *bight of lines*.

Felling should be done in advance of extraction so as not to interfere with the yarding operation. This may cause problems in pine sawtimber operations where the timber turns “blue” if it is left infield for too long (blue stain is caused by a fungal attack).

The presentation of timber is a key factor influencing productivity. Felling usually starts at the lowest point and worked upward so that operators do not work below felled timber. Timber should be felled so that extraction is facilitated and breakage minimised. This can be achieved by directional felling of the trees parallel to the contour. Trees tend to fall downhill, but can be felled across the slope by making use of wedges or other specialised felling techniques.

A herringbone pattern is most acceptable for both uphill and downhill yarding, as illustrated in Figure 117. Depending on the size of the trees, slope, etc., the rack width is normally between 30 and 60 m. In downhill yarding make sure the corridor is positioned perpendicular to the yaderer.

![Figure 117: Herringbone felling pattern: Uphill and downhill yarding](image)

Larger trees should, however, be felled across the slope (parallel to the contour) to minimise breakage.
9.6 Cable yarding productivity

South African cable yarding operations are not considered to be highly productive especially compared to ground based extraction operations. This is mostly due to the type of operation and the fact that mostly small yarders are being used. As with any other harvesting systems, the extraction machine and system configuration for a specific application will have an impact on productivity. Due to the inherent system complexities, sub-optimal equipment selection could have a more significant impact on productivity compared to simpler ground-based harvesting operations. This negative productivity impact also applies to incorrect operational techniques and poor or inadequate planning. Cable yarding operations require professional technical and systems knowledge to operate successfully and sustainably.

Factors influencing productivity in cable yarding operations include:
- Terrain conditions: steepness, slope shape, ground condition and ground roughness;
- Uphill or down-hill;
- Piece size (both dimensions and weight are important);
- Payload size;
- Extraction distance;
- Complexity of operation (eg: number of intermediate supports, species, training etc.).

### Common Cable Yarding Limitations

<table>
<thead>
<tr>
<th>Slope (%) – up \ down</th>
<th>unlimited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground condition</td>
<td>1 – 5</td>
</tr>
<tr>
<td>Ground roughness</td>
<td>1 – 5</td>
</tr>
<tr>
<td>Piece size (m³) (typical SA yarder)</td>
<td>&lt;1.5</td>
</tr>
<tr>
<td>Maximum extraction distance (m)</td>
<td>&lt;400</td>
</tr>
</tbody>
</table>

NOTE – these criteria serve as a guide only and need to be determined by an experienced professional in the context of the operation.

### Advantages and Disadvantages of Cable Yarding

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of labour</td>
<td>Safety risk – steep slopes</td>
</tr>
<tr>
<td>Less sensitive to ground conditions</td>
<td>Poor ergonomics – steep slopes</td>
</tr>
<tr>
<td>Can be used in extreme slope conditions</td>
<td>Low productivity</td>
</tr>
<tr>
<td>Can be used in all soil wetness conditions (full suspension)</td>
<td>High absenteeism and labour turn-over</td>
</tr>
<tr>
<td></td>
<td>Limited physical endurance, cannot work at night – no full double-shift.</td>
</tr>
</tbody>
</table>
10 Safe rigging practises

The word “rigging” (verb) as used in this section refers to the climbing and preparation of towers, tailtrees and intermediate supports.

10.1 General safety

- Rigging should be performed by people who have a thorough knowledge and practical experience of cable yarder rigging and all the related safe rigging practices (or who are training under the strict supervision of a qualified and experienced person);
- When the rigging height is higher than 8 m, an extra set of climbing equipment should be available at the work site, and another employee with sufficient climbing skills, should be available in the immediate vicinity to assist the rigger in an emergency;
- A competent person should examine all parts of the climbing equipment before use;
- Defective climbing equipment should not be used;
- No yarding or felling activities of any kind may be conducted within reach of the guylines or the tree in which the rigger is working;
- Noisy equipment may not be operated in the vicinity of where the rigger is working when such noise could interfere with the rigger’s signals (Figure 118).

Figure 118: No noisy equipment close to rigger

- Whilst the rigger is working in the tree, other employees should keep well clear of the tree to avoid being struck by falling objects;
- The rigger should give a warning (e.g. by blowing a whistle) when any equipment or material is in danger of dropping or is to be dropped deliberately;
- Loose equipment, rigging and other material should either be removed from the tree or securely fastened;
- Guylines or other cables attached to a tree in which the rigger is working should not be moved except on a signal from the rigger;
• Tree plates should be used to secure the rigging in the tree if there is a possibility of the block straps cutting into the tree;
• No rigging or topping may be carried out when visibility is impaired or during windy/stormy weather (Figure 119) Topping should only be done by a chainsaw operator qualified to work in these extreme cases.

![Figure 119: No rigging during stormy weather](image)

• When not in use, rigging should be stored so that it doesn’t present a hazard;
• A thorough inspection of all rigging should be performed before it is used;
• Climbing and rigging equipment should not be used for any other purpose other than for rigging the tree;
• Any tools carried by the rigger should be securely fastened to his belt or person;
• Should repair work need to be performed on the headgear of an erect tower, the headgear may be reached only by climbing up the fixed steps attached to the tower. If no fixed steps are present, the tower should be lowered for such repair work;
• Use a safety harness when working on the tower headgear in line with Occupational Health and Safety Act (85 of 1993) (Department of Labour, 1993).

### 10.2 Climbing equipment

• All climbing equipment should be properly constructed of sound material and should be maintained in a safe working condition;
• All parts of climbing equipment should comply with the manufacturer’s specifications as well as the standards set by the Occupational Health and Safety Act (85 of 1993) regarding maintenance, inspection, routine testing and storage;
• The following climbing equipment may be used:
  • Stepladders with acceptable safety features. Such ladders should be recorded in a register in accordance with the Machinery and Occupational Safety Act (6 of 1983);
• Climbing irons with spikes (long and sharp enough to hold in any tree in which it will be used), a suitable climbing belt and a suitable climbing rope (Figure 120);
• An additional safety rope (8 mm or thicker if wire rope is used; 5 mm or thicker if chain is used) if tree topping is to be performed.

Figure 120: Climbing equipment

10.2.1 Safe use of climbing irons

• The rigger must pass the climbing rope around the tree and fasten it to the climbing belt before leaving the ground;
• The fixed end of the climbing rope should be fastened to the climbing belt, and the standing end passed around the tree, then passed through the D-ring on the climbing belt and secured with a bowline (cat’s paw knot) or suitable mechanical rope adjuster (Figure 121);
• The climbing rope must be adjusted to the correct length periodically as the rigger climbs up the tree and the tree diameter decreases;
• The rigger must ensure that the spikes are properly embedded in the tree before taking each step up the tree and before flicking the climbing rope up to the next position;
• If branches impede the rigger, he should attach another climbing rope above the branch and secure himself before releasing the first rope and only then may he continue to climb;
• When the rigger reaches the correct height at which to work, he should again ensure that the spikes are securely embedded in the tree and then assume a comfortable working position;

When heavy rigging is used, a passblock and passline should preferably be used to lift the rigging from the ground up to the rigger. An assistant is required to lift the rigging (which is attached to the passline) to the rigger by pulling on the passline and to hold the rigging at the correct height whilst the rigger attaches the rigging to the tree.

Figure 121: Cat’s paw knot
10.2.2 Safe use of stepladders

The following safety procedures must be complied with when stepladders are used in rigging operations:

- When the rigger is to work at a height of more than 3 m, the stepladder should be tied to the tree and the rigger should be secured against falling by means of a safety belt/rope;
- When extension stepladders are used, the overlap should meet the manufacturer’s specification;
- When using stepladders longer than 6 m, at least one other person should assist the rigger to raise and lower the stepladder and to hold it in place until it is secured.

10.3 Safe tree topping practices

The following safe working procedures must be adhered to when topping trees:

- Only competent and trained (specifically for working with chainsaws at heights) chainsaw operators may be used to top trees;
- A complete risk assessment on the tree to be topped must be done before any such operation is undertaken;
- Refer to Section 10.2 for a list of the climbing gear required. Stepladders may not be used;
- Select the place for hanging the rigging before topping the tree. The extended part of the tree should be between one and 5 m above the guyline attachment;
- Follow the safety procedures in Section 10.2.1 and 10.2.2 to climb trees.
- Ensure that the rigger is secured to the tree with an additional safety wire rope (8 mm or thicker) or chain (5 mm or thicker). This is required in case the rigger cuts his normal climbing rope;
- The chainsaw to be used may not weigh more than eight kilograms;
- A chain or wire rope should be attached around the tree, below the topping cut, to prevent the tree from splitting (especially important when topping trees that are inclined to split).
- Use the following felling technique for topping the tree (Figure 122):
  ▪ Once the felling direction has been determined, make the top cut of the directional notch at approximately a 45° angle and for between ⅓ and ¼ of the tree’s diameter (where it will be topped). The directional notch should accurately face in the desired felling direction;
  ▪ Make the bottom cut of the directional notch to meet the top cut. Remove the resultant piece of wood;
  ▪ Make shallow side cuts at the same level as the bottom cut of the directional notch (no deeper than the guidebar width);
  ▪ Make the felling cut parallel to the bottom cut of the directional notch and slightly above it. Ensure that a sufficient hinge is left (approximately ⅓ of the tree diameter at the place where it is topped).
  ▪ As soon as the tree top begins to fall, the rigger should lower the chainsaw onto the rope to which it is attached and hold on tight to the climbing rope as the topped tree may sway severely as the top breaks off;
  ▪ Trees that are judged to be too dangerous should not be topped;
  ▪ If a tree doesn’t have an obvious direction of fall, felling wedges and the associated felling procedure should be followed.
10.4 Methods of tensioning guylines

There are various ways in which to tension wire rope guylines. Two of the most common methods used are discussed in this section. However, tensioning could also be done by hand where relatively small guylines are used.

10.4.1 Pass chain method

A pass chain consists of a chain with an open hook on one side. The chain is wrapped around the wire rope at least three times against the direction of pull. The live end of the chain is taken through the hook and the chain is tightened with a tensioner (e.g. a ratchet lever as shown in Figure 123).
10.4.2 Mule grip and Kito clamp

The mule grip and Kito clamp are devices for pulling, holding and tensioning wire rope. These devices could be attached to any tensioner (e.g. a Tirfor/“Come-Along” as shown in Figure 124).

