



LOAD  
RESTRAINT  
GUIDE  
2025



## Load Restraint Guide 2025

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# **LOAD RESTRAINT GUIDE**

**2025**

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# LOADING PERFORMANCE STANDARDS

- (1) A load on a heavy vehicle must be restrained by a load restraint system that:
- (a) prevents the load from moving in relation to the heavy vehicle (other than movement allowed under subsection (2)) in the circumstances mentioned in subsection (3); and
  - (b) at a minimum, is capable of withstanding the forces that would result in the circumstances mentioned in subsection (3).
- (2) A load may move in relation to a heavy vehicle if:
- (a) the vehicle's stability and weight distribution are not adversely affected by the movement; and
  - (b) the load does not become dislodged from the vehicle.

Examples of load movement that may be permitted under (2)

- load contained within the sides or enclosure of the heavy vehicle that is restrained from moving horizontally may be able to move vertically;
  - a load of very light objects, or a loose bulk load, that is contained within the sides or enclosure of the heavy vehicle may be able to move horizontally and vertically;
  - a bulk liquid load contained within the sides or enclosure of the heavy vehicle.
- (3) For subsection (1), the circumstances are that the loaded vehicle is subjected to:
- (a) any of the following, separately:
    - (i) 0.8 g deceleration in a forward direction;
    - (ii) 0.5 g deceleration in a rearward direction;
    - (iii) 0.5 g acceleration in a lateral direction; and
  - (b) if friction or limited vertical displacement is relied on to comply with (a)-0.2g acceleration in a vertical direction relative to the load.

# INTRODUCTION

## HOW TO USE THIS GUIDE

The **Load Restraint Guide** is a flexible resource, designed with 6 independent modules. You can refer to each module separately, but where necessary, the guide will direct you to additional modules for more information.

Here's a breakdown of the 6 modules:

1. **Overview** – This section covers the essentials of load restraint, including why loads need to be restrained, what your legal obligations are, load restraint methods, and key elements that make up a load restraint system.
2. **Loads** – Provides guidance on restraining specific load types like flat loads, sheets, bales, bags, and sacks.
3. **Vehicles and Equipment** – Focuses on standard vehicle structures and the equipment used for securing loads.
4. **Working Out Load Restraint** – Offers examples of specific cases to help calculate the amount of restraint required.
5. **Certification** – Explains the importance of certifying a load restraint system, who should certify it, and includes a template for certifiers.
6. **Technical Advice** – Contains more detailed information on load restraint calculations, aimed primarily at engineers and designers but open to anyone seeking deeper understanding.

In addition to the modules, the guide includes 8 appendices:

1. **Glossary** of key terms
2. List of **relevant standards**
3. List of **relevant legislation and publications**
4. Contact information for **Commonwealth, state, and territory regulatory authorities**
5. Contact information for **competent authorities in road transport of dangerous goods**
6. Tables for the **number of tie-down lashings based on equipment and friction levels**
7. Tables for **minimum lashing capacity for direct restraint**
8. An **index**.

### About this guide

A load restraint system is required to be able to withstand forces specified in the **Performance Standards**.

The Load Restraint Guide provides examples of how to restrain loads to meet those forces.

It is intended to be used as a **guide only**, as it is impossible to be prescriptive for the many different types, weights and shapes of loads that can be transported.

### Getting started

To work out how best to restrain a particular load:

- **Run through the steps** that make up the **key elements** of a load restraint system in the Overview module.
- **Check the Loads module** to find advice for your specific load type.
- **Check Vehicles and equipment** to be sure you're using everything safely and efficiently.
- **Look at the worked examples** in Working out load restraint.

# OVERVIEW

The Overview module covers the important load restraint information you need to get started, including:

- why you need to restrain the load
- what your legal obligations are
- the 10 steps that make up the key elements of a load restraint system, including a checklist that can be used to tick off each step
- a high-level overview of the different load restraint methods.

**If you perform or are responsible for any packing, loading or load restraint tasks, you should be familiar with all the information in this module.**

## HOW TO USE THIS MODULE

**Read through the Overview** to develop your general understanding of load restraint.

Once you understand all the information in this module, **use the [10 steps checklist](#)** every time you're creating a new load restraint system.

# WHY DO I NEED TO RESTRAIN MY LOAD?

## To be safe

- Loads that aren't restrained properly can injure or kill and can cause significant property damage.
  - If the load falls off it **endangers the lives of other road users** through a direct collision or by causing other drivers to swerve to avoid it.
  - If the load moves forwards it can **pierce the cabin and injure or kill the driver or passenger**.
  - If the load makes the vehicle unstable it can **cause an incident**, especially when taking corners.

## It's good for business

- Your corporate reputation and your financial position can suffer if you're involved in a load restraint incident due to:
  - adverse publicity
  - loss of contracts due to damaged goods
  - insurance excess payments
  - increase in insurance premiums.

## Unrestrained loads may move

- Forces from changes in speed, direction or slope may cause a load to shift.
- These forces result from normal driving conditions including braking, accelerating, cornering, road surfaces and air flow.
- **The weight of a load is not enough to hold it in place.**
  - A heavy load is just as likely to fall off as a light load because the heavier the load, the higher the forces it experiences.

## To comply with the law

If you're involved in **packing, loading, moving or unloading a vehicle**, you are responsible for complying with load restraint laws.

### Causes of load movement

Just like any unrestrained person in a vehicle, loads can move forwards, backwards, sideways and upwards:

- **Forward shifts** are caused by:
  - braking while driving forward,
  - accelerating in reverse, downhill slopes.
- **Backward shifts** are caused by:
  - braking in reverse, accelerating forward, uphill slopes.
- **Sideways shifts** are caused by:
  - cornering, cambered roads.
- **Upward shifts** are caused by:
  - uneven road surfaces.

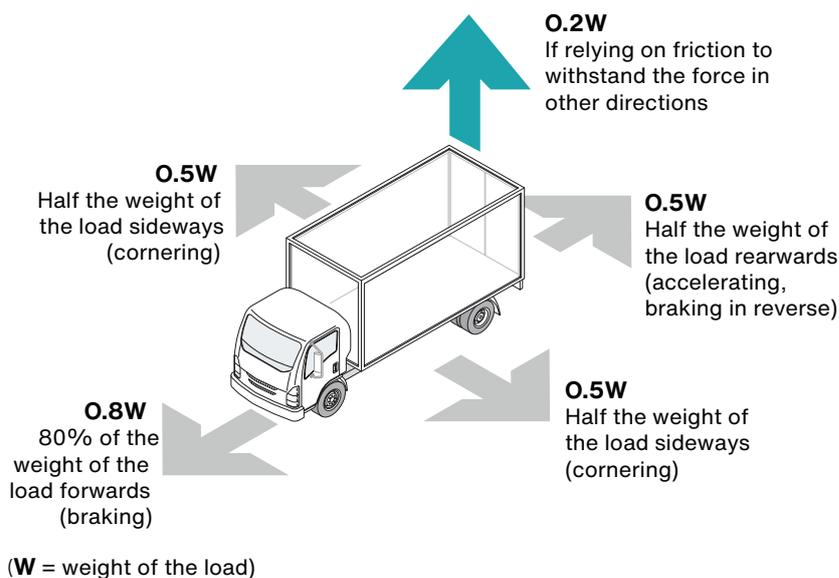
# KNOW YOUR LEGAL OBLIGATIONS

## Rules on load restraint

- You are legally responsible for restraining your load so that:
  - **It does not come off your vehicle under normal driving conditions**, including heavy braking and minor collisions. If it comes off, this is evidence you have breached the law.
  - **It does not negatively affect the stability of the vehicle**, which can cause the vehicle to roll over or swerve uncontrollably, and cause an accident.
  - **It does not stick out of the vehicle** in a way that could injure people, damage property or obstruct others' paths.
- **You must pick up any fallen load** if it is safe to do so, or arrange for someone to retrieve it.

## The law sets out Performance Standards for load restraint

- The [Loading Performance Standards](#) (Performance Standards) set out the minimum amount of force a restraint system must be able to withstand in each direction. For heavy vehicles, these forces are:



- If a load is restrained to meet the Performance Standards it will not fall off or affect the stability of the vehicle under expected driving conditions. This includes emergency braking and minor collisions.

### Want to know more?

The [Technical advice](#) module includes more information on the [Performance Standards](#), including how to apply them when designing a load restraint system.

## You can choose how to restrain your load to meet these standards

- The [Loading Performance Standards](#) define the required performance of a load restraint system, but do not specify how to achieve it.
- This guide provides general information about choosing, designing or using a load restraint system suitable for a load.
- Alternative load restraint methods can be used as long it meets the loading requirements. To assure yourself, it is good practice to determine if it meets the Loading Performance Standards. The best way to ensure this is to have the restraint system certified by a suitably qualified engineer ([Certification](#)).

## Everyone shares the responsibility for safety and compliance

- The *Heavy Vehicle National Law* (HVNL) includes provisions that make all parties in the Chain of Responsibility (CoR) responsible for the safety of transport activities related to the use of heavy vehicles throughout the entire supply chain including packing, loading and load restraint (equivalent provisions apply in WA and NT).
- Any CoR party (including an individual or corporation) who can control or influence transport activities, must ensure, so as far as is reasonably practicable, the safety of their transport activities. This includes implementing safe systems and practices that reduce or remove risks and do not cause or encourage HVNL breaches.
  - As a minimum, systems should include methods to identify, assess, control, monitor, review and remedy potentially unsafe situations or situations that could result in unsafe loading practices or load restraint system failures.
- Every party in the CoR must satisfy themselves that the vehicle, load and driver are safe and compliant with the HVNL loading requirements.

## Employers and workers have a duty of care to ensure the work environment is safe

- Work health and safety legislation sets out the key principles, duties and rights in relation to workplace health and safety.
- As an **employer (or person conducting a business or undertaking)** you must provide a safe and healthy workplace for your workers and contractors. This includes:
  - providing and maintaining safe equipment and safe systems of work (including loading and unloading)
  - maintaining the workplace in a safe condition
  - making sure workers have adequate information, instruction, training and supervision to work in a safe and healthy manner.
- As a **worker** you have a duty of care to make sure you work in a manner that is not harmful to your health and safety or the health and safety of others.
- SafeWork Australia can advise you on work and health and safety obligations.

## Who has committed an offence?

Any party in the CoR with control or influence over the activity that fails to ensure safety so far as is reasonably practicable can be held responsible for breach of primary duty. This includes:

- an **employer** of a heavy vehicle driver
- a **prime contractor** who engages a self-employed driver of a heavy vehicle under a contract for services
- an **operator** who directs the control and use of a heavy vehicle
- a **scheduler** for loaded goods
- a **consignor** of any loaded goods
- a **packer** of any loaded goods
- a **loading manager** of a premises
- a **loader** of any goods on a heavy vehicle
- an **unloader** of any goods on a heavy vehicle.

## Remember:

- More than one CoR Party can have the same duty.
- You cannot rely on any other CoR party to 'make the checks', or manage the risks on your behalf. You must ensure the safety of all transport activities you have control or influence over.

# WHAT ARE THE KEY ELEMENTS OF A LOAD RESTRAINT SYSTEM?

## There are 10 steps to follow when restraining a load

### Planning the load

1. Understand the load.
2. Choose a suitable vehicle for the load type and size.
3. Use a restraint system that is suitable for the load.
4. Position the load to maintain vehicle stability, steering and braking.
5. Check the vehicle structures and restraint equipment are in good working condition and strong enough to restrain the load.

### Loading (and unloading) the vehicle

6. Make sure the load is stabilised.
7. Make sure you understand and use safe work practices when loading and unloading a vehicle.
8. Make sure there is enough restraint to keep you and others safe.

### Driving according to the load and driving conditions

9. Allow for changes in vehicle stability, steering and braking when driving a loaded vehicle.
10. Check the load and its restraint regularly during the journey.

More information on these steps is detailed in the pages that follow. Once you've gone through each step in detail, use the checklist at the end of this module to make sure you don't miss a step.

### Alternatives to using this guide

You can use alternative load restraint methods provided you can show that they meet the Performance Standards. The best way to do this is to get your restraint system certified by a qualified engineer ([Certification](#)).

# PLANNING THE LOAD

## Step 1: Understand the load

- ✓ Think about the load to be transported.  
What are the load's characteristics:
  - weight
  - dimension
  - centre of gravity
  - crushable/fragile loads
  - wheels
  - friction levels
  - packaging or unitisation
  - any other important or unique features.
  
- ✓ Undertake a risk assessment on the load, keeping in mind its specific characteristics, and plan to mitigate any risks.  
  
For example, if the precise weight of the load is unknown, you could:
  - under-load for the first trip and verify the weight at some stage of the journey if the vehicle's weight cannot be accurately assessed at the time of loading.
  - fit scales to loading equipment and keep a "running" total of the weight of the load for each trip.

## Step 2: Choose a suitable vehicle for the load type and size

- ✓ Check the vehicle's load carrying capacity.

The vehicle should have adequate load capacity and sufficient space for the load.

- ✗ Do not allow the load to overhang.

If the load is long, the vehicle needs to be long enough to avoid excessive overhang. Excessive overhangs will affect the steering capacity, swept path and stability of your vehicle.

- ✓ Check the overall height of the load.

The overall height of a loaded vehicle must be safely lower than the height of any obstruction on your journey (such as a bridge or overhead wires).

- ✓ Choose a vehicle that gives the roll stability the load needs.

Loads with a **high centre of mass are less stable and increase the risk of vehicle rollover**. Such loads should be carried on a vehicle with a low platform height (for example, drop frame trailer or low loader) or on a vehicle with good roll stability.

Vehicles carrying [liquids](#) and [loose bulk materials](#) should be designed to completely contain the load and to minimise the effect of load movement on vehicle stability. Large tanks should be adequately baffled if not almost full or empty when transported.

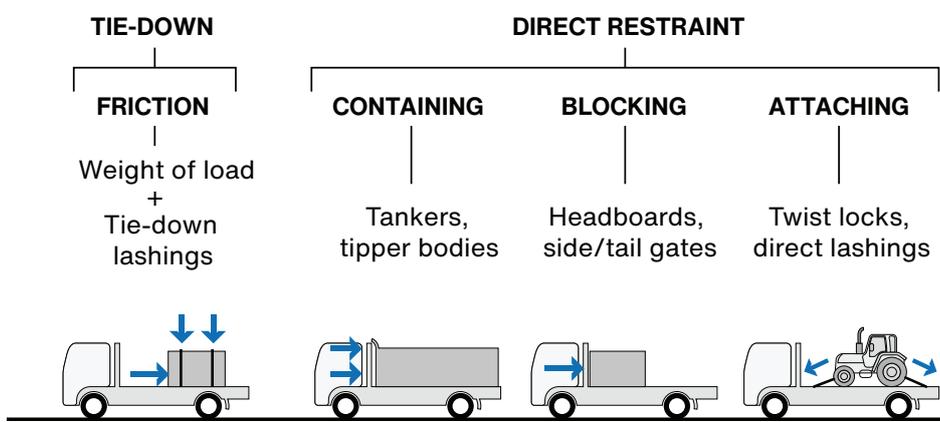
## Step 3: Use a restraint system that is suitable for the load

- ✓ Choose the restraint method that is most suitable given the load and vehicle.

Loads can be restrained by 2 basic methods: **tie-down** or **direct restraint (i.e. containing, blocking and attaching)**.

The following diagram shows the different restraint methods for controlling load movement in the forward direction. The same principles apply to backward and sideways movement.

Figure 1 Different restraint methods



- i** A combination of different restraint methods can be used and in some cases may be necessary to meet the Performance Standards.
- ✓ Make sure enough lashings are used with sufficient capacity if using the tie-down restraint method.  
Consider the weight of the load, whether the load is blocked or unblocked and the amount of friction between the surfaces of the load and the vehicle deck.
- ✓ Use a direct restraint method for loads that are difficult to tie down.  
Using direct lashings to attach a load is especially suitable where there is little or no friction between the load and the loading deck, such as:
  - slippery loads
  - loads on wheels.
- ✓ Make sure load-rated headboards and load-rated side/tail gates are used if the blocking restraint method is used.
- ✓ Make sure contained loads can't shift within the vehicle structure.
- ✓ Make sure the load restraint method used meets the [Performance Standards](#).

### Want to know more?

See the [Loads](#) module for **recommended restraint methods for particular types of loads**.

For more information on **tie-down** (including a comprehensive [Tie-down checklist](#)), **containing, blocking and attaching**, see [What are the different load restraint methods?](#) at the end of this module.

For **worked examples** of the different restraint methods, see [Working out load restraint](#).

## Step 4: Position the load to maintain vehicle stability, steering and braking

- ✓ Keep the centre of gravity low and close to the vehicle's centreline.

The position of a load has a significant impact on the vehicle's stability, particularly its rollover stability. Rollover stability is very sensitive to the centre of gravity of the vehicle. Rollover stability increases by lowering the centre of gravity.

- ✓ Load heavy objects first, and do not offset them to one side of the vehicle.

- ✓ Check the rollover stability.

Static rollover threshold (SRT) is a basic measure of rollover stability. High SRT values imply better resistance to rollover. **SRT calculators can be found online to help reduce the rollover risk.**

- ✓ Spread the load evenly across the deck, and share the weight between the axles.

The weight distribution of a load can also affect vehicle dynamics. For example:

- Overloading either the front or rear axle will affect the vehicle's steering ability.
- Uneven weight on the wheels influences the braking force of the wheels and can cause them to lock up.

Axle loads can be obtained by weighing or by calculation.

- ✗ Do not allow the load to excessively project from the vehicle.

A load should not excessively project from the front or sides of the vehicle because it could cause danger to other road users or damage to property.

- ✓ Face dangerous projections away from the driver.

A load with any potentially dangerous projections (e.g. boom from an excavator) should be placed in a way that minimises the risk to the driver if the load shifts during braking or a collision.

- ✓ Understand the legal mass and dimension requirements of your vehicle.

The *Heavy Vehicle National Law* covers mass and dimension requirements for heavy vehicles. Visit the National Heavy Vehicle Regulator website for more information on [mass and dimension requirements](#).

## Step 5: Check the vehicle structures and restraint equipment are in good working condition and strong enough to restrain the load

- ✓ Make sure that all equipment used in packing, loading and load restraint is serviceable and regularly maintained.

- ✓ Inspect all vehicle and restraint equipment before each trip to make sure it is in good working order.

Wear and damage on vehicle and restraint equipment can significantly reduce their strength and function. If there is any doubt about their reliability and safety, do not use them for the trip. Instead, replace them with equipment in good condition.

- ✓ Check the lashings.

Even minor wear and damage may considerably reduce performance compared with the lashings' rated capacity, putting you and others at risk.

- ✗ Do not use equipment weakened by cracked, broken or worn components for restraining loads.

- ✓ Check all locking and latching mechanisms are fully functional when being used for load restraint purposes.

- ✓ Use rated equipment.

Any vehicle structures and restraint equipment used in a restraint system must be strong enough to withstand the forces indicated in the [Performance Standards](#). Restraint equipment is rated by manufacturers to indicate its restraint capacity. **The restraint capacity of unrated equipment is very low.**

### Want to know more?

See the [Vehicles and equipment](#) module for more information on vehicle structures, restraint equipment, ratings and usage.

## LOADING THE VEHICLE

### Step 6: Make sure the load is stabilised

**i** Unstable and tall loads can tip over under heavy braking or cornering, even if they are restrained properly at the base. Paper rolls, 200 litre drums and gas cylinders are all examples of potentially unstable tall loads.

**i** A tall load can **tip forwards** if the length of the base is less than 80% of its height. It can **tip sideways** if the width of the base is less than 50% of its height.

**!** A load will also be unstable if it's on a base such as timber dunnage that is narrower than the base of the load.

#### To increase the stability of tall loads:

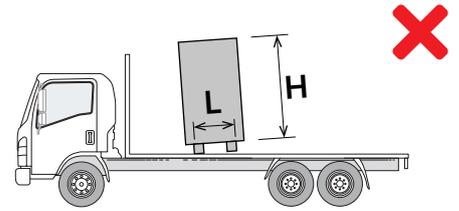
- ✓ Place unstable loads against a rigid structure (such as a headboard) to prevent them from tipping.
- ✓ Strap several unstable items together to form a stable pack.
- ✓ Fully tension lashings to increase load stability when using tie-down restraints.
- ✓ Use chains to prevent unstable loads tipping where possible as they have a limited amount of stretch.
- ✓ Use direct lashings to prevent a load tipping if further restraint is required.

**!** Rope and webbing straps can stretch and loosen – check them frequently if using these types of lashings to stabilise a load.

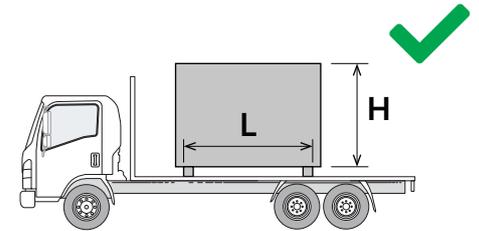
**!** Don't mix and match chains and straps on the same load. They have different stretch factors and breaking points, which may cause lashings to fail.

Always assess the restraint to its weakest point (for example, grab hooks may have a lower capacity than the chain strength).

Figure 2 Unstable forwards

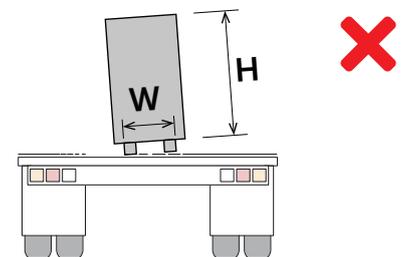


Length less than 80% of height

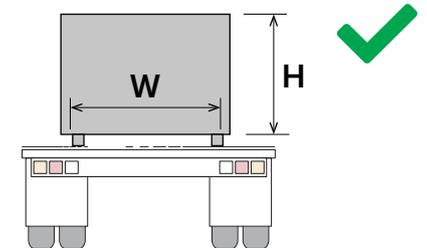


Length greater than 80% of height

Figure 3 Unstable sideways



Width less than 50% of height



Width greater than 50% of height

## Step 7: Make sure you understand and use safe work practices when loading and unloading a vehicle

- i** Multiple deaths and injuries occur each year in Australia as a result of incorrectly loading and unloading trucks. The following principles and actions are designed to prevent such events.

### Planning

- ✓ Plan to take into account the load, vehicle and equipment characteristics.

#### Loading plan

- ✓ Use appropriate loading equipment.
- ✓ Use the appropriate load restraint equipment and methods.
- ✓ Obey the relevant mass and dimension limits for load and route.

#### Unloading plan

- ✓ Check the load for movement or stability before removing restraints and unloading.
- ✓ Use appropriate equipment for unloading.

#### Documentation

- ✓ Document an appropriate loading and unloading procedure and load restraint system that is displayed and easily accessed by packers, loaders, drivers and other parties in the supply chain.
- ✓ Use loading, unloading and load restraint diagrams for different types of loads to support safe and compliant loading.
- ✓ Use a template that requires the person in control of packing or loading the goods to verify the accuracy of any records.

### Training

- ✓ Make sure everyone understands.
- ✓ Train all people on the loading and unloading site according to their role.
- ✓ Include loading and unloading exclusion zones in site inductions.

## Work execution

- ✓ Clarify who has authority.
  - The loader has authority over the activity and directs the truck driver or others to make sure the activity is safe.
  - The loader and the truck driver discuss how the loading and unloading will occur.
- ✓ Separate equipment and people.
- ✓ Establish the following zones:
  - **Loading and Unloading Exclusion Zone.** No people or other equipment can enter this area. Mark the area with fences, witches hats, electronic sensors, barriers or similar.
  - **Driver safety zone,** to allow line of sight between the loader and the truck driver to observe the loading or unloading.
- ✓ Include additional measures:
  - Good layout of the area to maximise visibility.
  - Additional spotters observing the activity.
  - Site-specific measures, especially for complex sites.

## Communication

- ✓ Check there is fit-for-purpose communication between the loader and the truck driver.
  - This includes hand signals, 2-way radio, talking, etc.
- ✓ Maintain line of sight between the loader and the driver.
  - If broken, the loader immediately stops and waits until the line of sight is re-established.
- ✓ Stop work if people enter the Loading and Unloading Exclusion Zone.
  - The Loading, Unloading Exclusion Zone (LUEZ) Guidelines provide more information on this topic.

## Step 8: Make sure enough restraint is used to keep you and others safe

- ✓ Restrain the load to prevent unacceptable movement during all expected conditions of operation.
  - Movement is unacceptable if it negatively impacts on weight distribution or the stability of the vehicle.
  - Expected conditions of operation include emergency braking and minor collisions.
  - Part or all of the load coming off the vehicle is a load restraint breach.
  
- ✓ Make sure the load restraint system can withstand the load restraint performance standard forces.
  - The vertical force only applies to tie-down restraint systems that rely on friction.

**If in doubt get your load restraint system certified by a qualified engineer.**

# DRIVE ACCORDING TO THE LOAD AND DRIVING CONDITIONS

## Step 9: Allow for changes in vehicle stability, steering and braking when driving a loaded vehicle

- ✓ Understand the effect the load type and its position can have on the vehicle's stability, steering and braking capacity.
  - ⚠ A truck carrying a load with a high centre of gravity will be less stable.
  - ⚠ A load that isn't evenly distributed across the width of the trailer will reduce the vehicle's stability when cornering.
  - ⚠ Vehicles carrying "live" loads (loads that can move) are more likely to overturn on corners. This includes bulk liquids, livestock, hanging meat, wet concrete, motor vehicles and large rubber-tyred equipment.
  - ⚠ If a load isn't evenly distributed along the length of the trailer, and there is more weight on some wheels than others, then each wheel will not brake with the same force. This can cause the wheels to lock up.
  - ⚠ Braking forces can be greater at low speed because of the "grabbing" effect.
  - ⚠ External factors such as high wind speeds can also reduce vehicle stability or blow the load off.
  
- ✓ Drive at an appropriate speed for the driving conditions.
  - Many rollovers are caused by inappropriate speed when changing direction, particularly on corners. Remember: The faster the vehicle is going, and the tighter the turn, the more likely a driver is to lose control.
  
- ⓘ You can learn more about vehicle dynamics and how to avoid a rollover by participating in a rollover prevention program.
  
- ✓ Be aware of the height and width of the loaded vehicle.
  - Make allowances for high and wide loads when driving around corners, under bridges and electric cables and near power poles, traffic lights and other obstructions.

## Step 10: Check the load and its restraint regularly during your journey

- ✓ Check the load and lashings regularly during the journey to make sure the load remains secure.

Some loads can settle and shift during a journey, causing lashings to loosen. The amount of checking required depends on many factors including the type of load, the type of restraint system, the roughness of the road and how well it's packed.

- ✓ Understand the characteristics of the load and know how often it needs to be checked during a journey.

Some loads require the lashings to be checked and retensioned after only a very short distance (e.g. bales, bags and sacks).

# LOAD RESTRAINT SYSTEM CHECKLIST

## Planning the load

- 1. Understand the load**   
Know the load's characteristics
- 2. Choose a suitable vehicle for the load type and size**   
Check the vehicle's carrying capacity and allowable overhang/height
- 3. Use a restraint system that is suitable for the load**   
Choose the most suitable restraint method for the load and vehicle
- 4. Position the load to maintain vehicle stability, steering and braking**   
Keep the centre of gravity as low as possible; don't exceed legal limits for overhang, height and width, mass and axle mass
- 5. Check the vehicle structures and restraint equipment are in good working condition and strong enough to restrain the load**   
Check all vehicle and restraint equipment is rated and fully functioning, and all worn/damaged equipment is repaired or replaced

## Loading (and unloading) the vehicle

- 6. Make sure the load is stabilised**   
Take steps to stabilise a load that is at risk of toppling over
- 7. Make sure you understand and use safe work practices when loading and unloading a vehicle**   
Create plans, train staff, create loading zones and communicate appropriately for the environment
- 8. Make sure enough restraint is used to keep you and others safe**   
The load restraint system must meet the Performance Standards

## Driving according to the load and driving conditions

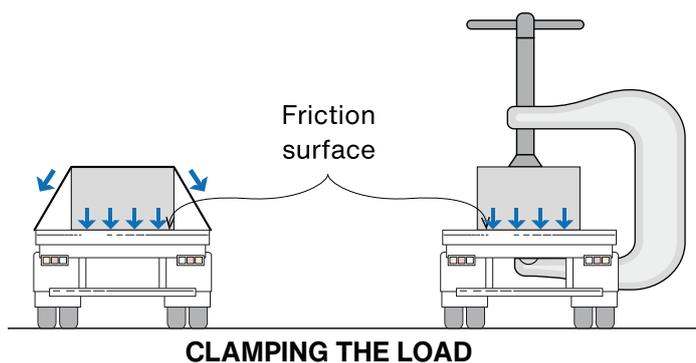
- 9. Allow for changes in vehicle stability, steering and braking when driving a loaded vehicle**   
Be aware of the changes in your vehicle's handling, height and width
- 10. Check the load and its restraint regularly during your journey**   
Loads can settle and shift; lashings may need to be re-tensioned

# WHAT ARE THE DIFFERENT LOAD RESTRAINT METHODS?

## TIE-DOWN RESTRAINT

- Under this method, friction stops the load from moving forwards, sideways and backwards. **Friction force comes from both the weight of the load and the clamping force of tie-down lashings. The weight of the load alone does not provide adequate restraint.**
- For tie-down to be effective, the load must be in contact with the vehicle throughout its journey. Tie-down lashings clamp the load to the vehicle to maintain friction.

### TIE-DOWN = CLAMPING FORCE



- Tie-down lashings include straps and chains. These normally pass over the top of a load and are attached to the vehicle on both sides.
- **Tie-down lashings need to be pre-tensioned to create the clamping force.** This is usually done using mechanical tensioners suitable for the type of lashing being used.
- When a load is tied down and restrained using friction, it must also be restrained vertically to withstand a minimum force of 20% of its weight (i.e.  $0.2W$ ); this stops it from shifting upwards (e.g. on rough roads) and keeps the load in contact with the vehicle throughout its journey.
- **Some loads are unsuitable** for tie-down restraint. These include:
  - crushable/fragile loads that can be damaged by lashings during tensioning
  - offset loads (i.e. loads that aren't positioned along the centreline of the truck) where lashings can loosen if the load shifts sideways
  - slippery loads because too many lashings are needed to create the necessary clamping force.

### Understanding friction

**Friction is the resistance to movement** caused by the roughness of 2 surfaces in contact with each other.

Friction depends only on the type of surfaces and the force between them. **A larger amount of contact surface area does not increase friction.**

Friction between smooth surfaces **can be increased** using timber dunnage or anti-slip rubber matting between the surfaces.

Friction **can be greatly reduced by:**

- oil or water between metal surfaces
- dust, sand or other particles between surfaces.

### Want to know more?

See the [Vehicles and equipment](#) module for more information about restraint equipment, including **tie-down lashings** and **tensioners**.

## Understanding how tie-down works

The amount of friction between the load and deck surfaces (and any surfaces in between) will affect how much weight each lashing can restrain. **The greater the friction, the more weight that can be restrained by each tie-down lashing.**

Typical friction levels for common loads are outlined below:

Table 1

TYPICAL FRICTION LEVELS	
Load	Friction
Wet or greasy steel on steel	VERY LOW
Smooth steel on smooth steel	LOW
Smooth steel on conveyor belt	LOW
Smooth steel on rusty steel	LOW TO MEDIUM
Smooth steel on timber	MEDIUM
Rusty steel on rusty steel	MEDIUM TO HIGH
Rusty steel on timber	HIGH
Smooth steel on rubber load mat	HIGH

The amount of pre-tension that can be achieved in a lashing will also affect the lashing capacity. **The greater the pre-tension, the more weight that can be restrained by each lashing.**

- [Table 2](#) lists examples of average pre-tension that can be achieved by different tensioners; however, it is important to know what tension you can get with your particular equipment.

Table 2

EXAMPLES OF AVERAGE PRE-TENSION			
Lashing	Size	Tensioner	Pre-tension
Rope	10 mm & 12 mm	Single hitch	50 kgf
		Double hitch	100 kgf
Webbing	25 mm	Hand ratchet	100 kgf
	35 mm	Hand ratchet	250 kgf
	50 mm	Truck winch	300 kgf
	50 mm	Hand ratchet (push up)	300 kgf
	50 mm	Hand ratchet (pull down)	600 kgf
Chain	7 mm & above	Turnbuckle	1,000 kgf

**The tension in any lashing must not exceed the manufacturer's lashing capacity.**

 The lashing capacity of unrated equipment, including rope, is very low.

- Tie-down lashings are most effective if they are vertical and tight. **The more a lashing is angled away from the load, the less the clamping force.** This is called the **angle effect**.

## TIE-DOWN ANGLE EFFECT

	APPROX. ANGLE	TIE-DOWN ANGLE EFFECT	TIE-DOWN EFFECTIVENESS
	90°	1.00	100%
	60°	0.85	85%
	45°	0.70	70%
	30°	0.50	50%
	15°	0.25	25%

- **The lower the lashing angle, the more lashings are required to give the same clamping force.** One strap at 90° is equivalent to 4 straps at 15°.
- Whether or not a load is blocked also affects the number of lashings needed. **If a load is blocked using rated equipment, some of the required restraint will be achieved by that equipment.**
- To find the number of lashings required for the load, divide the total weight of the load by the weight that each lashing can restrain and then round up to the next whole number. **The lashing capacity does not equal the amount of weight it can restrain.**

### Want to know more?

See the [Loads](#) module for **recommended restraint methods for particular types of loads.**

For **worked examples** of the different restraint methods, see [Working out load restraint.](#)

For more information on how to design a tie-down restraint system, including **how to calculate how many lashings you need**, see [Technical advice.](#)

## Tie-down checklist

- ✓ Work out the total weight of the load.
- ✓ Check the level of friction on the load (use interlayer packing to increase friction levels where necessary).
- ✓ Make sure the vehicle deck and load are free from oil, grease, water, dirt or other contaminants that can reduce friction.
- ✓ Choose tie-down lashing equipment.
- ✓ Tension the lashings.
 

To correctly pre-tension lashings:

  - use smooth, rounded corner protectors to prevent lashings losing tension during the journey.
  - where practical, place every second tensioner on the opposite side of the vehicle to maintain even load restraint OR use 2 tensioners on each lashing (one on each side of the load).
- ✓ Check the angle of the lashings.
 

If the load is too low to use tie-down lashings dunnage can be used to increase the angle by placing it:

  - under the load to lift it
  - on top of the load to increase the load height
  - between parts of the load.
- ✓ Check there are enough tie-down lashings to restrain all parts of the load.
- ✓ Use timber dunnage correctly.
  - ✓ Check it's strong enough for the load.
  - ✓ Make sure the dunnage is a suitable type and thickness for the load. Hardwoods of at least 65 mm thickness should be used.
  - ✓ Check the timber is relatively free of knots and splits.
  - ✓ Place the timber on its widest face.
  - ✓ Stack it at right angles (so the higher layer is square to the one below it) if the height of the dunnage needs to be raised.
  - ✗ Don't place timber dunnage on its narrow face or stack it directly on top of itself.
 

Dunnage can roll under heavy braking if placed incorrectly. This is extremely dangerous because it can cause lashings to loosen and all restraint can be lost.
  - ✓ Check the dunnage is lashed and secured.
 

Unsecured dunnage can work loose and become a dangerous missile to other road users.

## DIRECT RESTRAINT

- Direct restraint can be used for most loads. It is particularly useful for loads that are difficult to tie down.
- A load can be directly restrained by **attaching, blocking or containing** without any reliance on friction.

### Attaching

- Direct lashings are webbing straps, chains or twist locks that **attach a load directly onto a vehicle**.
- Direct lashings are especially suitable for loads with little or no friction between the load and the loading deck, such as:
  - slippery loads
  - loads on wheels.
- The required strength of the direct lashing depends on the weight of the load, the number of lashings and their direction.
- The **lashing strength is the lashing capacity or manufacturer's rating**, which should be marked on the lashing.
- The following tables cover the typical direct lashing capacity of some common lashings:

**Direct lashings must be angled in the opposite direction to any expected load movement.**

For example, the lashing angling down from the back of a car will stop the car from moving forwards.

Table 3

TYPICAL LASHING CAPACITY – ROPES AND WEBBING STRAPS	
Lashing	Lashing capacity
12 mm synthetic (silver) rope	300 kg
25 mm webbing	250 kg
35 mm webbing	1.0 t
50 mm webbing	2.0 t

Table 4

TYPICAL LASHING CAPACITY – CHAIN		
Chain type*:	with claw hooks or 'winged' grab hooks	with grab hooks or edge contact
6 mm transport chain	2.3 t	1.7 t
7.3 mm transport chain	3.0 t	2.3 t
8 mm transport chain	3.8 t	3.0 t
10 mm transport chain	6.0 t	4.5 t
13 mm transport chain	9.0 t	6.7 t
13 mm Grade 'T' chain**	10.0 t	7.5 t
16 mm Grade 'T' chain**	16.0 t	12.0 t

\*Different hooks have different lashing capacities. Chains that pass over sharp edges such as coaming rails have reduced lashing capacity. Total lashing capacity of a chain and hook should be regarded as the lowest rated value.

\*\* Grade 'T' lifting chain is also referred to as Grade 80 or 'Herc-alloy'.

- When direct lashings are angled at less than 25° from the horizontal, and at 45° from the centreline of the vehicle when viewed from above, a simple rule is to **select lashings with a combined lashing capacity of:**
  - in the **forward** direction = twice the weight of the load
  - in the **sideways** direction = the weight of the load
  - in the **backward** direction = the weight of the load.

Chains should be of the same length and at the same angle to be considered working together.

See worked example at [Direct restraint using simple rule](#).

## Blocking

- A headboard and side/tail gates can be used to **block the load** from moving horizontally (forwards, backwards or sideways) provided they are strong enough to withstand the forces indicated by the [Performance Standards](#).

## Containing

- A load can also be contained within a vehicle where the load is restrained against horizontal movement by the vehicle structure or by other parts of the load. For more information see [Contained loads](#).
- Contained, for heavy loads, means simultaneously fully blocked forwards, rearwards and sideways.

### Want to know more?

See the [Loads](#) module for **recommended restraint methods for particular types of loads**.

For **worked examples** of the different restraint methods, see the [Working out load restraint module](#).

For more information on how to design a restraint system, see [Technical advice](#).

# LOADS

This module sets out **advice on specific load types**, complete with diagrams for most concepts.

Similar load types have been grouped together because similar principles and techniques apply.

All of the guidelines in this module recommend methods for you to follow **so you can make sure the load meets the Performance Standards** and keep you and others safe.

## HOW TO USE THIS MODULE

**Read the guidelines that most closely match your specific load type**, or read through the whole module to learn more about restraint methods for different load types.

There are guidelines for restraining:

- [general freight](#)
- [dangerous goods](#)
- [packs, pallets and stillages](#)
- [rolls, reels, coils and drums](#)
- [pipes, tubes, rods and bars](#)
- [sheets and flat loads](#)
- [bales, bags and sacks](#)
- [contained loads](#)
- [large loads](#)
- [vehicles and mobile equipment](#)
- [bricks](#)
- [intermediate bulk containers \(IBCs\) and chemical tanks](#)
- [bulk bags](#)
- [livestock](#)
- [logs](#)
- [scaffolding](#)
- [turf](#).

### Diagrams in this module are indicative only.

For detail on vehicle structures and restraint equipment see [Vehicles and equipment](#).

To work out how much restraint to use, see the worked examples in the [Working out load restraint](#) module.

You can also find more information on restraint calculation in [Technical advice](#).

**If you want to use different methods to those recommended in the load type guides, you will need to be able to demonstrate the load restraint system meets the Performance Standards.**

# GENERAL FREIGHT

The guidelines below set out how you can meet the [Performance Standards](#) when restraining general freight. They are intended to be used as a guide only. You can also restrain using other methods. It is recommended that an engineer certifies alternative methods.

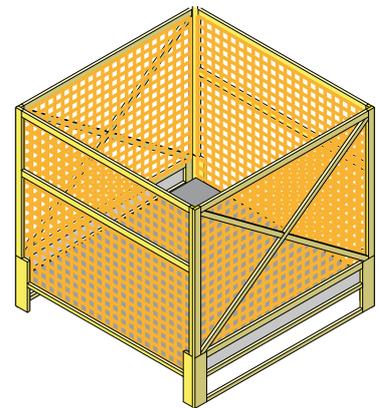
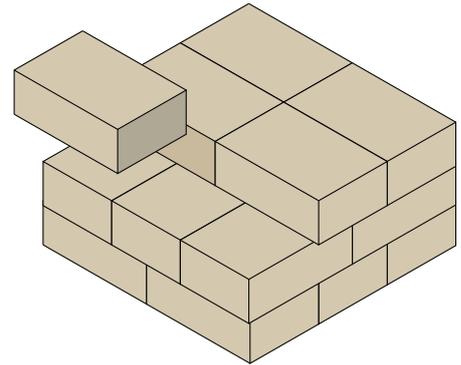
**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)), and [Technical advice](#).

General freight includes boxes, cartons, crates, bags, drums, plastic containers and pallets.

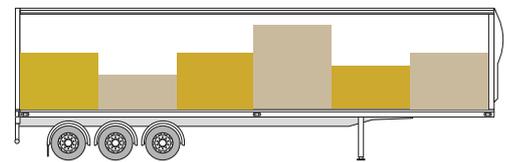
## GENERAL TIPS

- i** Containing a load of mixed freight is often easier than using tie-down due to variations in mass, size and shape between items – [Figure 5](#).
- i** Contain general freight in suitable vehicles such as vans, pantechnicons, curtain-sided trucks/trailers, flat tops with sides or gates (of suitable strength) or shipping containers – [Figure 6](#).

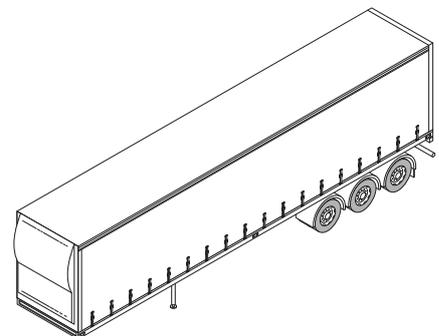
*Figure 4 Boxes, crate and pallet*



*Figure 5 Contained load*



*Figure 6 Curtain-sided truck/trailer*



# RESTRAINT METHODS

## Direct restraint

- ✓ Prevent freight movement by blocking with timber pallets or other materials when using containment and blocking methods – *Figure 7*.
- ✓ A cumulative gap of up to 200 mm front to back and up to 100 mm side to side is acceptable – *Figure 8*.

Figure 7 Gaps in load filled

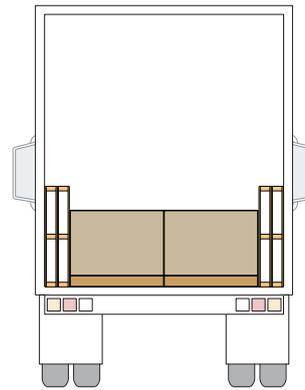
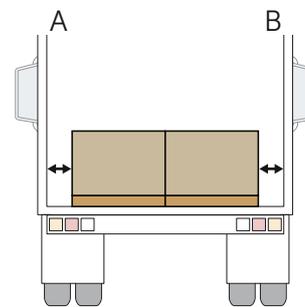
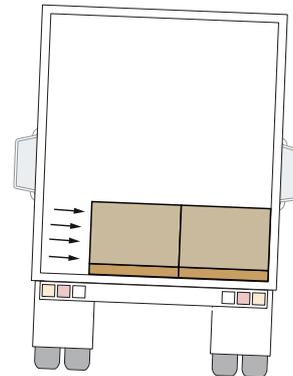


Figure 8 Keep cumulative gap small



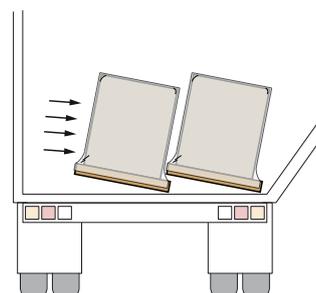
A + B less than 100 mm

Figure 9 Freight movement



- ⚠ Significant freight movement may affect the vehicle's stability – *Figure 9* or cause the load to dislodge – *Figure 10*.

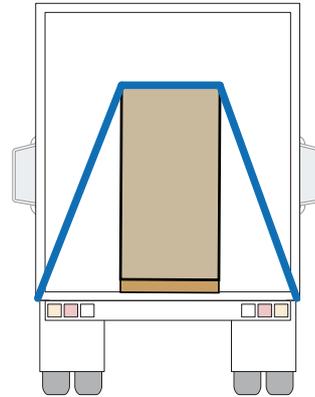
Figure 10 Freight dislodgement



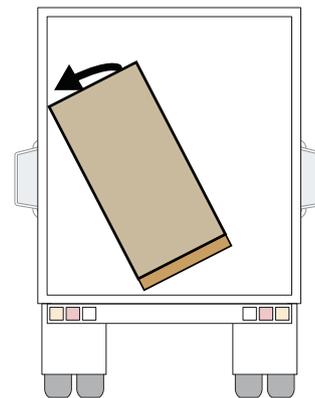
## Tie-down

- ✓ Tie down large individual loads that cannot be effectively contained – *Figure 11*.
- ⚠ Even when contained, large freight items can topple over if there are large gaps around the load, affecting the vehicle's stability (e.g. tall, slender freight) – *Figure 12*.

*Figure 11 Freight tied down*

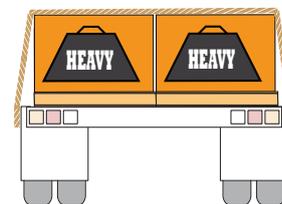


*Figure 12 Large freight topple*



- ✓ Apply webbing or chain lashings with appropriate lashing capacity to restrain the load or contain the load with a suitably rated containment body.
- ✗ Do not use rope to restrain heavy loads because rope does not have sufficient lashing capacity – *Figure 13*.

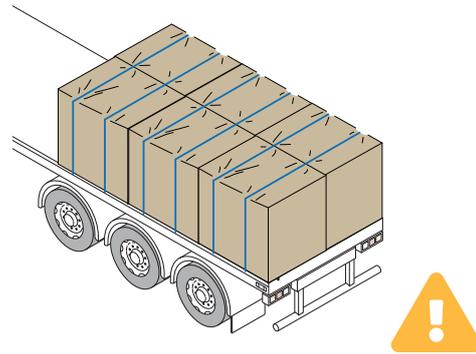
*Figure 13 Heavy freight tied down with rope*



✓ Contain compressible loads where tie-down is not suitable.

⚠ Compressible loads may distort under tie-down lashings, reducing the applied clamping – *Figure 14*.

*Figure 14 Freight crushed by lashings*

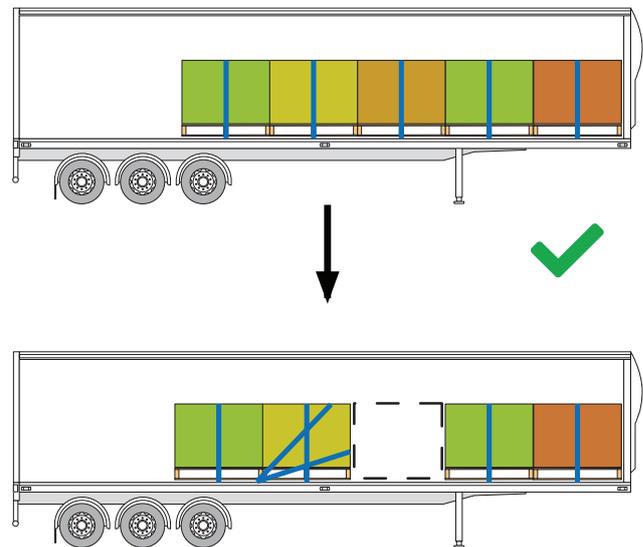


## DURING THE JOURNEY

✓ Rearrange and restrain multi-drop loads (i.e. loads delivered in parts at multiple locations) to maintain correct load distribution and restraint throughout the journey – *Figure 15*.

**i** See [worked example on multi-drop loads](#).

*Figure 15 Multi-drop load rearranged*



Extra lashing to restrain forward movement

# DANGEROUS GOODS

Loads of dangerous goods must be restrained as required by the [Performance Standards](#).

The Australian Code for the Transport of Dangerous Goods by Road & Rail sets out specific load restraint requirements that apply to dangerous goods.

Consignors, loading staff, drivers and operators involved in the transport of bulk and packaged dangerous goods must be familiar with the special requirements of the Australian Code for the Transport of Dangerous Goods by Road & Rail.

## GENERAL TIPS

### Dangerous goods class labels

- i** Many loads are marked with symbols indicating special handling information and instructions – [Figure 16](#).
- i** If a dangerous goods class label is present, there may be specific load restraint requirements in the Australian Code for the Transport of Dangerous Goods by Road & Rail.

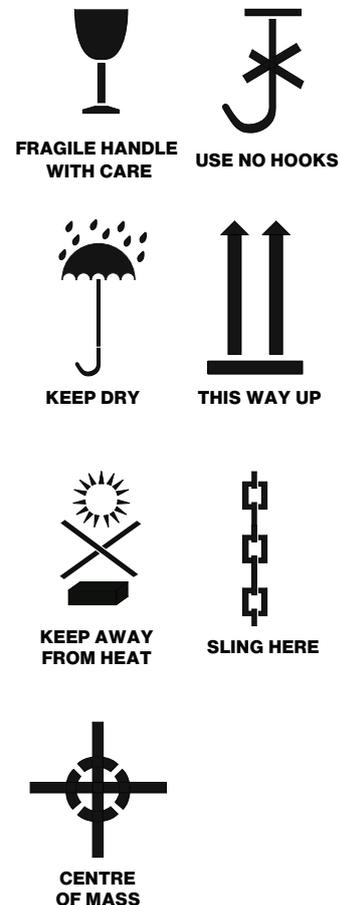
### International cargo symbols and signs

- i** International cargo symbols are normally black and between 100 mm and 200 mm high. Several different symbols may appear on each load to indicate a number of instructions (some examples are shown in – [Figure 17](#)).
- i** Symbols are normally placed in the upper left and right-hand corners of the main vertical face of the load and, if possible, are repeated on the other vertical faces.
- i** ‘SLING HERE’ and ‘KEEP AWAY FROM HEAT’ symbols are usually placed on the lower vertical face of the load.

Figure 16 Samples of dangerous goods class labels



Figure 17 Samples of international cargo symbols and dangerous goods class labels



# PACKS, PALLETS AND STILLAGES

The guidelines below set out how you can meet the [Performance Standards](#) when restraining loads that have been bound into packs, stacked on pallets or loaded in stillages. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

## UNITISING

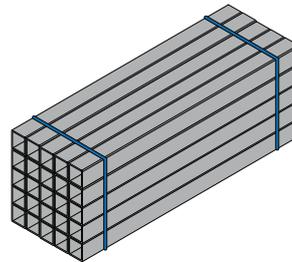
✔ Unitise loads to simplify the restraint requirements.

**i** Unitising methods include banding – [Figure 18](#), strapping – [Figure 19](#), gluing – [Figure 20](#), stretch wrapping – [Figure 21](#) and shrink wrapping – [Figure 22](#).

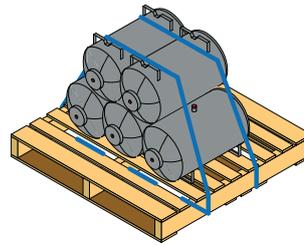
✔ Make sure unitising systems, independently of load restraint, are capable of withstanding the forces described in the [Performance Standards](#) and robust enough to withstand handling (e.g. being handled by forklifts).

Rated pallets and cages may be used.

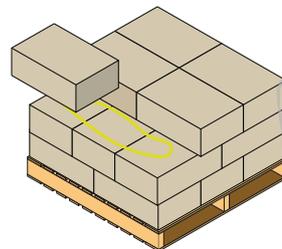
[Figure 18 Banding](#)



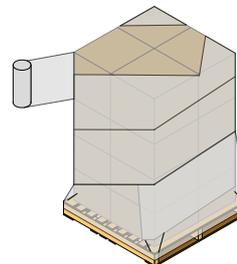
[Figure 19 Strapping](#)



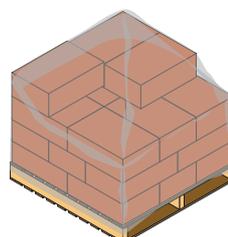
[Figure 20 Gluing](#)



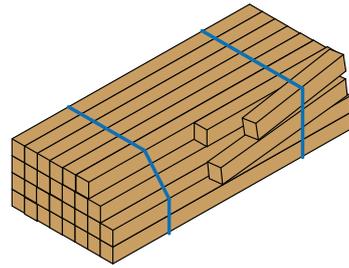
[Figure 21 Stretch Wrapping](#)



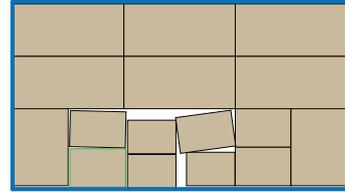
[Figure 22 Shrink Wrapping](#)



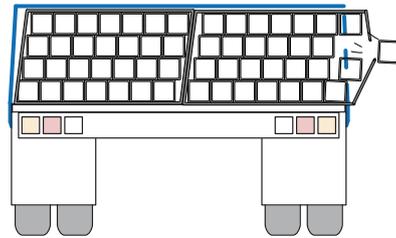
- ✓ Choose a unitising method that is appropriate to restrain all items in the pack – *Figure 23*.

*Figure 23 Partially unitised pack*

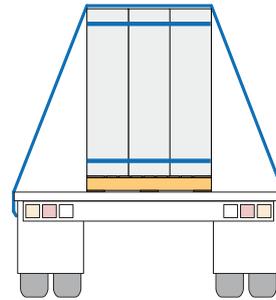
- ✓ Check all items in the load are effectively unitised – *Figure 24*.

*Figure 24 Lower items loose*

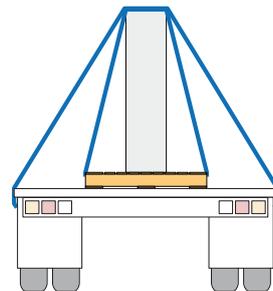
- ⚠ Items may dislodge from the vehicle if the unitising fails during transport – *Figure 25*.

*Figure 25 Unitising failure*

- ✓ Prevent tall items from toppling by unitising multiple items together – *Figure 26*.

*Figure 26 Tall items unitised*

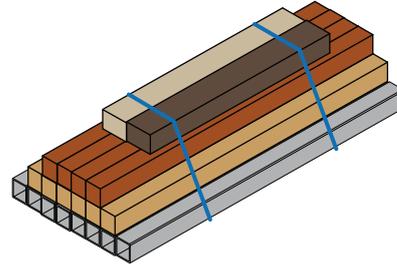
- ⚠ Tall items may topple under heavy braking or cornering, putting extra forces upon strapping or wrapping – *Figure 27*.

*Figure 27 Tall item may topple*

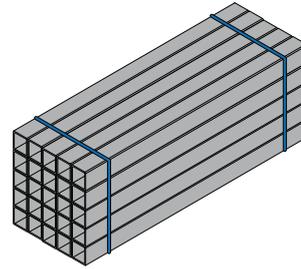
# PACKS

**i** Packs can comprise of multiple layers or stacks of material – *Figure 28* or bundles of individual lengths – *Figure 29* unitised together.

*Figure 28 Stacked material*

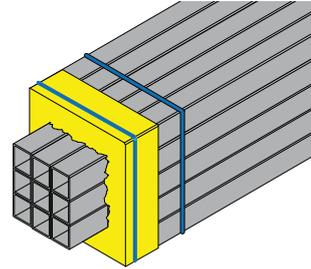


*Figure 29 Bundle*

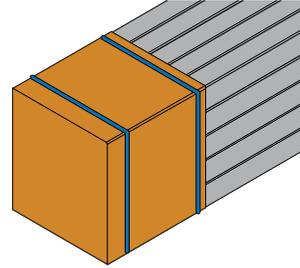
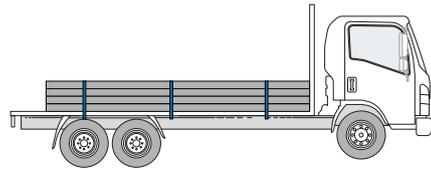


**x** Do not rely on unitising alone to restrain all items in a pack during transport – it may not be sufficient – *Figure 30*.

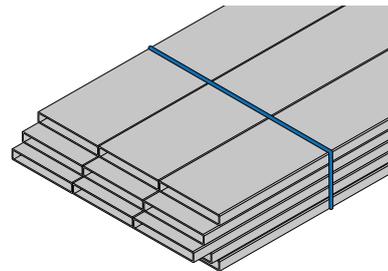
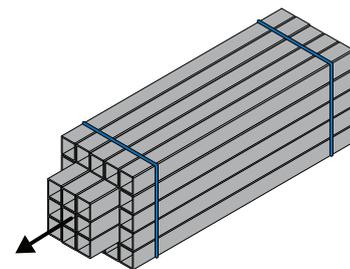
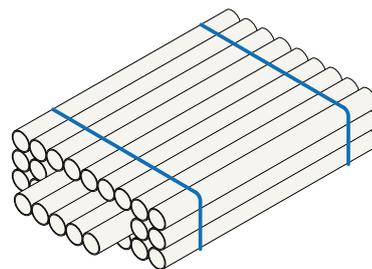
*Figure 30 Unitising failure*



- ✓ End wrap – *Figure 31* or block – *Figure 32* packs that are at risk of sliding or spearing.

*Figure 31 Pack end wrapped**Figure 32 Pack blocked against headboard*

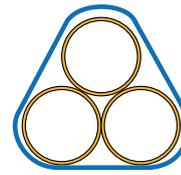
- ⚠ Packs containing low-friction items can slide or spear out of the pack – *Figure 33*, *Figure 34* and *Figure 35*.

*Figure 33 Steel sliding**Figure 34 Steel spearing**Figure 35 Plastic pipe spearing*

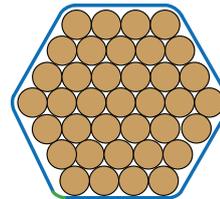
✓ Unitise packs of circular items in self-supporting shapes – *Figure 36*.

⚠ Pack shapes may prevent all items from being adequately unitised.

*Figure 36 Self-supporting shapes*



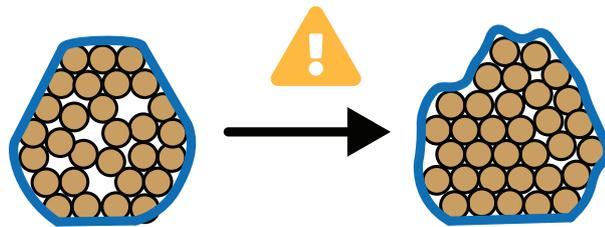
Triangular pack



Hexagonal pack

⚠ Bundles of small items can change shape when subject to forces during transport – *Figure 37*.

*Figure 37 Pack settled during transport*

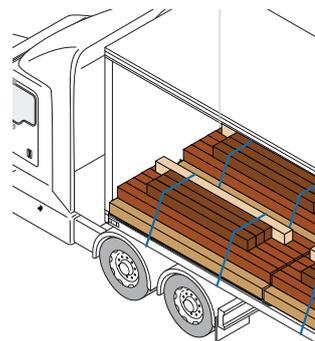


## Blocking and containing packs

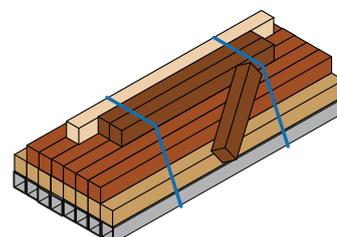
✓ Block or contain packs that are inadequately unitised and/or at risk of items dislodging – *Figure 38*.

⚠ Items can dislodge from inadequately unitised packs – *Figure 39*.

*Figure 38 Contained packs*

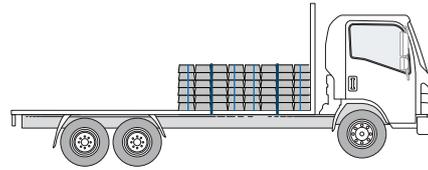


*Figure 39 Inadequately unitised pack*



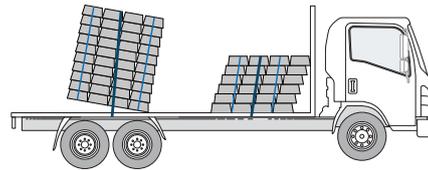
- ✓ Prevent packs tipping by blocking them – *Figure 40*.

*Figure 40 Unstable packs blocked*



- ⚠ Tall packs of multiple items may become unstable during transport – *Figure 41*.

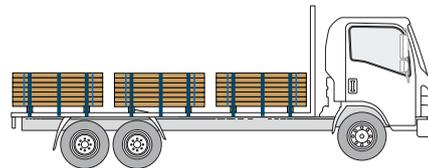
*Figure 41 Unstable packs*



## Tying down packs

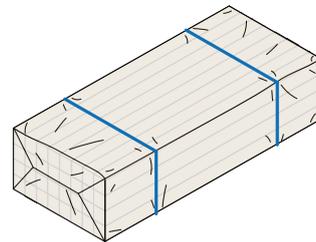
- ✓ Use tie-down to restrain packs that are well unitised – *Figure 42*.

*Figure 42 Packs tied down*



- ⚠ Packaging or weather protection may be low friction and therefore increase the number of tie-down lashings required – *Figure 43*.

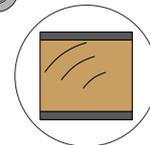
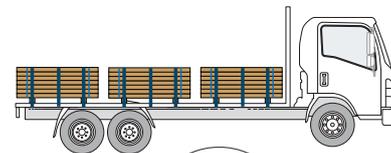
*Figure 43 Low friction weather protection*



- ⓘ Anti-slip rubber can reduce the required number of tie-down lashings; particularly for low-friction loads – *Figure 44*.

*Figure 44 Tie-down with anti-slip rubber*

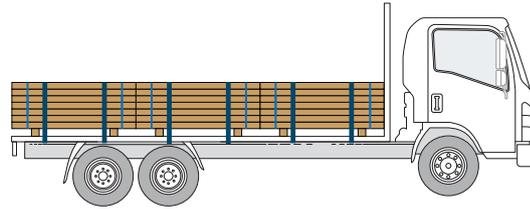
- ✓ If you do apply fewer tie-down lashings, you may need to make the unitising system stronger to resist the forces on the load during transport (e.g. packs of slippery sheets placed on anti-slip rubber need fewer webbing straps but are prone to breaking their banding).



Rubberised dunnage

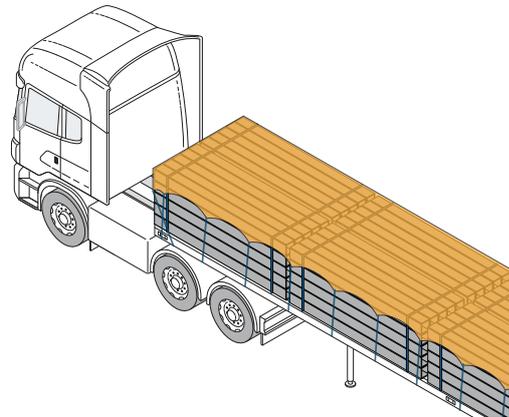
- ✓ Use forward blocking to reduce the required number of tie-down lashings and place less force on packaging – [Figure 45](#).

*Figure 45 Packs blocked and tied down*



- ✗ Do not use tarpaulins or curtain sides to restrain packs unless they are properly engineered for the specific load type. For more information see [Vehicles and equipment](#) – [Figure 46](#).

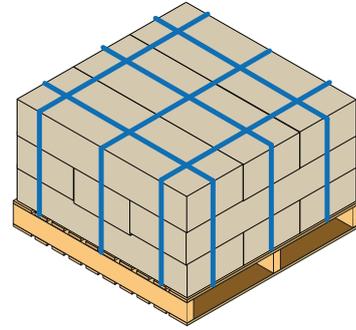
*Figure 46 Tarpaulin without tie-down*



## LOADS ON PALLETS

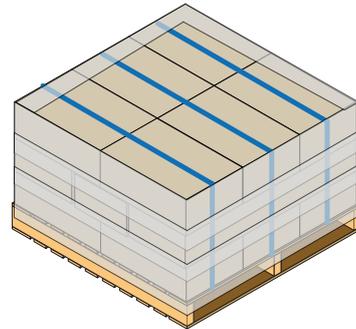
- ✓ To simplify restraint requirements, unitise items placed on pallets to the pallet itself – *Figure 47*.
- ✓ Make sure the unitising sufficiently secures all items to the pallet during transport.

*Figure 47 Items unitised to pallet*

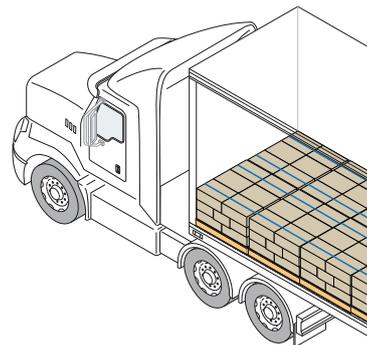


- ✓ Apply additional restraint or contain pallets if items can dislodge – *Figure 48* and *Figure 49*.

*Figure 48 Additional restraint – stretch wrap*

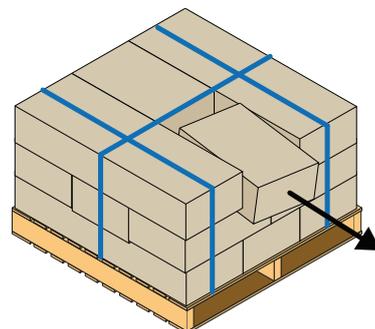


*Figure 49 Contained load*



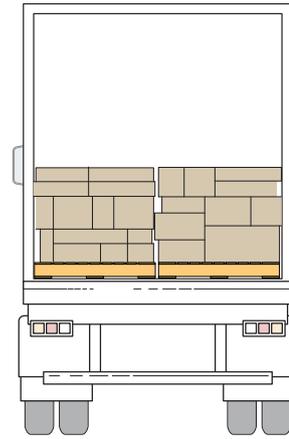
- ⚠ Items can dislodge from the pallet if the load is uncontained and the items are not sufficiently unitised – *Figure 50*.

*Figure 50 Insufficient unitising*



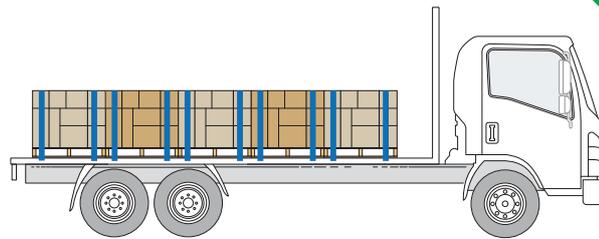
- ✓ Restrain items loosely stacked on pallets by containment – *Figure 51*.

*Figure 51 Loose items on pallet contained*



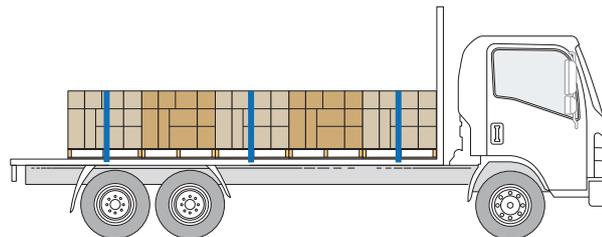
- ✓ Restrain sufficiently unitised pallets by tie-down – *Figure 52*.

*Figure 52 Pallets tied down*



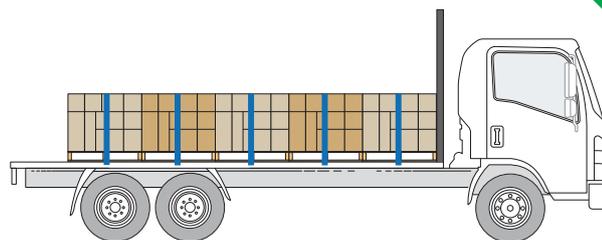
- ⚠ Make sure tie-down lashings apply clamping to all pallets in the load – *Figure 53*.

*Figure 53 Items in load unrestrained*



- ✓ Use suitably engineered forward blocking surfaces to reduce the number of tie-down lashings needed – *Figure 54*.

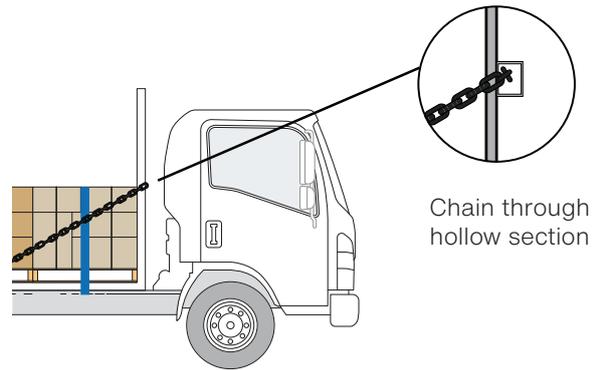
*Figure 54 Forward-blocking*



- ✓ Reinforce unrated headboards using chains (or similar) wrapped across the face of the blocking surface – [Figure 55](#).

- ⚠ Unrated reinforced blocking surfaces have limited restraint capacity.

*Figure 55 Unrated blocking reinforcement*

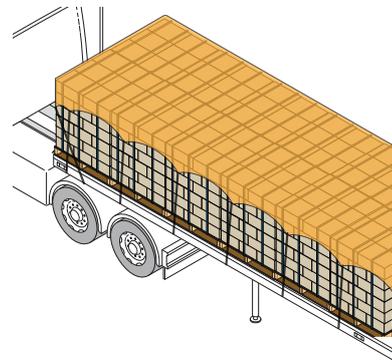


Chain through hollow section

Forward blocking

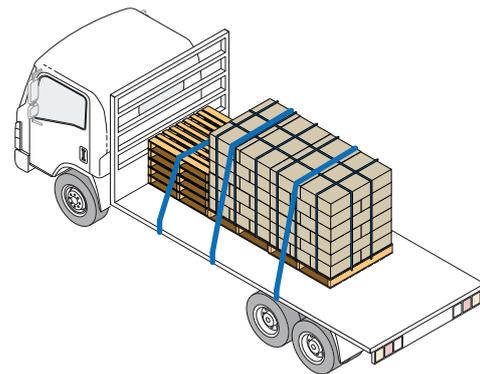
- ✗ Do not use tarpaulins or curtain sides to restrain packs unless they are properly engineered for the specific load type – [Figure 56](#). For more information see [Vehicles and equipment](#).

*Figure 56 Tarpaulin without tie-down*



- ✓ Use several empty pallets stacked on top of each other to block both the freight and the pallet itself – [Figure 57](#).

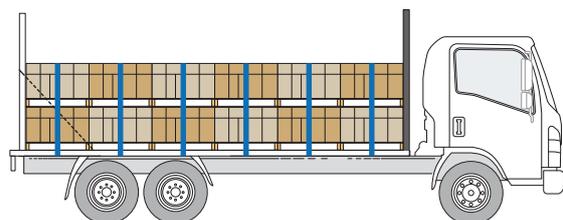
*Figure 57 Blocking with intermediate pallet*



- ✓ Stack palletised loads 2-high if the product is strong enough to support the upper layer without crushing.

- ✓ Tie down loads of pallets stacked 2-high and block them in the forward direction against a suitably engineered headboard – [Figure 58](#).

*Figure 58 Stacked load*



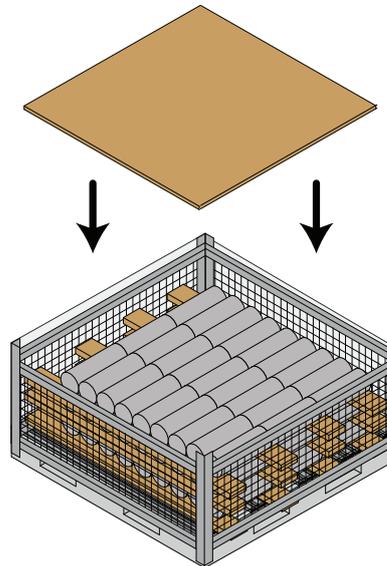
# LOADS IN STILLAGES (CAGES, CRATES)

- ✓ Transport loads made up of lots of loose pieces in stillages to simplify the restraint requirements.
- i Additional requirements from Australian Standard AS 4991-2004 Lifting Devices apply for stillages that are to be used as a lifting device.
- ✓ Make sure stillages adequately restrict the upward movement of items they contain to prevent them from dislodging – *Figure 59*.
- ! Uncovered or unwrapped items are prone to bounce during the trip. If the sides of the stillage are not high enough, then a top cover or wrapping will be required.

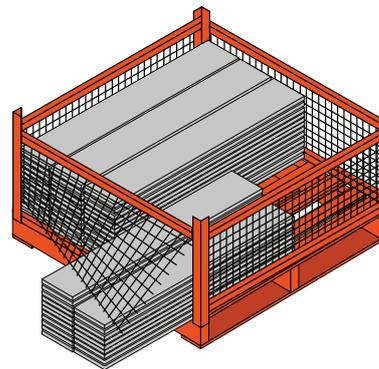
- ✓ Only use stillages that are suitably engineered and capable of restraining all items placed within them when subjected to the Performance Standard forces – *Figure 60*.

Rated equipment is recommended, where suitable and available.

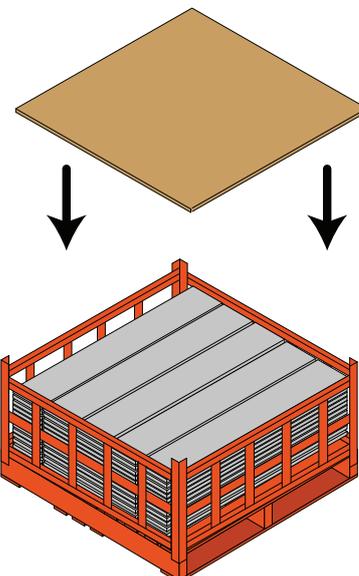
*Figure 59 Stillage with vertical containment*



*Figure 60 Stillage selection*



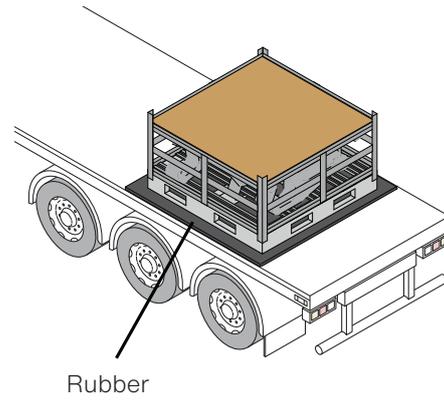
Stillage – insufficient strength



Stillage – suitable strength for freight

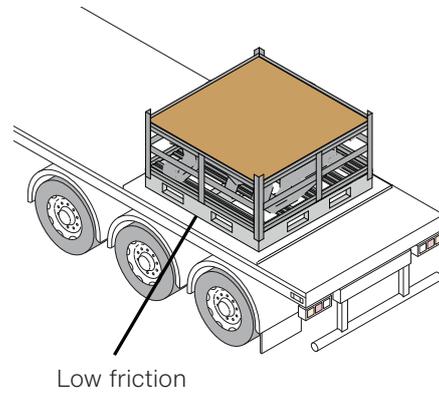
- ✓ When loading steel-based stillages onto a steel deck, place plywood, rubber or other suitable material on the deck to increase friction – *Figure 61*.

*Figure 61 Steel stillage on rubber*



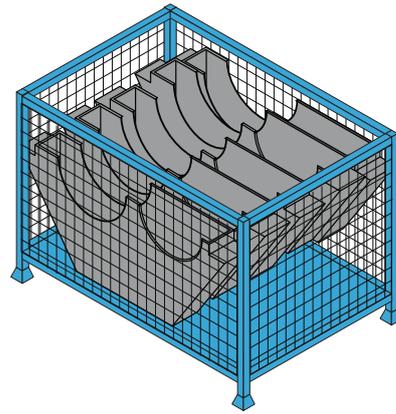
- ⚠ Loading stillages with steel bases directly onto steel decks creates a low-friction interface – *Figure 62*.

*Figure 62 Steel-on-steel interface*

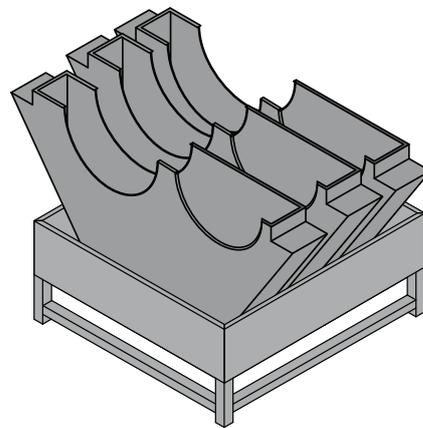


- ✓ Use stillages that are deep enough to securely contain the freight – *Figure 63*.

*Figure 63 Depth of coverage*



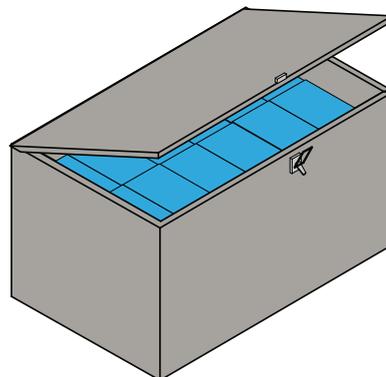
Suitable depth of coverage



Limited containment due to inadequate depth

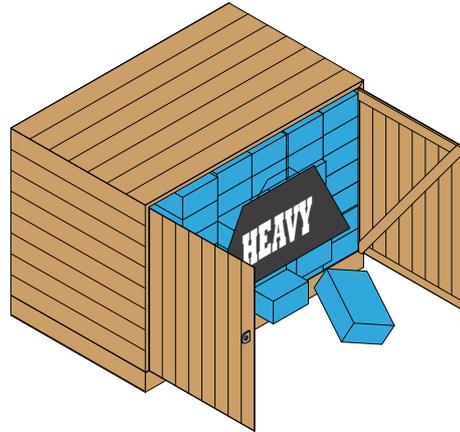
- ✓ Use lids to contain freight in stillages to prevent freight bouncing out – *Figure 64*.

*Figure 64 Stillage with lid*

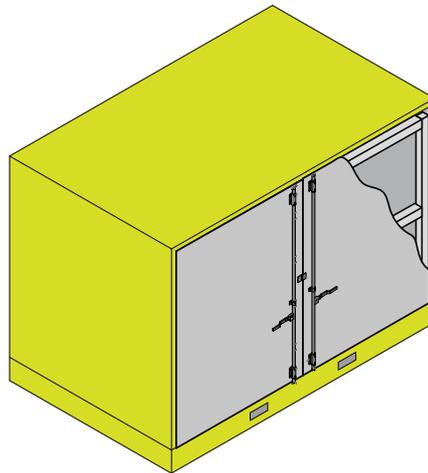


- ✓ Use suitably engineered side doors to prevent freight loss during transport – *Figure 65.*

*Figure 65 Side doors*



Insufficient strength for freight



Suitable strength for freight

# ROLLS, REELS, COILS AND DRUMS

The guidelines below set out how you can meet the [Performance Standards](#) when restraining rolls, reels, coils or drums. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

The term “**cylinders**” is used in the tips below that apply to all of these product types, otherwise the specific product type is named (e.g. “large reels or rolls”).

In addition to the guidelines provided here, industry has developed specific guidelines for these product types that may provide more detail.

## GENERAL TIPS

- ✓ Transport cylinders either horizontally (i.e. lying along or across a vehicle ([Figure 67](#) and [Figure 68](#)) or vertically (i.e. standing on their ends – [Figure 69](#)).

Figure 66 Roll, reel, coil and drum

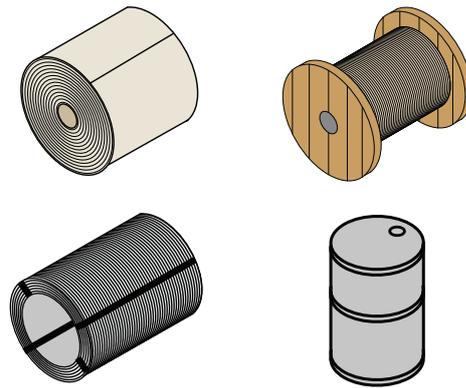


Figure 67 Horizontal along deck

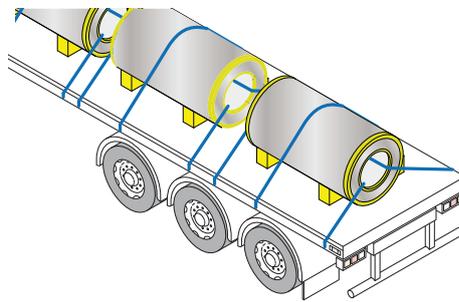


Figure 68 Horizontal across deck

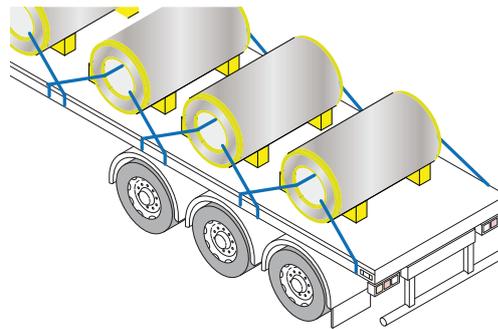
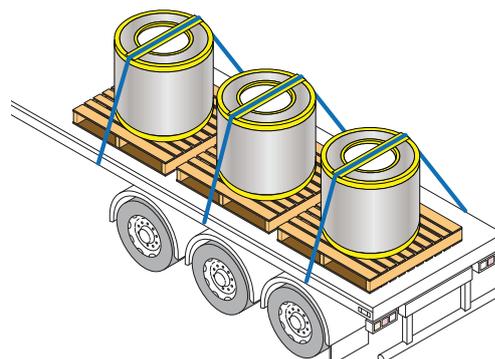
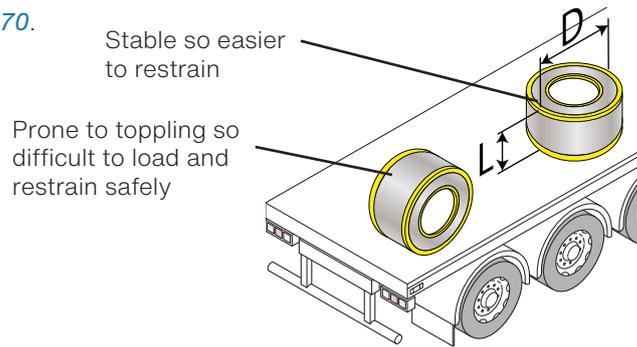


Figure 69 Vertical stacking



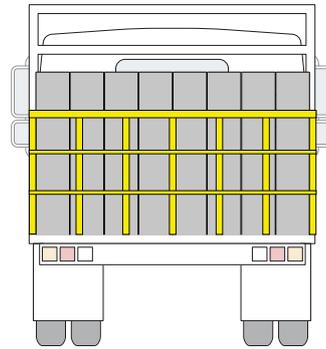
- ✓ Transport cylinders that have a length **less than** their diameter vertically to prevent them from toppling – *Figure 70*.

