LOAD RESTRAINT GUIDE 2018
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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)
   1. load contained within the sides or enclosure of the heavy vehicle that is restrained from moving horizontally may be able to move vertically;
   2. 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;
   3. 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 the load.
INTRODUCTION

HOW TO USE THIS GUIDE

The Load Restraint Guide is a modular document: you can use each module independently of the others. Where relevant, the guide will point you to other modules for more information.

The Load Restraint Guide is made up of six modules:

1. **Overview** – important foundational information about load restraint, including why you need to restrain your load, what your legal obligations are, load restraint methods, and key elements that make up a load restraint system.
2. **Loads** – advice on restraining specific load types such as sheets and flat loads, or bales, bags and sacks.
3. **Vehicles and equipment** – information about standard vehicle structures and equipment used in restraining loads.
4. **Working out load restraint** – examples of specific load restraint cases to help you determine how much load restraint you’ll need.
5. **Certification** – why you should have a load restraint system certified and who should do it, as well as a template that can be used by certifiers.
6. **Technical advice** – more detailed information on load restraint calculation. This module is aimed at engineers and designers but can be read by anyone wanting to better understand load restraint.

In addition to the modules, there are eight appendices to the Load Restraint Guide:

1. **Glossary** – covering definitions of key terms used in the guide.
2. A list of relevant standards.
3. A list of relevant legislation and publications.
4. Contact details for Commonwealth, state and territory regulatory authorities.
5. Contact details for the competent authorities for road transport of dangerous goods.
6. Tables covering the number of tie-down lashings for different equipment and friction levels.
7. Tables covering minimum lashing capacity for direct restraint.
8. An index.

About this guide

A load restraint system is legally 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.
The Overview module covers the important load restraint information you need to get started, including:

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

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 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:

  - O.5W Half the weight of the load sideways (cornering)
  - O.2W If relying on friction to withstand the force in other directions
  - O.5W Half the weight of the load rearwards (accelerating, braking in reverse)
  - O.8W 80% of the weight of the load forwards (braking)
  - O.5W Half the weight of the load sideways (cornering)

(W = weight of the load)

- If a load is restrained to meet these 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 Performance Standards define what is required but not how to do it. This guide provides general information to help you choose a load restraint system suitable for your load.
- 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).

Everyone shares the responsibility for compliance

- The Heavy Vehicle National Law has specific chain of responsibility provisions that relate to packing, loading and load restraint requirements relevant to the entire transport supply chain (equivalent provisions apply in WA and NT).
- Any person (including a corporation) who can control or influence transport activities, including packing, loading or restraining a load, must ensure, as far as is reasonably practicable, the safety of transport activities, including implementing safe systems and practices that remove risks and prevent any Heavy Vehicle National Law breaches.
  - As a minimum, reasonable actions include methods to identify, assess, control, monitor, review and remedy potentially unsafe situations or situations that could result in loading or load restraint breaches.
- Every person in the chain must satisfy themselves that the vehicle, load and driver are compliant and safe. Most importantly, the entire supply chain needs to be sure that the load restraint system meets the Performance Standards.
- Visit the National Heavy Vehicle Regulator website for more information on chain of responsibility.

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

There are 10 steps to follow when restraining your load

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

Loading (and unloading) the vehicle
6. Make sure your load is stabilised.
7. Make sure you understand and use safe work practices when loading and unloading a vehicle.
8. Make sure you use 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 your 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 your load

✅ Think about the load that you plan to transport.
  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 you do not know the precise weight of your load, 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 your load type and size

✅ Check your vehicle’s load carrying capacity.
Your vehicle should have adequate load capacity and sufficient space for the load.

❌ Do not allow your load to overhang.
If you have a long load your 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 your 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 you the roll stability your 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 your load

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

Loads can be restrained by two 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*

![Diagram of different restraint methods]

- **TIE-DOWN**
  - **FRICION**
    - Weight of load + Tie-down lashings
  - **CONTAINING**
    - Tankers, tipper bodies
  - **BLOCKING**
    - Headboards, side/tail gates
  - **ATTACHING**
    - Twist locks, direct lashings

- **DIRECT RESTRAINT**

A combination of different restraint methods can be used and in some cases may be necessary to meet the Performance Standards.

- **Make sure you are using enough lashings of sufficient capacity if using the tie-down restraint method.**

  You’ll need to take into account the weight of your load, whether the load is blocked or unblocked and the amount of friction between the surfaces of your 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 you are using load-rated headboards and load-rated side/tail gates if using the blocking restraint method.**

- **Make sure contained loads can’t shift within the vehicle structure.**

- **Make sure the load restraint method you use 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 your 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 your 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 your 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 your vehicle structures and restraint equipment are in good working condition and strong enough to restrain your 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 your 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 your load is stabilised

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.

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 your 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 lashing to fail.
- Always assess the restraint to its weakest point (for example, grab hooks may have a lower capacity than the chain ‘strength').
Step 7: Make sure you understand and use safe work practices when loading and unloading a vehicle

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 your 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, two-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 you use enough restraint to keep you and others safe

✅ Restrain your 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 your 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 your 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.

ℹ 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 your loaded vehicle.

- You should 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 your load and lashings regularly during your 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 your load and know how often it needs to be checked during a journey.

Some loads require the lashings to be checked and re-tensioned after only a very short distance (e.g. bales, bags and sacks).
LOAD RESTRAINT SYSTEM CHECKLIST

Planning the load

1. Understand your load
   Know your load’s characteristics

2. Choose a suitable vehicle for your load type and size
   Check your vehicle’s carrying capacity and allowable overhang/height

3. Use a restraint system that is suitable for your load
   Choose the most suitable restraint method for your load and vehicle

4. Position your 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 your vehicle structures and restraint equipment are in good working condition and strong enough to restrain your 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 your 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 you use enough restraint to keep you and others safe
   Your 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 you are using.

- 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 two 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**

<table>
<thead>
<tr>
<th>Load</th>
<th>Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet or greasy steel on steel</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Smooth steel on smooth steel</td>
<td>LOW</td>
</tr>
<tr>
<td>Smooth steel on rusty steel</td>
<td>LOW TO MEDIUM</td>
</tr>
<tr>
<td>Smooth steel on timber</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Smooth steel on conveyor belt</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Rusty steel on rusty steel</td>
<td>MEDIUM TO HIGH</td>
</tr>
<tr>
<td>Rusty steel on timber</td>
<td>HIGH</td>
</tr>
<tr>
<td>Smooth steel on rubber load mat</td>
<td>HIGH</td>
</tr>
</tbody>
</table>

- 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**

<table>
<thead>
<tr>
<th>Lashing</th>
<th>Size</th>
<th>Tensioner</th>
<th>Pre-tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rope</td>
<td>10 mm &amp; 12 mm</td>
<td>Single hitch</td>
<td>50 kgf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Double hitch</td>
<td>100 kgf</td>
</tr>
<tr>
<td>Webbing</td>
<td>25 mm</td>
<td>Hand ratchet</td>
<td>100 kgf</td>
</tr>
<tr>
<td></td>
<td>35 mm</td>
<td>Hand ratchet</td>
<td>250 kgf</td>
</tr>
<tr>
<td></td>
<td>50 mm</td>
<td>Truck winch</td>
<td>300 kgf</td>
</tr>
<tr>
<td></td>
<td>50 mm (push up)</td>
<td>Hand ratchet</td>
<td>300 kgf</td>
</tr>
<tr>
<td></td>
<td>50 mm (pull down)</td>
<td>Hand ratchet</td>
<td>600 kgf</td>
</tr>
<tr>
<td>Chain</td>
<td>7 mm &amp; above</td>
<td>Turnbuckle</td>
<td>1,000 kgf</td>
</tr>
</tbody>
</table>

⚠️ 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.

The formula to calculate the angle effect is:

\[ \text{Angle effect (AE)} = \frac{\text{Height of Load (H)}}{\text{Length of Lashing (L)}} \]

<table>
<thead>
<tr>
<th>APPROX. ANGLE</th>
<th>TIE-DOWN ANGLE EFFECT</th>
<th>TIE-DOWN EFFECTIVENESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>90°</td>
<td>1.00</td>
<td>100%</td>
</tr>
<tr>
<td>60°</td>
<td>0.85</td>
<td>85%</td>
</tr>
<tr>
<td>45°</td>
<td>0.70</td>
<td>70%</td>
</tr>
<tr>
<td>30°</td>
<td>0.50</td>
<td>50%</td>
</tr>
<tr>
<td>15°</td>
<td>0.25</td>
<td>25%</td>
</tr>
</tbody>
</table>

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.

The lower the lashing angle, the more lashings are required to give the same clamping force. One strap at 90° is equivalent to four 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 your load, you can 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 pre-tension in a lashing does not equal the amount of weight it can restrain.
Tie-down checklist

☑ Work out the total weight of your load.

☑ Check the level of friction on your 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 your tie-down lashing equipment.

☑ Tension your 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 two tensioners on each lashing (one on each side of the load).

☑ Check the angle of your lashings.

If your load is too low to use tie-down lashings you can use dunnage 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 you have enough tie-down lashings to restrain all parts of your load.

☑ Use timber dunnage correctly.

☐ Check it’s strong enough for your load.

☐ Make sure the dunnage is a suitable type and thickness for your 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 your dunnage is lashed and secured.

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

- 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:

Table 3  
**TYPICAL LASHING CAPACITY – ROPES AND WEBBING STRAPS**

<table>
<thead>
<tr>
<th>Lashing</th>
<th>Lashing capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 mm synthetic (silver) rope</td>
<td>300 kg</td>
</tr>
<tr>
<td>25 mm webbing</td>
<td>250 kg</td>
</tr>
<tr>
<td>35 mm webbing</td>
<td>1.0 t</td>
</tr>
<tr>
<td>50 mm webbing</td>
<td>2.0 t</td>
</tr>
</tbody>
</table>

Table 4  
**TYPICAL LASHING CAPACITY – CHAIN**

<table>
<thead>
<tr>
<th>Chain type*</th>
<th>with claw hooks or ‘winged’ grab hooks</th>
<th>with grab hooks or edge contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 mm transport chain</td>
<td>2.3 t</td>
<td>1.7 t</td>
</tr>
<tr>
<td>7.3 mm transport chain</td>
<td>3.0 t</td>
<td>2.3 t</td>
</tr>
<tr>
<td>8 mm transport chain</td>
<td>4.0 t</td>
<td>3.0 t</td>
</tr>
<tr>
<td>10 mm transport chain</td>
<td>6.0 t</td>
<td>4.5 t</td>
</tr>
<tr>
<td>13 mm transport chain</td>
<td>9.0 t</td>
<td>6.7 t</td>
</tr>
<tr>
<td>13 mm Grade ‘T’ chain**</td>
<td>10.0 t</td>
<td>7.5 t</td>
</tr>
<tr>
<td>16 mm Grade ‘T’ chain**</td>
<td>16.0 t</td>
<td>12.0 t</td>
</tr>
</tbody>
</table>

*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, rearways 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 your 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 your load restraint system meets the Performance Standards.
GENERAL FREIGHT

The checklist below sets out how you can meet the Performance Standards when restraining general freight. 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

1. 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.

2. 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.
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.

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

- 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.

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

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

Many loads are marked with symbols indicating special handling information and instructions – Figure 16.

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

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).

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.

‘SLING HERE’ and ‘KEEP AWAY FROM HEAT’ symbols are usually placed on the lower vertical face of the load.
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.

ℹ️ 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.

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

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

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

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

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

- Do not rely on unitising alone to restrain all items in a pack during transport – it may not be sufficient – *Figure 30*. 
End wrap Figure 31 or block Figure 32 packs that are at risk of sliding or spearing.

Items in packs of low-friction items can slide or spear out of the pack – Figure 33, Figure 34 and Figure 35.
Unitise packs of circular items in self-supporting shapes – Figure 36.

Pack shapes may prevent all items from being adequately unitised.

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

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.
Prevent packs tipping by blocking them – Figure 40.

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

**Tying down packs**

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

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

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

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

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.
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.

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

⚠ Items can dislodge from the pallet if the load is uncontained and the items are not sufficiently unitised – Figure 50.
Restrain items loosely stacked on pallets by containment – Figure 51.

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

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

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

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.

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.

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.

Forward blocking

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.

Forward blocking

Figure 57 Blocking With Intermediate Pallet

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

Tie down loads of pallets stacked two 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.
When loading steel-based stillages onto a steel deck, place plywood, rubber or other suitable material on the deck to increase friction – **Figure 61**.

Loading stillages with steel bases directly onto steel decks creates a low-friction interface – **Figure 62**.
Use stillages that are deep enough to securely contain the freight – *Figure 63*.  

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 63 Depth of coverage*  

*Figure 64 Stillage with lid*
Use suitably engineered side doors to prevent freight loss during transport – Figure 65.
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

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

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*.

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

Stable so easier to restrain

Prone to toppling so difficult to load and restrain safely

---

*Figure 70 Diameter and length of cylinder*

*Figure 71 Drums on end inside gates*

*Figure 72 Long Rolls Supported By Bearers*

*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.

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

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.

Restrain small rolls and reels against each other in pairs or groups of three. Use two restraints against forward movement for groups of three – Figure 79.
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.

ℹ️ Anti-slip rubber can reduce the required number of tied down lashings, particularly for low friction loads — Figure 81.

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

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.

✔ Restrain every cylinder by at least one lashing, unless they are unitised to a pallet – Figure 88.
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.
Do not restrain drums by tying them to centre posts horizontally as they will be able to move sideways – Figure 93.

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

**HORIZONTAL CYLINDERS**

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

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

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.

Make sure the chock or cradle system leaves an air gap between the coil and the vehicle deck – Figure 100 – inset.
Cradles can protect the load and distribute weight over the vehicle deck – Figure 101.

The wedge angle for cradles and chocks should be no less than 39° – 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.
**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*.

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

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

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

*Figures 105, 106, 107, 108*
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 checklist(s) for your load.

The checklists 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
LOADS

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/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 two pipes on the top layer unless the load is blocked forwards and rearwards – Figure 116.

More than two 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.

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 two 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.
PIPPES 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.
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 two lashings to further unitise and restrain small quantities of loose items.

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

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

✘ Don’t use twisted steel wire loops as the only form of unitisation on a pack – Figure 128.
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.
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 133.

✔ Support flexible long items (e.g. small-diameter pipes, timber, rod and rolled steel sections) at frequent intervals – Figure 132.

Long rigid items

✔ Support long rigid items (e.g. large-diameter metal pipes, concrete beams and heavy rolled steel sections) at only two points when transported on extendable trailers to allow the trailer to flex.

✔ Support long rigid items at two positions approximately 20% of the length of the item from each end – Figure 134.

✔ Locate supports above the axle group and kingpin.

Roof and ladder racks

✔ Restrain long items transported on roof or ladder racks by at least two 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.

<table>
<thead>
<tr>
<th>Length (mm)</th>
<th>Distance between supports (mm)</th>
<th>Maximum overhang (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,500</td>
<td>1,500</td>
<td>500</td>
</tr>
<tr>
<td>3,000</td>
<td>1,800</td>
<td>600</td>
</tr>
<tr>
<td>4,000</td>
<td>2,400</td>
<td>800</td>
</tr>
<tr>
<td>5,000</td>
<td>3,000</td>
<td>1,000</td>
</tr>
<tr>
<td>6,000</td>
<td>3,600</td>
<td>1,200</td>
</tr>
<tr>
<td>7,000</td>
<td>4,200</td>
<td>1,400</td>
</tr>
<tr>
<td>8,000</td>
<td>4,800</td>
<td>1,600</td>
</tr>
</tbody>
</table>
**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.

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

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*Figure 136 Large load of lengths*

*Figure 137 Large divided load of lengths*

*Figure 138 Bulk-stacked lengths*
✓ 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.

✓ 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.

✓ 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.
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 checklists 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 checklists 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.

ℹ Some sheet loads, such as oiled or laminated steel, may have low sheet-to-sheet friction, reducing the effectiveness of tie-down lashings.

ℹ 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.
Tie down

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

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

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

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

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 permits sufficient restraint.
- Check tie-down lashing angles are at least 30° to the horizontal – Figure 148.

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

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.

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

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

Tie-down lashings placed over two-abreast loads with a significant height difference may not provide adequate clamping to the shorter stack – Figure 154.
Restrain loose sheets transported in open vehicles to prevent load loss from airflow – *Figure 155.*

Loose sheets transported in open vehicles without tie down restraint may become dislodged by airflow – *Figure 156.*
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 checklist below includes important risks and tips that apply to all loads of bales, bags and sacks, while the specific checklists 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.

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.

ℹ️ The required number of tie-down lashings is dependent on the friction of the load.

ℹ️ Forward blocking may reduce the number of tie-down lashings required.

ℹ️ Paper between the lashings and bales may help keep lashing tension more even on each side.
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.

Block loads of three or more abreast bales in the forward and rearward directions – Figure 163.

Tie-down of bales loaded three abreast may not provide sufficient clamping to the centre bale if tie-down is used on its own – Figure 164.
High loads reduce vehicle stability and can cause vehicle rollover – Figure 168.

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 your load by transporting the load on a drop deck trailer – Figure 167.

Split tall loads into two parts and restrain separately to provide additional rigidity – Figure 165.

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

**BAGS AND SACKS**

**Restraint methods**

**Containment**

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

**Tie-down**

- Transport bags and sacks unitised on pallets wherever possible – Figure 172.
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](image)

⚠️ Restraint by tie-down only may not sufficiently restrain all items in the load – *Figure 174*.

![Figure 174 Loose bags, limited clamping](image)

✓ Rearrange the load to provide clamping to all items for loads where containment or unitisation is not possible – *Figure 175*.

✓ Place a maximum of two 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.

![Figure 175 Loose bags pyramid-stacked](image)

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

⚠️ An impractical number of lashings may be required for full loads of loose pyramid stacked bags or sacks – *Figure 176*.

![Figure 176 Full pyramid-stacked load](image)

✓ 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.
Fill gaps with empty pallets, dunnage, foam or other suitable materials – *Figure 179*.

- Do not leave gaps unblocked in contained loads as freight may move during transport and impact the containment body – *Figure 180*.

- Where tight packing is not possible, the total of all gap widths in any direction must be less than 200 mm front to back and 100 mm side to side – *Figure 181*.

- If freight is unable to be packed tightly, and there are cumulative gaps of more than 200 mm front to back or 100 mm side to side, use extra restraint on freight (for example, use lashings).
Make sure gates are high enough to prevent the load from bouncing out – *Figure 182*.

