Load security on rigid-sided lorries

NCM Day, GP White, K Nash, S Turner & P Stanworth
Harpur Hill
Buxton
Derbyshire
SK17 9JN

The project seeks to establish good practice for securing loads on rigid-sided lorries across various industry sectors. Good practice in this case is defined as those methods that are the most practical, involve the least risk of loads becoming unstable or falling, least risk to the operator/driver, and are practicable.

The scope of the project includes consideration of a range of methods currently used in the UK and abroad, as well as alternative methods for securing of different heavy cargoes on rigid-sided lorries. Reference is made to current European Standards and good practice guidelines, as well as regulations and guidance from countries outside the EU.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE Books
ACKNOWLEDGEMENTS

The authors wish to acknowledge the information and assistance provided to HSL during the preparation of this report by many individuals and organisations, including:

Wincanton
UPM-Kymmene
Road Haulage Association
Downton
Kröne
Indesit
Don Bur
Unite the union
Freight Transport Association
Tesco
Cartwright Group
The Road Distribution Action Group
Metropolitan Police
HSE
SMMT
CONTENTS

1 INTRODUCTION ............................................................................................................ 1
  1.1 Scope of the project .................................................................................................. 1
  1.2 Definitions .............................................................................................................. 2
    1.2.1 Terms .............................................................................................................. 2
    1.2.2 Types of HGV ................................................................................................ 3
      1.2.2.1 Flatbed trailers ....................................................................................... 3
      1.2.2.2 Curtain sider trailer ............................................................................... 4
      1.2.2.3 Rigid (box) sider trailer ........................................................................... 4
    1.2.3 Load security measures .................................................................................... 5
      1.2.3.1 Load restraint measures ........................................................................ 5
      1.2.3.2 Load containment measures ................................................................... 7
      1.2.3.3 Combined measures ................................................................................ 8
      1.2.3.4 Additional measures ............................................................................... 9
  1.3 The road haulage industry ....................................................................................... 10
    1.3.1 UK haulage ..................................................................................................... 10
    1.3.2 International haulage ..................................................................................... 11

2 INFORMATION GATHERING ...................................................................................... 12
  2.1 Literature review introduction .............................................................................. 12
  2.2 Legislation and Codes of Practice ......................................................................... 12
    2.2.1 UK legislation and Standards ........................................................................ 13
    2.2.2 UK guidance and Codes of Practice ............................................................... 20
    2.2.3 EU guidance and legislation .......................................................................... 24
    2.2.4 North American guidance and legislation ...................................................... 27
    2.2.5 Discussion ..................................................................................................... 29
  2.3 Accident data, insurance claims and load offences .............................................. 30
    2.3.1 Accidents on the road involving HGVs ......................................................... 30
      2.3.1.1 Statistics ................................................................................................. 30
      2.3.1.2 Insurance claims .................................................................................... 30
      2.3.1.3 Load offences ....................................................................................... 31
  2.4 Previous research .................................................................................................... 31
  2.5 Seminars, conferences and other information sources ....................................... 35
  2.6 Site visits ............................................................................................................... 36
    2.6.1 Company 1 .................................................................................................... 36
    2.6.2 Company 2 .................................................................................................... 38
    2.6.3 Company 3 .................................................................................................... 40
    2.6.4 Common issues ............................................................................................. 42

3 TECHNICAL ASSESSMENT ....................................................................................... 43
  3.1 The mechanism of load shift ................................................................................... 43
  3.2 Force required to overcome friction during cornering ......................................... 44
  3.3 Strength of the load restraint system .................................................................... 46
  3.4 Rollover ................................................................................................................. 47

4 TESTING .................................................................................................................. 48
  4.1 Computer simulations ............................................................................................ 48
  4.2 AutoDesk Inventor/VisualNastran Motion ............................................................ 48
4.3 VNM simulation parameters ..............................................48
  4.3.1 Trailer geometry ..................................................49
  4.3.2 Load geometry, configuration and other physical parameters ....49
  4.3.3 Straight line braking simulations ...................................50
  4.3.4 Roundabout simulations ..........................................51
4.4 Simulation results ......................................................51
  4.4.1 Straight braking simulation results ...............................51
  4.4.2 Roundabout simulation results ..................................52

5 PHYSICAL TESTING .....................................................54
  5.1 Coefficient of friction between a load and a trailer bed ...........54
  5.1.1 Work Undertaken .................................................55
  5.1.2 Testing of the effectiveness of webbing straps and bars .......55
     5.1.2.1 Findings & Assessment ....................................56
     5.1.2.2 Conclusions .................................................57
5.1.3 Load geometry, configuration and other physical parameters ....57

6 RISK ASSESSMENT ........................................................58
  6.1 Introduction .........................................................58
  6.2 Approach ....................................................................58
  6.3 Possible Scenarios .....................................................60
  6.4 Base Case Assessment ................................................61
  6.5 Load Security Measures ...............................................63
     6.5.1 Load security measures specific to roll cages and similar loads:..63
         6.5.1.1 Bars ...............................................................63
         6.5.1.2 Cross strapping ............................................63
     6.5.2 Load security measures suitable for all loads: ..................64
         6.5.2.1 Air bags .........................................................64
         6.5.2.2 Other packing materials ..................................64
     6.5.3 Load security measures for pallets, paper rolls etc: ..........64
         6.5.3.1 Fastenings to trailer bed ..................................64
  6.6 Assessment of Load Security Methods ..................................65
  6.7 Risk Matrices ...........................................................66
     6.7.1 Base case ...........................................................66
     6.7.2 Bars ....................................................................66
     6.7.3 Cross strapping ....................................................67
     6.7.4 Air bags ...............................................................67

7 DISCUSSION ..................................................................68

8 CONCLUSIONS ..............................................................71

9 APPENDICES ................................................................72
  9.1 Appendix A: Detailed HSE workshop findings .......................72
     9.1.1 Base case assessment .............................................72
     9.1.2 Load security measures ..........................................75
  9.2 Appendix B – Load security prosecutions ..............................79

10 BIBLIOGRAPHY .............................................................83

11 INDEX ......................................................................85
EXECUTIVE SUMMARY

The project seeks to establish good practice for securing loads on rigid-sided lorries across various industry sectors. Good practice in this case is defined as those methods that are the most practical, involve the least risk of loads becoming unstable or falling, least risk to the operator/driver, and are practicable.

Objectives

1. To consider the range of methods currently used in the UK and abroad to secure loads for road transport on rigid-sided lorries.

2. To assess the level of risk for the various systems under a range of normal vehicle manoeuvres with different load types.

3. To establish good practice for securing loads on rigid-sided lorries

Main Findings

1. Loads should be secured so that they do not move relative to the trailer bed during transport.

2. Loads should be placed against the trailer headboard if possible. If this is not possible for reasons of weight distribution, the gap to the headboard should be filled or an intermediate bulkhead could be used.

3. Friction alone should not be relied on as a method of load securing.

4. Cross-strapping the load was identified as the least-risk method for rollcages, however it would not be suitable for all types of load and positive locking may be the preferred option for loads that can be tightly packed such as uniform palletised goods.

5. There are costs involved in securing a load, both in terms of equipment and additional time, however against this must be set the costs of the potential consequences of load shift, such as product damage, vehicle damage, delays, death or injury, and prosecution in the event of an accident.

6. Communication between all parties involved in the loading, transport and unloading may help to avoid or ameliorate problems surrounding load securing.

7. Risk assessment and a loading plan prepared by someone competent to do so is the key to good load security. This does not have to be an onerous process but ‘thinking through’ the operation in advance may identify potential issues before they become a problem.
Recommendations

• Guidance on load securing has been in existence for many years and further detailed generic guidance may not be helpful. However, industry-specific additional guidance, particularly in the form of case studies, may help to illustrate ways particular loads could be secured.

• Existing good practice developed by some companies as a result of their own research could be shared more widely with other employers in the industry e.g. via their trade associations. This might avoid duplication of effort and assist in sharing good practice.

• The recent European Guidance on load security could be more extensively promoted in the UK in addition to the existing Department of Transport guidance, as they gives detailed, clear guidance on how to secure many types of loads safely.

• Examples of loading plans and risk assessments for the haulage industry could be made available to help companies plan their loading.

• Further work could be carried out to assess the suitability of the trailer structure to retain loads.
1 INTRODUCTION

1.1 SCOPE OF THE PROJECT

The project seeks to establish good practice for securing loads on rigid-sided lorries across various industry sectors. Good practice in this case is defined as those methods that are the most practical, involve the least risk of loads becoming unstable or falling, least risk to the operator/driver, and are practicable.

The scope of the project includes consideration of a range of methods currently used in the UK and abroad, as well as alternative methods for securing of different heavy cargoes on rigid-sided lorries. Reference will be made to current European Standards and good practice guidelines, as well as regulations and guidance from countries outside the EU.

The project will involve assessment of the level of risk for the various systems under a range of normal vehicle manoeuvres with different load types. Each method will bring its own risks and benefits and these will be considered. Consideration will also be taken of the differing cargo that may be transported and the risks and issues associated with them.

The ultimate aim of the project is to deliver a comprehensive review of practical methods of securing loads on rigid-sided lorries and direct the reader to practical, robust guidance on load restraint to enable them to minimise the risks to health and safety of all those working on and around rigid-sided vehicles.

This report was prepared by N. Day, Engineering Safety Unit, HSL, with the exception of Section 4, which was prepared by G. White, Engineering Safety Unit, HSL, and Section 5, which was prepared by K. Nash and S. Turner, Risk Assessment Section HSL.

This report should be read in conjunction with the HSE RR - Information collection and data mining in relation to accidents/incidents involving loads falling from vehicles/shifting loads (Corbett, 2008), and HSE RR662 Load security on curtain sided lorries (Day et al, 2008).
1.2 DEFINITIONS

1.2.1 Terms

The term ‘HGV’ (heavy goods vehicle) has been used in this report to refer to a goods vehicle over 3.5 tonnes. ‘LGV’ (large goods vehicle) is commonly used but the first term has been preferred to avoid confusion with vehicles under 3.5 tonnes.

The following definitions have also been used:

- **Load restraint**: securing the load to the trailer such that it cannot move independently of the trailer.
- **Load containment**: ensuring that, while the load may slide, it does not move outside the confines of the trailer.
- **Attachment point**: rigid part of the load on which the load restraint assembly is placed.
- **Direct lashing**: lashing procedure where the lashings are fixed directly to solid parts of the load or to attachment points.
- **Frictional lashing**: lashing procedure whereby the friction force is enhanced by adding a vertical force component to the weight of the load.
- **Lashing**: flexible device used in the securing of the load on a load carrier.
- **Lashing point**: securing device on a load carrier to which a lashing is directly attached.
- **Load restraint assembly**: systems and devices for securing of loads.
- **Web lashing**: means of securing, consisting of a tensioning device or tension retaining device and flat woven textile webbing with or without end fittings.
- **Sidestrapping**: Method of containing a load, where webbing straps are suspended from a rail/s in the roof of the trailer and then secured to the side of the chassis.
- **Overstrapping**: Method of restraining a load where a webbing strap passes over the load and is secured at each side of the chassis.
1.2.2 Types of HGV

HGVs can be categorised\(^1\) according to three main body types:

- articulated: that is, with a pivot point between the driver’s cab and the actual body of the vehicle. The trailer is attached to the tractor unit via a special coupling known as the fifth wheel;

- rigid: that is, with the cab and body built onto the same chassis unit and unable to pivot.

- Drawbar: that is, a rigid vehicle coupled to an entirely self-standing trailer via a drawbar.

Rigid vehicles are the most common type of truck, comprising approximately 73% of vehicles over 3.5 tonnes\(^2\).

With articulated and drawbar HGVs, the tractor unit can generally be detached from the trailer it pulls. The trailers used in articulated vehicles rely on the tractor unit for front support and are therefore fitted with ‘landing legs’ to provide support when detached from the tractor unit.

There are myriad body and trailer types, including flatbed, low loader, curtain sider, tilt, rigid (box) sider, temperature controlled body, doubledeck and skeletal (used to carry shipping containers). Three types are discussed in more detail in the following sections.

1.2.2.1 Flatbed trailers

Flatbed trailers feature a flat deck, usually wooden, mounted on the chassis with a headboard at the front end.

Flatbeds are used to transport a wide variety of loads. They are easily loaded because of the lack of restriction on access. Loads transported on flatbeds should always be secured to the vehicle chassis and, if possible, loaded so that they are in contact with the headboard.

---

\(^1\) As categorised in the DfT publication *Truck Specification for Best Operational Efficiency* (2005)
\(^2\) DfT – *Transport Statistics 2003*
1.2.2.2  **Curtain sider trailer**

Curtain sider trailers are essentially flatbed trailers with a weather-protection structure mounted on the bed of the trailer. They allow goods to be transported and protected from the weather, as well as providing the advantages of easy access to the sides of the trailer for loading and unloading as would be found on a flatbed trailer.

![Curtain sider trailer diagram](image)

Generally the weather protection structure is not rated for load restraint and should not be used to secure load restraint equipment, although trailers with a reinforced and rated superstructure are allowed for in European Standards.

Curtain-sided trailers are often supplied with straps suspended from rails running either along the centreline of the trailer roof, or along each side of the trailer roof. These suspended straps do not provide load restraint and should not be relied on for containment except with very light loads as their strength is dependent on the strength of the weather protection structure.

1.2.2.3  **Rigid (box) sider trailer**

Rigid siders comprise a rigid box body, with solid sides and usually solid rear-opening doors, although other options are available. Some rigid-sided vehicles are refrigerated, for the transport of chilled and frozen goods.

![Rigid sider trailer diagram](image)

Rigid siders are loaded via the rear doors, either manually, by fork or clamp truck, or by an automated loading system. If the trailer is tightly loaded there may be limited access to the load to fit load restraint equipment once the load is in place. Rigid
Load security measures can be broken into three categories: restraint, containment and combined. Different loads on different vehicles will require different methods of securing – what may be appropriate for one load may not be appropriate for another.

Friction between the load and the trailer bed helps to prevent the load from moving, however it is difficult to ensure a consistently high coefficient of friction and it provides no security against tipping of unstable loads. Even very heavy loads may not remain in place under their own weight. For these reasons friction should be seen as an aid rather than the sole load securing measure.

Load restraint measures involve the load being directly restrained from moving relative to the trailer bed. Examples of load restraint include direct strapping with straps or chains (this is often used with large machinery being transported) and overstrapping with webbing straps.

Positive fit (also referred to as positive blocking, positive locking) is a method by which the load is loaded so that it is in tight contact with part of the vehicle, for example the headboard or the rigid sides, or an accessory secured to the chassis, such as restraint bars.

It is important to ensure that whatever the load is placed against is strong enough to restrain the load in that direction, and that other directions of movement are also guarded against, for example a load loaded tight against the front headboard may still slide to the side and to the rear.

Examples of side rails, restraint bars and straps are shown on the following page.
1.2.3.2 **Load containment measures**

Load containment measures aim to ensure that all or part of a load cannot be ejected from the vehicle. Examples of load containment can include the rigid sides of a rigid-sided vehicle, or sliding gates and side slats on a curtain-sided vehicle. The photograph below shows an example of a storage and containment system for clothing.
1.2.3.3 Combined measures

Combined measures offer a combination of load restraint and load containment. The WALKI®Fix Road suspended tarpaulin with built-in restraint straps is an example of a combined measure, but this requires a roof structure to be suspended from. An example of a suspended system on a curtain-sided vehicle is shown in the photograph below. Other systems are available that can be used on flatbed vehicles, as shown in the picture on the right.

Photograph from cargo securing guidelines

Suspended tarpaulin system used on a curtain-sided vehicle
1.2.3.4 Additional measures

Friction Matting: The purpose of friction matting is to increase the coefficient of friction between the load and the trailer bed. This method is not considered practical for use on its own; it is more effective when it is used in addition to other safety measures. This method may prevent the goods slipping but may not prevent the load from toppling over. As a result all the issues described in the base case are relevant for this measure. There will be additional hazards due to working at height as well as possible MSD injuries.

Air bags: These can be suspended from the trailer roof, attached to the sides of the trailer, or placed between the load and the vehicle structure. They act to fill the voids either between parts of the load and/or between the load and the vehicle structure.

Nets: Often used on flatbed trailers, these can be used in curtain-sided double-decked trailers, but there are issues concerning the load shifting over the side of the top deck and being caught between the curtain and the trailer. This could potentially be a cause of rollover by making one side of the trailer unstable.

Intermediate bulkheads: These can be fitted when the load cannot be placed against the headboard of a trailer. Some have attachment points for webbing straps for additional restraint.