*Figure 70 Diameter and length of cylinder*

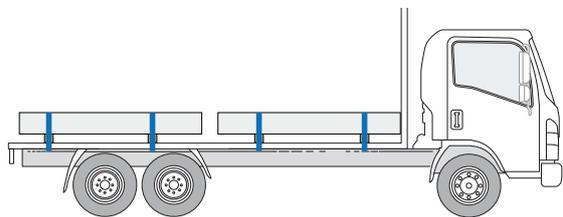


- ✓ Transport cylinders that have a length **greater than** their diameter either supported by suitably engineered vehicle structures or laid horizontally to prevent them from tipping – *Figure 71* and *Figure 72*.

*Figure 71 Drums on end inside gates*

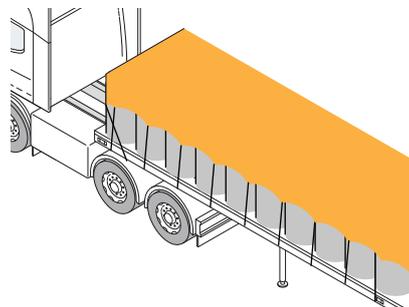


*Figure 72 Long rolls supported by bearers*

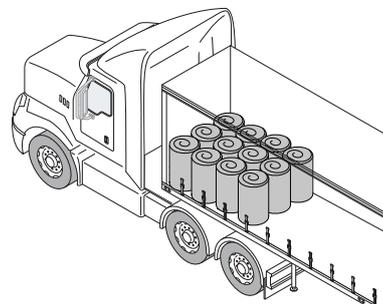


- ✗ Do not use tarpaulins or curtain sides as the sole form of restraint – *Figure 73* and *Figure 74*.

*Figure 73 Tarpaulin without tie-down*

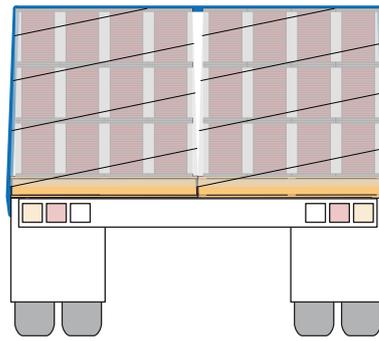


*Figure 74 Curtains without restraint*



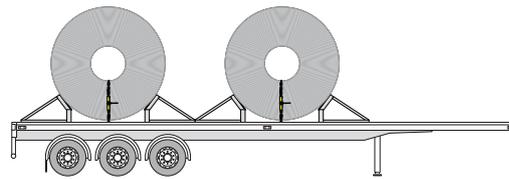
- ✓ Contain small rolls and reels in suitably engineered bodies or containers, if available; otherwise, unitise them to pallets and tie them down – *Figure 75*.

*Figure 75 Palletised small reels*

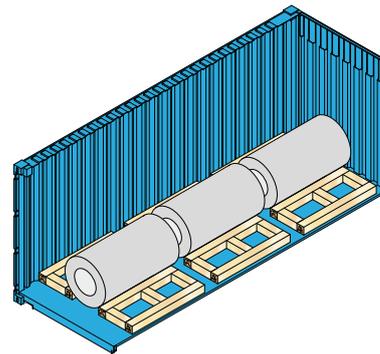


- ✓ Transport rolls and reels on specially equipped vehicles – *Figure 76* or in containers – *Figure 77* wherever possible.

*Figure 76 Specialised trailer*

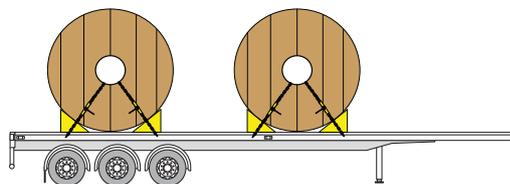


*Figure 77 Rolls in container*



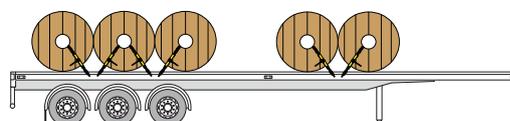
- ✓ Restrain large rolls or reels individually; use chocks, cradles or A-frames as part of a direct restraint or tie-down restraint system – *Figure 78*.

*Figure 78 Large reels restrained individually*



- ✓ Restrain small rolls and reels against each other in pairs or groups of 3. Use 2 restraints against forward movement for groups of 3 – *Figure 79*.

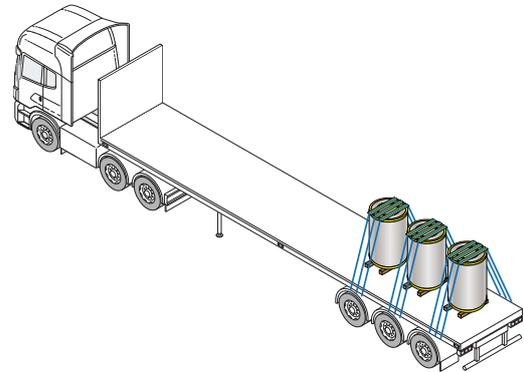
*Figure 79 Small reels restrained in groups of 2 or 3*



## LOW-FRICTION CYLINDERS

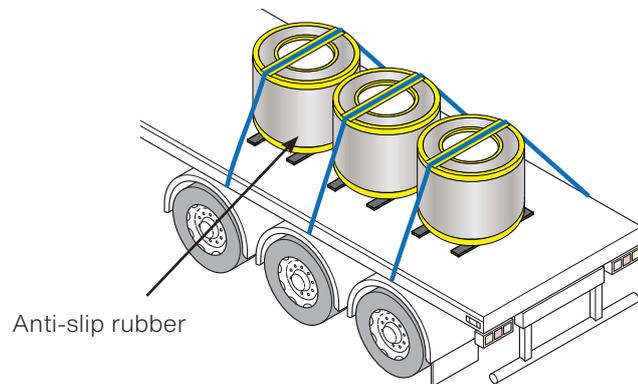
 Low-friction vertical cylinders will require a large number of tie-down lashings if they are not blocked – *Figure 80*. This may be impractical.

*Figure 80 Unblocked rolls tied down*



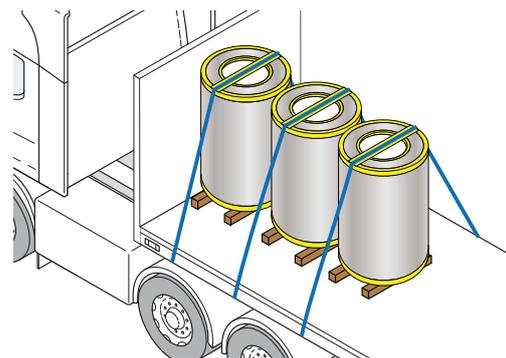
 Anti-slip rubber can reduce the required number of tie-down lashings, particularly for low friction loads – *Figure 81*.

*Figure 81 Rolls tied down on anti-slip*

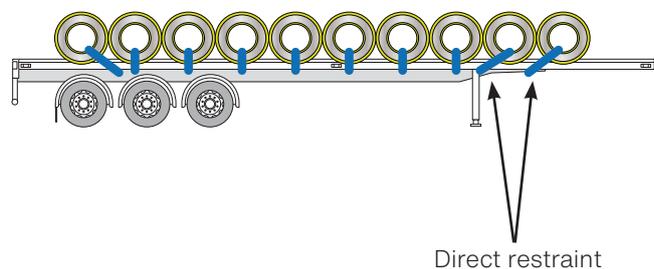


 Directly restraining or blocking cylinders in the forward direction will also reduce the required number of tie-down lashings – *Figure 82* and *Figure 83*.

*Figure 82 Blocked rolls tied down*



*Figure 83 Forward direct restraint*



# PREVENTING DAMAGE TO CYLINDERS

✔ Prevent damage to product and lashings by placing angled-edge corner protectors or specially fabricated core inserts between the lashings and the item – *Figure 84* and *Figure 85*.

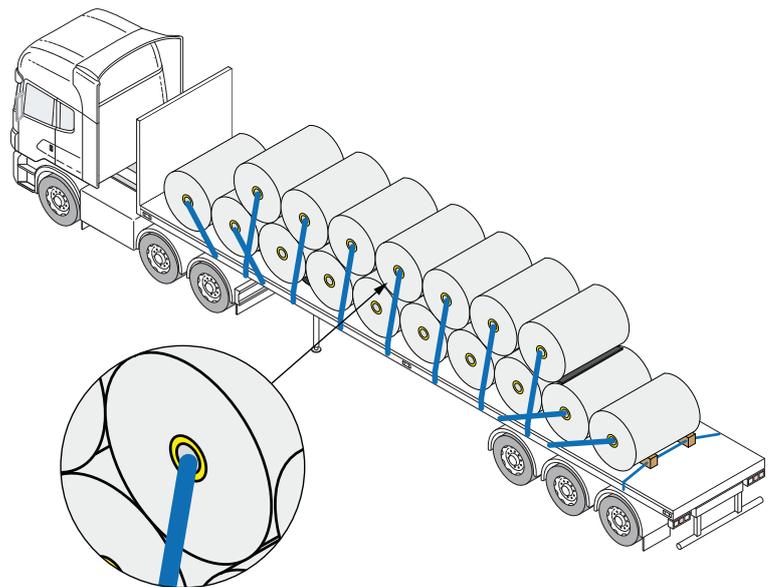
**i** Angled-edge corner protectors and core inserts can also prevent the lashings from slipping.

*Figure 84 Restraining vertical rolls*



Angled-edge corner protectors

*Figure 85 Restraining large diameter rolls*



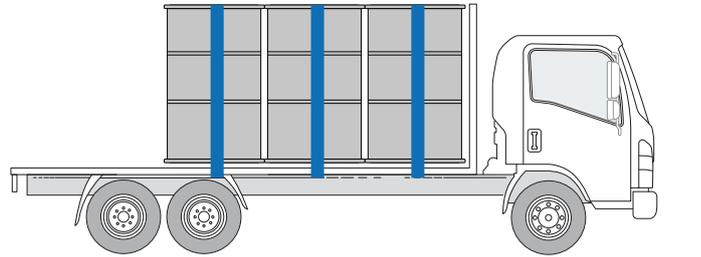
Fabricated core inserts

## VERTICAL CYLINDERS

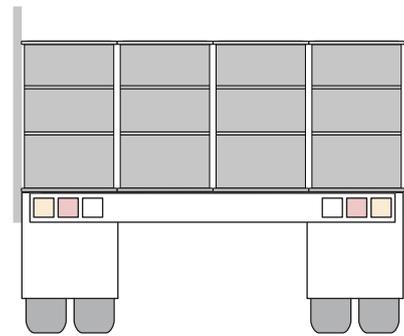
✓ Restrain vertical rolls, reels, coils and drums by tie-down and forward-blocking – *Figure 86*.

⚠ Containment systems often have insufficient capacity to restrain heavy rolls, reels, coils and drums – *Figure 87*.

*Figure 86 Drums tied down and blocked*

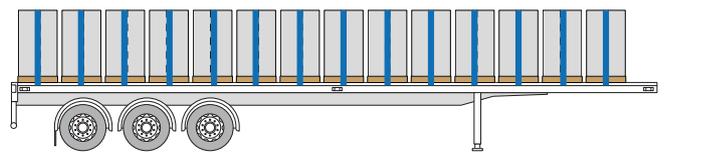


*Figure 87 Drums contained by lightweight gates*

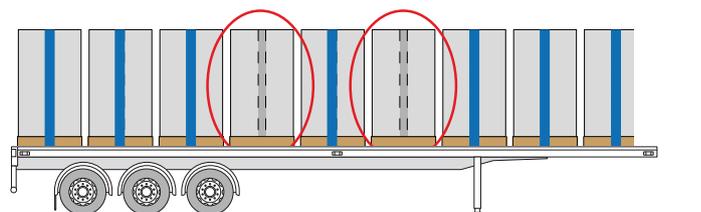


✓ Restrain every cylinder by at least one lashing, unless they are unitised to a pallet – *Figure 88*.

*Figure 88 All items tied down*



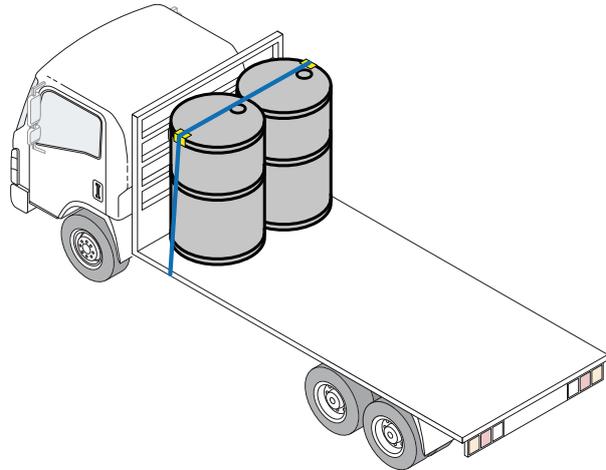
*Figure 89 Items not tied down*



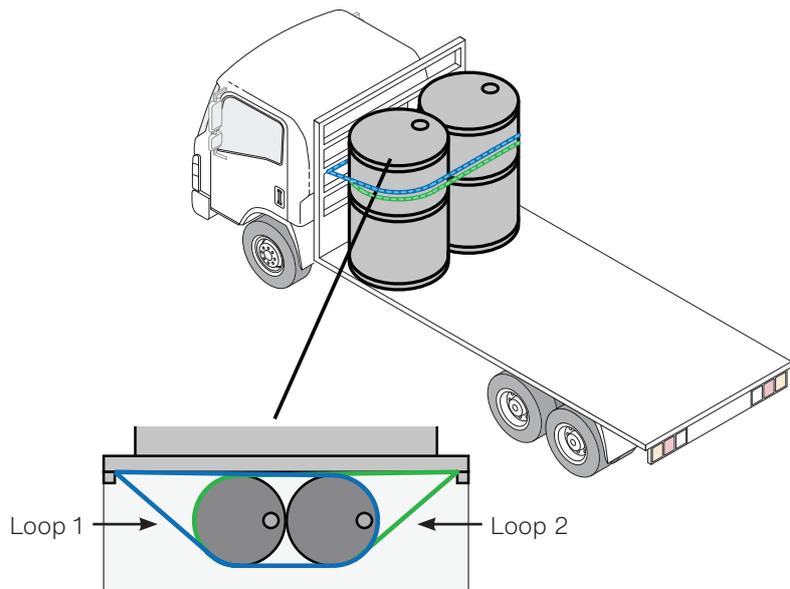
- ✓ To prevent sideways movement, restrain vertical cylinders against headboards by tie-down or by opposed loops – *Figure 90* and *Figure 91*.

- ✓ Transport tall cylinders vertically if blocked against a suitably engineered headboard (or similar) or adequately supported by surrounding product – *Figure 90* and *Figure 92*.

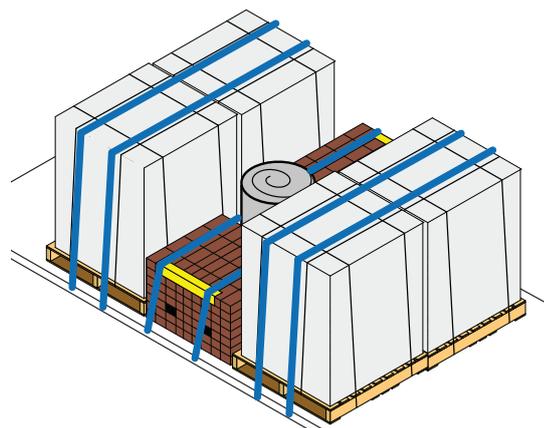
*Figure 90 Cylinders restrained against headboard – tie down*



*Figure 91 Cylinders restrained against headboard – opposed loops*

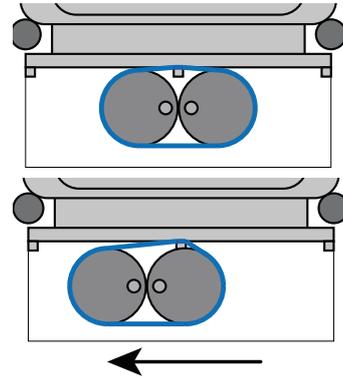


*Figure 92 Cylinders supported by product*



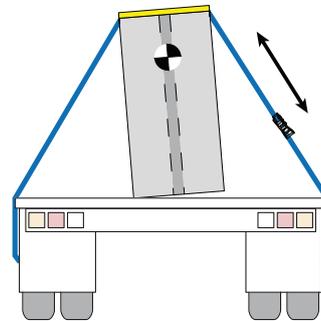
- ✘ Do not restrain drums by tying them to centre posts horizontally as they will be able to move sideways – *Figure 93*.

*Figure 93 Drums tied to centre post*



- ⚠ Webbing straps may not be suitable for restraining tall rolls at risk of toppling due to excessive stretch – *Figure 94*.

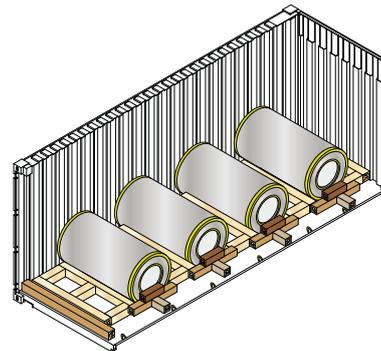
*Figure 94 Webbing stretch*



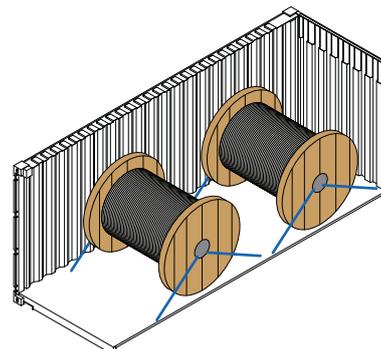
## HORIZONTAL CYLINDERS

- ✔ Directly restrain horizontal cylinders by containment using dunnage or chocks or direct lashings – *Figure 95* and *Figure 96*.

*Figure 95 Rolls contained with dunnage*



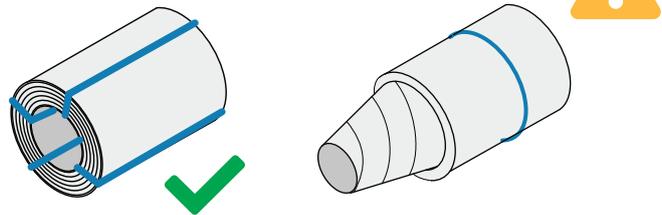
*Figure 96 Reels direct restraint*



- ✓ Wrap or strap horizontal sheet coils through the bore to prevent telescoping during transport – *Figure 97*.

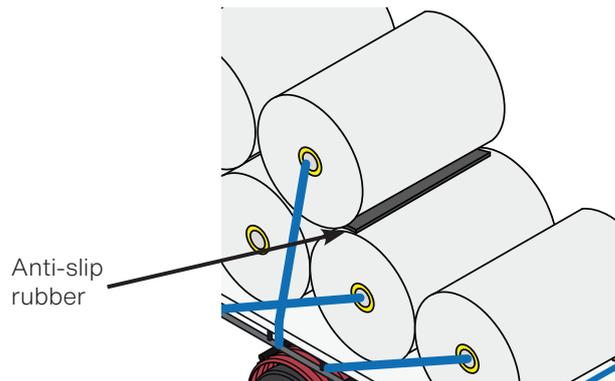
- ⚠ Telescoping can affect vehicle stability and cause loss of load – *Figure 97*.

*Figure 97 Sheet coil may telescope if not strapped*



*Figure 98 Interlayer packing*

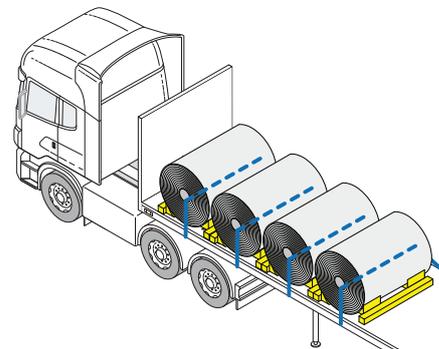
- ✓ Insert interlayer packing between layers of stacked low-friction horizontal rolls, reels and drums to increase friction – *Figure 98*.



*Figure 99 Cylinders on movable cradles*

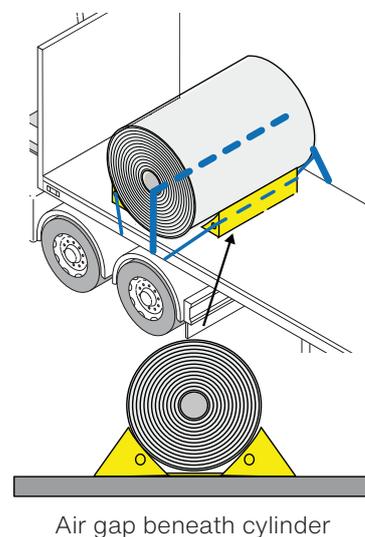
- ✓ Transport horizontal cylinders in fixed or movable individual cradles – *Figure 99*.

- ✓ Restrain chocks and wedges independently, in addition to the cylinder restraints, so that the chock or wedge cannot dislodge – *Figure 100*.



*Figure 100 Chocks restrained separately*

- ✓ Make sure the chock or cradle system leaves an air gap between the coil and the vehicle deck – *Figure 100*.



**i** Cradles can protect the load and distribute weight over the vehicle deck – *Figure 101*.

**i** The wedge angle for cradles and chocks should be no less than  $39^\circ$  – *Figure 101*.

✓ Make sure chocks are large enough for the cylinders they are to restrain (see [Chocks, cradles and A-frames](#)).

✓ To increase friction, place rubber (or similar) between the deck and steel cradles, chocks or wedges.

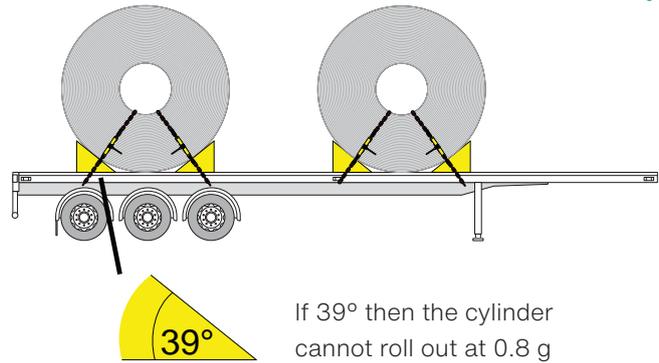
✗ Do not use tie-down over unblocked cylinders.

✓ Use cradles, wedges or chocks to prevent rolling during loading and unloading – *Figure 102*.

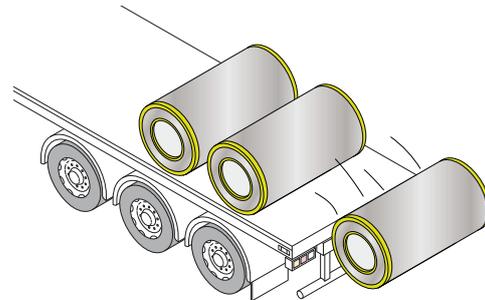
✓ Apply separate direct lashings for each direction to prevent forward and backward movement of uncontained or unblocked horizontal cylinders – *Figure 103*.

✓ Make sure all items in the load receive downward clamping from lashings to provide adequate sideways restraint and prevent rolling movement – *Figure 104*.

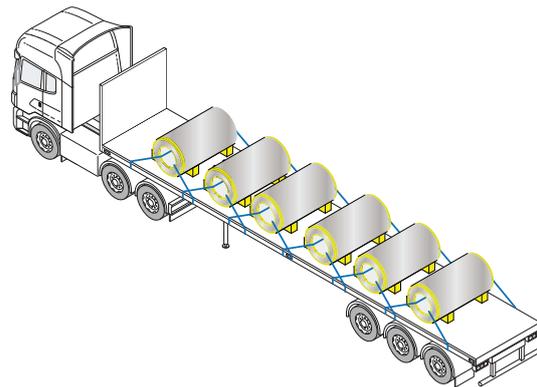
*Figure 101 Coils on wedges*



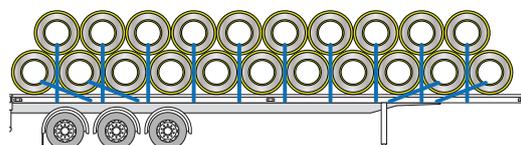
*Figure 102 Unchoked roll falling off truck*



*Figure 103 Direct restraint separate lashings*



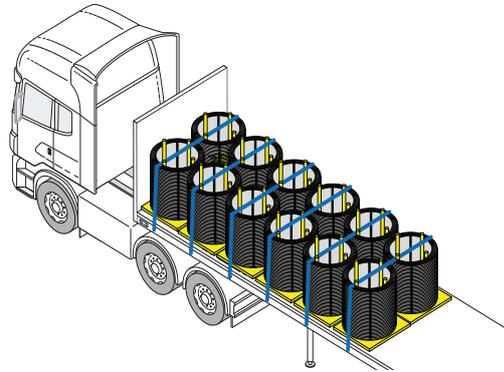
*Figure 104 Clamping not applied to all items*



## COILED ROD (ROD-IN-COIL)

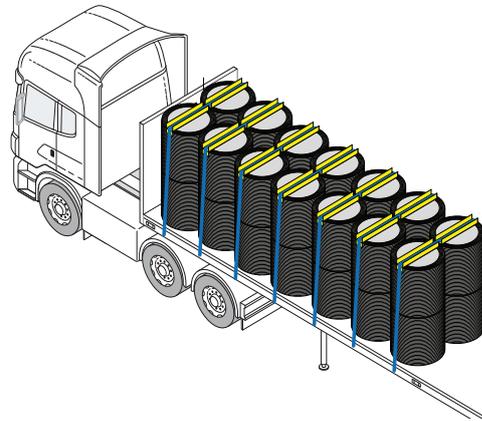
- ✓ Transport large numbers of metal coiled rod on purpose-built vehicles or with specifically designed tie-down systems – *Figure 105*.

*Figure 105 Purpose-built tie-down system*



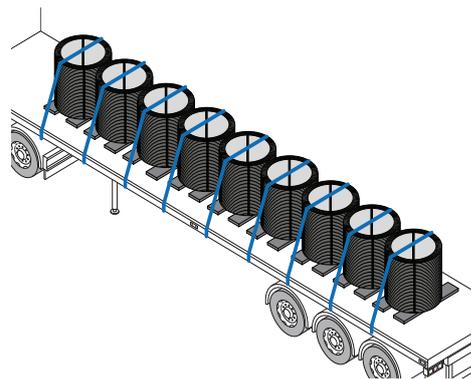
- ⚠ Double-stacked vertical coiled rod should be restrained by an engineered load restraint system – *Figure 106*.

*Figure 106 Stacked coiled rod*



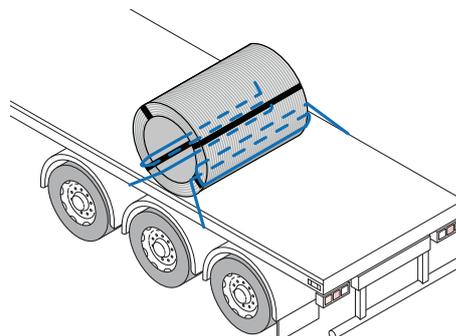
- ✓ Place anti-slip rubber between the freight and deck when restraining vertical coiled rod by tie-down – *Figure 107*.

*Figure 107 Full load of vertical coiled rod with anti-slip rubber*



- ✓ Horizontal coiled metal rod can be directly restrained by lashing through each bore – *Figure 108*.

*Figure 108 Coiled rod lashed through bore*



# PIPES, TUBES, RODS AND BARS

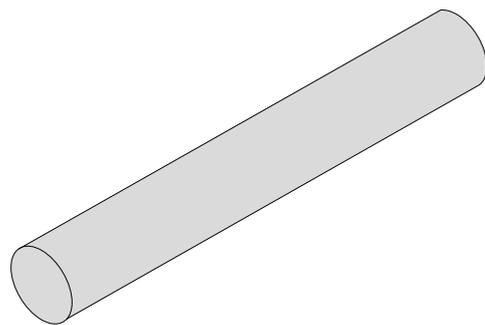
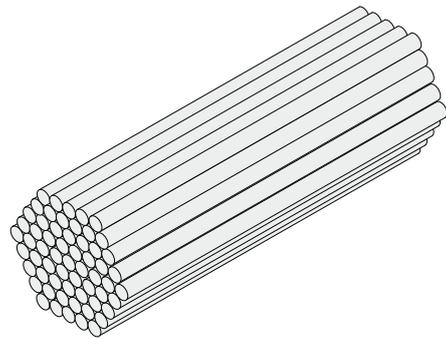
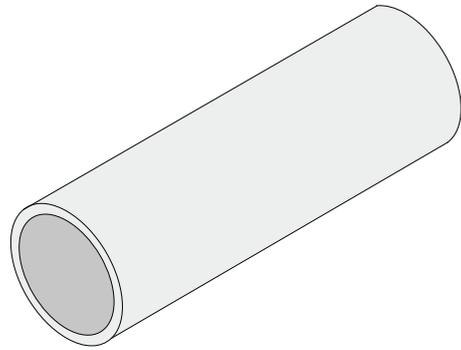
Round pipes, tubes, rods and bars are manufactured in various forms and lengths – including metal and plastic in long lengths and reinforced concrete in short lengths.

These types of items can roll around if not restrained properly. Metal and plastic are also low-friction materials that make these load items more slippery than items made of high-friction materials. These load items need to be restrained using specific methods to limit their movement sufficiently.

This guide provides general tips to apply to all round lengths. Extra guidance is also provided for pipes on scalloped dunnage, cradled pipes, loose lengths between stanchions, pipes on flat dunnage, unitised bundles, mixed loads of bundled items, long-length items and short-length items. Pipes and other round items may fall into more than one of the specific categories outlined above. Make sure you review the appropriate guideline(s) for the load.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining pipes, tubes, rods and bars. They are a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

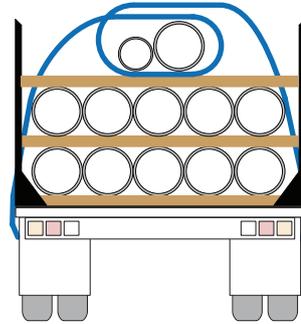
**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).



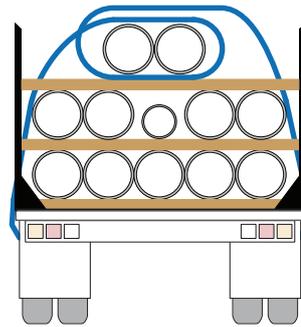
## GENERAL TIPS FOR ALL ROUND LENGTHS

- ✓ Check the number and type of lashings are appropriate for the size of the load.
- ✓ Check all items are restrained to prevent any items sliding out of the pack – *Figure 109*.
- ✓ Restrain loose pipes individually if the external lashings do not effectively clamp all pipes.
- ⚠ Tie-down lashings may not provide sufficient sideways restraint for loose pipes loaded on dunnage or nested – *Figure 110*.
- ✓ Restrain loose pipes sideways with suitably engineered stanchions.
- ✓ Use interlayer packing material (such as timber or rubber matting) to increase friction between individual sections.
- ⚠ Items with smooth surfaces (low friction) are difficult to restrain using tie-down.
- ✓ Protect spigoted, socketed, threaded, bevelled or flanged ends using a suitable packing material.
- ✓ When tying down fragile loads, use webbing lashings or appropriate protectors if using ropes or chains, to prevent load damage.
- ⚠ Soft or crushable loads can be damaged by restraint equipment particularly chains – *Figure 111*.

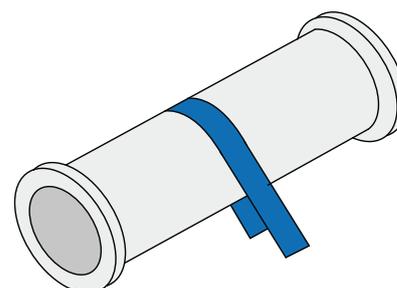
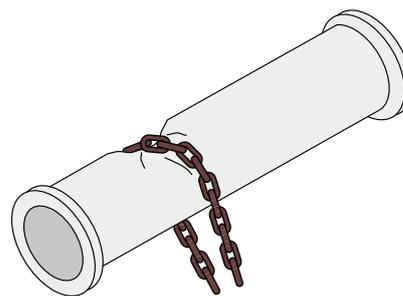
*Figure 109 Smaller pipe will be clamped once lashing is tensioned*



*Figure 110 Limited clamping on the centre pipe*



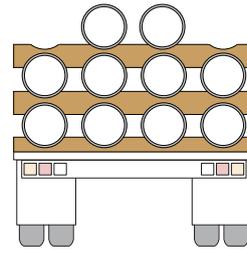
*Figure 111 Fragile freight*



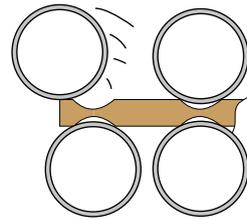
## PIPES ON SCALLOPED DUNNAGE

- ✔ Use scalloped dunnage, unitised bundles or containers if transporting large quantities regularly; this can reduce transport costs, product damage and loading/unloading time.
- ✔ Use dunnage that is scalloped top and bottom to prevent pipes rolling during transport and loading and unloading – [Figure 112](#).
  - ⚠ Pipes can roll sideways if the scallops are not deep enough – [Figure 113](#).
  - ⚠ Side pins, posts or stanchions may be required to prevent lengths rolling during loading/unloading – [Figure 114](#).
- ✔ Use stanchions that are suitably engineered to withstand impacts from loading and unloading equipment in addition to restraining the load.
- i Loads on scalloped dunnage that are sufficiently tied down to resist sideways forces do not require stanchions for sideways restraint during transport – [Figure 115](#).
- ✔ Load a maximum of 2 pipes on the top layer unless the load is blocked forwards and rearwards – [Figure 116](#).

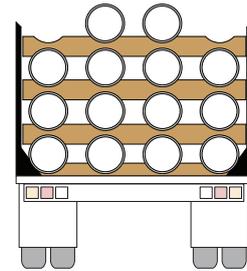
*Figure 112 Scalloped dunnage*



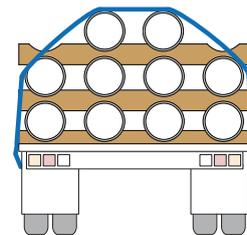
*Figure 113 Scallops not deep enough*



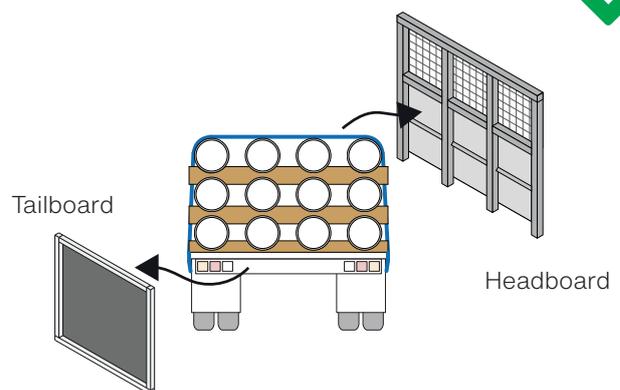
*Figure 114 Side posts for loading/unloading*



*Figure 115 Crowned load*



*Figure 116 Flat load with blocking*

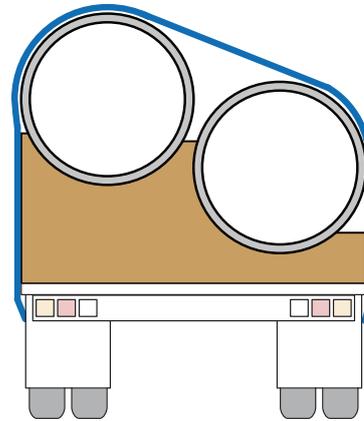


More than 2 pipes can be loaded on top when blocking is used

## CRADLED PIPES

- ✓ Tie down large diameter pipes on specially fabricated cradles or racks to prevent rolling and to distribute the weight evenly over the vehicle – [Figure 117](#).
- ⚠ Pipe cradles and racks may need to be secured independently of the load because the tie-down lashings may not prevent the rack toppling.
- ✓ To determine the dimensions of scallops and cradles see [Chocks, cradles and A-frames](#).
- ✓ Reduce cornering speeds when transporting high centre of mass loads.
- ⚠ Loads with a high centre of mass are less stable and more prone to causing vehicle rollover.

Figure 117 Cradled pipes



## LOOSE LENGTHS BETWEEN STANCHIONS

- ✓ Use suitably engineered stanchions that can restrain the whole load sideways – [Figure 118](#).
- ✓ Restrain every pipe in the load with a minimum of 2 stanchions on each side of the load.
- ✓ Check the pipes extend at least 300 mm beyond the outer stanchions in the forward and rearward directions – [Figure 119](#).
- ✓ Place longer lengths towards the outside of the stack and shorter lengths in the centre.
- ✗ Don't extend the top pipes more than half their height above the top of the stanchion.
- ✓ Block loads forwards and rearwards because clamping may not be effective for all pipes – [Figure 120](#).

Figure 118 Trailer with stanchions

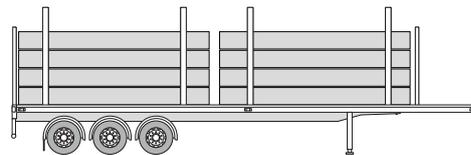


Figure 119 Minimum engagement

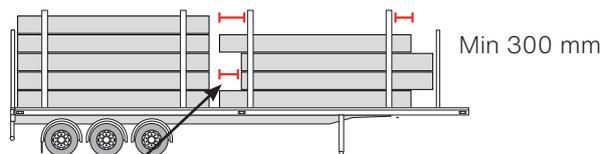
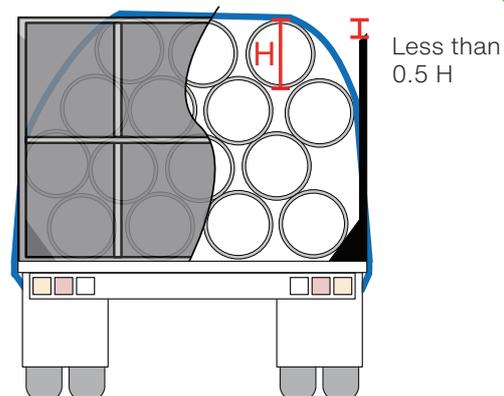


Figure 120 Blocking

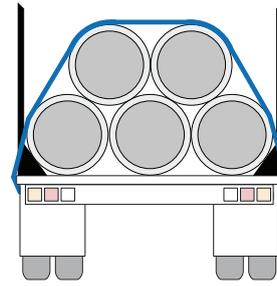


Load blocked, top lengths less than 0.5 H above stanchions

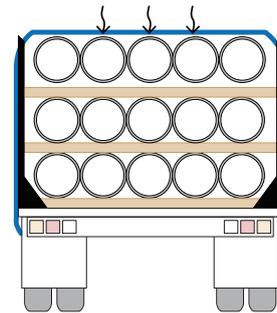
## PIPES ON FLAT DUNNAGE

- ✓ Check stanchions used with tie-down lashings are suitably engineered to accept sideways forces.
- ✓ Crown the load (i.e. ensure there are no gaps in the top layer), and check all pipes are clamped by tie-down lashings – *Figure 121*.
- ⚠ If crowning is not used, some pipes on the top layer may be unrestrained – *Figure 122*.
- ✓ Loads contained sideways should be blocked forwards and rearwards.
- ⚠ If loads are unblocked forwards and rearwards, apply belly-wrapped – *Figure 123*, opposed loops – *Figure 124* or load-choked – *Figure 125* lashings.
- ⚠ Friction between the pipes should be high if pipes are not blocked forwards and rearwards.

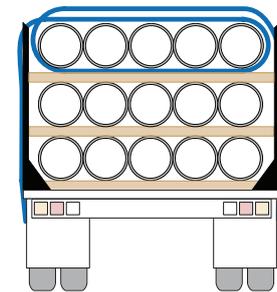
*Figure 121 Crowned load*



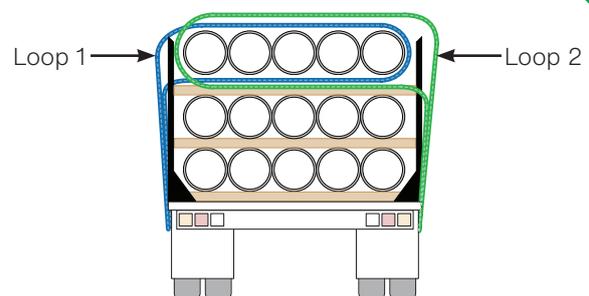
*Figure 122 Flat-topped load*



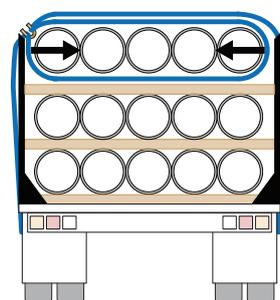
*Figure 123 Belly-wrapped load*



*Figure 124 Opposed loops*



*Figure 125 Load choked*



# UNITISED PIPES, BARS AND RODS

✔ Unitise items by packaging with appropriate strapping – *Figure 126*. Dunnage can help prevent items from regrouping.

⚠ Slippery or crushable lengths are not suitable for unitising with packaging strapping.

✔ Strapping can be used to prevent individual lengths spearing out from the group.

✔ Use packaging strapping to attach items to slotted dunnage for ease of handling if required – *Figure 127*.

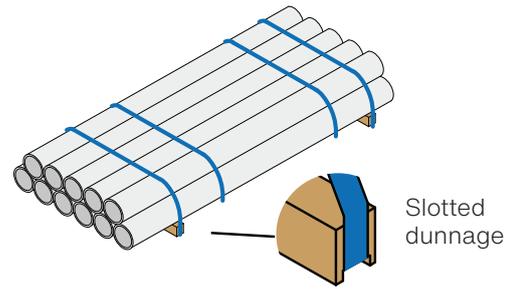
✔ Use belly wrapping with at least 2 lashings to further unitise and restrain small quantities of loose items.

✔ Restrain packs unitised with steel wire loops by applying belly-wrapped lashings.

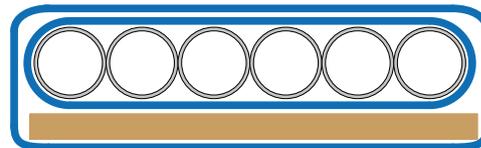
✘ Don't use twisted steel wire loops as the only form of unitisation on a pack – *Figure 128*.

✔ Loop belly-wrapped lashings over the top of the load to provide tie-down – *Figure 129*.

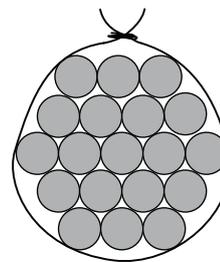
*Figure 126 Unitised lengths*



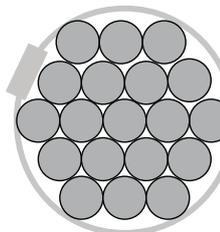
*Figure 127 Unitised lengths – end view*



*Figure 128 Unitising bundles*

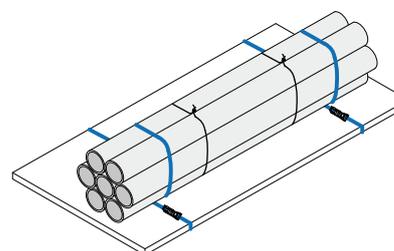
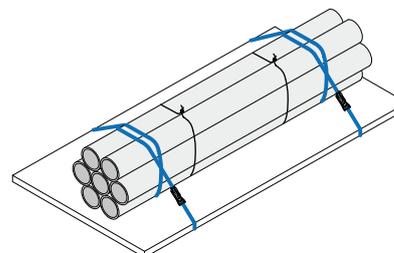


Bundles secured with twisted wire may not prevent spearing of loose lengths



Bundle unitised with packaging straps

*Figure 129 Belly-wrapped load*



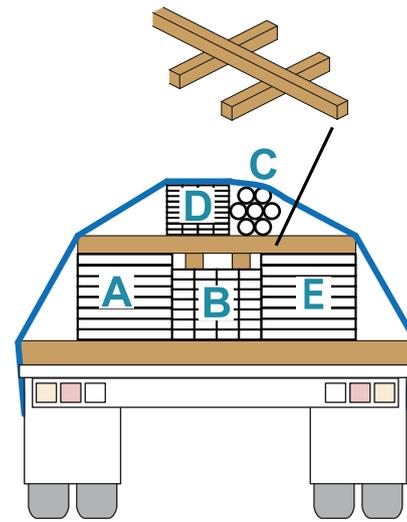
## MIXED LOADS OF BUNDLED LONG ITEMS

- ✓ Crown loads composed of multiple odd-sized bundles to apply even downward pressure across the load – *Figure 130*.
- ✓ Unitise bundles using belly-wrapped lashings and apply tie-down lashings over the top of the load.
- ⓘ Chains are most effective for belly wrapping.

- ✓ Divide loads to achieve more effective crowning if required – *Figure 131*.

⚠ Lashing points along the middle of the deck may be required for divided loads.

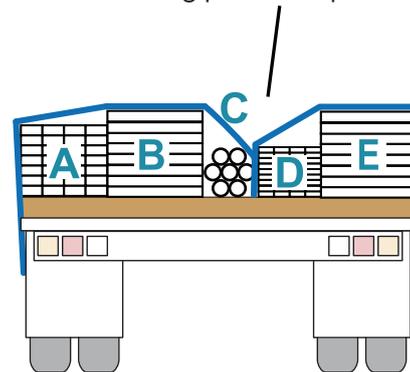
*Figure 130 Odd-bundle loads*



✓  
Load crowned

*Figure 131 Divide loads*

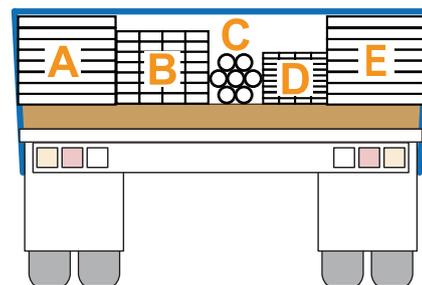
Central lashing points required



✓  
Load divided

B, C & D have no vertical clamping

✗



## LONG-LENGTH ITEMS

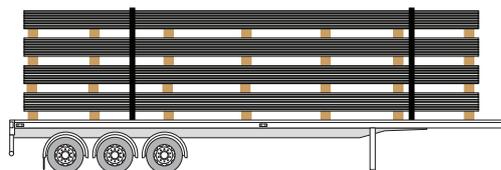
### Long flexible items

- ✓ Make sure long items are carried on sufficiently long vehicles to meet allowable length and overhang regulations, and to provide adequate support.
- ⚠ Loads of flexible long items may reduce the trailer capacity if dunnage is located away from the axle groups and/or kingpin – [Figure 132](#).
- ✓ Support flexible long items (e.g. small diameter pipes, timber, rod and rolled steel sections) at frequent intervals – [Figure 133](#).

Figure 132 Reduced trailer capacity



Figure 133 Flexible long lengths



Lengths supported at frequent intervals

### Long rigid items

- ✓ Support long rigid items (e.g. large diameter metal pipes, concrete beams and heavy rolled steel sections) at only 2 points when transported on extendable trailers to allow the trailer to flex.
- ✓ Support long rigid items at 2 positions approximately 20% of the length of the item from each end – [Figure 134](#).
- ✓ Locate supports above the axle group and kingpin.

Figure 134 Rigid long lengths

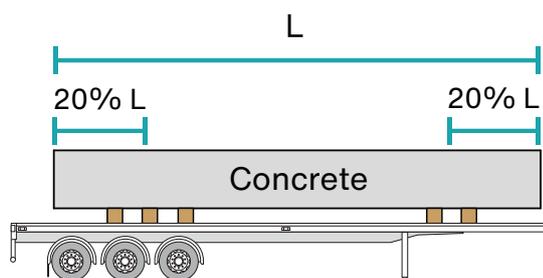
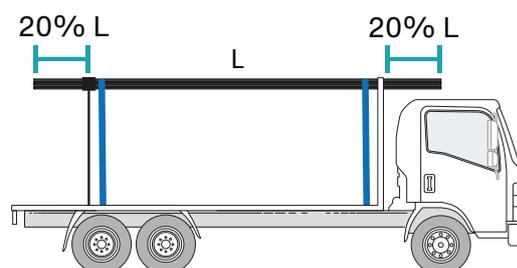


Figure 135 Long lengths on roof racks



### Roof and ladder racks

- ✓ Restrain long items transported on roof or ladder racks by at least 2 lashings.
- ⚠ Long items transported on roof or ladder racks must not overhang the rack by more than 20% in length – [Figure 135](#). Ensure vehicle dimension limits are not exceeded.

- ⓘ The load support points table provides indicative measurements for the required distance between supports and maximum overhang for items of different lengths.

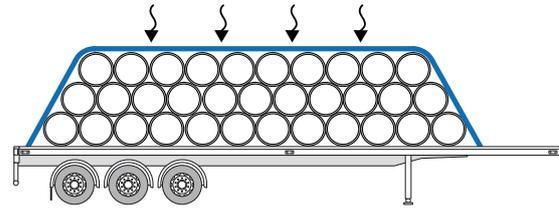
#### LOAD SUPPORT POINTS

Load	Distance between supports	Maximum overhang
2,500 mm	1,500 mm	500 mm
3,000 mm	1,800 mm	600 mm
4,000 mm	2,400 mm	800 mm
5,000 mm	3,000 mm	1,000 mm
6,000 mm	3,600 mm	1,200 mm
7,000 mm	4,200 mm	1,400 mm
8,000 mm	4,800 mm	1,600 mm

## SHORT PIPES

- ✓ Restrain short pipes placed across a vehicle by tie-down or containment.
- ✓ Divide and crown loads to apply adequate clamping to all lengths – *Figure 137*.
- ⚠ Tie-down restraint of large loads of lengths across the deck without crowning will not adequately clamp all lengths – *Figure 136*.
- ✓ Block crowned stacks of pipes at the base to control movement.

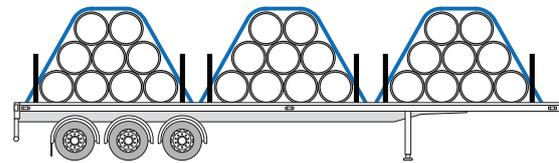
*Figure 136 Large load of lengths*



Insufficient clamping on middle lengths



*Figure 137 Large divided load of lengths*

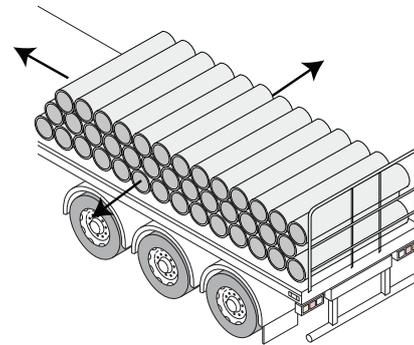


Load divided and crowned

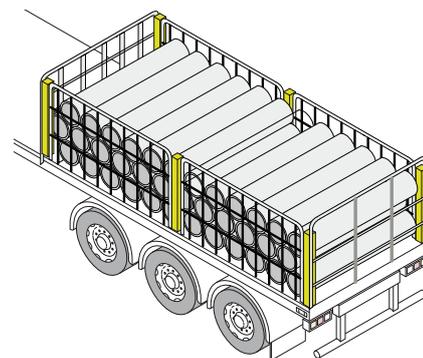


- ✓ Make sure bulk stacks restrained by containment only have suitably engineered blocking surfaces forwards, rearwards and sideways – *Figure 138*.

*Figure 138 Bulk-stacked lengths*



Load not restrained sideways or forwards



Load contained in all directions

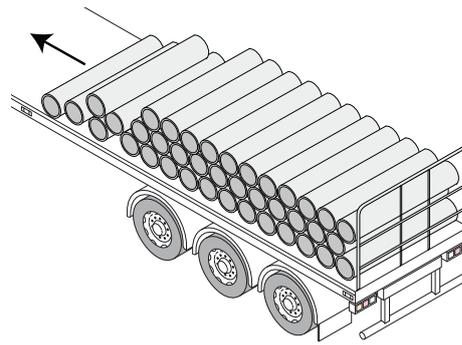


✓ Contain small, light pipes sideways using suitably engineered gates or other containment methods.

✓ Check load stability when determining the unloading sequence.

⚠ Bulk stacks may become unstable or collapse if unloaded incorrectly – [Figure 139](#).

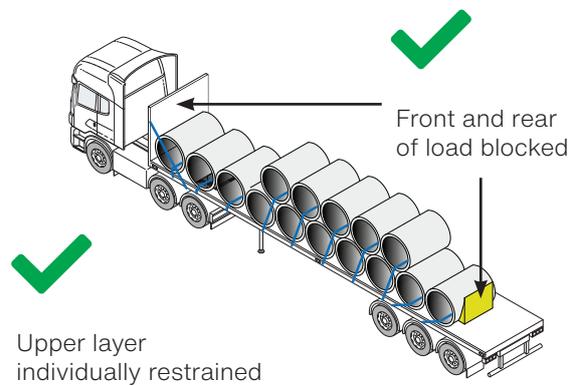
[Figure 139 Stack collapse](#)



✓ Individually tie down the top layer of stacked large-diameter pipes to positively clamp all lower layer pipes and prevent sideways movement – [Figure 140](#).

✓ Block or directly lash front and rearmost pipes to prevent movement of the stack – [Figure 140](#).

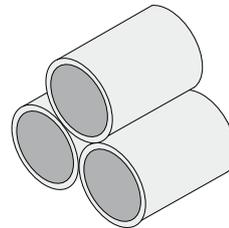
[Figure 140 Stacked large-diameter pipes](#)



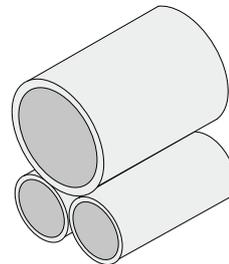
✓ Make sure all pipes in the stack are a similar diameter to prevent roll out – [Figure 141](#).

✓ Make sure all pipes in the stack are a similar length to allow sufficient clamping to be applied – [Figure 141](#).

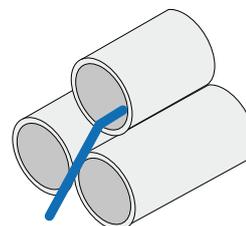
[Figure 141 Length and diameter of pipes](#)



Similar length and diameter



Large variation in diameter



Large variation in length

# SHEETS AND FLAT LOADS

Loads consist of sheet, plate or similar flat items manufactured from any material in palletised or loose form. You'll need to take into account the friction between sheets or plates when applying the guidelines below.

Sheet-to-sheet friction is affected by the material that the sheets or plates are made of, as well as the presence of external substances on the sheets. Total friction does not increase by having a large contact area.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining sheets and flat loads. They are a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

## LOW-FRICTION SHEET AND FLAT PLATE

### Restraint method

#### Direct restraint

- ✓ Block or directly lash low-friction sheet and flat plate loads in the forward direction – [Figure 143](#).
  - ❗ Some sheet loads, such as oiled or laminated steel, may have low sheet-to-sheet friction, reducing the effectiveness of tie-down lashings.
  - ❗ Loose particles (i.e. saw dust or powder) can make sheets more slippery and further reduce the effectiveness of tie-down lashings.
- ✓ Use suitably engineered sideways blocking systems (e.g. stanchions, pegs or stakes) for sideways restraint, if tie-down is insufficient – [Figure 144](#).

Figure 142 Loose sheets and palletised sheets

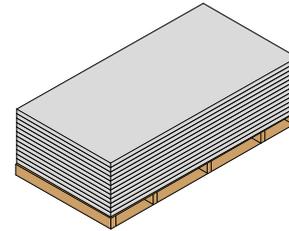
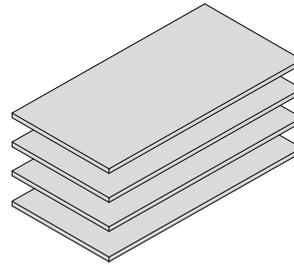


Figure 143 Forward blocking

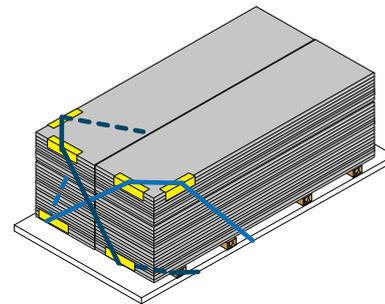
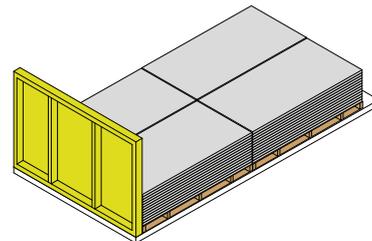
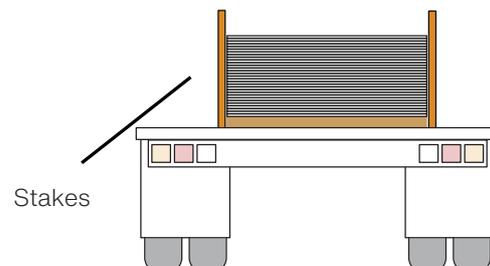


Figure 144 Flat plate restrained sideways by stakes

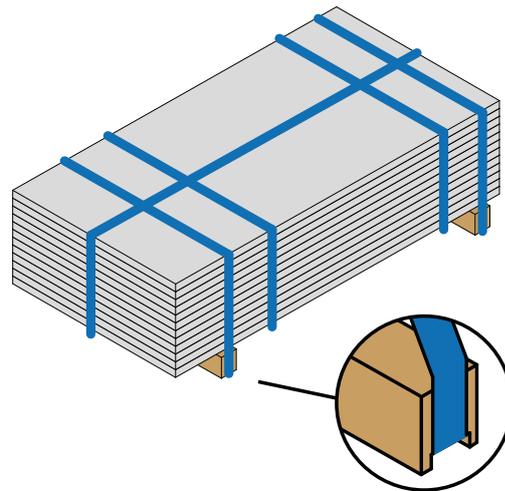


## Tie-down

- ✓ Low-friction sheets can be unitised into packs to simplify tie-down restraint requirements – *Figure 145*.

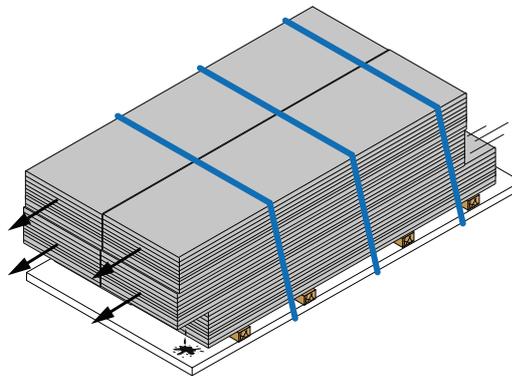
**i** Routing of the base timbers prevents the pack sitting on the low-friction banding and protects the banding from damage or dislodgement during handling.

*Figure 145 Unitised sheet pack*



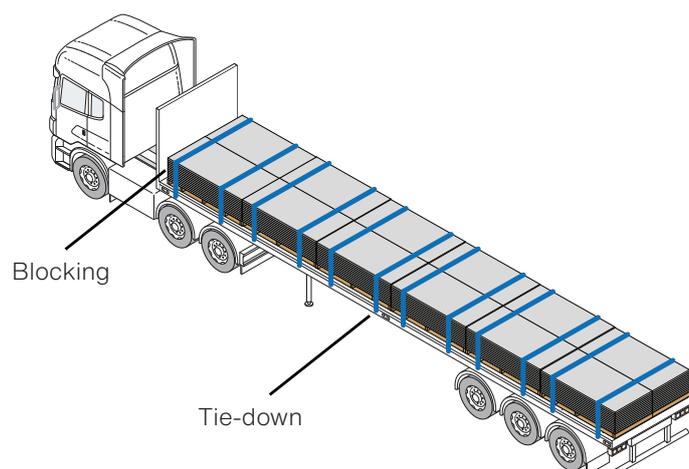
- ✗ Do not rely solely on tie-down lashings for forward restraint of low-friction sheets – *Figure 146*.

*Figure 146 Tie-down only*



- ✓ Tie-down lashings can be applied in addition to blocking or direct restraint in the forward direction for low-friction sheets – *Figure 147*.

*Figure 147 Blocking and tie-down – low-friction*



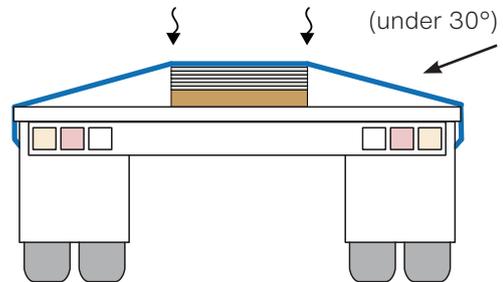
- ✓ Select tie-down lashings that will meet sideways and rearwards restraint requirements for forward-blocked loads.

## MEDIUM-FRICTION SHEET AND FLAT PLATE

✓ Restrain loose sheets using tie-down if the sheet-on-sheet friction provides sufficient restraint.

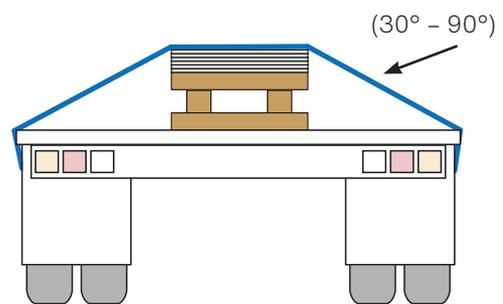
⚠ Check tie-down lashing angles are at least 30° to the horizontal – *Figure 148*.

*Figure 148 Lashing angle too small*

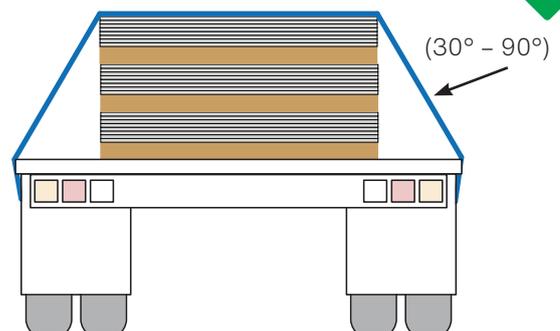


✓ Increase tie-down lashing angles, if required, by placing dunnage under the load – *Figure 149* or stacking multiple packs – *Figure 150*.

*Figure 149 Raised load*

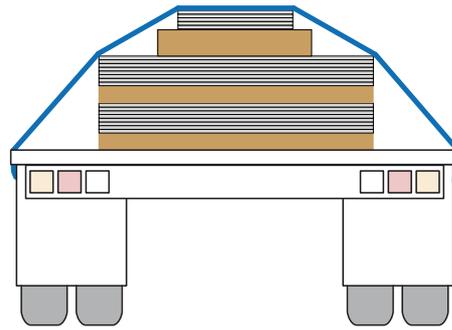


*Figure 150 Stacked load*



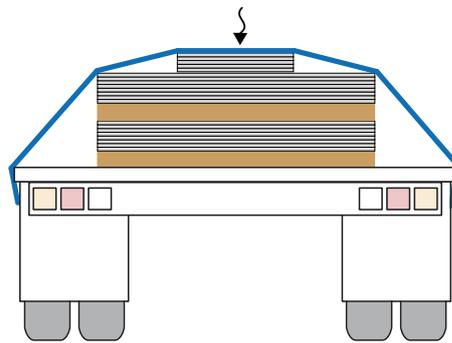
- ✓ Where required, increase clamping provided by tie-down lashings for the upper item of a stacked load of different widths by raising it on timber dunnage or similar – *Figure 151*.

*Figure 151 Upper item raised*



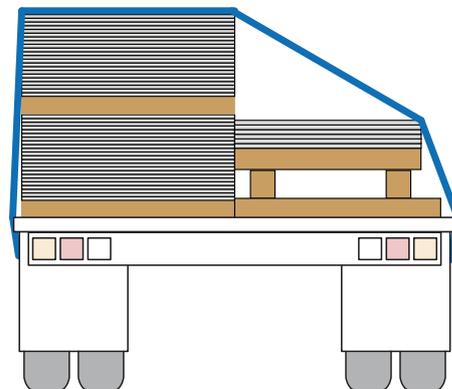
- ⚠ Tie-down lashings over stacked loads of different widths may not provide sufficient clamping to all items – *Figure 152*.

*Figure 152 Insufficient clamping upper item*



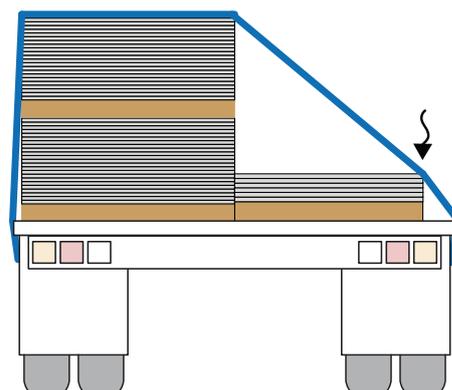
- ✓ Raise or rearrange the load to ensure adequate clamping is provided by the tie-down lashings to all items in a 2-abreast load, if there is significant height difference – *Figure 153*.

*Figure 153 Short stack raised on dunnage*



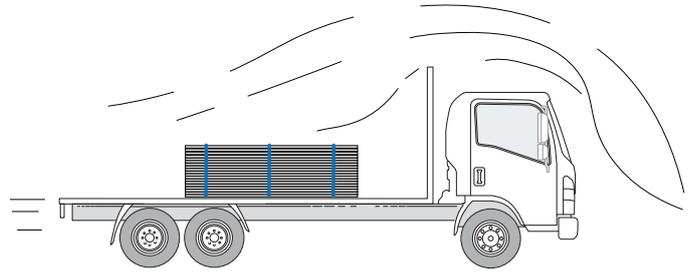
- ⚠ Tie-down lashings placed over 2-abreast loads with a significant height difference may not provide adequate clamping to the shorter stack – *Figure 154*.

*Figure 154 Insufficient clamping on short stack*



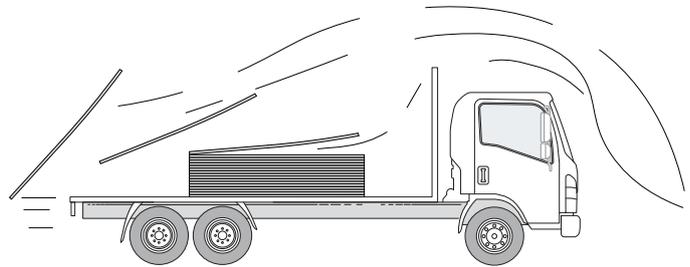
- ✓ Restrain loose sheets transported in open vehicles to prevent load loss from airflow – *Figure 155*.

*Figure 155 Open load tied down*



- ⚠ Loose sheets transported in open vehicles without tie-down restraint may become dislodged by airflow – *Figure 156*.

*Figure 156 Airflow load shift*



# BALES, BAGS AND SACKS

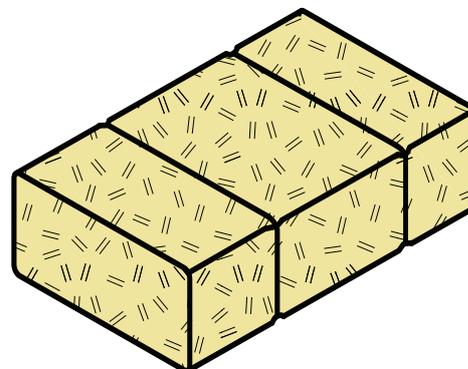
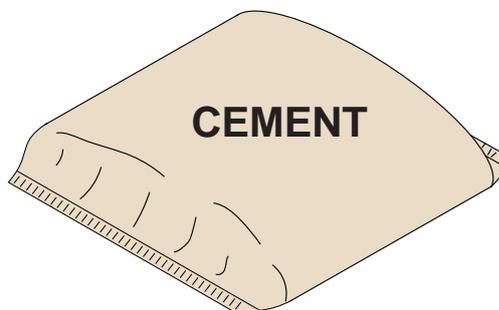
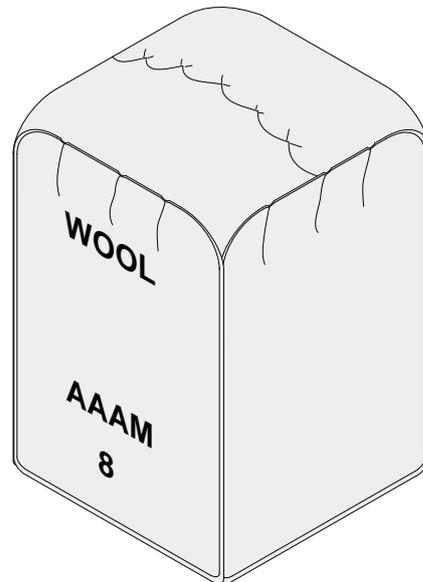
Baled loads include wool, cotton, wood pulp and hay. Loads of bags and sacks include cement, compound mix and sand.

The general guidelines below include important risks and tips that apply to all loads of bales, bags and sacks, while the specific sections that follow focus on the suggested restraint method for each type of load.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining bales, bags and sacks. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out Load Restraint](#)) and [Technical advice](#).

*Figure 157 Wool bale, cement bag and hay bale*



## GENERAL TIPS

- ✓ Use containment to restrain loads of bales, bags or sacks wherever possible.
- ✓ Use tie-down together with blocking or unitising to restrain low-friction loads when containment is not possible.
- ⚠ Bales, bags and sacks are often slippery (low friction) and difficult to restrain using tie-down alone.
- ✓ Check lashing tensions regularly when using tie-down to ensure tension is maintained, particularly as the load settles.

## BALES

### Restraint methods

#### Containment

✓ Restrain bales by containment – *Figure 158*.

⚠ Containment surfaces must be suitably engineered to restrain the freight type – *Figure 159*.

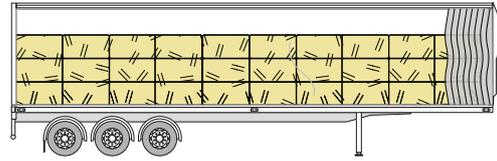
#### Blocking and tie-down

✓ Restrain bales using blocking and/or tie-down – *Figure 160*.

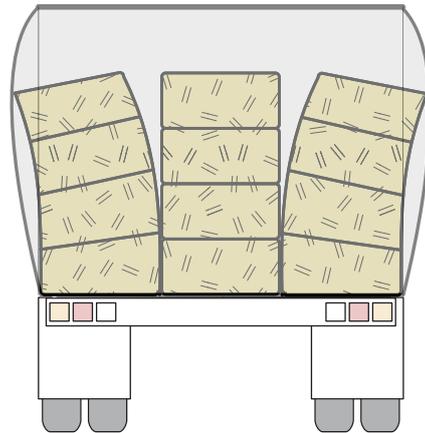
✓ Use forward and rearward blocking surfaces that are suitably engineered and rated to restrain the load – *Figure 161*.

- ⓘ The required number of tie-down lashings is dependent on the friction of the load.
- ⓘ Forward blocking may reduce the number of tie-down lashings required.
- ⓘ Paper between the lashings and bales may help keep lashing tension more even on each side.

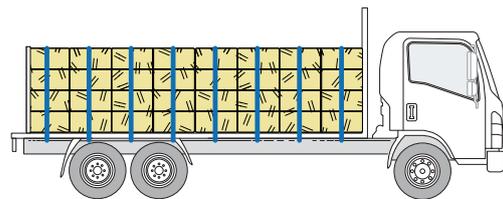
*Figure 158 Contained load*



*Figure 159 Overloaded curtains*



*Figure 160 Lashed and blocked load*

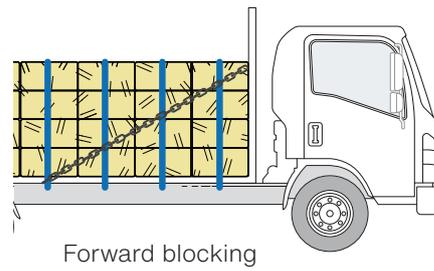


*Figure 161 Rated headboard*

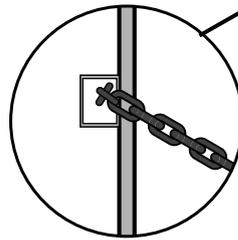


- ✓ Reinforce unrated blocking surfaces using chains (or similar) wrapped across the face of the blocking surface – *Figure 162*.
- ✓ Pass reinforcing chains through a hollow section welded to the blocking surface.
- ⓘ Reinforced unrated blocking surfaces have limited restraint capacity and may fail if used improperly.

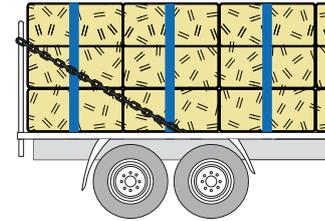
*Figure 162 Unrated blocking reinforcement*



Chain through hollow section

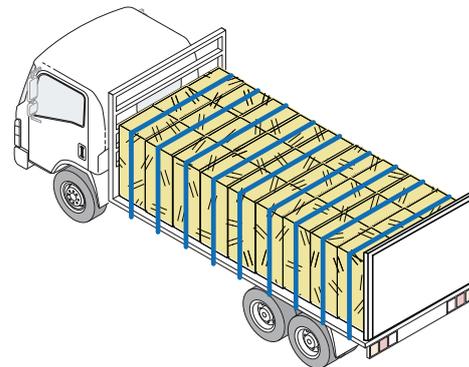


Rearward blocking



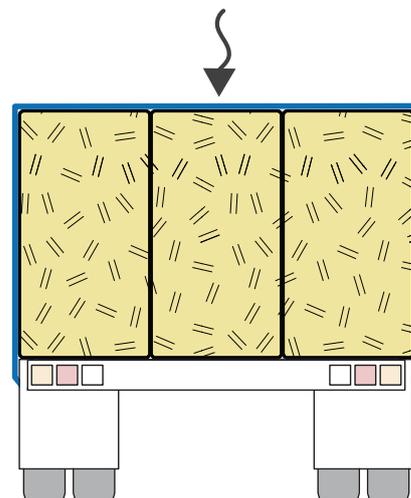
*Figure 163 Blocked loads 3-abreast*

- ✓ Block loads of 3 or more abreast bales in the forward and rearward directions – *Figure 163*.



*Figure 164 Limited clamping on middle bale*

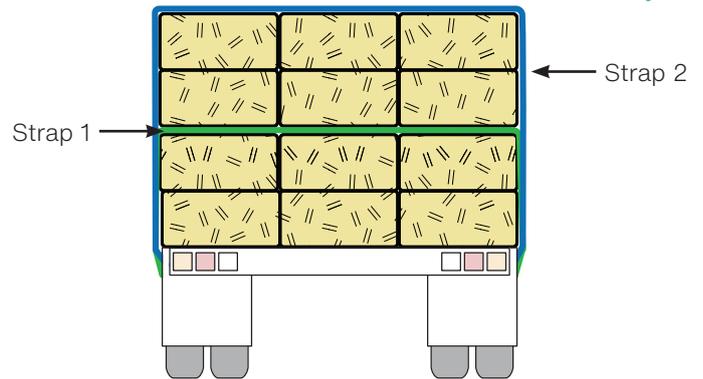
- ⚠ Tie-down of bales loaded 3-abreast may not provide sufficient clamping to the centre bale if tie-down is used on its own – *Figure 164*.



- ✔ Split tall loads into 2 parts and restrain separately to provide additional rigidity – *Figure 165*.

- ✔ Load and restrain the first half before loading the second half on top.

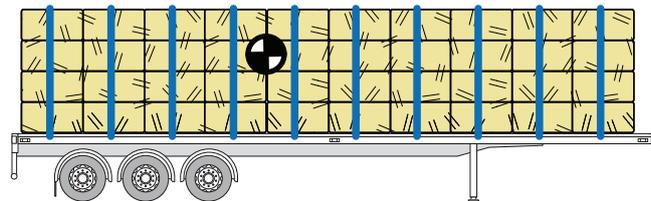
*Figure 165 Bales restrained in 2 halves*



- ⓘ Loads of bales are usually low or medium density and stacked high, which results in the load having a high centre of gravity – *Figure 166*.

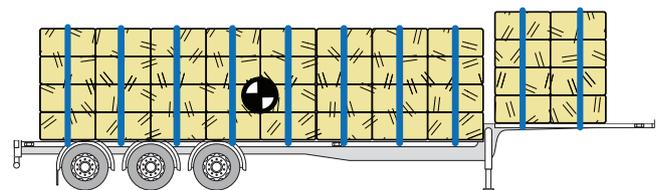
- ✔ Lower the centre of gravity height of the load by transporting the load on a drop deck trailer – *Figure 167*.

*Figure 166 Load on standard trailer*



High centre of gravity load

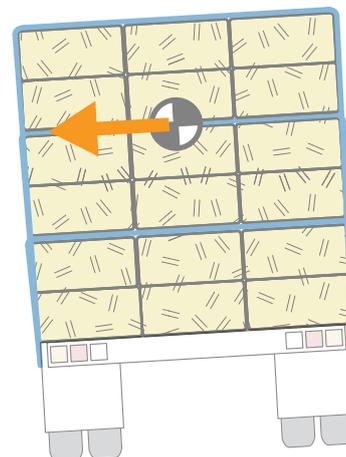
*Figure 167 Load on drop deck trailer*



Reduced centre of gravity height

- ⚠ High loads reduce vehicle stability and can cause vehicle rollover – *Figure 168*.

*Figure 168 High centre of gravity load*

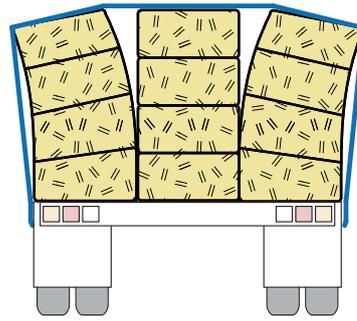


✘ Do not exceed the maximum allowable load width or height at any time.

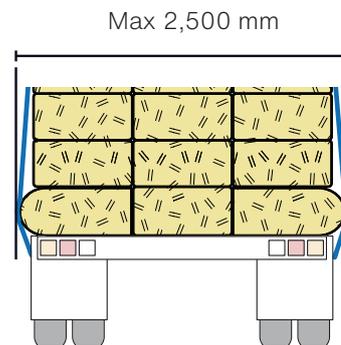
⚠ Tall loads may lean outwards at the top if tie-down is only used over the top of the load – *Figure 169*.

⚠ The load width and height may change after the load settles, pushing the load beyond the maximum allowable width – *Figure 170*.

*Figure 169 Bales leaning out at the top*



*Figure 170 Maximum allowable load width*



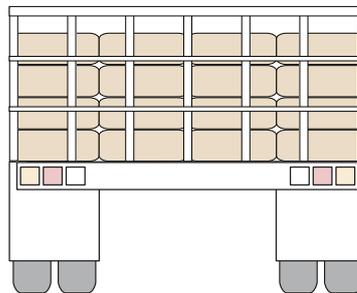
## BAGS AND SACKS

### Restraint methods

#### Containment

✔ Contain loose bags and sacks with rated gates or curtains – *Figure 171*.

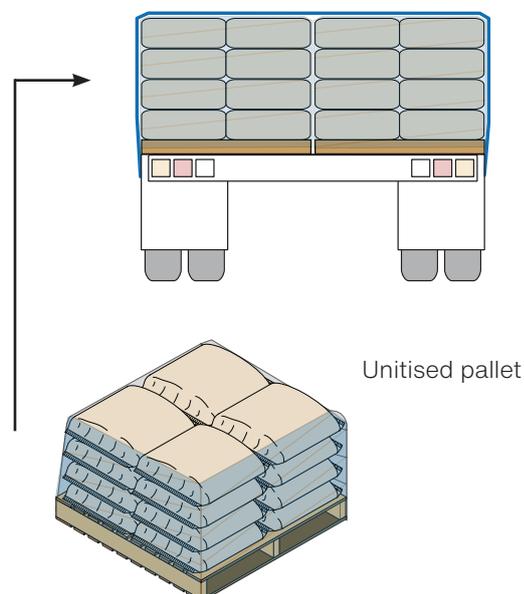
*Figure 171 Loose bags behind rated gates*



#### Tie-down

✔ Transport bags and sacks unitised on pallets wherever possible – *Figure 172*.

