

GUIDANCE ON TRAMWAYS

Railway Safety Publication 2



OFFICE OF RAIL REGULATION



OFFICE OF **RAIL REGULATION**

GUIDANCE ON TRAMWAYS

Responsibility for the regulation of health and safety on the railways was transferred from the Health and Safety Commission (HSC) and Health and Safety Executive (HSE) to the Office of Rail Regulation (ORR) on 1 April 2006.

This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

This document was originally produced by HSC/E entitled Railway Safety Principles and Guidance Part 2 Section G Guidance on Tramways, but responsibility for the subject/work area in the document has now moved to ORR. If you would like any further information, please contact the ORR's Correspondence Section - contact.cct@orr.gsi.gov.uk

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FOREWORD

With the exception of Blackpool, trams disappeared from the streets of British towns in the 1950s. In Europe many towns retained their tramways and over the years have progressively modernised them.

With the recent worldwide interest in the development of tramways (frequently referred to as 'light rail'), trams are again appearing on British streets. Systems are already open in several towns and cities, and many other systems are at various stages of planning and design. This document is one in the series of Railway Safety Publications issued by the office of Rail regulation.

As with all guidance, these documents are intended to give advice and not set an absolute standard.

This publication indicates what specific aspects of tramways need to be considered, especially their integration within existing highways.

Much of this guidance is based on the experience gained from the reintroduction of trams in the first few systems, but does not follow the particular arrangements adopted by any of these systems.

HM Railway Inspectorate (the Inspectorate) is indebted to the very many people who have contributed to the development of this document and, particularly in the latter stages, to the Confederation of Passenger Transport UK. It is hoped that promoters of tramways, and their design and construction teams, will find this guidance helpful, and that it will also be of help to others such as town planners and highway engineers, whose contribution to the development of a tramway system is essential.

1 INTRODUCTION

- 1 This guidance publication is intended to give guidance and advice to those involved in the design and construction of new and altered works, plant and equipment (which includes trains and other rail-mounted vehicles) capable of affecting the safety of railways, tramways or other guided transport systems, which require approval under the Railways and Other Transport Systems (Approval of Works, Plant and Equipment) Regulations 1994.²
- 2 This document does not intend to set out mandatory standards. It gives examples of established good practice acceptable to the Inspectorate to provide an acceptable level of safety for the public (passengers and others), employees and contractors.
- 3 When constructing or extending tramway systems or subsystems it may be appropriate to consider innovative solutions to particular problems. This document, while providing clear guidance on how tramways should be constructed, is not intended to inhibit technological improvements or restrict solutions to new problems.

APPLICATION OF THE GUIDANCE

- 4 Application of this guidance should provide a sufficient level of safety for approval to be given by the Inspectorate, provided that it has been demonstrated that the use of the guidance is wholly applicable to the works, plant or equipment.
- 5 If this is not the case, then the Inspectorate will wish to be satisfied that due consideration has been given to ensuring that all intolerable risks have been eliminated and that all remaining risks have been reduced to be as low as reasonably practicable (known as ALARP).

Effects on existing works

- 6 This document does not apply retrospectively to existing works, plant and equipment. However, new or altered works, plant and equipment might introduce incompatibilities or inconsistencies with the existing works, plant or equipment. In this case, approval may only be given if appropriate arrangements have been made to address these safety implications, which may include modifications to the existing works, plant or equipment.

Operating conditions

- 7 The choice and design of the works, plant and equipment will depend not only on the guidance expressed in this document but also on the operational requirements of the tramway.

8 In assessing the suitability of any proposed safety measures or arrangements, it is important to take into account:

- (a) normal operating conditions;
- (b) degraded conditions where any component or part of the tramway materially affecting safety has failed;
- (c) credible abnormal conditions to which the system may be subjected; and
- (d) emergency situations.

Designing and building

- 9 The guidance applies to the finished works, plant or equipment but not to the processes of designing or building. Designers and builders need to be aware of the responsibilities imposed upon them by the Construction (Design and Management) Regulations 1994³ as amended.
- 10 This document covers any new or altered works, plant and equipment for tramways. Their design and construction should take into account not only the safety of the users of the system but also that of other highway users. Any additions or alterations to a system should not degrade the level of safety of the original system.
- 11 While the procedures below are concerned primarily with the approval of the physical assets of a system (such as infrastructure and vehicles), the Inspectorate will not grant approval without being satisfied that the procedures for the operation and maintenance of the equipment will be safe. It is therefore important that the eventual operator of a new tramway, or of any modification or addition to a tramway, should be able to influence its design to ensure that it may be maintained and operated safely. The Inspectorate will expect this to be demonstrable, making it more likely that the tramway operator will be comfortable with the full responsibility for safety of operation of the system when it begins.

APPROVAL PROCEDURES

- 12 Guidance on the procedures to be adopted, and the format of the documents to be submitted by those seeking approval of projects, is contained in the publication *Guide to the approval of railway works, plant and equipment*.⁴
- 13 Where arrangements that differ from those set out in this guidance are proposed, those responsible for submitting the works for approval will be expected to demonstrate that such arrangements provide an equivalent level of safety.
- 14 Where changes are proposed to works, plant or equipment already in use, it will be expected that the changes should follow this guidance where this is reasonably practicable, rather than the earlier standards under which the existing works, plant or equipment were originally approved.

- 15 This document replaces the guidance given in the Ministry of Transport's 1926 memorandum *Tramways and light railways laid on public roads: Memorandum regarding details of construction of new lines and equipment*. It also replaces the technical requirements prescribed by or under the Tramways Act 1870 (now repealed).

DEFINITION OF TRAMWAY

- 16 For the purposes of this guidance, 'tramway' means a system of transport used wholly or mainly for the carriage of passengers, employing parallel rails which provide support and guidance for vehicles carried on flanged wheels, and in respect of which:

- (a) the rails are laid in a place to which the public have access; and
- (b) on any part of the system, the permitted speed of operation of the vehicles is limited to that which enables the driver of any such vehicle to stop it within the distance he can see to be clear ahead (in this document, referred to as 'operation by line-of-sight' and considered further in paragraph 22 and Chapter 7).

- 17 For the purposes of this guidance, tramways falling within the definition in paragraph 16 have been divided into three categories: integrated on-street tramways, segregated on-street tramways, and off-street tramways.

Integrated on-street tramways

- 18 In this category:

- (a) operation is by line-of-sight;
- (b) the rails are laid in the highway; and
- (c) the part of the highway occupied by the rails is capable of being used by other vehicles or by pedestrians.

Note: In this category, access to the tramway by others may be restricted, for example to pedestrians only, buses only or for access only.

Segregated on-street tramways

- 19 In this category (see also paragraph 89 of Chapter 2):

- (a) operation is by line-of-sight;
- (b) the rails are laid within the boundaries of a highway; and
- (c) the part of the highway occupied by the rails may be crossed by pedestrians, and by other vehicles at designated crossing points, but is not normally shared with other road vehicles except vehicles for maintenance purposes.

- 20 Integrated on-street tramways and segregated on-street tramways are together referred to as 'on-street tramways' for the purposes of this guidance.

Off-street tramways

- 21 In this category:
- (a) operation is by either line-of-sight or signalled, or by a combination of the two;
 - (b) the track is wholly segregated from any highway; and
 - (c) the alignment is wholly separate from any highway.

OPERATION BY LINE-OF-SIGHT

- 22 Tramways generally use line-of-sight operation. In this mode, a tram should be able to stop before a reasonably visible stationary obstruction ahead from the intended speed of operation, using the service brake. Relevant considerations are set out in paragraph 207.

SCOPE

- 23 This document provides guidance on the design, construction and operation of on-street tramways. For avoidance of doubt, the guidance also extends to tramways in the following circumstances:

- (a) aspects of off-street tramways where sections of track intersect with the highway, or change to or from on-street tramways; and
- (b) off-street tramways, which are governed by the requirements of other parts of the tramway system that are on-street.

- 24 An entirely off-street tramway, though falling within the definition of a tramway contained in this document, may be more appropriately regarded as a railway, in respect of which the guidance contained in RSPG Part 2 Sections A to E¹ is likely to be more relevant.

Note: This document is not intended to provide guidance for types of light rail transit falling outside the definition of a tramway, or for other modes of guided transport prescribed under Section 2 of the Transport and Works Act 1992.⁵

- 25 Guidance on historic and replica trams is provided in Appendix C - Heritage tramways.

TRAMWAYS AND ROAD TRAFFIC LAW

- 26 On-street vehicles are 'tramcars' for the purposes of road traffic legislation. In some instances, they are included in the definition of motor vehicles. The Tramcars and Trolley Vehicles (Modification of Enactments) Regulations 1992⁶ specifies the sections of the Road Traffic Regulation Act 1984⁷ and the Road Traffic Act 1988⁸ which do not apply, or apply with modifications, to tramcars.

- 27 Tramcars are not subject to the Road Vehicles (Construction and Use) (Amendment) Regulations 1996,⁹ including those parts that refer to passenger-carrying vehicles (PCV's), or to any of the lighting requirements, unless these are included in any act or order authorising the construction of the tramway or in any specific statutory instrument. However, a tramcar's fitness for purpose will be considered as part of the Inspectorate's assessment under which the system gains approval, and these regulations could set an appropriate standard. See also paragraph 265 of Chapter 8.

STREET WORKS PROTECTION ARRANGEMENTS

- 28 General requirements as to the carrying out of street works and reinstatement are imposed by the New Roads and Street Works Act 1991.¹⁰ The methods of protecting work sites on the street are described in a Code of Practice issued under that Act: *Safety at Street Works and Road Works*.¹¹

OTHER REGULATIONS AND STANDARDS

- 29 Works, plant or equipment may be subject to other specific regulations, for example, the Rail Vehicle Accessibility Regulations 1998¹² and the Electricity Safety, Quality and Continuity Regulations 2002.¹³ In implementing the guidance in this document, compliance with these regulations must be considered and specific reference is made to the more significant regulations.
- 30 Similarly, any material or article used in the provision of works, plant or equipment may need to comply with a specific standard. The guidance in this document does not make reference to these numerous standards; however, an indication is provided where standards may be appropriate.

Note: Any reference in this guidance to any material or article complying with a specific standard would normally be satisfied by compliance with any relevant standard recognised in any member state of the European Union, providing that the standard in question offers guarantees of safety, suitability and fitness for purpose equivalent to those offered by the standard referred to in this guidance.

STRUCTURE OF THE GUIDANCE

- 31 The guidance is laid out, as far as is practicable, in a logical sequence that follows the main elements of the tramway system. This will best assist those responsible for the design of works, plant or equipment.
- 32 A 'Note' is used to provide additional information that is relevant to the paragraph(s) of guidance that precede it.

TERMINOLOGY

- 33 Throughout the document the verbs listed below are used with the following specific meanings:
- (a) should - the primary verb for statements of guidance;
 - (b) may - where the guidance suggests options;
 - (c) must - only used where there is a legal requirement for the measures described to be employed. A reference to the relevant act or regulations will be provided;
 - (d) is (are) required - having decided upon a particular option or arrangement, some consequential choices stem from that first decision. This expression is used to indicate those consequential choices and where firmer guidance is considered appropriate.

Tram

- 34 In this document, vehicles that operate on tramways are referred to throughout as 'trams'. 'Tram' means a tram, or two or more trams coupled together, and includes non-passenger-carrying vehicles.

Highway

- 35 In this document, 'highway' is used to mean any, or any combination of, the following:
- (a) carriageway;
 - (b) bridleway;
 - (c) cycle lane;
 - (d) footpath;
 - (e) footway;
 - (f) land on the verge of a carriageway or between two carriageways; and
 - (g) any other place to which the public has access (including access only on making a payment).
- 36 The terms used here are more precisely defined in the Highways Act 1980¹⁴ for England and Wales, or for Scotland, in the Roads (Scotland) Act 1984.¹⁵

2 INTEGRATING THE TRAMWAY

- 37 This chapter provides guidance on the general design, layout and integration of the tramway with the highway.
- 38 Where the tramway is in a highway shared with other road users, its design and construction should allow it to be used by those other road users.
- 39 Where the tramway runs along the highway, crosses it, or is otherwise close to it, provisions to promote compatibility between trams and other road users should be incorporated into the highway design.
- 40 The operating arrangements for normal conditions and for emergency situations should be clearly defined for the type of infrastructure over which trams are operating. These should include appropriate audible and visible warnings, and evacuation and control procedures in case of emergencies. Provisions must be made during any road or tramway maintenance operations for the safe movement of pedestrians and other highway users.¹⁰
- 41 Any on-street tramway should be capable of being readily recognised as such by other road users. It should be easy to recognise the permitted routes for trams, and avoid the risk of confusion with permitted routes for road vehicles where these are different.
- Note:** Methods of distinguishing between carriageways for road vehicles and the track for trams may include traffic signs, carriageway markings, kerbs, bollards, barriers, planting or other appropriate means.
- 42 Particular attention should be paid to the design of road junctions, and locations where the form of tramway alignment changes (eg from side to central reservation, or from integrated to segregated on-street tramway).

ALIGNMENT CONSIDERATIONS

- 43 The alignment of the tramway should take into consideration:
- (a) the road layout, eg intersections, roundabouts etc;
 - (b) pedestrian footways and crossings;
 - (c) cyclists and cycle lanes;
 - (d) the needs of frontagers for access and property maintenance;
 - (e) public utilities;
 - (f) clearances on the highway (see Chapter 3);
 - (g) the permitted minimum radii of horizontal and vertical curvature, the combinations thereof and the engineering constraints for the tramway and its vehicles;
 - (h) the location and design of tramstops (see Chapter 5); and
 - (i) the location of overhead electric traction equipment and other fixed structures (see Chapter 6).

Note 1: The minimum radii for the tramway are largely determined by the type of tram selected, and in particular, by the overhangs and wheel spacing. Therefore, the track alignment, the tram design and the highway constraints form part of an iterative process upon which little specific guidance can be given.

Note 2: An assessment of the effect on traffic flows, as well as the ability (or lack of it) of the tram to conform to the curvature of the road at a roundabout or road junction, will dictate whether or not the track will have to cut through the middle. In either case, there will be a consequent need for signalling the traffic conflicts that arise.

ROAD INTERSECTIONS

44 In the design and operation of an on-street tramway it is particularly important to recognise that the behaviour of other road users will influence the safety of the tramway. The design and operation may need to take into account likely deliberate actions and errors of judgement by other road users.

On-street tramway intersections with other roads

45 At-grade intersections on on-street tramways should be regarded as highway junctions rather than railway level crossings. The arrangements for controlling the tramway and other road traffic at an intersection should be co-ordinated. At intersections with minor roads, the tramway should be regarded as if it were the major road even if the relative volume of traffic suggests otherwise.

Note: The degree of signing or signalling will depend on the needs of other road users as much as upon those of the tramway.

46 Physical level crossing barriers should not normally be used for on-street tramways.

47 The maximum permitted approach speed of trams to intersections may have to be limited to negotiate the junction safely. The approach speed to an intersection should enable a tram to stop safely if the intersection is obstructed. The place from which the intersection first comes clearly into view and then remains in view for the tram driver should be identified so that the available braking distance can be established. The permitted maximum speed should be based on the above distance and normal service braking rates.

Note: It is helpful if the view of the intersection includes the Stop or Give way positions on the other approaches. This aids judgement as to the likely movements of other vehicles.

48 The nearer edge of a *Stop* or *Give way* road marking to the developed kinematic envelope (DKE as defined in paragraph 107) should be positioned at least 500 mm from the edge of the DKE to allow for inaccurate stopping by road vehicles. A greater distance should be provided where sight lines permit.

49 Where a segregated on-street tramway runs immediately alongside a carriageway or in a central reservation between carriageways, and it intersects another road, the intersection should be signalled or signed.

- 50 Where a segregated on-street section of tramway runs parallel to, but some distance from, one side of a road, and a side road crosses the tramway tracks before joining the main road, signalling the road junction to include the tramway can often not be justified on current road traffic criteria. Nevertheless, some warning of a tram approaching from behind may be necessary for vehicles on the main road if there is insufficient room on the side road between the road intersection and the Give way or Stop line at the tramway crossing. Passive signs may be used, but may not have sufficient impact where the traffic flow on the tramway is light. In such circumstances, revisions to the highway layout or traffic management measures should be considered.
- 51 The road traffic light signals and signs required for the protection of at-grade crossings on tramways are prescribed in the Traffic Signs Regulations and General Directions 2002.¹⁶ Such signals should be controlled by a traffic signal controller, type-approved for tramway use by the Department for Transport. The detailed arrangements should be agreed with the Highway or Roads Authority.
- 52 Road junctions and intersections with on-street tramways should be treated in a way similar to a normal road layout. This should comply with the appropriate advice from the Department for Transport.
- 53 Signs giving warning of the presence of trams should be provided and details of these are in the Traffic Signs Regulations and General Directions 2002.¹⁶
- 54 Where road traffic light signals are provided, the tram should have a level of precedence agreed with the Highway Authority.

Off-street tramway intersections with the road

- 55 Intersections between a road and an off-street tramway should be treated as if they were intersections between a minor road on which the road traffic is travelling, and a major road on which the tram is travelling and has priority, regardless of the volume of road and tram traffic.
- 56 A junction should be signalled if the tram driver and road user cannot see each other. Conventional three-aspect signals for road vehicles and the tramway equivalent for trams should be used as described in Chapter 7. Signals should also be provided where a turning road vehicle may momentarily encroach on an adjacent or oncoming tram lane.
- 57 A non-signalled intersection between an off-street tramway and a road should be signed as if the tramway were the 'major' road. *Stop* or *Give way* signs should be provided on the road approaches for road traffic, with the 'Tram' sub-plate applied as appropriate. If necessary, the relevant warning sign and speed restriction sign should be provided on the tramway approaches.
- 58 Visibility from the minor road carrying the road traffic should comply with the appropriate advice from the Department for Transport.