![Figure 124: Mule grip and Tirfor used for tensioning support lines](image)

10.5 Rigging the yarding system

Before a yarder is set up on a landing and infield rigging commences, trees should be felled according to the compartment plan, with tailtrees and intermediate support trees left standing. Anchors for the tailtree, intermediate supports and the yarder should then be prepared.

10.5.1 Setting up the yarder

Yarders vary significantly in their setup requirements and procedures. Therefore, the manufacturer’s specific setup requirements and procedures must be strictly adhered to. As a guideline, some basic procedures are listed in this section.

A competent and authorised person should direct the entire setup process. The yarder should be moved into the predetermined position from which it will yard which must be a firm, stable site. Generally, the site should be as level as possible to ensure even spooling on the winch drums and balanced forces acting on the tower. Some yarders, however, are specifically designed to be levelled during the yarding process and therefore may not require a level site (Figure 125).

![Figure 125: Levelling the yarder](image)
Before the tower is raised, the following inspections must be carried out and defective components repaired if necessary:

- Inspect the rigging (e.g. guyline blocks, sheaves, shackles, etc.) on the tower thoroughly;
- Ensure that sheaves are turning freely;
- Replace any defective parts;
- Check the tower and fairlead for dents and cracks as this could reduce its strength;
- Inspect all components of the tower hinging and raising mechanisms.

Some yarders have mechanical or hydraulic outriggers which should be deployed to stabilise the machine before the tower is raised. Under certain circumstances, additional load-spreading supports (e.g. wooden blocks) may be required to distribute the weight exerted by the outriggers.

When raising the tower, make sure that the:

- Workers are properly instructed and know their specific assigned tasks;
- Workers are in view of the rest of the team if required to give signals;
- People not involved with the raising of the tower should stand clear of the operation.

To raise the tower, make sure that:

- The hydraulic hose reel (if fitted) must unspool freely;
- The tower lifting cylinder should be properly positioned on the tower with the pin in place;
- Whilst the tower is being raised, the stability of the yarder should be continuously checked;
- The tower is located in place with the locking pin.

When rigging the guylines:

- Ensure that the rigging requirements in Section 8.2 are complied with;
- Pull out the guylines and attach them to the anchors. Ensure that the anchors comply with the requirements in Chapter 7;
- Ensure that all shackles and clamps are attached in accordance with the requirements of Chapter 6.

If the machine requires a central cylinder beneath the tower, this can be lowered once the tower has been raised unless it is not required to be raised as part of the tower raising process (Figure 126). The central cylinder should lift the yarder to the point where the pressure is just taken off the tyres and axles. If the outriggers are not required to stabilise the yarder base during the yarding process, they should be raised before the skyline is finally tensioned.

![Figure 126: Central and side supports (outriggers) on the yarder](image-url)
10.5.2 Rigging intermediate supports

Guylines are typically anchored to stump anchors (Section 7.1). Guylines on intermediate supports may be anchored to standing trees (Section 7.6). Refer to Section 8.3 for the rigging requirements applicable to intermediate supports.

WARNING:
Intermediate supports could be pulled over when:

- The skyline cable is too slack or the chord slope change too steep;
- The carriage passes the support jack at too severe an angle;
- Intermediate supports are incorrectly rigged, guyed and/or anchored.

10.5.2.1 Single-tree support: Riderblock method

Refer to Section 8.2.5 for the applicable rigging requirements.

The riderblock single-tree support is rigged with a load-bearing guyline and at least two support guylines (Figure 127). The load-bearing guyline passes through the support jack, and through a block that is attached by a strap to the support tree. The load-bearing line is then secured onto the support jack. The guylines are attached to the support tree just above the strap.

The following rigging is taken out to the intermediate support:

- One load-bearing guyline, 2 support guylines and a strap (Section 8.2.5.1);
- Shackles, cable clamps and a block (Section 8.2.5.1);
- Support jack;
- Tensioning device;
- Climbing equipment.

Figure 127: Riderblock single-tree intermediate support
The following rigging procedure is recommended:

- Debranch the tree as you climb (if required);
- Hang the block from the strap in the support tree high enough to provide clearance for the timber as it passes over the support jack (Section 6.8.2);
- Rig two support guylines to the support tree at approximately the same height above the point where the strap (for the block) is attached. After the guylines have been wrapped either once or twice around the support tree, shackle them in accordance with the requirements in Section 6.5. Tension and attach the guylines to the anchors with cable clamps or shackles as indicated in Section 7.1.3;
- If a tensioner is used, attach it to the anchor that the load-bearing guyline will be attached to. Attach one end of the load-bearing line to the tensioner (two different tensioning methods are discussed in Section 10.4). Rig the other end of the line through the support jack, through the block in the support tree and back onto the support jack where it is attached. Ensure that the jack is hanging the correct way to allow for the carriage to pass over it. The support jack is now ready to be lifted off the ground;
- After the skyline is placed in the support jack, lift it off the ground into the required position and tension the load-bearing guyline. Pull enough of the load-bearing guyline past the anchor to be able to attach it to the anchor. Attach the guylines to the anchors with cable clamps or shackles as indicated in Section 7.1.3.

10.5.2.2 Single-tree support: Centre-block method

Refer to Section 8.2.6 for the applicable rigging requirements.

The centre-block single-tree support is rigged with a load-bearing guyline and at least two support guylines (Figure 128). The load-bearing guyline passes through a block that is attached by a strap to the support tree. The load-bearing line is then secured onto the support jack. The guylines are attached to the support tree just above the strap.

The following rigging is taken out to the intermediate support:

- One load-bearing guyline, two support guylines and a strap (Section 8.2.6.1);
- Shackles, cable clamps and a block (Section 8.2.6.1);
- Support jack;
- Tensioning device;
- Climbing equipment.
The following rigging procedure is recommended:

- Debranch the tree as you climb (if required);
- Hang the block from the strap in the support tree high enough to provide clearance for the timber as it passes over the support jack (Section 6.8.2);
- Rig two support guylines to the support tree at approximately the same height above the point where the strap (for the block) is attached. After the guylines have been wrapped either once or twice around the support tree, shackle them in accordance with the requirements in Section 6.5. Tension and attach the guylines to the anchors with cable clamps or shackles as indicated in Section 7.1.3;
- If a tensioner is used, attach it to the anchor that the load-bearing guyline will be attached to. Attach one end of the load-bearing line to the tensioner (two different tensioning methods are discussed in Section 10.4). Rig the other end of the line through the block in the support tree and secure it to the support jack. Ensure that the jack is hanging the correct way to allow for the carriage to pass over it. The support jack is now ready to be lifted off the ground;
- After the skyline is placed in the support jack, lift it off the ground into the required position and tension the load-bearing guyline. Pull enough of the load-bearing guyline past the anchor to be able to attach it to the anchor. Attach the guylines to the anchors with cable clamps or shackles as indicated in Section 7.1.3.

10.5.2.3 Double-tree support (M-support)

Refer to Section 8.3.7 for the applicable rigging requirements.

A double-tree support is rigged with a single continuous load-bearing guyline (Figure 129). This line runs from the first anchor over a block in the first tree, then through a block in the second tree to the second anchor.

The following rigging is taken out to the intermediate support:

- One load-bearing guyline and two straps;
- Shackles, cable clamps and two blocks;
- Support jack;
- Tensioning device;
- Climbing equipment.

Figure 129: Double-tree intermediate support
The following rigging procedure is recommended:

- Debranch the tree as you climb (if required);
- Hang the blocks from the straps in the support trees high enough to provide clearance for the timber as it passes over the support jack. The blocks should be at the same height (Section 6.8.2);
- Attach the load-bearing guyline to the first anchor and take the other end of the line through the first block, the support jack and the second block. Then pull the line to the second anchor. Ensure that the support jack is hanging the correct way to allow the carriage to pass. The one end of the guyline should be attached to the anchor with cable clamps or shackles as indicated in Section 7.1.3;
- Attach a tensioner to the second anchor and the other end of the guyline (two different tensioning methods are discussed in Section 10.4). The support jack is now ready to be lifted off the ground. After the skyline is placed in the support jack, lift it off the ground into the required position and tension the load-bearing guyline. Pull enough of the load-bearing guyline past the anchor to be able to attach it to the anchor. Attach the line to the anchors with cable clamps or shackles as indicated in Section 7.1.3.

10.5.3 Rigging a tailtree

Guylines are typically anchored to stump anchors (refer to Section 7.1 for the requirements applicable to stump anchors). Guylines on tailtrees (Figure 130) may be anchored to standing trees (refer to Section 7.5 for the applicable requirements). Refer to Section 8.3 for the rigging requirements applicable to tailtrees.

The following rigging is taken out to the tail support:

- Two guylines;
- Shackles and cable clamps;
- A tailtree block;
- Haulback line blocks and straps;
- Tensioning device;
- Climbing equipment.

Figure 130: Tailtree support
The following rigging procedure is recommended:

- Debranch the tree as you climb (if required);
- Hang the tailtree block from the strap in the support tree high enough to provide clearance when timber is yarded close to the tailtree. Refer to Section 8.3 for the correct way to hang blocks. Pass the skyline through the block and attach it to an anchor with shackles or cable clamps;
- Rig two guylines to the tailtree at approximately the same height above the point where the strap (for the block) is attached. After the guylines have been wrapped either once or twice around the support tree, shackle them in accordance with the requirements in Section 6.5. Tension and attach the guylines to the anchors with cable clamps or shackles as indicated in Section 7.1;
- In a standing skyline system, the haulback line block can be attached to the tailtree as it is guyed back as shown in Figure 130.

NOTE:
A skyline is not considered to be a support line.

10.5.4 Rigging haulback line blocks

Haulback line blocks are typically attached to stump anchors (refer to Section 7.1 for the requirements applicable to stump anchors). They can, however, also be attached to standing trees (refer to Section 7.5 for the applicable requirements) in order to keep the haulback line off the ground, thereby minimising damage to it.