Internal dividers

These can be used to improve positive locking across the width of the trailer bed and prevent loads from sliding across the bed if there are gaps between items.
1.3 THE ROAD HAULAGE INDUSTRY

1.3.1 UK haulage

The HSE research report RR662 *Load security on curtain-sided lorries* detailed the activities of the UK road haulage industry and it is not proposed to repeat the information presented in that report. However, the Department for Transport publication *Transport Statistics Great Britain: 2008 edition* provides updated statistics on the haulage industry.

In 2007 the quantity of goods moved by road rose from 167 billion tonne kilometres (2006) to 173 billion tonne kilometres. Overall, domestic goods moved rose by 4 billion tonne kilometres from 2006, with the rise in road transport partly offset by a fall in goods moved by water, pipeline and rail. The breakdown of the categories of goods moved is shown in Chart 1 below.

The majority (93%) of goods moved were transported by HGVs. 90% of those HGVs were classed as "over 25 tonnes".

72% of the journeys undertaken by HGVs were classed as "over 100 kilometres", however the overall average length of haul was 86 kilometres.

446,000 goods vehicles over 3.5 tonnes were licensed in the UK in 2007. These are divided in the DfT statistics into 'rigid' and 'articulated' (in reference to the connection between the tractor unit and the trailer rather than to the body type). There were 122,000 articulated vehicles listed; these are not sub-divided but 71% of these were in the 38 tonne GVW category. Of the 324,000 rigid vehicles, 92,000 were listed as 'box vans', and approximately two-thirds of those were in the 3.5 tonne to 7.5 tonne range.
1.3.2 International haulage

According to DfT statistics, UK-registered HGVs are primarily involved in transporting goods to the EU15 countries\(^4\), with the NMS12\(^5\) countries significantly behind.

In bilateral traffic (vehicle registered in either the originating or destination country), most traffic in terms of the quantity of goods moved was seen with the Irish Republic, with UK hauliers accounting for 71% of the market for goods transported to the Irish Republic and 47% of the goods transported from the Irish Republic. However, UK hauliers also had strong market share in goods transported to Sweden (98%), Luxembourg (88%) and Belgium (70%). It should be noted that these figures do not take account of goods transported by vehicles registered in a third country.

Overall, the primary markets for UK-registered vehicles were France, the Netherlands, Germany, Belgium and Spain.

---

\(^4\)'EU15' refers to Austria, Belgium, Denmark, Finland, France, Germany, Greece, Eire, Italy, Luxembourg, Netherlands, Portugal, Spain and Sweden.

\(^5\)'NMS12' refers to Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.
2 INFORMATION GATHERING

2.1 LITERATURE REVIEW INTRODUCTION

For ease of reference, the literature review has been broken down into four sections:

• Legislation, guidance and codes of practice in the UK and internationally
• Accident data
• HGVs ‘on the road’ behaviour
• Previous research on load securing

It should be noted that it became clear in the course of previous HSL load security research (Day et al, 2008; Corbett, 2008) that it was extremely difficult to obtain accurate statistics on the number and severity of incidents involving load shifts, since often an accident was not categorised as a load shift incident. For example, many of the RIDDOR-reportable accidents identified as having a load shift as the initiating event had been classified as ‘falls from height’ or ‘struck by falling object’. With accidents on the road, it was difficult to identify whether the load shift had been the initiating event or whether the load had shifted as a result of the accident. For that reason it is felt that raw statistics do not give a full picture of the actual accident rate.

2.2 LEGISLATION AND CODES OF PRACTICE

This section of the report has been divided into subsections for ease of reference.

• UK legislation and Standards
• UK Guidance and Good practice
• EU legislation, Standards and guidance
• North American legislation and guidance
• Australasian legislation and guidance

The similarities and variations between the various standards and guidance are discussed at the end of this section.
2.2.1 UK legislation and Standards

Legislation in the UK primarily focuses on the condition of a vehicle on the road, and there is specific legislation that encompasses the condition of the load. The UK Construction and Use Regulations\(^6\) state:

*The load carried by a motor vehicle or trailer shall at all times be so secured, if necessary by physical restraint other than its own weight, and be in such a position, that neither danger nor nuisance is likely to be caused to any person or property by reason of the load or any part thereof falling or being blown from the vehicle or by reason of any other movement of the load or any part thereof in relation to the vehicle.*

The Health and Safety at Work Act 1974 places duties on employers to ensure the health and safety of their employees and those who may be affected by their work activities. The Act states:

2 General duties of employers to their employees

(1) It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.
(2) Without prejudice to the generality of an employer’s duty under the preceding subsection, the matters to which that duty extends include in particular—
   (a) the provision and maintenance of plant and systems of work that are, so far as is reasonably practicable, safe and without risks to health;
   (b) arrangements for ensuring, so far as is reasonably practicable, safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances;
   (c) the provision of such information, instruction, training and supervision as is necessary to ensure, so far as is reasonably practicable, the health and safety at work of his employees;
   (d) so far as is reasonably practicable as regards any place of work under the employer’s control, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of means of access to and egress from it that are safe and without such risks;
   (e) the provision and maintenance of a working environment for his employees that is, so far as is reasonably practicable, safe, without risks to health, and adequate as regards facilities and arrangements for their welfare at work.

And

\(^6\) Road vehicles (Construction and Use) Regulations 1986 – SI 1986 No 1078
3 General duties of employers and self-employed to persons other than their employees

(1) It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.

(2) It shall be the duty of every self-employed person to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that he and other persons (not being his employees) who may be affected thereby are not thereby exposed to risks to their health or safety.

And

4 General duties of persons concerned with premises to persons other than their employees

(1) This section has effect for imposing on persons duties in relation to those who—
   (a) are not their employees; but
   (b) use non-domestic premises made available to them as a place of work or as a place where they may use plant or substances provided for their use there, and applies to premises so made available and other non-domestic premises used in connection with them.

(2) It shall be the duty of each person who has, to any extent, control of premises to which this section applies or of the means of access thereto or egress therefrom or of any plant or substance in such premises to take such measures as it is reasonable for a person in his position to take to ensure, so far as is reasonably practicable, that the premises, all means of access thereto or egress therefrom available for use by persons using the premises, and any plant or substance in the premises or, as the case may be, provided for use there, are safe and without risks to health.

The Act sets a standard of reasonably practicable for measures that may be taken to mitigate risks to employees or others affected by work activities. The Act states:

40 Onus of proving limits of what is practicable

In any proceedings for an offence under any of the relevant statutory provisions consisting of a failure to comply with a duty or requirement to do something so far as is practicable or so far as is reasonably practicable, or to use the best practicable means to do something, it shall be for the accused to prove (as the case may be) that it was not practicable or not reasonably practicable to do more than was in fact done to satisfy the duty or requirement, or that there was no better practicable means than was in fact used to satisfy the duty or requirement.

The Management of Health and Safety at Work Regulations 19997 state:

3-(1)

Every employer shall make a suitable and sufficient assessment of -

7 Statutory Instrument 1999 No. 3242; The Management of Health and Safety at Work Regulations 1999; HMSO
(a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and

(b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking

and

5-(1) Every employer shall make and give effect to such arrangements as are appropriate, having regard to the nature of his activities and the size of his undertaking, for the effective planning, organisation, control, monitoring and review of the preventive and protective measures

The Road Traffic Act 1991 states:

A person is also guilty of using a vehicle in a dangerous condition if he uses, or causes or permits another to use⁸, a motor vehicle or trailer on a road when the purpose for which it is used or the weight position or distribution of its loads, or the manner in which it is secured is such that the use of the motor vehicle or trailer involves a danger of injury to any person.

The maximum penalty for this offence if committed in respect of a goods vehicle is a £5000 fine, plus 3 penalty points and disqualification.

There are a number of British Standards relating to load security; these are primarily national implementations of European EN Standards and generally relate to either the trailer construction or the construction of lashings.

The constituent parts of BS EN 12195 set out the standards required for securing loads by chains or webbing straps.

BS EN 12195-1:2003, gives detailed guidance on lashing forces for load restraint assemblies and the calculation of restraint required. The Standard states:

The general requirements for safe transport are:

- the sum of forces in any direction equals zero
- the sum of moments in any plane equals zero

... 

Generally, load securing consists of balancing the forces of a load by locking, blocking and/or lashing. Locking, a completely positive connection, is mainly used in the transport of containers and is not usually combined with lashings. Blocking results in a positive connection in the blocked direction only and therefore is often combined with lashings.

The two basic lashing methods are:

---

⁸ My emphasis
- frictional lashing is characterized by a restraint that is produced by force on the loading area and a positive connection in the direction vertically down;
- direct lashing is a completely positive connection which permits the load to make small movements, the magnitudes of which depend on the flexibility of the lashing and forces acting on the load.

For a load restrained by frictional lashing, the Standard provides a formula for calculating the number of lashings required to secure the load against sliding.

\[
n \geq \frac{(C_{sv} - \mu_D c_z) m g}{k \mu_D \sin \alpha . F_T}
\]

Where \( n \) is the number of lashings, \( m \) is the mass of the load, \( g \) is the acceleration due to gravity, \( \mu_D \) is the dynamic friction factor, \( k \) is a factor given by tables in the Standard and \( \alpha \) is the vertical angle.

The Standard also states:

*Even if the tension forces are adjusted very carefully prior to the transport, there may be changes during transport. As a general rule, the tension forces during transport have to be checked at specified intervals.*

*A further basis, that the calculation of the tension forces can be replaced during frictional lashing by:*

- the presence of tension force indicators or other equipment for verifying or adjusting the tension forces;
- tensioning devices can be used, which are marked with the standard tension force \( S_{TF} \)

*If the basic requirements of the two preceding clauses are being observed, the following coefficients \( k \) are valid for the following values:*

- \( k = 1.5 \) when using one tensioning device for the lashing
- \( k \leq 2.0 \) when using a lashing with two tensioning devices per lashing, or if the value is proved by a tension force indicator on the other side than the tensioning device.

BS EN 12195-2: 2001 gives performance characteristics for textile webbing;

*The textile webbing shall be produced wholly from high tenacity yarns fast to light and heat stabilised with a tenacity of not less than 60 cN per tex from one of the following materials:*

Polyamide (PA), high tenacity continuous multifilament
Polyester (PES), high tenacity continuous multifilament
Polypropylene (PP), high tenacity continuous multifilament

*All seams shall be made from thread of the same material as that of the webbing and shall be made with a locking stitch*
The Standard also specifies how webbing straps should be marked:

Each complete web lashing, if it is intended that parts be separable, shall be marked with the following information if applicable on a label:

- lashing capacity LC
- lengths L_G, L_GF and L_GL in metre
- standard hand force S_HF
- standard tension force S_TF (daN) or winch force, based on the level for which the tensioning device has been type tested, when designed for frictional lashing
- warning: “Not for lifting!”
- material of the textile webbing
- manufacturer’s or supplier’s name or symbol
- manufacturer’s traceability code
- number and part of this European Standard
- year of manufacture
- elongation of textile webbing in % at LC

End fittings, tensioning devices, tension retaining devices and tension indicators of LC ≥ 5 kN shall be marked with the manufacturer’s or supplier’s name or symbol.

The value of LC shall be marked on parts with LC ≥ 5 kN in kN, on parts with LC ≤ 5 kN in daN.

Labels shall have the following colours:

- blue: PES webbing
- green: PA webbing
- brown: PP webbing

The Standard goes on to give direction on the information on use and maintenance of webbing to be provided by the manufacturer:

In selecting and using web lashings, consideration shall be given to the required lashing capacity, taking into account the mode of use and the nature of the load to be secured. The size, shape and weight of the load, together with the intended method of use, transport environment and the nature of the load will affect the correct selection. For stability reasons free-standing units of load have to be secured with a minimum of one pair of web lashings for frictional lashing and two pairs of web lashing for diagonal lashing.

The selected web lashings shall both be strong enough and of the correct length for the mode of use. Basic lashing rules:

- plan the fitting and removal operations of lashing before starting a journey
- keep in mind that during journeys parts of the load may have to be unloaded
- calculate the number of web lashings according to BS EN 12195-1
- only those web lashings designed for frictional lashing with S_TF on the label are to be used for frictional lashing
- check the tension force periodically, especially shortly after starting the journey

Because of different behaviour and elongation under load conditions, different lashing equipment (e.g. lashing chain and web lashings) shall not be used to lash the same load. Consideration shall also be given to ancillary fittings (components) and lashing devices in the load restraint assembly are compatible with the web lashing.

... Release of the web lashing: Care should be taken to ensure that the stability of the load is independent of the lashing equipment and that the release of the web lashing shall not cause the load to fall off the vehicle, thus endangering the personnel. If necessary attach lifting equipment for further transport to the load before releasing the tensioning device in order to prevent accidental falling and/or tilting of the load.

... Web lashings shall not be overloaded. Only the maximum hand force of 500 N (50 daN on the label; 1 daN = 1 kg) shall be applied. Mechanical aids such as levers, bars etc as extensions are not to be used unless they are part of the tensioning device.

The Standard also gives a list of hazards that may occur due to improper use of web lashings or non-use of securing devices.

a) Hazards of being hit by tilting or shifting loads, losing balance or falling during application and tensioning of the lashings due to defective equipment, sudden breakage or malfunction of the tensioning device leading to the sudden absence of the hand reaction force.

b) Injuries by pinching and shearing, hand and arm injuries during manipulation of tensioning devices due to sharp edges.

c) Hazards to the unloading personnel due to loads having moved or being tilted during transport because of inadequate securing, malfunction like recoil or breakage of equipment or defective equipment and then which may fall onto the personnel, especially when opening the side-panels.

d) Hazards due to wrong combinations made up by the operator.

e) Hazards to the unloading personnel by using tensioning devices in web lashings which do not permit their controlled release so allowing an unstable load to move suddenly.

f) Hazards to operators from excessive recoil of levers and cranks of the tensioning devices.

BS EN 12195-3:2001 for chains is similar in scope to Part 2 of BS EN 12195, and states:

...chains and tensioning devices conforming to this European Standard are designed and dimensioned such that the following hazards are taken into account, if they are used in accordance with the manufacturers instructions:

---

9 BS EN 12195-3:2001; Load restraint assemblies on road vehicles – Safety – Part 3: Lashing chains; British Standards Institution
a) Hazards of being hit, losing one’s balance or falling during application of force, due to defective equipment, sudden breakage or malfunction of the tensioning leading to the sudden absence of the hand reaction force.

b) Injuries by pinching and shearing, hand and arm injuries during manipulation of tensioning devices due to sharp edges of the chain and tensioning devices.

c) Hazards to the unloading personnel due loads (sic) having moved during transport, because of inadequate securing, malfunction like recoil or breakage of equipment or defective equipment and then may fall onto the personnel, especially when opening the side-panels.

d) Hazards due to wrong combinations made up by the operator.

BS EN 12640:2001 gives specific guidance on the number of lashing points required for vehicles in order to secure loads. It also states:

Vehicles with lashing points in compliance with this standard, shall be fitted with a marking plate … in a clearly visible place. For the convenience of users the tensile load should be indicated in daN.

BS EN 12642:2006 sets specific standards for the strength of trailer bodies, both rigid-sided and curtain-sided (although it should be noted that UK trailers are not necessarily built to BS EN 12642 standards). The Standard specifies two levels of structural strength: L – a standard trailer – and XL – a reinforced trailer. The sidewalls of a rigid-sided vehicle may be used for load containment and/or load restraint through positive locking, and the Standard sets out the test criteria for proving the strength of the sidewalls through static (airbag) testing and/or calculation and/or dynamic driving tests. The Standard states:

The following outlines the test conditions for standard vehicle body structures. These test conditions are designated by performance code “L”.

Vehicle body structures shall be tested in the condition in which they are designed to be used. Moreover, if they are equipped with removable components, these components shall be in position.

In the following test requirements specified, the following letters shall have the following meanings:
- P the weight force (in daN) of the vehicle to be tested at the authorised payload;
- F the force of pressure (in MPa).

In every test the test load shall be applied for at least 5 min.

Approval criteria
After finishing the tests applicable under Clause 5, the body structure shall show neither permanent deformation nor other changes which would impair its intended use; i.e. the body structure continues to work properly.

Strength of front wall

---

10 BS EN 12640:2001: Securing of cargo on road vehicles – Lashing points on commercial vehicles for goods transportation – Minimum requirements and testing; British Standards Institution

11 BS EN 12642:2006; Securing of cargo on road vehicles. Body structure of commercial vehicles. Minimum requirements; British Standards Institution
The front end wall is tested with a test force of 0.4 P, the maximum however being 5000 daN. The inner face of the front end wall to be tested shall be subjected to a test force uniformly distributed over the entire surface.