PEDESTRIAN FOOTWAYS AND CROSSINGS

- 59 In streets which have high densities of pedestrians, the pedestrians should be encouraged to use defined crossing points over the tram track. The crossings should have dropped kerbs and appropriate tactile marking. These crossings should be designed so that they are obviously the safest crossing point.
- 60 Where safe pedestrian routes are defined, there should be clearly recognised features to aid identification which may include the type of paving, signing, pedestrian signals, dropped kerbs, pedestrian guard rails or planters.
- 61 Crossing points on a tramway should be co-ordinated with the crossing points of any shared or adjacent carriageways. On off-street tramways, the preferred arrangement is to separate entirely the crossing points for any road and for the tramway, but if not separate, the arrangements for pedestrian crossings of on-street tramways should be used.
- 62 All designated crossings of tram tracks should be designed with the needs of mobility- and visually-impaired people in mind.
- 63 Special pedestrian signals should be used, with or without other signals, at places where the normal passive signing at pedestrian and other foot crossings is inadequate.

Note: The need for signalling will depend on factors such as visibility and vehicle and pedestrian traffic flow.

- 64 Where the platforms or tramstops lie in the centre of the road, and if those boarding or alighting from a tram have to cross one or more lanes of road traffic to reach the tramstop or platform, those crossing points may have to be treated as pedestrian crossings.
- 65 Tram drivers should be warned that they are approaching an off-street pedestrian footpath crossing. Where there is insufficient visibility of an approaching tram, an appropriate 'sound warning' sign should be provided for tram drivers.

Note: Careful consideration should be given to both visibility of pedestrians by tram drivers and visibility of approaching trams by pedestrians.

- 66 Where signals are provided at pedestrian crossings over tram tracks, they should be one of the types described in paragraphs 70 to 72.

Crossing layouts

- 67 Where reasonably practicable, the part of the crossing over the tram track should not be in-line with any other separately signalled pedestrian crossing or separate zebra crossings.
- 68 Fencing or pedestrian guard rails should be provided where necessary, to guide pedestrians to face oncoming trams before they cross the track, or to direct their attention to pedestrian crossing lights.

69 Part or all of such pedestrian crossings may be unsignalled if the circumstances at the site allow.

Note: For example, if the visibility along the tram tracks is good and the volume of tram traffic low, it may be possible to dispense with pedestrian signals when other circumstances (such as a high volume of adjacent road traffic) would dictate that the road crossing would be signalled. At other places it may be necessary to provide pedestrian signals across the tramway, but a zebra crossing may be sufficient across the road.

Pedestrian crossings linked with tramway signals

70 Where the tramway crossing cannot be separated in any way from the crossing of the remainder of the highway, positive indications which are visual, audible and, where practicable, tactile, should be given under the same conditions which apply at a traffic-signalled junction with a pedestrian phase or a signalled pedestrian crossing.

71 If the crossings are staggered, and it is appropriate, audible equipment to the appropriate specification issued by the Department for Transport may be suitable.

Pedestrian crossings with signals linked to approaching trams

72 Where the tramway crossing can be separated from the remainder of the highway crossing by the provision of refuges, or where the pedestrian crossing movement is parallel to the road over tram tracks only, ie where an off-street or segregated on-street tramway crosses or enters a road, only the warning of the approach of a tram should be given (no tram - no warning). The warning should be:

- (a) visual. For consistency with highway practice, a conventional red/green man pedestrian signal should be used where there are signals controlling tram or road traffic at the location concerned. Pedestrian signals consisting of twin vertically-disposed amber flashing lights displaying a tram symbol on each light, above a plate reading 'Tramway - Look both ways' (or right or left as appropriate), may be considered where there are no other signals and there is limited visibility of approaching trams for pedestrians;
- (b) audible. The sound of this warning should be distinctive and may be made either by the approaching tram or, preferably, at the pedestrian signal. In the latter case, the sound should not be confused with any other audible signal given to pedestrians; and, if practicable;
- (c) tactile. The design of the tactile surfaces should follow Department for Transport guidance.

73 School crossings over the tram-track part of the crossing may be provided by either type of signalled pedestrian crossing. However, where the provision of signals is inappropriate, advance-warning signs are required at the appropriate tram braking distance before reaching the school crossing patrol point.

CYCLE/TRAMWAY INTERFACE

74 Where a tram cannot pass a cyclist safely on the carriageway, provision should be made for cyclists where reasonably practicable.

Note 1: This can be done either by placing a separate cycle lane adjacent to the footway, by providing an alternative direct route or by providing a one-way cycle lane within the carriageway. In addition, kerbside cycling refuges may be appropriate on long, steep routes and on the approach to tramstops.

Note 2: Local cycling groups may provide useful information in relation to local cycle routes and relative user levels in addition to feedback on the most effective cycle route solutions for the tramway route under development.

75 Particular care should be taken to avoid pinch points with cycle lanes along the route, and where roadside platforms are provided, careful consideration of the impact on cyclists is necessary.

76 Where cycle lanes cannot be provided, the clearance between rail and kerb should be a minimum of 1000 mm, and consideration should be given to the removal of obstacles from that area, eg by the provision of drainage incorporated into the kerbs.

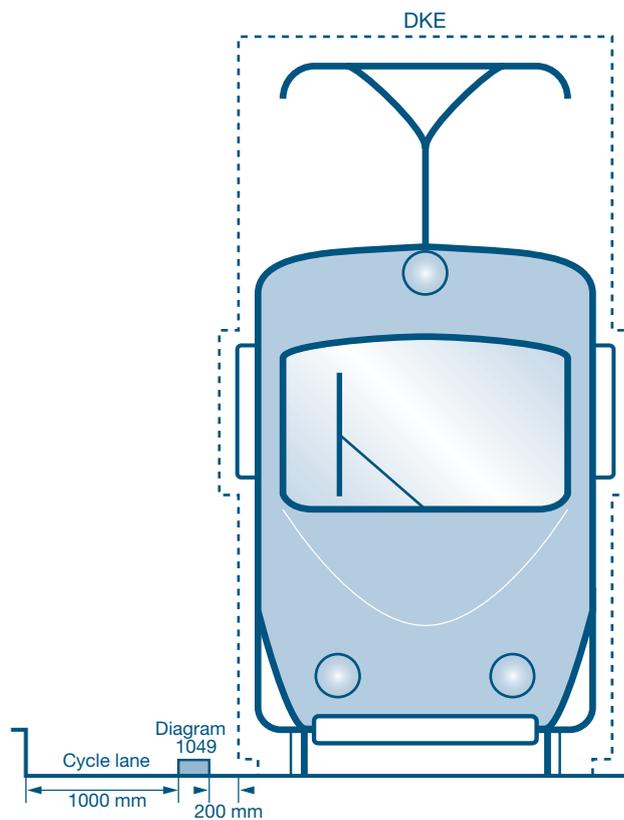


Figure 1: Clearances between tramway and cycle lane

Note: This clearance is intended to provide a clear route for cyclists in the absence of trams and, combined with the removal of obstacles from that area, reduces the likelihood of sudden movements by cyclists towards the tramway. It is not intended to provide clearances for trams to pass cyclists.

77 One-way cycle lanes should be clearly marked and signed as such; vehicle parking and loading prohibitions will be required. Wider cycle lanes within the carriageway to permit two-way cycling should be avoided.

- 78 To avoid the risks from unauthorised parking of vehicles fouling the DKE, the width of the cycle lane (between the kerb and the nearest edge of the line shown in the appropriate diagram of the Traffic Signs Regulations and General Directions 2002)¹⁶ should not be greater than 1000 mm and the edge of the line nearest to the tram track should be at least 200 mm from the DKE (see Figure 1).
- 79 Where it is necessary for cycle lanes to cross tram tracks, these intersections should be, as far as possible, at right angles to the tracks. Where the achieved crossing angle is less than 60°, consideration should be given to alternative crossing layouts and other measures that mitigate the risks faced by cyclists. Consideration should be given to measures that raise awareness of the presence of rails in the carriageway such as signage or use of texture.

FRONTAGERS

- 80 The needs of premises fronting the tramway, including access, should be carefully assessed.

Note 1: It may be necessary to provide dedicated loading/unloading and private parking bays to avoid the tram track becoming obstructed by vehicles.

Note 2: Obstructing a tram track can normally be made an offence under the powers authorising the construction and operation of the tramway or by means of relevant by-laws.

- 81 Where the tramway crosses entrances to or exits from premises, it should not be necessary to erect warning signs at each such location. Road traffic light signals may be necessary at busy locations or where sight lines are inadequate.

Note: If the place concerned is likely to attract drivers unfamiliar with the area (eg a factory), warning signs may be required.

PUBLIC UTILITIES

- 82 Public utilities in or under the highway should, where possible, be accessible while trams are operating. Any manholes should have their nearest edge at least 500 mm from the edge of the DKE. Where pipes and cables unavoidably have to pass under the track, they should be ducted or sleeved before the tracks are laid, to facilitate maintenance or renewal.

CHANGES BETWEEN SEGREGATED AND INTEGRATED ON-STREET TRAMWAYS AND OFF-STREET TRAMWAYS

- 83 Where a tramway joins, leaves or runs alongside a carriageway, it should be identified by appropriate signing, carriageway markings or traffic signals, in accordance with the Traffic Signs Regulations and General Directions 2002.¹⁶
- 84 Except as provided in paragraph 89, access to the off-street or segregated on-street sections of tramways by vehicles other than trams should be deterred by traffic signs, which may be supplemented by traffic regulation orders, by-laws etc.

Note: Suitable treatment of the road surface leading to a wholly segregated section of track, eg ballast, raised rough stonework or isolated cobbles set into the surface, would help to encourage compliance with the signs.

TRAMWAY PATH

85 The tramway path is the area reserved for a moving tram in its environment. It is derived from the DKE by adding the minimum appropriate clearance where this is specified in this document, or a clearance agreed with the Inspectorate if this document does not specify one. It therefore depends upon the DKE and upon the nature of the operational environment and the structures and features within it.

86 The path of an on-street tramway should be marked where it is not apparent from the carriageway or kerbs, and where it would be useful either to tram drivers or other road users to do so. Where such marking is necessary, it should be consistent with the prescribed markings shown in the Traffic Signs Regulations and General Directions 2002.¹⁶

Note 1: Such definition may be achieved by the use of colour, texture or differences of levels to enhance visibility.

Note 2: If yellow dot markings are to be continued through any yellow box markings at junctions, this marking may require an amendment to the yellow box markings.

87 If more than one type of tram is to be used on a system, the tramway path at any point should be determined by the characteristics of the tram type that has the widest DKE at that point.

88 Where two tracks are parallel to each other or converge, they should be enclosed within a single tramway path unless they are sufficiently far apart to allow a pedestrian refuge between them.

89 Access to segregated on-street sections may be permitted to emergency services vehicles or to other vehicles during traffic emergencies, preferably under police supervision. If access is to be permitted to such sections, then the sections should be clearly defined by lane lines and traffic signs. Other vehicles should also be discouraged by the use of hostile surfaces or change of level.

90 On segregated on-street sections, the boundaries of such sections should be adequately delineated and access to the track by other road vehicles, except at designated crossings, discouraged.

91 Kerbs may be required to separate a segregated on-street track from an adjacent carriageway unless vehicle barriers are installed, for example, to separate road vehicles from oncoming trams or to protect against collision of road vehicles with isolated lineside structures.

In pedestrian zones

- 92 To help visually-impaired people, the preferred method of marking the tramway path in pedestrian zones is for it to be slightly lower than that of the surrounding area, and for there to be a suitable colour contrast between surfaces. The tramway path and the surrounding areas should be demarcated using a battered kerb. Tripping hazards should be avoided in the tramway path and surrounding area, to reduce the risk of a pedestrian falling into the path of a tram.

Note: Where a change in level is not reasonably practicable, the road surface in the tramway path may be plainly identified by lines or other markings, as defined by the Traffic Signs Regulations and General Directions 2002¹⁶ or by differences in colour or texture of the pavement or road surfacings.

- 93 Crossing points should be marked with a dropped section with appropriate tactile surfaces.

PEDESTRIAN PROTECTION ARRANGEMENTS

- 94 Pedestrian guardrails may be used to direct pedestrians to safe crossing points. These guard rails should be appropriately set back (see paragraphs 111 and 113).
- 95 Fencing should be provided at places on the tramway where there is a significant risk to pedestrian safety. Access to the track, except at designated crossings, should be discouraged.
- 96 Appropriate forms of deterrent paving may be used to discourage both pedestrian and vehicular access.
- 97 In areas to which the public has access, street furniture, adjacent infrastructure and tram operating speeds should be designed to reflect the requirements for line-of-sight operation, as described in paragraph 22 and Chapter 7.

3 TRAMWAY CLEARANCES

- 98 This chapter provides guidance on the clearances in the tramway system, and also between the tramway and other parts of the highway. For information on electrical clearances refer to the guidance in Chapter 6 of this document. Clearances for staff safety on off-street sections should generally follow the guidance on clearances in RSPG Part 2 Section A Guidance on the infrastructure.¹ Proposals for sub-standard clearances should be discussed with the Inspectorate at the design stage.
- 99 Adequate lateral clearances should be provided, to allow trams to pass one another on adjacent tracks, or between trams and other road vehicles on adjacent carriageways. Additional clearances between trams and fixed structures should be provided to allow for the presence of people.
- Note:** If a high-sided vehicle is on a cambered road adjacent to a tramway, the clearance between the top of the vehicle and the higher parts of a tram could be less than the clearance at ground level.
- 100 These clearances should be developed from the kinematic envelopes for the trams and take into account additional allowances for pedestrians and road vehicles.
- 101 Where a system uses a variety of trams, the effects of different kinematic envelopes should be considered.

DEFINITION OF DEVELOPED KINEMATIC ENVELOPE

- 102 The definition of the developed kinematic envelope (DKE) is based upon the static envelope and the dynamic envelope.

Static envelope

- 103 The static envelope is that formed by the maximum cross-sectional dimensions of trams to be used on the tramway and, where applicable, their loads when at rest on straight and level track. It should take into account allowances for tolerances in the manufacture of the trams and the effects on the suspension of tram loading and loads arising from the wind and other weather.

Dynamic envelope

- 104 The dynamic envelope is the static envelope enlarged to allow for the maximum possible displacement of the tram in motion, with respect to the rails on straight track. It should take into account tram suspension characteristics, and allowances for tolerances in the maintenance of trams including wear. The effects of end-throw and centre-throw of trams on curved track are not included, and are disregarded in the development of the dynamic envelope.

Kinematic envelope

- 105 The kinematic envelope is the dynamic envelope enlarged to allow for the permitted tolerances in track gauge, alignment, level and cross-level and the dynamic and static effects of track wear.

106 A kinematic envelope should be established for every tram to be used on the tramway. It should include any external driving mirrors, unless they are designed to retract automatically when the tram is in motion. The kinematic envelope is speed dependent.

Note: Tramways are likely to make extensive use of slab or other forms of fixed track construction. Therefore, calculating the track construction tolerances separately may be the appropriate way of calculating the kinematic envelope.

Developed kinematic envelope

107 A DKE should be established by enlarging the kinematic envelope to take into account all the possible effects of curvature, including superelevation of the track, and end and centre throw of the tram. It too is speed dependent, but is unique to the particular location at a given speed.

108 Over-generous methods of calculation of the DKE should be avoided, as they may mislead other road users as to which parts of the highway are safely accessible to them, and may create unnecessary design constraints.

109 An enlarged DKE of a tram in a credible degraded mode (such as suspension failure) should not exceed the established DKE plus the clearance to any fixed object or the established DKE of a tram on an adjacent track.

CLEARANCES BETWEEN TRAMS

110 The clearances between the DKEs of two adjacent trams should be not less than:

- (a) without centre traction poles - 100 mm;
- (b) with traction poles between the two DKEs - 600 mm (but at least 100 mm from the face of the nearest side of a pole to each DKE).

Note: These clearances are minimum clearances up to 2100 mm above ground level. At heights above 2100 mm, reduced clearances may be acceptable.

CLEARANCES BETWEEN TRAMS AND STRUCTURES

111 The clearances between a DKE and other highway features or fixed structures should be as follows:

- (a) to the edge of a traffic lane - 200 mm;
- (b) to an isolated obstruction in the centre of the carriageway or on a side reservation - 100 mm;
- (c) to a kerb - 300 mm;
- (d) to a continuous obstruction in the centre of the carriageway or on a side reservation - 600 mm.

Note 1: These clearances are minimum clearances up to 2100 mm above ground level and where circumstances permit, greater clearances are encouraged. At heights above 2100 mm reduced clearances may be acceptable.

Note 2: 'Side reservation' means a section of segregated on-street tramway located alongside a carriageway.

112 Adequate clearances should be maintained between the DKE and any structure or pole, taking account of pedestrian movement.

