DVTA

Advice on retro-fitting

Seat Belts to

Minibuses and Coaches

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Contents

1. Introduction

As a result of legislation requiring seat belts to be fitted in minibuses and coaches carrying three or more children on an organised trip, a large number of vehicles will be retro-fitted with seat belts. The purpose of this document is to provide technical information and advice on how to install seat belts correctly. This advice is based on the technical requirements of the British and European seat belt and anchorage standards, and good engineering practice. *It is not intended to be a legal document or replace the existing technical standards*. Full details of the relevant legislation are shown in section 11 of this document.

2. General

There is a wide range of different minibuses and coaches currently in use. The ease with which seat belts can be installed will largely depend on the age and construction of the vehicle. It is not possible to discuss each type of vehicle in detail, however, there are design features that are common to both minibuses and coaches, and suitable technical standards for seat belts and their anchorages. These are explained in this document.

With older vehicles, especially those manufactured before 1988, it is unlikely that they would have been originally designed with any seat belts. Whilst this does not necessarily mean that seat belts cannot be retro-fitted to these vehicles, it is likely to be more difficult than fitting seat belts to a newer vehicle.

In some cases it may not be technically possible or economically viable to convert a vehicle. In such cases a newer vehicle that either has seat belts already fitted or can be more easily converted may be the only viable option. However, as long as it is technically feasible, age is no barrier to having a vehicle converted.

The level of expertise needed to carry out a conversion will largely depend on he nature of the conversion. Where this involves fitting seat belts to existing anchorages, this will be less than that needed to design and fabricate new seat belt anchorages. However, in either case it is essential to ensure that any work is carried out to a satisfactory standard. The seat belt installer should be prepared to confirm in writing that the restraint system is designed and installed to meet the appropriate European standards, ie approved belts are fitted, the belts are installed correctly and the anchorages are of an appropriate strength.

No matter how simple or complicated the conversion, the objective is the same; to provide seat belts that will, in the event of an accident, reduce the severity of an occupant's injuries. To achieve this objective, three main areas need to be considered in detail:

- the type and standard of seat belt to be fitted;
- the correct positioning of the belt; and
- the strength of the seat belt anchorage.

Whilst these areas are discussed in greater detail later in the document, if a seat belt approved to the British or European Standards is installed and the anchorages meet the European standard, the installer can be confident that the restraint system will provide a high level of occupant protection in the event of an accident.

3. Vehicle classification

Both the legislation and technical standards refer to different classifications and categories of vehicle. They are explained here for ease of reference.

3.1 UK Vehicle classification

A minibus is a motor vehicle construction or adapted to carry more than 8, but not more than 16 seated passengers in addition to the driver. (This definition includes less obvious vehicles such as Land Rovers and other similar vehicles that have more than 8, but not more than 16 seated passengers.)

A coach is defined as a type of large bus (ie a vehicle constructed or adapted to carry more than 16 seated passengers in addition to the driver) which has a gross weight of more than 7.5 tonnes and a maximum speed exceeding 60 mph.

A large bus which does not meet the weight or speed criteria of a coach is referred to as a bus in this document. This legislation does not apply to this type of vehicle.

3.2 European vehicle categories

An M1 category vehicle is used for the carriage of passengers and has no more than 8 seats in addition to the driver's seat.

An M2 category vehicle is used for the carriage of passengers and has more than 8 seats in addition to the driver's seat and a maximum weight not exceeding 5 tonnes.

An M3 category vehicle is used for the carriage of passengers and has more than 8 seats in addition to the driver's seat and a maximum weight exceeding 5 tonnes.

4. Vehicle construction

4.1 Minibus construction

A minibus is normally constructed by using one of the following methods:

- A factory/line built minibus is constructed in a single process, usually on a production line basis, by a vehicle manufacturer;
- A van derived minibus is produced by a specialist converter or body builder fitting windows and seating to a base van; or
- A coach-built minibus is produced by a specialist converter or body builder fitting a purpose built body on a separate vehicle chassis.

4.2 Coach construction

A coach is normally constructed by using one of the following methods:

- a specialist converter or body builder fitting a coach-built body on a separate vehicle chassis; or
- a manufacturer constructing a vehicle with a chassis which is integral with the body structure.

