7 TRAMWAYS

7.1. INTEGRATING THE TRAMWAY

Principle 7.1 Integrating the tramway

Tramways should be integrated into the roads environment so as to minimise any risks to other people as well as to users of the tramway.

7.1.1. General guidance

7.1.1.1. Where the tramway is shared with other people in the built environment, its design and construction should allow it to be used by those other people.

7.1.1.2. Where the tramway is in the built environment, crosses it, or is otherwise close to it, provisions to promote compatibility between trams and other built environment users should be incorporated into the built environment design.

7.1.1.3. The operating arrangements for normal conditions and for emergency situations should be clearly defined for the type of route and physical environment in which trams are operating. These should include appropriate audible and visible warnings, and evacuation and control procedures in case of emergencies. Provisions should be made during any road or tramway maintenance operations for the safe movement of pedestrians and other road users.

7.1.1.4. 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.

7.1.1.5. Particular attention should be paid to the design of road junctions, and locations where the form of tramway alignment changes (e.g. from side to central reservation, or from integrated to segregated on-street tramway). 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.

7.1.2. Alignment considerations

7.1.2.1. The alignment of the tramway should take into consideration:

a) the road layout, e.g. intersections, roundabouts etc;

b) pedestrian footways and crossings;

c) cyclists and cycle tracks;

d) the needs of frontagers;

e) public utilities;

f) clearances on the roadway (see Section 7.2);

g) the permitted minimum radii of curvature and the engineering constraints for the tramway;

h) the location and needs of tramstops (see Section 7.4);

i) the location of overhead electric traction equipment and other fixed structures (see Section 7.5).

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

7.1.2.3. The tramway should be developed in conjunction with suitable traffic management measures. 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 which arise.

7.1.3. Roadway intersections

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

7.1.4. On-street tramway intersections with the road

7.1.4.1. At-grade intersections on on-street tramways should be regarded as roadway junctions rather than railway level crossings. The arrangements for controlling the tramway and other road traffic at an intersection should be co-ordinated. The degree of signing or signalling will depend on the needs of other road users as much as upon those of the tramway.

7.1.4.2. 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. The signing and traffic signalling should reflect the priority given to the tramway at the junction.

7.1.4.3. Physical level crossing barriers are not considered to be appropriate for on-street tramways.

7.1.4.4. The maximum permitted approach speed of trams to intersections may have to be limited to enable them to negotiate the junction safely. The approach speed to an intersection should enable a tram to stop safely if the intersection is obstructed.

7.1.4.5. The place from which the intersection first comes clearly into view and then remains in view for the driver of the tram should be identified so that the available braking distance can be established. It is helpful if the view of the intersection includes the ‘Stop’ or ‘Yield’ positions on the other approaches. This aids judgement as to the likely movements of other vehicles.

7.1.4.6. The permitted maximum speed should be based on the above distance and normal service braking rates.

7.1.4.7. Road markings should be provided to indicate the swept path over the intersection. ‘Stop’ or ‘Yield’ road markings should be positioned outside the swept path allowing for a tolerance in stopping of the road vehicle.

7.1.4.8. 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.

7.1.4.9. 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 ‘Yield’ 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 road layout or traffic management measures should be considered. Similarly if traffic on the side road could back up across the tramway while waiting to join the main road, revisions to the road layout or traffic management measures should be considered.

7.1.4.10. The road traffic light signals and signs required for the protection of at-grade crossings on tramways are prescribed in the current regulations. Such signals should be controlled by a type of signal controller configured to provide the necessary tram phases and agreed with the Road Authority. The detailed arrangements should be agreed with the Road Authority.

7.1.4.11. Road junctions and intersections with on-street tramways should be treated in a way similar to a normal road layout.

7.1.4.12. Signs giving warning of the presence of trams should be provided and details of these are in the Traffic Signs Manual or authorisations made by the Minister for the Environment and Local Government.

7.1.4.13. Where road traffic light signals are provided, the tram should have a level of priority agreed with the Road Authority.

7.1.5. Off-street tramway intersections with the road

7.1.5.1. 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. The signing and traffic signalling should reflect the actual priority given to the tramway at the intersection.

7.1.5.2. Intersections on off-street tramways may be treated as level crossings if that is more appropriate (see Section 5 Level crossings).

7.1.5.3. 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 7.6. Signals should also be provided where a turning road vehicle may momentarily encroach on an adjacent or oncoming tram lane.

