Safety in the design, construction and use of bulk tipping containers

Prepared by New Alchemy and the Health and Safety Laboratory for the Health and Safety Executive 2010
This report provides information on the loading, transport and unloading of bulk materials in tipping containers. It has been prepared by a consultant appointed by the Health and Safety Laboratory (HSL) at the request of the Health and Safety Executive (HSE). Individual employers, trade associations and professional bodies have been consulted in the preparation of this report both in Great Britain and in parts of Europe. European employers have been consulted because of the international nature of many of the loading, transport and unloading operations with bulk tipping containers.

The report identifies a number of areas where positive management of the hazards associated with bulk tipping container, design, transport and use are required. Information is presented in a series of Annexes to assist those involved with these operations to review their arrangements.

A second study by the Health and Safety Laboratory which models the forces at work in the use of bulk tipping containers and their carrying vehicles appears as Annex 2 to this report. This report explores a number of design features and highlights some design issues for consideration by component and equipment designers.

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EXECUTIVE SUMMARY

This report considers the safety aspects of the loading and unloading of bulk tipping containers. In particular, it considers the safety aspects of the twist locks of road vehicles on which the containers sit for loading and unloading in the tipped position.

The stimulus for this report was an accident in which a road vehicle driver died during the unloading of a bulk tipping container.

The report concludes that there:

- is a pattern of incidents and accidents in the use of bulk tipping containers, the majority of which have been caused or contributed to by driver failure to close and secure twist locks in corner castings.

- are other incidents and accidents with these containers that have a wide variety of causes.

- is often a lack of understanding within several sectors of industry of the static, torsional and dynamic forces at work when bulk tipping containers are loaded and unloaded in the tipped position.

- insufficient attention is given to maintenance, use and information.

- are design improvements and technological advances which can be used to reduce some of the risks inherent in the use of bulk tipping containers.

There is useful information contained in this report for the following:

Manufacturers of:

- components
- bulk tipping containers
- bulk tipping container vehicles

and for bulk tipping container:

- transport operators
- hauliers
- consignors
- consignees
- lessors
These sectors with the assistance of their representative trade associations and professional bodies are encouraged to use the report to develop their own industry guidance and working practices.

A hierarchical approach to be based on a suitable risk assessment to the choices in the design of bulk tipping container unloading facilities is suggested.

The main areas where improvement is possible are:

- ensuring twist locks and tipping equipment is designed and manufactured specifically for bulk tipping applications
- ensuring operatives are specially trained in safe systems of work for bulk tipping operations
- proper maintenance and inspection of tipping equipment and safety critical components
- providing good information for use and maintenance

The report suggests standards be developed or reviewed to cover bulk tipping equipment, in particular twistlocks and shear block assemblies.

Detailed information and issues associated with the manufacture and use of bulk tipping containers is presented in a number of informative annexes to assist those involved to assess their risks and develop appropriate control solutions.

A separate report is attached to this report as Annex 2, prepared by the Health and Safety Laboratory. This discusses the forces at work during tipping. It demonstrates the pattern of distribution of these forces through the bulk tipping containers and onto the carrying vehicles and semi-trailers using computer modelling techniques. A number of specific material specification and design considerations for tipping vehicles and components are made in this second report.
1. INTRODUCTION

A serious accident occurred in December 2000 during the tipping charge of a bulk container that lead to the death of a driver. There were several contributory factors leading to the accident. The main cause, however, was the failure of one of the rear twist locks to hold the container on its carrying tipping semi-trailer because an essential component of the twist lock – the twist lock nut – was missing. That incident became the stimulus for this report.

At the time of preparing this report the Health and Safety Executive (HSE) is aware of at least one other death in the UK during bulk container tipping discharge in the 1990s. At least one other fatality has occurred in another EU Member State.

Details of accidents and incidents involving bulk tipping containers have been collected on an empirical basis. Evidence gathered in this way suggests that there may be 12 – 15 incidents a year in Europe involving these containers though some consultees consider this to be an under-estimate.

It has been determined that the predominant cause of accidents and incidents during the tipped loading and unloading of these containers appears to be the failure of drivers to ensure that all twist lock stem heads are fully rotated, engaged and secured against inadvertent opening inside the corner castings of the containers prior to tipping.

A number of other accidents and incidents have been recorded from interviews and other anecdotal sources involving the use of bulk tipping containers.

The potential for death or serious injury exists with the tipping of bulk containers.

This report contains information that may be useful to the following sectors of industry:

- suppliers of components for the manufacture of bulk tipping containers such as twist locks, container corner blocks (corner castings), landing legs, rotating bolsters, tipping rams, hoses, pressure and vacuum relief devices, interlocking devices, vehicle suspension systems, remote control devices, rotary valves, discharge funnels etc
- manufacturers of the bulk tipping container vehicles and semi-trailers which transport bulk containers especially those where loading or, in particular, unloading operations take place with the bulk tipping container in the elevated position on the vehicle or semi-trailer
- manufacturers of the various types of pressure, low pressure and non-pressure bulk tipping containers
- lessors which lease either the bulk tipping containers or tipping semi-trailers or both
- employers whose products are loaded and transported to their customers using bulk tipping containers (consignors)
- employers where the discharging of cargo from bulk tipping containers takes place (consignees)
• transport operators working with bulk tipping containers

• haulage companies who may e.g. work for transport operators for collection or delivery of laden bulk tipping containers
2. AIM OF REPORT

The main goal of this report is to provide advice in the use of twist lock technology when applied to bulk tipping containers in order to reduce the risk of injury e.g. through incidents of the kind which formed the stimulus for this report. The safety of other key elements used in the application of this technology is discussed in the main body of this report. Where other relevant information has been collected this has been included in informative annexes.

2.1 Methodology used in preparing the report

In order to ascertain current best practice and any perceived weaknesses in that best practice within the affected sectors of industry meetings were held with a representative selection of equipment manufacturers, suppliers of bulk materials, transport operators and receivers of materials in bulk. For the most part, these meetings took place at the consultees’ premises with engineers or operator’s management directly involved in the manufacture and operation of bulk tipping container technology. A number of national and international trade associations were also consulted through meetings arranged by their officers. Relevant European and international standards were reviewed. See Appendix 4 for a list of contributors.

Consultees were chosen on the basis of the author’s knowledge of the relevant sectors of the bulk tipping container industry and on the basis of consultees willingness to participate. In only one case did a proposed consultee refuse to take part.

HSL report MM/04/24 contained in Annex 2 has been used in this work.

The term ‘bulk tipping container’ is used in this report. It refers to any of the bulk transport equipment listed in Annex 3 used in conjunction with a tipping mechanism, unless the context clearly indicates a particular kind of this transport equipment.
3. ACCIDENTS AND HAZARDS

3.1 Failure Modes – Hazards Associated with Bulk Tipping Containers

The main hazard that arises from tipping bulk containers is that of their falling from the tilted position. This may be when:

- the container falls rearwards from a front tilted position onto its bottom cross rail;

  or

- slewing and falling to one side while tilted.

The most common reason for these occurrences is failure to secure the bulk tipping container properly to its tipping vehicle or semi-trailer with all four twist locks. Discussions and observations suggest that one of the main causes of these failures is due to worker error (mainly vehicle drivers) in failing to engage and secure all the twist locks fully in the corner castings of the bulk tipping container. An example of the consequences of such failures is to be seen at Image E in Annex 1.

Through discussions and observations, it has been concluded that there are other hazards associated with the use of bulk tipping containers. These include (the list is not considered to be exhaustive):

- twist lock failure
- fitting of unsuitable twist lock designs to tipping semi-trailers and vehicles
- inappropriate conversions of non-tipping semi-trailers to tippers
- failure of the rotating rear bolster(s) to rotate
- failure of tipping rams
- inadequate maintenance
- failure of weld seams in the equipment
- blockage of product flow causing backpressure
- failure to fit suitable vents on non-pressure bulk containers or their becoming blocked causing either negative or positive pressure build-up
- failure to fit pressure relief devices on tank shells and pipelines where pressure discharge takes place
- failure to distribute the load equally in the container
- inappropriate methods used to break angles of repose to increase payloads during filling
• inappropriate methods used to loosen congealed material in the containers during discharge e.g. by driving vehicle around with the container elevated and suddenly applying brakes
• instability of the bulk container and tipping chassis when elevated due to congealed material e.g. at the front (top) or in the corners of non-pressure bulk containers
• ground slope
• ground instability
• weakness in the ground surface on which the tipping loading or discharge takes place
• trapped digits in moving parts
• asphyxiation from the use of inert gases (nitrogen) for pressure discharge e.g. during subsequent cleaning processes
• hazards of asphyxiation during the installation and removal of liners in the containers
• hazards from dust explosions
• hazards from static electricity
• noise from vehicle mounted compressors used to fluidise substances for discharge and / or for pressure discharge
• vibration methods used to fluidise solids
• external overhead obstructions
• incorrectly installed and/or improperly constructed rear bulkheads when using the technique of temporarily converting a standard freight container into a bulk container
• excessive tipping angles and/or failure to discharge progressively through removing as much of the bulk substance as possible for the least elevation

3.2 Accidents and Incidents

Research has shown that accidents and incidents directly associated with the loading and unloading of bulk tipping containers occur regularly.

It is estimated that there are between 12 and 15 incidents a year in Europe. However, some employers have suggested that this is an under-estimate. This should be set against one to two million tipping operations per annum. As noted above, empirical evidence suggests that the majority of these arise from the failure of vehicle drivers to secure the four twist locks of their tipping semi-trailers in the closed position. These failures may cause the bulk container to slew
sideways in the tipped position or to slide to the ground. Such accidents and incidents have the potential to cause death or serious injury.

Analysis of the other accidents and incidents associated with bulk tipping container operations over the past 10 to 15 years have identified the following additional safety issues:

**Equipment Operation:**

- obstructions preventing the rotation of the rear bolster of tipping semi-trailers and vehicles, either external to them such as positioning of the semi-trailer too close to the wall of a pit into which the load is discharged (a fatality) or due to poor lubrication (see Images G, H, M for location of in service rear bolsters, Annex 1)
- where split, twin rotating bolsters are fitted, rotation at unequal speeds because of partial or complete seizure of one side due to lack of lubrication (see Image G, M for location of in service split rotating bolsters, Annex 1)
- unequal rising of twin tipping rams
- failure of a defective twist lock assembly due to poor welding during the tipping unloading operation which occurred close to the end of the unloading, minimising the hazardous effects (see Images B, C for an examples of failed twist lock assemblies, Annex 1)
- dangerous release of pressure due to worn bolts on manlids
- failure of a rear twist lock to withstand the sudden fall of a large part of the load of a substance known to compact (see Image D for evidence of what may happen due to rear twist lock failure, Annex 1)
- a seized rotating bolster which started to pull the twist lock stem out of its housing when elevation was attempted
- modification of corner castings by welding an extension onto the rear faces of the rear bottom castings to prevent ingress of swarf during the discharge of scrap metal. During one discharge operation, the vehicle was backed too close to a pit wall so that the extension piece attached to the corner castings fouled the wall during elevation which nevertheless continued eventually causing the container to fail

**Loading:**

- inappropriate techniques used to disturb the angle of repose of powdery substances during loading in order to increase payloads e.g. raising and lowering the tipping ram as quickly as it would allow causing damage to the loading gantry
- uneven distribution of the substance carried inside the bulk container causing slewing and fall
Loading or Unloading:

- striking of overhead obstructions such as power cables while elevating bulk containers
- unstable ground conditions e.g. due to culverts or other ducting under apparently firm concrete floors and e.g. due to the washing away of soil underneath a concrete base. Landing legs broke through the concrete cap when lowered leading to toppling
- loss of stability in the elevated position due to wind

Manufacture/Modification:

- failure of an aluminium alloy corner casting due to poor welding of sections together
- failure of a twist lock assembly possibly due to unsuitable or no heat treatment of welds after installation on the tipping semi-trailer (see Images B, C for examples of failed twist lock assemblies, Annex 1)
- inappropriate modification of existing semi-trailers for tipping purposes including poor welding
- toppling due to a modification to extend a tank shell in order to increase the payload where full engineering assessment of the additional forces sustained had not taken place. The circumstances of this particular incident are said to have been exacerbated by windy conditions, a lateral sloping surface, lack of rear stabilising legs and due to the fact that unloading had to take place on a public road
- failure of a tipping platform due to insufficient supporting cross members

Unloading:

- attempts to dislodge compacted material inside a bulk container of bone meal by driving around and applying the brakes
- slewing sideways during discharge due to product ‘cling’ in one of the top corners of the container
- failure of temporarily installed bulkheads when standard freight containers are used for bulk transport, exacerbated by an excessive tipping angle

Miscellaneous:

- some empty containers raised to drain cleaning water fell against each other due to wind
- springing open of the rear doors of a bulk non-pressure container due to failure to close the vertical locking bars properly. A quantity of the substance inside its plastic liner fell out. This happened aboard ship and may have been exacerbated by the motion of the ship
- overturning due to excessive speed within a rail to road intermodal transfer station
• a bulk tipping container asphyxiatiion incident due to the presence of nitrogen not being notified to a cleaner

• corrosion of a tank shell caused when cleaning out a water soluble substance that became corrosive when wet

• employee in a south Europe country overcome by nitrogen while attempting to remove a plastic liner. Container had come from a northern European country but no warning passed on about the presence of nitrogen

• implosion of a pressure tank due to partial vacuum as the tank cooled down after hot wash. Tank was not fitted with a vacuum relief valve

• incidents resulting in death have been recorded in the United Kingdom with bulk tipping vehicles such as three in a six-week period between November 1989 and January 1990 during the discharge of viscous loads (cotton cake and bone meal) from tipping vehicles with hinged tailgates. Whilst these were not bulk tipping containers, these incidents could have occurred with some designs of bulk tipping containers. In each of these incidents the tailgate latching devices were not designed for the impact of the sudden fall of compacted material on the person opening the tailgates. These incidents have implications for the use of bulk tipping containers of this kind of design.

• collapse of a stack of 30’ bulk tipping containers in the cells of a cellular ship due to (a) heavy dangerous goods tank containers being stacked on top and (b) due to exceeding the CSC maximum gross stacking mass of the bulk containers (see image F).

The Images A to F in Annex 1 illustrate some of the failure modes.

All identification has been removed as far as practical.
4. MAIN TIPPING ELEMENTS

4.1 Tipping and Related Equipment

Bulk containers requiring tilted unloading (or tilted loading):

- will usually be transported to the point of unloading (or loading) on tipping semi-trailers with a drawing tractor unit or, where gross mass makes it possible, on rigid tipping vehicles with a varying number of axles

- may be transferred at some unloading points to a tipping platform. In such cases the main tipping elements are located on the tipping platform rather than the carrying vehicle or semi-trailer. The use of a tipping vehicle or semi-trailer is unnecessary when these tipping platforms are used

- there are some semi-trailers in use in certain parts of Europe where the whole trailer tilts rotating on the rear axle in which case rotating bolsters are not needed (see below). These are not known to be in use in the UK

- may be transported to the point of unloading (or loading) on normal container vehicles or semi-trailers to which a tipping platform is temporarily attached – see Image T, Annex 1

Recent technological advances allow the discharge of some pressure bulk containers without the need for tipping.

Bulk tipping container technology employs some important structures and components (main tipping elements). Some of the components are considered to be critical to safety. These safety-critical components are described in this part of the report. Safety issues concerning these elements of equipment are discussed in Chapter 5.

The safety-critical components elements include:

- Twist lock assemblies
- Rotating rear transverse bolsters
- Front lifting transverse bolsters
- Landing legs
- Hydraulic tipping rams
- Vehicle and/or semi-trailer suspension systems
- Corner blocks often referred to as corner castings (these are part of the bulk container)
4.2 Twist Locks

Twist locks are fitted to container vehicles or semi-trailers. They are used to retain the container on the vehicle or semi-trailer. There will be a minimum of four located along the sides, usually close to the vehicle or semi-trailer front and rear. On tipping vehicles and semi-trailers the rear pair will normally be attached to the extremities of a transverse rotating bolster and the front pair to the extremities of a transverse bolster linked to the tipping ram. In some cases discussed below, the rotating point may be below the level of the deck of the vehicle or semi-trailer. Nevertheless the rear twist locks must still be linked to the rotating mechanism.

Twist locks consist of five main components:

- A load bearing surface capable of supporting the base of a corner casting of a container or swap body
- A collar (shear block) - some designs may not have a shear block or the shear block is retractable below the level of the load bearing surface e.g. to facilitate the transport of containers and swap bodies of different lengths.
- A rotating head which projects into a corner casting and used to secure a container or swap body to a means of transport. The heads are an extension of a shaft which may be threaded. The head and shaft are known as a twist lock pin or stem (The term stem is preferred in this report). The heads are mushroom-like in shape
- An arrangement for rotating the head and securing it inside a corner casting
- A housing for the whole assembly

Twist lock assemblies can be seen in Images H, J, L and W in Annex 1.

On some designs the collar may be in two half sections or, more rarely, is in one complete section.

In principle, there are two main types of twist lock, ‘snap shut’ and ‘screw down’. Industry tends towards the screw down variety for bulk tipping container applications. Later in the report, where the safety issues concerning twist lock closure mechanisms are discussed, investigation has shown that only the latter type is to be recommended for bulk tipping containers – but see below.

Discussions have shown that there is a preference among some bulk container operators, particularly the larger ones, of using semi-automatic or even fully automatic twist locks. In the case of semi-automatic twist locks, these close automatically as soon as a container is placed on a carrying vehicle or semi-trailer. They have to be manually released in order to remove the container from the vehicle or semi-trailer. See Image J, Annex 1.

In a less common application, fully automatic twist locks may be fitted. Fully automatic twist locks have a pneumatic or electronic actuating mechanism allowing e.g. drivers to close and / or to release the twist locks from switches inside the driver’s cab. An image of a fully automatic twist lock is not presented in this report as this feature cannot easily be demonstrated in a still photograph.
Occasionally, there may be more than four fitted in order to accommodate bulk tipping containers of different lengths. In this case it is necessary for intermediate position twist locks to be fully retractable so as not to foul on the bulk tipping container body.

4.3 Corner Castings

Corner castings (also called corner fittings, corner pieces, corner blocks) are fittings generally located at the top and bottom corner of containers to provide a means of supporting, stacking, handling and securing containers to the means of transport. They have orifices of prescribed shapes and dimensions to facilitate handling and securing. ISO 1161 provides the main standard for their dimensions and to some extent their performance. See Image M, Annex 1.

4.4 Rotating Rear Bolsters

The vast majority of bulk tipping vehicles and semi-trailers are fitted with rotating transverse bolsters at the rear. They are attached across the rear of bulk tipping container vehicles or semi-trailers to facilitate the tilting of bulk tipping containers. They may be “full width” or may consist of two shorter bolsters with a gap in the centre. They usually consist of bearings inside a cylindrical section and attached to plates used to attach them to bulk tipping container vehicles and semi-trailers. The rotating parts may be protected with a cylindrical metal cover. As mentioned above, the rear twist locks are attached to them. Split bolsters are preferred by some operators as they are said better to facilitate access to the rear outlet hatches and valves of bulk containers and to aid free flowing during unloading. See Images G, H, and M, Annex 1 for examples of both types of rotating rear bolsters.

4.5 Front Lifting Bolsters

Front lifting transverse bolsters usually consist of a vertical framework attached to a tipping ram extending laterally across the front of a bulk container tipping vehicle or semi-trailer to which two twist lock assemblies are attached. They facilitate the raising of the front of bulk tipping containers. See Images J and Q, Annex 1 for examples of front lifting bolsters.

On some bulk tipping container semi-trailers there may be linking beams between the front and rear bolsters. On others there are no physical connections between the two bolsters. The advantages of making a physical connection between the two bolsters are discussed later in this report.

4.6 Tipping Rams

The usual means of elevating bulk tipping containers is by means of a vertical hydraulic ram attached to the front bolster of bulk tipping container vehicles and semi-trailers. There is usually only one ram for reasons discussed later in the report. See Images J and Q, Annex 1 for examples of tipping rams attached to front bolsters. Power to operate the hydraulic tipping rams may be provided by a separate donkey engine mounted on the vehicle or semi-trailer or may be provided by a power take-off from the vehicle engine.

In rare applications, the tipping ram is located between the main longitudinal beams of the bulk tipping container vehicle or semi-trailer and, through a base frame on which the containers sits, causes the front of the bulk tipping container to rise.
4.7 Landing Legs

A pair of retractable landing legs is fitted towards the front of semi-trailers. They are used to support semi-trailers when the tractor unit is detached. They consist of a sleeve, usually square section, and a leg which can be lowered and raised with a winding mechanism. Each leg has a plate or small solid wheel attached to its foot - see Image K, Annex 1.

It is common practice to fit additional stabilising support for tipping bulk container semi-trailers. This support is usually in the form of a second pair of ‘landing legs’ at the rear. These are provided to aid the distribution of the static, torsional and dynamic forces in the tipped position. They also assist with lateral stability. Their design may differ from the types usually fitted at the front e.g. by having a larger plate providing a greater “footprint” area of contact with the ground. See Image L, Annex 1.

4.8 Vehicle Suspension Systems

Vertical and centrifugal forces act on vehicles, semi-trailers and bulk tipping containers causing movement due e.g. to road imperfections, cornering, manoeuvring in traffic. Bulk container tipping vehicles and semi-trailers are fitted with suspension systems intended primarily to dampen and reduce the impact of these vertical and centrifugal forces. In the case of bulk tipping container vehicles and semi-trailers, movement may also occur during tipping especially if there is a sudden fall of the load inside them.

There are several different suspensions systems in use including single leaf springs, multileaf springs and air suspensions. Most bulk tipping vehicles, semi-trailers and tractor units are fitted with an air pressure suspension (except for front steering axles) consisting of synthetic rubber bags (also called balloons). A pair of bags is fitted to each axle adjacent to the inner faces of the tyres. The bags are inflated from an air pressure reservoir and are fitted with a device for deflation. The air may be released from the bags so that it is rendered inactive e.g. during periods out of use. See Image N, Annex 1, for an example of air suspensions.
5. SAFETY ISSUES ASSOCIATED WITH THE MAIN TIPPING ELEMENTS

5.1 Issues Concerning Tipping Main Tipping Elements

Research undertaken for this work has shown that the component and equipment manufacturers generally recognise that the loading and unloading of bulk tipping containers is a special case. Suppliers have usually taken steps to recognise this in the design of components supplied for fitting to bulk container tipping vehicles and semi-trailers. For example, the manufacturers of what is perhaps the most safety critical component, the twist lock, recognise that their use on tipping semi-trailers and vehicles is a special application of this technology in need of special designs, particularly for the rear pair.

There may be some lack of attention on the part of some tipping bulk container semi-trailer and vehicle manufacturers to ensuring that components recommended for tipping use are selected especially where these are supplied through dealers.