The majority of coaches are produced with a coach-built body. However, in recent years there has been a growing trend to construct vehicles with an integral body and chassis.

4.3 Minibus and coach floor construction

The floor of a minibus or coach is normally constructed in one of two ways. Either a wooden floor is fixed to steel outriggers which are then fastened to the vehicle's chassis, or a pressed steel floor incorporates outriggers and forms an integral part of the vehicle. The latter type is more commonly used in factory and van derived minibuses. Whether seat belts are fixed to the floor or the seats, significant reinforcement will be needed to the floor structure.

In the event of an accident involving a vehicle with a separate chassis, any loading on the seat belt anchorages will be transmitted to the vehicle's body mountings on the chassis. For vehicles not originally designed to have seat belts, these mountings should be examined to see if any extra strengthening is required.

5. Seat belts

5.1 Type of seat belt

The minimum legal requirement is to fit a lap belt. This type of belt will offer protection against an occupant being ejected or thrown around inside the vehicle – a major cause of death and serious injury in a roll over accident. A three point belt (lap and diagonal belt) may also be fitted, as it is generally recognised as offering greater protection. However, technically it is more difficult to fit and certainly for some older vehicles it may not be feasible. Therefore, when choosing the type of seat belt, the level of protection must be considered against the practicability of fitting and the cost of the conversion.

A seat belt can either be a static type or include a retractor. A static type of seat belt is generally less expensive and easier to install, but needs the wearer to adjust the belt manually. It can also be less accessible if not stowed away correctly. Seat belts incorporating a retractor are more expensive to purchase and more difficult to fit, but are designed to automatically adjust to the occupant and stow away neatly when not in use. This will ensure the belt is worn safely and removes the risk of passengers tripping on a discarded belt.

5.2 Seat belt approval markings

To ensure that a good quality seat belt is fitted only those approved to either the British or European standards should be fitted. A seat belt approval can be

for a specific vehicle or for general use. The latter provides greater flexibility for installers, as it allows this type of belt to be fitted to a range of vehicles with slightly differing installations. A seat belt should always be supplied with fitting instructions and, in the case of a belt which meets European standards, information should also be provided about the types of vehicle for which it is suitable.

An approved belt will display one of the following approval marks:

- the letter "e" followed by a number, indicating the belt meets the European Commission Directive 77/541/EEC as last amended by 96/36/EEC;
- the letter "E" followed by a number, indicating the belt meets the United Nations Economic Commission for Europe Regulation No 16, as amended (04 being the latest revision);
  (The number alongside the approval mark represents the country that granted the approval, eg 1 for Germany, 2 for France, 3 for Italy and 11 for the UK. Also displayed on the belt are the approval number and markings which identify the different features of the belt. *Annex 2 gives an example of a European approval mark and an explanation of the markings*.)
- the British Standard "Kitemark" followed by either BS3254: 1960 (no longer issued for new approvals) or BS3254: part 1:1988. Showing compliance to British Standards.

5.3 Positioning of a seat belt

For a seat belt to be effective it must be positioned so that it can be worn correctly. As well as following the seat belt manufacturer's fitting instructions, the general requirements are that:

- a lap belt, or the lap section of a 3 point belt, is positioned to lie across the wearer's pelvis and not the stomach; this is to reduce the risk of abdominal injury and to prevent 'submarining';

- an upper anchorage of a three point belt is located above and behind the shoulders of an average sized adult; this is to minimise the risk of the belt slipping off the shoulder;

- a seat belt either adjusts automatically to fit the wearer, or has a manual adjusting device readily accessible to the wearer and which can be tightened by the wearer with one hand;

- a buckle's release mechanism is clearly visible and accessible to both the wearer and a rescuer, but is not able to open accidentally;

- rigid parts such as buckles and adjusting devices are not positioned so as to increase the risk of bodily injury to the wearer, and the buckle is positioned at or below the hip of the wearer;

- where the buckle is in contact with the wearer the width of the contact surface is not less than 46 mm;

- seat belts incorporating a retractor are installed so that the retractor operates effectively and stows the belt efficiently; and

- the risk of damage to the belt by contacting sharp rigid parts of the vehicle or seat structure is avoided.