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

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.

Restrain all loads supported on springs and/or pneumatic tyres that can bounce out of their containment — Figure 185.

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.
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.

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.

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.

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.

To understand more about your load restraint responsibility, see the information on chain of responsibility in the Overview module.
Pack loads tightly within containers to prevent the load from moving sideways or horizontally – Figure 191 and Figure 192.

Fill gaps with empty pallets Figure 193 and Figure 194, dunnage, foam, custom framing or other suitable materials.
Use rated inflatable dunnage as part of restraint systems within containers – Figure 195.

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

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

For more information see Inflatable dunnage in the Vehicles and equipment module.
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.

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.

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.

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.
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.
Other loose bulk loads

- Vertically restrain lightweight bulk loads with rated load covers – Figure 204.

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

Do not transport loose loads on platform-bodied vehicles without sides or gates or on tipper bodies without tailgates – Figure 208.
✓ Arrange the load to stop sideways load movement, or fill gaps with sand (or similar) – Figure 209.

✓ Gaps in contained bulk loads may permit freight to move during transport and affect the vehicle’s stability – Figure 210.
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.

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).
RESTRRAINT METHODS

Contained loads

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

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

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

Make sure the load does not reach higher than half a brick above the gates – Figure 220.
**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*.

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

- ✅ Always make sure blocking surfaces are suitably engineered.

- ⚠ Unblocked loads will require more lashings than blocked loads – *Figure 224*.
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.

CONTAINERS

- 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.

- Restrain shipping containers with four twist locks – Figure 227.
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.

If containers are empty and twist locks are not fitted, restrain them using tie-down or crossed chains – Figure 229 and Figure 230.

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).
Load containers with doors to the rear of the carrying vehicle at all times – Figure 232.

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

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.
TANKS, BINS AND SKIPS

✔ Directly restrain tanks, bins and skips (full or empty) with lashings or positive-locking devices – Figure 234.

ℹ 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.

⚠ Laden ISO tanks can reduce vehicle stability, particularly when partially filled.

✔ Use drop deck trailers or similar to improve vehicle stability – Figure 236.
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.

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

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

- 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.

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

![Figure 240 Portable building – directly restrained](image1)

![Figure 241 Portable building – separate lashings](image2)

![Figure 242 Portable building – tied down](image3)

![Figure 243 Portable building – winch restraint](image4)
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).

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

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

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

- Block the fabrication in the forward and sideways directions wherever possible – Figure 249.
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.
Transport large/tall vehicles and mobile equipment on low loaders to increase vehicle stability – Figure 252 and Figure 253.

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

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

- Loop chains around suitable parts of the load for restraint *Figure 256*, such as at designated lifting or lashing points.
- 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*.

- 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*. 
Make sure lashing points are fitted in locations that permit adequate restraint – Figure 261.

Chain tension limited by freight damage

Lashing points should be clearly identified by colour-coding or labelling, and have their restraint capacity specified – Figure 262.

Use front and rear towing brackets as lashing points Figure 263. Ensure attachments at lashing points cannot work themselves loose during transport.

If towing brackets, do not incorporate round pins. Connect chains using appropriately rated shackles to prevent chain damage – Figure 264.
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.

For more information on restraint equipment, see the Vehicles and equipment module.
Attach two separate lashings to directly restrain vehicles or equipment – Figure 268.

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

Movable parts and attachments

- Restrain any part of the equipment that can move or rotate — Figure 270.
- Restrain auxiliary components (buckets, blades, rippers, etc.) on the deck using containment and/or tie-down/direct restraint — Figure 271.
**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.*

**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.*

- Make sure at least 75% of the normal contact area of the tyres or tracks is supported *Figure 274,* and ensure any unsupported tyre or track does not project more than 150 mm beyond the vehicle deck or extension – *Figure 275.*
**RESTRRAINING EQUIPMENT ON METAL TRACKS OR WHEELS**

- 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.*

- If using four chains to restrain tracked equipment, attach two chains at the rear – angled approximately 30° to the forward direction, and two chains at the front – angled at approximately 45° to the rearward direction – *Figure 277.*
If the front of tracked equipment is blocked to prevent forward movement, attach a minimum of two chains at the front to prevent rearward and sideways movement, and two at the rear to prevent sideways movement – *Figure 278*.

Do not use tie-down restraint for equipment on metal tracks because there is not enough friction to adequately restrain it – *Figure 279*. 
Do not restrain tracked machines by angled chains attached to the tracks or track shoes with grab hooks because grab hooks are not designed for tip loading nor rated for this purpose – Figure 280 and Figure 281.

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.
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.

❌ 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.

✅ 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.

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.

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.

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

Do not rely on brakes to prevent wheels rotating.
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.

Steeply angled chains pull down on the load more than chains at a lower angle, making the bouncing worse – Figure 292.
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.

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.

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

- Restraine 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 two points – Figure 296.

- The rubber tyres are likely to provide adequate sideways restraint.

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

- 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.
Motor vehicles

- Transport motor vehicles on specialised carrying vehicles or on general freight vehicles – Figure 298.

- 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.

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

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.
If using direct restraint, attach restraints to the axles, suspension or lashing points.

Make sure direct lashings are angled at 25° to the horizontal to minimise bounce, and within 30° of the centreline of the carrying vehicle – Figure 304.

Attach at least two direct lashings at each end of the vehicle so that downward force is applied to all wheels.

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° (i.e. 1:2) or give an equivalent force of 20% of the weight on the axle at that end.
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.

INTERMEDIATE BULK CONTAINERS (IBCs)

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

✓ Where a suitably engineered blocking surface is not available, use crossover straps to block the load – Figure 308.
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.

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.

Multiple lashings applied to IBCs may crush or damage the container – Figure 310.

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

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

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

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

✅ 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.
PARTIALLY FILLED IBCs AND TANKS

Liquid slosh in partially filled IBCs and chemical tanks can affect vehicle stability – Figure 316 and Figure 317.
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.
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.

 ✓ 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.
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.

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 two webbing straps to the final row of each group.

Additional straps may be required depending on the weight of the 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.
During the journey

⚠️ 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 checklist below sets 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 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.

ℹ️ 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, where practical.

ℹ️ 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.

ℹ️ 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.
  - 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 reduce effluent loss, where practical.

- Ensure crates and any effluent containment devices are prepared correctly prior to loading, and are functioning as designed, to minimise effluent loss.
  - 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.
  - The loading density can be obtained from the Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock — Edition 1, Version 1.1.

- When carrying livestock on multiple deck crates, ensure all multiple deck crates are loaded from the lowest deck up and animals are penned appropriately.
  - 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.

  - 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.
Restraining logs will depend on whether they are pulp or saw logs, in long or short lengths and with bark on or off. You will need to take into account the friction of the logs in your load when applying the checklist 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 two 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 Figure 329, where lashings are not sufficient alone to properly restrain the logs.
- 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.

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.

❌ Don’t extend the top outer logs more than half their height above the top of the stanchion.

✔️ 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.

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.

ℹ️ Automated winch systems can be installed to maintain lashing tension during transport.

Figure 331 Load not crowned

Clamping not applied to all logs

Figure 332 Load crowned

Top logs less than 0.5 H above stanchions

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.

GENERAL TIPS

✓ Restrain scaffolding in purpose-built stillages wherever possible – Figure 335.

✓ Block lengths loaded in H-frames to prevent spearing – Figure 336.
⚠ Lengths unitised or tied down in H-frames may spear out during transport if not blocked – Figure 337.

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

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

**GENERAL TIPS**

- Transport turf in rigid containers Figure 341 or inside rated curtain trucks Figure 342 or pantech trucks to prevent load loss.
Unitise loosely stacked turf to the pallet with stretch wrap or wide-aperture plastic mesh – Figure 343.

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.

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.
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?

- Side gates work as a containment solution providing sideways restraint.

- **Rated side gates** have been tested for load restraint and certified to meet the forces in the Performance Standards.

- Certification of rated side gates should specify details about the load that the gates can restrain, including size, shape, weight and packaging.

- Ratings are usually stated in one of three 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.*

- **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.*
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.

✅ 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.

HOW TO USE SIDE GATES

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

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

**Important**: **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*. **
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.

⚠️ 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.

### 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*. 
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.

**CHECKLIST FOR CERTIFIERS AND DESIGNERS**

- 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).

For examples of different load cases see Design for containing or blocking in the Technical advice module.
HEADBOARDS AND LOADING RACKS

WHAT ARE RATED HEADBOARDS AND LOADING RACKS?

**Note:** 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*.

**Note:** A loading rack is a pipe gate that has been reinforced by direct restraint chains – *Figure 365*.

**Note:** Plywood, metal sheeting or mesh can be used behind a loading rack to spread the load and support product packaging.

**Note:** If there is no rating stated on the headboard or loading rack, it is assumed to be unrated.

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.
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.
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.

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.

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 ¾ 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.

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.

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

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

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

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.
BARRIERS

WHAT ARE BARRIERS?

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 two parts to maintain correct axle weight limits.

HOW TO USE BARRIERS

Make sure that the barrier is loaded against the freight – Figure 380 and Figure 381.

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.

Barriers can restrain the load against all the forward forces or act together with tie-downs to provide all of the forwards restraint.
**SIDE CURTAINS**

**WHAT ARE SIDE CURTAINS?**

- Side curtains are flexible sheets that are secured to the vehicle.
- Unrated side curtains are used to provide weather-proofing.
- 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.
- Rated side curtains will have a certification label attached to them and/or a certification document – *Figure 382*.
- 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.

Ratings are usually stated in one of three 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.*
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 weather-proof 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.
- 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.
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.
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.

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?

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

WHEN TO USE CHOCKS, CRADLES AND A-FRAMES

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.

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.
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.

**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 397 Direct lashings used to restrain load**

Direct lashings restraining a load against a chock

**Figure 398 Chocks or dunnage needs to be restrained**

Chocks held in by steel brace

**Figure 399 High levels of friction between all contact surfaces when utilising tie-down**
CHECKLIST FOR CERTIFIERS AND DESIGNERS

1. 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*.

2. 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° – *Figure 401*.

3. 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.
TARPAULINS

WHEN TO USE TARPAULINS

The main function of a tarpaulin is for weather protection – not load restraint – Figure 402.

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.

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.

Replace or temporarily repair any torn tarpaulins or side curtains to prevent further damage during a journey – Figure 405.
SYNTHETIC ROPES

WHEN TO USE SYNTHETIC ROPES

✅ 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 your load.

HOW TO USE SYNTHETIC ROPES

✅ Use only synthetic fibre ropes that comply with Australian Standard AS/NZS 4345 Motor vehicles – Cargo Restraint Systems – Transport Fibre Rope.

✅ 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.

✅ 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.

✅ 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.

⚠️ After a rope is tightened, it will often lose tension after a short time and the rope will need retightening.

✅ Most of the applied tension is lost because of the friction of the rope as it passes over itself in the knot.
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.

ℹ 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.

ℹ This damage can be recognised by the hairy appearance of fibres.
WEBBING

WHAT IS WEBBING?

- Webbing is a lightweight restraint system used throughout the transport industry.
- Webbing assemblies include load-rated webbing material with specified stitching and sewing patterns, together with end fittings, tensioning devices and a rating tag.
- 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.
- The lashing capacity is displayed on each assembly that complies with the relevant Australian Standard – Figure 409.
- 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 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.
- 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.
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

ℹ️ Tensioners can be attached to the vehicle by a truck winch or an in-line hand ratchet – 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.
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.
Tensioning webbing straps

Webbing straps are tensioned using either attached clip-on sliding winches, in-line tensioners or geared winches.

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.

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 two-thirds – 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 three.

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.
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 can lead to broken 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.

CHECKLIST FOR CERTIFIERS AND DESIGNERS

- When assessing the serviceability of webbing and attachments in relation to AS4380, 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.
CHAIN

WHAT IS TRANSPORT CHAIN?

Transport chain is a highly durable lashing type with low-stretch characteristics.

Chain used for load restraint should comply with Australian Standard AS/ NZS 4344 Motor vehicles – Cargo restraint systems – Transport chain and components.

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.

All transport chain made to AS 4344 is marked at least every 500 mm with its lashing capacity – Figure 420.

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.

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.
**HOW TO USE CHAIN**

- Always use transport chain that complies with AS 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](image1)

- 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*.

![Figure 423 Rounded corner protectors help equalise tension and protect the load](image2)

- 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](image3)

- 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**

- The two types of shortening hooks used on chains are grab hooks (plain or winged) and claw hooks – 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.
Chain tensioners

✔ Use turnbuckles or other ratchet tensioners, including gear-type tensioners and hybrid webbing tensioners, to tension chains – Figure 428 and Figure 429.

Turnbuckles are screw tensioners operated by either a ratchet or sliding lever Figure 430; they have no kickback when released and can achieve high tensions.

Some turnbuckles have a much higher strength rating and are suitable for tensioning larger chains.

✔ Make sure the turnbuckle can rotate freely.

⚠ If a turnbuckle does not rotate freely it will cause the chain to twist and prevent it from fully tightening.

✔ Wherever possible, use common chain tensioners (such as turnbuckles) when using chain for tie-down restraint, as they will provide higher pretensions than standard webbing tensioners.
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.

⚠️ 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”

Figure 432 Damaged chain links
When assessing the serviceability of chains and attachments in relation to AS 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.

Chains should be joined using a joining link with a rating at least equal to the lashing capacity of the chain.

Long lashings are more elastic than short lashings and can absorb larger shocks without breaking.

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.
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.

ℹ 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.

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).

ℹ 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.

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.

ℹ️ 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.

HOW TO USE WIRE ROPES

ℹ️ 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.

ℹ️ The nearest bending point must be at least three times the rope diameter clear of the clamp end or splice.

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

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 three rope diameters containing more than four broken wires
- any rope length equivalent to six rope diameters containing more than six 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

ℹ️ 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.

ℹ️ 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 one-third of its specified minimum breaking strength.
SPECIALISED BODIES

WHAT ARE SPECIALISED BODIES?

- Specialised bodies are specifically designed to carry a certain type of load.
- Specialised bodies include pantechnicon bodies, tippers, tankers (including ISO tank containers), bins, skips, stillages, removable tanks and closed and open containers.
- 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.
- 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 cannot 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.
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.
UPRIGHTS

WHAT ARE UPRIGHTS?

- Uprights are pins, pegs, stanchions and bolsters or any other device that blocks a sideways load force.
- 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.

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).
WHAT TO LOOK FOR WHEN USING UPRIGHTS

- Make sure the uprights provide adequate sideways restraint for your 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 torn – Figure 451.

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.
- 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.

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?

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.

The pre-tension generated by the lashing tensioner can remove slack from lashings used in direct restraint.

Pre-tension capability of a tensioner is critical for the tie-down capacity of lashings used in tie-down restraint.

The key types of tensioners and their applicable uses are listed below.

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

<table>
<thead>
<tr>
<th>LASHING SIZE</th>
<th>TENSIONER</th>
<th>PRE-TENSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mm &amp; 12 mm</td>
<td>Single hitch knot</td>
<td>50 kgf</td>
</tr>
<tr>
<td>10 mm &amp; 12 mm</td>
<td>Double hitch knot</td>
<td>100 kgf</td>
</tr>
<tr>
<td>25 mm</td>
<td>Hand ratchet</td>
<td>100 kgf</td>
</tr>
<tr>
<td>35 mm</td>
<td>Hand ratchet</td>
<td>250 kgf</td>
</tr>
<tr>
<td>50 mm</td>
<td>Truck winch</td>
<td>300 kgf</td>
</tr>
<tr>
<td>50 mm</td>
<td>Hand ratchet (push-up)</td>
<td>300 kgf</td>
</tr>
<tr>
<td>50 mm</td>
<td>Hand ratchet (pull-down)</td>
<td>600 kgf</td>
</tr>
<tr>
<td>7 mm &amp; above</td>
<td>Turnbuckle</td>
<td>1,000 kgf</td>
</tr>
</tbody>
</table>

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 pre-tension.

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.
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.

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

**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?

Interlayer packing is material that sits between layers in a load. It includes cardboard, carpet, anti-slip mats, rubber matting, plywood and timber dunnage.

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.

**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. 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.
Support very rigid loads (e.g., large diameter steel pipes or concrete beams) in only two positions using two 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 two positions with highly flexible trailers such as extendibles.

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 466 Flexible loads may require additional dunnage and lashings

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

Inflatable dunnage is also referred to as ‘pneumatic load control systems’ or ‘air bags’.

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.
WINCH TRACKS

CHECKLIST FOR ENGINEERS AND DESIGNERS

1. The design of winch tracks must take into account the magnitude and direction of the lashing force and the spacing of the track supports.

2. 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.

ℹ 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 four 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.
LATCHES, LOCK AND HINGES

CHECKLIST FOR CERTIFIERS AND DESIGNERS

1. Latches, locks, hinges and other attachments should be designed to prevent them separating by road-induced vibration and affect loads.

2. 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.

3. 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 pantechicon trailer
TIE RAILS AND LOAD ANCHOR POINTS

WHAT ARE TIE RAILS AND LOAD ANCHOR POINTS?

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

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

1. Check attachment points have a suitable rating for both the weight of the load and methods of load restraint to be used.

2. The horizontal section of tie rails are not strong enough for use with chain lashings without bending – Figure 474.

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

WHERE TO LOCATE LASHINGS

1. Secure the webbing strap tie-down lashings at or near the tie rail vertical support points on the horizontal rail – Figure 475.

2. Secure the webbing strap direct lashings on the tie rail vertical supports.

3. Secure the chain tie-down lashings or direct lashings on the tie rail vertical supports – Figure 475.
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

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.

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).

Lashing points on vehicles carried on roll-on roll-off vessels and on rail rolling stock require specific ratings for the application.

Anchor points should be designed to withstand the expected minimum breaking load for the lashing(s) mounted at that point – Figure 479.

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.
STRAPPING

WHEN TO USE STRAPPING

Strapping can be steel, nylon or polyester and is used for unitising loads into packs or bundles – Figure 480 and Figure 481.

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.

Steel strapping has a high tensile strength with minimal stretch. It is unaffected by heat or chemicals.

Polyester strapping has a lower strength than steel. Polyester is ideal for strapping packs where some settlement may occur.

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.
HOW TO USE STRAPPING

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.

The rating of a strapping assembly for lashing purposes should be no greater than half of its specified minimum breaking strength.