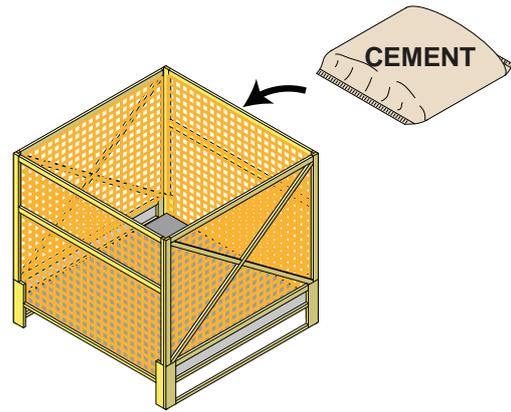
*Figure 172 Palletised bags*



- ✔ Alternately, unitise loose bags and sacks by placing them in stillages – [Figure 173](#).

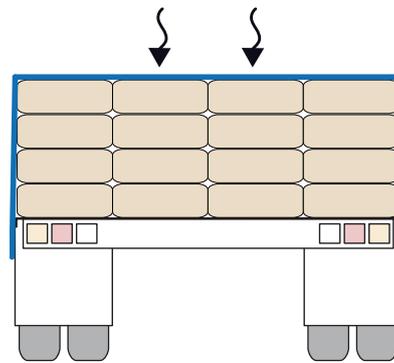
See [Packs, pallets and stillages](#) for more information on unitising.

*Figure 173 Loose bags in stillages*



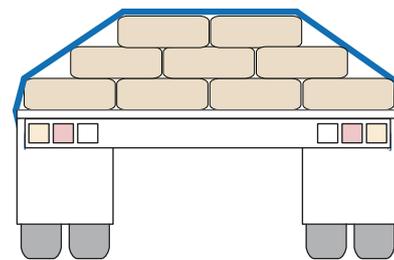
- ⚠ Restraint by tie-down only may not sufficiently restrain all items in the load – [Figure 174](#).

*Figure 174 Loose bags, limited clamping*



- ✔ Rearrange the load to provide clamping to all items for loads where containment or unitisation is not possible – [Figure 175](#).

*Figure 175 Loose bags pyramid-stacked*



- ✔ Place a maximum of 2 items on the top layer of pyramid-stacked loads.

- ⚠ Tie-down in this arrangement is only suitable for loads of light bags and sacks that are not low friction.

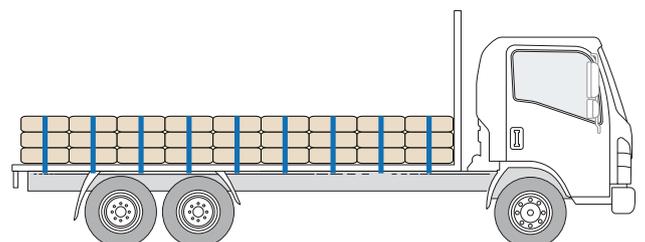
Medium-friction load using tie-down only

- ✔ Each bag should receive vertical clamping from the applied tie-down lashing(s).

*Figure 176 Full pyramid-stacked load*

- ⚠ An impractical number of lashings may be required for full loads of loose pyramid stacked bags or sacks – [Figure 176](#).

- ✔ Unitise or contain loads of bags and sacks where tie-down is impractical.



Many lashings are needed if tie-down is used on its own for a full load

# CONTAINED LOADS

Contained loads include loads transported in containers, tippers, drop-sided vehicles, pantechnicon and curtain-sided vehicles, flat-top vehicles with gates, and tankers.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining contained loads. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

## GENERAL TIPS

- ✓ Always pack contained loads tightly to minimise movement horizontally.
- ✓ Fill gaps with empty pallets, dunnage, foam or other suitable materials.
- ✗ Do not leave gaps unblocked in contained loads as freight can move during transport.

## PANTECHNICON, CURTAIN-SIDED AND FLAT-TOP

- ✓ Pack loads tightly within the vehicle body and sides to prevent the load from moving sideways or forwards or backwards – [Figure 178](#).
- ✓ Where freight is wrapped onto a pallet, make sure sufficient packaging is applied to prevent freight movement on the pallet.

Figure 177 Container, curtain-sided, tipper truck and flat-top with gates

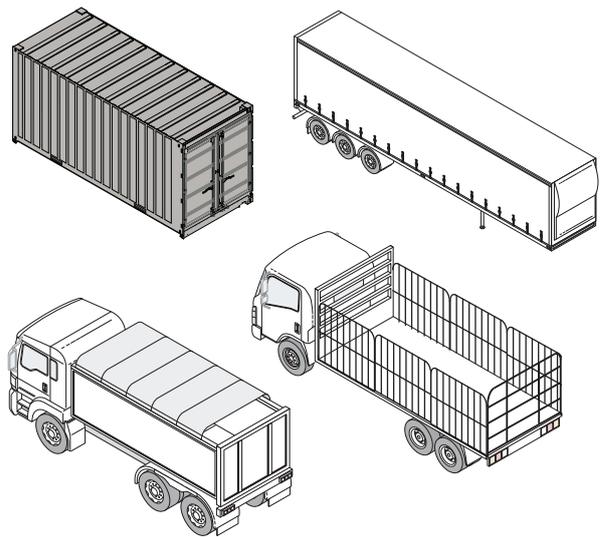
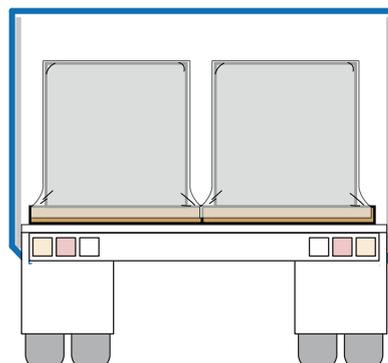
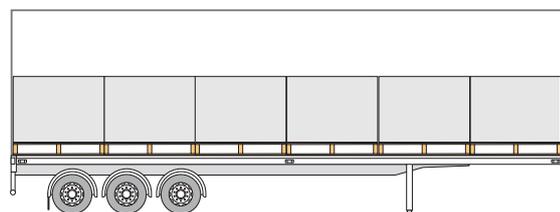


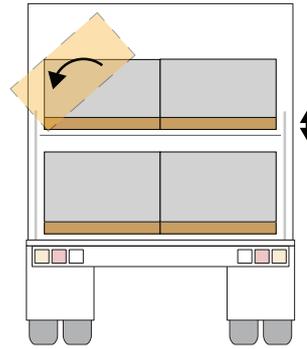
Figure 178 Contained load tightly packed



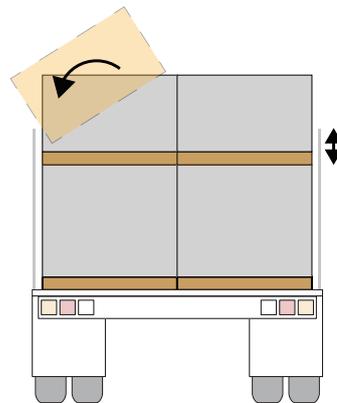


 Make sure gates are high enough to prevent the load from bouncing out – *Figure 182*.

*Figure 182 Containment by gates*



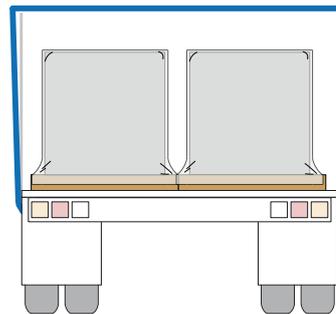
Insufficient containment height on mezzanine deck



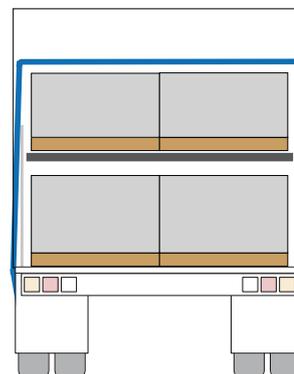
Insufficient containment height for stacked pallets

 Lash gates to provide additional strength and prevent the load from bouncing out over the gates – *Figure 183*.

*Figure 183 Lashed gates*



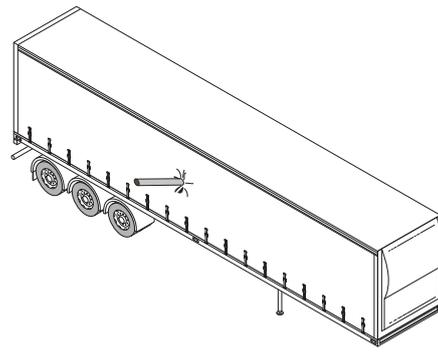
Flat top – gates lashed



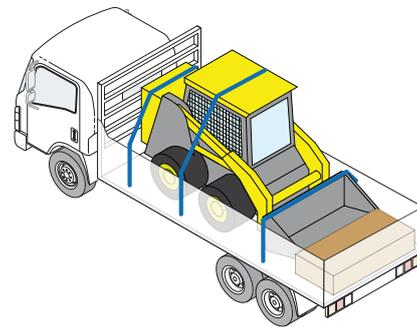
Curtain-sided vehicle – gates lashed

For more information see [Side gates](#) in the Vehicles and equipment module.

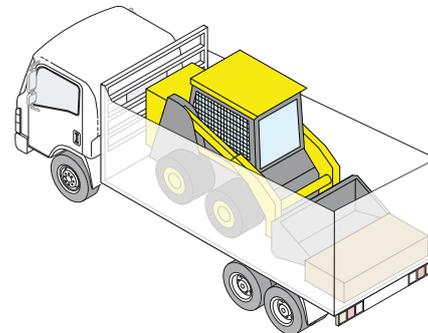
- ✓ Use side curtains to contain loads only if the vehicle and curtain system are certified for the particular application.
- ✗ Do not use side curtains to restrain any load that may damage the curtains, such as sharp objects – [Figure 184](#).

*Figure 184 Damaged side curtain*

- ✓ Restrain all loads supported on springs and/or pneumatic tyres that can bounce out of their containment – [Figure 185](#).

*Figure 185 Suspended load*

Limited restraint from short containment walls – lashed for extra restraint



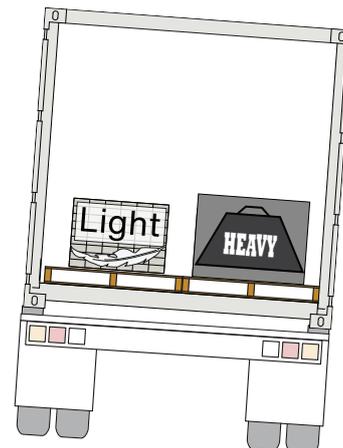
Suitably contained



For more information see [Vehicles and equipment](#) in this module.

## CONTAINERS

- ✓ When loading freight into containers, make sure there is even weight distribution both across the width and preferably along the length of the container.
- ⚠ Uneven weight distribution may affect the stability of the carrying vehicle – [Figure 186](#).

*Figure 186 Unbalanced load*

**i** Consignors should advise drivers how a containerised load is packed so that they can understand the impact of the load on the vehicle's stability and drive accordingly.

**i** Consignors should mark the centre of gravity on the container if it is more than 10% of the container length away from the container centre – *Figure 187*.

**i** Drivers should request information on the packing of the container from the consignor.

**✓** Load light freight on top of heavy freight to lower the centre of gravity and increase vehicle stability – *Figure 188*.

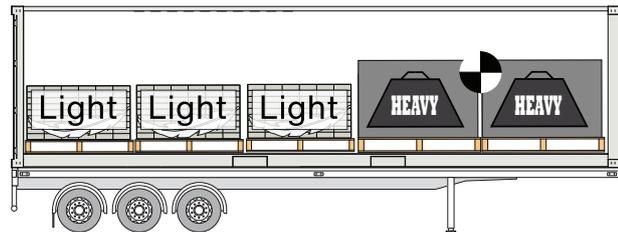
**✓** Make sure blocked loads do not exceed the allowable wall or floor loads for all modes of transport in the supply chain.

**i** For maximum wall and floor loads in general purpose containers refer to Australian Standard AS 3711.4 Freight containers Part 4: General purpose containers.

**✗** Do not exceed the manufacturer specified maximum allowable load mass of the container or vehicle – *Figure 189*.

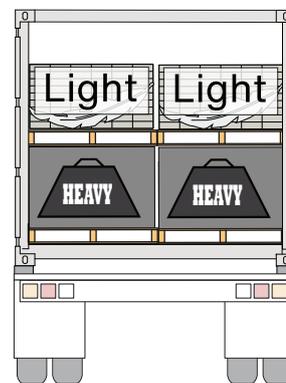
**✗** Do not exceed the maximum allowable axle masses of the carrying vehicle – *Figure 190*.

*Figure 187 Offset centre of gravity*

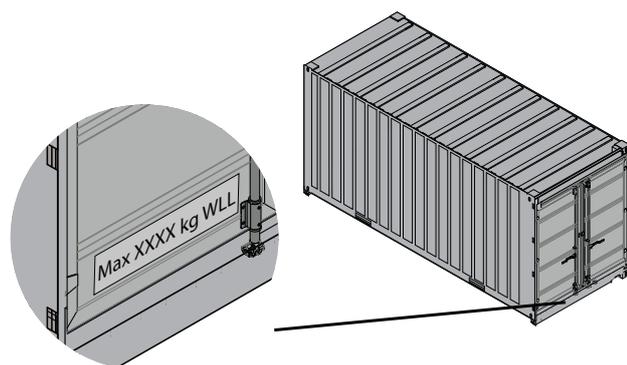


To understand more about your load restraint responsibility, see the information on [chain of responsibility](#) in the Overview module.

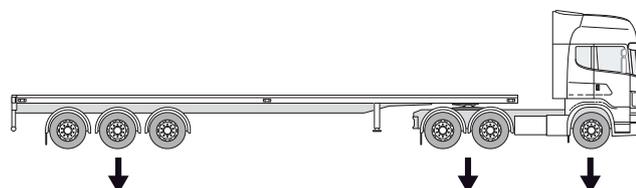
*Figure 188 Light on heavy load*



*Figure 189 Manufacturer-specified capacity*

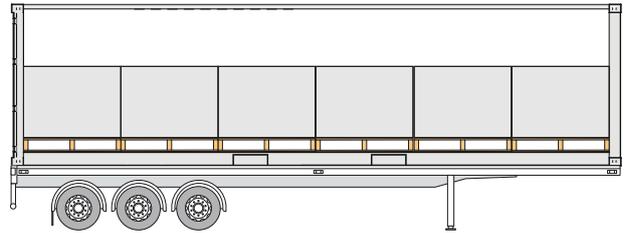


*Figure 190 Maximum allowable axle masses*

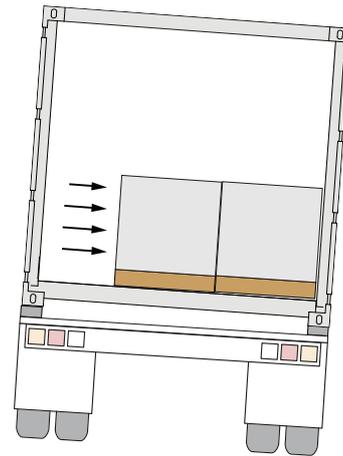


- ✓ Pack loads tightly within containers to prevent the load from moving sideways or horizontally – *Figure 191* and *Figure 192*.

*Figure 191 Containerised load – tightly packed*



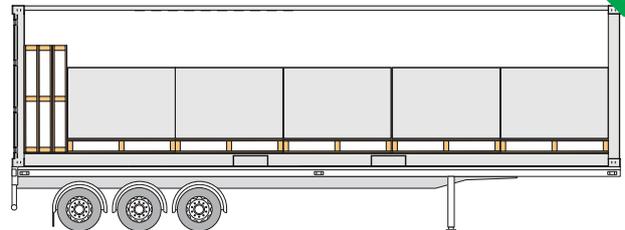
*Figure 192 Sideways movement*



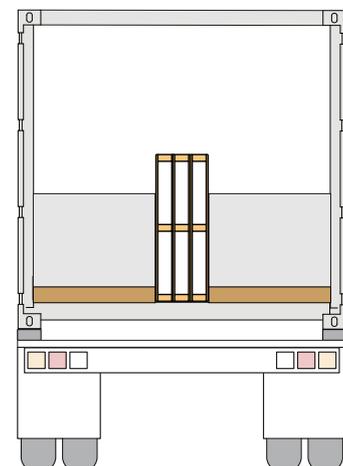
Sideways gaps in load

- ✓ Fill gaps with empty pallets – *Figure 193* and *Figure 194*, dunnage, foam, custom framing or other suitable materials.

*Figure 193 Containerised load – gaps filled*



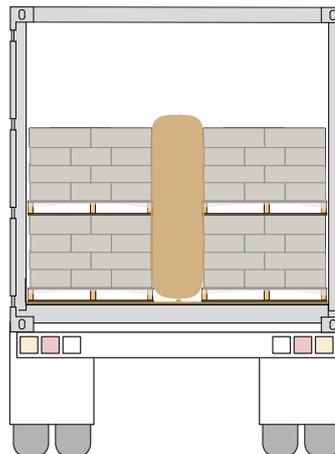
*Figure 194 Sideways movement*



Gap filled with pallets

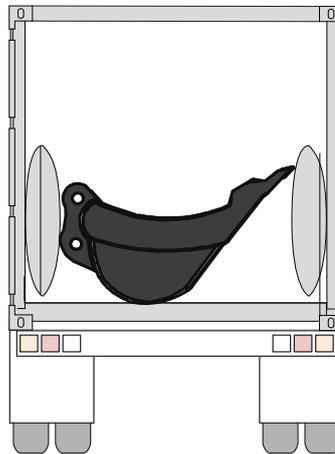
- ✓ Use rated inflatable dunnage as part of restraint systems within containers – *Figure 195.*

*Figure 195 Load packed with air bags*



- ✗ Do not use inflatable dunnage to restrain sharp objects – *Figure 196.*

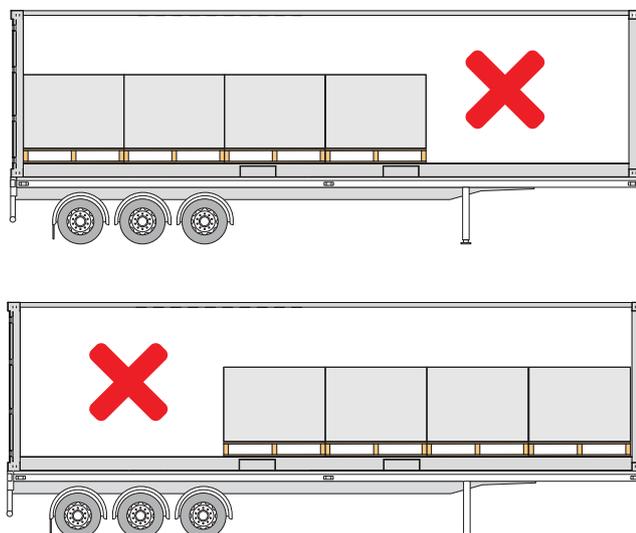
*Figure 196 Air bags with sharp load*



For more information see [Inflatable dunnage](#) in the Vehicles and equipment module.

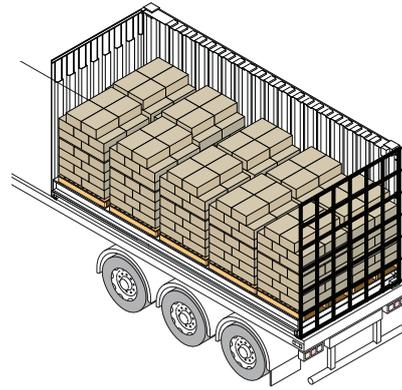
- ✗ Do not leave gaps unblocked in containerised loads because freight may move during transport and impact the container walls – *Figure 197.*

*Figure 197 Gaps in containerised load*



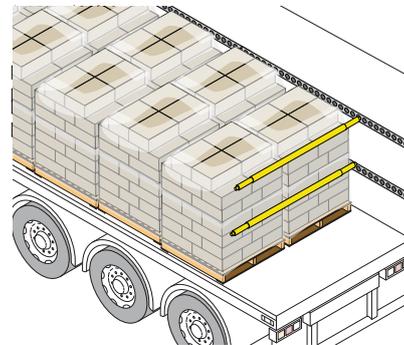
- ✓ Use lashings, webbing nets or gates to prevent loads that may have shifted during transport from falling out when the doors are opened – *Figure 198*.

*Figure 198 Webbing net to prevent load shift*



- ⚠ Only use shoring/blocking bars to stabilise loads because they have limited load restraint capacity – *Figure 199*. Rated bars may be suitable for blocking some loads.

*Figure 199 Shoring bars*

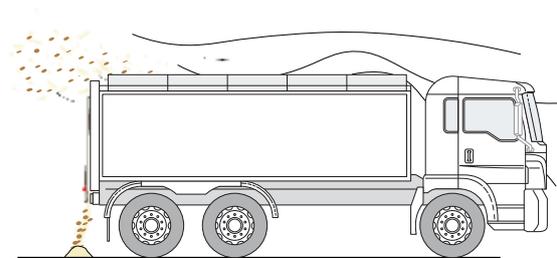


## LOOSE BULK LOADS

- ⓘ Loose bulk loads include quarry products, primary produce, liquids and demolition waste.

- ✓ Transport loose bulk loads in tippers, drop-sided vehicles or tankers.

*Figure 200 Powder leaking*

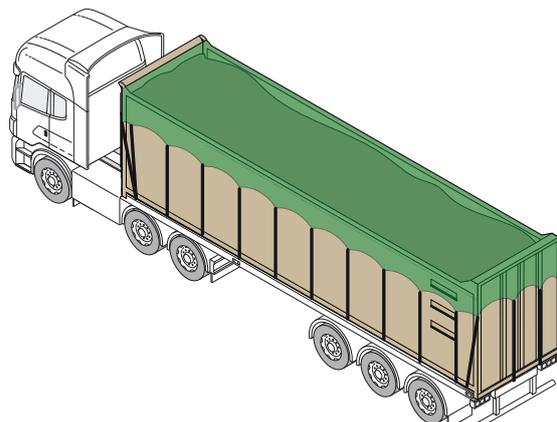


## Granular/powdered material

- ✓ Transport fine powdered material in fully enclosed tankers to prevent product loss – *Figure 200*.
- ✓ If unable to transport granular/powdered bulk loads in fully enclosed tankers, cover loads using tarpaulins or load covers – *Figure 201*.

- ⓘ 'Wetting' or 'skinning' agents can restrain fine particles without the need for tarpaulins for a limited time.

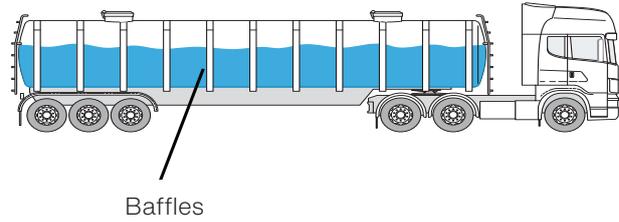
*Figure 201 Covered loose bulk load*



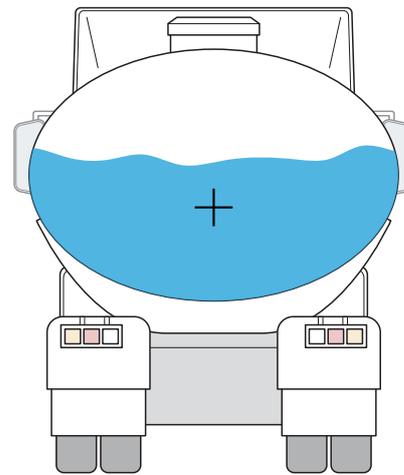
## Liquids

- ✓ Transport loads with liquid content in fully sealed bodies to prevent leakage onto the road – *Figure 202*.
- ✓ Make sure tankers have baffles or compartments installed to stop liquid slosh, which can otherwise affect the vehicle's stability.
- ⚠ Part-filled tanks are prone to sideways liquid movement that can affect the vehicle's stability – *Figure 203*.

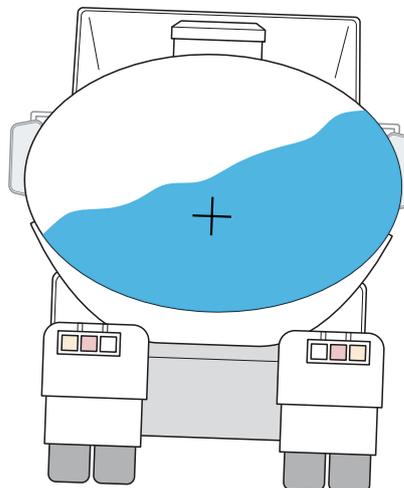
*Figure 202 Liquid tanker – side view*



*Figure 203 Liquid tanker – rear view*



Part-filled tank



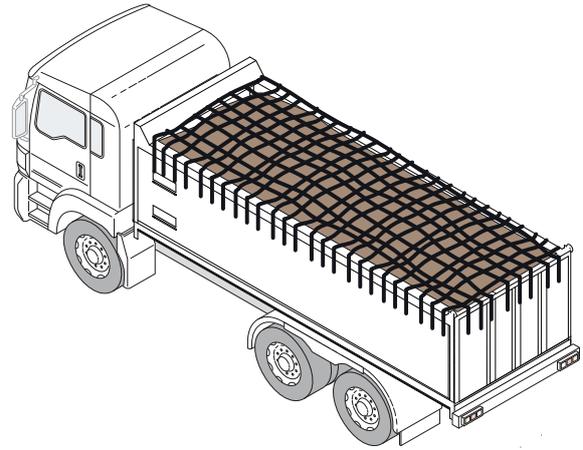
Sideways liquid movement



## Other loose bulk loads

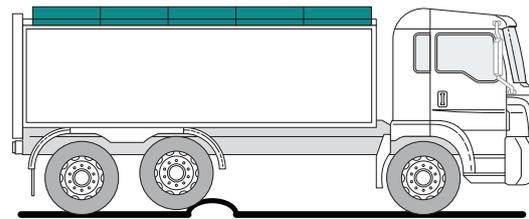
- ✓ Vertically restrain lightweight bulk loads with rated load covers – [Figure 204](#).

*Figure 204 Load cover*



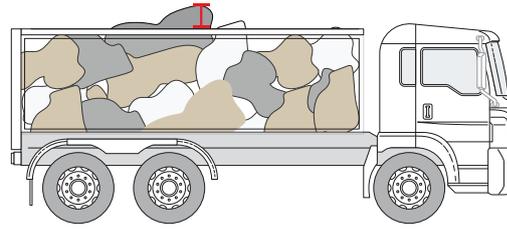
- ✓ Cover heavier bulk loads using load nets or tarpaulin to stop load items from becoming dislodged or bouncing out of the vehicle body – [Figure 205](#).

*Figure 205 Contained bulk load*



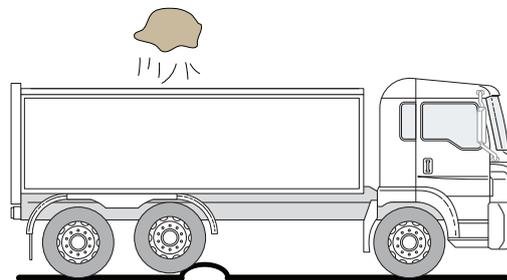
 Loose bulk loads extending above the height of the containment walls can bounce out – *Figure 206*. Loads also may be blown.

*Figure 206 Load exceeding containment*



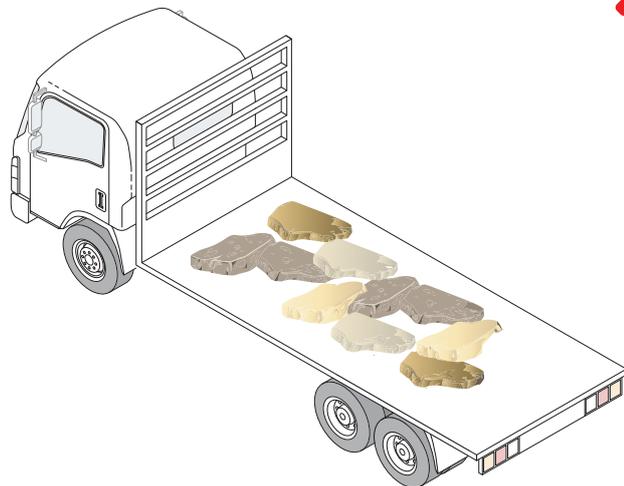
 Loose bulk loads can become dislodged when travelling over bumps, even if they do not extend above the containment walls – *Figure 207*.

*Figure 207 Load dislodged*



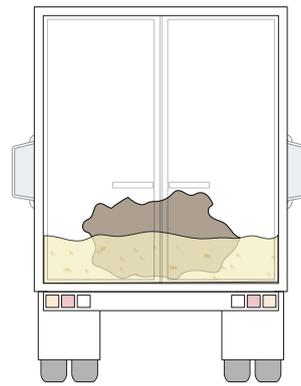
 Do not transport loose loads on platform-bodied vehicles without sides or gates or on tipper bodies without tailgates – *Figure 208*.

*Figure 208 Loose bulk load – no containment*

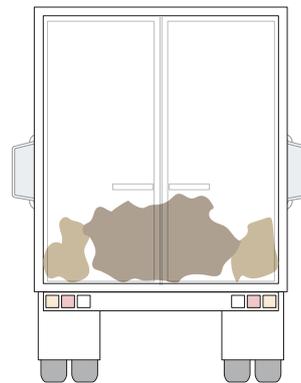


- ✓ Arrange the load to stop sideways load movement, or fill gaps with sand (or similar) – [Figure 209](#).

*Figure 209 Gaps in contained bulk load filled*



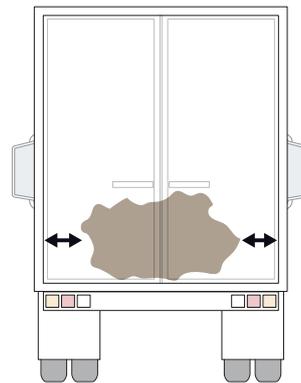
Gaps filled with sand



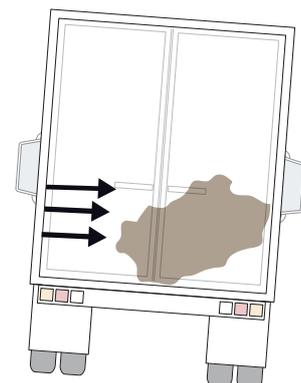
Load arranged to prevent sideways movement

- ⚠ Gaps in contained bulk loads may permit freight to move during transport and affect the vehicle's stability – [Figure 210](#).

*Figure 210 Gaps in contained bulk load*



Sideways gaps



Vehicle stability

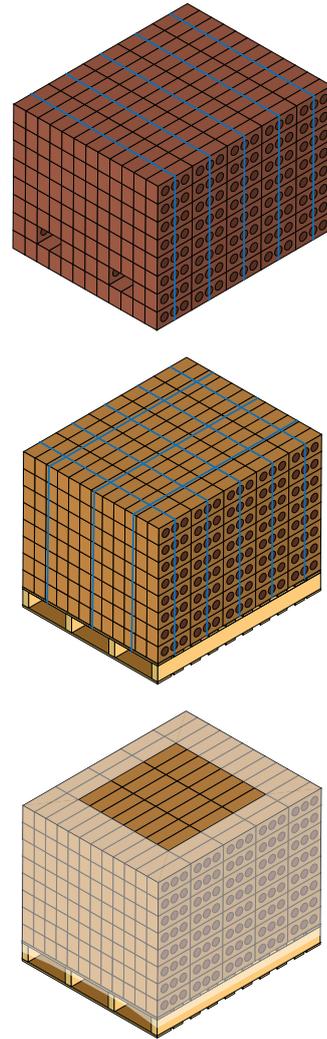
# BRICKS

Bricks are generally packaged together – either by strapping to form a pack (with or without pallets) or shrink-wrapped to a pallet.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining bricks. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

Figure 211 Brick packs



## GENERAL TIPS

- ✓ Make sure bricks cannot dislodge from their pack if the load is contained – [Figure 212](#) and [Figure 213](#).
- ⚠ Brick packs must be suitably packaged to meet the [Performance Standards](#) and withstand handling (e.g. being handled by forklifts).

Figure 212 Brick dislodging from pack

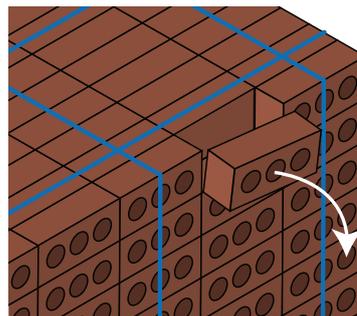
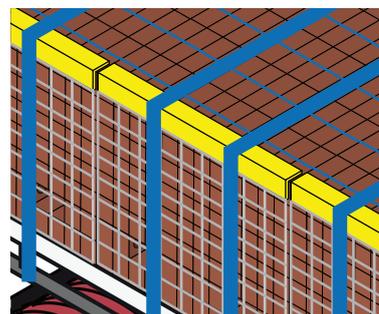


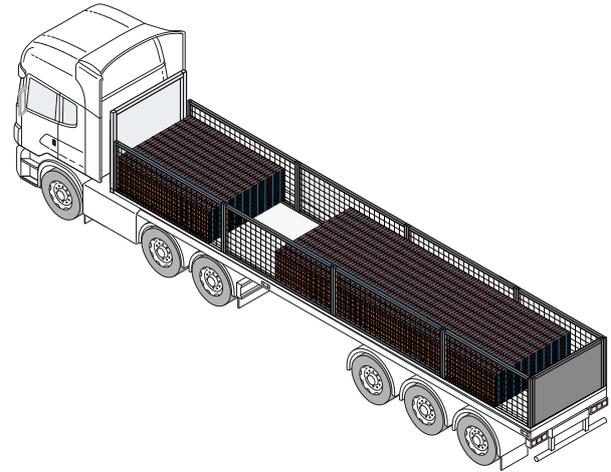
Figure 213 Mesh preventing bricks from dislodging



# RESTRAINT METHODS

## Contained loads

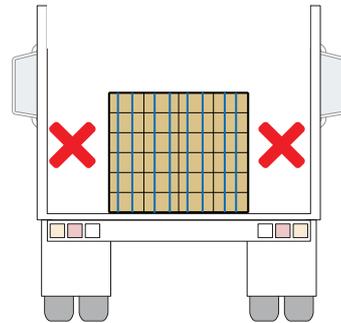
✓ Bricks should be blocked forwards, rearwards and sideways, with no gaps – *Figure 214* and *Figure 215*.



*Figure 214 Unblocked load forwards and rearwards*

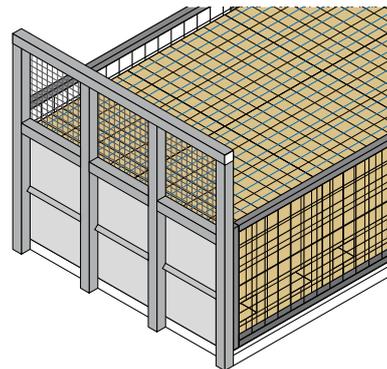


*Figure 215 Unblocked load sideways*



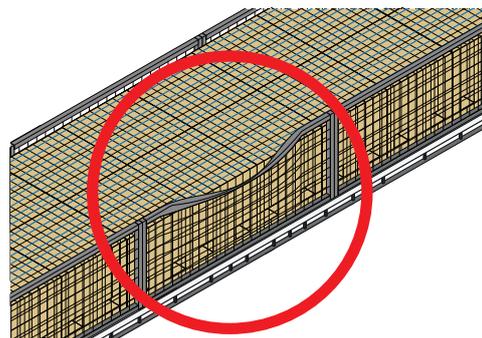
✓ Use rated devices for forward, rearward and sideways blocking, such as certified headboards, tailboards and gates or other blocking devices rated by an engineer – *Figure 216*.

*Figure 216 Blocked against headboard*



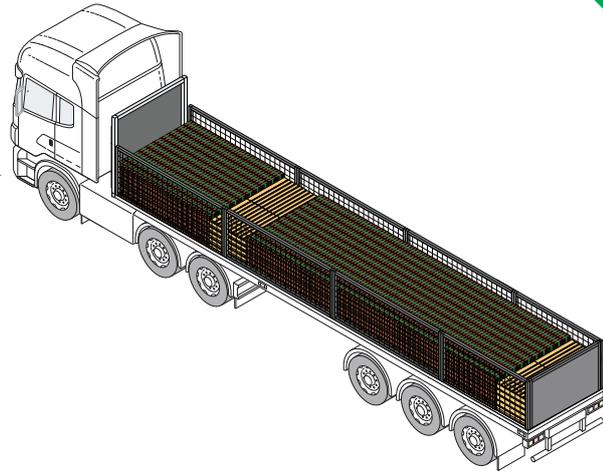
✗ Do not use a rated blocking device that has been damaged because the damage may have reduced its blocking capacity – *Figure 217*.

*Figure 217 Damaged side gate*

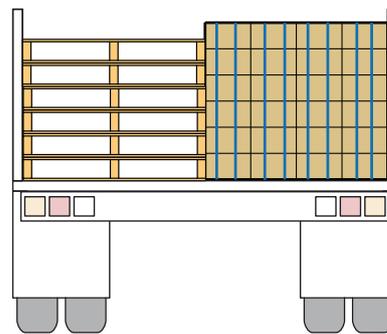


- ✓ Block intermediate gaps in a load with empty pallets or other devices capable of withstanding the [Performance Standards](#) forces applied during transport – [Figure 218](#) and [Figure 219](#).

*Figure 218 Gaps blocked with pallets*

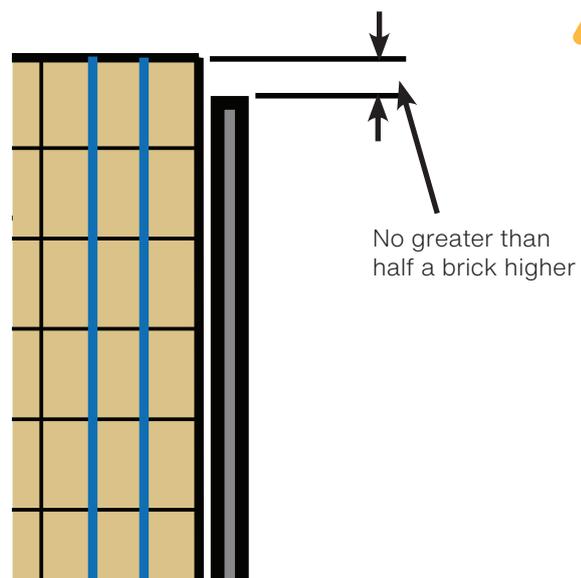


*Figure 219 Load blocked sideways*



- ⚠ Make sure the load does not reach higher than half a brick above the gates – [Figure 220](#).

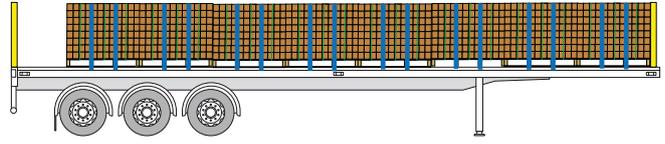
*Figure 220 Brick containment*



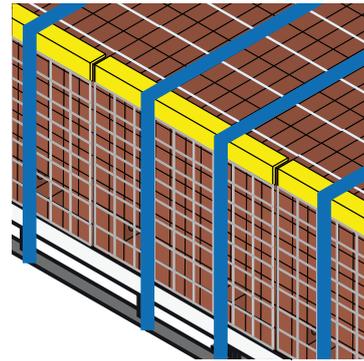
## Tie-down loads

- ✓ Restrain brick packs by tie-down if they are sufficiently unitised – *Figure 221*.
- ⚠ If not fully contained, unitisation should be able to meet the forces indicated by the [Performance Standards](#) so no bricks fall out. Steel mesh frames may be suitable.
- ✓ Make sure protective corners are used when restraining brick packs with webbing straps so that the straps are not damaged – *Figure 222*.

*Figure 221 Tied down brick load*



*Figure 222 Protective corners used with webbing*



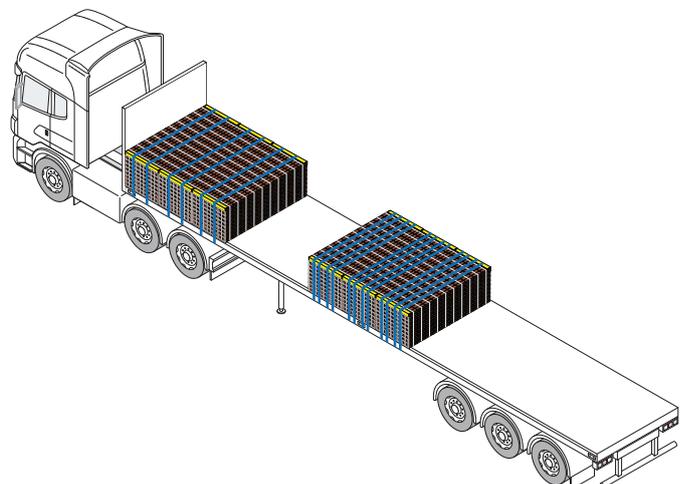
- ⚠ Tie-down lashings should apply clamping to all brick packs in the load – *Figure 223*.

*Figure 223 Brick packs unrestrained*



- ✓ Always make sure blocking surfaces are suitably engineered.
- ⚠ Unblocked loads will require more lashings than blocked loads – *Figure 224*.

*Figure 224 Blocked and unblocked tie-down loads*



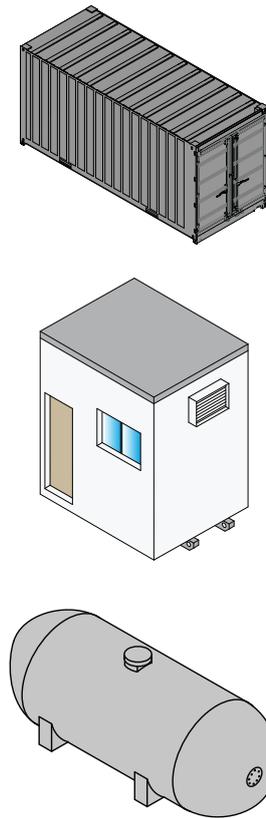
# LARGE LOADS

Large loads are large individual items such as containers, tanks, portable buildings, castings, large fabrications, transformers and other tall loads.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining large loads. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

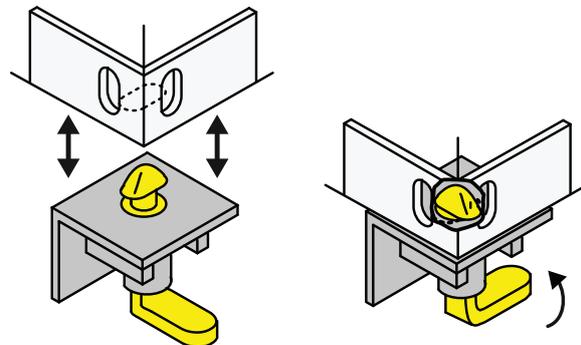
Figure 225 Container, tank and portable building



## CONTAINERS

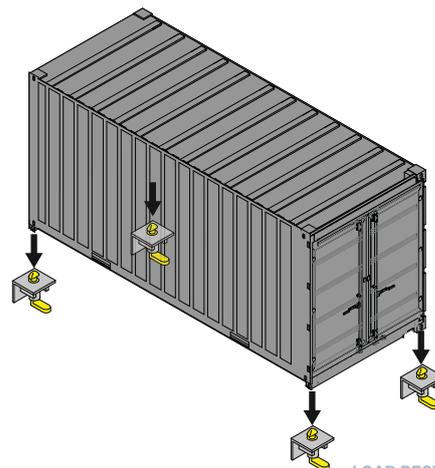
**i** All ISO and most other shipping containers and flat platforms are equipped with corner castings designed to interlock with mating “twist locks” for lifting or restraint – [Figure 226](#).

Figure 226 Container twist lock



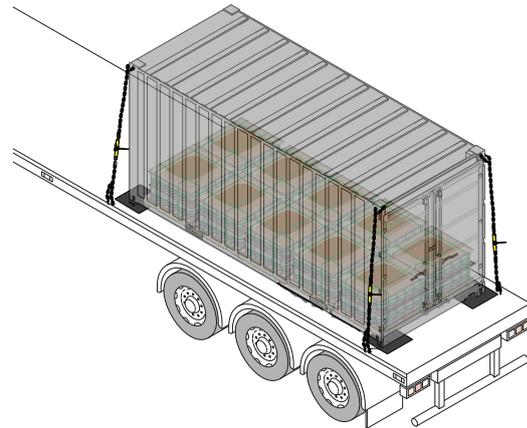
✓ Restrain shipping containers with 4 twist locks – [Figure 227](#).

Figure 227 Container restrained by twist locks



- ✓ Make sure direct restraint of loaded shipping containers is part of an engineered load restraint system.
- ✗ Do not lash shipping containers if they are carrying any load – [Figure 228](#).
- ⚠ Tie rail anchor points are not strong enough to restrain laden shipping containers.

*Figure 228 Direct restraint tie rail*



- ✓ If containers are **empty** and twist locks are not fitted, restrain them using tie-down or crossed chains – [Figure 229](#) and [Figure 230](#).

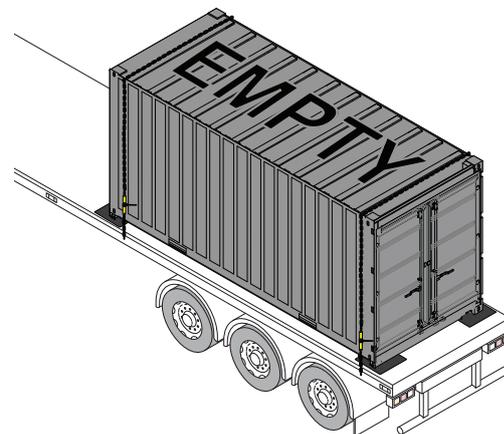
*Figure 229 Empty container tied down*



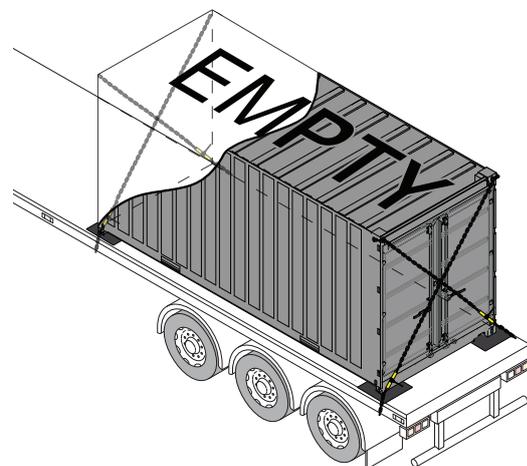
- ✓ Place empty containers on rough sawn timber, anti-slip rubber matting or other high-friction material if restraining them by tie-down or crossed chains.

- ⚠ Timber or anti-slip matting placed under the container must be strong enough to withstand high pressures without disintegrating.

- ✗ Do not restrain empty containers with cross chains or tie-down on low-friction surfaces (i.e. steel on steel).



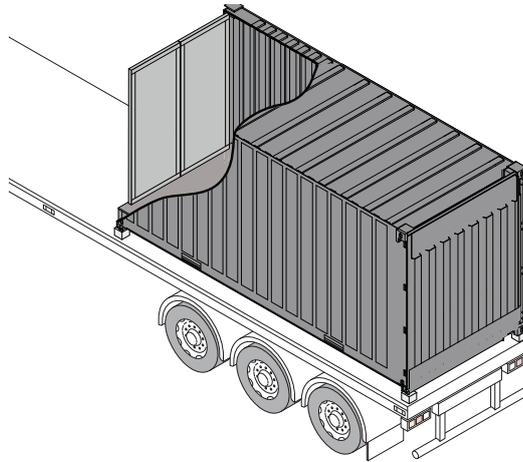
*Figure 230 Empty container cross-chained*



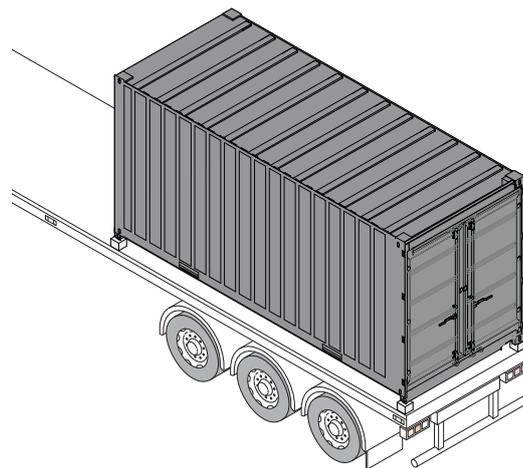
- ✓ Load containers with doors to the rear of the carrying vehicle where possible – *Figure 232*.

- ⚠ If doors are towards the front of the carrying vehicle, the forward restraint may not be adequate for heavy loads – *Figure 231*.

*Figure 231 Loaded container with doors to the front*



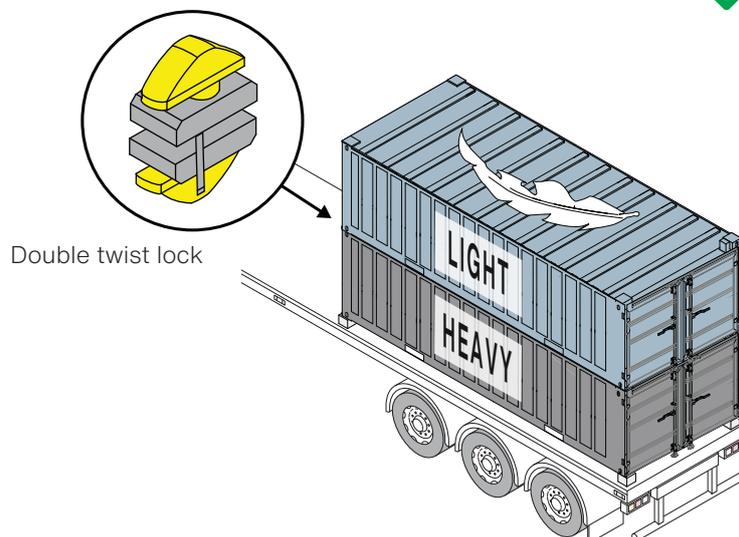
*Figure 232 Loaded container with doors to the rear*



- ✓ Stack low-height containers and flat platforms (where required) with double twist lock fittings – *Figure 233*.

- ✓ Keep the heavier container at the bottom to lower the centre of gravity and maximise vehicle stability.

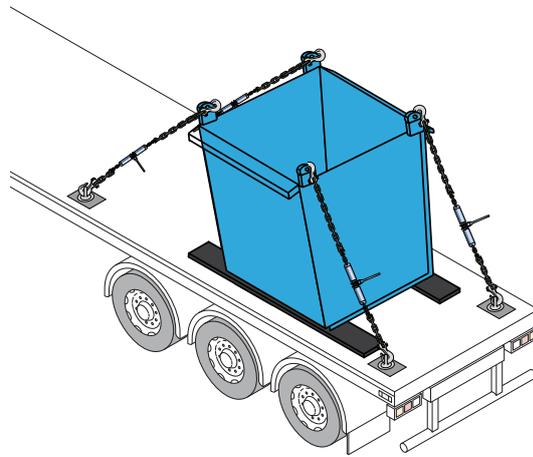
*Figure 233 Stacked low-height containers*



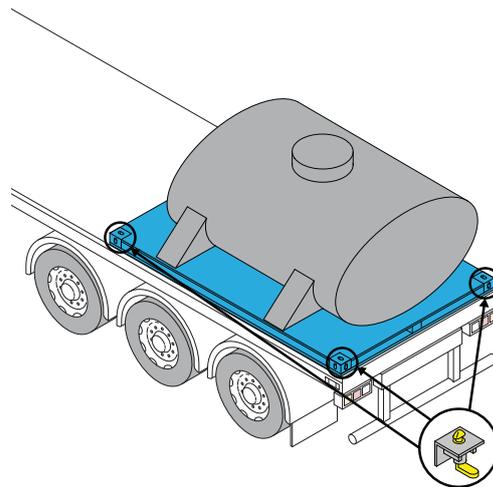
## TANKS, BINS AND SKIPS

- ✓ Directly restrain tanks, bins and skips (full or empty) with lashings or positive locking devices – *Figure 234*.
- ⓘ Lashing anchor points or mounting frames should be fitted to the tank, bin or skip and suitably engineered to provide restraint.
- ✓ Place tanks, bins and skips on rough sawn timber, anti-slip rubber matting or another suitable friction material.
- ✗ Do not restrain tanks, bins or skips by tie-down or direct restraint on low-friction surfaces (e.g. steel on steel).
- ✓ Mount small tanks to a frame and secure with twist locks – *Figure 235*.

*Figure 234 Skip restrained on truck*

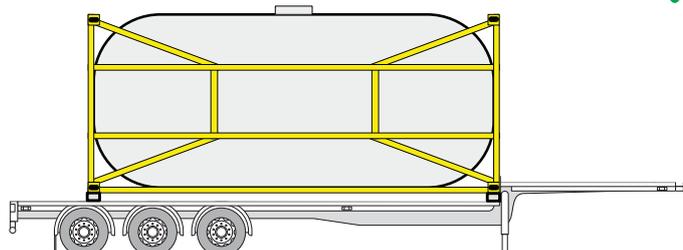


*Figure 235 Tank restrained with twist locks*



- ⚠ Laden ISO tanks can reduce vehicle stability, particularly when partially filled.
- ✓ Use drop deck trailers or similar to improve vehicle stability – *Figure 236*.

*Figure 236 ISO tank on drop deck trailer*



## BLADDERS AND FLEXIBLE TANKS

✓ Bladders and flexible tanks can be transported inside rigid containers – *Figure 237*.

ⓘ For maximum wall loads in general purpose containers refer to Australian Standard AS 3711.4 Freight containers Part 4: General purpose containers.

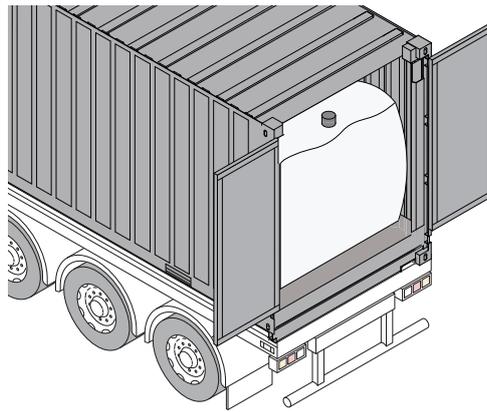
⚠ Always consider product surge and its affect on the carrying vehicle's stability – *Figure 238*.

⚠ The container walls may not be rated to restrain the full specified payload and/or liquid surge forces.

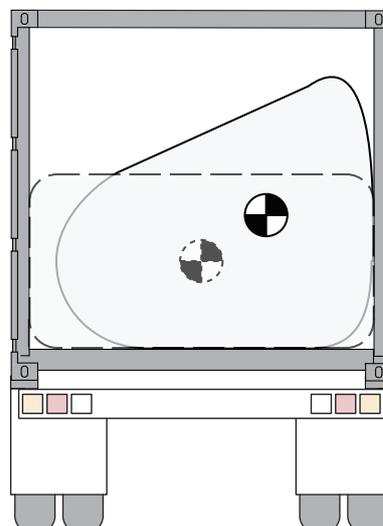
✓ Transport containers holding flexible tanks on drop deck trailers (or similar) to improve load stability – *Figure 239*.

⚠ Flexible tanks in containers often have a high centre of mass, which can reduce vehicle stability.

*Figure 237 Flexible tank inside container*

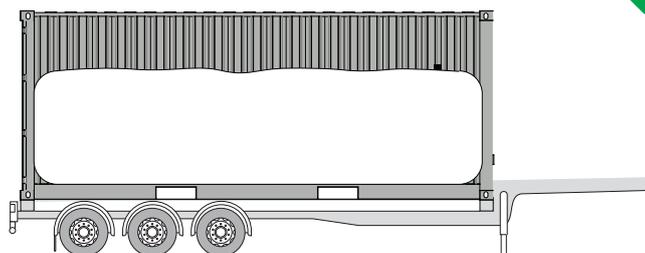


*Figure 238 Flexible tank product surge*



For more information see the **Container Owners Association Code of Practice for Flexitanks**.

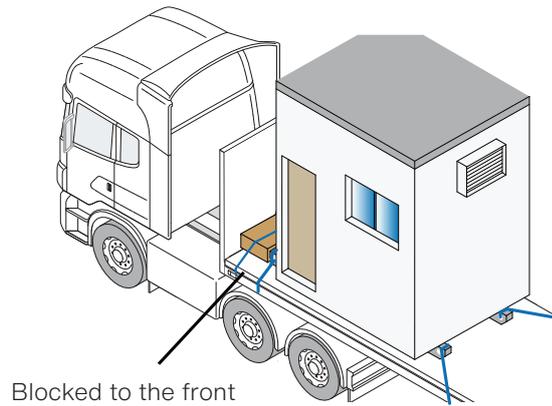
*Figure 239 Flexible tank on drop deck trailer*



## PORTABLE BUILDINGS

- ✓ Provided it is suitably engineered, a portable building can be directly restrained using lashings connected to a base frame or steel skid – *Figure 240*.
- ✓ Block the frame or skid in the forwards direction wherever possible.

*Figure 240 Portable building – directly restrained*



- ✓ When using direct lashings, apply separate lashings to each corner of the frame or skid – *Figure 241*.

*Figure 241 Portable building – separate lashings*



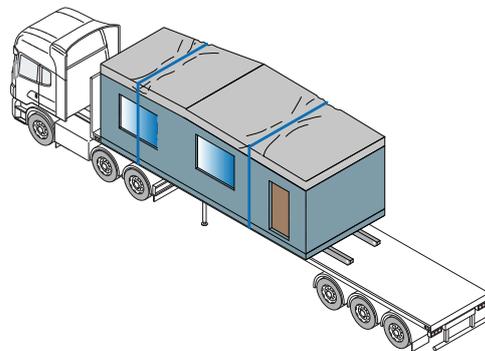
- i** Portable building restraint systems must allow for wind-load forces during transport.



- ✓ Make sure large openings are supported so that wind load during transport does not compromise the integrity of the building.

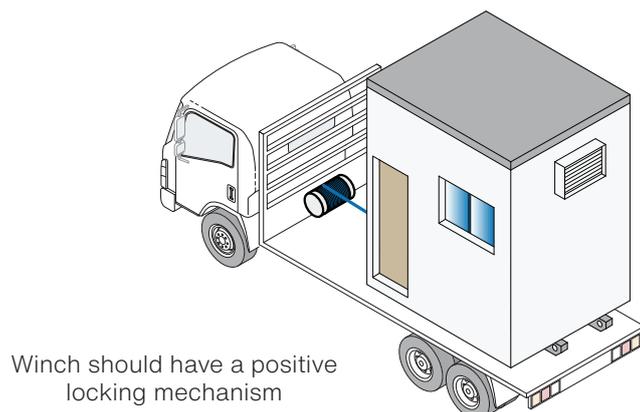
- ✗ Do not use tie-down restraint for portable buildings because the buildings can crush under the restraint forces – *Figure 242*.

*Figure 242 Portable building – tied down*



- !** Only use recovery winches for restraining loads if fitted with a positive locking mechanism – *Figure 243*.

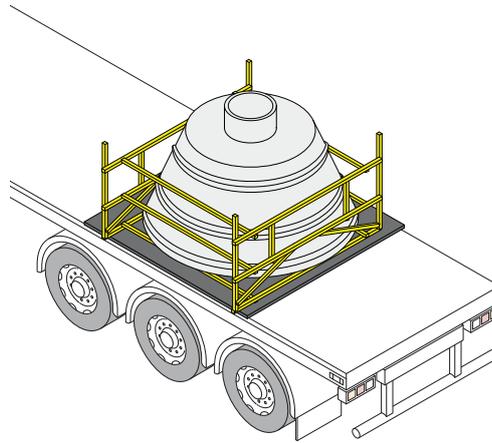
*Figure 243 Portable building – winch restraint*



## LARGE CASTINGS AND FABRICATIONS

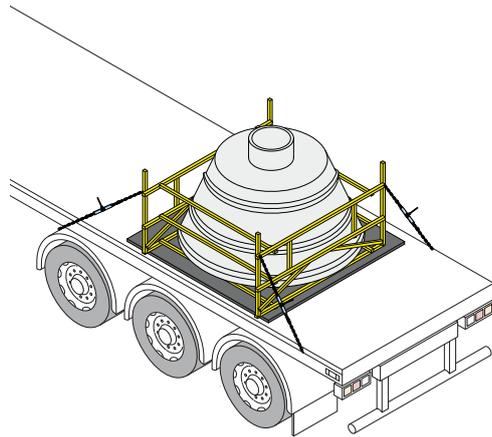
- ✓ Transport large irregular-shaped castings on suitably engineered frames or cradles.
- ✓ Load frames or cradles on timber or anti-slip rubber matting – *Figure 244*.
- ✓ Make sure there are no low-friction interfaces (i.e. steel on steel).

*Figure 244 Large casting on anti-slip rubber*



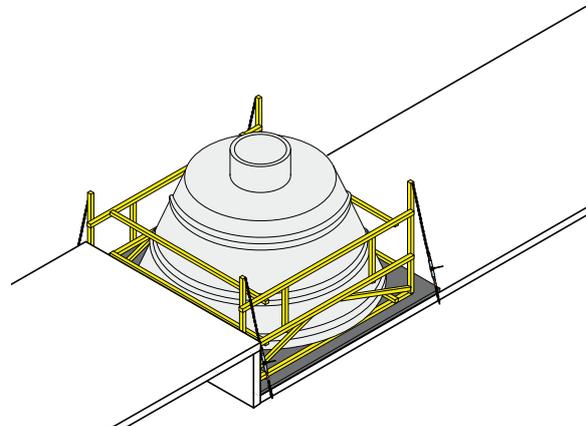
- ✓ Restrain the frame or cradle by tie-down or direct restraint – *Figure 245*.

*Figure 245 Large casting – directly restrained*



- ✓ Block the frame or cradle in the forward direction wherever possible – *Figure 246*.

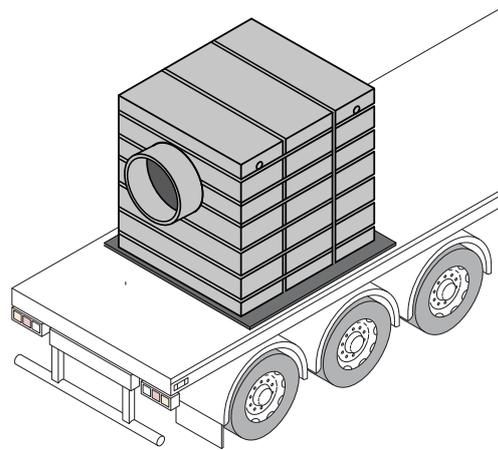
*Figure 246 Large casting – blocked forwards*



- ✓ Transport large fabrications on timber dunnage or anti-slip rubber matting – *Figure 247.*

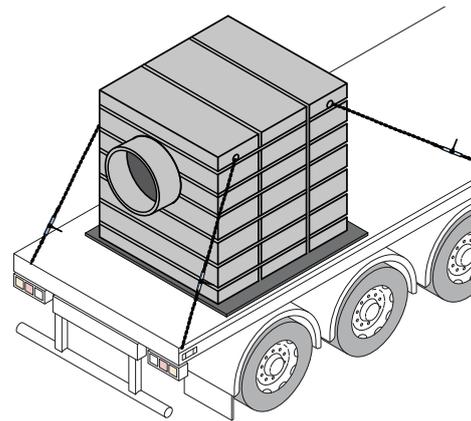
- ✓ Make sure there are no low-friction interfaces (i.e. steel on steel).

*Figure 247 Large fabrication on anti-slip rubber*



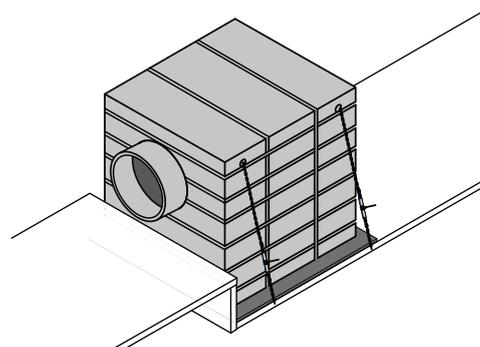
- ✓ Restrain large fabrications by tie-down or direct restraint – *Figure 248.*

*Figure 248 Large fabrication – directly restrained*



- ✓ Block the fabrication in the forward and sideways directions wherever possible – *Figure 249.*

*Figure 249 Large fabrication – blocked to front*



# VEHICLES AND MOBILE EQUIPMENT

Vehicles and mobile equipment includes all rubber-tyred, steel-wheeled or tracked vehicles and mobile equipment.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining vehicles and mobile equipment.

They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

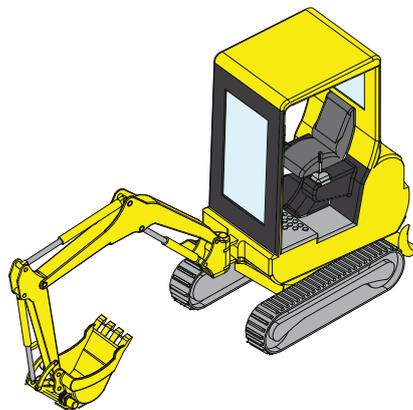
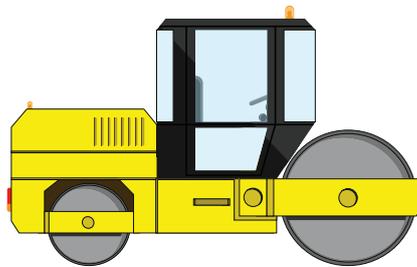
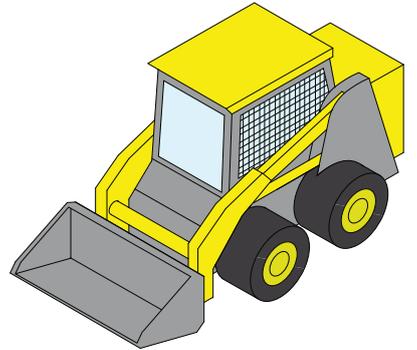
**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

## GENERAL TIPS

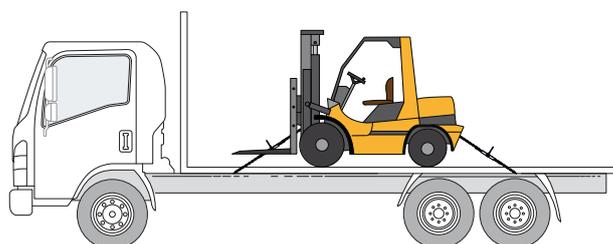
- ✓ Look out for the manufacturer's loading and restraint recommendations and the lashing points fitted to the vehicle/mobile equipment by the manufacturer.
- ✓ Make sure manufacturer-supplied recommendations are compliant with Australian (or ISO) load restraint regulations.

- ✓ Transport small vehicles and mobile equipment on general freight vehicles – [Figure 251](#).

*Figure 250 Rubber-tyred, steel-wheeled and steel-tracked vehicles*

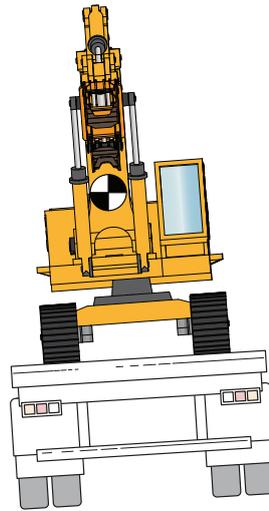


*Figure 251 General freight vehicle*

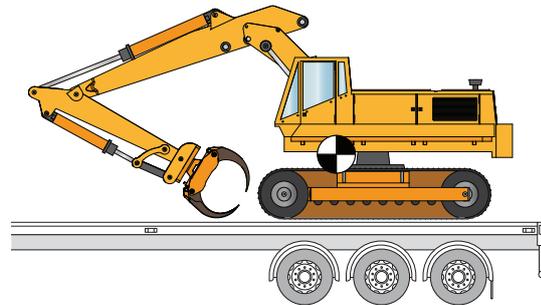


- ✓ Transport large/tall vehicles and mobile equipment on low loaders to increase vehicle stability – *Figure 252* and *Figure 253*.

*Figure 252 High centre of gravity load*

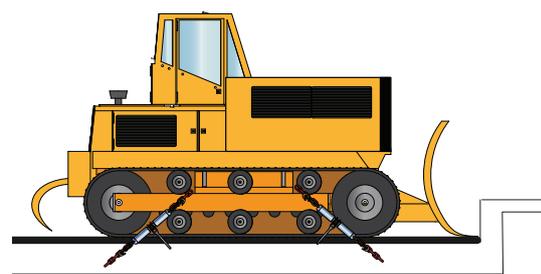


*Figure 253 Excavator on low loader*



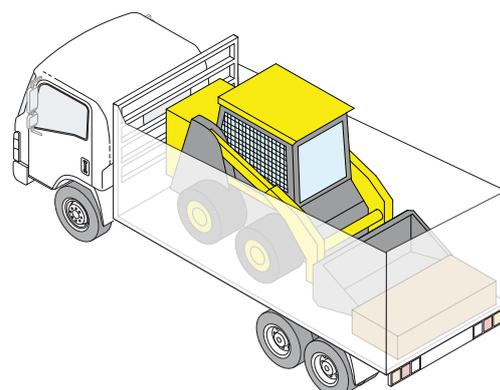
- ✓ Restrain vehicles and mobile equipment by direct lashings and/or blocking wherever possible. Lashings should be of the same type, same length and equivalent angles to work together – *Figure 254*.

*Figure 254 Direct restraint with blocking*



- ✓ Alternatively, restrain vehicles and mobile equipment by containing them within the body structure of the carrying vehicle – *Figure 255*.

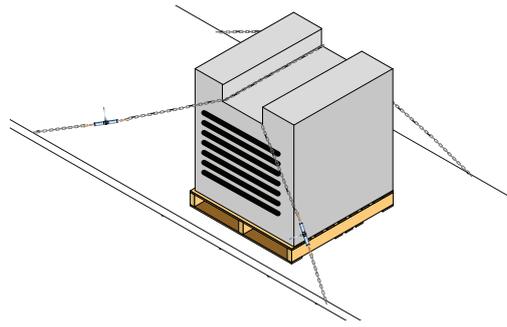
*Figure 255 Contained mobile equipment*



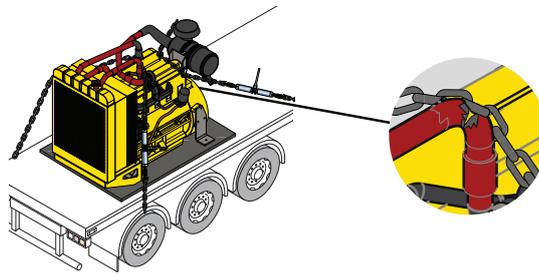
## Equipment

- ✓ Loop chains around suitable parts of the load for restraint, such as at designated lifting or lashing points – [Figure 256](#).
- ✓ Ensure sufficient clamping is provided to the restrained object when using looped lashings.
- ⚠ Looped chains may damage fragile components or work loose if components crush during transport – [Figure 257](#).

*Figure 256 Chains looped around equipment*



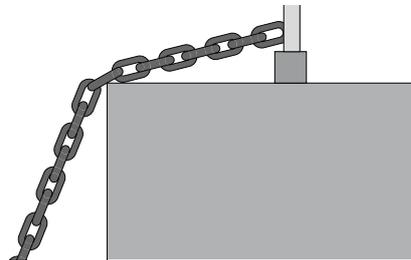
*Figure 257 Looped chain damaging equipment*



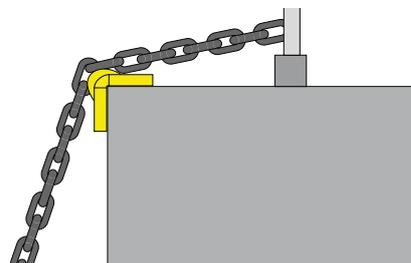
- ✓ If the chain is positioned over a sharp edge, use suitable rounded corner protectors or reposition it to give a straight line pull – [Figure 259](#) and [Figure 260](#).

- ⚠ Chains applied over a sharp edge will not perform at their rated capacity – [Figure 258](#).

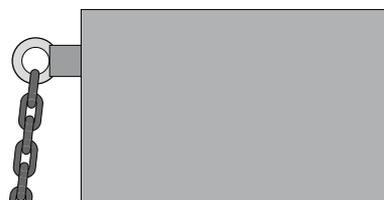
*Figure 258 Chain over sharp edge*



*Figure 259 Rounded corner protector*

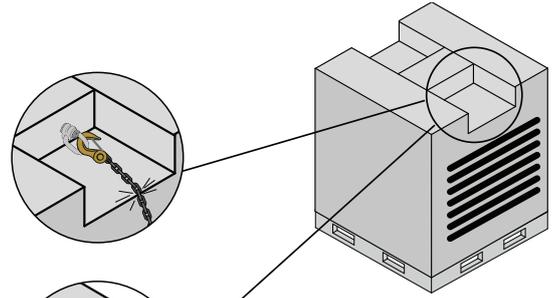


*Figure 260 Straight line pull*

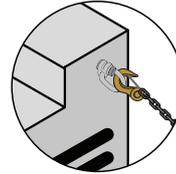


- ✓ Make sure lashing points are fitted in locations that permit adequate restraint – [Figure 261](#).

Chain tension limited by freight damage



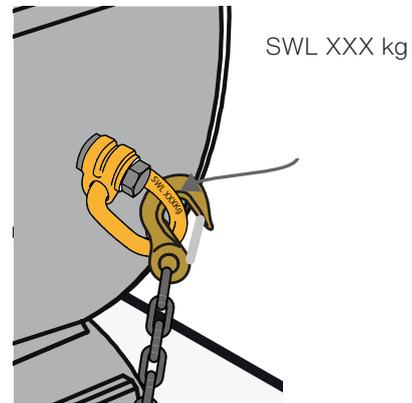
Direct pull



[Figure 261 Lashing point location](#)

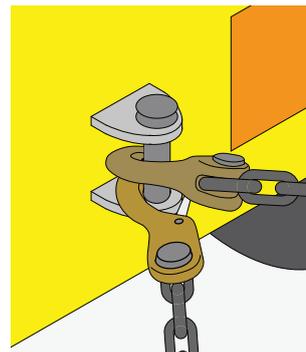
- ⓘ Lashing points should be clearly identified by colour-coding or labelling, and have their restraint capacity specified – [Figure 262](#).

[Figure 262 Lashing point identification](#)



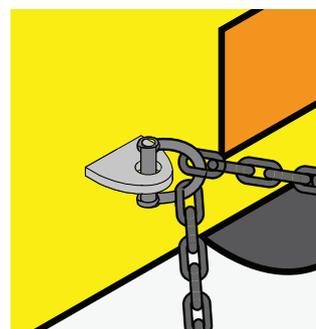
- ✓ Use front and rear towing brackets as lashing points. Ensure attachments at lashing points cannot work themselves loose during transport – [Figure 263](#).

[Figure 263 Towing bracket pin lashing point](#)



- ✓ If towing brackets do not incorporate round pins, connect chains using appropriately rated shackles to prevent chain damage – [Figure 264](#).

[Figure 264 Towing bracket shackle lashing point](#)



✗ Do not use lifting lugs as lashing points if they are unsuitable for the chosen load restraint method.

⚠ Lifting lugs are often incorrectly positioned for load restraint (even if identified as tie-down points) – [Figure 265](#).

✓ Restrain vehicles and mobile equipment using chain, webbing or wire rope lashings.

✓ Use chain to restrain all vehicles and mobile equipment that are fitted with suitable attachment points.

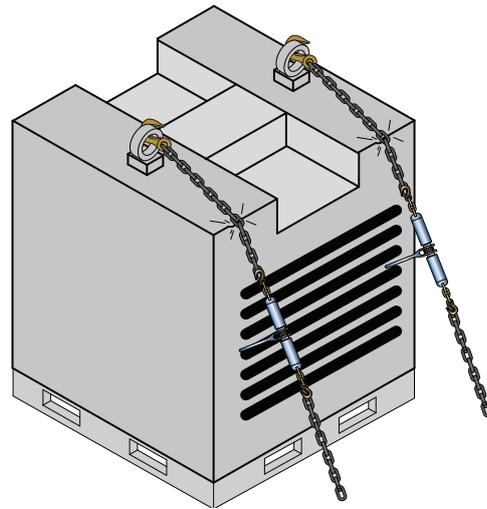
ⓘ Webbing lashings are only suitable if restraining light motor vehicles or equipment.

✓ Make sure winches used to tension wire rope have a positive locking feature – [Figure 266](#).

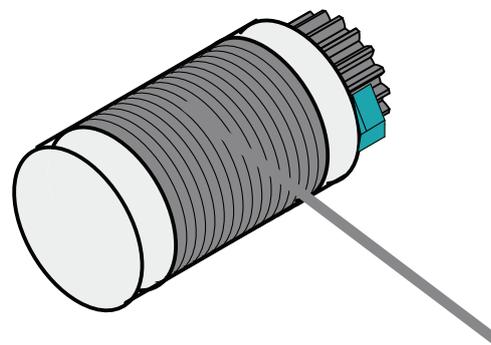
✗ Do not rely on hydraulic pressure to prevent the winch from unwinding.

ⓘ The lashing capacity of wire rope is one-third of its maximum breaking strength.

*Figure 265 Lifting lugs*



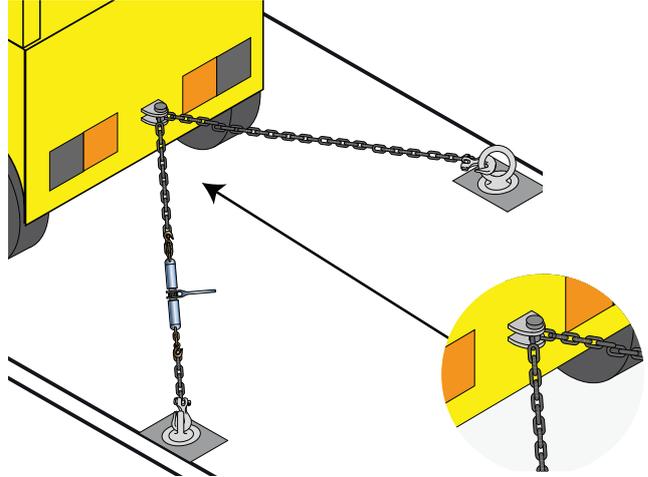
*Figure 266 Winch with positive lock*



For more information on restraint equipment, see the [Vehicles and equipment module](#).

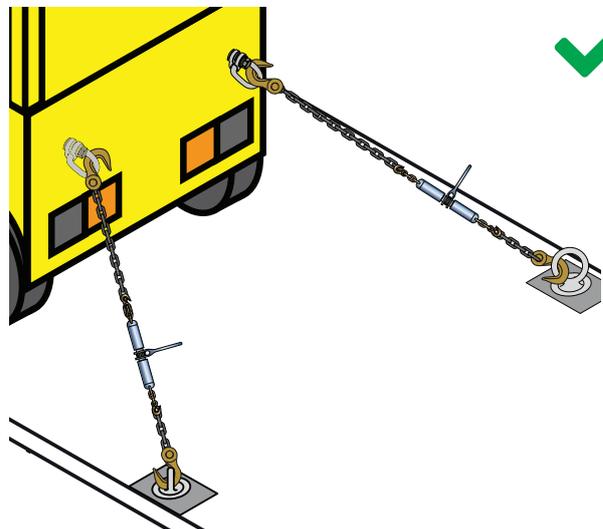
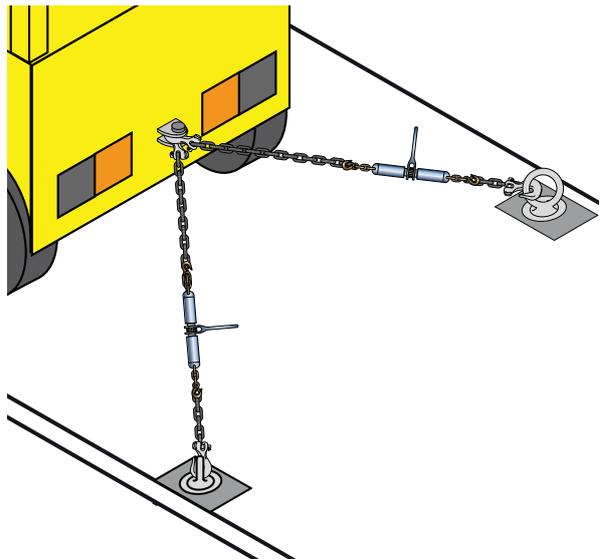
- ✘ Do not use a single lashing passed across the deck through a lashing point, as this will not directly restrain sideways movement – *Figure 267*.

*Figure 267 Limited sideways restraint*



- ✔ Attach 2 separate lashings to directly restrain vehicles or equipment – *Figure 268*.

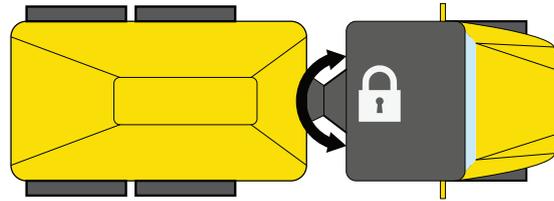
*Figure 268 Where sideways resistance is required, attach 2 separate lashings to directly restrain vehicles or equipment*



## Articulated vehicles

- ✓ Engage steering locks on articulated machines before transporting – *Figure 269*.
- ✓ Operate steering controls at least twice while the engine is off to relieve residual hydraulic pressure.

