Review of side and underrun guard regulations and exemptions

by T L Smith and I Knight

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REVIEW OF SIDE AND UNDERRUN GUARD REGULATIONS AND EXEMPTIONS

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Executive summary

TRL was commissioned by the UK Department for Transport (DfT) to investigate the potential benefits of an integrated approach to the design of safety guards and spray suppression equipment for HGVs. The project aims to identify and quantify the potential benefits of an integrated spray suppression and underrun protection structure. In particular the project will aim to assess:

- Safety benefits to vulnerable road users through improved sideguards
- Safety benefits for all road users through reduced spray
- Cost and environmental benefits through improved fuel economy resulting from improved vehicle aerodynamics

As part of this work the project aims to develop a test method for quantifying whole vehicle spray that could be used as a regulatory test.

The project has been split into three modules in order to reflect the above objectives. This report has been written as part of the module of the project studying the potential benefits of improving the underrun protection through improved integration. The report reviews the UK and European Regulations relating to safety guards for HGVs and compares these regulations to each other as well as relevant standards from other countries. The objective of this work is to identify any anomalies within, or inconsistencies between, standards that may prevent or discourage an integrated approach to the design of underrun protection.

Both UK and European regulations permit exemptions from underrun regulation for certain vehicle types. A second objective of this report is to review those exemptions to assess whether they are truly justified.

The review of regulations has simply been carried out as a desktop review that highlights common areas and differences in approach amongst UK, EC and UNECE regulations and between front, side and rear regulations for each.

The review of exemptions has been based upon reviewing the regulations described above and collecting a variety of information concerning the construction and use of vehicles that are exempt. There is a very wide variety of vehicle designs and constructions in use that qualify for exemptions and an even wider variety of situations that they work in. The review cannot, therefore, be completely exhaustive and there is, inevitably, a degree of judgement used when interpreting the information. However, the evidence did give reasonably strong indications of the suitability of the various exemptions permitted by the different regulations.

The main conclusions of the work are presented below.

UK, EC and UNECE regulations governing the fitment of front, rear and side safety guards exist separately. Each regulation is written independently considering only the individual aspect of protection, for example side, that it relates to. Nothing in the regulations prohibits integrating the safety guards all around the vehicle but it is not necessarily straightforward to do so and there is little to encourage such an approach.

A fundamental difference exists between the sideguard regulations and the front and rear guard regulations. Sideguards are designed to protect vulnerable road users while the other two are required to protect car occupants. This leads to very different geometrical and structural requirements. However, there is no reason for these differences to limit an integrated design of safety guard.

There are some inconsistencies in approach and detail between the various regulations. The safety requirement for the front and rear regulations is exactly the same – prevent the front of a passenger car from running underneath the HGV structure at survivable collision speeds (e.g. 56 km/h). However, the requirements for the two most critical aspects of the design, strength and ground clearance, are very different. Front underrun guards have to be considerably stronger and lower than rear underrun guards.
Differences also exist in more detailed areas. The test forces are required to be applied in different ways for each different regulation and there are subtle differences in the places that they are required to be applied.

There are some omissions and wording in the regulations that may discourage an integrated approach for some vehicles. The rearguard regulation specifies the mounting points that must be used in a prescriptive manner rather than a performance based manner, which may stifle some innovative approaches. The sideguard regulation permits sidguards behind the rear wheels but does not have any requirements for them and the wording of the regulation is such that it is difficult to conform for the space ahead of the axles on a centre axle drawbar trailer. This can leave substantial gaps when rigid vehicles with large rear overhangs tow such trailers.

The UK regulations exempts a large list of specific vehicle types from their requirements. The EC Directives offers exemptions for any vehicle type that meet a few generic conditions. Evidence of the structure and use of exempt vehicles has been collected and analysed and it suggests that a large number of the vehicle types and operations currently exempt are unlikely to truly require the exemption for technical reasons, although there may be cost implications in some cases. However, for many of the vehicle types it is possible that some of the exempt vehicles do genuinely require the exemption.

Alternative approaches to the exemption issues are discussed. One possibility identified is that the exemptions should be considered based on criteria such as the use of the vehicle off-road, the use of auxiliary equipment, and the presence of other vehicle structure in the areas requiring safety guards. Each exemption should then have a rigorous definition of what is required to qualify, as follows:

- The front underrun regulation already refers to the “G” class off-road vehicle as defined in the EC Framework Directive. If this was applied to all of the regulations and no other generic exemption existed that could be used for terrain issues then substantial numbers of exemptions would be ended. However, a number of unjustified exemptions would still be likely to exist because the “G” class definition of off-road capability is not particularly demanding. Ideally, a more demanding definition of off-road use could be created such that only vehicles that needed to travel completely off road, that is not just poor quality unmade roads, qualified for exemptions to safety guard regulations.

- A generic definition of “impractical” or “inconsistent with use” could be kept in the regulations and used in combination with type approval guidelines that defined what qualified for this exemption in much more detail. This should be restricted to vehicles where the fitment and use of ancillary equipment made it impossible to fit safety guard prevention. The guidelines should encourage innovative designs such as adjustable, movable or demountable guards to be considered before exemptions were granted. Exemptions should only be granted where a defined cost benefit analysis clearly showed fitment was unreasonable.

- Some vehicles are exempt where the only obvious reason for such an exemption is that the vehicle structure occupies the place where the safety guard would be, such as a low-loader. This allows the possibility that some vehicles could have structures that were inadequate strength or insufficiently smooth. An alternative would be to end the exemption for such vehicles but allow vehicle structure to substitute for a safety guard provided the principle requirements of strength and geometry are adhered to.
1 Introduction
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The project has been split into three modules in order to reflect the above objectives. This report has been written as part of the module of the project studying the potential benefits of improving the underrun protection through improved integration. The report reviews the UK and European Regulations relating to safety guards for HGVs and compares these regulations to each other as well as relevant standards from other countries. The objective of this work is to identify any anomalies within, or inconsistencies between, standards that may prevent or discourage an integrated approach to the design of underrun protection.

Both UK and European regulations permit exemptions from underrun regulation for certain vehicle types. A second objective of this report is to review those exemptions to assess whether they are truly justified.
2 Sideguard Regulations

2.1 Commonalities between UK and Europe

For the purpose of the following analysis of regulations/directives pertaining to lateral protection (sideguards), the EC Directive 89/297 and UNECE Regulation 73 are considered to be identical. It is important to note that there are small differences between these two documents, which are shown in Table 1 below. However, the remaining technical requirements and vehicle exemptions and derogations are common to both documents.

Table 1. Differences between UNECE Regulation 73 and EC Directive 89/297

<table>
<thead>
<tr>
<th>UNECE Regulation 73</th>
<th>EC Directive 89/297</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.4.3</td>
<td>2.4.3</td>
</tr>
<tr>
<td>On a motor vehicle where the 300mm dimension referred to in paragraph 7.4.1.1 falls within the cab, the guard shall be so constructed that the gap between its forward edge and the cab panels does not exceed 100mm and, if necessary, shall be turned in through an angle not exceeding 45 degrees.</td>
<td>On a motor vehicle where the 300mm dimension referred to in point 2.4.1.1 falls within the cab, the guard shall be so constructed as to meet the cab panels and if necessary be turned through an angle not exceeding 45 degrees. A longitudinal gap of 100mm shall be permitted between the forward edge and the cab panels in the case of suspended or tilt cabs.</td>
</tr>
<tr>
<td>7.4.4</td>
<td>2.4.4</td>
</tr>
<tr>
<td>On a motor vehicle where the 300mm dimension referred to in point 7.4.1.1 falls behind the cab and the sideguard is extended forward to within 100mm of the cab, as an option to the manufacturer, then the provisions of paragraph 7.4.3 must be met.</td>
<td>On a motor vehicle where the 300mm dimension referred to in point 2.4.1.1 falls behind the cab and the sideguard is extended forward as indicated in point 2.4.3 as an option to the manufacturer, the provisions of 2.4.3 must be met.</td>
</tr>
</tbody>
</table>

Many of the technical requirements and some of the derogations and exemptions for sideguards are the same for both the Road Vehicles (Construction and Use) Regulations 1986 – Regulation 51 and the EC Directive 89/297. This section lists the requirements that are shared by the two regulations. Sections 2.2 and 2.3 list the requirements of each regulation that are not shared.

2.1.1 Technical requirements

The requirements of these regulations are considered satisfied if:

- The vehicle is equipped with a sideguard that meets the technical requirements below.

Or

- The sides of the vehicle are designed and/or equipped that by their shape and characteristics their component parts together meet the technical requirements below, they be regarded as replacing the side guards.

The technical requirements state that:

- The outer surface must be smooth, flat or horizontally corrugated.

- Adjacent parts may overlap provided that the overlapping edge faced rearwards or downwards, or there is a longitudinal gap of not more than 25mm, provided that the rearward part does not protrude outboard of the forward part.
Domed heads of bolts or rivet may protrude beyond the surface to a maximum distance of 10mm.

All external edges and corners shall be rounded with a minimum radius of 2.5mm.

The sideguard shall have a ground clearance of 550mm with the vehicle positioned on level ground or in the case of a semi-trailer positioned so that the load platform is horizontal.

The maximum distance from the rearmost edge of the sideguard and a vertical tangent to the leading edge of the tyre to the rear is 300mm.

For a semi-trailer with landing legs, the maximum distance between foremost edge of the sideguard and the vertical centre-line of the landing legs is 250mm to the rear of the landing legs.

For a trailer the maximum permitted distance between the foremost edge of the sideguard and the vertical tangent to the rearmost part of the tyre in front is 500mm.

For a motor vehicle the maximum permitted distance between the foremost edge of the sideguard and the vertical tangent to the rearmost part of the tyre in front is 300mm.

The sideguard shall not increase the vehicles overall width.

No sideguard shall have a vertical gap measuring more than 300mm.

2.1.2 Exemptions and Derogations
The following exemptions are included in both the UK and EC regulations:

- A motor car or a heavy motor car constructed or adapted to form part of an articulated vehicle (UK); tractors for semi-trailers (EC).
- A trailer specially designed and constructed (and not merely adapted – UK) to carry items of exceptional length such as round timber, beams or girders

2.2 The Road Vehicles (Construction and Use) Regulations 1986 Regulation 51
The preceding section described elements of the UK and EC regulations that contained the same, or very similar, requirements. This section describes elements of the UK regulation that are different to the equivalent EC Directive.

2.2.1 Fitment
The definition of vehicle types to which sideguards must be fitted is different between the two regulations. The UK regulation applies to a wheeled goods vehicle being:

- A motor vehicle first used on or after 1st April 1984 with a gross weight which exceeds 3500kg; or
- A trailer (including semi-trailers) manufactured on or after 1st May 1983 with an unladen weight which exceeds 1020kg; or
- A semi-trailer manufactured before 1st May 1983 which has a relevant plate showing a gross weight exceeding 26,000kg and which forms part of an articulated vehicle with a relevant train weight exceeding 32,520kg.

2.2.2 Technical requirements
The following technical requirements are specific to C & U Regulation 51:
In a case specified in column 2 of Table 2 the highest edge of a sideguard shall be as specified in column 3.