Strength of rear and end wall
The rear end wall is tested with a test force of 0.25 P, the maximum however being 3100 daN. The inner face of the rear end wall to be tested shall be subjected to a test force uniformly distributed over the entire surface.

Strength of side walls - Box type bodies
Each side wall is tested with a test load of 0.3 P. The inner surface of each side wall to be tested shall be subjected to the test force uniformly distributed over the entire surface. The rear walls may be closed. In the case of symmetrical construction, one side wall only needs to be tested.

It is suggested that the majority of rigid-sided vehicles constructed in the UK are built to the L standard rather than the reinforced XL standard.

### 2.2.2 UK guidance and Codes of Practice

Within the UK, load security practice is guided by the Department of Transport Code of Practice 12 ('the DfT guidance'). This states:

*The basic principle upon which this CoP is based is that the combined strength of the load restraint system must be sufficient to withstand a force not less than the total weight of the load forward, so as to prevent the load moving under severe braking, and half of the weight of the load backwards and sideways.*

...Friction alone cannot be relied upon to keep the load in place. When the vehicle is moving, vertical movement caused by bumps will reduce any restraining force due to friction. This can reduce to zero if the load even momentarily leaves the bed of the truck.

And:

*The total load restraint system will generally consist of a combination of:*

- a. lashings secured to anchorage points attached to the vehicle chassis, which includes cross bearers, outriggers etc;
- b. bulking arrangements including headboards, bulkheads, spigots, transverse beams, shoring bars etc which are securely attached to the vehicle;
- c. friction between the load and the vehicle platform.

---

12 Department of Transport; Code of Practice – Safety of Loads on Vehicles (3rd Edition)
In most circumstances it would be appropriate to obtain the majority of the total restraint required from (a), and the remaining part from (b). Benefits accrued from (c) should be regarded as a bonus.

The DfT guidance also states:

All equipment used for securing loads should be regularly inspected for wear or damage. Inspection arrangements should be in accordance with the manufacturer’s instructions. Special attention should be paid to webbing and rope to ensure that there is no visible deterioration due to constant use, due to fraying of the strands. They should also be inspected to ensure that they have not been cut or damaged in any other way through misuse.

...Sleeves and corner protectors should be used to prevent damage to both the load and the restraint equipment where it passes over a sharp corner.

When a vehicle changes direction – cornering on roundabouts, overtaking etc – friction is not enough to stop unsecured cargo moving. It is wrong to assume that the weight of the load will keep it in position.

In order to achieve maximum vehicle stability the load should be placed so that the centre of gravity is kept as low as practicable and near to the vehicle’s centre line. This means that, where possible:

a) The load should be spread to give an even weight distribution over the whole floor area;

b) When a load is stacked the larger and heavier items should be placed at the bottom;

c) The heavier items should be placed nearer to the centre line of the vehicle and the lighter ones towards the sides;

d) When a load is stacked the lower packages should be strong enough to support the others when the vehicle is braking, cornering or accelerating.

Driving Standards Agency guidance\textsuperscript{13} states:

Sudden acceleration forward might cause an insecure load to fall off the back of a vehicle. Similarly, if harsh braking is applied the load may attempt to continue moving forward.

...Any sudden steering movement may also unsettle the load and cause it to move. Any movement of the load is likely to make the vehicle unstable.

The DSA guidance deals specifically with load restraint, stating:

When securing a load you need to take into account

• The nature of the load
• The suitability of the vehicle

\textsuperscript{13} The official DSA guide to driving goods vehicles, DSA 2006
The stability of the load
• The type of restraint
• Protection from weather
• Prevention of theft
• Ease of delivery

The object is to ensure a secure load and a stable vehicle when
• Braking
• Steering

Even in emergency situations

…

A load may consist of large heavy pieces of machinery but that doesn’t mean it will stay in place throughout a journey. Fatal accidents have occurred through such items falling from a vehicle or shifting under braking or cornering, therefore they should always be secured solidly and carefully.

INDG379\textsuperscript{14} states that almost all deaths in the haulage and distribution industry are due to four types of accident – being struck by a moving vehicle, falling loads, falls from vehicles and collapsing or overturning vehicles. It also states than more than seven out of ten major injuries are due to slips and trips, being struck by moving or falling objects, falls from less than 2 metres and manual handling.

In terms of responsibility for the load, The DfT guidance states:

The driver is ultimately responsible for the load carried on their vehicle, whether or not they were involved in the securing of the load.

If a load, or part of a load, falls into water and causes pollution, and the waters are controlled, this is an offence under the Water Resources Act 1991. This could attract a maximum fine of £20,000, together with the cost of cleaning up the affected water.

While the DSA guidance states:

The driver is responsible for the contents of their vehicle and needs to ensure that it is loaded correctly for stability and ease of access.

HSE workplace transport guidance\textsuperscript{15} states:

By law, employers have a general duty to ensure that the health and safety of their employees and members of the public is not put at risk as a result of the work that they do.

…

The law requires that health and safety risks at work are controlled as far as is ‘reasonably practicable’.

\textsuperscript{14}INDG379 - Health and safety in road haulage; \url{http://www.hse.gov.uk/pubns/indg379.pdf}; HSE

\textsuperscript{15} Work Transport safety – An overview: Health & Safety Executive (2005)
By law, every employer must make sure that work equipment (including vehicles) is suitable for the purpose for which it is provided or used.

Vehicles should be suitable for any loads carried, and there must be well-placed anchor points that are strong enough to allow the load to be properly secured.

Workplace transport guidance does not cover transport on the public highway, however it does cover large goods vehicles off the public highway, for example during loading and unloading.

HSE guidance on the sheeting and unsheeting of tipper lorries\(^\text{16}\) sets out the legal duties covering adequate risk assessment, safe systems of work, use and maintenance of work equipment and training and supervision that apply to all work activities and workplaces. The risks identified relating to accessing the trailer bed would appear to be equally applicable to working on all trailers, and the approach to be taken in assessing the risks of work activities is detailed.

The insurance company Norwich Union produces a guidance leaflet, *Safe loading, cargo handling and the transit of goods*, which states:

> It is easier to prevent a load from moving in the first place than to stop it once it has started moving, thus a load must be restrained in such a way that no part of it can move in any direction relative to the vehicle.

The leaflet gives practical advice in the form of "do's and don'ts" to assist in the loading and securing process.

---

\(^{16}\) Sheeting and unsheeting of tipper lorries: Guidance for the road haulage industries; HSE (1996)
2.2.3 EU guidance and legislation

The European Best Practice Guidelines on Cargo Securing for Road Transport\(^{17}\) provide detailed guidance on securing many common types of load on common types of vehicles. The basic physics of load shift are explained and guidance is given on the different types of restraint and containment that can be used to effectively secure a load.

The Guidelines give ‘Ten Commandments’ for load security:

- Before the vehicle is loaded, check that its load platform, bodywork and any load securing equipment are in sound and serviceable condition.
- Secure the cargo in such a way that it cannot shove away, roll-over, wander because of vibrations, fall off the vehicle or make the vehicle tip over.
- Determine the securing method(s) best adapted to the characteristics of the cargo (locking, blocking, direct lashing, top-over lashing or combinations of these).
- Check that the vehicle and blocking equipment manufacturers’ recommendations are adhered to.
- Check the cargo securing equipment is commensurate with the constraints it will encounter during the journey. Emergency braking, strong cornering to avoid an obstacle, bad road or weather conditions have to be considered as normal circumstances likely to happen during a journey. The securing equipment must be able to withstand these conditions.
- Each time cargo has been (un)loaded or redistributed, inspect the cargo and check for overload and/or poorly balanced weight distribution before starting. Ensure that the cargo is distributed in such a way that the centre of gravity of the total cargo lies as close as possible to the longitudinal axis and is kept as low as possible: heavier goods under, lighter goods above.
- Check the cargo securing regularly, wherever possible, during the journey. The first check should preferably be done after a few kilometres drive at a safe place to stop. In addition the securing should also be checked after heavy braking or another abnormal situation during driving.
- Wherever possible, use equipment which supports the cargo securing such friction mats, walking boards, straps, edge beams, etc.
- Ensure that the securing arrangements do not damage the goods transported.
- Drive smoothly, i.e. adapt your speed to the circumstances so as to avoid brisk change of direction and heavy breaking. If you follow this advice, the forces exerted by the cargo will remain low and you should not encounter any problems.

In terms of responsibility for load securing, the Guidelines state:

"Loading and unloading should be carried out by appropriately trained staff that are aware of the risks involved. Drivers should also be aware of the additional risk of the load, or parts of the load, moving when the vehicle is being driven. This applies to all vehicles and to all types of load."

\(^{17}\)http://ec.europa.eu/transport/roadsafety/vehicles/best_practice_guidelines_en.htm
From a legal point of view, the liability for the loading/unloading operations should be assumed by the driver, within his responsibilities, and the person(s) who have executed them. In practice quite often the driver has to couple to a pre-loaded trailer or pick up a pre-loaded and sealed container. Another frequent situation is where the loading operation is carried out by the shipper’s employees, even obliging the driver to wait elsewhere until the loading of the vehicle has been completed.

Therefore, all involved parties must be aware of their respective responsibilities. One cannot state that in all circumstances the driver is the sole person responsible for the load carried on his vehicle.

The Guidelines also state:

Planning is the key to achieving efficient, reliable and safe transportation of cargo.

It should be noted that the EU Guidelines are extremely comprehensive and therefore it is not proposed to detail every section of the Guidelines.

The Nordic Road Association report, Equipment for efficient cargo securing and ferry fastening of vehicles, states:

Vehicles must be equipped with effective technical equipment for lashing and securing cargo to ensure safe road transport

...  

In road transportation accelerations occur due to:

Heavy breaking (sic)

Driving in sharp curves

And forward accelerations or immediately after heavy breaking

The magnitude of the accelerations and forces in the above situations are according to most authority regulations the following:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backwards</td>
<td></td>
<td>0.5g</td>
</tr>
<tr>
<td>Sideways</td>
<td>0.5g</td>
<td></td>
</tr>
</tbody>
</table>

The German VDI 2702 guidelines provide detailed guidance on lashing procedures and calculating the minimum number of straps required to secure a load depending on the type of lashing used.

The IMO/ILO/UN ECE Guidelines for packing Cargo Transport Units takes a slightly different approach to calculating the number of lashings required to the method given in EN 12195-1, since it uses the static coefficient of friction (typically higher than the dynamic coefficient of friction), uses the same lateral acceleration for tipping as well as sliding, uses a different factor for the total pretension of overstraps and takes account of internal friction between rows within the load. The effect of the guidelines
is to reduce the number of overstraps required. The cost burden of securing to the EN Standard has been represented to be uneconomical\textsuperscript{18}. It should be noted that example calculations\textsuperscript{19} used to promote the IMO/ILO/UN ECE guidelines as superior to EN 12195-1 assume that overstraps are the only method of restraining the load and it might be expected that if the load is particularly vulnerable to tipping some other method of securing would be used in combination with overstrapping.

The EU Guidelines state that either the IMO/ILO/UN ECE or EN 12195-1 can be used as the basis for calculating the number of lashings required.

\textsuperscript{18}http://www.mariterm.se/download/Difference\%20IMO\%20and\%20CEN.pdf

\textsuperscript{19}Verification of level of basic parameters important for the dimensioning of cargo securing arrangements (VERIFY) www.mariterm.se/download/Cargo\%20Securing\%20Standards.ppt
2.2.4 North American guidance and legislation

The US Cargo Securement Rules, which became effective from January 2004, implemented the North American Cargo Securement Standard Model Regulations, which were developed to reflect a multi-year research program to evaluate US and Canadian cargo securement regulations, industry good practice and recommendations presented during a series of public meetings involving US and Canadian industry experts. The guidance document on the Rules states:

FMCSA requires that cargo securement systems be capable of withstanding the forces associated with following three deceleration/accelerations, applied separately:

(1) 0.8 g deceleration in the forward direction;
(2) 0.5 g acceleration in the rearward direction; and
(3) 0.5 g acceleration in a lateral direction.

These values were chosen based on researchers' analysis of studies concerning commercial motor vehicle performance. The analysis indicated that the highest deceleration likely for an empty or lightly loaded vehicle with an antilock brake system, all brakes properly adjusted, and warmed to provide optimal braking performance, is in the range of 0.8-0.85 g. However, a typical loaded vehicle would not be expected to achieve a deceleration greater than 0.6 g on a dry road.

The typical lateral acceleration while driving in a curve or on a ramp at the posted advisory speed is in the range 0.05-0.17 g. Loaded vehicles with a high center of gravity roll over at a lateral acceleration above 0.35 g. Lightly loaded vehicles, or heavily loaded vehicles with a lower center of gravity, may withstand lateral acceleration forces greater than 0.5 g.

and

Cargo must be firmly immobilized or secured on or within a vehicle by structures of adequate strength, dunnage or dunnage bags, shoring bars, tiedowns or a combination of these.

Articles of cargo that are likely to roll must be restrained by chocks, wedges, a cradle or other equivalent means to prevent rolling. The means of preventing rolling must not be capable of becoming unintentionally unfastened or loose while the vehicle is in transit.

Articles of cargo placed beside each other and secured by transverse tiedowns must be:

(1) Placed in direct contact with each other, or
(2) Prevented from shifting towards each other while in transit.

…

20 US Department of Transportation; Understanding the Federal Motor Carrier Safety Administration’s Cargo Securement Rules; Publication No. MC-P/PSV-04-001
The aggregate working load limit of any securement system used to secure an article or group of articles against movement must be at least one-half times the weight of the article or group of articles.

The Rules make a distinction between prevention against loss of load (load containment) and prevention against shifting of load (load restraint).

The Rules also state:

When an article of cargo is not blocked or positioned to prevent movement in the forward direction, the number of tiedowns needed depends on the length and weight of the articles. There must be-

One tiedown for articles 5ft\(^{21}\) or less in length, and 1,100 lbs\(^{22}\) or less in weight;
Two tiedowns if the article is-
   (1) 5ft or less in length and more than 1,100 lbs in weight; or
   (2) Greater than 5ft but less than 10ft, regardless of weight

If an article is blocked, braced or immobilized to prevent movement in the forward direction by a headerboard, bulkhead, other articles that are adequately secured, or other appropriate means, it must be secured by at least one tiedown for every 10 ft\(^{23}\) of article length, or fraction thereof.

The Rules also echo UK Standards in the importance of checking webbing straps at intervals during transit.

The Rules specify particular conditions for transporting shipments of particular goods, such as paper reels that, individually or together, weigh 2,268 kg (5,000 lbs) or more. The guidelines are dependent on the method of loading and the type of vehicle used.

Similarly, the Canadian National Safety Code for Motor Carriers – Standard 10: Cargo Securement, states:

Cargo transported by a vehicle shall be contained, immobilized or secured so that it cannot

a) leak, spill, blow off, fall from, fall through or otherwise be dislodged from the vehicle, or
b) shift upon or within the vehicle to such an extent that the vehicle’s stability or manoeuvrability is adversely affected.

A carrier shall not permit a driver to operate a vehicle where the cargo transported in or on the vehicle is not contained, immobilized or secured in accordance with this Standard.

\(^{21}\) Approximately 1.5m
\(^{22}\) Approximately 499 kg
\(^{23}\) Approximately 3m
FMCSA requires that cargo securement systems be capable of withstanding the forces associated with following (sic) three deceleration/accelerations, applied separately:

(1) 0.8g deceleration in the forward direction;
(2) 0.5g acceleration in the rearward direction; and
(3) 0.5g acceleration in a lateral direction.

On and after January 1, 2010, a person shall not use a tiedown or a component of a tiedown to secure cargo to a vehicle unless it is marked by the manufacturer with respect to its working load limit.

2.2.5 Discussion

The North American guidelines are generally technically consistent with each other and also with UK and EU guidance.

The physics of load shift, and the fundamental remedies to prevent load shift, are the same on a rigid-sided vehicle as they would be on a curtain-sided vehicle; the guidance agrees that loads should be restrained so that they do not move independently of the vehicle they are transported on under normal driving conditions.

On a rigid-sided vehicle the methods of load securing may vary from those employed on a curtain-sided vehicle, particularly if the load is packed to the sidewalls. The construction of the trailer may allow for the sidewalls to act as part of the restraint system through positive locking.