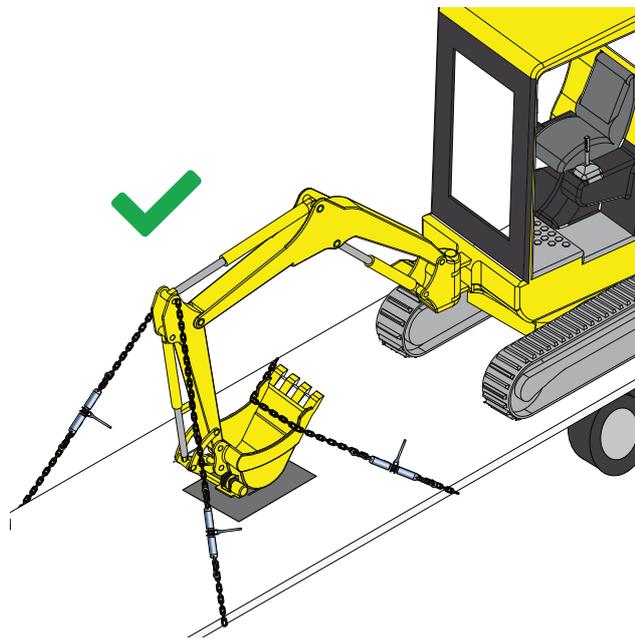
*Figure 269 Steering lock – articulated haul truck*



## Movable parts and attachments

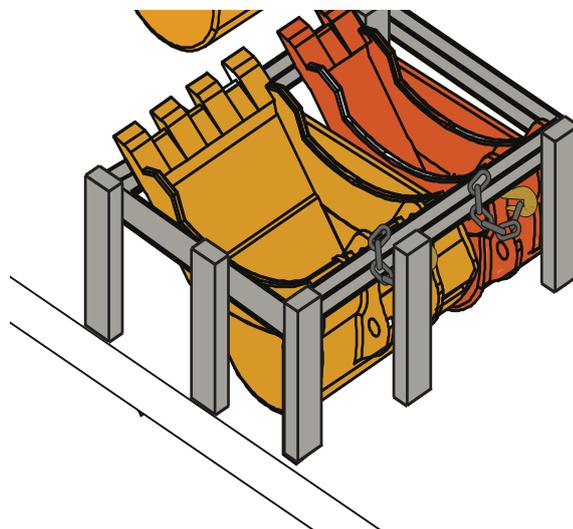
- ✓ Restrain any part of the equipment that can move or rotate – *Figure 270*.

*Figure 270 Restraint of movable parts*



- ✓ Restrain auxiliary components (buckets, blades, rippers, etc.) on the deck using containment and/or tie-down/direct restraint – *Figure 271*.

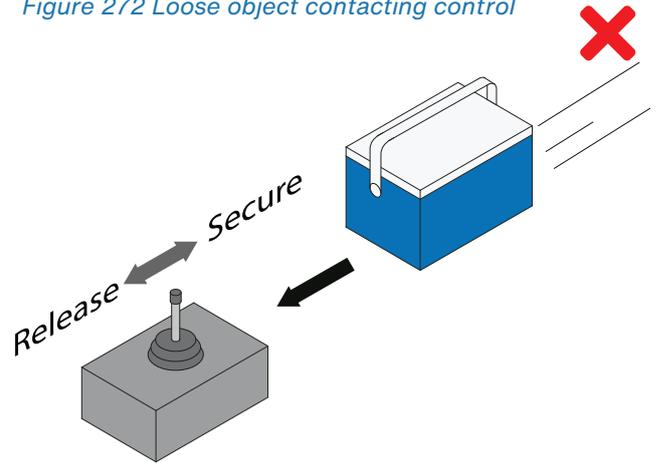
*Figure 271 Restraint of auxiliary components*



## Controls

- ✓ Follow the manufacturer's recommendations on transmission control positioning and the application of parking brakes.
- ✓ Remove or restrain any loose objects that could move and contact controls during transport – *Figure 272*.

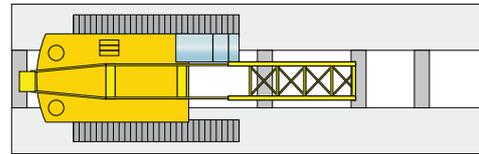
Figure 272 Loose object contacting control



## Wide loads

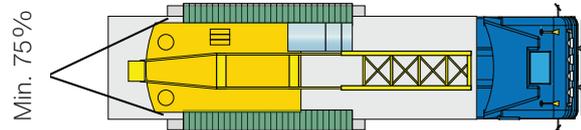
- ✓ Transport mobile equipment and vehicles that are wider than a standard trailer on outriggers or extensions, or on a widening low loader – *Figure 273*.

Figure 273 Widening trailer



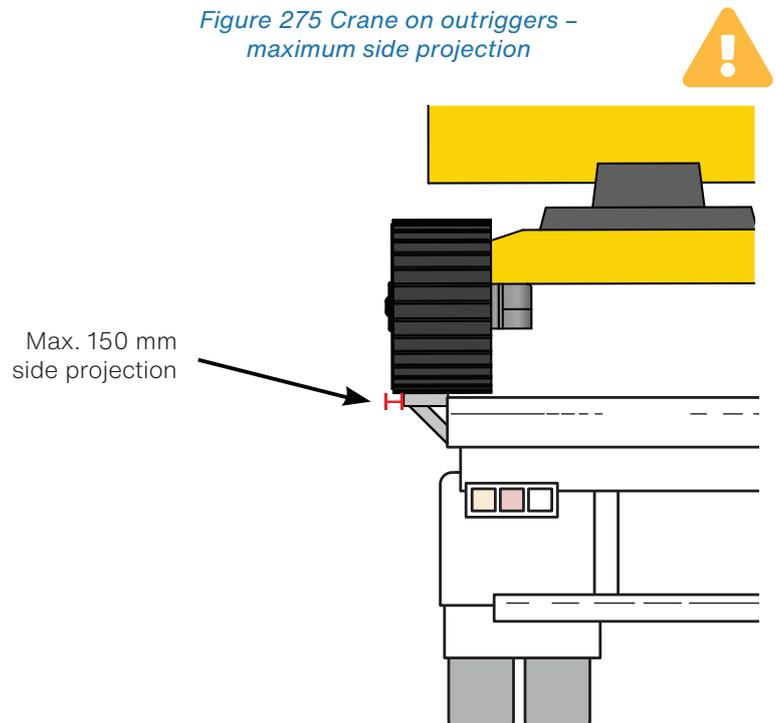
- ✓ Make sure at least 75% of the normal contact area of the tyres or tracks is supported – *Figure 274*.

Figure 274 Crane on outriggers



- ⚠ Ensure any unsupported tyre or track does not project more than 150 mm beyond the vehicle deck or extension – *Figure 275*.

Figure 275 Crane on outriggers – maximum side projection

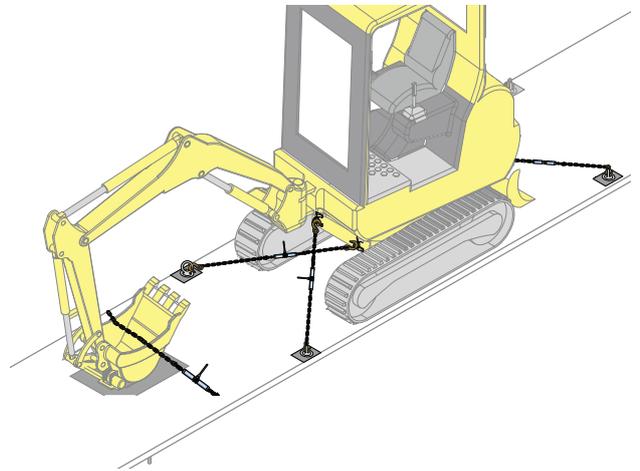


## RESTRAINING EQUIPMENT ON METAL TRACKS OR WHEELS

**i** The information in this section refers to equipment on metal tracks; however, the same principles apply to equipment on metal wheels and rollers.

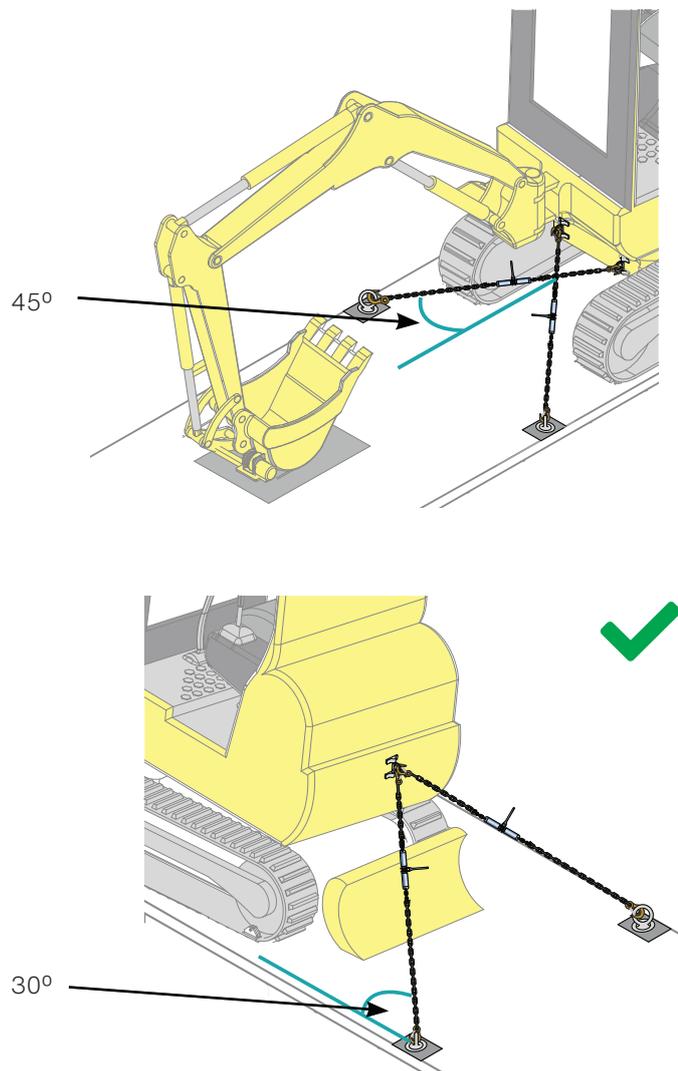
✓ Always use direct lashings to restrain tracked equipment in the forward and rearward directions – *Figure 276*.

*Figure 276 Excavator – direct restraint*



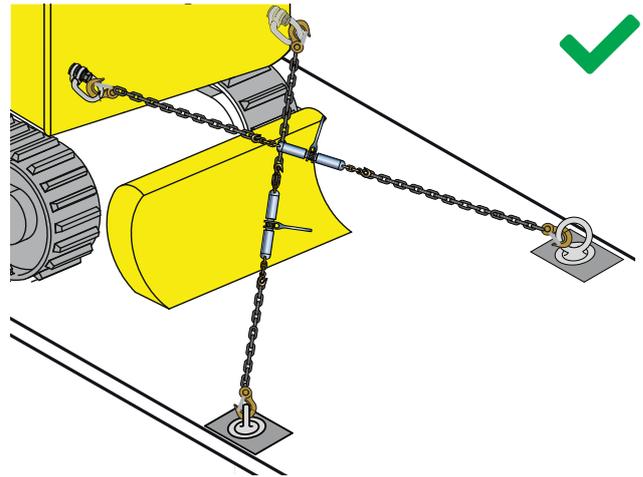
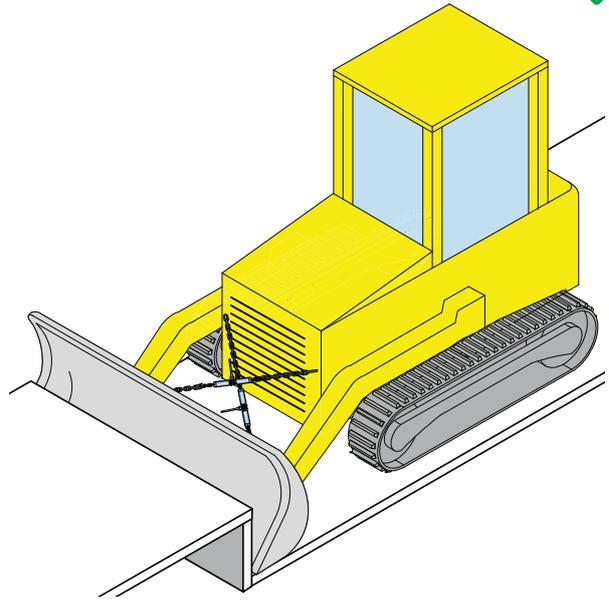
✓ If using 4 chains to restrain tracked equipment, attach 2 chains at the front – angled at approximately  $45^\circ$  to the rearward direction, and 2 chains at the rear – angled approximately  $30^\circ$  to the forward direction. – *Figure 277*.

*Figure 277 Restrained by 4 chains*



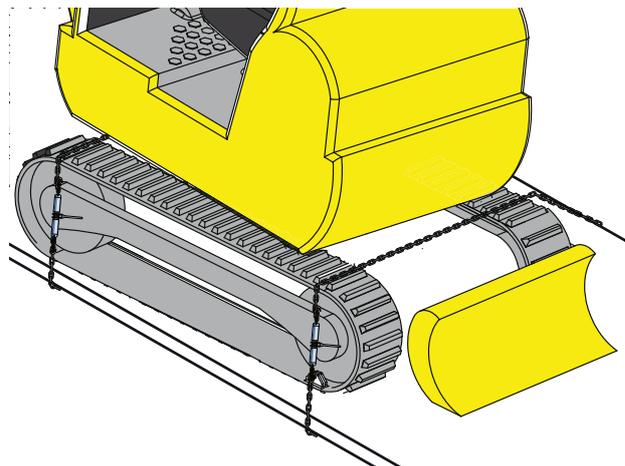
- ✓ If the front of tracked equipment is blocked to prevent forward movement, attach a minimum of 2 chains at the front to prevent rearward and sideways movement, and 2 at the rear to prevent sideways movement – *Figure 278*.

*Figure 278 Direct restraint – blocked at front*



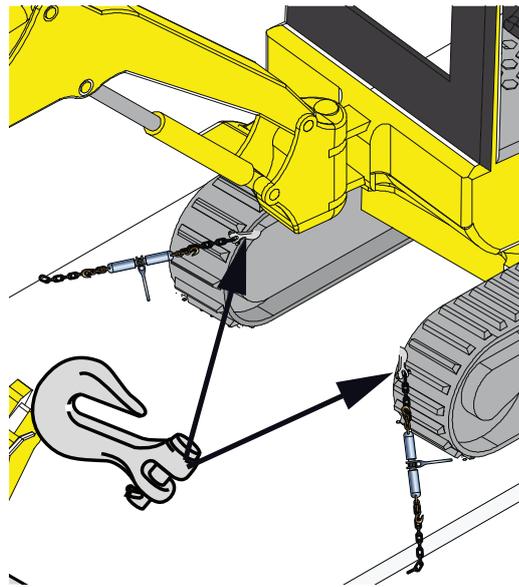
- ✗ Do not use tie-down restraint for equipment on metal tracks because there is not enough friction to adequately restrain it – *Figure 279*.

*Figure 279 Tracked equipment – not suitable for tie-down*

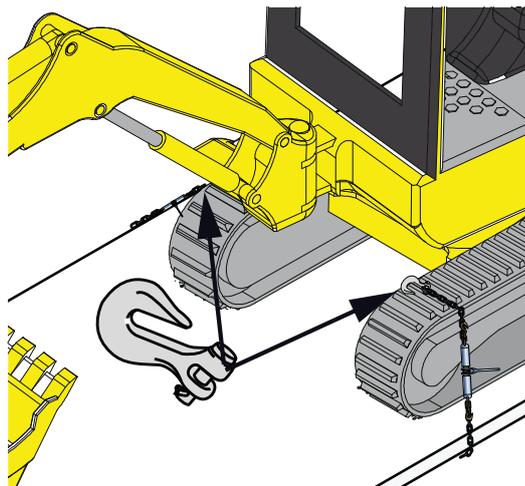


- ✘ Do not restrain tracked machines by angled chains attached to the tracks or track shoes because grab hooks are not designed for tip loading nor rated for this purpose – [Figure 280](#) and [Figure 281](#).

*Figure 280 Direct restraint on tracks*

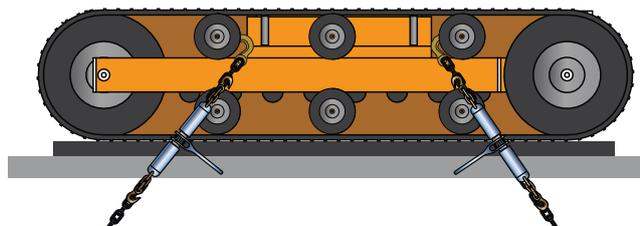


*Figure 281 Direct restraint on track shoe*



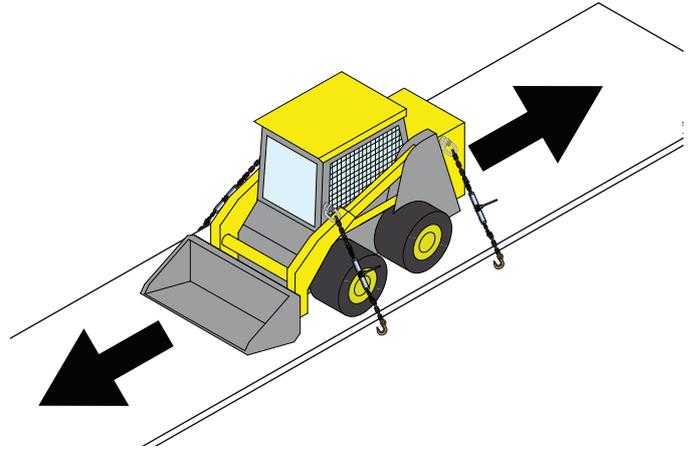
- ✔ If tracked equipment is placed on timber decking or rubber matting, use a combination of tie-down and direct lashings for forward and rearward restraint – [Figure 282](#).

*Figure 282 Tracked equipment on rubber*



- ✓ Where a combination of tie-down and direct restraint is used, attach restraint equipment to the undercarriage or body, not the tracks, to ensure the load does not move by taking up free play in the transmission.
- ✗ Do not rely on transmission and wheel parking brakes, engine braking or hydraulic winches for restraint (unless winches are fitted with positive mechanical locks – for example, winches with pawl locks) – *Figure 283*.

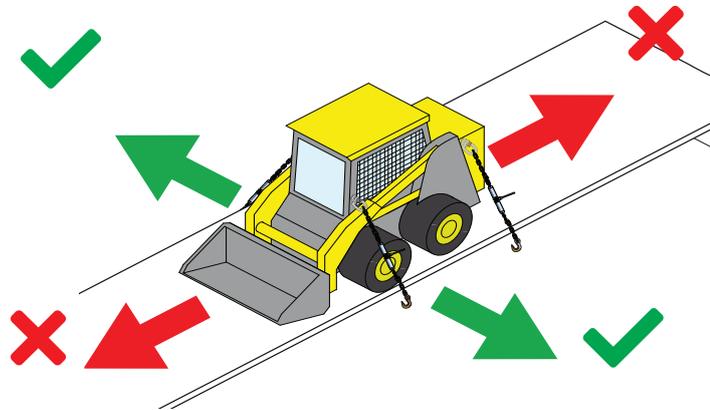
*Figure 283 Do not rely on brakes*



# RESTRAINING VEHICLES AND EQUIPMENT ON RUBBER TYRES OR TRACKS

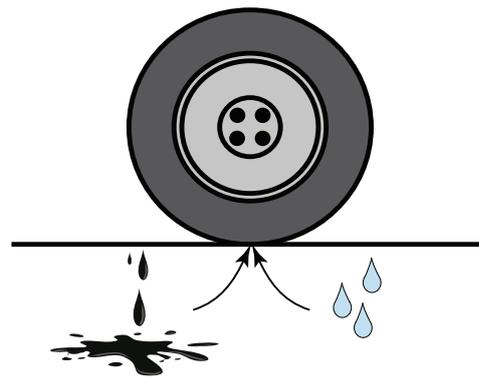
- ✓ Directly restrain rubber-tyred vehicles and equipment in the forward and rearward direction, wherever possible.
- ⚠ If you are using tie-down lashings to restrain rubber-tyred and rubber-tracked vehicles, make sure it is only in the sideways direction – not in the forward or rearward directions – *Figure 284*.

Figure 284 Tie-down for sideways only



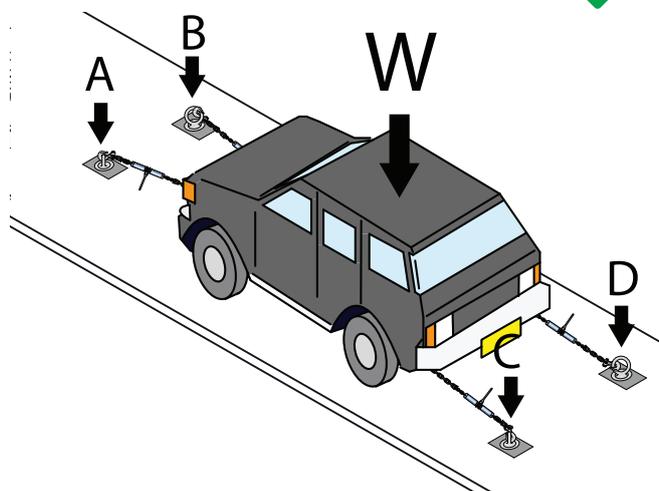
- ✗ Do not use tie-down restraint at all if friction between wheels/tracks and loading decks is extremely low (i.e. when wet or greasy) – *Figure 285*.
- ✓ Make sure the vehicle/equipment's tyres are always in contact with the deck.

Figure 285 Low-friction surface



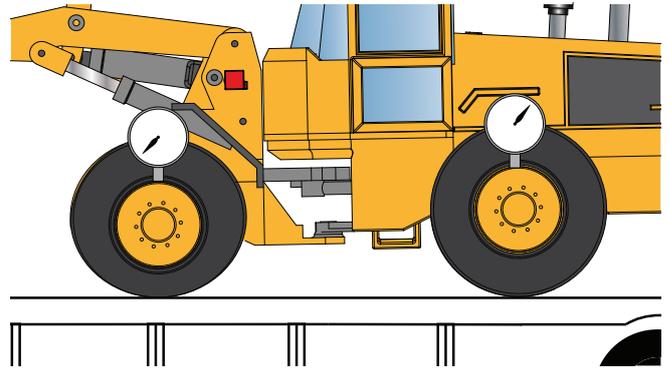
- ✓ In all cases, pre-tension lashings to provide a clamping force equal to a minimum of 20% of the load's weight, as this will keep tyres in contact with the deck – *Figure 286*.

Figure 286 Minimum pre-tension

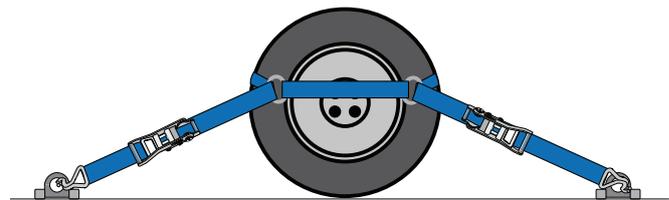


$$A + B + C + D = 20\% W$$

- ✓ Check the tyres to ensure they are the correct pressure and have no leaks before transporting, as this may lower the height of equipment and cause lashings to slacken – *Figure 287*.
- ✓ To prevent lashings becoming detached if the chain slackens, use chain assemblies or wire to tie chain tensioners into position.

*Figure 287 Check tyre pressure*

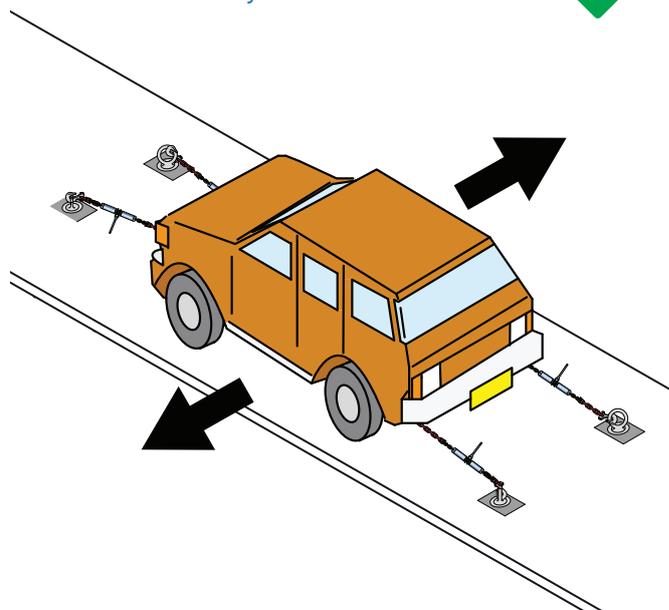
- i** Where lashings prevent a wheel from rotating, friction from the rubber can provide some of the load restraint in the forward and rearward directions – *Figure 288*.

*Figure 288 Lashing preventing rotation*

- i** If tyres are not lashed, friction from the tyres can provide some of the load restraint in the sideways direction only – *Figure 289*.

*Figure 289 Friction-assisted sideways restraint*

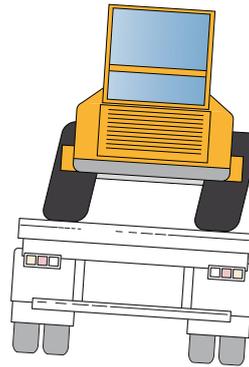
- ✗ Do not rely on brakes to prevent wheels rotating.



**i** Large and medium-sized equipment and motor vehicles can experience significant movement when being transported, including:

- loads swaying excessively (e.g. equipment on large balloon tyres) – *Figure 290*.
- vehicles bouncing on their tyres or suspension due to high shock forces in lashings – *Figure 291*.

*Figure 290 Excessive load sway*

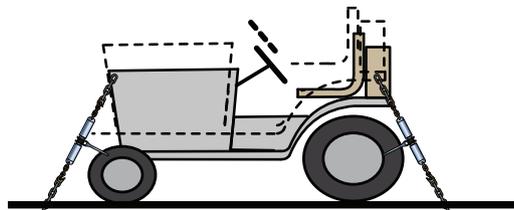


*Figure 291 Shock forces from bouncing*

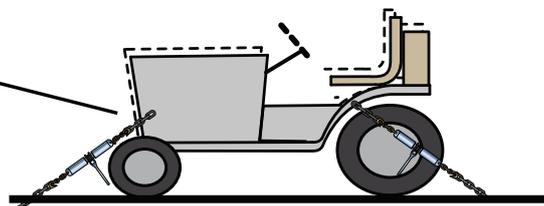


**i** Steeply angled chains pull down on the load more than chains at a lower angle, increasing the shock effect of load bouncing – *Figure 292*.

*Figure 292 Lashing angle effect on bouncing*



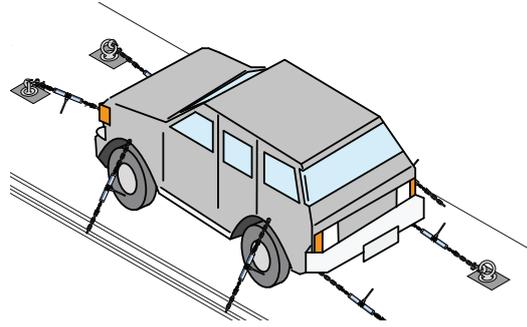
Lashing point lowered



✓ To minimise bounce:

- angle direct lashings on vehicles/equipment at no more than 25° to the horizontal (i.e. 1:2)
- add vertical lashings at each wheel position – *Figure 293*.

*Figure 293 Vertical lashings at wheel positions*



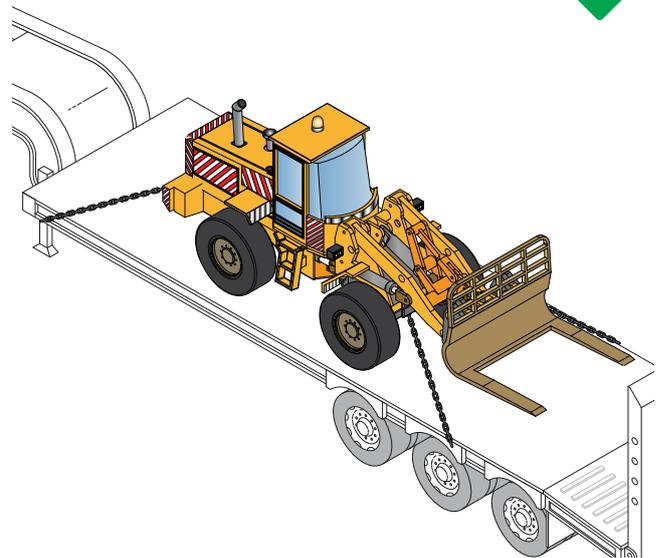
✓ If using vertical lashings at the wheels, make sure they have a lashing capacity of at least half the weight of the equipment and are as tight as possible.

✓ To prevent bounce altogether, remove the wheels or support the vehicle/equipment on blocks.

✓ Directly restrain rubber-tyred vehicles/equipment if the load can sway excessively – *Figure 294*.

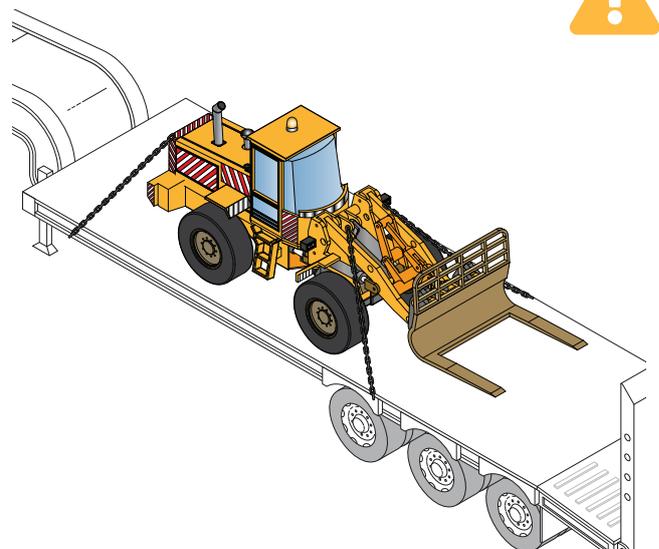
✓ Fit new lashing points to large equipment, if required, to provide adequate restraint.

*Figure 294 Load directly restrained*



**i** Lugs on some large equipment are positioned for lifting (not load restraint) and can result in high lashing angles and excessive bounce – *Figure 295*.

*Figure 295 Steep lashing angle*

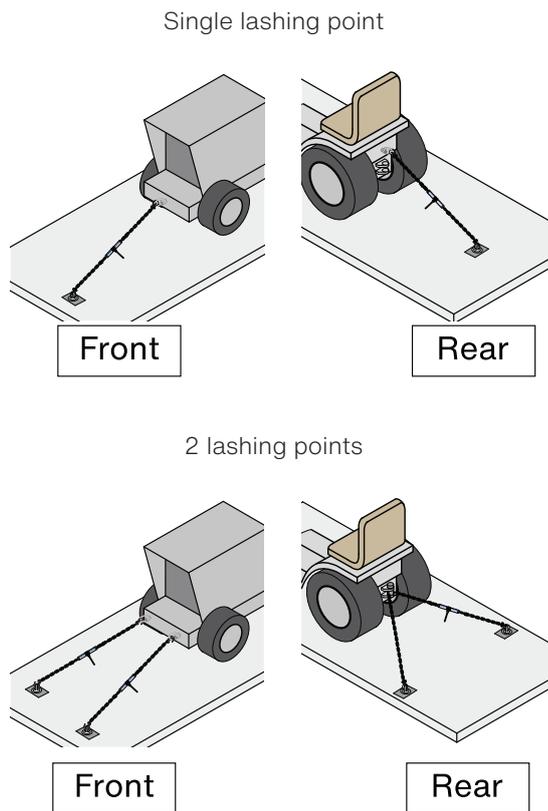


## Small equipment

- ✓ Restrain small equipment such as mowers, skid-steer loaders, etc. by direct lashings or containment.
- ✓ If using direct lashings, attach at least one lashing to the equipment at each end to provide forward and rearward restraint.
- ✓ Connect lashings directly from the equipment to the deck, or passed through a lashing point (i.e. towing bracket), and attach to the deck at 2 points – *Figure 296*.

**i** The rubber tyres are likely to provide adequate sideways restraint.

*Figure 296 Small rubber-tyred equipment*



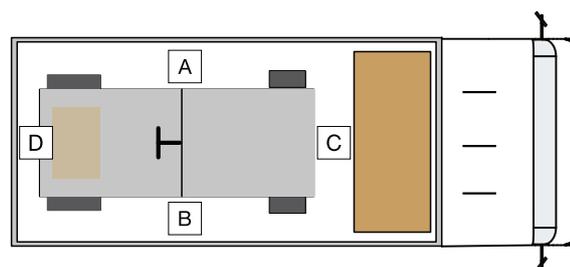
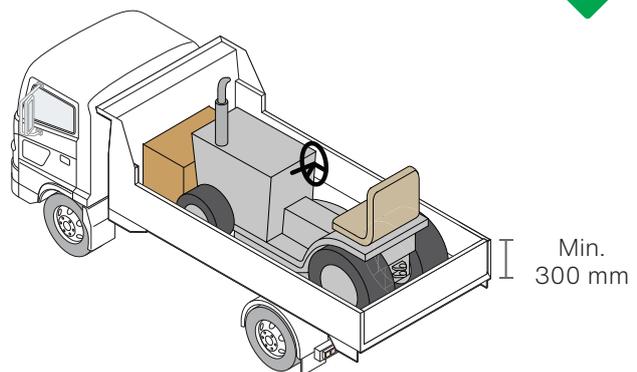
- ✓ If containing small equipment, make sure the containment bodies are suitably engineered to restrain the equipment.

**i** Containment bodies should have walls that sit at least 300 mm above the deck or higher than the top of any equipment tyres, whichever is greater – *Figure 297*.

- ✓ If there are gaps between the equipment and walls that are greater than 100 mm side to side or 200 mm front to back, fill them with packing that is the same height as the walls and that is separately restrained.

✗ Do not restrain small vehicles by containment if there are unfilled gaps greater than 100 mm side to side or 200 mm front to back.

*Figure 297 Adequate containment*



## Motor vehicles

- ✓ Transport motor vehicles on specialised carrying vehicles or on general freight vehicles – *Figure 298*.
- i** Modern light vehicles are equipped with special underbody brackets to enable lashings to be attached; some brackets are designed for vertical lashings and are only suitable for use with purpose-built car carriers.
- ✗ Do not transport vehicles unrestrained on car carriers, even if it appears the motor vehicles are contained by the car carrier structure.
- ✓ Restrain motor vehicles using wheel restraint, tie-down restraint or direct lashing.
- ⚠ Make sure lashings attached to axles or wheels do not damage brake pipes, hoses, anti-lock brake sensors or other components – *Figure 299*.

Figure 298 Car carrier

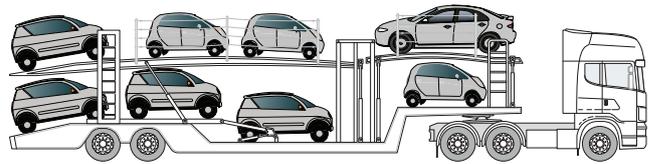
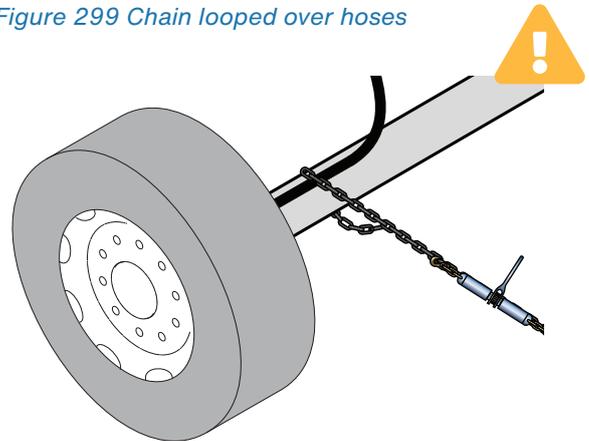
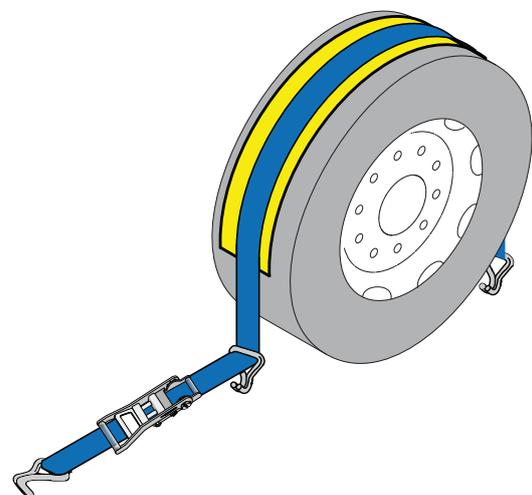


Figure 299 Chain looped over hoses

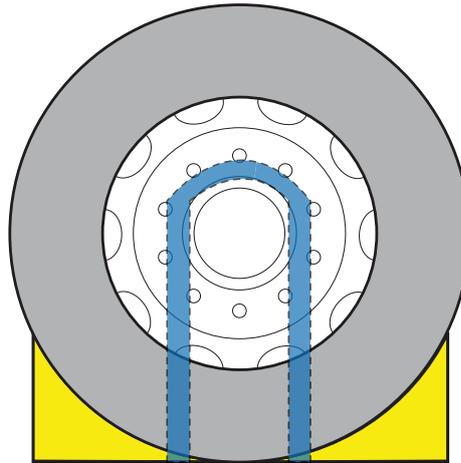
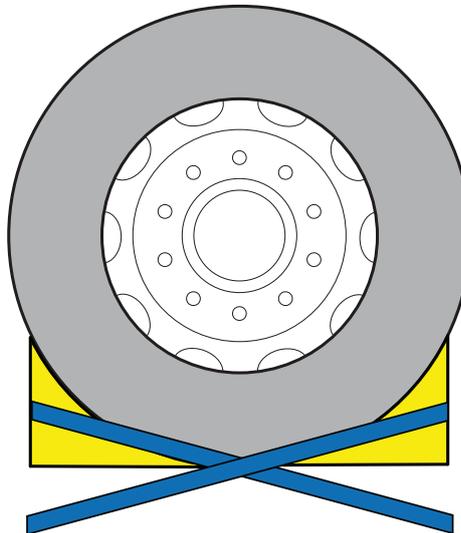


- ✓ If using wheel restraint, attach direct lashings or tie-down lashing assemblies to the wheels of the vehicle – *Figure 300*.

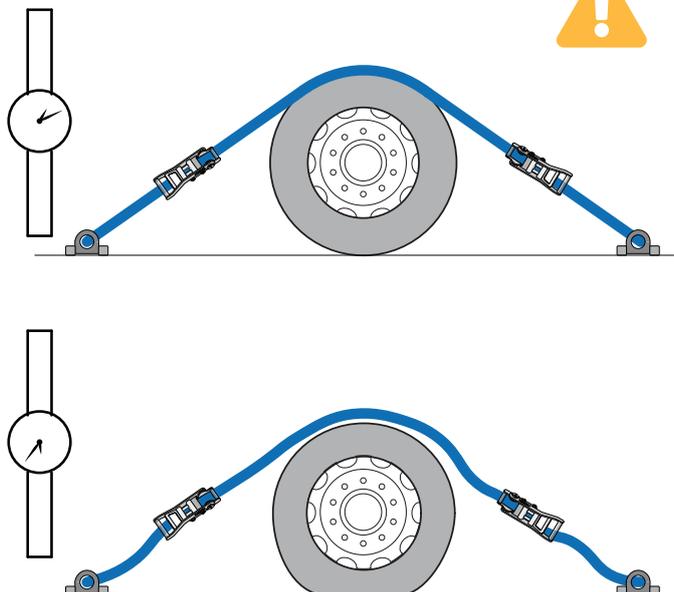
Figure 300 Tie-down lashing attached to wheel



- ✓ If using tie-down restraint, attach vertical chains or straps underneath the vehicle and tension them using a fixed winch.
- ✓ Make sure the wheels are prevented from rotating by chocks or recesses in the deck, or the tie-down restraint will not work – *Figure 301*.
- ✗ Do not use tie-down lashings if the vehicle parking brakes or transmission locks are the only way of preventing the wheels from rotating.
- ✓ Restrain chocks and any other loose equipment (including ramps and lashing assemblies) to prevent them from dislodging from the vehicle during transport – *Figure 302*.

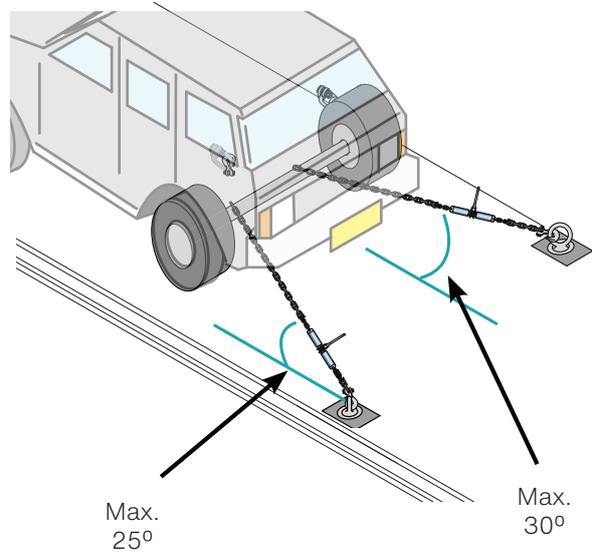
*Figure 301 Chocked wheel**Figure 302 Chocks restrained*

- ✓ Check tyre pressure before and during the journey.
- ⚠ Wheel restraint and tie-down depend on the tyres remaining inflated during transport; if the tyre loses air, all restraint is lost – *Figure 303*.

*Figure 303 Loss of tyre pressure*

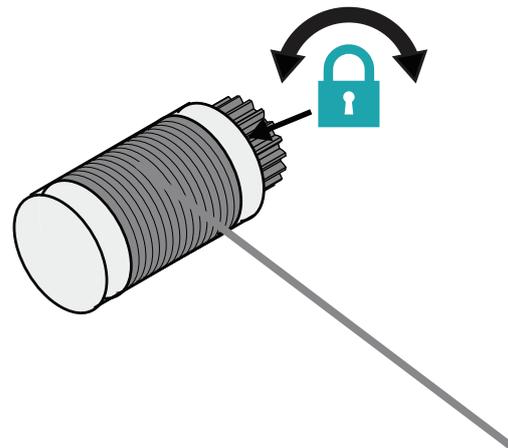
- ✓ If using direct restraint, attach restraints to the axles, suspension or lashing points.
- ✓ Make sure direct lashings are angled at  $25^\circ$  to the horizontal to minimise bounce, and within  $30^\circ$  of the centreline of the carrying vehicle – *Figure 304*.
- ✓ Attach at least 2 direct lashings at each end of the vehicle so that downward force is applied to all wheels.

*Figure 304 Motor vehicle directly restrained*



- ✓ Only use recovery winches to restrain loads if they are fitted with a positive lock mechanism – *Figure 305*.
- ⚠ If using a recovery winch, it should be tensioned to pull down on one end of the vehicle at a minimum of  $25^\circ$  (i.e. 1:2) or give an equivalent force of 20% of the weight on the axle at that end.

*Figure 305 Winch with positive lock*



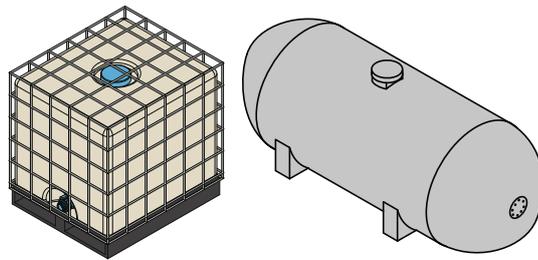
# INTERMEDIATE BULK CONTAINERS AND CHEMICAL TANKS

Intermediate bulk containers (IBCs) and chemical tanks are reusable industrial containers designed to transport and store bulk liquids.

The guidelines below set out how you can meet the [Performance Standards](#) when restraining IBCs and chemical tanks. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

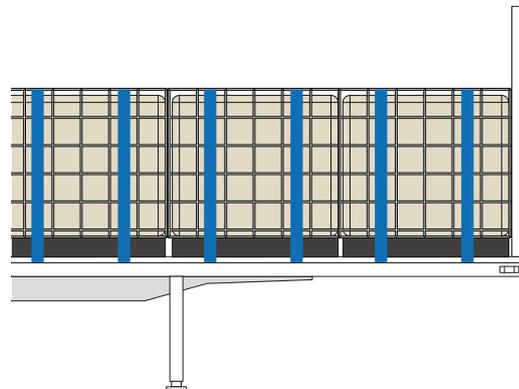
Figure 306 IBC and chemical tank



## INTERMEDIATE BULK CONTAINERS (IBCs)

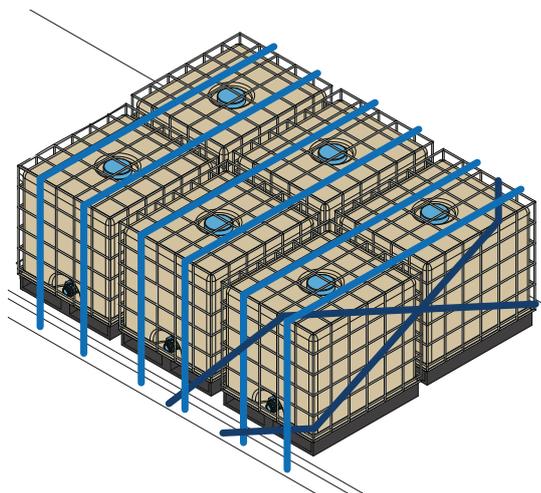
- ✓ Block IBCs in the forward direction wherever possible to reduce the required number of tie-down lashings – [Figure 307](#).

Figure 307 Blocked against headboard



- ✓ Where a suitably engineered blocking surface is not available, use crossover straps to block the load – [Figure 308](#).

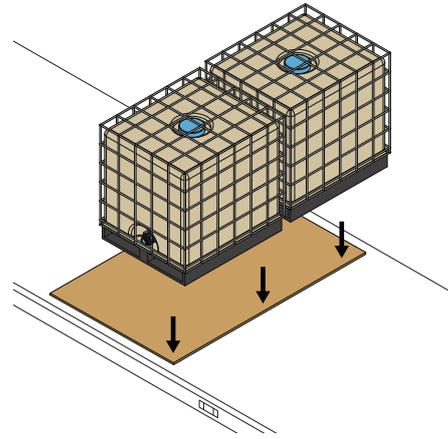
Figure 308 Crossover strap blocking



✓ Place IBCs that have low-friction bases on timber or rubber surfaces to improve friction – *Figure 309*.

✗ Do not use carpet to separate IBCs from a steel deck because it is low friction.

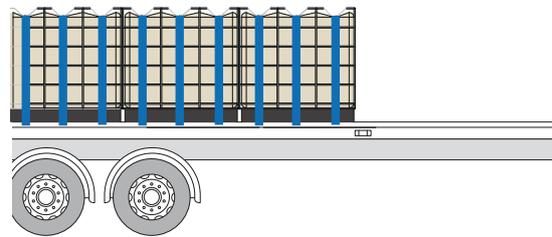
*Figure 309 IBCs on plywood*



⚠ IBCs placed directly on a steel deck and not blocked in the forward direction require a large number of lashings for safe transport, which may be impractical – *Figure 310*.

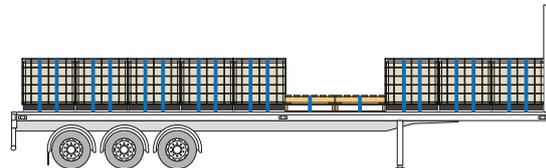
⚠ Multiple lashings applied to IBCs may crush or damage the container.

*Figure 310 Unblocked load*



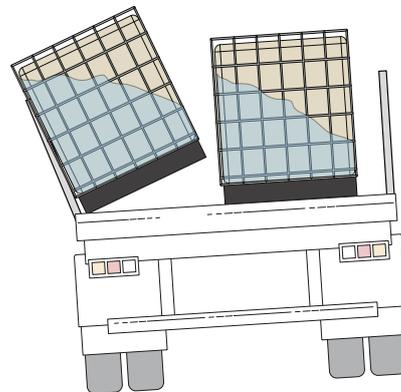
✓ Use empty pallets tied down to fill gaps in loads – *Figure 311*.

*Figure 311 Gaps filled with pallets*



✗ Do not rely on unrated gates as the sole form of restraint – *Figure 312*.

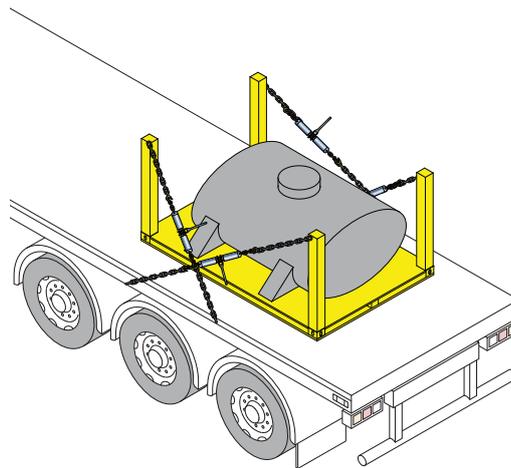
*Figure 312 Unrated gates*



## CHEMICAL TANKS

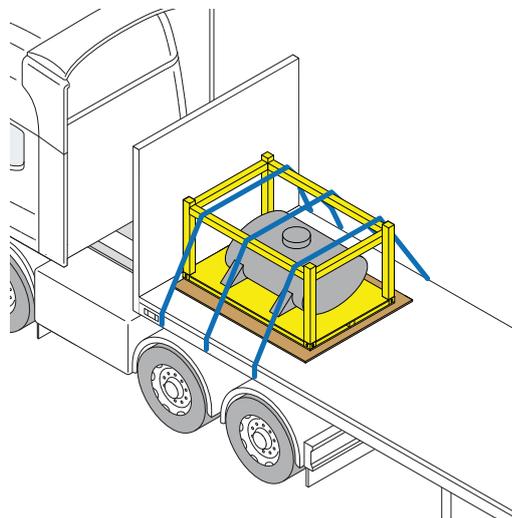
- ✓ Restrain chemical tanks on skids using direct restraint attached to the skid wherever possible – *Figure 313*.

*Figure 313 Direct restraint of chemical tank*



- ✓ Restrain small tanks using tie-down where lashing angles and tank/skid structure permit adequate restraint – *Figure 314*.

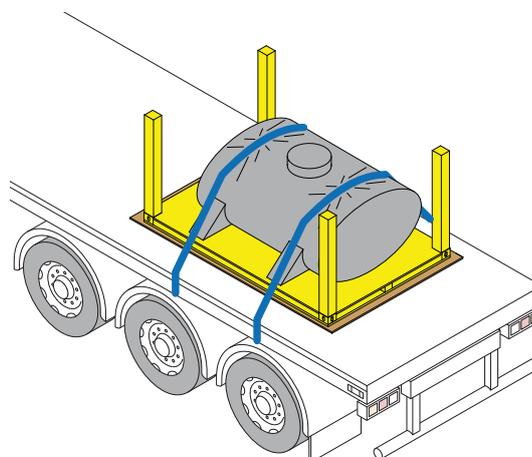
*Figure 314 Small tank tied down*



- ✓ If using tie-down, block in the forward direction and place rubber or timber between the tank frame and the deck to increase friction.

- ⚠ Tie-down lashings placed over chemical tanks may damage the tank structure – *Figure 315*.

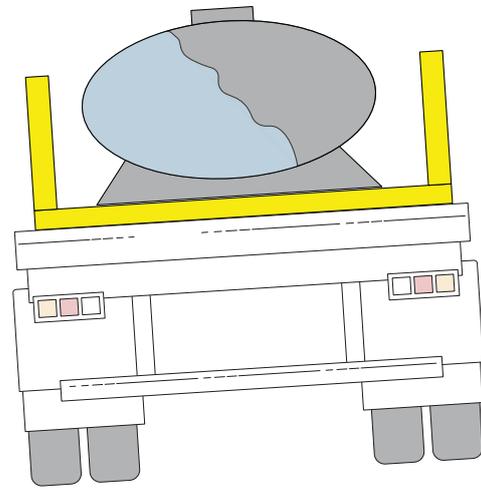
*Figure 315 Tie-down over chemical tank*



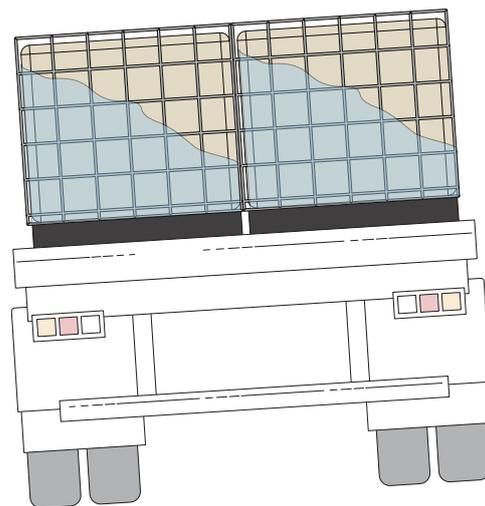
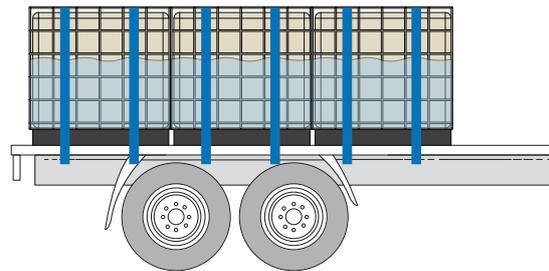
## PARTIALLY FILLED IBCs AND TANKS

⚠ Liquid slosh in partially filled IBCs and chemical tanks can affect vehicle stability – [Figure 316](#) and [Figure 317](#).

*Figure 316 Liquid slosh in chemical tank*



*Figure 317 Liquid slosh in partially filled IBCs*



## DANGEROUS GOODS

- i** If a dangerous goods class label is present refer to the **Australian Code for the Transport of Dangerous Goods by Road & Rail** for additional requirements – *Figure 318*.

*Figure 318 Example dangerous goods label*



# BULK BAGS

Bulk bags are industrial containers made of flexible fabrics. They are used to transport powdered and granular materials.

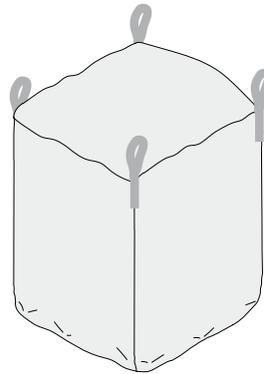
The guidelines below set out how you can meet the [Performance Standards](#) when restraining bulk bags. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

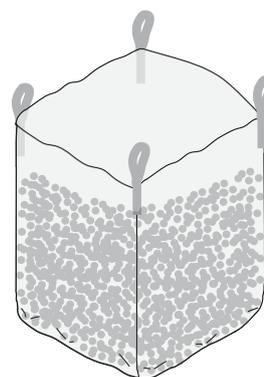
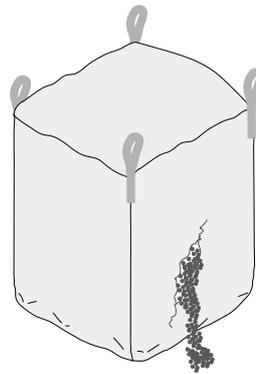
## GENERAL TIPS

- ✓ Make sure bulk bags are in good condition and free of cuts and tears – [Figure 320](#).

*Figure 319 Bulk bag*

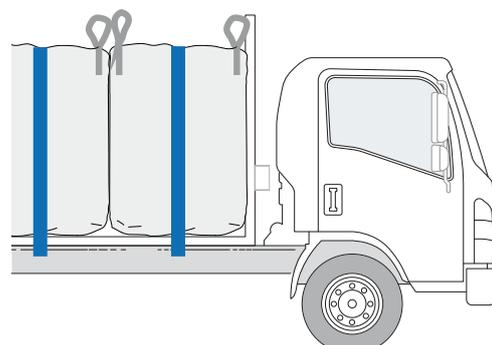


*Figure 320 Bulk bag condition*



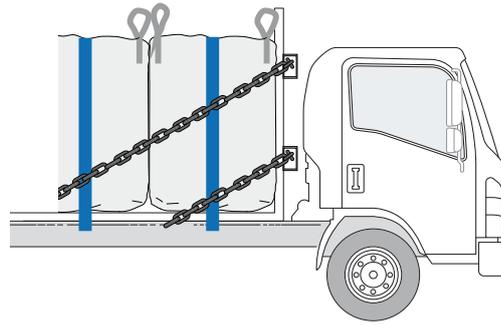
- ✓ Load bulk bags in groups without gaps and block in the forwards direction – [Figure 321](#).
- ✓ Containing bulk bags can be an effective form of restraint.

*Figure 321 Bulk bags blocked forwards*



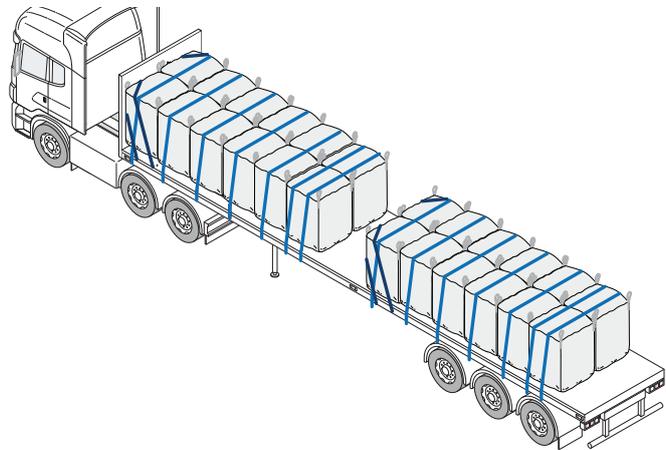
- ✓ Reinforce unrated blocking surfaces using chains (or similar) wrapped across the face of the blocking surface – *Figure 322*.
- ✓ Pass reinforcing chains through a hollow section welded to the blocking surface.
- ⚠ Reinforced unrated blocking surfaces have **limited restraint capacity and may fail** if used improperly.

*Figure 322 Reinforced unrated headboard*



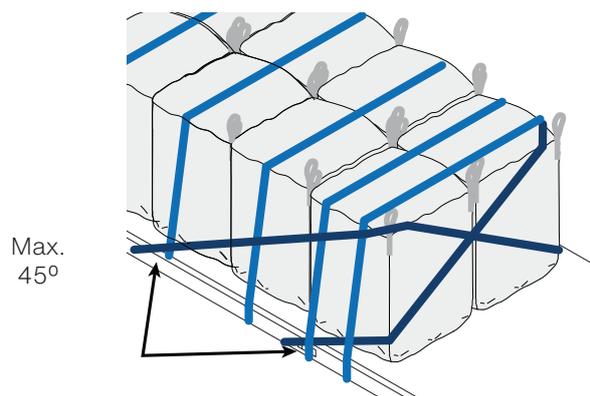
- ✓ Split full loads into multiple groups to reduce the load on each blocking surface – *Figure 323*.
- ✓ Apply a minimum of one webbing strap to every row and 2 webbing straps to the final row of each group.
- ⓘ Additional straps may be required depending on the weight of the load.

*Figure 323 Split load*



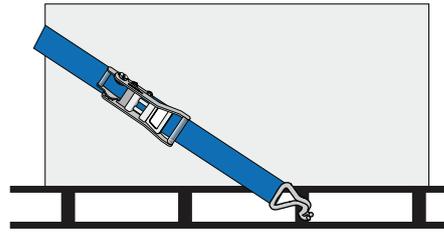
- ✓ Where a suitably engineered blocking surface is not available, block bags with crossover straps angled at a maximum of 45° to the horizontal – *Figure 324*.

*Figure 324 Crossover strap blocking*

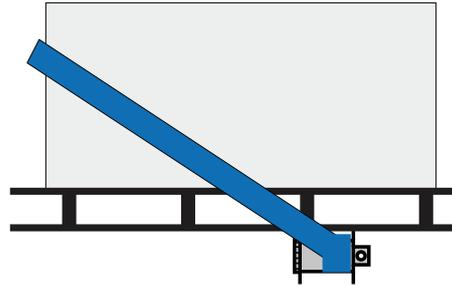


- ✓ Tension crossover straps using in-line ratchets – *Figure 325*.

*Figure 325 Crossover strap tension*



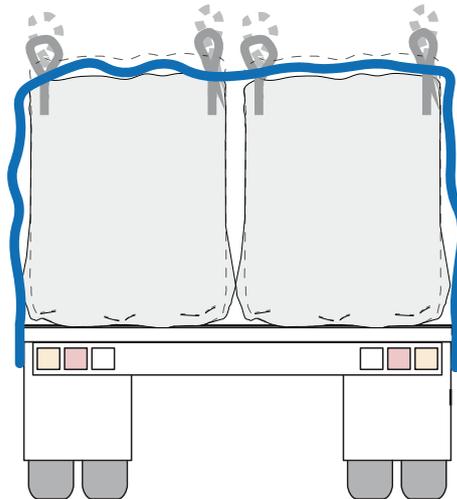
- ✗ Do not use drum winches to tension crossover straps.



## During the journey

*Figure 326 Load settle*

- ⚠ Lashings may become loose during transport as the load settles – *Figure 326*.
- ✓ Check lashing tensions at regular intervals during transport and re-tighten as required.



# LIVESTOCK

Livestock covers any type of farm animal including but not limited to cattle, sheep, pigs, goats, horses, deer, camels, buffalo and chickens.

The guidelines below set out how you can meet the [Performance Standards](#) when carrying livestock. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Note:** While the primary aim of this advice is to contain livestock and related materials within the vehicle, this must be done in a manner that is safe, practical and humane.

For more information go to [www.nhvr.gov.au/ricp](http://www.nhvr.gov.au/ricp), the [Australian Animal Welfare Standards and Guidelines for the Land Transport of Livestock](#), or contact your local livestock transport association.

## PLANNING THE JOURNEY

- ✓ Always consider the welfare of the driver, handlers, other road users and animals when planning, loading, transporting and unloading livestock.
  - ❗ Livestock can be unpredictable in their actions, while on the vehicle and especially when loading, unloading and cross-loading.
  - ⚠ Unforeseen delays and extreme weather events can affect the welfare of livestock.
  - ⚠ Loaders and unloaders can be injured by the livestock.
- ✓ Plan for effluent management when transporting livestock.
  - ❗ Factors such as variations in road gradient, unpredictable braking events and the possibility of heavy rain can make effluent containment difficult.
  - ⚠ Excessive effluent generation during transport can cause welfare issues inside the crate. Effluent spilled from the vehicle may increase risks to safety, biosecurity and the environment.
- ✓ Always carefully plan and prepare for your trip when transporting livestock.
  - ❗ Pre-trip planning and stock preparation (including appropriate water and feed levels) are a vital part of the transport process. This responsibility is shared by all supply chain parties.

## BEFORE LOADING

- ✓ Check animals are adequately prepared prior to the journey, including application of appropriate feed curfews to minimise effluent generation in transit.
- ✓ Use purpose-built livestock vehicles wherever possible.
  - i** Livestock crates are designed to contain specific species and include non-bruising materials, non-slip flooring, ventilation, pens or partitions and internal/external ramps.
- ✓ Ensure livestock crates meet ventilation requirements for livestock.
- ✓ Use trailer effluent containment devices to control effluent loss.
- ✓ Ensure crates and any effluent containment devices are prepared correctly prior to loading, and are functioning as designed, to control livestock effluent.
  - i** Effluent containment devices are most effective when appropriate feed curfews are applied and roadside or destination-managed facilities are available to empty tanks and wash out trailers.
- ✓ Ensure livestock are fit and healthy prior to loading.

## WHEN LOADING

- ✓ Ensure the correct livestock loading density is being used when you are loading livestock.
  - i** The loading density can be obtained from the Australian Animal Welfare Standards and Guidelines – Land Transport of Livestock.
- ✓ When carrying livestock on multiple deck crates, ensure all multiple deck crates are loaded from the lowest deck up and animals are penned appropriately.
  - w** Livestock trailers have a relatively high centre of gravity and animals may move in transit, reducing a vehicle's cornering ability and increasing rollover risk.
- ✓ Minimise or remove the physical interface between handlers and animals when loading or unloading livestock.
  - i** Using experienced livestock handlers and well designed ancillary equipment such as loading/unloading ramps, pivot access landing frames, overhead gantries, cross-loading structures and forcing yards will improve animal flow and greatly reduce risks to livestock and handlers.

## DURING THE JOURNEY

- ✓ Check road and weather conditions for the whole of your journey to manage the welfare of livestock.
- ✓ Take rest breaks based on the climate and the animal species type, age and condition.
- ✓ Ensure adequate water, feed and spelling yards are available for longer journeys.
- ✓ Use smooth driving techniques, without sudden turns or stops, to minimise excessive movements of livestock and to prevent injuries, bruising, slipping and falling of livestock.
- ✓ Where practical, take opportunities to clean the vehicle of waste and empty effluent containment devices where supporting infrastructure is available.

# LOGS

Restraining logs will depend on whether they are pulp or saw logs, in long or short lengths and with bark on or off. Take into account the friction of the logs in the load when applying the guidelines below (e.g. debarked logs with a high sap content are low-friction logs, while those with bark on and a low sap content are medium-friction logs).

The guidelines below set out how you can meet the [Performance Standards](#) when restraining logs. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

## LOOSE LOGS BETWEEN STANCHIONS

### Restraint method

- ✓ Restrain all logs to prevent any sliding out of the pack.
- ✓ Use more restraints for low-friction logs.
  - ⚠ Friction of logs varies significantly between log type and seasonal conditions.
- ✓ Use stanchions to restrain loads sideways – [Figure 328](#).
- ✓ Ensure the stanchions are strong enough to restrain the load as required by the [Performance Standards](#).
- ✓ Restrain every log in the load with a minimum of 2 stanchions on each side of the load.
- ✓ Check that all log lengths extend at least 300 mm beyond the outer stanchions in the forward and rearward directions, where lashings are not sufficient alone to properly restrain the logs – [Figure 329](#).
- ✓ Place longer logs towards the outside of the stack and shorter logs in the centre.
- ✓ Block the load in the forward direction to reduce the number of tie-down lashings required – [Figure 330](#).

Figure 327 Pulp log, softwood saw log, hardwood saw log



Figure 328 Trailer with stanchions

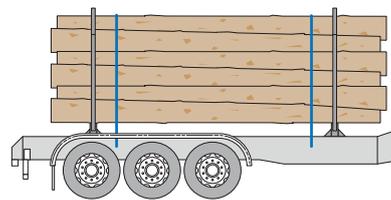


Figure 329 Minimum engagement

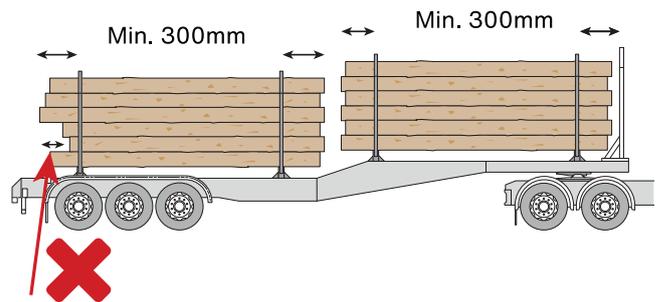
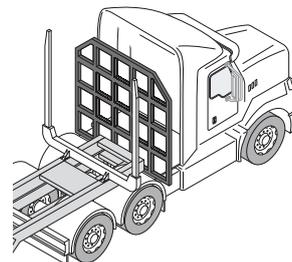
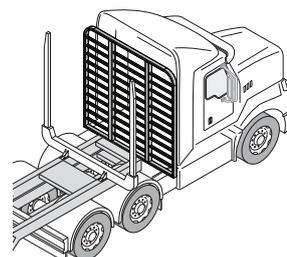


Figure 330 Forwards blocking

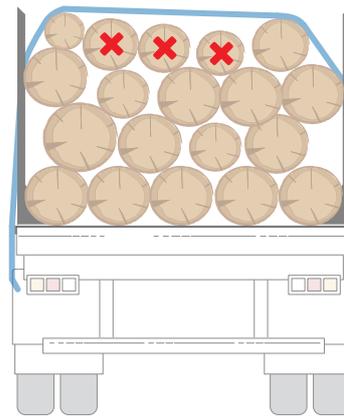


Fitting the headboard to the trailer is best practice



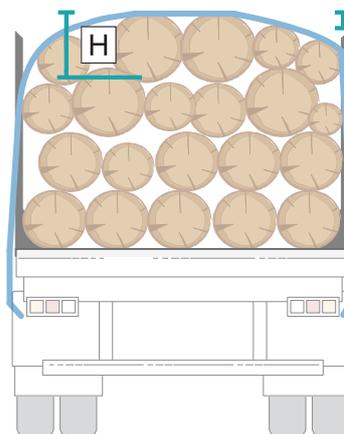
Cab guards fitted to prime movers are not suitable for load restraint but offer driver protection

- ✓ Tension both sides when using webbing straps, where practical and safe.
  - ⚠ If tensioned on one side only, webbing straps will lose significant tension due to high friction between the logs and lashings.
- ✓ Crown loads to ensure all logs are clamped by tie-down lashings – *Figure 331*.

*Figure 331 Load not crowned*

Clamping not applied to all logs

- ✗ Don't extend the top logs of the crown more than half their height above the top of the stanchion – *Figure 332*.
- ✓ Restrain non-uniform logs individually if they are not effectively restrained by tie-down lashings or blocked forwards and rearwards.
  - ⚠ Differences in log shape may prevent all logs from being effectively clamped by tie-down lashings.
  - ⚠ Use caution when loading and restraining non-uniform logs.

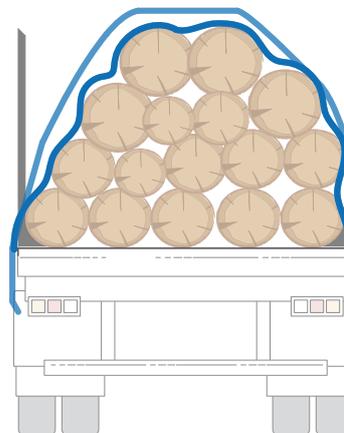
*Figure 332 Load crowned*

Less than 0.5 H

Top logs less than 0.5 H above stanchions

## During the journey

- ✓ Check lashings and load position regularly during transit, and re-tension lashings as required.
  - ⚠ Loads can settle during transit, particularly when exiting the coupe (i.e. the section of forest being actively harvested) – *Figure 333*.
- ⓘ Automated winch systems can be installed to maintain lashing tension during transport.

*Figure 333 Load settle*

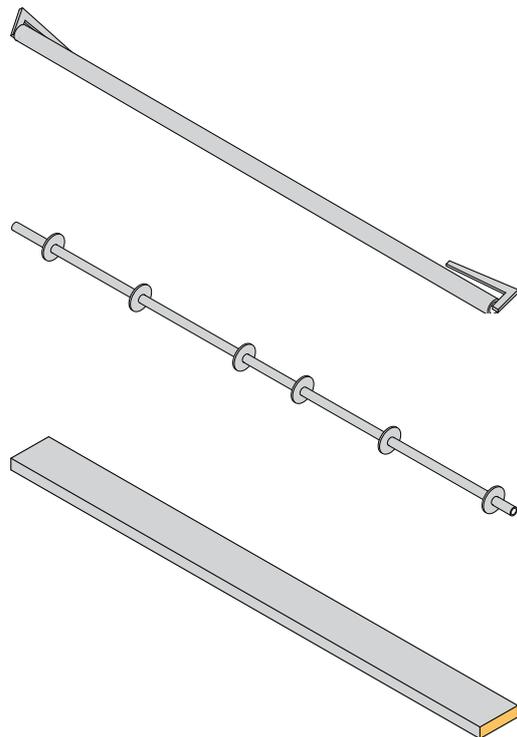
Load settled – lashings loose

# SCAFFOLDING

The guidelines below set out how you can meet the [Performance Standards](#) when restraining scaffolding. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

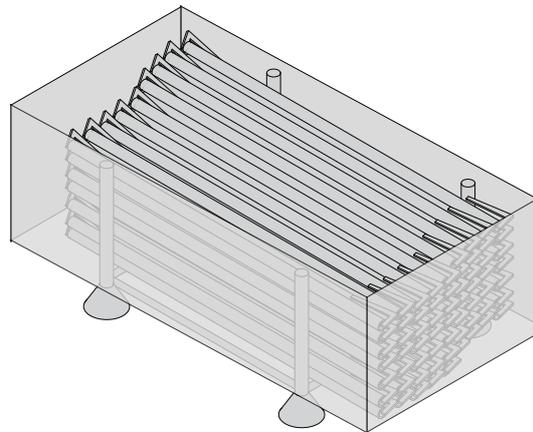
Figure 334 Ledger, standard and deck



## GENERAL TIPS

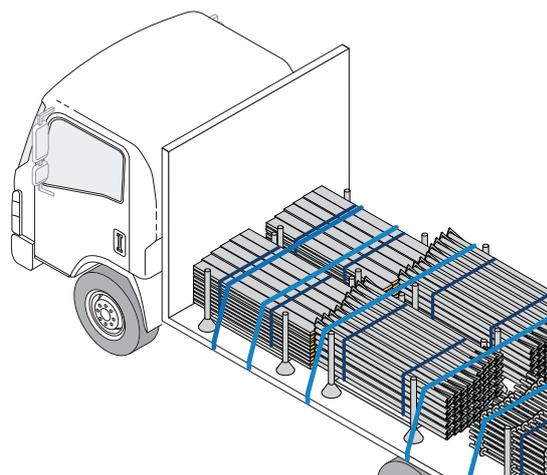
✓ Restrain scaffolding in purpose-built stillages wherever possible – [Figure 335](#).

Figure 335 Scaffold stillage



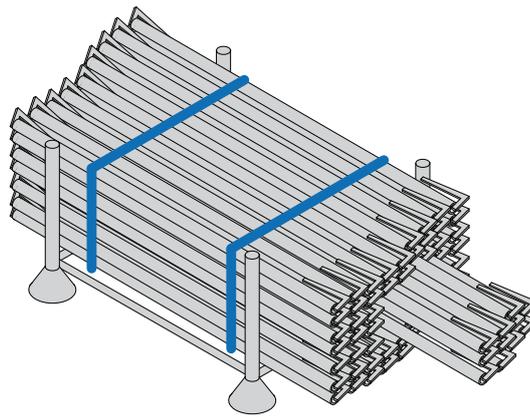
✓ Block lengths loaded in H-frames to prevent spearing – [Figure 336](#).

Figure 336 Blocked load



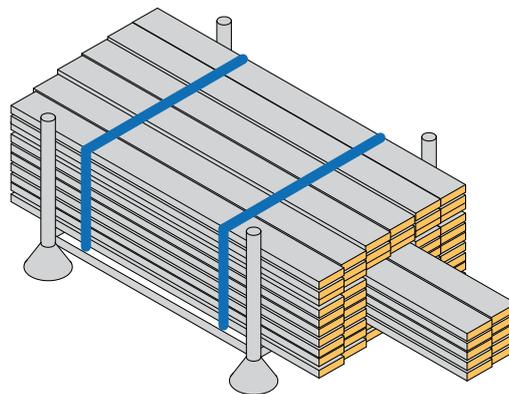
⚠ Lengths unitised or tied down in H-frames may spear out during transport if not blocked – *Figure 337*.

*Figure 337 Ledgers spearing*



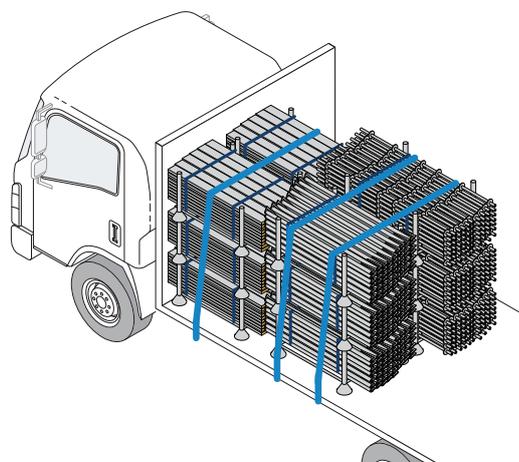
⚠ Decks can be low friction and may spear out during transport when loaded in bundles – *Figure 338*.

*Figure 338 Decks spearing*



⚠ Stacked H-frames may affect vehicle stability – *Figure 339*.

*Figure 339 Stacked H-frames*



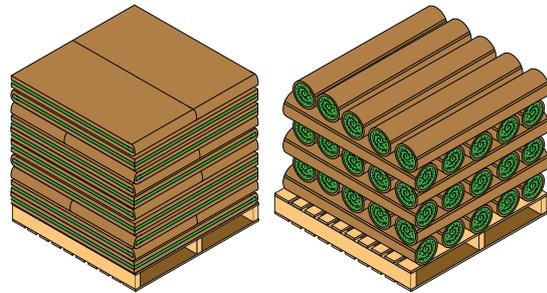
# TURF

The guidelines below set out how you can meet the [Performance Standards](#) when restraining turf. They are intended to be used as a guide only. You can restrain using other methods. It is recommended that an engineer certifies alternative methods.

**Diagrams are indicative only.** For more information on restraint equipment see [Vehicles and equipment](#). To work out how many lashings to use, see the worked examples (in [Working out load restraint](#)) and [Technical advice](#).

Layered or rolled turf is generally transported on pallets – [Figure 340](#).

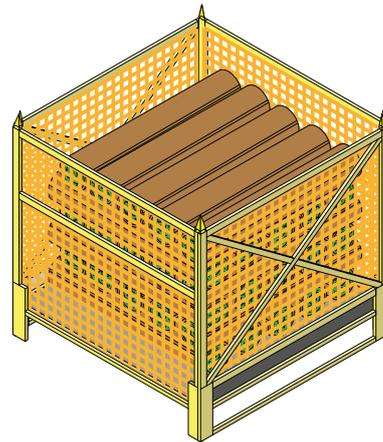
*Figure 340 Layered turf, rolled turf*



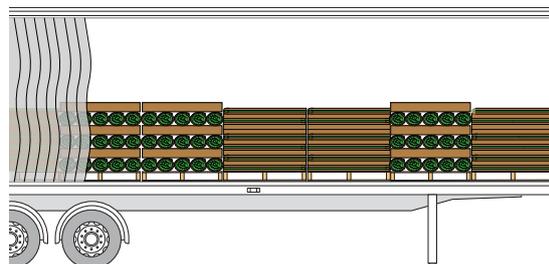
## GENERAL TIPS

- ✓ Transport turf in rigid containers – [Figure 341](#) or inside rated curtain trucks – [Figure 342](#) or pantech trucks to prevent load loss.

*Figure 341 Rigid container*

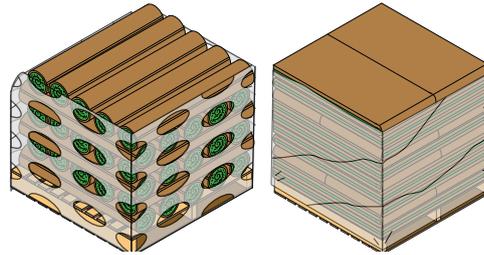


*Figure 342 Rated curtain truck*



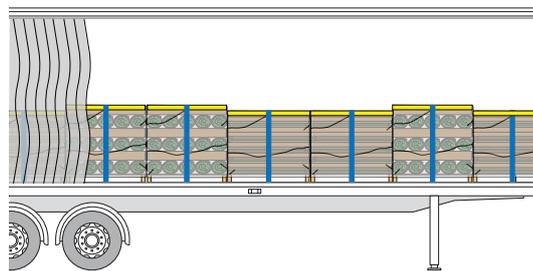
- ✓ Unitise loosely stacked turf to the pallet with stretch wrap or wide-aperture plastic mesh – *Figure 343*.

*Figure 343 Unitised pallet*



- ✓ Apply at least one webbing strap to each row of turf over plastic corners to evenly distribute tie-down forces across the pallet – *Figure 344*.

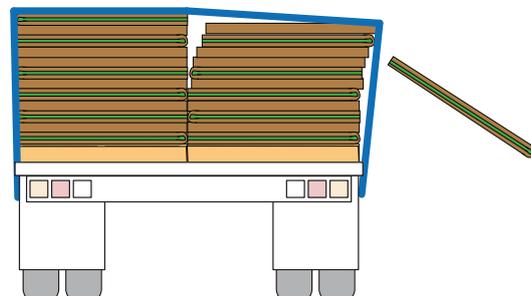
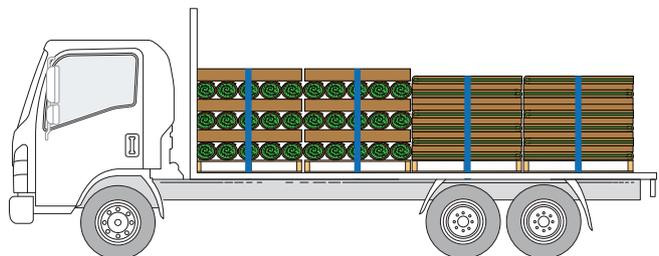
*Figure 344 Load tied down*



- ⓘ Additional lashings may be required depending on the weight of each pallet.