10.5.5 Pre-rigging

The rigging of the yarder can be time-consuming. To save time and increase production, the rack could be pre-rigged with an extra set of rigging equipment before the yarder arrives at the landing. Refer to Figure 131. The following procedures are recommended for pre-rigging:

- Rig the intermediate support trees to the point where the support jack is still on the ground;
- If a haulback line is used, remember to rig anchors that will be used for the haulback line blocks;
- Prepare the anchors for the tower guylines.
- If a strawline is available, the following extra steps can be taken:
  - Ensure that all the tailtree blocks and haulback line blocks are rigged;
  - Lay sections of the strawline out, from the yarder, through the haulback line blocks, and back to the yarder;
  - Once the yarder arrives at the designated position, the strawline will be used to pull out the haulback line, which will in turn pull out the heavier skyline. This procedure is discussed in Section 10.6.1.

Figure 131: Rack after pre-rigging is completed
10.6 Rigging typical yarding systems as used in South Africa

These yarding systems are used in South Africa.

10.6.1 Rigging a typical skyline system that requires a haulback cable

After the yarder has been set up and guyed down, the skyline should be pulled out to the tailtree. The skyline can be pulled in various ways:

- By hand;
- By an independent winch or sledge;
- By using the straw line;
- By using the haulback line.

The following is the recommended procedure using the haulback line to pull out the skyline – refer to Figure 132 (it may be amended to suit particular circumstances):

**NOTE:**

Extensions to skylines should be at least equal in breaking strength to the skyline to which they are attached.
**Step 1 – Pull out the haulback cable**

- Connect the sections of the strawline that have been laid out as described in Section 10.5.5: Pre-rigging. At the yarder the strawline is connected to the haulback line. The haulback line is pulled out by the strawline. If a strawline is not available, pull out the haulback line by hand.

**Step 2 – Connect the skyline and mainline**

- Once the haulback line has been threaded through all the infield blocks and has been returned to the yarder, it is attached to the skyline and mainline with a pass chain. A loop of approximately 20 m should be given from the end of the skyline to the pass chain attachment.

**Step 3 – Pull out the skyline and mainline**

- Pull the skyline and the mainline out to the tailtree with the haulback line. A member of the yarding team should accompany the pass chain attachments at a safe distance to stop the yarder operator if the rigging snags on stumps, branches, etc.

**Step 4 – Disconnect the skyline**

- At the tailtree, the pass chain is unhitched, and the 20 m loose loop in the skyline is dragged by hand through the block already hanging in the tailtree, to the prepared anchor.

**Step 5 – Pull the mainline back to the yarder.**

- Connect the haulback line and the mainline again and pull the haulback line back to the yarder with the mainline. The haulback line and the mainline are now at the tower for attachment to the carriage.

*Figure 132: Getting working cables into position*
Step 6 – Rig the skyline cable
- Wrap the skyline around the anchor and tie it with a shackle or cable clamps;
- Place the skyline in the groove of the support jack before the load-bearing guyline at the intermediate support is raised and anchored. Whilst the support jack is being raised, hold the skyline in place with a piece of soft wire or hose clamp wrapped around the support jack and skyline. This will be cut after the first few turns by the action of the carriage crossing the support jack.

Step 7 – Mount the carriage to the skyline
- Place the carriage onto the skyline and check the following:
  - Ensure that the skyline carriage is compatible with the support jack;
  - Ensure that the carriage sheaves are the correct size for the skyline;
  - Ensure that the carriage brakes are working (if applicable);
  - Pull the mainline through the carriage and attach the rigging (e.g. T-bar, fallblock, etc.) via a swivel;
  - Connect the haulback line to the carriage (if a haulback is used) by means of a shackle and a swivel.

Step 8 – Stabilising the yarder
- Lift the side supports (outriggers) off the ground, whilst keeping the central support in place. Ensure that the weight of the yarder is on the central support, and not on the wheels;
- Tension the guylines until the tower is vertical;
- Tighten the skyline to the desired deflection;
- The yarder is now ready to work.

10.6.2 Rigging a typical gravity return skyline
A gravity return skyline can be rigged in a similar fashion to the procedure described in Section 10.6.1. The only difference is that a haulback cable is not used in the system and therefore is not hauled out. Hence, the skyline cable can be pulled out directly to the tailhold using a strawline or by hand.

10.6.3 Rigging a typical running skyline as used in South Africa
- Refer to Section 4.2.3;
- Rig the tower in accordance with Section 10.6.1;
- If there is sufficient deflection, attach the haulback block directly to a tailhold. Alternatively, if a tailtree is required for increased deflection, rig the tailtree with guylines and a haulback block;
- Pull the end of the haulback line through the carriage, passing under the top sheave of the carriage;
- The haulback line is then pulled out to the haulback block, passed through the haulback block, and pulled back to the yarder. This can be done using a straw line or by hand;
- Attach the haulback line to the carriage;
- Thread the mainline through the carriage, passing above the lower sheave, and attach the rigging (e.g. T-bar and ring sliders);
- Stabilise the yarder as described in Section 10.6.1, with the exception that the skyline is not used;
- The yarder is now ready to work.
10.7 Common hazards caused by incorrect rigging

- Guyline failure caused by:
  - Insufficient number of guylines;
  - Incorrect guyline angles;
  - Insufficient guyline strength;
  - Incorrect guyline tension;
  - Small sheaves;
  - Fatigued guylines;
  - Guylines that are not in the lead at the point of attachment to the anchor.

- Anchor failure caused by:
  - Using the wrong type of anchor system for the particular situation;
  - Poor selection and notching of stumps;
  - Incorrect guyline tension;
  - Overloading of the yarding system.

- When yarding on convex slopes, cables will rub heavily on the ground causing wear and tear, which could lead to wire rope failure. Wire rope running over rock will also be damaged and could cause fires;

- Poor selection of intermediate supports and tailtrees (i.e. crooked trees, trees with dead tops, etc.) could injure workers;

- Intermediate supports, towers and tailtrees can be pulled over if rigged incorrectly;

- Failure of rigging accessories due to not matching all the accessories and cables within the system.
11 Start-up and shut-down procedures

NOTE:
The start-up and shut-down procedures described in this Chapter are those for a multi-span standing skyline system. Adapt the procedure accordingly if any other system is used, as not all the procedures will be applicable.

Any faults found during the start-up and shut-down procedures, or during the working day, should be reported to the supervisor and rectified before continuing to yard. Under no circumstances should the yarder be started, yarding commenced, or continued, if any serious defects are encountered.

11.1 Start-up procedures

Adhere to the following procedures during start up of the systems.

11.1.1 Before starting the yarder

Before starting the yarder for the first time each day the operator must:

- Ensure that the daily maintenance check on the yarder has been completed using the manufacturer’s handbook and/or a checklist;

Example of a start-up checklist

Check the following:

- Fuel level;
- Engine oil level;
- Engine coolant level;
- Hydraulic oil level;
- Battery water level, terminals and cables;
- Transmission oil level;
- Fan belt and alternator belt tension and condition;
- Functioning of fan belt emergency shut-down device (if fitted);
- Functioning of accelerator and engine cut-off levers;
- Visually check the air intake pipes and air cleaner for cracks and secureness;
- Visually check the condition and secureness of the bands, control levers and linkages – for the skyline, mainline and haulback line drums and bandbrakes;
- All machine guards and covers are fitted and secure;
- Visually check for loose bolts, attachments, etc.;
- Visually check for broken pipes, fittings, oil leaks, etc.;
- Visually check the electrical wiring and fittings for secureness;
- Grease all grease points;
- Check the tower lifting cylinder and pins and the tower hinging and locking pins for secureness.
• Ensure that the daily rigging check on the yarder and infield rigging equipment has been completed using the manufacturer’s handbook and/or a checklist.

**Example of a rigging checklist**

Check the following on the **yarder rigging** and take the required rectifying action:

- Check all guyline cables and cable eye ends for wear and damage, and that all shackles/cable clamps are secure and correctly installed around anchors. Check that anchors are in no danger of being pulled over. If anchor stumps are used, ensure that the stumps are in no danger of dislodging or breaking up;
- Check that guyline cables are correctly spooled onto guyline drums and that there are a minimum of three wraps on the storage section and two wraps on the tension section. The guylines should always cross over to the tension section;
- Check that all guylines are correctly tensioned;
- Check that the guylines are not crossed over each other or other wire ropes and that they are “in the lead” from the guyline blocks at the top of the tower;
- Check the guyline drums and locking pawls for wear, cracks, damage, secureness and lubrication;
- Check that all guyline locking pawls are engaged;
- Check that the central support cylinder has not sunk into the ground, thus exerting pressure on the wheels and axles;
- Check that the side supports (outriggers) are off the ground;
- Check that the machine is still level and the tower vertical;
- Check the tower headgear for cracks, damage and that sheaves are turning freely;
- Check all the rigging for wear, cracks, damage and secureness.

Check the following on the **working cables**:

- Check all ends of all working cables for wear and damage, i.e. spliced eyes, crimped eyes, fittings and fixtures (e.g. swivels, shackles, T-bars, hammerlocks, etc.);
- Check the carriage mounting points of these cables for wear, cracks or damage;
- Check choker cables/chains and other choking accessories for wear and damage;
- During the working day check, for damaged and worn wire rope (as the wire spools off and onto the drums). Stop and investigate suspect wire rope. Rectify problem areas before continuing;
- When a haulback line is used, it is good practice to check the complete length of the cable and all fittings, such as swivels, shackles, straps and blocks by walking along the haulback line;

Check the following on intermediate supports, tailtrees and haulback line block trees:

- Check that all rigged trees are still standing and have not been blown over by the wind during the night. All dangerously leaning trees should be felled and alternative trees rigged;
- Check the condition of all anchors;
- Check that all guyline cables are properly secured and that all shackles and other fittings are secure and in good condition. Check the guylines for wear and damage;
- Check that all rigging blocks are secure and not sliding down the tree. Look for tell-tale signs of debarking at the point of attachment around the tree;
- Check that all the haulback line blocks are still in position and that the sheaves turn freely. Also check that all shackles, straps, blocks are secure and in good condition.
• Identify trees, timber, rocks or other objects that may roll, slide or fall into the work area;
  • Ensure that there are no persons loitering on, or close to the yarder, and that there are no maintenance personnel working on the yarder;
  • Ensure that there are no persons directly under, or dangerously close to, any working cables in the entire cable yarder setting;
  • Walk completely around the yarder and ensure that no obstacles or personnel are in the danger area before start-up (Chapter 12).