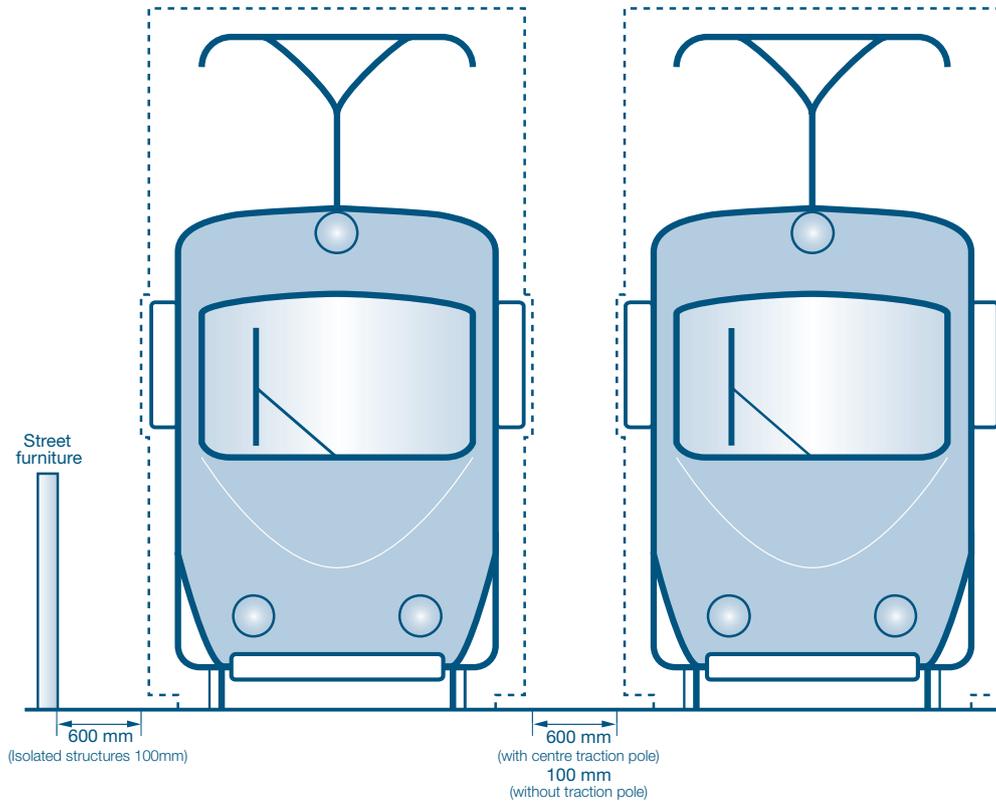


Figure 2: Minimum clearances in pedestrian-only areas

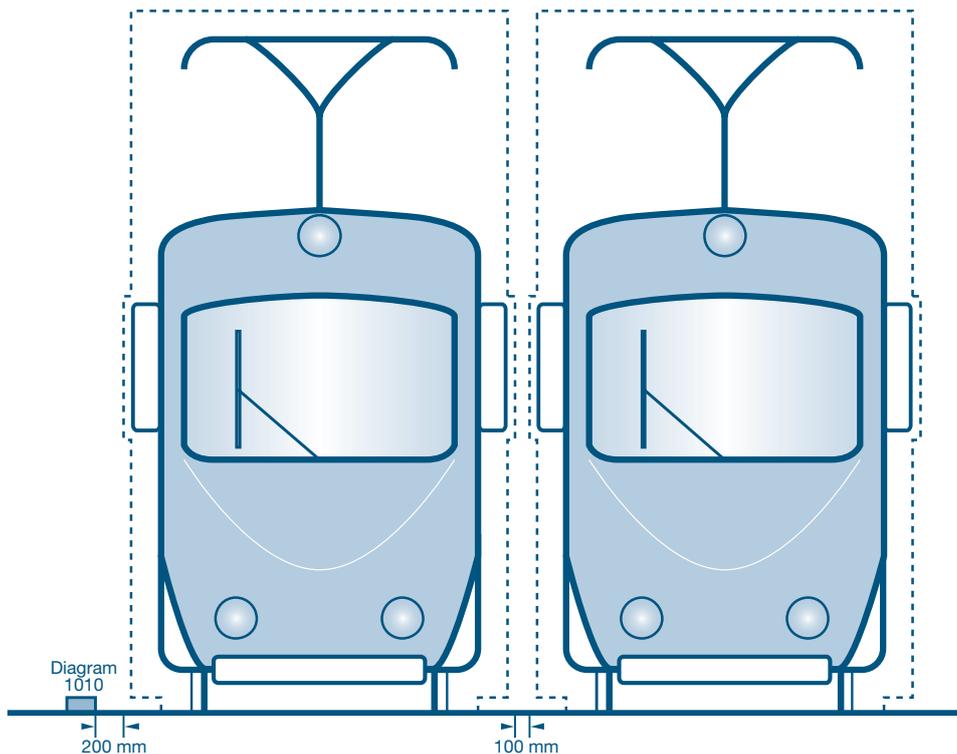


Figure 3: Minimum clearances for tramway in carriageway with shared lanes

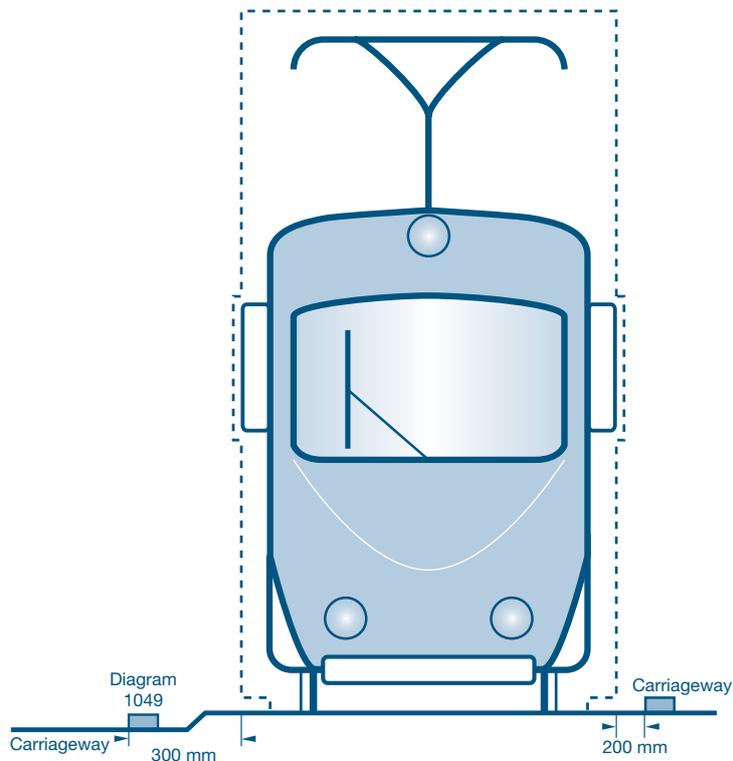


Figure 4: Minimum clearances on reserved sections of carriageway

Explanatory note to Figure 4, note 1:

The lane lining (prescribed in diagrams 1049, 1012.1 or 1012.3 of the Traffic Signs Regulations and General Directions 2002,¹⁶ all 150 mm wide) should be at the foot or road traffic side of the slope, and the edge of the lane lining furthest from the DKE should be at least 300 mm outside the DKE. The top of the slope should be outside the DKE.

Explanatory note to Figure 4, note 2:

The tram track should be nominally 125 mm above the normal carriageway surface. However, where other service vehicles, such as buses substituting for trams or those of the emergency services, may need to use the lane, suitable access and egress points should be provided but where ordinary road vehicles may need to use the lane because of an obstruction in their normal lane, a lesser height (75 mm) may be used by agreement with the Highway Authority and the Inspectorate.

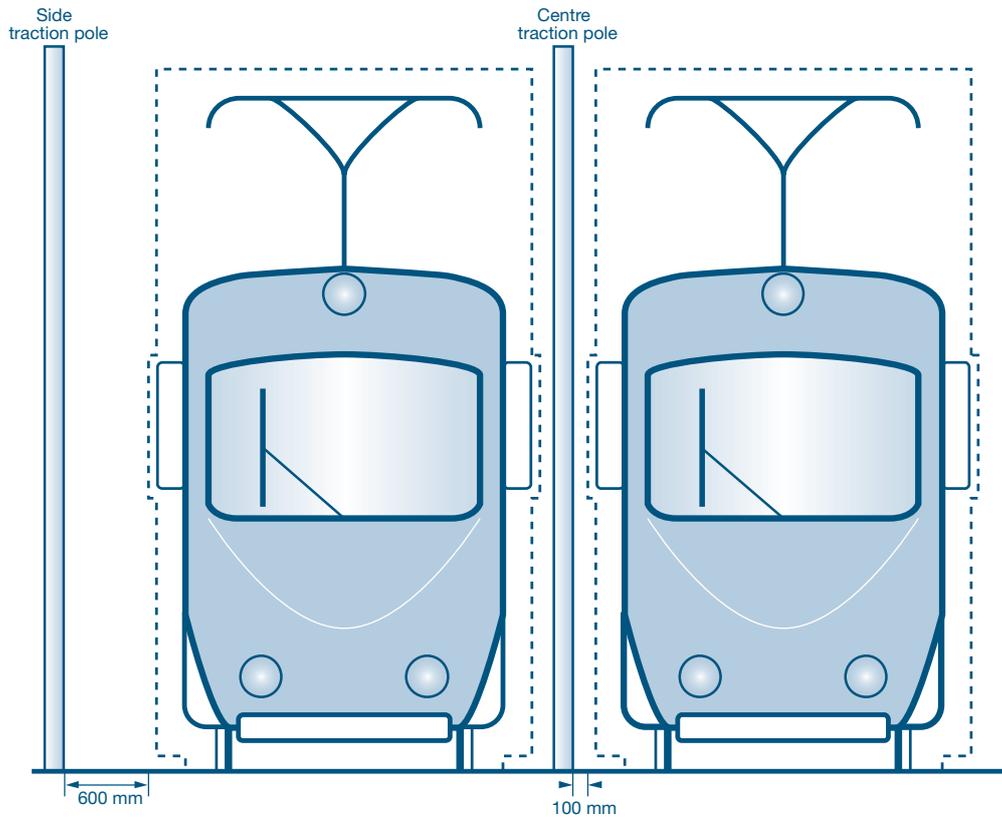


Figure 5: Minimum clearances to traction poles

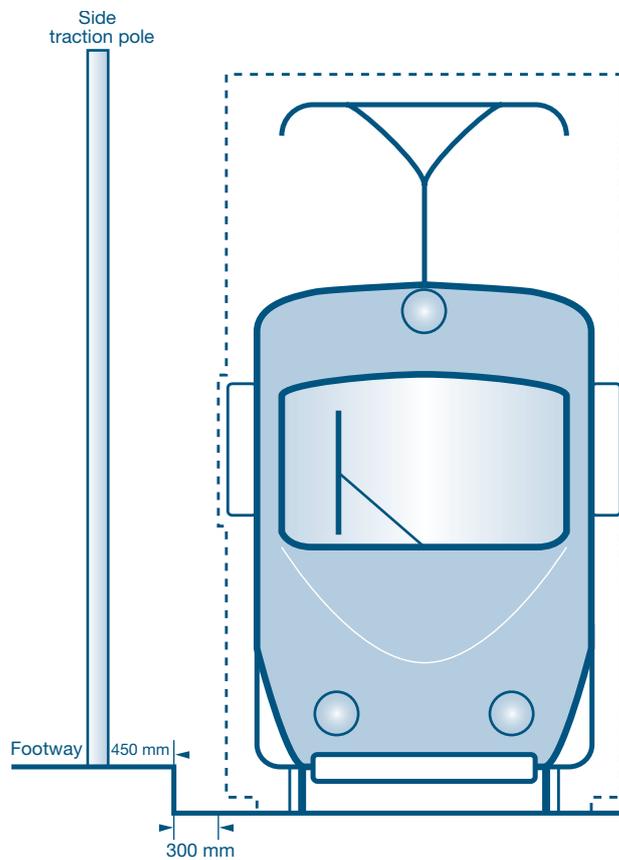


Figure 6: Minimum clearances to electric traction poles on a footway

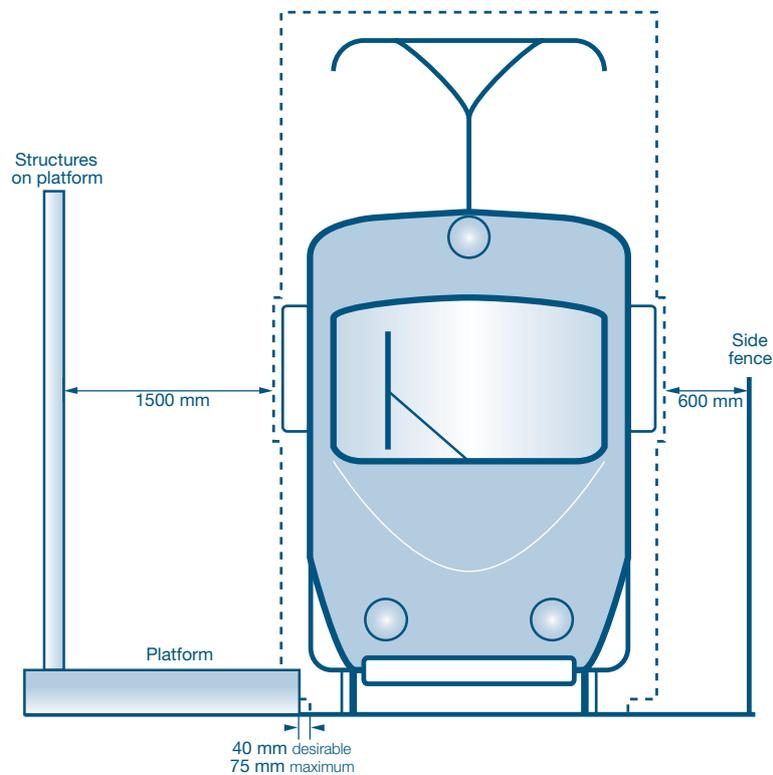


Figure 7:Clearances at tram stops and fences

113 Figure 2 shows the minimum clearances in a pedestrian precinct, Figure 3 the minimum clearances in a carriageway with shared lanes, Figure 4 the minimum clearances on a reserved section of a carriageway, Figure 5 minimum clearances between a tram and an electric traction pole, Figure 6 minimum clearance between a tram and a side electric traction pole on a footway and Figure 7 minimum clearances at tramstops and fences.

CLEARANCES ON HIGHWAYS

114 Lanes used by trams and other large vehicles, such as buses, coaches and heavy goods vehicles, should normally be 3650 mm wide for a two-lane carriageway. Lane widths that are shared between trams and other road vehicles will probably be dictated by the needs of the latter. A minimum lane width should be 3250 mm unless agreed with the Highway Authority and the Inspectorate.

Note 1: The Road Vehicles (Construction and Use) (Amendment) Regulations 1996⁹ permit vehicles up to 2500 mm wide, and mirrors can be outside this. Therefore, the effective overall width of such a vehicle can be as much as 3000 mm. This is of particular relevance for lanes adjacent to those used by trams.

Note 2: The widths of the lanes used by trams are based on a tram having an overall width of 2650 mm. Where narrower trams are used, the recommended lane widths for sole use by trams may be reduced accordingly. Conversely where wider trams are used, the recommended lane widths might be increased accordingly.

4 THE INFRASTRUCTURE

115 This chapter provides guidance on the infrastructure of the tramway system including the track, bridges, tunnels and infrastructure identification.

THE TRACK

Running rails

116 The following guidance applies to all tramway track laid in the carriageway or in pedestrian areas. For tramway tracks that are ballasted, see the relevant guidance in RSPG Part 2 Section A *Guidance on the infrastructure*.¹

117 Steel running rails should conform to the appropriate British or European Standard or an equivalent standard acceptable to the Inspectorate. The rail section(s) and materials, and wheel profile(s) should be carefully selected so as to be mutually compatible in terms of derailment prevention, ride, noise, wear and adhesion.

Note 1: Consideration will need to be given to adhesion levels achievable with new rails. Generally these levels improve with use.

Note 2: Magnetic properties of the rail will affect the performance of electromagnetic track brakes.

118 Flangeways of rails laid in the street should be kept as narrow and shallow as is reasonably practicable so as to avoid nuisance to other road users. Where such rails are laid or coated in elastomer or similar flexible material, particular care should be exercised to provide an adequate boundary with the wearing surface of the adjoining carriageway or other surfaces.

119 Grooved rails should have suitable drainage provided at appropriate intervals and locations (eg areas of ponding, bottom of gradients), and when laid in the highway, connected to surface water drainage systems. The drains should be capable of being easily cleaned to allow removal of sand and other debris. The provision of drainage slots should not render the rail incapable of providing sufficient support or guidance for trams.

Note: The effect of the presence of rail grooves on highway drainage may be significant.

120 Where rails are laid in a carriageway that is used by rubber-tyred vehicles travelling in the same general direction as the rails, the effect that the steel rail and any flexible filling will have upon the skid resistance of the carriageway surface should be considered, particularly when vehicles move across the carriageway and their tyres cross over the rails at shallow angles. The track should be located within the carriageway so that, so far as is reasonably practicable, it does not coincide with the path normally taken by the wheels of rubber-tyred vehicles.

Note: Additional warnings of the risk of skidding may need to be given to motorists. Rubber-tyred vehicles may skid when accelerating, as well as when braking or cornering.

- 121 The carriageway incorporating the tramway should be engineered to present a surface which:
- (a) can support the normal loads of vehicles using the carriageway; and
 - (b) has a seal to minimise the ingress of water at the interface between rail and adjacent road surfaces, where such ingress could cause damage to the highway surface.
- 122 Where flexible filling material is used, that material should, so far as reasonably practicable, have a skid resistance comparable with normal road surface material.
- 123 So far as is technically feasible, when first laid, the head of the rail should be level with the adjacent road surface.

Track geometry

- 124 The maximum horizontal and vertical curvature, the maximum gradient, the maximum track twist on a tramway, and combinations thereof, should be established taking account of the physical constraints of the route, the capability of the tram, and the effects of speed, curvature and gradient on the passengers.
- 125 Where circumstances permit, superelevation should be provided on the tram track, and the cross section of the highway should accommodate this.

Note: Other matters to be considered include whether surface water drainage can be directed away from the grooves in the rails by providing a cross-fall, and whether the surface between the rails (the four-foot) has to be cambered.

Tramway points in the highway

- 126 Points should not be located where the movement of the blades would cause a hazard to other road users or where road vehicles could damage the points. The moving blades of the points should not normally be located:
- (a) at places in the street where there are concentrations of pedestrians, such as at formally identified crossings;
 - (b) where there would be a particular danger to cyclists or motorcyclists; or
 - (c) in busy traffic, or where traffic lanes cross or merge with a tram lane, particularly where this is also aggravated by a turning movement.

Note 1: Pre-sorting, with interlaced track or double-headed rails or other techniques, may be used where practicable to achieve this objective.

Note 2: Where points have to be located at the places identified in paragraph 126, special precautions may be necessary to minimise the risk (see Chapter 7 and Appendix B).

- 127 Where a point indicator is the primary means used to allow a tram to approach facing points at a speed higher than that which would allow the driver to observe the lie of the points and stop in advance of an incorrectly set route or misaligned point blade, the point indicator and point detection circuits should be designed to meet inherently failsafe criteria.

- 128 If point blades are misaligned or an incorrect route is set, a tram that cannot proceed should not obstruct other trams (other than a following tram) or traffic. Where the points are some distance beyond the road junction, an appropriate arrangement is shown in Appendix B.
- 129 Where points are located in off-street sections of the tramway, provision should be made to deter access to those areas where the moveable portion of the points would cause a hazard to the public.