- ⚠ Loosely stacked palletised turf transported on flat-top vehicles without containment is not recommended because it can dislodge from the vehicle during transport – *Figure 345*.

*Figure 345 Turf dislodging*



# VEHICLES AND EQUIPMENT

This module provides details of standard vehicle structures and restraint equipment used in restraining loads.

## HOW TO USE THIS MODULE

**Read about specific equipment or vehicle structures,** or just to get an understanding of the main types of equipment that are used in load restraint.

There are guidelines on the safe and effective use of:

- [side gates](#)
- [headboards and loading racks](#)
- [barriers](#)
- [side curtains](#)
- [chocks, cradles and A-frames](#)
- [tarpaulins](#)
- [synthetic ropes](#)
- [webbing](#)
- [chain](#)
- [stretch and shrink wrapping](#)
- [wire ropes](#)
- [specialised bodies](#)
- [uprights](#)
- [loading equipment](#)
- [lashing tensioners](#)
- [interlayer packing](#)
- [dunnage](#)
- [inflatable dunnage](#)
- [tyres](#)
- [winch tracks](#)
- [ISO-type container twist locks](#)
- [latches, lock and hinges](#)
- [tie rails and load anchor points](#)
- [strapping](#).

# SIDE GATES

## WHAT ARE SIDE GATES?

- i** Side gates work as a containment solution providing sideways restraint.
- i** **Rated side gates** have been tested for load restraint and certified to meet the forces in the [Performance Standards](#).
- i** Certification of rated side gates should specify details about the load that the gates can restrain, including size, shape, weight and packaging.
- i** Ratings are usually stated in one of 3 different ways:
  - allowable weight per pallet space ([Figure 346](#) A or B)
  - allowable weight per pallet width ([Figure 347](#) A and B)
  - total payload of an evenly distributed weight along the trailer – [Figure 348](#).

Figure 346 Pallet space rating systems

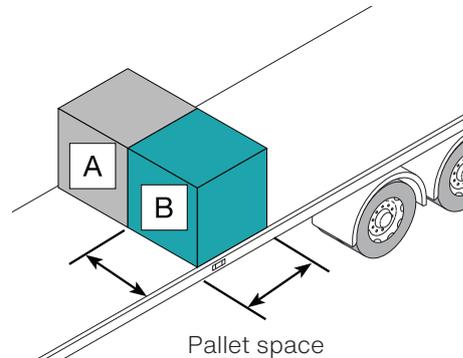


Figure 347 Pallet width rating systems

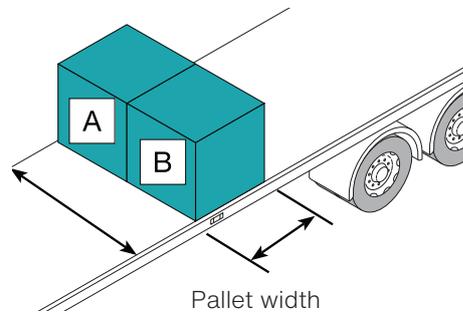
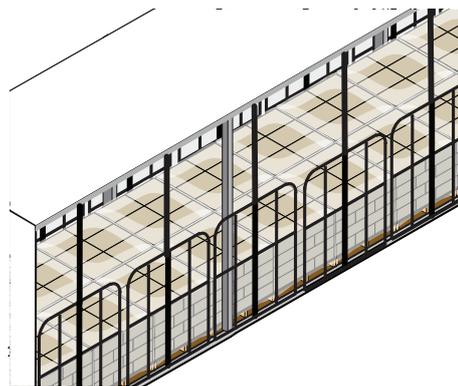
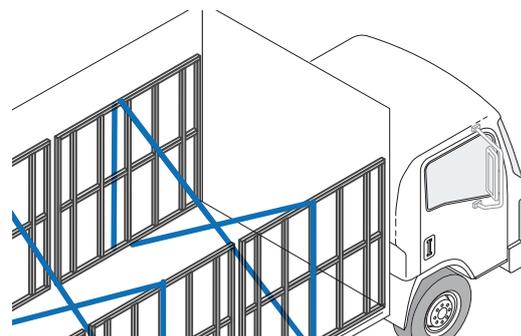


Figure 348 Total payload rating



- i** **Unrated side gates** have limited restraint capacity; they should be braced – that is, supported at the top by diagonal cross-lashings to the opposite tie rails, tied-down, or attached to other structures such as bulk heads or loading racks – [Figure 349](#).

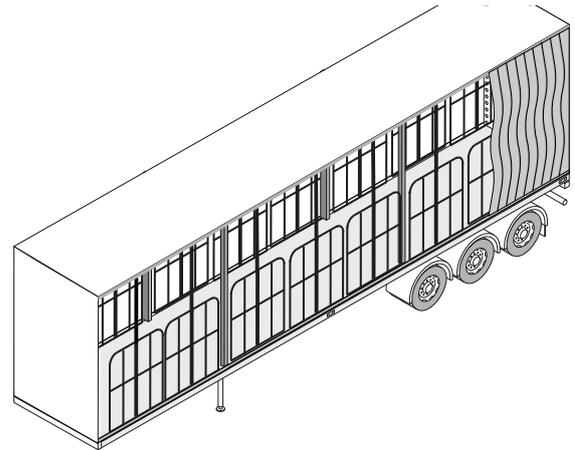
Figure 349 Braced unrated gates



## WHEN TO USE SIDE GATES

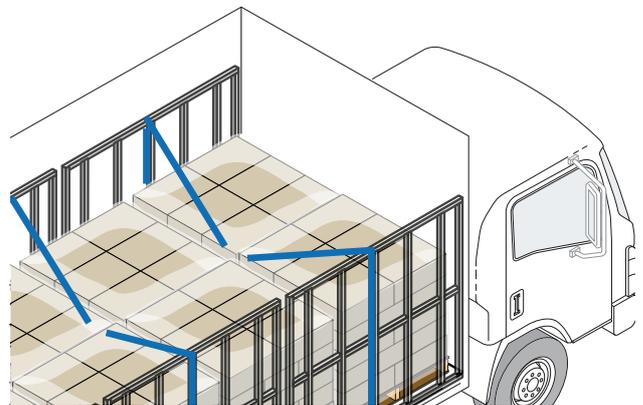
- ✓ Use **rated gate systems** as a containment solution providing sideways restraint for **many load types**, as specified in the certification – *Figure 350.*

*Figure 350 Rated gates system*



- ✓ Use braced, tied-down **unrated side gates** for sideways restraint **only if** the load is relatively lightweight and in a rigid and stable single layer – *Figure 351.*

*Figure 351 Braced unrated gates with load*



## HOW TO USE SIDE GATES

- ✓ Make sure there are no gaps in the load in the forward, backward or sideward directions – *Figure 352.*

*Figure 352 Gaps between the load*



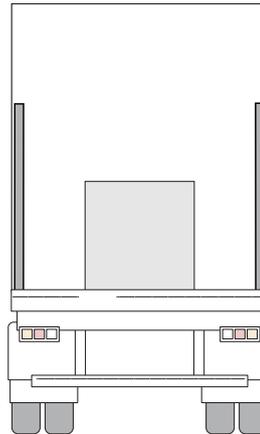
- ✓ If there are gaps in the load, block them in all directions with empty pallets or stillages – *Figure 353.*

*Figure 353 Gaps blocked within the load*

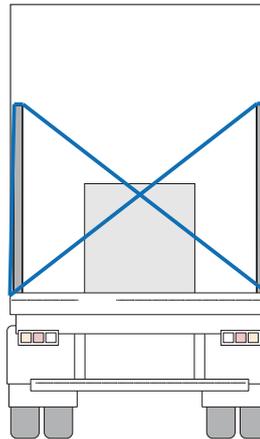


- ⚠️ If the load has gaps, the side gates cannot prevent sideways movement, which may result in vehicle instability – [Figure 354](#) and [Figure 355](#).

*Figure 354 Rated gates with a gap to the side*

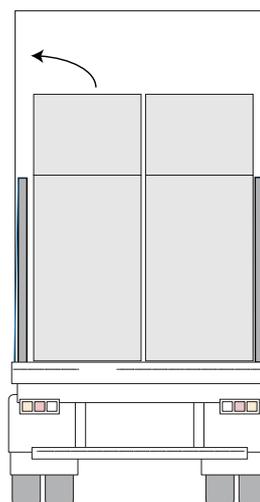


*Figure 355 Braced unrated gates with a gap to the side*



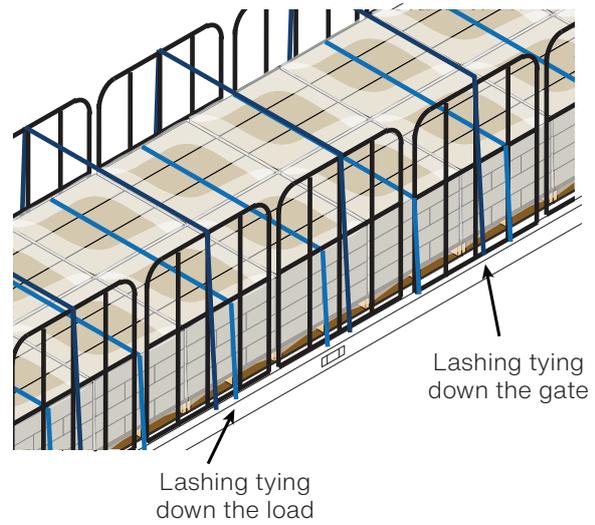
- ✅ Check the certification of **rated side gates** before you load the vehicle to be sure the gates have been rated to restrain the type of load you are carrying.
- ✅ When using **rated side gates**, make sure the top of each side gate is well above the base of any item of the load.
- ⚠️ Loads stacked substantially higher than the height of the rated side gate can dislodge when travelling over bumps or on rough roads, especially when cornering – [Figure 356](#).
- ✅ Check all parts of a **rated side gate system** regularly for damage; certification on rated side gates may be invalid if any part of the gate system is damaged.

*Figure 356 Rated gates with a stacked load above gate*



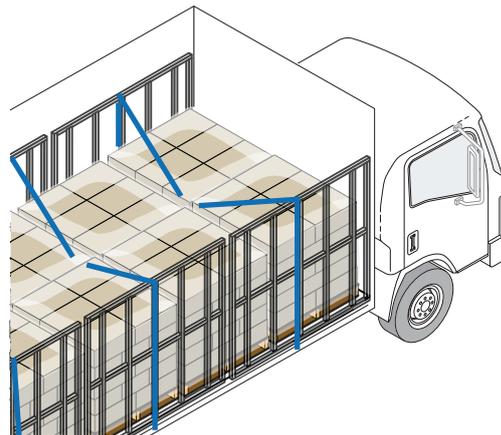
- ✓ When using **unrated side gates**, restrain the load using the gates and other restraints – i.e. by using tie-down or direct lashings, blocking and/or containment by other vehicle structures – *Figure 357*.

*Figure 357 Tied-down load and gates*

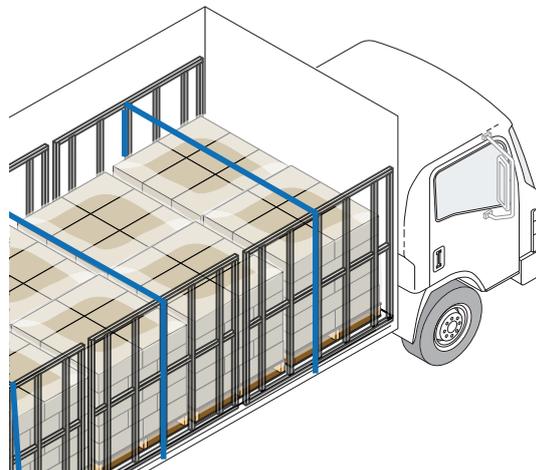


- ⓘ **Unrated side gates** can provide sideways restraint for very lightweight loads but **only if** the gates are braced or restrained by lashing straps that are tensioned over the top of opposite gates – *Figure 358* and *Figure 359*.

*Figure 358 Braced unrated gates*

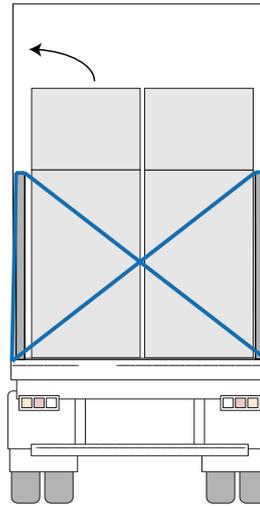


*Figure 359 Tied-down gates for very lightweight loads*



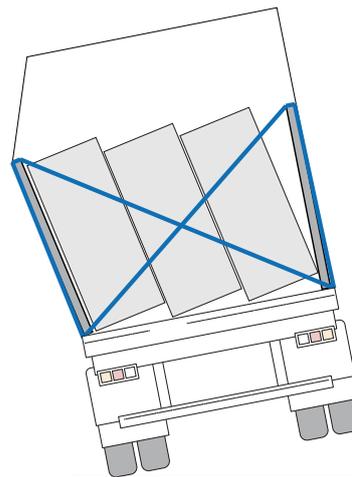
- ✓ If using **unrated side gates** to restrain very lightweight loads, make sure the load is not stacked one layer above the height of the gates.
- ⚠ Braced gates may not be able to prevent the top layers from tipping sideways – *Figure 360*.
- ✗ Do not use braced unrated side gates alone for sideways restraint of tall, unstable loads even if the load is very lightweight.

*Figure 360 Braced unrated gates with a stacked load above gate*



- ⚠ Braced unrated gates will not be able to prevent tall, unstable loads from toppling sideways – *Figure 361*.
- ✓ Use locking pins or tie-down lashings to restrain **unrated side gates** so they do not dislodge.

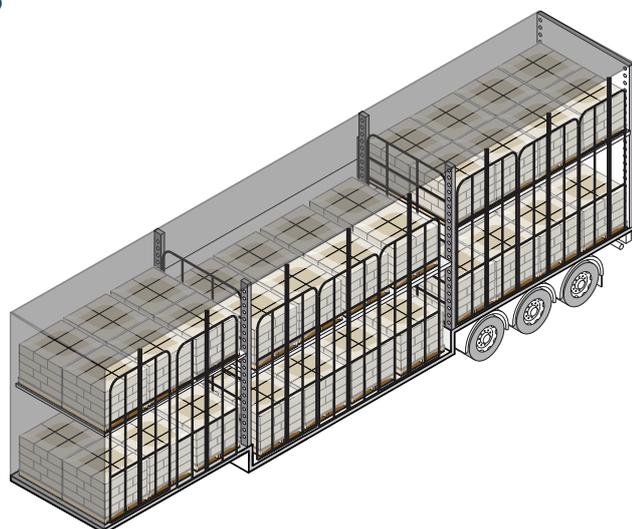
*Figure 361 Braced unrated gates with a tall load*



## WHAT TO LOOK FOR WHEN USING SIDE GATES

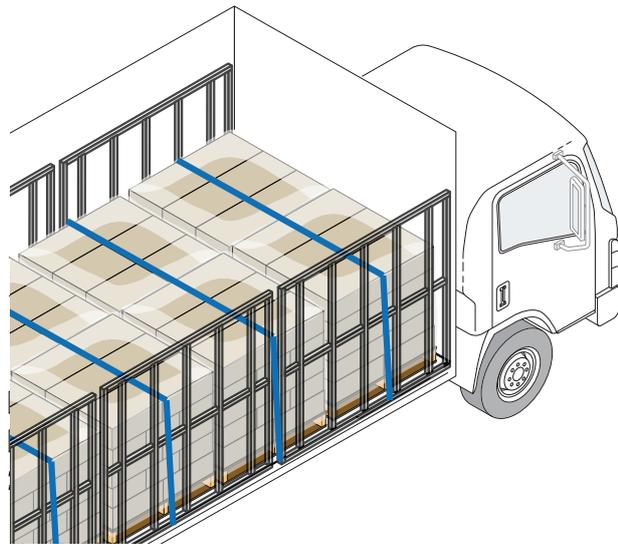
- ✓ Check that side gates are locked into place with locking pins (or, for unrated gates, tied down) so that they do not fall out.
- ✓ Check for load items that can pass through the gaps in the gates.
- ✓ Check the load is not stacked unsafely above the height of the side gates.
- ✓ If using **rated side gates**, check with the vehicle body manufacturer to confirm that the gates are capable of restraining stacked and mezzanine loads – *Figure 362*.

*Figure 362 Rated gates on a mezzanine trailer*



- ✓ If using tie-down lashings to restrain **unrated side gates**, check that they do not greatly affect the tie-down angle applied to the load – [Figure 363](#).

*Figure 363 Tie-down lashing containing gates without affecting lashing angle*



## CHECKLIST FOR CERTIFIERS AND DESIGNERS

For examples of different load cases see [Design for containing or blocking](#) in the Technical advice module.

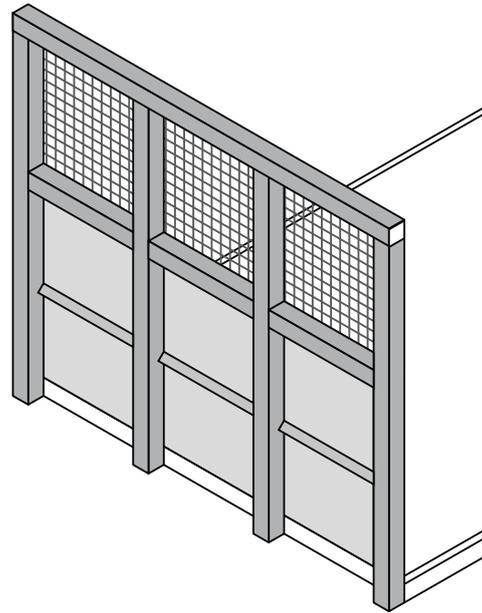
- ✓ Test that the side gates meet the forces indicated by the load restraint [Performance Standards](#).
- ✓ When designing **rated side gates**, take multiple loading cases into account.
- ✓ The amount of sideways deflection of any part of a gate should be limited to 100 mm for determining its load restraint capacity at 0.5 g sideways. Side deflection should not make the vehicle over width.
- ✓ When evaluating the suitability of side gates for a particular application, the manufacturer, supplier and vehicle owner should take into account the following factors:
  - the height of the load (whether the load is on the deck or stacked)
  - the type of load (whether the load is on wheels, 'bouncy' or likely to be affected by air flow)
  - the type of suspension (vehicles with stiff suspensions will require higher gates or sides, especially when travelling near empty)
  - the rear overhang of the body (long rear overhangs can magnify the effect of bumps and rough roads).

# HEADBOARDS AND LOADING RACKS

## WHAT ARE RATED HEADBOARDS AND LOADING RACKS?

- i** Rated headboards have been certified to withstand a certain force. They are designed based on accepted limits on strength and deflection for the load weight and design g-force – *Figure 364*.
- i** A loading rack is a pipe gate that has been reinforced by direct restraint chains – *Figure 365*.
- i** Plywood, metal sheeting or mesh can be used behind a loading rack to spread the load and support product packaging.
- i** If there is no rating stated on the headboard or loading rack, it is assumed to be unrated.

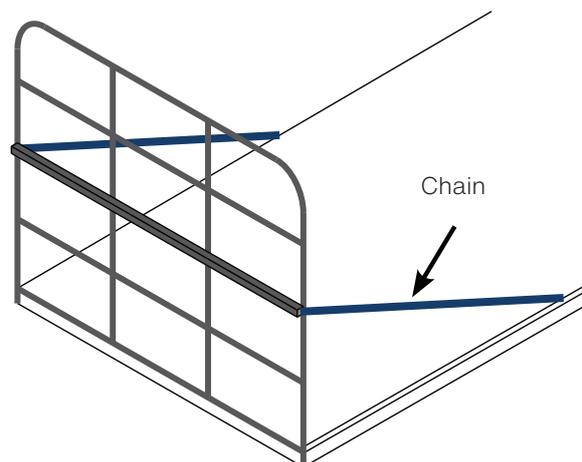
*Figure 364 Typical rated headboard*



## WHEN TO USE HEADBOARDS AND LOADING RACKS

- ✓** Use headboards and loading racks to provide some or all of the **forward** restraint, depending on whether they are rated, reinforced or otherwise.
- ⚠** Additional restraints will be required for other directions.
- ⚠** Most headboards and loading racks that are not rated are not strong enough to fully restrain heavy loads under heavy braking.
- ✓** Use **rated headboards** to provide some or all of the forwards restraint (depending on rating), as follows:
  - as part of full blocking systems, where the load is blocked sideways and rearwards by other means of restraint, or
  - in combination with tie-down restraint to reduce the number of tie-down lashings required.

*Figure 365 Reinforced “pipe gate” style load rack*



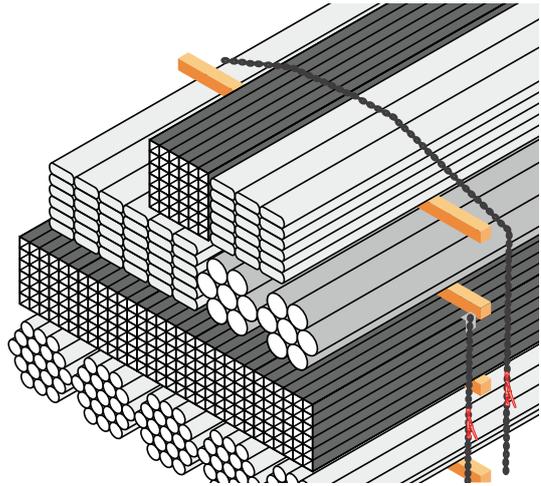
✓ Use **rated headboards** when the load consists of long, slender products in multiple packs that may spear (e.g. pipes, beams, rail, logs) – *Figure 366*.

✓ Use **loading racks** to provide some or all of the forward blocking for heavier unit loads, in combination with tie-down restraint, reducing the number of tie-down lashings required.

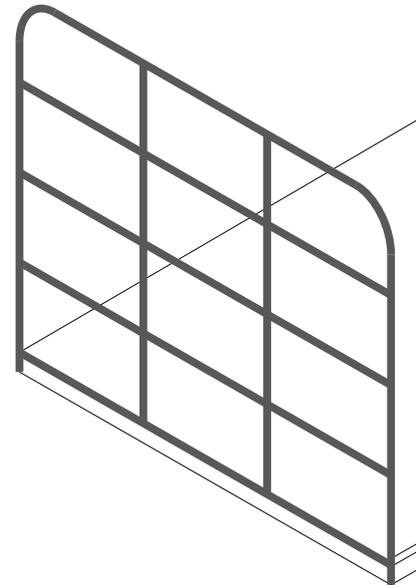
✓ Use **loading racks** when product spearing is not a concern.

✓ Use **pipe gates** (i.e. unreinforced loading racks) in combination with tie-down restraint to provide some of the forward blocking for very lightweight loads only – *Figure 367* and *Figure 368*.

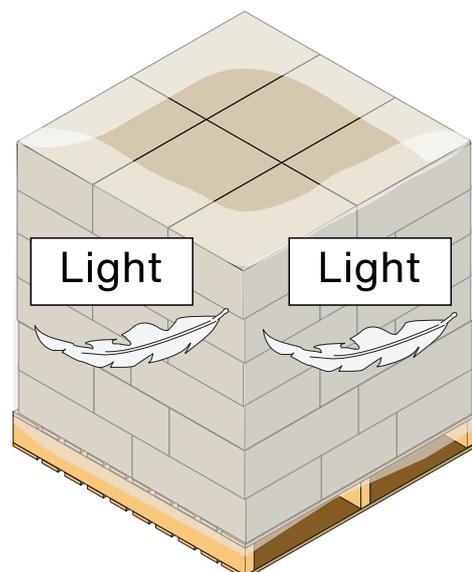
*Figure 366 Loads at risk of spearing forwards*



*Figure 367 Unrated “pipe gate” style load rack*



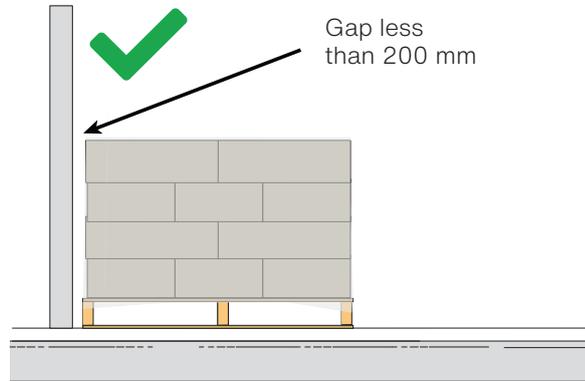
*Figure 368 Lightweight unit load*



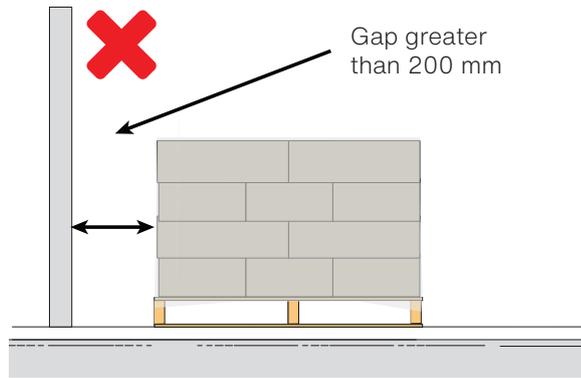
## HOW TO USE HEADBOARDS AND LOADING RACKS

- ✓ Position the load as close as practical to the headboard or loading rack.
- ⓘ Within 200 mm to the headboard is generally considered blocked – [Figure 369](#) and [Figure 370](#).

*Figure 369 Blocked load against headboard*

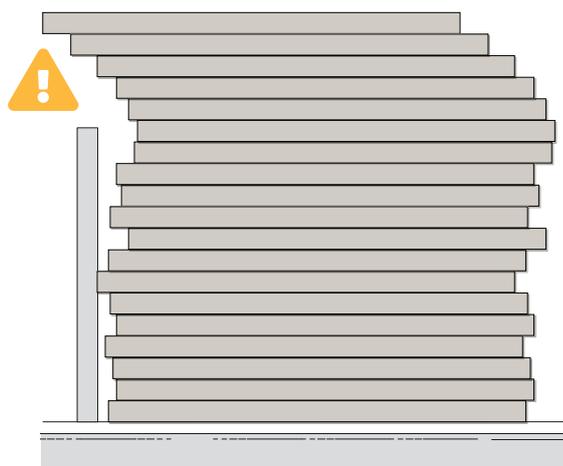


*Figure 370 Unblocked load*



- ✓ Make sure the load does not sit above the height of the headboard, unless the packaging is of adequate strength to contain the product against the full forward force – [Figure 371](#).

*Figure 371 Unblocked top portion of load*

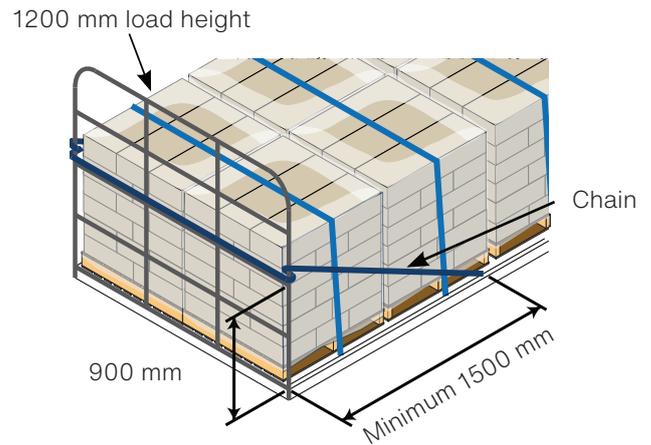


- ✓ If using **rated headboards**, check the rating is suitable to restrain the load before loading the vehicle. If needed, use additional restraint for forward blocking.

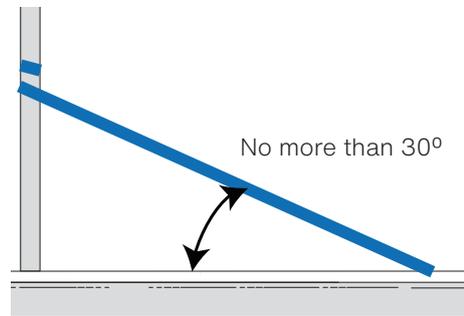
✓ If **reinforcing a loading rack/pipe gate** with a chain:

- Make sure the chain is located at  $\frac{3}{4}$  of the height of the load and at a 30 degree lashing angle – *Figure 372* and *Figure 373*.
- Take up all slack in the chain.

*Figure 372 Chained pipe gate*

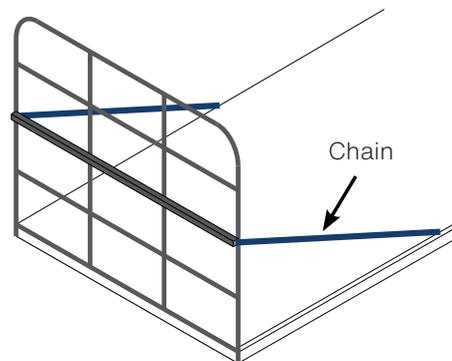


*Figure 373 Chains should be kept below 30°*



✓ To help keep the reinforcing chain in position on a loading rack, feed it through the bore of a square, hollow tube welded to the front of the gate – *Figure 374*.

*Figure 374 Reinforced “pipe gate” style load rack*



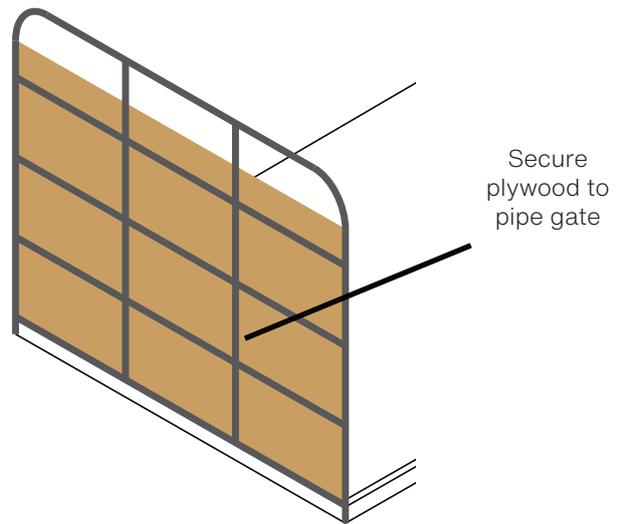
✓ Place moveable load racks that have been reinforced/supported with 2 chains along the trailer, as required – *Figure 375*.

*Figure 375 Supported moveable load rack with 2 chains may be placed along the trailer*



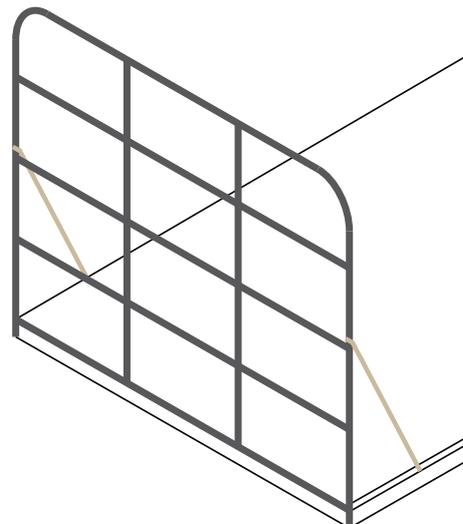
- ✓ Restrain any plywood, metal sheeting or mesh that is used behind a loading rack, separately to the load – *Figure 376*.
- ✓ If using **unrated headboards** or **loading racks** that have not been reinforced, use additional restraint for forward blocking.

*Figure 376 Plywood sheeting used to contain the load*



- ✗ Do not attach separate lashings to the side posts of a loading rack/pipe gate in order to reinforce it because the middle uprights will not be supported – *Figure 377*.

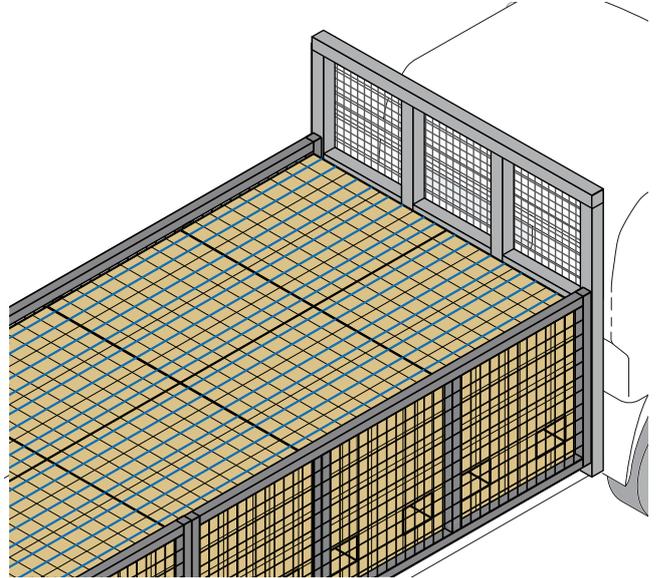
*Figure 377 “Pipe gate” load rack restrained with rope on side post*



## CHECKLIST FOR CERTIFIERS AND DESIGNERS

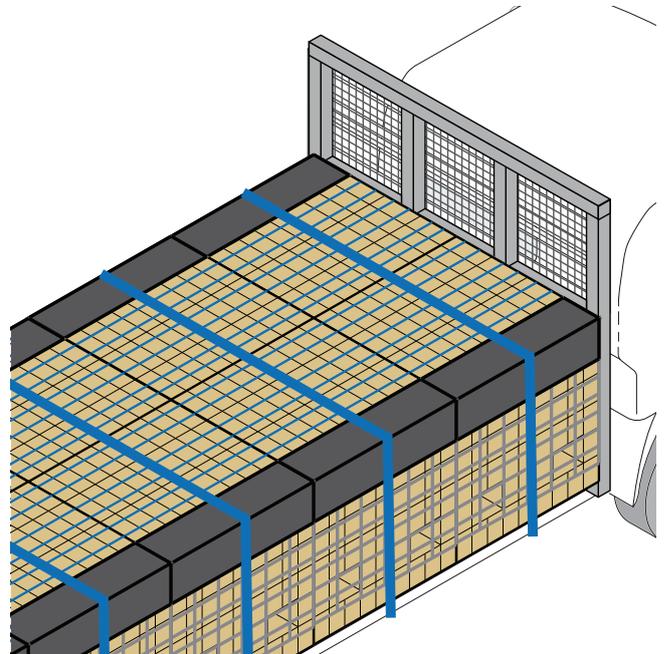
- ✓ Test that headboards meet the forces in the load restraint [Performance Standards](#).
- ✓ When designing **rated headboards**, take multiple loading cases into account.
- ✓ Test the forces that headboards can withstand. When used as a full containment blocking solution, the headboard must withstand forces equal to 80% of the weight of the load – [Figure 378](#).

*Figure 378 Headboards relied upon for all forward restraint must restrain the load at 0.8 g*



- ✓ If the load is tied down, the sum of the forward restraint from the tie-down and the headboard should withstand forces equal to 80% of the weight of the load. In the case that tie-down is sufficient to restrain the load at 0.5 g, the headboard should be sufficient to restrain the load at 0.3 g – [Figure 379](#).

*Figure 379 Headboards used with tie-downs can safely restrain heavier loads than when used without tie-downs*



# BARRIERS

## WHAT ARE BARRIERS?

- i** Barriers are movable blocking devices, also known as “intermediate headboards”.

## WHEN TO USE BARRIERS

- ✓ Use barriers when there are gaps between loads along the length of the truck and the rear part of the load needs to be blocked in the forward direction.
- ✓ Use barriers to restrain the rear part of a load that is separated into 2 parts to maintain correct axle weight limits.

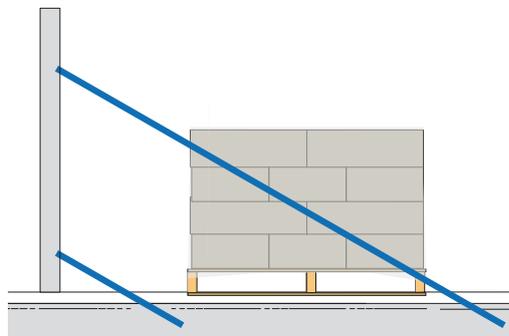
## HOW TO USE BARRIERS

- ✓ Make sure that the barrier is placed against the freight – *Figure 380*.
- i** Barriers are usually placed against the load after loading; chains are then applied to lash the barrier.
- ✓ Make sure that the barrier and its support chains are strong enough to block the forward forces from the load.
- ✓ Chain the barrier to the tie rails on both sides, near the top and bottom.
- i** Barriers can restrain the load against all the forward forces or act together with tie-downs to provide all of the forwards restraint.

*Figure 380 Load against barrier*



*Figure 381 Load not against barrier*

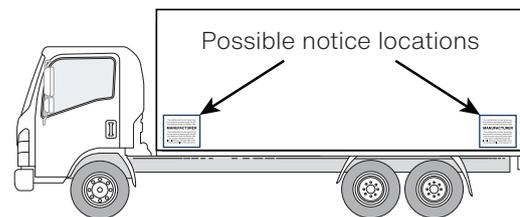


# SIDE CURTAINS

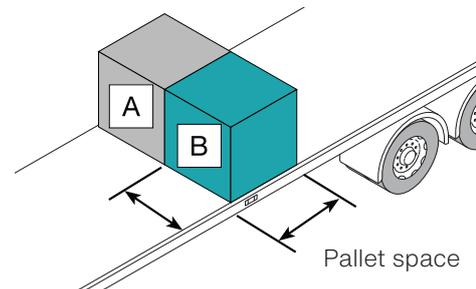
## WHAT ARE SIDE CURTAINS?

- i** Side curtains are flexible sheets that are secured to the vehicle.
- i** Unrated side curtains are used to provide weather-proofing.
- i** Rated side curtains have been tested and certified to meet a certain level of load restraint for sideways forces. Load restraint curtains cannot be used alone; a compliant restraint system also requires methods for forward and rearward restraint, and additional sideways restraint may also be needed.
- i** Rated side curtains will have a certification label attached to them and/or a certification document – [Figure 382](#).
- i** Certification should specify if gates are required to be used with the side curtains, as well as details about the load that the curtains can restrain, including size, shape, weight and packaging.
- i** Ratings are usually stated in one of 3 different ways:
  - Allowable weight per pallet space – [Figure 383](#)
  - Allowable weight per pallet width – [Figure 384](#)
  - Total payload of an evenly distributed weight along the curtain – [Figure 385](#).

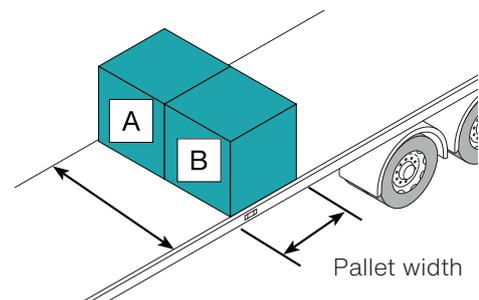
[Figure 382 Load-rated side curtain certification](#)



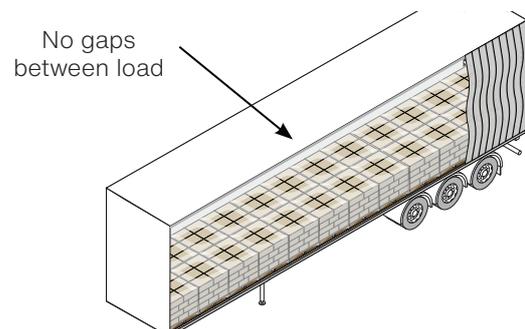
[Figure 383 Pallet space rating systems](#)



[Figure 384 Pallet width rating systems](#)



[Figure 385 Total payload – fully blocked load](#)



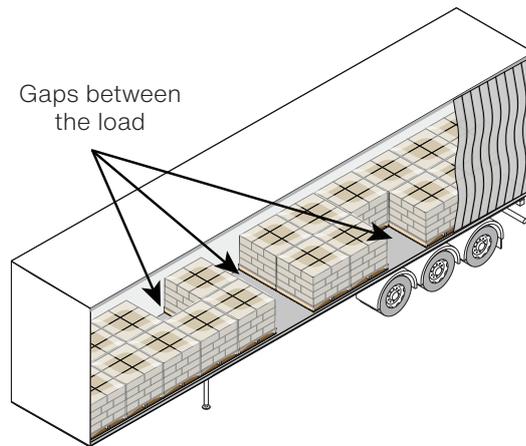
## WHEN TO USE SIDE CURTAINS

- ✓ Use **rated** side curtains to provide effective sideways blocking for many load types, as specified on the certification (e.g. palletised goods, bulk loads and lightweight full loads).
- ✓ Use **unrated** side curtains to weatherproof the load and protect it from dust.

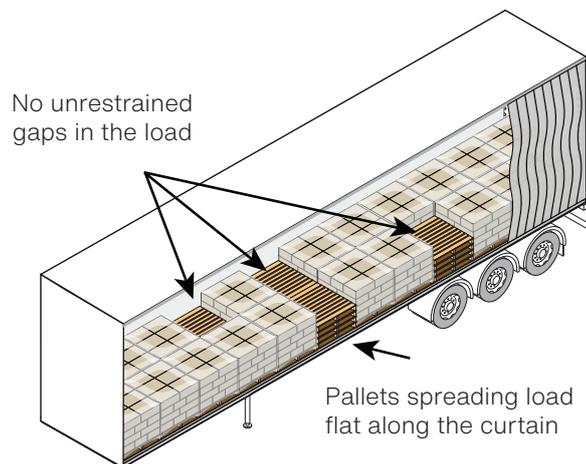
## HOW TO USE RATED SIDE CURTAINS

- ✓ Always check the certification on **rated** side curtains and only use them in accordance with their certification – i.e. with or without side gates, and with the type of load (size, weight, etc.) that they are certified to restrain.
- ✓ Make sure that there are no gaps in the load in the forward, rearward or sideward directions.
- ✓ If there are gaps in the load, block them with empty pallets or stillages to spread the load flat along the curtain – *Figure 386* and *Figure 387*.

*Figure 386 Curtains only restrain sideways – rear and forward also need restraint*

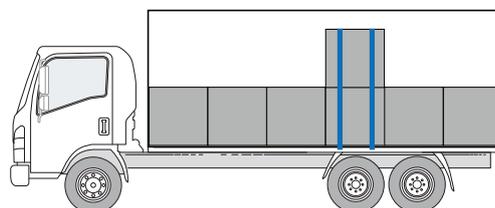


*Figure 387 Load blocked front and rear with pallets*



- ✓ If there are gaps in the base or top layer of a stacked load, use additional direct restraint methods to secure the load in all directions. Tie-down may not be adequate for forward blocking – *Figure 388*.

*Figure 388 Stacked loads may require extra restraint if not fully blocked in all directions*



⚠️ If any gaps are left unblocked, the load can shift causing the curtain to fail and the vehicle to become unstable – [Figure 389](#).

✅ Make sure **rated** side curtains are certified to restrain stacked, tall and mezzanine loads before using them with those types of loads. Make sure there are no significant gaps.

✅ If curtains can restrain stacked and mezzanine loads, add the total weight of both layers when checking against the curtain rating – [Figure 390](#).

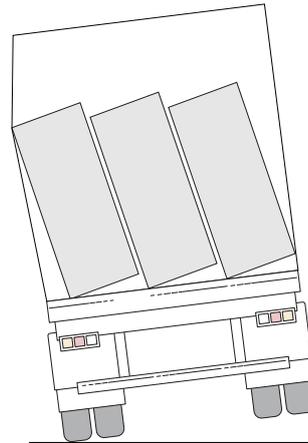
✅ If you are unsure about whether a **rated** side curtain can restrain a particular load, check with the manufacturer or with a suitably qualified and experienced engineer.

✅ Check all parts of the curtain system regularly for damage; certification on **rated** side curtains may be invalid if any part of the curtain system is damaged.

✅ If using **unrated** side curtains, restrain the load as if the curtain did not exist – i.e. by using tie-down or direct lashings, blocking and/or containment by other vehicle structures.

❌ Do not use rated or unrated side curtains for any loads that could damage the curtain – e.g. heavy items with sharp edges, or loads with sharp spearing items – [Figure 391](#) and [Figure 392](#).

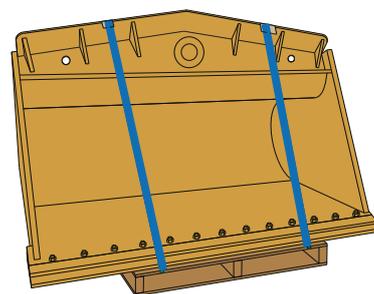
[Figure 389](#) Load shift causing vehicle instability



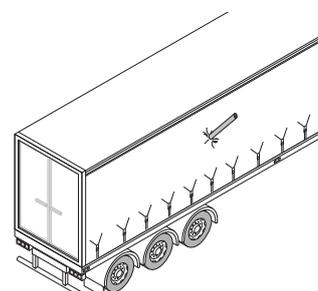
[Figure 390](#) Add both layers to check curtain rating (highlighted)



[Figure 391](#) An individual item with sharp edges can exert force between curtain reinforcing



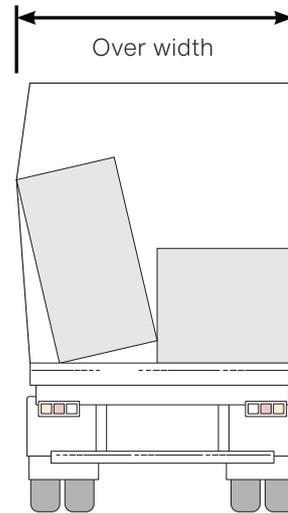
[Figure 392](#) Loads like steel bars or pipes could pierce the curtain



## WHAT TO LOOK FOR WHEN USING RATED SIDE CURTAINS

- ✓ Look for bulging, particularly when the vehicle is stationary, as this can make the vehicle wider than the maximum legal width – [Figure 393](#).
- ✓ Check the load regularly during your journey to make sure it is adequately restrained and has not shifted.
- ✓ Look out for load items that may fit between the curtain reinforcing.

*Figure 393 Over width due to bulging*



## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- ✓ Test that the curtains meet the forces in the load restraint [Performance Standards](#).
- ✓ When designing side curtains, take multiple loading cases into account.
- ✓ Load restraint rating of side curtain systems (including retrofitted systems) must take into account the strength and deflection of all components – e.g. the roof, curtain reinforcing elements, rollers.
- ✓ The amount of sideways deflection of any part of a curtain should be limited to 100 mm for determining its load restraint capacity at 0.5 g sideways. Even a small amount of bulging could make a vehicle over width.
- ✓ Clearly state if curtains are capable of restraining stacked and mezzanine loads or individual boxed loads.

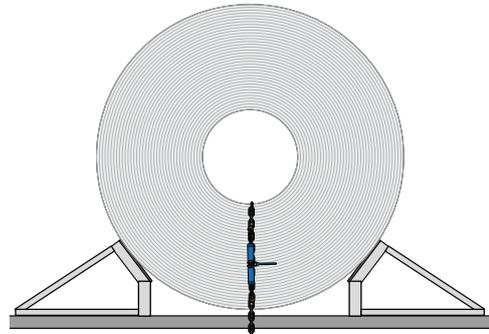
For examples of different load cases see [Design for containing or blocking](#) in the Technical advice module.

# CHOCKS, CRADLES AND A-FRAMES

## WHAT ARE CHOCKS, CRADLES AND A-FRAMES?

- i** Chocks, cradles and A-frames are typically made from either timber or metal and are used to assist in restraining loads prone to rolling.

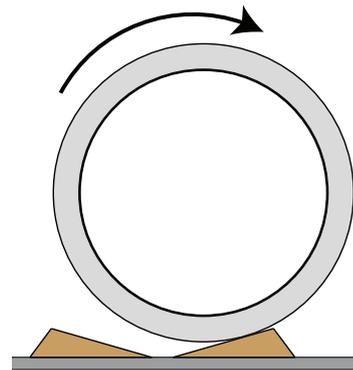
Figure 394 A-frame preventing coil from rolling



## WHEN TO USE CHOCKS, CRADLES AND A-FRAMES

- i** Chocks, cradles and A-frames are designed to:
  - prevent cylindrical objects from rolling – *Figure 394*
  - support other load restraint to prevent rolling – *Figure 395*
  - prevent movement during loading and unloading.

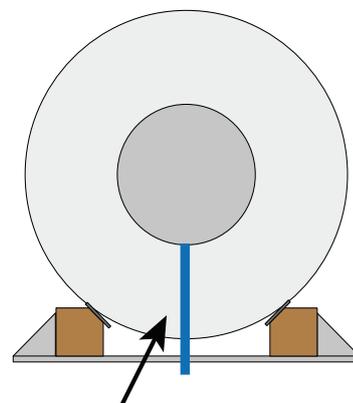
Figure 395 Cradles can assist in preventing objects from rolling



## HOW TO USE CHOCKS, CRADLES AND A-FRAMES

- ✓** Place chocks, cradles and A-frames underneath or at the base of load items.
- ⚠** Chocks, cradles and A-frames can be attached to the vehicle and/or the load.
- ✗** Never use sandbags or sawdust bags during transport. These are only suitable for use as chocks during loading and unloading because they can deform and move under road-induced vibration.
- ✓** Where tie-down lashings are used to restrain load items on cradles or A-frames, the direction of the lashings should be as vertical as possible between the cradle or trestle contact point and vehicle tie point – *Figure 396*.

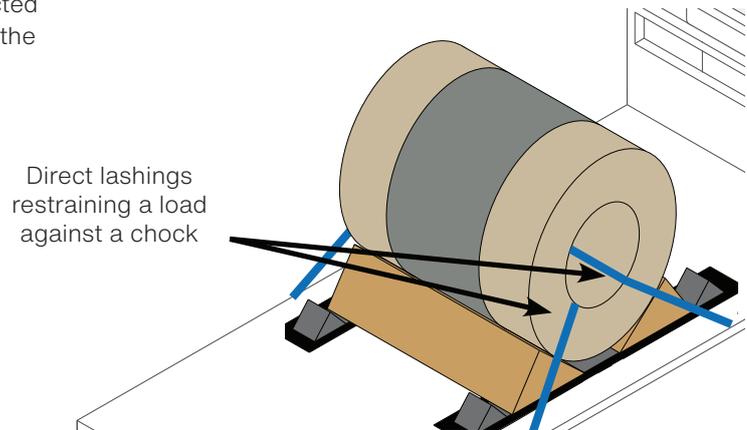
Figure 396 Tied-down lashings used to restrain load



Tie-down lashing as vertical as possible

- ✓ Where direct lashings are used to restrain loaded cradles and A-frames, the direction of the lashings should be opposite to the expected direction of movement, which would result if the load were unrestrained – *Figure 397*.

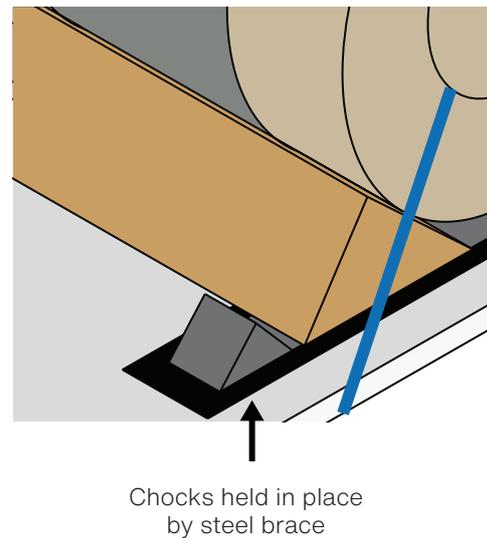
*Figure 397 Direct lashings used to restrain load*



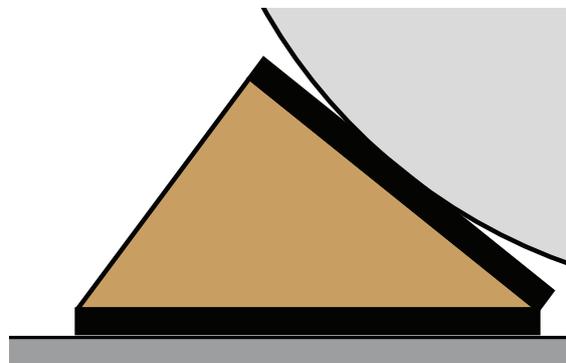
## WHAT TO LOOK FOR WHEN USING CHOCKS, CRADLES AND A-FRAMES

- ✓ Make sure chocks, cradles and A-frames are the correct size and strength for the load.
- ✓ Make sure chocks, cradles and A-frames have good friction contact surfaces and provision for attaching lashings to secure the chocks onto the vehicle – *Figure 398* and *Figure 399*.
- ⚠ Check the chock material is strong enough to withstand being split or crushed by the load and is resistant to bending when exposed.
- ⚠ Make sure cylindrical objects fit snugly and can't rock in between chocks.

*Figure 398 Chocks or dunnage needs to be restrained*



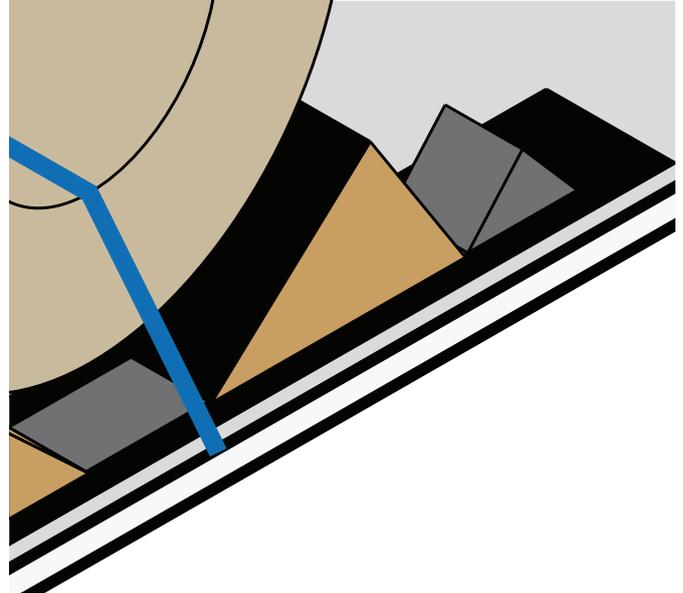
*Figure 399 High levels of friction between all contact surfaces when utilising tie-down*



## CHECKLIST FOR CERTIFIERS AND DESIGNERS

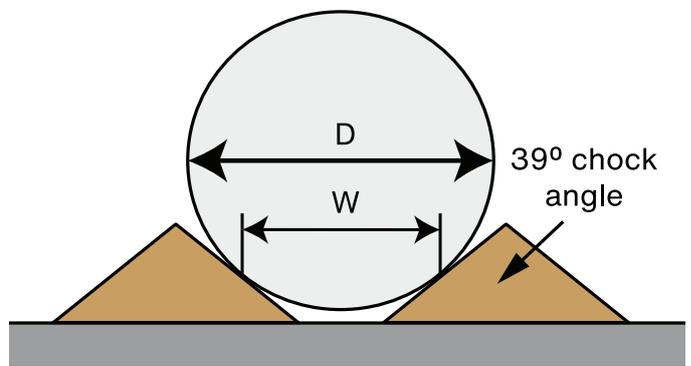
- i** Where cradles, chocks and A-frames are fabricated from metal, designers should take into account the low friction between them and metal decks (and also, the low friction between the load and the metal frame). Provide for capping or facing with timber or rubber to increase the friction – *Figure 400*.

*Figure 400 Rubber capping to increase friction*



- i** Cylindrical items will not roll if the ratio of the distance between the cradle/cylinder contact lines ( $W$ ) to the diameter of the cylinder ( $D$ ) is equal to or greater than 5:8, which is equivalent to a wedge angle of  $39^\circ$  – *Figure 401*.
- i** Cradles can be designed to allow them to be adjusted for different-sized cylinders, reducing the forces required in the lashings. The cradles should be adjusted so the cylinder rests on the edges and not the bottom of the cradle.

*Figure 401 When designing cradles and chocks to prevent rolling, they should have a ratio of  $W:D$  of not less than 5:8*



Greater than or equal to  
 $W:D = 5:8$

# TARPAULINS

## WHEN TO USE TARPAULINS

- i** The main function of a tarpaulin is for weather protection – not load restraint – *Figure 402*.
- i** Tarpaulins can also act as a secondary restraint system where a small item might become loose from the main load, such as a loose can or bottle.
- ✗** Never rely on tarpaulins as the primary restraint system unless specially designed and tested for the purpose.
- i** Cap tarpaulins help to prevent some types of gates from lifting out of their mountings if the load puts pressure on an adjoining gate.

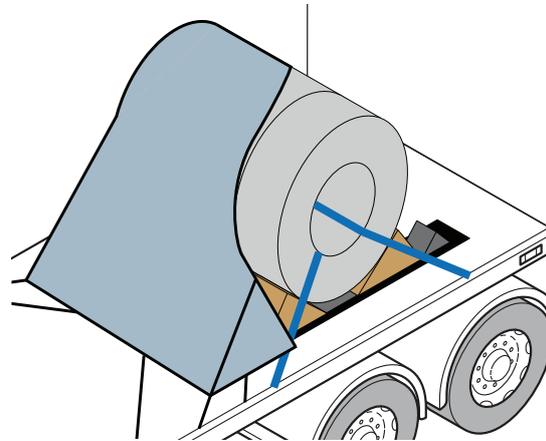
## HOW TO USE TARPAULINS

- ✓** Apply at least enough restraint for the tarpaulin to ensure it does not become loose in the wind.
- ✓** Position tarpaulins so that any overlapping layers face rearwards to prevent penetration of wind or rain – *Figure 403*.

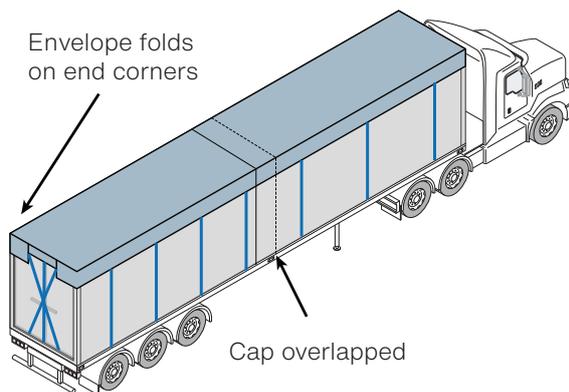
## WHAT TO LOOK FOR WHEN USING TARPAULINS

- ✓** When attaching tarpaulins, ensure any compulsory lamps, reflectors, number plates, rear marking plates etc, are not obscured, and any loose ropes or tarpaulin flaps are secured.
- ⚠** Check tarpaulins are in a sound condition without tears or holes – *Figure 404*.
- i** Replace or temporarily repair any torn tarpaulins or side curtains to prevent further damage during a journey – *Figure 405*.

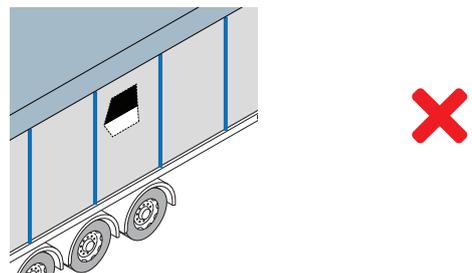
*Figure 402 Load restrained under tarpaulin*



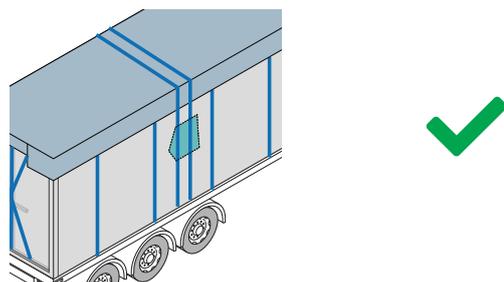
*Figure 403 Cap tarpaulin*



*Figure 404 Damaged tarpaulin*



*Figure 405 Repaired tarpaulin*

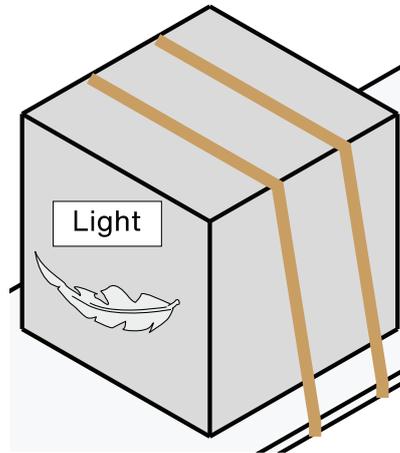


# SYNTHETIC ROPES

## WHEN TO USE SYNTHETIC ROPES

- i** Synthetic ropes should only be used for restraining relatively lightweight loads (up to 50 kg). They have low strength and cannot be tensioned sufficiently to restrain heavy loads – *Figure 406*.
- !** Other rated webbing straps and tensioning systems are preferred over ropes, which should be a last resort.
- ✗** Never use natural fibre rope to restrain the load.

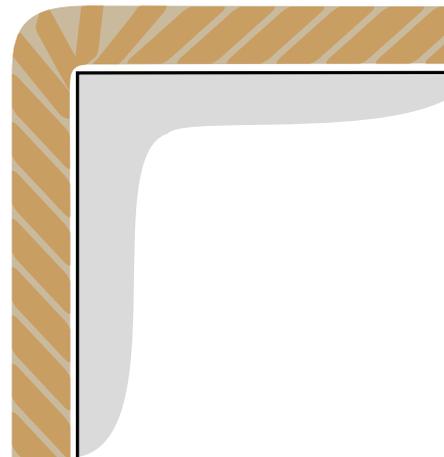
*Figure 406 Rope is only suitable for lightweight loads*



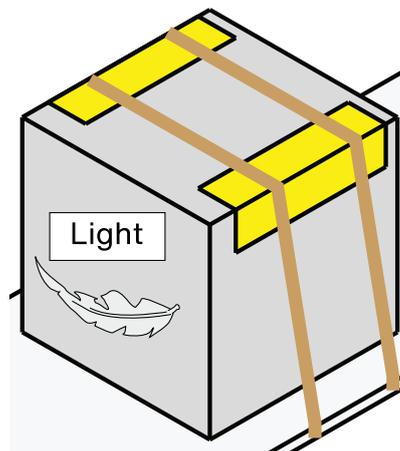
## HOW TO USE SYNTHETIC ROPES

- ✓** Use corner protectors, sleeves or other packing material where lashings and sharp loads contact each other. This protects them from damage – *Figure 407* and *Figure 408*.
- i** Smooth, rounded corner protectors on rough edges enables high tension on both sides of the load, increasing the load restraint.
- ✓** Select a rope with adequate strength and length, and tension it correctly to match the load weight. Make sure the rope is in good condition.
- i** Ropes are attached to the tie rails and tensioned using knots. To be effective, the right knot must be used and securely tied.
- ✓** Tension rope using a single or double “truckie’s” hitch. The double hitch gives about twice the tension of a single hitch.
- i** After a rope is tightened, it will often lose tension after a short time and the rope will need retightening.
- i** Most of the applied tension is lost because of the friction of the rope as it passes over itself in the knot.

*Figure 407 Rope can be damaged over sharp and rough edges*



*Figure 408 Protective corners should be used to protect rope*



## WHAT TO LOOK FOR WHEN USING SYNTHETIC ROPES

-  Check the condition of the rope by examining it at about one metre intervals, both externally and between the strands.
  
-  If any of the following conditions exist, the rope must be replaced:
  - wear or mechanical damage caused by excessive loading, knotting and bending
  - exposure to chemicals, including acid and alkaline solutions, and organic solvents; these chemicals weaken or soften the rope fibres, which can then break easily
  - exposure to high temperatures
  - prolonged exposure to sunlight or ultraviolet light.
  
-  This damage can be recognised by the hairy appearance of fibres.

# WEBBING

## WHAT IS WEBBING?

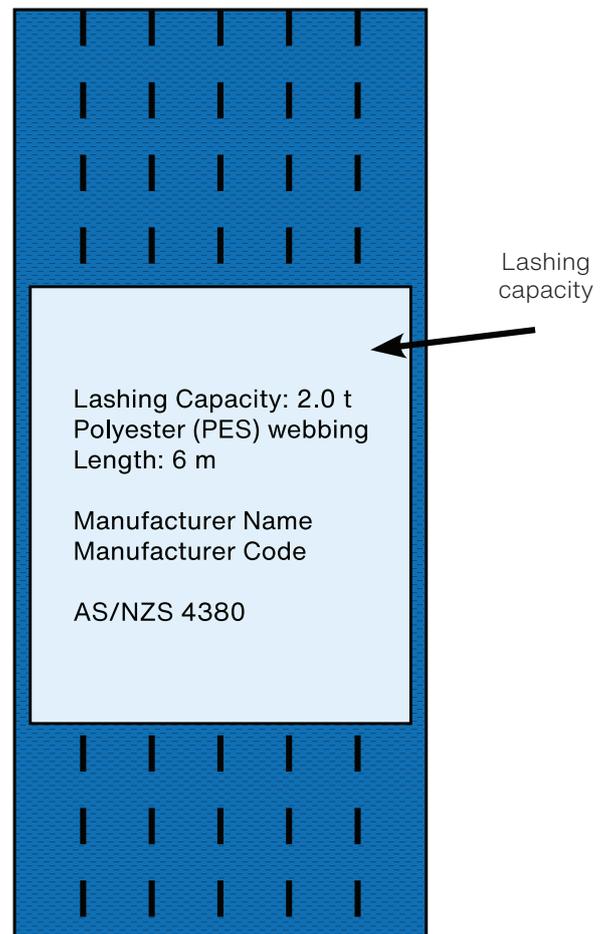
- i** Webbing is a lightweight restraint system used throughout the transport industry.
- i** Webbing assemblies include load-rated webbing material with specified stitching and sewing patterns, together with end fittings, tensioning devices and a rating tag.
- i** Webbing assemblies with either attached or in-line ratchet winches must comply with Australian Standard AS/NZS 4380 Motor vehicles – Cargo restraint systems – Transport webbing and components.\*
- i** The lashing capacity is displayed on each assembly that complies with the relevant Australian Standard – [Figure 409](#).
- i** The lashing capacity of a webbing assembly does not equal the pretension force. Typical lashing capacity for a 50 mm webbing strap is 2,000 kgf, whereas pretension is only 300 kgf.
- ⚠** You cannot just add webbing lashing capacity to match the mass of the load. See the [Tie-down worked examples](#) for how to work out the number of lashings you need.
- ✗** Do not use webbing assemblies that do not comply with AS/NZS 4380 for load restraint purposes because they can have much lower ratings.

## WHEN TO USE WEBBING

- ✓** Use webbing to restrain:
  - palletised goods
  - loads that can settle or deform during transport (e.g. bags and sacks)
  - loads that can damage easily from lashings
  - loads that don't have sharp edges.
- i** Webbing is more elastic than chains or steel strapping. Webbing will retain some of its initial tension during transport if a load deforms slightly or settles.
- ✗** Do not use webbing assemblies with chemicals or at high temperatures without referring to the manufacturer's instructions.

\* *Withdrawn refer to "List of Relevant Standards" for more information.*

Figure 409 Example of webbing label



# HOW TO USE WEBBING

## Webbing assemblies

- ✓ Make sure that webbing assembly components have an adequate lashing capacity for the load.
- ✗ Do not use webbing strap that has any knots in it.
- ✗ Do not use straps that are joined by knots or any other means that are not approved by the manufacturer.

## Attaching webbing straps

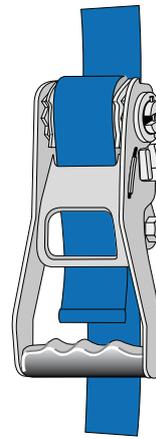
- i** Webbing can be attached to the vehicle by an in-line hand ratchet or a truck winch – *Figure 410* and *Figure 411*.

- ✓ Clip truck winches onto tie rails or slide them into special tracks under the coaming rails – *Figure 411*.

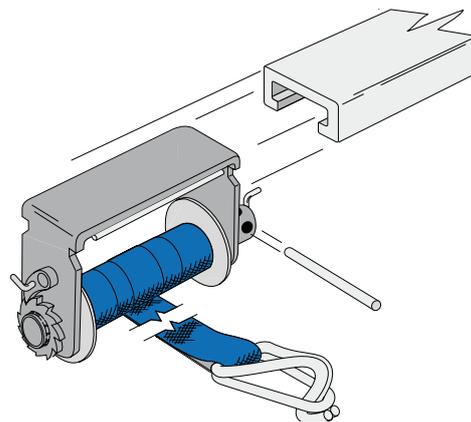
- ✓ Attach in-line tensioners (hand ratchet winches or over-centre buckles) to tie rails using a webbing strap and hook.

- ✗ Do not use knots to attach webbing strap to tie rails – *Figure 412*.

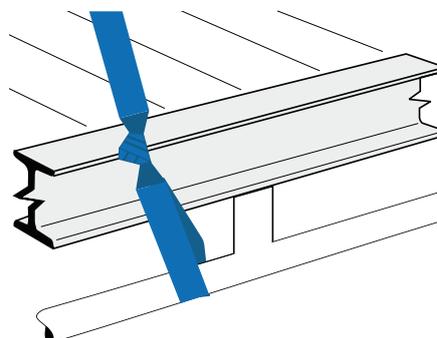
*Figure 410 In-line hand ratchet*



*Figure 411 Truck winch into rail*



*Figure 412 Knots cannot be used with webbing*



## How to protect webbing straps

- ✓ Always check for sharp edges and rough and high friction surfaces because they prevent the lashing tension from equalising on both sides of the load – *Figure 413*.
- ✓ Corner protectors, sleeves or other packing material should be used where lashings and loads contact each other, especially on sharp or abrasive loads – *Figure 413*.
- ⓘ Smooth, rounded corner protectors enable high tension on both sides of the load.
- ⓘ Longer, rigid corner protectors are also useful in distributing the load across compressible or bendable products – *Figure 414*.

Figure 413 Webbing strap can be cut by sharp edges

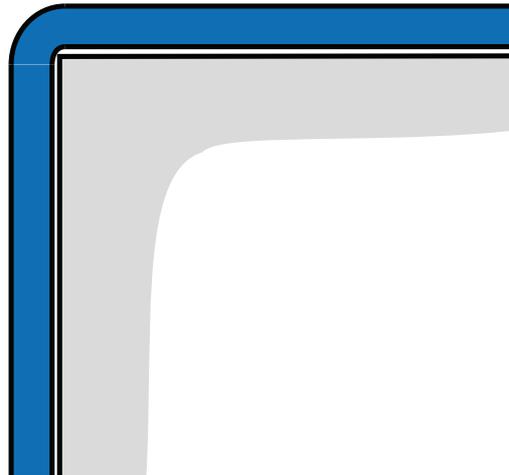
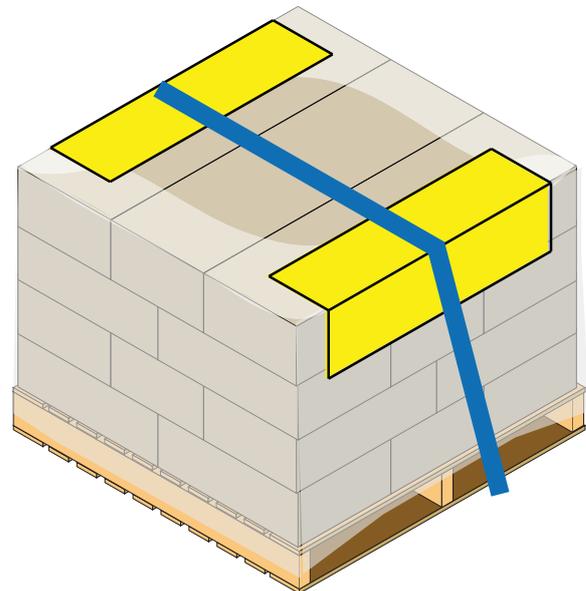


Figure 414 Rigid corner protectors distribute the load across the pallet



## Tensioning webbing straps

- i** Webbing straps are tensioned using either attached clip-on sliding winches, in-line tensioners or geared winches.
- i** The amount of tension produced by a truck winch or hand ratchet depends on the length of the handle, how large the diameter of the webbing spool becomes during tightening, and the number of ratchet teeth.
- i** Hand ratchets that operate by pulling the handle downwards will normally produce much more pretension (600 kgf) than push-up ratchets and standard truck winches (300 kgf) – *Figure 415*.
- ✓** Loop the strap over a standard triangular end fitting to obtain higher tensions; the lashing capacity can be doubled and the pretension increased by an extra  $\frac{2}{3}$  – *Figure 416*.
- ✓** For effective pretension when tensioning hand ratchet winches, make sure there are at least one and a half turns of strapping on the spindle, and no more than 3.
- i** Using long lashings makes it easier to obtain high tension consistently (the ‘draw in’ length between each click of a webbing ratchet does not increase the tensions as much as it does on a short lashing).
- ✓** Make sure the strapping is wound evenly across the drum of the winch or ratchet.
- ⚠** The effectiveness of the tensioner decreases significantly as the thickness of the layers of webbing increases – *Figure 417*.
- ⚠** During your journey, you should regularly check and re-tension your webbings as needed.

Figure 415 High pretension “pull down to operate” ratchet

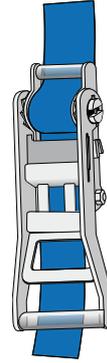


Figure 416 High pretension tie-down

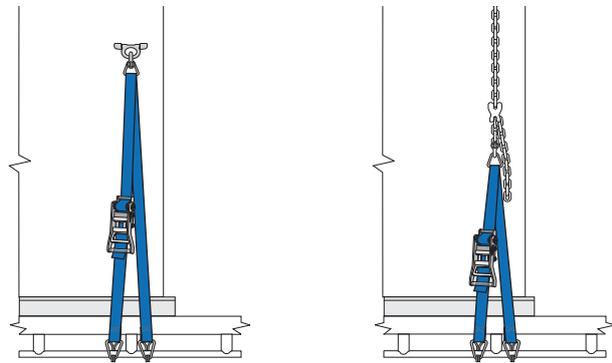
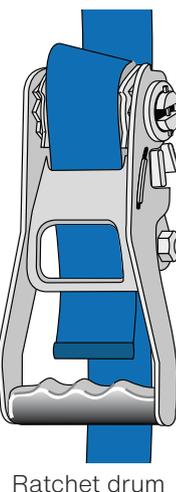
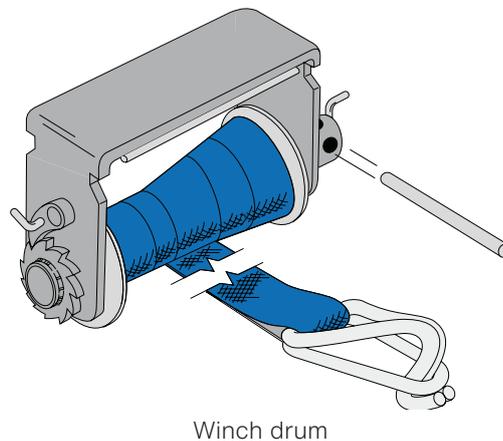


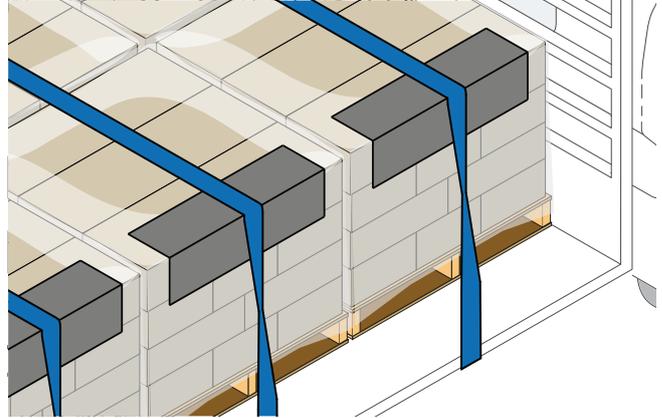
Figure 417 Webbing layered unevenly



## WHAT TO LOOK FOR WHEN USING WEBBING

- ✓ Check there are no knots or twists in the strapping.
- ⓘ While webbing straps should not be excessively twisted, a half-turn may help to prevent vibration and flapping – *Figure 418*.
- ✓ Check strapping is not attached to anchor points using knots.
- ✓ Look out for webbing that appears furry because this indicates the webbing is worn and load-bearing fibres may be broken.
- ✓ Look out for any damage caused by cuts and abrasions, particularly where the webbing contacts the load and the coaming rails.

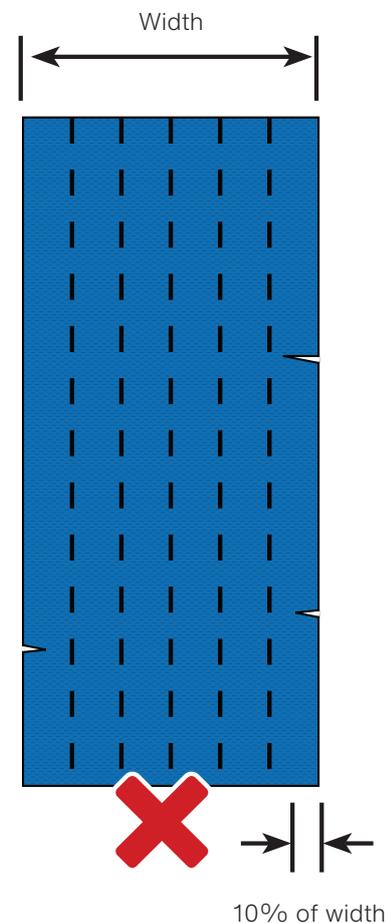
*Figure 418 Webbing with half a twist tying the load*



## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- ✓ When assessing the serviceability of webbing and attachments in relation to AS/NZS 4380, if any of the following conditions exist, replace the webbing or attachment:
  - Webbing weakened by 10% or more of its original minimum breaking strength by any of the following:
    - wear, damage or stitching failure caused by excessive loading, knotting and bending
    - exposure to chemicals, including acid and alkaline solutions and organic solvents
    - exposure to high temperatures
    - prolonged exposure to sunlight or ultraviolet light (fibres will appear hairy). Webbing that appears hairy or furry indicates the webbing is worn, and may indicate load-bearing fibres are broken.
  - Webbing repaired in a manner not approved by the manufacturer.
  - Any attachments (tensioner, hook and keeper, etc.) weakened by 10% or more, or prevented from functioning by wear, damage or corrosion.

*Figure 419 Worn webbing example*



# CHAIN

## WHAT IS TRANSPORT CHAIN?

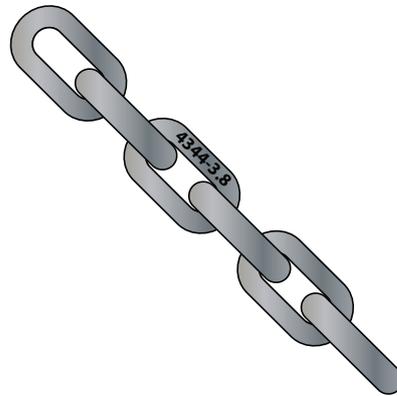
- i** Transport chain is a highly durable lashing type with low-stretch characteristics.
- i** Chain used for load restraint should comply with Australian Standard AS/NZS 4344 Motor vehicles – Cargo restraint systems – Transport chain and components.\*
- i** The most common chain used is 8 mm high-tensile transport chain with a typical lashing capacity of 3,800–4,000 kg. Other sizes of chain are 6, 7.3, 10, 13 and 16 mm.
- i** All transport chain made to AS/NZS 4344 is marked at least every 500 mm with its lashing capacity – *Figure 420*.

\*Withdrawn refer to "List of Relevant Standards" for more information.

## WHEN TO USE CHAIN

- ✓** Use chain to restrain strong rigid loads that are not easily damaged, or where the product can be protected from contact damage.

*Figure 420 AS/NZS 4344 chain*

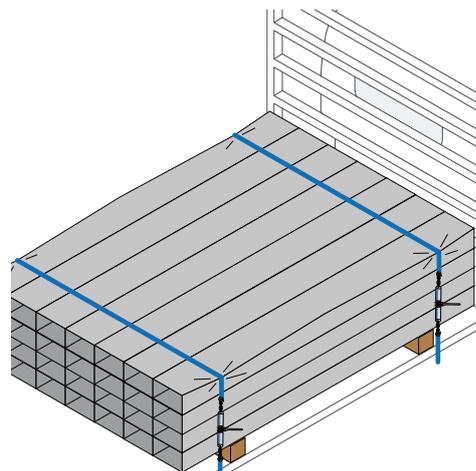


- ✗** Do not use chain to tie down loads that can crush or settle – *Figure 421*.

- ⚠** Chain can slacken completely if a load settles or deforms during transport, losing all restraint on the load.

- ✗** Do not use transport chain for any lifting or unloading because it is not designed for this purpose.

*Figure 421 Do not use chain on crushable loads*



## HOW TO USE CHAIN

- ✓ Always use transport chain that complies with AS/NZS 4344.
- ✓ When selecting a chain for load restraint, consider its size, strength, hardness and elongation.
- ⓘ Chains manufactured from low-strength materials are heavier, bulkier and more prone to damage and wear than higher tensile chain.
- ✓ Use corner protectors, sleeves or other packing material where lashings and loads contact each other – [Figure 422](#).