**Table 2. Requirements for highest edge of sideguard**

<table>
<thead>
<tr>
<th>Item</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Case</td>
<td>Requirement about highest edge of sideguard</td>
</tr>
<tr>
<td>1</td>
<td>Where the floor of the vehicle to which the sideguard is fitted –</td>
<td>Not more than 350mm below the lower edge of the side-rave</td>
</tr>
<tr>
<td></td>
<td>(i) laterally extends outside the tangential plane;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) is not more than 1.85m from the ground;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) extends laterally over the whole length of the sideguard with which the vehicle is required by this regulation to be fitted; and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iv) is wholly covered at its edge by a side-rave the lower edge of which is not more than 150mm below the underside of the floor.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Where the floor of the vehicle to which the sideguard is fitted –</td>
<td>Not more than 350mm below the structure of the vehicle where it is cut by the tangential plane.</td>
</tr>
<tr>
<td></td>
<td>(i) extends laterally outside the tangential plane; and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) does not comply with all the provisions specified in sub-paragraphs (ii) , (iii) and (iv) in item 1 above,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>And any part of the structure of the vehicle is cut within 1.85m of the ground by the tangential plane.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Where –</td>
<td>Not less than the height of the upper surface of the load carrying structure of the vehicle.</td>
</tr>
<tr>
<td></td>
<td>(i) no part of the structure of the vehicle is cut within 1.85m of the ground by the tangential plane; and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) the upper surface of the load carrying structure of the vehicle is less than 1.5m from the ground.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>A vehicle specially designed, and not merely adapted, for the carriage and mixing of liquid concrete.</td>
<td>Not less than 1m from the ground</td>
</tr>
<tr>
<td>5</td>
<td>Any other case</td>
<td>Not less than 1.5m from the ground.</td>
</tr>
</tbody>
</table>

The distance between the foremost edge of the sideguard fitted to a semi-trailer and a transverse plane passing through the centre of the vehicle’s king pin (rearmost one if more than one) shall not exceed 3m.

No sideguard shall be more than 30mm inboard of the vertical plane tangential to the outermost part of the tyre (excluding distortion caused by the weight of the vehicle) fitted to the outermost wheel at the rear and on the same side of the vehicle.
Except for the semi-trailers described in 2.2 above, every sideguard shall be capable of withstanding a force of 2kN applied perpendicularly to any part of its surface by the centre of a circular ram of maximum diameter 220mm, and during such application –

- No part of the sideguard shall be deflected by more than 150mm, and
- No part of the sideguard which is less than 250mm from its rearmost part shall be deflected by more than 30mm.

Every sideguard shall cover an area extending to at least 100mm upwards from its lowest edge 100mm downwards from its highest edge and 100mm rearwards and inwards from its foremost edge and no sideguard shall have any vertical surface measuring less than 100mm.

2.2.3 Exemptions and derogations

The following vehicles are not required to be fitted with sideguards:

- A motor vehicle with a maximum gross weight which exceeds 3,500kg and was first used before 1st April 1984
- A trailer (including semi-trailers) with an unladen weight that exceeds 1,020kg manufactured before 1st May 1983
- A semi-trailer manufactured before 1st May 1983 with a gross weight less than 26,000kg and which forms part of an articulated vehicle with a relevant train weigh less than 32,250kg.
- A motor vehicle with a maximum speed that does not exceed 15mph
- An agricultural trailer
- Engineering plant
- A fire engine
- An agricultural motor vehicle
- A vehicle constructed so that it can be unloaded by part of the vehicle being tipped rearwards or sideways
- A vehicle owned by the Secretary of State for Defence and used for naval, military or air force purposes
- A vehicle to which no bodywork has been fitted and which is being driven or towed –
  - For the purpose of a quality or safety check by its manufacturer or a dealer in, or distributor of, such vehicles;
  - To a place where, by previous arrangement, bodywork is to be fitted or work preparatory to fitting of bodywork is to be carried out; or
  - By previous arrangement to premises of a dealer in, or distributor of, such vehicles.
- A vehicle being driven or towed to a place, where by previous arrangement, a sideguard is to be fitted so that it complies with this regulation
- A refuse vehicle
- A vehicle specially designed and constructed, and not merely adapted, to carry other vehicles loaded onto it from the front or the rear
- A trailer with a load platform –
  - No part of any edge of which is more than 60mm inboard from the tangential plane; and
The upper surface of which is not more than 750mm from the ground throughout that part of its length under which a sideguard would have to be fitted if this exemption did not apply.

- A trailer having a base or centre in a country outside Great Britain from which it normally starts its journeys. Provided that a period of not more than 12 months has elapsed since the vehicle was last brought into Great Britain.

- An agricultural trailed appliance.

Derogations exist for some vehicle types. These vehicles must be fitted with sideguards, however, they do not have to meet all of the technical requirements. The following derogations are mentioned in the C & U Regulation 51:

- An extendible trailer must meet all of the technical requirements of the regulation when at its minimum length. When the trailer is extended the sideguard is not required to meet the specifications for the distance between the rearmost and foremost edge of the sideguard and the relevant vehicle structure as described above.

- For a trailer designed and constructed (not merely adapted) to carry a demountable body or container the sideguard must meet the technical specifications as though a body or container was in position. The sideguards must remain in place when the body or container is removed.

- For a vehicle designed solely for the carriage of a fluid substance in a closed tank which is permanently fitted to the vehicle and provided with valves and hose or pipe connections for loading and unloading, the technical requirements must be met so far as is practical.

- For a vehicle that requires additional stability during loading and unloading or while being used for operations for which it is designed or adapted and is fitted with an extendible device on one or both sides to provide such stability, the technical requirements must be met so far as is practical.

2.3 Directive 89/297/EEC (UNECE Regulation 73) - Sideguards

Notwithstanding Table 1, above, for the purposes of this analysis the EC Directive and the UNECE regulation are considered to be identical. This section will describe the requirements of these instruments that are different to, or not included in, the UK construction and use regulation.

This directive became effective on the 1st June 1990 (for type approval) and is applicable to:

- Goods vehicles with a maximum mass exceeding 3.5 tonnes (N2 and N3) with a maximum design speed greater than 25km/h

- Trailers (including semi-trailers) with a maximum mass exceeding 3.5 tonnes (O3 and O4) with a design speed greater than 25km/h

In addition, this directive specifically mentions that it does not prevent any country from having additional requirements for the vehicle parts forward of the front wheels and rearward of the rear wheels.

2.3.1 Technical requirements

The following technical requirements are in addition to those that are shared with the Road Vehicles (Construction and Use) Regulation 51. In some cases the EC Directive provides additional detail about a requirement, for example, the position of the forward edge of the sideguard has additional requirements.

For a sideguard:
• The main part of its surface is not more than 120mm inboard of the maximum width of the vehicle.

• The forward end may be turned inwards on some vehicles.

• The rearward end shall not be more than 30mm inboard from the outermost edge of the rear tyres over at least the rearmost 250mm.

• The device may consist of a flat panel or 1 or more horizontal rails, or a combination of panels and rails.

• Rails shall be not less than:
  - 50mm high for N2 and O3 vehicles;
  - 100mm high and essentially flat for N3 and O4 vehicle.

• The forward edge of the sideguard shall be positioned:
  - Where the 300mm dimension (section 2.1.1 technical requirement point 9) falls within the cab, the guard shall be constructed so that the gap between the forward edge and the cab panels does not exceed 100mm, and if necessary turned through an angle not exceeding 45 degrees. If the front edge of the sideguard is within 100mm of the cab, then the manufacturer has the option to meet the same requirement as if the 300mm dimension falls within the cab as described above.
  - For a semi-trailer in any case, the distance from the front edge of the guard to the transverse plane through the kingpin in its rearmost position may not exceed 2.7m.

• Where the forward edge lies in an otherwise open space the edge shall consist of a continuous vertical member extending the whole height of the guard. The outer and forward faces of this member shall measure at least:
  - 50mm rearwards and be turned 100mm inwards in the case of N2 and O3 vehicles;
  - 100mm rearwards and be turned 100mm inwards in the case of N3 and O4 vehicles.

• A continuous vertical member is not required on the rear edge.

• The upper edge of the guard shall not be more than 350mm below that part of the structure of the vehicle, cut or contacted by a vertical plane tangential to the outer surface of the tyres except in the following cases:
  - Where the plane does not cut the structure of the vehicle, then the upper edge shall be level with the surface of the load carrying platform, or 950mm from the ground, whichever is less.
  - Where the plane cuts the structure of the vehicle at a level more than 1.3m above the ground, then the upper edge of the sideguard shall not be more than 950mm above the ground.
  - On a vehicle specially designed and constructed, and not merely adapted, for the carriage of a container or demountable body, the upper edge of the guard may be determined as above, with the container or body being considered as part of the vehicle.

• Sideguards shall essentially be rigid, securely mounted and made of metal or any other suitable material. The sideguard shall be considered suitable if it is capable of withstanding a horizontal static force of 1kN applied perpendicularly to any part of its surface by the centre of a ram with diameter 220mm +/- 10mm, and if the deflection of the guard under load is less than:
  - 30mm over the rearmost 250mm of the guard, and
  - 150mm over the remainder of the guard.
Components permanently fixed to the vehicle may be incorporated in the sideguard, provided that they meet the dimensional requirements of this regulation.

The guard may not be used for attachment of brake, air or hydraulic pipes.

### 2.3.2 Exemptions and derogations

The following vehicles are exempt from Directive 89/297/EEC (UNECE Regulation 73):

- Tractor units for semi-trailers
- Trailers specially designed and constructed for the carriage of very long loads of indivisible length
- Vehicles designed and constructed for special purposes where it is not possible, for practical reasons, to fit such lateral protection
- Any motor vehicle or trailer designed for use on the road, with or without bodywork and with a maximum speed less than 25km/h

The following derogations are also included:

- An extendible trailer shall comply with all the geometrical and strength requirements when closed to its minimum length. When the trailer is extended the sideguards shall not comply with the ground clearance requirement, the upper edge to vehicle structure requirement or the strength requirements. It will also not have to comply with the distance from either the front wheel or the rear wheel.
- A tank vehicle, designed solely for the carriage of a fluid in a closed tank permanently fitted to the vehicle and provided with hose or pipe connections for loading or unloading, shall be fitted with sideguards which comply so far as is practicable with all the requirements. Strict compliance may be waived only where operational requirements make this necessary.
- On a vehicle fitted with extendible legs to provide additional stability, during loading, unloading or other operations or which the vehicle is designed, the sideguard may be arranged with additional gaps where necessary to permit extension of the legs.
- On a vehicle equipped with anchorage points for ro-ro transport, gaps shall be permitted within the sideguard to accept the passage and tension of fixing ropes.

### 2.4 Summary of differences between UK and Europe

The EC Directive was introduced several years after the UK Regulation and does not require any vehicle to retro-fit sideguards. The UK Regulation required that all semi-trailers manufactured before the sideguard introduction date (1st May 1983) that had a gross weight in excess of 26,000 kg were to be retro-fitted with sideguards. The EC Directive also includes more details, particularly with regard to turning in the front end of the sideguard.