Some resistance has been shown on the part of bulk tipping container vehicle and semi-trailer manufacturers in accepting advice from equipment suppliers on the preferred method of installation.

It has been suggested by some component manufacturers, too, that there may be some counterfeiting of components taking place, such components not likely to perform as well as those of the original supplier.

Research undertaken for this work has shown that, in particular, consignees receiving deliveries in bulk tipping containers have little appreciation of the design and construction of the containers, the bulk tipping vehicles and semi-trailers, especially as to what may constitute best practice in design and construction and with respect to any design and construction limitations of the tipping elements.

5.2 Safety Issues Associated with Twist Locks and Suitability of Twist locks for Tipping Applications

There are many designs of twist lock. Many designs are for a specific purpose including specific designs for bulk tipping applications. Accidents have occurred because twist locks not recommended for bulk tipping applications have been fitted to bulk tipping vehicles and semi-trailers.

As noted earlier in this report, many of the incidents that occur during tipping of bulk containers result from the failure of drivers or other workers to ensure all twist locks are fully engaged in the corner castings, fully closed and locked. It is possible that these incidents may have been avoided if sensors and interlocking mechanisms were employed which prevented tipping unless twist locks are engaged, closed and locked. Research and discussion has shown that such technology is available but, in the main and with some notable exceptions, it is seldom fitted to the tipping vehicles or tipping semi-trailers.

Arguments put forward by some consultees for not fitting such equipment include operators who consider that the use of such technologies provide a comfort to drivers so that they may not be as diligent in carrying out their duties as maybe they should if safety in this respect depended solely on driver skill and attention. Others suggest that these technologies are sensitive and may easily break down in service while drivers are far from their bases and far from maintenance.
facilities with consequent disruption to operations and additional costs. Others yet again argue that the operating conditions are inimical to the use of such technologies e.g. in dirty conditions where the operating sensors and mechanisms may become clogged up.

Given that failure to engage, close and lock twist locks appears to be the predominant cause of incidents by quite a margin, the industry must be challenged to find reliable interlocking mechanisms which will prevent this being the cause of so many of them. It can be done. Evidence from research shows that the sectors of industry for which the use of bulk tipping container technology is secondary to their main business are far better at using interlocking mechanisms than those for which the transport of materials in bulk tipping containers is their primary business.

As noted above, suppliers of twist locks have recognised that the use of this technology for bulk tipping containers is a special case. Studies of existing standards show that they do not specify any particular requirements for twist locks for this application. Research and discussion has shown that this has led manufacturers to find their own approaches to enhancing safety, none of which correlate very well with each other. One manufacturer informed the author that his design has a number of additional features in the design of the twist lock stem which include:

- A larger diameter
- A wider mushroom head to give a greater area of grip by the lips of the head inside the corner casting
- Testing separately to ensure the stems can withstand the (then) minimum 2g impact testing required for tank containers conforming to the †International Convention for Safe Containers (CSC)


Another informed the author that the stem is hardened to get an ultimate strength of 120 tonnes i.e. 3 to 4 times that of a normal twist lock. Yet another treats each tipping application as a special case and the twist lock assembly would be designed and manufactured to suit.

Whilst these approaches to safety are laudable, they are not consistent and not necessarily based on a complete research of the behaviour of bulk tipping containers, their cargoes, bulk tipping vehicles/semi-trailers and the behaviour of the twist locks.

HSL report MM/04/24 (at Annex 2) contains the results of some structural analysis to determine how static, dynamic and torsional forces occurring during bulk tipping container discharging pass through the rear twist locks. In the tipped position, these are taking almost all the forces, the front tipped twist locks playing only a minor role in retaining the container in place. Certain findings and conclusions are reached in that report including:

- The conclusion that the twist lock stem should have a large radius into the head.
- The finding that depending on the level of friction between the head of the stem and inner faces of the corner casting, loadings are taken mainly by the shear block

These conclusions and findings need to be considered by the manufacturers of the twist lock assemblies, the manufacturers of the bulk container tipping vehicles and semi-trailers and by
those involved in tipping loading and discharge of bulk containers. Discussions with manufacturers did not produce any indications that any particular design considerations had been taken into account in designing the shear blocks (this may benefit from more research into industry best practice).

It is concluded in HSL report MM/04/24 that the level of friction between the lips of the head of the twist lock stem inside corner castings is important. As noted above, discussions with one twist lock manufacturer show that it has decided to increase the dimensions of the head so that it gives a greater area of contact inside the corner casting. None of the research undertaken for this report has shown during maintenance and use that steps are taken to ensure that lubricants do not spread onto the contact areas, either in the corner castings or, as is more likely to occur, on the lips of the twist lock stem heads.

Other research carried out jointly by a component manufacturer and an operator suggest that there must be as little relative movement of the head of the twist lock as possible inside the corner casting during tipping. Bending moments on the twist lock stem in excess of 14715 Nm (sic1500 tonnes) may be produced if there is even the slightest slack in the tightening of the twist lock nut. The conclusions of HSL report MM/04/24 and these other findings need to be considered by those designing and manufacturing twist locks, selecting and fitting them to bulk tipping containers and semi-trailers, during tipping operations and during maintenance. Discussions with bulk tipping container manufacturers and operators suggest that the level of friction is important to prevent relative movement inside corner castings.

As noted above, there are two main types of twist lock, “snap-shut” and “screw down”. In the United Kingdom, the snap-shut version is most commonly seen variety of twist lock assembly fitted to ordinary freight container road vehicles and semi-trailers. This kind of twist lock assembly is typically not used in other European countries where, indeed, their use may be outlawed. With snap-shut twist locks, the twist lock stem head is engaged in the container corner castings and rotated through 90° to obtain closure. Whilst this kind of twist lock will secure containers to vehicles and semi-trailers, it will not guarantee that there is no relative movement of the twist lock stem head inside the corner casting. For this reason, the use of this kind of twist lock should not be considered as suited to tipping applications. The technical justifications for this judgement are outlined in HSL report MM/04/24 reproduced at Annex 2.

The designs of twist lock assembly that have a threaded stem and a large nut for tightening after insertion of the stem head into corner castings (or equivalently functioning semi- or automatic twist locks – see below) is very much to be preferred. These designs do not allow relative movement of the head inside the corner castings. Snap shut twist locks are commonly found on the front lifting bolster of bulk tipping semi-trailers and may be satisfactory for this application.

As noted above, semi-automatic and even fully automatic twist locks are fitted to some bulk tipping vehicles and containers. The majority of incidents that occur during bulk tipping container unloading are due to road vehicle driver error in failing to close the twist locks correctly. As a result of research and discussions, it is recommended that automatic or semi-automatic twist locks are actively considered for use in bulk tipping container operations. Fully automatic twist locks operated electronically from controls in the vehicle cab are available and are in use. They can reduce the risk of vehicle driver error still further.

Automatic and semi-automatic twist locks must be kept in proper operational condition considering the nature of operation. Even though the operation may be fully automatic, driver vigilance is always necessary before tipping to ensure that twist locks are fully engaged in corner castings. For example, twist locks may close even though the stem heads have not
entered the corner casting due to mis-alignment of the bulk tipping container as it is being placed on the vehicle or semi-trailer. In such cases the container may rest on the top of the heads.

Automatic or semi-automatic twist locks may not comply with the regulations in some countries which demand that the twist locks must be capable of being screwed down but, nevertheless, consideration should still be given to using these kinds of twist locks on semi-trailers and vehicles used in the United Kingdom.

Some semi-automatic designs do not rotate fully across the inner surfaces of the corner castings. It has not been possible to identify any evidence that this has had any impact on the safety of bulk tipping containers but if the warning that there needs to be as much friction between the lips of the twist lock head and the surfaces of the corner castings demonstrated in report HSL MM/04/24 is heeded, manufacturers and users may wish to consider revising their designs.

Nevertheless, semi-automatic and fully automatic twist locks can reduce the risk of driver error. They may, for example, be linked to interlocking mechanisms (see below) to preventing vehicle movement or preventing the tipping extending unless the lock is engaged.

As mentioned earlier, some bulk tipping container semi-trailers are fitted with one or more pairs of twist locks with retractable shear blocks. This is done in order to accommodate bulk tipping containers of different lengths, for example, both 30 feet and 40 feet long containers. The forces passing through the shear blocks are explored in the report HSL MM/04/24.

Through research and discussion, some important maintenance issues on twist lock components which are considered to be critical for safety have been identified. Little, if any, guidance is given on inspection and maintenance procedures, what defects to look for and at what stage due to wear and tear components should be replaced. Many owners of bulk tipping container vehicles and semi-trailers limit their maintenance to no more than ensuring that the twist locks rotate and adding some lubrication.

Some port operators report occasions where container crane and container lift truck drivers have begun lifting operations with semi-automatic twist locks still engaged in the twist locks. Incidents of this kind may, in part, be due to crane and lift truck drivers’ lack of familiarity with this kind of twist lock, or a failure to check, that can be resolved by training.

As a result of research and discussion, it is suggested that a more suitable inspection and maintenance regime would include, e.g.

- inspecting the tie bar or handle used to rotate manually operated twist locks into position to ensure that it is held securely in place and cannot fall out. The chain of events which lead to the death of the driver which is the stimulus for this report probably started with the shaking loose of a split pin reamed into place through the base of the twist lock stem into the tie bar
- checking the threads on the twist lock stem and nut for wear
- checking that there are no cracks on the nut
- checking for signs of metal fatigue and/or corrosion
• inspecting twist lock stem where it passes into the head to ensure that no cracking has occurred

• ensuring that no lubricant spreads onto the lips of the twist lock head

The frequency of these inspections should coincide with the frequency of service and inspection required by the operating licence of the operator.

The study suggests that it is unusual for any manufacturers of twist lock assemblies and/or bulk tipping container vehicle or semi-trailers to provide any inspection and maintenance instructions. Only one manufacturer of bulk tipping container semi-trailers was found during this work who gave guidance e.g. on how much wear on the threads of twist locks stems should be allowed before replacement.

The study shows that the cause of some accidents with bulk tipping containers has been associated with conversions by the owners of non-tipping semi-trailers to tipping trailers – see, for example, the converted semi-trailer at Image A, Annex 1. When converted, the welding of the twist lock assembly to the rotary bolster has been inexpertly done. Twist locks are not necessarily changed for a type recommended for bulk tipping container applications. Such conversions should be carried out by specialists who understand the static and dynamic forces encountered with bulk tipping containers.

5.3 Safety Issues Associated with Corner Castings

Corner castings should conform to the dimension and performance requirements of ISO 1161 as a minimum. Corner castings on swap body tipping containers may have to have slightly longer dimensions. However, in no case should the dimensions of the orifices be increased if this will result in a reduced area upon which the lips of the twist lock heads grip.

Research suggests that there is little evidence to show any particular safety issues with corner castings made from steel.

However, some bulk tipping containers are constructed in aluminium alloys, including the corner castings. Aluminium alloy corner castings are often manufactured by extruding in two or three parts which are subsequently welded together. In discussion with some manufacturers of bulk tipping containers, it has been suggested that this kind of manufacturing process produces a weaker corner casting. It has been suggested to the author that the bottom orifice opens out over time due to the force exerted by the twist lock stem head with the attendant risk of the twist lock stem head slipping through this orifice. One manufacturer of aluminium alloy bulk tipping containers decided, because of this concern, to manufacture its corner castings in one piece by milling from a block. Research and discussion with other consultees does not show wear on aluminium alloy corner casting bottom orifices to be a significant phenomenon. Also, there does not appear to be any evidence to suggest that one method of manufacture is better than another.

Nevertheless, owners should examine their aluminium bulk tipping containers for signs of wasting and widening of the base orifice which could lead to the head of the twist lock stem slipping through.
One accident known to have resulted in a death occurred because the rear vertical orifices of the corner castings of a bulk tipping container carrying scrap metal swarf were closed off with a triangular shaped section. Discharge was to take place by directing the material over the wall of a pit. The vehicle was stationed so close to the wall that the triangular sections rested on it. As elevation was attempted, the rear bolster could not rotate in keeping with the rising front bolster causing the container to break in two and releasing the load. Such modifications should not be attempted and other means used to prevent e.g. swarf, dirt entering the twist lock mechanism. Research has shown that it is possible to enclose twist locks assemblies so that ingress of foreign matter is prevented. Making such modifications may have also resulted in the container exceeding permitted dimensions for construction and use.

5.4 Rotating Rear Bolsters

Incidents with bulk tipping containers have occurred due to problems with rotating bolsters. These appear predominantly to have occurred with split bolsters (see above). Problems encountered include one not rotating at the same speed as the other or even not at all. Some operators insist because of this danger on using single full width bolsters only. Although arguments are put forward to suggest that split rotating bolsters are necessary to facilitate access to the discharge outlet of bulk tipping containers by some operators others maintain that sufficient access can still be provided with single piece full-width rotating bolsters.

Where split bolsters are used, consideration should be given to providing a link (torsion bar) between the two so that elevation is not possible if the bolster(s) fail to rotate or rotate at unequal speed. Best practice suggests the link should be spring loaded to ensure proper return after use. In this case if one or other or both are not rotating properly, it will be possible to see the link showing above the level of the bulk tipping vehicle or semi-trailer deck when the bulk tipping container has been removed. Some semi-trailer manufacturers have addressed this issue in their designs.

Some rear bolsters may have insufficient provision for lubrication resulting in them not rotating freely, reflecting poor design. Others do not have sufficient protection from the ingress of dirt or other clogging material, again reflecting poor design.

The position of the rear rotating bolster on the bulk tipping vehicle or semi-trailer is important to safety. Some bolsters rotate from a position below the platform of the bulk tipping vehicle or semi-trailer though most do not. In discussions with operators, some maintain that the rotating bolsters should always be in line with the deck height of the bulk tipping vehicle or semi-trailer and at the same height as the rear twist locks.

The importance of the rear rotating bolster being at the same height as the deck height of the bulk tipping vehicle or semi-trailer is shown in the report HSL MM/04/24 at Annex 1.

The report HSL MM/04/24 also suggests that the rear twist locks on bulk tipping vehicles and semi-trailers should be as far forward as practical. This consideration was not put forward by any of the consultees interviewed for this report. It may not be easily achieved as other restrictions on the overall length of vehicles determined by “construction and use regulations” may intervene.

The report also suggests that the vertical distance between the pivot point and the twist lock platform is also important and it is suggested that this should be as small as possible. The horizontal distance between the pivot point and the furthest forward contact point between the twist lock and the container should be as large as possible.
At the design stage, due account should be taken of the static, dynamic, and torsional forces applied through the twist lock pins attached to the rotating bolsters in their specification and also with respect to the geometry of the rotating bolster in relation to the position of the twist locks.

For these reasons, operators need to ensure that the equipment is used and maintained in accordance with the manufacturer’s instructions.

5.5 Linking the Rear Bolster to the Front Bolster

There are advantages in safety to be gained in reducing the torque imposed on the rear twist locks and rotating bolster(s).

Work on this report has shown that a best practice is growing within the operating industry to require the front and rear bolsters of bulk tipping container semi-trailers and vehicles to be linked with two parallel beams. On most designs, it has been observed that the rotating rear and the front bolsters are not normally connected. One operating consultee reported suffering distortion of the rear twist lock assembly and could not initially discover why. Eventually it was shown that if the rear twist locks were not firmly screwed down a severe bending moment could be produced on the assembly in the order of 14715Nm as noted above. It was calculated through the research carried out jointly by the twist lock manufacturer and the bulk tipping container operator concerned that the risk could be significantly reduced by linking the front and rear bolsters together.

The benefit of linking the front and rear bolsters has been investigated by the HSL. It is concluded in report HSL MM/04/24 that there is an advantage to be gained by linking the two bolsters. Of those consultees who did not require the two bolsters to be linked many appeared not to have considered the magnitude and distribution of the static, torsional and dynamic forces at work on the twist locks of bulk tipping vehicles and semi-trailers or if they did, preferred not to incur the additional cost and more particularly the additional tare mass of the bulk tipping vehicles and semi-trailers.

5.6 Tipping Rams - Work Carried Out Under Elevated Bulk Tipping Containers

The dangers for workers carrying out their duties under tipped vehicle bodies which are not additionally propped up are well documented and are not further discussed here. Nevertheless, operators, maintenance workers, consignors, consignees and bulk tipping container cleaners should consider the dangers from work to be carried out in the raised condition. Apart from during maintenance, operatives may sometimes be required to work under laden bulk tipping containers in the elevated position e.g. to try to loosen compacted material by hammering on the exterior of the container. Reliance on the tipping ram alone to support the elevated bulk tipping container should be discouraged when such work has to be undertaken.

An issue which has emerged from this study concerns whether single or twin tipping rams should be fitted. Dangers may arise if twin rams are fitted if one fails to raise at the same rate of elevation as the other. This has been seen to be a cause of incidents with bulk tipping container vehicles and semi-trailers. Best practice in recent times shows a preference for single ram, some consignee consultees going so far as to ban the entry of vehicles and semi-trailers fitted with twin rams. It is therefore recommended that dual tipping rams are not used to elevate front bolsters in case the rams do not elevate in tandem.
Failures of tipping rams in service are known e.g. due to loss of hydraulic oil, rupture of seals etc. This may result in sudden collapse of the ram with attendant dangers. Some consultees insist on the use of rams which, should this happen, will descend slowly and at an even rate. This best practice should be encouraged.

5.7 Interlocking Devices

Work on this study has shown that whilst some interlocking devices to prevent tipping rams rising in unsafe situations are available, typically, little use is made of them. Examples of such interlocking devices which could be used include preventing the tipping ram from rising if:

- twist locks are not fully engaged and closed
- vehicle and semi-trailer brakes have not been applied
- there is lateral inclination of the bulk tipping container
- stabilising landing legs have not been lowered
- air suspensions systems are inflated (see below and Appendix 1)
- wind speed is excessive

The use of all of these interlocking devices should be considered.

Manufacturers have given some consideration to fitting interlocking mechanisms with a greater or lesser degree of enthusiasm for them. Some may offer them as optional extras to their customers rather than as standard features. Operators and sub-contractor hauliers are sometimes reluctant to take up interlocking mechanism options when they purchase bulk tipping vehicles or semi-trailers

A close-up of the sensing part of an interlocking mechanism fitted to a twist lock assembly is shown at Image O, Annex 1.

5.8 Remote Control

There is a risk of bulk tipping containers toppling sideways in the raised condition and causing injury or even death. The incident that stimulated this report was such an incident. Another incident of this kind is shown in Image E, Annex 1. Other accidents of this kind have occurred. Also, if there is a failure of the system of retention of bulk tipping containers in the elevated position on the vehicle or semi-trailer, bulk tipping containers may slip backwards again risking injury and death. It is desirable, therefore, that workers should be able to stand well away from bulk tipping containers in the elevated position e.g. outside the likely fall zones at the rear or to each side and yet still be able to carry out their duties. Remote control devices will facilitate the reduction of this danger. For bulk tipping containers, their carrying vehicles and semi-trailers, such devices are rarely provided.

In the UK bulk tipping road tankers are often fitted with a push button control attached to a cable, a so-called “wander lead” to allow operatives to raise and lower tipping rams while standing away from the tanker. These devices are seldom used on bulk tipping vehicles and semi-trailers. More extensive use of these devices should be encouraged. It is important that
the cable is long enough for operatives to carry out raising and lowering duties well outside rear and side fall zones.

Radio control technology to raise and lower bulk tipping containers appears not to be used with bulk tipping containers. Their use should be considered in suitable conditions, taking into account, for example, the likely development of static electricity on the substance(s) to be unloaded and the safe operation of such equipment in explosive zones.

5.9 Legs

Rear landing legs are fitted to many bulk tipping semi-trailers to assist with stability. Some operators consider these to be essential. Others were more selective, not always having them fitted to their semi-trailers. Such operators did not consider them always to be essential if the substance(s) being transported has/have a low bulk density and is/are free-flowing.

In deciding whether to fit this additional stabilising support, operators should consider as a high safety priority the need to ensure that the elevation of containers takes place with them perfectly laterally horizontal. Given the demonstration in report HSL MM/04/24 of the effects of lateral inclination in increasing the forces passing through rear twist locks, it should only be in the most exceptional circumstances that they are not fitted.

Rear landing legs also offer the benefit of sharing in the distribution of static, dynamic and torsional forces with the rear tyres of the bulk tipping vehicle or semi-trailer during tipped loading and unloading.

As mentioned above, articulated semi-trailers are fitted with landing legs towards the front in order to support them when the tractor unit is detached. A few situations have been identified where the discharge of bulk tipping containers takes place with the tractor unit detached. One consultee required three pairs of landing legs to be fitted to their bulk tipping semi-trailers in recognition of the static and dynamic forces which occur during bulk tipping container discharge. Where bulk containers on semi-trailers are to be loaded or unloaded without the tractor unit attached, the fitting of additional landing legs or other means of support provided at intermediate positions between the front and rear of the semi-trailers should be considered.

5.10 Vehicle Suspension Systems

Suspension systems are another safety critical feature during tipping. Semi-trailer and vehicle manufacturers should exercise care to ensure the chosen system is suitable for normal road transport purposes and also for tipping. The position of the rear axles and the suspension system can have a bearing on the transmission of dynamic, static and torsional forces. It is important that the geometry of the position of the axles relative to the position of the rotating bolster and rear twist locks is considered. As far as possible commensurate with other ‘construction and use’ requirements, the positioning of the axles and suspension system should be such as to reduce as much as possible increased moments due to the forces sustained during tipping. The position of the axles should be such as to provide an optimal method of distributing the static, dynamic and torsional forces to ground.

Most bulk tipping semi-trailers in service today have an air pressure suspension system. As described above, it is possible to deflate and re-inflate the bags holding the pressurised air. An issue identified during research for this report concerns whether air suspension systems should remain inflated and active or deflated when bulk tipping containers are tilted for loading (or sometime also for loading). Bulk tipping vehicle and semi-trailer manufacturers do not usually
specify whether air suspension systems should be left inflated or whether they should be

deflated during loading and unloading bulk tipping containers in the elevated position. The issue

has ramifications for the timing of the deployment of rear landing legs where fitted.

Different approaches are in use. Some consultees would say that the suspension system should

remain inflated. In this condition, all axles and tyres are able to share in the transmission of the

static and dynamic forces passing through the rear twist locks. The contact area of each tyre

with the ground as well as the contact area of the feet of the landing legs is then used. Tyre

defections are kept low. However the lateral stability of the tipped bulk container and vehicle is

reduced, as ‘bounce’ is possible if there is a sudden movement of loads during unloading.

Other consultees would say that the air suspension system should be deflated as its purpose is

only for normal conditions of transport and is not designed for tipping bulk containers. It should

play no part in load bearing during loading or unloading. The risk of ‘bounce’ is reduced if there

is a sudden movement of the load. Some opinions suggest that the stiffer the complete tipped

structure the better. However, the static and dynamic forces are not distributed over each axle

risking overloading, lateral stability tends to be handled by one axle only and the contact area

with the ground is reduced.