11.1.2 Starting the yarder

When the operator is sure that everybody is in the “clear”, the operator should follow the manufacturer’s safe starting procedure.

Example of a start-up procedure

Turn the key to the “ON” position and check the following:

✓ Green oil light comes on;
✓ Red alternator lights come on;
✓ Temperature gauges move;
✓ All parking brakes are applied, clutches “off” and transmission in neutral;

Start the engine (don’t crank the engine for more than 30 seconds every two minutes) and check the following:

✓ Green oil and red alternator lights go off. If these lights stay on, switch off immediately and call the supervisor;
✓ Check all applicable gauges;
✓ Idle the engine for three minutes;
✓ Shift gears through first, second, third, neutral, reverse, neutral;
✓ Check transmission oil level again while the engine is idling;
✓ Check the functioning of the signalling system;
✓ Check the functioning of all winch drum controls and brakes.

Each day after start-up, but before yarding commences, the operator must:

• Sound the signal and lower the skyline cable to the ground (if not already on the ground). Do the daily carriage check and start-up procedure;
• Raise the skyline cable, and perform the carriage functions to ensure that the carriage is safe to use;
• Check all controls for proper functioning and response before starting the work cycle;
• If the skyline cable is not raised or lowered as part of the start-up procedure, the quick release mechanism of the skyline should be tested by executing an emergency release of the skyline. This is fitted to the yarder as a safety mechanism;
• Check all radio-controlled equipment, voice communication and signal systems before yarding commences.
11.2 Raising and lowering of a skyline cable

- Before moving any cables, ensure that no persons are in danger of being struck by a moving cable. Then sound the signal or communicate that the particular cable is to be moved;

- When raising the skyline, follow the manufacturer’s safe operating procedures. The following general principles apply:
  - For skyline drums that have partitions, raise the skyline enough to take up the slack, and then feed the cable over to the adjacent tension compartment using a steel rod (Figure 133).
  - Don’t use your hands to guide the cable!

![Figure 133: Skyline drum with adjacent tension compartment](image)

- Raise the skyline to the desired deflection, engage the skyline brake before disengaging the skyline tension mechanism. Only after the operator is sure that the brake is on and holding, should he signal the workers that it is safe to enter the area below the skyline cable;

- Never use more skyline unloaded tension than is necessary for each skyline setting. Check that the skyline loaded tension never exceeds the manufacturer’s recommendations, i.e. check that the pressure settings of the skyline raising mechanism are not exceeded (if fitted to the yarder);

- Never operate above the manufacturer’s recommendations for wire rope size and capacity;

- The skyline brake should be set, according to the manufacturer’s recommendations, to slip when the safe working load of the skyline is exceeded (if fitted). It should be checked and reset at least once a month, when it has been tampered with, and when slip occurs with small loads;

- Before lowering a tensioned skyline to the ground, check that nobody is beneath it, warn the team, then lower the skyline;

- After each raising or lowering of the skyline, check that it is still in the support jack.
11.3 Shut-down procedure

When shutting-down the yarder at the end of the day the operator should follow the manufacturer’s safe shut-down procedure.

<table>
<thead>
<tr>
<th>Example of a shut-down procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Idle the engine for three minutes before turning it off;</td>
</tr>
<tr>
<td>✓ Check that nobody is below the skyline nor in front of the yarder (in the danger area), give warning and then slacken off the skyline.</td>
</tr>
<tr>
<td>✓ Engage the park brakes on all winch drums and secure the carriage.</td>
</tr>
<tr>
<td>✓ Disengage clutches.</td>
</tr>
<tr>
<td>✓ Shift transmission to neutral.</td>
</tr>
<tr>
<td>✓ Switch off the engine.</td>
</tr>
<tr>
<td>✓ Turn the ignition to the “OFF” position.</td>
</tr>
<tr>
<td>✓ Visually inspect the machine for defects.</td>
</tr>
</tbody>
</table>
12 Safe yarding practices

NOTE:
The procedures described in this Chapter are for a multi-span standing skyline. Adapt the procedures accordingly if any other system is used, as not all of the procedures will be applicable.

This chapter deals with safe yarding procedures that will ensure the safety of the whole team.

12.1 General safe yarding practises

Safe yarding practices include the following:

12.1.1 Safe practices for the yarder operator

The yarder operator should comply with the following generic safety practises:
- Obey the instructions as given by authorised personnel. Confirm with authorised personnel if a signal is not understood; stop, ensure that the signal is understood and then continue;
- Don’t move a working cable without warning the other team members;
- Ensure that everyone is out of the danger area before the carriage is released;
- Don’t move a working cable without being signalled by the chokerman or dechoker to do so;
- Stop the operation if the signalling system is defective; investigate and take rectifying action before continuing;
- Drop the skyline immediately in an emergency (Figure 134) (e.g. when the carriage is running away). Use the skyline quick release mechanism to do so.

Figure 134: Drop the skyline when the carriage is out of control

- Slacken all working cables before any team member approaches the rigging to conduct checks or to do repairs;
- Operate the yarder with smooth changes in speed and gentle use of controls and brakes;
- Apply the brakes on all working drums whenever the yarder is left, even if only for a short time;
- Apply the brakes on all working drums and shut the engine down if the yarder is to be left for a long period.
12.1.2 Safe practices while working cables are moving and/or under tension

Comply with the following while working cables are moving and/or under tension:

- Don’t stand or move in the bight formed (Figure 135) by any cables unless:
  - Protected by standing trees of sufficient size; or

  ![Figure 135: Don’t stand in the bight of any cable](image)

  • Extra safety precautions have been taken to protect workers from being struck by a working cable should it break or become loose through the failure of a block or a block strap.

  • Don’t stand or move within 1½ tree lengths of intermediate supports, tailtrees, tree anchors or haulback line block trees (Figure 136);

  ![Figure 136: Danger area around support trees](image)

  • In skyline operations, don’t stand or move within 10 m on either side of the skyline cable during haul-in, or within 4 m on either side of the skyline during haul-out (Figure 137);

  ![Figure 137: Danger area under skyline](image)
• In highlead operations, cables can siwash severely sideways. If the potential exists for siwashing, don’t enter the potential siwashing area until the highlead carriage or butttrigging has returned infield, has stopped and the lines have been slackened;

• During break-out and haul-in, workers who perform slackpulling (these workers could be separate ones from the chokermen), should move at least 1½ times the distance of the longest choked log/tree length from the skyline cable until the load has passed them. This will ensure that they are out of the danger area should the log/tree length upend or swing sideways as it passes them;

• During break-out, chokermen should move out of reach of timber swinging or upending, at a distance of least 1½ times the length of the longest choked log/tree length as measured from the choked end. Refer to Figure 138;

![Figure 138: Chokerman out of reach of timber](image)

• Prechoking should never be done directly under the skyline cable;

• On steep slopes in uphill yarding where the possibility exists that timber could slide downhill during the haul-in cycle, pre-choking should not be permitted within 1½ log/tree lengths (of the longest choked log/tree length) on either side of the skyline cable, until the load has been landed and positively prevented from sliding downhill towards workers. In areas where the possibility of timber sliding back down doesn’t exist, pre-choking is not allowed within 10 m on either side of the skyline cable during haul-in once the load has passed the workers or within 4 m on either side of the skyline during haul-out;

• If loads are fully suspended, workers should not enter the area within 1½ log/tree lengths (of the longest choked log/tree length) on either side of the skyline cable, because log/tree lengths could fall in any direction if they slip off the choker;
• When yarding on steep side slopes, workers should not stand on the downhill side of the skyline cable as timber, rocks, etc. could slide or roll downhill towards them, unless they are protected by standing trees (Figure 139).

EXCEPTION:
In exceptional cases, where yarding takes place in very steep terrain and/or the trees are very tall, workers may stand or move within 1½ tree lengths of intermediate supports, tailtrees, tree anchors or haulback line block trees. The following conditions however apply:

• If due to space contraints, steep slopes and/or tall trees, it is impractical for the workers to move more than 1½ tree lengths away; AND

• Workers should stand directly behind a safety tree which was purposely left standing to provide such protection. The safety tree should be on the opposite side of the load and the direction in which the skyline is pulled to the side;

• These trees should be felled and removed before the site is completed.

Figure 139: Worker behind safety tree

12.2 Haul-out
During the haul-out cycle the empty carriage is returned infield.

12.2.1 Common hazards
• The skyline may break or chokers may be thrown forward when the carriage is stopped, thereby injuring workers;

• In downhill operations, the haulback line is under tension and can therefore cause accidents.
12.2.2 Safe practises for the yarmer operator

During haul-out, the yarmer operator should comply with the following:

- Obey the instructions as given by the head chokerman and dechoker;
- Ensure that a stop, or similar apparatus, is placed on the skyline, close to the tower, to protect the tower from being hit by the carriage in downhill yarding (Figure 140).

![Figure 140: Place a stop at the tower in downhill operations](image)

- Raise the empty chokers in a controlled manner up to the carriage in order to avoid the chokers from swinging excessively. The chokers may only be raised once the load has been dechoked and the yarmer operator has been instructed by the dechoker to do so;
- Ensure that all loose cables have been wound in before the carriage is hauled-out;
- Return the carriage infield by braking smoothly on the mainline in uphill yarding. This will prevent overwinds. Control the free spool on the mainline when the carriage is hauled-out with the haulback line in downhill or flat terrain yarding;
- Slow down for intermediate supports;
- Slow the carriage down smoothly as it approaches the choking position. Then proceed to stop the carriage;
- Stop the carriage slightly in front of, or above the timber to be choked in uphill yarding (Figure 141). In downhill yarding stop the carriage uphill from the timber to be choked so that the chokerman can pull the slack/chokers downhill towards the timber to be choked.

![Figure 141: Stop carriage uphill of timber in downhill operations](image)
Check the working cables for defects. If bad sections of wire rope or connections are encountered, stop immediately, rectify the problem and then continue;

Be alert to objects being dislodged and rolling down the slope in downhill yarding (Figure 142).