6. Seat belt anchorages

6.1 General

Seat belt anchorages must be positioned correctly to ensure the correct lie of the belt and to withstand extremely high loads in the event of an accident. For vehicles that do not have seat belt anchorages, it will be necessary to design and fabricate safe anchorages. To ensure an anchorage is safe it should comply with the strength and location requirements of the European standard. *These requirements are set out in Annex 1.*

When designing a seat belt anchorage a combination of vehicle testing, theoretical calculations, tests on key elements of the system, sound engineering judgement, comparison with known effective solutions on the same vehicle, and a degree of over-engineering should be used.

Where vehicles are supplied with seat belt anchorages which have passed a full scale test to an appropriate European standard, it is preferable to use these anchorages.

For some more recent vehicles, it may be possible for the converter to upgrade the vehicle's structure to the same standard as that of a new vehicle on which tests may have been conducted. This will normally involve the use of a retro-fit kit and be subject to advice from the vehicle manufacturer.

For older vehicles where it is not practicable to conduct a full scale test of the anchorages, or base the conversion on the design of a newer vehicle, some limited component testing may be the only viable options. However, it has to be accepted that these simpler tests will not provide the reassurance of a formal full scale test.

6.2 Testing of seat belt anchorages

The European standards for anchorages refer to a full scale static pull test. With new vehicles, the manufacturer should be in a position to provide a vehicle, and the funding, for a full scale test. The testing of the anchorages would form part of the vehicle's development and give an assurance to the manufacturer that the anchorages have been correctly designed.

A full scale test involves each row of seats/seat belt anchorages in a vehicle being tested. The severity of the test is such that by its very nature it is destructive.

Normally someone wishing to fabricate anchorages in an existing vehicle will not have the same opportunity as the vehicle manufacturer. One answer is to

complete a representative test, which may be the only practical alternative to a full scale test. This test should be based on the "worse case" anchorages in the vehicle and should include all relevant components. From this, it may be reasonable to assume that if the test is successful, the remaining anchorages in the vehicle should be safe.

There are a number of commercial or research organisations and universities that have the expertise and facilities to conduct a static pull test on seat belt anchorages.

6.3 Reinforcing plate

Where possible, seat belt anchorages should be located in a chassis member or other strong structural member of the vehicle to reduce the amount of strengthening required. The area where the anchorages are to be located must be free from corrosion or other structural defects that are likely to affect the structural integrity of the anchorage.

The anchorage should have a nut with a threaded hole of 7/16 inch (20UNF) welded or otherwise suitably secured to the underside of the reinforcing plate. This will allow after market seat belts to be installed without difficulty. However, a vehicle manufacturer who fits seat belts as standard may use an alternative thread size.

The reinforcing plate should be fabricated from a steel plate of sufficient size and thickness. The exact size of the plate will depend on the location and the strength required. If the location of the anchorage is contoured the reinforcing plate should be formed to the same shape of the area and have no sharp edges.

The plate should be securely attached to the underside of the area being reinforced, normally by welding (including spot welding), riveting or bolting. To avoid any increased risk of corrosion in this critical area some form of anti-rust coating should also be used.

7. Seating

Most seating (a seat is defined as having a minimum width of 400mm) in a minibus or coach will either consist of a steel framework supporting a steel seat pan, or be of a tubular steel construction. Where seating is constructed with tubular seat frames the tubing should not be drilled to accept seat belt anchorages, as this will severely weaken the structure.

For some types of seat it may be necessary to consider whether an occupant's head can contact a harsh object, likely to cause injury, such as a hard grab rail or seat stanchion, in the event of an accident. Where this is likely, the object should be well padded. If replacement seating is being considered, it is advisable to use high backed seats or seats fitted with a head restraint. Both of these will better protect against a whiplash injury.

7.1 Seats with integral seat belts

An effective and popular method of retro-fitting seat belts to a minibus or coach is to attach them to the seat frame. Generally, the trend is to fit three point seat belts to a minibus, and lap belts to a coach. An advantage of using integral seat belts is that it reduces any risk of a passenger tripping over a seat belt. A further advantage is that the seat back can provide a location for an upper anchorage, especially where no body structure is available.