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.

Further requirements for strapping are contained in Australian Standard AS 2400.13 Packaging – Tensional Strapping.

WHAT TO LOOK FOR WHEN USING STRAPPING

Monitor your load throughout your 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.
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 your load.

There are 12 case studies covered in this module. They are:

<table>
<thead>
<tr>
<th>Case</th>
<th>Description</th>
<th>Load</th>
<th>Vehicle</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Tie-down restraint with webbing straps</td>
<td>Three rows of pallets blocked against a rated headboard</td>
<td>A prime mover and flat-bed semi-trailer combination</td>
<td>50 mm webbing straps, truck winch</td>
</tr>
<tr>
<td>Case 2</td>
<td>Tie-down restraint with webbing straps</td>
<td>Five rows of pallets unblocked</td>
<td>A prime mover and flat-bed semi-trailer combination</td>
<td>50 mm webbing straps, truck winch</td>
</tr>
<tr>
<td>Case 3</td>
<td>Tie-down restraint with chains</td>
<td>A stack of two-tonne precast concrete panels</td>
<td>A flat-tray semi-trailer</td>
<td>8 mm transport chain, standard load binder</td>
</tr>
<tr>
<td>Case 4</td>
<td>Tie-down restraint with webbing straps</td>
<td>Bundles of plastic wrapped timberboard, pyramid stacked</td>
<td>Flat-tray semi-trailer</td>
<td>50 mm webbing straps, standard ratchet tensioner</td>
</tr>
<tr>
<td>Case 5</td>
<td>Direct restraint using simple rule</td>
<td>4 tonne metal track equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 6</td>
<td>Direct restraint using calculations</td>
<td>15 tonne front-end loader</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 7</td>
<td>Direct restraint using calculations or load tables</td>
<td>15 tonne front-end loader</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 8</td>
<td>Partially blocked load with rated curtains</td>
<td>Palletised freight blocked against headboard</td>
<td>Prime mover and curtain sider combination</td>
<td></td>
</tr>
<tr>
<td>Case 9</td>
<td>Unblocked load with rated curtains</td>
<td>Palletised freight, unblocked at the rear of the vehicle</td>
<td>Prime mover and curtain sider combination</td>
<td></td>
</tr>
<tr>
<td>Case 10</td>
<td>Fully blocked load with rated curtains</td>
<td>Palletised freight, blocked in all directions</td>
<td>Prime mover and curtain sider combination</td>
<td></td>
</tr>
<tr>
<td>Case 11</td>
<td>Rated curtains with a mezzanine deck</td>
<td>Palletised freight</td>
<td>Prime mover and curtain sider combination</td>
<td></td>
</tr>
<tr>
<td>Case 12</td>
<td>Multi-drop load with rated curtains</td>
<td>Palletised freight, multiple drop-offs</td>
<td>Prime mover and curtain sider combination</td>
<td></td>
</tr>
</tbody>
</table>
TIE-DOWN RESTRAINT WORKED EXAMPLES

CASE 1: TIE-DOWN RESTRAINT WITH WEBBING STRAPS

Load:
- Three 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 (two pallets per row)

Vehicle:
- A prime mover and flat-bed semi-trailer combination

Equipment:
- Straps: 50 mm webbing straps
- Tensioner: truck winch (average pre-tension 300 kgf)

IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

Step 1: Which part of the load do I want to restrain?
I want to restrain the three 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-bed semi-trailer 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 your 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 your 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** (two 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-bed 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 your 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, we assume you can get a lashing angle greater than 60°.

The table below outlines the number of lashings you need to restrain the load weight when using 50 mm webbing straps with a lashing pre-tension of 300 kgf if your load is BLOCKED and you have a MEDIUM level of friction.

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm webbing straps</td>
<td>At least 75°</td>
<td>Push-up hand ratchet or truck winch</td>
</tr>
<tr>
<td></td>
<td>AE &gt; 0.95</td>
<td>300 kgf</td>
</tr>
<tr>
<td></td>
<td>At least 60°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AE &gt; 0.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 45°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AE &gt; 0.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 30°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AE &gt; 0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 15°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AE &gt; 0.25</td>
<td></td>
</tr>
</tbody>
</table>

Table note: Blocked loads 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.

Your load weight 1,400 kg (per row of pallets) is under 2,000 kg. Therefore, you need one strap for a row of pallets.

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:
- Five rows of pallets that are unblocked (the rear portion – Figure 488).
- Each pallet weighs 700 kg. A row of pallets weighs 1,400 kg (two pallets per row).

Vehicle:
- A prime mover and flat-bed semi-trailer combination.

Equipment:
- Straps: 50 mm webbing straps.
- Tensioner: truck winch (average pre-tension 300 kgf).

IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

Step 1: Which part of the load do I want to restrain?
I want to restrain the five rows of pallets at the rear of the truck.

Step 2: What vehicle will I use?
A prime mover and flat-bed semi-trailer 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.
Choosing 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 your 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 your 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.

- 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.

Working out the numbers:

Step 6: What is the mass of the load?

The mass of a row of pallets is **1,400 kg** (two 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-bed 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 your 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, we assume you can get a lashing angle greater than 60°.

The table below outlines the number of lashings you need to restrain the load weight (per row of pallets) when using 50 mm webbing straps with a lashing pre-tension of 300 kgf if your load is UNBLOCKED and you have a MEDIUM level of friction.

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-Tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm webbing straps</td>
<td>Push-up hand ratchet or truck winch</td>
<td>300 kgf</td>
</tr>
</tbody>
</table>

### UNBLOCKED (RESTRAINED TO 0.8G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>At least 60° AE &gt; 0.85</td>
</tr>
<tr>
<td></td>
<td>Example: Smooth steel on timber</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>570 kg</td>
<td>510 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,100 kg</td>
<td>1,020 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,600 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>4</td>
<td>2,100 kg</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>2,600 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>6</td>
<td>3,100 kg</td>
<td>3,000 kg</td>
</tr>
<tr>
<td>7</td>
<td>3,600 kg</td>
<td>3,500 kg</td>
</tr>
<tr>
<td>8</td>
<td>4,100 kg</td>
<td>4,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>4,600 kg</td>
<td>4,500 kg</td>
</tr>
<tr>
<td>10</td>
<td>5,100 kg</td>
<td>5,000 kg</td>
</tr>
</tbody>
</table>

Your 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, three 50 mm webbing strap can restrain 1,500 kg. Therefore, you need three straps for each row of pallets.

⚠️ Note that each row of pallets needs three straps, not just the front row. All rows have the forward force.

⚠️ Three 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 two-tonne precast concrete panels (four panels) – Figure 492.
- Each panel weighs two tonnes. The total mass is eight tonnes.

Vehicle:
- Flat-tray semi-trailer.

Equipment:
- Chain: 8 mm transport chain.
- Tensioner: standard load binder (average pre-tension 750 kgf).

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 flat-tray semi-trailer.

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 your load type.
   This is a load of precast concrete panels.
   See the Loads module for information on other load types.

✔ Check how to use your 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 eight tonnes \(8,000 \text{ kg}\)

⚠ 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 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 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 your 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, we assume you can get a lashing angle greater than 60°.

The table below outlines the number of lashings you need to restrain the load weight when using 8 mm transport chains with a lashing pre-tension of 750 kgf if your load is UNBLOCKED and you have a MEDIUM level of friction.

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mm transport chain</td>
<td>Over-centre tensioner</td>
<td>750 kgf</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>At least 75° AE &gt; 0.95</th>
<th>At least 60° AE &gt; 0.85</th>
<th>At least 45° AE &gt; 0.70</th>
<th>At least 30° AE &gt; 0.50</th>
<th>At least 15° AE &gt; 0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000 kg</td>
<td>1000 kg</td>
<td>750 kg</td>
<td>750 kg</td>
<td>750 kg</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2000 kg</td>
<td>2000 kg</td>
<td>1500 kg</td>
<td>1500 kg</td>
<td>1500 kg</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3000 kg</td>
<td>3000 kg</td>
<td>2000 kg</td>
<td>2000 kg</td>
<td>2000 kg</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4000 kg</td>
<td>4000 kg</td>
<td>3000 kg</td>
<td>3000 kg</td>
<td>3000 kg</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5000 kg</td>
<td>5000 kg</td>
<td>4000 kg</td>
<td>4000 kg</td>
<td>4000 kg</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6000 kg</td>
<td>6000 kg</td>
<td>5000 kg</td>
<td>5000 kg</td>
<td>5000 kg</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7000 kg</td>
<td>7000 kg</td>
<td>6000 kg</td>
<td>6000 kg</td>
<td>6000 kg</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>8000 kg</td>
<td>8000 kg</td>
<td>7000 kg</td>
<td>7000 kg</td>
<td>7000 kg</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>9000 kg</td>
<td>9000 kg</td>
<td>8000 kg</td>
<td>8000 kg</td>
<td>8000 kg</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10000 kg</td>
<td>10000 kg</td>
<td>9000 kg</td>
<td>9000 kg</td>
<td>9000 kg</td>
<td></td>
</tr>
</tbody>
</table>

To calculate the restraint requirements for different equipment and friction levels see the tie-down lashing tables.

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.

Your 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, seven 8 mm transport chains can restrain 9,000 kg. Therefore, you need seven chains to restrain this load.

This stack needs seven chains. At least half of these chains needs to be placed over the top layer. The top layer needs at least four 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 three chains. Alternatively all seven chains could be over the whole stack.

Seven chains per stack seems a lot, but this is what is required if the front of the load is not blocked.
CASE 4: TIE-DOWN RESTRAINT WITH WEBBING STRAPS

Load:
- Bundles of timberboard plastic wrapped, pyramid stacked (three bundles) – Figure 493.
- Each bundle weighs 500 kg. The total mass of the load is 1,500 kg.

Vehicle:
- Flat-tray semi-trailer.

Equipment:
- Lashing: 50 mm webbing straps.
- Tensioner: standard ratchet tensioner (average pre-tension 300 kgf).

IDENTIFY THE LOAD, VEHICLE AND EQUIPMENT:

Step 1: Which part of the load do I want to restrain?
I want to restrain the three bundles of timber in the middle of the truck.

Step 2: What vehicle will I use?
A flat-bed truck.

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 your 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 your 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 two 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-bed truck. The friction level is MEDIUM.

ℹ️ 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 your calculation is correct:

- Lashing pre-tension amount (Step 3) 300 kgf
- Blocking (Step 5) UNBLOCKED
- Load weight (Step 6) 500 kg (top bundle only)
- Friction level (Step 7) VERY LOW

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 60° 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.

ℹ️ See Interlayer packaging for more information.
Your 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, four 50 mm webbing straps can restrain 560 kg. Therefore, you need four straps to restrain this portion of the load.

Entire load:

The table below outlines the number of lashings you need to restrain the load weight when using 50 mm webbing straps with a lashing pretension of 300 kgf if your load is UNBLOCKED and you have a MEDIUM level of friction.

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Pre-Tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 60° AE &gt; 0.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 45° AE &gt; 0.70</td>
<td>At least 35° AE &gt; 0.25</td>
</tr>
<tr>
<td>Static friction:</td>
<td>0.2</td>
<td>Example: Smooth deal on rusty dirt</td>
</tr>
<tr>
<td>1</td>
<td>100 kg</td>
<td>170 kg</td>
</tr>
<tr>
<td>2</td>
<td>380 kg</td>
<td>510 kg</td>
</tr>
<tr>
<td>3</td>
<td>570 kg</td>
<td>610 kg</td>
</tr>
<tr>
<td>4</td>
<td>770 kg</td>
<td>760 kg</td>
</tr>
<tr>
<td>5</td>
<td>960 kg</td>
<td>860 kg</td>
</tr>
<tr>
<td>6</td>
<td>1,100 kg</td>
<td>960 kg</td>
</tr>
<tr>
<td>7</td>
<td>1,300 kg</td>
<td>1,050 kg</td>
</tr>
<tr>
<td>8</td>
<td>1,500 kg</td>
<td>1,150 kg</td>
</tr>
<tr>
<td>9</td>
<td>1,700 kg</td>
<td>1,300 kg</td>
</tr>
<tr>
<td>10</td>
<td>1,900 kg</td>
<td>1,400 kg</td>
</tr>
</tbody>
</table>

Your load weight is 1,500 kg (entire mass of the load). Based on a lashing angle greater than 60°, when a load is UNBLOCKED and the friction level is VERY LOW, four 50 mm webbing straps can restrain 560 kg. Therefore, you need four straps to restrain the entire load.

To calculate the restraint requirements for different equipment and friction levels see the tie-down lashing tables.

Choose the highest number of lashings.

You should use the highest number of straps to ensure the load is adequately restrained. Therefore you need four straps 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 RERAINT
WORKED EXAMPLES

USEFUL INFORMATION

**With direct restraint, the goal is to determine what strength lashings you need to adequately restrain your 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.

**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 sideward).**

**For more information on direct lashing angles see Lashing angles.**
CASE 5:
DIRECT RESTRAINT USING SIMPLE RULE

Load:
- 4 tonnes 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).

✔ Check your direct lashing angles for all directions of movement (forwards, backwards and sidewards).

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](image)

The rear lashings provide both sideways and forward restraint. They are stronger than necessary for sideways restraint because the forward restraint requirements are high.
CASE 6: DIRECT RESTRAINT USING CALCULATIONS

Load:
- 15 tonne front-end loader – Figure 499

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.

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Rear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lashing (chain) length</td>
<td>3,500 mm (L2 in diagram)</td>
<td>3,500 mm (L1 in diagram)</td>
</tr>
<tr>
<td>Distance between the tie points along the trailer</td>
<td>3,400 mm (R2 in diagram)</td>
<td>3,400 mm (F1 in diagram)</td>
</tr>
<tr>
<td>Distance between the tie points across the trailer</td>
<td>300 mm (S2 in diagram)</td>
<td>300 mm (S1 in diagram)</td>
</tr>
</tbody>
</table>

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 you divide the distance between the tie points along the truck (F1) by the lashing length (L1):

\[
3,400 \text{ (F1)} \div 3,500 \text{ (L1)} = 0.97 \text{ (forward direct angle effect)}
\]

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 you divide the distance between the tie points across the truck by the lashing length for both chains:

Front chain \( \frac{300 \text{ (S2)}}{3,500 \text{ (L2)}} = 0.086 \) (sideways direct angle effect)

Rear chain \( \frac{300 \text{ (S1)}}{3,500 \text{ (L1)}} = 0.086 \) (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.

ℹ️ 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.

<table>
<thead>
<tr>
<th></th>
<th>Front</th>
<th>Rear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lashing (chain)</td>
<td>4,000 mm (L2 in diagram)</td>
<td>4,000 mm (L1 in diagram)</td>
</tr>
<tr>
<td>length*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*longer chains used to cross the deck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance between the tie points along the trailer</td>
<td>3,400 mm (R2 in diagram)</td>
<td>3,400 mm (F1 in diagram)</td>
</tr>
<tr>
<td>Distance between the tie points across the trailer</td>
<td>2,000 mm (S2 in diagram)</td>
<td>2,000 mm (S1 in diagram)</td>
</tr>
</tbody>
</table>

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** you divide the distance between the tie points along the truck (F1) by the lashing length (L1).

\[ \frac{3,400 \text{ (F1)}}{4,000 \text{ (L1)}} = 0.85 \] (forward direct angle effect)

_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 you divide the distance between the tie points across the truck by the lashing length for both chains:

Front chain \[ \frac{2,000 \text{ (S2)}}{4,000 \text{ (L2)}} = 0.5 \text{ (sideways direct angle effect)} \]
Rear chain \[ \frac{2,000 \text{ (S1)}}{4,000 \text{ (L1)}} = 0.5 \text{ (sideways direct angle effect)} \]

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 you divide the distance between the tie points along the truck (R2) by the lashing length (L2):

\[ \frac{3,400 \text{ (R2)}}{4,000 \text{ (L2)}} = 0.85 \text{ (rearward direct angle effect)} \]

For more information see Lashing angles.

Step 5: What strength lashings do you need to restrain your load? CALCULATION

To restrain your 15,000 kg load you will need the following strength lashings:

<table>
<thead>
<tr>
<th>Direction</th>
<th>Restraint required</th>
<th>Angle effect</th>
<th>Required lashing strength (per lashing)</th>
<th>For example (from Table 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forwards</td>
<td>12,000 kg (6,000 kg per lashing)</td>
<td>0.85</td>
<td>6,000 kg ÷ 0.85 = 7,059 kg</td>
<td>13 mm transport chain with claw hooks or winged grab hooks</td>
</tr>
<tr>
<td>Sideways</td>
<td>7,500 kg (3,750 kg per lashing)</td>
<td>0.50</td>
<td>3,750 kg ÷ 0.50 = 7,500 kg</td>
<td>13 mm transport chain with claw hooks or winged grab hooks</td>
</tr>
<tr>
<td>Rearwards</td>
<td>7,500 kg (3,750 kg per lashing)</td>
<td>0.85</td>
<td>3,750 kg ÷ 0.85 = 4,412 kg</td>
<td>10 mm transport chain with claw hooks or winged grab hooks</td>
</tr>
</tbody>
</table>

Taking the highest lashing strength required (7,500 kg), a 13 mm 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.
Step 5 (ALTERNATIVE): What strength lashings do you need to restrain your 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.

For forward direction restraint, see Table 10 Minimum lashing capacity – direct restraint forwards (80% of load weight) using two chains.

For sideways and rearward direction restraint, see Table 11 Minimum lashing capacity – direct restraint sideways or rearwards (50% of load weight) using two chains.

Your forward direct angle effect is 0.85 (see Step 2). To restrain your 15,000 kg load in the forward direction you will need a lashing strength of 7.1 tonne. For example (from Table 4), a 13 mm transport chain with claw hooks or winged grab hooks.