Guidance on load securing tends to focus on lashing arrangements, whether webbing straps or chain. However, on a rigid-sided vehicle lashing a load may not be an easy option and restricted access may present a hazard to personnel accessing the trailer bed to secure load restraint equipment.

Although some responsibility for the safety of the load on the road lies with the driver of the vehicle, guidance indicates that responsibility cannot be placed on the driver alone, particularly if he/she has not been involved with the loading of the vehicle. Employers have specific duties under the Health & Safety at Work Act to ensure the safety both of their employees and anyone else affected by their work activities.
2.3 ACCIDENT DATA, INSURANCE CLAIMS AND LOAD OFFENCES

2.3.1 Accidents on the road involving HGVs

2.3.1.1 Statistics

2,476 HGV drivers or passengers were killed or injured on the road in 2007, a slight fall on the 2006 figure. 15% of these were fatalities or serious injuries. The relatively low fatality rate for HGV drivers and passengers (1.8% of the total fatalities on UK roads) most likely reflects the protection afforded to them by the vehicle cab.

2.3.1.2 Insurance claims

Insurance data is no longer published with the DfT statistics, however it can be seen from the DfT data obtained previously in RR662 that although HGVs have approximately one quarter of the exposure of private cars, the total estimated cost of their claims is almost a third of that of private cars and their average claim is broadly comparable with the average claim by private car drivers.

The frequency of claims for HGVs increased by 9% in 2005, while in the same year the claim frequency for cars declined by 4% (comprehensive insurance) and 24.7%.

24 “Private Cars” has been used to refer to private vehicles with both comprehensive and non-comprehensive insurance

25 Average claim of ‘private car’ drivers: £2,948
(non-comprehensive insurance). However, the figures for other years suggest there is little correlation between the type of vehicle and the frequency of claims.

### 2.3.1.3 Load offences

The Home Office *Statistical Bulletin (England and Wales)* states that in 2004 12,800 load offences were dealt with by official police action\(^{26}\), however it is not clear from the bulletin what constitutes a load offence.

UK Courts have found drivers liable for loads shifting. In 2003, an HGV driver was stopped by police on the M25 with the nearside wheels of his curtain-sider trailer six inches off the carriageway. Two pallets laden with tinplate coils, completely unsecured to the trailer, had moved in transit and were only contained within the trailer by the curtain. The owner/driver was prosecuted for dangerous driving and was sentenced to £1000 fine, £235 costs, a 12-month disqualification and ordered to take a retest before renewing his licence\(^{27}\).

While drivers can be prosecuted for insecure loads, action can also be taken against employers for insecure loads. A steel company and haulage firm were fined a total of £37,500 after steel beam fell from a vehicle and fatally injured the driver in 2005\(^{28}\). Another haulage firm was fined heavily following the death of one of their drivers in 2006 after unsecured steel shifted under normal braking, smashing through the front bulkhead of the trailer\(^{29}\).

### 2.4 PREVIOUS RESEARCH

The System Concepts Ltd scoping study for HSE\(^{30}\) identifies particular areas of concern for falling loads, notably the paper industry (paper reels), and brewing (kegs).

While the focus of this project is primarily the issue of loads falling during loading/unloading and causing injury to those involved in these operations, the consequences of load movement during transit can also be serious. The TRL research report, *The Security of Cross Loaded Round Timber*\(^{31}\), identified that, between 1991 and 1994, there were 1,202 incidents in the UK where a dislodged vehicle load in the carriageway caused an accident leading to injury.

Research carried out by Sheffield Hallam University for HSE\(^{32}\) on curtain-siders in 2003 concluded that there was little evidence to support changes in what was referred to as “existing best practice” (side strapping), except in the transportation of high centre-of-gravity loads where the risk of rollover could be mitigated by careful driving and maximum speed recommendations. The research focused on the risks of rollover during transit rather than load movement during loading/unloading.

TFK – the Swedish Transport Research Institute, in co-operation with MariTerm AB, prepared a report on the securing of paper reels, *Verification of level of basic

---

26 ‘Official police action’ being defined in this case as court proceedings, written warnings, fixed penalties and vehicle defect rectification notices.
27 Source: Surrey Police – see Appendix B
28 Source: GNN – see Appendix B
29 Source: HSE – see Appendix B
30 System Concepts Ltd for HSE; Sheet and unsheeting of non-tipper lorries – A health and safety scoping study; 2000
31 TRL Limited for HSE; Research report 077: The security of cross-loaded round timber; 2003
32 Sheffield Hallam University for HSE; Transport at Work: Rollover of lorries transporting paper reels; 2003
parameters important for the dimensioning of cargo securing arrangements\textsuperscript{33}, in 2004 to compare existing IMO/ILO/UN ECE Guidelines with the German VDI Standards for load securing and EN 12195-1. (The EU Best Practice Guidelines state that either the IMO/ILO/UN ECE Guidelines or EN 12195 can be used to dimension load securing arrangements.)

The efficacy of round-turn lashing\textsuperscript{34} was also compared with that of over-top lashing and it was concluded that over-top lashings were more effective at preventing reels from tipping than round-turn lashings.

The US Society of Automotive Engineers carried out extensive research on the rollover of heavy commercial vehicles\textsuperscript{35}. The research suggested that:

\begin{quote}
...it is relatively hard for truck drivers to perceive their proximity to rollover while driving.
\end{quote}

The report also states that, by their nature, HGVs are inherently less stable than small goods vehicles and private cars, and that high lateral accelerations can occur at relatively low speeds.

Sampson & Cebon, 2001\textsuperscript{36}, looked at the roll stability of HGVs using numerical models and concluded that it was not possible to control simultaneously and independently all axle load transfers and body roll angles.

Transport Engineering Research New Zealand (TERNZ) carried out research\textsuperscript{37} for the New Zealand Land Transport Safety Authority to investigate the effect of vehicle stability on accident rates. The study found that, compared to Australia, USA and Europe, New Zealand has a high percentage (29\%) of reported rollover incidents. Of the incidents investigated as part of the study, 40\% involved vehicles that did not meet the SRT\textsuperscript{38} (Static Roll Threshold) target value of 0.35g expected in New Zealand.

The inherent instability of HGVs was also investigated the Guidance on Good Practice\textsuperscript{39} produced by the Corrugated Packaging Association, Paper Agents Association and The Paper Federation of Great Britain.

Testing of reels with diameters of 2.5 and 2.8 m was carried out by MIRA and this appeared to show that the reels were stable when sidestrapped, although the speed of the vehicle and details of the test track for the tests were not quoted.

The Guidance considers the use of sidestrapping for paper products and states:

\textsuperscript{33} Nordstrom, R; Andersson, P; Sokjer-Petersen, S; Verification of level of basic parameters important for the dimensioning of cargo securing arrangements; 2004
\textsuperscript{34} ‘Round-turn lashing’ refers to the practice of binding a number of items together to form a single unit. This can be horizontal or vertical, and it is intended to increase stability.
\textsuperscript{35} WINKLER, C.B, BLOWER, D.F, ERVIN, R.D & CHALASANI, R.M; Rollover of heavy commercial vehicles; SAE 2000
\textsuperscript{36} SAMPSON, D.J.M. & CEBON, D; Achievable roll stability of heavy road vehicles; Proc. IMechE, Journal of Automobile Engineering (2001)
\textsuperscript{37} MUELLER, T.H, DE PONT, J.J & BAAS, P.H; Heavy vehicle stability versus crash rates; TERNZ
\textsuperscript{38} The SRT is defined as the maximum steady turning lateral acceleration without rollover
\textsuperscript{39} Safe transport of reels of corrugating case materials by road – Guidance on Good Practice (2001)
It is always better, if possible, to load from the headboard. This will help to minimise any forward movement of the load during transit. When load distribution does not permit this due to drive axle overload or other weight constraints, then forward restraining measures must be employed with the first reel on the off side to help counter natural road camber.

The Guidance also gives examples of Safe Systems of Work for loading reels. It should be noted that the guidance is focussed on transport using curtain-sided vehicles.

MIRA carried out research for HSE in 2004 to investigate the stability of Tarmac products and the report\(^\text{40}\) recommended that, amongst other points:

> *Payloads should be loaded tight to the headboard to prevent load shift during braking.*

> ...

> *Webbing ratchet straps are the preferred method of load restraint, but should only be used on centre gap payloads in conjunction with adequate dunnage…*

> ...

> *The headboard should be considered to be an integral part of the restraint method.*

> ...

> *Anchorage points on the semi-trailer should be distinguished from roping hooks and should have their rating indicated on the vehicle.*

BOMEL Ltd carried out research for DfT to investigate the link between company safety culture and work-related road accidents\(^\text{41}\). The research found that, although smaller companies often lacked the safety management systems of larger companies, the larger companies were not necessarily better at addressing driver safety management.

Time pressure was identified as a significant risk factor for HGV drivers, along with road design, other road users and loading/unloading restrictions. The three most significant factors for risk reduction for HGV drivers were found to be planning, fatigue and management/supervision.

Case studies in the research report identified issues such as poor route planning, carried out in an ad hoc fashion, and confused lines of responsibility for self-employed contract drivers.

PSL carried out research for HSE\(^\text{42}\) to investigate drivers’ perceptions of the hazards surrounding loading and unloading of HGVs and LGVs. The report identified a number of issues, including manual handling, vehicle/pedestrian segregation, load security and training. Lack of communication was also identified as an issue, particularly in terms of identifying possible hazards such as restricted access for unloading in advance and passing that information on to the driver.

\(^{40}\) Research report 272; Load Security Investigation; MIRA Ltd 
\(^{41}\) BOMEL LTD; Road Safety Research Report No. 51 – Safety Culture and work-related road accidents; Department for Transport, 2004 
\(^{42}\) PSL; Safe sites: Driver’s perceptions; HSE Research Report 276 (2004)
Middlesex University Business School carried out research for HSE\textsuperscript{43} to investigate health and safety attitudes and behaviour in small businesses. The report identified that although awareness of specific health and safety legislation and guidance in small businesses was considered to be low, this did not necessarily correlate with poor practice and/or an unwillingness to operate safely. Risk assessment and health and safety management tended to be more informal and less structured, however, than the more systematic approach that might be adopted by a larger company. Cost was considered to be a significant issue for small businesses in complying with health and safety requirements.

IWHO and Loughborough University carried out research for HSE\textsuperscript{44} on industry perception of the cost implications of health and safety failures. The research identified that organisations were concerned about the potential costs of major incidents but appeared to be less concerned about actual costs due to more frequent, minor accidents and/or work-related ill-health. Other concerns were identified which appeared to be more influential in improving health and safety performance; this included increased insurance premiums, effect on corporate image and reputation, customer and client expectations, lowered staff morale, and reduced productivity.

HSL’s previous work on load security on curtain-sided vehicles, HSE report RR662, \textit{Load security on curtain-sided lorries}, found a number of issues with how loads are transported currently. Some of those issues were specific to curtain-sided vehicles, however there were also a number of issues which would appear to be equally applicable to rigid-sided vehicles, such as:

1. Loads should be secured so that they do not move relative to the trailer bed during transport.
2. Load restraint is not the same as load containment. Some loads may require a combination of both.
3. Loads should be placed against the trailer headboard if possible. If this is not possible for reasons of weight distribution, the gap to the headboard should be filled or an intermediate bulkhead could be used.
4. Friction alone should not be relied on as a method of load securing.
5. There are costs involved in securing a load, both in terms of equipment and additional time, however against this must be set the costs of the potential consequences of load shift, such as product damage, vehicle damage, delays, death or injury, and prosecution in the event of an accident.
6. Communication between all parties involved in the loading, transport and unloading may help to avoid or ameliorate problems surrounding load securing.
7. Risk assessment and a loading plan prepared by someone competent to do so is the key to good load security. This does not have to be an onerous process but ‘thinking through’ the operation in advance may identify potential issues before they become a problem.

\textsuperscript{43} Middlesex University Business School; \textit{Cultural influences on health and safety attitudes and behaviour in small businesses}; HSE Research Report 150 (2003)

\textsuperscript{44} HAEFELI, K, HASLAM, C, & HASLAM, R; \textit{Perceptions of the cost implications of health and safety failures}; Institute of Work, Health & Organisations and Loughborough University for HSE (2005)
2.5 SEMINARS, CONFERENCES AND OTHER INFORMATION SOURCES

Information and anecdotal information was collected from a number of sources during the course of the research project from events such as the Commercial Vehicles Show, informal stakeholder discussion, unpublished research reports commissioned by individual companies, load shifts resulting in a fatality investigated by HSE, and the RDAG\textsuperscript{45} Working Group.

It is not proposed to detail the information received from each of these sources; in some cases information was given to HSL in confidence, and in some cases the information cannot be disclosed as court proceedings are pending. However, information obtained from these sources generally reflected information obtained during site visits and quoted sources.

The most common securing methods used in rigid-sided vehicles were:

- Positive locking (loading so that the load is tightly packed to the headboard and side walls)
- Restraint bars that lock into side rails
- Webbing straps that are secured to side rails to prevent loads sliding longitudinally along the trailer bed
- Internal dividing bars (to partition the load along the length of the trailer bed and/or across the width of it)
- Lashings (generally for a small number of large items loaded along the centreline of the trailer, with access to both sides. The lashings were secured to dedicated attachment points in the trailer floor.)

One issue that was brought out through industry consultation was that load shift on the road leading to vehicle loss of control and/or rollover often occurred in particular circumstances; specifically, roundabouts, bends in the road and evasive manoeuvres (for example, if a car pulled out in front of the HGV, causing the HGV driver to swerve).

Often the resultant accident appeared to be blamed on the driver, excessive speed often being quoted, or the road surface. Comment was made that, in the wake of an accident, it was often difficult if not impossible to ascertain whether a load shift had been the causative event or whether the load shift was a consequence of the accident.

Poor communication was identified as a significant issue in many accidents, with drivers reporting that they were often given little information about their load, and assistance was not necessarily available if the load shifted in transit. Drivers also expressed the view that any persistence on their part in trying to ensure that a load was secured properly could endanger their continued employment.

\textsuperscript{45} Road Distribution Action Group
2.6 SITE VISITS

Site visits were carried out to three companies on six sites between June 2007 and September 2008. The normal loading/unloading operation was observed and, where possible, drivers and/or loaders were questioned about their routine.

2.6.1 Company 1

Company 1 is a major European company specialising in supply chain management across a wide range of industry sectors. A number of sites were visited during the course of the research, however one site has been selected as a typical operation for this case study.

The site chosen for this case study was a distribution centre warehousing a wide variety of domestic goods in preparation for retail distribution throughout the UK and Eire. The majority of goods were dispatched in rollcages, with some goods being palletised and transported as such.

A part-loaded rigid-sided vehicle is shown in the photograph below:

![Photograph of a part-loaded rigid-sided vehicle](image)

The rollcages were loaded by warehouse operatives so that they were in contact with the trailer headboard and at regular intervals along the length of the trailers straps were fastened in an ‘X’ shape between the side rails fitted to both sides of the vehicle. Restraint bars were also placed across the load; these were also secured into the side rails. The fitting of the restraints is shown in the photograph on the following page:
On some deliveries, double-deck trailers were used in preference to single-decks. An example of a loaded double-deck rigid side is shown in the photograph to the left.

To facilitate the loading of these vehicles, special loading bays had been constructed with lift platforms so that rollcages could be loaded onto both decks.

Drivers were not involved in the loading and securing process and took the trailer on the road as presented to them. It should be noted that on a fully loaded rigid-sided vehicle it is usually impossible to see more than the first row of the load in front of the rear doors, hence any post-loading examination would be essentially futile.

Many of the deliveries were multi-drop, i.e. to more than one delivery site. For that reason the trailers were often loaded in drop order.

**Company 1 issues**

- Generally loads appeared to be well restrained within the trailers and load restraint equipment appeared to be in good condition.
- Loading in drop order might present issues of weight distribution on the double-deck trailers.
Company 2’s businesses focus on magazine papers, fine and speciality papers, converting materials and wood products.

The Company has production sites in numerous countries worldwide and an extensive sales network. The Company’s main market areas are Europe and North America.

Company 2 transports paper reels for the most part on curtain-sided trailers, however waste products are brought into its conversion facility in rigid-sided vehicles and the company is looking to make full use of the vehicles by using them to transport paper reels.

The reels are loaded onto trailers by clamp trucks. Depending on their size, the reels are typically transported either stacked on end on the trailer bed, or laid horizontally on the trailer bed in cradles or on chocks.