Figure 142: Be alert to dislodged objects

12.2.3 Safe practises for chokermen

During haul-out the chokermen should comply with the following:

- Give instructions (only the head chokerman) to the yarder operator regarding the position and the speed of the carriage as well as when it should be stopped;
- The head chokerman to instruct the yarder operator to stop the carriage slightly in front, or above the timber to be choked in uphill yarding, uphill form the timber to be choked, and in downhill yarding, so that the chokermen can pull the slack/chokers downhill towards the timber to be choked. If a radio-controlled carriage is used the head chokerman should stop the carriage himself (in the required position);
- Be aware of the danger area as the carriage stops, since chokers may be thrown forward. Keep at a safe distance;
- Comply with the applicable safety practises in Section 12.1.2;
- Check the working cables for defects. If bad sections of wire rope or connections are encountered, stop immediately, rectify the problem and then continue;
- Be alert to objects being dislodged and rolling down the slope.

12.2.4 Safe practises for the dechoker

During haul-out the dechoker should comply with the following:

- Give instructions to the yarder operator at the beginning of the cycle;
- Don’t stand or move within 4 m on either side of the skyline.

12.3 Choking

Choking involves attaching the log to the cable by means of chains. The following should be taken into account to ensure safe chocking of logs.

12.3.1 Common hazards

- The skyline may break thereby injuring workers;
- Dislodged objects may injure workers.
12.3.2 Safe practises for chokermen

During choking the chokermen should comply with the following:

- Give instructions to the cable yarder operator (only the head chokerman);
- Move into the danger area only when the carriage arrives back infield, is stationary and is instructed by the head chokerman to do so. Wait for the carriage to come to a definite stop and the chokers to fall to the ground before they are approached;
- Once the working cables are under tension, the chokermen should stay clear of all dangerous areas;
- Inspect the timber to be choked prior to taking the chokers out. This will decrease the choking time;
- Don’t stand directly under the carriage if not absolutely necessary to do so (Figure 143);

![Figure 143](image)

**Figure 143:** Don’t stand unnecessarily under the carriage

- Pick up the chokers and mainline and move away from the skyline as quickly as possible. When pulling out the mainline laterally, walk with the mainline cable between yourself and the downhill side (i.e. stay above the mainline);
- Approach and choke timber from the upper side, if practicable;
- Assume that if timber is lying in an unstable position or if the object that keeps it from rolling is not visible, that it may move at anytime (Figure 144). Approach such situations with extreme caution. Do not enter or work in the area below such timber;

![Figure 144](image)

**Figure 144:** Be aware of timber that could start rolling
• Ensure that the load size is proportional to the capacity of the yarding and the strength of the cables, as well as to the size of support trees, the effectiveness of anchors and to the available deflection;
• Don’t overload the cable yarding and gear. Unhook timber if the load is too heavy;
• Choke timber in a straight lead to the carriage. Zigzagging the mainline through sliders damages the mainline and sliders. It may also cause logs to move in unexpected directions. Keep zigzagging as close to the straight as possible (Figure 145);

![Figure 145: Choke in a straight lead](image)

• Always choke the timber lying on top first;
• Choke timber with the open side of the hook facing away from the direction of pull (Figure 146);

![Figure 146: Correct choking of timber](image)

• Ensure that chokers are properly secured before breaking out (if timber drops out during yarding it causes shock and extra stresses in all the rigging);
• Shorten up a long choker after break-out, or notify the yarding operator of the situation;
• Attach chokers as near as possible to the end of timber. In general, this distance should be approximately one metre. Where for practical reasons this is not possible and the timber could upend or swing, the chokerman should notify the other chokermen and the yarding operator;
• If timber is choked in the middle, instruct the yarder operator to break-out the load, stop and slacken the mainline, then rechoke the timber within 1 metre from the end. Then send in the turn;
• Check the working cables for defects. If bad sections of wire rope or connections are encountered, stop immediately, rectify the problem and then continue;
• Be alert to objects being dislodged and rolling down the slope;
• Comply with the applicable safety practises in Section 12.1.2.

RECOMMENDATION:
Pre-choke loads or use tag lines to ensure minimum carriage delay before break-out commences.

12.3.3 Safe practises for the yarder operator
During choking the cable yarder operator should comply with the following:
• Obey the instructions as given by the head chokerman;
• Be alert to objects being dislodged and rolling down the slope in downhill operations.

12.4 Break-out
Break-out is the initial movement of timber from the felled position.

12.4.1 Common hazards
• The yarder, intermediate supports and tailtrees may be pulled over or fail;
• Cables may fail or become loose;
• Swinging or upending timber may cause injury to workers;
• Siwashed cables may cause debris to fly through the air when cables are tensioned;
• Breaking-out timber with too much power or too fast can cause timber to break, sending broken tips, debris or chokers flying towards chokemen;
• Dislodged objects and moving timber may injure workers.

12.4.2 General safety
Take cognisance of the following during break-out:
• Whenever practical, break loads out at an angle of 45° to the skyline. Avoid breaking-out perpendicular to the skyline;
• When breaking-out loads laterally close to the yarder, intermediate supports or tailtrees, smaller loads than normal should be extracted with extreme caution. Lateral yarding will cause the skyline to deflect sideways into the direction of pull, which may cause excessive tension in the rigging. This could lead to the yarder, intermediate support or tailtree leaning or even falling over (Figure 147);

![Figure 147: Beware of pulling the yarder over when yarding heavy loads close to yarder](image)

• When yarding timber from an area where an intermediate support is present, extract as much timber from in front of the support as possible;

• When yarding around intermediate supports, tailtrees and their guylines, extreme caution is required to prevent interference with such intermediate supports, tailtrees and guylines;

• When yarding tree lengths around support trees, which may cause the support trees to break or be pulled over, cut the tree lengths into shorter lengths.

12.4.3 Safe practises for chokermen

Before signalling the break-out, the chokermen should comply with the following:

• Communicate special hazards to the yarder operator (e.g. rocky areas and/or gullies the load should move over; the proximity of the break-out to intermediate supports or tailtrees; loose boulders, stumps, etc. that may dislodge and roll or slide downhill towards the yarder in downhill yarding; critical points in the skyline profile that may affect the payload and the carriage speed over these points, gut-hooked timber that may cause problems going through intermediate supports and at the landing);

• Move into the clear where movement will not be restricted, preferably uphill of the load and the direction of pull. Remain on your feet, face the load and concentrate on the break-out;

• Comply with the applicable safety practises in Section 12.1.2;

• Move away from other timber that could be moved when the load is broken-out;

• Move out of reach of any timber swinging or upending. Refer to Section 12.1.2 for details;

• Be aware of objects rolling down the slope.
When signalling the break-out, the chokermen should comply with the following:

- The head chokerman to give the “go ahead” signal to break-out the load once everyone has a secure footing, the choker team is out of harm’s way, and you have a good position to observe the load from the time of break-out, it being locked in the carriage and until it is well on its way to the landing.

During the break-out, the chokermen should comply with the following:

- The head chokerman to communicate to the yarder operator when a load is fouled, investigate and take rectifying action. Ensure that the lines are slack before clearing the fouled load. If the haulback line is used to free a fouled load, take extreme caution not to exceed the safe working load of such line;
- Don’t stop the cycle (where practical) should timber fall from the load, rather send it with the next load;
- Ensure that the load is broken-out slowly until the load is under control.

12.4.4 Safe practises for the yarder operator

During the break-out, the yarder operator should comply with the following:

- Obey the instructions as given by the head chokerman;
- Ensure that the load is broken-out slowly (this will reduce shock loads) until the load is under control;
- Be alert to objects being dislodged and rolling down the slope in downhill operations.

12.4.5 Safe practises for the dechoker

During the break-out, the dechoker should comply with the following:

- Don’t stand within 10 m on either side of the skyline or in front of the yarder.

12.5 Haul-in

During the haul-in cycle, a load is brought to the landing.

12.5.1 Common hazards

- The yarder, intermediate supports and tailtrees may be pulled over or fail;
- Cables may fail or become loose;
- During haul-in, objects can slide or roll towards workers and equipment (Figure 148);

Figure 148: Be aware of dislodged objects
- At critical points in the yarding profile, loads coming in at too high a speed can hit high points, causing excessive shock to the wire ropes and yarder;
- Overloading wire ropes and rigging by yarding too big a load;
- The skyline drum brake, which enables the skyline drum to slip when the skyline safe working load is exceeded, has been disabled or set incorrectly;
- Where downhill yarding is undertaken, pay particular attention to overrunning loads (Figure 149). Provide an adequate distance between the slope and the cable yarder to ensure the safety of all.

![Figure 149: Cable yarder should be in a safe position](image)

### 12.5.2 General safety

Take cognisance of the following during haul-in:

- It is safer and more productive to yard lighter loads than to overload the rigging and the yarder;
- While yarding the first 30 m of a rack, the landing often becomes congested because of the short cycle times;
- Match the yarder’s production to that of the loader clearing the landing;
- No person is allowed to ride on a load or rigging. It is prohibited to hold onto moving loads, chokers or rigging;
- When yarding timber around intermediate supports, tailtrees and their guylines, extreme caution is required to prevent interference with such intermediate supports, tailtrees and guylines;
- Take special precautions with a gravity-return system. A Catch-A-Peti could be installed to keep the mainline permanently in the air (Figure 150).
12.5.3 Safe practises for chokermen

During haul-in, the chokermen should comply with the following:

- The head chokerman to signal the yarder operator to slow down as the load approaches the carriage;
- Comply with the applicable safety practises in Section 12.1.2;
- Watch the carriage approach intermediate supports, particularly when breaking-out close to support trees when the carriage is running skew to the load. If it is anticipated that the carriage will not pass the support jack, stop the carriage and re-assess the situation (e.g. drop the load, run the empty carriage through the support, then pull the load up into the carriage) and only then proceed;
- Check the passage of the carriage over the intermediate support. If it appears that the skyline is too slack for the carriage to pass the support jack, stop the carriage, drop the load, tension the skyline and then proceed (this is particularly necessary with long spans where the skyline brake may slip due to overloading of the skyline cable);
- Stop the yarder operator if a load is fouled onto a stump or any other obstacle. Instruct him to slacken the mainline, check that the load is stable, investigate, take rectifying action and then proceed with haul-in;
- Ensure that the skyline, mainline or haulback line is not overloaded when trying to free a fouled load, rather:
  - Move the carriage to a better position;
  - Unhook jammed timber;
  - Unhook extra timber, if the load is too heavy.
- Be aware of objects rolling down the slope;
- Start to pre-choke timber for the next load if it is safe to do so, and the load is well on the way.
12.5.4 Safe practises for the yarder operator

During haul-in, the yarder operator should comply with the following:
- Obey the instructions as given by the head chokerman;
- After the load has reached the carriage, accelerate the mainline smoothly to optimum speed without excessive bouncing of the load and the skyline;
- Slow the mainline speed as the carriage approaches and passes an intermediate support;
- Accelerate the carriage to its optimum speed again;
- Slow down the carriage as it approaches the landing;
- Stop the carriage at the landing on the instruction of the dechoker;
- Control the load by using the haulback line until the load is safely on the landing in downhill operations;
- Be alert to objects being dislodged and rolling down the slope in downhill operations.