<table>
<thead>
<tr>
<th>Mass of load (kilograms)</th>
<th>Angle effect AE = &gt;0.85</th>
<th>Angle effect AE = &gt;0.70</th>
<th>Angle effect AE = &gt;0.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1.5</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>4</td>
<td>1.9</td>
<td>2.3</td>
<td>3.2</td>
</tr>
<tr>
<td>5</td>
<td>2.4</td>
<td>2.9</td>
<td>4.0</td>
</tr>
<tr>
<td>6</td>
<td>2.9</td>
<td>3.5</td>
<td>4.8</td>
</tr>
<tr>
<td>7</td>
<td>3.3</td>
<td>4.0</td>
<td>5.6</td>
</tr>
<tr>
<td>8</td>
<td>3.8</td>
<td>4.6</td>
<td>6.4</td>
</tr>
<tr>
<td>9</td>
<td>4.3</td>
<td>5.2</td>
<td>7.2</td>
</tr>
<tr>
<td>10</td>
<td>4.8</td>
<td>5.8</td>
<td>8.0</td>
</tr>
<tr>
<td>11</td>
<td>5.2</td>
<td>6.3</td>
<td>8.8</td>
</tr>
<tr>
<td>12</td>
<td>5.7</td>
<td>6.9</td>
<td>9.6</td>
</tr>
<tr>
<td>13</td>
<td>6.2</td>
<td>7.5</td>
<td>10.4</td>
</tr>
<tr>
<td>14</td>
<td>6.6</td>
<td>8.0</td>
<td>11.2</td>
</tr>
<tr>
<td>15</td>
<td>7.1</td>
<td>8.6</td>
<td>12.0</td>
</tr>
</tbody>
</table>
Your **sideways direct angle effect** is 0.50 (see Step 3). To restrain your **15,000 kg** load the sideways direction will need a lashing strength of **7.5 tonne**. For example (from Table 4), a **13 mm** transport chain with claw hooks or winged grab hooks.

Your **rearwards direct angle effect** is 0.85 (see Step 4). To restrain your **15,000 kg** load in the rearwards direction you will need a lashing strength of **4.5 tonne**. 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** 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.**
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 curtain sider combination

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 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 weight 700 kg each
- There are five rows of pallets in Group 2
  – Figure 502

Vehicle:
- A prime mover and curtain sider combination

**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 502).

**Step 2: What vehicle will I use?**

A prime mover 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 is 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.

ℹ️ 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.

ℹ️ 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 five rows of pallets in Group 2 – *Figure 503*

Vehicle:
- A prime mover and curtain sider combination

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 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 your load is a multi-drop load the restraint methods are likely to change during your 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**

- **ℹ️** 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**

- **ℹ️** 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 curtain sider combination with a mezzanine deck

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 on the mezzanine deck.

Step 2: What vehicle will I use?
A prime mover 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 to 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 your load is a multi-drop load the restraint methods are likely to change during your 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 prime mover and curtain sider combination

IDENTIFY THE LOAD:

Step 1: Which parts 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.
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.

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.

ℹ️ For more information on how to work out the number of lashings see tie-down worked examples.
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 laws.

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

<table>
<thead>
<tr>
<th><strong>Load restraint system</strong></th>
<th>Name of the load restraint system covered by the certification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Client</strong></td>
<td></td>
</tr>
<tr>
<td>Contact name</td>
<td>Address ABN, contact details (phone, email, website)</td>
</tr>
<tr>
<td>Company name</td>
<td></td>
</tr>
<tr>
<td><strong>Load restraint certifier</strong></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Address ABN, contact details (phone, email, website)</td>
</tr>
<tr>
<td>Company name</td>
<td></td>
</tr>
<tr>
<td><strong>Declaration</strong></td>
<td>Engineer’s statement that the load restraint system described will meet the Performance Standards, and any conditions that apply to the declaration</td>
</tr>
<tr>
<td><strong>Date of certification</strong></td>
<td>Date</td>
</tr>
<tr>
<td><strong>Description of the load</strong></td>
<td>Products, size and weight, unitising system</td>
</tr>
<tr>
<td><strong>Description of the vehicle</strong></td>
<td>Vehicle type, weight, integral restraint equipment, floor type</td>
</tr>
<tr>
<td><strong>Load restraint equipment</strong></td>
<td>Load restraint equipment used, including size, tension, friction material, interlayer packing etc.</td>
</tr>
<tr>
<td><strong>Loading and configuration</strong></td>
<td>Configuration of the load, in words and in a drawing (Attach extra page for drawing(s) if required)</td>
</tr>
<tr>
<td><strong>Load restraint method</strong></td>
<td>Description of the restraint method, in words and in a drawing</td>
</tr>
<tr>
<td><strong>Operational advice</strong></td>
<td>Maintenance schedule, safety precautions, tensioning or re-tensioning procedures and other special requirements (attach extra page(s) if required)</td>
</tr>
</tbody>
</table>
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.
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 two 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.

FRICTION COEFFICIENT

The friction coefficient (µ) is used to compare the load restraint friction force between two 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

<table>
<thead>
<tr>
<th>Load</th>
<th>Static friction coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet or greasy steel on steel</td>
<td>0.01–0.1</td>
</tr>
<tr>
<td>Smooth steel on smooth steel</td>
<td>0.1–0.2</td>
</tr>
<tr>
<td>Smooth steel on rusty steel</td>
<td>0.2–0.4</td>
</tr>
<tr>
<td>Smooth steel on timber</td>
<td>0.3–0.4</td>
</tr>
<tr>
<td>Smooth steel on conveyor belt</td>
<td>0.3–0.4</td>
</tr>
<tr>
<td>Rusty steel on rusty steel</td>
<td>0.4–0.7</td>
</tr>
<tr>
<td>Rusty steel on timber</td>
<td>0.6–0.7</td>
</tr>
<tr>
<td>Smooth steel on rubber load mat</td>
<td>0.6–0.7</td>
</tr>
</tbody>
</table>

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’.

\[
\text{Angle effect (AE)} = \frac{\text{Height of Load (H)}}{\text{Length of Lashing (L)}}
\]

<table>
<thead>
<tr>
<th>APPROX. ANGLE</th>
<th>TIE-DOWN ANGLE EFFECT</th>
<th>TIE-DOWN EFFECTIVENESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>90˚</td>
<td>1.00</td>
<td>100%</td>
</tr>
<tr>
<td>60˚</td>
<td>0.85</td>
<td>85%</td>
</tr>
<tr>
<td>45˚</td>
<td>0.70</td>
<td>70%</td>
</tr>
<tr>
<td>30˚</td>
<td>0.50</td>
<td>50%</td>
</tr>
<tr>
<td>15˚</td>
<td>0.25</td>
<td>25%</td>
</tr>
</tbody>
</table>

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.

\[
\text{Angle effect (AE)} = \frac{\text{Height of load (H)}}{\text{Length of lashing (L)}}
\]

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**

<table>
<thead>
<tr>
<th>Lashing</th>
<th>Size</th>
<th>Tensioner</th>
<th>Pre-tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rope</td>
<td>10 mm &amp; 12 mm</td>
<td>Single hitch</td>
<td>50 kgf</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Double hitch</td>
<td>100 kgf</td>
</tr>
<tr>
<td></td>
<td>25 mm</td>
<td>Hand ratchet</td>
<td>100 kgf</td>
</tr>
<tr>
<td></td>
<td>35 mm</td>
<td>Hand ratchet</td>
<td>250 kgf</td>
</tr>
<tr>
<td></td>
<td>50 mm</td>
<td>Truck winch</td>
<td>300 kgf</td>
</tr>
<tr>
<td></td>
<td>50 mm</td>
<td>Hand ratchet (push-up)</td>
<td>300 kgf</td>
</tr>
<tr>
<td></td>
<td>50 mm</td>
<td>Hand ratchet (pull-down)</td>
<td>600 kgf</td>
</tr>
<tr>
<td>Webbing</td>
<td>50 mm</td>
<td>Hand ratchet</td>
<td>100 kgf</td>
</tr>
<tr>
<td>Chain</td>
<td>7 mm &amp; above</td>
<td>Turnbuckle</td>
<td>1000 kgf</td>
</tr>
</tbody>
</table>

- 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.
# NUMBER OF LASHINGS

Table 7

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mm transport chain</td>
<td>Over-centre tensioner</td>
<td>750 kg</td>
</tr>
</tbody>
</table>

**BLOCKED**
(RESTRAINED TO 0.5 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction: 0.6</th>
<th>Example: Rusty steel on timber or smooth steel on rubber load mat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>1 7,200 kg</td>
<td>6,400 kg 5,300 kg 3,700 kg 1,900 kg</td>
</tr>
<tr>
<td></td>
<td>At least 60° AE &gt; 0.85</td>
<td>2 14,000 kg</td>
<td>12,000 kg 10,000 kg 7,500 kg 3,800 kg</td>
</tr>
<tr>
<td></td>
<td>At least 45° AE &gt; 0.70</td>
<td>3 21,000 kg</td>
<td>19,000 kg 15,000 kg 11,000 kg 5,800 kg</td>
</tr>
<tr>
<td></td>
<td>At least 30° AE &gt; 0.55</td>
<td>4 28,000 kg</td>
<td>25,000 kg 21,000 kg 15,000 kg 7,700 kg</td>
</tr>
<tr>
<td></td>
<td>At least 15° AE &gt; 0.25</td>
<td>5 36,000 kg</td>
<td>32,000 kg 26,000 kg 18,000 kg 9,700 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 45,000 kg</td>
<td>38,000 kg 31,000 kg 22,000 kg 11,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 50,000 kg</td>
<td>45,000 kg 37,000 kg 26,000 kg 13,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 57,000 kg</td>
<td>51,000 kg 42,000 kg 30,000 kg 15,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 65,000 kg</td>
<td>58,000 kg 47,000 kg 33,000 kg 17,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 72,000 kg</td>
<td>64,000 kg 53,000 kg 37,000 kg 19,000 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Static friction: 0.4</th>
<th>Example: Smooth steel on timber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 5,700 kg</td>
<td>11,000 kg 10,000 kg 8,400 kg 6,000 kg 3,000 kg 1,500 kg</td>
</tr>
<tr>
<td></td>
<td>2 11,000 kg</td>
<td>17,000 kg 15,000 kg 12,000 kg 9,000 kg 4,600 kg</td>
</tr>
<tr>
<td></td>
<td>3 25,000 kg</td>
<td>30,000 kg 26,000 kg 21,000 kg 15,000 kg 7,700 kg</td>
</tr>
<tr>
<td></td>
<td>4 34,000 kg</td>
<td>40,000 kg 36,000 kg 29,000 kg 21,000 kg 10,000 kg</td>
</tr>
<tr>
<td></td>
<td>5 46,000 kg</td>
<td>52,000 kg 46,000 kg 38,000 kg 27,000 kg 13,000 kg</td>
</tr>
<tr>
<td></td>
<td>6 57,000 kg</td>
<td>65,000 kg 58,000 kg 47,000 kg 33,000 kg 17,000 kg</td>
</tr>
<tr>
<td></td>
<td>7 72,000 kg</td>
<td>85,000 kg 72,000 kg 55,000 kg 37,000 kg 19,000 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Static friction: 0.25</th>
<th>Example: Smooth steel on conveyer belt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 1,400 kg</td>
<td>2,800 kg 2,500 kg 2,100 kg 1,500 kg 770 kg</td>
</tr>
<tr>
<td></td>
<td>2 3,400 kg</td>
<td>4,400 kg 3,800 kg 3,100 kg 2,200 kg 1,100 kg</td>
</tr>
<tr>
<td></td>
<td>3 6,700 kg</td>
<td>7,200 kg 6,200 kg 5,500 kg 3,700 kg 1,900 kg</td>
</tr>
<tr>
<td></td>
<td>4 8,600 kg</td>
<td>9,800 kg 9,000 kg 7,400 kg 5,200 kg 2,700 kg</td>
</tr>
<tr>
<td></td>
<td>5 11,000 kg</td>
<td>10,000 kg 10,000 kg 8,400 kg 6,000 kg 3,100 kg</td>
</tr>
<tr>
<td></td>
<td>6 13,000 kg</td>
<td>12,000 kg 11,000 kg 9,500 kg 6,700 kg 3,400 kg</td>
</tr>
<tr>
<td></td>
<td>7 14,000 kg</td>
<td>12,000 kg 10,000 kg 7,500 kg 3,800 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Static friction: 0.2</th>
<th>Example: Smooth steel on rusty steel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 960 kg</td>
<td>860 kg 760 kg 700 kg 500 kg 250 kg</td>
</tr>
<tr>
<td></td>
<td>2 1,900 kg</td>
<td>2,000 kg 1,700 kg 1,400 kg 1,000 kg 510 kg</td>
</tr>
<tr>
<td></td>
<td>3 2,800 kg</td>
<td>2,500 kg 2,100 kg 1,500 kg 770 kg</td>
</tr>
<tr>
<td></td>
<td>4 3,800 kg</td>
<td>3,400 kg 2,800 kg 2,000 kg 1,000 kg</td>
</tr>
<tr>
<td></td>
<td>5 4,800 kg</td>
<td>4,300 kg 3,500 kg 2,500 kg 1,200 kg</td>
</tr>
<tr>
<td></td>
<td>6 5,700 kg</td>
<td>5,100 kg 4,200 kg 3,000 kg 1,500 kg</td>
</tr>
<tr>
<td></td>
<td>7 6,700 kg</td>
<td>6,600 kg 4,900 kg 3,500 kg 1,800 kg</td>
</tr>
<tr>
<td></td>
<td>8 7,700 kg</td>
<td>6,900 kg 5,600 kg 4,000 kg 2,000 kg</td>
</tr>
<tr>
<td></td>
<td>9 8,600 kg</td>
<td>7,700 kg 6,300 kg 4,500 kg 2,300 kg</td>
</tr>
<tr>
<td></td>
<td>10 9,600 kg</td>
<td>8,600 kg 7,000 kg 5,000 kg 2,500 kg</td>
</tr>
</tbody>
</table>
# NUMBER OF LASHINGS

### Table 8

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm webbing straps</td>
<td>Push-up hand ratchet or truck winch</td>
<td>300 kgf</td>
</tr>
</tbody>
</table>

### BLOCKED

(RESTRAINED TO 0.5 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
</tr>
<tr>
<td>Static friction: 0.6</td>
<td>Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyer belt)</td>
</tr>
<tr>
<td>1</td>
<td>2,800 kg</td>
</tr>
<tr>
<td>2</td>
<td>5,700 kg</td>
</tr>
<tr>
<td>3</td>
<td>8,600 kg</td>
</tr>
<tr>
<td>4</td>
<td>11,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>14,000 kg</td>
</tr>
<tr>
<td>6</td>
<td>17,000 kg</td>
</tr>
<tr>
<td>7</td>
<td>20,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>23,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>26,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>28,000 kg</td>
</tr>
</tbody>
</table>

### HIGH FRICTION

<table>
<thead>
<tr>
<th>Static friction: 0.4</th>
<th>Example: Smooth steel on timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>2</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>3</td>
<td>6,900 kg</td>
</tr>
<tr>
<td>4</td>
<td>9,200 kg</td>
</tr>
<tr>
<td>5</td>
<td>11,000 kg</td>
</tr>
<tr>
<td>6</td>
<td>13,000 kg</td>
</tr>
<tr>
<td>7</td>
<td>16,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>18,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>20,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>23,000 kg</td>
</tr>
</tbody>
</table>

### MEDIUM FRICTION

<table>
<thead>
<tr>
<th>Static friction: 0.25</th>
<th>Example: Smooth steel on conveyer belt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>570 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,700 kg</td>
</tr>
<tr>
<td>4</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>5</td>
<td>2,800 kg</td>
</tr>
<tr>
<td>6</td>
<td>3,400 kg</td>
</tr>
<tr>
<td>7</td>
<td>4,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>9</td>
<td>5,200 kg</td>
</tr>
<tr>
<td>10</td>
<td>5,700 kg</td>
</tr>
</tbody>
</table>

### LOW FRICTION

<table>
<thead>
<tr>
<th>Static friction: 0.2</th>
<th>Example: Smooth steel on rusty steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>380 kg</td>
</tr>
<tr>
<td>2</td>
<td>770 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>4</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>5</td>
<td>1,900 kg</td>
</tr>
<tr>
<td>6</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>7</td>
<td>2,700 kg</td>
</tr>
<tr>
<td>8</td>
<td>3,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>3,400 kg</td>
</tr>
<tr>
<td>10</td>
<td>3,800 kg</td>
</tr>
</tbody>
</table>
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:
- $AE = \frac{1.2}{1.6} = 0.75$

**Step 2:** Refer to the tables

**8 mm transport chain, pre-tension 750 kgf – Table 7**
- 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**
- 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 your load. This number must be larger than your 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 two 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 five 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.
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:

**Stable single load**
- 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).

**Unstable single load**
- restraint forces are distributed unevenly over the height of the load.

**Stacked load**
- restraint forces are distributed over the height of each load item.

**Point load**
- restraint force acts at point of contact.

**Loose bulk load**
- restraint forces are evenly distributed over the height of the load.

**Impact load**
- 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 two-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 1.
- 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 1.
- 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.
DESIGN FOR DIRECT ATTACHMENT

When you are attaching a load directly to a vehicle, consider the following two 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”](image)

For lashing L₁

- Angle Effect (AE₁) Forwards = Distance (F₁) ÷ Length of Lashing (L₁)
- Angle Effect (AE₁) Sideways = Distance (S₁) ÷ Length of Lashing (L₁)

For lashing L₂

- Angle Effect (AE₂) Rearwards = Distance (R₂) ÷ Length of Lashing (L₂)
- Angle Effect (AE₂) Sideways = Distance (S₂) ÷ Length of Lashing (L₂)
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”

<table>
<thead>
<tr>
<th>ANGLE</th>
<th>DIRECT LASHING ANGLE EFFECT</th>
<th>DIRECT LASHING EFFECTIVENESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>25°</td>
<td>0.90</td>
<td>90%</td>
</tr>
<tr>
<td>30°</td>
<td>0.86</td>
<td>86%</td>
</tr>
<tr>
<td>45°</td>
<td>0.70</td>
<td>70%</td>
</tr>
<tr>
<td>60°</td>
<td>0.50</td>
<td>50%</td>
</tr>
</tbody>
</table>

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 two 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 two chains directly restraining forward movement.