A further alternative view is to deflate the system partially, lower the rear landing legs, eliminate any lateral tilt and then complete deflation.

An industry perspective on these issues has been provided by the Society of Motor

Manufacturers and Traders at Appendix 1.

5.11 Inspection and Maintenance of the Main Tipping Elements

Inspection and maintenance issues were a major contributory factor in the accident which lead
to the death of the driver and which is the stimulus for this report. Although it was known that

the nut on the rear right hand twist lock stem was missing, the bulk tipping container semi-

trailer was kept in service. The driver attached some webbing through the twist lock assembly

and the container corner casting which broke on elevation. Attempts had been made to locate a
replacement nut but not in time to undertake the scheduled delivery.

Whilst inspections of the main tipping elements take place during routine maintenance of bulk

 tipping container vehicles and semi-trailers, this may be limited to checking that the tipping

element is inspected and lubricated but little more.

For example, only one consultee reported that the wear on the threads of twist lock stems would

be measured and, when a pre-determined amount of wear found (1 mm), the twist lock stem

would be replaced. Even that was a recent development in the consultee’s maintenance

programme.

Little consideration appears to be given to examining safety critical items such as twist lock

stems for signs of fatigue or corrosion or the development of cracks e.g. underneath the twist

lock stem head where it joins the stem itself.

Insufficient diligence may be being used to ensure that when components have to be replaced,

indeed, when a complete assembly has to be replaced, only those components recommended by
the manufacture for bulk tipping container work are acquired.

Further information on the inspection and maintenance of bulk tipping containers, vehicles and

semi-trailers is given at Annex 12.
6. Other considerations

6.1 Hierarchy of Choice for Unloading of Bulk Containers; Risk Assessment.

Unloading of bulk containers usually involves the tipping of the container so that gravity assists unloading. Consignors, consignees, bulk container operators and others involved in the unloading should consider the following options when deciding how the unloading will be safely completed:

- design, construct and operate the bulk containers so that they can be unloaded in the horizontal position
- transfer at the unloading point to a purpose built unloading platform
- unloading of the bulk tipping container on the carrying vehicle by elevation where the vehicle and container will be supported by a suitable structure in case of slewing sideways
- unloading of the bulk tipping container on the carrying vehicle by elevation where the vehicle and container are placed in a ‘fall zone’ where should the vehicle and container begin to slew sideways, it will fall within an exclusion zone
- unloading of the bulk tipping container on the carrying vehicle

The above list is presented as a hierarchy with horizontal unloading representing a higher level of inherent safety than tipping. The first option is being used in at least one case.

A risk assessment methodology should be used to inform any decision.

6.2 Instructions for Use and Maintenance - Flow of Information

In order to control the risks associated with tipping there should be a full set of operation and maintenance instructions for bulk tipping equipment including instructions for securing bulk tipping containers on their carrying vehicles and semi-trailers. These should be built up starting with component suppliers such as the suppliers of twist locks, tipping rams etc. There should be a complete exchange of technical specifications, conditions of use and possible misuse as well as preventative maintenance, component replacement and repair.

This is not happening to the extent necessary to ensure safety. For example, earlier in this report, some component suppliers report resistance in accepting installation advice on the part of tipping vehicle and trailer manufacturers whom they supply. Another example of this not happening is of pressure bulk tipping container manufactures and lessors who may not always pass on full technical details of their equipment to lessees such as the location, settings and flow capacity of pressure relief devices and the basis on which the flow capacity has been determined.

Exchange of information should be a two-way process in that e.g. consignees should convey their experiences from bulk tipping container unloading to operators and consignors who, in turn, should use feedback of this kind to inform component suppliers, bulk tipping container manufacturers and tipping vehicle / semi-trailer manufacturers to improve their designs.
The flow charts below provide examples of how written instructions for these purposes may be exchanged:

Further information concerning instructions to be assembled and passed on to operators and carriers by manufacturers of bulk tipping containers, vehicles and semi-trailers is given in Annex 7.

The Provision and Use of Work Equipment Regulations 1998 (PUER) apply to employers, the self-employed and to persons who have control to any extent of work equipment and the way in which work equipment is used at work. Whilst an employer such as a consignee has a responsibility for the safe unloading of bulk tipping containers as a type of work equipment, by the nature of transport operations, it follows that there are other duty holders who would have a responsibility for the safe operation of bulk tipping containers. This may be because they will have some control of the equipment such as operators, hauliers, lessors and the equipment manufacturers.

Employers are responsible for ensuring that work equipment is so constructed or adapted as to be suitable for the purpose for which it is used. This duty extends to taking into account the risks to health and safety of persons in selecting work equipment. In selecting work equipment, account has to be taken of its installation, inspection and maintenance. Such employers have a need to know that bulk tipping containers are safe for use at their premises for loading and unloading purposes. They need to be assured that competent persons are in charge of the use of
the equipment on their premises and that competent persons are in charge of its inspection and maintenance.

Many consignees appear to be dependent to a great extent on operators and their sub-contractor hauliers for ensuring that the bulk tipping containers, their carrying vehicles and semi-trailers are safe for use on their site. Few, if any, consignees operate their own bulk tipping containers and vehicles so that they are reliant in a great degree on the operators and sub-contractor hauliers for ensuring that the equipment is safe for use on their premises. In turn, operators and sub-contractors must rely on lessors, component and equipment manufacturers to supply equipment which is safe for use. Full and complete provision of installation, operation and maintenance instructions built up into a package of instructions for the bulk tipping containers and their carrying vehicles / semi-trailers must be an important tool for all duty holders.

Among the hazards to be considered are the risks of any article or substance falling from work equipment, its rupture or disintegration and unintended or premature discharge. These are specific hazards that may arise from the use of bulk tipping containers. Consignors and consignees need to be made aware of these dangers. In turn, consignors would have a duty to inform consignees whom they intend to supply with substances in bulk tipping containers of the risks associated with their use for unloading. Similarly, operators and sub-contractor hauliers would have a duty to inform consignees of the specific risks associated with the use of the bulk tipping containers and their tipping vehicles / semi-trailers. In order for a duty holder such as a consignee to be fully informed so as to enable him to comply with his legal responsibilities, there must be an exchange of information by both the consignor and the operators / sub-contractors. This does not currently happen to the extent necessary to ensure safety in the use of bulk tipping container technology.

6.3 European and International Standards

There are a number of relevant EN and ISO standards (see Annex 3 and Appendix 2) for containers and swap bodies. Persons intending to use these containers for built tipping should undertake a review of the relevant design standards to establish whether these are satisfactory in their provisions for bulk tipping containers, their component, and carrying tipping semi-trailers and vehicles. In particular ISO 1161:1984 ‘Series 1 Freight Containers - Corner castings – Specification - the primary standard for corner castings and Twist locks - and ISO 3874:1997 ‘Series 1 Freight Containers – Handling and Securing’ should be reviewed where they apply to twist locks to ensure they deal with the static, torsional and dynamic forces which occur during tipping loading and unloading. The use of twist lock technology for tipping discharge was probably not considered at the time these standards were developed. They may not be adequate to encompass the forces at work during tipping of bulk containers.

There may be a need to reconsider the design of twist lock pins used for tipping purposes with respect to their diameters and hardening processes during manufacture and so as to ensure sufficient area of grip between the lips of the twist lock head and the inner surfaces of the corner castings.

In addition, there may be a need to reconsider the closure mechanisms of twist locks to ensure through design criteria incorporated into standards that no relative movement of the twist lock stem head is possible when these are closed within the corner castings.

The relevant sectors of industry are invited to consider whether a review of these standards should be initiated to ensure they convey an understanding of the behaviour of the twist lock assemblies and what is transpiring between the twist lock stem head when closed inside the
corner casting of bulk tipping containers. New or improved standards could serve to provide all sectors with an understanding of:

- how twist lock technology is applied to tipping semi-trailers and vehicles for bulk containers
- how twist locks should be manufactured, used and maintained
- and to identify the limitations of use of this technology in tipping applications

It may be desirable for standards to be developed for the rotating bolsters fitted to bulk tipping container vehicles and semi-trailers taking into account the geometry of the bolster in relation to the height and longitudinal position of the twist lock assemblies.

Standards could usefully be developed to provide criteria for the materials from which twist lock assemblies and corner castings should be manufactured for tipping applications.

Standards could also be usefully improved and/or developed for bulkheads installed in standard freight containers and used to convert them temporarily into bulk containers. This work should be extended to encompass the methods of installation and strength requirements of hooks used to hold plastic liners in place both for purpose-built bulk tipping containers and for standard freight containers used temporarily as bulk tipping containers. Incidents have occurred due to the collapse of temporary bulkheads fitted in standard freight containers.

6.4 Wall Thickness

An EN Standard for swap bodies and the CSC provide some general requirements for the load bearing strength for the side and end walls of non-pressure bulk tipping containers. Suppliers, lessors and operators (owners) of non-pressure bulk tipping swap bodies should:

- be able to demonstrate that the side wall and end wall the strength of Class C swap bodies and (ISO) containers is sufficient for all substances carried in them in bulk or to have the strength of the side walls and end walls enhanced e.g. by using alternative materials and / or increasing wall thicknesses
- ensure that any additional side and / or end wall strength for bulk tipping containers is taken into account in any repairs

Where a design has been strengthened to cope with bulk loading and discharge, the method of strengthening e.g. by additional wall strength, choice of material of construction etc. should be made known by the supplier to lessors and operators in documentation and be indicated on the bulk tipping swap body. Lessors should also inform the lessee of this.

6.5 Statutory Annual Inspection of Large Goods Vehicles

It had been intended to recommend that the statutory annual inspections (MOTs) of Large Goods Vehicles (LGVs) be extended to include the inspection of twist locks where fitted. However, this has been overtaken by events during the preparation of this report and has now become part of LGV MOTs.
7. Principal Findings and Main Conclusions

The following industry issues have been identified. It should be said that these are generalisations. There were notable exceptions.

The principal findings of this report are that:

- the twist locks fitted to some bulk container tipping vehicles and semi-trailers are not those recommended for this purpose by the manufacturer

- it is a strength of the component manufacturers that they have recognised this though they make the unacceptable complaint that they cannot control dealers through whom they trade to ensure only those components deemed suitable for bulk tipping container applications are supplied to vehicle and semi-trailer manufactures and for spares or modification purposes

- there is a lack of understanding in the importance and function of the twist lock in tipping discharges among many of the sectors of industry especially among consignees involved in using bulk tipping containers

- there is a lack of understanding of the static, torsional and dynamic forces passing through twist locks securing the bulk containers to tipping semitrailers and vehicles amongst consignors, operators and consignees

- information from suppliers concerning installation, use, maintenance and repair of components, bulk tipping containers, vehicles and semi-trailers is either not produced, or insufficient and even where provided by one supplier to another is not necessarily passed on along the line to eventual users of the technology

- driver error is often the cause of accidents and incidents with bulk tipping containers

- there is a wide variety of other accidents with bulk tipping containers with other causes

- training of drivers in bulk tipping container loading and unloading is perceived to be important and often takes place but could be better structured to measure its effectiveness – see Annex 8

- training of other staff such as loaders and unloaders either does not take place or is insufficient in content in the health and safety issues concerning the loading and unloading of bulk tipping containers

- the effectiveness of the training provided is not measured.

- a good quality driver handbook dealing with bulk tipping container loading and unloading is considered essential. Responsible employers give a handbook to their drivers that include detailed instructions in the preparation of bulk tipping containers for loading, the loading and discharge operation. Examples have been seen that are of a high quality e.g. plentiful diagrams and pictures of how to do their work. Examples have also been seen where driver employers do not provide a handbook at all

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written procedures, diagrams, etc for loading and unloading for both drivers and site personnel where they exist lack precision, detail and do not show an appreciation of the engineering issues involved in bulk tipping container loading and unloading

little use, with notable exemptions, is made of interlocking mechanisms to reduce risks prior to elevation, during elevation and during decent of bulk tipping containers especially to detect twist locks which have not been properly engaged and closed

little use is made of remote control technology during tipped loading and unloading to reduce the risk of drivers and operatives having to work close up to bulk tipping containers

the various sectors of industry involved with bulk tipping containers tend to have an understanding that tipped loading and discharging has its own risks but in many cases the technical knowledge could be better shared and the depth of information improved

in particular, there is either weak or non-existent technical communication between consignors and consignees concerning the use and safety precautions to be taken when tipped unloading is to take place

consignors and consignees tended to regard the bulk tipping containers, the semi-trailers and vehicles which carry them as the province of the transport operator and his haulier and for which they have little or no direct responsibility

little use is made of comprehensive risk assessment techniques in the design and operation of bulk tipping container loading and, particularly, unloading points e.g. to eliminate tipping or reduce the risks

there can be a concentration on the ‘construction and use’ requirements for road worthiness on the part of bulk tipping container vehicle and semi-trailer manufacturers to the extent that the safety aspects of good engineering for loading and unloading purposes may not be fully researched and addressed

The main conclusions of this report are that:

- persons who carry out the maintenance and repair of twist locks are not made aware that manufacturers of twist locks have special designs which they recommend for tipping applications and that only the recommended designs should be used including when replacing components while in service

- good communication is necessary between all participants engaged in the design, manufacture, modification, maintenance and repair of bulk tipping containers and their carrying vehicles and semi-trailers - see information on the communication process given in Annex 6

- there are no recognised training / qualifications for drivers of bulk tipping containers in relation to the tipping, loading and unloading operation – see Annex 8
- tipping vehicle and semi-trailer manufacturers tend to concentrate on the 'construction and use' requirements and do not always give sufficient attention to the design issues relating to tipping bulk containers

- national, European and international standards concerning containers, swap bodies and their carrying vehicles and semi-trailers may not adequately cover the safety issues concerning the design, construction and use of bulk tipping container technology

- specialist operators of the bulk tipping containers tend to have an understanding of the dangers associated with their loading and unloading. In turn they attempt to manage their drivers and/or sub-contractor drivers so as to ensure this understanding is passed on. However, there are no substantial qualification barriers to entry into the operating business by either specialist operators or e.g. shipping lines which offer bulk transport in containers as a part of their portfolio of container services

- sufficient consideration has not always been given to the container equipment e.g. floor strength, welding procedures, temporary bulkheads, latching and unlatching of tail gates

The findings and conclusions of HSL report MM/04/24 contained in Annex 2 suggest some areas worthy of further consideration by tipping system designers.
8. Issues for Consideration

A significant number of issues have been identified in this report. These are presented for consideration by those involved with the design, manufacture and use of bulk container tipping equipment. They are covered in the following Annexes but the main issues are:

- only those twist lock assemblies specifically designed and recommended by the manufacturer for use with bulk tipping vehicles and semi-trailers should be fitted
- other components used in bulk tipping container technology should be those recommended by the manufacturer.
- a risk assessment should be made for bulk tipping container loading and unloading, examining whether tipping can be avoided or, if not, made safe including proper attention to the securing of bulk tipping containers to their tipping semi-trailers or vehicles
- full training of drivers and other operating staff which is measured for its effectiveness in bulk tipping containers should be given - additional information on training is given in Annex 7
- maintenance regimes for bulk tipping containers, vehicles and semi-trailers need to be reviewed to ensure all elements, and the types and limits of deterioration are covered
- consideration should be given to the greater use of interlocking devices to prevent tipping of bulk containers if twist locks are not fully engaged and closed in corner castings
- consideration should be given to the greater use of remote control of tipping operations
- drivers should never be left unsupervised during bulk tipping container loading and unloading. There should always be an additional person present e.g. to raise the alarm
- drivers should be provided with a comprehensive handbook for bulk tipping container loading and discharge. The content of handbooks is further discussed in Annexes 7 and 8
- suppliers of bulk tipping containers, vehicles and semi-trailers should supply users with a full specification, correct (and abusive) use and maintenance instructions, in turn, built up from instructions provided by component suppliers
Annex 1: Images Accompanying the Main Part of this Report

Image A: Damaged bulk tipping container semi-trailer
Image B: Failed twist lock components from a damaged bulk tipping container semi-trailer
Image C: Distorted twist lock housing on a failed bulk tipping container semi-trailer
**Image D:** Slewed toppling of a bulk pressure swap body tank due to failure of one of the rear twist locks
Image E: Slewed toppling of a bulk pressure swap body tank due to failure to ensure all twist locks were fully engaged and closed
Image F: 30 foot bulk tipping container crushed in the hold of a container ship due to stacking beyond its CSC design and certified maximum permitted gross mass

(Reproduced with permission)
Image G: A pair of split rotating bolsters which have been detached from a bulk tipping container semi-trailer
Image H: A full length rotating bolster on a bulk tipping container semi-trailer and screw down twist lock

Screw down twist lock bolster
Twist lock nut
Shear block
Full width rotating stem

Mushroom-like head of the twist lock stem

NB: The trailers in this image are referred to as ‘semi-trailers’ because they do not have any front wheels. They rely on the wheels of the tractor unit attached to the front for mass distribution and articulation.
Image J: A front lifting bolster on a bulk tipping container semi-trailer fitted with semi-automatic twist locks
Image K: Front landing legs

Retractable ladder fitted to assist with access to the top of bulk tipping containers e.g. in order to open and close loading hatches.
Image L: A rear landing leg

A raised rear landing leg
Image M: Corner casting, heal plates, mirror visible indicator

- Coloured end of lever to show up in driver’s rear mirror if twist lock not closed
- Corner casting
- Split twin rotating bolster
- “Heel plates”
Image N: The air bags or balloons of an air suspension system.

An “Air Bag”, part of an air suspension system.
Image O: Example of interlocking mechanism fitted to twist locks
Annex 2

Health and Safety Laboratory Report MM/04/24: The use of Twist Locks on Tipping Containers by Dr. James Hobbs
The use of Twist Locks on Tipping Containers

MM/04/24

Project Leader: James Hobbs
Author(s): James Hobbs, PhD
Science Group: Engineering Control
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Available to the public

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EXECUTIVE SUMMARY

OBJECTIVES

The objectives of this work were to evaluate the loads and stresses in twist locks under a variety of conditions and for a variety of twist lock geometries.

MAIN FINDINGS

1. Depending on the level of friction, the loading is mainly taken by the shear block. As a result the area at the junction between the shear block and the twist lock platform is highly stressed.

2. The level of friction between the corner casting and the twist lock has a far greater effect on the load taken by the shear block than the pre-load in the stem.

3. Relatively small angles of inclination have a large effect on the loads in the twist locks. At an angle of just 4°, the longitudinal loads in the lower twist lock double, while the load on the upper twist lock reduces to zero.

4. The effect of wind loading has been quantified. Containers with flat rectangular sides are approximately twice as susceptible to wind loading as cylindrical tankers. However, even a gale force wind on a flat-sided container would increase the longitudinal force on the twist lock by less than 20 kN.

5. At full elevation there is a strong tendency for the twist lock to rotate around its pivot. The moment about the pivot point is highly dependent on the height of the twist lock above the pivot point, and the horizontal distance from the pivot to the furthest forward point of contact with the container.

6. This rotating moment is resisted mainly by the force acting from the stem, resulting in high stresses. The geometry of the stem has a significant effect on the maximum stresses, with large radii between the shank and the head being the main factor.

7. Using beams to prevent rotation of the rear bolster relative to the container could reduce the stresses in the stem by approximately 30% and prevent the container detaching from the vehicle in the event of the stem head not being engaged.
1 INTRODUCTION

In the transportation of bulk powder or granular substances, the use of tipping freight containers is common. Often, the containers are designed to be swapped between vehicles and are connected to the vehicle by twist locks at each corner. There have been a number of serious incidents concerning the use of tipping freight containers where the container has detached from the twist locks resulting in the container falling from the vehicle. Obviously, this is a very dangerous occurrence and indeed, there have been a number of fatalities.

The incidents have occurred for a number of reasons, including failure of the shear block, failure of the stem or perhaps more commonly, failure to engage the stem by the operator. The aim of this project was to develop guidance for the industry and establish best practise.

This report details the load and stress analysis of the twist locks. This work has investigated a number of loading conditions, including tipping the container while the vehicle is inclined and subject to wind loading. The highest stressed components have been identified, along with the salient factors that effect stresses, such as the geometry of the twist lock components and friction.
2 FORCES ACTING ON TWIST LOCKS

2.1 DYNAMIC LOADING

One of the problems with discharging powders is compaction, where the powder sticks together to form a solid block. This commonly occurs during transit and makes discharge more difficult. During discharge a compacted block of powder may suddenly release when the container is in an elevated position, releasing a large mass that then impacts on the bottom end of the container generating large forces.

To assess the potential impact forces from this scenario is very difficult as powder flow is highly complex. A number of attempts were made using a dynamic finite element package with fluid–structure interaction capabilities, modelling the powder as if water but with the appropriate density for a powder. However, the properties were too far from the real properties to give any meaningful results.

A more reliable estimate, although still a very rough estimate, can be obtained by calculating the momentum of a block of powder and assuming that it is brought to rest when hitting the bottom of the container. For this analysis, the worst case would be for the container to contain a compacted volume of powder occupying the upper half of the container at full elevation (45°). Assuming a mass of the powder block of 13 tonnes at 6 m along the container, the momentum just before impact with the end of the container would be approximately 112 tonnes m/s. This assumes that there is a friction force on the block arising from a coefficient of friction of 0.2.

The most difficult factor to estimate is the time taken for this momentum to be lost during contact with the end of the container. As force = rate of change of momentum (i.e. force = momentum / time, if momentum is brought to zero by the force), the length of time is important. It is likely that the powder would not move as a block, but would flow and change shape as it descended. This should mean that the impact would not be instantaneous, but occur over a short time period. For a period of 1 second, the force would be 112 kN, for 2 seconds, the force would halve to 56 kN.

While these forces are high, they are not far in excess of the 87 kN longitudinal static force estimated for a full container at full elevation (see section 2.4.1). However, reducing the impact force time could greatly increase the maximum force. Further work is needed if more accurate values are needed.

2.2 FORCES AT TWIST LOCKS FROM CONTAINER

In order to allow tipping, twist locks are free to rotate. However, if the twist locks rotate independently of the container there is a risk of the twist locks becoming disengaged and the container would then be unsupported. With the container in the horizontal position the load on the twist locks is in the vertical direction, normal to the twist locks. As the container is elevated, the longitudinal forces increase and the normal forces decrease. Figure 1 shows a schematic diagram of a vehicle with a container in the elevated
position, and indicates the longitudinal and normal directions referred to throughout this report.

The forces acting on the twist locks were calculated by resolving the forces and moments and the relative longitudinal and normal forces are shown in Figure 2. At elevations above approximately 35° the longitudinal forces exceed the normal forces.