7.1.5.4. 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 'Yield' signs in conjunction with tram warning signs, and speed restriction signs if necessary, should be provided on the road approaches to the tramway for road traffic in accordance with relevant regulations. Visibility from the minor road carrying the road traffic should comply with the appropriate advice of the Department of Transport (DoT).

7.1.6. Pedestrian footways and crossings

7.1.6.1. 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.

7.1.6.2. 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.

7.1.6.3. Crossing points on a tramway should be co-ordinated with the crossing points of any shared or adjacent carriageways.

7.1.6.4. On off-street tramways it should be possible to separate entirely the arrangements for any road and for the tramway, but if not, the requirements for pedestrian crossings of on-street tramways will apply.

7.1.6.5. All designated crossings of tram tracks should be designed with the needs of mobility and visually impaired people in mind.

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

7.1.6.7. 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.

7.1.6.8. Where signals are provided at pedestrian crossings over tram tracks they should be one of the types described in section 7.1.8 or 7.1.9

7.1.7. Crossing layouts

7.1.7.1. Where practicable, the part of the crossing over the tram track should not be in line with the other separately signalled pedestrian crossing or separate zebra crossings.

7.1.7.2. 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 the flashing pedestrian warning lights.

7.1.7.3. Part or all of such pedestrian crossings may be unsignalled if the circumstances at the site allow. 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 road traffic, dictate that the road crossing has a pelican. At other places it may be necessary to provide pedestrian signals across the tramway but a zebra is sufficient across

the road.

7.1.8. Pedestrian crossings linked with tramway signals

7.1.8.1. Where the crossing of the tramway cannot be separated in any way from the crossing of the remainder of the road, 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 at a pelican crossing.

7.1.8.2. If the crossings are staggered and it is appropriate, audible equipment may be suitable subject to the approval of the Road Authority.

7.1.9. Pedestrian crossings with signals linked to approaching trams

7.1.9.1. Where the tramway crossing can be separated from the remainder of the road crossing by the provision of refuges, or where the pedestrian crossing movement is parallel to the road over tram tracks only, i.e. 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 have three elements:

a) *visual*. Pedestrian signals consisting of twin vertically disposed amber flashing lights, above a plate reading 'Tramway - Look both ways' (or right or left as appropriate) as prescribed in the relevant authorisations made by the Minister for the Environment and Local Government; and

b) *audible*. The sound of this warning should be quite 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.

7.1.9.2. 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 will be required at the appropriate tram braking distance before reaching the school-crossing patrol point.

7.1.9.3. Tram drivers should be warned that they are approaching a pedestrian footway crossing.

7.1.9.4. Where there is insufficient visibility of an approaching tram, a prescribed 'sound warning' sign for tram drivers should be provided.

7.1.10. Cycle tracks

7.1.10.1. Where tram tracks are on the side of the carriageway rather than the centre, particular provision should be made where practicable for cyclists. This can be done either by placing a separate cycle track adjacent to the footway or by providing a one-way cycle track within the carriageway. Roadside platforms are, therefore, not readily compatible with nearside cycle tracks on the roadway. Provision should be in accordance with relevant standards subject to the approval of the Railway Safety Commission (RSC).

7.1.10.2. One-way cycle tracks should be clearly marked and signed as such; vehicle parking and loading prohibitions will be required. Wider cycle tracks within the carriageway to permit two-way cycling should not be provided unless they are physically separated from the tramway and satisfy Road Authority requirements.

7.1.10.3. To avoid the risks from unauthorised parking of vehicles fouling the developed kinematic envelope, the width of the cycle track (between the kerb and the furthest edge of the road marking line) should not be greater than 1500mm and the edge of the road marking line nearest to the tram track should be at least 200mm from the developed kinematic envelope (see Figure 1).

7.1.10.4. Where it is necessary for cycle tracks to cross tram tracks, these intersections should be as far as possible at right angles to the tram tracks.

7.1.11. Frontagers

7.1.11.1. The needs of premises fronting the tramway, including access, should be carefully assessed. It may be necessary to provide dedicated loading/unloading and parking bays to avoid the tram track becoming obstructed by vehicles. Obstructing a tram track can normally be made an offence under the powers authorising the construction and operation of the tramway or relevant by-laws, ref. S66 Transport (Railway Infrastructure) Act 2001 .