On the company’s curtain-sided vehicles, the reels are loaded from the side of the vehicle and once in place they can then be easily overstrapped. On the rigid-sided vehicles, the company are making use of special moving trailer floors that allow heavy loads to be loaded from the rear doors of an enclosed trailer. There are variations on this idea – for example air-inflated ‘rails’ – but the general principle is to allow the load to be moved without any kind of manual exertion.

When used with paper reels, each reel is ‘presented’ to the moving floor by clamp truck, and it then moves into the trailer. The trailers observed during the site visit had reels loaded in two columns along the length of the trailer bed. For unloading the direction of the floor is reversed so that the load moves out of the interior of the trailer.

To prevent a gap being left between the front of the load and the headboard (due to location of the moving floor machinery), the company had devised their own system of packing which appeared to work very well.

Although the structure of the rigid-sider does offer load containment, there are issues that were noted with this type of loading, specifically the restricted access which renders it impractical to use the company’s standard load restraining procedures. Gaps of approximately 50-75mm were noticed between the reels and the sidewalls; because of the size of the reels and the necessity of being able to fit the clamp arms between the reels and the sidewalls it was not possible to load the reels tight against the sidewalls.

Drivers were not involved in the loading of the trailers and did not see the loads before they went out on the road. Loading (and securing on the curtain-sided vehicles) was done by the company’s employees; the drivers were employed by contracted specialist haulage companies. Loads were transported to a single destination.
Company 2 issues

• Reels on the rigid-sided vehicles were not restrained to the trailer they were transported on, and load security relied on the containment offered by the trailer structure.

• Although the company had addressed the issue of the gap between the load and the headboard, there were gaps between the load and the sidewalls which could result in load movement and possible damage to the sidewalls.
2.6.3 Company 3

Company 3 is a national high street retailer selling a wide variety of goods. The warehouse visited is a regional distribution centre for primarily large, bulky electrical items and white goods.

Goods are brought into the RDC on rigid-sided and curtain-sided vehicles as well as shipping containers. The trailers are unloaded by fork or clamp truck via unloading bays equipped with dock levellers.

Once unloaded, goods are stacked until such time as they are required for distribution to high street stores. Consignments, which are generally multi-drop loads, are aggregated in an area adjacent to the loading bays and then loaded onto curtain-sided or rigid-sided vehicles by fork or clamp truck, or pallet truck.

Drivers are not permitted to enter the warehouse where loading and unloading is carried out and they do not inspect the loads before taking them out.

Goods arriving generally did not appear to be secured, although overstrapping was observed on the load brought in on one curtain-sided vehicle.

In containers and rigid-sided vehicles, goods appeared to be tightly packed to the side walls but the stacks did not always appear to be stable, particularly once unloading began. There was no mechanism, such as a rear bar, to prevent the load from toppling when the doors were opened if the load had shifted during the journey such that it had become unstable.
It was noted that the unloading area was relatively smooth and flat, so that the trailers were level during the unloading process. It is possible that an unstable load would be more likely to topple when the doors were opened if the trailer was parked on an incline in a delivery yard or at the roadside outside a high street shop.

All of the goods being stored in the warehouse were bulky items of some weight, and the potential consequences of such loads shifting either on the road or during loading and unloading would appear to be severe.

**Company 3 issues**

- Loads arriving at the warehouse were often not secured and there were concerns about the stability of stacked products during unloading.

- Lack of securing was potentially more serious on the curtain-sided vehicles in terms of road-related risk but the potential for injury from a falling load in the workplace was arguably greater for the rigid-sided trailers and containers because there would probably not be any external indication (such as a bulge in the curtain) that there was anything amiss.
2.6.4 Common issues

During the course of the site visits and stakeholder consultations that were carried out for RR662, it became clear there were a number of common issues relating to the use of curtain-sided vehicles, regardless of the industry sector or size of company. Not every site had these issues however they appeared to be common enough to warrant comment. Many of those same issues also appeared to be common to rigid-sided vehicles.

- **Lack of communication between interested parties.** Some sites had a number of companies/self-employed drivers working together and communication was often not optimal between them in terms of planning the loading of the vehicles to minimise the risk of the load moving and inconvenience at the unloading point/s. This lack of communication was not inevitable – some companies had specifically addressed this issue and it appeared to be working very well.

- **Driver being isolated from the loading of his trailer.** There can be very good reasons why drivers should not be present at the loading of their trailers but it is important then to recognise that drivers need to be aware of what they are carrying and how it has been secured.

- **Perceived cost of securing loads.** Many of those consulted cited the cost – in terms of equipment\(^46\) and slower loading times – as a deterrent to securing loads in accordance with the DfT Code. Within an industry under tight financial constraints, it was not perceived to be a commercial advantage to insist on rigorous load securing. It should be noted that companies were suffering financial loss in terms of product damage, vehicle damage, lost time and (generally) minor injuries due to loads shifting, leading to disruption and employee time off work/cost of employing temporary cover, but these costs appeared to be accepted as inevitable.

- **Commercial disadvantage.** There was understandable reluctance among some companies to bring in load securing methods that would place them at a commercial disadvantage against competitors who did not secure their loads.

One issue that is peculiar to rigid-sided vehicles is the lack of access to the trailer bed once the vehicle is loaded. This makes it particularly difficult to secure many types of loads using ‘standard’ securing methods such as overstrapping.

The rigid sides of these trailers also make it much more difficult to easily detect an issue with the load. On a curtain-sided vehicle, it may be very obvious that the load has shifted because there is a bulge in the curtain but the first intimation of an issue on a rigid-sided trailer may be the load falling out when the driver/loader opens the rear doors at the destination site.

\(^{46}\) This was often cited as an issue with webbing straps. A box of 8 straps manufactured to BS EN 12195 from a UK manufacturer costs in the region of £50.
3 TECHNICAL ASSESSMENT

3.1 THE MECHANISM OF LOAD SHIFT

Without restraint an object at rest is held at rest on a surface by static friction. The object will not begin to move unless a force is applied to it that is of sufficient magnitude to overcome the static friction. Newton’s 3rd Law\(^{47}\) states that for every force acting on an object, there is an equal and opposite reaction.

For example, the weight of an object, W, which acts vertically downwards, has an equal and opposing reaction force, R, which acts vertically upwards. If an attempt is made to pull the object sideways using a force, F, an opposing force, \(\mu R\), resists the movement of the object.

\[
\begin{array}{c}
\text{R} \\
\mu R \\
W
\end{array}
\]

Only when F is greater than \(\mu R\) will the object move. At the point of movement \(F = \mu R\), hence if the weight of the object is known and the force required to just move the object is measured, we can calculate the coefficient of friction, \(\mu\), between the object and the surface it rests on, can be calculated from the equation:

\[
\mu = \frac{F}{R}
\]

Up to the point of the object moving, \(\mu\) is known as the coefficient of static friction, \(\mu_S\). Once the object is moving, \(\mu\) is known as the coefficient of dynamic friction, \(\mu_D\). \(\mu_D\) is generally less than \(\mu_S\) – it is generally easier to move an object that is already in motion than to get it moving from rest.

This principle is important for load transport, since the trailer and its load should ideally behave as one object and the aim of load securing should be to prevent the load from moving relative to the trailer. The load securing system should be capable of withstanding forces exerted on the load and hence keep the load in place.

\(^{47}\) Sir Isaac Newton developed three laws of motion, presented in the Principia Mathematica Philosophiae Naturalis. These are commonly referred to as Newton’s Laws.
Loads often begin to move in cornering, as evidenced by the reported ‘hot spots’ of corners, roundabouts and motorway slip roads. A vehicle going round a corner is in fact travelling around an imaginary circle with a radius, \( r \).

At any moment in time the vehicle has a linear velocity, \( v \). This is the speed the vehicle travels in a straight line. If the vehicle stopped travelling in a circle at that moment in time, it would continue in a straight line at this velocity, \( v \).

However, assuming that it continues to move around the circumference of the imaginary circle, the vehicle also has an angular velocity, \( \omega \). This is the speed at which the vehicle travels in a circle. The angular velocity is related to the linear velocity and the radius of the circle by the equation:

\[
\omega = \frac{v}{r}
\]

As the vehicle travels around the corner, there is an acceleration towards the centre of the circle known as the centripetal acceleration, \( \Omega \). \( \Omega \) is given by the equation \( r \times \omega^2 \). Once the acceleration is known, the ‘centrifugal force’ \( F \) can be calculated. Since \( F=m \Omega \) and \( \Omega = r \times \omega^2 \), \( F = mr \omega^2 \).

This force, in the case of a load on the trailer bed, is not a force pushing the load outwards; rather, it is the force the trailer must exert on the load (via the load restraint system) to turn the load into the corner with the trailer.

An everyday example of this effect is that of a passenger in a car that is going round a corner: it seems, to the passenger, that they are being ‘pushed’ against the car bodywork by a force acting outwards.

However, what is actually happening is that the car is turning, while the passenger’s body – being separate from the car – is not turning at the same rate. The car is exerting a force on the passenger so that the passenger travels around the corner with the car.
Ideally, therefore, a load should be secured to the trailer it is carried on so that it and the trailer move as one. If the load is not secured, it may continue to move in the original direction of travel as the trailer turns into the corner and thus be ejected from the trailer.

The forces acting as the vehicle traverses the corner are related directly to the vehicle speed and to the radius of the corner. Higher speeds and tighter corners will lead to higher forces, which lower speeds and gentler corners will lead to lower forces. The load restraint system needs to be capable of withstanding these forces and preventing the load from moving relative to the trailer bed.

The friction between the load and the trailer bed should not be relied on as a method of load restraint: the DfT guidance makes it clear that friction is an added bonus and even a high-friction floor surface may become damaged or contaminated in such a way that its efficacy is affected.
3.3 STRENGTH OF THE LOAD RESTRAINT SYSTEM

The DfT guidance indicates that the combined strength of the load restraint system should withstand a force not less than the total weight of the load forward and half of the load to the side and to the rear.

Hence, a load with a mass of 15 tonnes should be transported with a load restraint system capable of withstanding 14.7 tonne force in the forward direction and 7.4 tonne force to the side and rear.

The headboard can act as part of the load restraint system, according to the DfT guide, and should withstand at least half the rated payload of the vehicle, i.e a trailer rated for 20 tonnes should be fitted with a headboard capable of withstanding a force of 10 tonne force.

However, the headboard rating is dependent on the load being as close to the headboard as possible. For weight distribution reasons it is not always possible to place the load so that it is in contact with the headboard. A gap between the load and the headboard has a significant effect on the force exerted on the headboard in the event of a sudden deceleration, particularly if the load is free to move on the trailer bed.

As the trailer slows, the load continues to move forward at essentially its original speed until it impacts the headboard. Both the load and the headboard may be damaged by the impact or, particularly if the load has a small contact area with the headboard, all or part of the load may penetrate the headboard and impact the rear of the driver’s cab.
3.4 ROLLOVER

A number of those consulted during the research voiced the opinion that securing loads so that they did not move adversely affected vehicle stability.

The position of the line of action of the centre of gravity is shown in red in the three diagrams below, representing – from left to right – a stable trailer, an unstable trailer with a strapped load, and an unstable trailer with a load that has slid to one side.

Once the line of action of the centre of gravity moves outside the lines of contact with the road surface (the tyres), the trailer will roll over. It can be seen from the third diagram that an unsecured load sliding to one side of a trailer can significantly contribute to the likelihood of vehicle rollover.
4 TESTING

4.1 COMPUTER SIMULATIONS

The simulations were intended to predict the likely movement of loads and to assess the effectiveness of different restraint methods whilst the lorry carried out various manoeuvres (e.g. braking in a straight line, manoeuvring round a roundabout, setting off up an incline etc.).

Section 2 is a brief description of the software that was used to carry out the simulations.

4.2 AUTODESK INVENTOR/VISUALNASTRAN MOTION

For a number of years HSL staff have used 3 dimensional (3D) computer simulations to carry out dynamic modelling of engineering components and mechanisms.

For this project 3 dimensional (3D) parts and assemblies were created using a computer aided design (CAD) program called AutoDesk Inventor (AI). The parts/assemblies were then transferred into a dynamic modelling program, called Visual Nastran Motion (VNM).

In VNM individual parts are treated as rigid bodies. Constraints (e.g. rigid joints, revolute joints etc.) are used to define/control the relative motion of connected parts. Collisions between parts can also be modelled. Parameters such as coefficient of friction and coefficient of restitution are defined for parts that are set to collide.

The motion of parts (e.g. accelerations, velocities and displacements) can be specified using formulae, input tables or slide controls. Output data such as accelerations, velocities, displacements, torques, forces etc. can be obtained from simulations. The simulations are based on the laws of physics with the relative motion of parts being calculated on a time step basis.

Once a simulation has run successfully and a time-history has been generated individual bitmap images and animation (.avi) files can be exported. Bitmap images have been used to create a number of Figures used in this report.

In Section 3 I describe how the simulations for this project were generated

4.3 VNM SIMULATION PARAMETERS

As with all computer-based simulations, assumptions were made and hence, there were limitations. For this project, the most important issue was to assess how the load would be affected whilst the trailer performed manoeuvres.

At an early stage it was decided that a model of a lorry bed with full suspension etc. would be too complex and that a more feasible option, within the time constraints, was to define the motion of the trailer bed as remaining parallel to the ground.
4.3.1 Trailer geometry

The geometry for the rigid sided trailer parts, used in the simulations, was obtained from the Fruehauf website (www.fruehauf.com). Figure 1 shows the trailer drawing that was used as a basis for the AI parts. The drawing actually shows a curtain sided trailer, hence, for the simulations each side of the trailer was clad with a large flat panel to represent the rigid sides of the trailer. In the bitmap images that were exported from VNM, and used in Figures of this report, the side panels were shown translucent such that the contained load was clearly visible.

![Figure 1 – Rigid sided trailer dimensions](image)

As shown in Figure 1 the overall length of the trailer was 13.6 m, its height was 2.7 m and its width was 2.6 m. The bed of the trailer was modelled as a flat surface (i.e. not as shown in Figure 1). The cross-section and position of each upright and horizontal member of the frame was based on the information given in the drawing. This was also true for the geometry and position of each wheel and axle.

4.3.2 Load geometry, configuration and other physical parameters

Simulations were created that were intended to predict the likely motion of unrestrained palletised goods on the bed of the trailer whilst the trailer was braked in a straight line and when it manoeuvred round a roundabout.

Rigid blocks were used to represent pallets of goods. Each block was defined as 0.8 m x 0.8 m x 1 m in height and with a mass of 1000 kg.

In VNM, for each simulation, the blocks were set to collide with each other, with relevant parts of the trailer (i.e. the bed of the trailer, uprights, rigid side panels, bulkhead etc.) and the
ground/road. For colliding parts, the coefficient of friction was defined as 0.3 and the coefficient of restitution was defined as 0.1.

For the simulations, the block configuration was such that they were stacked two high with two rows of stacks (one row at either side of the longitudinal centreline).

4.3.3 Straight line braking simulations

For the straight line braking simulations, parts to represent a straight section of road and the ground at the side of the road were created in AI. Three simulations were created. For each braking simulation, sixteen blocks were used (i.e. two rows of eight blocks).

One simulation was created with the 2 rows of blocks against the bulkhead of the trailer. Braking was carried out from an initial constant velocity of 30 kmh\(^{-1}\). The second simulation was identical except that the braking was from a constant velocity of 50 kmh\(^{-1}\). The third braking simulation was also from a velocity of 50 kmh\(^{-1}\), but for this simulation the blocks were set back 1 m from the bulkhead, as shown in Figure 2 below.

![Figure 2](image)

Hence, the motion of the trailer was as follows:

<table>
<thead>
<tr>
<th>Initial velocity (kmh(^{-1}))</th>
<th>Stopping distance (m)</th>
<th>Braking time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>9.7</td>
<td>2.3</td>
</tr>
<tr>
<td>50</td>
<td>27.0</td>
<td>3.9</td>
</tr>
</tbody>
</table>
4.3.4 Roundabout simulations

One simulation was created with the centre position of the bulkhead travelling at a resultant constant velocity of 30 kmh\(^{-1}\).

Eight blocks were used for the payload (i.e. two rows of four blocks). Parts were created to represent a roundabout with a radius of 20 m. The path of the trailer was such that two points on the trailer, one at the centre of the bulkhead and one at the centre of the middle axle, followed the same path when viewed in plan. This was achieved by defining the motion of the bulkhead (i.e. time, x position and y position) and by creating a spherical joint on a curved slot for the centre point of the middle axis of the trailer. The trailer path was defined such that the entry and exit radius was 16 m and such that, when rounding the roundabout, the trailer followed a 22 m radius that was concentric to the roundabout.