12.5.5 Safe practises for the dechoker

During haul-in, the dechoker should comply with the following:
- Don’t stand within 4 m on either side of the skyline or in front of the yarder;
- Instruct the yarder operator to stop the carriage at the landing;
- Be alert to objects being dislodged and rolling down the slope in downhill operations;
- Be aware of the position of the all equipment and personnel on the landing.

12.6 Landing the load and dechoking

The dechoker is in control of the landing chute and should direct the loader and yarder operator’s activities. They should observe and obey the dechoker’s signals.

12.6.1 Common hazards

- Danger to workers on the landing due to incoming timber and cables;
- Gut-hooked timber may push other timber on the landing toward the dechoker or yarder. They could also be misjudged and land on the yarder;
- Landing a load onto a timber stack can be dangerous to dechoke, as it may roll sideways onto the dechoker or slide back infield;
- If the timber stack in front of the yarder gets too big, the incoming load may push timber into the yarder or toward the dechoker and loader;
- The dechoker may be injured by moving timber and equipment.

12.6.2 Safe practises for the dechoker

During dechoking and landing the load, the dechoker should comply with the following:
- Signal the yarder operator to lower the load if the yarder operator is unable to to see all equipment and personnel;
- Ensure that the load is safely landed, secured and that the cables are slack before the load is approached. Signal the yarder operator of the intent to dechoke the load. Ensure that the signal is acknowledged. Therefore, confirm with the yarder operator that it is safe to move in;
• Stop the operation if a dangerous situation is observed;
• Ensure that the yarder operator re-dumps the load if it has been dumped in a crossed or unsafe manner;
• Instruct the yarder operator to raise the chokers and part of the load if all the chokers can’t be reached safely. Move well into the clear before the yarder operator frees the chokers;
• Don’t get between timber or where it could roll onto you while dechoking;
• Don’t work under moving lines or directly in front of the yarder when the lines are under tension;
• Be aware of the loader clearing timber from the landing as the ends may swing through the dechoking area (**Figure 151**);

![Figure 151: Dechoker should be aware of the loader at all times](image)

• Instruct the loader operator as and when required;
• Watch out for loose shackles and pins in the rigging. Ensure that they are tight or are replaced when required;
• Take extreme caution when dechoking from a timber stack (i.e. when the yarder produces more that the unit clearing the landing);
• Don’t stand in front of the load being landed;
• Be alert to objects being dislodged and rolling down the slope in downhill operations;
• If a steep slope in front of the yarder exists and the timber can’t be contained in the landing chute, the timber should only be dechoked once it is prevented from sliding downhill by a loader, brow logs, log brakes or is tied to the yarder.
12.6.3 Safe practices for the yarder operator

During dechoking and landing the load, the yarder operator should comply with the following:

- Obey the instructions as given by the dechoker;
- Practice extreme caution when lowering a mix of short and long timber as short timber often land on one end and then fall in any direction when the load is further lowered to the ground (Figure 152). Therefore, lower the load to the ground further out from the landing, then drag it closer to the yarder, or the dechoker can direct the loader operator to grab short timber so that they are prevented from falling onto the yarder.

![Figure 152: Short logs can fall in any direction](image)

- Be aware of unevenly choked or gut-hooked timber that may stick out of the rest of the load. Lower the load further out from the landing, let the dechoker unhook the longer timber, then bring in the rest of the load;
- Lower the load to the ground in a controlled manner – don’t drop it;
- Don’t land the load while dechokers or loaders are working in the landing chute;
- Wait for the dechoker’s signal before chokers are raised to the carriage. Only do so once the dechoker has moved well into the clear;
- Ensure that a stable timber stack is built in cold-deck operations with no crossed over timber in the stack. Therefore, ensure that timber is correctly aligned in the pile*;
- Stop yarding if timber stacks become to high for safe dechoking.

12.6.4 Safe practises for the loader operator

During dechoking and landing the load, the loader operator should comply with the following:

- Obey the instructions as given by the dechoker;
- Don’t remove timber from the landing chute while the dechoker is dechoking;
- Don’t remove timber from the landing chute during break-out as the cables are under the most tension. The tower will most likely fall in this direction in the event of anchor or guyline failure. Clear the landing chute when signalled by the dechoker to do so. Removing timber from the chute is permissible while the empty carriage is returning infield, during the choking cycle or after the load is locked in the carriage and the carriage is on the haul-in cycle.

* See difference between hot and cold-deck situations in glossary.
12.6.5 Methods to prevent timber from sliding of the landing

If the slope in front of the yarder is very steep, timber can slide back when being landed. This situation often occurs with small yarders on steep terrain and small landings. The following methods can be helpful in these situations:

Brow logs

Brow logs consist of one or more logs chained to high stumps just below the landing. The load is yarded past the brow log(s) (Figure 153). When the lines are slackened, the timber rests against the brow log(s), preventing it from sliding back. This timber should be progressively removed.

Log brakes

A log brake is a device consisting of steel spikes on which the load is landed. The steel spikes prevent the load from sliding downhill (Figure 154).
12.7 Stacking of timber

Follow the following guidelines when stacking timber hauled by the yarer.

12.7.1 Common hazards

- Operators fail to ensure that personnel are in safe positions while timber is being moved, stacked or loaded;
- Operators fail to leave a gap between the loader’s tail swing and stacks or any other obstacle.

12.7.2 General safety

Take cognisance of the following:
- Ensure that stacks are built on firm level ground. Don’t built stacks on the edge of a fill;
- Take adequate measures to prevent stacks from collapsing or timber falling off the stacks;
- Use the excavated area adjacent to constructed landings, the area along the roadside or any other suitable areas for stacking;
- Don’t use a chainsaw on stockpiled, stacked or heaped timber.
13 Dismantling and moving procedures

The yarder tower may only be lowered by, or under the direction, of a competent and qualified person. The manufacturer’s safe working procedures should be adhered to. All personnel not directly engaged in the lowering should stay well clear during the operation. The person lowering the tower should ensure, beforehand, that the soil around the base of the yarder’s wheels or outriggers has not subsided, since it will cause the yarder to tilt dangerously when the tower is lowered. Therefore, ensure that the base of the yarder is and will remain level.

13.1 Dismantling procedure

When harvesting at a site has been completed, the yarder should be dismantled for transportation to a new site. The dismantling procedure will depend on the cable yarder system used.

**NOTE:**
The procedure described below is for a standing skyline with an intermediate support, tailtree and haulback line. Adapt the procedure accordingly if any other system is used, as not all of the procedures will be applicable.

Check the following for wear, cracks, damage, secureness and lubrication:
- The tower hinging mechanism;
- The tower raising and lowering mechanism.

The following is a suggested procedure for dismantling a yarder (it may be amended to suit a particular yarder):
- Attach any excess rigging in the stand to the carriage and haul the carriage back to the yarder with the mainline;
- Lower the skyline;
- Remove the carriage from the skyline;
- Disconnect the intermediate support jack, tailtree block and the skyline from its anchor;
- Wind in the skyline and remove any rigging attached to it. Also remove any rigging attached to the mainline;
- Disconnect the haulback line from the carriage and wind it in;
- Load the carriage onto the yarder or disconnect the mainline from the carriage and wind it in if the carriage is to be moved separately from the yarder;
- Lower the side supports (outriggers) to stabilise the yarder;
- Lift the central support;
- Disengage the tower guylines from their anchors and wind them in. Ensure that the guylines are wound correctly onto their drums;
- Lower the tower with the tower-lifting cylinder into the tower support;
- Fasten the rigging to the tower;
- Lift the side supports (outriggers).
13.2 Moving procedure

When moving the yarder from one landing to another, ensure that all working cables are wound onto their drums. Also ensure that the guylines are spooled onto the guyline winch drums, unless:

- The yarder is moved short distances i.e. on continuous roadside landings; **AND**
- The guylines are all swung to lay directly behind the travel direction, neatly in the lay; **AND**
- A competent person, who is communicating with the person moving the yarder, is supervising the move and watching the guylines trailing behind; **AND**
- The yarder is moved at a safe speed.
14 General safety rules

All work should adhere to the appropriate general safety rules laid out in the FESA *Guidelines for Forest Engineering Practices* (2013), as well as all prescriptions laid out in this chapter (which deal specifically with safety rules for cable yarding operations).

- Report all unsafe behaviour by anyone to the supervisor;
- Don’t allow untrained and unauthorised personnel to operate any equipment;
- Don’t allow an untrained team on-site, unless a fully trained and competent person accompanies them, and only after they have had a cable yarding induction course;
- Don’t allow anyone to climb onto equipment unless the operator has given approval;
- Suspend all yarding operations during adverse weather conditions (e.g. high wind, bad visibility or lightning);
- Ensure that the loader operator knows of each person working in his proximity, as his field of vision is usually limited;
- Don’t pass alongside trucks while they are being loaded as timber may be thrown over the load, fall off the load or roll from a stack;
- Situate rest facilities well clear of all landing work. Ensure that waste disposal facilities are available. Make provision for an area free of landing activities where chainsaws can be maintained and accessories stored;
- Assign a flagman to direct traffic should trees fall onto a public road;
- Notify the relevant power company when working in the proximity of power lines. Consult the relevant authority for the specific requirements applicable;
- Stacking under power lines is prohibited;
- Don’t guide cables onto drums with your hands or feet. Use a steel rod or any other recognised instrument and appropriate gloves.