### Table 9

<table>
<thead>
<tr>
<th>Mass of load (kilograms)</th>
<th>Angle effect AE = &gt; 0.85</th>
<th>Angle effect AE = &gt; 0.70</th>
<th>Angle effect AE = &gt; 0.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>48</td>
<td>58</td>
<td>80</td>
</tr>
<tr>
<td>200</td>
<td>95</td>
<td>115</td>
<td>160</td>
</tr>
<tr>
<td>300</td>
<td>142</td>
<td>172</td>
<td>240</td>
</tr>
<tr>
<td>400</td>
<td>189</td>
<td>229</td>
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<td>500</td>
<td>236</td>
<td>286</td>
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<td>750</td>
<td>353</td>
<td>429</td>
<td>600</td>
</tr>
<tr>
<td>1,000</td>
<td>471</td>
<td>572</td>
<td>800</td>
</tr>
<tr>
<td>1,500</td>
<td>706</td>
<td>958</td>
<td>1,200</td>
</tr>
<tr>
<td>2,000</td>
<td>942</td>
<td>1,143</td>
<td>1,600</td>
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<td>3</td>
<td>1.5</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>4</td>
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<tr>
<td>30</td>
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<td>17.2</td>
<td>24.0</td>
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</tbody>
</table>
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 two 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 \((L_1)\):

\[
AE_1 = \frac{1.5}{2.0} = 0.75
\]

**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 two 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 \((0.8 \times 8,000 \text{ kg})\) is, \(0.8 \times 8,000 \text{ kg} = 6,400 \text{ kg}\).

**Step 3:** Each chain must provide, \(6,400 \text{ kg} ÷ 2 = 3,200 \text{ kg}\) 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 \(3,200 \text{ kg} ÷ AE = 3,200 \text{ kg} ÷ 0.75 = 4,267 \text{ kg}\).

**Step 5:** From Table 4, or chain manufacturers’ specifications, select chains each with a lashing capacity of at least 4.267 tonnes.

**Result:** Therefore two 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.
**GLOSSARY**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>air bag</td>
<td>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.</td>
</tr>
<tr>
<td>aggregate trailer mass</td>
<td>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.</td>
</tr>
<tr>
<td>anchor point</td>
<td>Fitting or attachment on a vehicle or load to secure lashings.</td>
</tr>
<tr>
<td>baffles</td>
<td>Barriers fitted crosswise and lengthwise inside tanks to limit surging of fluids (or loads that behave like fluids) during acceleration, braking and cornering.</td>
</tr>
<tr>
<td>baulking</td>
<td>See blocking.</td>
</tr>
<tr>
<td>bolster</td>
<td>Rigid support base commonly used to support logs on jinkers.</td>
</tr>
<tr>
<td>blocking</td>
<td>Material, usually timber, placed between the load and the vehicle structure, to prevent movement of the load (also see dunnage).</td>
</tr>
<tr>
<td>cap tarpaulin</td>
<td>A smaller tarpaulin fitted over the top of a load and only part of the sides (also see tarpaulin).</td>
</tr>
<tr>
<td>centre of gravity</td>
<td>The centre of balance of a load (also called ‘centre of mass’).</td>
</tr>
<tr>
<td>chain of responsibility</td>
<td>Laws under the Heavy Vehicle National Law and Regulations that hold that anyone who has influence over the transport activity is responsible for safety on the road (often abbreviated to “CoR laws”).</td>
</tr>
<tr>
<td>chocks</td>
<td>Usually wedge-shaped blocks used to prevent movement of the load (also see wedges).</td>
</tr>
<tr>
<td>claw hook</td>
<td>A chain hook in the shape of a claw.</td>
</tr>
<tr>
<td>coaming</td>
<td>A frame border around the outside of a vehicle’s loading deck.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>coefficient of friction ($\mu$)</td>
<td>A measure of the friction between two 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.</td>
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<tr>
<td>contained load</td>
<td>A load prevented from dislodging from the vehicle by the vehicle structure (gates, sides, racks, headboards, stanchions, etc.) or other parts of the load.</td>
</tr>
<tr>
<td>corner protectors</td>
<td>Material used to protect lashings and the exposed edges of loads and vehicles, and to allow lashings to slide freely when being tensioned.</td>
</tr>
<tr>
<td>cradle</td>
<td>A frame shaped to support a rounded object.</td>
</tr>
<tr>
<td>cross-member</td>
<td>A support placed crosswise below the loading deck.</td>
</tr>
<tr>
<td>crowning</td>
<td>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.</td>
</tr>
<tr>
<td>deck</td>
<td>The load-carrying surface of a vehicle.</td>
</tr>
<tr>
<td>direct restraint</td>
<td>A form of load restraint where the load is restrained by containing, blocking or attaching.</td>
</tr>
<tr>
<td>dunnage</td>
<td>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 blocking).</td>
</tr>
<tr>
<td>fastening device</td>
<td>A device for attaching lashings to a vehicle and/or to a load (also called “fastener”).</td>
</tr>
<tr>
<td>flush deck</td>
<td>A flat loading deck without a raised coaming.</td>
</tr>
<tr>
<td>force</td>
<td>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.</td>
</tr>
<tr>
<td>friction</td>
<td>The resistance of one surface sliding across another.</td>
</tr>
<tr>
<td>g</td>
<td>The acceleration due to gravity, equal to 9.81 m/s$^2$.</td>
</tr>
<tr>
<td>gates</td>
<td>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”.</td>
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<tr>
<td>gross combination mass</td>
<td>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”).</td>
</tr>
<tr>
<td>gross trailer mass</td>
<td>The mass on the axle(s) of a trailer when fully loaded and connected to a towing vehicle (also called “GTM”).</td>
</tr>
<tr>
<td>gross vehicle mass</td>
<td>The maximum mass of a motor vehicle when loaded, as specified by its manufacturer (also called “GVM”).</td>
</tr>
<tr>
<td>headboard</td>
<td>Usually a permanent vertical frame used at the front of a vehicle’s loading deck to contain its load (also called a “bulkhead”).</td>
</tr>
<tr>
<td>lashings</td>
<td>Fastening devices (e.g. hooks, winches, etc.), chains, cables, ropes or webbing straps used to restrain loads.</td>
</tr>
<tr>
<td>lashing capacity</td>
<td>The maximum force (in kilograms) that a lashing system is designed to sustain in use.</td>
</tr>
<tr>
<td>load binder</td>
<td>A device used for tensioning a lashing.</td>
</tr>
<tr>
<td>load capacity</td>
<td>The difference between the GVM or GTM of a vehicle and its tare mass.</td>
</tr>
<tr>
<td>load mat</td>
<td>A sheet of material used to increase friction and protect the load (also called “anti-slip mat” or “friction mat”).</td>
</tr>
<tr>
<td>loading rack</td>
<td>See gates.</td>
</tr>
<tr>
<td>mass</td>
<td>A measure of the amount of matter in an object; in this guide, mass is referred to in kilograms (kg) or tonnes (t).</td>
</tr>
<tr>
<td>pallet</td>
<td>A portable platform or tray onto which loads are placed for handling.</td>
</tr>
<tr>
<td>pantechnicon</td>
<td>A vehicle with a body enclosed by solid rigid sides and a roof.</td>
</tr>
<tr>
<td>pawl</td>
<td>A lever or lock that prevents reverse rotation on a winch.</td>
</tr>
<tr>
<td>PBS-approved vehicle</td>
<td>Any vehicle assessed by the National Heavy Vehicle Regulator as meeting the Performance-Based Standards.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
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<tr>
<td>Performance Standards</td>
<td>The outcomes to be achieved by a load restraint system (see Performance Standards).</td>
</tr>
<tr>
<td>pockets</td>
<td>Housings or slots fixed to the vehicle to locate gates, stakes or loading pegs.</td>
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<tr>
<td>pre-tension</td>
<td>The initial tension in a lashing resulting from initial tightening by the operator.</td>
</tr>
<tr>
<td>rope hooks</td>
<td>Attachments fixed to the surrounds of the loading deck for securing of tarpaulin and tie-down ropes.</td>
</tr>
<tr>
<td>rope rail</td>
<td>See tie rail.</td>
</tr>
<tr>
<td>shackle</td>
<td>A metal coupling link closed by a bolt that can be used for attaching chain fittings.</td>
</tr>
<tr>
<td>shoring bar</td>
<td>Adjustable metal beam used to restrain or segregate sections of load (also called a “shoring pole”).</td>
</tr>
<tr>
<td>sling</td>
<td>A length of hemp-core rope, webbing or steel-wire rope with eyes (i.e. loops) formed at each end.</td>
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<tr>
<td>spreader</td>
<td>A spar or frame extending across the vehicle body structure used to support tarpaulins and side gates.</td>
</tr>
<tr>
<td>stake</td>
<td>An upright metal rod or section (also called a “peg” or “pin”).</td>
</tr>
<tr>
<td>stanchion</td>
<td>A large upright fixed to the side of a vehicle for sideways restraint.</td>
</tr>
<tr>
<td>stillage</td>
<td>A metal structure for containing individual items of load.</td>
</tr>
<tr>
<td>strut</td>
<td>A rigid member that can support loads in the direction of its length.</td>
</tr>
<tr>
<td>tare mass</td>
<td>The mass of an unladen motor vehicle or trailer.</td>
</tr>
<tr>
<td>tarpaulin</td>
<td>A waterproof sheet used to cover and protect goods from the weather (also called “tarp”).</td>
</tr>
<tr>
<td>tensioner</td>
<td>A device used to tighten a lashing.</td>
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<td>Term</td>
<td>Definition</td>
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<tr>
<td>tie-down</td>
<td>A form of load restraint where the load is restrained by friction (also called ‘indirect restraint’).</td>
</tr>
<tr>
<td>tie rail</td>
<td>A round rail that skirts the perimeter of the loading deck below the coaming rail.</td>
</tr>
<tr>
<td>truck winch</td>
<td>A device used for tensioning a lashing that is normally placed under the coaming rail and may be fixed in position using the tie rail or slide on a track (also see winch).</td>
</tr>
<tr>
<td>turnbuckle</td>
<td>A device for tensioning consisting of a threaded sleeve and two mating threaded ends.</td>
</tr>
<tr>
<td>twist lock</td>
<td>A locking device with a rotating head that normally engages a corner casting on the load.</td>
</tr>
<tr>
<td>unitised load</td>
<td>Multiple separate items bound together to form a single item of load.</td>
</tr>
<tr>
<td>wedge</td>
<td>A piece of rigid material that is thick at one end and tapers to a thinner edge at the other (also see chocks).</td>
</tr>
<tr>
<td>weight</td>
<td>The force exerted by gravity on a mass (e.g. 1 kgf (= 9.81 N) is the weight of a 1 kg mass).</td>
</tr>
<tr>
<td>winch</td>
<td>A device for tensioning lashings via a rotating spool.</td>
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</table>
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

SAI Global Information Services
GPO Box 5420
Sydney NSW 2001
Tel: 131 242
Web: https://infostore.saiglobal.com/
Email: sales@saiglobal.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

Motor Vehicles

- Motor vehicles – Anchorages and anchor points for securing internal cargo AS/NZS 4384

Fibre Ropes

AS 4142 (Parts 1 & 2)

Short-link Chain for Lifting Purposes

AS 2321

Short-link Chain for Lifting Purposes

AS 3569

Shackles

AS 2741

Shank Hooks and Large-eye Hooks – Maximum 25t

AS 3777

Thimbles for Wire Rope

AS 1138

Packaging – Tensional Strapping

AS 2400.13

Load Anchorage Points for Heavy Vehicles

Nzs 5444

Pressure Vessels

AS 1210

Load restraint for LP Gas cylinder distribution

AS 5714:2015

Storage & Handling of LP Gas

AS/NZS 1596

Anhydrous Ammonia – Storage and Handling

AS 2022

Road Tank Vehicles for Dangerous Goods – General Requirements

AS 2809 (Parts 1-6)

Lifting Devices

AS 4991

Freight Containers

AS/NZS 3711 (Parts 1-9)

Motor Vehicles – Cargo Barriers for Occupant Protection

AS/NZS 4034 (Parts 1 & 2)

Lashing and Securing Arrangements on Road Vehicles for Sea Transportation on Ro/Ro Ships

ISO 9367 (Parts 1 & 2)

Securing of Cargo on Road Vehicles, Lashing Points on Commercial Vehicles for Transportation, Minimum Requirements and Testing

DIN EN 12640-2001

AS Australian Standard

NZS New Zealand Standard

ISO International Organisation for Standardisation

DIN German Institute for Standardisation
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. 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

- Australian Light Vehicle Standards Rules 2015
- 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:**

<table>
<thead>
<tr>
<th>Commonwealth and National Bodies</th>
<th>Commonwealth and National Bodies</th>
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<tbody>
<tr>
<td>Department of Infrastructure,</td>
<td>National Transport Commission</td>
</tr>
<tr>
<td>Regional Development and Cities</td>
<td>Level 3, 600 Bourke Street</td>
</tr>
<tr>
<td>GPO Box 594</td>
<td>MELBOURNE VIC 3000</td>
</tr>
<tr>
<td>CANBERRA ACT 2601</td>
<td>Tel: (03) 9236 5000</td>
</tr>
<tr>
<td>Tel: 1800 075 001</td>
<td>Web: <a href="http://www.ntc.gov.au">www.ntc.gov.au</a></td>
</tr>
<tr>
<td>Web: <a href="http://www.infrastructure.gov.au">www.infrastructure.gov.au</a></td>
<td>Email: <a href="mailto:enquiries@ntc.gov.au">enquiries@ntc.gov.au</a></td>
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<table>
<thead>
<tr>
<th>National Heavy Vehicle Regulator</th>
<th>National Heavy Vehicle Regulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO Box 492</td>
<td>PO Box 492</td>
</tr>
<tr>
<td>FORTITUDE VALLEY QLD 4006</td>
<td>FORTITUDE VALLEY QLD 4006</td>
</tr>
<tr>
<td>Tel: 1300 696 487 Fax: (07) 3309 8777</td>
<td>Tel: 1300 696 487 Fax: (07) 3309 8777</td>
</tr>
<tr>
<td>Email: <a href="mailto:info@nhvr.gov.au">info@nhvr.gov.au</a></td>
<td>Email: <a href="mailto:info@nhvr.gov.au">info@nhvr.gov.au</a></td>
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**State and territory bodies:**

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<thead>
<tr>
<th>Australian Capital Territory:</th>
<th>Victoria:</th>
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<tbody>
<tr>
<td>Access Canberra</td>
<td>VicRoads</td>
</tr>
<tr>
<td>PO Box 158</td>
<td>60 Denmark Street</td>
</tr>
<tr>
<td>CANBERRA CITY ACT 2601</td>
<td>KEW VIC 3101</td>
</tr>
<tr>
<td>Tel: 132 281 Fax: (02) 6207 6084</td>
<td>Tel: (03) 9854 2666</td>
</tr>
<tr>
<td>Email: <a href="mailto:vitu@act.gov.au">vitu@act.gov.au</a></td>
<td>Email: <a href="mailto:enquiries@act.gov.au">enquiries@act.gov.au</a></td>
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<tr>
<th>Queensland:</th>
<th>New South Wales:</th>
</tr>
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<tbody>
<tr>
<td>Department of Transport and Main Roads</td>
<td>Transport for NSW</td>
</tr>
<tr>
<td>PO Box 673</td>
<td>PO Box K659</td>
</tr>
<tr>
<td>FORTITUDE VALLEY QLD 4006</td>
<td>HAYMARKET NSW 1240</td>
</tr>
<tr>
<td>Tel: (07) 3405 0985</td>
<td>Tel: (02) 8202 2200 Fax: (02) 8202 2209</td>
</tr>
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<table>
<thead>
<tr>
<th>Northern Territory:</th>
<th>South Australia:</th>
</tr>
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<tbody>
<tr>
<td>Department of Infrastructure,</td>
<td>Department of Planning, Transport and Infrastructure</td>
</tr>
<tr>
<td>Planning and Logistics</td>
<td>GPO Box 1533</td>
</tr>
<tr>
<td>GPO Box 2520</td>
<td>ADELAIDE SA 5001</td>
</tr>
<tr>
<td>DARWIN NT 0801</td>
<td>Tel: 1300 872 677</td>
</tr>
<tr>
<td>Tel: (08) 8999 5511</td>
<td>Web: <a href="http://www.dpti.sa.gov.au">www.dpti.sa.gov.au</a></td>
</tr>
<tr>
<td>Web: <a href="http://www.transport.nt.gov.au">www.transport.nt.gov.au</a></td>
<td>Email: <a href="mailto:info@dpti.sa.gov.au">info@dpti.sa.gov.au</a></td>
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<tr>
<th>Tasmania:</th>
<th>Western Australia:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of State Growth Transport</td>
<td>Department of Transport</td>
</tr>
<tr>
<td>GPO Box 536</td>
<td>140 William Street</td>
</tr>
<tr>
<td>HOBART TAS 7001</td>
<td>PERTH WA 6000</td>
</tr>
<tr>
<td>Tel: 1300 139 933</td>
<td>Tel: (08) 6551 6000</td>
</tr>
<tr>
<td>Email: <a href="mailto:info@stategrowth.tas.gov.au">info@stategrowth.tas.gov.au</a></td>
<td>Email: <a href="mailto:enquiries@transport.wa.gov.au">enquiries@transport.wa.gov.au</a></td>
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</table>
COMPETENT AUTHORITIES FOR ROAD TRANSPORT OF DANGEROUS GOODS


State and territory bodies:

**Australian Capital Territory:**
Dangerous Substances and Licensing Team
Access Canberra
PO Box 358
CANBERRA CITY ACT 2601
Tel: 132 281 Fax: (02) 6207 6084
Web: www.accesscanberra.act.gov.au
Email: dangeroussubstances@act.gov.au

**Queensland:**
*Rail Transport*
Rail Regulation Unit
Department of Transport and Main Roads
PO Box 673
FORTITUDE VALLEY QLD 4006
Tel: (07) 3066 2915
Web: www tmrqld.gov.au
Email: rsr@tmrqld.gov.au

**Road Transport**
Industry and Operator Authorisation Unit
Department of Transport and Main Roads
PO Box 673
FORTITUDE VALLEY QLD 4006
Tel: (07) 3066 2995 Fax: (07) 3066 2453
Web: www.tmr.qld.gov.au
Email: dgu@tmr.qld.gov.au

**New South Wales:**
*Premises-based activities (including packaging approvals, labelling and classification)*
The Competent Authority
SafeWork NSW
Locked Bag 2906
LISAROW NSW 2252
Tel: 131 050
Web: www.safework.nsw.gov.au
Email: contact@safework.nsw.gov.au

*Transport-related matters*
Hazardous Materials Unit
NSW EPA
PO Box A290
SYDNEY SOUTH NSW 1232
Tel: 131 555
Web: www.epa.nsw.gov.au
Email: d.goods@epa.nsw.gov.au

**Northern Territory:**
NT WorkSafe
GPO Box 1722
DARWIN NT 0801
Tel: 1800 019 115 Fax: (08) 8999 5141
Web: www.worksafe.nt.gov.au
Email: ntworksafe@nt.gov.au