4.4 SIMULATION RESULTS

4.4.1 Straight braking simulation results

The following is a brief summary of the results obtained from the straight line braking simulations:

- from 30 kmh\(^{-1}\), with the blocks against the bulkhead, there was little relative movement between individual blocks or between the blocks and trailer. To illustrate I created Figure 3 which consists of a bitmap image that was exported at the end of the simulation;

Figure 3
• from 50 km$^{-1}$, with the blocks against the bulkhead, similar results were obtained i.e. little relative movement between blocks and between blocks and the trailer;

• from 50 km$^{-1}$, with the blocks set back 1 m from the bulkhead, under braking the blocks moved/slid together towards the bulkhead and eventually collided with it. They then remained against the bulkhead as the trailer came to rest.

4.4.2 Roundabout simulation results

For the 30 km$^{-1}$ roundabout simulation the unrestrained blocks moved/slid as the trailer followed the path described above. Hence:

• on the 16 m entry radius the blocks slid towards, and then grouped together, against the offside panel of the trailer. To illustrate I created Figure 4;

![Figure 4](image)

• on the 22 m radius, round the roundabout, the blocks slid towards, and then grouped together, against the nearside panel. To illustrate I created Figure 5, shown on the following page;

• on the exit radius the blocks slid towards, and then grouped together, against the offside panel.

If the rigid side panels had not restrained the load, during the simulation, some or all of the blocks would have fallen from the bed of the trailer.
5 PHYSICAL TESTING

5.1.1 Coefficient of friction between a load and a trailer bed

The coefficient of friction between a load and a trailer bed was measured for comparison with values quoted in European Standards. The values were measured on curtain-sided trailers, however since the purpose was to confirm the standard values it was felt that this made no discernable difference.

The measurements were taken both on industrial premises, testing the resistance to movement of a 700kg paper reel on three different trailer beds, and at HSL, testing the resistance to movement of a 370kg palletised load on a trailer bed. The measurements on industrial premises were taken with and without friction matting underneath the reel.

A sideways force was applied to the reel in each condition using a Tirfor hand-operated winch and the force required to initiate movement of the reel measured using a calibrated Dynafor 10-tonne load link.

Table 1 – testing of a paper reel

<table>
<thead>
<tr>
<th>Test</th>
<th>Force required to initiate movement (tonne f)</th>
<th>Force required to initiate movement (N)</th>
<th>Calculated coefficient of friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trailer 1, no friction matting</td>
<td>0.20</td>
<td>1961.33</td>
<td>0.29</td>
</tr>
<tr>
<td>Trailer 1, friction matting</td>
<td>0.41 – 0.60</td>
<td>4020.73 – 5883.99</td>
<td>0.59 – 0.86</td>
</tr>
<tr>
<td>Trailer 2, no friction matting</td>
<td>0.20</td>
<td>1961.33</td>
<td>0.29</td>
</tr>
<tr>
<td>Trailer 2, friction matting</td>
<td>0.42 – 0.55</td>
<td>4118.49 – 5393.66</td>
<td>0.60 – 0.79</td>
</tr>
<tr>
<td>Trailer 3, no friction matting</td>
<td>0.22 – 0.25</td>
<td>2157.46 – 2451.66</td>
<td>0.31 – 0.36</td>
</tr>
</tbody>
</table>

Where a range has been given, the first value is the force required to initiate the initial movement of the reel; the second value is the force required where some discontinuity in the trailer bed had provided additional resistance to movement. For the purposes of further calculation, the first value has been used.

Without friction matting underneath the paper reel, the average coefficient of friction of the three trailers was 0.30. With friction matting, the average coefficient of friction was 0.60.

48 Calibration certificate attached
5.1.2 Testing of the effectiveness of webbing straps and bars

To test the practicality of securing loads within a rigid-sided trailer, it was decided to test the securing of roll cages, which are commonly used in rigid-sided trailers, with a selection of commonly-used restraint methods.

Webbing straps looped around the cages and secured to rails fastened to the side walls are often used to restrain roll cages. Restraint bars, which fit into the same rails, are also often used.

The testing was carried out in a 40ft rigid sided articulated trailer, bought specifically for this project. Roll cages, restraint bars and rails (fitted to the inside of the trailer) were bought specifically for the project. Webbing straps used in the tests were taken from HSL equipment stores.

M. Ratcliffe, of the HSL Engineering Support Team, and P. Stanworth, HSL Engineering Safety Unit, carried out the testing. HSL’s Visual Presentation Services made a video record of testing.

5.1.2.1 Work Undertaken

Three roll cages were loaded onto the trailer, and restrained in a row at the front end, against the bulkhead. Five different methods of restraint were used in turn. These are explained in more detail in Appendix D, but briefly they consisted of two types of loop strapping, two types of cross strapping and a restraint bar.

To test the effectiveness of each restraint method a force was applied to the cages, directed towards the rear of the vehicle, to simulate the conditions the vehicle load might experience in transit. This was done by threading two web slings horizontally across the three cages, one at the top, and one at the bottom. These slings were then taken towards the rear of the trailer, where they were attached to further slings and in turn to a Tirfor, secured to concrete blocks behind the vehicle. The Tirfor was used to apply the necessary force, which was measured by a load cell in the line.

The maximum capacity of each of the roll cages was 500kg. BS 12195-2 gives the force that a load will experience to the front as 1 x the weight of the load and to the side as being 0.5 x the weight of the load. Since the front bulkhead would normally be expected to withstand some of the forward acceleration, an acceleration of 0.5g was chosen for the test. To replicate this, for the combined weight of the three roll cages, the tension in the Tirfor was increased until the load cell in the line was reading approximately 0.75 tonnes.

This force was applied to the three roll cages, in each of the five restraint configurations in turn. Linked video cameras were used to record movement of the roll cages and the reading on the load cell. A small pointer was attached to the central roll cage, which moved over a scale on the trailer floor, to give an indication of movement.

As a final test, the restraint bar was refitted, and the tension in the Tirfor increased until the breaking point of the restraint bar was reached.
5.1.2.2  Findings & Assessment

The tests found that all five methods used provided a reasonable degree of restraint to movement of the roll cages.

It was noted that the three roll cages did not act as one when under load. There was a tendency for the two outer cages to rotate inwards, slightly towards the centre of the trailer i.e. the outer edges of the outer roll cages were displaced the most under load. The effect of this was that in some tests, the centre roll cage would move towards the back of the trailer as the load was applied (as expected), but then as the load was increased, it was pushed back towards the front of the trailer by the rotation of the cages on either side of it.

It had been intended to measure movement of the roll cages by use of the pointer and scale on the centre of the inner roll cage. Testing showed that this was not the point of greatest movement. However, by use of the video, and reference to the scale, and other markers, such as the track on the side of the trailer, it was possible to get a reasonable indication of the movement of the outer parts of the roll cages.

The rotation of the outer cages was caused by the loading method, which included looping a sling through the cages, and then turning it towards the rear and centre of the trailer. However, the differential movement was not considered to be a significant concern, as it would be expected that in a real life scenario the cages would be loaded differently, and therefore subject to different loads under acceleration, leading to potential differences in displacement.

The table below records the displacement of the roll cages for each restraint method when under load.

<table>
<thead>
<tr>
<th>Restraint Method</th>
<th>Centre cage / (mm)</th>
<th>Outer Cage / (mm)</th>
<th>Centre cage / (mm)</th>
<th>Outer Cage / (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop strap with return</td>
<td>10</td>
<td>55</td>
<td>Minimal</td>
<td>80</td>
</tr>
<tr>
<td>Loop strap without return</td>
<td>Minimal at 0.5t 10 at 0.45t</td>
<td>80</td>
<td>Minimal</td>
<td>100</td>
</tr>
<tr>
<td>Restraint bar</td>
<td>Minimal</td>
<td>20</td>
<td>Minimal</td>
<td>25</td>
</tr>
<tr>
<td>Cross strap with return</td>
<td>Minimal</td>
<td>5</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Cross strap without return</td>
<td>Minimal</td>
<td>20</td>
<td>2</td>
<td>40</td>
</tr>
</tbody>
</table>

The above data suggests that cross strapping provides greater stability than loop strapping, and that extending the anchor points of the ratchet straps forward of the rear line of the roll cages (i.e. providing a return on the strap) increases load stability in both cases. The use of a restraint bar gave similar performance to the use of cross strapping with a return.
In addition to the above data it was noted that:

- When the return on the ratchet strap (i.e. the extent to which the anchor points of the straps extend forward of the rear line of the roll cages) is minimised, then the tension on the strap pulls in a direction almost perpendicular to the rail on which it is anchored. As the load was applied to the cages, increasing the tension in the ratchet straps, the hook on the ratchet strap was found to damage the track on which it is anchored. Subsequently it was found to be very difficult to remove the hooks from the tracks where this had occurred.
- Where the anchor points of the ratchet straps were made to extend forward of the rear line of the roll cages (i.e. a significant return is included), then the tension in the strap pulls closer to the line of the rail on which it is anchored. In this case, no damage was caused to the rail, and the hook was easily removed at the end of the test.
- The ratchet mechanism must be positioned across the line of the three roll cages. This is because there is insufficient room to operate it when positioned between the end cage and the side of the trailer. As the section of strap that is permanently attached to the ratchet is typically only 500mm long, then the length of a return that can be introduced when the straps are in place is limited to 500mm. However, this length was found to be sufficient to improve performance and operate effectively.
- As the cross strapping method involves fitting two straps, as opposed to the one used in the loop strapping method, it takes longer to install.
- The restraint bars are quicker and easier to install than the strapping methods.
- It was expected that there be a loose fit between the restraint bar and the roll cages – because the bar fits in to predetermined slots, and cannot be tightened against the cages, like a ratchet strap. However, in practice this was not found to be the case, and the cages were securely held in place by the restraint bars.

In the case of the sixth test, where a restraint bar was used to secure the roll cages in position, before being loaded to failure, a maximum load of 0.94t was achieved. At this load the bar began to deform, and as it did so tension was relived in the Tirfor line. We continued pull the line using the Tirfor, but this just had the effect of further deforming the bar, and the tension in the line dropped further. Finally at a load of 0.75t the restraint bar failed. Examination of the bar showed it had kinked and bent, about 140mm from one end. The bend gave a deflection of approximately 70mm.

5.1.2.3 Conclusions

1. All five of the restraint methods selected held the roll cages in place, allowing for varying amounts of deflection, up to the test load of 0.75t.
2. When strapping restraint methods are used it is important to ensure that the strap not only runs along the rear of the roll cages, but turns at the end of the row, and is secured to the trailer at a point forward of the rear edge of the cages. This makes the restraint more effective, and reduces the likelihood of damage to the tracking to which the straps are anchored.
3. The cross strapping method proved more effective than the loop strapping method, at securing the load.
4. For the loads involved in the test, the restraint bars were equally effective as any other method at restraining the load.
6 RISK ASSESSMENT

6.1 INTRODUCTION

A risk assessment is a formal method of looking at the likelihood and consequences from hazards. Risk assessment allows all possible scenarios to be considered, and then to look at how often they might occur, and what the cost of each scenario might be, both in terms of financial cost and also human health. The risk assessment can aid the decision making process by assessing the impact of risk control measures.

Load shift on goods vehicles is a common problem that can lead to serious incidents due to rollover or falling loads with serious consequences, in the worst case resulting in multiple fatalities. The likelihood and consequences of these scenarios could potentially be reduced with the introduction of load security measures such as strapping or air bags. This risk assessment has been carried out with a view to assessing what load restraint methods are reasonably practicable for implementing across the haulage industry as a whole, since the benefit in terms of the net reduction in risk needs to be assessed against the effort (time, trouble and cost) required to implement the measures. The purpose of this risk assessment is to estimate how much each load security measure reduces the overall risk, taking into account any new hazards that may be introduced by the implementation of the load security method, for example musculoskeletal injuries from the additional physical activity etc. The risk assessment will give an indication of the level of risk for each load security method relative to the base case. This should then enable the load security measures to be ranked, and will allow judgements to be made on their reasonable practicability.

Loads transported on rigid sided trailers may shift in transit, particularly when the load is unrestrained. The consequences of such load shift could vary from a few toppled boxes with no resulting injury through to a multiple vehicle pile up on a motorway with multiple fatalities. There are various methods of restraining loads, some of which are specific to the type of load being carried. There are also various different scenarios that may result from shifted load. Both of these factors will be looked at in this report.

6.2 APPROACH

Risk assessments can be qualitative or quantitative. A quantitative approach requires data on the type of scenario, the probability, the frequency, severity etc. Such data specifically relating to rigid sided trailers is not readily available in the public domain. Most of the available data focuses on major accidents that have been reportable under RIDDOR. If this data were used, then the results would be skewed to the higher order events, as minor, possibly more frequent events would not be accounted for in the data.

A qualitative approach uses simple terms such as ‘more likely’ or ‘very hazardous’ in order to compare the risks. In this case, a qualitative approach was taken in order to assess the hazards and associated risks for the loads on rigid sided trailers.

The qualitative risk assessment allows one method of restraint to be compared to another using a simple rating system. The ratings used in this report are detailed in Table 1. The lower the rating assigned to a scenario, the less likely, or the lower the consequences of the event.
Some events can have a high consequence, for example multiple fatalities (rating 6), but only have a small chance of actually occurring (rating 1). Other events can have a very low consequence, for example no or very minor injury (rating 1), but occur very frequently, many times per hour (rating 6). Average ratings will be used rather than the worst case. For example, the worst case consequence from an event may be multiple fatalities, but in reality this would be very rare. More than 3 day injuries may be the most likely result. In this case the consequence would be given as 3 rather than 6.

The frequency and consequence descriptions have been previously used for a similar assessment of curtain sided trailers. The same ratings are used here in order to compare the two types of trailers.

A base case will be considered, that is, a rigid sided trailer with no restraint on the load in a variety of different scenarios. Each scenario will be examined in turn with the risk estimated using the frequency and consequence scales. Reasons for the estimate will also be recorded. The assessment will then be repeated for each of the load security measures that can be applied, by comparison to the base case, looking at how each different scenario will be affected.

### Table 1 Qualitative ratings used for risk assessment

<table>
<thead>
<tr>
<th>Rating</th>
<th>Cumulative Frequency</th>
<th>Consequence</th>
<th>Safety</th>
<th>Health</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Descriptor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1 in 10 years or less</td>
<td>Negligible</td>
<td>Slight</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>minor injury with no absence</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1 per year</td>
<td>Low</td>
<td>Low</td>
<td>Short term reversible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Requires first aid, less than 3 day minor injury</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1 per month</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Long term reversible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>More than 3 days injury</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 per day</td>
<td>High</td>
<td>High</td>
<td>Long term irreversible</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Major injury</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 per hour</td>
<td>Very high</td>
<td>Very high</td>
<td>Permanent severe disability/fatality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single fatality</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Many per hour or greater</td>
<td>Severe</td>
<td>Severe</td>
<td>Multiple fatality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multiple fatality</td>
<td></td>
</tr>
</tbody>
</table>
6.3 POSSIBLE SCENARIOS

The following scenarios were considered as the most likely types of accidents that can occur as a result of unsecured loads:

1. **Rollover**

   Heavy braking, accelerating and sharp bends can all lead to an unsecured load shifting sufficiently to cause the trailer to rollover. This in turn pulls the tractor unit over. Rollovers are relatively common accidents, which may be attributed to road conditions, excessive speed, weather conditions, driving error or load shift.

2. **Load ejection during transit**

   Load movement in the trailer can occur with sufficient force to pierce the front bulkhead. This would be more common on heavy braking. Load may also puncture the sidewalls, but this would probably be more likely with curtain sided trailers.

3. **Falling objects when doors are opened**

   Loads that have shifted during transit can fall from the trailer once the rear doors are opened. This type of accident is very common. It may be anticipated that part of the load will fall, in which case the operator would be prepared to move out of the way. However, injuries have also been sustained when moving out of the way of falling objects, for example, tripping whilst taking avoiding action.

4. **Falls from heights**

   Personnel may need to be on the trailer bed when loading/unloading, or when re-securing shifted loads. There is the potential for people to fall as much as 2 metres to the ground from the trailer bed. Only the time spent adjusting shifted loads is considered in this assessment. It is assumed that loading and unloading takes place in a suitable environment, and this would be covered by other risk assessments.