BRIDGES AND VIADUCTS

- 130 The safety principles and guidance given in RSPG Part 2 Section A *Guidance on the infrastructure*,¹ and in RSPG Part 2 Section C *Guidance on electric traction systems*,¹ should be applied so far as they are appropriate to the design and construction of all bridges and structures carrying a tramway.

Bridges carrying the tramway

- 131 Adequate derailment containment should be provided on all bridges and structures and elsewhere where the consequences of derailment would result in a significant hazard.
- 132 As an alternative to the derailment containment measures given in RSPG Part 2 Section A,¹ longitudinal pits or drainage channels which will contain a derailed wheel may be used. In a shared carriageway, the pit or channel should be covered with a frangible cover.

Note: It is recognised that existing bridges over highways may not meet the requirements for new bridges. As long as the aspects specifically mentioned in the above paragraph are satisfactorily addressed, other modifications to bring such bridges into full conformity with the provisions of RSPG Part 2 Section A1 might not be essential.

Bridges over the tramway

- 133 Bridge parapets should deny access to the live overhead electrical traction power system, in accordance with the guidance provided in RSPG Part 2 Section A.¹
- 134 Bridges and supporting structures within 5220 mm of the centre-line of a tram track should be designed to withstand the nominal impact forces. Designers should be able to demonstrate that they have used credible impact criteria in developing the design. Existing structures that do not meet this requirement should be modified or should be protected by cutwaters or other deflecting barriers.

TUNNELS

- 135 The safety principles and guidance on tunnels given in RSPG Part 2 Section A *Guidance on the Infrastructure*¹ should be followed, as far as is appropriate.
- 136 Double-track tunnels may be acceptable. New tunnels should be designed so that walkways outside the DKE are available. If the walkway forms part of the highway it should meet current highway design standards.

137 Where former railway tunnels are used and the trams have doors on both sides, the available space should be used to provide one generous-width centre walkway if it is not possible to provide adequate side walkways.

Note: Where the size of a former railway tunnel does not allow a walkway to be provided, then the track may be used as a walkway as long as:

- (a) there is sufficient clearance for the tram doors to open and allow passenger egress;
- (b) the track provides an acceptable walking surface;
- (c) the tunnel is illuminated; and
- (d) the tramway operates on line-of-sight through the tunnel.

ACCESS CONTROL

138 An on-street tramway has no restriction on access. However, where special risks occur, appropriate deterrent measures should be provided.

139 Particular attention needs to be given to the protection of the electric traction system from unauthorised people. Such protective measures should be designed with the needs of the environment in mind (see Chapter 6).

140 The design of the tracks, paving, overhead line equipment and other infrastructure associated with the tramway should take account of the needs of pedestrians and other highway users, and make appropriate provisions for their safety.

141 While the tramway is normally unfenced, some fencing may be necessary to segregate or direct pedestrians away from it at particular locations.

142 Special consideration should be given to the needs of mobility-impaired people, whether on foot or in wheelchairs, or using pushchairs.

143 Where an on-street tramway changes to off-street track, deterrents should be provided to discourage trespass by both pedestrians and road vehicles.

IDENTIFICATION OF THE INFRASTRUCTURE

144 A means of identifying any location along the tramway should be provided, for example, by numbering the overhead line supports. All bridges and other fixed structures, as appropriate, should be uniquely and conspicuously identified.

GRADIENTS

145 Locations at which a tram may routinely 'turn back', or other places where the tram driver is routinely required to leave the driving position, should not be on a gradient steeper than 1 in 500 (0.2%) unless other suitable and sufficient control measures are provided to mitigate the risk of uncontrolled tram movement. If steeper gradients are to be incorporated into the design of the tramway, this should be discussed with the Inspectorate at the earliest opportunity.

TERMINATING TRACKS

- 146 Where a tram track terminates, arrangements should be made for a tram that overruns the normal limit of operations to be brought to a halt or contained safely. The arrangements may include one or more of buffer stops, sand drags, soft macadam surfacing over the rails, energy-absorbing architectural features such as large planters, or other appropriate measures. Selection of the arrangements for a location should be on the basis of performance, the risks arising from an overrun, and suitability for the surrounding environment. The means chosen should discourage pedestrians from lingering in an overrun area.

5 TRAMSTOPS

147 This chapter gives guidance on tramstops.

Note: The term 'tramstop' includes stops with a raised platform above pavement level and those with platforms at pavement level.

TRAMSTOP LOCATION

148 The needs of passengers, pedestrians and other road users should be reflected in the design of tramstops and associated pedestrian routes. Design factors include:

- (a) sightlines;
- (b) gradients and curvature;
- (c) lighting; and
- (d) pedestrian desire lines.

149 Tramstops should be sited so that:

- (a) people who cross to the tramstop have adequate visibility of approaching trams and road traffic;
- (b) tram drivers have adequate visibility of the tramstop;
- (c) tram drivers have adequate visibility of people at or approaching the tramstop; and
- (d) other road vehicle drivers have adequate visibility of pedestrians approaching or leaving a tramstop.

150 If visibility is poor, then crossings equipped with pedestrian signals may be considered.

151 Particular attention should be given to the design of tramstops and platform edges to minimise risks to pedestrians and other road users.

152 When tramstops are located on gradients, consideration should be given to the difficulties that might be created for those who are mobility impaired.

TRAMSTOP PLATFORMS

153 Platforms may form part of the footway or other public areas accessible to pedestrians.

154 Platforms should be provided with a tactile surface in a contrasting colour. Platform edges should also be clearly defined with a strip of lighter colour. Design of the tactile surfaces should follow Department for Transport guidance.

155 Platform length should be sufficient to match the passenger door arrangements of the longest tram or normal combination of trams using the part of the system on which the tramstop is located. The length of the platform should include an allowance for inaccurate stopping.

PLATFORM HEIGHT

- 156 Platform height should be determined by the height of the tram floor or passenger door threshold.
- 157 Where platforms are provided and the height difference between the footway and the platform is more than 400 mm, the non-tramway edge may need to be fenced. Continuous steps may be provided instead of a fence and the appropriate tactile markings should be used.
- 158 Differences in height between tram floor and platforms must not exceed 50 mm at doors which are intended to be used by mobility-impaired passengers.¹² Where such access is only provided at some doors, adequate signage should be provided to indicate the door or doors which provide it. To ensure compliance throughout the life of the system, adequate wear and maintenance tolerances should be considered in the design.

Note: Mobility-impaired people are a very much wider group than wheelchair users. For example, people with prams and pushchairs have the same need for level access.

PLATFORM WIDTH

- 159 Platform width should give adequate unobstructed space for passengers boarding and alighting and should take into account pedestrian movements along the platform and the likely accumulations of waiting passengers. Consideration should be given to congestion likely to be caused adjacent to ticket vending machines and beneath shelters.
- 160 The minimum width between the tramway edge of the platform and any structure on the platform, except for the roofs of shelters, should not be less than 1500 mm.
- 161 An island platform should normally be at least 3000 mm wide, but may be narrower for low platforms.

Note: An island platform is one that lies directly between two tramway tracks. A platform between a tramway track and another carriageway lane not used by trams is a side platform.

PLATFORM CLEARANCES

Between platforms and trams

- 162 Horizontal clearance between platforms and door thresholds must not exceed 75 mm at doors which are intended to be used by mobility-impaired passengers.¹² Where such access is only provided at some doors, adequate signage should be provided to indicate the door or doors that provide it. To ensure compliance throughout the life of the system, adequate wear and maintenance tolerances should be considered in the design.

Note 1: The dimension of 75 mm is the maximum that must be maintained over the life of the system and it is recommended that at installation a figure of 40 mm is achieved to help ensure compliance with the Rail Vehicle Accessibility Regulations 1998¹² over the life of the system.

Note 2: The amounts by which the static vehicle profile (see Chapter 3) will be increased to form the kinematic envelope or the DKE are speed dependent, therefore the gap is also speed dependent; constraining this increase by the platform edge may require the imposition of a speed limit through the tramstop.

163 A recess below a platform coping is not required for tram platforms. However, a step to enable pedestrians to gain access to a low platform from the carriageway may be provided.

164 Where a side platform has road traffic adjacent to the non-tramway side a fence or barrier should be provided, clearances should be provided in accordance with the appropriate advice from the Department for Transport.

Vertical clearance

165 There should be clear headroom of at least 2300 mm. This applies to shelters, signs and all other structures on platforms. No shelter, sign or other structure on a platform should encroach within 450 mm of the edge of a carriageway used by other road vehicles.

166 Shelters, signs and other structures on the platforms should be designed to prevent access to overhead electric traction equipment.

LIGHTING AT TRAMSTOPS

167 Tramstops should be adequately and uniformly illuminated during the hours of darkness. Illumination may be provided by adjacent carriageway lighting.

ACCESS TO TRAMSTOPS

168 A safe and convenient access to tramstops should be provided for all, including mobility-impaired people.

169 The design of the infrastructure adjacent to platforms and pedestrian crossings at tramstops should be such as to minimise injury to a person struck by a tram. The surrounding surface should be at a level relative to the rail that allows the tram's pedestrian underrun protection to operate effectively.

170 If the access is via a ramp at any platform, that ramp should not be steeper than 1 in 20 (5%). Access ramps steeper than 1 in 20 (5%) but not more than 1 in 12 (8.5%) may be provided if space is limited. In this case the ramp should be fitted with a handrail.

Note: Where access to a tramstop is by ramp from an adjacent road bridge, the length of the ramp will, if the slope is 1 in 20 (5%), be in the order of 100 m where the road is over the tramway and 160 m where it is under it. Intermediate flat landings will increase these ramp lengths by 20 m to 30 m. The total length of such an access may be considered to be excessive by the more elderly or mobility-impaired people and lifts may have to be provided.

6 ELECTRIC TRACTION SYSTEMS

- 171 This chapter provides guidance on the overhead electric traction system for tramways.
- 172 Trams should usually be supplied with electric traction power from overhead line systems at a voltage not exceeding 750 V dc nominal. This voltage may be higher or lower subject to the agreement of the Inspectorate.
- 173 Exposed live conductor rails or similar systems should not be used on on-street sections. Exceptionally they may be used on off-street sections, with appropriate protection arrangements, after prior consultation with the Inspectorate.
- 174 On on-street systems, ac power supply systems should not be used without prior consultation with the Inspectorate. On off-street systems, ac power supply systems may be used, and the guidance given in RSPG Part 2 Section C *Guidance on electric traction systems*¹ should be followed.
- 175 The design of overhead electric traction power supply systems for off-street tramways should, in so far as is appropriate, follow the guidance for main-line railways (see RSPG Part 2 Section C *Guidance on electric traction systems*).¹

OVERHEAD LINE EQUIPMENT

- 176 Structures supporting an overhead electric traction power supply system should be positioned so that they neither significantly obstruct the highway nor are unduly exposed to damage from an errant road vehicle or tram.
- 177 Electric traction supply poles with cantilever arms, or a system of span wires between traction poles or building attachments may be used to support the overhead line equipment.

Note 1: The general requirements for clearances to electric traction supply poles are given in Chapter 3.

Note 2: Where footways are a minimum width (normally 1800 mm) the Highway Authority may require the poles to be located beyond the back of the footway.

- 178 All electric traction poles in public places should be resistant to climbing.
- 179 Structures supporting the overhead line equipment should be at least double insulated from live components. The primary insulation should be as close as possible to the live conductors.

Note: The risk of insulation degradation, leading to hazardous potential differences, may be reduced to an acceptable level by the use of multiple insulators or lengths of continuous insulation in the contact wire support system of the overhead line equipment.

Security of overhead line in the event of collapse or loss of any one support

- 180 The design of the overhead line supports should aim to minimise the vulnerability of each support to damage. The loss of any one support (eg as a result of a fire loosening a building fixing or of a pole being struck and damaged by a road vehicle) may release tension in the overhead line system but the design should allow other supports to prevent live equipment from sagging below 5200 mm above the highway. Off highway, it may sag lower provided that it remains out of reach of pedestrians. Connections between the pole and the contact wire should be mechanically weaker than the contact wire system itself to ensure that if a pole is damaged, the connection will break before the live equipment is dragged down.

Use of electric traction power supply poles for street lighting or other electrical equipment

- 181 Where electric traction poles are used to support the street lighting system or other electrical equipment, precautions should be taken so that even under fault conditions, one power system cannot adversely affect the other. Where it is proposed that street lighting or other electrical equipment is to be fitted to existing electric traction power supply poles, prior agreement from the Inspectorate should be obtained.

Note: Precautions may include double insulation in respect of the different electrical systems, and specially designed earthing systems.

- 182 Street lighting or other electrical equipment should be designed and installed so that it can be maintained safely without affecting the tramway system.

MANAGEMENT AND SAFE OPERATION OF POWER SUPPLY

- 183 The design of the electric traction power supply system should ensure that accessible voltages do not exceed 60 V. The spacing of electrical sub-stations may be significant and minimising the return resistance by the use of adequate rail section or additional return conductors should be considered. Proposals that may create higher voltages in areas considered to be less accessible should be discussed with the Inspectorate at the design stage.

- 184 Isolating switches should be provided to give effective and efficient means of control of the power supply system under both normal and emergency conditions. Such switches should be protected from casual interference by unauthorised people and located so as not to cause a hazard. It is preferable for isolators to be located in secure trackside cabinets but should it be necessary to mount isolators on traction supply columns, consideration should be given to protecting people from accessible live parts and ensuring a safe means of manual operation.

Note: Factors such as the proximity of buildings and the need for access for such matters as window cleaning may dictate the location of isolators.

- 185 Suitable earthing arrangements should be provided so that, either in emergency or as part of a planned isolation, normally live equipment can be earthed. Such arrangements should be capable of use without exposing staff to risks from road or tram traffic and should not be capable of being interfered with by traffic or the public.

- 186 The electric traction supply feeding system should be capable of discriminating between fault currents and normal system load currents. The protection equipment should be able to detect all credible faults, for example, highly resistive arcing faults remote from a traction substation.
- 187 High-speed dc feeder circuit breakers should be provided that are capable of automatically disconnecting all power feeds to a short circuit in the traction system. Automatic re-close should not normally be provided, and any proposals should be discussed with the Inspectorate at an early stage.

Sectioning

- 188 The electric traction system conductors should be sectioned electrically and provision should be made to enable the electric traction supply to be disconnected. Where necessary, means should be provided to permit the equipment to be earthed or otherwise made safe.

Central control facilities

- 189 The tramway operational control room should have provision for the safe and efficient management of the electric traction power supply system. Where the traffic control is located separately from the electric traction power supply control, communication facilities should be provided between the two (see Chapter 7).
- 190 There should be a monitoring system that clearly shows the actual position or status of all switches, isolators, circuit breakers or other devices controlling the power supply. This system should have provision to record all status indications, alarms and operator actions.
- 191 Arrangements for control of the traction supply should be such that under all normal or failure conditions of the control system, a need for the emergency discharge of that supply at a particular location can be met within the response time required by the emergency services.
- 192 Sufficient information should be permanently displayed, or otherwise immediately available for display in the electric traction supply control facility, to enable the controller to:
- (a) relate, with sufficient accuracy, the electrical distribution system to the geography of the tramway; and
 - (b) make safe the area affected by an incident in terms of tramway operation and electrical supply.

Avoidance of dangerous touch potentials to adjacent structures

- 193 Where it is possible to touch equipment at the return and earth potentials simultaneously, the hazard should be assessed to ensure that dangerous touch potentials are mitigated in other ways.

Note: Unbonded structures and other conductive equipment alongside the tramway will normally be at the 'mother' earth potential of the locality. The rails and body of a tram may be at a different potential from local earth, particularly at sites remote from feeder stations and under fault current conditions.

194 Where equipment has to be connected to a different earthing system, precautions should be taken to prevent danger to people who could touch both systems simultaneously.

Use of running rails as return conductors

195 Where the running rails are used for the return of electric traction current:

- (a) the along-track resistance should be designed and maintained to be as low as reasonably practicable; and
- (b) the rails should be nominally insulated from earth and not deliberately earthed at any point; but
- (c) the rails within the confines of depots should be earthed.

Minimisation of leakage of stray current to earth

196 The design of the electric traction supply system should ensure that leakage of stray current is normally minimised.

Note 1: Leakage of direct current may give rise to the risk of galvanic corrosion to structures and apparatus.

Note 2: Direct currents in the earth may lead to dangerous malfunction of equipment (eg interference with railway track circuits).

Note 3: To avoid excessive leakage current, the depot traction supply may require a separate traction substation that is normally not connected to the main tramway traction feeding system.

ELECTRICAL CLEARANCES

197 The clearances required are divided into two categories:

- (a) Static clearance - defined as the minimum distance required between the earthed material of any structure and the live parts of the overhead line equipment, under any permissible conditions of maintenance and taking account of climatic effects.
- (b) Passing clearance - defined as the minimum distance required under any permissible conditions of operation and maintenance between:
 - (i) the earthed material of any structure or tram and the live parts of the overhead line equipment;
 - (ii) any earthed material and the current collector; and
 - (iii) any live parts of the overhead line equipment and parts of the tram other than the current collector. It takes into account dynamic effects including the uplift from a pantograph.

198 The appropriate clearances for tramway systems are:

	UP TO AND INCLUDING 750V DC (NOMINAL)	UP TO AND INCLUDING 1500V DC (NOMINAL)
	Normal minimum	Normal minimum
Static clearance	75 mm	150 mm
Passing clearance	25 mm	100 mm

199 Any reduction in electrical clearances should be discussed with the Inspectorate at the design stage in each case. For voltages up to 750 V dc nominal, the static clearance may be reduced with prior agreement from the Inspectorate, as long as sufficient insulation is provided.

Note: For voltages up to 750 V dc nominal, the smallest achievable clearances result more from physical constraints than from electrical considerations.

200 The vertical clearance between the underside of new structures (or ones which are being significantly modified) and the DKE should not be less than 400 mm, to accommodate the necessary electrical clearances over the tramway.