**South Australia:**
Dangerous Substances Team
SafeWork SA
GPO Box 465
ADELAIDE SA 5001
Tel: 1300 365 255 Fax: (08) 8226 4999
Web: www.safework.sa.gov.au
Email: dangerous.substances@sa.gov.au

**Western Australia:**
Resources Safety and Dangerous Goods
Department of Mines, Industry Regulation and Safety
Mineral House
100 Plain Street
EAST PERTH WA 6004
Tel: (08) 9358 8002 Fax: (08) 9358 8000
Web: www.dmp.wa.gov.au
Email: resourcesafety@dmins.wa.gov.au
## NUMBER OF TIE-DOWN LASHINGS

**8MM TRANSPORT CHAIN, TURNBUCKLES**

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mm transport chain</td>
<td>Turnbuckles</td>
<td>1,000 kgf</td>
</tr>
</tbody>
</table>

### BLOCKED

(RESTRAINED TO 0.5 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Lashing angle (from horizontal)</th>
<th>Lashing angle (from horizontal)</th>
<th>Lashing angle (from horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>At least 60° AE &gt; 0.85</td>
<td>At least 45° AE &gt; 0.70</td>
<td>At least 30° AE &gt; 0.50</td>
</tr>
<tr>
<td></td>
<td>At least 15° AE &gt; 0.25</td>
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<tr>
<td>Static friction:</td>
<td>0.6</td>
<td>Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9,600 kg</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>2,500 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>19,000 kg</td>
<td>17,000 kg</td>
<td>14,000 kg</td>
<td>10,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,100 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28,000 kg</td>
<td>25,000 kg</td>
<td>21,000 kg</td>
<td>15,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7,700 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>38,000 kg</td>
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<td>28,000 kg</td>
<td>20,000 kg</td>
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<td>57,000 kg</td>
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<tr>
<td></td>
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<td>15,000 kg</td>
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<tr>
<td>7</td>
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<td></td>
<td></td>
<td>18,000 kg</td>
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</tr>
<tr>
<td>8</td>
<td>77,000 kg</td>
<td>69,000 kg</td>
<td>56,000 kg</td>
<td>40,000 kg</td>
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<td></td>
<td></td>
<td>20,000 kg</td>
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<td></td>
</tr>
<tr>
<td>9</td>
<td>86,000 kg</td>
<td>77,000 kg</td>
<td>63,000 kg</td>
<td>45,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23,000 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>96,000 kg</td>
<td>86,000 kg</td>
<td>70,000 kg</td>
<td>50,000 kg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25,000 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### HIGH FRICTION

| 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                   | 25,000 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                       |                                  |                                  |

### MEDIUM FRICTION

| Static friction:    | 0.25                            |
|                    | Example: Smooth steel on conveyer 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                        |                                  |                                  |

### LOW FRICTION

| 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**

*8MM TRANSPORT CHAIN, TURNBUCKLES*

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mm transport chain</td>
<td>Turnbuckles</td>
<td>1,000 kgf</td>
</tr>
</tbody>
</table>

**UNBLOCKED**
*(RESTRAINED TO 0.8 G)*

### Static friction: 0.6
*Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyer belt)*

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 60° AE &gt; 0.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 45° AE &gt; 0.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 30° AE &gt; 0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 15° AE &gt; 0.25</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Static friction: 0.4</th>
<th>Example: Smooth steel on timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1.900 kg</td>
<td>1.700 kg</td>
</tr>
<tr>
<td>2 3.800 kg</td>
<td>3.400 kg</td>
</tr>
<tr>
<td>3 5.700 kg</td>
<td>5.100 kg</td>
</tr>
<tr>
<td>4 7.700 kg</td>
<td>6.900 kg</td>
</tr>
<tr>
<td>5 9.600 kg</td>
<td>8.600 kg</td>
</tr>
<tr>
<td>6 11.000 kg</td>
<td>10.000 kg</td>
</tr>
<tr>
<td>7 13.000 kg</td>
<td>12.000 kg</td>
</tr>
<tr>
<td>8 15.000 kg</td>
<td>13.000 kg</td>
</tr>
<tr>
<td>9 17.000 kg</td>
<td>15.000 kg</td>
</tr>
<tr>
<td>10 19.000 kg</td>
<td>17.000 kg</td>
</tr>
</tbody>
</table>

### Static friction: 0.25
*Example: Smooth steel on conveyer belt*

<table>
<thead>
<tr>
<th>Static friction: 0.2</th>
<th>Example: Smooth steel on rusty steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 870 kg</td>
<td>780 kg</td>
</tr>
<tr>
<td>2 1,700 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>3 2,600 kg</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>4 3,500 kg</td>
<td>3,100 kg</td>
</tr>
<tr>
<td>5 4,300 kg</td>
<td>3,900 kg</td>
</tr>
<tr>
<td>6 5,200 kg</td>
<td>4,700 kg</td>
</tr>
<tr>
<td>7 6,100 kg</td>
<td>5,500 kg</td>
</tr>
<tr>
<td>8 7,000 kg</td>
<td>6,200 kg</td>
</tr>
<tr>
<td>9 7,900 kg</td>
<td>7,000 kg</td>
</tr>
<tr>
<td>10 8,700 kg</td>
<td>7,800 kg</td>
</tr>
</tbody>
</table>
### NUMBER OF TIE-DOWN LASHINGS

**8MM TRANSPORT CHAIN, OVER-CENTRE TENSIONER**

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mm transport chain</td>
<td>Over-centre tensioner</td>
<td>750 kgf</td>
</tr>
</tbody>
</table>

**BLOCKED**

(RESTRAINED TO 0.5 G)

#### Static friction:

- **High friction**: 0.6
  - Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyer belt)

#### Medium friction**: 0.4
  - Example: Smooth steel on timber

#### Low friction**: 0.25
  - Example: Smooth steel on conveyer belt

#### Very low friction**: 0.2
  - Example: Smooth steel on rusty steel

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>At least 60° AE &gt; 0.85</td>
<td>At least 45° AE &gt; 0.70</td>
</tr>
<tr>
<td>1</td>
<td>7,200 kg</td>
<td>6,400 kg</td>
<td>5,300 kg</td>
</tr>
<tr>
<td>2</td>
<td>14,000 kg</td>
<td>12,000 kg</td>
<td>10,000 kg</td>
</tr>
<tr>
<td>3</td>
<td>21,000 kg</td>
<td>19,000 kg</td>
<td>15,000 kg</td>
</tr>
<tr>
<td>4</td>
<td>28,000 kg</td>
<td>25,000 kg</td>
<td>21,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>36,000 kg</td>
<td>32,000 kg</td>
<td>26,000 kg</td>
</tr>
<tr>
<td>6</td>
<td>43,000 kg</td>
<td>38,000 kg</td>
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</tr>
<tr>
<td>7</td>
<td>50,000 kg</td>
<td>45,000 kg</td>
<td>37,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>57,000 kg</td>
<td>51,000 kg</td>
<td>42,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>65,000 kg</td>
<td>58,000 kg</td>
<td>47,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>72,000 kg</td>
<td>64,000 kg</td>
<td>53,000 kg</td>
</tr>
</tbody>
</table>

| 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 |

| 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 |

| 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

**8MM TRANSPORT CHAIN, OVER-CENTRE TENSIONER**

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mm transport chain</td>
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</tbody>
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#### UNBLOCKED

(RESTRAINED TO 0.8 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
</tr>
<tr>
<td>1</td>
<td>4,300 kg</td>
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<tr>
<td>2</td>
<td>8,600 kg</td>
</tr>
<tr>
<td>3</td>
<td>13,000 kg</td>
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<tr>
<td>4</td>
<td>17,000 kg</td>
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<td>5</td>
<td>21,000 kg</td>
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<td>7</td>
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</tr>
<tr>
<td>8</td>
<td>34,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>39,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>43,000 kg</td>
</tr>
</tbody>
</table>

#### HIGH FRICTION

Static friction: 0.6  
Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Static friction: 0.4  Example: Smooth steel on timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,400 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,800 kg</td>
</tr>
<tr>
<td>3</td>
<td>4,300 kg</td>
</tr>
<tr>
<td>4</td>
<td>5,700 kg</td>
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<td>5</td>
<td>7,200 kg</td>
</tr>
<tr>
<td>6</td>
<td>8,600 kg</td>
</tr>
<tr>
<td>7</td>
<td>10,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>11,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>13,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>14,000 kg</td>
</tr>
</tbody>
</table>

#### MEDIUM FRICTION

Static friction: 0.25  Example: Smooth steel on conveyor belt

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Static friction: 0.2  Example: Smooth steel on rusty steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>650 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,300 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,900 kg</td>
</tr>
<tr>
<td>4</td>
<td>2,600 kg</td>
</tr>
<tr>
<td>5</td>
<td>3,200 kg</td>
</tr>
<tr>
<td>6</td>
<td>3,900 kg</td>
</tr>
<tr>
<td>7</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>8</td>
<td>5,200 kg</td>
</tr>
<tr>
<td>9</td>
<td>5,900 kg</td>
</tr>
<tr>
<td>10</td>
<td>6,500 kg</td>
</tr>
</tbody>
</table>

#### LOW FRICTION

Static friction: 0.2  Example: Smooth steel on rusty steel

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Static friction: 0.25  Example: Smooth steel on conveyor belt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>480 kg</td>
</tr>
<tr>
<td>2</td>
<td>960 kg</td>
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<tr>
<td>3</td>
<td>1,400 kg</td>
</tr>
<tr>
<td>4</td>
<td>1,900 kg</td>
</tr>
<tr>
<td>5</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>6</td>
<td>2,800 kg</td>
</tr>
<tr>
<td>7</td>
<td>3,300 kg</td>
</tr>
<tr>
<td>8</td>
<td>3,800 kg</td>
</tr>
<tr>
<td>9</td>
<td>4,300 kg</td>
</tr>
<tr>
<td>10</td>
<td>4,800 kg</td>
</tr>
</tbody>
</table>
### NUMBER OF TIE-DOWN LASHINGS

**50MM WEBBING STRAPS, PULL-DOWN HAND RATCHET**

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm webbing straps</td>
<td>Pull-down hand ratchet</td>
<td>600 kgf</td>
</tr>
</tbody>
</table>

**BLOCKED**

(RESTRAINED TO 0.5 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
</tr>
<tr>
<td>Static friction: 0.6</td>
<td></td>
</tr>
<tr>
<td>Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5,700 kg</td>
</tr>
<tr>
<td>2</td>
<td>11,000 kg</td>
</tr>
<tr>
<td>3</td>
<td>17,000 kg</td>
</tr>
<tr>
<td>4</td>
<td>23,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>28,000 kg</td>
</tr>
<tr>
<td>6</td>
<td>34,000 kg</td>
</tr>
<tr>
<td>7</td>
<td>40,000 kg</td>
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<tr>
<td>8</td>
<td>46,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>52,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>57,000 kg</td>
</tr>
<tr>
<td>Static friction: 0.4</td>
<td></td>
</tr>
<tr>
<td>Example: Smooth steel on timber</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>2</td>
<td>9,200 kg</td>
</tr>
<tr>
<td>3</td>
<td>13,000 kg</td>
</tr>
<tr>
<td>4</td>
<td>18,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>23,000 kg</td>
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<tr>
<td>6</td>
<td>27,000 kg</td>
</tr>
<tr>
<td>7</td>
<td>32,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>37,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>41,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>46,000 kg</td>
</tr>
<tr>
<td>Static friction: 0.25</td>
<td></td>
</tr>
<tr>
<td>Example: Smooth steel on conveyor belt</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>3</td>
<td>3,400 kg</td>
</tr>
<tr>
<td>4</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>5</td>
<td>5,700 kg</td>
</tr>
<tr>
<td>6</td>
<td>6,900 kg</td>
</tr>
<tr>
<td>7</td>
<td>8,100 kg</td>
</tr>
<tr>
<td>8</td>
<td>9,200 kg</td>
</tr>
<tr>
<td>9</td>
<td>10,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>11,000 kg</td>
</tr>
<tr>
<td>Static friction: 0.2</td>
<td></td>
</tr>
<tr>
<td>Example: Smooth steel on rusty steel</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>770 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>3</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>4</td>
<td>3,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>3,800 kg</td>
</tr>
<tr>
<td>6</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>7</td>
<td>5,400 kg</td>
</tr>
<tr>
<td>8</td>
<td>6,100 kg</td>
</tr>
<tr>
<td>9</td>
<td>6,900 kg</td>
</tr>
<tr>
<td>10</td>
<td>7,700 kg</td>
</tr>
</tbody>
</table>
# NUMBER OF TIE-DOWN LASHINGS

50MM WEBBING CHAIN, PULL-DOWN HAND RATCHET

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm webbing straps</td>
<td>Pull-down hand ratchet</td>
<td>600 kgf</td>
</tr>
</tbody>
</table>

## UNBLOCKED
(RESTRAINED TO 0.8 G)

### NUMBER OF TIE-DOWN LASHINGS

### Lashing angle (from horizontal)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>At least 75° AE &gt; 0.95</th>
<th>At least 60° AE &gt; 0.85</th>
<th>At least 45° AE &gt; 0.70</th>
<th>At least 30° AE &gt; 0.50</th>
<th>At least 15° AE &gt; 0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3,400 kg</td>
<td>3,100 kg</td>
<td>2,500 kg</td>
<td>1,800 kg</td>
<td>930 kg</td>
</tr>
<tr>
<td>2</td>
<td>6,900 kg</td>
<td>6,200 kg</td>
<td>5,000 kg</td>
<td>3,600 kg</td>
<td>1,800 kg</td>
</tr>
<tr>
<td>3</td>
<td>10,000 kg</td>
<td>9,300 kg</td>
<td>7,600 kg</td>
<td>5,400 kg</td>
<td>2,700 kg</td>
</tr>
<tr>
<td>4</td>
<td>13,000 kg</td>
<td>12,000 kg</td>
<td>10,000 kg</td>
<td>7,200 kg</td>
<td>3,700 kg</td>
</tr>
<tr>
<td>5</td>
<td>17,000 kg</td>
<td>15,000 kg</td>
<td>12,000 kg</td>
<td>9,000 kg</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>6</td>
<td>20,000 kg</td>
<td>18,000 kg</td>
<td>15,000 kg</td>
<td>10,000 kg</td>
<td>5,500 kg</td>
</tr>
<tr>
<td>7</td>
<td>24,000 kg</td>
<td>21,000 kg</td>
<td>17,000 kg</td>
<td>12,000 kg</td>
<td>6,500 kg</td>
</tr>
<tr>
<td>8</td>
<td>27,000 kg</td>
<td>24,000 kg</td>
<td>20,000 kg</td>
<td>14,000 kg</td>
<td>7,400 kg</td>
</tr>
<tr>
<td>9</td>
<td>31,000 kg</td>
<td>28,000 kg</td>
<td>22,000 kg</td>
<td>16,000 kg</td>
<td>8,300 kg</td>
</tr>
<tr>
<td>10</td>
<td>34,000 kg</td>
<td>31,000 kg</td>
<td>25,000 kg</td>
<td>18,000 kg</td>
<td>9,300 kg</td>
</tr>
</tbody>
</table>

### HIGH FRICTION

**Static friction:** 0.6

**Example:** Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>1 kg</th>
<th>2 kg</th>
<th>3 kg</th>
<th>4 kg</th>
<th>5 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,100 kg</td>
<td>1,000 kg</td>
<td>840 kg</td>
<td>600 kg</td>
<td>310 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,300 kg</td>
<td>2,000 kg</td>
<td>1,600 kg</td>
<td>1,200 kg</td>
<td>620 kg</td>
</tr>
<tr>
<td>3</td>
<td>3,400 kg</td>
<td>3,100 kg</td>
<td>2,500 kg</td>
<td>1,800 kg</td>
<td>930 kg</td>
</tr>
<tr>
<td>4</td>
<td>4,600 kg</td>
<td>4,100 kg</td>
<td>3,300 kg</td>
<td>2,400 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>5</td>
<td>5,700 kg</td>
<td>5,100 kg</td>
<td>4,200 kg</td>
<td>3,000 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>6</td>
<td>6,900 kg</td>
<td>6,200 kg</td>
<td>5,000 kg</td>
<td>3,600 kg</td>
<td>1,800 kg</td>
</tr>
<tr>
<td>7</td>
<td>8,100 kg</td>
<td>7,200 kg</td>
<td>5,900 kg</td>
<td>4,200 kg</td>
<td>2,100 kg</td>
</tr>
<tr>
<td>8</td>
<td>9,200 kg</td>
<td>8,300 kg</td>
<td>6,700 kg</td>
<td>4,800 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>9</td>
<td>10,000 kg</td>
<td>9,300 kg</td>
<td>7,600 kg</td>
<td>5,400 kg</td>
<td>2,700 kg</td>
</tr>
<tr>
<td>10</td>
<td>11,000 kg</td>
<td>10,000 kg</td>
<td>8,400 kg</td>
<td>6,000 kg</td>
<td>3,100 kg</td>
</tr>
</tbody>
</table>

### MEDIUM FRICTION

**Static friction:** 0.4

**Example:** Smooth steel on timber

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>1 kg</th>
<th>2 kg</th>
<th>3 kg</th>
<th>4 kg</th>
<th>5 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,100 kg</td>
<td>1,000 kg</td>
<td>840 kg</td>
<td>600 kg</td>
<td>310 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,300 kg</td>
<td>2,000 kg</td>
<td>1,600 kg</td>
<td>1,200 kg</td>
<td>620 kg</td>
</tr>
<tr>
<td>3</td>
<td>3,400 kg</td>
<td>3,100 kg</td>
<td>2,500 kg</td>
<td>1,800 kg</td>
<td>930 kg</td>
</tr>
<tr>
<td>4</td>
<td>4,600 kg</td>
<td>4,100 kg</td>
<td>3,300 kg</td>
<td>2,400 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>5</td>
<td>5,700 kg</td>
<td>5,100 kg</td>
<td>4,200 kg</td>
<td>3,000 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>6</td>
<td>6,900 kg</td>
<td>6,200 kg</td>
<td>5,000 kg</td>
<td>3,600 kg</td>
<td>1,800 kg</td>
</tr>
<tr>
<td>7</td>
<td>8,100 kg</td>
<td>7,200 kg</td>
<td>5,900 kg</td>
<td>4,200 kg</td>
<td>2,100 kg</td>
</tr>
<tr>
<td>8</td>
<td>9,200 kg</td>
<td>8,300 kg</td>
<td>6,700 kg</td>
<td>4,800 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>9</td>
<td>10,000 kg</td>
<td>9,300 kg</td>
<td>7,600 kg</td>
<td>5,400 kg</td>
<td>2,700 kg</td>
</tr>
<tr>
<td>10</td>
<td>11,000 kg</td>
<td>10,000 kg</td>
<td>8,400 kg</td>
<td>6,000 kg</td>
<td>3,100 kg</td>
</tr>
</tbody>
</table>