Figure 422 Corner protectors used between chain and load

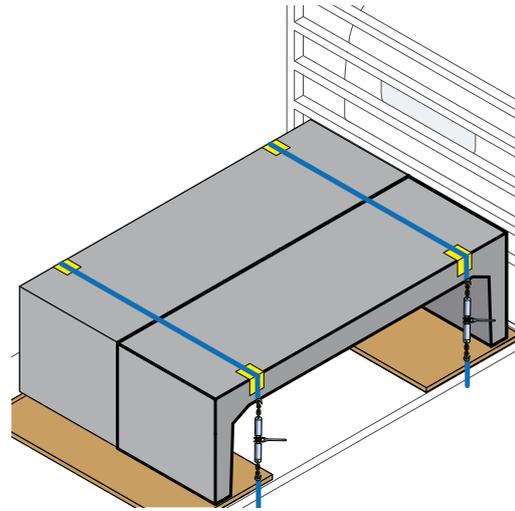


Figure 423 Rounded corner protectors help equalise tension and protect the load



- ⓘ Sharp edges and rough surfaces prevent the lashing tension from equalising on both sides of the load. Smooth, rounded corner protectors enable high tension on both sides of the load, increasing the load restraint – [Figure 423](#).
- ⚠ Chains can cause damage where they contact a load, unless a suitable protector is used.
- ✓ Straighten out any twists in larger chains before tensioning it.

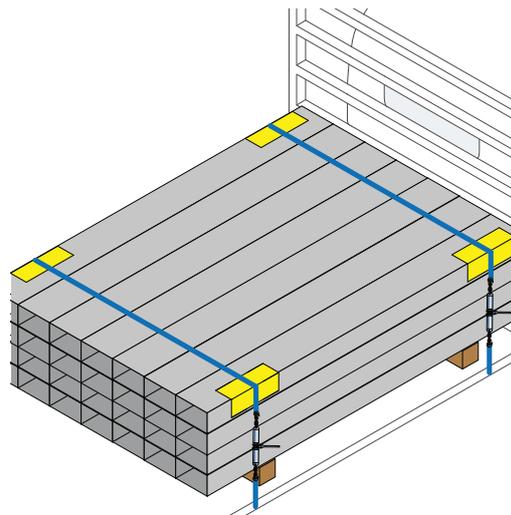
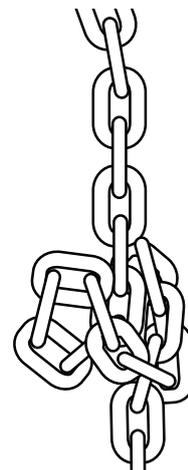


Figure 424 Do not use chain with knots



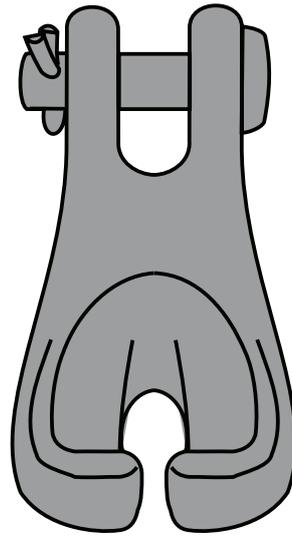
- ✓ Make sure the chain under tension is free of knots – [Figure 424](#).
- ✓ Make sure the chain is attached to anchor points using appropriate hooks (see [Tie rails and load anchor points](#) for more details).
- ✗ Do not attach the chain to an anchor point using knots.
- ✗ Do not use chain that has been joined with wire or bolts, or with joining links that do not match the lashing capacity of the chain assembly.



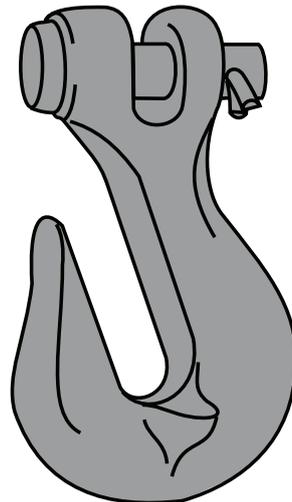
## Hooks

- i** The 2 types of shortening hooks used on chains are claw hooks and grab hooks (winged or plain) – *Figure 425*, *Figure 426* and *Figure 427*.
- ✓** Always select hooks that match the size of the chain.
- ✓** Use winged grab hooks wherever possible because they will prevent the chain link from bending and will not weaken the chain.
- ⚠** Plain grab hooks weaken the chain by bending the links they contact, reducing the lashing capacity of the chain by 25%.
- ⚠** Claw hooks distribute the force evenly into the chain; however, some claw hooks will distort and fail before the chain breaks.
- ⚠** Hooks can become uncoupled if the chain slackens when the load settles during a journey. Some claw hooks have a shallow slot, making them more likely to fall off.

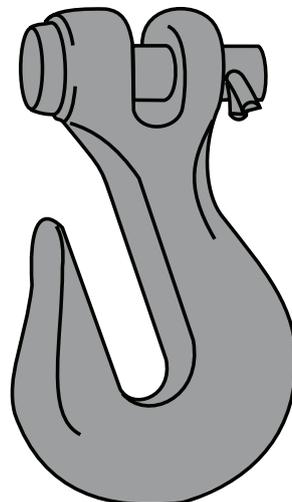
*Figure 425 Claw hook*



*Figure 426 Grab hook with wings*



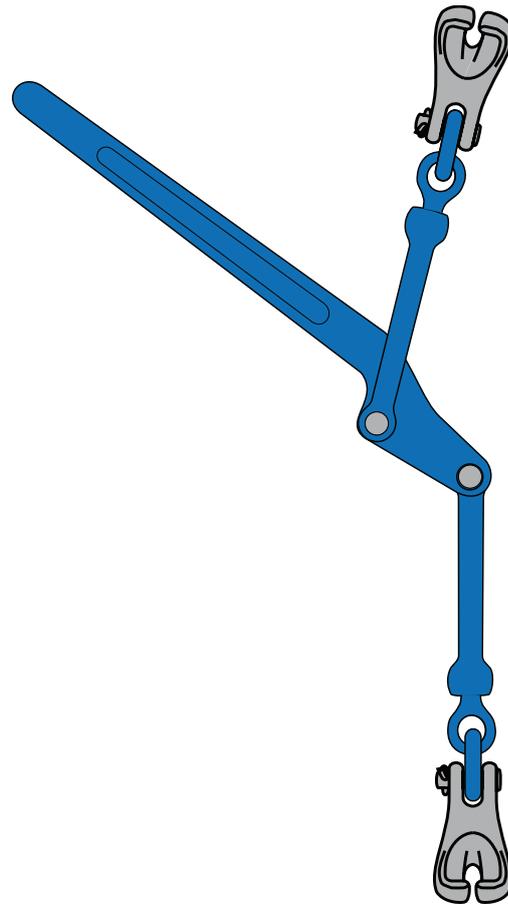
*Figure 427 Grab hook without wings*





-  Use of over-centre tensioners (dogs) is **strongly discouraged**. Use an alternative chain tensioner where possible. Your local WH&S agency may be able to provide further information on the risks.

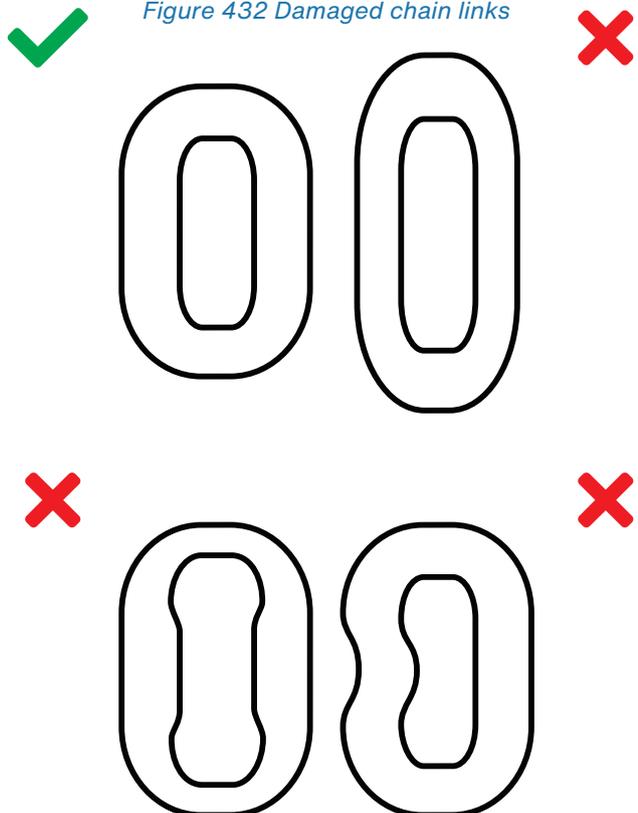
Figure 431 Over-centre lever or “dog”



## WHAT TO LOOK FOR WHEN USING CHAINS

-  Check there are no knots or twists in any sections of chain under tension.
-  Check there are no sections of chain attached to anchor points using knots.
-  Check there are no sections of chain joined with wire or bolts, or any links that do not match the lashing capacity of the chain assembly.
-  If a chain has been used to tow heavy vehicles, thoroughly inspect the chain prior to using it for load restraint and discard it if it is stretched or damaged in any way – [Figure 432](#).

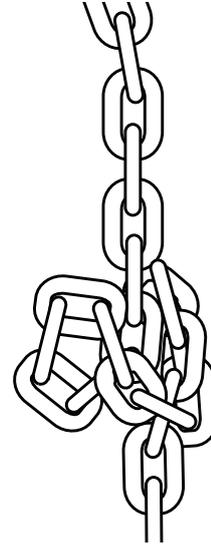
Figure 432 Damaged chain links



## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- ✔ When assessing the serviceability of chains and attachments in relation to AS/NZS 4344, if any of the following conditions exist, replace the chain or attachment:
  - Any link weakened by wear, damage or corrosion that reduces its diameter by more than 10%.
  - Any bent, twisted, stretched or collapsed link – [Figure 432](#).
  - Any link repaired by welding (except when approved by the original manufacturer) or any unsuitable repair link or joined by a bolt or wire.
  - A knot in any portion of the chain – [Figure 433](#).
  - Any attachment (turnbuckle, load binder, grab hook, etc.) weakened or prevented from functioning by wear, damage or corrosion.

*Figure 433 Do not use chain with knots*



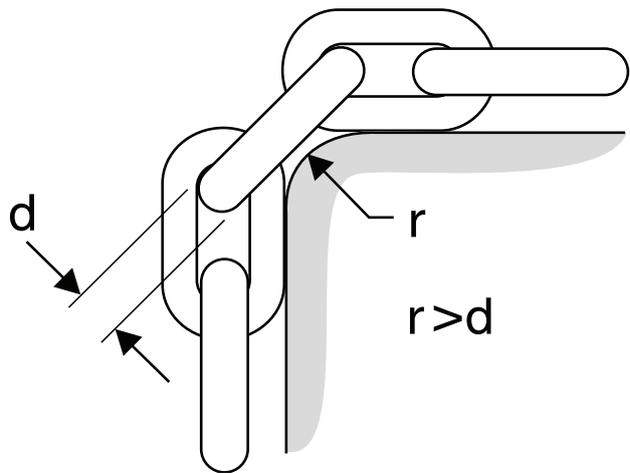
- i Chains should be joined using a joining link with a rating at least equal to the lashing capacity of the chain.
- i Long lashings are more elastic than short lashings and can absorb larger shocks without breaking.
- i Using long lashings makes it easier to obtain high tension consistently (the 'draw in' length between each chain link with a tensioner does not increase the tension as much as it does on a short lashing).

- ✔ Protect chains over sharp edges or rough surfaces to maintain their full lashing capacity.

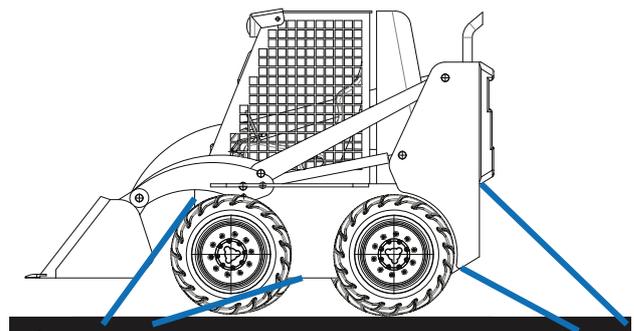
- ⚠ The lashing capacity of the chain is reduced by 25% where the corner radius ( $r$ ) is less than the chain size ( $d$ ) – [Figure 434](#).

- ✔ If securing large loads with multiple chains, allow for uneven loading and stretch characteristics caused by variations in chain lengths – [Figure 435](#).

*Figure 434 Derating of chain*



*Figure 435 A large load secured with multiple chains could have uneven loading*

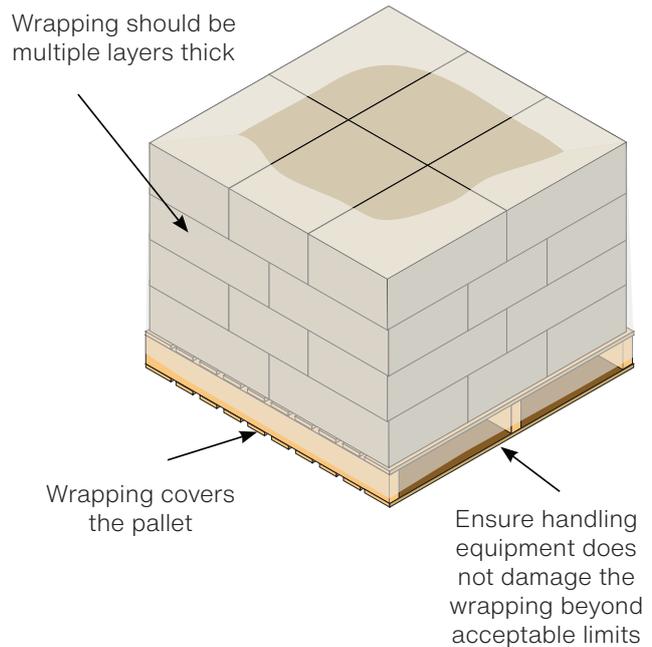


# STRETCH AND SHRINK WRAPPING

## WHEN TO USE STRETCH AND SHRINK WRAPPING

- ✓ Use stretch and shrink film wrapping to consolidate multiple product items into one pack, making them more stable and easier to restrain – [Figure 436](#).
- ✓ Use stretch and shrink wrapping to protect products from the elements.
- ⓘ Stretch and shrink wrapping can be used as part of a load restraint system provided it is of sufficient strength or sufficiently layered to withstand the forces indicated by the [Performance Standards](#).

*Figure 436 Multiple items packaged to a pallet with wrapping*



## HOW TO USE STRETCH AND SHRINK WRAPPING

- ✓ Protect the wrapping from cuts or tearing by avoiding exposure to sharp edges or points in the product itself.
- ✓ Make sure the wrapping is multiple layers thick to sufficiently unitise and protect the product from damage when handling (e.g. by forklift).
- ⓘ The number of wrapping layers required depends on the weight and interlayer friction of the product.
- ✓ Extend the wrapping to include the pallet if unitising loads with low-friction layers.

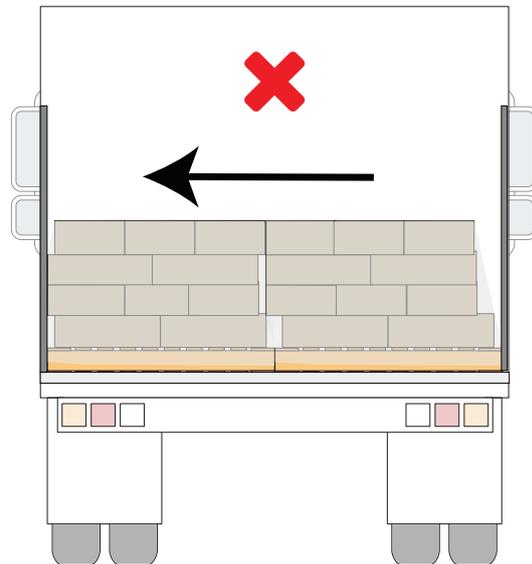
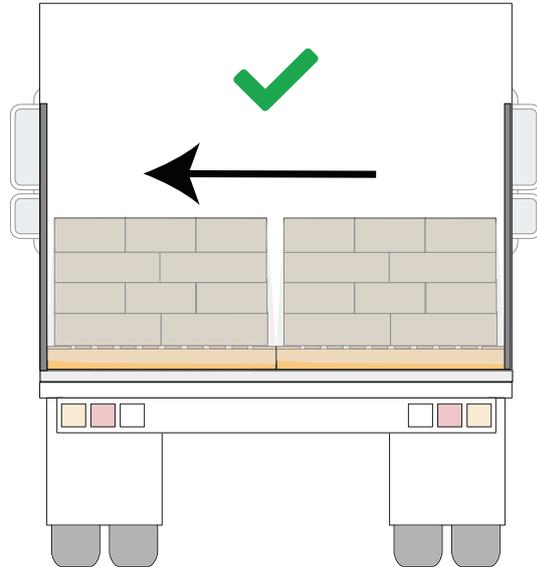
## WHAT TO LOOK FOR WHEN USING STRETCH AND SHRINK WRAPPING

- ✓ Make sure any distortion to the wrapping by handling equipment (e.g. forklift tines) is minor and does not adversely affect the performance of the wrapping.

### CHECKLIST FOR CERTIFIERS AND DESIGNERS

- ✓ When using stretch or shrink wrapping as part of a load restraint system, for example in conjunction with forward blocking, the wrapping must be sufficiently layered and of sufficient strength to withstand the forces in the [Performance Standards](#) – *Figure 437*.

*Figure 437 Packaging must be capable of restraining load-to-transport forces*



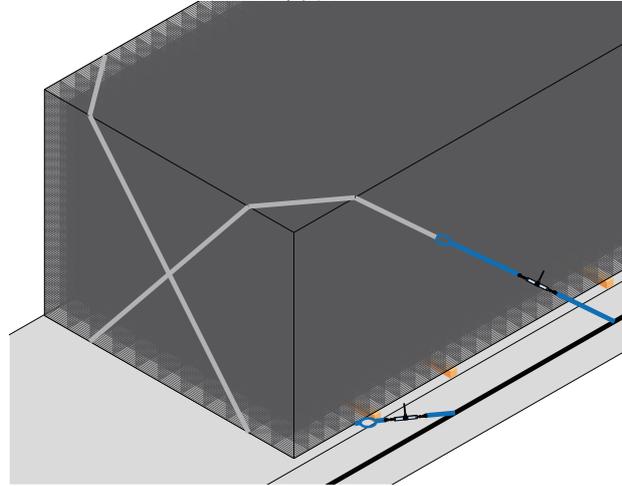
**Note:** When relying on drop-in gates, the load must be rigid. Stretch-wrapped pallets in this case must be capable of holding against the 0.5g performance standard at the very least.

# WIRE ROPES

## WHEN TO USE WIRE ROPES

- ✓ Steel wire rope with appropriate end fittings and tensioning winches can be used to effectively secure loads that settle during transport.
- ⓘ Wire ropes have greater stretch characteristics than chain while having a high lashing capacity – *Figure 438*.
- ✓ Wire rope is commonly used to tie-down loads on marine flat racks.

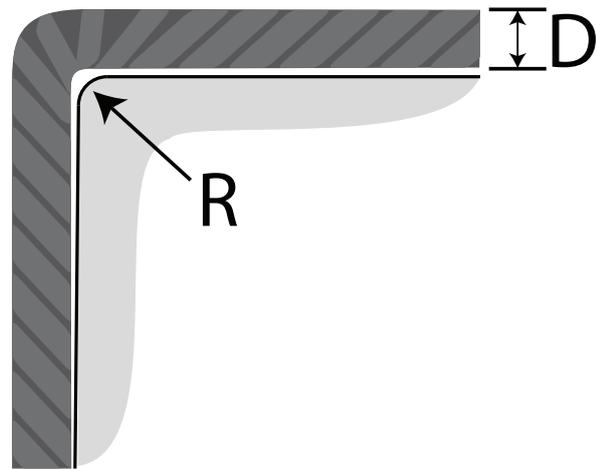
*Figure 438 Wire rope is effective with settling loads such as reinforcing mesh*



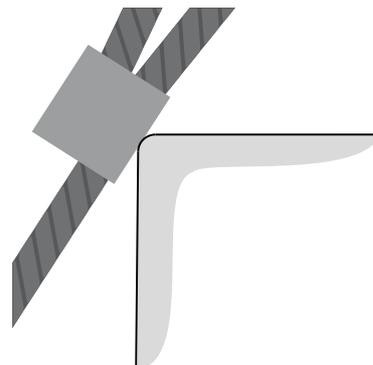
## HOW TO USE WIRE ROPES

- ⓘ Wire rope is tensioned with a winch or turnbuckle.
- ✓ Make sure attachments and joiner are rated to at least the lashing capacity of the wire rope.
- ✗ Do not use commercial-grade and lower strength shackles with 12 mm or larger wire rope.
- ✓ Put protection in place for wire rope used over sharp edges or rough surfaces to prevent damage.
- ✓ Sharp edges are those where the corner radius (R) is less than the rope diameter (D) – *Figure 439*.
- ✗ Wire ropes must not be bent near a clamp or splice – *Figure 440*.
- ⓘ The nearest bending point must be at least 3 times the rope diameter clear of the clamp end or splice.

*Figure 439 Sharp edges are when the rope diameter (D) is larger than the corner radius (R)*



*Figure 440 Wire rope cannot be bent near a splice or clamp*



## WHAT TO LOOK FOR WHEN USING WIRE ROPES

-  Assess the serviceability of wire ropes and attachments in relation to the relevant standards.
-  If any of the following conditions exist, the rope or attachment should be replaced:
  - any rope length equivalent to 3 rope diameters containing more than 4 broken wires
  - any rope length equivalent to 6 rope diameters containing more than 6 broken wires
  - any rope length equivalent to 30 rope diameters containing more than 16 broken wires
  - any rope where the diameter is reduced by more than 10% by abrasion
  - any rope that has been crushed or flattened by more than 15% of its nominal diameter
  - any rope that is significantly notched or kinked
  - any rope weakened by corrosion
  - any attachment (shackle, thimble, turnbuckle, hook, etc.) weakened or prevented from functioning by wear, damage or corrosion.

## CHECKLIST FOR CERTIFIERS AND DESIGNERS

-  Australian Standard AS 3569 Steel Wire Ropes specifies requirements for steel wire ropes for all purposes. It also specifies materials, manufacture, marking, packing and test requirements.
-  The manufacturer's rating of wire rope manufactured in accordance with Australian Standard AS 3569 Steel Wire Ropes, or other equivalent International Standard, should be no greater than  $\frac{1}{3}$  of its specified minimum breaking strength.

# SPECIALISED BODIES

## WHAT ARE SPECIALISED BODIES?

- i** Specialised bodies are specifically designed to carry a certain type of load.
- i** Specialised bodies include pantechnicon bodies, tippers, tankers (including ISO tank containers), bins, skips, stillages, removable tanks and closed and open containers.
- i** Many specialised bodies will have a restraint system built into them (e.g. side tracks inside a pantechnicon body).

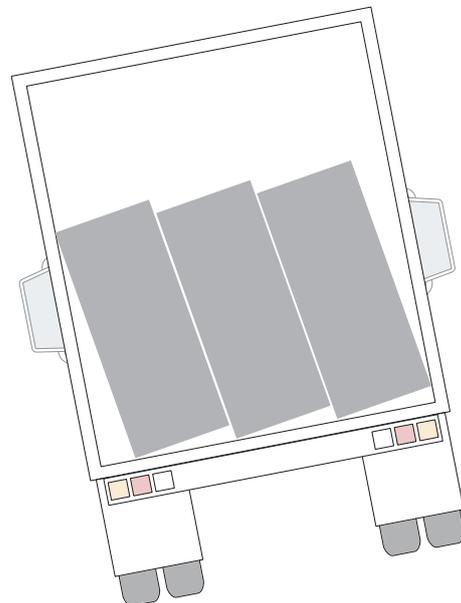
## WHEN TO USE SPECIALISED BODIES

- ✓** Use specialised bodies for the load type they were designed for.
- i** Tanks and tankers can be designed for bulk liquids and fine, granular materials, including powders.
- ✗** Do not restrain heavy individual loads by containment unless the restraining structure can limit load movement such that the performance standards are met.

## HOW TO USE SPECIALISED BODIES

- ✓** Make sure specialised bodies used to restrain loads by containment can adequately restrain the load and meet the [Performance Standards](#).
- ⚠** Load movement within containment bodies can still cause vehicle instability or can cause loads to be dislodged from the vehicle – [Figure 441](#).
- ✓** Obtain load restraint ratings for containment systems from the manufacturer, if not already marked on the vehicle body.
- ⚠** Bulkheads, side walls, tanks and other containment systems have a limit to their load restraint capacity.

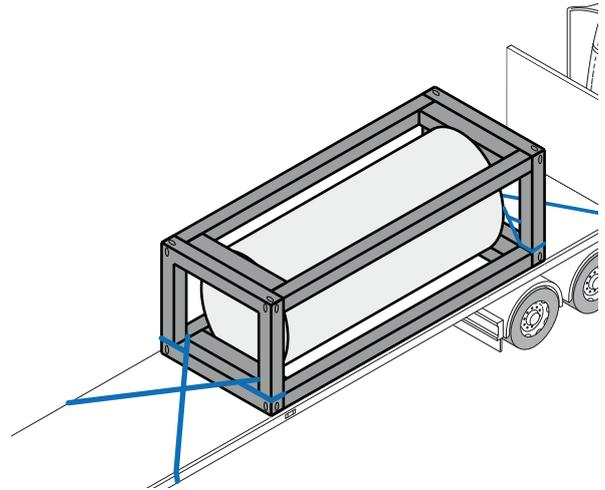
*Figure 441 Load movement can make the vehicle unstable*



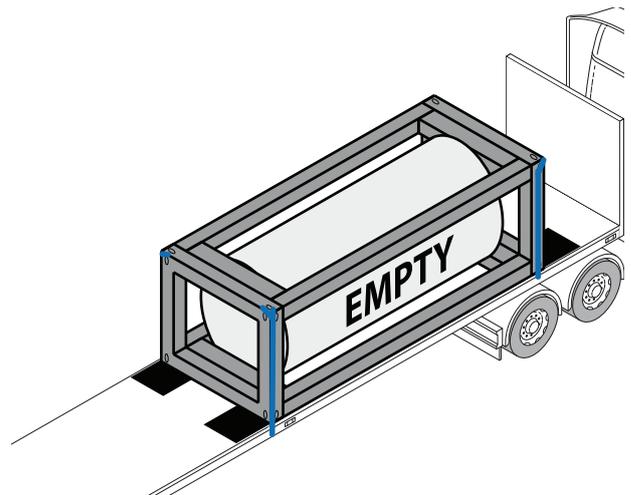
- ✓ Transport loaded ISO tank containers on low trailers.
- ✓ Secure demountable ISO tanks using twist locks or other positive locking devices.
- ✓ Alternatively, restrain demountable tanks using direct lashings, provided that the tank and vehicle are equipped with suitable anchor points. An engineer should certify the restraint method.
- ✓ If using direct lashings to restrain an ISO tank, position each anchor point on the support structure so that the lashing angle is low (to optimise the direct lashing angle effect) – [Figure 442](#).
- ✗ Do not restrain ISO tanks by tie-down unless they are empty.
- ✓ If using tie-down lashings to restrain an empty ISO tank, place the tank on a timber or a rubber load mat, and position each anchor point on the support structure so that the tie-down lashing angle is high (to optimise the tie-down lashing angle effect) – [Figure 443](#).
- 📘 If a dangerous goods class label is present refer to the Australian Code for the Transport of Dangerous Goods by Road & Rail for additional requirements.

- ✓ Fit open bodies designed for loose bulk loads with covers to prevent load loss from the effects of air flow and rough roads – [Figure 444](#).
- ✓ Make sure covers for open bodies that are fitted with fixed tracks, winches or handles do not cause the vehicle to become over width or over length.

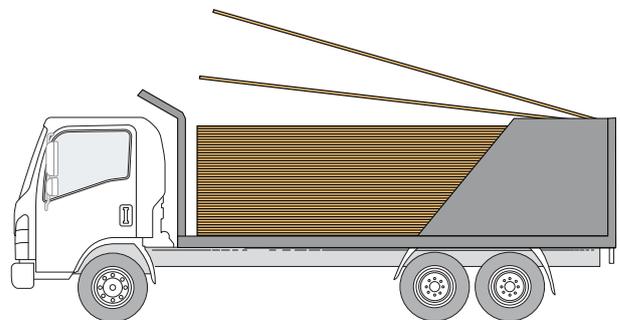
*Figure 442 ISO tank held down by direct restraint*



*Figure 443 Empty ISO tank secured by tie-down*



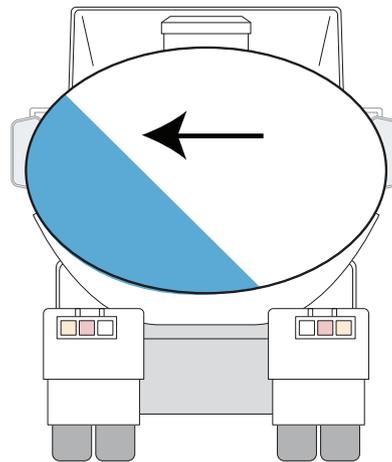
*Figure 444 Open bodies have the potential for air flow to remove loads*



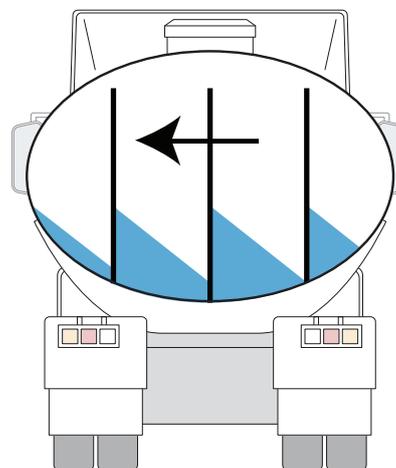
## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- ✓ The equipment together with its load must be designed so that it can be adequately restrained to the vehicle.
- ✓ All tanks should be designed so that the centre of mass of the laden vehicle is as low as possible.
- ✓ The load restraint design should take into account the dynamic nature of the load, for example, the effect of liquid surge in all directions.
- ✓ Fit baffles and compartments to tanks or tankers that may be required to travel partially full to minimise any movement of liquid contents that could cause vehicle instability, especially during cornering – [Figure 445](#) and [Figure 446](#).
- ✓ Refer to the Australian Code for the Transport of Dangerous Goods by Roads & Rail for additional requirements when designing specialised bodies that may carry dangerous goods.

*Figure 445 Liquid movement without baffles*



*Figure 446 Liquid movement with baffles*



# UPRIGHTS

## WHAT ARE UPRIGHTS?

- i** Uprights are pins, pegs, stanchions and bolsters or any other device that blocks a sideways load force.
- i** Some uprights are designed to be modular and can fit multiple size loads.

## WHEN TO USE UPRIGHTS

- ✓** Use uprights to block rigid loads that cannot fall apart (e.g. long products and flat plates) from sideways load forces.

Figure 447 Loose-fitting uprights should be restrained

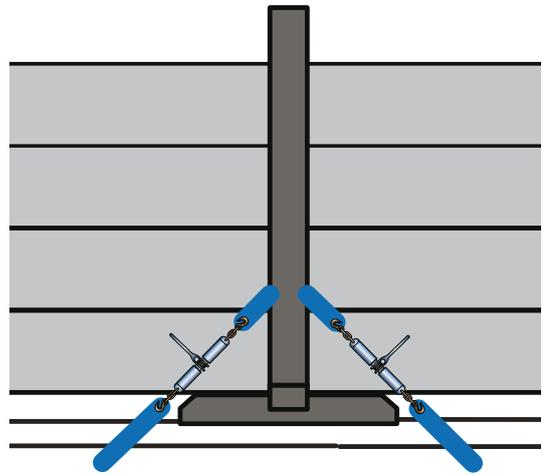


Figure 448 Gap between stanchion and load

## HOW TO USE UPRIGHTS

- ✓** To reduce the risk of loose-fitting removable uprights dislodging from the vehicle on bumpy or rough roads, restrain them:
  - directly, using locking pins or attaching chains, etc. – [Figure 447](#)
  - indirectly, using tight fitting mounting sockets.
- ✓** Make sure gaps between the load and the uprights are as small as practical, and in any case no greater than 50 mm – [Figure 448](#) and [Figure 449](#).
- ✓** Use vertical lashings in addition to uprights if required (i.e. depending on the height and design of uprights).

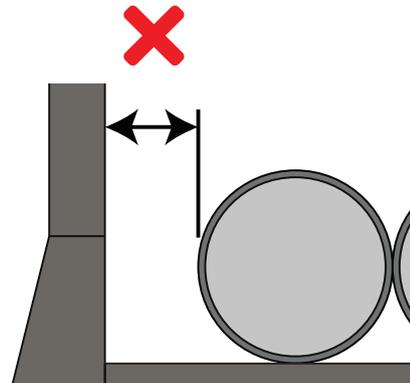
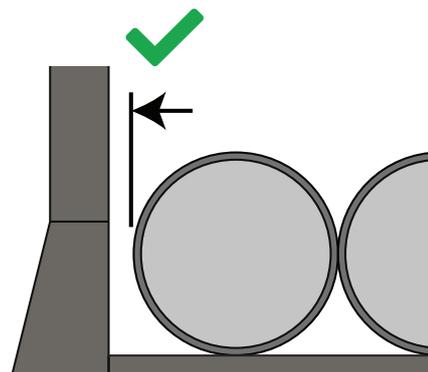


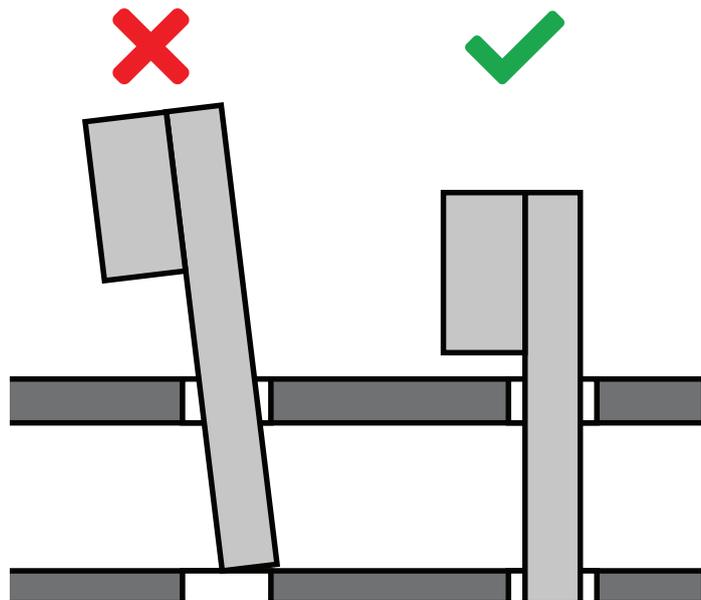
Figure 449 No greater than 50 mm gap between stanchion and load



## WHAT TO LOOK FOR WHEN USING UPRIGHTS

- ✓ Make sure the uprights provide adequate sideways restraint for the load.
- ✓ Make sure all direct restraint components are straight and undamaged.
- ✓ Make sure uprights are engaged in both top and bottom engaging holes – *Figure 450*.
- ✓ Make sure engaging holes are not elongated or worn – *Figure 451*.

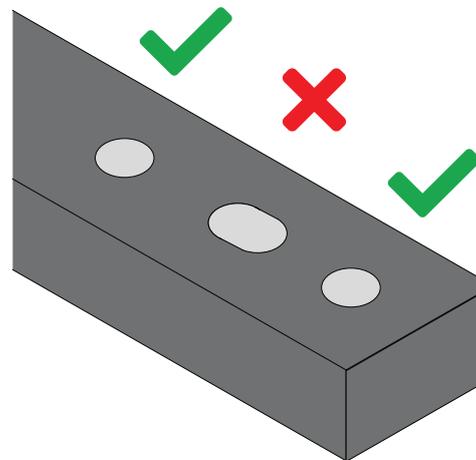
*Figure 450 Pins must be fully engaged*



## CHECKLIST FOR ENGINEERS, CERTIFIERS AND DESIGNERS

- ✓ Vehicles regularly carrying loose plate, sheets, boards, rods, pipes and other similar items may be fitted with pockets along the sides and across the deck in various positions so that stakes, pins, pegs, posts or stanchions can be fitted where required to provide direct restraint.
- ✓ Separate detachable frames that are adjustable in position and have provision for stakes, pins, pegs, posts or stanchions, can be used as an alternative to fixed pockets on the vehicle.
- ✓ Design removable stakes, pins, pegs, posts and stanchions so they cannot become dislodged during a journey. Design an adequate engagement length in its socket or the use of a positive locking method.
- i An adequate engagement length will be determined by the engineer or designer, but is unlikely to be less than 100 mm.
- ✓ When designing uprights, take multiple loading cases into account.
- ✓ Tall pins (where the pin centre of gravity is well above the socket) must include some retaining mechanism to stop the pin from bouncing out of its socket, especially when the vehicle is unloaded.

*Figure 451 Elongation of locating hole*



For examples of different load cases see [Design for containing or blocking](#) in the Technical advice module.

# LOADING EQUIPMENT

## WHAT IS LOADING EQUIPMENT?

-  Loading equipment includes side loaders, truck-mounted cranes and other on-vehicle cranes.

## HOW TO USE LOADING EQUIPMENT

-  Fully retract and restrain stabilising legs and crane arms before moving the vehicle.

## CHECKLIST FOR CERTIFIERS AND DESIGNERS

-  Design loading equipment to immobilise the vehicle and/or provide an audible and visual warning, if the stabilising legs and crane arms are not in the retracted transport position when moving the vehicle.

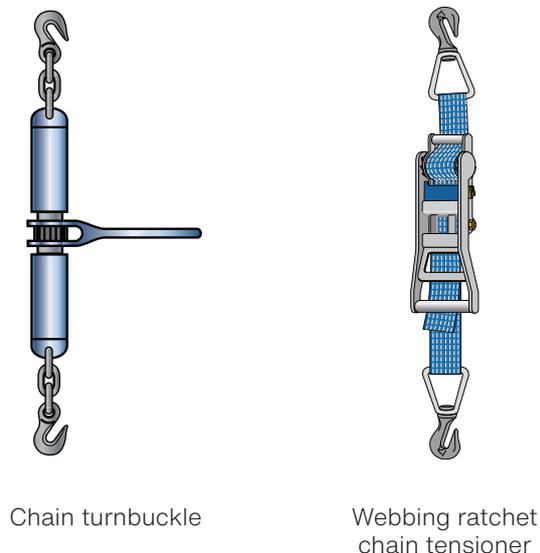
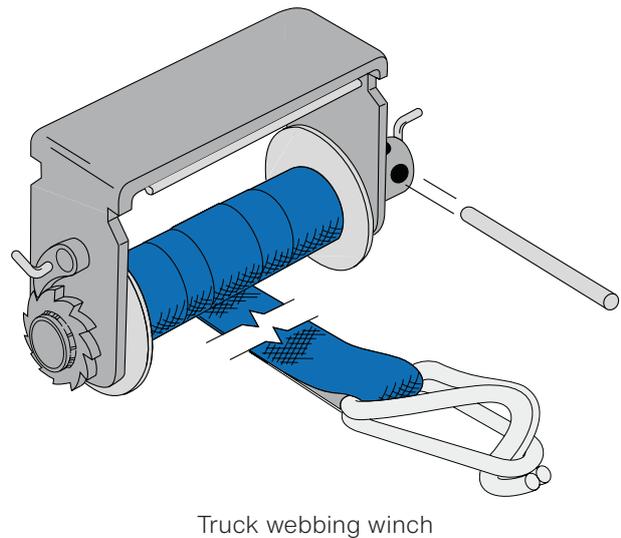
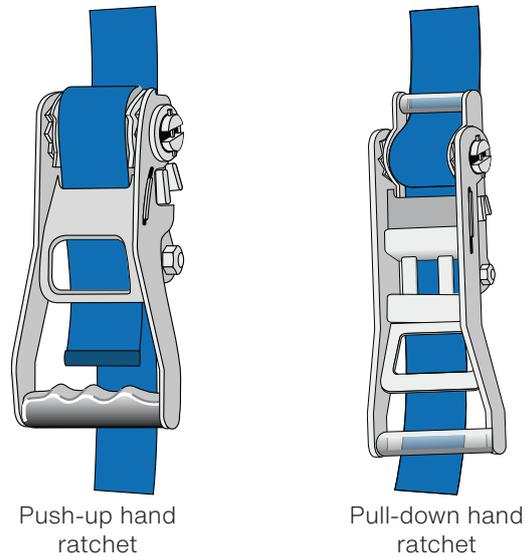
# LASHING TENSIONERS

## WHAT ARE LASHING TENSIONERS?

- i** Lashing tensioners provide pre-tension to the lashings used in tie-down or direct restraint; most lashings (other than rope or small webbing) require greater tensioning than can be applied by hand – *Figure 452*.
- i** The pre-tension generated by the lashing tensioner can remove slack from lashings used in direct restraint.
- i** Pre-tension capability of a tensioner is critical for the tie-down capacity of lashings used in tie-down restraint.
- i** The key types of tensioners and their applicable uses are listed below.

TENSIONER TYPE	APPLICATION
<b>In-line webbing ratchet for webbing</b>	Any webbing lashing application
<b>Under-deck winch drum for webbing</b>	Tie-down webbing lashings
<b>High pretension variant of webbing ratchets</b>	Higher pre-tension in webbing lashings (tie-down or direct restraint)
<b>In-line webbing ratchet for chain</b>	Chain lashings (tie-down or direct restraint)
<b>In-line ratchet for chain</b>	Chain lashings (tie-down or direct restraint)
<b>Turnbuckle (including ratchet-type)</b>	Chain or wire rope (tie-down or direct restraint)
<b>Under-deck geared winch</b>	Webbing or chain lashings depending on the set-up (tie-down restraint only)
<b>Auto-tensioning winch</b>	Webbing or chain lashings (tie-down restraint only) Uses pneumatics to maintain tension (with ratchet fail-safe)

Figure 452 Tensioner types



## HOW TO USE LASHING TENSIONERS

- ✓ Select a tensioner to suit the lashing system used and the desired pre-tension.
- ❗ Tensioners are labelled or stamped with their lashing capacity.
- ❗ Average tensioner pre-tensions for standard equipment are shown below; operation of the tensioner to a point of reasonable effort will usually produce the average forces listed.

TENSIONER	SIZE	TENSIONER	PRETENSION
<b>Rope</b>	10 mm & 12 mm	Single hitch knot	50 kgf
	10 mm & 12 mm	Double hitch knot	100 kgf
<b>Webbing</b>	25 mm	Hand ratchet	100 kgf
	35 mm	Hand ratchet	250 kgf
	50 mm	Truck winch	300 kgf
	50 mm	Hand ratchet (push-up)	300 kgf
	50 mm	Hand ratchet (pull-down)	600 kgf
<b>Chain</b>	7 mm & above	Turnbuckle	1,000 kgf

- ❗ The average pre-tensions listed above only apply if the lashings are fully tensioned. Higher forces can be achieved using high pre-tension equipment.
- ⚠ Manufacturers will provide tensioners with standard and/or higher pre-tension capability, and some tensioners will be labelled accordingly. If you are unsure, always assume only the standard pretension.
- ✓ Make sure that when a webbing tensioner is tensioned, there is a minimum of one and a half wraps of webbing wrapped onto the spool – [Figure 453](#).
- ⚠ Use of over-centre tensioners (dogs) is **strongly discouraged**. Use an alternative chain tensioner where possible. Your local WH&S agency may be able to provide further information on the risks – [Figure 454](#).

Figure 453 Minimum one and a half wraps around spool

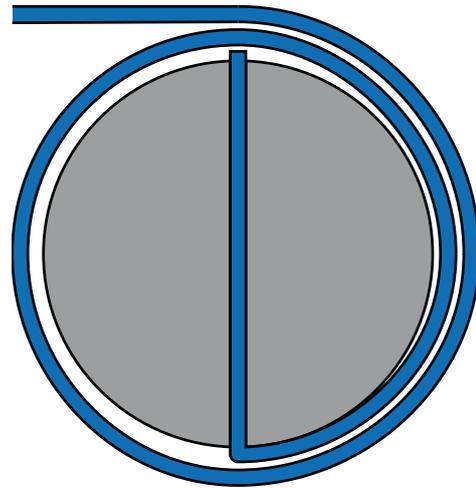
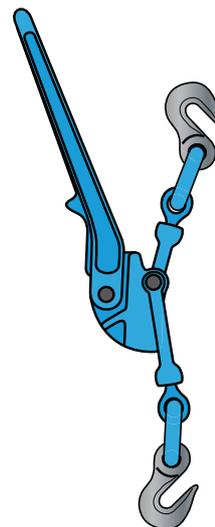
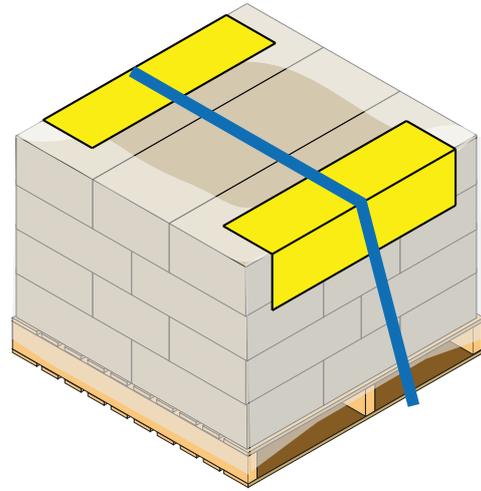


Figure 454 Over-centre lever binder (dog)



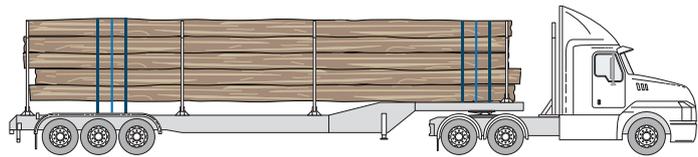
- ✓ Use high-quality rigid corner protectors to protect the load (and lashing) because this will allow full pre-tension – *Figure 455*.
- ✓ Check and maintain tensioners and connectors regularly.

*Figure 455 Protective corners used to achieve full tension*



- ✓ Powered winches automatically retension a load during transport and are particularly useful for loads that settle, such as logs – *Figure 456*.

*Figure 456 Logging truck with powered winches*



## CHECKLIST FOR ENGINEERS, CERTIFIERS AND DESIGNERS

- ✓ Tensioners should be designed to:
  - minimise the potential for inadvertent release of the tension
  - minimise the potential for kick-back during tensioning or release that could injure operators or bystanders
  - minimise the effort required to achieve the appropriate pretension.
- ✓ Tensioners and connectors should exhibit no permanent deformation and should be fully functional after being subjected to a force equal to 1.25 times their lashing capacity.
- ⓘ Webbing, chain and wire rope lashing assemblies all require mechanical tensioners and connectors, which must be manufactured and marked to recognised standards. The marking will ensure traceability in case of product failure.
- ✓ Make sure lashings can withstand the pre-tension generated by any high pre-tension system.
- ✓ When designing load restraint systems that require pre-tensions higher than the averages described in this guide, label equipment capable of providing the higher pre-tension.
- ⚠ It is critical that users can identify the pre-tension capability of a tensioner used on lashings in tie-down restraint.

# INTERLAYER PACKING

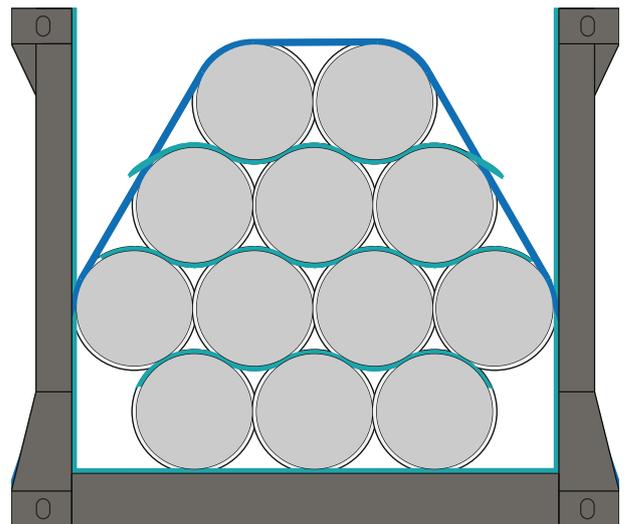
## WHAT IS INTERLAYER PACKING?

- i** Interlayer packing is material that sits between layers in a load. It includes cardboard, carpet, anti-slip mats, rubber matting, plywood and timber dunnage.
- i** Rubber matting can be natural or synthetic rubber plain sheet, or anti-slip load mat made from recycled tyres.

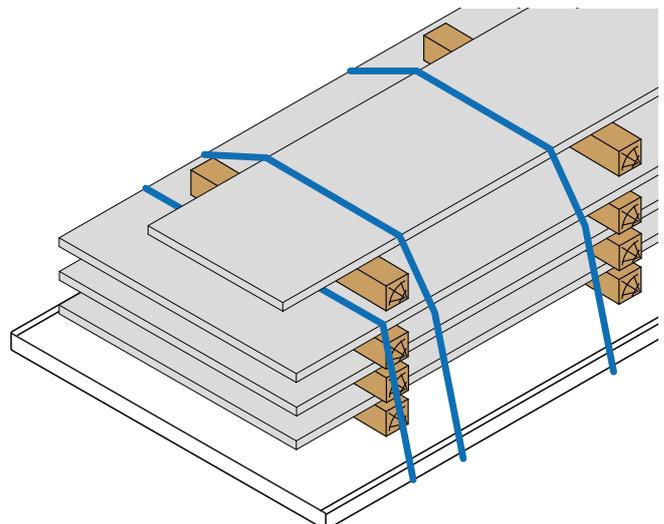
## WHEN TO USE INTERLAYER PACKING

- ✓** Use interlayer packing to increase the friction between low-friction load items (e.g. metal on metal) and reduce the number of tie-down lashings needed – [Figure 457](#) and [Figure 458](#).
- ✓** Use interlayer packing to stabilise loads containing tall columns of product.

*Figure 457 Metal pipes with rubber interlayer packing to increase friction between pipes*



*Figure 458 Metal plates with timber dunnage to increase friction between plates*



## HOW TO USE INTERLAYER PACKING

- ✓ Separate the load layers with interlayer packing – *Figure 459* and *Figure 460*.
- ⓘ Anti-slip mat is very effective in dry and wet conditions.
- ✗ Do not use conveyor belt material as interlayer packing because it is too slippery.
- ✗ Do not use the slip-sheets included with pallet loads when using tie-down restraint because their friction level is low.

Figure 459 Palletised cans without interlayer packing

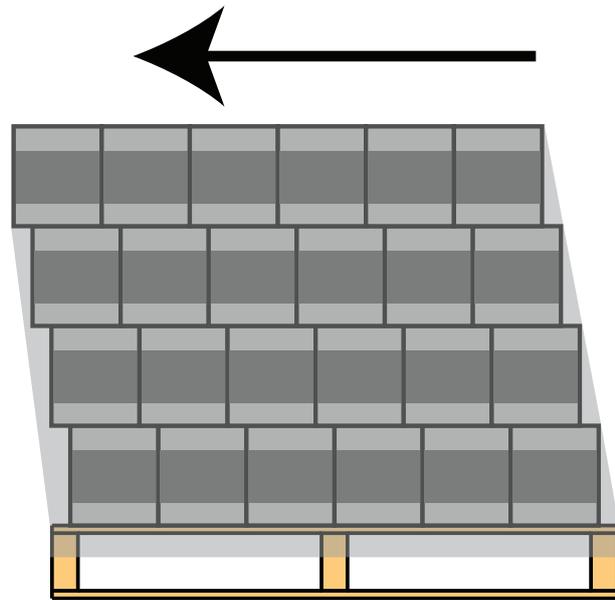
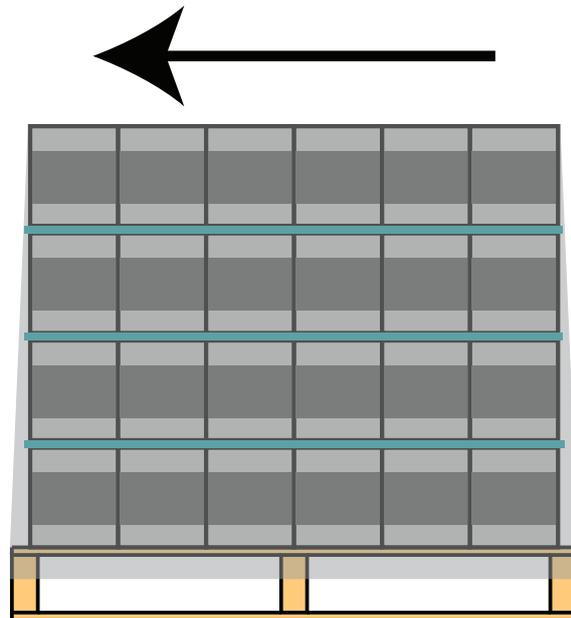


Figure 460 Palletised cans with interlayer packing



## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- ✓ Use the lowest friction through the load when calculating restraint requirements.
- ⚠ The static friction coefficient of loads on anti-slip load matting is usually more than  $0.6\mu$ . However, this may be reduced for coated products, oily surfaces or dust residue.

# DUNNAGE

## WHY USE DUNNAGE?

-  Dunnage is the packing placed under and between parts of the load.
-  Dunnage is generally made from either hardwood or softwood timber and is either square or rectangular in cross-section.
-  Dunnage is used to:
  - elevate the load to increase lashing angles
  - increase the stability of the load
  - separate parts of the load
  - increase friction between the load and the deck, or between parts of the load
  - allow for easier loading and unloading.

## HOW TO USE DUNNAGE

-  Select the size and timber grade/type used for dunnage based on the load and the maximum span between support points.
-  Use rough-sawn hardwood wherever possible.
-  Limit use of softwood to situations where:
  - the dunnage will only be used once
  - the dunnage is separating flat surfaces
  - loads are light.
-  Do not use softwood for heavy or sharp loads.
-  Dunnage that supports heavy loads on small areas of contact (e.g. large steel sections) should be strong enough to prevent it crushing or splitting.
-  If using materials other than timber that have low levels of friction, coat the dunnage in rubber (or similar) to increase the friction level.
-  Make sure dunnage is placed so that it is as stable as possible.
-  If dunnage is placed directly on the deck, bolt it to the deck or fit it with special stabilising brackets.
-  Always place rectangular dunnage on its wider face.
-  Do not place dunnage on its narrow face because it can topple over, resulting in a loss of lashing tension and restraint.

✓ If multiple layers of dunnage are required, stack pieces alternatively at right angles to keep it stable – *Figure 461*.

✗ Do not stack pieces on top of each other (in parallel) because layers of dunnage can dislodge, resulting in a loss of lashing tension and restraint.

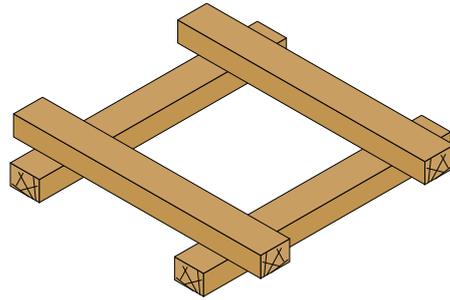
✓ If dunnage spans between support points, make sure it is strong enough to support the weight of the load, tie-down clamping forces and shock from any bumps in the road – *Figure 462*.

✓ Add additional supports, use stronger dunnage or rearrange the load if needed – *Figure 462*.

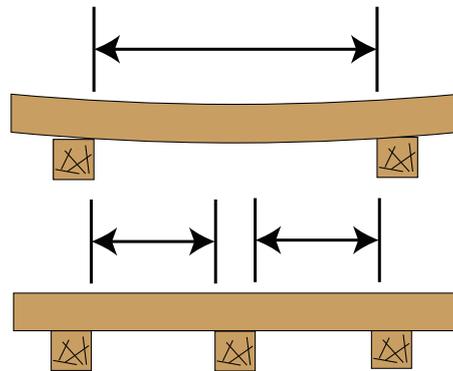
✓ Where the load has multiple layers, align dunnage and lashings vertically – *Figure 463*.

⚠ If dunnage is placed between lashing positions, it can work loose when the vehicle and load both flex during transport – *Figure 464*.

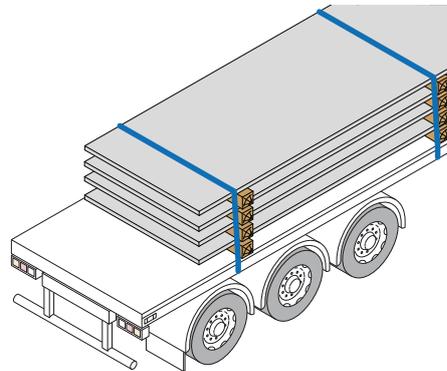
*Figure 461 If multiple layers of dunnage are required, stack alternatively*



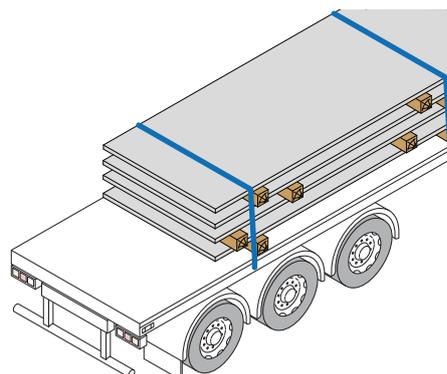
*Figure 462 If the dunnage is not strong enough for the span, use additional supports*



*Figure 463 Dunnage aligned with lashing position*

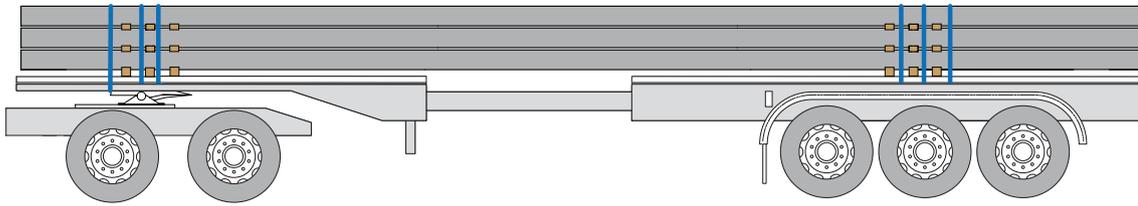


*Figure 464 Dunnage and webbing not aligned*



- ✓ Support very rigid loads (e.g. large diameter steel pipes or concrete beams) in only 2 positions using 2 larger pieces of dunnage or multiple tightly arranged lengths of standard dunnage – *Figure 465*.

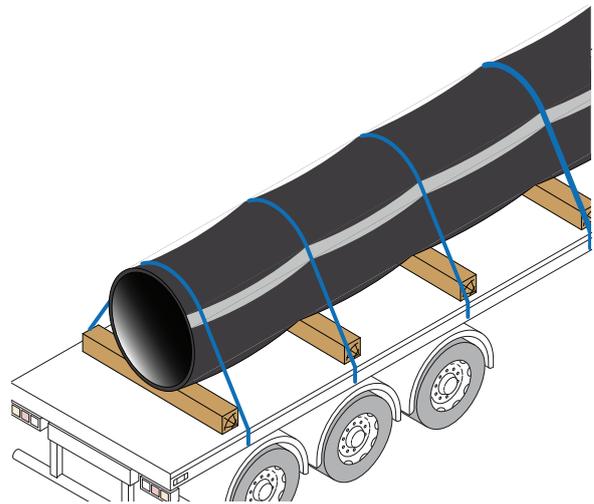
*Figure 465 Dunnage and lashings on an extendable trailer with a rigid load*



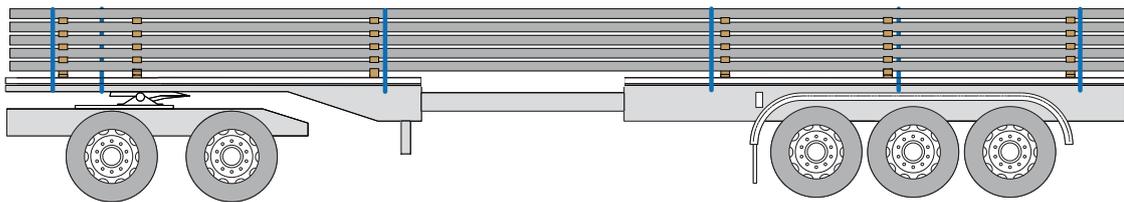
- ⚠ It is especially critical to support rigid loads in only 2 positions with highly flexible trailers such as those that extend.

*Figure 466 Flexible loads may require additional dunnage and lashings*

- ✓ Support flexible loads (e.g. plastic pipes or thin metal sheets) in multiple positions along their length, in line with lashings – *Figure 466* and *Figure 467*.



*Figure 467 Dunnage and lashings on an extendable trailer with a flexible load*



## WHAT TO LOOK FOR WHEN USING DUNNAGE

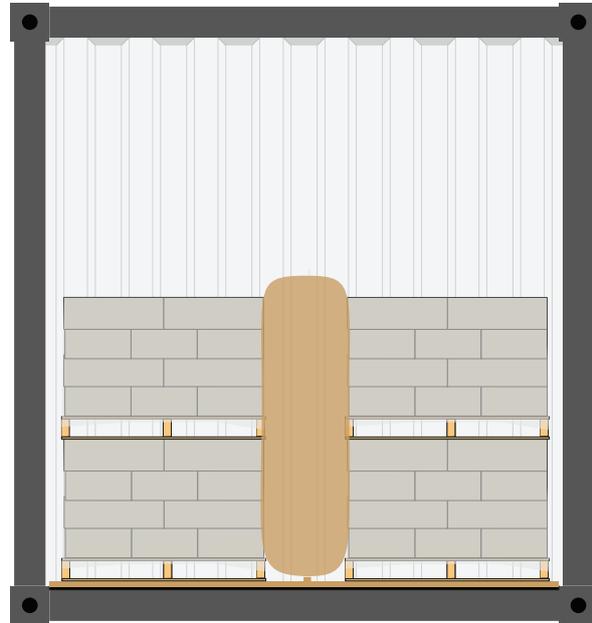
- ✓ Check all dunnage is secured on the vehicle when not in use.
- ✓ Make sure timber dunnage is relatively free of knots and splits, especially where the dunnage may span gaps, to reduce the risk of the timber splitting under load forces during transport.

# INFLATABLE DUNNAGE

## WHEN TO USE INFLATABLE DUNNAGE

- i** Inflatable dunnage is also referred to as 'pneumatic load control systems' or 'air bags'.
- i** Inflatable dunnage can be disposable or reusable and is available in a wide variety of sizes.
- ✓** Inflatable dunnage can be used to separate loads contained in van bodies and containers – *Figure 468*.
- ✓** Inflatable dunnage is used to fill gaps in a containment system.
- ✓** Inflatable dunnage must be used strictly in accordance with the manufacturer's instructions.

*Figure 468 Air bag used to block sideways movement in a container*

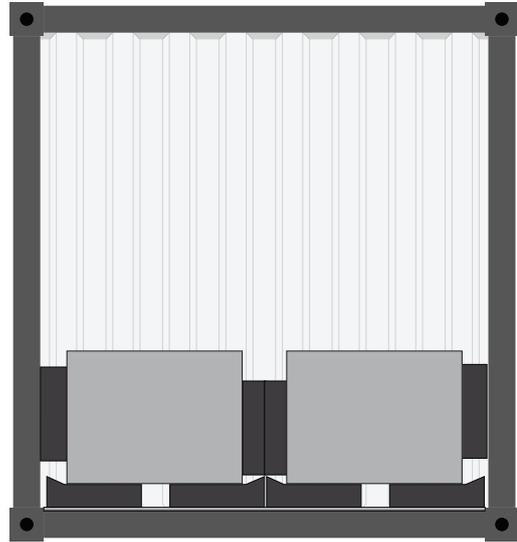


# TYRES

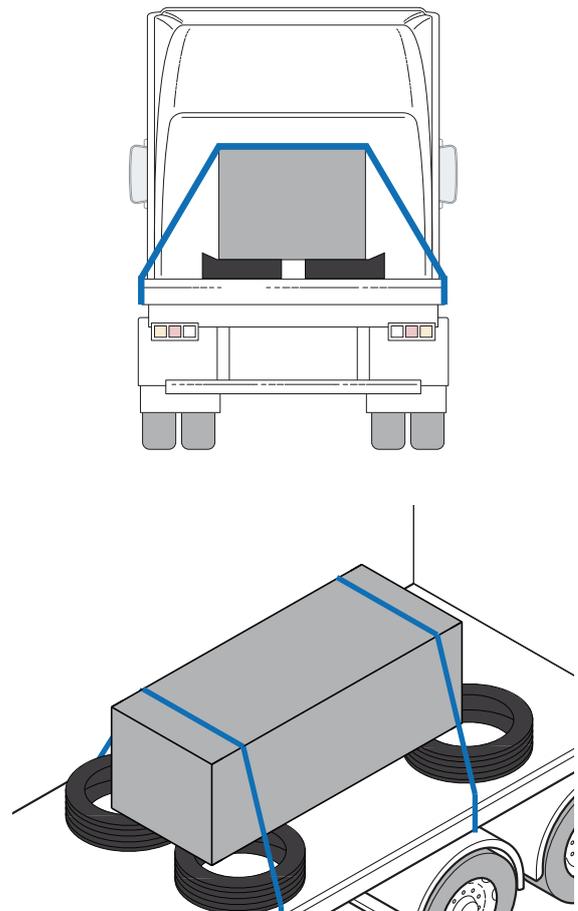
## WHEN TO USE TYRES

- ✓ Rubber tyres can be used to separate contained loads – *Figure 469*.
- ✓ They can be used as wheel chocks on vehicles and mobile equipment that are restrained with tie-down lashings.
- ✓ Rubber tyres or parts of tyres can be used under heavy loads to increase friction for tie-down – *Figure 470*.

*Figure 469 Tyres used to block a load in a container*



*Figure 470 Tyres used to improve friction*

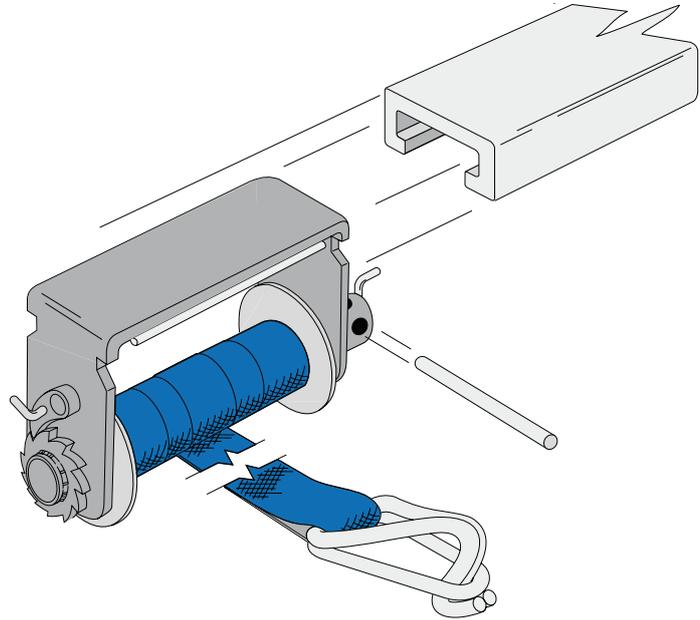


# WINCH TRACKS

## CHECKLIST FOR ENGINEERS AND DESIGNERS

- i** The design of winch tracks must take into account the magnitude and direction of the lashing force and the spacing of the track supports.
- i** The rated track capacity should be clearly and permanently marked on the vehicle.

Figure 471 Truck winch into winch track



# ISO-TYPE CONTAINER TWIST LOCKS

## WHEN TO USE ISO-TYPE CONTAINER TWIST LOCKS

- ✓ Use container twist locks to restrain ISO-type containers because they are the most efficient and secure way to restrain the load.
- ⓘ Generally twist locks are laid out to specific ISO-type container base patterns.

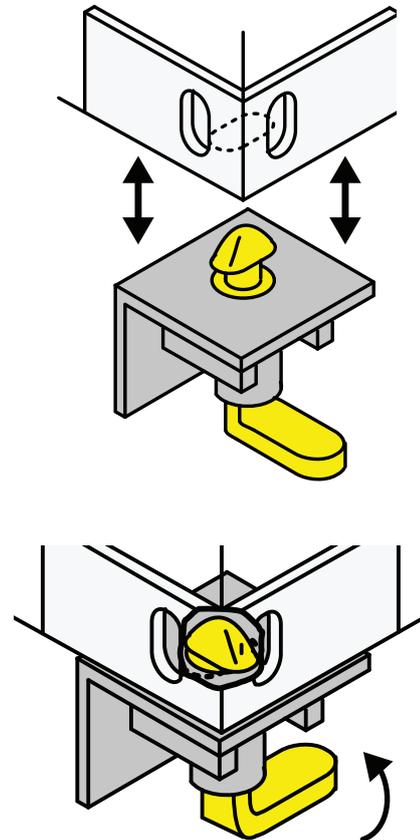
## HOW TO USE ISO-TYPE CONTAINER TWIST LOCKS

- ✓ You should engage all 4 container twist locks when carrying ISO-type containers.
- ✗ Do not use twist locks if they are damaged or if the pin does not engage correctly.

## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- ✓ ISO-type container twist locks must be compatible with the dimensional requirements of the AS/NZS 3711 series of standards for freight containers.
- ✓ Where the twist lock support structure is only designed for restraining empty containers or other light loads, the maximum weight should be clearly marked on the vehicle.
- ✓ Twist locks may be used as anchorages for other demountable items such as A-frames for pre-cast concrete panels. If used for other than container securing an engineer should check that the twist locks are suitable for all loading and transport conditions.

Figure 472 Container twist lock engaging

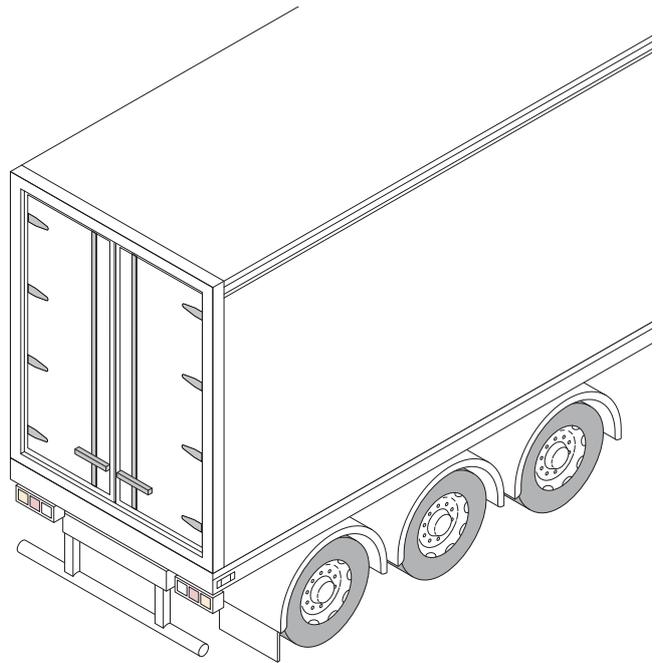


# LATCHES, LOCKS AND HINGES

## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- i** Latches, locks, hinges and other attachments should be designed to prevent them separating by road-induced vibration and affect loads.
- i** These items can suffer fatigue cracking if not properly designed. If failure occurs, the load can dislodge from the vehicle. An unsecured swinging door or gate can cause severe injury and damage.
- i** If doors, gates and drop sides are designed for travel in the open position, the vehicle must meet the legal length and width limits when they are both open and closed. They must be capable of being positively restrained when travelling so as to stop them swinging out into the path of other road users.

*Figure 473 Latches, locks and hinges used on a pantechnicon trailer*



# TIE RAILS AND LOAD ANCHOR POINTS

## WHAT ARE TIE RAILS AND LOAD ANCHOR POINTS?

- i** Tie rails and fixed anchor points, such as lashing rings, hooks and tie rail support points, are structures on a vehicle.

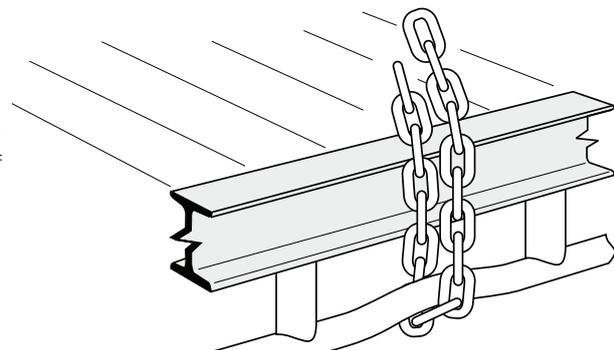
## WHEN TO USE TIE RAILS AND LOAD ANCHOR POINTS

- i** Tie rails and anchor points allow for lashings to be attached to vehicles for load restraint.

## HOW TO USE TIE RAILS AND LOAD ANCHOR POINTS

- ✓** Check attachment points have a suitable rating for both the weight of the load and methods of load restraint to be used.
- ⚠** The horizontal section of tie rails are not strong enough for use with chain lashings without bending – *Figure 474*.

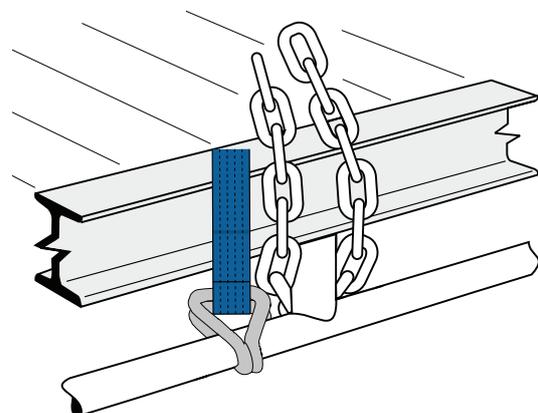
*Figure 474 Chain tied to the centre of the tie rail*



## WHERE TO LOCATE LASHINGS

- ✓** Secure the webbing strap tie-down lashings at or near the tie rail vertical support points on the horizontal rail – *Figure 475*.
- ✓** Secure the webbing strap direct lashings on the tie rail vertical supports.
- ✓** Secure the chain tie-down lashings or direct lashings on the tie rail vertical supports – *Figure 475*.

*Figure 475 Lashing tied to tie rail support*



- i** Tarpaulin ropes can be attached to tie rails at any point in their length because they are not used for load restraint.

- ✘ Do not tie lashings to the tie rails by knots – *Figure 477*.
- ⚠ Make sure hand ratchets and end fittings are not pressing against the coaming rail or the load because they might distort or bend – *Figure 476*.
- ⚠ Make sure chain grab hooks are attached to chain only. They must not be attached to coaming rail flanges or directly to the load unless specifically designed for that application.

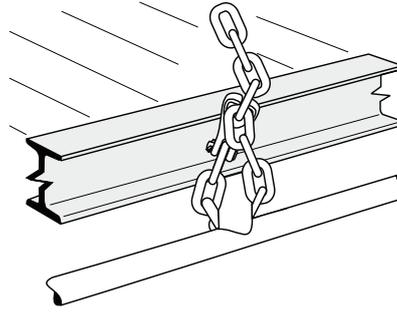
## CHECKLIST FOR CERTIFIERS AND DESIGNERS

- i** The maximum restraint force for tie-down applications where load shift cannot occur is the maximum pre-tension force exerted by the operator when tensioning the lashings (e.g. a webbing hand ratchet may have a lashing capacity of 2,500 kgf but the pretension is only 300 kgf).

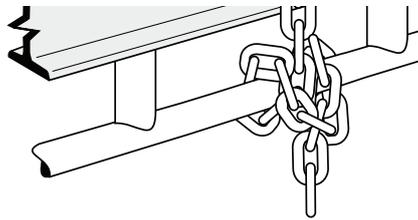
For proprietary anchor points, consider the average pre-tension listed in [Understanding how tie-down works](#), in the Overview.

- i** The maximum restraint force for direct restraint applications (mobile equipment) and tie-down applications where load shift can occur (tested and certified applications) is the effective lashing capacity of the lashing (usually chain).
- i** Lashing points on vehicles carried on roll-on roll-off vessels and on rail rolling stock require specific ratings for the application.
- i** Anchor points should be designed to withstand the expected minimum breaking load for the lashing(s) mounted at that point – *Figure 479*.
- i** When lashings are connected after bending around a tight corner, such as the coaming rail of a traditional type tie rail – *Figure 478*, most of the lashing tension will be transmitted into the coaming rail by friction. In such circumstances, an engineer may use testing, analysis or other means to determine an appropriate anchorage strength.

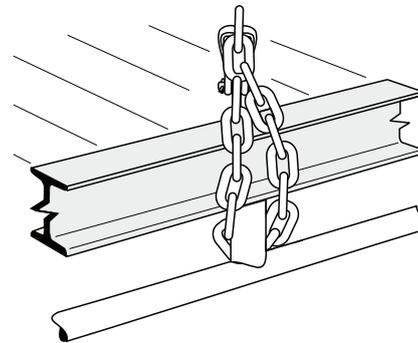
*Figure 476 Lashing end fitting in contact with coaming rail*



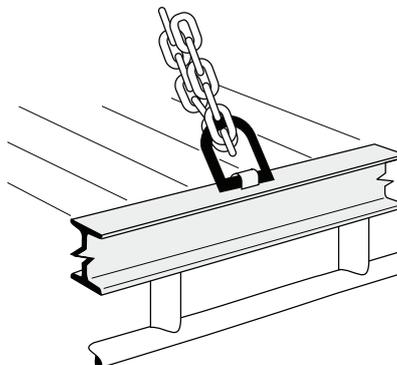
*Figure 477 Lashing tied with knot*



*Figure 478 Lashing end fitting above coaming rail*



*Figure 479 Lashing tied to anchor point*

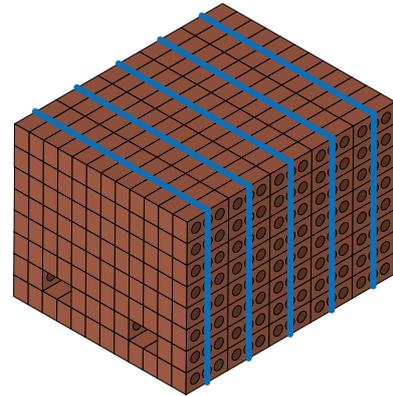


# STRAPPING

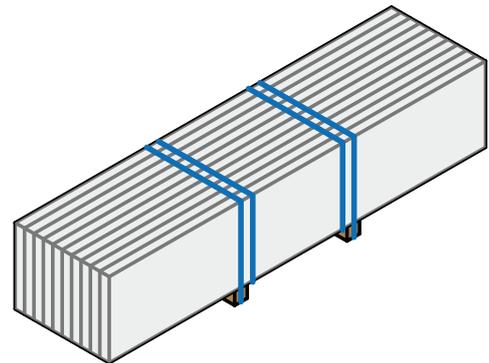
## WHEN TO USE STRAPPING

- i** Strapping can be steel, nylon or polyester and is used for unitising loads into packs or bundles – *Figure 480* and *Figure 481*.
- i** Loads with low-frictional surfaces require high clamping forces for effective restraint. Strapping is therefore very suitable for unitising and lashing heavy and slippery loads. Steel strapping is often used on container flats or bases.
- i** Steel strapping has a high tensile strength with minimal stretch. It is unaffected by heat or chemicals.
- i** Polyester strapping has a lower strength than steel. Polyester is ideal for strapping packs where some settlement may occur.

*Figure 480 Strapping used to unitise a load of bricks*



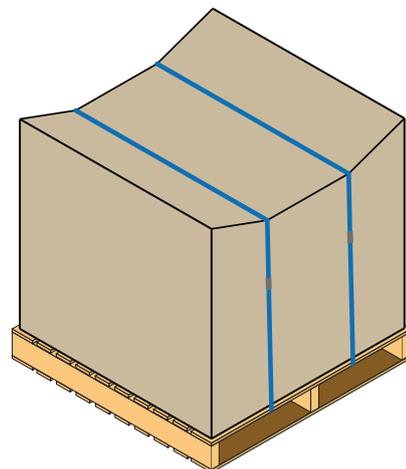
*Figure 481 Strapping used to unitise a load with dunnage*



- i** Strapping is very suitable as a lashing for heavy objects, especially on container flats and pallets.

- ✗** Steel strapping should not be used to tie down loads that can crush or settle because it may loosen during the journey – *Figure 482*.

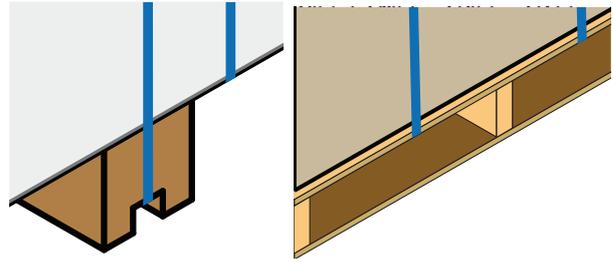
*Figure 482 Steel strapping should not be used on crushable items*



## HOW TO USE STRAPPING

- i** Strapping can be highly pre-tensioned using manual or powered tensioners.
- ⚠** Check the joint strength of strapping, as it is generally lower than the strapping strength; use the lower strength when calculating restraint requirements.
- i** The rating of a strapping assembly for lashing purposes should be no greater than half of its specified minimum breaking strength.
- i** When unitising multiple items onto a pallet or dunnage, place the strapping around the dunnage or pallet or, ideally, in rebates on the timber – *Figure 483*.
- i** Further requirements for strapping are contained in Australian Standard AS 2400.13 Packaging – Tensional Strapping.