Height

201 The height of the contact wire or any other live part of the overhead electric traction supply system must not be less than 5800 mm above the surface of any carriageway at the maximum temperature of the wire.¹³ Any proposal to use a lower position (for example, because of an existing bridge) would require an exemption from the Secretary of State and should be discussed with the Inspectorate at the design stage.

Note: Snow and ice loading may reduce the height of the contact wire or other live parts above the carriageway.

202 At other places accessible to the public, the position of the contact wire or any other uninsulated live part of the overhead electric traction supply system must be not less than 5200 mm above the ground or from a surface on which a person might reasonably stand, at the maximum temperature of the wire.¹³ Any proposal to use a lower position (for example, because of an existing bridge) would require an exemption from the Secretary of State and should be discussed with the Inspectorate at the design stage.

Note: Snow and ice loading may reduce the height of the contact wire or other live parts.

203 Where the headroom below the contact wire is reduced, the 'safe height' should be indicated on road traffic signs. Both advance warning signs shown in diagrams 779 and 780.1A of the Traffic Signs Regulations and General Directions 2002¹⁶ and, at the obstruction, the signs shown in diagrams 779 and 780A, should be provided. The indicated safe height for voltages up to 750 V dc should be at least 460 mm less than the actual headroom unless height gauges are installed, in which case the indicated safe height should be at least 380 mm less than the actual headroom.

Arrangements for overhead electric traction power supply systems on Department for Transport high load routes

204 Special arrangements should be provided where a Department for Transport high load route intersects a tramway where diversion of the route is not possible, such as a means of lifting the overhead line equipment for the passage of a high load.

7 CONTROL OF MOVEMENT

205 This chapter, together with Appendix B, provides guidance on the proper control of tram movements on a tramway.

206 The objectives are to control the movement of trams, prevent collisions and prevent possible derailment on points and crossings.

Note: Where a tramway operates on a segregated right of way, any signalling may be similar to that used on a mainline railway (see RSPG Part 2 Section D *Guidance on signalling*).¹ Otherwise, tramways predominantly operate on the basis of line-of-sight. When operating in this mode, tramway Proceed signals have a similar meaning to road traffic signals, ie it is the tram's turn to proceed but only if it is safe to do so.

207 Line-of-sight driving should be used on all on-street tramways. In this mode, a tram should be able to stop before a reasonably visible stationary obstruction ahead (including a signal displaying a Stop aspect or points indicator displaying an inappropriate aspect), from the intended speed of operation, by using the service brake. Relevant considerations may include:

- (a) the available sighting distance;
- (b) the intended speed of operation;
- (c) the braking performance of the tram, taking into account the gradient and tram brake equipment response time;
- (d) the effectiveness of the tram headlamps, if it is intended to operate in darkness in unlit areas, or the effectiveness of any illumination of the track;
- (e) the expected driver reaction time, which will depend upon what other actions the driver is expected to be carrying out at the location;
- (f) the visibility of signals and points indicators;
- (g) the topology of the surrounding area including side roads/walkways;
- (h) surrounding amenities.

Note: Should single line working be considered over a distance that exceeds the drivers forward visibility then the method of control to be adopted should be agreed with the Inspectorate at an early stage.

208 Exceptionally, where the probability of an obstruction on the line is low, the design may be based on use of the hazard brake. Any proposals that rely on this should be discussed with the Inspectorate at the design stage.

209 The probability and consequences of a moving pedestrian or vehicle infringing the DKE, or of a signal reverting to a Stop aspect when the tram is too close to stop, should be minimised. Relevant additional design considerations and actions may include:

- (a) local pedestrian desire lines;
- (b) design of pedestrian routes so as to encourage pedestrians to face towards any oncoming tram before crossing the track;
- (c) design and location of parking bays, equipment cabinets, overhead line poles, vegetation and other street furniture and features, so as to avoid places of concealment for pedestrians;

- (d) provision of barriers between places of concealment and the DKE;
- (e) design of access routes to and from tramstops so that passengers are discouraged from crossing the track at places other than designated crossing points;
- (f) traffic calming features or other measures to discourage motorists from overshooting stop lines on roads that intersect or form a junction with the tramway;
- (g) intervisibility between approaching trams and vehicles emerging onto the tramway;
- (h) the creation of one-way streets to prevent vehicles emerging from junctions where the sight lines are particularly poor;
- (i) tram speed restrictions;
- (j) compulsory audible warning by approaching trams;
- (k) measures to deter pedestrian access to some areas;
- (l) warning signs and notices for those approaching the tramway;
- (m) elimination of features likely to distract tram drivers or divide their attention.

210 Conflicting road and tram movements at road intersections and places where a tramway crosses a carriageway should (where necessary) be controlled by highway signalling.

211 In tunnels or other enclosed alignments, horizontal or vertical curvature may limit sighting distance. This may result in a speed restriction to ensure safe line-of-sight operation. To overcome this limitation, a form of signalling which is designed to maintain a safe distance between vehicles may be used.

Note: This option is only available in tunnels or other places where other traffic and pedestrians are excluded.

212 Part-time traffic signals may be employed to allow the use of emergency crossovers and other infrequently required tramway routes on the highway. The appropriate signing for part-time traffic signals on the highway as given in the Traffic Signs Regulations and General Directions 2002¹⁶ should be provided. This may need to be supplemented to give more information to other road users (eg "tram reversing").

213 Where it is necessary to control the movement of trams during roadworks, consideration should be given to adapting portable signals to show tram aspects.

TRACK SHARING

214 An appropriate form of protection to avoid collision is required to be fitted if any section of track is shared between a tramway system and a railway system with different and incompatible characteristics.

Note: An appropriate form of protection may be provided either by using a compatible form of automatic train protection, or by access for the railway system to the connections at the entry and exit to the shared track (or portion of shared track) only being allowed after the line between those connections has been proved to have been cleared by the tramway system.

LOCATION OF TRAM SIGNALS

215 On the highway, the layout and positioning of tram signals, and the associated staging and phasing at intersections, should follow current highway traffic engineering

principles. Particular attention should be paid to the requirements of turning traffic in the design, location and staging of traffic signals.

- 216 Where tram signals on the highway are required for headway purposes, including starting signals from tramstops or to control tram movements over reversing crossovers in regular service use, their locations should be agreed with the Highway Authority.
- 217 Where the tramway track layout allows for the reversal of trams in a way that would result in the tram moving in the opposite direction to other road traffic, road traffic signals to stop the other road traffic while the tram reverses are required.

TRAM DETECTION

- 218 Detection systems should be configured so that the failure of an individual detector does not compromise the safe operation of a road junction or pedestrian crossing.

Note: The form of detection for trams may be different from those used for other vehicles on the highway.

- 219 If each driving position of a tram is separately identified for route calling and route releasing, then suitable arrangements should be provided to ensure only one driving position is active at any one time under normal operating conditions.

POINT CONTROL, DETECTION AND INDICATION

- 220 The control arrangements for a particular set of points should be appropriate to the type of operation. They may be either manually operated by the tramway staff (by controls operated from the tram) or remotely from the tramway control room (subject to appropriate arrangements to ensure public safety).
- 221 Where points have the facility to be manually operated by the use of a lever or other such means, access to and operation of such points should not present a risk of personal injury.
- 222 The operation of powered points should be entirely under the control of the tramway system and may be pre-selected. Point indication should be provided separately and not by means of interlocking with the signalling system.
- 223 Power operated on-street points should throw only when a tram is sufficiently close to them to discourage anyone from being on the moving part, but in enough time for the tram driver to determine the lie of the points before reaching them.
- 224 The switch blades (or their equivalent) of any points used in the facing direction should be positively held in position during the passage of a tram. Mechanisms that allow the points to be 'trailed' may be used. Such interlocking should be effective from the time the point indicator shows the correct route, to the clearance of the last wheel.
- 225 Where spring force or hydraulic pressure is used to achieve the requirements of paragraph 224, a speed restriction through the points may be required. Otherwise, controlled or worked points should be provided. Points may be automatically operated but they should be mechanically held in position.

226 If track-circuits are not used to call and hold a route over a track junction, other means should ensure that, once set and an appropriate indication given to one tram, the points cannot be moved until the whole of that tram has passed over that junction.

227 An indication of the lie of facing or non-trailable power-operated trailing points that are used regularly by passenger-carrying trams should be given to the tram driver by a visual indicator of a colour distinguishable from white (but not red or green), positioned close to the points.

228 Indication is not required for points in depots or for emergency trailing crossovers which become facing only when used, provided that the tram driver can observe the position of the point blades from the driving position before driving over them.

Note: Where necessary to avoid clutter, the indicator may be co-located with the tram signal at the road junction.

229 If the points are incorrectly set or are misaligned, the place where the tram should stop should be clearly marked. If this is not immediately before the points, the point indicator may be more appropriately placed or duplicated at the stopping point.

Reversal and 'wrong direction' running

230 Fixed tram signals to enable running in the 'wrong' direction in an emergency are not required.

231 Wrong direction movements on on-street tramways should only be made under the control of a person holding an authority granted by the chief constable.

DESIGN AND CONSTRUCTION OF TRAM SIGNALS

232 A tram signal should be provided at all road traffic signalled installations for each direction from which a tram may approach.

233 Two or more trams should not normally operate through a signalled highway junction consecutively, in the same direction, and within the same phase. Any proposal to do so should be discussed with the Inspectorate at an early stage.

234 Traffic signals applicable to tramways must comply with the Traffic Signs Regulations and General Directions 2002.¹⁶

Note: The Traffic Signs Regulations and General Directions 2002¹⁶ define those signs and signals that a tram driver must obey.

235 The tram signals approved for on-street tramways may be used on the off-street sections to avoid confusion to the tram driver.

236 The tram signal may be a single lamp design showing a bar or dot symbol, a multi-lamp design showing an array of not fewer than five white lights in each aspect, or an array of light emitting diodes displaying an equivalent aspect.

Note 1: The diagonal bar is used to indicate to the tram driver that the road traffic light signal controller has set an appropriate phase for a diverging movement by the tram.

Note 2: Depending on the arrangements, it may also be necessary for the tram driver to confirm that the tram route has been correctly set to agree with the direction indicated by the tram signal.

237 The tram signal design, as specified by the Traffic Signs Regulations and General Directions 2002,¹⁶ should make provision against showing an indecipherable aspect, for example, by being able to detect a defined minimum acceptable performance for each aspect and alerting the control room to the condition. Alternatively, a standard three-aspect road traffic light signal head may be used and suitable masks should then be fitted to create the required white light symbols.

Note: Tram signals mounted in standard three-aspect signal heads require authorisation as they are not prescribed in the Traffic Signs Regulations and General Directions 2002.¹⁶

238 Duplicate or additional primary tram signals may be provided if necessary. Secondary signals beyond the junction should not normally be required.

239 Tram signals should normally be located on the left-hand side of the track. They may be located on the right-hand side of on-street tramways (ie between pairs of tracks), subject to the clearance requirements being met.

TRAMWAY AND ROAD TRAFFIC SIGNS

240 Signs for other road users consequent upon the introduction of a tramway are prescribed in the Traffic Signs Regulations and General Directions 2002.¹⁶ Signs that are not prescribed in these regulations should be specifically authorised by the Department for Transport.

241 A proliferation of signs should be avoided.

242 Signs applicable to tram drivers only should be as prescribed in the Traffic Signs Regulations and General Directions 2002¹⁶ and mounted so as to be conspicuous to drivers of trams but presenting as little distraction to other road users as possible, eg on electric traction supply poles. Details of these signs are in Appendix A - Tramway signs for tram drivers.

SPEED LIMITS

243 Prescribed lineside signs shown in diagram 976 in the Traffic Signs Regulations and General Directions 2002,¹⁶ indicating the maximum permitted speed, should be shown throughout a tramway. All signs should be similarly mounted. These signs would normally be located wherever:

- (a) the maximum permitted speed on a section of tramway changes; or
- (b) the maximum permitted speed of a tramway located in the carriageway differs from the limit for other road vehicles.

Note: In certain situations, generic speed restrictions would normally be applied at specific locations (eg through tramstops) and these may be provided for by the application of operational procedures, rather than individual signs for each restriction, and agreed with the Inspectorate.

244 The maximum permitted speed of a tram on a carriageway shared with other road traffic may be the same as, or lower than (but should not be higher than) that for other traffic.

245 The maximum permitted speed of a tram on a segregated on-street section may be higher than that for other road traffic provided that the presence of the tramway is clearly indicated to other road users. The higher speed should be agreed with the Police, the Highway Authority and the Inspectorate. A traffic regulation order may be required.

CONTROL OF TRAM SIGNALS

246 Where tram signals are associated with ordinary road traffic signals on on-street tramways, they should be controlled by the local road traffic light signal controller with appropriate tramway functionality.

247 Signalling equipment and software to be used on the highway are required to be to an approved design in accordance with the Traffic Signs Regulations and General Directions 2002.¹⁶

248 The control hierarchy should be such that whatever additional tramway controls are superimposed upon the local controller, it should be able to function on its own, including the processing of tram demands, if the transmission link to a central controller fails.

249 The local road traffic light signal controller should not be involved with determining route information for the tram, but should be presented with the appropriate demand being received from the tram detection equipment. In certain circumstances it may be necessary for an interface unit to be interposed between the controller and the tram detection equipment. This arrangement should similarly be able to function on its own if the link to any tramway supervisory or control system fails. The fundamental system may be developed further to encompass higher order traffic control systems.

250 Wherever the control of the tram signals is through a normal road traffic light signal controller, the detection of the lie of the points on a running line should be shown through a separate point indicator.

251 The design of the control system should be such that intersections can be safely controlled, allowing such precedence for trams as may be agreed with the Highway Authority, as described in Appendix B - Road and tram traffic signalling integration.

252 In fixed-time systems, the tram phases should run irrespective of the presence of a tram. For demand-dependent systems, tram signal phases should run in conjunction with parallel and complementary phases for other road users.

253 Where tram movements conflict with other road traffic flows, separate stages or phases should be provided solely for tram movement. *Proceed* aspects for trams should not return to *Stop* before any parallel *Proceed* signal for other road vehicles. An allowance should be made to give the tram earlier warning of the impending *Stop*, and so reduce the risk of the tram overrunning the stop line and a longer all-red period (ie the inter-green period) may be required following the termination of the tram phase.

Note: Where phases for segregated on-street trams always run with traffic phases in a stage (regardless of whether trams are detected on the approach), this may result in delays to other traffic and loss of capacity at the junction.

254 The design of a pedestrian crossing should ensure that, subject to a timeout in the event of an undue delay, the *Proceed* aspect for pedestrians (and the *Stop* aspect for a tram) cannot be given if an approaching tram is within its service braking distance of the crossing.

TRAMWAY CONTROL ROOM

255 The tramway operations control room and electrical control room should normally be combined.

256 The design of the tramway control room should provide a working environment that minimises distraction and fatigue, to avoid the risk of error by the staff responsible for the control of operations. All information necessary to control the system safely should be continuously displayed. The integrity of controls and indications should be appropriate to the extent to which safety depends upon their correct operation. Both normal and degraded modes of operation should be taken into consideration when assessing the risks and the level of integrity required. The control room equipment essential for the safe operation should be protected from the consequences of electrical supply failure at the control room. Any loss of power or changeover to battery supplies should not cause a loss of integrity in the ability to control the system.

257 Display screens capable of showing the track layout and positions of tramstops should be provided. Display screens for the electrical supply systems should be provided that are capable of showing the locations of feeding points, and the actual position and status of circuit-breakers and section isolators. If any diagram or diagrams respond to the position of vehicles, the lie of points or switches, position of circuit breakers or aspect of tram signals, such information should be clearly displayed. Switching between displays in the course of an operation is not acceptable if this gives rise to a consequent need to remember the status of relevant items. A fixed line diagram or diagrams should also be provided to enable operations to continue in the event that the display screen equipment is unavailable.

258 Telephone links should be provided between the local emergency services control room(s) and the tramway control room. Tramway control room staff should be made aware of any incoming calls on such a link, even if other communications systems share the same equipment. A similar link should be provided to the controlling signal-box of any rail system that crosses or shares an alignment with the tramway. All such links should continue to function if mains power is lost at the tramway control-room.

259 Whenever control-room staff pass messages that are critical to safe operation, all messages should be recorded and the recordings kept for at least 24 hours. Where safety is dependent on communications between control-room staff, these communications should be similarly recorded.

Radio communications systems

260 An adequate system of radio communication between the tramway operational control room and trams should be provided. A system allowing selective calling and identification of individual trams should be provided if instructions that are critical to safe operation are to be passed by radio. The radio system should incorporate the facility for each of the emergency services and tramway personnel to use their own portable radios within their own command structure; this facility should be functional throughout any running tunnels, and within any access shafts and cross passages.

261 Voice communications between control and the tram driver should be kept separate from those between the tram driver and the passengers so as to prevent the latter from overhearing control messages.

262 On tramways where the trams are crewed by one person and have significant parts of their route in tunnels or on viaducts, the operation of the driver's safety device should, after an appropriate interval, open a direct means of communication between the system controller and passengers.

8 TRAM DESIGN AND CONSTRUCTION

263 RSPG Part 2 Section F *Guidance on trains*¹ gives some general guidance that is also appropriate to trams. This chapter gives guidance on those aspects that are specific to trams.

Note 1: Some of this guidance may not be applicable to heritage trams (see Appendix C - Heritage tramways).

Note 2: For guidance on the design and construction of non-passenger-carrying trams, see Appendix D - Non-passenger-carrying vehicles used on tramways.

GENERAL GUIDANCE

264 A tram should be designed so that it is safe for its users (passengers or members of staff) and does not endanger other users of the highway.

265 In general, a tram which operates on-street should conform to the current Road Vehicles (Construction and Use) (Amendment) Regulations 1996⁹ for road vehicles in so far as appropriate. Although not subject to the mandatory requirements for road vehicles, trams should nevertheless include features in their construction and performance that make them safe for use on the highway and in other places where they share the infrastructure with other users.

266 The tram design should ensure that the tram is conspicuous at all times.

COMPATIBILITY

Relationship with road traffic light signal and point controllers

267 A tram to be used on the highway should be equipped with a system of communication to permit it to be detected by highway signal controllers so that the appropriate stage and phase can be called on the road traffic light signals. The system, or a similar one, should also be able to request a specific route at junctions and actuate the safe operation of the points.