7.1.11.2. Where the tramway crosses accesses to premises, it should not normally be necessary to erect warning signs within each access. However, if the place concerned is likely to attract drivers unfamiliar with the area (e.g. a factory), warning signs should be provided. Road traffic light signals may be necessary at busy locations.

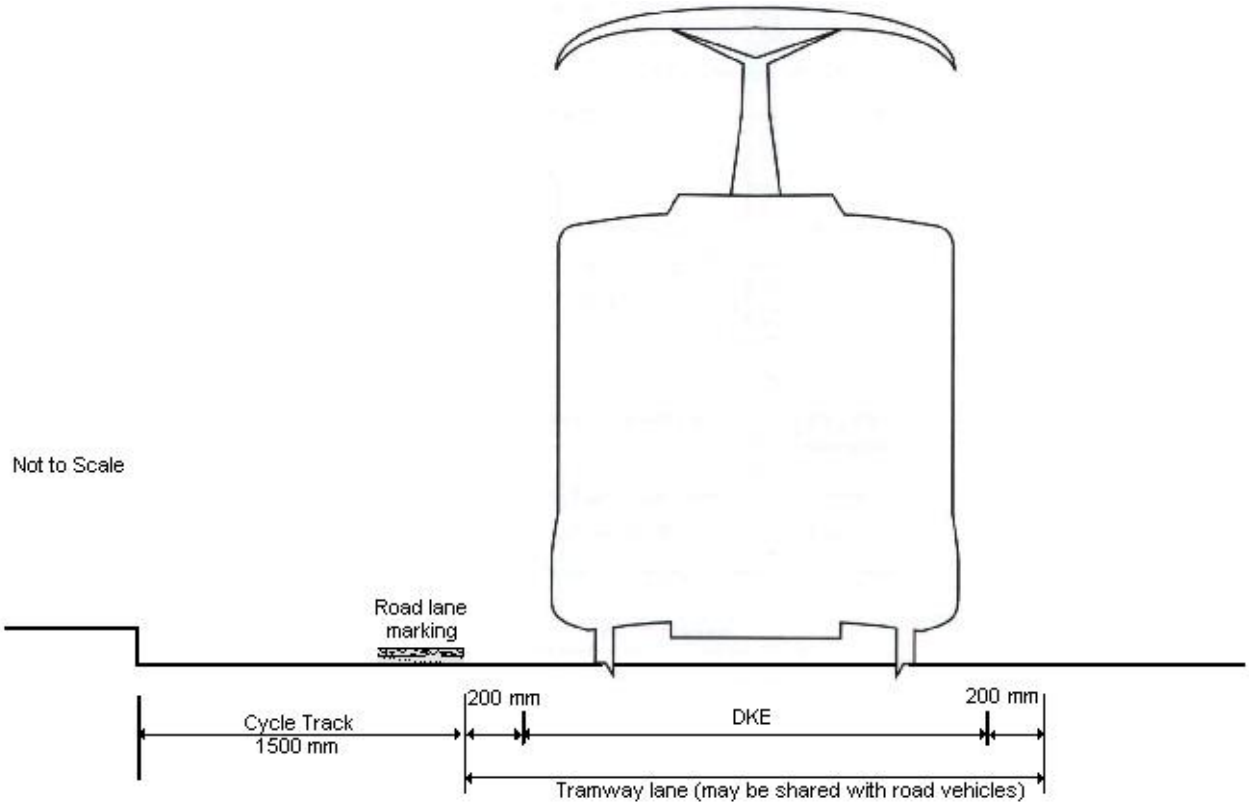

Figure 1: Cycle track adjacent to tramway

7.1.12. Public utilities

7.1.12.1. Where the route of any public utility or other service has not been removed from the swept path, any manholes provided should, where possible, be outside the swept path. Where they unavoidably have to cross the track, they should be ducted or sleeved before the tracks are laid to facilitate maintenance or renewal.

7.1.12.2. Access to any chamber or duct within the swept path will be subject to an approved safe system of work.

7.1.13. Changes between segregated and integrated on-street tramways and off-street tramways

7.1.13.1. 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 relevant regulations.

7.1.13.2. Access by traffic other than trams to the off-street or segregated on-street sections of tramways should be barred by appropriate traffic signs.

7.1.13.3. Suitable treatment of the roadway surface leading to a wholly segregated section of track, e.g. ballasted track, raised rough stonework or isolated cobbles set into the surface, would help to encourage compliance with the signs.