### LOW FRICTION

**Static friction:** 0.25

**Example:** Smooth steel on conveyor belt

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>1 kg</th>
<th>2 kg</th>
<th>3 kg</th>
<th>4 kg</th>
<th>5 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>520 kg</td>
<td>470 kg</td>
<td>380 kg</td>
<td>270 kg</td>
<td>140 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,000 kg</td>
<td>940 kg</td>
<td>770 kg</td>
<td>540 kg</td>
<td>280 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,500 kg</td>
<td>1,400 kg</td>
<td>1,100 kg</td>
<td>810 kg</td>
<td>420 kg</td>
</tr>
<tr>
<td>4</td>
<td>2,100 kg</td>
<td>1,800 kg</td>
<td>1,500 kg</td>
<td>1,000 kg</td>
<td>560 kg</td>
</tr>
<tr>
<td>5</td>
<td>2,600 kg</td>
<td>2,300 kg</td>
<td>1,900 kg</td>
<td>1,300 kg</td>
<td>700 kg</td>
</tr>
<tr>
<td>6</td>
<td>3,100 kg</td>
<td>2,800 kg</td>
<td>2,300 kg</td>
<td>1,600 kg</td>
<td>840 kg</td>
</tr>
<tr>
<td>7</td>
<td>3,600 kg</td>
<td>3,300 kg</td>
<td>2,600 kg</td>
<td>1,900 kg</td>
<td>980 kg</td>
</tr>
<tr>
<td>8</td>
<td>4,200 kg</td>
<td>3,700 kg</td>
<td>3,000 kg</td>
<td>2,100 kg</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>9</td>
<td>4,700 kg</td>
<td>4,200 kg</td>
<td>3,400 kg</td>
<td>2,400 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>10</td>
<td>5,200 kg</td>
<td>4,700 kg</td>
<td>3,800 kg</td>
<td>2,700 kg</td>
<td>1,400 kg</td>
</tr>
</tbody>
</table>

### VERY LOW FRICTION

**Static friction:** 0.2

**Example:** Smooth steel on rusty steel

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>1 kg</th>
<th>2 kg</th>
<th>3 kg</th>
<th>4 kg</th>
<th>5 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>380 kg</td>
<td>340 kg</td>
<td>280 kg</td>
<td>200 kg</td>
<td>100 kg</td>
</tr>
<tr>
<td>2</td>
<td>770 kg</td>
<td>690 kg</td>
<td>560 kg</td>
<td>400 kg</td>
<td>200 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,100 kg</td>
<td>1,000 kg</td>
<td>840 kg</td>
<td>600 kg</td>
<td>310 kg</td>
</tr>
<tr>
<td>4</td>
<td>1,500 kg</td>
<td>1,300 kg</td>
<td>1,100 kg</td>
<td>800 kg</td>
<td>410 kg</td>
</tr>
<tr>
<td>5</td>
<td>1,900 kg</td>
<td>1,700 kg</td>
<td>1,400 kg</td>
<td>1,000 kg</td>
<td>510 kg</td>
</tr>
<tr>
<td>6</td>
<td>2,300 kg</td>
<td>2,000 kg</td>
<td>1,600 kg</td>
<td>1,200 kg</td>
<td>620 kg</td>
</tr>
<tr>
<td>7</td>
<td>2,700 kg</td>
<td>2,400 kg</td>
<td>1,900 kg</td>
<td>1,400 kg</td>
<td>720 kg</td>
</tr>
<tr>
<td>8</td>
<td>3,000 kg</td>
<td>2,700 kg</td>
<td>2,200 kg</td>
<td>1,600 kg</td>
<td>820 kg</td>
</tr>
<tr>
<td>9</td>
<td>3,400 kg</td>
<td>3,100 kg</td>
<td>2,500 kg</td>
<td>1,800 kg</td>
<td>930 kg</td>
</tr>
<tr>
<td>10</td>
<td>3,800 kg</td>
<td>3,400 kg</td>
<td>2,800 kg</td>
<td>2,000 kg</td>
<td>1,000 kg</td>
</tr>
</tbody>
</table>

---

For lashing L1

Angle Effect (E1) Forwards = Distance (F1) ÷ Length of Lashing (L1)

Angle Effect (E1) Sideways = Distance (S1) ÷ Length of Lashing (L1)

For lashing L2

Angle Effect (E2) Rearwards = Distance (R2) ÷ Length of Lashing (L2)

Angle Effect (E2) Sideways = Distance (S2) ÷ Length of Lashing (L2)
**NUMBER OF TIE-DOWN LASHINGS**

50MM WEBBING STRAPS, PUSH-UP HAND RATCHET OR TRUCK WINCH

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm webbing straps</td>
<td>Push-up hand ratchet or truck winch</td>
<td>300 kgf</td>
</tr>
</tbody>
</table>

**BLOCKED**

(RESTRAINED TO 0.5 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>0.6</td>
<td>Rusty steel on timber or smooth steel on rubber load mat (not conveyer belt)</td>
</tr>
<tr>
<td></td>
<td>At least 60° AE &gt; 0.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 45° AE &gt; 0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 30° AE &gt; 0.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 15° AE &gt; 0.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**HIGH FRICTION**

<table>
<thead>
<tr>
<th>Static friction: 0.6</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,800 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>2,100 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>2,700 kg</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>8,400 kg</td>
<td>6,000 kg</td>
</tr>
<tr>
<td>5,500 kg</td>
<td>3,000 kg</td>
</tr>
<tr>
<td>3,000 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>4,500 kg</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>6,000 kg</td>
<td>3,100 kg</td>
</tr>
<tr>
<td>7,500 kg</td>
<td>3,800 kg</td>
</tr>
<tr>
<td>9,000 kg</td>
<td>4,600 kg</td>
</tr>
</tbody>
</table>

**MEDIUM FRICTION**

<table>
<thead>
<tr>
<th>Static friction: 0.4</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,300 kg</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>1,600 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>1,200 kg</td>
<td>840 kg</td>
</tr>
<tr>
<td>1,200 kg</td>
<td>600 kg</td>
</tr>
<tr>
<td>1,800 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>1,600 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>2,400 kg</td>
<td>1,800 kg</td>
</tr>
<tr>
<td>2,400 kg</td>
<td>1,800 kg</td>
</tr>
<tr>
<td>3,600 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>3,600 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>3,600 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>4,800 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>6,400 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>8,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>8,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>10,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>12,000 kg</td>
<td>2,400 kg</td>
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<tr>
<td>14,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>16,000 kg</td>
<td>2,400 kg</td>
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<tr>
<td>18,000 kg</td>
<td>2,400 kg</td>
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<tr>
<td>20,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>20,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>22,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>24,000 kg</td>
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<tr>
<td>26,000 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>28,000 kg</td>
<td>2,400 kg</td>
</tr>
</tbody>
</table>

**LOW FRICTION**

<table>
<thead>
<tr>
<th>Static friction: 0.25</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>570 kg</td>
<td>510 kg</td>
</tr>
<tr>
<td>420 kg</td>
<td>300 kg</td>
</tr>
<tr>
<td>300 kg</td>
<td>150 kg</td>
</tr>
<tr>
<td>1,100 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>840 kg</td>
<td>600 kg</td>
</tr>
<tr>
<td>600 kg</td>
<td>310 kg</td>
</tr>
<tr>
<td>1,700 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>1,200 kg</td>
<td>900 kg</td>
</tr>
<tr>
<td>900 kg</td>
<td>460 kg</td>
</tr>
<tr>
<td>2,300 kg</td>
<td>2,100 kg</td>
</tr>
<tr>
<td>1,600 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>1,200 kg</td>
<td>620 kg</td>
</tr>
<tr>
<td>2,800 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>2,100 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>1,500 kg</td>
<td>770 kg</td>
</tr>
<tr>
<td>4,000 kg</td>
<td>3,600 kg</td>
</tr>
<tr>
<td>2,900 kg</td>
<td>2,100 kg</td>
</tr>
<tr>
<td>2,100 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>4,600 kg</td>
<td>4,100 kg</td>
</tr>
<tr>
<td>3,300 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>2,400 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>5,200 kg</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>3,800 kg</td>
<td>2,700 kg</td>
</tr>
<tr>
<td>2,400 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>5,700 kg</td>
<td>5,100 kg</td>
</tr>
<tr>
<td>4,200 kg</td>
<td>3,000 kg</td>
</tr>
<tr>
<td>3,400 kg</td>
<td>3,100 kg</td>
</tr>
<tr>
<td>2,500 kg</td>
<td>820 kg</td>
</tr>
<tr>
<td>2,800 kg</td>
<td>2,400 kg</td>
</tr>
</tbody>
</table>

**VERY LOW FRICTION**

<table>
<thead>
<tr>
<th>Static friction: 0.2</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>380 kg</td>
<td>340 kg</td>
</tr>
<tr>
<td>280 kg</td>
<td>200 kg</td>
</tr>
<tr>
<td>100 kg</td>
<td>100 kg</td>
</tr>
<tr>
<td>770 kg</td>
<td>690 kg</td>
</tr>
<tr>
<td>560 kg</td>
<td>400 kg</td>
</tr>
<tr>
<td>200 kg</td>
<td>200 kg</td>
</tr>
<tr>
<td>1,100 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>840 kg</td>
<td>600 kg</td>
</tr>
<tr>
<td>310 kg</td>
<td>310 kg</td>
</tr>
<tr>
<td>1,500 kg</td>
<td>1,300 kg</td>
</tr>
<tr>
<td>1,100 kg</td>
<td>800 kg</td>
</tr>
<tr>
<td>410 kg</td>
<td>410 kg</td>
</tr>
<tr>
<td>1,900 kg</td>
<td>1,700 kg</td>
</tr>
<tr>
<td>1,400 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>510 kg</td>
<td>510 kg</td>
</tr>
<tr>
<td>2,300 kg</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>1,600 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>620 kg</td>
<td>620 kg</td>
</tr>
<tr>
<td>2,700 kg</td>
<td>2,400 kg</td>
</tr>
<tr>
<td>1,900 kg</td>
<td>1,400 kg</td>
</tr>
<tr>
<td>720 kg</td>
<td>720 kg</td>
</tr>
<tr>
<td>3,000 kg</td>
<td>2,700 kg</td>
</tr>
<tr>
<td>2,200 kg</td>
<td>1,600 kg</td>
</tr>
<tr>
<td>820 kg</td>
<td>820 kg</td>
</tr>
<tr>
<td>3,400 kg</td>
<td>3,100 kg</td>
</tr>
<tr>
<td>2,500 kg</td>
<td>1,800 kg</td>
</tr>
<tr>
<td>930 kg</td>
<td>930 kg</td>
</tr>
<tr>
<td>3,800 kg</td>
<td>3,400 kg</td>
</tr>
<tr>
<td>2,800 kg</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>1,000 kg</td>
<td>1,000 kg</td>
</tr>
</tbody>
</table>
# NUMBER OF TIE-DOWN LASHINGS

## 50MM WEBBING STRAPS, PUSH-UP HAND RATCHET OR TRUCK WINCH

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm webbing straps</td>
<td>Push-up hand ratchet or truck winch</td>
<td>300 kgf</td>
</tr>
</tbody>
</table>

## UNBLOCKED

(RESTRAINED TO 0.8 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>0.6</td>
<td>Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</td>
</tr>
<tr>
<td>1</td>
<td>1,700 kg</td>
<td>1,500 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>2</td>
<td>3,400 kg</td>
<td>3,100 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>3</td>
<td>5,200 kg</td>
<td>4,600 kg</td>
<td>3,800 kg</td>
</tr>
<tr>
<td>4</td>
<td>6,900 kg</td>
<td>6,200 kg</td>
<td>5,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>8,600 kg</td>
<td>7,700 kg</td>
<td>6,300 kg</td>
</tr>
<tr>
<td>6</td>
<td>10,000 kg</td>
<td>9,300 kg</td>
<td>7,600 kg</td>
</tr>
<tr>
<td>7</td>
<td>12,000 kg</td>
<td>10,000 kg</td>
<td>8,900 kg</td>
</tr>
<tr>
<td>8</td>
<td>13,000 kg</td>
<td>12,000 kg</td>
<td>10,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>15,000 kg</td>
<td>14,000 kg</td>
<td>11,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>17,000 kg</td>
<td>15,000 kg</td>
<td>12,000 kg</td>
</tr>
</tbody>
</table>

## HIGH FRICTION

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 60° AE &gt; 0.85</td>
<td>0.4</td>
<td>Smooth steel on timber</td>
</tr>
<tr>
<td>1</td>
<td>570 kg</td>
<td>510 kg</td>
<td>420 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,100 kg</td>
<td>1,000 kg</td>
<td>840 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,700 kg</td>
<td>1,500 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>4</td>
<td>2,300 kg</td>
<td>2,000 kg</td>
<td>1,600 kg</td>
</tr>
<tr>
<td>5</td>
<td>2,800 kg</td>
<td>2,500 kg</td>
<td>2,100 kg</td>
</tr>
<tr>
<td>6</td>
<td>3,400 kg</td>
<td>3,100 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>7</td>
<td>4,000 kg</td>
<td>3,600 kg</td>
<td>2,900 kg</td>
</tr>
<tr>
<td>8</td>
<td>4,600 kg</td>
<td>4,100 kg</td>
<td>3,300 kg</td>
</tr>
<tr>
<td>9</td>
<td>5,200 kg</td>
<td>4,600 kg</td>
<td>3,800 kg</td>
</tr>
<tr>
<td>10</td>
<td>5,700 kg</td>
<td>5,100 kg</td>
<td>4,200 kg</td>
</tr>
</tbody>
</table>

## MEDIUM FRICTION

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 45° AE &gt; 0.70</td>
<td>0.25</td>
<td>Smooth steel on conveyor belt</td>
</tr>
<tr>
<td>1</td>
<td>260 kg</td>
<td>230 kg</td>
<td>190 kg</td>
</tr>
<tr>
<td>2</td>
<td>520 kg</td>
<td>470 kg</td>
<td>380 kg</td>
</tr>
<tr>
<td>3</td>
<td>790 kg</td>
<td>700 kg</td>
<td>570 kg</td>
</tr>
<tr>
<td>4</td>
<td>1,000 kg</td>
<td>940 kg</td>
<td>770 kg</td>
</tr>
<tr>
<td>5</td>
<td>1,300 kg</td>
<td>1,100 kg</td>
<td>960 kg</td>
</tr>
<tr>
<td>6</td>
<td>1,500 kg</td>
<td>1,400 kg</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>7</td>
<td>1,800 kg</td>
<td>1,600 kg</td>
<td>1,300 kg</td>
</tr>
<tr>
<td>8</td>
<td>2,100 kg</td>
<td>1,800 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>9</td>
<td>2,300 kg</td>
<td>2,100 kg</td>
<td>1,700 kg</td>
</tr>
<tr>
<td>10</td>
<td>2,600 kg</td>
<td>2,300 kg</td>
<td>1,900 kg</td>
</tr>
</tbody>
</table>

## LOW FRICTION

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 30° AE &gt; 0.50</td>
<td>0.2</td>
<td>Smooth steel on rusty steel</td>
</tr>
<tr>
<td>1</td>
<td>190 kg</td>
<td>170 kg</td>
<td>140 kg</td>
</tr>
<tr>
<td>2</td>
<td>380 kg</td>
<td>340 kg</td>
<td>280 kg</td>
</tr>
<tr>
<td>3</td>
<td>570 kg</td>
<td>510 kg</td>
<td>420 kg</td>
</tr>
<tr>
<td>4</td>
<td>770 kg</td>
<td>690 kg</td>
<td>560 kg</td>
</tr>
<tr>
<td>5</td>
<td>960 kg</td>
<td>860 kg</td>
<td>700 kg</td>
</tr>
<tr>
<td>6</td>
<td>1,100 kg</td>
<td>1,000 kg</td>
<td>840 kg</td>
</tr>
<tr>
<td>7</td>
<td>1,300 kg</td>
<td>1,200 kg</td>
<td>980 kg</td>
</tr>
<tr>
<td>8</td>
<td>1,500 kg</td>
<td>1,300 kg</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>9</td>
<td>1,700 kg</td>
<td>1,500 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>10</td>
<td>1,900 kg</td>
<td>1,700 kg</td>
<td>1,400 kg</td>
</tr>
</tbody>
</table>
## NUMBER OF TIE-DOWN LASHINGS
### 35MM WEBBING STRAPS, HAND RATCHET

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-Tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 mm webbing straps</td>
<td>Hand ratchet</td>
<td>250 kgf</td>
</tr>
</tbody>
</table>

### BLOCKED
(RESTRAINED TO 0.5 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>0.6</td>
<td>Rusty steel on timber or smooth steel on rubber load mat (not conveyer belt)</td>
</tr>
<tr>
<td></td>
<td>At least 60° AE &gt; 0.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 45° AE &gt; 0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 30° AE &gt; 0.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least 15° AE &gt; 0.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### HIGH FRICTION

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,200 kg</td>
<td>640 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,100 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>3</td>
<td>3,500 kg</td>
<td>1,200 kg</td>
</tr>
<tr>
<td>4</td>
<td>5,300 kg</td>
<td>1,900 kg</td>
</tr>
<tr>
<td>5</td>
<td>7,000 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>6</td>
<td>10,000 kg</td>
<td>3,200 kg</td>
</tr>
<tr>
<td>7</td>
<td>15,000 kg</td>
<td>4,500 kg</td>
</tr>
<tr>
<td>8</td>
<td>14,000 kg</td>
<td>5,100 kg</td>
</tr>
<tr>
<td>9</td>
<td>19,000 kg</td>
<td>5,800 kg</td>
</tr>
<tr>
<td>10</td>
<td>21,000 kg</td>
<td>6,400 kg</td>
</tr>
</tbody>
</table>