*Figure 483 Strapping should go around the pallet or dunnage and load*



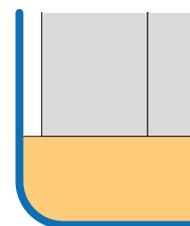
## WHAT TO LOOK FOR WHEN USING STRAPPING

- ✓** Monitor the load throughout the journey and re-tension any strapping that has slackened due to settlement of the load.
  - ⚠** Strapping used on loads prone to settling will slacken as the load settles, reducing its effectiveness as a restraint – *Figure 484*.
- ✓** Round or bevel any sharp timber corners on dunnage so that the timber is not crushed by the strapping – *Figure 485*.
  - ⚠** If the timber dunnage is crushed excessively, the strapping will loosen, reducing its effectiveness as a restraint – *Figure 486*.

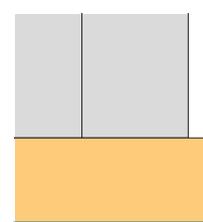
*Figure 484 Strapping should not be used on settling items*



*Figure 485 Strapping over a rounded corner*



*Figure 486 Strapping over a sharp corner*



# WORKING OUT LOAD RESTRAINT

This module includes detailed worked examples for a variety of load restraint cases. By going through the worked examples, you'll have a better understanding of how to work out how much load restraint you'll need for the load.

There are 12 case studies covered in this module. They are:

- |                 |   |
|-----------------|---|
| <b>Case 1:</b>  | <a href="#">Tie-down restraint with webbing straps</a><br><b>Load:</b> 3 rows of pallets blocked against a rated headboard<br><b>Vehicle:</b> A prime mover and flat-tray semitrailer combination<br><b>Equipment:</b> 50 mm webbing straps, truck winch                    |
| <b>Case 2:</b>  | <a href="#">Tie-down restraint with webbing straps</a><br><b>Load:</b> 5 rows of pallets unblocked<br><b>Vehicle:</b> A prime mover and flat-tray semitrailer combination<br><b>Equipment:</b> 50 mm webbing straps, truck winch  |
| <b>Case 3:</b>  | <a href="#">Tie-down restraint with chains</a><br><b>Load:</b> A stack of 2-tonne precast concrete panels<br><b>Vehicle:</b> A prime mover and flat-tray semitrailer combination<br><b>Equipment:</b> 8 mm transport chain, standard load binder                            |
| <b>Case 4:</b>  | <a href="#">Tie-down restraint with webbing straps</a><br><b>Load:</b> Bundles of plastic wrapped timberboard, pyramid stacked<br><b>Vehicle:</b> A prime mover and flat-tray semitrailer combination<br><b>Equipment:</b> 50 mm webbing straps, standard ratchet tensioner |
| <b>Case 5:</b>  | <a href="#">Direct restraint using simple rule</a><br><b>Load:</b> 4 tonne metal track equipment  |
| <b>Case 6:</b>  | <a href="#">Direct restraint using calculations</a><br><b>Load:</b> 15 tonne front-end loader   |
| <b>Case 7:</b>  | <a href="#">Direct restraint using calculations or load tables</a><br><b>Load:</b> 15 tonne front-end loader  |
| <b>Case 8:</b>  | <a href="#">Partially blocked load with rated curtains</a><br><b>Load:</b> Palletised freight blocked against headboard<br><b>Vehicle:</b> A prime mover and semitrailer with rated side curtains   |
| <b>Case 9:</b>  | <a href="#">Unblocked load with rated curtains</a><br><b>Load:</b> Palletised freight, unblocked at the rear of the vehicle<br><b>Vehicle:</b> A prime mover and semitrailer with rated side curtains   |
| <b>Case 10:</b> | <a href="#">Fully blocked load with rated curtains</a><br><b>Load:</b> Palletised freight, blocked in all directions<br><b>Vehicle:</b> A prime mover and semitrailer with rated side curtains  |
| <b>Case 11:</b> | <a href="#">Rated curtains with a mezzanine deck</a><br><b>Load:</b> Palletised freight<br><b>Vehicle:</b> A prime mover and semitrailer with rated side curtains and a mezzanine deck  |
| <b>Case 12:</b> | <a href="#">Multi-drop load with rated curtains</a><br><b>Load:</b> Palletised freight, multiple drop-offs<br><b>Vehicle:</b> A rigid truck with rated curtains   |

# TIE-DOWN RESTRAINT WORKED EXAMPLES

## CASE 1:

### TIE-DOWN RESTRAINT WITH WEBBING STRAPS

#### Load:

- 3 rows of pallets blocked against a rated headboard (the front portion indicated in – *Figure 487*).
- Each pallet weighs 700 kg. A row of pallets weighs 1,400 kg (2 pallets per row).

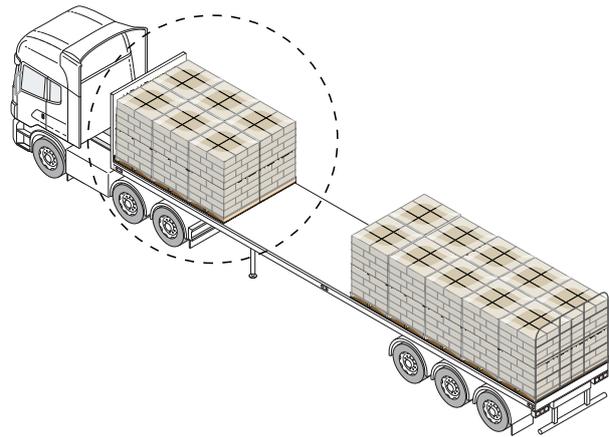
#### Vehicle:

- A prime mover and flat-tray semitrailer combination.

#### Equipment:

- Straps: 50 mm webbing straps.
- Tensioner: truck winch (average pre-tension 300 kgf).

*Figure 487 Pallets blocked against a rated headboard – front portion of the load*



## IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

### Step 1:

#### Which part of the load do I want to restrain?

I want to restrain the 3 rows of pallets at the front of the truck. These pallets are positioned at the front of the truck, against the headboard.

### Step 2:

#### What vehicle will I use?

A prime mover and flat-tray semitrailer combination.

### Step 3:

#### What restraint equipment will I use?

Webbing straps (50 mm) and truck winch (average pre-tension: **300 kgf**).

- ✓ Check what level of tension you can get with your equipment.
- ✓ Check your equipment is rated.
- ⚠ Unrated equipment should not be used for restraint purposes.

## CHOOSE A SENSIBLE RESTRAINT METHOD:

### Step 4:

#### What restraint methods may be suitable for my combination of load, vehicle and equipment?

For this example, **tie-down restraint** is a suitable restraint method based on the load type, the vehicle and the equipment available.



Check the load type.

This is a load of pallets – see [Packs, pallets and stillages](#) for more information on suitable restraint methods.

See the [Loads module](#) for information on other load types.



Check how to use the equipment correctly.

See the [Vehicle and equipment module](#) for more information.

### Step 5:

#### Can I block the load?

**Yes** – this part of the load can be **BLOCKED** against the rated headboard (capable of withstanding 0.3 of the total load weight).



Position the load against the headboard, or with a small gap (no more than 200 mm from the headboard).



Block the load tightly so the sum of any gaps along the trailer (front to rear of the load) is less than 200 mm.



A load is not regarded as blocked if it is greater than 200 mm away from the headboard or the cumulative amount of gaps along the trailer (front to rear) is greater than 200 mm.

## WORK OUT THE NUMBERS:

### Step 6:

#### What is the mass of the load?

The mass of a **row** of pallets is **1,400 kg** (2 pallets at 700 kg each).



Restrain each row **separately**.



Simply restraining the front and rear rows **WILL NOT** provide adequate restraint to meet the Performance Standards.



If you underestimate the mass, you are likely to put yourself and others at risk due to insufficient restraint. Double-check your calculations!

### Step 7:

#### How much friction?

The load is **timber** pallets on a **steel** flat-tray truck. The friction level is **MEDIUM**.



For a list of typical friction levels see [Table 1: Typical friction levels](#).



Friction levels within a load can vary. You need to design your tie-down restraint system for the lowest friction level. This is where the load is most likely to fail.

Step 8:  
**How many lashings do I need?**  
**EASY OPTION – USE THE TABLES**

Recheck the following to make sure the calculation is correct:

- Lashing pre-tension amount **(Step 3)** **300 kgf**
- Blocking **(Step 5)** **BLOCKED**
- Load weight **(Step 6)** **1,400 kg**
- Friction level **(Step 7)** **MEDIUM**

For this example, assume a **lashing angle greater than 60°**.

The table below outlines the number of lashings needed to restrain the **load weight** when using 50 mm webbing straps with a lashing pre-tension of **300 kgf** if the load is **BLOCKED** and has a **MEDIUM** level of friction.

Lashings:	Tensioner:		Pre-tension:			
50 mm webbing straps	Push-up hand ratchet or truck winch		300 kgf			
<b>BLOCKED</b> (RESTRAINED TO 0.5G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	2	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	3	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	4	9,200 kg	8,300 kg	6,700 kg	4,800 kg	2,400 kg
	5	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	6	13,000 kg	12,000 kg	10,000 kg	7,200 kg	3,700 kg
	7	16,000 kg	14,000 kg	11,000 kg	8,400 kg	4,300 kg
	8	18,000 kg	16,000 kg	13,000 kg	9,600 kg	4,900 kg
	9	20,000 kg	18,000 kg	15,000 kg	10,000 kg	5,500 kg
	10	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg

**Table note:** Blocked load tables are based on a headboard capable of withstanding forces from 0.3 g. If the headboard used provides less than 0.3 g forward restraint, use the unblocked table to calculate the number of lashings required.

Based on a lashing angle greater than 60°, when a load is **BLOCKED** and the friction level is **MEDIUM**, one 50 mm webbing strap can restrain **2,000 kg**.

The **load weight 1,400 kg** (per row of pallets) is under **2,000 kg**. Therefore, **one strap for a row of pallets** is needed.

To calculate the restraint requirements for different equipment and friction levels see the [tie-down lashing tables](#).

**Tips:**

**Block loads if possible.** Unblocked loads will need a lot more lashings because the tie-downs need to resist the potential forward forces (equivalent to 80% of the weight).

**Increasing friction levels** can reduce the number of lashings needed. Friction can be increased using interlayer packaging or dunnage.

**Keep lashing angles greater than 60°** wherever possible. The lower the lashing angle the less effective the tie-down lashing will be. Lashing angles can be increased by using dunnage.

## CASE 2:

### TIE-DOWN RESTRAINT WITH WEBBING STRAPS

**Load:**

- 5 rows of pallets that are unblocked (the rear portion – *Figure 488*).
- Each pallet weighs 700 kg. A row of pallets weighs 1,400 kg (2 pallets per row).

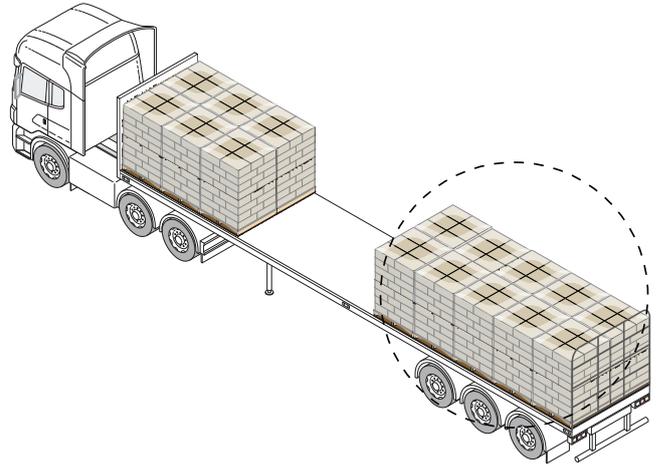
**Vehicle:**

- A prime mover and flat-tray semitrailer combination.

**Equipment:**

- Straps: 50 mm webbing straps.
- Tensioner: truck winch (average pre-tension 300 kgf).

*Figure 488 Unblocked pallets – rear portion of the load*



## IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

**Step 1:**

### Which part of the load do I want to restrain?

I want to restrain the 5 rows of pallets at the rear of the truck.

**Step 2:**

### What vehicle will I use?

A prime mover and flat-tray semitrailer combination.

**Step 3:**

### What restraint equipment will I use?

Webbing strap (50 mm) and truck winch (average pre-tension: **300 kgf**).

- ✓ Check what level of tension you can get with your equipment.
- ✓ Check your equipment is rated.
- ⚠ Unrated equipment should not be used for restraint purposes.

## CHOOSE A SENSIBLE RESTRAINT METHOD:

Step 4:

### What restraint methods may be suitable for my combination of load, vehicle and equipment?

For this example, **tie-down restraint** is a suitable restraint method based on the load type, the vehicle and the equipment available.

✓ Check the load type.

This is a load of pallets – see [Packs, pallets and stillages](#) for more information on suitable restraint methods.

See the [Loads module](#) for information on other load types.

✓ Check how to use the equipment correctly.

See the [Vehicle and equipment module](#) for more information.

Step 5:

### Can I block the load?

In this case, the rear portion of the load is **UNBLOCKED**. Tie-down needs to provide all the restraint.

⚠ Unblocked loads will need a lot more lashings because the tie-downs need to resist the potential forward forces (equivalent to 80% of the weight). The lashing count may be double or more than of blocked loads in many cases.

## WORK OUT THE NUMBERS:

Step 6:

### What is the mass of the load?

The mass of a row of pallets is **1,400 kg** (2 pallets at 700 kg each).

✓ Restrain each row **separately**.

⚠ Simply restraining the front and rear rows **WILL NOT** provide adequate restraint to meet the Performance Standards.

⚠ If you underestimate the mass, you are likely to put yourself and others at risk due to insufficient restraint. Double-check your calculations!

Step 7:

### How much friction?

The load is **timber** pallets on a **steel** flat-tray truck. The friction level is **MEDIUM**.

📘 For a list of typical friction levels see [Table 1: Typical friction levels](#).

⚠ Friction levels within a load can vary. You need to design your tie-down restraint system for the lowest friction level. This is where the load is most likely to fail.

#### Tips:

💡 If your friction level is low you can improve the friction by using higher friction rubbers/load mats or interlayer packaging material.

📘 See [Interlayer packaging](#) for more information.

Step 8:  
**How many lashings do I need?**  
**EASY OPTION – USE THE TABLES**

Recheck the following to make sure the calculation is correct:

- Lashing pre-tension amount (**Step 3**) **300 kgf**
- Blocking (**Step 5**) **UNBLOCKED**
- Load weight (**Step 6**) **1,400 kg**
- Friction level (**Step 7**) **MEDIUM**

For this example, assume you can get a **lashing angle greater than 60°**.

The table below outlines the number of lashings needed to restrain the **load weight** when using 50 mm webbing straps with a lashing pre-tension of **300 kgf** if the load is **UNBLOCKED** and a **MEDIUM** level of friction.

Lashings:		Tensioner:		Pre-tension:		
50 mm webbing straps		Push-up hand ratchet or truck winch		300 kgf		
<b>UNBLOCKED</b> (RESTRAINED TO 0.8G)						
Number of lashings		Lashing angle (from horizontal)				
		At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	570 kg	510 kg	420 kg	300 kg	150 kg
	2	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	3	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	4	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	5	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	6	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	7	4,000 kg	3,600 kg	2,900 kg	2,100 kg	1,000 kg
	8	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	9	5,200 kg	4,600 kg	3,800 kg	2,700 kg	1,300 kg
	10	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg

The load weight is **1,400 kg** (per row of pallets). Based on a **lashing angle greater than 60°**, when a load is **UNBLOCKED** and the friction level is **MEDIUM**, 3x 50 mm webbing strap can restrain **1,500 kg**. Therefore, **3 straps for each row of pallets** is needed.

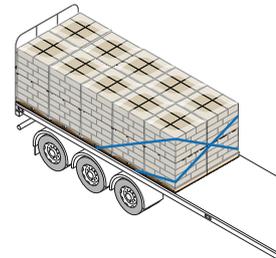
-  Note that each row of pallets needs 3 straps, not just the front row. All rows have the forward force.
-  3 straps per row seems a lot, but this is what is required if the front of the load is not blocked forwards.

**Tips:**

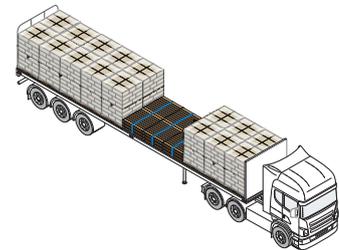
-  To reduce the number of straps required you can block with:
  - crossover straps – [Figure 489](#), or
  - stacked pallets – [Figure 490](#), or
  - a pallet on end tied back a ‘de facto’ headboard – [Figure 491](#).

To calculate the restraint requirements for different equipment and friction levels see the tie-down lashing tables.

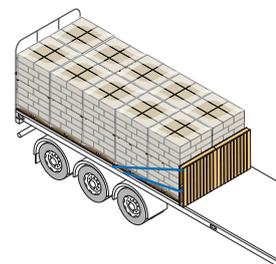
*Figure 489 Crossover straps*



*Figure 490 Stacked pallets*



*Figure 491 Pallet on end tied back*



## CASE 3: TIE-DOWN RESTRAINT WITH CHAINS

### Load:

- A stack of 2-tonne precast concrete panels (4 panels) – *Figure 492*.
- Each panel weighs 2 tonnes. The total mass is 8 tonnes.

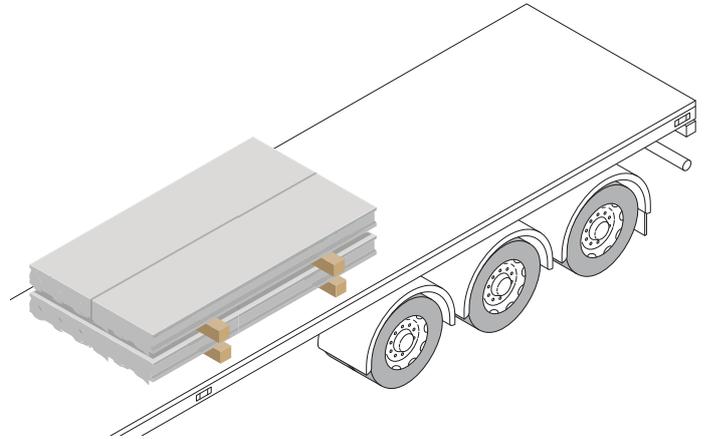
### Vehicle:

- A prime mover and flat-tray semitrailer combination.

### Equipment:

- Chain: 8 mm transport chain.
- Tensioner: standard load binder (average pre-tension 750 kgf).

*Figure 492 Precast concrete panels on a flat tray*



## IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

### Step 1:

#### Which part of the load do I want to restrain?

I want to restrain the entire stack of precast concrete panels.

### Step 2:

#### What vehicle will I use?

A prime mover and flat-tray semitrailer combination.

### Step 3:

#### What restraint equipment will I use?

Transport chain (8 mm) and standard load binder (average pre-tension: **750 kgf**).

- ✓ Check what level of tension you can get with your equipment.
- ✓ Check your equipment is rated.
- ⚠ Unrated equipment should not be used for restraint purposes.

## CHOOSE A SENSIBLE RESTRAINT METHOD:

### Step 4:

#### What restraint methods may be suitable for my combination of load, vehicle and equipment?

For this example, **tie-down restraint** is a suitable restraint method based on the load type, the vehicle and the equipment available.



Check the load type.

This is a load of precast concrete panels.

See the [Loads module](#) for information on other load types.



Check how to use the equipment correctly.

See the [Vehicle and equipment module](#) for more information.

### Step 5:

#### Can I block the load?

In this case, it is impractical to block the load. As the load is **UNBLOCKED** tie-down needs to provide all the restraint.



Unblocked loads will need a lot more lashings because the tie-downs need to resist the potential forward forces (equivalent to 80% of the weight).

## WORK OUT THE NUMBERS:

### Step 6:

#### What is the mass of the load?

The mass of the load is 8 tonnes (**8,000 kg**).



If you underestimate the mass, you are likely to put yourself and others at risk due to insufficient restraint. Double-check your calculations!

### Step 7:

#### How much friction?

The load is precast concrete panels on **timber** dunnage on a **steel** flat-tray truck. The friction level is **MEDIUM**.



For a list of typical friction levels see [Table 1: Typical friction levels](#).



Friction levels within a load can vary. You need to design your tie-down restraint system for the lowest friction level. This is where the load is most likely to fail.

#### Tips:



If your friction level is low you can improve the friction by using higher friction rubber/load mats or interlayer packaging material.



See [Interlayer packaging](#) for more information.

Step 8:  
**How many lashings do I need?**  
**EASY OPTION – USE THE TABLES**

Recheck the following to make sure the calculation is correct:

- Lashing pre-tension amount **(Step 3)** **750 kgf**
- Blocking **(Step 5)** **UNBLOCKED**
- Load weight **(Step 6)** **8,000 kg**
- Friction level **(Step 7)** **MEDIUM**

For this example, assume a **lashing angle greater than 60°**.

The table below outlines the number of lashings needed to restrain the **load weight** when using 8 mm transport chains with a lashing pre-tension of **750 kgf** if the load is **UNBLOCKED** and a **MEDIUM** level of friction.

Lashings:		Tensioner:			Pre-tension:	
8 mm transport chain		Over-centre tensioner			750 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	2	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	3	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	4	5,700 kg	5,100 kg	4,200 kg	4,200 kg	1,500 kg
	5	7,200 kg	6,400 kg	5,300 kg	5,300 kg	1,900 kg
	6	8,600 kg	7,700 kg	6,300 kg	6,300 kg	2,300 kg
	7	10,000 kg	9,000 kg	7,400 kg	7,400 kg	2,700 kg
	8	11,000 kg	10,000 kg	8,400 kg	8,400 kg	3,100 kg
	9	13,000 kg	11,000 kg	9,500 kg	9,500 kg	3,400 kg
	10	14,000 kg	12,000 kg	10,000 kg	10,000 kg	3,800 kg

To calculate the restraint requirements for different equipment and friction levels see the [tie-down lashing tables](#).

The load weight is **8,000 kg**. Based on a **lashing angle greater than 60°**, when a load is **UNBLOCKED** and the friction level is **MEDIUM**, 7x 8 mm transport chains can restrain **9,000 kg**. Therefore, **7 chains** are needed to restrain this load.

- i** This stack needs 7 chains. At least half of these chains needs to be placed over the top layer. The top layer needs at least 4 chains (enough to restrain that layer, with the “extra” tension contributing to restraining the bottom layer) and the other lower layer could use the other 3 chains. Alternatively all 7 chains could be over the whole stack.

**!** 7 chains per stack seems a lot, but this is what is required if the front of the load is not blocked.

**Tips:**

- 💡** Reduce the number of chains by blocking.
- 💡** You can block with direct restraint crossover chains or by placing the load against a step deck or rated headboard.

## CASE 4: TIE-DOWN RESTRAINT WITH WEBBING STRAPS

### Load:

- Bundles of timberboard plastic wrapped, pyramid stacked (3 bundles) – *Figure 493*.
- Each bundle weighs 500 kg. The total mass of the load is 1,500 kg.

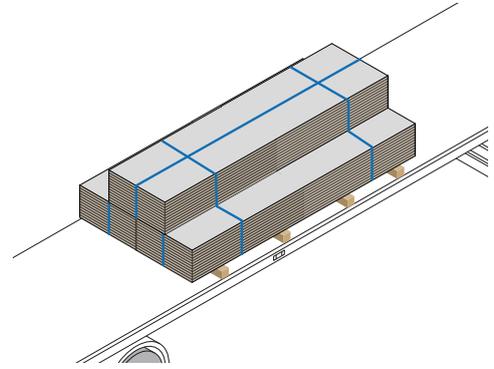
### Vehicle:

- A prime mover and flat-tray semitrailer combination.

### Equipment:

- Lashing: 50 mm webbing straps.
- Tensioner: standard ratchet tensioner (average pre-tension 300 kgf).

*Figure 493 Pyramid stacked timberboard with plastic wrapping*



## IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

### Step 1:

#### Which part of the load do I want to restrain?

I want to restrain the 3 bundles of timber in the middle of the truck.

### Step 2:

#### What vehicle will I use?

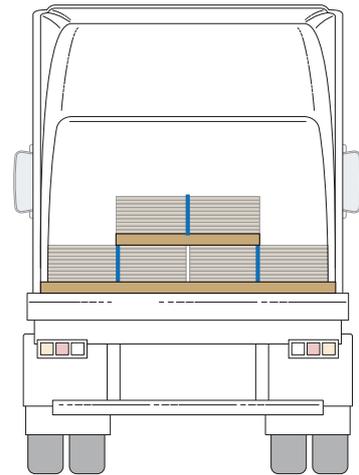
A prime mover and flat-tray semitrailer combination.

### Step 3:

#### What restraint equipment will I use?

Webbing strap (50 mm) and ratchet tensioner (average pre-tension: **300 kgf**).

- ✓ Check what level of tension you can get with your equipment.
- ✓ Check your equipment is rated.
- ⚠ Unrated equipment should not be used for restraint purposes.



## CHOOSE A SENSIBLE RESTRAINT METHOD:

Step 4:

### What restraint methods may be suitable for my combination of load, vehicle and equipment?

For this example, **tie-down restraint** is a suitable restraint method based on the load type, the vehicle and the equipment available.

✓ Check the load type.

This is a load of timber – see [Packs, pallets and stillages](#) for more information on suitable restraint methods.

See the [Loads module](#) for information on other load types.

✓ Check how to use the equipment correctly.

See the [Vehicle and equipment module](#) for more information.

Step 5:

### Can I block the load?

In this case, the load is **UNBLOCKED**.  
Tie-down needs to provide all the restraint.

⚠ Unblocked loads will need a lot more lashings, because the tie-downs need to resist the potential forwards forces (equivalent to 80% of the weight).

## WORK OUT THE NUMBERS:

Step 6:

### What is the mass of the load?

The mass of the top portion of the load is **500 kg**. The total mass of the timber bundles is **1,500 kg**.

⚠ Simply restraining for the entire load mass in this situation could lead to the top layer potentially being under restrained.

⚠ If you underestimate the mass, you are likely to put yourself and others at risk due to insufficient restraint. Double-check your calculations!

## Step 7: How much friction?

 There are **2 different friction levels** in this load.  
You should:

-  Calculate the number of lashings required to **restrain the portion of the load with the lowest friction.**
-  Check that the number of lashings is enough to restrain the **entire mass of the load.**

In this example, the **top portion** of the load is plastic on plastic (one plastic wrapped bundle sitting on top of the other plastic wrapped bundles). Plastic on plastic is very slippery and therefore has a **VERY LOW** friction level.

For the **bottom portion**, the load is timber dunnage on a steel flat-tray truck. The friction level is **MEDIUM**.

 For a list of typical friction levels see [Table 1: Typical friction levels](#).

## Step 8: How many lashings do I need? EASY OPTION – USE THE TABLES

### Top portion:

Recheck the following to make sure the calculation is correct:

Lashing pre-tension amount ( <b>Step 3</b> )	<b>300 kgf</b>
Blocking ( <b>Step 5</b> )	<b>UNBLOCKED</b>
Load weight ( <b>Step 6</b> )	<b>500 kg</b> <b>(top bundle only)</b>
Friction level ( <b>Step 7</b> )	<b>VERY LOW</b>

We assume you can only get a **lashing angle of 45°** when restraining the top portion; however, you can get a **lashing angle greater than 75°** when strapping the entire load.

### Tips:

 If your friction level is low you can improve the friction by using higher friction rubbers/load mats or interlayer packaging material.

 See [Interlayer packaging](#) for more information.

The table below outlines the number of lashings needed to restrain the **load weight** when using 50 mm webbing straps with a lashing pretension of **300 kgf** if the load is **UNBLOCKED** and it has a **VERY LOW** level of friction.

Lashings:	Tensioner:		Pre-tension:			
50 mm webbing straps	Push-up hand ratchet or truck winch		300 kgf			
<b>UNBLOCKED</b> (RESTRAINED TO 0.8G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on timber			
	1	190 kg	170 kg	140 kg	100 kg	51 kg
	2	380 kg	340 kg	280 kg	200 kg	100 kg
	3	570 kg	510 kg	420 kg	300 kg	150 kg
	4	770 kg	690 kg	560 kg	400 kg	200 kg
	5	960 kg	860 kg	700 kg	500 kg	250 kg
	6	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	7	1,300 kg	1,200 kg	980 kg	700 kg	360 kg
	8	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	9	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	10	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg

The load mass is **500 kg** (for the top bundle). Based on a **lashing angle of 45°**, when a load is **UNBLOCKED** and the friction level is **VERY LOW**, 4x 50 mm webbing straps can restrain **560 kg**. Therefore, **4 straps** are needed to restrain this portion of the load.

### Entire load:

The table below outlines the number of lashings needed to restrain the **load weight** when using 50 mm webbing straps with a pre-tension of **300 kgf** if the load is **UNBLOCKED** and a **MEDIUM** level of friction.

Lashings:	Tensioner:		Pre-tension:			
50 mm webbing straps	Push-up hand ratchet or truck winch		300 kgf			
<b>UNBLOCKED</b> (RESTRAINED TO 0.8G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	570 kg	510 kg	420 kg	300 kg	150 kg
	2	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	3	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	4	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	5	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	6	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	7	4,000 kg	3,600 kg	2,900 kg	2,100 kg	1,000 kg
	8	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	9	5,200 kg	4,600 kg	3,800 kg	2,700 kg	1,300 kg
	10	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg

To calculate the restraint requirements for different equipment and friction levels see the [tie-down lashing tables](#).

The load weight is **1,500 kg** (entire mass of the load). Based on a **lashing angle greater than 75°**, when a load is **UNBLOCKED** and the friction level is **MEDIUM**, 3x 50 mm webbing straps can restrain 1,700 kg. Therefore, at least **3 straps** are needed to restrain the entire load.

✔ Choose the highest number of lashings.

The highest number of straps should be used to ensure the load is adequately restrained. Therefore **4 straps** are needed to restrain the entire load.

⚠ Friction levels within a load can vary. You need to design your tie-down restraint system for the lowest friction level. This is where the load is most likely to fail.

# DIRECT RESTRAINT WORKED EXAMPLES

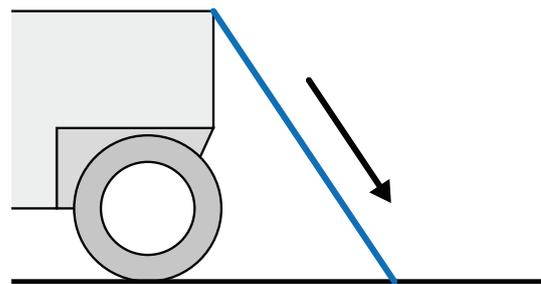
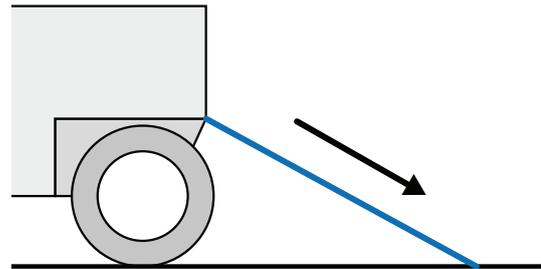
## USEFUL INFORMATION

**i** With direct restraint, the goal is to determine **what strength lashings** is needed to adequately restrain the load mass. This will be affected by the **direct lashing angle effect**.

**⚠** When using direct restraint, the **direct lashing angle** should be as low as possible – [Figure 494](#).

**This is opposite to the tie-down restraint method.**

*Figure 494 Keeping the direct lashing angle as low as possible*

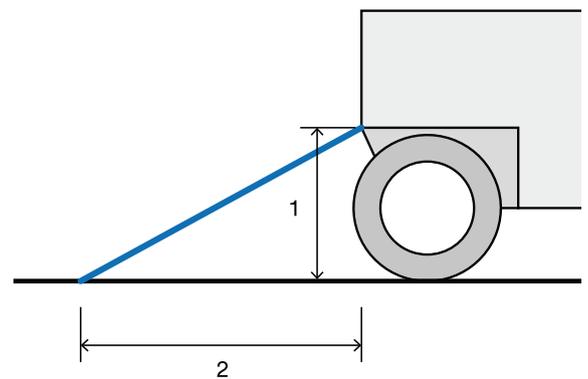


**✓** A good rule of thumb for direct lashings is a slope of 1 in 2 or approximately 25° from the horizontal – this will give you a direct lashing angle effect of 0.9 or 90% effectiveness – [Figure 495](#).

**✓** Remember to check your direct lashing angles for all directions of movement (forwards, backwards and sideways).

**✓** For more information on direct lashing angles see [Lashing angles](#).

*Figure 495 Slope of 1 in 2*



## CASE 5: DIRECT RESTRAINT USING SIMPLE RULE

### Load:

- 4-tonne metal track equipment.

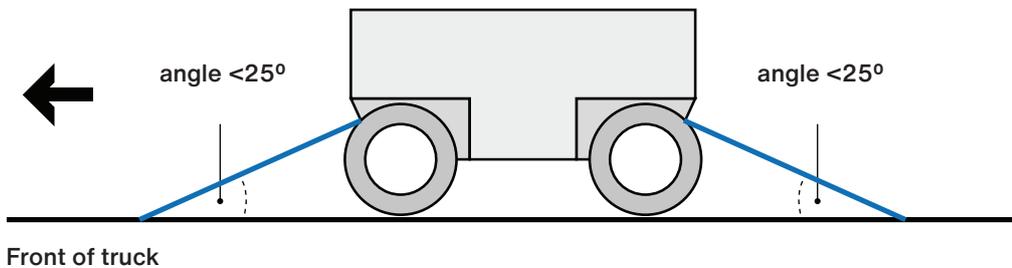
### Direct lashing angles

 To use this simple rule your direct lashing angle should be less than 25° from the horizontal – [Figure 496](#). All lashings should be the same type, of similar lengths, and 45° from the relevant restraint directions – [Figure 497](#).

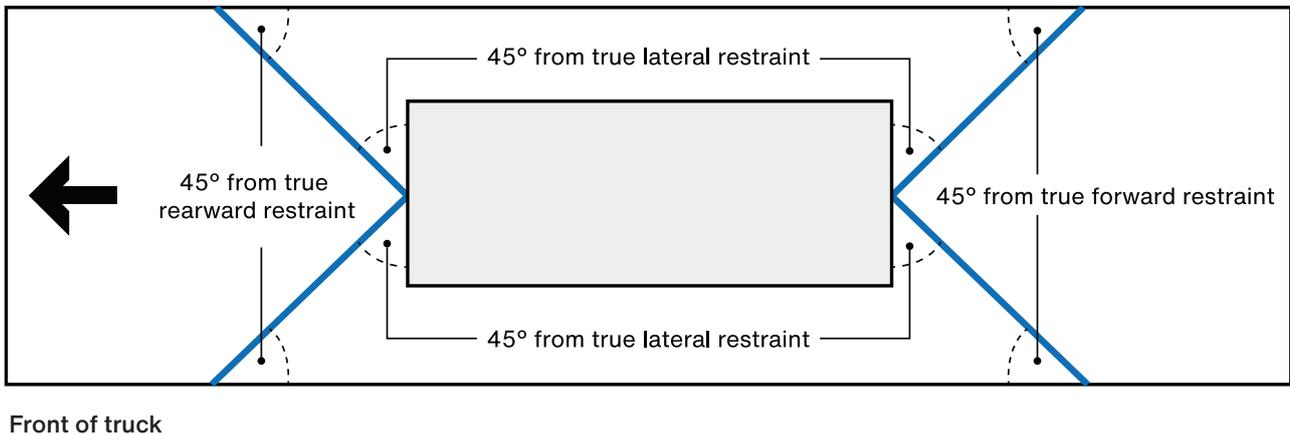
### Note:

This rule can only be used if the lashings are all 25° or less from the horizontal. If lashings are any steeper, you need to use an alternative method (see [Cases 6 and 7](#)).

*Figure 496 25° from the horizontal*



*Figure 497 45° from the relevant restraint direction*



-  Check your direct lashing angles for all directions of movement (forwards, backwards and sideways).

The simple rule is to select lashings whose combined lashing capacity is:

- in the forward direction = **twice the weight of the load** (i.e. each lashing has a capacity that matches the weight of the load).
- in the sideways direction = **the weight of the load**.
- in the rearward direction = **the weight of the load** (i.e. each lashing has a capacity that matches half of the weight of the load).

Step 1:

### What is the mass of the load?

The total mass of the load is **4,000 kg**.

Step 2:

### What capacity lashing do you need for forward restraint?

Each lashing must have a capacity of **4,000 kg**, to match the weight of the load to be restrained. Combined, they have a capacity that matches twice **the weight of the load**.

Step 3:

### What capacity lashing do you need for sideways restraint?

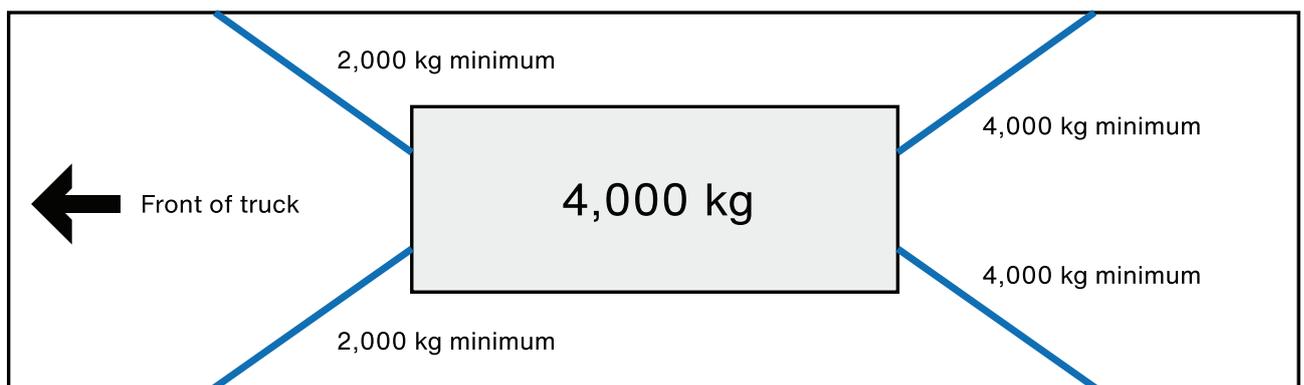
Each lashing must have a capacity of **2,000 kg** to match half the weight of the load to be restrained. Combined, they have a capacity that matches **the weight of the load**.

Step 4:

### What capacity lashing do you need for rearward restraint?

Each lashing must have a capacity of **2,000 kg** to match half the weight of the load to be restrained. Combined, they have a capacity that matches **the weight of the load**.

Figure 498 Lashing capacity



The rear lashings provide both sideways and forward restraint.

## CASE 6: DIRECT RESTRAINT USING CALCULATIONS

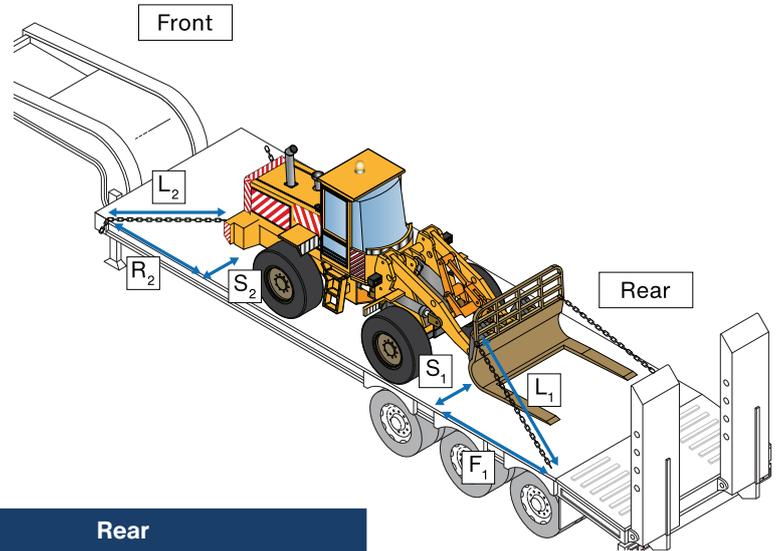
### Load:

- 15 tonne front-end loader – *Figure 499*.

*Figure 499 Front-end loader*

### Direct lashing angles:

- For this example, we will determine the direct lashing angle effect using a simple calculation. To do this we need to know the following information.



	Front	Rear
Lashing (chain) length	3,500 mm (L2 in diagram)	3,500 mm (L1 in diagram)
Distance between the tie points along the trailer	3,400 mm (R2 in diagram)	3,400 mm (F1 in diagram)
Distance between the tie points across the trailer	300 mm (S2 in diagram)	300 mm (S1 in diagram)

### Step 1:

#### What is the mass of the load?

The total mass of the load is **15,000 kg**.

### Step 2:

#### What is your direct lashing angle effect in the forward direction?

The **rear** chains provide the forward restraint.

To determine the **forward direct angle effect** divide the **distance between the tie points along the truck (F1)** by the **lashing length (L1)**:

$$3,400 (F1) \div 3,500 (L1) = 0.97 \text{ (forward direct angle effect)}$$

**i** For more information see [Lashing angles](#).

## Step 3:

**What is your direct lashing angle effect in the sideways direction?**

Both the **front and rear** chains provide the sideways restraint. To determine the **sideways direct angle effect** divide the **distance between the tie points across the truck** by the **lashing length** for both chains:

**Front chain**     $300 (S2) \div 3,500 (L2) = 0.086$  (sideways direct angle effect)

**Rear chain**     $300 (S1) \div 3,500 (L1) = 0.086$  (sideways direct angle effect)



**0.086 sideways direct angle effect is very low.**

At this angle the direct lashing will have less than 9% effectiveness in the sideways direction.

To meet the sideways restraint requirement of 7,500 kg (50% of the load mass), each chain would need to restrain 3,750 kg. With only a 9% level of effectiveness, the chain's **lashing capacity would need to be 43,750 kg**. There are no chains available to provide this capacity.



Do not transport this load until you have properly restrained it.



The sideways direct angle effect can be improved by **increasing the distance between tie points across the truck**. This can be done by using a diagonal tie point. See worked example [Case 7](#).

## CASE 7: DIRECT RESTRAINT USING CALCULATIONS OR LOAD TABLES

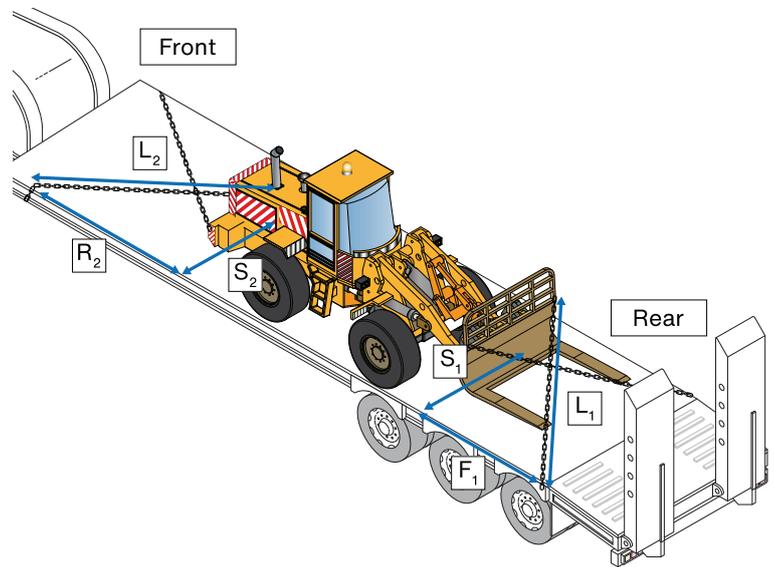
### Load:

- 15 tonne front-end loader – *Figure 500*.

### Direct lashing angles:

- For this example, we will determine the direct lashing angle effect using a simple calculation. To do this we need to know the following information.

*Figure 500 Front-end loader*



	FRONT	REAR
Lashing (chain) length* *longer chains used to cross the deck	4,000 mm (L2 in diagram)	4,000 mm (L1 in diagram)
Distance between the tie points along the trailer	3,400 mm (R2 in diagram)	3,400 mm (F1 in diagram)
Distance between the tie points across the trailer	2,000 mm (S2 in diagram)	2,000 mm (S1 in diagram)

### Step 1:

#### What is the mass of the load?

The total mass of the load is **15,000 kg**.

### Step 2:

#### What is your direct lashing angle effect in the forward direction?

The **rear** chains provide the forward restraint.

To determine the **forward direct angle effect** divide the **distance between the tie points along the truck (F1)** by the **lashing length (L1)**:

**3,400 (F1) ÷ 4,000 (L1) = 0.85** (forward direct angle effect)

**i** For more information see [Lashing angles](#).

## Step 3:

**What is your direct lashing angle effect in the sideways direction?**

Both the **front and rear** chains provide the sideways restraint. To determine the **sideways direct angle effect** divide the **distance between the tie points across the truck** by the **lashing length** for both chains:

**Front chain**                       $2,000 (S2) \div 4,000 (L2) = 0.5$  (sideways direct angle effect)

**Rear chain**                         $2,000 (S1) \div 4,000 (L1) = 0.5$  (sideways direct angle effect)

**i** For more information see [Lashing angles](#).

## Step 4:

**What is your direct lashing angle effect in the rearward direction?**

The **front** chains provide the rearward restraint.

To determine the **rearward direct angle effect** divide the **distance between the tie points along the truck (R2)** by the **lashing length (L2)**:

$3,400 (R2) \div 4,000 (L2) = 0.85$  (rearward direct angle effect)

**i** For more information see [Lashing angles](#).

## Step 5:

**What strength lashings is needed to restrain the load? CALCULATION**

To restrain a **15,000 kg** load the following strength lashing is needed:

DIRECTION	RESTRAINT REQUIRED		REQUIRED LASHING STRENGTH (PER LASHING)	FOR EXAMPLE (FROM TABLE 4)
Forwards (80% of the weight)	12,000 kg (6,000 kg per lashing)	0.85	$6,000 \text{ kg} \div 0.85 = 7,059 \text{ kg}$	13 mm transport chain with claw hooks or winged grab hooks
Sideways (50% of the weight)	7,500 kg (3,750 kg per lashing)	0.50	$3,750 \text{ kg} \div 0.50 = 7,500 \text{ kg}$	13 mm Grade 'T' chain hooks or winged grab hooks
Rearwards (50% of the weight)	7,500 kg (3,750 kg per lashing)	0.85	$3,750 \text{ kg} \div 0.85 = 4,412 \text{ kg}$	10 mm transport chain with claw hooks or winged grab hooks

**Note:** Chain capacity is reduced by 25% due to contact with coaming rail.

**Taking the highest lashing strength required (7,500 kg), a 13 mm Grade 'T' chain with claw hooks** or winged grab hooks is necessary in **all directions** to restrain the load.

**i** For more information see [Table 4 Typical lashing capacity – chain](#) or [Table 3 Typical lashing capacity – ropes and webbing straps](#).

**i** The lashing strength is the lashing capacity or manufacturer's rating, which should be marked on the lashing.

**⚠** Chains should be of the same length and at the same angle to be considered working together.

Step 5 (ALTERNATIVE):  
**What strength lashings is needed to restrain the load?**  
**USING LOAD TABLES**

Once you know the direct angle effect for each direction, you can also use the load tables to determine the lashing strength you need.

- i** For **forward direction restraint**, see [Table 9 Minimum lashing capacity – direct restraint forwards \(80% of load weight\) using 2 chains](#).
- i** For **sideways and rearward** direction restraint, see [Table 10 Minimum lashing capacity – direct restraint sideways or rearwards \(50% of load weight\) using 2 chains](#).

The **forward direct angle effect is 0.85** (see Step 2). To restrain a **15,000 kg** load in the forward direction a lashing strength of **7.1 tonne** is needed. For example (from Table 4), a **13 mm Grade 'T' transport chain with claw hooks or winged grab hooks**.

MINIMUM LASHING CAPACITY – DIRECT RESTRAINT FORWARDS (80% OF LOAD WEIGHT) USING 2 CHAINS			
Mass of load (kilograms) (tonnes)	Angle effect AE = >0.85	Angle effect AE = >0.70	Angle effect AE = >0.50
3	1.5	1.8	2.4
4	1.9	2.3	3.2
5	2.4	2.9	4.0
6	2.9	3.5	4.8
7	3.3	4.0	5.6
8	3.8	4.6	6.4
9	4.3	5.2	7.2
10	4.8	5.8	8.0
11	5.2	6.3	8.8
12	5.7	6.9	9.6
13	6.2	7.5	10.4
14	6.6	8.0	11.2
15	7.1	8.6	12.0

The **sideways direct angle effect is 0.50** (see Step 3). To restrain the **15,000 kg** load in the sideways direction a lashing strength of **7.5 tonne** is needed. For example (from Table 4), a **13 mm Grade 'T' transport chain with claw hooks or winged grab hooks**.

#### MINIMUM LASHING CAPACITY – DIRECT RESTRAINT SIDEWAYS OR REARWARDS (50% OF LOAD WEIGHT) USING 2 CHAINS

Mass of load (kilograms) (tonnes)	Angle effect AE = >0.85	Angle effect AE = >0.70	Angle effect AE = >0.50
3	0.9	1.1	1.5
4	1.2	1.5	2.0
5	1.5	1.8	2.5
6	1.8	2.2	3.0
7	2.1	2.5	3.5
8	2.4	2.9	4.0
9	2.7	3.3	4.5
10	3.0	3.6	5.0
11	3.3	4.0	5.5
12	3.6	4.3	6.0
13	3.9	4.7	6.5
14	4.2	5.0	7.0
15	4.5	5.4	7.5

The **rearwards direct angle effect is 0.85** (see Step 4). To restrain a **15,000 kg** load in the rearwards direction a lashing strength of **4.5 tonne** is needed. For example (from Table 4), a **10 mm transport chain with grab hooks or edge contact**.

**Taking the highest lashing strength required (7.5 tonne), a 13 mm Grade 'T' transport chain with claw hooks or winged grab hooks** is necessary in **all directions** to restrain the load.

-  For more information see [Table 4 Typical lashing capacity](#) – chain or [Table 3 Typical lashing capacity - ropes and webbing straps](#).
-  The lashing strength is the lashing capacity or manufacturer's rating, which should be marked on the lashing.
-  Chains should be of the same length and at the same angle to be considered working together.

#### MINIMUM LASHING CAPACITY – DIRECT RESTRAINT SIDEWAYS OR REARWARDS (50% OF LOAD WEIGHT) USING 2 CHAINS

Mass of load (kilograms) (tonnes)	Angle effect AE = >0.85	Angle effect AE = >0.70	Angle effect AE = >0.50
3	0.9	1.1	1.5
4	1.2	1.5	2.0
5	1.5	1.8	2.5
6	1.8	2.2	3.0
7	2.1	2.5	3.5
8	2.4	2.9	4.0
9	2.7	3.3	4.5
10	3.0	3.6	5.0
11	3.3	4.0	5.5
12	3.6	4.3	6.0
13	3.9	4.7	6.5
14	4.2	5.0	7.0
15	4.5	5.4	7.5

# RATED CURTAINS WORKED EXAMPLES

## CASE 8:

### PARTIALLY BLOCKED LOAD WITH RATED CURTAINS

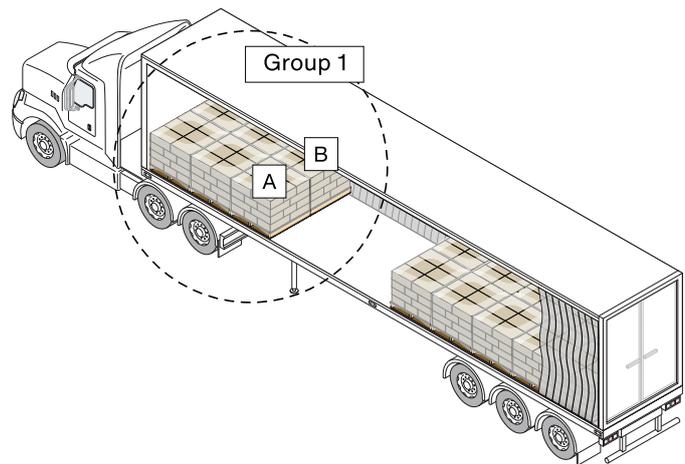
#### Load:

- Palletised general freight (pallets A and B) – *Figure 501*.
- Pallet A weighs 600 kg and Pallet B weighs 750 kg.
- Each row of pallets in group 1 is the same.

#### Vehicle:

- A prime mover and semitrailer with rated side curtains.

*Figure 501 Palletised general freight – front portion*



## IDENTIFY THE LOAD AND VEHICLE:

### Step 1:

#### Which part of the load do I want to restrain?

I want to restrain the load of pallets at the front of the truck (Group 1 in – *Figure 501*).

### Step 2:

#### What vehicle will I use?

A prime mover and semitrailer with rated side curtains.

## CHOOSE A SENSIBLE RESTRAINT METHOD:

### Step 3:

#### Is the load blocked forwards?

**Yes** – this part of the load is fully blocked in the forward direction, up to 0.8 g.

- ✓ Check the load is positioned within 200 mm of the headboard.
- ✓ Check the load is tightly packed and that the sum of any gaps along the trailer (front to rear of the load) is less than 200 mm.

## Step 4:

**Is the load blocked sideways?**

To check if the load is blocked sideways you need to know the **side curtain rating capacity** and the **load mass**.

-  Check the sum of any gaps across the load is less than 100 mm.
-  If the gaps are too big you need to use other restraints or fill the gaps.
-  If unsure about the curtain rating, ask the manufacturer.
-  For more information on using side curtains see the [Vehicle and equipment](#) module.

## Step 5:

**Is the load blocked rearwards?**

**No** – there is a gap greater than 200 mm at the rear of the load.

## Step 6:

**Do I need extra restraints?**

**Yes** – the load is not effectively restrained rearwards. You can **block** the back of the load (see [Case 2](#)) or **use extra lashings** to give a tie-down effect.

-  Do not transport this load until you have properly restrained it.
-  You need to tie down the **entire mass of Group 1** (1,350 kg x 3 = 4,050 kg), not just the rear most pallets.
-  For more information on how to work out the number of lashings see [tie-down worked examples](#).

**Side rating capacity – per pallet width**

-  If your rating capacity is per pallet width, you need to know the mass of one row of pallets. This is the pallet width.

For this example, the mass of a pallet width is **1,350 kg** (Pallet A 600 kg + Pallet B 750 kg).

If the rating capacity per pallet width is greater than **1,350 kg** then the load is **BLOCKED SIDEWAYS**.

-  If your curtains do not have a sufficient rating capacity, you will need extra restraints to meet the sideways forces.

**Side rating capacity – per pallet space**

-  If your rating capacity is per pallet space, you need to know the mass of the heaviest pallet in the row. This is the pallet space.

For this example, the mass of the heaviest pallet is **750 kg** (Pallet B).

If the rating capacity per pallet space is greater than **750 kg** then the load is **BLOCKED SIDEWAYS**.

-  If your curtains do not have a sufficient rating capacity, you will need extra restraints to meet the sideways forces.

## CASE 9: UNBLOCKED LOAD WITH RATED CURTAINS

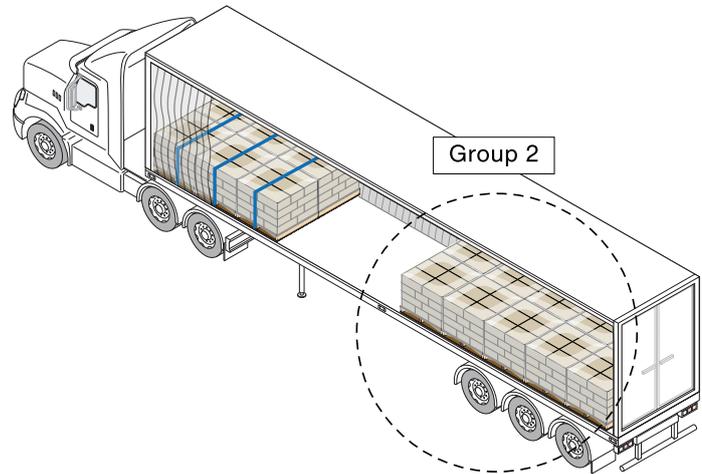
### Load:

- All pallets weigh 700 kg each.
- There are 5 rows of pallets in Group 2 – [Figure 502](#).

### Vehicle:

- A prime mover and semitrailer with rated side curtains.

*Figure 502 Palletised general freight – rear portion*



## IDENTIFY THE LOAD AND VEHICLE:

### Step 1:

#### Which part of the load do I want to restrain?

I want to restrain the load of pallets at the back of the truck (Group 2 in – [Figure 502](#)).

### Step 2:

#### What vehicle will I use?

A prime mover and semitrailer with rated side curtains.

## CHOOSE A SENSIBLE RESTRAINT METHOD:

### Step 3:

#### Is the load blocked forwards?

**No** – there is a gap greater than 200 mm at the front of the load.

 You need to decide how to restrain the load in the forward direction before going further. **The rating capacity of the curtains are irrelevant.**

 Do not transport this load until you have properly restrained it.

#### Restraining the load in the forward direction: Option 1

 **Use extra lashings** to give a tie-down effect.

 You need to tie down the **entire mass of Group 2** (1,400 kg x 5 = 7,000 kg), not just the front row of pallets.

 For more information on how to work out the number of lashings see [tie-down worked examples](#).

#### Restraining the load in the forward direction: Option 2

 Block the load. This can be done with stacked pallets, crossover straps or a pallet on end tied back to make a de facto headboard.

 See [Case 10](#) for a fully blocked load using load rated curtains.

## CASE 10: FULLY BLOCKED LOAD WITH RATED CURTAINS

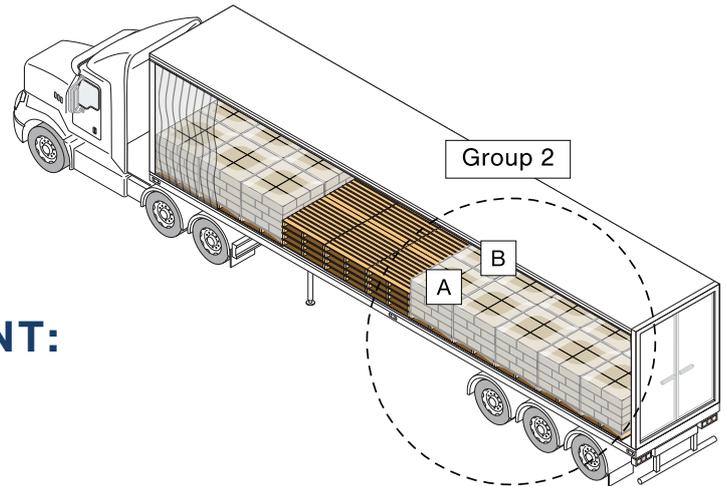
### Load:

- Palletised general freight.
- Pallet A weighs 600 kg and Pallet B weighs 800 kg.
- There are 5 rows of pallets in Group 2 – *Figure 503*.

### Vehicle:

- A prime mover and semitrailer with rated side curtains.

*Figure 503 Palletised general freight – rear portion*



## IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

### Step 1: Which part of the load do I want to restrain?

I want to restrain the load of pallets at the back of the truck (Group 2 in *Figure 503*).

### Step 2: What vehicle will I use?

A prime mover and semitrailer with rated side curtains.

## CHOOSE A SENSIBLE RESTRAINT METHOD:

### Step 3: Is the load blocked forwards?

**Yes** – this part of load is fully blocked in the forward direction, up to 0.8 g.

- ✓ Check the load is tightly packed and that the sum of any gaps along the trailer (front to rear of the load) is less than 200 mm.

## Step 4:

### Is the load blocked sideways?

To check if the load is blocked sideways you need to know the **side curtain rating capacity** and the **load mass**.

-  Check the sum of any gaps across the load is less than 100 mm.
-  If the gaps are too big you need other restraints or to fill the gaps.
-  If unsure about the curtain rating, ask the manufacturer.
-  For more information on using side curtains see the [Vehicle and Equipment module](#).

## Step 5:

### Is the load blocked rearwards?

**Yes** – the gap at the rear of the load is less than 200 mm and the blocking device is rated to 0.5 weight of the whole load.

## Step 6:

### Do I need extra restraints?

**No** – The load is effectively restrained in all directions.

-  If the load is a multi-drop load the restraint methods are likely to change during the journey as parts of the load are delivered, creating gaps. See [Case 12](#) for more information on multi-drop loads.

### Side rating capacity – per pallet width

-  If your rating capacity is per pallet width, you need to know the mass of one row of pallets. This is the pallet width.

For this example, the mass of a pallet width is **1,400 kg** (Pallet A 600 kg + Pallet B 800 kg).

If the rating capacity per pallet width is greater than **1,400 kg** then the load is **BLOCKED SIDEWAYS**.

-  If your curtains do not have a sufficient rating capacity, you will need extra restraints to meet the sideways forces.

### Side rating capacity – per pallet space

-  If your rating capacity is per pallet space, you need to know the mass of the heaviest pallet in the row. This is the pallet space.

For this example, the mass of the heaviest pallet is **800 kg** (Pallet B).

If the rating capacity per pallet space is greater than **800 kg** then the load is **BLOCKED SIDEWAYS**.

-  If your curtains do not have a sufficient rating capacity, you will need extra restraints to meet the sideways forces.

## CASE 11: RATED CURTAINS WITH MEZZANINE DECK

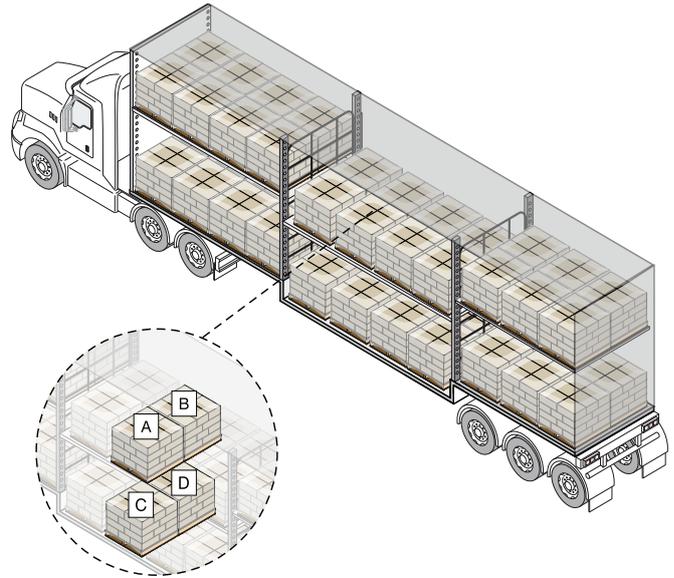
### Load:

- Palletised general freight.
- Pallet A weighs 600 kg, Pallet B weighs 750 kg, Pallet C weighs 1,000 kg and Pallet D weighs 800 kg – *Figure 504*.

### Vehicle:

- A prime mover and semitrailer with rated side curtains and a mezzanine deck.

*Figure 504 Palletised general freight on a mezzanine deck*



## IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

### Step 1:

#### Which part of the load do I want to restrain?

I want to restrain the load of pallets on the mezzanine deck.

### Step 2:

#### What vehicle will I use?

A prime mover and semitrailer with rated side curtains and a mezzanine deck.

## CHOOSE A SENSIBLE RESTRAINT METHOD:

### Step 3:

#### Is the load blocked forwards?

**Yes** – the load on the deck is fully blocked to 0.8 g with a suitably reinforced pipe rack.

- ✓ Check the load is tightly packed and that the sum of any gaps along the trailer (front to rear of the load) is less than 200 mm.

#### Step 4: Is the load blocked sideways?

To check if the load is blocked sideways you need to know the **side curtain rating capacity** and the **load mass**.

- ✓ Check the sum of any gaps across the load is less than 100 mm.
- ⚠ If the gaps are too big you need other restraints or fill the gaps.
- ⚠ If unsure about the curtain rating, ask the manufacturer.
- ℹ For more information on using side curtains see the [Vehicle and Equipment module](#).

#### Step 5: Is the load blocked rearwards?

**Yes** – the gap at the rear of the load is less than 200 mm and the blocking device is rated to 0.5 weight of the whole load.

#### Step 6: Do I need extra restraints?

**No** – The load is effectively restrained in all directions.

- ⚠ If the load is a multi-drop load the restraint methods are likely to change during the journey as parts of the load are delivered, creating gaps. See [Case 12](#) for more information on multi-drop loads.

#### Side rating capacity – per pallet width

- ℹ If your rating capacity is per pallet width, you need to know the mass of one row of pallets on the lower deck **AND** the mass of one row of pallets on the mezzanine deck.

For this example, the mass of the lower deck pallet row is **1,800 kg** (Pallet C 1,000 kg + Pallet D 800 kg).

The mass of the mezzanine deck pallet row is **1,350 kg** (Pallet A 600 kg + Pallet B 750 kg).

If the rating capacity per pallet width is greater than **3,150 kg (1,800 kg + 1,350 kg)** then the load is **BLOCKED SIDEWAYS**.

- ⚠ If your curtains do not have a sufficient rating capacity, you will need extra restraints to meet the sideways forces.

#### Side rating capacity – per pallet space

- ℹ If your rating capacity is per pallet space, you need to know the **heaviest combined mass** of a pallet space for the lower and mezzanine deck (A+C or B+D).

For this example, the mass of the heaviest pallet space combination is **1,600 kg** (Pallet A 600 kg + Pallet C 1,000 kg).

If the rating capacity per pallet space is greater than **1,600 kg** then the load is **BLOCKED SIDEWAYS**.

- ⚠ If your curtains do not have a sufficient rating capacity, you will need extra restraints to meet the sideways forces.

## CASE 12: MULTI-DROP LOAD WITH RATED CURTAINS

### Load:

- Palletised general freight – multi-drop.

### Vehicle:

- A rigid truck with load rated curtains.

## IDENTIFY THE LOAD:

### Step 1:

#### Which part of the load do I want to restrain?

- ⚠ In a multi-drop load, gaps greater than 200 mm will appear along the truck in what was a fully blocked load when it left the depot – *Figure 505*, and *Figure 506*.

- ✓ Recheck your restraint method after each drop to assess if all parts of the load are fully restrained in all directions.

- ⚠ Load rated curtains only provide sideways restraint. Where there are gaps additional forward and rear restraint will be required.

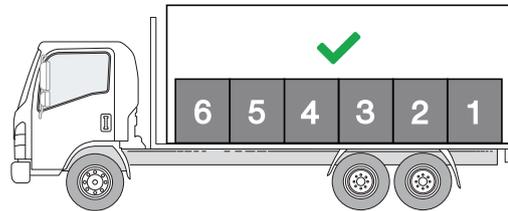
## CHOOSE A SENSIBLE RESTRAINT METHOD:

### Step 2:

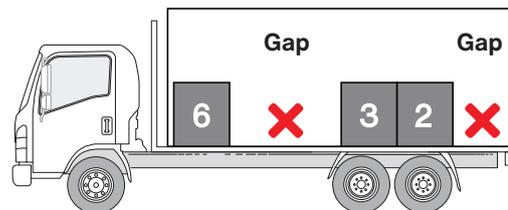
#### Plan the load for multi-drops

- ✓ Minimise the number of gaps in a multi-drop load by placing earlier drops at the back of the truck – *Figure 507*.
- ⚠ Even when the number of gaps are minimised with a load plan, gaps must still be blocked or extra lashings used to ensure the load is restrained in all directions.
- ⚠ You also need to consider mass distribution (axle weights) for each stage of transporting a multi-drop load.

*Figure 505 Fully blocked leaving the depot*

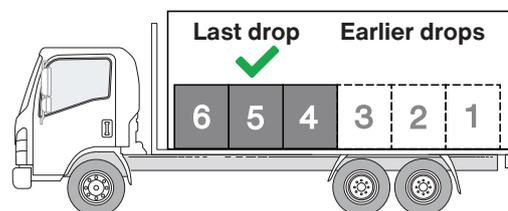


*Figure 506 Gaps greater than 200 mm along the truck after drop-off*



*In the example above Pallet 6 is no longer restrained rearwards and Pallets 3 and 2 are no longer restrained forwards or rearwards*

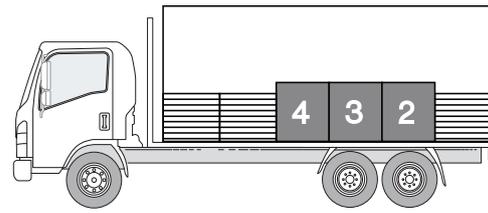
*Figure 507 Only the gap at the rear needs to be blocked or restrained with extra lashings*



## Step 3:

**Can I block the gaps?**

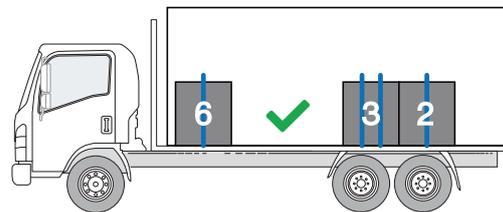
- ✓ Use stacked pallets, crossover straps or a pallet on end tied back as a de facto headboard – *Figure 508*.
- ✓ Check the sum of any gaps along the load is less than 200 mm.

*Figure 508 Gaps filled with stacked pallets*

## Step 4:

**Do I need extra restraints?**

- ✓ **Use extra lashings** to give a tie-down effect if you cannot block the load in the forward and/or rearward direction – *Figure 509*.
- ❗ For more information on how to work out the number of lashings see [tie-down worked examples](#).

*Figure 509 Extra lashings are needed if you cannot fill the gaps*

*In the example above Pallets 2 and 6 are **restrained rearwards** and Pallet 3 is **restrained forwards**.*

# CERTIFICATION

This module will guide you on load restraint certification, including:

- **the benefits** of having your load restraint system certified
- **who can certify** systems
- **information required for certification.**

## HOW TO USE THIS MODULE

Once you understand load restraint certification, **use the load restraint certification template** when certifying your system.

**You can use your own certification template. It should present all the information listed in this module under [What should certification include?](#)**

# LOAD RESTRAINT SYSTEM CERTIFICATION

Having a qualified engineer certify your load restraint system has a number of benefits:

- it maximises safety for your employees and the public
- it assures you the system meets the Performance Standards
- it assists enforcement officers to verify that the system meets the Performance Standards
- it may provide a defence under Chain of Responsibility.

## WHO CAN CERTIFY LOAD RESTRAINT SYSTEMS?

To be able to certify that a load restraint system complies with the Performance Standards, a person should have the appropriate skills, experience and qualifications. The person should be:

- a Chartered Professional Engineer with load restraint expertise who is legally able to practise engineering in the jurisdiction
- someone who has an understanding of vehicle design and detailed knowledge of load restraint issues.

## WHAT SHOULD CERTIFICATION INCLUDE?

Certification of a load restraint system represents expert advice that the load restraint system meets the Performance Standards.

A report on the certification may be in hardcopy or electronic form. The report should be clear and concise and include:

1. the name of the load restraint system
2. the date of certification
3. the name and contact details of the client requiring the certification
4. the name and contact details of the load restraint system certifier
5. a description of the load type and any unitising system used
6. the type(s) of vehicles, including vehicle floor type
7. the load restraint equipment used, including size, tension, friction material, interlayer packing, etc.
8. a description and drawing of the loading and configuration of the load
9. a description and drawing of the load and restraint system, including the location of all key vehicle body components and their location when used in an on-road loading situation
10. the maintenance schedule, safety precautions, tensioning or re-tensioning procedures and other special requirements, if appropriate
11. an appendix of the load restraint calculations and test results
12. instructions on how to ensure the load restraint system operates as designed, for loaders and drivers.

**Note:** A copy of the report should be kept for future reference by all relevant parties.

# RESTRAINT SYSTEM CERTIFICATION TEMPLATE

<b>Load restraint system</b>	Name of the load restraint system covered by the certification	
<b>Client</b>		
Contact name Company name	Address	ABN, contact details (phone, email, website)
<b>Load restraint certifier</b>		
Name Company name	Address	ABN, contact details (phone, email, website)
<b>Declaration</b>	Engineer's statement that the load restraint system described will meet the Performance Standards, and any conditions that apply to the declaration	
<b>Date of certification</b>	Date	
<b>Description of the load</b>	Products, size and weight, unitising system	
<b>Description of the vehicle</b>	Vehicle type, weight, integral restraint equipment, floor type	
<b>Load restraint equipment</b>	Load restraint equipment used, including size, tension, friction material, interlayer packing, etc.	
<b>Loading and configuration</b>	Configuration of the load, in words and in a drawing	(Attach extra page for drawing(s) if required)
<b>Load restraint method</b>	Description of the restraint method, in words and in a drawing	
<b>Operational advice</b>	Maintenance schedule, safety precautions, tensioning or re-tensioning procedures and other special requirements (attach extra page(s) if required)	

# TECHNICAL ADVICE

This module provides more detailed guidance on load restraint methods and calculation. The module is mostly aimed at engineers and designers, but it can be read by anyone wanting to understand more about load restraint concepts and to calculate the amount of load restraint required.

## HOW TO USE THIS MODULE

To begin, **read through the information on the [Performance Standards](#)**. Understanding the Performance Standards is critical when designing a restraint system, as all restraint systems must be able to meet these requirements.

Once you understand the Performance Standards, **read through the information on design for the different load restraint methods: tie-down, containing or blocking, unitising and direct attachment. Refer to the reference tables, diagrams and formulae** to calculate the amount and type of restraint to use when designing a tie-down or direct restraint system.

# TECHNICAL ADVICE FOR ENGINEERS AND DESIGNERS

The specialised information in this module is useful to engineers and designers when designing and selecting load restraint systems.

## LOADING PERFORMANCE STANDARDS

- (1) A load on a heavy vehicle must be restrained by a load restraint system that:
- (a) prevents the load from moving in relation to the heavy vehicle (other than movement allowed under subsection (2) in the circumstances mentioned in subsection (3); and
  - (b) at a minimum, is capable of withstanding the forces that would result in the circumstances mentioned in subsection (3).
- (2) A load may move in relation to a heavy vehicle if:
- (a) the vehicle's stability and weight distribution are not adversely affected by the movement; and
  - (b) the load does not become dislodged from the vehicle.

Examples of load movement that may be permitted under (2)

- load contained within the sides or enclosure of the heavy vehicle that is restrained from moving horizontally may be able to move vertically;
  - a load of very light objects, or a loose bulk load, that is contained within the sides or enclosure of the heavy vehicle may be able to move horizontally and vertically;
  - a bulk liquid load contained within the sides or enclosure of the heavy vehicle.
- (3) For subsection (1), the circumstances are that the loaded vehicle is subjected to:
- (a) any of the following, separately:
    - (i) 0.8 g deceleration in a forward direction;
    - (ii) 0.5 g deceleration in a rearward direction;
    - (iii) 0.5 g acceleration in a lateral direction; and
  - (b) if friction or limited vertical displacement is relied on to comply with (a)-0.2 g acceleration in a vertical direction relative to load.

The Load Restraint Guide **sets out how the Performance Standards** may be met. It is intended to be used as a **guide only**, as it is impossible to be prescriptive for the many different types, weights and shapes of loads that can be transported.

**If you want to use different methods to those recommended in the load-type guides, you will need to be able to demonstrate your load restraint system meets the Performance Standards.**

## STABILITY AND MASS DISTRIBUTION

For the purposes of load restraint, an **adverse effect on the vehicle's stability** is one that:

- causes the static rollover threshold (SRT) to drop by more than 10%
- causes the SRT to drop below 0.35 g, or
- for vehicles with an SRT already below 0.35 g, causes the SRT to fall by 0.01 g.

Static rollover threshold is the static sideways force that would first cause a wheel to lift off the road and commence rollover of the vehicle.

For the purposes of load restraint, an **adverse effect on the weight distribution** on the vehicle means:

- the load shifts to the extent that if the vehicle was stopped and weighed, any axle, or axle group, would be loaded above legal limits, or
- the load has rocked or sloshed forwards or backwards by so much that it is likely to significantly change the vehicle's handling or braking characteristics.

### What happens if SRT drops by more than 10%?

Any drops in SRT greater than 10% will have a significant impact on a vehicle's handling, making it very difficult to drive.

**For example**, a heavy load shifts sideways within a container, lowering the vehicle's original SRT of 0.45 g by 15% to 0.38 g (for rollover on its 'worst' side) and to 0.52 g (to the 'best' side). While the load is still contained, there is now a substantial difference between the 2 sides of the vehicle. Its handling characteristics will be significantly affected and it will be very difficult to drive safely.

## METHODS OF LOAD RESTRAINT

When you are selecting and calculating the strength of various restraint systems for loads that are contained or secured on a vehicle, consider each of the following load restraint methods:

- **tie-down** to clamp the load against the vehicle body structure
- **containing** the load within the body structure
- **blocking** the load against a body structure or attachment
- **attaching** the load directly to the body structure.

# DESIGN FOR TIE-DOWN METHOD

Tie-down loads are restrained by friction between the load and the vehicle. Friction can also restrain load items in contact with other load items.

The friction is a result of the weight of the load and the extra clamping force applied by lashings.

## FRICITION COEFFICIENT

The friction coefficient ( $\mu$ ) is used to compare the load restraint friction force between 2 surfaces. The static friction coefficient applies before movement begins and the dynamic friction coefficient applies once movement occurs.

The dynamic friction coefficient is generally much lower than the static friction coefficient. This means a load may show some resistance to begin with, but once it starts slipping it will usually slip quickly. Where the design of a restraint system relies on the weight of the load plus lashing pre-tension, the static friction coefficient may be used.

Where the design relies on the weight of the load plus tensioning by load shift, the dynamic friction coefficient must be used.

Some typical static friction coefficients are listed in the table below.

*Table 5*

TYPICAL STATIC FRICTION COEFFICIENT LEVELS	
Load	Static friction coefficient
Wet or greasy steel on steel	0.01-0.1
Smooth steel on smooth steel	0.1-0.2
Smooth steel on conveyor belt	0.2-0.3
Smooth steel on rusty steel	0.2-0.4
Smooth steel on timber	0.3-0.4
Rusty steel on rusty steel	0.4-0.7
Rusty steel on timber	0.6-0.7
Smooth steel on rubber load mat	0.6-0.7

These figures are a guide and must not be used to design a load restraint system without testing. Where the static friction coefficient is not known, you must test the load or choose a conservative value. The tests must take into account all possible combinations of surface conditions that may be encountered, such as wet, dry or greasy.

## LASHING ANGLES

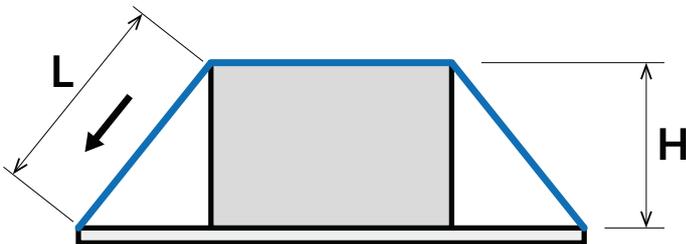
If a tie-down lashing is not vertical between the load and the tie point, its effectiveness is reduced below 100% – *Figure 511*. This is called the tie-down ‘angle effect’.

*Figure 511 Tie-down angle effect*

	APPROX ANGLE	TIE-DOWN ANGLE EFFECT	TIE-DOWN EFFECTIVENESS
	90°	1.00	100%
	60°	0.85	85%
	45°	0.70	70%
	30°	0.50	50%
	15°	0.25	25%

The angle effect (AE) can be calculated by dividing the height (H) of the load by the length (L) of the lashing between the load and the tie point on the vehicle – *Figure 512*.

*Figure 512 Calculating the tie-down angle effect*



$$\text{Angle effect (AE)} = \text{Height of load (H)} \div \text{Length of lashing (L)}$$

The tie-down force from each lashing is the sum of the lashing tension on each side of the load, multiplied by the angle effect.

## LASHING PRE-TENSION

The pre-tension is the force in the lashing provided by a mechanical tensioner or a knot. The amount of pre-tension in a lashing affects the amount of weight that can be restrained by that lashing.

To maintain the friction force during normal driving, the load must always remain in contact with the deck during road vibration and over bumps. To achieve this, **the tie-down lashings must be pre-tensioned to provide a minimum clamping force of 20% of the weight of the load.**

**Note:** The tension in any lashing must not exceed the manufacturer's lashing capacity.

Average lashing pre-tensions are shown in [Table 6](#). The figures shown in the table are operator and equipment-dependent.

The pre-tension on the side of the load that is tensioned is normally greater than the pre-tension on the other side (possibly several times greater). If the tensioner is positioned on top of the load, the pre-tension is the same on both sides. Always check the lashing pre-tension on both sides of a load, and never assume it is the same on both sides.

In some circumstances, for example lashings over high friction materials, it is advisable to establish the pre-tension that can be achieved by the equipment, and by each operator, using in-line load indicators.

[Table 6](#)

EXAMPLES OF AVERAGE PRE-TENSION			
Lashing	Size	Tensioner	Pre-tension
Rope	10 mm &	Single hitch	50 kgf
	12 mm	Double hitch	100 kgf
Webbing	25 mm	Hand ratchet	100 kgf
	35 mm	Hand ratchet	250 kgf
	50 mm	Truck winch	300 kgf
	50 mm	Hand ratchet (push-up)	300 kgf
	50 mm	Hand ratchet (pull-down)	600 kgf
Chain	7 mm & above	Turnbuckle	1000 kgf

- Where 75 mm and 100 mm webbing straps are used, their tensioners may not achieve as much pre-tension as the 50 mm tensioners, even though their lashing capacity is greater. The larger tensioners are sometimes designed for different purposes. Check their rating with the manufacturer.
- The pre-tension achieved with chain tensioners is approximately the same for 7 mm, 8 mm, 10 mm and 13 mm chains.