7.1.14. Tramway path

7.1.14.1. The swept path of an on-street tramway should be marked where it is not apparent from the carriageway or kerbs. Such definition may be achieved by the use of carriageway markings, colour, texture or differences in levels to enhance differentiation.

7.1.14.2. The widest swept path of any tram on the system should be used.

7.1.14.3. Where two tracks are converging or parallel to each other, they should be enclosed within a

single pair of markings unless they are sufficiently far apart to allow a pedestrian refuge between them.

7.1.14.4. Swept path markings should be continued through any yellow box markings at junctions.

7.1.14.5. Where the tramway alignment varies from that of other traffic (e.g. at junctions) and conventional carriageway markings could cause confusion to other road users, suitably sized yellow markings may be used at 1500mm centres to delineate the swept path.

7.1.14.6. The reserved track used for segregated on-street tramways, which may be made available to other vehicles in traffic emergencies, should be clearly defined both at the start and along its length, by lane lines and traffic signs. Other vehicles should also be discouraged by the use of a hostile texture or change of level.

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

7.1.14.8. 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 isolated lineside structures.

7.1.15. Pedestrian zones

7.1.15.1. To help visually impaired people, the preferred method of marking the swept path in pedestrian zones is for it to have a different tactile surface (such as an exposed aggregate finish) to that of the surrounding area and for there to be a suitable colour contrast between surfaces. Tripping hazards within the swept path should be avoided.

7.1.15.2. Crossing points should be marked with appropriate tactile surfaces.

7.1.16. Pedestrian protection arrangements

7.1.16.1. Pedestrian guard rails may be used to direct pedestrians to safe crossing points. These guard rails should be appropriately set back (see sections 7.2.4 and 7.2.5.5).

7.1.16.2. 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. If the boundary of an off-street tramway is not fenced, it should be marked in some other way.

7.1.16.3. Appropriate forms of deterrent paving may be used to discourage both pedestrian and vehicular access.

7.1.16.4. Suitable low-growing, ground-cover shrubs may be used at the track-side to deter pedestrian trespass. The shrubs may be planted in containers which are fixed or not easily removable. The total height of shrubs and any container should not exceed 600mm so as to avoid places of concealment for children. The shrubs and containers should be set back at least 300mm and preferably 600mm from the swept-path.

7.2. CLEARANCES

Principle 7.2 Clearances

The operating environment of trams among other traffic and pedestrians requires clearance rules that are particular to this mode of operation.

7.2.1. General guidance

7.2.1.1. Lateral clearances adequate to allow trams to pass one another on adjacent tracks or between trams and other road vehicles on adjacent carriageways should be provided. Additional clearances between trams and fixed structures should be provided to allow for the presence of people. It should be noted that 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 the tram can be less than the clearance at ground level.

7.2.1.2. These clearances should be developed from the kinematic envelope for the trams and take into account additional allowances for pedestrians and road vehicles. Section 7.5 contains guidance relating the electrical clearances.

7.2.2. Definition of kinematic envelope

7.2.2.1. The definition of the kinematic envelope is based upon the static vehicle profile and the dynamic vehicle profile.

7.2.2.2. The *static vehicle profile* is that formed by the maximum permitted cross-sectional dimensions of trams 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 of tram loading on the suspension.

7.2.2.3. The *dynamic vehicle profile* is the static vehicle profile enlarged to allow for the maximum possible displacement of the tram at rest or 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 vehicle profile.

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

7.2.2.5. 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, and the extended position of any coupler. The kinematic envelope is speed dependent.

7.2.2.6. 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.

7.2.2.7. A *developed kinematic envelope (DKE)* is the maximum width under any circumstances of a tram in motion at a particular point.

7.2.2.8. A developed kinematic envelope 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 also is speed dependent, but is unique to the particular location at a given speed. This may be used to advantage where clearances are tight or need to be restricted, e.g. at tramstops.