14.1 Safe work practises on landings

- The yarder operator to obey signals given by the dechoker.
- Stop the operation when required for safety reasons, e.g.:
  - Faulty wire ropes;
  - People in the danger area;
  - Unauthorised people on, or near, the yarder whilst it is working;
  - Dangerous choking or dechoking of timber;
  - People under the skyline or in the danger area infield;
  - Any other dangerous situation.
- Do not discard off-cuts, reject logs, tops, etc. over the edge of the landing if workers are downhill from the landing. Such material may roll or slide downhill, or can be knocked off the edge of the landing by incoming loads.
- All landing workers to use safe positions on the landing;
- Do not cross-cut or debranch timber in the landing chute under moving and/or tensioned cables. This may only be done in emergencies after both the yarder and loader operator have been notified of the emergency;
• Do not lift timber or any other material over the heads of workers on the landing (Figure 155);

Figure 155: Do not lift any material over other people

• Ensure that all personnel are in safe positions when timber is moved, stacked or loaded;
• Ensure that a gap of approximately one metre is left between the loader’s tail swing and any timber stack or obstacle;
• Use recognised signals to signal equipment operators;
• Workers to get the operator’s permission before entering the working circle of a loader;
• The loader or processor unit clearing in front of the yarder has right of way on the landing. Everyone working on the landing should be aware of this;
• Provide sufficient illumination if flat terrain yarding is performed during hours of darkness. It should allow for the operation to be safe. The source of illumination should be located and directed so as to create the minimum of shadows and glare. If a portable tailhold is used, the lights should be directed on the equipment to allow the person to visually ascertain that the equipment remains stable;
• Ensure that tower guylines are visible (e.g. tie or wrap tape around them).
• Transport vehicles are not allowed to travel under tower guylines unless:
  ▪ They are guided through by a team member; AND
  ▪ Sufficient clearance is provided for such vehicle.

14.2 Equipment safety

• An approved and inspected fire extinguisher should be provided at locations where equipment is used;
• Fuel should be stored in approved, well-marked containers, located at a safe distance from all fire hazards and where they can be safely accessed by vehicles and equipment that need to be refuelled;
• Don’t refuel equipment while the engine is running;
• Equipment operators should ground or secure all movable parts when these are not in use;
• Equipment operators should shut down the engine when the equipment has stopped and apply brake locks (if fitted);
• Equipment operators should ensure that when equipment is transported from one location to another, that the transport vehicle is of sufficient rated capacity and that the equipment is properly secured;
Follow the correct lock-out procedures;

• Equipment should be kept free of any material that could cause slips and falls;

• Equipment should be kept free of flammable material;

• Safe means of access to all yorder and winch controls should be provided for the operator;

• Suitable guards should be fitted to protect the operator from ropes, broken shackles, or other equipment that may break while in use. Guards should also be provided for exposed moving parts. They should be in place at all times while the equipment is in operation;

• The pedal of any brake or other mechanism operated by foot should have a non-slip surface or be fitted with a non-slip pad;

• Exhaust pipes should be located or insulated in such a way that workers will be protected from accidental contact with the pipes or mufflers, and so that exhaust gases will be directed away from the operator and other workers;

• All cable yarders should be fitted with a skyline drum release mechanism (free-spooling mechanism) that provides instantaneous release in an emergency;

• All cable yarders used for live skyline operations should have an efficient skyline brake with a facility for releasing tension (slip) in an overloaded situation. Structural modifications or additions, which affect the capacity or safe operation of cable yarders, should be made only under the direction of the manufacturer or a registered engineer who should ensure that in no case will the original safety factor of the equipment be reduced;

• An operator’s manual or operating instructions should be supplied with each machine. It will describe operational, maintenance and safe practices.

NOTE:

Training should be provided by the manufacturer or a recognised training institution when cable yarders are purchased, thereby ensuring that all limitations are known and that the purchaser has a sound and safe understanding of cable yarding.

### 14.3 Additional rigging safety

- Where gear ratios or other devices have been installed to increase the line pull, the size of the rigging should be increased accordingly, so that it will safely withstand the increased strains;

- Rigging should be arranged and operated so that it, as well as the load, will not foul or saw against lines, straps, blocks or other equipment/material.

### 14.4 Personal protective equipment (PPE)

- Personal protective equipment should be maintained in a safe and effective condition or be removed from service;

- Upper body cover should be of a high-visibility colour, which contrasts with the background to enable equipment operators to readily see the person wearing it;

- Footwear should consists of ankle boots with a steel toe-cap. The sole should provide good grip;

- Gloves or other suitable hand protection should be worn whenever chains or wire ropes are handled;

- Wear the appropriate protective clothing for the task at hand;

- Wear appropriate dust mask when working in very dusty situations, as required;

- Wear hand, eye and face protection when cutting wire rope with a hammer type or scissors type wire rope cutter.
15 Communications

In South Africa, hand signals and voice radio signals are most commonly used to control cable yarding operations. Voice radio signals are normally not accompanied by radio whistle signals as is the international practice.

VHF (Very High Frequency) radio whistle signals (sound signals) are typically used internationally, but are prohibitively expensive. The radio whistle system consists of radio transmitters, usually worn around the waist that activates a “whistle” (loud air horn) on the yarder when a transmitter button is pushed. Each movement of a line has a specific audible whistle signal (consisting of a combination of long and short blasts on the air horn) that sounds out over the whole work area, so that all personnel in the area can hear what cable is to be moved. Where voice radio signals are used internationally, they are normally accompanied by a whistle signal (i.e. the voice radio signal is given by the head chokerman and the command is repeated by the yarder operator who manually activates the air horn in the yarder with the corresponding combination of short and long blasts before the line is moved).

15.1 General rules

No matter what signalling system is used, the following general rules should be adhered to:

- Only one chokerman, normally the head chokerman, may give signals to the yarder operator;
- Any worker may give the emergency signal;
- Signals should be standardised, understood by all workers and posted in the yarder;
- Signalling the yarder operator, or any other member, by throwing sticks, etc. in the air is prohibited;
- The yarder operator should not move any cable before receiving a signal;
- The yarder operator should not move any cable if a signal is unclear and/or not understood. If in doubt, the operator should repeat the signal, as he understands it, and wait for confirmation from the signaller;
- The yarder operator should ensure that correct signals are adhered to and poor signalling is reported to the supervisor;
- The head chokerman should ensure all chokerman are in the clear before signalling the yarder operator.

15.2 Communication signals

Use the following communication signals

15.2.1 Hand Signals

Hand signals may be used at any time as an emergency signal. Hand signals may only be used to control a cable yarding operation if:

- The signallers are within 100 m of one another and clearly visible. The signaller closest to the yarder operator should also be within 100 m from the yarder operator;
- If intermediate signallers are used, between the yarder operator and the head chokerman giving the original signal, they should signal quickly, concisely and almost simultaneously with the head chokerman;
- When poor visibility occurs (e.g. in thick mist or heavy rain) yarding shall cease until visibility improves.
15.2.2 Voice radio signals

Where voice radio signals are used they should comply with the following:

- Dedicated channels should be used and the channel should be such that it can’t be switched accidentally;
- Ensure that nobody else is using the same frequency in the vicinity.
- If radio block-out or interference occurs, or voice signals become inaudible and not clearly understood all yarding should cease or an alternative signalling system used;
- Test the system daily before yarding commences;
- Use only radio channels in simplex mode (not through repeaters).

15.2.3 VHF radio whistle signals (sound signals)

Where radio whistle signals are used they should comply with the following:

- Radios should be licensed and the frequencies approved by the local radio licensing authority;
- If radio block-out or interference occurs, or sound signals become inaudible and not clearly understood all yarding should cease or an alternative signalling system used;
- Test the system daily before yarding commences;
- At least two members of the choking team shall carry transmitters, except if the team consists of only one person.
16 References and general reading


DE LABORDE, R.M. Cable yarding in Southern Africa: An analysis of its productivity and possible procedures for its improvement. Institute for Commercial Forestry Research, P.O. Box 375, Pietermaritzburg, 3200, South Africa.


ERASMUS, D., 1994. National Terrain Classification System for Forestry. Institute for Commercial Forestry Research, P.O. Box 375, Pietermaritzburg, 3200, South Africa.


STUDIER, D., 1993. *Carriages for skylines.* Forest Research Laboratory, College of Forestry, Oregon State University, Oregon 97310, USA


17 Glossary

A
Anchor: Any stump, tree, deadman, timber bundle, equipment, rock or any other acceptable device to which a skyline, guyline or haulback line block is attached.

Anchor tree: A standing tree used as an anchor.

B
Back end: The furthest point away from a landing or yarder in a setting.

Bight: A hazardous zone contained within lines, either slack or under tension. The area is made dangerous when a slack cable is tensioned. An unintentional bend or deviation in the lines caused by trees, stumps, or other obstacles preventing the line from running straight. The angle formed by a line passing through a block or around any obstacle.

Blind lead: The situation where the line of sight from the tower to the tailtree/tailhold is obstructed by an intermediate ridge or convex slope.

Block: A metal case enclosing one or more sheaves to facilitate a change of direction of a wire rope, or to gain a mechanical advantage in transmission of power through a wire rope.

Break-out: The initial movement of timber from the felled position during extraction.

Breaking strength (BS): The greatest loading that a rope can withstand without breaking.

Butt: The large end of a felled tree or log.

Buttrigging: A system of swivels, shackles and chains that connects the haulback line and mainline, and to which the chokers are attached.

C
Cable clamp: An U-bolt cable connector (e.g. Crosby clamp).

Cable yarding: An extraction system employing a stationary machine with winches, tower, blocks and wire ropes to extract timber from the felling site to a landing.

Capstan: A powered spool, designed to pull a wire rope by means of friction.

Carriage: A load-bearing device that travels freely on sheaves running on a wire rope for the extraction of timber.

Catch-a-Peti: A simple construction consisting of two sheaves set between two metal plates. This device is designed to keep the mainline off the ground and out of the working area in front of the yarder.

Chain and Board: A graphic method of calculating the skyline load path and deflection, by pinning a length of light chain to a drawing board covered with grid paper.

Choke: To wrap a choker around felled timber and pull it tight prior to yarding.

Choker: Short length of wire rope, chain, or synthetic rope, fitted with hooks, etc., or other connecting devices, which forms a noose round the end of felled timber to be extracted. It is used to connect felled timber to the main extraction cable.

Choker chain: See choker.

Chokerman: A person who sets chokers under the direction of the head chokerman.