The main technical differences between the two regulations are:

- The strength of the sideguards; the UK requires the sideguards to withstand twice the force than for the EC Directive (2kN compared to 1kN) for the same amount of deflection
- The maximum distance from the forward edge of the guard to the kingpin; 3.0m for UK compared with 2.7m for Europe
- The minimum distance of the highest edge of the sideguard from the ground for vehicles without a load platform. The UK regulation specifies that the upper surface of the sideguard shall be not less than 1.5m, except for the special cases outlined. The EC Directive specifies a minimum distance of 0.95m from the ground
- The minimum rail height; 100mm for all vehicles in UK and 100mm for N3 and O4 or 50mm for N2 and O3 vehicles
- Maximum distance inboard of the vehicle edge; 30mm for whole guard in UK and 30mm for rearmost 250mm of guard, otherwise 120mm for Europe

2.5 Other national regulations

At the present time there is no Federal Motor Vehicle Safety Standard (FMVSS) or regulation for lateral protection of trucks (sideguards). Unlike Europe, the US research appears to be more concerned with the side underrun of cars into trucks.

In Australia, Monash University (*Lambert and Rechnitzer, 2002*) studied front, rear and side underrun regulations as part of a Review of Truck Safety. The only side underrun regulation identified in this document was UNECE Regulation 73. The authors recommended an Australian Design Rule based upon the European Regulation; however they also recommended the following changes:

- Only smooth panels or surfaces should be allowed, i.e. no rail designs
- Ground clearance of 350mm
3 Rear Underrun Regulations

Directive 79/490/EEC was introduced before the Road Vehicles (Construction and Use) Regulations 1986, therefore, UK Regulation 49 is based upon the EC Directive. Instead of meeting the technical requirements of the UK regulation, a vehicle may comply with the EC Directive. This section lists the differences between the UK and European regulations. Other national regulations are also introduced.

3.1 Definition of “rear underrun protective device”

Directive 79/490/EEC provides the following definition of a “rear underrun protective device”:

A device for protection against underrun from the rear generally consists of a cross-member and linking components connected to the chassis side-members or whatever replaces them. Such a device must have the following characteristics:

- The device must be fitted as close to the rear of the vehicle as possible. When the vehicle is unladen the lower edge of the device must at no point be more than 55cm from the ground. For a trailer with a single axle or two close-coupled axles, the UK regulation specifies that the ground clearance must be measured when the coupling of the trailer to the tow vehicle is at the height specified by the trailer manufacturer.

- The width of the device must at no point exceed the width of the rear axle measured at the outermost point of the wheels, excluding bulging of the tyres close to the ground. The device must not be more than 10cm shorter than the width of the rear axle on either side. When there is more than one rear axle the width of the widest one should be considered. The UK regulation specifies that for a vehicle with a demountable body or multiple devices, the device must be no more than 30cm shorter on either side.

- The section height of the cross-member must be not less than 10cm. The lateral extremities of the cross-member must not bend to the rear or have a sharp outer edge; this condition is fulfilled when the lateral extremities of the cross-member are rounded on the outside and have a radius of curvature of not less than 2.5mm.

- The device may be so designed that its position at the rear of the vehicle can be varied. In this event, there must be a guaranteed method of securing it in the service position so that any unintentional change of position is precluded. It must be possible for the operator to vary the position of the device by applying a force not exceeding 40daN.

- The device must offer adequate resistance to forces applied parallel to the longitudinal axis of the vehicle, and be connected, when in the service position, with the chassis side members or whatever replaces them. This requirement will be satisfied if it is shown that both during and after the application the horizontal distance between the rear of the device and the rear extremity of the vehicle does not exceed 40cm at any of the points P1, P2 and P3 shown in Figure 1 below.
In measuring the distance, any part of the vehicle which is more than 3m above the ground when the vehicle is unladen must be excluded (the UK regulation adds that the 40cm should be measured exclusive of any tail lift)

- Points P1 are located 30cm (or 35cm in UK regulation) from the outer edges of the wheels on the rear axle. Points P2 are symmetrical about the longitudinal centre-line of the vehicle on the line joining points P1 and are at a distance of between 70 and 100cm from each other. The exact positions of points P2 are defined by the manufacturer. The height above the ground of points P1 and P2 must be defined by the manufacturer within the lines that bound the device horizontally. The height must not, however, exceed 60cm when the vehicle is unladen. P3 is the centre point of the straight line joining points P2
- A horizontal force equal to 12.5% of the maximum technically permissible weight of the vehicle, but not exceeding 25kN must be applied successively to both points P1 and point P3
- A horizontal force equal to 50% of the maximum technically permissible weight of the vehicle, but not exceeding 100kN must be applied successively to points P2
- The forces must be applied separately. The order in which the forces are applied may be specified by the manufacturer
- Whenever a practical test is performed the following conditions must be fulfilled:
  - The device must be connected to the chassis side-members of the vehicle or whatever replaces them
  - The specified forces must be applied by rams which are suitably articulated (eg by means of universal joints) and must be parallel to the median longitudinal plane of the vehicle via a surface not more than 25cm in height (the exact height must be indicated by the manufacturer) and 20cm wide, with a radius of curvature of 5±1mm at the vertical edges; the centre of the surface is placed successively at points P1, P2 and P3

### 3.2 Fitment criteria

#### 3.2.1 The Road Vehicles (Construction and Use) Regulations 1986 - Regulation 49

The Road Vehicles (Construction and Use) Regulations 1986 applies to the following vehicles:
A motor vehicle with a maximum gross weight which exceeds 3500kg and which was first used on or after 1\textsuperscript{st} April 1984; or

A trailer manufactured on or after 1\textsuperscript{st} May 1983 with an unladen weight which exceeds 1020kg

The following vehicles are exempt:

- A motor vehicle with a maximum speed not exceeding 15mph
- A motor car or heavy motor car constructed or adapted to form part of an articulated vehicle
- An agricultural trailer
- Engineering plant
- A fire engine
- An agricultural motor vehicle
- A vehicle fitted at the rear with apparatus specially designed for spreading material on the road
- A vehicle so constructed that it can be unloaded by part of the vehicle being tipped rearwards
- A vehicle owned by the Secretary of State for Defence and used for naval, military or air force purposes
- A vehicle to which no bodywork has been fitted and which is being driven or towed-
  - For the purpose of a quality or safety check by its manufacturer or a dealer in, or distributor of, such vehicles; or
  - To a place where, by previous arrangement, bodywork is to be fitted or work preparatory to the fitting of bodywork is to be carried out; or
  - By previous arrangement to premises of a dealer in, or distributor of, such vehicles;
- A vehicle which is being driven or towed to a place where by previous arrangement a device is to be fitted so that it complies with this regulation
- A vehicle designed and constructed, and not merely adapted, to carry other vehicles loaded onto it from the rear
- A trailer specially designed and constructed, and not merely adapted, to carry round timber, beams or girders, being items of exceptional length
- A vehicle fitted with a tail lift so constructed that the lift platform forms part of the floor of the vehicle and this part has a length of at least 1m measured parallel to the longitudinal axis of the vehicle
- A trailer having a base or centre in a country outside Great Britain from which it normally starts its journeys, provided that a period of not more than 12 months has elapsed since the vehicle was last brought into Great Britain
- A vehicle specially designed, and not merely adapted, for the carriage and mixing of liquid concrete
- A vehicle designed and used solely for the delivery of coal by means of a special conveyor which is carried on the vehicle and when in use is fitted to the rear of the vehicle so as to render its being equipped with a rear underrun protective device impracticable
- An agricultural trailed appliance

If a vehicle to which the regulation applies is fitted with a tail-lift, bodywork or other parts that would make fitting a rear underrun protective device impractical, it shall instead be fitted with one
or more devices that do not protrude beyond the overall width of the vehicle and comply with the following requirements:

- Where more than one device is fitted there shall be a gap of no more than 50cm between one device and the device next to it
- Not more than 30cm shall lie between the outermost end of a device nearest to the outermost part of the vehicle to which it is fitted and the longitudinal plane passing through the outer end of the rear axle of the vehicle on the same side of the vehicle. In the case of a vehicle fitted with more than one rear axle, the plane through the outer end of the widest rear axle on the same side of the vehicle should be used

For a vehicle fitted with a demountable body the maximum distance between the edge of the device and the maximum width of the rear axle should not exceed 30cm. The points P1 are located 35cm from the longitudinal planes tangential to the outer edges of the wheels on the rear axle.

For a trailer with a single axle or two close-coupled axles the 55cm ground clearance at the rear is measured when the coupling of the trailer with the towing vehicle is at the height recommended by the manufacturer of the trailer.

Instead of complying with the above technical requirements a vehicle may comply with Directive 79/490/EEC.

### 3.2.2 Directive 79/490/EEC (UNECE Regulation 58)

The EC Directive mentions vehicles of category M1, M2, M3, N1, O1 and O2. However, this report only considers the requirements for larger goods vehicles and their trailers of category N2, N3, O3 and O4.

Any vehicle of category N2, N3, O3 or O4 is deemed to offer effective protection over their whole width against underrun from the rear by vehicles of category M1 and N1 if:

- the vehicle is equipped with a special rear underrun protective device that meets the technical requirements below, or
- the vehicle is designed and or equipped at the rear that by virtue of their shape and characteristics, its component parts can be regarded as replacing the rear underrun protective device. Components whose combined function satisfies the technical requirements below are considered to form a rear underrun protective device.

The European documents exempt:

- Tractors for semi-trailers
- “slung” trailers and other similar trailers for the transport of logs or other very long items
- vehicles for which rear underrun protection is incompatible with their use

### 3.3 Other national rear underrun regulations

In the USA there are two standards relating to rear underrun, FMVSS 223 Rear Impact Guards, and FMVSS 224 Rear Impact Protection. FMVSS 223 states that a rear underrun guard must be able to withstand a force of 50kN at its central point (P2) and at a point near the end of the guard (P1). It must also be able to withstand a force of 100kN at a point between the centre and the end of the guard (P3). The guard must not deflect by more than 125mm; however a particular guard is not required to be tested at more than one location. A guard must be able to absorb 5,650J energy within the first 125mm of deflection at each point P3. FMVSS 224 states that the guard must have a maximum ground clearance of 560mm. This standard also incorporates tests to assess energy absorbing (hydraulic) devices.
In Brazil, researchers have been highly critical of the American standards for rear underrun protection. The Brazilians proposed a standard that required larger forces to be applied to the guard and a specified sequence for the application of the forces. The forces applied are dependent upon the mass of the vehicle. The maximum forces applied are 100kN at points at the centre (P3) and towards the end of the guard (P1), and 150kN at the points between the centre and ends of the guard (P2). The Brazilian standard also states a maximum allowable deflection of 125mm at each of the points P1, P2 and P3.