7.2.2.9. The *swept path* of a tram is the area reserved for a moving tram which includes an allowance for pedestrian or road vehicle safety. The boundaries of the swept path are the closest it is safe to approach a moving tram. The extent of the swept path beyond the DKE should be determined on a location specific basis taking in to account the clearance requirements and physical features of the route

7.2.3. Clearances between trams

7.2.3.1. The clearances between two adjacent developed kinematic envelopes should be not less than:

a)	without centre traction poles;	200mm
b)	with centre traction poles;	600mm*
c)	with centre fence	1200mm

* but at least 200mm from the face of either side of pole to each DKE (see Figure 5)

7.2.4. Clearances between trams and roadway features or structures

7.2.4.1. The clearances between a developed kinematic envelope and other roadway features or fixed structures should be as follows:

	Roadway feature/structure	Clearance
a)	the edge of a traffic lane	200mm
b)	traction pole in the centre of the carriageway or on a side reservation (see Figure 8)	200mm
c)	kerb	300mm
d)	fence in the centre of the carriageway or on a side reservation (see Figure 6)	600mm

7.2.4.2. The clearances described in section 7.2.4.1 are minimum clearances and, where circumstances permit, greater clearances should be considered. Adequate clearances should be maintained between the swept path and any structure or pole, taking account of any possible pedestrian movement. These minimum clearances are illustrated in Figure 2 and Figure 3.