## HOW MANY LASHINGS? – USING TIE-DOWN LOAD TABLES

The following load tables can be used to determine the number of tie-down lashings required to restrain a load. Note the following:

- The tables include loads with or without blocking in front, on high, medium, low and very low friction surfaces. They **take into account the required minimum clamping force of 20% of the weight of the load.**
- If the tie-down provides the required 0.5 g sideways and rearward restraint it will also provide a 0.5 g forward restraint.
- The tables **are based on a headboard that is, on its own, capable of withstanding the forces resultant from 0.3 g.**
- If the blocking used in your system provides less than 0.3 g forward restraint, you can still use the tables to calculate the number of lashings (but you will need to regard the load as unblocked).

Load tables for different equipment and friction levels are available in the Appendices.

**Example: How to work out the number of lashings you need (using load tables).**

A vehicle is carrying an **8 tonne load**. The load is **blocked** against a strong headboard (able to withstand 30% of the weight of the load, being 2.4 tonnes). The load is supported on timber dunnage that provides **medium friction**. **The height of the load** is 1.2 metres and the **length of the lashing** between the top of the load and the tie point is 1.6 metres on each side. **How many webbing straps or chains are required?**

**Step 1:** Calculate the angle effect (AE) 1.2 metres (H) divided by 1.6 (L) metres:

- $AE = 1.2 \div 1.6 = 0.75$

**Step 2:** Refer to the tables

**8 mm transport chain, pre-tension 750 kgf – Table 7 (page 248)**

- The load is blocked. Check the top of the table states **BLOCKED**.
- The **angle effect** (AE) is 0.75, therefore the fourth column (AE > 0.70) applies.
- The friction is classed as medium, therefore the **MEDIUM FRICTION** section applies.

**50 mm webbing strap, pre-tension 300 kgf – Table 8 (page 249)**

- The load is blocked. Check the top of the table states **BLOCKED**.
- The **angle effect** (AE) is 0.75, therefore the fourth column (AE > 0.70) applies.
- The friction is classed as medium, therefore the **MEDIUM FRICTION** section applies.

**Step 3:** Find the number of lashings

To find the number of lashings, look down the fourth column (AE > 0.70) and find the number of kilograms that is closest to the mass of the load. This number must be **larger** than the load mass, **not smaller**.

**8 mm transport chain, pre-tension 750 kgf – Table 7**

The total weight of the load is 8 tonne or 8,000 kg. Looking down the fourth column of [Table 7](#) in the **MEDIUM FRICTION** section the closest number is 8,400 kg. Looking across the row, you can see that **2 chains** are required to restrain 8,400 kg.

**50 mm webbing strap, pre-tension 300 kgf – Table 8**

The total weight of the load is 8 tonne or 8,000 kg. Looking down the fourth column of [Table 8](#) in the **MEDIUM FRICTION** section the closest number is 8,400 kg. Looking across the row, you can see that **5 lashings** are required to restrain 8,400 kg.

## Tensioning by load shift - principles for designing a specialised load restraint system

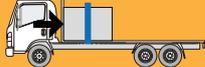
Specialised load restraint systems can be designed to incorporate load shift to increase lashing tension. As the load shifts forwards under heavy braking, the lashings stretch and clamp the load harder against the deck thus increasing the friction force.

These systems must allow for very small forward load shifts only and must be capable of absorbing the energy required to stop the moving load.

Always ensure that such systems are designed and certified by specialised engineers.

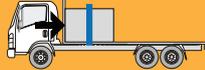
# NUMBER OF LASHINGS

Table 7

Lashings:		Tensioner:			Pre-tension:	
8 mm transport chain		Over-centre tensioner			750 kgf	
<b>BLOCKED</b> (RESTRAINED TO 0.5 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	7,200 kg	6,400 kg	5,300 kg	3,700 kg	1,900 kg
	2	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg
	3	21,000 kg	19,000 kg	15,000 kg	11,000 kg	5,800 kg
	4	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
	5	36,000 kg	32,000 kg	26,000 kg	18,000 kg	9,700 kg
	6	43,000 kg	38,000 kg	31,000 kg	22,000 kg	11,000 kg
	7	50,000 kg	45,000 kg	37,000 kg	26,000 kg	13,000 kg
	8	57,000 kg	51,000 kg	42,000 kg	30,000 kg	15,000 kg
	9	65,000 kg	58,000 kg	47,000 kg	33,000 kg	17,000 kg
	10	72,000 kg	64,000 kg	53,000 kg	37,000 kg	19,000 kg
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	2	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	3	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	4	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	5	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
	6	34,000 kg	31,000 kg	25,000 kg	18,000 kg	9,300 kg
	7	40,000 kg	36,000 kg	29,000 kg	21,000 kg	10,000 kg
	8	46,000 kg	41,000 kg	33,000 kg	24,000 kg	12,000 kg
	9	52,000 kg	46,000 kg	38,000 kg	27,000 kg	13,000 kg
	10	57,000 kg	51,000 kg	42,000 kg	30,000 kg	15,000 kg
<b>LOW FRICTION</b>	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	2	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	3	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	4	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	5	7,200 kg	6,400 kg	5,300 kg	3,700 kg	1,900 kg
	6	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	7	10,000 kg	9,000 kg	7,400 kg	5,200 kg	2,700 kg
	8	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	9	13,000 kg	11,000 kg	9,500 kg	6,700 kg	3,400 kg
	10	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	960 kg	860 kg	700 kg	500 kg	250 kg
	2	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	3	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	4	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	5	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg
	6	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	7	6,700 kg	6,000 kg	4,900 kg	3,500 kg	1,800 kg
	8	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	9	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	10	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg

# NUMBER OF LASHINGS

Table 8

Lashings:		Tensioner:			Pre-tension:	
50 mm webbing straps		Push-up hand ratchet or truck winch			300 kgf	
<b>BLOCKED</b> (RESTRAINED TO 0.5 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
HIGH FRICTION	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	2	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	3	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	4	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	5	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg
	6	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	7	20,000 kg	18,000 kg	14,000 kg	10,000 kg	5,400 kg
	8	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	9	26,000 kg	23,000 kg	19,000 kg	13,000 kg	6,900 kg
	10	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
MEDIUM FRICTION	Static friction: 0.4		Example: Smooth steel on timber			
	1	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	2	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	3	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	4	9,200 kg	8,300 kg	6,700 kg	4,800 kg	2,400 kg
	5	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	6	13,000 kg	12,000 kg	10,000 kg	7,200 kg	3,700 kg
	7	16,000 kg	14,000 kg	11,000 kg	8,400 kg	4,300 kg
	8	18,000 kg	16,000 kg	13,000 kg	9,600 kg	4,900 kg
	9	20,000 kg	18,000 kg	15,000 kg	10,000 kg	5,500 kg
	10	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
LOW FRICTION	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	570 kg	510 kg	420 kg	300 kg	150 kg
	2	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	3	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	4	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	5	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	6	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	7	4,000 kg	3,600 kg	2,900 kg	2,100 kg	1,000 kg
	8	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	9	5,200 kg	4,600 kg	3,800 kg	2,700 kg	1,300 kg
	10	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
VERY LOW FRICTION	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	380 kg	340 kg	280 kg	200 kg	100 kg
	2	770 kg	690 kg	560 kg	400 kg	200 kg
	3	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	4	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	5	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	6	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	7	2,700 kg	2,400 kg	1,900 kg	1,400 kg	720 kg
	8	3,000 kg	2,700 kg	2,200 kg	1,600 kg	820 kg
	9	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	10	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg

# DESIGN FOR CONTAINING OR BLOCKING

When you are designing for containing or blocking, and there is no tie-down to resist a vertical force of 0.2 g, you must exclude the restraint effect of friction when assessing the restraint capacity.

This is because when the vehicle hits a bump, the resulting jolt can break the friction contact between the load items. Even a load resting on very high friction rubber load mat can “walk” to the low side of the trailer during a journey, if it is not tied down.

If the load is not tied down you must also exclude the effect of a raised side coaming rail when assessing restraint capacity, as the load could jump over the coaming rail in a bump.

If you are designing vehicle body structures such as headboards, loading racks, barriers, curtain sides, side gates and drop sides, take the following “loading cases” into account:

<b>Stable single load</b>	restraint forces act at the lower edge of a free-standing structure (e.g. gates) or are distributed over the height of the load with a fully supported structure (e.g. side wall of a pantechnicon).
<b>Unstable single load</b>	restraint forces are distributed unevenly over the height of the load.
<b>Stacked load</b>	restraint forces are distributed over the height of each load item.
<b>Point load</b>	restraint force acts at point of contact.
<b>Loose bulk load</b>	restraint forces are evenly distributed over the height of the load.
<b>Impact load</b>	restraint forces could be very high (simulation or testing required).

A single load is a single item or a unitised number of items that are placed in a single layer on the deck. Pallets with the load wrapped and strapped to the pallet or strapped packs such as bricks are examples of unitised loads. Items stacked loosely on a pallet cannot be considered a single load, no matter how much friction is between them. They must be considered as separate loose single items.

A stacked load is a number of loose single items or unitised packs of items stacked on top of each other. Pallets stacked 2-high, loose cartons and many stretch-wrapped pallet loads are examples of stacked loads.

## Want to know more?

See the [Glossary](#) for a definition of Contained Load, and the [Loads](#) module for recommended restraint methods.

To understand more about load stability, see [Step 6: Make sure your load is stabilised](#) of the Key elements of a load restraint system.

Loose loads that cannot be stacked are considered as a loose bulk load.

A point load is where a non-uniform shaped load item has a part that juts out (e.g. the arm sticking out of a piece of machinery that may make contact with the side wall of a curtain-sided trailer).

An impact load is a load that by its nature will move around when contained unless blocked (e.g. a roll cage) – this movement must be taken into account when designing suitable restraint for it.

To meet the Performance Standards, the side restraint system must not only prevent the load dislodging from the vehicle, it also must not allow the load to shift in such a way that makes the vehicle unstable.

## DESIGN FOR UNITISING

Pallets and packs can be loaded against a headboard or supported by other load. You can test the integrity of a pallet or pack, as follows:

- Restrain the pallet or pack in the same way that it would be transported.
- Where the pallet or pack will be supported by a headboard capable of withstanding 0.3 g (either directly, or indirectly by another load which is supported by a headboard), tilt the pallet or pack to 30° (equivalent to a minimum horizontal acceleration of 0.5 g). See footnote.<sup>1</sup>
- Where the pallet or pack will not be supported by a headboard capable of withstanding 0.3 g (either directly or indirectly as described above), tilt the pallet or pack to 53° (equivalent to a minimum horizontal acceleration of 0.8 g). See footnote.<sup>1</sup>
- If the packing arrangement or layers in the pallet or pack are not symmetrical when viewed from above, rotate the pallet or pack 90° and repeat the above tests.

The pallet or pack must not show any slippage or significant distortion during these tests.

1. *The angles specified above are worst case. With proper engineering consideration of lashing, static friction coefficients and load shape, more moderate angles may be suitable for testing. It is strongly recommended that engineering advice is sought if you wish to pursue testing at more modest angles.*

### **The higher the centre of mass of the load, the greater the effect of any load shift on the stability of the vehicle.**

For example, if a relatively lightweight, loose, bulk-volume load with a centre of mass 1,500 mm above the trailer deck shifts sideways during a sudden swerve, bulging a side curtain outwards, the effect on the vehicle stability could be much more severe than a single level of heavy pallets moving 50 mm to 100 mm sideways.

# DESIGN FOR DIRECT ATTACHMENT

When you are attaching a load directly to a vehicle, consider the following 2 cases:

1. The restraint system provides no additional clamping force to the vehicle.

The friction forces between the load and the deck must not be considered in this case, for example, shipping container twistlocks.

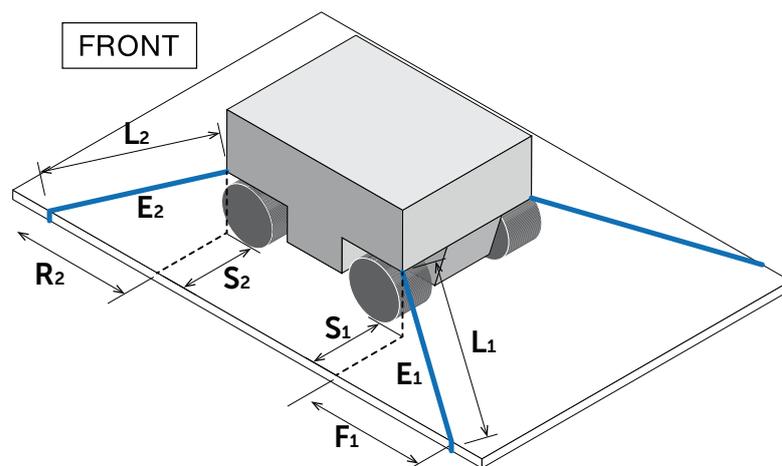
2. The restraint system is pre-tensioned or angled to provide additional clamping force to the vehicle.

When load movement produces increased tension in lashings that are angled downwards, additional clamping forces result. The friction forces between the load and the deck can be added to the direct restraint forces, for example, sideways restraint of steel tracked equipment.

## LASHING ANGLES

The angle of the lashing determines the tension that develops in the lashing to restrain a load. You can calculate the effectiveness of direct lashings (the angle effect AE) by measuring the horizontal distance in the direction of restraint from the tie point on the load to the tie point on the vehicle and dividing it by the length of the lashing – *Figure 510*.

*Figure 510 Calculating the direct lashing “angle effect”*



### For lashing $L_1$

Angle Effect ( $AE_1$ ) Forwards = Distance ( $F_1$ ) ÷ Length of Lashing ( $L_1$ )

Angle Effect ( $AE_1$ ) Sideways = Distance ( $S_1$ ) ÷ Length of Lashing ( $L_1$ )

### For lashing $L_2$

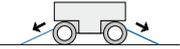
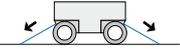
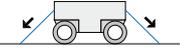
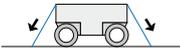
Angle Effect ( $AE_2$ ) Rearwards = Distance ( $R_2$ ) ÷ Length of Lashing ( $L_2$ )

Angle Effect ( $AE_2$ ) Sideways = Distance ( $S_2$ ) ÷ Length of Lashing ( $L_2$ )

As **direct lashings** become **more vertical**, they become **less effective** in providing horizontal restraint – *Figure 513*.

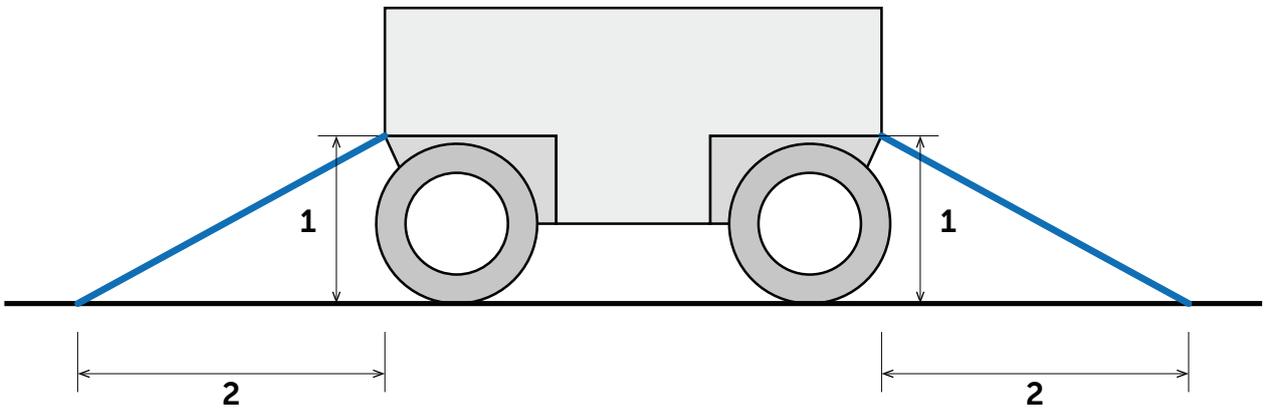
Note that this is **opposite to tie-down lashings** where the effectiveness improves as lashings become more vertical.

*Figure 513 Calculating the direct lashing “angle effect”*

	ANGLE	DIRECT LASHING ANGLE EFFECT	DIRECT LASHING EFFECTIVENESS
	25°	0.90	90%
	30°	0.86	86%
	45°	0.70	70%
	60°	0.50	50%

A **recommended angle** for direct lashings is a slope of 1 in 2 or approximately 25° to the horizontal – *Figure 514*. The lashings will then have an effectiveness of 90% (an angle effect of 0.9).

*Figure 514 Recommended angle for direct lashings*



## PRE-TENSIONED DIRECT LASHINGS

When lashings are paired for direct restraint, they should be equivalent type length and angles. Significant differences can lead to capacity being reached in one of the pair before the other, which may lead to catastrophic failure.

Where a load is restrained by pre-tensioned direct lashings that act in opposite directions, the amount of pre-tension in the lashings can reduce their capacity to restrain the load.

When the load is subjected to a force in one direction, the tension in the lashings opposing the force is increased, but the tension in the opposite lashings is reduced. This effect varies depending on the type, length, size or angle of the lashings.

If the lashings where tension has increased are stiffer than the opposite lashings, the force in them will be greater than needed to restrain the load. This is because the more elastic opposite lashings remain partly tensioned.

This effect is more likely to be experienced when different types of lashings such as webbing and chain are used together. **Lashings of equal elasticity should be used and should be symmetrically placed to overcome this effect.**

## WHAT STRENGTH CHAINS? – USING LOAD TABLES

You can use the following load tables to select the minimum size of chain required when 2 chains are used to prevent movement in a particular direction. The tables list the lashing capacity for loads from 100 kg to 30 tonnes.

Larger lashing capacity than is provided in the tables is needed when:

- restraining heavier loads
- restraining loads in the forward direction
- lashings are angled ineffectively (not opposite to the direction of motion).

Table 9 shows the minimum strength (lashing capacity) required for each of 2 chains directly restraining forward movement.

Table 9

<b>MINIMUM LASHING CAPACITY – DIRECT RESTRAINT FORWARDS (80% OF LOAD WEIGHT) USING 2 CHAINS</b>			
<b>Mass of load (kilograms)</b>	<b>Angle effect AE = &gt; 0.85</b>	<b>Angle effect AE = &gt; 0.70</b>	<b>Angle effect AE = &gt; 0.50</b>
100	48	58	80
200	95	115	160
300	142	172	240
400	186	229	320
500	236	286	400
750	353	429	600
1,000	471	572	800
1,500	706	958	1,200
2,000	942	1,143	1,600
<b>(tonnes)</b>			
3	1.5	1.8	2.4
4	1.9	2.3	3.2
5	2.4	2.9	4.0
6	2.9	3.5	4.8
7	3.3	4.0	5.6
8	3.8	4.6	6.4
9	4.3	5.2	7.2
10	4.8	5.8	8.0
11	5.2	6.3	8.8
12	5.7	6.9	9.6
13	6.2	7.5	10.4
14	6.6	8.0	11.2
15	7.1	8.6	12.0
16	7.6	9.2	12.8
17	8.0	9.8	13.6
18	8.5	10.3	14.4
19	9.0	10.9	15.2
20	9.5	11.5	16.0
21	9.9	12.0	16.8
22	10.4	12.6	17.6
23	10.9	13.2	18.4
24	11.3	13.8	19.2
25	11.8	14.3	20.0
26	12.3	14.9	20.8
27	12.8	15.5	21.6
28	13.2	16.0	22.4
29	13.7	16.6	23.2
30	14.2	17.2	24.0

**Example: Determining the number of chains using the load tables.**

Find the minimum transport chain size that can be used to restrain an **8 tonne steel** wheeled roller on a steel deck (no friction) **using 2 chains to prevent forward movement**. The **length of chain** ( $L_1$ ) between tie points is 2.0 metres. The **distance between the tie points** ( $F_1$ ) measured along the vehicle is 1.5 metres – *Figure 513*.

**Step 1:** Calculate the angle effect (AE) - 1.5 metres ( $F_1$ ) divided by 2.0 metres ( $L_1$ ):

- $AE_1 = 1.5 \div 2.0 = 0.75$

**Step 2:** Refer to the tables:

- Refer to *Table 9*; as the angle effect is above 0.70 the third column applies.
- Refer to the 'Mass of Load' 8 tonne row: the minimum lashing capacity is 4.6 tonnes.
- From *Table 4*; or using chain manufacturers' specifications, select chains each with a lashing capacity of at least 4.6 tonnes.

**Result:** The 2 chains must be at least either 10 mm transport chain using claw hooks or winged grab hooks, or 13 mm transport chain using plain grab hooks.

## WHAT STRENGTH CHAINS? – BY CALCULATION

The strength of the chains in the above example (with a weight of 8 tonne) can be calculated using the actual lashing angle. This may result in smaller size chains being required.

**Step 1:** The angle effect in the forward direction,  $AE = 0.75$ .

**Step 2:** The required forward restraint (0.8 g) is,  $0.8 \times 8,000 \text{ kg} = 6,400 \text{ kg}$ .

**Step 3:** Each chain must provide,  $6,400 \text{ kg} \div 2 = 3,200 \text{ kg}$  of restraint (on the assumption that any tension in the opposite chains has slackened to zero).

**Step 4:** Because of the angle effect, the chain tension is  $3,200 \text{ kg} \div AE = 3,200 \text{ kg} \div 0.75 = 4,267 \text{ kg}$ .

**Step 5:** From *Table 4*, or chain manufacturers' specifications, select chains each with a lashing capacity of at least 4.267 tonnes.

**Result:** Therefore 2x 10 mm transport chains using either claw hooks, winged grab hooks or grab hooks are the **minimum** required.

# DESIGN FOR COMBINED TIE-DOWN AND DIRECT RESTRAINT

There are many load restraint systems where both tie-down and direct restraint can combine to meet the Performance Standards.

Use the methods of calculation outlined previously when designing combined systems.

# APPENDICES

## GLOSSARY

**Air bag** An inflatable barrier placed between a section of the load and the vehicle to stop any movement of the load. It can be disposable or reusable.

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**Aggregate trailer mass** The total mass of a trailer carrying the maximum load as specified by the trailer manufacturer (also called **ATM**). It includes the mass on the drawbar as well as the mass on the axles.

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**Anchor point** Fitting or attachment on a vehicle or load to secure lashings.

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**Baffles** Barriers fitted crosswise and lengthwise inside tanks to limit surging of fluids (or loads that behave like fluids) during acceleration, braking and cornering.

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**Baulking** See **Blocking**.

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**Bolster** Rigid support base commonly used to support logs on **Jinkers**.

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**Blocking** Material, usually timber, placed between the load and the vehicle structure, to prevent movement of the load (also see **Dunnage**).

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**Cap tarpaulin** A smaller tarpaulin fitted over the top of a load and only part of the sides (also see **Tarpaulin**).

---

**Centre of gravity** The centre of balance of a load (also called “centre of mass”).

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**Chain of Responsibility** Part of the Heavy Vehicle National Law that requires parties in the Chain of Responsibility (CoR), other than drivers, to ensure that transport activities are carried out in a way that eliminates or minimises public risks so far as is reasonably practicable, when heavy vehicles are used on a road.

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**Chocks** Usually wedge-shaped blocks used to prevent movement of the load (also see **Wedges**).

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**Claw hook** A chain hook in the shape of a claw.

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**Coaming** A frame border around the outside of a vehicle’s loading deck.

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<b>Coefficient of friction (<math>\mu</math>)</b>	A measure of the friction between 2 surfaces in contact, equal to the amount of force required to make one surface slide relative to the other, divided by the force that presses them together.
<b>Contained load</b>	A load prevented from dislodging from the vehicle by the vehicle structure (gates, sides, racks, headboards, stanchions, etc.) or other parts of the load.
<b>Corner protectors</b>	Material used to protect lashings and the exposed edges of loads and vehicles, and to allow lashings to slide freely when being tensioned.
<b>Cradle</b>	A frame shaped to support a rounded object.
<b>Cross-member</b>	A support placed crosswise below the loading deck.
<b>Crowning</b>	A method of arranging a load so that there is a curve at the top of the load (with the middle part higher than the sides), so that the whole of the load is restrained with downward force.
<b>Deck</b>	The load-carrying surface of a vehicle.
<b>Direct restraint</b>	A form of load restraint where the load is restrained by containing, blocking or attaching.
<b>Dunnage</b>	Packing placed either between items of a load or between the base of a load and the surface of the vehicle's loading deck (also see <b>Blocking</b> ).
<b>Fastening device</b>	A device for attaching lashings to a vehicle and/or to a load (also called "fastener").
<b>Flush deck</b>	A flat loading deck without a raised coaming.
<b>Force</b>	A push or pull that, unless balanced, will cause a mass to change its velocity – i.e. cause the mass to move, stop moving, change direction or change speed. Force is normally measured in Newtons (N) or kiloNewtons (kN) however, in this guide, force is referred to in kilograms force (kgf) or tonnes force.
<b>Friction</b>	The resistance of one surface sliding across another.
<b>g</b>	The acceleration due to gravity, equal to 9.81 m/s <sup>2</sup> .
<b>Gates</b>	Permanent or removable vertical frames used at the front, sides and rear of a vehicle's loading deck to contain its load. The front gate is usually called a "loading rack" or "load rack".
<b>Gross combination mass</b>	The value specified by the manufacturer of a vehicle as being the sum of its gross vehicle mass plus the maximum loaded mass of any trailer (or motor vehicle) that it can tow in combination (also called "GCM").

<b>Gross trailer mass</b>	The mass on the axle(s) of a trailer when fully loaded and connected to a towing vehicle (also called “GTM”).
<b>Gross vehicle mass</b>	The maximum mass of a motor vehicle when loaded, as specified by its manufacturer (also called “GVM”).
<b>Headboard</b>	Usually a permanent vertical frame used at the front of a vehicle’s loading deck to contain its load (also called a “bulkhead”).
<b>Lashings</b>	Fastening devices (e.g. hooks, winches, etc.), chains, cables, ropes or webbing straps used to restrain loads.
<b>Lashing capacity</b>	The maximum force (in kilograms) that a lashing system is designed to sustain in use.
<b>Light weight load</b>	A load up to 50 kg.
<b>Load binder</b>	A device used for tensioning a lashing.
<b>Load capacity</b>	The difference between the <b>GVM</b> or <b>GTM</b> of a vehicle and its <b>tare mass</b> .
<b>Load mat</b>	A sheet of material used to increase friction and protect the load (also called “anti-slip mat” or “friction mat”).
<b>Loading rack</b>	See <b>Gates</b> .
<b>Mass</b>	A measure of the amount of matter in an object; in this guide, mass is referred to in kilograms (kg) or tonnes (t).
<b>Pallet</b>	A portable platform or tray onto which loads are placed for handling.
<b>Pantehnicon</b>	A vehicle with a body enclosed by solid rigid sides and roof.
<b>Pawl</b>	A lever or lock that prevents reverse rotation on a winch.
<b>PBS-approved vehicle</b>	Any vehicle assessed by the <a href="#">National Heavy Vehicle Regulator</a> as meeting the Performance-Based Standards.

<b>Performance Standards</b>	The outcomes to be achieved by a load restraint system (see <a href="#">Performance Standards</a> ).
<b>Pockets</b>	Housings or slots fixed to the vehicle to locate gates, stakes or loading pegs.
<b>Pre-tension</b>	The initial tension in a lashing resulting from initial tightening by the operator.
<b>Rope hooks</b>	Attachments fixed to the surrounds of the loading deck for securing of tarpaulin and tie-down ropes.
<b>Rope rail</b>	See <b>Tie rail</b> .
<b>Shackle</b>	A metal coupling link closed by a bolt that can be used for attaching chain fittings.
<b>Shoring bar</b>	Adjustable metal beam used to restrain or segregate sections of load (also called a “shoring pole”).
<b>Sling</b>	A length of hemp-core rope, webbing or steel-wire rope with eyes (i.e. loops) formed at each end.
<b>Spreader</b>	A spar or frame extending across the vehicle body structure used to support tarpaulins and side gates.
<b>Stake</b>	An upright metal rod or section (also called a “peg” or “pin”).
<b>Stanchion</b>	A large upright fixed to the side of a vehicle for sideways restraint.
<b>Stillage</b>	A metal structure for containing individual items of load.
<b>Strut</b>	A rigid member that can support loads in the direction of its length.
<b>Tare mass</b>	The mass of an unladen motor vehicle or trailer.
<b>Tarpaulin</b>	A waterproof sheet used to cover and protect goods from the weather (also called “tarp”).
<b>Tensioner</b>	A device used to tighten a lashing.
<b>Tie-down</b>	A form of load restraint where the load is restrained by friction (also called “indirect restraint”).
<b>Tie rail</b>	A round rail that skirts the perimeter of the loading deck below the coaming rail.

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<b>Truck winch</b>	A device used for tensioning a lashing that is normally placed under the coaming rail and may be fixed in position using the <b>tie rail</b> or slide on a track (also see <b>Winch</b> ).
<b>Turnbuckle</b>	A device for tensioning consisting of a threaded sleeve and 2 mating threaded ends.
<b>Twist lock</b>	A locking device with a rotating head that normally engages a corner casting on the load.
<b>Unitised load</b>	Multiple separate items bound together to form a single item of load.
<b>Wedge</b>	A piece of rigid material that is thick at one end and tapers to a thinner edge at the other (also see <b>Chocks</b> ).
<b>Weight</b>	The force exerted by gravity on a mass (e.g. 1 kgf (= 9.81 N) is the weight of a 1 kg mass).
<b>Winch</b>	A device for tensioning lashings via a rotating spool.

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## LIST OF RELEVANT STANDARDS

A list of all standards applicable to the transport of dangerous goods can be found in the Australian Code for the Transport of Dangerous Goods by Road & Rail.

Information on how to obtain the current versions of the following standards may be available from:

### Standards Australia

GPO Box 476

Sydney NSW 2001

Tel: (02) 9237 6000

Web: [www.standards.org.au](http://www.standards.org.au)

### Intertek Inform

GPO Box 5420

Sydney NSW 2001

Tel: 13 12 42

Web: <https://www.intertekinform.com/>

Email: [sales@intertekinform.com](mailto:sales@intertekinform.com)

### Cargo Restraint Systems

- Motor vehicles – Cargo Restraint Systems – Transport Chain and Components\* AS/NZS 4344
- Motor vehicles – Cargo Restraint Systems – Transport Webbing and Components\* AS/NZS 4380
- Motor vehicles – Cargo Restraint Systems – Transport Fibre Rope\* AS/NZS 4345

<b>Short-link Chain for Lifting Purposes</b>	AS 2321
<b>Steel wire ropes – Product specification</b>	AS 3569
<b>Shackles</b>	AS 2741
<b>Shank Hooks and Large-eye Hooks – Maximum 60t</b>	AS 3777
<b>Thimbles for Wire Rope</b>	AS 1138
<b>Packaging – Tensional Strapping</b>	AS 2400.13
<b>Load Anchorage Points for Heavy Vehicles</b>	NZS 5444
<b>Pressure Vessels</b>	AS 1210
<b>Load restraint for LP Gas cylinder distribution</b>	AS 5714
<b>LP Gas - Storage and handling</b>	AS/NZS 1596
<b>Anhydrous Ammonia – Storage and Handling</b>	AS/NZS 2022
<b>Road Tank Vehicles for Dangerous Goods – General Requirements</b>	AS 2809 (Parts 1-6)
<b>Lifting Devices</b>	AS 4991
<b>Freight Containers</b>	AS/NZS 3711 (Parts 1-9)
<b>Motor Vehicles – Cargo Barriers for Occupant Protection</b>	AS/NZS 4034 (Parts 1 & 2)
<b>Lashing and Securing Arrangements on Road Vehicles for Sea Transportation on Ro/Ro Ships</b>	ISO 9367 (Parts 1 & 2)
<b>Securing of Cargo on Road Vehicles, Lashing Points on Commercial Vehicles for Transportation, Minimum Requirements and Testing</b>	DIN EN 12640-2001

**AS** Australian Standard

**NZS** New Zealand Standard

**ISO** International Organisation for Standardisation

**DIN** German Institute for Standardisation

*Note: \*Standard has been withdrawn. A withdrawn standard indicates that it is not up to date technically; does not reflect current practice; is not suitable for new and existing applications; or is not compatible with current views and expectations regarding quality, safety and the environment.*

# LIST OF RELEVANT LEGISLATION AND PUBLICATIONS

Information on the availability and contact details for the following national model legislation/publications or their updates may be obtained from the NTC website: [www.ntc.gov.au](http://www.ntc.gov.au). However, please check local state and territory laws when establishing legal obligations because jurisdictions may have varied the national laws when implementing them.

- Australian Code for the Transport of Dangerous Goods by Road & Rail
- Australian Code for the Transport of Explosives by Road & Rail

These codes are available from:

**Canprint Information Services**

**16 Nyrang Street**

**FYSHWICK ACT 2609**

**Tel: (02) 6295 4422**

**Fax: (02) 6295 4473**

**Email: [canprint@canprint.com.au](mailto:canprint@canprint.com.au)**

- Australian Light Vehicle Standards Rules 2015
- Heavy Vehicle National Law Act 2012
- Heavy Vehicle (Fatigue Management) National Regulation 2013
- Heavy Vehicle (General) National Regulation 2013
- Heavy Vehicle (Mass, Dimension and Loading) National Regulation 2013
- Heavy Vehicle (Vehicle Standards) National Regulation 2013
- Australian Animal Welfare Standards and Guidelines, Land Transport of Livestock, Edition 1, Version 1.1

# COMMONWEALTH, STATE AND TERRITORY TRANSPORT REGULATORY AUTHORITIES

## Commonwealth and national bodies:

### Department of Infrastructure, Transport, Regional Development, Communications and the Arts

GPO Box 594  
CANBERRA ACT 2601  
Tel: 1800 075 001  
Web: [www.infrastructure.gov.au](http://www.infrastructure.gov.au)

### National Heavy Vehicle Regulator

PO Box 492  
FORTITUDE VALLEY QLD 4006  
Tel: 13 NHVR (13 64 87)  
Web: [www.nhvr.gov.au](http://www.nhvr.gov.au)  
Email: [info@nhvr.gov.au](mailto:info@nhvr.gov.au)

### National Transport Commission

Level 3, 600 Bourke Street  
MELBOURNE VIC 3000  
Tel: (03) 9236 5000  
Web: [www.ntc.gov.au](http://www.ntc.gov.au)  
Email: [enquiries@ntc.gov.au](mailto:enquiries@ntc.gov.au)

## State and territory bodies:

### Australian Capital Territory:

Access Canberra  
GPO Box 158  
CANBERRA CITY ACT 2601  
Tel: 13 22 81  
Web: [www.accesscanberra.act.gov.au](http://www.accesscanberra.act.gov.au)

### Victoria:

Transport Victoria  
GPO Box 2392  
MELBOURNE VIC 3001  
Tel: 13 37 78  
Web: [www.transport.vic.gov.au](http://www.transport.vic.gov.au)

### Queensland:

Department of Transport and Main Roads  
PO Box 673  
FORTITUDE VALLEY QLD 4006  
Tel: 13 QGOV (13 74 68)  
Web: [www.tmr.qld.gov.au](http://www.tmr.qld.gov.au)

### New South Wales:

Transport for NSW  
PO Box K659  
HAYMARKET NSW 1240  
Tel: 13 15 00  
Web: [www.transport.nsw.gov.au](http://www.transport.nsw.gov.au)

### Northern Territory:

Department of Logistics and Infrastructure  
GPO Box 2520  
DARWIN NT 0801  
Tel: (08) 8999 5511  
Web: [www.dli.nt.gov.au](http://www.dli.nt.gov.au)

### South Australia:

Department for Infrastructure and Transport  
GPO Box 1533  
ADELAIDE SA 5001  
Tel: 1300 872 677  
Web: [www.dit.sa.gov.au](http://www.dit.sa.gov.au)

### Tasmania:

Department of State Growth Transport  
GPO Box 536  
HOBART TAS 7001  
Tel: 1800 030 688  
Web: [www.stategrowth.tas.gov.au](http://www.stategrowth.tas.gov.au)

### Western Australia:

Department of Transport  
GPO Box C102  
WA 6839  
Tel: 13 11 56  
Web: [www.transport.wa.gov.au](http://www.transport.wa.gov.au)

## COMPETENT AUTHORITIES FOR ROAD TRANSPORT OF DANGEROUS GOODS

Information on the transport of dangerous goods and details of the competent authorities can be obtained from:

[https://infrastructure.gov.au/transport/australia/dangerous/str\\_compauth.aspx](https://infrastructure.gov.au/transport/australia/dangerous/str_compauth.aspx)

### State and territory bodies:

#### Australian Capital Territory:

Occupational Hygiene & Dangerous Substances Team  
WorkSafe ACT  
GPO Box 158  
CANBERRA CITY ACT 2601  
Tel: 13 22 81  
Web: [www.worksafe.act.gov.au](http://www.worksafe.act.gov.au)  
Email: [DangerousSubstances@worksafe.act.gov.au](mailto:DangerousSubstances@worksafe.act.gov.au)

#### Queensland:

*Road Transport*  
Industry and Operator Authorisation Unit  
Department of Transport and Main Roads  
PO Box 673  
FORTITUDE VALLEY QLD 4006  
Tel: (07) 3066 2995  
Web: [www.tmr.qld.gov.au](http://www.tmr.qld.gov.au)  
Email: [dgu@tmr.qld.gov.au](mailto:dgu@tmr.qld.gov.au)

#### Northern Territory:

NT WorkSafe  
GPO Box 1722  
DARWIN NT 0801  
Tel: 1800 019 115  
Web: [www.worksafe.nt.gov.au](http://www.worksafe.nt.gov.au)  
Email: [ntworksafe@nt.gov.au](mailto:ntworksafe@nt.gov.au)

#### Tasmania:

Manager Accreditation and Licensing  
WorkSafe Tasmania  
PO Box 56  
ROSNY PARK TAS 7018  
Tel: 1300 366 322 (local calls) or (03) 6166 4600  
Web: [www.worksafe.tas.gov.au](http://www.worksafe.tas.gov.au)  
Email: [wstinfo@justice.tas.gov.au](mailto:wstinfo@justice.tas.gov.au)

#### Victoria:

Dangerous Goods Unit  
WorkSafe Victoria  
1 Malop Street  
GEELONG VIC 3220  
Tel: 1800 136 089  
Web: [www.worksafe.vic.gov.au](http://www.worksafe.vic.gov.au)  
Email: [dangerousgoodsunit@worksafe.vic.gov.au](mailto:dangerousgoodsunit@worksafe.vic.gov.au)

#### New South Wales:

*Transport-related matters*  
Unit Head Pesticides and Chemicals  
Environment Protection Authority  
Locked Bag 5022  
PARAMATTA NSW 2124  
Tel: 13 15 55  
Web: [www.epa.nsw.gov.au](http://www.epa.nsw.gov.au)  
Email: [envsolclr.requests@epa.nsw.gov.au](mailto:envsolclr.requests@epa.nsw.gov.au)

#### South Australia:

CHEM Team  
SafeWork SA  
GPO Box 465  
ADELAIDE SA 5001  
Tel: 1300 365 255  
Web: [www.safework.sa.gov.au](http://www.safework.sa.gov.au)  
Email: [chem.safework@sa.gov.au](mailto:chem.safework@sa.gov.au)

#### Western Australia:

WorkSafe Petroleum Safety and Dangerous Goods Directorate  
Department of Energy, Mines, Industry Regulation and Safety  
Level 2, 1 Adelaide Terrace  
EAST PERTH WA 6004  
Tel: +61 8 9358 8002  
Web: [www.demirs.wa.gov.au](http://www.demirs.wa.gov.au)  
Email: [dgsb@demirs.wa.gov.au](mailto:dgsb@demirs.wa.gov.au)

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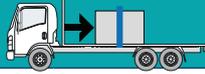
# NUMBER OF TIE-DOWN LASHINGS

## 8 MM TRANSPORT CHAIN, TURNBUCKLES

Lashings:		Tensioner:			Pre-tension:	
8 mm transport chain		Turnbuckles			1,000 kgf	
<b>BLOCKED</b> (RESTRAINED TO 0.5 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg
	2	19,000 kg	17,000 kg	14,000 kg	10,000 kg	5,100 kg
	3	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
	4	38,000 kg	34,000 kg	28,000 kg	20,000 kg	10,000 kg
	5	48,000 kg	43,000 kg	35,000 kg	25,000 kg	12,000 kg
	6	57,000 kg	51,000 kg	42,000 kg	30,000 kg	15,000 kg
	7	67,000 kg	60,000 kg	49,000 kg	35,000 kg	18,000 kg
	8	77,000 kg	69,000 kg	56,000 kg	40,000 kg	20,000 kg
	9	86,000 kg	77,000 kg	63,000 kg	45,000 kg	23,000 kg
	10	96,000 kg	86,000 kg	70,000 kg	50,000 kg	25,000 kg
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	2	15,000 kg	13,000 kg	11,000 kg	8,000 kg	4,100 kg
	3	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	4	30,000 kg	27,000 kg	22,000 kg	16,000 kg	8,200 kg
	5	38,000 kg	34,000 kg	28,000 kg	20,000 kg	10,000 kg
	6	46,000 kg	41,000 kg	33,000 kg	24,000 kg	12,000 kg
	7	54,000 kg	48,000 kg	39,000 kg	28,000 kg	14,000 kg
	8	61,000 kg	55,000 kg	45,000 kg	32,000 kg	16,000 kg
	9	69,000 kg	62,000 kg	50,000 kg	36,000 kg	18,000 kg
	10	77,000 kg	69,000 kg	56,000 kg	40,000 kg	20,000 kg
<b>LOW FRICTION</b>	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	2	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	3	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	4	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	5	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg
	6	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	7	13,000 kg	12,000 kg	9,800 kg	7,000 kg	3,600 kg
	8	15,000 kg	13,000 kg	11,000 kg	8,000 kg	4,100 kg
	9	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	10	19,000 kg	17,000 kg	14,000 kg	10,000 kg	5,100 kg
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	1,200 kg	1,100 kg	940 kg	660 kg	340 kg
	2	2,500 kg	2,300 kg	1,800 kg	1,300 kg	690 kg
	3	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	4	5,100 kg	4,600 kg	3,700 kg	2,600 kg	1,300 kg
	5	6,400 kg	5,700 kg	4,700 kg	3,300 kg	1,700 kg
	6	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	7	9,000 kg	8,000 kg	6,500 kg	4,600 kg	2,400 kg
	8	10,000 kg	9,200 kg	7,500 kg	5,300 kg	2,700 kg
	9	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	10	12,000 kg	11,000 kg	9,400 kg	6,600 kg	3,400 kg

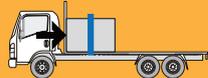
# NUMBER OF TIE-DOWN LASHINGS

## 8 MM TRANSPORT CHAIN, TURNBUCKLES

Lashings:		Tensioner:			Pre-tension:	
8 mm transport chain		Turnbuckles			1,000 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
HIGH FRICTION	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	2	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	3	17,000 kg	15,000 kg	12,000 kg	8,900 kg	4,600 kg
	4	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	5	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
	6	34,000 kg	31,000 kg	25,000 kg	18,000 kg	9,300 kg
	7	40,000 kg	36,000 kg	29,000 kg	21,000 kg	10,000 kg
	8	46,000 kg	41,000 kg	33,000 kg	24,000 kg	12,000 kg
	9	52,000 kg	46,000 kg	38,000 kg	27,000 kg	13,000 kg
	10	57,000 kg	51,000 kg	42,000 kg	30,000 kg	15,000 kg
MEDIUM FRICTION	Static friction: 0.4		Example: Smooth steel on timber			
	1	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	2	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	3	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	4	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	5	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg
	6	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	7	13,000 kg	12,000 kg	9,800 kg	7,000 kg	3,600 kg
	8	15,000 kg	13,000 kg	11,000 kg	8,000 kg	4,100 kg
	9	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	10	19,000 kg	17,000 kg	14,000 kg	10,000 kg	5,100 kg
LOW FRICTION	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	870 kg	780 kg	640 kg	450 kg	230 kg
	2	1,700 kg	1,500 kg	1,200 kg	900 kg	470 kg
	3	2,600 kg	2,300 kg	1,900 kg	1,300 kg	700 kg
	4	3,500 kg	3,100 kg	2,500 kg	1,800 kg	940 kg
	5	4,300 kg	3,900 kg	3,200 kg	2,200 kg	1,100 kg
	6	5,200 kg	4,700 kg	3,800 kg	2,700 kg	1,400 kg
	7	6,100 kg	5,500 kg	4,400 kg	3,100 kg	1,600 kg
	8	7,000 kg	6,200 kg	5,100 kg	3,600 kg	1,800 kg
	9	7,900 kg	7,000 kg	5,700 kg	4,000 kg	2,100 kg
	10	8,700 kg	7,800 kg	6,400 kg	4,500 kg	2,300 kg
VERY LOW FRICTION	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	640 kg	570 kg	470 kg	330 kg	170 kg
	2	1,200 kg	1,100 kg	940 kg	660 kg	340 kg
	3	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	4	2,500 kg	2,300 kg	1,800 kg	1,300 kg	690 kg
	5	3,200 kg	2,800 kg	2,300 kg	1,600 kg	860 kg
	6	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	7	4,500 kg	4,000 kg	3,200 kg	2,300 kg	1,200 kg
	8	5,100 kg	4,600 kg	3,700 kg	2,600 kg	1,300 kg
	9	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	10	6,400 kg	5,700 kg	4,700 kg	3,300 kg	1,700 kg

# NUMBER OF TIE-DOWN LASHINGS

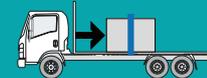
## 8 MM TRANSPORT CHAIN, OVER-CENTRE TENSIONER

Lashings:		Tensioner:			Pre-tension:	
8 mm transport chain		Over-centre tensioner			750 kgf	
<b>BLOCKED</b> (RESTRAINED TO 0.5 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	7,200 kg	6,400 kg	5,300 kg	3,700 kg	1,900 kg
	2	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg
	3	21,000 kg	19,000 kg	15,000 kg	11,000 kg	5,800 kg
	4	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
	5	36,000 kg	32,000 kg	26,000 kg	18,000 kg	9,700 kg
	6	43,000 kg	38,000 kg	31,000 kg	22,000 kg	11,000 kg
	7	50,000 kg	45,000 kg	37,000 kg	26,000 kg	13,000 kg
	8	57,000 kg	51,000 kg	42,000 kg	30,000 kg	15,000 kg
	9	65,000 kg	58,000 kg	47,000 kg	33,000 kg	17,000 kg
	10	72,000 kg	64,000 kg	53,000 kg	37,000 kg	19,000 kg
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	2	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	3	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	4	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	5	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
	6	34,000 kg	31,000 kg	25,000 kg	18,000 kg	9,300 kg
	7	40,000 kg	36,000 kg	29,000 kg	21,000 kg	10,000 kg
	8	46,000 kg	41,000 kg	33,000 kg	24,000 kg	12,000 kg
	9	52,000 kg	46,000 kg	38,000 kg	27,000 kg	13,000 kg
	10	57,000 kg	51,000 kg	42,000 kg	30,000 kg	15,000 kg
<b>LOW FRICTION</b>	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	2	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	3	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	4	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	5	7,200 kg	6,400 kg	5,300 kg	3,700 kg	1,900 kg
	6	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	7	10,000 kg	9,000 kg	7,400 kg	5,200 kg	2,700 kg
	8	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	9	13,000 kg	11,000 kg	9,500 kg	6,700 kg	3,400 kg
	10	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	960 kg	860 kg	700 kg	500 kg	250 kg
	2	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	3	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	4	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	5	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg
	6	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	7	6,700 kg	6,000 kg	4,900 kg	3,500 kg	1,800 kg
	8	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	9	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	10	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg

# NUMBER OF TIE-DOWN LASHINGS

## 8 MM TRANSPORT CHAIN, OVER-CENTRE TENSIONER

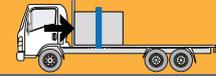
Lashings:		Tensioner:			Pre-tension:	
8 mm transport chain		Over-centre tensioner			750 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8 G)						
Number of lashings		Lashing angle (from horizontal)				
		At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25
HIGH FRICTION	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	2	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	3	13,000 kg	11,000 kg	9,500 kg	6,700 kg	3,400 kg
	4	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	5	21,000 kg	19,000 kg	15,000 kg	11,000 kg	5,800 kg
	6	26,000 kg	23,000 kg	19,000 kg	13,000 kg	6,900 kg
	7	30,000 kg	27,000 kg	22,000 kg	15,000 kg	8,100 kg
	8	34,000 kg	31,000 kg	25,000 kg	18,000 kg	9,300 kg
	9	39,000 kg	35,000 kg	28,000 kg	20,000 kg	10,000 kg
10	43,000 kg	38,000 kg	31,000 kg	22,000 kg	11,000 kg	
MEDIUM FRICTION	Static friction: 0.4		Example: Smooth steel on timber			
	1	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	2	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	3	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	4	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	5	7,200 kg	6,400 kg	5,300 kg	3,700 kg	1,900 kg
	6	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	7	10,000 kg	9,000 kg	7,400 kg	5,200 kg	2,700 kg
	8	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	9	13,000 kg	11,000 kg	9,500 kg	6,700 kg	3,400 kg
10	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg	
LOW FRICTION	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	650 kg	590 kg	480 kg	340 kg	170 kg
	2	1,300 kg	1,100 kg	960 kg	680 kg	350 kg
	3	1,900 kg	1,700 kg	1,400 kg	1,000 kg	520 kg
	4	2,600 kg	2,300 kg	1,900 kg	1,300 kg	700 kg
	5	3,200 kg	2,900 kg	2,400 kg	1,700 kg	880 kg
	6	3,900 kg	3,500 kg	2,800 kg	2,000 kg	1,000 kg
	7	4,600 kg	4,100 kg	3,300 kg	2,300 kg	1,200 kg
	8	5,200 kg	4,700 kg	3,800 kg	2,700 kg	1,400 kg
	9	5,900 kg	5,300 kg	4,300 kg	3,000 kg	1,500 kg
10	6,500 kg	5,900 kg	4,800 kg	3,400 kg	1,700 kg	
VERY LOW FRICTION	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	480 kg	430 kg	350 kg	250 kg	120 kg
	2	960 kg	860 kg	700 kg	500 kg	250 kg
	3	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	4	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	5	2,400 kg	2,100 kg	1,700 kg	1,200 kg	640 kg
	6	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	7	3,300 kg	3,000 kg	2,400 kg	1,700 kg	900 kg
	8	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	9	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
10	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg	



# NUMBER OF TIE-DOWN LASHINGS

## 50 MM WEBBING STRAPS, PULL-DOWN HAND RATCHET

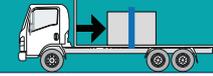
Lashings:		Tensioner:			Pre-tension:	
50 mm webbing straps		Pull-down hand ratchet			600 kgf	
<b>BLOCKED</b> (RESTRAINED TO 0.5 G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
HIGH FRICTION	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	2	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	3	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	4	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	5	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
	6	34,000 kg	31,000 kg	25,000 kg	18,000 kg	9,300 kg
	7	40,000 kg	36,000 kg	29,000 kg	21,000 kg	10,000 kg
	8	46,000 kg	41,000 kg	33,000 kg	24,000 kg	12,000 kg
	9	52,000 kg	46,000 kg	38,000 kg	27,000 kg	13,000 kg
10	57,000 kg	51,000 kg	42,000 kg	30,000 kg	15,000 kg	
MEDIUM FRICTION	Static friction: 0.4		Example: Smooth steel on timber			
	1	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	2	9,200 kg	8,300 kg	6,700 kg	4,800 kg	2,400 kg
	3	13,000 kg	12,000 kg	10,000 kg	7,200 kg	3,700 kg
	4	18,000 kg	16,000 kg	13,000 kg	9,600 kg	4,900 kg
	5	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	6	27,000 kg	24,000 kg	20,000 kg	14,000 kg	7,400 kg
	7	32,000 kg	29,000 kg	23,000 kg	16,000 kg	8,600 kg
	8	37,000 kg	33,000 kg	27,000 kg	19,000 kg	9,900 kg
	9	41,000 kg	37,000 kg	30,000 kg	21,000 kg	11,000 kg
10	46,000 kg	41,000 kg	33,000 kg	24,000 kg	12,000 kg	
LOW FRICTION	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	2	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	3	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	4	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	5	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	6	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	7	8,100 kg	7,200 kg	5,900 kg	4,200 kg	2,100 kg
	8	9,200 kg	8,300 kg	6,700 kg	4,800 kg	2,400 kg
	9	10,000 kg	9,300 kg	7,600 kg	5,400 kg	2,700 kg
10	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg	
VERY LOW FRICTION	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	770 kg	690 kg	560 kg	400 kg	200 kg
	2	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	3	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	4	3,000 kg	2,700 kg	2,200 kg	1,600 kg	820 kg
	5	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	6	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	7	5,400 kg	4,800 kg	3,900 kg	2,800 kg	1,400 kg
	8	6,100 kg	5,500 kg	4,500 kg	3,200 kg	1,600 kg
	9	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
10	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg	



# NUMBER OF TIE-DOWN LASHINGS

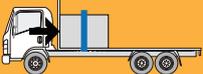
## 50 MM WEBBING STRAPS, PULL-DOWN HAND RATCHET

Lashings:		Tensioner:			Pre-tension:	
50 mm webbing straps		Pull-down hand ratchet			600 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8 G)						
Number of lashings		Lashing angle (from horizontal)				
		At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25
HIGH FRICTION	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	2	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	3	10,000 kg	9,300 kg	7,600 kg	5,400 kg	2,700 kg
	4	13,000 kg	12,000 kg	10,000 kg	7,200 kg	3,700 kg
	5	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	6	20,000 kg	18,000 kg	15,000 kg	10,000 kg	5,500 kg
	7	24,000 kg	21,000 kg	17,000 kg	12,000 kg	6,500 kg
	8	27,000 kg	24,000 kg	20,000 kg	14,000 kg	7,400 kg
	9	31,000 kg	28,000 kg	22,000 kg	16,000 kg	8,300 kg
10	34,000 kg	31,000 kg	25,000 kg	18,000 kg	9,300 kg	
MEDIUM FRICTION	Static friction: 0.4		Example: Smooth steel on timber			
	1	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	2	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	3	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	4	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	5	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	6	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	7	8,100 kg	7,200 kg	5,900 kg	4,200 kg	2,100 kg
	8	9,200 kg	8,300 kg	6,700 kg	4,800 kg	2,400 kg
	9	10,000 kg	9,300 kg	7,600 kg	5,400 kg	2,700 kg
10	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg	
LOW FRICTION	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	520 kg	470 kg	380 kg	270 kg	140 kg
	2	1,000 kg	940 kg	770 kg	540 kg	280 kg
	3	1,500 kg	1,400 kg	1,100 kg	810 kg	420 kg
	4	2,100 kg	1,800 kg	1,500 kg	1,000 kg	560 kg
	5	2,600 kg	2,300 kg	1,900 kg	1,300 kg	700 kg
	6	3,100 kg	2,800 kg	2,300 kg	1,600 kg	840 kg
	7	3,600 kg	3,300 kg	2,600 kg	1,900 kg	980 kg
	8	4,200 kg	3,700 kg	3,000 kg	2,100 kg	1,100 kg
	9	4,700 kg	4,200 kg	3,400 kg	2,400 kg	1,200 kg
10	5,200 kg	4,700 kg	3,800 kg	2,700 kg	1,400 kg	
VERY LOW FRICTION	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	380 kg	340 kg	280 kg	200 kg	100 kg
	2	770 kg	690 kg	560 kg	400 kg	200 kg
	3	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	4	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	5	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	6	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	7	2,700 kg	2,400 kg	1,900 kg	1,400 kg	720 kg
	8	3,000 kg	2,700 kg	2,200 kg	1,600 kg	820 kg
	9	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
10	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg	



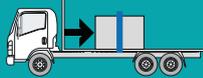
# NUMBER OF TIE-DOWN LASHINGS

## 50 MM WEBBING STRAPS, PUSH-UP HAND RATCHET OR TRUCK WINCH

Lashings:		Tensioner:			Pre-tension:	
50 mm webbing straps		Push-up hand ratchet or truck winch			300 kgf	
<b>BLOCKED</b> (RESTRAINED TO 0.5 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	2	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	3	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	4	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	5	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg
	6	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	7	20,000 kg	18,000 kg	14,000 kg	10,000 kg	5,400 kg
	8	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
	9	26,000 kg	23,000 kg	19,000 kg	13,000 kg	6,900 kg
	10	28,000 kg	25,000 kg	21,000 kg	15,000 kg	7,700 kg
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	2	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	3	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	4	9,200 kg	8,300 kg	6,700 kg	4,800 kg	2,400 kg
	5	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	6	13,000 kg	12,000 kg	10,000 kg	7,200 kg	3,700 kg
	7	16,000 kg	14,000 kg	11,000 kg	8,400 kg	4,300 kg
	8	18,000 kg	16,000 kg	13,000 kg	9,600 kg	4,900 kg
	9	20,000 kg	18,000 kg	15,000 kg	10,000 kg	5,500 kg
	10	23,000 kg	20,000 kg	16,000 kg	12,000 kg	6,200 kg
<b>LOW FRICTION</b>	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	570 kg	510 kg	420 kg	300 kg	150 kg
	2	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	3	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	4	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	5	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	6	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	7	4,000 kg	3,600 kg	2,900 kg	2,100 kg	1,000 kg
	8	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	9	5,200 kg	4,600 kg	3,800 kg	2,700 kg	1,300 kg
	10	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	380 kg	340 kg	280 kg	200 kg	100 kg
	2	770 kg	690 kg	560 kg	400 kg	200 kg
	3	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	4	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	5	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	6	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	7	2,700 kg	2,400 kg	1,900 kg	1,400 kg	720 kg
	8	3,000 kg	2,700 kg	2,200 kg	1,600 kg	820 kg
	9	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	10	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg

# NUMBER OF TIE-DOWN LASHINGS

## 50 MM WEBBING STRAPS, PUSH-UP HAND RATCHET OR TRUCK WINCH

Lashings:		Tensioner:			Pre-tension:	
50 mm webbing straps		Push-up hand ratchet or truck winch			300 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8 G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
HIGH FRICTION	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	2	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	3	5,200 kg	4,600 kg	3,800 kg	2,700 kg	1,300 kg
	4	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	5	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	6	10,000 kg	9,300 kg	7,600 kg	5,400 kg	2,700 kg
	7	12,000 kg	10,000 kg	8,900 kg	6,300 kg	3,200 kg
	8	13,000 kg	12,000 kg	10,000 kg	7,200 kg	3,700 kg
	9	15,000 kg	14,000 kg	11,000 kg	8,100 kg	4,100 kg
10	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg	
MEDIUM FRICTION	Static friction: 0.4		Example: Smooth steel on timber			
	1	570 kg	510 kg	420 kg	300 kg	150 kg
	2	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	3	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	4	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	5	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	6	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	7	4,000 kg	3,600 kg	2,900 kg	2,100 kg	1,000 kg
	8	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	9	5,200 kg	4,600 kg	3,800 kg	2,700 kg	1,300 kg
10	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg	
LOW FRICTION	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	260 kg	230 kg	190 kg	130 kg	70 kg
	2	520 kg	470 kg	380 kg	270 kg	140 kg
	3	790 kg	700 kg	570 kg	400 kg	210 kg
	4	1,000 kg	940 kg	770 kg	540 kg	280 kg
	5	1,300 kg	1,100 kg	960 kg	680 kg	350 kg
	6	1,500 kg	1,400 kg	1,100 kg	810 kg	420 kg
	7	1,800 kg	1,600 kg	1,300 kg	950 kg	490 kg
	8	2,100 kg	1,800 kg	1,500 kg	1,000 kg	560 kg
	9	2,300 kg	2,100 kg	1,700 kg	1,200 kg	630 kg
10	2,600 kg	2,300 kg	1,900 kg	1,300 kg	700 kg	
VERY LOW FRICTION	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	190 kg	170 kg	140 kg	100 kg	51 kg
	2	380 kg	340 kg	280 kg	200 kg	100 kg
	3	570 kg	510 kg	420 kg	300 kg	150 kg
	4	770 kg	690 kg	560 kg	400 kg	200 kg
	5	960 kg	860 kg	700 kg	500 kg	250 kg
	6	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	7	1,300 kg	1,200 kg	980 kg	700 kg	360 kg
	8	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	9	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
10	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg	

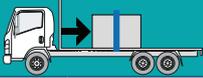
# NUMBER OF TIE-DOWN LASHINGS

## 35 MM WEBBING STRAPS, HAND RATCHET

Lashings:		Tensioner:			Pre-tension:	
35 mm webbing straps		Hand ratchet			250 kgf	
<b>BLOCKED</b> (RESTRAINED TO 0.5 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	2,400 kg	2,100 kg	1,700 kg	1,200 kg	640 kg
	2	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg
	3	7,200 kg	6,400 kg	5,300 kg	3,700 kg	1,900 kg
	4	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg
	5	12,000 kg	10,000 kg	8,800 kg	6,200 kg	3,200 kg
	6	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg
	7	16,000 kg	15,000 kg	12,000 kg	8,700 kg	4,500 kg
	8	19,000 kg	17,000 kg	14,000 kg	10,000 kg	5,100 kg
	9	21,000 kg	19,000 kg	15,000 kg	11,000 kg	5,800 kg
	10	24,000 kg	21,000 kg	17,000 kg	12,000 kg	6,400 kg
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	2	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	3	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	4	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	5	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg
	6	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	7	13,000 kg	12,000 kg	9,800 kg	7,000 kg	3,600 kg
	8	15,000 kg	13,000 kg	11,000 kg	8,000 kg	4,100 kg
	9	17,000 kg	15,000 kg	12,000 kg	9,000 kg	4,600 kg
	10	19,000 kg	17,000 kg	14,000 kg	10,000 kg	5,100 kg
<b>LOW FRICTION</b>	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	480 kg	430 kg	350 kg	250 kg	120 kg
	2	960 kg	860 kg	700 kg	500 kg	250 kg
	3	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	4	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	5	2,400 kg	2,100 kg	1,700 kg	1,200 kg	640 kg
	6	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	7	3,300 kg	3,000 kg	2,400 kg	1,700 kg	900 kg
	8	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	9	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	10	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	320 kg	280 kg	230 kg	160 kg	86 kg
	2	640 kg	570 kg	470 kg	330 kg	170 kg
	3	960 kg	860 kg	700 kg	500 kg	250 kg
	4	1,200 kg	1,100 kg	940 kg	660 kg	340 kg
	5	1,600 kg	1,400 kg	1,100 kg	830 kg	430 kg
	6	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	7	2,200 kg	2,000 kg	1,600 kg	1,100 kg	600 kg
	8	2,500 kg	2,300 kg	1,800 kg	1,300 kg	690 kg
	9	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	10	3,200 kg	2,800 kg	2,300 kg	1,600 kg	860 kg

# NUMBER OF TIE-DOWN LASHINGS

## 35 MM WEBBING STRAPS, HAND RATCHET

Lashings:		Tensioner:			Pre-tension:	
35 mm webbing straps		Hand ratchet			250 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8 G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	<b>Static friction: 0.6</b>		<b>Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</b>			
	1	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	2	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	3	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	4	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	5	7,200 kg	6,400 kg	5,300 kg	3,700 kg	1,900 kg
	6	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	7	10,000 kg	9,000 kg	7,400 kg	5,200 kg	2,700 kg
	8	11,000 kg	10,000 kg	8,400 kg	6,000 kg	3,100 kg
	9	13,000 kg	11,000 kg	9,500 kg	6,700 kg	3,400 kg
10	14,000 kg	12,000 kg	10,000 kg	7,500 kg	3,800 kg	
<b>MEDIUM FRICTION</b>	<b>Static friction: 0.4</b>		<b>Example: Smooth steel on timber</b>			
	1	480 kg	430 kg	350 kg	250 kg	120 kg
	2	960 kg	860 kg	700 kg	500 kg	250 kg
	3	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	4	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	5	2,400 kg	2,100 kg	1,700 kg	1,200 kg	640 kg
	6	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	7	3,300 kg	3,000 kg	2,400 kg	1,700 kg	900 kg
	8	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	9	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
10	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg	
<b>LOW FRICTION</b>	<b>Static friction: 0.25</b>		<b>Example: Smooth steel on conveyor belt</b>			
	1	210 kg	190 kg	160 kg	110 kg	58 kg
	2	430 kg	390 kg	320 kg	220 kg	110 kg
	3	650 kg	590 kg	480 kg	340 kg	170 kg
	4	870 kg	780 kg	640 kg	450 kg	230 kg
	5	1,000 kg	980 kg	800 kg	560 kg	290 kg
	6	1,300 kg	1,100 kg	960 kg	680 kg	350 kg
	7	1,500 kg	1,300 kg	1,100 kg	790 kg	410 kg
	8	1,700 kg	1,500 kg	1,200 kg	900 kg	470 kg
	9	1,900 kg	1,700 kg	1,400 kg	1,000 kg	520 kg
10	2,100 kg	1,900 kg	1,600 kg	1,100 kg	580 kg	
<b>VERY LOW FRICTION</b>	<b>Static friction: 0.2</b>		<b>Example: Smooth steel on rusty steel</b>			
	1	160 kg	140 kg	110 kg	83 kg	43 kg
	2	320 kg	280 kg	230 kg	160 kg	86 kg
	3	480 kg	430 kg	350 kg	250 kg	120 kg
	4	640 kg	570 kg	470 kg	330 kg	170 kg
	5	800 kg	720 kg	580 kg	410 kg	210 kg
	6	960 kg	860 kg	700 kg	500 kg	250 kg
	7	1,100 kg	1,000 kg	820 kg	580 kg	300 kg
	8	1,200 kg	1,100 kg	940 kg	660 kg	340 kg
	9	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
10	1,600 kg	1,400 kg	1,100 kg	830 kg	430 kg	

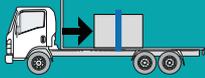
# NUMBER OF TIE-DOWN LASHINGS

## 25 MM WEBBING STRAPS/12 MM ROPE, HAND RATCHET/DOUBLE HITCH

Lashings:		Tensioner:			Pre-tension:	
25 mm webbing straps/12 mm rope		Hand ratchet/double hitch			100 kgf	
<b>BLOCKED (RESTRAINED TO 0.5 G)</b>						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	960 kg	860 kg	700 kg	500 kg	250 kg
	2	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	3	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	4	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	5	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg
	6	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
	7	6,700 kg	6,000 kg	4,900 kg	3,500 kg	1,800 kg
	8	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
	9	8,600 kg	7,700 kg	6,300 kg	4,500 kg	2,300 kg
	10	9,600 kg	8,600 kg	7,000 kg	5,000 kg	2,500 kg
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	770 kg	690 kg	560 kg	400 kg	200 kg
	2	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	3	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	4	3,000 kg	2,700 kg	2,200 kg	1,600 kg	820 kg
	5	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	6	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	7	5,400 kg	4,800 kg	3,900 kg	2,800 kg	1,400 kg
	8	6,100 kg	5,500 kg	4,500 kg	3,200 kg	1,600 kg
	9	6,900 kg	6,200 kg	5,000 kg	3,600 kg	1,800 kg
	10	7,700 kg	6,900 kg	5,600 kg	4,000 kg	2,000 kg
<b>LOW FRICTION</b>	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	190 kg	170 kg	140 kg	100 kg	51 kg
	2	380 kg	340 kg	280 kg	200 kg	100 kg
	3	570 kg	510 kg	420 kg	300 kg	150 kg
	4	770 kg	690 kg	560 kg	400 kg	200 kg
	5	960 kg	860 kg	700 kg	500 kg	250 kg
	6	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	7	1,300 kg	1,200 kg	980 kg	700 kg	360 kg
	8	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	9	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	10	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	120 kg	110 kg	94 kg	66 kg	34 kg
	2	250 kg	230 kg	180 kg	130 kg	69 kg
	3	380 kg	340 kg	280 kg	200 kg	100 kg
	4	510 kg	460 kg	370 kg	260 kg	130 kg
	5	640 kg	570 kg	470 kg	330 kg	170 kg
	6	770 kg	690 kg	560 kg	400 kg	200 kg
	7	900 kg	800 kg	650 kg	460 kg	240 kg
	8	1,000 kg	920 kg	750 kg	530 kg	270 kg
	9	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	10	1,200 kg	1,100 kg	940 kg	660 kg	340 kg

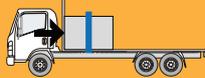
# NUMBER OF TIE-DOWN LASHINGS

## 25 MM WEBBING STRAPS/12 MM ROPE, HAND RATCHET/DOUBLE HITCH

Lashings:		Tensioner:			Pre-tension:	
25 mm webbing straps/12 mm rope		Hand ratchet/double hitch			100 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8 G)						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	<b>Static friction: 0.6</b>		<b>Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</b>			
	1	570 kg	510 kg	420 kg	300 kg	150 kg
	2	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	3	1,700 kg	1,500 kg	1,200 kg	890 kg	460 kg
	4	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	5	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	6	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	7	4,000 kg	3,600 kg	2,900 kg	2,100 kg	1,000 kg
	8	4,600 kg	4,100 kg	3,300 kg	2,400 kg	1,200 kg
	9	5,200 kg	4,600 kg	3,800 kg	2,700 kg	1,300 kg
	10	5,700 kg	5,100 kg	4,200 kg	3,000 kg	1,500 kg
<b>MEDIUM FRICTION</b>	<b>Static friction: 0.4</b>		<b>Example: Smooth steel on timber</b>			
	1	190 kg	170 kg	140 kg	100 kg	51 kg
	2	380 kg	340 kg	280 kg	200 kg	100 kg
	3	570 kg	510 kg	420 kg	300 kg	150 kg
	4	770 kg	690 kg	560 kg	400 kg	200 kg
	5	960 kg	860 kg	700 kg	500 kg	250 kg
	6	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	7	1,300 kg	1,200 kg	980 kg	700 kg	360 kg
	8	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	9	1,700 kg	1,500 kg	1,200 kg	900 kg	460 kg
	10	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
<b>LOW FRICTION</b>	<b>Static friction: 0.25</b>		<b>Example: Smooth steel on conveyor belt</b>			
	1	87 kg	78 kg	64 kg	45 kg	23 kg
	2	170 kg	150 kg	120 kg	90 kg	47 kg
	3	260 kg	230 kg	190 kg	130 kg	70 kg
	4	350 kg	310 kg	250 kg	180 kg	94 kg
	5	430 kg	390 kg	320 kg	220 kg	110 kg
	6	520 kg	470 kg	380 kg	270 kg	140 kg
	7	610 kg	550 kg	440 kg	310 kg	160 kg
	8	700 kg	620 kg	510 kg	360 kg	180 kg
	9	790 kg	700 kg	570 kg	400 kg	210 kg
	10	870 kg	780 kg	640 kg	450 kg	230 kg
<b>VERY LOW FRICTION</b>	<b>Static friction: 0.2</b>		<b>Example: Smooth steel on rusty steel</b>			
	1	64 kg	57 kg	47 kg	33 kg	17 kg
	2	120 kg	110 kg	94 kg	66 kg	34 kg
	3	190 kg	170 kg	140 kg	100 kg	51 kg
	4	250 kg	230 kg	180 kg	130 kg	69 kg
	5	320 kg	280 kg	230 kg	160 kg	86 kg
	6	380 kg	340 kg	280 kg	200 kg	100 kg
	7	450 kg	400 kg	320 kg	230 kg	120 kg
	8	510 kg	460 kg	370 kg	260 kg	130 kg
	9	570 kg	510 kg	420 kg	300 kg	150 kg
	10	640 kg	570 kg	470 kg	330 kg	170 kg

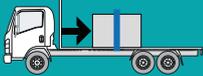
# NUMBER OF TIE-DOWN LASHINGS

## 12 MM ROPE, SINGLE HITCH

Lashings:		Tensioner:			Pre-tension:	
12 mm rope		Single hitch			50 kgf	
<b>BLOCKED (RESTRAINED TO 0.5 G)</b>						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
<b>HIGH FRICTION</b>	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	480 kg	430 kg	350 kg	250 kg	120 kg
	2	960 kg	860 kg	700 kg	500 kg	250 kg
	3	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	4	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	5	2,400 kg	2,100 kg	1,700 kg	1,200 kg	640 kg
	6	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
	7	3,300 kg	3,000 kg	2,400 kg	1,700 kg	900 kg
	8	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
	9	4,300 kg	3,800 kg	3,100 kg	2,200 kg	1,100 kg
	10	4,800 kg	4,300 kg	3,500 kg	2,500 kg	1,200 kg
<b>MEDIUM FRICTION</b>	Static friction: 0.4		Example: Smooth steel on timber			
	1	380 kg	340 kg	280 kg	200 kg	100 kg
	2	770 kg	690 kg	560 kg	400 kg	200 kg
	3	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	4	1,500 kg	1,300 kg	1,100 kg	800 kg	410 kg
	5	1,900 kg	1,700 kg	1,400 kg	1,000 kg	510 kg
	6	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	7	2,700 kg	2,400 kg	1,900 kg	1,400 kg	720 kg
	8	3,000 kg	2,700 kg	2,200 kg	1,600 kg	820 kg
	9	3,400 kg	3,100 kg	2,500 kg	1,800 kg	930 kg
	10	3,800 kg	3,400 kg	2,800 kg	2,000 kg	1,000 kg
<b>LOW FRICTION</b>	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	96 kg	86 kg	70 kg	50 kg	25 kg
	2	190 kg	170 kg	140 kg	100 kg	51 kg
	3	280 kg	250 kg	210 kg	150 kg	77 kg
	4	380 kg	340 kg	280 kg	200 kg	100 kg
	5	480 kg	430 kg	350 kg	250 kg	120 kg
	6	570 kg	510 kg	420 kg	300 kg	150 kg
	7	670 kg	600 kg	490 kg	350 kg	180 kg
	8	770 kg	690 kg	560 kg	400 kg	200 kg
	9	860 kg	770 kg	630 kg	450 kg	230 kg
	10	960 kg	860 kg	700 kg	500 kg	250 kg
<b>VERY LOW FRICTION</b>	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	64 kg	57 kg	47 kg	33 kg	17 kg
	2	120 kg	110 kg	94 kg	66 kg	34 kg
	3	190 kg	170 kg	140 kg	100 kg	51 kg
	4	250 kg	230 kg	180 kg	130 kg	69 kg
	5	320 kg	280 kg	230 kg	160 kg	86 kg
	6	380 kg	340 kg	280 kg	200 kg	100 kg
	7	450 kg	400 kg	320 kg	230 kg	120 kg
	8	510 kg	460 kg	370 kg	260 kg	130 kg
	9	570 kg	510 kg	420 kg	300 kg	150 kg
	10	640 kg	570 kg	470 kg	330 kg	170 kg

# NUMBER OF TIE-DOWN LASHINGS

## 12 MM ROPE, SINGLE HITCH

Lashings:		Tensioner:			Pre-tension:	
12 mm rope		Single hitch			50 kgf	
<b>UNBLOCKED</b> (RESTRAINED TO 0.8 G)						
						
Number of lashings	Lashing angle (from horizontal)					
	At least 75° AE > 0.95	At least 60° AE > 0.85	At least 45° AE > 0.70	At least 30° AE > 0.50	At least 15° AE > 0.25	
HIGH FRICTION	Static friction: 0.6		Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)			
	1	280 kg	250 kg	210 kg	150 kg	77 kg
	2	570 kg	510 kg	420 kg	300 kg	150 kg
	3	860 kg	770 kg	630 kg	450 kg	230 kg
	4	1,100 kg	1,000 kg	840 kg	600 kg	310 kg
	5	1,400 kg	1,200 kg	1,000 kg	750 kg	380 kg
	6	1,700 kg	1,500 kg	1,200 kg	890 kg	460 kg
	7	2,000 kg	1,800 kg	1,400 kg	1,000 kg	540 kg
	8	2,300 kg	2,000 kg	1,600 kg	1,200 kg	620 kg
	9	2,600 kg	2,300 kg	1,900 kg	1,300 kg	690 kg
	10	2,800 kg	2,500 kg	2,100 kg	1,500 kg	770 kg
MEDIUM FRICTION	Static friction: 0.4		Example: Smooth steel on timber			
	1	96 kg	86 kg	70 kg	50 kg	25 kg
	2	190 kg	170 kg	140 kg	100 kg	51 kg
	3	280 kg	250 kg	210 kg	150 kg	77 kg
	4	380 kg	340 kg	280 kg	200 kg	100 kg
	5	480 kg	430 kg	350 kg	250 kg	120 kg
	6	570 kg	510 kg	420 kg	300 kg	150 kg
	7	670 kg	600 kg	490 kg	350 kg	180 kg
	8	770 kg	690 kg	560 kg	400 kg	200 kg
	9	860 kg	770 kg	630 kg	450 kg	230 kg
	10	960 kg	860 kg	700 kg	500 kg	250 kg
LOW FRICTION	Static friction: 0.25		Example: Smooth steel on conveyor belt			
	1	43 kg	39 kg	32 kg	22 kg	11 kg
	2	87 kg	78 kg	64 kg	45 kg	23 kg
	3	130 kg	110 kg	96 kg	68 kg	35 kg
	4	170 kg	150 kg	120 kg	90 kg	47 kg
	5	210 kg	190 kg	160 kg	110 kg	58 kg
	6	260 kg	230 kg	190 kg	130 kg	70 kg
	7	300 kg	270 kg	220 kg	150 kg	82 kg
	8	350 kg	310 kg	250 kg	180 kg	94 kg
	9	390 kg	350 kg	280 kg	200 kg	100 kg
	10	430 kg	390 kg	320 kg	220 kg	110 kg
VERY LOW FRICTION	Static friction: 0.2		Example: Smooth steel on rusty steel			
	1	32 kg	28 kg	23 kg	16 kg	9 kg
	2	64 kg	57 kg	47 kg	33 kg	17 kg
	3	96 kg	86 kg	70 kg	50 kg	25 kg
	4	120 kg	110 kg	94 kg	66 kg	34 kg
	5	160 kg	140 kg	110 kg	83 kg	43 kg
	6	190 kg	170 kg	140 kg	100 kg	51 kg
	7	220 kg	200 kg	160 kg	110 kg	60 kg
	8	250 kg	230 kg	180 kg	130 kg	69 kg
	9	280 kg	250 kg	210 kg	150 kg	77 kg
	10	320 kg	280 kg	230 kg	160 kg	86 kg

# MINIMUM LASHING CAPACITY FOR DIRECT RESTRAINT

Table 10

<b>MINIMUM LASHING CAPACITY – DIRECT RESTRAINT FORWARDS (80% OF LOAD WEIGHT) USING 2 CHAINS</b>			
<b>Mass of load (kilograms)</b>	<b>Angle effect AE = &gt; 0.85</b>	<b>Angle effect AE = &gt; 0.70</b>	<b>Angle effect AE = &gt; 0.50</b>
100	48	58	80
200	95	115	160
300	142	172	240
400	189	229	320
500	236	286	400
750	353	429	600
1,000	471	572	800
1,500	706	958	1,200
2,000	942	1,143	1,600
<b>(tonnes)</b>			
3	1.5	1.8	2.4
4	1.9	2.3	3.2
5	2.4	2.9	4.0
6	2.9	3.5	4.8
7	3.3	4.0	5.6
8	3.8	4.6	6.4
9	4.3	5.2	7.2
10	4.8	5.8	8.0
11	5.2	6.3	8.8
12	5.7	6.9	9.6
13	6.2	7.5	10.4
14	6.6	8.0	11.2
15	7.1	8.6	12.0
16	7.6	9.2	12.8
17	8.0	9.8	13.6
18	8.5	10.3	14.4
19	9.0	10.9	15.2
20	9.5	11.5	16.0
21	9.9	12.0	16.8
22	10.4	12.6	17.6
23	10.9	13.2	18.4
24	11.3	13.8	19.2
25	11.8	14.3	20.0
26	12.3	14.9	20.8
27	12.8	15.5	21.6
28	13.2	16.0	22.4
29	13.7	16.6	23.2
30	14.2	17.2	24.0

# MINIMUM LASHING CAPACITY FOR DIRECT RESTRAINT

Table 11

<b>MINIMUM LASHING CAPACITY – DIRECT RESTRAINT SIDEWAYS OR REARWARDS (50% OF LOAD WEIGHT) USING 2 CHAINS</b>			
<b>Mass of load (kilograms)</b>	<b>Angle effect AE = &gt; 0.85</b>	<b>Angle effect AE = &gt; 0.70</b>	<b>Angle effect AE = &gt; 0.50</b>
100	30	36	50
200	59	72	100
300	89	108	150
400	118	143	200
500	148	179	250
750	221	268	375
1,000	295	358	500
1,500	442	536	750
2,000	589	715	1,000
<b>(tonnes)</b>			
3	0.9	1.1	1.5
4	1.2	1.5	2.0
5	1.5	1.8	2.5
6	1.8	2.2	3.0
7	2.1	2.5	3.5
8	2.4	2.9	4.0
9	2.7	3.3	4.5
10	3.0	3.6	5.0
11	3.3	4.0	5.5
12	3.6	4.3	6.0
13	3.9	4.7	6.5
14	4.2	5.0	7.0
15	4.5	5.4	7.5
16	4.8	5.8	8.0
17	5.0	6.1	8.5
18	5.3	6.5	9.0
19	5.6	6.8	9.5
20	5.9	7.2	10.0
21	6.2	7.5	10.5
22	6.5	7.9	11.0
23	6.8	8.3	11.5
24	7.1	8.6	12.0
25	7.4	9.0	12.5
26	7.7	9.3	13.0
27	8.0	9.7	13.5
28	8.3	10.0	14.0
29	8.6	10.4	14.5
30	8.9	10.8	15.0

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