### MEDIUM FRICTION

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,700 kg</td>
<td>510 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,800 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>3</td>
<td>4,200 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>4</td>
<td>5,600 kg</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>7,000 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>6</td>
<td>8,400 kg</td>
<td>3,000 kg</td>
</tr>
<tr>
<td>7</td>
<td>9,800 kg</td>
<td>3,600 kg</td>
</tr>
<tr>
<td>8</td>
<td>11,000 kg</td>
<td>4,100 kg</td>
</tr>
<tr>
<td>9</td>
<td>13,000 kg</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>10</td>
<td>15,000 kg</td>
<td>5,100 kg</td>
</tr>
</tbody>
</table>

### LOW FRICTION

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,400 kg</td>
<td>250 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,800 kg</td>
<td>500 kg</td>
</tr>
<tr>
<td>3</td>
<td>4,200 kg</td>
<td>750 kg</td>
</tr>
<tr>
<td>4</td>
<td>5,600 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>7,000 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>6</td>
<td>8,400 kg</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>7</td>
<td>9,800 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>8</td>
<td>11,000 kg</td>
<td>3,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>13,000 kg</td>
<td>3,500 kg</td>
</tr>
<tr>
<td>10</td>
<td>15,000 kg</td>
<td>4,000 kg</td>
</tr>
</tbody>
</table>

### VERY LOW FRICTION

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Static friction:</th>
<th>Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>700 kg</td>
<td>160 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,000 kg</td>
<td>250 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,300 kg</td>
<td>350 kg</td>
</tr>
<tr>
<td>4</td>
<td>1,600 kg</td>
<td>500 kg</td>
</tr>
<tr>
<td>5</td>
<td>1,900 kg</td>
<td>650 kg</td>
</tr>
<tr>
<td>6</td>
<td>2,200 kg</td>
<td>830 kg</td>
</tr>
<tr>
<td>7</td>
<td>2,500 kg</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>8</td>
<td>2,800 kg</td>
<td>1,300 kg</td>
</tr>
<tr>
<td>9</td>
<td>3,100 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>10</td>
<td>3,400 kg</td>
<td>1,600 kg</td>
</tr>
</tbody>
</table>

### Tension Calculation

For lashing L1
Angle Effect (E1) Forwards = Distance (F1) ÷ Length of Lashing (L1)
Angle Effect (E1) Sideways = Distance (S1) ÷ Length of Lashing (L1)

For lashing L2
Angle Effect (E2) Rearwards = Distance (R2) ÷ Length of Lashing (L2)
Angle Effect (E2) Sideways = Distance (S2) ÷ Length of Lashing (L2)
### NUMBER OF TIE-DOWN LASHINGS

**35MM WEBBING STRAPS, HAND RATCHET**

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 mm webbing straps</td>
<td>Hand ratchet</td>
<td>250 kgf</td>
</tr>
</tbody>
</table>

#### UNBLOCKED

(RESTRAINED TO 0.8 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
</tr>
<tr>
<td>Static friction: 0.6 Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1,400 kg</td>
</tr>
<tr>
<td>2</td>
<td>2,800 kg</td>
</tr>
<tr>
<td>3</td>
<td>4,300 kg</td>
</tr>
<tr>
<td>4</td>
<td>5,700 kg</td>
</tr>
<tr>
<td>5</td>
<td>7,200 kg</td>
</tr>
<tr>
<td>6</td>
<td>8,600 kg</td>
</tr>
<tr>
<td>7</td>
<td>10,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>11,000 kg</td>
</tr>
<tr>
<td>9</td>
<td>13,000 kg</td>
</tr>
<tr>
<td>10</td>
<td>14,000 kg</td>
</tr>
</tbody>
</table>

| Static friction: 0.4 Example: Smooth steel on timber |
| 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 |

| Static friction: 0.25 Example: Smooth steel on conveyor belt |
| 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 |

| Static friction: 0.2 Example: Smooth steel on rusty steel |
| 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

**25mm webbing straps/12mm rope, Hand ratchet/double hitch**

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 mm webbing straps/12 mm rope</td>
<td>Hand ratchet/double hitch</td>
<td>100 kgf</td>
</tr>
</tbody>
</table>

**BLOCKED**  
(RESTRAINED TO 0.5 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th>Static friction</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>0.6</td>
<td>Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</td>
</tr>
<tr>
<td></td>
<td>At least 60° AE &gt; 0.85</td>
<td>Static friction</td>
<td>Smooth steel on timber</td>
</tr>
<tr>
<td></td>
<td>At least 45° AE &gt; 0.70</td>
<td>Static friction</td>
<td>Smooth steel on conveyor belt</td>
</tr>
<tr>
<td></td>
<td>At least 30° AE &gt; 0.50</td>
<td>Static friction</td>
<td>Smooth steel on rusty steel</td>
</tr>
<tr>
<td></td>
<td>At least 15° AE &gt; 0.25</td>
<td>Static friction</td>
<td>Smooth steel on rusty steel</td>
</tr>
</tbody>
</table>

### HIGH FRICTION

<table>
<thead>
<tr>
<th>Static friction: 0.6</th>
<th>Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 960 kg</td>
<td>860 kg 700 kg 500 kg 250 kg</td>
</tr>
<tr>
<td>2 1,900 kg</td>
<td>1,700 kg 1,400 kg 1,000 kg 510 kg</td>
</tr>
<tr>
<td>3 2,800 kg</td>
<td>2,500 kg 2,100 kg 1,500 kg 770 kg</td>
</tr>
<tr>
<td>4 3,800 kg</td>
<td>3,400 kg 2,800 kg 2,000 kg 1,000 kg</td>
</tr>
<tr>
<td>5 4,800 kg</td>
<td>4,300 kg 3,500 kg 2,500 kg 1,200 kg</td>
</tr>
<tr>
<td>6 5,700 kg</td>
<td>5,100 kg 4,200 kg 3,000 kg 1,500 kg</td>
</tr>
<tr>
<td>7 6,700 kg</td>
<td>6,000 kg 4,900 kg 3,500 kg 1,800 kg</td>
</tr>
<tr>
<td>8 7,700 kg</td>
<td>6,900 kg 5,600 kg 4,000 kg 2,000 kg</td>
</tr>
<tr>
<td>9 8,600 kg</td>
<td>7,700 kg 6,300 kg 4,500 kg 2,300 kg</td>
</tr>
<tr>
<td>10 9,600 kg</td>
<td>8,600 kg 7,000 kg 5,000 kg 2,500 kg</td>
</tr>
</tbody>
</table>

### MEDIUM FRICTION

<table>
<thead>
<tr>
<th>Static friction: 0.4</th>
<th>Example: Smooth steel on timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 770 kg</td>
<td>690 kg 560 kg 400 kg 200 kg</td>
</tr>
<tr>
<td>2 1,500 kg</td>
<td>1,300 kg 1,100 kg 800 kg 410 kg</td>
</tr>
<tr>
<td>3 2,300 kg</td>
<td>2,000 kg 1,600 kg 1,200 kg 620 kg</td>
</tr>
<tr>
<td>4 3,000 kg</td>
<td>2,700 kg 2,200 kg 1,600 kg 820 kg</td>
</tr>
<tr>
<td>5 3,800 kg</td>
<td>3,400 kg 2,800 kg 2,000 kg 1,000 kg</td>
</tr>
<tr>
<td>6 4,600 kg</td>
<td>4,100 kg 3,300 kg 2,400 kg 1,200 kg</td>
</tr>
<tr>
<td>7 5,400 kg</td>
<td>4,800 kg 3,900 kg 2,800 kg 1,400 kg</td>
</tr>
<tr>
<td>8 6,100 kg</td>
<td>5,500 kg 4,500 kg 3,200 kg 1,600 kg</td>
</tr>
<tr>
<td>9 6,900 kg</td>
<td>6,200 kg 5,000 kg 3,600 kg 1,800 kg</td>
</tr>
<tr>
<td>10 7,700 kg</td>
<td>6,900 kg 5,600 kg 4,000 kg 2,000 kg</td>
</tr>
</tbody>
</table>

### LOW FRICTION

<table>
<thead>
<tr>
<th>Static friction: 0.25</th>
<th>Example: Smooth steel on conveyor belt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 190 kg</td>
<td>170 kg 140 kg 100 kg 51 kg</td>
</tr>
<tr>
<td>2 380 kg</td>
<td>340 kg 280 kg 200 kg 100 kg</td>
</tr>
<tr>
<td>3 570 kg</td>
<td>510 kg 420 kg 300 kg 150 kg</td>
</tr>
<tr>
<td>4 770 kg</td>
<td>690 kg 560 kg 400 kg 200 kg</td>
</tr>
<tr>
<td>5 960 kg</td>
<td>860 kg 700 kg 500 kg 250 kg</td>
</tr>
<tr>
<td>6 1,100 kg</td>
<td>1,000 kg 840 kg 600 kg 310 kg</td>
</tr>
<tr>
<td>7 1,300 kg</td>
<td>1,200 kg 980 kg 700 kg 360 kg</td>
</tr>
<tr>
<td>8 1,500 kg</td>
<td>1,300 kg 1,100 kg 800 kg 410 kg</td>
</tr>
<tr>
<td>9 1,700 kg</td>
<td>1,500 kg 1,200 kg 900 kg 460 kg</td>
</tr>
<tr>
<td>10 1,900 kg</td>
<td>1,700 kg 1,400 kg 1,000 kg 510 kg</td>
</tr>
</tbody>
</table>

### VERY LOW FRICTION

<table>
<thead>
<tr>
<th>Static friction: 0.2</th>
<th>Example: Smooth steel on rusty steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 120 kg</td>
<td>110 kg 94 kg 66 kg 34 kg</td>
</tr>
<tr>
<td>2 250 kg</td>
<td>230 kg 180 kg 130 kg 69 kg</td>
</tr>
<tr>
<td>3 380 kg</td>
<td>340 kg 280 kg 200 kg 100 kg</td>
</tr>
<tr>
<td>4 510 kg</td>
<td>460 kg 370 kg 260 kg 130 kg</td>
</tr>
<tr>
<td>5 640 kg</td>
<td>570 kg 470 kg 330 kg 170 kg</td>
</tr>
<tr>
<td>6 770 kg</td>
<td>690 kg 560 kg 400 kg 200 kg</td>
</tr>
<tr>
<td>7 900 kg</td>
<td>800 kg 650 kg 460 kg 240 kg</td>
</tr>
<tr>
<td>8 1,000 kg</td>
<td>920 kg 750 kg 530 kg 270 kg</td>
</tr>
<tr>
<td>9 1,100 kg</td>
<td>1,000 kg 840 kg 600 kg 310 kg</td>
</tr>
<tr>
<td>10 1,200 kg</td>
<td>1,100 kg 940 kg 660 kg 340 kg</td>
</tr>
</tbody>
</table>
# Number of Tie-Down Lashings

25mm Webbing Straps/ 12mm Rope, Hand Ratchet/Double Hitch

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 mm webbing straps/ 12 mm rope</td>
<td>Hand ratchet/double hitch</td>
<td>100 kgf</td>
</tr>
</tbody>
</table>

## Unblocked (Restrained to 0.8 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
<td>At least 60° AE &gt; 0.85</td>
</tr>
<tr>
<td>Static friction: 0.6</td>
<td>Example:</td>
<td>Rusty steel on timber or smooth steel on rubber load mat (not conveyor belt)</td>
</tr>
<tr>
<td>1</td>
<td>570 kg</td>
<td>510 kg</td>
</tr>
<tr>
<td>2</td>
<td>1,100 kg</td>
<td>1,000 kg</td>
</tr>
<tr>
<td>3</td>
<td>1,700 kg</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>4</td>
<td>2,300 kg</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>5</td>
<td>2,800 kg</td>
<td>2,500 kg</td>
</tr>
<tr>
<td>6</td>
<td>3,400 kg</td>
<td>3,100 kg</td>
</tr>
<tr>
<td>7</td>
<td>4,000 kg</td>
<td>3,600 kg</td>
</tr>
<tr>
<td>8</td>
<td>4,600 kg</td>
<td>4,100 kg</td>
</tr>
<tr>
<td>9</td>
<td>5,200 kg</td>
<td>4,600 kg</td>
</tr>
<tr>
<td>10</td>
<td>5,700 kg</td>
<td>5,100 kg</td>
</tr>
</tbody>
</table>

## High Friction

<table>
<thead>
<tr>
<th>Static friction: 0.4</th>
<th>Example: Smooth steel on timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>190 kg</td>
</tr>
<tr>
<td>2</td>
<td>380 kg</td>
</tr>
<tr>
<td>3</td>
<td>570 kg</td>
</tr>
<tr>
<td>4</td>
<td>770 kg</td>
</tr>
<tr>
<td>5</td>
<td>960 kg</td>
</tr>
<tr>
<td>6</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>7</td>
<td>1,300 kg</td>
</tr>
<tr>
<td>8</td>
<td>1,500 kg</td>
</tr>
<tr>
<td>9</td>
<td>1,700 kg</td>
</tr>
<tr>
<td>10</td>
<td>1,900 kg</td>
</tr>
</tbody>
</table>

## Medium Friction

<table>
<thead>
<tr>
<th>Static friction: 0.25</th>
<th>Example: Smooth steel on conveyor belt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>87 kg</td>
</tr>
<tr>
<td>2</td>
<td>170 kg</td>
</tr>
<tr>
<td>3</td>
<td>260 kg</td>
</tr>
<tr>
<td>4</td>
<td>350 kg</td>
</tr>
<tr>
<td>5</td>
<td>430 kg</td>
</tr>
<tr>
<td>6</td>
<td>520 kg</td>
</tr>
<tr>
<td>7</td>
<td>610 kg</td>
</tr>
<tr>
<td>8</td>
<td>700 kg</td>
</tr>
<tr>
<td>9</td>
<td>790 kg</td>
</tr>
<tr>
<td>10</td>
<td>870 kg</td>
</tr>
</tbody>
</table>

## Low Friction

<table>
<thead>
<tr>
<th>Static friction: 0.2</th>
<th>Example: Smooth steel on rusty steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64 kg</td>
</tr>
<tr>
<td>2</td>
<td>120 kg</td>
</tr>
<tr>
<td>3</td>
<td>190 kg</td>
</tr>
<tr>
<td>4</td>
<td>250 kg</td>
</tr>
<tr>
<td>5</td>
<td>320 kg</td>
</tr>
<tr>
<td>6</td>
<td>380 kg</td>
</tr>
<tr>
<td>7</td>
<td>450 kg</td>
</tr>
<tr>
<td>8</td>
<td>510 kg</td>
</tr>
<tr>
<td>9</td>
<td>570 kg</td>
</tr>
<tr>
<td>10</td>
<td>640 kg</td>
</tr>
</tbody>
</table>
### Lashings:

<table>
<thead>
<tr>
<th>Lashing Angle (from horizontal)</th>
<th>At least 75° AE &gt; 0.95</th>
<th>At least 60° AE &gt; 0.85</th>
<th>At least 45° AE &gt; 0.70</th>
<th>At least 30° AE &gt; 0.50</th>
<th>At least 15° AE &gt; 0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 mm rope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Tensioner:

- Single hitch

### Pre-tension:

- 50 kgf

#### L2 FRONT L1 E1 E2 R2 F1 S2 S1

- For lashing L1
  - Angle Effect (E1) Forward = Distance (F1) ÷ Length of Lashing (L1)
  - Angle Effect (E1) Sideways = Distance (S1) ÷ Length of Lashing (L1)

- For lashing L2
  - Angle Effect (E2) Rearwards = Distance (R2) ÷ Length of Lashing (L2)
  - Angle Effect (E2) Sideways = Distance (S2) ÷ Length of Lashing (L2)

#### BLOCKED (RESTRAINED TO 0.5 G)

- Number of lashings
- Lashing angle (from horizontal)
- Static friction
- Example

### HIGH FRICTION

- Static friction: 0.6
- Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyer belt)

### MEDIUM FRICTION

- Static friction: 0.4
- Example: Smooth steel on timber

### LOW FRICTION

- Static friction: 0.25
- Example: Smooth steel on conveyer belt

### VERY LOW FRICTION

- Static friction: 0.2
- Example: Smooth steel on rusty steel
# NUMBER OF TIE-DOWN LASHINGS

12MM ROPE, SINGLE HITCH

<table>
<thead>
<tr>
<th>Lashings:</th>
<th>Tensioner:</th>
<th>Pre-tension:</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 mm rope</td>
<td>Single hitch</td>
<td>50 kgf</td>
</tr>
</tbody>
</table>

**UNBLOCKED**

(RESTRAINED TO 0.8 G)

<table>
<thead>
<tr>
<th>Number of lashings</th>
<th>Lashing angle (from horizontal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At least 75° AE &gt; 0.95</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Static friction:</td>
<td>Example: Rusty steel on timber or smooth steel on rubber load mat (not conveyer belt)</td>
</tr>
<tr>
<td>1</td>
<td>280 kg</td>
</tr>
<tr>
<td>2</td>
<td>570 kg</td>
</tr>
<tr>
<td>3</td>
<td>860 kg</td>
</tr>
<tr>
<td>4</td>
<td>1,100 kg</td>
</tr>
<tr>
<td>5</td>
<td>1,400 kg</td>
</tr>
<tr>
<td>6</td>
<td>1,700 kg</td>
</tr>
<tr>
<td>7</td>
<td>2,000 kg</td>
</tr>
<tr>
<td>8</td>
<td>2,300 kg</td>
</tr>
<tr>
<td>9</td>
<td>2,600 kg</td>
</tr>
<tr>
<td>10</td>
<td>2,800 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Static friction:</th>
<th>Example: Smooth steel on timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>96 kg</td>
</tr>
<tr>
<td>2</td>
<td>190 kg</td>
</tr>
<tr>
<td>3</td>
<td>280 kg</td>
</tr>
<tr>
<td>4</td>
<td>380 kg</td>
</tr>
<tr>
<td>5</td>
<td>480 kg</td>
</tr>
<tr>
<td>6</td>
<td>570 kg</td>
</tr>
<tr>
<td>7</td>
<td>670 kg</td>
</tr>
<tr>
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## MINIMUM LASHING CAPACITY FOR DIRECT RESTRAINT

*Table 10*

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<th>Mass of load (kilograms)</th>
<th>Angle effect AE = &gt; 0.85</th>
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## Minimum Lashing Capacity for Direct Restraint

### Table 11

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<th>Mass of load (kilograms)</th>
<th>Angle effect ( AE = &gt; 0.85 )</th>
<th>Angle effect ( AE = &gt; 0.70 )</th>
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<td>36</td>
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