Chord: Straight line between points of support of a cable yarder.
Clearfell: To fell and extract an entire compartment.
Clearance: The minimum vertical distance between a loaded skyline and the ground.
Climbing irons: Strap-on metal spikes to enable a rigger to climb a standing tree.
Cold-deck: Pile of logs for later transportation when harvesting/yarding are done.
Compartment: Numbered sub-division of a plantation.
Clinometer: A hand-held instrument for measuring angles of a slope.
Core: The centre strand of a wire rope.
Corridor: A straight cleared extraction strip.
Crosscut: To cut timber across the grain, hence, to cut trees into logs.

D
D.b.h.: Tree diameter at breast height.
Deadman: A solid object, usually a log, buried in the ground to form an anchor.
Dechoker: A person who unhooks chokers at a landing. Also known as a chaser.
Deflection: The vertical distance between the chord and the skyline at mid-span.
Downhill yarding: Extracting a load downhill.
Drum: A spool on which a wire rope is wound.

E
Elastic limit: The tension limit of wire rope whereby it will return to its original length after the tension is released.
Equaliser block: A block used to distribute a load equally between anchor points.
Extension: A rope joined to another rope to increase its length.
Extraction: General term for removing timber from a felling area to a landing or a road.
Eye: A loop at the end of a rope.
Eye splice: A loop formed by bending a rope’s end back and splicing it into the line.

F
Factor of safety: See “Safety Factor”.
Fairlead: A device containing sheaves or rollers used to guide a moving rope onto a drum so that it would spool evenly.
Fallblock: A heavy block, generally balanced so that most of its weight is at the bottom. It rides in the loop of the mainline.
Fell: To cut-down standing trees in a pre-determined and controlled manner.
Feller buncher: A self-propelled machine designed to fell and bunch trees.
Felling wedge: See “Wedge”.
Flange: Side-wall or rim of a drum, wheel or sheave.
Fouled: Rope or load caught behind an obstruction.
Full suspension: See “Suspension, Full”.
Gravity return: See “Shotgun system”.

Guyline: A length of wire rope or synthetic rope, attached to near the top of a tree, tower, etc. at one end, and to an anchor at the other end. The purpose of a guyline is to hold the tower, tree, etc. upright against the forces imposed on it. A load-bearing guyline is a guyline that supports the support jack and skyline at an intermediate support. A support guyline is a guyline that doesn’t support the support jack and skyline at an intermediate support.

Hammerlock: Device for connecting chains.

Hard hat: Headgear designed to protect the wearer’s head.

Haul: To extract timber with a cable yarder from infield to the landing.

Haulback line: A wire rope used to return the mainline and buttrigging or carriage to the breaking-out point.

Haulback line block: A block through which the haulback line runs.

Head chokerman: The person who directs the chokermen.

Highlead: A simple cable yarding system that extracts timber using two working cables, namely the haulback line and the mainline. Differs from other cable yarding systems as it is a ground lead system except that lift is provided to the logs by the height of the tower as the logs approach the landing.

Hot-deck: Pile of logs from which logs are hauled as soon as they are yarded.

Intermediate support: A device rigged to support a skyline in order to maintain clearance over an obstacle or convex ground.

IWRC: Independent Wire Rope Core

Kink: A sharp bend in a wire rope.

Landing: A selected or prepared area to which timber is extracted and where it may be sorted, processed, loaded or stacked.

Lang’s Lay: Wire rope in which the individual wires are wound in the same direction as the strands.

Lateral yarding: The initial breaking-out and movement of timber to the corridor.

Lay: (Of wire rope) Describes the direction strands of a wire rope are wound about the core.

Lead: The alignment of wire rope with blocks, etc.

Lean: (Of tree) The inclination of a tree from the perpendicular.

Lift: The amount of vertical lifting ability in a system to carry timber over obstructions.

Line pull: The pulling force exerted on a wire rope from a drum, usually measured when the drum is half-full expressed in kilograms, tonnes or Newton.
Line speed: The speed a wire rope travels while being wound onto a drum (measured in metres per minute when the drum is half full).

Live skyline: Live skylines have one end of the skyline cable fixed and the other attached to a winch drum so that it can be raised or lowered as required.

Load: i. Force applied to a wire rope.

ii. Refers to the amount of timber that is extracted to the landing in each cycle.

Loader: Machine designed to load, stack and sort timber.

Long splices: A splice, approximately 15 m long, used to join lines. It passes through blocks easily because it does not increase line diameter.

M
Mainline: Primary yarding cable used to pull loads from stump to landing.

Mid-choked: Timber that is choked close to the middle, as opposed to the end.

Midspan: Half the distance on the chord between the yarder and the tailhold.

Molly: A single strand of wire rope wrapped around in the lay of the strand a number of times to form a loop. It is normally used to prevent pins and bolts from unscrewing. The strand is taken through the hole in the pin and is then turned into a molly.

Monocable: A cable system in which an endless operating line is driven by a capstan winch.

Motor-manual: Refers to work carried out by hand-held power tools.

Multi-span: Skyline having one or more intermediate supports.

N
North Bend: A skyline system where the mainline runs through a fallblock and is connected to the skyline carriage. Buttrigging is attached to the fallblock and the haulback line is attached to the buttrigging.

Notch: Groove cut into a stump to prevent a rope slipping off.

O
Operating ropes: Moving ropes which are hauled-in or out.

Over-run: Where rope being spooled off a drum is allowed to go slack. Often results in a bird’s nest.

Overwound: Rope spooled on or wound off the top of a drum.

Out of lead: When sheaves are out of alignment or lines will not spool properly onto a drum.

P
Partial suspension: See “Suspension, partial”.

Pass chain: A chain that is used to pull or hold a rope.

Pawl: A stopping device or ratchet to prevent a drum from slipping.

Pre-choke: To attach chokers to timber while the previous load is being extracted.

Pre-rig: Rigging a rack before the yarding team shifts.
R

Rack: The total area that will be harvested with the cable yarder remaining in one position.

Regular Lay: Regular lay wire rope is made with the wires in each strand laid in the opposite direction to that of the strands in the wire rope.

Rigging: (noun): Equipment used in setting up a cable system, e.g. blocks, chains, ropes, etc.
(verb): To prepare a tree or tower for yarding by guying and anchoring it, as well as attaching all the other rigging equipment required (e.g. blocks, straps, etc.).

Rigger: A person who installs rigging.

Rope: (Synonym: line) Normally a wire rope, but can be synthetic.

Running ropes: Moving ropes which are wound in or out during yarding.

Running skyline: This is a cable yarding system where a carriage rides on the haulback line which, when tensioned against the mainline, provides lift for the carriage and its load.

S

Safe Working Load (SWL): Calculated permissible load that can be applied to a component.

Shackle: A U-shaped metal connector, having a removable pin or threaded bolt through its ends, used on rigging, blocks, straps, etc.

Sheave: The flanged wheel or pulley of a block that wire rope runs over.

Shovel yarder: A converted excavator based yarder that does not need guylines and can selfstand.

Shotgun system: An uphill cable yarding system using only two lines. The carriage is returned by gravity.

Siwashed: An unintentional bight in a line caused by stumps or other objects, preventing the line from running straight. A line not running in a straight line by being bent around a tree, stump or rock.

Skyline: A wire rope extended between the yarder and the tailhold which provides lift and on which the carriage travels.

Slack: Section of wire rope that is free of tension.

Slackpulling carriage: Carriage designed to feed out slack to facilitate breaking-out or to pull laterally a distance from the corridor.

Slackpulling line: The line that passes through a slack-pulling carriage that allows for lateral yarding.

Snagged: See “Fouled”.

Snapline: A guyline in the front of the yarder that prevents the yarder from falling back when the skyline breaks.

Span: The distance between two supports (tower, tail support or tailhold) that suspends the skyline.

Splice: (noun): Section of rope woven into another piece of rope to form a splice, or back into itself to form an eye.
(verb): To join ends of wire rope by interweaving strands.

Split-level landing: The landing is stepped as a means of reducing the excavation necessary. The yarder is sited on the higher level and timber is landed on the lower level.

Standing skyline: The skyline cable is fixed at both ends. The skyline cable is not moved during the cycle.
| **Strand:** | A component part of a wire rope consisting of wires wound spirally together, which is then helically laid with other strands, around a core, to form the rope. |
| **Strap:** | A short length of wire rope or synthetic rope with an eye in each end, used to hang a block. |
| **Strawline:** | A light wire rope, which is usually taken out by hand and is then used for setting up operating ropes. |
| **Support jack:** | A hanger device used to support a skyline at intermediate supports. |
| **Suspension:** | **Full:** Timber is lifted completely of the ground in a yarding system, and remains off the ground during the haul-in section of the cycle.  
**Partial:** Timber is dragged on the ground with a portion of it always in contact with the ground during the haul-in section of the cycle. |
| **Support tree:** | Tree on which an intermediate support is rigged. |
| **Swaged wire rope:** | Wire rope that has been reduced one size in diameter by a pounding action to replace the same nominal sized wire rope but having a greater strength. This wire rope appears to be normal wire rope that is evenly worn. |

**T**

| **Tailhold:** | The object to which a haulback line block (at the back end) is fastened, or the object to which the end of a skyline is anchored. |
| **Tailtree:** | A rigged tree, at the back end, to provide lift for a skyline. |
| **Tensile strength (grade):** | Strength rating of steel. Used in description of wire ropes. |
| **Thimble:** | A metal ring formed with a grooved outer edge so that it fits within an eye splice to maintain its shape and protect the rope. |
| **Thinning:** | Felling selected trees in a stand to a prescribed pattern. |
| **Timber:** | A stem or a length of a stem, after felling or crosscutting. |
| **Tower:** | A portable steel mast, usually part of a cable yarder. |
| **Tree plate:** | A steel plate with a hook at the bottom, spiked to a tree at the point where guylines and straps are hung, designed to prevent ropes cutting into the wood. |
| **Turn:** | One or more logs that are yarded to the landing at one time. |

**U**

| **Upend:** | To cause timber to flip end from end by coming in contact with a stationary object. Uphill yarding: Extracting the load uphill. |
| **Underwound:** | Rope wound on or wound off the bottom of a drum. |

**W**

| **Working Load Limit (WLL):** | See Safe Working Load. |
| **Wedge:** | Tapered plastic or metal tool, which is driven into the felling cut to prevent a tree from sitting back, or to lever it towards the desired felling direction. |