5. **Musculoskeletal injuries (MSDs)**

   MSD injuries are associated with manual handling, particularly in this case lifting and bending. Possible causes are moving shifted/fallen loads, applying load security measures and opening and closing the doors. It is likely that lifting aids, such as pedestrian forklifts are not available during transit. MSDs are the most common cause of workplace injury.
6.4 BASE CASE ASSESSMENT

For the purposes of this risk assessment, a base case was first assessed, that is, a rigid sided trailer with no load restraint methods applied to the load. The use of this base case is not designed to reflect any real lorry on the road, but instead a lorry where the load has been placed on the floor of the trailer with no restraints. A number of other assumptions were made about the base case lorry:

1. No load security measures are applied.
2. Loading is carried out in accordance with DfT guidance, e.g. heavy items are loaded at the bottom on the centre line of the trailer with lighter items stacked on top of them. No gaps are present between the load and the front bulkhead and between parts of the loads.
3. The operators are in good health with no existing musculoskeletal problems.
4. The trailer and tractor unit are in good working order, with no defects that might adversely affect their ability to contain the load.
5. Only the load is being considered as a factor in the incident. Other factors such as weather, road conditions, driving style etc are not being considered.

These assumptions were made to ensure that only the effect of the load security measures is assessed. If less ‘perfect’ loading, or unfit operators were also taken into account, then further assumptions and assessments would need to be made/carried out. The loading should be carried out with existing guidance applicable to the specific type of load.
The load security measures that can be applied to rigid sided trailers may vary from those that can be applied to curtain sided trailers. Generally, load security on rigid sided trailers relies on the strength of the sidewalls. The load security method applied will depend on the type of load being transported.

6.5.1 Load security measures specific to roll cages and similar loads:

6.5.1.1 Bars

The bars are rigid metal and are sprung loaded. They are fitted by tensioning the bar (reducing the overall length) and placing it into rails down either side of trailer where the tension is released, holding the bar in place. The bars and side rails are usually specified by the customers, and may not be standard on build. There are no standards for the position of the bars or the side rails. The number and frequency of bars placed in the trailer will be dependant on the procedures of the individual company.

Potential problems with bars:
- Can be difficult to fit.
- Always fitted behind the roll cages, may not be flash against them.
- May allow some forward/backward motion.
- Allows up/down motion.
- Side to side motion limited by the number of roll cages.
- Easily damaged or misplaced.
- Rely on strength of sidewalls.

6.5.1.2 Cross strapping

The straps used for cross strapping are fabric straps with metal hooks at either end. They can be either one fixed length or adjustable by some means. They fit into the rails down either side of trailer. The straps and rails may be specified by the customer and may not be fitted as standard. The instructions for use will depend on the operator's procedures.

Potential problems with straps:
- Can be difficult to fit and tension.
- Can be 'loop lashed', either 'shallow return' with the loop placed slightly behind the roll cage on either side, or 'long return' with the loops placed half way down the width of the roll cage. The latter method can make it difficult to attach the second end due to reaching around the cage. The former can damage the side rails.
- Effectiveness depends on the tension in the straps, and the condition of the straps.
- May depend on how many cross straps are done, e.g. 1x3 or 3x3 blocks of roll cages.
- May not be suitable for all loads.
- Rely on strength of side walls.
6.5.2 Load security measures suitable for all loads:

6.5.2.1 Air bags

Air bags may be permanently positioned inside the trailer in a deflated fashion and inflated automatically from the outside of the trailer, or they may be fitted manually. On inflation, the air bags that fill available free space in the trailer. They are currently not common in UK.

- Easily damaged in loading/unloading.
- Effectiveness depends on load and vehicle.
- Not effective at stopping loads already in motion.

6.5.2.2 Other packing materials

Wooden blocks, polystyrene blocks etc.

- Simple and low cost.
- Stops load moving rather than stops moving load.
- Can be modified to suit load.
- Not necessarily suitable for roll cages.

These will not be discussed further here because of the wide variation of materials and applications to which they could be applied. If they are applied appropriately, then they are likely to stop or significantly reduce motion. This will reduce the likelihood of all scenarios, with the exception of MSDs, which may increase depending on the nature of the material (heavy, bulky etc).

6.5.3 Load security measures for pallets, paper rolls etc:

6.5.3.1 Fastenings to trailer bed.

Less common in rigid sided trailers due to strapping to floor rather than chassis.

- Easier to transport on curtain sided trailers where loading/unloading is easier due to increased access.
- May use chocks, blocks etc on trailer floor.
- Specially built frames for steel coils etc.
- Side and over strapping generally not available on rigid box trailers.
6.6 ASSESSMENT OF LOAD SECURITY METHODS

In order to assess the effectiveness of each load security method in turn, it is assumed that one method is applied to the base case. The other assumptions made are as follows:

1. The load security measures are applied appropriately, and in line with company policies.
2. The load security measures are in good condition.
3. The load security measures contain/restrain the weight of the goods they are designed to hold.
4. The load securing complies with the DfT Code of Practice.
5. The workers involved in the loading are in good health.

Each scenario identified in the base case will be looked at with each load security measure applied. No other scenarios were identified which might arise because of the application of a load security measure.

Fastenings to the trailer bed are not assessed because the assessment will be different depending on the load and the design of the trailer.
6.7  RISK MATRICES

A risk matrix is a visual representation of the likelihood and consequence of events. In this example, a 6 by 6 grid represents the ratings given to the likelihood and consequence of an event.

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consequence</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

The colours are another visual aid to demonstrate how the perceived risk may improve on application of the load restraint measures. The colours do not represent what is acceptable or recommended, but an arbitrary level of risk. For example, an event with a likelihood of 3 and a consequence of 2 is marked ‘X’.

The risk matrices were developed from the workshop findings, which can be found in Appendix A.

6.7.1  Base case

Where R = rollover, LE = load ejection, FL = falling loads, FH = falls from height and MSD = Musculoskeletal disorders

6.7.2  Bars

66
### 6.7.3 Cross strapping

<table>
<thead>
<tr>
<th>Consequence</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Likelihood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6.7.4 Air bags

<table>
<thead>
<tr>
<th>Consequence</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Likelihood</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

During the course of the research it became clear that the issue of securing loads on rigid-sided vehicles is far from straightforward, and in many ways more complicated than that of securing loads on curtain-sided vehicles. Rigid-sided vehicles, while having the advantage of a rigid structure to provide side containment, present problems in easily accessing the trailer bed and in being able to assess the loads. Additionally, the carrier must be assured that the sidewalls of the trailer are robust enough to provide lateral support to the load.

The fundamental physics relating to load shift remain the same for rigid-siders as they are for curtain-siders: a load that is not secured can and will shift if the forces acting on it overcome the friction between the load and the trailer bed. Any loss of contact between the load, however momentary, between the load and the trailer bed removes the effect of friction and therefore friction alone cannot be relied on as a method of load securing.

Vehicles on the road do not travel in a state of equilibrium – they accelerate, brake, turn corners and make emergency manoeuvres, all of which tend to cause the load to shift. Anecdotal evidence suggests that corners, motorway slip roads and roundabouts are the most common sites for rollover and this was borne out by the computer modelling.

Previous research has generally focused on the risk of rollover on the roads, but load shifts also increase the risks when the vehicle reaches its destination. Unstable loads may fall from the trailer when the rear doors are opened, striking the driver or loader, or causing them to take avoiding action which leads to an accident. Loads that have shifted may be impossible to unload by fork lift truck or clamp truck and require manual unloading, with the attendant risks of manual handling and falls from height.

Even without the risks of death and injury, load shifts can have significant financial consequences: vehicular, product and reputation damage due to rollover or other road accidents, or product damage if the load falls from the vehicle during unloading. Delays during unloading due to load shift can have both financial and contractual consequences if the haulier is committed to deliveries to a strict timetable.

The requirement to secure loads for road transport in the UK is not a new one; the Department of Transport Code of Practice was originally published in 1972 and is now on its third edition. The more recent European Guidelines for Cargo Securing give detailed examples of how to secure loads.

The site visits and industry consultations identified that there were issues common to many sectors of the haulage industry, such as time pressure, increasing general costs leading to financial pressure on firms and varied and often complicated arrangements between warehousing and haulage operators. This last issue was considered to be significant, as the involvement of a number of parties on a particular site often appeared to lead to confusion over who was responsible for load security and a disinclination for one party to bear the costs. Time pressure was often cited as a reason for not securing loads, as was pressure from customers. There appeared to be great reliance on the strength of the trailer structure to ensure that the load was not ejected from the vehicle on the road, without consideration of how an unsecured load might affect the stability of the vehicle and/or how an unsecured load could fall out of
the trailer once the rear doors were opened. With a rigid-sided trailer it is unlikely that there would be any outward sign that a load had shifted and become unstable.

Training appeared to be variable for staff involved in the loading of vehicles. Some companies had very thorough training for both drivers and loaders, with clear, illustrated guidance, training videos and dedicated training staff. At the other end of the scale, some companies appeared to rely on drivers’ general experience and/or loaders ‘picking up’ the correct methods of load securing from their colleagues.

Introducing safety measures aims to help protect the general public as well as the employees involved in unloading the cargo. For example, the incidence of rollover could be reduced by simple measures such as:

- Making sure the vehicle is not loaded beyond its capacity;
- Evenly distributing the load across the vehicle;
- Using specifically designed vehicles for carrying loads.
- Securing the load so that its movement does not make the vehicle unstable.

Interventions may introduce additional risks such as working at heights and/or manual handling. Falls from height is a cause of many workplace accidents; these can occur due to factors such as inappropriate footwear, bad weather, lack of proper access equipment or insufficient training. The incidence of falls could be reduced by measures such as:

- Platforms and/or gantries to be used when personnel need to access the trailer bed of the vehicle;
- Slip resistant walkways
- Fall-arrest harness systems.
- Passive fall-arrest systems, such as airbags
- Avoiding the need for personnel to access the trailer

Testing of the common securing methods for rollcages in rigid-sided vehicles indicated that the best method was cross-strapping with return, so that the strap was essentially looped around the cage. Minimal movement of the cages was seen under load with this type of arrangement. However, this method will not be suitable and/or practicable for all load types. Positive locking can work very well if the load is tightly packed to the headboard and side walls but ideally some kind of rear restraint should be fitted to prevent the load sliding to the rear. Particular consideration should be given to multi-drop loads, as positive locking only works if the trailer is packed tightly to the front and sides.

Some loads will not be suitable for either cross strapping or positive locking, e.g. palletised loads not packed to the sides or single items of machinery. These loads should be secured just as they would be on any other type of trailer to prevent them moving relative to the vehicle. Unstable loads should be supported, ideally in a transport frame or cradle so that they remain stable at all times, even if the load restraints are removed.
Restraining the load in this way, as with cross-strapping, does require access to the trailer bed and the use of restraint equipment which introduce their own risks that need to be controlled.

At the heart of good load security is the principle of risk assessment. Risk assessment should identify the particular risks of transporting a particular load, the type of vehicle best suited to transport it, any particular issues for the loading and unloading of the load, and hence the most practicable method of securing the load.

UK and international guidance underlines the importance of planning the loading and unloading of a vehicle to take account of issues such as the nature of the site being delivered to, the nature of the load, and the need for load securing. This type of planning does not have to be onerous; indeed, it can often be advantageous in that it allows the operator to identify possible problems in advance.

Securing loads carries a cost in terms of equipment, time and any additional risks such as working at heights. However, shifting loads also carry costs in terms of death or injury, product damage, vehicle damage, time lost due to 'clean-up', risks introduced if reactive measures have to be taken, possible fines and/or prosecution if an accident occurs, and damage to a company’s reputation caused by repeated and/or serious accidents.
8 CONCLUSIONS

1. Loads should be secured so that they do not move relative to the trailer bed during transport.

2. Loads should be placed against the trailer headboard if possible. If this is not possible for reasons of weight distribution, the gap to the headboard should be filled or an intermediate bulkhead could be used.

3. Friction alone should not be relied on as a method of load securing.

4. Cross-strapping the load was identified as the least-risk method for rollcages, however it would not be suitable for all types of load and positive locking may be the preferred option for loads that can be tightly packed such as uniform palletised goods.

5. There are costs involved in securing a load, both in terms of equipment and additional time, however against this must be set the costs of the potential consequences of load shift, such as product damage, vehicle damage, delays, death or injury, and prosecution in the event of an accident.

6. Communication between all parties involved in the loading, transport and unloading may help to avoid or ameliorate problems surrounding load securing.

7. Risk assessment and a loading plan prepared by someone competent to do so is the key to good load security. This does not have to be an onerous process but ‘thinking through’ the operation in advance may identify potential issues before they become a problem.
## APPENDICES

### 9.1 APPENDIX A: DETAILED HSE WORKSHOP FINDINGS

#### 9.1.1 Base case assessment

<table>
<thead>
<tr>
<th>Load Security Measure</th>
<th>Scenario</th>
<th>Likelihood</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>Rollover</td>
<td>Changes in direction or speed, for example on roundabouts, slip roads etc, can cause the load to shift. Friction between the load and the bed of the trailer is not sufficient to stop an unsecured load moving.</td>
<td>Consequences will depend on the circumstances of the accident - the type of road, how many people are in the vicinity, type of load etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rollover due to shift of load is may not as common as rollover due to adverse weather. However, several incidents have been reported on slip roads of lorries overturning due to load shift.</td>
<td>It is likely that disruption to the road network will be more severe than injury/fatalities could be. Minor injury to the driver can be expected.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid sided trailers tend to be higher than curtain sided trailers and can have multiple floors. These factors make the chances of rollover higher for rigid sided trailers.</td>
<td>Injuries may involve pedestrians and other road users, but most rollovers will not affect any one else.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depends on the load and circumstances of the incident. Large, heavy items may crush nearby vehicles or pedestrians, whilst lighter items may scatter causing delayed effects such as vehicles swerving. Ejected articles may scatter over a wide area causing disruption to more road users.</td>
<td></td>
</tr>
<tr>
<td>Rating: 3</td>
<td></td>
<td>Rating: 3</td>
<td></td>
</tr>
</tbody>
</table>

| Base case             | Ejection | Ejection can occur through the front bulkhead or the rear doors. Mostly likely due to heavy braking. Unlikely to eject through the sides (depending on the load). | Depends on the load and circumstances of the incident. Large, heavy items may crush nearby vehicles or pedestrians, whilst lighter items may scatter causing delayed effects such as vehicles swerving. Ejected articles may scatter over a wide area causing disruption to more road users. |
|                       |          | Likelihood of ejection in a rigid sided trailers is likely to be slightly higher than that of rollover, but not enough to move it into the next | |

Rating: 3
<table>
<thead>
<tr>
<th>Load Security Measure</th>
<th>Scenario</th>
<th>Likelihood</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>category.</td>
<td>Will cause damage to load. The consequences could be more severe than that of a rollover. Lorry drivers are less likely to be injured if the load is ejected from the rear, but may be more seriously injured if ejected from the front. Other road users may swerve to avoid falling objects, but this may cause further incidents. Worst case would be a multi vehicle pile up, potentially causing fatalities and serious injuries. This is unlikely in the majority of incidents.</td>
</tr>
<tr>
<td>Base case</td>
<td>Falling loads when doors are opened</td>
<td>Shifting load will not be obvious until the doors are open, by which time it will be too late. Roll cages, coils and large paper rolls etc may travel some distance away from the lorry, and potentially with some speed. Ejection through front bulkhead more likely when load has been incorrectly loaded, e.g. leaving a gap between the load and the front bulkhead. Likely to be under reported for lesser events and near misses.</td>
<td>In many cases the load misses the driver because they are aware of the risks and are prepared for any events which may occur. However, moving quickly out of the way may cause further injuries, such as slips, trips and falls. Roll cages may travel some distance from the lorry, causing others in the vicinity to move/be injured. May also cause damage to nearby vehicles etc. Will cause damage to load. Worst case result is a person being crushed by falling heavy items, but unlikely to result in multiple fatalities. It is likely that a lot of this type of event goes unreported as no injury or damage is sustained.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rating: 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rating: 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Security Measure</td>
<td>Scenario</td>
<td>Likelihood</td>
<td>Consequence</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Base case</td>
<td>Falls from height</td>
<td>Falls resulting in the driver falling from the trailer bed when trying to move the shifted load. Only likely from the rear doors, as all other sides are closed. The floor of the trailer may be slippery, especially if the floor is metal and/or the surface is wet/oily. The time spent by the driver on the trailer adjusting shifted loads will be less than that of curtain sided trailer because it will not be as obvious that loads have shifted. Reduction may not be sufficient to reduce the likelihood of a fall.</td>
<td>Falling from a height of approximately 2 metres can have the potential for death if landing is awkward. Very likely to result in major to serious injury. Many falls result in minor to major injuries.</td>
</tr>
<tr>
<td>Base case</td>
<td>MSDs</td>
<td>MSDs likely when drivers are manually moving shifted loads, without the use of specialist equipment. Injuries could also be sustained when retrieving fallen loads. MSDs with roll cages may depend on the type of floor installed in the trailer, with higher friction floors requiring more effort to move the cage. Incidents are likely to be under reported, especially with minor injuries.</td>
<td>No fatalities are likely with MSDs. Many will result in more than 3 days sick. MSDs account for a third of all absences from work. Many minor injuries are likely to occur and go unreported. This will reduce the overall consequence rating.</td>
</tr>
</tbody>
</table>
### 9.1.2 Load security measures