![Diagram of vehicle with tipping container](image)

**Figure 1** Schematic diagram of vehicle with tipping container
2.3 THE EFFECT OF LATERAL INCLINATION & WIND LOADING

2.3.1 Lateral Inclinations

The effect of lateral inclination (where the container is unloaded on ground sloping sideways) on the forces acting on the twist locks was investigated. The forces shown in Figure 3 are the longitudinal forces in line with the containers longest dimension. To aid visualisation of the angles represented, small images are included representing level ground, and inclinations of 6° and 14°. The values shown in the Figure assume a container with even weight distribution (i.e. either completely full or empty) at an elevation of 45°. As the effect of inclination is independent of load, the effect is shown in terms of percentage of load when level.

As can be seen, the forces on the lower twist lock (the ‘downhill’ side due to the inclination) double as the forces in the higher twist lock reduce to zero at approximately 4°. Although beyond this inclination, the forces in the longitudinal direction in the higher twist lock become negative, the normal forces on the twist lock always act to keep the container in contact, i.e. there is never a tendency for the container to lift off the twist lock for the angles covered here.

Figure 3 shows that inclination has a larger effect on the longitudinal forces than the normal forces, increasing the ratio between the two. A high ratio detrimentally effects the stresses in the stem of the twist lock (see section 2.4) although for this case the problem is alleviated somewhat when both twist locks are connected to a common bolster, because the inclination has an opposite effect on the two twist locks.
All these calculations assume that the lateral force applied by the ram to the top of the container is negligible. Allowing for this force would reduce the effect of inclination on the twist lock forces slightly.

![Graph showing the effect of inclination on twist lock forces]

**Figure 3** Forces on the twist locks due to lateral inclination (with container in elevated position)

### 2.3.2 Wind Loading

The forces acting on a body due to wind loading can be calculated if the drag coefficient appropriate for the geometry is known, using the following equation:

\[ F = \frac{C_d \times \rho \times A \times V^2}{2} \]  

**Equation 1**

where \( C_d \) is the drag coefficient appropriate for the geometry, \( \rho \) is the density of the air, \( A \) is the area normal to the wind direction and \( V \) is the wind speed. A \( C_d \) value of 1.2 is appropriate for a rectangular plate with an aspect ratio of 5, while for a cylinder with the same aspect ratio, a value of 0.74 would be appropriate.

The forces derived for a flat-sided container and a cylindrical vessel subjected to a range of wind speeds were then assumed to be acting on the centre of one side of the container. The resulting forces acting on the twist locks are shown in Figure 4. Wind speeds are shown in miles per hour, as this is likely to be the most familiar to the operators, and is the unit used in the Met. Office weather forecasts. To help with the interpretation of the wind speeds, the Beaufort wind scale is shown in Table 1. The forces graph shows wind speed of up to hurricane force, which firstly are never experienced in Europe and secondly, no operator would consider tipping a trailer in a hurricane. Only the positive
forces on the leeward twist lock are shown; for the windward side, the forces have the same magnitude but are negative.

The forces shown in Figure 4 are due to the wind loading only and should be added to loads arising from other factors. However, the forces are small compared to the other forces; a gale force wind would add approximate 18 kN to the load in a twist lock for a flat-sided container, or 11 kN for a cylindrical container. This work has looked at the effect of wind on the loads in the twist lock, but has not analysed the effect of wind on the overall stability of the vehicle while tipping. This would be highly dependent of the total weight of the vehicle, container and goods.

![Figure 4 Longitudinal forces on twist locks due to side wind loading (with container in elevated position)](image)

<table>
<thead>
<tr>
<th>Force knots</th>
<th>Speed km/h</th>
<th>Speed mph</th>
<th>Name</th>
<th>Conditions on Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt; 1</td>
<td>&lt; 2</td>
<td>&lt; 1</td>
<td>Calm</td>
</tr>
<tr>
<td>1</td>
<td>1-3</td>
<td>1-5</td>
<td>1-4</td>
<td>Light air</td>
</tr>
<tr>
<td>2</td>
<td>4-6</td>
<td>6-11</td>
<td>5-7</td>
<td>Light breeze</td>
</tr>
<tr>
<td>3</td>
<td>7-10</td>
<td>12-19</td>
<td>8-11</td>
<td>Gentle breeze</td>
</tr>
<tr>
<td>4</td>
<td>11-16</td>
<td>20-29</td>
<td>12-18</td>
<td>Moderate breeze</td>
</tr>
</tbody>
</table>

Smoke rises vertically.  
Smoke drifts and leaves rustle.  
Wind felt on face.  
Flags extended, leaves move.  
Dust and small branches move.
<table>
<thead>
<tr>
<th>Wind Speed</th>
<th>Wind Force</th>
<th>Effect on Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Fresh breeze</td>
<td>Small trees begin to sway.</td>
</tr>
<tr>
<td>6</td>
<td>Strong breeze</td>
<td>Large branches move, wires whistle, umbrellas are difficult to control.</td>
</tr>
<tr>
<td>7</td>
<td>Near gale</td>
<td>Whole trees in motion, inconvenience in walking.</td>
</tr>
<tr>
<td>8</td>
<td>Gale</td>
<td>Difficult to walk against wind. Twigs and small branches blown off trees.</td>
</tr>
<tr>
<td>9</td>
<td>Strong gale</td>
<td>Minor structural damage may occur (shingles blown off roofs).</td>
</tr>
<tr>
<td>10</td>
<td>Storm</td>
<td>Trees uprooted, structural damage likely.</td>
</tr>
<tr>
<td>11</td>
<td>Violent storm</td>
<td>Widespread damage to structures.</td>
</tr>
<tr>
<td>12</td>
<td>Hurricane</td>
<td>Severe structural damage to buildings, widespread devastation.</td>
</tr>
</tbody>
</table>

**Table 1** The Beaufort wind scale with effects seen on land
2.4 EFFECT OF FORCES ON TWIST LOCKS

The geometry of the twist lock varies between vehicles, but has a marked effect on the moments around the bolster. The two salient dimensions are the vertical distance from the centre of the rotating bolster to the bottom of the twist lock, and the horizontal distance from the centre of the bolster to the furthest forward component that is part of the rotating assembly. These two dimensions are illustrated in Figure 5, as $H$ and $d$ respectively. Due to the high longitudinal forces, the tendency is for the twist lock to rotate toward the rear of the vehicle (counter-clockwise in the diagram).

It should be noted that the twist lock need not be situated directly above the centre of rotation. Placing the twist lock further forward than the pivot point would increase $d$ and reduce the counter-clockwise moment. The moment is unlikely to act in a clockwise direction (rotating the top of the twist lock towards the front of the vehicle) as the point of application of the normal force could be anywhere on the twist lock platform. In the event of a tendency for clockwise rotation, the application point would move toward the back of the platform, reducing the moment.

![Figure 5 Schematic diagram of the forces acting on a twist lock](image)

There are a number of forces potentially acting to prevent the twist lock rotating. The main one arises from the stem clamping the corner casting of the container. The other forces come from torques preventing the bolster from rotating, either by having a single bolster connecting the two twist locks, or by using beams connecting the bolster to the front of the container.
The stem acts to apply a couple to the twist lock preventing rotation if the couple is equal to the moment from the main forces. As the twist lock is being forced to rotate, the stem applies a force onto the corner casting, as shown in Figure 6. For the container to remain in equilibrium, this force must be balanced with a force of the same magnitude\(^1\). This would be applied at the same position as force \(F_N\) in Figure 5. The magnitude of the couple would be equal to the force applied by the stem multiplied by the distance between the application points. This would be the distance \(d\) (from Figure 5) plus half the width of the head.

![Figure 6 Couple due to action of stem resisting twist lock rotation](image)

### 2.4.1 Example calculations

A stated above, the exact geometry of the twist locks and their attachment vary between vehicles, but some calculations have been performed using rough estimates of some of the dimensions to obtain an estimation of the forces. Some of the following dimensions are those of the recommended twist lock for tipping from the manufacturer Blairs (William Cook).

Horizontal distance from pivot point to furthest forward point of contact, \(d = 80\) mm  
Half width of head, \(W_h = 27\) mm  
Couple span, \(S = d + W_h = 107\) mm  
Distance from pivot point to top of platform, \(H = 100\) mm

Total mass of container and goods, \(m = 30\) tonne  
Elevation angle = 45°  
Longitudinal force, \(F_L = 87.0\) kN  
Normal force, \(F_N = 62.8\) kN

The moment about the pivot point arising from the main forces is:

\[
M = F_L \times H - F_N \times d \tag{Equation 2}
\]

\[
M = 3.67kNm
\]

\(^1\) The balancing force would be slightly higher to balance moments in the container. However, the distance of the twist lock from the pivot point at the front of the container means this difference in force would be negligible.
To prevent rotation of the twist lock and loss of the container, this moment must be resisted by either an equal torque on the bolster or a couple from the action of the stem. Assuming all the moment is resisted by the stem couple, the force applied by the stem is:

\[ F_p = \frac{M}{S} \quad \text{Equation 3} \]

\[ F_p = 33.1 \text{kN} \]

2.5 EFFECT OF BEAMS CONNECTING BOLSTERS

The above example assumes that all of the moment on the twist lock around the pivot is resisted by a couple generated by the stem. However, if the bolster were prevented from rotating, the torque in the bolster would take some of the moment.

If the bolster is prevented from rotating by connecting it to the front bolster using beams, it is possible to estimate the proportion of the moment taken by the beams and the stem. The moment acting at the end of the beams would cause the end of the beam (and therefore the bolster) to rotate slightly. For this rotation to occur, the head of the stem must deflect. The deflection of the stem head, \( \delta \), is dependent on the force taken by the stem, and therefore the moment taken by the stem. Therefore, the stem head deflection is present in the equations for the moment taken by both components so the relationship between the two moments can be determined.

For the following equations, \( L = \) length, \( E = \) Young’s modulus, \( I = \) second moment of area, \( A = \) cross sectional area, and the subscripts \( b \) refer to the beams and \( p \) refer to the pin (stem).

For the beams:

\[ \theta_b = \frac{M_b \cdot L_b}{4E_b \cdot I_b} \quad \text{Equation 4} \]

\[ \theta_b = \frac{\delta}{S} \quad \text{Equation 5} \]

\[ \therefore M_b = \frac{E_b \cdot I_b \cdot \delta}{L_b \cdot S} \quad \text{Equation 6} \]

The deflection of the stem head is a combination of bending and elongation due to the force on the stem head:

\[ \delta = \frac{M_p \cdot L_p \cdot W_b}{E_p \cdot I_p} + \frac{F_p \cdot L_p}{E_p \cdot A_p} \quad \text{Equation 7} \]

\[ M_p = F_p \cdot S \quad \text{Equation 8} \]
By combining equations 6, 7 and 8, and assuming $E_b = E_p$ the following expression can be obtained:

$$
\frac{M_b}{M_p} = \frac{4I_b \cdot L_p}{L_b \cdot S^2} \left( \frac{S \cdot W_b}{I_p} + \frac{1}{A_p} \right)
$$

Equation 9

Equation 9 is dependent only on the geometry of the beams and the twist lock, and assumes that both the twist lock stem and the beams are fixed at one end. Assuming geometry as in the example above, plus beams of 12 m length and an I-section of 127 mm $\times$ 76 mm (which gives an approximate mass for the beams of 300 kg), the figure obtained from this expression was 0.42, indicating that the stem takes approximately 70% of the total moment, with the beams taking the other 30%. The angle of rotation of the twist lock under these conditions would be less than 0.2°.

The main purpose of preventing the bolster from rotating is to prevent the twist rotating and disengaging with the container when the stem has not been engaged, either due to operator error or twist lock failure. In this case, it is important that the beams are stiff enough to carry the full torque. Under the full torque from the example in section 2.4.1, the maximum stress in the beams would be 74 MPa and the angle of the twist lock would be 0.6°.

### 2.6 FRICITION

The longitudinal force is taken by a combination of load on the shear block and friction. The friction is proportional to the normal force between the corner casting and the platform of the twist lock. The normal force consist of three main components:

1. The normal force due to the weight of the container
2. The tightening force applied to the twist lock stem
3. Extra force applied by the stem to prevent rotation of the twist lock

The pre-load will be constant through the tipping of the container but the other two normal forces, and the longitudinal force, vary with elevation angle. Figure 7 shows the results of the varying forces on the force taken by the shear block. Three different values for the friction coefficient are shown, with two levels of pre-load in the twist lock stem. The friction coefficients range from 0.1, representing greased steel on steel contact, and 0.74, representing dry, clean steel and steel contact. As can be seen from the figure, the friction coefficient has a significant effect on the load taken by the shear block. The effect pre-load has is highly dependent on the friction, having very little effect when the friction is low.
Figure 7 The effect of friction coefficient and stem pre-load on the load taken by the shear block

These values in Figure 7 are based on the conditions used in section 2.4.1. The highest force for the coefficient of friction value of 0.1 was 76 kN. This reduced to 38 kN for a friction value of 0.5 and down to 15 kN for a friction value of 0.74. All these figures are for no significant pre-load in the twist lock stem. The friction between the stem head and the plate has not been included in the calculation as it is possible that the stem could move slightly, and the normal force at the stem is less significant than force at the platform. If the stem friction force was included, the effect of the friction would be slightly higher, reducing the load taken by the shear block.

2.7 HEEL PLATES

Heel plates are often fitted to the back to twist locks to prevent the container slipping off the vehicle should the twist lock fail or not be tightened. The effectiveness of this arrangement has been doubted by some in the industry but it is still common practise.

Assuming that the bolster is not restrained in any way, a simple analysis of the forces shows that in the majority of cases heel plates would be ineffective. The tendency of the twist lock to rotate is not affected at all as the moment, due to the longitudinal force, is the same whether the force is applied to the shear block of the heel plate. With no torque from the bolster, and no stem, there would be no forces acting to prevent the rotation of the twist lock, so the locks would rotate even for a very small rotating moment.

If a continuous bolster is assumed, where both twist locks are connected to a single bolster, the heel plate could be slightly more effective. In this case, the moment on both twist locks would need to be resisted by the stem couple on one twist lock. The forces in
the stem to generate the couple needed would probably be very high and it is likely that the stem would fail.

The third scenario, where beams are used to prevent unwanted rotation of the bolster, the heel plate could be effective, in that the twist lock would not rotate and the container would stay on the vehicle. However, the container would be prevented from sliding off the twist lock by the shear block, so there would be no advantage of the heel plate over the shear block.
3 STRESSES IN TWIST LOCKS

3.1 THE SHEAR BLOCK

The maximum force obtained for the load taken by the shear block (see section 2.6) was 76 kN for a full container elevated at 45° with a low value of friction between the corner casting and the twist lock platform. The load was applied to a boundary element model of a twist lock and the resulting maximum principal stress can be seen in Figure 8. The highest stresses occur in the fillet between the shear block and the twist lock platform where a stress of 625 MPa was obtained. The model does not take into account any yielding of the material, which would reduce the peak stresses. However, it is undesirable to have yielding occur in normal operation, especially as the loads would be applied each time the container was unloaded.

However, the force used for this model was very conservative, representing a full container elevated to 45° with a very low friction coefficient and the friction on the stem neglected. Assuming a slightly higher coefficient of friction would bring the stresses down to more acceptable levels.

Figure 8 Results for a load of 76 kN on the shear block.

3.2 THE STEM

The technical drawings of a twist lock obtained from Blairs showed that the radius between the shank and the head was 1 mm. Small radii such as this can lead to very high stress concentrations in highly loaded components. To assess the effect of the different stem geometries on the stresses occurring in the stem, a number of detailed boundary element models were created.
Figure 9 shows contours of maximum principal stress in a stem of 38 mm diameter with a radius of 4 mm between the shank and the head (Model D). The model takes advantage of the two planes of symmetry through the stem, modelling one quarter of the stem. Loads were applied by fixing a line of nodes on the head representing the line at which contact would be made with the container corner casting, and by applying a tensile force to the bottom end of the stem equivalent to a total load of 1 tonne.

![Image: Maximum principal stresses in the stem with a 38 mm diameter shank and radius of 4 mm (Model D)](image_url)

**Figure 9 Maximum principal stresses in the stem with a 38 mm diameter shank and radius of 4 mm (Model D)**

It is not only the radius between the head and the shank that can be varied. Some designs of twist locks use larger diameter stems or intermediate blocks, creating an extra step between the head and the shank. A stem with a 52 mm diameter shank and a 2 mm radius was modelled (Model C) and the principal stresses are shown in Figure 10. In this case, the head of the stem was widened slightly. The maximum principal stress was 70.4 MPa, significantly below the 107.6 MPa in the 38 mm diameter stem with the same 2 mm radius.
Figure 10 Maximum principal stresses in the stem with a 52 mm diameter shank and radius of 2 mm and wider head (Model C)

The stem with the intermediate step between the head and the shank produced the lowest maximum principal stress. In this stem, the shank was 38 mm, with a 4 mm radius between the shank and the intermediate step, and a radius of 2 mm between the step and the head, as shown in Figure 11 (Model E). The step was 6 mm high across the full width of the head and was 53 mm in length. This configuration gave the lowest values of stress of all the geometries tested, with a maximum principal stress of 51.2 MPa.

The results from all of the stems modelled are listed in Table 2.
Figure 11 Maximum principal stresses in the stem with a 38 mm diameter shank and radius of 4 mm into an intermediate block and a 2 mm radius between the block and the head (Model E)

<table>
<thead>
<tr>
<th>Model</th>
<th>Stem Diameter</th>
<th>Radius (mm)</th>
<th>Maximum Stress (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>38</td>
<td>1</td>
<td>151.7</td>
</tr>
<tr>
<td>B</td>
<td>38</td>
<td>2</td>
<td>107.6</td>
</tr>
<tr>
<td>C</td>
<td>52</td>
<td>2</td>
<td>70.4</td>
</tr>
<tr>
<td>D</td>
<td>38</td>
<td>4</td>
<td>75.9</td>
</tr>
<tr>
<td>E</td>
<td>38</td>
<td>4</td>
<td>51.2</td>
</tr>
</tbody>
</table>

Table 2 Stresses in the twist locks under tightening load

Two of the models were re-run with the load obtained from the previous section (2.4.1), i.e. 33 kN. This load was applied near one edge of the head, not evenly across the full width as in the previous models. This is more realistic if the stem is resisting the rotation of the twist lock. As the stem was not longer loaded symmetrically, half models had to be created. The models used in the investigation were models A and E, the models with the highest and lowest stresses from the original analysis respectively.

The peak maximum principal stress in model A (38 mm diameter, 1 mm radius) was 750 MPa and the peak stress in model E (with intermediate block) was 470 MPa. The contours of maximum principal stress for this model are shown in Figure 12. For the axial loading, the peak stress in model E was approximately a third of the stress in model A. In the case of bending loads, the difference has narrowed, with the peak stress in model E being approximately two thirds of that in model A.
Figure 12 Contours of maximum principal stress in a stem under bending loading (Model E)
4 RESULTS FROM EXPERIMENTAL TESTS

4.1 THE SHEAR BLOCK

A number of static load tests were carried out on Blair non-retractable screw-down twist locks (part number BLR 149) by, or on behalf of, the manufacturer. Both the failure load of the shear block and the stems were obtained. The failure load of the shear block was 367 kN when applied to the end of the shear block (in the longitudinal direction). However, the failure occurred due to elastic deformation of the rig, rather than failure of the twist lock itself, although there was some plastic deformation of the shear block chamfer into the plate.

The high failure load is reassuring, as the load is in excess of any of the loads calculated. However, this was a static load, and the repeated loads seen in service would have to be significantly lower than the failure load to avoid fatigue problems.

4.2 THE STEM

Two different stems were tested, the standard stem (BLR149NRS) and the high tensile stem (BLR149NRS HTS). The failure load for the standard stem was 35.2 tons (344 kN) and the failure load of the high tensile stem was 42.2 tons (413 kN). The standard stem failed by part of the stem head shearing off. The failure of the high tensile stem occurred in the fixture, rather than the stem, although the stem was found to be significantly distorted after the test.

Again, the strength of the stem exceeded the strength necessary to withstand the loads calculated.
5 CONCLUSIONS

There are a number of conclusions to be drawn from this work concerning the best design and operation of twist locks for tipping applications.

1. Depending on the level of friction, the loading is mainly taken by the shear block. As a result the area at the junction between the shear block and the twist lock platform is highly stressed.

2. The level of friction between the corner casting and the twist lock has a far greater effect on the load taken by the shear block than the pre-load in the stem.

3. Relatively small angles of inclination have a large effect on the loads in the twist locks. At an angle of just 4°, the longitudinal loads in the lower twist lock double, while the load on the upper twist lock reduces to zero.

4. The effect of wind loading has been quantified. Containers with flat rectangular sides are approximately twice as susceptible to wind loading as cylindrical tankers. However, even a gale force wind on a flat-sided container would increase the longitudinal force on the twist lock by less than 20 kN.

5. At full elevation there is a strong tendency for the twist lock to rotate around its pivot. The moment about the pivot point is highly dependent on the height of the twist lock above the pivot point, and the horizontal distance from the pivot to the furthest forward point of contact with the container.

6. This rotating moment is resisted mainly by the force acting from the stem, resulting in high stresses. The geometry of the stem has a significant effect on the maximum stresses, with large radii between the shank and the head being the main factor.

7. Using beams to prevent rotation of the rear bolster relative to the container could reduce the stresses in the stem by approximately 30% and prevent the container detaching from the vehicle in the event of the stem head not being engaged.
6 ADVISORY COMMENTS

The results from this analysis of the twist lock components indicate that the following aspects of design and usage should be considered.

- As the stresses in a twist lock can be high, twist locks recommended by the manufacturer for tipping applications must be used.
- The following have been shown to reduce the stresses in the components:
  1. a large radius where the stem joins onto the head.
  2. a small vertical distance between the pivot point and the twist lock platform.
  3. a large horizontal distance between the pivot point and the furthest forward contact point between the twist lock and the container
  4. levelling the vehicle before discharge commences
  5. maintaining friction between the container corner casting and the twist lock

- Fitting beams connecting the front and rear bolsters is advisable as this may prevent the container from disengaging if the stem head is not engaged on the twist lock
Annex 3

Types of Bulk Tipping Container

The bulk tipping containers referred to in this report may be:

- non-pressure ISO containers of various lengths and heights purpose built to transport powdery and granular materials in bulk
- non-pressure ordinary ISO freight containers transformed temporarily for the transport of bulk materials by the installation of a bulkhead inside the back doors
- non-pressure swap bodies of various lengths and widths
- low pressure ‘cubic containers’, usually of swap body dimensions
- pressure ISO tank containers and swap body tanks intended for the transport of bulk materials.