If the intention is to use existing seats, which were not originally designed for seat belts, significant strengthening of the seat frame will be required. With three point seat belts the significant loading on the upper anchorage, could result in the collapse of the seat, trapping the occupant. Therefore, the extent and cost of modification needed to cater for a three point seat belt on an existing seat will normally not be justified. *Annex 1 gives details of the test load requirements that need to be met.*

In the event of an accident, where a seat belt is attached to a seat there is a significant increase in the forces acting on the seat mountings to the floor. These forces include not only the loading from the seat belt, but also those created by the mass of the seat. The result is that in a frontal collision the front seat mountings will exert a compressive force while the rear mountings will apply a tensile force to the floor structure. *Annex 1 gives details of the test load requirements that need to be met.*

Suitable methods of securing a seat to a floor can include a separate additional structure fixed to the inside of the vehicle, or the use of steel reinforcing plates and steel box sections that are fitted to the inside and underside of the vehicle. These areas must be free from corrosion or other structural defects that are likely to affect the structural integrity of the anchorages.

Reinforcing plates and steel box sections should be fabricated using steel plate of sufficient size and thickness. The exact size and thickness will depend on the location and the strength required. If the locations are contoured the reinforcing plate should be formed to the same shape as the area which it reinforces and have no sharp edges.

7.2 Seat tracking

A simple, but effective, method of securing seats to the vehicle is to use tracking incorporated in the floor or the side of the vehicle. It is particularly useful when there is a need to vary seat layout, change the vehicle's seating capacity or to accommodate wheelchairs or extra luggage.

Where replacement seats incorporating seat belts are fitted, it will be necessary to check that the tracking and the method used to secure it to the floor is capable of withstanding the increased loading that would occur in an accident. For seat belts that are mounted directly to the floor, the correct angle of the belts must be maintained if the seat layout is changed.

8. Increase in vehicle weight

As a consequence of installing a restraint system there will be an increase in the vehicle's unladen weight. The extent of this will largely depend on the

type of restraint system, the type of seating and the degree of reinforcement it has been necessary to use. For vehicles operating at or near their maximum permitted weight, an increase in unladen weight could result in the vehicle exceeding its maximum permitted weight when fully laden. It may therefore be necessary to reduce the seating capacity to compensate for the increase in weight.

9. Confirmation that the standards are met

Whether a conversion is simply fitting seat belts to existing anchorages or fabricating new anchorages, it is essential that the work is carried out to a safe standard.

An installer should therefore be prepared to confirm in writing that the restraint system is designed and installed to meet the appropriate European standards, ie approved belts are fitted, the belts are installed correctly and the anchorages are of an appropriate strength.

10. Details of relevant legislation and standards

The seat belt requirements for children are contained in Regulation 57 of the Motor Vehicles (Construction and Use) Regulations (Northern Ireland) 1999, Statutory Instrument No 454.

Regulations 54, 55 and 56 of the Motor Vehicles (Construction and Use) Regulations (Northern Ireland) 1999, S1 No 299 define the statutory requirement for seat belt anchorages, seat belts and their maintenance respectively. They refer to technical standards in the European Community Directives (EC), and British Standards (BS).

Technical standards for seat belt anchorages are contained in:

- EC Directive 76/115/EEC (with amending Directives 81/575/EEC, 82/318/EEC, 90/629/EEC and 96/38/EEC.

Technical standards for seat belts are contained in:

- EC Directive 77/541/EEC (with amending Directives 82/319/EEC, 90/628,EEC and 96/36/EEC).
- BS3254: 1960 (no longer issued for new approvals) or BS 3254: Part 1: 1988. The latter is usually only used for retro-fit seat belts.

Copies of the relevent Northern Ireland regulations can be obtained, subject to the appropriate fee, from The Stationery Office, (Bookshop), 16 Arthur Street, Belfast BT1 4GD.

Annex 1. SEAT BELT ANCHORAGE REQUIREMENTS

Effective anchorage positions

Lower Anchorages	
Lateral spacing	At least 320mm apart. Each anchorage should be at least 120mm laterally from the seating centreline.
Angle of belt, viewed from side	Between 20^o and 80^o to the horizontal
Upper Anchorage (if fitted)	
Vertical location	At least 110mm laterally from the seating position centreline.
Vertical location	On a plane at least 475mm above the height of the non-compressed seat cushion.
Longitudinal location	With an occupant of average stature in the seat, the upper anchorage must lie to the rear of the shoulder

The effective anchorage position is what determined the lie of the belt across the wearer. This may be different from the actual anchorage location that fixes the belt to the vehicle.