The following recommendations for a rigid barrier were made by researchers in Australia (Lambert and Rechnitzer, 2002):

- A ground clearance preferably of 350mm and no more than 400mm
- A minimum distance from the rear of the vehicle to the barrier no more than 300mm
- Full width to the outer edge of the tyres or truck body (note that this will be a problem for trucks with bodies that significantly extend beyond the outer sides of the tyres)
- 200kN at P1, 150kN at P2, 100kN at P3 (where points are the same as European)

The following additional requirements were recommended for an energy absorbing barrier:

- A stroke of at least 300mm and preferably more
- Energy absorption capacity of 50kJ
- Residual strength after full energy absorption the same as for the rigid barrier
4 Front Underrun Regulations

4.1 UK and EC regulations/directives

Directive 2000/40/EC applies to:

- Font underrun protective devices as separate technical units intended to be fitted to vehicles of category N_2 and N_3
- Vehicles of category N_2 and N_3 with regard to the installation of front under-un protective devices which have been type approved as separate technical units
- Vehicles of category N_2 and N_3 with regard to their front underrun protection

The requirements of the directive do not apply to:

- Off-road vehicles of category N_2 and N_3
- Vehicles such that their use is incompatible with the provisions of front underrun protection

The technical requirements of this directive are taken from UNECE Regulation 93, the main points of which are summarised below:

The requirements of a front underrun protective device (FUPD) are:

- The FUPD shall offer adequate resistance to forces applied parallel to the longitudinal axis of the vehicle and also satisfy certain dimensional requirements.
- The section height of the FUPD cross-member shall not be less than 100mm for category N_2 vehicles and 120mm for category N_3 vehicles. The lateral extremities of the cross-member shall not bend to the front or have a sharp outer edge (rounded with a radius of curvature not less than 2.5mm)
- The device may be designed so that its position can be varied, however, there shall be a guaranteed method of securing it in its service position to prevent it from being unintentionally moved
- The outermost surface of every front guard installation shall be essentially smooth or horizontally corrugated. Domed heads of bolts or rivets may protrude up to 10mm beyond the surface
- Points P1 are located 200mm from the longitudinal planes tangential to the outermost points of the tyres on the front axle
- Points P2 are symmetrical about the longitudinal centre-line of the vehicle at a distance of between 700 and 1200mm from each other (defined by manufacturer)
- The height from the ground of points P1 and P2 shall not exceed 445mm when the vehicle is unladen
- Point P3 is in the vertical longitudinal median plane of the vehicle, all points are shown in Figure 2 below:
The test forces shall be applied to each of the test points in separate tests on the same vehicle or device, or, if requested by the manufacturer, on different vehicles or different samples. If the structure and components of the vehicle that are relevant to the front underrun protection are located substantially symmetrically about the longitudinal centre-line the tests at points P1 and P2 shall be carried out only on one side.

The forces shall be applied as rapidly as possible and the vehicle or device must withstand the force for 0.2 seconds.

A horizontal force equal to 50% of the maximum weight of the vehicle or intended vehicle type but not exceeding 80kN shall be applied successively to points P1.

A horizontal force equal to 100% of the maximum weight of the vehicle or intended vehicle type but not exceeding 160kN shall be applied successively to points P1.

If the device is discontinuous and is reduced in cross-section between the points P2 then the tests shall continue by applying a force at P3 equal to that applied at P1.

The maximum horizontal and vertical displacements of each test point during the application of the forces shall be recorded.

The requirements for the installation of an approved FUPD are:

- The FUPD shall be fitted to the vehicle so that the horizontal distance measured in the rearward direction from the foremost part of the vehicle to the front of the device does not exceed 400mm less the recorded deformation measured at any of the test points. When measuring these distances, any part of the vehicle that is more than 2m above the ground shall be excluded.
The maximum ground clearance from the underside of the FUPD shall be no more than 400mm between the two points P1 in the installed position. Outboard of each point P1 this height may be greater than 400mm providing the underside is not above a plane passing through the underside of the FUPD directly below P1 and forming a slope at 15º above the horizontal.

The maximum ground clearance with respect to the underside of the FUPD between the points P1 shall be no more than 450mm taking into account their movement during the application of the test load.

The width of the FUPD shall at no point exceed the width of the mudguards covering the wheels of the foremost axle nor shall it be more than 100mm shorter on either side than the foremost axle measured at the outermost points of the tyres, or 200mm shorter on either side, measured from the outermost points of the access steps to the driver’s cabin.

Any vehicle in one of the categories N2 or N3 will be deemed to satisfy the conditions of this directive provided that the vehicle is equipped with a FUPD which has not been separately approved or is so designed and/or equipped at the front that, by virtue of their shape and characteristics, its component parts can be regarded as replacing the FUPD.

### 4.2 Other national regulations

Currently there are no other requirements for front underrun protection in non-European countries. However, Australian research (*Lambert and Rechnitzer, 2002*) has recommended the following requirements for rigid front underrun protection:

- Ground clearance of no more than 350mm
- Full width to the outer edge of tyres or mudguards
- A frontal projection of at least 300mm to provide buffer space in impacts with the sides of cars, and hence reduce the opportunity for direct head to vehicle body contact
- Curved at the ends to reduce concentrated loads being applied in angled collisions
- A layer of progressive crush material applied to the hard surfaces that starts off “soft” for impacts with unprotected road users and the side of cars
- 400kN applied at P1, 300kN applied at P2, 200kN applied at P3

This research also made the following additional recommendations for energy absorbing devices:

- A stroke equal to the maximum possible without leading to impacts on the steering wheels or axle and preferably 500 to 600mm
- An energy absorption capacity of 100kJ
- Progressive crush that starts off “soft” for impacts with unprotected road users and increases in stiffness to suit frontal impacts with a range of cars
- The residual strength after full energy absorption to be the same as for the rigid barrier
5 Proposed European Whole Vehicle Type Approval

The European Commission is currently considering a proposal for a directive to replace the current framework Directive 70/156/EC for European type-approval. The proposal aims to extend principles of whole vehicle type-approval, currently applied to cars and motorcycles, to the approval of goods vehicles and other vehicle types. The proposal incorporates a split level approach to type-approval and it is thought that the procedure could be operational in 2007. The new directive will mean that Community type-approval procedures will be compulsory and will form the basis of the national requirements. Type-approval will continue to be authorised by combining separate type-approvals for its constituent systems, components and technical units. A new multi-stage type-approval method has been introduced to bring the type-approval procedure in line with the manufacture of commercial vehicles. For example, the initial manufacturer carries out type approval of the chassis including the suspension, power unit, tyres and brakes, for which a type-approval certificate is issued. The second manufacturer, the bodybuilder, adds the bodywork and presents the completed vehicle for type-approval. In this way the type approval of rear and side underrun protection is likely to be the responsibility of the bodybuilder, although front underrun is likely to remain the responsibility of the chassis manufacturer.

The proposed framework directive includes the administrative provisions and general technical requirements for the approval of all new vehicles within its scope and also includes the requirements for all of the sub-systems, components and separate technical units intended for those vehicles. The specific technical requirements are laid down in separate directives. The proposed directive applies to the type-approval or individual approval of vehicles designed and constructed for use on the road and of systems, components and separate technical units designed and constructed for such vehicles.

The directive does not apply to the type-approval or individual approval of the following vehicles:

- agricultural or forestry tractors and trailers designed and constructed specifically to be towed by them
- quadricycles
- vehicles designed and constructed for use principally on construction sites or in quarries, port or airport facilities
- armoured vehicles designed and constructed for use by the army, civil defence and forces responsible for maintaining public order
- mobile machinery – self propelled vehicle which is designed and constructed specifically to perform work off the road or to perform specific work in agriculture or forestry and which, because of its construction characteristics, is not suitable for carrying passengers or for transporting goods. Machinery mounted on a motor vehicle chassis shall not be considered as mobile machinery
- tracked vehicles
- vehicles intended exclusively for racing on roads
- prototypes of vehicles used on the road under the responsibility of a manufacturer to perform a specific test programme

The proposed framework directive includes an article exempting new technologies or new concepts to allow type-approval of systems that are incompatible with one or more separate directive provided they can be demonstrated to offer an equivalent level of safety. In theory this could allow the development and approval of active underrun devices that may vary height or stiffness to be appropriate for the particular type of collision they become involved in.
6 Discussion of Regulations

The UK regulations for front, side and rear underrun protection have been developed over a period of time and are increasingly similar to the EC Directives. The UK regulation for sideguards is very different to the EC Directive, whereas the UK Regulation for front underrun refers directly to the EC Directive. In future it is likely that European Whole Vehicle Type Approval will mean that EC Directives will form the basis of all of the UK national regulations for underrun protection.

6.1 Test Forces

One of the inconsistencies noted in the regulations is that the test forces that the front underrun barrier is required to withstand are higher than for those used for the rear. At first glance this situation might appear logical. Front and rear underrun guards are primarily designed to protect car occupants that collide with an HGV when it is the front of the car that is involved in the collision. Where such a collision occurs with the front of an HGV the vehicles are usually travelling in opposing directions prior to the impact. Where the car strikes the rear of an HGV they were usually travelling in the same direction. For this reason closing speeds are typically much greater in accidents involving the HGV front than those involving the HGV rear. The typical front accident, therefore, applies a greater force to the HGV than the typical collision with the rear of the HGV, which is consistent with the different forces required by the different regulations. This approach means that both front and rear underrun guards are capable of protecting a similar percentage of the fatalities that collide with the front and rear respectively.

However, cars are designed to offer protection at or below certain impact speeds, for example 56km/h (EC frontal impact directive 97/27/EC). It can, therefore, be argued that both the front and rear underrun barriers should be designed to withstand forces associated with a survivable impact, that is, an impact with a closing speed of 56 km/h or less. As stated previously, the closing speeds, and therefore the forces applied to the underrun guard, in frontal collisions are typically greater than in collisions with the rear. Therefore, if both front and rear underrun guards are designed to withstand the same forces then the rear underrun guard will protect a greater percentage of the fatalities that collide with it than the front underrun guard will. This approach would maximise the benefits that could be obtained from rigid underrun protection.

It is likely that the reason for the difference in test forces is not as a result of a deliberate choice of approach to the problem of accidents with the front and the rear of an HGV. The regulation for the rear underrun guard was introduced in 1983 and the regulation for the front was introduced in 2003. A more likely reason for the difference is simply that cars are, in general, now heavier and stiffer than they used to be. The success of EuroNCAP in improving crashworthiness standards is considered to have been a substantial influence on this change. These changes to car structure mean that a modern car is likely to impose much higher loads on an underrun device than a car that was modern at the time that the rear underrun regulation was written, more than 20 years ago. In addition to this, the research tools available to quantify the forces involved have also improved. For example, many crash tests are now carried out using recently developed “load cell walls”, which can quantify the force imposed by any particular part of the interacting structure. The front underrun standard is, therefore, more likely to be an appropriate standard for today’s vehicle fleet. If an integrated approach to underrun protection aimed at maximising the number of people protected is taken then it is clear that the forces required by the rear underrun regulation should, at least, be brought into line with those required for the equivalent front underrun guard.