There are several methods of use of non-pressure bulk tipping containers including:

- normal containers which are temporarily converted for the transport of bulk products by the insertion of a plastic liner of similar internal volume to that of the container and the placing of a bulkhead (there are several types in use) across the rear doors – see image U. The product to be transported is loaded inside the plastic liner e.g. by throwers, augers or conveyor belt. The plastic liner is removed and disposed of after unloading.
- bulk containers specifically designed and manufactured for this purpose into which the product to be transported is loaded through a sequence of circular hatches along the median line of the roof of the container.
- bulk containers as above where plastic liners are inserted with sleeves pulled through top hatches for loading. The plastic liners are removed and disposed of after unloading.
- ‘open top’ containers covered by an fixed-in-place tarpaulin.

Some photographs appear on the next three pages illustrating many of the kinds of bulk tipping container which are the subject of this report. All identification has been removed as far as possible.
**Image P:** Bulk pressure swap body tank

This container is slightly wider than a standard ISO freight container.
Image Q: Bulk pressure swap body tank showing tipping ram and front bolster

Front Tipping Bolster

Tipping Ram
Image R: Bulk tipping non-pressure container
Image S: ‘Cubic’ low pressure bulk swap body container

Image T: Conversion kit to convert non-tipping vehicle or semi-trailer to tip
Image U: Ordinary freight container converted temporarily for bulk use
**Image V:** Tipping platform onto which bulk tipping containers are transferred for discharge
Non-pressure bulk containers designed for the purpose typically have a full width hatch across the lower part of the rear to which a funnel is attached to guide product during unloading into a rotary valve. A flow of air underneath the rotary valve fluidises the product so that it can be conveyed into the storage silo or directly into the production process. Some may have rear doors so that the container can be used conventionally.

Other non-pressure designs may have a large circular opening at the rear, typically 30 cm diameter, centrally located across the width, with stop valve. A short, large diameter hose is attached to the opening to feed the product to be unloaded into a rotary valve. Fillet plates inside these bulk containers guide the product towards the opening.

Normal containers temporarily converted to bulk use are usually unloaded by clipping a funnel to the bulkhead to feed the product into a rotary valve either land based or mounted on the vehicle carrying the container.

‘Cubic containers’ are designed for low-pressure unloading, typically with a maximum allowable working pressure of 1.0 bar. They achieve a larger volume of capacity compared to pressure tanks and have a near square cross section supported by external ribs along their length.

There are some containers in use e.g. for the transport of wastes and aggregates, where a hinged full width and near full height tailgate opens for unloading.

Research has shown that there are other innovative technologies in the use of containers for bulk, for example a container that has an opening floor, hinged to one side running the full length of the container.

**Horizontal Discharge**

As mentioned in the main body of this report, through recent technological development, some pressure bulk tipping containers can be discharged by pressure without the need for tipping. The system may not be suited to every substance transported in bulk. The manufacturer maintains commercial confidentiality over the precise details of the system.

**Discharge on Tipping Platforms**

Also as mentioned in the main body of this report, some consignees have installed a permanent tipping platform on to which bulk tipping containers are transferred. Whilst tipping platforms can be more robustly manufactured consignees who opt for this method of discharge use container lifting equipment which in itself is costly and has its own attendant risks. See Image V.
Annex 4

Information and Safety Issues Concerning International Conventions, Standards and Regulations

Information is given and certain safety issues are raised in this annex concerning:

• ISO standards for Series 1 Freight Containers and EN standards for swap bodies
• The International Convention for Safe Containers (CSC)
• Minimum wall thickness requirements for solid wall swap bodies
• Minimum wall thickness requirements and the CSC
• Pressure and Non Pressure Bulk Tipping Containers for Dangerous Goods
• Pressure Tanks and Low Pressure Cubic Containers – Conformity, examination and testing according to the Pressure Equipment Directive (PED)
• Requirements for owners to develop a scheme of routine examination and testing according to the Pressure Systems Safety Regulations 2000 for (non-dangerous goods) pressure equipment
• Requirements The Pressure Systems Safety Regulations 2000 to ensure accidental pressure rise in non-pressure equipment to be prevented

International Standards for Series 1 Freight Containers and European Standards for Swap Bodies; Shortcomings of Standards for Bulk Container Technology

There are a number of International Standards Organisation (ISO) and European (EN) standards for the design, construction and use of freight containers and swap bodies. A non-exhaustive list is given in Appendix 2.

All sectors of industry involved with the design, construction, examination, testing, operating of bulk tipping containers including consignors and consignees should familiarise themselves with the relevant standards, their purpose and their limitations. In particular, for the purposes of this report, the need for a familiarity with the following two standards is emphasised:

• ISO 1161:1984 Series 1 Freight Containers – Corner castings – Specification
• ISO 3874:1997 ‘Series 1 Freight Containers – Handling and Securing

These standards do not necessarily address the use of corner castings and twist locks used to secure bulk tipping containers on tipping chassis and vehicles. The limitations of these standards are discussed in this annex.

Swap body bulk containers (i.e. not intended for fully multimodal operations and of different dimensions in at least one plane from ISO Series 1 freight containers) are designed and manufactured in accordance with the relevant European EN standards. Whilst the EN standards reference ISO 1161 as far as the internal dimensions and dimensions of orifices of corner
In the context of swap casting, the external dimensions and profiles may be adjusted to suit a particular swap body.

**International Convention for Safe Containers and the Freight Container (Safety Convention) Regulations 1984**

Many States are signatories to the CSC including the United Kingdom. The provisions of the Convention are imposed by The Freight Container (Safety Convention) Regulations 1984*. The Convention lays down provisions for the design, construction, examination and testing of containers meeting the definition of ‘container’ in the CSC.

*At the time of completing this report, a review of the CSC was under way.

Manufacturers, lessors, operators (owners) of bulk containers which are used in transport in the United Kingdom should note that the United Kingdom has applied the provisions of the CSC to all containers whether in use in national or international transport.

CSC defines a container to which its provisions apply as an article of transport equipment which is:

(a) of a permanent character and accordingly strong enough for repeated use; and
(b) designed to facilitate the transport of goods by one or more modes of transport without intermediate reloading; and
(c) designed to be secured or readily handled or both, having corner castings for these purposes, and
(d) of a size such that the area enclosed by the outer bottom corners is either
   (i) if the container is fitted with top corner castings, at least 7 metres; or
   (ii) in any square other case, at least 14 square metres.

Many swap bodies including bulk tipping swap body containers as well as ISO bulk containers meet the ‘footprint’ definition of ‘container’ in the CSC.

The CSC imposes duties on owners of containers, too. They must ensure that their containers are inspected once they are five years old and then at 36 month intervals thereafter. Alternatively an Approved Continuous Examination Programme (ACEP) may be used by owners.

It is the duty under CSC for the owner to have his containers ‘examined in accordance with the procedure either prescribed or approved by the Contracting Party concerned’.

Owners of freight containers including swap body tanks and swap bodies used in international trade will be accepted for use within the United Kingdom if the owners can demonstrate that their examination schemes have been authorised for use by the competent authority for CSC in their country. In the UK the competent authority is the Health and Safety Executive.
Solid Wall Box Type Swap Bodies - Side Wall and End Walls

European standard EN 283 for Class C swap bodies prescribes that the side walls for this (non-pressure type) Class need only be tested for 0.3P where P is the maximum payload. This minimum requirement may not be sufficient for bulk tipping swap bodies.

Bulk Tipping Containers - Side Wall and End Walls

The CSC prescribed that the end walls of containers should normally be tested to 0.4P and the side walls to 0.6P. These minimum requirements may not be sufficient for bulk tipping (ISO) containers. Suppliers and operators (owners) of (ISO) bulk tipping containers should be able to demonstrate that the strength of the side wall and end wall is sufficient for all substances carried in them or to have the strength of the side walls and end walls. The CSC states that ‘that in all phases of the operation of containers, the forces as a result of motion, location, stacking, and gravitational forces should not exceed the design strength of the container’.

Pressure and Non Pressure Bulk Tipping Containers for Dangerous Goods

Pressure and non-pressure bulk tipping containers intended for the carriage of dangerous goods must comply with the relevant provisions of the Regulations Concerning the International Carriage of Dangerous Goods by Rail (RID) and The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR). Where the sea mode is used, they should also comply with the International Maritime Dangerous Goods Code (IMDG Code).

Pressure Tanks and Low Pressure Cubic Containers – Conformity, Examination and Testing

Cylindrical bulk pressure tanks and ‘cubic’ containers intended for the transport of non-dangerous goods should conform to the requirements of the Pressure Equipment Directive, or the national equivalent regulations which implement the corresponding European Directives as appropriate to their design where the working pressure is more than 0.5 bar.

The Pressure Systems Safety Regulations 2000 require owners to develop safe working practices, a scheme of routine examination and testing, and the need to appoint a competent person to carry out the examination and testing at appropriate intervals.

Non-pressure Bulk Containers and Prevention of Pressure Rise

Many purpose-built bulk containers are designed for loading and unloading without the use of pressure (see image R). The Pressure Systems Safety Regulations 2000 require that if such containers could become pressurised, they should be vented and that precautions should be taken to ensure venting devices are kept open at all times and free from obstruction. There have been accidents and incidents involving positive and negative pressure in non-pressure bulk containers including:

- pressure rise e.g. due to blocked vents or inadvertent diversion of a pressure stream from under a rotary valve into a lined container.

- creation of negative pressure conditions, especially ordinary freight containers used temporarily for bulk consignments which do not have a venting system built into the containers.
Annex 5

General Information for the Design, Manufacture and Supply of Components for Bulk Tipping Containers, Vehicles and Semi-trailers

The information given in this annex is intended for those engaged in the design and manufacture of components used in bulk tipping container technology including manufacturers of Twist Locks, Landing Legs, Tipping Rams, Relief Devices, Interlocking and Remote Operation Control Equipment and Service Equipment (Funnels, Rotary Valves etc.). The information given here is in addition to the information given in the main body and elsewhere in this report.

The fatal accident which provided the stimulus to the preparation of this report and other accidents and incidents set out earlier in this report have shown that component failure and / or driver error in the use of components are a major cause of these accidents and incidents. Because of this, it is suggested that those engaged in the design and manufacture of components and service equipment used on bulk tipping containers and the vehicles or semi-trailers which carry them:

• provide in their detailed drawings and other written instructions for mounting that this is done in such a way that full access for maintenance and repair can be carried out

• state the welding procedures and welder qualifications required for installation and when being replaced. Incidents have occurred as a result of poor welding during the conversion of non-tipping to tipping semi-trailers. There may be resistance to accepting guidance from manufacturers as to how their components should be mounted

• include in their inspection and maintenance instructions what are unacceptable wear and tear necessitating replacement. Little guidance is given on inspection, maintenance and, in particular, unacceptable wear and tear is generally not given for safety critical components

• they are not interchangeable with non-tipping designs especially for twist locks assemblies. Component manufacturers report difficulty controlling their distributors from supplying designs not recommended for tipping applications. Preventing interchangeability would assist in reducing this

• state in catalogues and other publicity material which design or designs are recommend for tipping purposes and which, therefore, must not be used. This is especially important in the case of twist lock assemblies. Catalogues will indicate which designs suppliers recommend for tipping applications but there may be nothing to guide catalogue users to the relevant place in the catalogues for the recommended design nor any indication in the catalogues that the remaining designs of which there are often many are not recommended for tipping

• exercise control over their distributors to ensure that they fully understand the differences between tipping applications and general applications of what they supply so as to ensure only designs or their spare parts specified for tipping usage are sold. This is particularly important with respect to the supply of twist locks for tipping applications
Twist locks – Design, Manufacture and Supply

As noted in the main body of the report and elsewhere, there are many designs of twist locks, often designed and manufactured for a specific purpose including the very special application of this technology to bulk tipping containers. Twist lock manufacturers must recognise that there are special dangers associated with the use of twist locks for tipping applications, that the static and dynamic loads on them are different and more severe than in non-tipping applications. Responsible manufacturers of twist locks have recognised the tipping application as a special case and have developed designs to meet this particular use. As the stresses in the twist locks can be high, only those twist lock designs recommended by the manufacturers for tipping applications should be used.

For reasons discussed in the main body of the report and elsewhere, “snap-shut” twist locks which allow relative movement of the stem head inside corner castings should not be supplied for bulk tipping container applications.

Methods of manufacture should be suited to this application including hardening techniques. Suitable materials should be used.

Reamed-in split pins or similar devices susceptible to loosening by vibration should not be used to retain safety-critical parts of twist lock assemblies such as bars used to rotate twist locks. The design shown in Image W below is considered to be less than suitable, as the clip retaining the bar to be used to rotate the twist lock stem head into position could be lost allowing the bar to fall out and the retaining nut rotate off the stem. Twist locks similar to this one were fitted to the tipping semi-trailer involved in the fatal accident.

It is suggested that twist locks with retractable shear blocks are not used as the rear twist lock on bulk tipping container vehicles and semi-trailers. As noted in the main body of the report, this kind of twist lock is sometimes fitted in order to accommodate bulk tipping containers of different lengths.

Twist locks without shear blocks should never be used at the rear.

It is suggested that automatic or semi-automatic twist locks are actively considered for use in bulk tipping container operations. Some major operators specify the use of this kind of twist lock already.
Close-up of a Rear Twist lock Mounted on a Tipping Semi-trailer Supporting a Swap Body Bulk Pressure Container Through Engaging the Twist lock Stem in the Corner Casting

User instructions provided by semi-automatic and automatic twist lock suppliers should stress that vehicle driver must always check the full engagement of twist locks in the corner casting. Automatic twist locks may, for example, rotate to the closed position with the container resting on top due to misalignment when being lifted onto the vehicle. A driver would not necessarily be aware of this unless he makes a visual inspection.

User instructions should provide a warning that drivers and other relevant workers e.g. port, rail terminal and repair/storage depots ensure that all semi-automatic twist locks are released before attempting to remove a bulk tipping container from its carrying vehicle or semi-trailer.

Some of these twist locks have the possibility to be overridden by the driver. Drivers should not be able to override the operation of automatic or semi-automatic twist locks.

Suppliers of twist locks should consider:
Design:

- the benefits of having as large a radius as possible in twist lock stems where they go into the head due to the static, dynamic and torsional forces which pass through them
- the design and dimensions of the twist lock stem head in terms of its area of contact and grip in the closed position inside the corner castings of the bulk containers
- ensuring the twist lock stem heads rotate fully through 90° into the twist lock to ensure greatest possible friction inside the corner castings
- ensuring that their designs can accommodate all designs of bulk tipping container and that e.g. there should be no need to dismantle any part of the twist lock assembly in order to attach a particular kind of container. There is a design of twist lock and tipping semi-trailer where this is required
- ensuring that their designs will provide full base area contact with the bulk tipping container corner castings as a minimum
- effects of vibration to their designs - that vibration e.g. due to road surfaces cannot shake loose or otherwise render ineffective tie bars used to rotate the twist lock stem head into the closed position
- features that facilitate the removal of dirt and debris which may have accumulated in the twist lock housing

Manufacture:

- ensuring that materials of manufacture are suitable for bulk tipping container applications including through suitable process for toughening of metal, noting that the provisions of international standards may not be adequate for bulk tipping container applications of twist lock technology

Supply and Mounting on Vehicles and Semi-trailers:

- stating in their mounting instructions it is preferable that the twist locks be so mounted that the upper face of the housing will provide full base area contact with the bulk tipping container corner castings as a minimum
- ensuring that the twist locks supplied are suited to the maximum permitted gross mass (CSC, UIC◊) of the bulk containers to be carried
- reviewing the instructions for the installation of corner castings in bulk tipping containers to ensure that they are appropriate for this application
- including in the user instructions for twist locks for tipping that achieving good friction inside corner castings is essential to safety. The instructions should stress

◊ Union Internationale de Chemins de Fer, a body based in Paris which produces, among other things, standards for the international operation of railways.
the importance of friction in holding the bulk tipping container in place, how this is to be achieved and by what means

- a warning in the user instructions that if there is the slightest doubt as to the condition of the twist locks, the vehicle or semi-trailer is to be withdrawn from service instantly. User instructions should state clearly the correct usage of the twist locks and any mis-use to be avoided.

Use, Maintenance and Repair:

The inclusion in the inspection and maintenance instructions of:

- checking wear on corner castings and giving guidance on what level of wear is acceptable
- checking all main and secondary locking mechanisms for signs of damage, wear and malfunction
- lubrication by what lubricant and where to be applied. The instructions should stress the need to ensure lubrication does not spread to the under sides of the twist lock stem head or onto the plates which support corner castings
- the frequency and detail of examination and maintenance requirements
- a recommendation for fitters and other maintenance personnel to be trained in the correct examination and maintenance procedures, their frequency and criteria for acceptance for a further period of use
- a recommendation for fitters and other maintenance personnel to look out for forgeries when obtaining spare parts

Corner Castings – Design, Manufacture and Supply

Manufacturers should establish manufacturing criteria to ensure that there is no likelihood that twist lock stem head could slip through these corner castings through any defect in materials of construction or due to wear and tear.

Suppliers of corner castings for bulk tipping containers should:

Design:

- consider the static, dynamic and torsional forces which pass through corner castings for these containers, noting that international standards may not be adequate

Manufacture:

- ensure that only suitable metallic materials are chosen for the corner castings fitted to bulk tipping containers noting that international standards may not be adequate
- ensure there is suitable toughening of the metal after manufacture
- ensure that where corner castings are fabricated in two or more sections to be welded together, suitable welding techniques are used including using the skills of properly qualified welders, where necessary
Supply and Mounting on Bulk Tipping Containers:

- provide full instructions for the proper installation in bulk tipping containers, including relevant drawings, material specifications, toughening processes which have been carried out at the manufacturing stage and any processes which may be necessary to carry out after installation
- ensure that the corner castings supplied are suited to the maximum permitted gross mass (CSC, UIC) of the bulk containers to be carried

Use, Maintenance and Repair:

Include in the inspection and maintenance instructions for:

- checking for wear on the orifices of corner castings and give guidance as to how much wear should be allowed before the corner castings should be replaced
- the frequency and detail of examination and maintenance regimes
- a recommendation for fitters and other maintenance personnel to be trained in the correct examination and maintenance procedures, their frequency and criteria for acceptance for a further period of use
- a recommendation for fitters and other maintenance personnel to look out for forgeries when obtaining spare parts

Rotating Bolsters – Design, Manufacture and Supply

Due account should be taken of the dynamic, static and torsional forces applied through the twist lock pins attached to the rotating bolsters in their specification and also with respect to the geometry of the rotating bolster in relation to the position of the twist locks.

Where split bolsters are used, consideration should be given to providing a link (torsion bar) between the two so that elevation is not possible if the bolster(s) fail to rotate or rotate at unequal speed.

Rotating Bolster Designers, Manufacturers and Installers should consider:

Design:

- the design of rotating bolsters are such as to allow for full lubrication e.g. using greasing channels and, at the same time prevent the ingress of moisture or foreign matter likely to cause failure. An outer casing protecting the rotating parts is recommended. Some consultees follow this example of good practice

Supply and Mounting on Vehicles and Semi-trailers:

- wherever possible single, full width bolsters are mounted to reduce the risk from unequal rotation
- suppliers provide full mounting instructions for the bolsters on the tipping vehicle or semi-trailer
Use, Maintenance and Repair:

- suppliers point out in their instructions for the use of their rotating bolsters that users are to be alert to dangers from split, twin rotating bolsters rotating at unequal speed during elevation operations
- suppliers provide full maintenance instructions for the rotating bolsters including the correct method of lubrication. Detailed maintenance instructions of this kind are not always provided
- suppliers provide advice in dealing with emergencies with rotating bolsters such as from failure to rotate or rotation at unequal speed

Landing Legs – Design, Manufacture and Supply

As noted in the main body of this report, it is common practice to fit additional stabilising support for tipping bulk container semi-trailers, usually in the form of a second pair of ‘landing legs’ at the rear.

In deciding whether to fit this additional stabilising support, vehicle and semi-trailer manufacturers in conjunction with operators and lessors should consider the need to ensure that the elevation of containers takes place with them perfectly laterally horizontal.

The design of landing legs used for stabilising purposes should compare the merits of having:

- more robust construction
- longer, reinforced sleeve for the leg
- shorter legs
- reinforced rigid foot with a larger contact area with the ground
- heavier duty winding mechanism

than the landing legs typically fitted in forward positions to semi-trailers of ordinary articulated vehicles for support when the tractor unit is detached. Some manufacturers have designs of this kind which they recommend for tipping applications.

Tipping Rams – Design, Manufacture and Supply

Opinions collected for this report suggest that dual tipping rams are not used to elevate front bolsters in case the rams do not elevate in tandem.

Suppliers should also:

Design:

- consider fitting an audible warning if lateral tilt becomes unacceptable or, better, an interlocking mechanism so that raising is not possible if tilting
- consider providing protection so that the tipping mechanism cannot be accidentally operated. At least one consultee follows this good practice
• consider providing protection so that tipping cannot continue unattended once started

• consider fitting a pilot-operated check valve or flow restrictor in case of hydraulic hose failure. At least one consultee recommended this as good practice ensuring that drivers or other workers cannot override the non-return valve

Use, Maintenance and Repair:

• including in inspection and maintenance instructions the action to be taken by drivers and other employees if there is any operational failure while elevating, while in elevation and while descending. Ideally, if there is a failure, the ram should automatically descend slowly and at the same time emit an audible warning

• including in the use instructions guidance on tipping height to be used for discharge and speed of lowering (sudden stops) restrictions associated with the operation

• providing an explanation of the significance of any audible warnings

• stressing the need to ensure that products are equally distributed in bulk tipping containers so that e.g. excessive torsional force on the tipping rams is avoided

• stressing the need to control the decent speed

• include in operating instructions details of the fluids to be used in operation

Axles and Suspension Systems – Design, Manufacture and Supply

As noted in the main body of this report, it is important that the geometry of the position of the axles relative to the position of the rotating bolster and rear twist locks. To repeat, as far as possible commensurate with other ‘construction and use’ requirements, the positioning of the axles and suspension system should be such as to reduce as much as possible increased moments due to the forces sustained.

The following issues are also worthy of consideration:

Supply and Mounting on Vehicles and Semi-trailers:

• the suitability of axles and suspension systems not only for ‘construction and use’ purposes but also with respect to the static, dynamic and torsional forces which may occur in tipping applications

• the use of an interlocking mechanism so that where draining the air is the adopted practice, raising of the tipping rams is not possible with the suspension system still inflated

• protecting the operation of the air inlet valve with an interlocking mechanism so that accidental re-inflating of the deflated system cannot happen while the semi-trailer or vehicle is in the tipped position
Use, Maintenance and Repair:

- the degree that the air suspension systems should be deflated, partially deflated or completely deflated prior to starting elevation for tipped loading or unloading. The information from suppliers should indicate when in the sequence of the unloading operation the air suspension system should be deflated where they consider this necessary e.g. prior to, during or after lowering the rear stabilising legs (see above and Appendix 1)

- indicate in their instructions for the use of suspensions systems for bulk tipping container applications dangers to be alert for in operation such as possible rupture of the flexible air pressure reservoirs. They should indicate what action should be taken by drivers and other employees if there is any operational failure of suspension systems especially in the tipped position

Pressure and Vacuum Relief Valves – Design, Manufacture and Supply

Pressure relief valves are being fitted routinely to pressure bulk tipping containers. Ideally they should also be fitted with vacuum relief valves. The fitting of pressure and vacuum relief valves is discussed in the following annex.