Anchorage test loads

ANCHORAGE LOADS*$_1$			
	Cars *$_3$(M1)	**Minibuses (M2)**	**Coaches (M3)**
Lap belt	22.25 KN	11.1 KN	7.4 KN
Lap and diagonal belt: Lapsection *$_2$	13.5 KN	6.75 KN	4.5 KN
Diagonal section *$_2$	13.5 KN	6.75 KN	4.5 KN
Additional forward load per seat – Integral seat belts only	20 x weight of complete seat.	10 x weight of complete seat.	6.6 x weight of complete seat.

*$_1$ The load is applied through the belt in a forward direction. Anchorages must withstand the load for not less than 0.2 seconds.

*$_2$ Both sections are simultaneously tested.

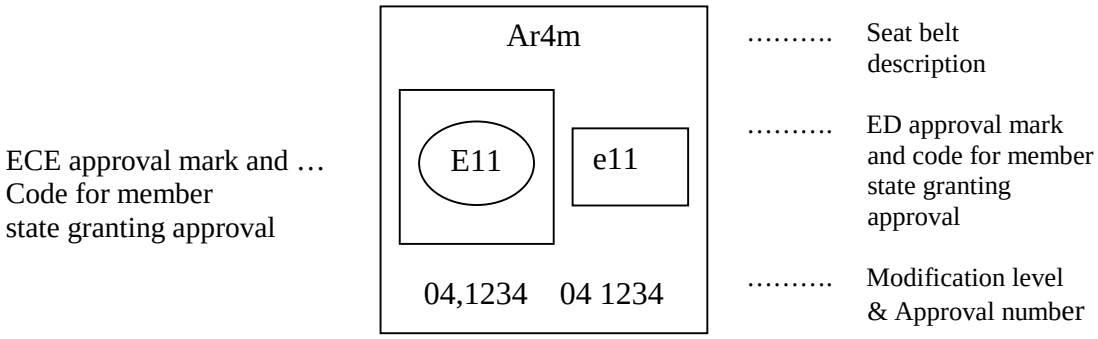
*$_3$ This column has been included as some seat belt installers have been installing seat belts to this higher standard.

M1 category vehicle is used for the carriage of passengers and has no more than eight Seats in addition to the driver's seat.

M2 category vehicle is used for the carriage of passengers, and has more than eight seats in addition to the driver's seat and a maximum mass not exceeding 5 tonnes.

M3 category vehicle is used for the carriage of passengers, and has more than eight seats in addition to the driver's seat and a maximum mass exceeding 5 tonnes.

ANNEX 2 EXAMPLE OF EUROPEAN APPROVAL LABEL FOR SEAT BELTS



Explanation of markings

The **approval mark** consists of an (E) marking (in the case of approval to an **UNECE** Regulation) or an [e] marking (in the case of approval to an EU Directive. If a seat belt is approved to both standards, both markings may appear on the same label.

The number by the side of the marking represents the country which gave the original approval – in this case, 11 (for the UK) – but approvals from other participating countries or member states are equally acceptable.

The **approval number** will be different for every approved belt type. The first two digits represent the amendment level of the regulation to which the approval relates. 04 is the current approval level for ECE Regulation 16. 04 is the current approval level for EC Directive 77/541/EEC as last amended by 96/36/EEC.

The **seat belt description** outlines the main design features as follows:

A for a three-point belt
B for a lap belt, and
S for a special-type belt (normally a harness belt).

Additional letters may be used as follows:

r for a retractor belt, followed by;
3 for an automatic retractor (which locks the belt against the wearer) or
4 for an emergency-locking retractor (the standard inertia-reel type). An additional **m** is used to denote multi-sensitive mechanisms, and an additional **N** is used for reduced sensitivity systems (suitable for buses, but not for cars).

The above example illustrates a three-point belt with a multi-sensitive emergency locking retractor, allocated the approval number 1234. It is approved in the UK to the 04 series of UNECE Regulation 16, and to the EC Directive 77/541/EEC as last amended by 96/36/EEC.