External lighting

268 The external lighting of trams which run on-street should conform so far as practicable with the Road Vehicle Lighting Regulations 1989,¹⁷ in so far as both the construction of the tram and the achievement of the following objectives will allow:

- (a) in the forward direction, it should uniquely identify the vehicle as a tram;
- (b) bi-directional trams should carry the full range of lights and reflectors for running in either direction; and
- (c) lights and reflectors on the sides of the tram should be similar to those required for large goods vehicles rather than those for passenger-carrying vehicles.

269 The following arrangements are considered to meet these objectives:

	FACING FORWARD	FACING REARWARD	ALONG THE SIDES
Headlights	Two white dippable and a third white dipped mounted centrally above them	-	-
Position lights	Two white	Two red	-
Outline marker lights	Two white	Two red	-
Side marker lights	-	-	At least three for a 30 m long tram - Amber
Direction indicators	Two amber	Two amber	Amber (combined with side marker lights)
Reflectors	Two amber (may be combined with direction indicators)	Two amber (may be combined with direction indicators)	At least three for a 30 m long tram, 1 m above road level - Amber
Brake lights	-	Two or two clusters - Red	-
Fog lights	-	Two high-intensity - Red	-

Lamp positions

270 Lamps should be positioned as close as practicable to the positions prescribed within the Road Vehicle Lighting Regulations 1989.¹⁷ Due allowance should be made for the construction and shape of the ends of the tram in permitting variations from the specified heights and distances from the sides. The following guidelines are generally considered to offer a suitable arrangement:

- (a) all the lamps, except the centrally-mounted headlight and the side-mounted lights, should be placed as close as possible to the side of the tram, preferably at a distance of not greater than 400 mm;
- (b) front and rear position lamps and direction indicators should be approximately 1500 mm from the ground;
- (c) the end outline marker lamps should not be below the top of the windscreen at either end; and
- (d) the main pair of headlamps should be placed between 500 mm and 1200 mm from ground level and the central headlamp, above the windscreen.

271 While running on-street:

- (a) all the headlamps, the position lights, end outline lamps and the side marker lights should be lit. The other lamps should be lit as the occasion demands;
- (b) all the white lamps and none of the red lamps should show forward in the direction of travel and vice versa to the rear;
- (c) the front, rear and side direction indicators should all flash together. If combined

side marker lights and side direction indicators are provided, the indicators should be substantially brighter than the marker lights;

- (d) the normal road vehicle configuration for hazard warning lights should apply; and
- (e) for safety purposes, it should be possible to leave the hazard warning lights on with the driver's key removed.

272 On systems that are exclusively line-of-sight off-street tramways, the following lamps should be provided:

- (a) three headlamps, front position lights and rear position lights;
- (b) brake lights; and
- (c) higher-intensity rear fog lamps (which may be used in place of the rear position light, but care should be taken not to override the visibility of the brake lights).

Note: The side marker lamps required for other sections of tramway need not be lit on the off-street sections. It is not necessary for the direction indicators to operate on off-street sections unless required to do so by the operating requirements of the system.

273 Where different arrangements apply for on-street tramways and off-street tramways, a single selector switch should be provided in each cab to change the configuration of the lights when changing from one type to the other.

274 The light output of the various lamps and size of reflectors should conform as near as practicable to those specified in the Road Vehicle Lighting Regulations 1989.¹⁷ The following points should be noted:

- (a) care should be taken not to oversize the side marker lamps;
- (b) external 'door open' lights may be provided, but these should be designed so as to give no confusion with the lights required to be shown when the tram is in motion; and
- (c) a tram should not display a red light or reflector at the front.

Driving mirrors

275 Except on trams used solely on off-street tramways, mirrors or other devices should be provided to give the tram driver a rearward facing view along both body sides when the tram is in motion. Such mirrors or devices should be included within the DKE.

Audible warnings

276 Trams should be fitted with an adequate audible warning device at the driving ends. The warning emitted should be in keeping with the environment in which the tram runs. The warning should be loud enough to indicate the approach of a tram without causing injury or undue alarm to those in the proximity.

277 The warning device should have two levels of sound where trams run both on-street and off-street:

- (a) the lesser level, for use on-street to alert people of the tram's presence, should produce a sound that is distinctive compared with that emitted by other road vehicles; and

- (b) the greater sound level, for use in emergencies and off-street, should be adequate to warn staff who are working on the track that a tram is approaching.

Pedestrian protection and obstacle deflection

- 278 Collision protection should be provided for pedestrians as follows:
- (a) the tram ends and sides should be continuously skirted. The bodywork and skirting should be designed to deflect people who may come into contact with the tram and stop them from passing beneath;
 - (b) exceptionally and with prior agreement of the Inspectorate, where the skirting at the end of a tram does not provide adequate protection due to the topography of the system, there should be a guard in front of the leading wheels designed to prevent people or objects being run over by the tram, with adequate clear space to prevent crush injuries; and
 - (c) the guard should be positioned as close to the highway surface and to the wheels as is reasonably practicable. It may have a deflecting lower edge of pliable material to close the gap to the surface of the highway.
- 279 Effective obstacle deflection equipment should be provided to reduce the risk of derailment. This equipment may be attached to the running gear or to the tram underframe. Such protection is in addition to that provided in relation to pedestrian collision.

Running gear

- 280 Tram running gear should take the following into account:
- (a) the need to minimise noise;
 - (b) the use of grooved rail, and in some areas, the use of flange running at points and crossings.

STRUCTURAL INTEGRITY

Underframe and body

- 281 The underframe and body, including any articulation joint, should be designed to:
- (a) be of sufficient mechanical strength to withstand the anticipated loads in normal use;
 - (b) mitigate against the effects of a collision with another tram, road vehicle or buffer stops in a way which minimises injury to passengers, staff and other road users; and
 - (c) have adequate jacking points, with their positions clearly identified on the outside of the tram and accessible for use by the emergency services.

Windows

- 282 Windscreens and other forward-facing windows should be able to resist impact from projectiles or other objects. Other tram windows should conform to the current standards for passenger-carrying vehicles on the highway.
- 283 It should not be possible or necessary for people to lean out of windows or other apertures or throw large objects through them.

- 284 Cab windows should not open in such a manner as would allow the tram driver to extend any part of the body, including the head, beyond the kinematic envelope while the tram is moving, unless full clearances exist throughout the tramway system.

Couplers

- 285 Couplers and drawgear may be one of two different types:
- (a) for regular service use. They should be fitted if the operation of the tram system demands it; or
 - (b) for emergency use only in all other cases.
- 286 Any coupler fitted to a tram operating on an on-street tramway should be designed to fold away or otherwise be retracted when not in use. The extended position of the coupler should be included within the kinematic envelope.
- 287 On trams fitted with couplers, adequate fenders or protective covers are required to mitigate damage to other vehicles in the event of an accident. The end of any folded or retracted coupler, or any fixed coupler (if permitted), should be within the bodywork and protrude as little as possible beyond the fenders. Any sharp edges or points should be covered and provided with suitable fenders.
- 288 Couplers should be designed to withstand the loads for which they are intended.
- 289 The coupler should be designed to accept at least the load imposed when hauling or propelling a 'dead' tram, at 10% overload of its maximum laden weight, anywhere on the system.

INTERIORS

Driver's cab

- 290 The cab should be designed on ergonomic principles. All the controls and indications needed while driving should be convenient to use and located so as to minimise the risk of error.
- 291 The interior layout of the cab should be designed to prevent portable objects being placed where they would obscure the tram driver's visibility or interfere with the controls. There should be stowage provided for the driver's personal effects, and a convenient location for any timetables, documentation or notices to which drivers may need to refer frequently.
- 292 The design of the driver's cab should offer optimum internal and external visibility for the driver.
- 293 Consideration should be given to the driver's access to and egress from the cab. If the cab does not have an external door, an external saloon door located immediately behind the cab should be provided. Such a saloon door should be provided with separate internal and external controls for the use of staff. Where access and egress is only possible via the passenger saloon, a removable cab side window should be fitted for emergency egress.

- 294 Tram signals, signs, passengers waiting at tramstops and other road traffic should be clearly visible from the cab under all credible operating conditions. Suitable means of obscuring the sun and for preventing distraction as a result of reflected light from cab instruments or saloon lighting should be provided.
- 295 Mirrors or other devices may be provided to enable the tram driver to observe passengers boarding and alighting, and to confirm that no passenger has been trapped by a closed door. If the mirrors extend beyond the kinematic envelope, they should retract automatically as the tram moves away.
- 296 The cab should afford sufficient heating, cooling and ventilation to allow the driver to remain comfortable under all credible operating conditions. The driver should be able to control the temperature in the cab. Where the driver will be required to change ends, the system should ensure that the cab the driver changes to offers the same comfort level.

Driving controls and indications

- 297 The driving controls and indications available to the tram driver should enable the tram to be operated safely. The controls for (or displays of) any signalling system should not detract from this.
- 298 Consideration should be given to the position of the driver. The driver should normally be located in the centre of the cab or to the right of centre.
- 299 The following should be provided:
- (a) a traction and brake controller, which incorporates a hazard braking position (it may also incorporate a driver's safety device);
 - (b) a driver's safety device, designed so that it cannot be kept in the operating position other than by a vigilant tram driver;
 - (c) an emergency brake button, in addition to (a);
 - (d) a speedometer, calibrated in km/h;
 - (e) a data recorder, having sufficient channels to record information pertinent to the investigation of accidents involving the tram and capable of being calibrated, downloaded and presented as evidence;
 - (f) an emergency 'pantograph down' button for pantograph systems, or equivalent button for different systems;
 - (g) switches to operate the main tram traction power supply circuit-breakers; and
 - (h) means to disable the controls at non-active driving positions so as to prevent interference with them.
- 300 The button controls for (c) and (f) of paragraph 299 are required to be different in shape to other button controls and should be mushroom-shaped. They should also be distinctively coloured. The emergency brake button should be red.
- 301 Controls may be provided to:
- (a) limit the speed generally or when operating in a particular mode, eg on-street;
 - (b) protect against wheel slip when accelerating or wheel slide when braking;

- (c) operate sanding gear;
- (d) control environmental conditions inside the tram; and
- (e) control the functions of the internal and external communication apparatus so as to prevent mutual interference and cross-talk.

Design of passenger saloon

- 302 The interior layout and fittings of passenger trams should be designed to minimise injuries to passengers and tram crew.
- 303 Doorway handrails should not be accessible from the exterior when the doors are closed.
- 304 The ratio of seating to standing passengers is a matter for the operator, but for planning purposes the density of standing passengers should not normally exceed 4 passengers/m² of available standing space.
- 305 Gross laden weight calculations and floor strength requirements should be based on a standing passenger density of 8 passengers/m² of available standing space.
- 306 Internal steps and stairways must meet the requirements of the Rail Vehicle Accessibility Regulations 1998.¹²
- 307 Interior lighting in trams should meet the lighting levels provided in other passenger-carrying vehicles. In common with these vehicles, additional lighting in doorways, steps and internal stairways may be required.
- 308 Lower lighting levels are acceptable in the event of electric traction power being lost. The level of lighting should be sufficient to enable the tram to be evacuated.

Interior fittings

- 309 Interior fittings of passenger-carrying trams should be designed so as not to cause injury in normal operation and to minimise secondary injuries to passengers should the tram be involved in an accident. Interior fittings should include the following:
 - (a) adequate grab-rails and stanchions of an appropriate size for mobility-impaired passengers, and of a colour easily seen by the visually impaired;
 - (b) hanging straps, if fitted, should have limited movement and be secure under load;
 - (c) interior glass which conforms to current passenger-carrying vehicle standards and has protected exposed edges; and
 - (d) passenger-operated buttons (door opening, alarm, stopping request).
- 310 Facilities must be provided for mobility-impaired passengers in accordance with the Rail Vehicle Accessibility Regulations 1998.¹²

Emergency equipment

- 311 Equipment for emergency use should be carried on each tram. Suitable provision should be made for stowing emergency equipment. The following should be carried:
 - (a) a fire extinguisher;

- (b) other emergency gear, including (if necessary) track-circuit operating clips;
- (c) a position for a hand lamp sited so that in emergency, the lamp can be used as a temporary tail light; and
- (d) a first-aid kit.

ACCESS AND EGRESS

Doors and door controls

- 312 Tram doors should be designed to operate safely.
- 313 Doors and associated areas should be designed so as to minimise the danger of trapping injury. They should be fitted with obstacle detection equipment and should not operate with excessive force. It should be possible to release limbs or other objects trapped by the doors without difficulty.
- 314 Facilities should be provided for passengers in accordance with the Rail Vehicle Accessibility Regulations 1998.¹²
- 315 Where fitted, folding steps or sliding plates should be interlocked with the electric traction power controller and brakes to prevent movement of the tram when they are deployed.
- 316 When the vehicle is moving, external passenger doors should be secured in the closed position. It should not be possible for the tram to start unless all external passenger doors are fully closed and secured. In the event of doors or their control system moving from the 'closed' position while the tram is moving, traction power should be removed automatically and the brakes should be applied.
- 317 Passenger door controls and the method of operation should be clearly and unambiguously signed.
- 318 All passenger doors should be provided with a means to allow passengers to release the doors in the event of an emergency.
- 319 The door arrangements should enable passengers and tram crew to evacuate safely. It should be possible for passengers to open designated external doors once the tram is stationary. Door emergency releases should be operable to allow the opening of external and internal doors even if there is a failure of any tram equipment, power supply etc.

Door controls

- 320 If passenger-operated door control buttons are provided, they:
 - (a) must be compliant with the Rail Vehicle Accessibility Regulations 1998;¹² and
 - (b) should be made operational when the tram is correctly located at a tramstop and/or it is safe to disembark.

- 321 Emergency opening devices fitted inside the tram should be able to be used by the passengers without the help of the tram driver. The operation of these devices should be brought to the attention of the driver. It should not be possible to open the doors until the tram is at (or nearly at) a standstill.
- 322 There should be a means of releasing designated external doors from the outside in an emergency.
- 323 The design and labelling of internal and external door emergency releases should deter non-emergency use.
- 324 The tram driver should be able to easily identify which emergency door-opening device has been operated. After operation, the device should be able to be cancelled only by the driver or other members of the tramway staff.
- 325 If the external emergency release device is also intended to be used as a means of opening tram-crew access doors, it should be possible to reset it from both inside and outside the tram.

COMMUNICATIONS

- 326 Alarm points should be provided so that in an emergency, it is possible for passengers to communicate to the tram crew, and for the crew (or, where required, the tramway system controller) to communicate to the passengers.
- 327 Where there are request stops, facilities for requesting the tram to stop should be provided and the use of this facility indicated both in the cab and in a prominent position in the passenger compartment. Such equipment must comply with the Rail Vehicle Accessibility Regulations 1998.¹²

POWERED SYSTEMS

- 328 The electrical and other powered systems and equipment on trams should not endanger other systems or people in either normal operational, maintenance or failure modes. Consideration should be given to the location of equipment that the driver may need to access for resetting, to ensure neither the driver nor passengers are exposed to risk.
- 329 Safety-critical systems should be designed to fail to a safe mode, either by redundancy or before safety-critical levels are reached. Suitable alarms or interventions should be provided as necessary.
- 330 Preventative measures should be provided to guard against fire or a system overload under fault conditions, and to enable a tram to be either operated safely under emergency conditions in the event of failure, or to be recovered or otherwise removed from causing an obstruction on the highway, or both.

- 331 A battery should be provided which, in the event of failure of the electric traction power supply, can provide sufficient interior and exterior lighting (appropriate to the tram system).
- 332 The power-supply system onboard the tram should provide an adequate, protected path for the return current and should be protected against the effects of accidents and unauthorised access to the live parts.
- 333 The power systems should be appropriately guarded against unauthorised access.

Electric traction power supply

- 334 The design and construction of the collector for the electric traction power supply and associated isolators and protective devices should take into account the need to avoid hazard either to tram operating staff or to the public.
- 335 Over-current protection and isolation arrangements should be provided as close to the source as possible. The main traction power circuit breakers and line fuses should be roof-mounted for overhead electric traction systems. These may be below the underframe for conductor-rail systems.
- 336 Overhead systems should be fitted with roof-mounted lightning surge arrestors.
- 337 Sufficient and effective bonded paths to the tyres of the wheels from the superstructure should be provided on any tram used on an electric tramway system or on an alignment shared with an electric railway. The return path, if this is through the rails, should be designed to ensure that conductivity remains sufficient through the wheels at all times.

Isolating devices

- 338 The following means of isolating the tram from the traction supply should be provided:
- (a) a control by which the tram driver may isolate the power supply between the current collector(s) and the electrical equipment, without leaving the cab;
 - (b) a control by which the tram driver may disengage the current collector(s) from the source without leaving the cab; and
 - (c) a control by which the current collector(s) may be disengaged from the traction supply which is accessible from ground level outside the tram; its position should be marked.
- 339 Additionally, a means of isolating the battery should be provided which is accessible from ground level outside the tram; its position should be clearly marked. Other electrical circuits should also be protected by isolating switches and circuit breakers, which may be combined as appropriate.
- 340 On trams that use overhead lines as the power source, it should be possible to raise and lower the current collector manually when the tram has discharged batteries. After raising the current collector manually, the tram should then be capable of being re-energised and charging the batteries using only the supply from the overhead line.

Equipment and cables needed for re-energisation need not be isolated in accordance with paragraphs 338 and 339. However, the amount of equipment and cabling which is not so isolated should be minimised.

Electrical equipment protection

- 341 Electric traction power cables should be routed so that they are protected from mechanical damage. In addition, the following precautions should be taken:
- (a) where the cable route passes through a fire barrier, adequate fire stopping should be provided; and
 - (b) if the cable route passes through the passenger compartment, this should be by the shortest practicable route.
- 342 The operating voltage of electrical equipment in areas accessible to passengers should not exceed 50 V.
- 343 Cubicles containing equipment at electric traction power supply voltage which have to be in the cab must be locked or appropriately secured. Warning notices must be displayed.¹⁸
- 344 Cubicles containing power control equipment that could emit toxic fumes if set on fire should not be ventilated into the passenger compartment.