The set-to-open, fully open and reset pressures, as well as the flow capacity of the pressure relief devices, are not always being stated in the instructions provided for the pressure bulk container manufacturers.

Supply and Mounting on Pressure Bulk Tipping Containers:

- suppliers indicate in their drawings, specifications and written instructions for installation on the tank shell and service equipment the suitable locations for installation of pressure and vacuum relief devices

Use, Maintenance and Repair:

- suppliers include in their instructions for examination and maintenance the set pressures and flow capacities pressure and vacuum relief valves so that users of the tanks are aware of any pressure or flow limitations

Funnels and Rotary Valves - Design and Manufacture and Supply

Funnels should be designed so that they cannot easily become detached and, as far as practical, be without risk from e.g. damage to hands when installing on to, removing from the bulk containers and during cleaning.

Suppliers of rotary valves should:

Design:

- ensure they are designed so as to avoid foreign matter falling into them
• afford protection against the risk of hands, limbs, clothing etc. becoming caught up in them. Accidents have occurred where hand digits have been lost during the use of rotary valves

Supply and Mounting:
• provide instructions for the mounting of rotary valves on tipping vehicles and semi-trailers including welding techniques, sliding mechanism, etc

Use, Maintenance and Repair:
• include in inspection and maintenance instructions the action to be taken by drivers and other employees if there is any operational failure of the rotary valve

Locking Bars for Non-pressure Bulk Tipping Containers - Design and Manufacture and Supply

Some purpose-built non-pressure bulk tipping containers are fitted with rear doors for e.g. gaining access to install liners or for use as conventional containers as well. Others may have a large tail-gate which swings open for discharge whilst those purpose-built non-pressure bulk tipping containers, as already noted, may have a full width rear hatch onto which a discharge funnel is attached for discharge. Locking bars are fitted to secure the doors / tail gates / rear hatches.

Ordinary freight containers can also be temporarily converted for bulk transport as already noted. In such situations, the locking bars on such containers must be strong enough and must sufficiently engage in the locking mechanism so that they cannot open.

Suppliers of locking bars should:

Design:
• ensure their designs are suitable for and able to withstand likely static and dynamic forces encountered during tipping discharge
• ensure their designs avoid the danger of drivers and other workers having to stand in front of rear doors or tailgates to open them in the tipped position
• consider the use of remote control opening mechanisms

Supply and Mounting:
• provide instructions for the mounting of the locking bars

Use, Maintenance and Repair:
• include in inspection and maintenance instructions the action to be taken by drivers and other employees if there is any operational failure of the locking bars
Liners - Design and Manufacture and Supply

Plastics liners are installed in bulk tipping containers in some applications of this technology. They are usually removed after use together with any residues.

Suppliers and users of liners should:

**Design:**

- ensure their designs will not lead to any inadvertent pressure rise
- reduce the risk of envelopment and suffocation of workers who have to install and remove them through their design
- ensure their designs will not block venting systems on non-pressure bulk containers. At least one supplier tapers the design towards the front to reduce the risk of blocking vents

**Use:**

- provide instructions for installing and removing the liners
- include in the instructions the action to be taken by drivers and other employees if there is any operational failure of the liners
- state in their instructions for installing and removing the liners, the size and type of bulk tipping container they are intended for and in which, therefore, they should not be fitted e.g. because they may block the venting devices of the containers
Annex 6

General Information for the Design and Manufacture of Bulk Tipping Containers, Vehicles and Semi-trailers Including Modifications

Note: information given here is applicable manufacturers, lessors and any other suppliers.

This annex contains general information applicable to those engaged in the design and manufacture of bulk tipping containers vehicles and semi-trailers which carry them and components which are mounted on them. The information given here should be read in conjunction with other information given in the main body and elsewhere in this report. The information given here should also be taken into account by those who carry out the modification of bulk tipping containers vehicles and semi-trailers, particularly when converting non-tipping semi-trailers to bulk tipping container semi-trailers.

Design and Manufacture of Bulk Tipping Containers Vehicles and Semi Trailers

Accidents and incidents have occurred due to equipment failure including due to inappropriate conversions of non-tipping semi-trailers.

Innovative technology is not always being applied to reduce the risk drivers and other workers when loading and discharging bulk tipping containers.

The manufacture of these semi-trailers and vehicle bodies is a specialist activity. It should be undertaken only by those undertakings with the proper engineering expertise as is demonstrated by some of the incidents reported in the main body of this report where conversion of non-tipping semi-trailers attempted by some operators has caused accidents.

The information here does not replace ‘construction and use’ requirements which need to be met for use of vehicles on the public highway.

Bulk tipping container semi-trailer manufacturers and vehicle body manufacturers should install ancillary equipment such as twist lock assemblies, rotating bolsters, stabilising landing legs, other landing legs, tipping rams and their motors:

- which are those recommended for the purpose
- taking into account the installation recommendations of the supplier of particular component; and
- in particular with respect to the geometry in positioning rotating bolsters and twist lock assemblies

Research undertaken for this report shows that because of the need to ensure that bulk tipping containers are laterally horizontal, suppliers should fit at least two spirit levels or similar devices so that any lateral inclination of bulk tipping semi-trailers or vehicles can be detected and eliminated through a stabilising process such as using the rear landing legs. Small lateral inclinations may increase the loadings on twist locks significantly. This example of good practice is followed extensively.
There is an interlocking device available on the market which prevents tipping if lateral inclination is excessive though little use of it has been made so far.

In addition to the information given in the main body and elsewhere in this report, the following additional issues are raised for bulk tipping container semi-trailer and vehicle suppliers to consider.

Designers of bulk tipping container vehicles and semi-trailers should:

**Design:**

- because incidents have occurred due to rotating bolsters seizing up or because e.g. through lack of lubrication, ingress of dirt, internal corrosion etc not rotating as fast as required by the speed of elevation of the tipping rams consider providing a 'tell-tale' device such as a return spring to indicate whether there is a problem with bolsters rotating

- use is made of finite element analysis and other computer aided design / manufacture techniques to assess suitability of designs with respect to the static, dynamic and torsional forces at work in the use of bulk tipping containers and their carrying semi-trailers and vehicles. Where relevant, joint analyses should be made by component manufacturers, the container manufacturers and the tilting vehicle or semi-trailer manufacturers

- ensure that all components critical to safety fitted to them are only those that are specified by the suppliers for tipping applications

- consider the vertical distance between the pivot point of the rotating bolster on vehicles and semi-trailers and the twist lock platform which ideally should be as small as possible. The design and manufacture of bulk tipping containers should be such that they can be accommodated on vehicles and semi-trailers of this kind of design

- consider the horizontal distance between the pivot point of the rotating bolster and the furthest forward contact point between the twist lock and the container which ideally should be as large as possible. The design and manufacturer of the bulk tipping container should be such they can be accommodated on the vehicles and semi-trailers of this kind of design

- consider fitting beams connecting the front and rear bolsters as these reduce the torque on the rotating bolster if the twist lock head has not been fully engaged in the corner casting e.g. due to operator (driver) error, the main cause of incidents

- design all components so that there is full access for maintenance and repair to be carried out

- consider whether three sets of landing legs should be fitted i.e. in addition to any rear stabilising landing legs and the usual front part at a mid point if tipping for loading or unloading is to take place without the tractor unit attached to the semi-trailer in order to provide adequate support for laden bulk tipping containers

- consider in their designs where drivers and other workers will have to stand or be to carry out their duties so that as far as practicable, they are not exposed to risks to their health and safety
• consider the use of interlocking mechanisms for the purposes indicated in this report
• consider the provision of remote controls for safety critical operations

**Manufacture:**

• all components should be mounted in such a way that full access for maintenance and repair can be carried out
• the welding procedures recommended by component suppliers are used for mounting them during manufacture with a corresponding need to ensure that welders are suitably qualified
• where detailed drawings and written instructions are provided by component suppliers to show how these are to be mounted including material thickness etc of the mounting points on vehicles, semi-trailers and bulk tipping containers these are followed during manufacture
• operating and maintenance decals including those provided by component suppliers should be displayed in prominent positions
• mark the bar or handle which turns the twist lock pins into the closed position with a fluorescent or similar highly visible colour so that e.g. drivers can notice unclosed twist locks in their driving mirrors. As mentioned in the main body of this report and elsewhere, the most common cause of accidents and incidents with bulk tipping containers is drivers who do not close all the twist locks fully. This good practice enables drivers to notice that they may not have done so as they look in their driving mirrors
• install components in such a way that they can be easily examined and maintained. This is not always the case

**Interlocking Devices**

Consideration should be given to the following interlocking mechanisms for use on bulk tipping container semi-trailers and vehicles to prevent tipping in the following circumstances:

• when stabilising landing legs have not been lowered
• when air suspension systems are inflated (see Section 5.10 and Appendix 1)
• when twist locks are not fully engaged and closed
• when wind speed is excessive
• when there is lateral inclination
Design and Manufacture of Bulk Pressure Tank Containers, Swap Body Tanks and ‘Cubic Containers’ - General

Pressure tanks should be designed and constructed and repaired in accordance with the provisions of a recognised pressure vessel code and relevant pressure equipment regulations. They should also conform to relevant ISO or EN standards and The Freight Containers (Safety Convention) Regulations 1984 or the CSC.

Service equipment such as pressure relief valves, outlet valves, manlid assemblies, flexible and rigid pipework should be installed:

- which are recommended for the purpose
- taking into account the installation recommendations of the particular component
- so that examination, maintenance and repair or replacement can be carried out

Not all service equipment can be easily examined or maintained.

Because incidents have occurred with bulk tipping pressure containers, suppliers of bulk tipping pressure containers should consider:

Design:

- avoid places such as corners where product may congeal by e.g. chamfering the interiors, fitting fillet plates, surface treatment. Accidents and incidents have occurred due to product “cling”
- installing vibration equipment to break up congealed material where there is the risk of “cling” from the substances to be carried
- where there is a risk of vacuum conditions occurring suitable vacuum relief devices are fitted.
- fit a pressure balancing device to compensate for changes in ambient temperature where the operating area may be where extremes of low or high ambient temperatures occur. This example of good practice was being followed in some instances
- fit ‘safe bolts’ to guard against inadvertent opening of tank shell manlids while under pressure
- consider whether the substances to be carried may cause abrasion and thinning of the shells. Consultees advise that some substances including certain types of cement, lignite, some detergent additives and waste paper have produced shell thinning
Pressure vessel bulk tanks should be fitted with pressure relief devices. Industry practice is typically to fit at least three relief valves for the:

- tank shell
- air supply for unloading (top air)
- air supply to the outlet filter (bottom air)

The set-to-open, fully open and reset pressures of each pressure relief device should be determined in relation to the working pressure of the tank shell and pipework.

Manufacturers of bulk tipping pressure containers determine the flow capacity of the pressure relief devices on the basis of the air supply from compressors mounted on bulk tipping vehicles (typically 800m³ per hour @ 2 bar). In sizing the flow capacity manufacturers do not typically recognise that the pressurising medium may come from another source e.g. compressed air or nitrogen supplies provided by consignees which may permit a larger flow volume.

The set pressures and venting capacities of pressure relief devices are not always communicated to users in operating and maintenance instructions nor is the rationale for which has been used to determine the relief capacity of pressure relief devices stated.

Where there is a risk of vacuum conditions vacuum relief devices are fitted. The set pressure and capacity of the vacuum relief devices should be determined in relation to the volumetric capacity of the tank shell and the external overpressure for which the shell has been designed.

### Design and Manufacture of Non-Pressure Bulk Tipping Containers and Swap Bodies

The floors of bulk tipping containers should be designed for a specific static load. The maximum load per square metre should be stated in the instructions for users and repairers mentioned below. Failures of bulk tipping containers have occurred because the floor strength limit has been exceeded.

Tipping application should be considered in selecting ancillary equipment such as outlet hatches, opening flaps, outlet valves, and loading hatches assemblies. These should be installed so that maintenance and repair or replacement can be carried out.

Non-pressure bulk containers should be fitted with suitably dimensioned vents in their structure so as to prevent overpressurisation. The vents should be so designed that they are unlikely to become blocked during use. This is a routine practice but it may not be always obvious to users e.g. consignors and consignees what they are or where they are fitted. For this reason it is suggested that their location on the bulk tipping container should be indicated and made known in operating and maintenance instructions.

Non-pressure tipping containers should conform to relevant ISO or EN standards and The Freight Containers (Safety Convention) Regulations 1984 or the CSC.

Suppliers of bulk pressure tipping containers should consider:
Design:

- the end walls and side walls of non-pressure tipping containers to ensure they are adequate for the substances to be carried and the service to which they will be put
- avoiding the creation of places such as corners where product may congeal by e.g. rounding the interiors, fitting fillet plates, providing a suitable surface treatment.
- installing vibration equipment to shake loose congealed material or e.g. guides for rods to be inserted to break up congealed material
- ensuring end door locking bars, tail gate and other closures at the end of these bulk containers can withstand the static and dynamic forces which may be imposed on them while tipping
- whether the substances to be carried may cause abrasion and thinning of the walls. Consultees advise that some substances including certain types of cement, lignite, some detergent additives and waste paper have produced wall thinning
Annex 7

Information for Manufacturers including Modifications of Bulk Tipping Containers, Vehicles and Semi-trailers Concerning Details of Use, Maintenance and Repairs to be Passed on to Operators, Hauliers etc.

Note: information given here is applicable to manufacturers, lessors and any other suppliers.

General Information for Manufacturers Concerning the Passing on of Details

- safety information is not always assembled, consolidated and passed on to eventual users of bulk tipping containers, their carrying semi-trailers and vehicles
- inappropriate conversions of non-tipping trailers has taken place
- maintenance and repair guidelines are often inadequate

Manufacturers of bulk tipping container vehicles and semi-trailers (and those carrying out modifications) should:

Use, Maintenance and Repair:

- provide full inspection and maintenance instructions. These should include inspection and maintenance instructions from the component suppliers which should be passed on to the purchaser. The instructions should not only refer to lubrication but other inspection and maintenance instructions important for safety including unacceptable wear and tear especially to safety-critical components which have been mounted on the bulk tipping container, vehicle or semi-trailer. The instructions should describe the action to be taken by workers e.g. drivers and other employees if there is any operational failure
- provide instructions for use and maintenance in the form of durable decals that can be applied to the bulk tipping containers, vehicles or semi-trailers
- stress in their inspection and maintenance instructions the essential need to ensure that only supplier’s recommended spare parts are used, especially for twist locks for tipping applications and give warnings that look-alike components which may not give the same level of safety performance are sometimes found in the market place

Specific Information for the Manufacturers Including Modifications for the Use, Maintenance and Repair of Bulk Pressure Tank Containers, Swap Body Tanks and ‘Cubic Containers’ Concerning the Passing on of Details

Manufacturers (and modifiers) of bulk pressure tank containers, swap body tanks and ‘cubic containers’ should:

- provide operators (owners) with a full specification of the bulk tipping containers including details of the standards to which they conform and the specifications of individual items of service equipment. The specifications provided may not always be as full in content as they may be e.g. in not explaining the rationale for the set pressures and flow capacities of pressure and vacuum relief devices
• state in the instructions they provide the pressure vessel code used to design the bulk pressure tank containers and that any repairs to the tank shell should be made following any relevant provisions of the pressure vessel code. Suppliers should explain in their instructions for maintenance and use the significance using a pressure vessel code and the pressure equipment regulations for design and construction purposes. The importance of these codes and regulations is not always fully understood by operators

• emphasise in the examination, maintenance and repair instructions for bulk pressure tank containers which they provide any safety-critical components for tipping which have been fitted

• the instructions also state that repairs to the framework of the bulk pressure tank containers should be carried out so as to conform to the original design approval for CSC purposes. Operators (owners) do not always fully understand the requirements of the CSC

• explain in their instructions the requirements of The Pressure Systems Safety Regulations 2000 with respect to the duty on owners to develop safe working practices, a scheme of routine examination and testing, and the need to appoint a competent person to carry out the examination and testing at appropriate intervals

• provide details of the set-to-open, fully-open and reset pressures of pressure relief devices. They should also provide details of the flow capacity of the relief valves and give warnings as to the consequences if the pressure fluid(s) exceed the flow capacity. The rationale behind the determination of the set-to-open, fully-open and reset pressures should be explained as well as the rationale supporting the way in which the required flow rates have been determined

• clearly indicate the correct operation of safety-critical components in the use instructions they provide. The instructions should clearly indicate unsafe operating conditions. They should incorporate the instructions for use of the various safety-critical components from their suppliers. Instructions for use do not always explain their correct operation, unsafe conditions and what to do if they arise

• stress that accidental indentations of the tank shell should not be ignored as these may spread and / or widen into tears. Some suppliers have stressed the importance of explaining this phenomenon as an example of good practice

Specific Information for the Manufacturers Including Modifications for the Use, Maintenance and Repair of Non-Pressure Bulk Tipping Containers and Swap Bodies Concerning the Passing on of Details

Manufacturers (and modifiers) of bulk pressure tank containers, swap body tanks and ‘cubic containers’ should ensure:

• they provide operators (owners) with a full specification of the bulk tipping containers including details of the standards to which they conform, floor strength and any aspects of the design and construction which exceed than the requirements of relevant standards, The Freight Containers (Safety Convention) Regulations
1984 or the CSC in order to meet the operating conditions of bulk tipping containers. Information supplied to operators and users is not always sufficient

- the maintenance instructions mention that repairs to the non-pressure bulk tipping containers should be carried out so as to conform to the original design approval for CSC purposes. Operators (owners) do not always fully understand the requirements of the CSC

- explain in their use and maintenance instructions the location of any venting systems and their venting capacities that have been built into non-pressure bulk tipping containers.

- stress the dangers from inadvertent pressure rise or vacuum conditions as incidents have occurred.
Annex 8

Safe Operation of Bulk Tipping Containers - Recruitment and Training of Drivers; Training of other Members of Staff; Establishing the Competency of Members of Staff

Recruitment and Training of Drivers, Operatives and Maintenance Staff Engaged in Loading and Unloading Bulk Tipping Containers

As noted in the main body of this report and elsewhere, driver error is often the cause of accidents and incidents with bulk tipping containers. Operators and their subcontractors should develop a policy for the selection of drivers that includes e.g. health and fitness, alcohol and drugs abuse. They should carry out theoretical and practical training and re-training of drivers particularly where they are involved in loading and unloading. Similar policies should be adopted for the recruitment of loading and unloading operatives employed by consignors and consignees as well as for the recruitment of maintenance staff. Guidance given in this Annex is based on guidance set out in an Health and Safety Executive guide to employee training and from indications that driver and other employee training is not always to the standards that could be expected.

A good training scheme for drivers may encompass among other features:

- imparting a willingness and enthusiasm for conducting bulk tipping container loading and unloading in the safest manner possible
- encouraging a good dialogue between the trainees and the trainer as to how safe loading and unloading will be achieved
- provision in conditions which promote the concentration of the trainees on the safety issues e.g. comfort, free from distractions and where the trainees can easily see the trainer and the training aids he/she uses and where refreshments and toilet facilities are provided
- is customised to reflect the knowledge and ability of the trainees
- trainers with good technical expertise in the subject that can be imparted at the level of understanding of the trainees
- trainers who keeps up to date with the subject e.g. reflecting any relevant changes in legislation, new or modified equipment being used for bulk tipping container work, changes in customer loading and unloading facilities or those of new customers, new on-site rules at customer premises, modifies his/her presentations in the light of new experiences
- is supported by high quality training materials and training aids
- has a limited class size suited to ensuring proper interaction between the trainees and the trainer
- has suitable tests or other measures to ensure learning has taken place
- is supported by after-course care and surveillance
is supported by refresher training at suitable intervals

Proper training of newly recruited drivers and other staff including maintenance staff engaged in loading and unloading of bulk tipping containers is recognised as critical for safety. The training should be well planned or organised. Whilst employers recognise the importance of driver training for bulk tipping containers, the training is not organised and followed up in as systematic a way as is desirable.

Because of this it is suggested that as a **first step** employers:

- formally identify the skills and knowledge needed for the job
- compare these skills with the current skills and knowledge of recruits and identify any gaps
- review experiences of injuries, near misses or ill health
- consult existing drivers, operatives, maintenance staff or their representatives for their views on training content and how it is carried out
- consider the awareness training needs of directors, managers and supervisors so that they gain an appreciation of the importance of bulk container vehicle drivers. In connection with this assessment of the training need and its provision, how the employer manages health and safety should also be taken into account, who is responsible for what, by whom and how hazards are identified and risks evaluated and what measures are to be used by drivers to control them

As a **second step**, employers should decide and prioritise the provision of training by considering:

- whether the law requires specific training
- where lack of information and / or training might result in serious harm
- that training for new employees is always a priority
- where providing training will benefit the largest number of staff
- the opinions of other employees and their representatives

The **third step** is to choose appropriate training methods and resources. It is suggested that the following training methods be considered:

- giving information and instruction
- training in the classroom
- coaching or on-the-job training
- in groups or individually
• interactive learning

Employers should also consider who could help them with the training such as:

• industry or national training organisations
• employer bodies and qualification-awarding bodies
• trade unions
• further education colleges
• private training organisations
• independent health and safety consultants

In some circumstances, government-assisted finance packages may be available to meet some of the costs of the training.

Training should be delivered in an easy-to-understand manner using a variety of methods to deliver the training (the fourth step). In the case of tipping operations for loading or unloading, in particular, the use of video / DVD training films has been found to be effective. These may be produced by the employer or e.g. by industry organisations. Training should include both classroom and on-the-job training.

As a fifth step, employers should check that the training has worked. Evidence that the training has worked includes whether the drivers and other loading and unloading operatives:

• understand what is required of them?
• have acquired the knowledge and skills needed to work safely with bulk containers?
• are actually working in the way they have been trained?
• are providing feedback from their experience doing their job?
• need further information and / or training?
• have changed their behaviour and working practices?

Employers do not always measure the effectiveness of the training.

Employers should monitor whether there has been an improvement in health and safety performance and whether the most suitable training methods have been used. In particular, employers should monitor that twist locks have been closed and screwed down and that the need for defect reporting, unsafe operating conditions reporting is understood.

In the context of the five steps for managing bulk container driver training, both classroom and on-the-job training methods are used. The techniques of loading and unloading can be explained in the classroom followed by e.g.

• a period of on-the-job training with an experienced driver of one to two weeks leading to
• a probationary period where the new recruit carries out the work under the supervision of the experienced driver and then

• observation of the new recruit at work by an experienced technical manager or engineer with formal appraisal, authorisation and recording.