Although they could substantially affect the relative protection offered by the different guards, none of the differences described would prevent a manufacturer from producing a vehicle where the underrun protection was integrated all of the way around the vehicle. However, the differences do demonstrate that the regulations themselves haven’t been designed from an integrated or harmonised point of view and this is unlikely to encourage an integrated approach to meeting the requirements.
6.2 Test Methods

The geometry of the surfaces used to apply forces to the sideguards to test their strength are different to those used to test the front and rear underrun devices. The sideguards are tested using a circular ram with a maximum diameter of 220mm. Front and rear underrun devices use a rectangular ram 250mm high (exact height specified by the manufacturer) and 200mm wide with a radius of curvature of 5mm at the vertical edges. The reason for this difference is not known but it should be noted that the magnitude of forces involved differs widely. For example, 1kN for sideguards compared with 100kN for rear guards.

The way in which the ram applies the test force is also different between the regulations. For rear and side underrun the rate of application of the force is not specified and it has always been interpreted as a quasi-static test. Equally there is no time period specified for which the rear or side protection must withstand the force. However, in the front underrun regulation it is required that the test force is applied “as quickly as possible”, although there is no further guidance on what sort of rate is implied by this statement. It is not known why the front regulation is worded in this way or whether it leads to any significant problems. However, it does leave the regulation open to interpretation.

When a force is applied very rapidly it can generate “shock loading”, which can result in much greater stresses within the structure. In such a case a dynamic test would be more difficult to pass than a static test. Some materials exhibit “strain hardening” behaviour and appear stiffer when forces are applied more rapidly to them than when they are applied slowly. This allows the possibility that the test method could be tailored to suit the material used in order to pass the requirement. However, it is also true that rapid application of force is more realistic when considering real crashes. This is supported by the requirement that the guard must withstand the force for at least 0.2 seconds, which is typical of the duration of a car frontal crash into a barrier. When considering the suitability of the test methods, it is worth noting that for all of the underrun regulations the test loads are applied sequentially which is not representative of what happens in real impacts. In real impacts the forces applied to the underrun guard are all applied within the same 0.2 second period.

The positions, P1 and P2, to which the forces are applied on the front and rear underrun devices are different. For example P1 is 300mm from the outer edges of wheels on the rear axle and, but 200mm from the outer edges of the wheels on the front axle.

Again, none of these differences prevent an integrated approach to safety guard design but neither do they encourage such an approach.

6.3 Dimensional requirements

The ground clearance of underrun protection is one of the key parameters affecting its performance. The maximum ground clearance for rear and side protection is 550mm. However, for the front it is 400mm. There are operational reasons for this associated with the shorter overhang of the body at the front compared with the often large rear overhang and wheelbase. Larger overhangs are more likely to result in ground clearance problems for underrun protection. However, it is worth noting at this stage that not all HGVs have a large rear overhang, but all HGVs are required to have an underrun guard that can have a ground clearance suitable for a large rear overhang. Also, many HGVs that do have relatively large rear overhangs are voluntarily fitting side and rear guards that are much lower than required by the regulations. A series of examples is shown in Figure 1, below.
Figure 1. Examples of low ground clearance HGVs

It can be seen that the ramp and departure angles permitted by these designs will be very small, yet they were all HGVs easily found in-service on UK roads. The photographs show no evidence of damage to suggest that grounding of the vehicle had been a problem in service. However, the photos only represent one fixed point in time for these vehicles and it is possible that they had been damaged previously and repaired before the time of the photograph.

The sideguard regulation states that for a trailer (other than a semi-trailer) the maximum distance from the leading edge of the sideguard to a vertical tangent to the rearmost part of the tyre in front is 500mm. This requirement is sensible for a full trailer that is equipped with one or more axles at the front and the rear but it is not possible to apply it to a trailer with centre axles as shown in Figure 2 below. This is because the distance to the tyre in front of the leading edge of the sideguard will depend on the design of the towing vehicle and the separation between towing and towed vehicles, both of which will vary greatly.
However, Figure 2 illustrates the gap that can be left as a result and clearly shows that it is still possible for vulnerable road users to fall under the wheels of such a trailer if there are no sideguards fitted in front of the trailer axles. It can also be seen that for a vehicle combination such as this the fitment of sideguards behind the rear wheels of the towing vehicle could also offer substantial benefits.

Again, the anomalies and differences noted in this section can have a substantial affect on the performance of the protection but do not prevent an integrated design. However, as before, there is little to encourage an integrated approach.

6.4 Installation

In order to integrate the side and rear safety guards, additional sideguards must be fitted behind the rear wheels. This is not prevented by the regulations and is, in fact, expressly permitted by the European Directive. However, it is in excess of the current requirements and, as such, there is no regulatory control on the structures that might form part of an integrated guard. The sideguard behind the rear wheels may also have to be angled. A requirement of the rear underrun regulation is that the device must not protrude past the outer surface of the tyre. If the sideguard is designed to cover the wheels, then the rear section must be angled to meet the rear underrun device. A regulation that includes all the requirements to design a vehicle with integrated guards may encourage more manufacturers to take this approach.

The wording of the rear underrun regulation is prescriptive in at least one place and could potentially stifle innovative solutions such as integrated safety guards. The regulation requires that the rear underrun device is mounted to the chassis side members or whatever replaces them. It is assumed that this is to ensure the mounting points have sufficient strength to withstand the possible load and it also implies a traditional central beam chassis construction. However, the regulation already contains a test requirement that certain loads should not result in the rearguard moving or crushing such that it is more than 400mm from the rear of the vehicle. If the rearguard can meet this requirement, why should a further constraint be necessary?

A number of vehicle and trailer manufacturers have seen the potential aerodynamic and styling or image benefits of having glass fibre panelling around the vehicle. However, for many of these the end product still falls a little short of a fully integrated safety guard concept, as shown in Figure 3, below.
Figure 3. Partially integrated safety guard

It can be seen that although the glass fibre panel type sideguards extend behind the rear wheels and around the rear of the trailer there is still a separate rear underrun guard constructed in the traditional manner and not linked to the integrated guard. One of the benefits of an integrated approach is that the sideguard behind the rear wheels can be used to strengthen the rear guard at its edges. Another benefit is that there is a smooth surface for the vulnerable road user to contact all the way along the length of the vehicle. This design of trailer misses out on these potential benefits because the rear guard is not connected to the sideguard and the sideguard behind the rear wheels tapers in-board of the vehicle, which leaves the rear guard as a sudden protrusion, which could cause injury to a vulnerable road user in contact with the side panelling.
7 Analysis of Exemptions

7.1 Introduction

When the rear underrun and sideguard regulations were introduced there was strong opposition from industry, with the main concern being the effect of smaller ground clearances on operations. This opposition was overcome by exempting some vehicles from the regulations. These vehicle types are described in Sections 3 and 4. In an analysis of accidents involving HGVs, it was estimated that up to four percent of pedal cyclist and one percent of pedestrian fatalities could have been prevented by ending the exemptions for the fitment of sideguards (Knight, 2000). Where the fitment of rear underrun protection was known, 28% of HGVs involved in fatal accidents where a car collided with the rear, were not fitted with any type of rear guard. In fact, 88% of these exempt vehicles were exempt because of their tipping bodies (Knight 2000).

This section of the report investigates whether the exemptions for sideguards and rearguards are justified. Many of the exemptions relate to the use of the vehicle and a certain amount of subjective opinion is inevitable in discussions of the subject. TRL has attempted to tackle this problem by collecting evidence of both the use that vehicles are put to in-service and the construction of vehicles with and without safety guards in order to try to determine what likely and extreme situations will be encountered in-service and whether the fitment of a current regulatory minimum underrun device would have an adverse affect on the vehicles ability to operate in those environments.

The main part of this work has considered the exemptions specified by the UK Construction and Use regulations because they list specific vehicle types. The interpretation of the more generic exemptions permitted by EC Directives is considered separately and relates them to those discussed previously. The final section discusses potential future approaches to exemptions.

7.2 Tipping vehicles

Anecdotal evidence suggests that the main reason for the exemption of tipping vehicles is that they require space for the tipping mechanisms and are required to drive off road. TRL has searched the internet and publications to collect evidence of the construction and use of such vehicles to help determine whether these concerns are justified.

In reality the tipping mechanism is provided by hydraulic rams underneath the container which is pivoted to the rear or side. TRL found no evidence of tipping mechanisms being situated in areas of the vehicle that would interfere with underrun protection. If the underrun device were fitted to the tipping body rather than the chassis then the action of tipping could cause problems in some cases. However, in all cases it should be possible to mount the underrun device direct to the chassis, which should eliminate these difficulties.

Studying trade publications as well as adverts from manufacturers promoting the capabilities of tipping vehicles shows that in many cases the vehicles being discussed are not really used off-road in the most severe sense of the word. Much of the use of these vehicles appears to take place on the public highway and most of the “off-road” situations are in fact un-made roads on sites such as quarries and construction sites. Examples of common site situations are shown in Figure 4 below.
Figure 5 shows an example of a vehicle being used off-road. It is important to note that this vehicle is in fact a military vehicle and so is exempt on two counts (the military exemption is discussed in section 6.3).
Figure 5. Military tipping vehicle being used off road

It can be seen from Figure 5 than the vehicle is up to the centre of its axles in mud, which is a similar height to the ground clearance offered by sideguards. Also the picture shows that the vehicle has structure between the axles where the sideguards should be fitted. This does not appear to prevent this vehicle from travelling over such terrain. However, the vehicle in the picture is leaning to the near-side and ground clearance may not be as favourable on the side that cannot be seen. It is likely that in this type of off-road use ground clearance could become an issue. However, it must be noted that on extensive internet searches no examples of ordinary road-going civilian tippers engaging in this kind of extreme off-road use were found. It is also worth noting that ground clearance is likely to be less of an issue in this situation than traction. Any vehicle not equipped with all-wheel drive is likely to struggle in these circumstances.

Figure 6 shows the most extreme example identified where a civilian vehicle was being used off-road. It is possible that these vehicles are tipping vehicles voluntarily equipped with sideguards but it is also possible that they are “walking floor” trailers instead of tippers and, therefore, not exempt from the regulations. In either case, it can be clearly seen that the vehicles are articulated combinations and will, therefore, have limited traction ability for off-road use. The fact that such vehicles with limited traction and reduced ground clearance due to sideguard fitment are still chosen for use on this type of terrain tends to suggest that the exemption for tipping vehicles is not justified because the majority, where evidence of use could be found, were operating on much easier terrain than this.

Figure 6. Articulated tipping vehicles being used off road

Figure 7 shows a photograph used to advertise a tipping vehicle that can “tackle the worst sites” and a mixer from the same product range, which is not exempt from fitting sideguards.

Figure 7. Tipping vehicle and mixing vehicle advertising pictures
The chassis’ of these two vehicles will be almost identical and they are often used on the same types of road surface in the same locations, namely construction sites. Therefore if the mixer can negotiate the terrain that is found on such “off-road” sites while equipped with sideguards why must the tipper still be exempt? Again, this lends further weight to the argument that the exemption is not justified.

Further steps have been taken by one particular concrete mixer company, RMC. Figure 8, below, shows a trial vehicle that they are operating, which incorporates a number of measures aimed at reducing the incidence and severity of collisions with vulnerable road users.