CONTROL SYSTEMS

Traction power controller

- 345 The traction power control system should be of robust design, using safety-critical techniques in hardware and software systems to guard against unsafe conditions in failure modes.
- 346 Whatever traction control system is used, it should be designed so as to prevent:
- (a) the taking of power or release of the brakes when any external doors are detected as not closed, or when folding or sliding steps or ramps are deployed;
 - (b) the taking of power when the braking systems are not available;
 - (c) the enabling of controls, except the safety brake, from more than one driving position at a time; and
 - (d) the movement of the tram in a direction opposite to that selected by the tram driver.

Note: A combined traction and brake controller is preferred.

- 347 Where a single microprocessor is used for safety-critical functions in the tram control system, it should be designed to appropriate safety-critical standards.
- 348 Jerk rates during starting and acceleration should not exceed 0.8 m/s³.

Brakes

- 349 Trams should be fitted with:
- (a) a continuous system for the control of the service brake, operable from the driving position in service on trams coupled in service conditions;
 - (b) a parking brake which is automatically applied when the tram is 'shut down'; and
 - (c) brakes that remain partially applied when the tram is brought to a standstill until the controller is operated to take power to move the tram.
- 350 Where the braking force applied through the wheels is insufficient to meet the required braking performance, an electromagnetic brake or brakes acting directly on the track should be fitted to achieve the required performance.
- 351 The braking system should be designed so that:
- (a) an assisting vehicle (another tram or a recovery vehicle) can operate the brakes on a failed tram if they are operable; and
 - (b) if the brakes on a failed tram are inoperable, the brakes of the assisting vehicle should be such as to enable it to haul and to control the failed tram at slow speeds.
- 352 An irrevocable brake application should result from:
- (a) a lack of correspondence between vital control systems;
 - (b) insufficient air pressure, hydraulic pressure or electrical supply to operate the service brakes or traction control system;
 - (c) the loss of brake activating pressure;
 - (d) the accidental parting of articulated or coupled trams; and
 - (e) the unintended deployment of steps or boarding devices, or when an external passenger door is no longer detected as closed.

Brake performance

- 353 Trams running on-street should have:
- (a) a service brake that provides a retardation rate of about 1.3 m/s^2 from the maximum permitted speed of operation, controllable by the driver. The jerk rates on application of the service brake (and on stopping) should not exceed 0.8 m/s^3 . This retardation may be achieved through a combination of dynamic and friction braking, but in the event of dynamic brake failure, the friction brake should be able to maintain the service brake performance under all credible loading conditions and permitted service speeds;
 - (b) a hazard brake with a maximum instantaneous retardation rate of between 3 and 4 m/s^2 , and a retardation rate of at least 2.5 m/s^2 for a stop from the maximum permitted speed of operation. The control for this should be incorporated into the main brake controller (or traction/brake controller where one is used), but should not easily be applied inadvertently. This brake application should be revocable by the driver. The application and stopping jerks should be limited so far as is reasonably practicable and should not normally exceed 1 m/s^3 ; and

(c) a brake of high integrity, irrevocable by the driver once applied until the vehicle has come to a stand. This brake should provide a retardation rate at least equivalent to the service brake and should not be capable of degradation by any automatic control systems.

354 The parking brake should be able to hold a fully laden tram, or to hold it (in any load condition) and another (unladen) tram with failed or isolated brakes on the steepest gradient on the system.

355 A brake application should occur automatically if a tram rolls back after stopping on an uphill gradient. The tram should stop within 500 mm under all loading conditions on the steepest gradient on the system.

356 Equipment should be provided to optimise traction and braking performance under credible adhesion conditions.

Note: Such equipment is likely to include sanders and slip/slide regulation systems.

APPENDIX A - TRAMWAY SIGNS FOR TRAM DRIVERS

- 1 This appendix provides guidance on the tramway signs that give instructions to tram drivers.

Note: The tramway signs have been designed so as to reduce the risk of their being confused with other road traffic signs.

- 2 The design and sizes of tramway signs must comply with diagram 976 of the Traffic Signs Regulations and General Directions 2002.¹⁶ The size should be selected so as to ensure the sign is clearly visible and legible. Signs should normally have black legends, symbols and borders on a white background - use of other colours should be agreed with the Inspectorate.
- 3 The tramway signs should be used consistently throughout a tramway system and should be consistent with those used by tramways operating on the highway.
- 4 A maximum speed sign is shown in the Traffic Signs Regulations and General Directions 2002.¹⁶ Figure 8 shows a *Stop* sign, Figure 9 a *Give way* sign, and Figure 10 indicates the maximum permitted tram speed, and Figure 11 shows an instruction sign. The instruction sign should be used with a separate plate mounted below it conveying the specific instruction applicable.
- 5 Should a tramway wish to use signs other than those illustrated below, they should discuss their proposals with the Inspectorate.

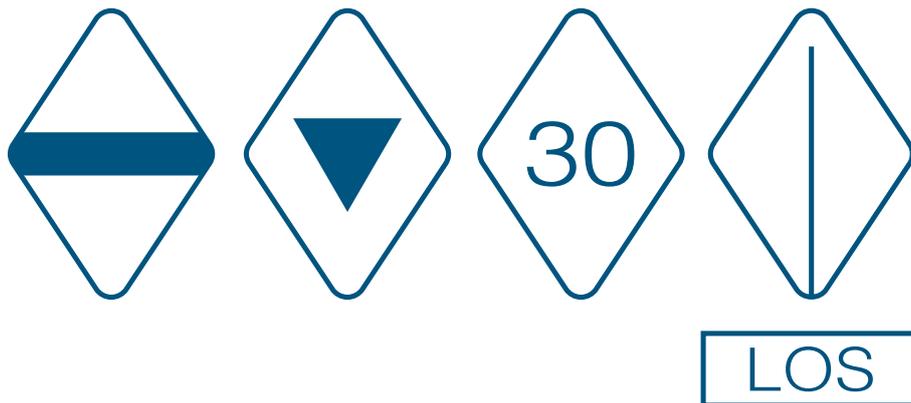


Figure 8:
To indicate to tram traffic the requirement to stop, and not to proceed until it is safe to do so

Figure 9:
To indicate to tram traffic the requirement to give way to other trams or other road vehicle traffic

Figure 10:
To indicate the maximum permissible speed of tram operation until amended by another speed variation instruction

Figure 11:
To indicate to tram traffic the requirement to observe the instruction conveyed by the accompanying plate. The plate conveys a specific instruction to the tram driver. Permitted variants include: other letters, or text conveying other meanings

APPENDIX B - ROAD AND TRAM TRAFFIC SIGNALLING INTEGRATION

- 1 This appendix provides guidance on the integration of tram signalling with road traffic light signalling. To give the appropriate priority to trams, the tram phase (when demanded) may need to run before any parallel or similarly compatible phase for other road users is initiated. The tram phases should terminate at the same time as any parallel stage or phase for other road vehicles. The following examples illustrate ways in which detectors may be positioned. Figure 12 indicates typical tram detector positions.

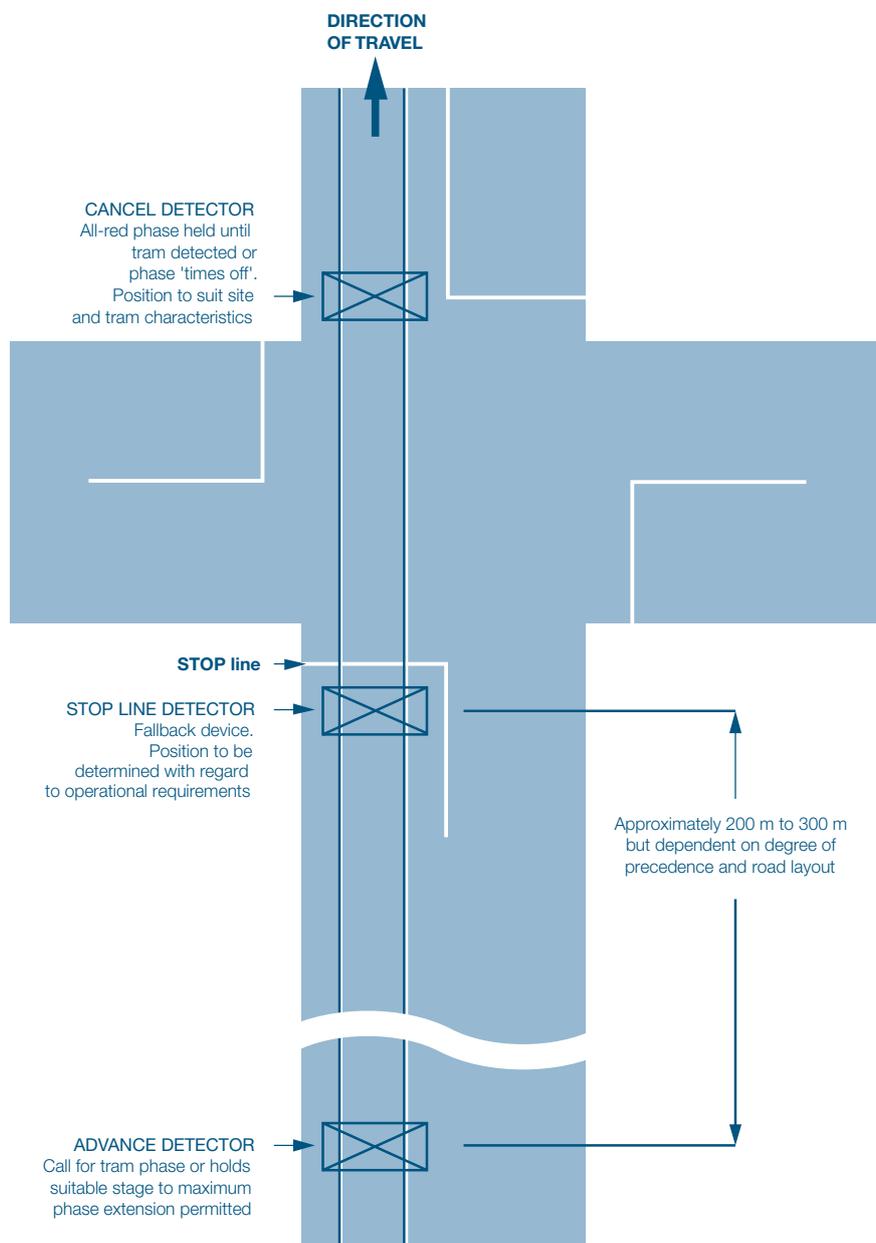


Figure 12: Tram detector positions

CONTROLLED INTERSECTIONS

- 2 Tram detectors should be provided where road traffic light control systems employ some degree of demand dependency. The detector's function is to register a demand in the road traffic light controller to call up the tram phase in the next appropriate stage in the sequence.
- 3 Tram selective detectors should respond only to trams. Selective detectors may also pass information for tramway operational purposes.
- 4 A stop line detector should be provided. It should register a tram demand if none is already present. If the tram *Proceed* signal is already present, departure from the stop line detector may initiate a red period. A cancel detector should be provided on the downstream side of the stop line to enable the red period to be terminated before the end of the maximum period once a tram has cleared the intersection.
- 5 The minimum provision should be a 'stop line detector' and a 'cancel detector'.
- 6 An advanced detector may be provided further upstream of the stop line detector on the tram approach to secure a tram *Proceed* indication without requiring the tram to stop at the stop line. The advanced detector may then be used to prioritise the tram phase if required, including making provision for the passage of a tram in the opposite direction on a parallel track.

Note: The maximum degree of priority that can be given will depend on the distance of the advanced detector from the stop line, tram running speeds, and the staging and timing arrangements for the intersection.

- 7 Further advanced detectors may be necessary to allow the tram the maximum precedence, to permit it to run unimpeded through the intersection, or to improve junction capacity for other road users.

Note: The distance between the outermost of these detectors and the intersection will be governed by the maximum permitted speed of the trams and the maximum attainable speed, whichever is less, and the time taken for the signal controller to change to the appropriate stage, the objective being for the *Proceed* aspect to be shown before or just as the tram reaches an overall service braking distance (including reaction time) from the stop line.

- 8 The signal aspect defined in regulation 42(e) and diagram 3013.5 of the Traffic Signs Regulations and General Directions 2002¹⁶ should be displayed for a period commensurate with the service braking performance and approach speed of trams. A shorter period, commensurate with the emergency braking performance, may be used if the signalling design ensures that a signal will only return to *Stop* as a tram is approaching under exceptional conditions (for example an emergency services vehicle hurry call or a fault). However, the period should be consistently applied throughout each individual system.

Note: The nominal time for this aspect to be displayed is normally five seconds, but may be varied between systems according to local geographic, climatic and traffic conditions, which may affect the braking performance of the trams.

Priorities at controlled intersections

- 9 'Hurry call' signals for emergency service vehicles should override all other demands.
- 10 Where a tramstop is located between where the advanced detector would be positioned and an intersection, a 'tram ready to start' (TRTS) detector should be provided so that the tram driver can initiate the tram phase when the tram is ready to depart from the tramstop. Figure 13 shows a tramstop with a TRTS detector.

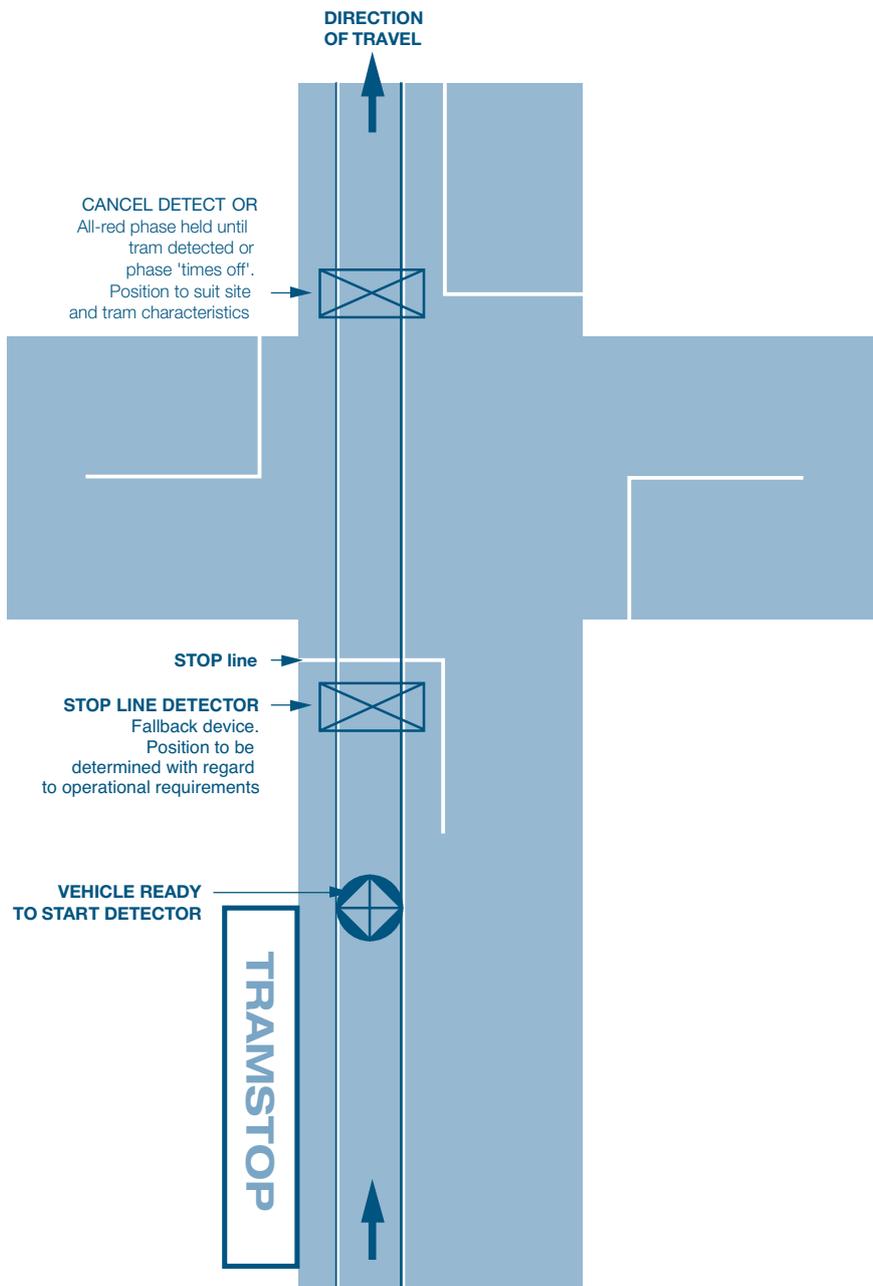


Figure 13: Tramstop and TRTS positions at an intersection

- 11 Where a tramstop is so close to the intersection that the TRTS detector would be located with or very close to the stop line detector, then the TRTS detector should replace and also assume the role of the stop line detector.
- 12 If the last detector before a junction is a TRTS detector but the tram can move forward from this detector to the stop line at the junction, means should be provided for a tram phase demand if the driver forgets to use the TRTS feature and moves forward off the detector.

Note: Some of the methods used to deal with detector faults (see paragraphs 26 and 27) may be appropriate.

PEDESTRIAN CROSSINGS

- 13 A pedestrian crossing located at a signalled road intersection should be controlled by the road traffic light controller.
- 14 Where pedestrian crossings cross both the road and the on-street tram track in one continuous crossing, the tram signal aspects shown should be harmonised with the road traffic red and green aspects.

Signalled pedestrian crossings

- 15 A hold detector should always be installed to prevent the tram signal changing to Stop after the tram is within its service braking distance (although the hold detector may be subject to a timeout if the tram is unduly delayed).