• periodic checking by supervision to ensure that training continues to be followed

Employers should ascertain that the trainers they choose to use, whether in the classroom or on-the-job, have the necessary knowledge, experience and skills in bulk container loading and unloading. Employers should also ensure that the trainers they choose have good communication skills.

It is suggested that the training provided for drivers include the following topics (the list is not exhaustive):

• the proper method of closing twist locks and the need to ensure all are fully closed when a bulk container is being loaded, carried and unloaded

• the importance of properly functioning and maintained twist locks for their own safety and that of others

• positioning as far as possible of bulk tipping containers against the shear block of the twist lock assembly

• the importance of free rotation of rotating bolsters and where split bolsters are fitted, the importance of equal rotation

• correct and incorrect use of interlocking mechanisms and remote control devices

• correct use of personal protection equipment and clothing

• hazards of dust explosions

• safe methods of installation and removal of disposable liners where used

• in-line positioning of tractor units and semi-trailers

• vehicle alignment for tipping

• hazards of over head obstructions

• application of vehicle brakes the for loading and unloading

• lowering and raising stabilising landing legs

• activation or de-activation of air suspension systems prior to loading and unloading (noting the discussion of this matter in the main body of this report and Appendix 2)

• dangers from wind pressure, wind direction etc during tipping, when drivers should take advice, stressing that they must not be the sole arbiters on when loading or unloading in the tipped position may take place
• importance of tipping for loading or unloading on firm ground
• elimination of lateral tilt and the importance of ensuring no lateral deviation from vertical in the tipped position
• earthing for loading and unloading
• measures to be taken to avoid accidental rise in pressure during non-pressure bulk container loading and unloading
• measures to be taken to avoid excessive pressure during loading and unloading of pressure bulk containers
• location and function of pressure relief devices and vents
• correct use of tipping rams
• correct use of donkey engines, power take-off devices etc
• safe methods of loading bulk containers in the horizontal position including for breaking the angle of repose and ensuring even distribution of the load over the floor area of non-pressure bulk containers
• safe methods of loading bulk containers in the tipped position
• safe methods of unloading in the horizontal position
• safe methods of unloading in the tipped position including progressive tipping stage by stage during unloading
• safe methods of attaching and detaching unloading funnels, hoses, earthing leads etc
• safe methods of extending or fitting in-line rotary valves and safe methods of their use
• safe methods of pressurising, monitoring pressure levels and depressurising bulk pressure containers
• safe methods for fluidising powdery and granular substances
• dangers from sudden surge, cling, ‘rat holing’, ‘bridging’, ‘arching’ phenomena and safe methods for dislodging congealed material
• hazards from exposure to the substances loaded or unloaded and the protection required
• noise hazards
• vibration hazards
• hazards from asphyxiating gases
• safe places while monitoring loading and unloading operations

• measures to be taken if twist locks, tipping rams, landing legs, rotating bolsters, locking bars, interlocking mechanisms etc. malfunction

• hazards arising from attempting to drive vehicles away with loading or unloading equipment still attached or improperly stowed away

• maximum permitted gross mass of the vehicle and of bulk containers (CSC)

• importance of marking bulk containers which contain an unsafe atmosphere such as from the use of asphyxiating gases

• importance of ensuring all openings are closed after use especially for multi-modal transport

• reporting of unsafe work conditions, practices and occurrences

• use of asphyxiating gases such as nitrogen and precautions to be taken to warn others such as cleaning and maintenance staff etc of the presence of a nitrogen rich atmosphere

• where to stand to carry out their duties when connecting up, commencing loading or discharge, during the loading or discharge process and during disconnection after loading or unloading

• safe methods of cleaning and removing liners, etc.

All training should be recorded.

Employers should continue to monitor employees for signs of alcohol and drug abuse.

Refresher training or reassessment should be carried out from time to time, which should also include on-the-job monitoring to ensure no unsafe practices have been developed. The refresher training should review the loading and unloading operations, recall any incidents and what can be learnt from them, a reminder of all the safety devices fitted, where to stand during loading and unloading, the importance of closing twist locks etc. Refresher training should be carried out whenever there is a change or modification of bulk tipping containers, semi-trailers, vehicles or equipment used in loading and unloading.

There should be an active dialogue between drivers and trainers.

The training should include the pre-use and pre-tip driver checks and drivers should be taught that under no circumstances should they attempt to use any bulk tipping container vehicle or semi-trailer with the slightest defect.

Emergency procedures during loading and unloading should be taught including using any information provided by the equipment suppliers as to what to do in an emergency.

Drivers should be encouraged to report any unsafe loading or unloading conditions they encounter at any stage of their employment. Drivers should be informed that loading or unloading in the tipped position should not be attempted if there is any doubt concerning safety.
It is recognised that each employer will provide the training for drivers in his or her own way. Employers (hauliers) may work primarily or even exclusively for an operator of bulk containers. These employers are encouraged to seek the help and co-operation of the operators to whom they are contracted in delivering the training, monitoring of the effectiveness of the training and in the refresher training.

Where the substances are dangerous goods, drivers should receive the mandatory training and take the necessary examinations to obtain a national vocational training certificate (ADR certificate). These certificates should be renewed at the prescribed intervals (5 years). This training does not replace the training described in the preceding paragraphs.

**Training of Other Employees**

It is stressed that the training and retraining loading / unloading operatives and others such as maintenance staff in their duties with respect to the loading, operation, unloading, maintenance and repair of bulk tipping containers use of bulk tipping containers and the tipping vehicles which carry them is essential. They should be informed that loading or unloading in the tipped position should not be attempted if there is any doubt concerning safety.

A good understanding of the safety issues concerning loading and unloading especially in the tipped position must be imparted to them. They should understand, in particular, the importance of closing the twist locks so that no relative movement of the twist lock stem head inside the corner castings is possible and of allowable and non-allowable wear and tear on them.

**Training and Competence – Accredited Training Scheme**

The affected sectors of industry are encouraged to work with each other towards the development of an accredited training scheme for bulk tipping container drivers and other workers. This would ensure objectivity in the training provided and ensure that all drivers and workers are trained to the same minimum high standard.
Annex 9

Driver Handbooks

Some employers of drivers issue a well prepared and thought out driver’s handbook covering loading and unloading of bulk tipping containers in which e.g.

- written instructions
- diagrams
- photographic sequences

can be given and shown on how to load and unload bulk containers. Good quality handbooks include plentiful diagrams and photographic sequences. This is considered to be a highly effective way of providing information for the driver.

Instructions, diagrams, etc in the handbook should cover the topics mentioned in the annex on training – see Annex 8.

Driver handbooks should clearly indicate where drivers should stand and walk around their vehicles during loading and unloading of bulk tipping containers.
Annex 10

Information for Consignors, Consignees and Operators

Consignors, consignees and operators should make themselves fully aware:

- of the risks associated with use of bulk tipping containers
- of any design limitations at the loading or unloading facilities
- of any equipment or container limitations such as pressure limitations

Consignors, consignees and operators should consider safety aspects of the loading and unloading of bulk tipping containers when planning the transport operation. Consignors should advise their customers accordingly with the assistance of their chosen operator(s)

Consignors and consignees should act in conjunction with operators in the design of loading and unloading facilities to enable safe operation of bulk loading and unloading facilities. Information for the design of loading and unloading facilities is given in the separate Annex 15.

General Information for all Loading and Unloading Operations

The behaviour of substances, bulk tipping containers and their carrying semi-trailers and vehicles is both complex, safety critical and dependent for the distribution of forces on the geometry of tipping semi-trailers. These need to be understood by all concerned with loading and unloading bulk tipping containers, especially with respect to the design, use and maintenance of twist locks.

Pre-use checks using suitable check list of all equipment should be made on tipping vehicles and semi-trailers with particular emphasis on the condition and functioning of twist locks prior to departure from haulier depots. Vehicles and semi-trailers which have defects for loading or discharge should be taken out of service. (This advice does not override operators’ and subcontractors’ duties under the ‘construction and use’ regulations.)

Loading or unloading must never be attempted until it has been confirmed that all twist locks are fully engaged and screwed down. This is especially important for loading or unloading in the tipped position with the bulk tipping container wherever possible resting against the shear blocks. Over tightening should be avoided. It should be noted that as tipping commences, the settling of the container against the shear blocks and / or movement of the substance inside the bulk tipping container may induce some further tightening of the rear twist lock on one side and slackening on the other side. A further check of tightness may be needed.

Even though the operation of the twist locks may be semi- or fully automatic, drivers and other operatives must still check these are fully engaged and closed before tipping, (noting that interlocking mechanisms may, in any case, prevent tipping if fitted).

Prominent notices should be displayed at all loading and unloading places stating what should and should not be done in the interests of health and safety.

Consignors, consignees, operators, sub-contractors and drivers should ensure that:

- all unnecessary personnel are excluded from loading and unloading areas
• tractor unit and semi-trailer are in line especially for tipped loading and unloading

• brakes have been applied and if possible the vehicle disabled from movement until the loading process is complete. Consideration should be given to using interlocking devices so that loading or unloading cannot commence if brakes or other means of securing the vehicle have not been engaged. Wheel chocks, where provided, should be deployed

• where sliding bogie semi-trailers are used, the bogie has been locked in the correct position for loading or unloading and that, where fitted, hinged twist locks are locked in place

• all stabilising and other landing legs have been lowered

• there is no lateral inclination of the bulk tipping container

• where unloading has taken place under pressure, a safe system of depressurising is used

• the maximum allowable working pressure of pressure bulk tipping containers is not exceeded

• the flow through pressure relief devices will not exceed their rated flow capacity

• all hoses have a pressure rating at least equal to the maximum allowable working pressure of bulk pressure containers or e.g. the pressure used in rotary valve unloading

• pressurised hoses have a means of restraint in case they inadvertently become detached under pressure

• where nitrogen or other inert gas is used for any purpose during loading or unloading, it is used safely and that the bulk container is durably and clearly marked in conspicuous places such as on outlets and loading hatches that nitrogen or other inert gas is present (see the dangerous goods regulations)

• where there is a risk of dust explosions or the development of static electricity, suitable precautions should be taken to minimise these dangers

• inhalation of dusts is avoided

• loaders and unloaders are advised of and clearly understand the venting system on non-pressure bulk containers and that loading and unloading takes place in such a way as to avoid vent blockage and pressure build up or partial vacuum. All should be alert to the risk of sudden rises in pressure e.g. due to blockages. All should be alert to the risk of implosion if pressure conditions lower than atmospheric pressure arise

• all personnel are informed as to where to be, where to stand to do their work during the loading and unloading operation taking into account the possibility of tipped bulk containers falling rearwards to ground or slewing sideways.
where liners and bulkheads are to be installed prior to loading or removed after unloading, the safety instructions for these operations e.g. to reduce the risk of asphyxiation are followed. The atmosphere should be checked for acceptable levels of oxygen before entering the container.

where plastic liners have been inserted in containers, these are vented after loading to avoid e.g. causing distortion of the walls.

e all openings on the bulk container are closed after loading or unloading. In this connection, employees should be made aware of the consequences for transport by rail if any loose component of the bulk container such as top hatch covers and manlids could bounce up and hit overhead electric power cables, bridges, station canopies etc.

tarpaulins, where fitted e.g. to ‘open-top’ containers should be closed and secured so that no part of the tarpaulin or its closure system remains loose.

vehicles are not driven away with any removable equipment such as earthing leads, hoses etc are still attached.

consideration should be given to requiring employees to wear a high visibility garment.

drivers and other members of staff are issued with any necessary protective clothing and equipment for the loading operation.

protection is afforded to all workers from the effects of vibration such as when attempting to dislodge non-flowing product and noise such as from blowers and compressors.

adequate protection is afforded to drivers and other members of staff all workers to prevent falling from a height.

drivers report all defects on semi-trailers and vehicles, particularly those affecting safety during tipping operations. Drivers should make these reports on all semi-trailers and vehicles whether occasionally or permanently allocated to them.

comprehensive checklists are used covering all safety issues are developed and completed prior to loading and unloading.

drivers are never left to complete loading or unloading operations on their own. There should be constant attendance throughout.

where it is not obvious that a freight container contains a bulk load, this is indicated on e.g. the door locking bars.

a check is made to ensure all residual pressure has been dissipated before disconnecting hoses.

all concerned recognise that some substances with a water content may freeze in cold ambient temperatures with consequent dangers from ‘cling’ etc. at these times.
• no pressure vessel tank should be entered e.g. for cleaning until an assessment of the oxygen level and other gases, liquids or solids present has been made. A ‘permit to work’ system should be employed

When standard ISO containers are converted temporarily for the transport of bulk materials, precautions should be taken to ensure:

• temporary rear bulkheads are strong enough to withstand the mass of the load bearing down on it during tipping discharge including acceleration forces due to the sudden movement of compacted material

• there is no inadvertent rise in pressure or creation of partial vacuum conditions

• tipping takes place with one of the rear doors closed as an additional precaution

Where loading or unloading in the tipped position takes place with the bulk container on the semi-trailer or vehicle, consignors, consignees, operators and drivers should ensure:

• a check should be made that the receiving silos have sufficient capacity (including venting capacity) to accept the consignment

• tipping operations are clear of all overhead obstructions such as power cables, pipework, gantries etc. in whatever direction the vehicles face. In this connection the possibility of vehicles entering the loading point from opposite directions should be considered or of modifications to overhead conditions where the height of tipping vehicles has been overlooked

• loading takes place progressively in the sense that the container should not be elevated to full height immediately. Rather part loading should take place with progressive raising of the container at appropriate intervals to distribute the product inside

• lowering of the bulk container after loading should be undertaken slowly and carefully bearing in mind there may be some movement of congealed product towards the front

• loading or unloading should not be attempted where the total mass will exceed the gross mass / geometry for which the tipping rams have been designed

**Specific Information for Loading in the Horizontal Position**

Where loading in the horizontal position takes place with the bulk container on the semi-trailer or vehicle, consignors should ensure:

• in order to ensure even distribution of the substance during top loading in the bulk container, a sequence of loading through the top hatches should be devised e.g. filing through the middle hatch first, the two adjoining hatches second and the outermost hatches filled last

• where the substance forms an angle of repose leaving voids which have to be filled, a safe method of breaking the angle of repose is devised e.g. using a thrower inside the loading hatches
Specific Information for Unloading in the Tipped Position on the Vehicle

Where unloading of bulk containers takes place in the tipped position on the semi-trailer or vehicle, consignors should ensure:

• all employees are aware of the dangers of sudden movement of the load as tipping progresses and also the dangers from compacted material clinging to the roof, front wall or upper sides of the bulk tipping container. All should also be aware of the danger of loads which slide down one side of the bulk container creating an imbalance and risk of toppling
Annex 11

Guidance for Hauliers, Loaders and Unloaders of Bulk Tipping Containers

General Information for all Loading and Unloading Operations

The information given here is aimed at ensuring safety during bulk tipping container loading and operations, especially in the use of twist locks for this purpose.

Competent supervisors and / or managers should supervise drivers and operatives during loading and unloading operations, especially in the tipped position. Supervisors and / or managers may according to circumstances be from those in charge of the loading point, the unloading point, the bulk tipping container operator, the haulier. Drivers should be audited to ensure that correct procedures are being followed.

Pre-use checks using suitable check list of all equipment should be made on tipping vehicles and semi-trailers with particular emphasis on the condition and functioning of twist locks prior to departure from haulier depots. Vehicles and semi-trailers which have defects for loading or discharge should be taken out of service. (This advice does not override operators’ and subcontractors’ duties under the ‘construction and use’ regulations.)

These checks should be repeated upon arrival at the premises of consignors and consignees jointly by the consignor and driver or consignee and driver as appropriate.

Loading or unloading must never be attempted until it has been confirmed that all twist locks are fully engaged and screwed down. This is especially important for loading or unloading in the tipped position with the bulk tipping container wherever possible resting against the shear blocks. Over tightening should be avoided.

It should be noted that as tipping commences, the settling of the container against the shear blocks and / or movement of the substance inside the bulk tipping container may induce some further tightening of the rear twist lock on one side and slackening on the other side. A further check of tightness may be needed.

Prominent notices should be displayed at all loading and unloading places stating what should and should not be done in the interests of health and safety.

Excessive tipping should be avoided. During unloading, as little tipping as is needed to start the flow of the substance should be used. Further tipping should be used progressively and as little as possible, sufficient to keep the flow going. Full elevation should never be used from the outset of an unloading operation.

Consignors, consignees, operators, sub-contractors and drivers should ensure that:

- all unnecessary personnel are excluded from loading and unloading areas
- tractor unit and semi-trailer are in line especially for tipped loading and unloading
- brakes have been applied and if possible the vehicle disabled from movement until the loading process is complete. Consideration should be given to using interlocking devices so that loading or unloading cannot commence if brakes or other means of
securing the vehicle have not been engaged. Wheel chocks, where provided, should be deployed

- where sliding bogie semi-trailers are used, the bogie has been locked in the correct position for loading or unloading and that, where fitted, hinged twist locks are locked in place

- all stabilising and other landing legs have been lowered

- there is no lateral inclination of the bulk tipping container

- where unloading has taken place under pressure, a safe system of depressurising is used

- the maximum allowable working pressure of pressure bulk tipping containers is not exceeded

- the flow through pressure relief devices will not exceed their rated flow capacity

- all hoses have a pressure rating at least equal to the maximum allowable working pressure of bulk pressure containers or e.g. the pressure used in rotary valve unloading

- pressurised hoses have a means of restraint in case they inadvertently become detached under pressure

- where nitrogen or other inert gas is used for any purpose during loading or unloading, it is used safely and that the bulk container is durably and clearly marked in conspicuous places such as on outlets and loading hatches that nitrogen or other inert gas is present (see the dangerous goods regulations).

- where there is a risk of dust explosions or the development of static electricity, suitable precautions should be taken to minimise these dangers

- inhalation of dusts is avoided

- loaders and unloaders are advised of and clearly understand the venting system on non-pressure bulk containers and that loading and unloading takes place in such a way as to avoid vent blockage and pressure build up or partial vacuum. All should be alert to the risk of sudden rises in pressure e.g. due to blockages. All should be alert to the risk of implosion if pressure conditions lower than atmospheric pressure arise

- all personnel are informed as to where to be, where to stand to do their work during the loading and unloading operation taking into account the possibility of tipped bulk containers falling rearwards to ground or slewing sideways

- where liners and bulkheads are to be installed prior to loading or removed after unloading, the safety instructions for these operations e.g. to reduce the risk of asphyxiation are followed. Atmosphere should be checked for acceptable levels of oxygen before entering the container
• where plastic liners have been inserted in containers, these are vented after loading to avoid e.g. causing distortion of the walls

• all openings on the bulk container are closed after loading or unloading. In this connection, employees should be made aware of the consequences for transport by rail if any loose component of the bulk container such as top hatch covers and manlids could bounce up and hit overhead electric power cables, bridges, station canopies etc

• tarpaulins, where fitted e.g. to ‘open-top’ containers should be closed and secured so that no part of the tarpaulin or its closure system remains loose

• vehicles are not driven away with any removable equipment such as earthing leads, hoses etc are still attached

• consideration should be given to requiring employees to wear a high visibility garment

• drivers and other members of staff are issued with any necessary protective clothing and equipment for the loading operation

• protection is afforded to all workers from the effects of vibration such as when attempting to dislodge non-flowing product and noise such as from blowers and compressors

• adequate protection is afforded to drivers and other members of staff all workers to prevent falling from a height

• drivers report all defects on semi-trailers and vehicles, particularly those affecting safety during tipping operations. Drivers should make these reports on all semi-trailers and vehicles whether occasionally or permanently allocated to them

• comprehensive checklists are used covering all safety issues are developed and completed prior to loading and unloading

• drivers are never left to complete loading or unloading operations on their own. There should be constant attendance throughout

• where it is not obvious that a freight container contains a bulk load, this is indicated on e.g. the door locking bars

• a check is made to ensure all residual pressure has been dissipated before disconnecting hoses

• all concerned recognise that some substances with a water content may freeze in cold ambient temperatures with consequent dangers from ‘cling’ etc. at these times

• no pressure vessel tank should be entered e.g. for cleaning until an assessment of the oxygen level and other gases, liquids or solids present has been made. A ‘permit to work’ should be employed
When standard ISO containers are converted temporarily for the transport of bulk materials, precautions should be taken to ensure no there is no inadvertent rise in pressure or creation of partial vacuum conditions.

**Additional Information for all Loading and Unloading Operations in the Tipped Position**

Where loading or unloading in the tipped position takes place with the bulk container on the semi-trailer or vehicle, consignors, consignees, operators and drivers should ensure:

- a check should be made that the receiving silos have sufficient capacity (including venting capacity) to accept the consignment

- tipping operations are clear of all overhead obstructions such as power cables, pipework, gantries etc. in whatever direction the vehicles face. In this connection the possibility of vehicles entering the loading point from opposite directions should be considered or of modifications to overhead conditions where the height of tipping vehicles has been overlooked

- where practicable loading takes place progressively in the sense that the container should not be elevated to full height immediately. Rather part loading should take place with progressive raising of the container at appropriate intervals to distribute the product inside

- lowering of the bulk container after loading should be undertaken slowly and carefully bearing in mind there may be some movement of congealed product towards the front

- loading or unloading should not be attempted where the total mass will exceed the gross mass / geometry for which the tipping rams have been designed

**Additional Information for Loading in the Horizontal Position**

Where loading in the horizontal position takes place with the bulk container on the semi-trailer or vehicle, consignors should ensure:

- in order to ensure even distribution of the substance during top loading in the bulk container, a sequence of loading through the top hatches should be devised e.g. filing through the middle hatch first, the two adjoining hatches second and the outermost hatches filled last

- where the substance forms an angle of repose leaving voids which have to be filled, a safe method of breaking the angle of repose is devised e.g. using a thrower inside the loading hatches
Additional Information for Unloading in the Tipped Position on the Vehicle

Where unloading of bulk containers takes place in the tipped position on the semi-trailer or vehicle, consignors should ensure:

- all employees are aware of the dangers of sudden movement of the load as tipping progresses and also the dangers from compacted material clinging to the roof, front wall or upper sides of the bulk tipping container. All should also be aware of the danger of loads which slide down one side of the bulk container creating an imbalance and risk of toppling.
Annex 12

Maintenance of Bulk Containers, Tipping Semi-trailers and Vehicles

Operators should have systems in place to ensure that bulk tipping vehicles, semi-trailers and bulk containers are inspected and maintained in accordance with manufacturers’ instructions.

There are several components fitted to bulk tipping container semi-trailers and vehicles which can affect the overall stability in the tipped position. Whilst wear on any one component may not be significant, the accumulating effect of wear on two or more components may be. Suppliers and operators should consider this phenomenon during design and during use of semi-trailers and vehicles.