![Image of RMC safety features](image)

**Figure 8. RMC safety features**

Of particular note is the sideguard arrangement. This is a vehicle that will regularly go “off road” on sites and concrete production facilities yet it is fitted with a main sideguard that exceeds minimum requirements because it is a flat panel design. In addition to this, the sideguard incorporates a movable part that provides an additional low rail that is much lower than the maximum ground clearance required by regulation. This low rail is deployed for road use and raised again for off-road use such that ground clearance whilst on site is not compromised. This suggests that innovative but simple design is capable of removing the need for off-road exemptions.

Many tipping vehicles currently have structures between their axles that limit ground clearance and ramp angle by amounts comparable to regulatory minimum standard safety guards. Of particular note are the landing legs for semi-trailers. On rigid vehicles, fuel tanks and other structures often reduce ground clearance. Figure 9 shows two vehicles where ground clearance is reduced by the vehicle structure. Although vehicle structures may prevent vulnerable road users from falling under the wheels of the vehicle, there may be protrusions that can also cause serious injury.
Typically, the height of axle centres for full sized HGV wheels is approximately 500mm from the floor. If a straight line is imagined through the axle centres of the vehicles shown in Figure 9, it can be seen that although the vehicles are not equipped with safety guards the ground clearance is compromised by other structures such as fuel tanks, air tanks and tow hooks. Figure 4 also shows that ground clearance is often reduced by landing legs on articulated vehicles. These devices are installed in these positions voluntarily by manufacturers, and body builders, and operators do not seem to view them as a cause for concern. However, it can be seen that the structures that limit the ground clearance in these cases do not fulfil all of the requirements of safety guards and would offer little or no protection to vulnerable road users or car occupants.

7.3 Refuse vehicles

Refuse vehicles are defined as vehicles designed for and solely used in connection with street cleansing, the collection or disposal of refuse or the collection or disposal of the contents of gullies or cesspools.

Unlike tipping vehicles the ability to travel off-road is probably not the main reason for the exemption for refuse vehicles. The nature of the refuse vehicles purpose means that they necessarily must be fitted with a variety of equipment such as bin lifts, hydraulic equipment, controls, sweeping brushes, water jets and suction hoses. Figure 10 shows how such bodywork and equipment can limit the ground clearance to the rear and side of a dustcart.
A dustcart, as shown in Figure 10, above, will usually be used on ordinary urban roads but may also collect refuse from premises with poor quality or unmade roads. The ground clearance at the rear of the vehicle is already low because of the existing bodywork and equipment. It would be impractical to fit a rear guard around the equipment at the rear of the vehicle. However, if the exemption was ended the clause in the regulation that allows the guard to be replaced by existing vehicle bodywork would allow the current arrangement provided the main requirements of the underrun device could be met. In reality this would mean that the current regulation could be satisfied if the vehicle structure could withstand the test forces without exceeding the maximum deformation.

Given that the off-road capability of refuse collectors is typically limited and other structures and devices limit the ground clearance between the wheels there seems little justification in the exemption for this particular type of refuse vehicle. The equipment between the axles of the vehicle shown in Figure 10 could easily be positioned such that the controls were accessible from between the rails of a traditional sideguard design or the controls could be surface mounted in a flat panel design of sideguard.
Vehicles that are used for street cleaning are often fitted with a large amount of ancillary equipment under the body between the axles where sideguards are normally fitted. This equipment can be seen clearly in Figure 11.

Figure 11 Street cleaner equipment

This type of equipment may prevent a cyclist or pedestrian from falling under the wheels, however, there are many sharp edges that may cause other severe injuries. It could therefore be argued that such vehicles should have their equipment boxed in by sideguards to provide a less aggressive surface. This is an important consideration because many of these vehicles are used in urban areas in close proximity to the kerb. The main difficulty with this approach for this type of vehicle is that the equipment is required to move to allow the vehicle to perform the operations it was designed for. Therefore a moveable sideguard that can be stowed when the vehicle is being used to clean, but installed when the vehicle is travelling but not cleaning would probably be necessary. Such a measure would add to the complexity of either the vehicle (if automated) or the operation (if manual). However, it is unlikely to be considered impractical because it is a simple and straightforward operation to design and build (if automated) or to perform (if manual).

7.4 Vehicles owned by the Secretary of State for Defence

Vehicles that are used by the military, navy or air force may be required to travel over many different types of terrain as shown earlier in Figure 5. Although many of the vehicles are driven on roads, they may be required to be able to change between being on the road to being off road. For any vehicle that may potentially be used in a combat operation the use to which it may be put, or terrain that it may cross, are extremely diverse. For these types of operations, the use of safety guards, or even demountable safety guards, is not practical.

The Secretary of State for Defence may own some vehicles that are not used for such operations and travel solely on road, for example troop transporters or delivery vehicles that are not used in operations. If there is no off-road use and no complex machinery or equipment fitted to the vehicles that could obstruct safety guards then there is no technical justification for such vehicles to be exempt from the regulations.

A system whereby some of the defence vehicles are exempt on grounds of off-road or operational use and standard vehicles must comply with regulations could be envisioned. However, the costs and
benefits of implementing such a system should be considered in the light of the potentially small number of vehicles that might be affected and the possibility that the exposure to risk of those vehicles, that is the distance travelled on the public road, might be very small.

7.5 Fire engines

Many fire engines are designed to store large amounts of water as well as equipment that needs to be easily accessible in emergency situations. These storage requirements often mean that the space between the axles of the vehicle are employed as storage, thus reducing the ground clearance. This is clearly illustrated in Figure 12 below. The ground clearance between the axles may be estimated from the picture by considering the diameter of the tyres. The vehicle specification for a similar fire engine states a tyre designation of 285/70R 19.5, which provides a rolling radius of approximately 450mm. From Figure 12 it can be seen the ground clearance is approximately the same or slightly less than the rolling radius. This is a ground clearance lower than that required for vehicles that are not exempt from the sideguard regulation, so, provided that the bodywork meets the strength requirement of the regulation, the probability of a pedestrian or cyclist falling under the wheels is going to be smaller than many vehicles that are fitted with sideguards. However, there may be some designs of fire engine that have higher ground clearances. These vehicles should not be exempt from the fitment of sideguards unless they are specifically designed for off-road use as shown in Figure 13.

Figure 12 Fire engine
It can clearly be seen that ground clearance could become an issue on this type of terrain and that the vehicle shown has been designed with this in mind and does not have other structures limiting the ground clearance. It should also be noted that all three axles of the vehicle are driven to provide maximum traction and off-road capability.

7.6 Agricultural motor vehicles and trailers

Agricultural motor vehicles must be able to travel off road in order to be able to perform their function. Some agricultural vehicles and their trailers are only used on the road for short periods. However, when they are on the road they are often slow moving and so susceptible to impacts to the rear or side when turning across the carriageway. It is often not practical to fit underrun protection or sideguards to an agricultural vehicle, but it may be practical to fit demountable sideguards or rear underrun protection to the trailers and produce a code of practice for their use.

However, there are some vehicles, such as the JCB Fastrac or the Unimog, that are primarily used for transporting produce or equipment between fields and, therefore, spend a large proportion of their time on the public road. These vehicles are capable of travelling much faster than agricultural tractors and have now been classified as HGVs in relation to the approval of their braking systems. It may be appropriate to consider these vehicles as HGVs with regard to the fitment of safety guards as well.

7.7 Trailers designed to carry items of exceptional length

Trailers that are designed to carry items of exceptional length often have a low structure between the axles or, where the load forms part of the chassis, have no structure at all between the axles. Extendible trailers have a derogation to the sideguard regulation which means that when the trailer is extended there may be large gaps between the sideguard and the axles. If it possible to design a trailer that extends, it must also be possible to design extendible sideguards.

An example of an extendible trailer carrying an item of exceptional length is shown in Figure 14.
It is clear from Figure 14 that it is not practical to fit sideguards in the expanse between the axles where there is no vehicle structure at all. It may, however, be possible to fit sideguards in front of the axle on the rear load platform. When considering this type of vehicle it is important to consider two aspects. Firstly, the number of road movements of this type of vehicle is very small. Secondly, these vehicles typically only move at low speed and are unlikely to be in the position of overtaking pedal cyclists in urban situations. A final consideration is that many such load movements are required by law to be accompanied by a police or civilian escort. These factors combine to mean that the risk of an accident where a safety guard could have been of benefit is very small in relation to other vehicle types discussed in this report.

7.8 Vehicles designed to carry other vehicles loaded from the front or rear

Vehicles that are designed to carry vehicles loaded from the rear are exempt from fitting rear underrun protection. Vehicles that are designed to carry vehicles loaded from the front or rear are also exempt from fitting sideguards. There is no obvious global reason why vehicles that are designed to carry other vehicles should be exempt from the fitment of safety guards. There is no fundamental reason why the loading mechanism, for example ramps, should get in the way of a rear underrun guard or a sideguard. It is unlikely that a car transporter will be required to travel off-road for any substantial proportion of its time. It is possible that this exemption came about because the structure of car transporters is typically very low anyway to allow two layers of vehicles to be transported without the vehicle becoming excessively tall. An example of such a vehicle is shown in Figure 15 below.
The transporter shown in Figure 16, below, does have sideguards fitted even though it is not required to.

![Figure 16. Car transporter with sideguards](image)

If the sideguards were not fitted, then this vehicle would pose a threat to vulnerable road users because there is no structure between the axles. This vehicle uses a movable load platform to enable vehicles to be loaded and unloaded and does not have a rear underrun device, even though such a device should not prevent the load bed from reaching the ground. However, in the travelling position shown the structure is sufficiently low to occupy the space that would normally be occupied by the rear underrun guard. In this case the clause permitting existing vehicle structure or bodywork to substitute for the presence of a rear guard could be used instead of the exemption. In this way, if the structure of the vehicle is high then an underrun guard must be fitted but if it is low then it does not, although the bodywork in that area should be able to withstand the underrun forces. Where a rear underrun guard is required the fact that the bodywork is high relative to the ground means that there should always be sufficient space to design a loading and unloading system that is not obstructed by the presence of the underrun device.

### 7.9 Vehicles where the tail lift forms part of the load platform

The most common example of this type of vehicle is a bread delivery lorry. The tail lift is stowed in the horizontal position and forms the rearmost part of the load platform. The tail lift is boxed in by the vehicle's body such that it is not immediately obvious from the outside that the rearmost portion of the load bed is actually a tail lift. In this type of design the rearmost part of the chassis is typically more than a metre forward of the rear door of the vehicle. Some of these vehicles do fit rear underrun protection; however this is fitted to the rear of the chassis, in front of the tail lift. An simple line diagram illustrates the principle in Figure 17 below.
It can be clearly seen that the underrun guard is positioned such that more than a metre of underrun can occur before the front of a car contacted the rear underrun guard. At this point the rear of the HGV will be inside the passenger compartment of almost all cars. In addition to this it must be considered that the floor at the rear of the vehicle is in fact the tail lift, which is a horizontal sheet of metal that at its rearward edge is tapered to a point to enable trolleys to be wheeled on and off with no difficulty.

As with some of the other exemptions, such as military vehicles, the number of this type of vehicle on the roads will be relatively small. However, this particular design of vehicle is likely to present a much greater hazard than most of the other exempt vehicles.