ROAD TRAFFIC LIGHT CONTROLLERS

- 16 Communication is required between the road traffic signal controller and any tram detectors. The road traffic signal controller should analyse the information from these tram detectors to determine when to call and cancel the tram phases. Tram route information for the intersection may be supplied directly by the detectors or from a tramway traffic control facility.
- Note:** It may also be necessary to provide an interface unit between the road traffic light controller and the tram detection equipment.
- 17 In situations where points are located more than a maximum tram length downstream of an intersection, information regarding the lie of the points will not be provided to the tram signal, but the proposed route may be indicated in the Proceed aspect. This situation is illustrated in Figure 14.
 - 18 Where the tram turnout lies within a tram length of an intersection, the points should be located on the approach to the intersection to avoid a tram stopping on the intersection awaiting the points being set and a *Proceed* aspect being given. This situation is illustrated in Figure 15.
 - 19 Local point indicators should be provided adjacent to the point ends. Only these indicators, and not the tram signal, should show the lie of the points.

- 20 The routing of trams and the detection and control of point mechanisms should be wholly contained within the tramway control system.

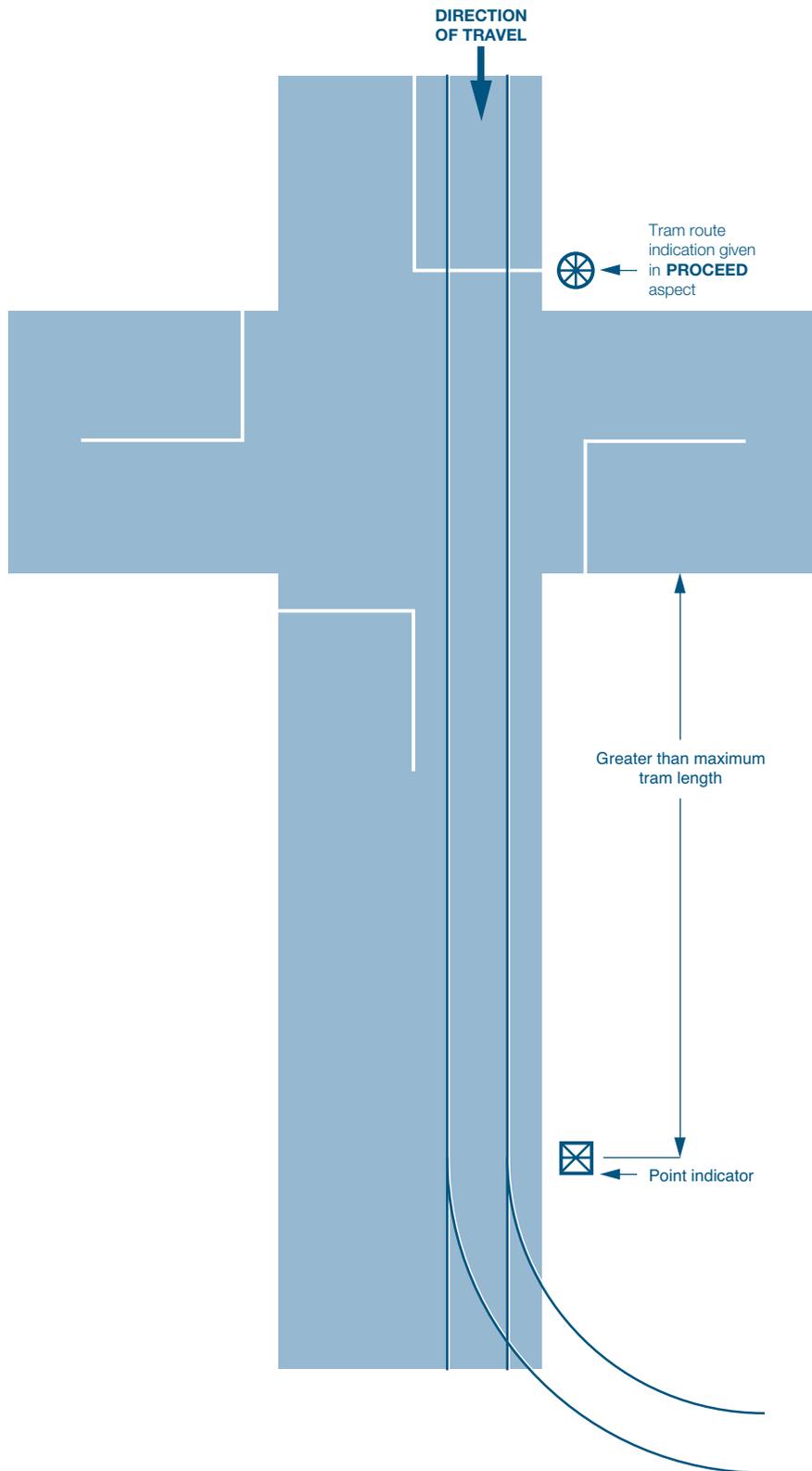


Figure 14: Tram junctions with points after road intersection

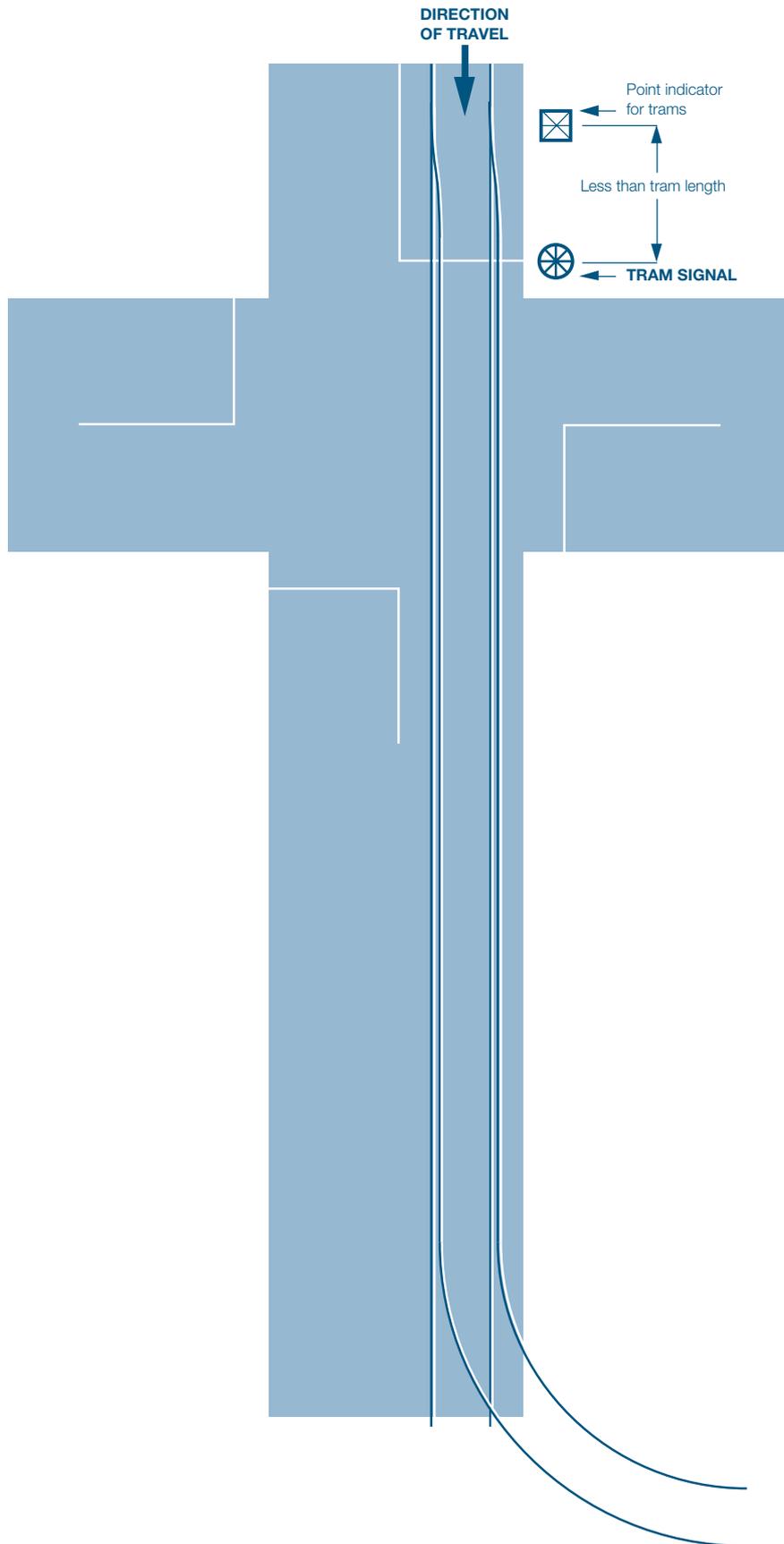


Figure 15: Tram junctions with points before road intersection

URBAN TRAFFIC CONTROL SYSTEMS

- 21 The tram signal system may be interfaced with an urban traffic control system (UTC). The interface will depend on the individual UTC used. However, suitable tram detector arrangements in keeping with those described above are required for all types of UTC.

EQUIPMENT MONITORING

- 22 The road traffic light controller is required to monitor the failure of lamps in the tram signal.
- 23 The road traffic light controller should be designed to monitor tram detectors to ensure they are functioning correctly and do not cause any conflicting aspect to be shown.
- 24 Where tramway systems operate within a UTC area, the road traffic light signals will be monitored regularly; in addition, monitoring of the tram signal lamps is required. To prevent a misleading tram signal aspect being shown in a combined, single-unit array, having individual lamps or clusters of light emitting diodes (LEDs), a minimum of three out of the five lamps or clusters should be lit. Where the aspect is provided by a fibre optic or LED display giving the appearance of a continuous band, the monitoring system should reveal the condition that less than 60% of the band is visible or the light output of the band has fallen below 60% of the normal. In either case, provision should be made for the control room or UTC to be alerted.
- 25 Where tram systems operate outside UTC areas, or in towns and cities without UTC, a monitoring system that complies with the current Department for Transport specifications should be provided.

Note: A change of design of some existing road traffic light controllers may be required.

- 26 The default mode during a detector failure should provide the following facilities unless an agreed equivalent system is installed:
- (a) the failure of an advanced detector should not register a demand for a tram phase;
 - (b) the failure of a stop line detector should register a permanent demand for a tram phase; and
 - (c) the failure of a cancel detector should cause the all-red period to run to the maximum time permitted (sufficient to allow a tram to clear the intersection in accordance with current traffic management practice).
- 27 An alternative means of registering a tram demand is required in the event of failure of a detector, such as a TRTS detector which doubles as a stop line detector. Alternatives may be:
- (a) the creation of a plausible demand (see Note 1);
 - (b) recognition of a stop line detector registering a permanent demand (see Note 2);
 - (c) a key-operated override switch located at the local traffic controller (see Note 3); or
 - (d) remote input from the UTC system (see Note 4).

Note 1: If any detector fails where other detectors are available for inputting plausible demands, they may be used to call up a tram phase.

Note 2: Where a road traffic light controller can recognise that a stop line detector is registering a permanent demand, eg by reference to inputs from other detectors, the demand may be downgraded to a non-priority demand. Where this is not possible, a tram phase should have a maximum time allotted to it, following which it should be shut down and the tram phase thereafter appear automatically at a fixed time within each cycle, either running concurrently with other appropriate phases or separately.

Note 3: A key-operated override switch may be provided to enable a tram input command to a road traffic light controller if any of the tramway equipment upstream of and including the tramway interface unit should fail.

Note 4: A facility for the tramway control room or the local urban traffic control centre to insert a tram demand via the UTC equipment may be used to assist trams which are unable to indicate their presence to the local road traffic signal equipment.

APPROVAL

28 All equipment:

- (a) used to control road traffic on the highway;
- (b) connected to a road traffic light controller; or
- (c) housed with the road traffic light controller;

must be approved by the Department for Transport before being put into service.¹⁶ Further information regarding approval procedures can be obtained from the Traffic Control and Communications Division of the Department.

29 Systems employing radio techniques must be approved by the Secretary of State.¹⁹

APPENDIX C - HERITAGE TRAMWAYS

- 1 This appendix provides guidance on heritage tramways, the use of historic trams on new or existing tramways, and the design and use of replicas of historic trams.
- 2 Some heritage tramways possess works, plant and equipment (including vehicles) which do not meet the terms of the guidance in this document in all respects. Where such works, plant and equipment have been in use over a sustained period, and these disparities have been countered by suitable operating practices and staff training, the guidance should not be taken as suggesting that these arrangements should be disturbed so long as the works, plant and equipment continue to be used with these safeguards.
- 3 The guidance in the main part of this document should be followed whenever it is reasonably practicable to do so. This particularly applies to matters of electrical safety and to clearances between trams and structures.
- 4 In this appendix:
 - (a) open-top tram means a single-deck tram without a roof, or a double-deck tram without a roof over all or part of the upper deck;
 - (b) open-sided tram means a tram having open sides giving direct access to the seats (a 'toastrack' tram or 'combination' tram) or a tram having side windows capable of being stowed to a substantial extent within its body sides or roof (a 'semi-convertible' tram).

TRAMWAY CLEARANCES

- 5 It may not be practicable to establish a precise kinematic envelope for each tram on a heritage system. However, it should be possible to establish a generous tramway path to cover all trams used or likely to be used on the tramway.
- 6 On tramways that operate open-sided trams, the clearances given in Chapter 3 should be increased so that there is at least 830 mm between the DKE and any structure, including poles. This clearance may be reduced when restraining bars are fitted to the sides of such trams.
- 7 On tramways that operate open-top trams, the clearance to the underside of a structure over the tramway from the floor of the open deck should not be less than 2000 mm. This clearance should be increased to the value required by paragraph 11 if there are overhead electrical conductors.

THE INFRASTRUCTURE

Track

- 8 The weight of rail should be appropriate to the maximum axle loading and permitted speed. Section 45 of the Transport and Works Act 1992⁵ enables directions to be given as to the axle loadings and speeds.

- 9 On ballasted track, the ballast should be level with the top of the rail to allow any drop-down lifeguards to function efficiently. This may be unnecessary, with the agreement of the Inspectorate, if the line is fenced or other means of deterring unauthorised access to the track are in place.

Electric traction system

- 10 The minimum wire height above the floor of the upper deck of any open-top tram should not be less than 2750 mm. Where this is not practicable, any special precautions and operating instructions should be agreed with the Inspectorate.

CONTROL OF MOVEMENT

- 11 Indicators to show the lie of any facing points may not be required. If they are not provided, the operating procedures should require each driver to confirm the correct setting of the switch blade or blades before passing over the points.
- 12 A simple form of access control, instead of an interlocked signalling system, may be used on lines with single-line working. The method to be adopted should be agreed with the Inspectorate.

ROLLING STOCK

- 13 A tram may employ horses, internal or external combustion engines, cables, or electricity to provide traction power. Guidance on electric traction power is given in Chapter 8.

Note: Separate guidance is available on steam locomotives.²⁰

- 14 The external lighting requirements for trams given in Chapter 8 may be relaxed. As a minimum, one or more headlamps and a tail lamp should be provided. Where reasonably practicable, trams (other than horse-drawn trams) operating in roads with other types of road traffic should be fitted with brake lights even though they may not have been originally so fitted.
- 15 The braking performance of heritage trams may be less than that given in the guidance in Chapter 8, providing the speed of operation and the operating rules of the system are appropriate to the actual braking performance.
- 16 The guidance on brakes, lifeguards and lighting may not be appropriate to horse-drawn trams.
- 17 Drop-down lifeguard trays actuated by movable gates at the end and sides of the leading end of a tram may be used instead of a fixed lifeguard.
- 18 Coupled trams should have compatible buffing and drawgear, and braking systems. They should have comparable end-loading strengths.

- 19 This guidance may be set aside if it becomes necessary to recover a failed vehicle in non-passenger service.
- 20 Heritage trams are not required to comply with the guidance in Chapter 8 governing fire-safety, except that suitable fire extinguishers should be carried.

Open-top trams

- 21 On open-top trams, adequate clearance should be provided between the upper deck floor or any place where a person could reasonably be expected to stand, and any exposed live electrical equipment. This clearance and other arrangements made to protect against risks from an overhead power supply conductor, and any special operating instructions, should be agreed with the Inspectorate.
- 22 On open-top trams, adequate safeguards should be in place to minimise the risk of people being struck by the overhead power supply collector of any such vehicle as a result of the dewirement or rotation of the collector or of any part of it becoming detached.
- 23 Edge protection commensurate with the height above ground should be built into the tram to protect against falls. The height of the top rail on the sides and ends of an open-top tram should be agreed with the Inspectorate.

APPENDIX D - NON-PASSENGER-CARRYING VEHICLES USED ON TRAMWAYS

- 1 Non-passenger-carrying vehicles should follow the design principles detailed in this guidance where practicable or appropriate. However, where such vehicles are infrequently used or unpowered or are self-propelled works vehicles, some features may be difficult to achieve or may be considered unnecessary. The Inspectorate should be consulted if some relaxation is proposed.
- 2 Vehicles used for tramway maintenance may be exempt from some of the operational provisions for passenger-carrying trams. The degree of exemption will depend on:
 - (a) the type of tramway system;
 - (b) when the vehicles are used, ie in or out of service hours; and
 - (c) whether the vehicles are self-propelled or not.
- 3 Works trams and other similar vehicles should follow (unless specifically excluded below) the guidance given in Chapter 8 for:
 - (a) underframe and body;
 - (b) driver's cab;
 - (c) mirrors;
 - (d) external lights and audible warning devices; and
 - (e) braking performance.
- 4 Works vehicles are not required to follow the guidance for couplers, which may be non-folding and need not be fitted with fenders or protective covers. Additional operational control measures may be required to minimise risk to pedestrians and other vehicles.
- 5 Unpowered works vehicles are not required to follow the guidance for:
 - (a) underrun protection;
 - (b) skirts; and
 - (c) lighting and audible warnings; but
 - (d) must carry side marker lights.
- 6 Unpowered works vehicles used at the extreme leading end of a works train should carry the appropriate forward lighting and be equipped with a position from which a member of the staff can safely operate the emergency brakes and an audible warning device. Vehicles at the rear of a train should carry the appropriate rear lights. End outline marker lights are not required unless the top of the vehicle body is more than 2500 mm above rail level.
- 7 Powered non-passenger-carrying vehicles used exclusively within possessions may not need to comply with the lighting requirements described in Chapter 8.

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