<table>
<thead>
<tr>
<th>Load Security Measure Applied</th>
<th>Scenario</th>
<th>Likelihood</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bars (sprung loaded)</td>
<td>Rollover</td>
<td>Will not reduce side-to-side motion of the load. Risk of rollover remains unchanged from base case.</td>
<td>No increase in severity. Rating: 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ejection</td>
<td>Some forward/backward motion is restricted. The position of the bar depends on the availability of slots in the side rails of the trailer. Bars may break in transit if the load is continually coming into contact with it, effectively removing the restraint method. Insufficient numbers of bars may be present in the trailer for the load. Each haulage company has its own procedure for how many and where the bars should be placed. (Assumes correct bar for trailer/side rail)</td>
<td>No increase in severity. Rating: 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Falling loads when doors opened</td>
<td>Likely to reduce the number of incidents of this type if applied appropriately. If the bars have been damaged during transit, then the restraint method will no longer be effective.</td>
<td>No increase in severity. Rating: 2</td>
</tr>
<tr>
<td>Scenario</td>
<td>Likelihood</td>
<td>Consequence</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>Falls from height</td>
<td>The driver/loader must enter the trailer to apply and remove the bars. The only fall from height will be from the rear of the vehicle, and as such the rating will not be reduced.</td>
<td>No increase in severity.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rating: 3</td>
<td>Rating: 4</td>
<td></td>
</tr>
<tr>
<td>MSDs</td>
<td>MSDs are likely to increase because of the weight and size/shape of the bars. The bars need lifting and pushing into place under tension. There is potential that the bar doesn't lock correctly into position, causing it to spring out again (either immediate or delayed) and injure the driver.</td>
<td>No increase in severity of consequences.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rating: 5</td>
<td>More incidents with bars are likely to go unreported.</td>
<td></td>
</tr>
<tr>
<td>Cross strapping</td>
<td>Cross strapping is not likely to stop side to side motion because the straps are placed in front of the load, and like bars, are dependant on the availability of slots in the side rails. Loop lashing may reduce the side to side motion (either shallow or long return) depending on the tension in the strap, and the suitability of the load. The method of strapping will depend on the company policy.</td>
<td>No increase in severity.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rating: 2</td>
<td>Rating: 3</td>
<td></td>
</tr>
<tr>
<td>Load Security Measure Applied</td>
<td>Scenario</td>
<td>Likelihood</td>
<td>Consequence</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Ejection</td>
<td>Some forward/backward motion will be restricted. Straps may lose tension during transit, or be damaged by the load.</td>
<td>No increase in severity. Rating: 4</td>
<td></td>
</tr>
<tr>
<td>Falling loads when doors open</td>
<td>Likely to reduce the number of incidents of this type if applied appropriately.</td>
<td>No increase in severity. Rating: 2</td>
<td></td>
</tr>
<tr>
<td>Falls from height</td>
<td>The driver/loader must enter the trailer to apply and remove the straps. The only fall from height will be from the rear of the vehicle, and as such the rating will not be reduced.</td>
<td>No increase in severity. Rating: 4</td>
<td></td>
</tr>
<tr>
<td>MSDs</td>
<td>MSDs are likely to increase due to the additional physical activity required to apply and remove the straps. Tension must be applied to ensure a good fit/contact. Loop lashing (long return) has the potential of addition reaching postures.</td>
<td>Additional incidents, plus the under reporting of the more minor incidents. Rating: 2</td>
<td></td>
</tr>
<tr>
<td>Air bags</td>
<td>Load inhibited from movement.</td>
<td>No increase in severity. Rating: 3</td>
<td></td>
</tr>
<tr>
<td>Rollover</td>
<td>Load inhibited from movement.</td>
<td>No increase in severity. Rating: 4</td>
<td></td>
</tr>
<tr>
<td>Ejection</td>
<td>Load inhibited from movement.</td>
<td>No increase in severity. Rating: 2</td>
<td></td>
</tr>
<tr>
<td>Falling loads when doors open</td>
<td>Load inhibited from movement.</td>
<td>No increase in severity. Rating: 2</td>
<td></td>
</tr>
<tr>
<td>Load Security Measure Applied</td>
<td>Scenario</td>
<td>Likelihood</td>
<td>Consequence</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Falls from height</td>
<td>No additional risks if load restraint measure is applied from outside the trailer. Less likely to need to move loads.</td>
<td>No increase in severity. Rating: 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rating: 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MSDs</td>
<td>No additional MSD risks. Less likely to need to move loads.</td>
<td>No increase in severity. Rating: 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rating: 3</td>
<td></td>
</tr>
</tbody>
</table>
9.2 APPENDIX B – LOAD SECURITY PROSECUTIONS

Man who brought misery to motorway users convicted of dangerous driving

A man responsible for endangering motorists on the M25 last May has been disqualified from driving for a year.

Graham Thomas, 55, of Dartford Place, Bonymaen, Swansea, pleaded guilty at Guildford Crown Court to dangerous driving. He admitted being in charge of a Renault articulated curtainsider goods vehicle which was tilting dangerously due to an unsecured load inside.

He was driving along the westbound carriageway of the M25 from Reigate towards Leatherhead around 9.45 am on 28th May 2003, when he was seen by police from the opposite carriageway. The vehicle was being driven with the semi-trailer leaning over at an alarming angle. It looked as if the vehicle was so precarious that it would topple over.

Motorway Control Room staff, utilising the motorway camera system, continually monitored the progress of the Renault goods vehicle. Whilst police units responded the driver was seen to stop momentarily in a coned off area before continuing to drive out from that safe area and rejoin the main carriageway. He travelled a distance of 4 kilometres before being stopped by a Strategic Roads Police Patrol.

It was obvious that there was a serious problem with the load that had shifted. Officers saw that the nearside trailer wheels had lifted off the road surface by up to 6 inches and the load was leaning to the offside and into the next carriageway. The load weighed 19 tonnes and consisted of two pallets each loaded with a reel of tinplate coil. Neither of these pallets was secured in any way to the trailer bed, thus relying upon their own weight to retain them. The only item retaining the load within the vehicle was the fabric of the trailer curtain.

The load was redistributed before the lorry could be moved again. This involved the closure of three lanes while work was undertaken to move the two pallets.

The M25 motorway had various lane closures in place from 10am to 3pm as a result of this incident. At the time restricted running lanes were also in operation nearby following separate damage to Oaklawn Bridge at Leatherhead. Congestion and long delays ensued.

The driver and operator Graham Thomas appeared at Guildford Crown Court on Friday 18th June 2004. He pleaded guilty to dangerous driving and was sentenced to £1000 fine, £235 costs, a 12-month disqualification and was ordered to take a retest before renewing his licence.

Source: http://www.surrey.police.uk/news_item.asp?artid=4575
HSE demands that loads are safely secured after driver dies

The Health and Safety Executive (HSE) has warned employers that they must properly restrain loads on vehicles - whatever the distance travelled.

The warning follows the prosecution of Coastal Container Line Limited, which is a wholly owned subsidiary of the Mersey Docks and Harbour Company, after a driver died when his load of sheet steel shifted and punched through the back of his cab.

Coastal Container Line Limited was today fined £150,000 and ordered to pay costs of £26,732 at Liverpool Crown Court.

The company had earlier pleaded guilty to charges under Section 2(1) and Section 3 of the Health & Safety at Work etc Act 1974 at South Sefton Magistrates Court and had been committed for sentence at the Crown Court.

The prosecution follows an incident on 14 September 2006 at Seaforth docks in Bootle, when 37-year-old Lawrence Allen was driving an HGV with approximately 25 tonnes of sheet steel loaded on a trailer.

The steel was being moved between Gladstone Steel Terminal and the quayside, using roads within the dock complex – a distance of around one and a half miles. As he slowed his vehicle on approach to a roundabout the load shifted and the sheet steel slid forwards and punched through the back of the cab, pinning him between his seat and the steering wheel. Mr Allen suffered crush injuries and died at the scene.

Kevin Jones, the HSE inspector who investigated the accident, said:

"The investigation identified a number of failings including a lack of planning and inadequate training for drivers. A key factor was the practice not to secure the steel but to rely upon the weight of the steel and friction to hold the load in place while the vehicle was moving.

"The transport of steel between the steel terminal and the quayside had been taking place in this manner for at least eight months, putting not only the drivers at risk but also members of the public using the roads within the dock complex.

"Employers must ensure that there is suitable and sufficient planning for transport operations, and make sure that loads are adequately restrained. Friction alone should never be relied upon to secure a load."

Company and sole trader fined £37,500 after steel beam falls from vehicle and fatally injures the driver

The Health and Safety Executive (HSE) has today warned road haulage and steel fabrication companies of the importance of having properly secured heavy loads, following the death of a driver in Leith.

Steel fabrication company, McDonald and Ross Ltd, and a road haulage sole trader, Ron Boyd Trading, were today fined a total of £37,500 at Edinburgh Sheriff Court. Mr Nicholas McKellar age 45, died after a steel beam weighing almost 1000kg fell from a vehicle as it was being unloaded, on 10 October 2005.

McDonald and Ross Ltd of Mayfield Industrial Estate, Dalkeith were fined £30,000; having pleaded guilty to a breach of Section 3(1) of the Health and Safety at Work etc Act 1974 (HSW Act), and Ron Boyd Trading, also of Mayfield Industrial Estate, was fined £7,500 after pleading guilty to a breach of Section 2(1) of HSW Act.

HSE Inspector Isabelle Martin commented after the case:

'‘It is entirely foreseeable that a load on a vehicle will move during transit on the road. It is therefore important that the load is placed onto the vehicle in its most stable orientation and that appropriate measures are taken to ensure that it cannot fall from the vehicle at any time. It is also important that the stability of the load is assessed prior to beginning to unload it.

"This incident could, therefore, easily have been prevented. The beam that fell from the vehicle was one of three identical beams placed on the vehicle. Each of these beams could have been placed on their side therefore making it very unlikely that they could fall."'

NOTES TO NEWS EDITORS

1. Section 2(1) of HSW Act states, "It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees."

2. Section 3(1) of HSW states, "It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety."

3. The Maximum fine for breaches of Section 2(1) and Section 3(1) of HSW Act on indictment in the Sheriff Court is an unlimited fine for each offence.

4. McDonald and Ross Ltd were contracted by a residential developer to fabricate, deliver and erect a steel framed building in Arthur Street, Leith. However they were unable to deliver the steel to the construction site themselves and therefore subcontracted delivery to The Ron Boyd Group.

5. On 8 October 2005, McDonald and Ross, partially assisted by Nicholas McKellar, employed as a driver by Ron Boyd, loaded the steel for the 4th floor of the building onto one of Ron Boyd’s vehicles. The vehicle containing the steel was then driven from
Mayfield to the site in Arthur Street, Leith on the morning of 10 October 2005 by Mr McKellar. Mr McKellar arrived at the site and was met by two of McDonald and Ross Ltd's employees and directed to park next to the pavement across the road from the construction site, where the steel was to be unloaded. Mr McKellar began to remove the straps that retained the load on the vehicle, however the load had become unstable and a steel beam fell to the ground striking Mr McKellar.

6. The HSE investigation revealed that McDonald and Ross Ltd had failed to assess the risks involved in loading and unloading steel. They also failed to ensure that the steel was correctly placed upon the timber bearers on the vehicle. Ron Boyd had failed to ensure that his employees involved in loading, unloading and transporting steel to site had been properly trained.

7. Contractors should have made arrangements for the safe delivery and unloading of materials to their sites. A number of simple steps can prevent this type of accident occurring. Guidance has recently been published by the British Constructional Steel Association.

10 BIBLIOGRAPHY

BS EN 12195-1:2003; Load restraint assemblies on road vehicles – Safety – Part 1: Calculation of lashing forces; British Standards Institution

BS EN 12642:2006; Securing of cargo on road vehicles – Body structure of commercial vehicles – Minimum requirements; British Standards Institution

BS EN 12641-1:2005; Swap bodies and commercial vehicles. Tarpaulins. Minimum requirements; British Standards Institution

BS 5759:1987; Webbing load restraint assemblies for use in surface transport; British Standards Institution

BS EN 13698-1:2003; Pallet production specification – Part 1: Construction specification for 800 mm x 1200 mm flat wooden pallets; British Standards Institution


Road vehicles (Construction and Use) Regulations 1986 – SI 1986 No 1078

Department of Transport; Code of Practice – Safety of Loads on Vehicles (3rd Edition)

Department of Transport; Transport of Goods by Road in Great Britain; 2004

Department of Transport; Road Freight Statistics; 2005

Department of Transport; Truck Specification for Best Operational Efficiency; 2005

New Zealand Land Transport Safety Authority; Heavy vehicle stability guide; Version 1.0

UK National Association of Steel Stockholders; Safe delivery and unloading of steel products (Issue 1)

Victoria WorkSafe; Safety by design – Eliminating manual handling injuries in road transport; Victoria State Government (Australia), 2nd Edition

Australian Road Transport Suppliers Association; Design of Vehicle Body Systems for Load Restraint Compliance; 2004

FENN, B; HANLEY, J; SIMMONS, I; & SMITH, T; The security of cross loaded round timber; TRL Limited (2003)

PULFORD, T; Load security investigation; MIRA Limited (2004)

Safety Culture and Work-Related Road Accidents; BOMEL Limited for DfT

National Safety Code for Motor Carriers - STANDARD 10: CARGO SECUREMENT

Traffic Commissioners’ Annual Reports 2005–06; Department of Transport

NORDSTRÖM, R; ANDERSSON, P; SÖKJER-PETERSEN, S; Verification of level of basic parameters important for the dimensioning of cargo securing arrangements; TFK/MariTerm AB
## INDEX

<table>
<thead>
<tr>
<th>Term</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>accident</td>
<td>29, 30, 31</td>
</tr>
<tr>
<td>curtain sided lorries</td>
<td>1</td>
</tr>
<tr>
<td>Definitions</td>
<td>1</td>
</tr>
<tr>
<td>friction</td>
<td>40, 96, 97, 98, 101, 112</td>
</tr>
<tr>
<td>Friction</td>
<td>5</td>
</tr>
<tr>
<td>guidance</td>
<td>17, 20, 21, 23</td>
</tr>
<tr>
<td>headboard</td>
<td>5, 100</td>
</tr>
<tr>
<td>insurance</td>
<td>34</td>
</tr>
<tr>
<td>legislation</td>
<td>12, 25, 27</td>
</tr>
<tr>
<td>manual handling</td>
<td>40</td>
</tr>
<tr>
<td>pallets</td>
<td>44, 77, 87</td>
</tr>
<tr>
<td>paper reels</td>
<td>37, 51, 54</td>
</tr>
<tr>
<td>Positive fit</td>
<td>5</td>
</tr>
<tr>
<td>responsibility</td>
<td>19, 22, 35, 41, 95</td>
</tr>
<tr>
<td>road haulage industry</td>
<td>7</td>
</tr>
<tr>
<td>safety culture</td>
<td>38</td>
</tr>
<tr>
<td>scope of the project</td>
<td>1</td>
</tr>
<tr>
<td>side strapping</td>
<td>37</td>
</tr>
<tr>
<td>speed</td>
<td>36</td>
</tr>
<tr>
<td>stability</td>
<td>37, 40, 43</td>
</tr>
<tr>
<td>strapping angle</td>
<td>102</td>
</tr>
<tr>
<td>work-related road accidents</td>
<td>38</td>
</tr>
</tbody>
</table>
The project seeks to establish good practice for securing loads on rigid-sided lorries across various industry sectors. Good practice in this case is defined as those methods that are the most practical, involve the least risk of loads becoming unstable or falling, least risk to the operator/driver, and are practicable.

The scope of the project includes consideration of a range of methods currently used in the UK and abroad, as well as alternative methods for securing of different heavy cargoes on rigid-sided lorries. Reference is made to current European Standards and good practice guidelines, as well as regulations and guidance from countries outside the EU.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.