The reasons for other exemptions (justified or not) discussed in this report are that the vehicle would be unable to fulfil its purpose if it were fitted with safety guards. For example, the exemption for tippers is because of claims that they would be unable to negotiate quarries to collect their goods, or building sites to deliver them, if they were fitted with safety guards. It would be unreasonable to claim that a vehicle could not deliver bread from a bakery to a shop if it did not incorporate a tail lift as part of the floor. In this case, it is clear that ending the exemption may have an impact on aspects of the delivery operation in terms of speed and efficiency and may, therefore, have a cost penalty. However, it would not prevent the operation from taking place and there should be no impact on competition because it should affect all bread manufacturers and transporters equally.

7.10 Vehicles designed for the carriage and mixing of concrete

Concrete mixers are exempt from fitting rear underrun protective devices. This is clearly not an issue of ground clearance because such vehicles are required to fit sideguards. It is likely that the basis of this exemption is the practicality of fitting a device at the rear without affecting the operation of the equipment for delivery of the concrete or possibly the ability to mount the guard within 400mm of the rear of the vehicle. An example of a concrete mixer is shown in Figure 18, below.
It can be seen that although there is a considerable amount of equipment at the rear of the vehicle there is a light bar situated across the rear of the vehicle, which presumably does not cause operational problems. It is highly likely that a rear underrun cross member could be positioned just below the light bar, and in line with it, and be mounted to the end of the chassis. Although many of the bodywork structures do overhang rearwards of that position they are mostly very high from the ground. It is, therefore, likely that such a rearguard could provide positive protection benefits without compromising the vehicle operation. This suggests that the exemption is not justified.

7.11 Other types of exempt vehicle

Motor vehicle with a maximum speed of 15mph/25kph or less – these types of vehicle are still capable of overtaking pedestrians and some pedal cyclists. They will also present a hazard to other road users, such as car occupants, specifically because of their, often unexpected, low speed. There is no obvious reason why a vehicle should be exempt solely because it is not capable of exceeding 15 mile/h. It is likely that the basis of the exemption is associated with specific types of vehicle such as agricultural tractors or machines, or perhaps some construction machines, that happen to all have maximum speeds of 15 mile/h or less. However, most of these vehicles (e.g. agricultural vehicles & engineering plant) are covered by their own separate exemption. The inclusion of such a generic exemption allows the possibility that a vehicle that does not merit an exemption could earn one simply because of its maximum speed.

It is considered that this exemption is not justified on its own merits. It is possible that some of the vehicles covered by this exemption are justified but these should be considered separately in terms of their ground clearance requirements, interference with equipment essential to the purpose of the vehicle and the use of the vehicle in areas of risk.

Engineering plant and agricultural trailed appliances – There is a huge diversity of design and purpose of vehicle within this category. Many of those vehicles contained within the category will be used off road and/or employ a variety of moving equipment or machinery that could interfere with the
fitment of safety guards. In addition to this, a substantial proportion of this type of vehicle will spend most of its time on construction sites and will travel relatively few miles on the public road. In fact it is often the case that if engineering plant has to be moved large distances between jobs it will be carried on the back of another HGV where its lack of safety guards will present no additional risk to other road users.

On a purely technical level each type of device should be considered on its own merits to determine whether safety guards should be fitted. However, this approach is unlikely to show a cost benefit because the number of different types of vehicle is very high in relation to the total number of vehicles in this category. It would, therefore, require a large amount of administrative effort for a small number of affected vehicles.

Vehicle with no bodywork – it is not feasible for a vehicle with no bodywork that is going to have body work fitted to meet the requirements of the regulations because the design of the sideguards or underrun device are often dependant upon the design of the body.

Vehicle being taken to have sideguards/underrun fitted – this exemption is justified

Foreign trailers – there is no specific technical reason for foreign trailers to be exempt. However, this is a decreasing problem because the majority of trailers in the UK are covered by EC Directives.

A motor car or heavy motor car constructed or adapted to form part of an articulated vehicle – there is no apparent technical justification for an exemption from the sideguard regulation. In many cases there are other structures between the axles such as fuel and air tanks, which do often fill the gaps that would otherwise allow a vulnerable road user to fall between the wheels. Because of the presence of these structures ending the exemption would not necessarily result in the fitment of sideguards for most tractor units because there is a clause that allows the guard to be replaced by other structures provided the alternative structure meets the main requirements of the regulation. However, these structures can often have hard protrusions that may be injurious to vulnerable road users when they collide with them. These protrusions and, hence, injuries could be prevented by the use of flat panel sideguards in the same way as being considered for other parts of the vehicle as part of this project. In the same way as they might for rigid vehicles and trailers they may be able offer benefits of fuel efficiency, spray suppression and improved image. In fact, some tractor units for articulated vehicles do voluntarily fit such integrated sideguards. Wherever possible manufacturers and operators should be encouraged to fit sideguards to tractor units but it is not clear that ending the current exemption would actually achieve that objective.

Tractor units are also exempt from fitting rear underrun guards. The fitment of a rear guard to a tractor unit is unlikely to have any substantial impact on the operation of equipment or the off-road capability of the vehicle. However, there will be a small reduction in payload and a resultant increase in operating costs and the benefits of fitting the protection will also be very small. The exposure to accident risk at the rear is very small because tractor units are almost always used as part of a combination such that the trailer will prevent most collisions with the rear of the tractor. It is possible that a car could collide with the rear of a tractor unit towing a semi-trailer whilst the combination was negotiating a tight corner such that there was a large articulation angle. However, these accident circumstances are also likely to be extremely rare.

A vehicle fitted at the rear with apparatus specially designed for spreading material on the road – This type of vehicle is exempt from the fitment of rear underrun guards and the basis of this exemption is the practicality of fitting a rear underrun guard in a similar area of the vehicle to the mechanism that fulfils the purpose of the vehicle. Technically, it should not be that difficult to design and build a vehicle that can fulfil both functions but it is likely to require a change from current designs and the exposure to risk is very low because of the small number of this type of vehicle on the road at any given time.

Coal delivery conveyor – these vehicles are similar to those directly above where the exemption is based around the potential interference between the guards and the specific equipment required for this type of vehicle. It should be possible to design guards in conjunction with the equipment such that
both can operate effectively together. However, there will be very few coal vehicles and it is likely there will be fewer and fewer in future.

**Low loaders** - these trailers are a low structure and therefore there is no need to fit sideguards and rear underrun protection to prevent underrun and vulnerable road users being run over. However, it could be argued that the exemption is not required because there is already a clause in the regulation allowing body structure to substitute for the safety guard where it exists as a standard part of the vehicle in a position where underrun protection is required.

### 7.12 Exemptions from EC Directives

The exemptions from the current EC Directives are:

- **Sideguards**
  - Tractor units for semi-trailers
  - Trailers specially designed and constructed for the carriage of very long loads of indivisible length
  - Vehicles designed and constructed for special purposes where it is not possible, for practical reasons, to fit such lateral protection
  - Any motor vehicle or trailer designed for use on the road, with or without bodywork and with a maximum speed less than 25km/h

- **Rear underrun protection**
  - Tractors for semi-trailers
  - “slung” trailers and other similar trailers for the transport of logs or other very long items
  - Vehicles for which rear underrun protection is incompatible with their use

- **Front underrun protection**
  - Off-road vehicles of category N₂ and N₃
  - Vehicles such that their use is incompatible with the provisions of front underrun protection

Where the exemptions from the rear and side Directives relate to specific vehicle types the interpretation is the same as for the UK regulations, as discussed above. For example it is considered that the exemption of tractor units from the requirements for rear protection is appropriate but that requiring sideguards, particularly flat panel sideguards, for tractor units could be beneficial. However, the other exemptions for rear and side and both exemptions for front protection are very different and require separate consideration.

The sideguard Directive contains an exemption for:

“*Vehicles designed and constructed for special purposes where it is not possible, for practical reasons, to fit such lateral protection*”

This particular exemption is completely open to subjective interpretation. It is evident from studying vehicles on the road that tipping vehicles must be considered to qualify for this objective but, as shown in Section 7.2, it is a matter of considerable debate whether it is not possible, for practical reasons, to fit the devices to this particular type of vehicle.

The rearguard Directive contains an exemption for:

“*Vehicles for which rear underrun protection is incompatible with their use*”

Although worded differently this could be interpreted to mean principally the same vehicle types as the exemption above for sideguards and it is equally open to subjective interpretation.
The front underrun Directive is a little different in terms of its exemptions. Firstly, it specifically exempts HGVs that are designated for off-road use according to the “G-class” definition in the framework Directive, independent of body type or other classification. This is a categorisation that would restrict the amount of tippers that were exempt from the regulation because and 6*2 or 8*2 tippers would not qualify because of insufficient driven axles and other tippers would be disqualified on ground clearance issues before underrun was fitted. More details of this approach are presented in section 7.13.1, below.

Although the regulation includes this exemption, which could potentially limit the number of exempt vehicles compared with those exempt from side and rear, it also still includes the exemption:

“Vehicles for which front underrun protection is incompatible with their use”

Since the interpretation of this same exemption for rear guards, and an equivalent one for sideguards, seems to allow all tipping vehicles it seems unlikely that the introduction of the “g-class” exemption will actually have limited the number of exempt tippers at all.

### 7.13 Potential alternative approaches to exemptions

The evidence shown in preceding sections strongly suggests that many of the exemptions to safety guard regulations are not justified. Part of the problem may well be the wording of the regulations and exemptions themselves. For example, the UK regulations exempt a series of specific vehicles based on criteria such as the body type and/or the type of load carried. The EC Directives tend toward the opposite extreme where most exempt vehicles will obtain their exemption through a subjective interpretation of how one generic exemption applies to any particular vehicle or operation. Both of these approaches allow the possibility that vehicles or operations that do not strictly require an exemption can gain one. It is, therefore, important to consider what design or operational factors are truly limited or affected by the fitment of safety guards and to re-structure the exemptions based upon these factors independent of vehicle type or load.

Analysis of the exemptions in the UK and EC regulations/Directives suggest that the basic factors determining whether a vehicle is exempt are as follows:

- The off road capability (e.g. Tippers, agricultural vehicles, military vehicles etc)
- The use of ancillary equipment essential to the vehicle function (e.g. road sweepers, concrete mixers etc)
- The presence of chassis/body structure in the areas covered by the safety guard requirements

The following sections will discuss possible approaches to defining whether such factors are relevant to any particular vehicle and whether they merit an exemption.

#### 7.13.1 Off-road performance

At present, it is considered that many of the exemptions from safety guard regulations have been based on the requirement for that specific type of vehicle to be able to travel “off-road”. However, with the possible exception of front underrun regulations, the exemption tends to be awarded based on vehicle type such that the “off-road” use is never objectively defined.