Operators and their subcontractors should carry out proper maintenance of all bulk tipping containers, vehicles and semi-trailers with particular emphasis on maintenance and condition of twist locks. Maintenance should be carried out by competent persons who have received training in their duties and responsibilities.

It is important that operators convey all the instructions they receive concerning the maintenance of their bulk containers, semi-trailers, vehicles and components to those who carry out this work especially where the proper maintenance is critical to safe unloading. The flow of information should follow the patterns set out in the diagrams earlier in the report.

Particular attention should be given to the maintenance of twist locks. Proper maintenance of rotating bolsters, stabilising landing legs, tipping rams, interlocking devices and remote controls are also important. It is suggested that the maintenance of tipping semi-trailers and vehicles includes a check that:

- no components of the twist locks are broken, or lost e.g. through vibration
- all nuts, tee bars, securing pins or screws are present on the twist lock stems.
- twist lock nuts can be screwed up
- there is no excessive wear on the threads of the twist lock head stems (maximum wear of no more than 1.00mm is suggested elsewhere in this report)
- there is no fissure cracking under the head of the twist lock stems
- the mounting of the twist lock assembly to bolsters is in good condition and free from cracks
- securing nuts are in good working condition, free from cracks or manufacturing defects
- all primary and secondary locking mechanisms are in good working condition
- examination of automatic and semi-automatic twist locks is carried out in a similar way to that for twist locks with additional attention to the condition of the automatic and semi-automatic mechanism taking into account any adverse operating situations
• All components including any replacement components are those recommended by the manufacturer - “look-alike” or lower specification parts should not be used.

All defective components must be repaired or replaced before the semi-trailer or vehicle is used again. The semi-trailers and / or vehicles should be quarantined against inadvertent use before the repair or replacement takes place. The whole assembly should remain as that recommended by the twist lock manufacturer for tipping applications including material strength, dimensions etc. Lubrication should be applied but should not cover the lips of the twist lock head nor the plate of the twist lock assembly upon which bulk tipping corner castings rest.

Check lists should be developed and used for servicing vehicles and semi-trailers fitted with twist locks. These should cover the condition, thread wear on twist-lock pins, missing or worn components, signs of fatigue, corrosion etc. i.e. not just a check for proper functioning and lubrication. The check lists should contain an indication as to what is acceptable or unacceptable e.g. if thread wear on twist lock pins is excessive (1.00 mm is suggested elsewhere in this report).

As part of their daily checks and / or when taking over a bulk tipping container semi-trailer, drivers should check the condition of all twist locks and refuse any vehicle or semi-trailer where there is the slightest defect.

Maintenance should include the examination of:

• Rotating bolsters to check that it or they is / are completely free to rotate, all lubrication channels are free, that they are fully lubricated and the ingress of foreign matter has not occurred. They should be also be examined for signs of cracking.

• Stabilising landing legs to check that no components are damaged or where replacement parts are needed that only those parts including complete replacement legs recommended by the supplier for tipping applications are used.

• Tipping rams, interlocking devices and remote controls - according to the instructions received from the supplier. The recommended fluids should be used for tipping rams.

• All gaskets and other seals to ensure they are fit for use.

• Manlids and their retaining bolts / safe bolts are in good condition, in particular to ensure there is no significant wear on the threads of swing bolt stems and nuts which could lead to failure of the manlid under pressure.

• All safety critical assemblies and components for signs of metal fatigue and corrosion.

Detailed records of the maintenance of tipping semi-trailers and vehicles should be kept for the life of the vehicle. Where defects are detected, periodic analysis to identify trends should take place.
Annex 13

Acceptance of New Equipment / On-hiring Leased Equipment

All new and second-hand purchased bulk tipping containers, vehicles and semi-trailers should be checked by the operator or subcontractor at the time of purchase for conformity to specification. Such checking should include a check that safety-critical components such as twist locks, landing legs, rotating bolsters, tipping rams, locking bars, interlocking mechanisms, pressure relief valves, vents etc are those specified by the component supplier for the intended use and are installed and functioning correctly. In particular, vehicles and semi-trailers fitted with unsuitable twist locks should not be accepted.

Similar checks should be made when leased equipment is taken on hire.

Check-lists should be used for carrying out these checks.
Annex 14

Information for the Design of Loading and Unloading Facilities

Loading and unloading facilities should be well lit.

Wind impact should be reduced.

Overhead obstructions for vehicle access especially for tipping are eliminated. Incidents have occurred because of overhead obstructions.

Loading and unloading facilities should be designed as far as practicable to avoid blockages that could cause excessive (back) pressure.

It is important that tractor units and bulk tipping semi-trailers are in line and free from lateral inclination. Consideration should be given to installing curbs or similar devices to ensure articulated vehicles are in line. Tractor units and semi-trailers not in line have contributed to the causes of incidents.

There should be good hard standing for vehicles engaged in tipped loading and unloading. The loading or unloading area should as far as practicable be level. As mentioned in the main body of this report, incidents as have occurred due to vehicles having to stand on unstable ground or where an apparently sound base covers culverts which gave way because the landing legs are lowered on to the surface covering them.
Annex 15

Other Safety Issues Concerning the Use of Bulk Tipping Containers: Appointment of Subcontractor Hauliers; Use of “Heel Plates”; Wind Loadings; Working at a Height; Substances Transported and Bulk Densities; Angle of Repose

Appointment of Subcontractor Hauliers

Many operators of bulk containers use subcontractor hauliers. These may be long-term subcontractors working under formal contract arrangements or casual hauliers working with the operator on a day-to-day basis.

Operators should ensure their subcontractor hauliers to ensure that their management of health and safety, training and refresher training of drivers and maintenance is at least at the standard set out in this report.

Regular safety auditing of subcontractor hauliers and their drivers should be carried out by the operator to ensure that health and safety standards are being adhered to, training is complete and maintenance carried out effectively. Operators should consider inviting consignors and consignees to witness these audits.

There should be no differences in safety requirements and performance between operators who have their own vehicles and subcontractors. Some operators apply controls to their subcontractors in this way whilst others may not reach these levels of control even to the extent of applying little or no control over their subcontractors.

Use of “Heel Plates”

It is the practice of many participants in the bulk tipping container industries to fit so-called ‘heel plates’ or ‘kick plates’ to tipping semi-trailers and vehicles (see Images M, Annex 1 and Image X below). Their intention is to reduce the risk of bulk tipping containers slipping off semi-trailers and vehicles in the tipped position. There are no industry or other performance standards for these plates. Whilst this remains the case, there is likely to be little gain in safety from fitting them though their use is not discouraged.
Windy conditions have an affect on the lateral stability of bulk containers in the elevated condition. It is recommended that as part of the risk assessment of loading and unloading facilities, the effects of wind on the stability of bulk tipping containers in the tipped position be taken into account. Factors to be considered when making assessments will vary case by case. However, the following points should be included in considering the risks created by windy conditions:

- where practicable, the facility should be fully shielded from wind effects
- alternatively, facilities should be so designed that in the tipped position, the rear of the bulk container faces the prevailing wind direction
- account should be taken of the action of the suspension system of the tipping semi-trailer or vehicle and “bounce” if left active during the loading or discharge
- wind funnelling effects should be avoided
It is suggested that decisions as when loading or unloading in the tipped position should not be attempted due to dangerous wind strength are not left to vehicle drivers alone. Site management should take this decision. Advice may be sought from the bulk tipping container operator or his subcontractor haulier.

There is an attempt in Health and Safety Report MM/04/24 to show the additional forces which can pass from flat-sided bulk containers through the rear twist locks. Whilst the additional loadings are comparatively small, it should be noted that the report does not deal with the overall stability of the combined semi-trailer, vehicle and container and resistance to overturning.

Several employers have reported that they have taken an empirical decision to forbid tipped loading and unloading when wind speeds rise to Beaufort scale 4 and above.

**Working at a Height**

There are working at a height issues associated with the use of bulk tipping containers where safe access and the prevention of falls needs to be considered.

**Substances Transported and Bulk Densities**

There are many substances transported in bulk using bulk tipping containers. Some may be in granular form. Other substances may be in a fine powder form. Some may have a high water content and others not. The extent to which these substances flow easily under gravity and/or fluidise when discharged by pressure has an impact on safety.

Polymers for the use in the manufacture of plastics materials form a considerable proportion of the substances carried and tend to be reasonably free flowing, especially as they are typically in granular rather than fine powder form. Other substances such as starches, dextroses may not flow so easily.

The substance being unloaded at the time of the accident which was the stimulus for this report is used as an ingredient in many powder form domestic washing detergents and therefore must be assumed to be easily soluble in water. Substances of this kind, it must be assumed, are liable to caking during transport causing difficulties during unloading such as clinging to the container until inertia is overcome. Caked materials towards the front of the bulk tipping container are prone, therefore, to sudden falls into the space already voided. This phenomenon has been the cause of other accidents with bulk tipping containers. It may also have been a contributory factor in another fatal accident in another country.

Sometimes it is necessary to attempt to loosen congealed material using vibration in e.g. the crude form of hitting the outside of the container with wooden batons or similar instruments. It is recommended that a risk assessment of the most suitable method of dislodging congealed material is carried out.

Many of the substances transported in bulk tipping container have a low mass to volume density. Some, however, have a high mass to volume density. The density of solid materials may be measured in several ways. The most important measurement of density in the use of bulk tipping containers is arguably the “bulk density” rather than e.g. particle size. As many of the substances have a low “bulk density” as measured in tonnes to cubic metre of capacity of the bulk tipping container i.e. less than one tonne to the cubic metre, it follows that most operators of bulk tipping containers seek to purchase (or lease) containers with as high a volume as possible.
Consignors, operators, their subcontractor hauliers and consignees should take the flow characteristics, bulk densities and volumetric capacity of the chosen bulk tipping container into account when assessing the risks involved in the use of this technology.

**Angle of Repose**

Loading of bulk tipping containers usually takes place through a series of openings in the roof. Filling in this way may lead to a conical shaped heap of the substance forming under each opening leaving a void between them inside the container. The angel of these cones is usually referred to as the “angle of repose”. This phenomenon means that there may be a loss of payload inside the container unless action is taken to dislodge the cones and to distribute the substance evenly. Once the cones have been dislodged, more of the substance can then be added. Breaking the angle of repose is particularly important where the substance has a low bulk density.

Accidents have happened through efforts to break the angle of repose. As mentioned elsewhere in this report, therefore, that consignors, operators and their subcontractor hauliers consider the risks involved in any methods they may adopt to break angles of repose.
Appendix 1

Opinion of Society of Motor Manufacturers and Traders Guidance on air suspension systems for semi-trailers

Stability of tipping semi-trailers

This subject should not be restricted to advice on the use of tipping semi-trailers with air suspension. It is the application and the basic design of the vehicle that are most fundamental to the issue. The dump or not to dump part of the subject has become confused and muddled by virtue of some trailer suppliers' claims concerning the performance of their offerings to operators.

It may be beneficial to separate the various uses and types of loads to which tipping semi trailers are put in order to provide some sensible and practical advice.

It is fairly easy to differentiate between a large volume powder tanker travelling long distances and making only one delivery per day, the delivery itself being prolonged and a general purpose tipper making perhaps two, three or more deliveries per day. It should be borne in mind that when tipping the centre of gravity of the vehicle is not only raised but is shifted rearwards to the point that if the load in a typical maximum GVW articulated vehicle is restrained and the body is fully tipped then the load on the semi-trailer bogie is increased from less than 24,000kgs to more than 30,000kgs.

A large volume powder tanker may be an ISO container mounted on a tipping skeletal chassis or it may be a discrete vehicle. What they have in common is that they would both take a long time to unloading and some drivers are very happy to tip to full extension and find refreshment instead of lifting the barrel in stages, sufficient to maintain flow of product. These vehicles generally tip in the same place time after time and are stationary during the entire unloading procedure.

Stability and safety could be greatly enhanced by:

1) Specific ground reinforcement at the unloading location to accept the loads imposed by the stabilising devices;

2) Stabilising devices to be attached to the trailer chassis, be positioned as close as practicable to the tipping hinge point and incorporate spreader plate ‘feet’;

3) Stabilising devices, and the structure they are attached to, must be capable of supporting the entire transmitted load including the mass of the trailer bogie;

4) Tipping with the trailer suspension air pressure exhausted AFTER deployment of the stabilising devices; to eliminate all the flexible components in the trailer construction (suspension and tyres).

For ‘general purpose’ tippers (the vast majority of tipping operations) a completely different set of circumstances prevails. While it may be that a large proportion of loads are unloaded through, for example, a grain hatch, there is still a common need to unloading loads onto the ground. When this is done it is absolutely essential to be able to move forward during the tipping procedure so as to allow the load to clear the body. It is clear that stabilising devices would not
be a practical proposition in this case. It is also unlikely that the ground surface would be capable of supporting the concentrated load involved without collapse.

In the case of this type of operation, there is also a strong argument against exhausting the suspension air pressure in that to do so would increase the loads on the rearmost axle, wheels and tyres beyond their design capacity. The ground pressure is also increased as a result and, where surfaces cannot be reinforced, this creates an added danger of ground failure under the supporting tyre.

There is also greater danger in exhausting suspension air pressure to unloading in that the ground may not be level or rising to the rear of the vehicle. If there is a bump under a leading axle or the ground falls away from the rear then it is not the rearmost axle that accepts the entire bogie load but the one that is on the highest point. This promotes a situation almost certain to create instability through chassis collapse or deformation. These ‘general purpose’ tippers will usually be tipping on simply prepared and non-reinforced surfaces.

If stabilising devices were to be deployed then they should be capable of supporting all the bogie mass. Much attention must be taken in the design of the stabilising devices and their attachment to the chassis as all tipping loads would pass through them. They must extend out to ensure body mass centre of gravity cannot pass beyond ground support positions and incorporate feet capable of spreading load appropriately; great care must be taken to ensure ground conditions are suitable for safe deployment.

The safest way to promote stability when tipping on non-reinforced surfaces is to ensure that the vehicle itself is designed to be inherently stable and to maintain air pressure in the suspension so as to spread the load evenly between all axles and tyres.

**SMMT Trailer Technical Committee**  
**16/09/2004**
Appendix 2

International standards and conventions

Main Tank and Bulk Container International Standards.
Main European Standards for Swap Body Tanks and Bulk Swap Bodies.
Other Important Documents

ISO Standards

1. ISO 668:1995 'Series 1 Freight Containers - Classification, dimensions and ratings'.
3. ISO 1161:1984 'Series 1 Freight Containers - Corner castings - Specification'.
5. ISO 1496-3:1995 (+ amendment) 'Series 1 Freight Containers - Specification and Testing Part 3 Tank Containers for liquids, gases and pressurized dry bulk'.
7. ISO 2308:1972 ‘Hooks for Lifting Freight Containers of up to 30 tons Capacity – Basic Requirements.’
8. ISO 3874:1997 ‘Series 1 Freight Containers – Handling and Securing’
10. ISO 9669:1990 'Freight Containers - Interface Connections for Tank Containers'.

European Standards (CEN Standards) for Swap Bodies

5. EN13044:2000 ‘Swap Bodies – Coding, identification and Marking.’

**EN Standards for Pressure Dangerous Goods Tanks**


Other standards are in preparation.

**OIML Standard**

1. R80 Road and Rail Tankers. This standard contains procedures for the volumetric calibration of road tankers and rail tankers (but not tank containers)

**BIC Codes**

1. ‘Containers BIC Code’ (The Official Register of Internationally Protected ISO Alpha Codes for the Identification of Container Owners). (Issued annually).

**Union Internationale des Chemins de Fer (UIC) Leaflets**

1. UIC Leaflet 591. Small and medium-size containers - Technical conditions with which containers must comply in order to be accepted for use in international traffic, 2nd edition, 01.01.98

2. UIC Leaflet 592-2. Large containers for transport on wagons - Technical conditions to be fulfilled by large containers accepted for use in international traffic. 6th edition, 01.11.2004

3. UIC Leaflet 592-3. Large containers (CT), swap bodies (CM) and transport frames for horizontal transhipment (CA) – Standard report on acceptance tests, 2nd edition, 01.01.1998

4. UIC Leaflet 592-4. Swap bodies which can be handled by grabs - Technical conditions. 1st edition, 01.07.1985, reprinted 01.07.1995

5. UIC Leaflet 593. Privately-owned containers, transcontainers and 'T' Containers – Conditions of Approval, 2nd edition, 01.01.70, reprinted 01.04 1981 including amendment 1

**Convention for Safe Containers**

1. CSC - The Convention for Safe Containers - 1996 Edition, IMO Sales number 282E, ISBN 92 801 1411 5 (under review at the time this report was produced)
Appendix 3

Other Useful Guidance and Information

1. Institute of Road Transport Engineers Guide to Tipper Stability.

2. Road Haulage Association’s Guide to Tipping (edited by Kerrill Spencer.) (currently out of print and awaiting revision – which may be delayed to incorporate anything relevant from this Guidance.)


5. Section Paper: Results from an Investigation of Tri-axle Tipping Trailer Stability Using the Crane Rig, HSE Research and Laboratory Services Division, Buxton, 1986.


8. Health and Safety Executive / Local Authorities Enforcement Liaison Committee (HELA) Local Authority Circular Number 85/2

9. European Chemical Transport Association’s Guidelines on Tipping Equipment

Appendix 4

List of Contributors

The author and the Health and Safety Executive wish to express their grateful thanks to the many individuals, companies and trade associations who gave unstintingly of their time, knowledge, expertise and experience to enable this report to be drawn up. The following companies were consulted either directly through face-to-face meetings at their premises or through meetings with trade associations at which representatives of those companies were present.

ADM Milling Ltd.
Atcomex Company NV, Belgium
Added Logistics NV, Belgium (now taken over by Vos Logistics with headquarters in Oss, The Netherlands)
BASF AG, Germany.
Bayards Aluminium Constructions BV, The Netherlands
Bertschi UK Ltd.
BP Services NV, Belgium
The British Chemical Distributors and Traders Association
British Gypsum Ltd.
Bruhn Spedition GmbH, Germany
Bulkauf Ltd.
Bulliment Ltd.
Bulmers Logistics (Teeside) Ltd.
Burg Intermodal BV, Belgium
Chemical Industries Association
Clyde Materials Handling
Cobra Containers S.P.A., Italy
Comipass s.a.s., France:
Corus Trailers Ltd.,
William Cook Intermodal
Cronos Containers Ltd.
W.H. Davis Ltd.
Degussa AG, Germany
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Du Pont Sabanci Polyester UK Ltd.
Duraloc Ltd.
European Chemical Industry Council (CEFIC), Belgium
European Chemical Transport Association (ECTA), Belgium
European Petrochemical Association (EPCA), Belgium
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Freightliner Ltd.
Freight Transport Association
GM Waste Ltd.
GCA Transport Ltd.
General Trailers, France,
Hoyer Nederland BV, The Netherlands
Hoyer-Talke GmbH & Co. KG, Germany (now Talke GmbH)
ICHCA International Ltd.
Ineos Olefins Ltd.
JOST-Werke GmbH & Co. KG, Germany
London and Scandinavian Metallurgical Co. Ltd.
Robert McBride Ltd.
Martrans Ltd.
Mobile Plastics Europe, Belgium
Multi-Stroke Ltd.
Barry Napper & Co.
Pellegrini Trasporti S.r.l, Italy
Proctor and Gamble Ltd.
RMC Group Services Ltd. / Rugby Ltd.
Road Haulage Association
Schneider Fahrzeug- und Container Technick GmbH, Germany
 Tankspeed Ltd.
Tamplin Engineering Ltd.
TDG European Chemicals
TIP Tanker Services Ltd.
UBC Ltd. (now part of the Interbulk group)
Van Hool NV, Belgium
Verbrugge Internationale Wegtransporten BV, The Netherlands
Viridor Ltd.

The following organisations and companies contributed to the report through electronic, telephone and/or written correspondence:

Health and Safety Authority, Ireland
Hoyer UK Ltd.
Institute of Road Transport Engineers (Society of Operations Engineers)
Marine Accident Investigation Branch of the Department for Transport
Solvay Chemicals International SA, Belgium
Unilever Faberge UK Ltd.
Appendix 5

Curriculum Vitae Synopsis of the Author

Roy Boneham grew up in the City of Coventry in the West Midlands region of England. He attended the University of Bradford in Yorkshire, England between 1966 and 1968 from where he graduated with a Bachelor of Science degree with Honours.

He joined the major UK-based chemical manufacturer Albright & Wilson Ltd for whom he worked for eight years mainly in posts concerned with distribution logistics.

In 1977 he joined the European short-sea integrated Lift-on/Lift-off container shipping line Bell Lines Ltd where he headed up their tank container operations. The company was extremely active in the transport of bulk powder and granular materials using non-pressure freight containers.

While at Bell Lines, Roy was instrumental in founding the Association of Tank Container Operators (ATCO), becoming its first Secretary in 1980.

Later, from 1985 to 1987 he spent two years with the UK daughter company of the Hoyer group with wide ranging responsibilities including leading a team from within the group promoting the transport of powdery and granular materials.

He founded his own training and consultancy practice in the transport of dangerous goods called New Alchemy which he has been running ever since then.

At the same time as founding his training and consultancy practice, his services as Secretary of the ATCO were confirmed when this role was taken over on a part-time basis. In 1994 ATCO became the European Portable Tank Association (EPTA) which he served as its Executive Officer. This was to become the International Tank Container Organisation (ITCO) in 1998.

He has served as an industry representative on European and international committees involved with drawing up recommendations and regulations for the transport of dangerous goods including the prestigious UN Committee of Experts on the Transport of Dangerous Goods, the RID/ADR/ADN Joint Committee and the ADR Committee(WP.15) at the UN in Geneva. He has also been involved with the activities of relevant Directorates within the European Commission in Brussels and with the drafting of international standards. He sits on advisory committees of The Department for Transport and one of its agencies, the Maritime and Coastguard Agency, on the transport of dangerous goods.

In 1998 he was appointed one of the UK’s Chief Examiners for the Dangerous Goods Safety Adviser qualification and is also the Chief Examiner for this qualification in the Republic of Ireland.
Safety in the design, construction and use of bulk tipping containers

This report provides information on the loading, transport and unloading of bulk materials in tipping containers. It has been prepared by a consultant appointed by the Health and Safety Laboratory (HSL) at the request of the Health and Safety Executive (HSE). Individual employers, trade associations and professional bodies have been consulted in the preparation of this report both in Great Britain and in parts of Europe. European employers have been consulted because of the international nature of many of the loading, transport and unloading operations with bulk tipping containers.

The report identifies a number of areas where positive management of the hazards associated with bulk tipping container, design, transport and use are required. Information is presented in a series of Annexes to assist those involved with these operations to review their arrangements.

A second study by the Health and Safety Laboratory which models the forces at work in the use of bulk tipping containers and their carrying vehicles appears as Annex 2 to this report. This report explores a number of design features and highlights some design issues for consideration by component and equipment designers.

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