It is possible to consider a number of levels of “off-road” performance:

- On-road – that is roads made of hard surfaces such as concrete or asphalt
- Unmade road – clearly travelled roads, tracks or trails, constructed from packed earth and or gravel
- Completely off-road – travel where no road, track, or trail exists. Surfaces and profiles can be anything that naturally occurs from rock through to deep mud or water and can involve steep gradients
Initial consideration of how to define vehicles that should be exempt was based upon the definition of off-road vehicles contained in EC Directive 70/156. The definition of an off-road (Type G) vehicle is as follows:

- Category N2, M2, or M3 vehicles with a maximum mass not exceeding 12 tonnes are considered to be off-road vehicles either if all their wheels are designed to be driven simultaneously, including vehicles where the drive to an axle can be disengaged, or if the following three requirements can be satisfied:
  - At least one front and at least one rear axle are designed to be driven simultaneously, including vehicles where the drive to one axle can be disengaged
  - There is at least one differential locking mechanism or at least one mechanism having a similar effect
  - They can climb a 25% gradient calculated for a solo vehicle

- Vehicles in category M3 with a maximum mass exceeding 12 tonnes or in category N3 are to be considered off-road vehicles if the wheels are designed to be driven simultaneously, including vehicles where the drive to one axle can be disengaged, or if the following requirements are satisfied:
  - At least half the wheels are driven
  - There is at least one differential locking mechanism or at least one mechanism having a similar effect
  - They can climb a 25% gradient calculated for a solo vehicle
  - At least four of the following six requirements are satisfied, where no account of underrun protection is made when measuring angles:
    - The approach angle must be at least 25°
    - The departure angle must be at least 25°
    - The ramp angle must be at least 25°
    - The ground clearance under the front axle must be at least 250mm
    - The ground clearance between the axles must be at least 300mm
    - The ground clearance under the rear axle must be at least 250mm

According to this definition it is not possible for articulated vehicles to be officially classified as a Type G off-road vehicle. This is because to travel off-road a vehicle needs to be able to offer much better traction than many HGVs and, therefore, the Directive specifies that at least half of the wheels must be driven. No current road going trailer uses powered axles, to the best of the authors’ knowledge, and so this requirement cannot be met. Even if the vehicle combination is considered as a single vehicle, of current configurations, only a 6*4 tractor towing a single axle trailer has half of the axles driven. Therefore, if it is argued that exemptions are justified for off-road vehicles, then using
the EC Directive definition of a type G off-road vehicle in the underrun protection regulations would end the exemptions to all three requirements for articulated vehicles.

However, many rigid tippers are capable of meeting the requirements described above, particularly those with only two axles where standard two-wheel drive is sufficient to meet the traction requirement of half of the wheels being driven. For example, Table 3 shows details of two twin axle rigid tipper chassis.

### Table 3. Analysis of tipper chassis

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Tipper</th>
<th>Tipper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle model</td>
<td>Mercedes ATEGO 1823K</td>
<td>Mercedes ATEGO 1823AK</td>
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<td>GVW</td>
<td>17.0 t</td>
<td>17.0 t</td>
</tr>
<tr>
<td>Height of centre of axle</td>
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<td>520 mm</td>
</tr>
<tr>
<td>Number of axles</td>
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<td>2</td>
</tr>
<tr>
<td>Number of driven axles</td>
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<td>2</td>
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<tr>
<td>Diff lock</td>
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<td>Yes</td>
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<tr>
<td>Gradability</td>
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<td>Wheelbase</td>
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<td>Front overhang</td>
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<tr>
<td>Height of front (estimated)</td>
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<td>740 mm</td>
</tr>
<tr>
<td>Rear overhang</td>
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<td>1150 mm</td>
</tr>
<tr>
<td>Height of rear</td>
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<tr>
<td>Minimum clearance between axles (with sideguards)</td>
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<td>550 mm</td>
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<tr>
<td>Ramp angle</td>
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<td>32</td>
</tr>
<tr>
<td>Approach angle</td>
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<tr>
<td>Departure angle</td>
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<td>Off-road vehicle</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Items shown in red are those that do not meet the requirements for a ‘G’ class vehicle. Both vehicles are category N3 so only four of the six ground clearance requirements must be met. This shows that the 1823K cannot be classified as ‘G’ class and would, therefore, lose its exemption if this method were adopted. The 1823 AK would, however, still be granted an exemption. The table also shows that only a single very small change to one of the ground clearance under the front or rear axle or the approach angle would be required to meet the type G requirements and maintain the exemption. If the definition of a type G vehicle were used to justify exemptions from safety guards regulations then all 6*2 and 8*2 tipper would lose their exemption. However, many other rigid tipper would retain their exemption and it is likely that over time more, or even all, rigid tipper would be designed to meet the criteria and maintain their exemption.
Table 2 also reveals that the type G definition is not particularly demanding. As shown in Figure 5, traction is likely to be a major issue in serious off-road use but a vehicle can still be classified as an “off-road” vehicle when equipped with only two wheel drive. Also, the minimum ground clearance required to meet the 25º ramp angle requirement for this wheelbase is only 432 mm. This could be comfortably achieved by a vehicle equipped with sideguards, which suggests either that the minimum level of off road use considered by the regulation is not very demanding or that sideguards do not restrict off-road use. If the rear ground clearance is reduced to 550mm, as if a rear underrun device had been fitted, the departure angle is reduced to 26º, which also still allows the vehicle to be classified as off road.

It can be seen that using the type G classification to define the exemptions from safety guards regulations would offer substantial benefits by reducing the number of exempt vehicles from the road. However, the definition would need to be made considerably more demanding to end the exemptions for many other vehicles that do not get used in very severe off-road operations.

An alternative approach to this problem would be to require adjustable (as shown in Figure 8) or demountable safety guards for off-road vehicles such that they are equipped when travelling in areas of risk (on-road) and can move or remove them when required to travel off road. Guards that were adjusted manually could potentially be achieved relatively simply with little cost or weight implications but would require enforcement action to ensure that drivers always deployed them on-road. Guards that could be adjusted automatically from switches in the cab would be more likely to be used but would be more complex and would therefore increase cost and weight.

7.13.1.1 Ancillary equipment

The use of ancillary equipment can create genuine difficulties installing underrun guards. However, in many cases it would still be possible to fit guards that improved safety without compromising operational performance, although in some cases this may require innovative design and increase cost. In the EC Directives, vehicles with extensive ancillary equipment are exempt under the condition that protection need not be fitted where it is impractical or inconsistent with its use. A suitable approach to this particular problem may be to keep a generic exemption but then to issue guidelines or a code of practice for type approval agencies that helps them to define what constitutes “impractical” or “inconsistent with its use”. This could be based upon a variety of specific criteria relating to the type of vehicle and its use as well as more generic criteria perhaps associated with certain percentage cost or weight increases if safety guards are fitted. Guidelines or a code of practice also have the advantage that they are easier to amend and update than regulations such that it will be relatively easy to keep them up to date in light of new technology or vehicle designs.

7.13.1.2 The presence of chassis/body structure

The presence of chassis or body structure in areas where underrun protection is required can potentially remove the need for underrun protection. However, there are a number of vehicles currently exempt from the regulations, for example fire engines or dustcarts, that do voluntarily have body structure in the areas covered by the safety guard regulations. For these vehicles the structure does not have to conform to any of the strength or protrusion requirements of the regulations and, therefore, may not offer the protection intended by the regulations.

An appropriate way to deal with such vehicles may be to end any specific exemptions and to amend the regulation such that vehicle or body structure may replace the safety guard provided that it can be demonstrated that it fulfils the principle requirements for dimensions, strength and presenting a smooth surface to vulnerable road users. A vehicle such as a fire engine could still be exempt from the requirements if it can be categorised as an off-road vehicle and vehicles such as a dustcart could still be exempt if it can be shown that the use it is put to makes it impractical to do so under the guidelines system discussed above.
8 Conclusions

1. UK, EC and UNECE regulations governing the fitment of front, rear and side safety guards exist separately. Each regulation is written independently considering only the individual aspect of protection, for example side, that it relates to. Nothing in the regulations prohibits integrating the safety guards all around the vehicle but it is not necessarily straightforward to do so and there is little to encourage such an approach.

2. A fundamental difference exists between the sideguard regulations and the front and rear guard regulations. Sideguards are designed to protect vulnerable road users while the other two are required to protect car occupants. This leads to very different geometrical and structural requirements. However, there is no reason for these differences to limit an integrated design of safety guard.

3. There are some inconsistencies in approach and detail between the various regulations. The safety requirement for the front and rear regulations is exactly the same – prevent the front of a passenger car from running underneath the HGV structure at survivable collision speeds (e.g. 56 km/h). However, the requirements for the two most critical aspects of the design, strength and ground clearance, are very different. Front underrun guards have to be considerably stronger and lower than rear underrun guards and, will, therefore be considerably more effective.

4. Differences also exist in more detailed areas. The test forces are required to be applied in different ways for each different regulation and there are subtle differences in the places that they are required to be applied.

5. There are some omissions and wording in the regulations that may discourage an integrated approach for some vehicles. The rearguard regulation specifies the mounting points that must be used in a prescriptive manner rather than a performance based manner, which may stifle some innovative approaches. The sideguard regulation permits sideguards behind the rear wheels but does not have any requirements for them and the wording of the regulation is such that it is difficult to conform for the space ahead of the axles on a centre axle drawbar trailer. This can leave substantial gaps when rigid vehicles with large rear overhangs tow such trailers.

6. The UK regulations exempts a large list of specific vehicle types from their requirements. The EC Directives offers exemptions for any vehicle type that meet a few generic conditions. Evidence of the structure and use of exempt vehicles has been collected and analysed and it suggests that a large number of the vehicle types and operations currently exempt are unlikely to truly require the exemption for technical reasons, although there may be cost implications in some cases. However, for many of the vehicle types it is possible that some of the exempt vehicles do genuinely require the exemption.

7. Alternative approaches to the exemption issues are discussed. One possibility is that the exemptions should be considered based on criteria such as the use of the vehicle off-road, the use of auxiliary equipment, and the presence of other vehicle structure in the areas requiring safety guards. Each exemption should then have a rigorous definition of what is required to qualify, as follows:

   a. The front underrun regulation already refers to the “G” class off-road vehicle as defined in the EC Framework Directive. If this was applied to all of the regulations and no other generic exemption existed that could be used for terrain issues then substantial numbers of exemptions would be ended. However, a number of unjustified exemptions would still be likely to exist because the “G” class definition of off-road capability is not particularly demanding. Ideally, a more demanding definition of off-road use could be created such that only vehicles that needed to travel completely off road, that is not just poor quality unmade roads, qualified for exemptions to safety guard regulations.
b. A generic definition of “impractical” or “inconsistent with use” could be kept in the regulations and used in combination with type approval guidelines that defined what qualified for this exemption in much more detail. This should be restricted to vehicles where the fitment and use of ancillary equipment made it impossible to fit safety guard prevention. The guidelines should encourage innovative designs such as adjustable, movable or demountable guards to be considered before exemptions were granted. Exemptions should only be granted where a defined cost benefit analysis clearly showed fitment was unreasonable.

c. Some vehicles are exempt where the only obvious reason for such an exemption is that the vehicle structure occupies the place where the safety guard would be, such as a low-loader. This allows the possibility that some vehicles could have structures that were inadequate strength or insufficiently smooth. An alternative would be to end the exemption for such vehicles but allow vehicle structure to substitute for a safety guard provided the principle requirements of strength and geometry are adhered to.

References