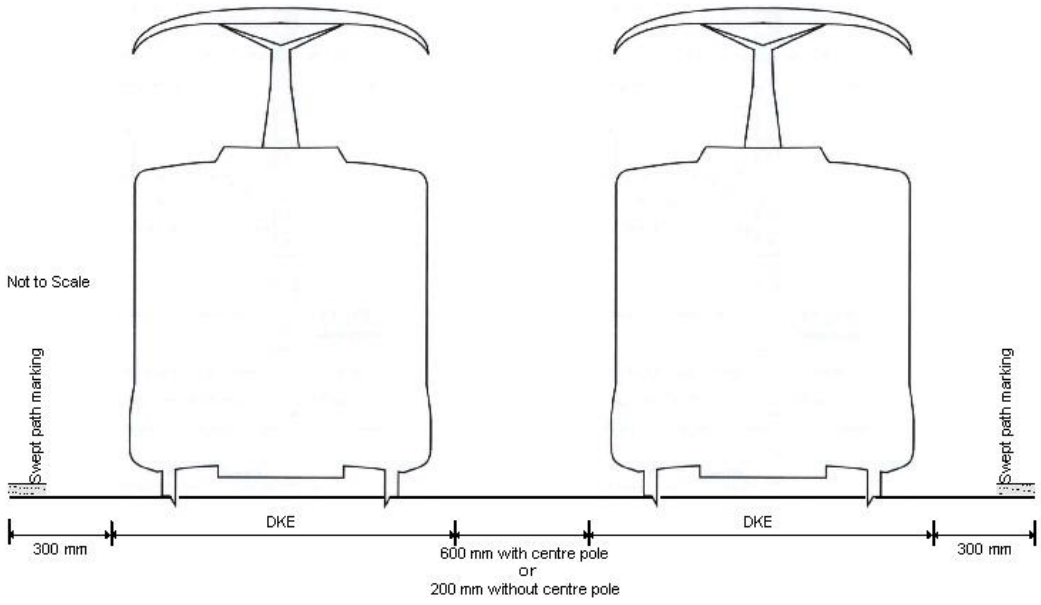

Figure 2: Minimum clearances in a pedestrian precinct

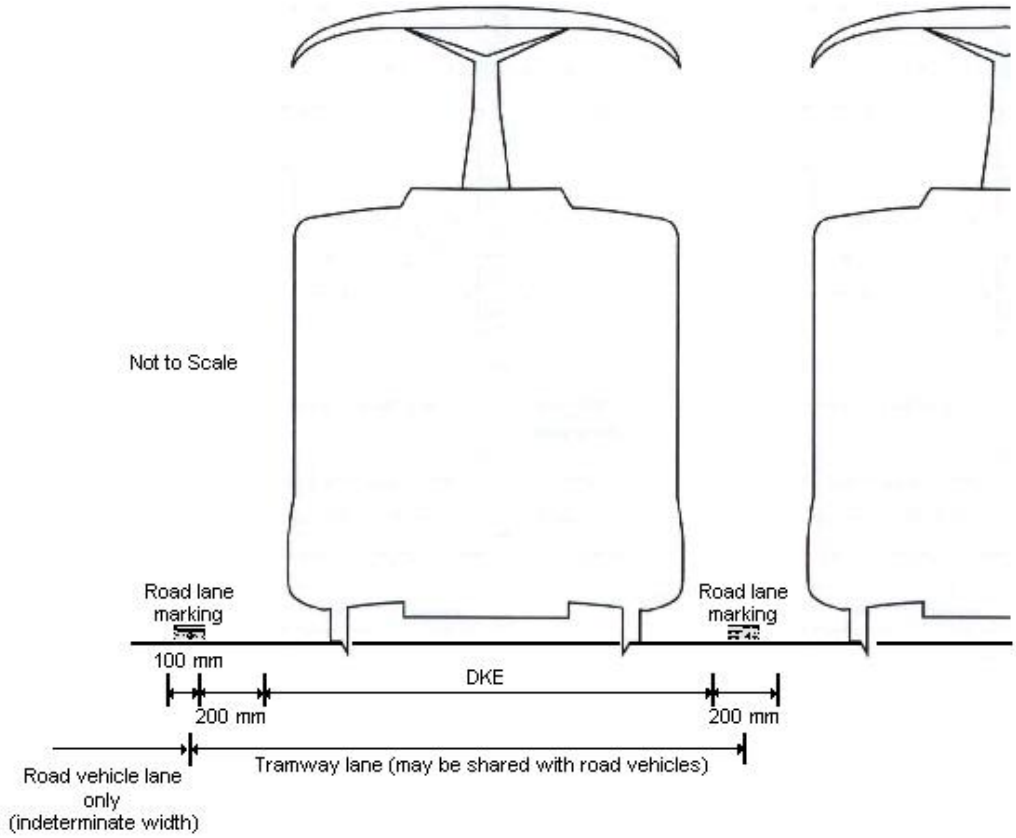

Figure 3: Minimum clearances in a carriageway with shared lanes

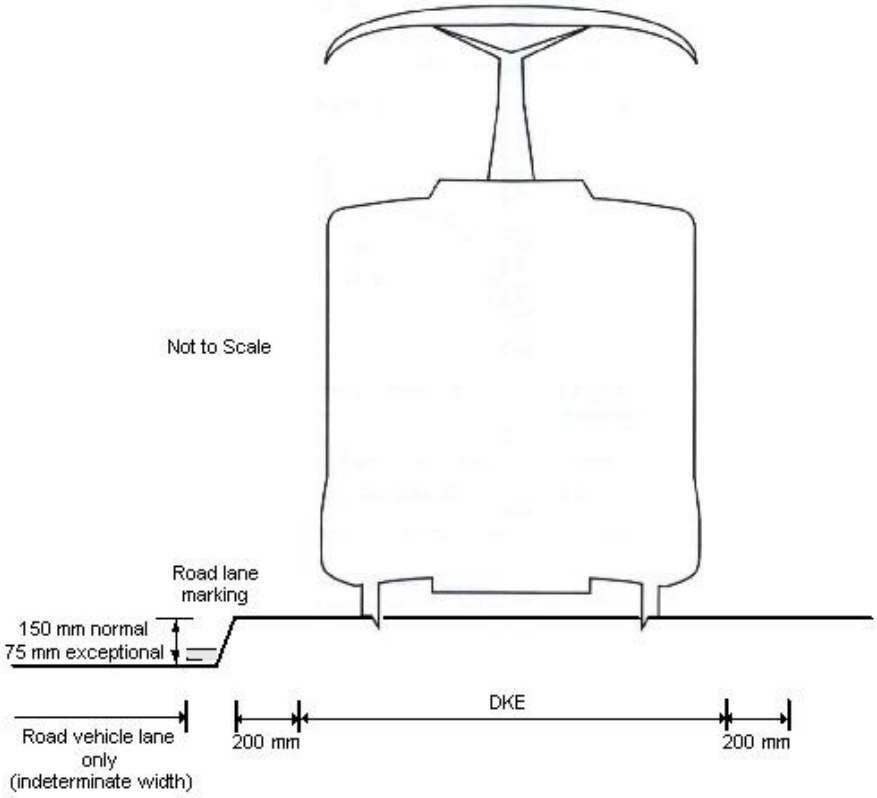

Figure 4: Minimum clearances on a reserved part of carriageway in centre of carriageway

7.2.4.3. When the tram runs along a reserved centre part of the carriageway the surface of the tram lane should be raised above the adjacent road vehicle lane. The road lane marking as in Figure 4 should be at the foot or road traffic side of the longitudinal sloped (and textured) surface and the edge of the line furthest from the developed kinematic envelope should be at least 300mm outside the developed kinematic envelope. The top of the slope should be outside the developed kinematic envelope.

7.2.4.4. The tram lane in Figure 4 should be nominally 150mm 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 accesses 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 (75mm) may be used by agreement with the Road Authority and the RSC.

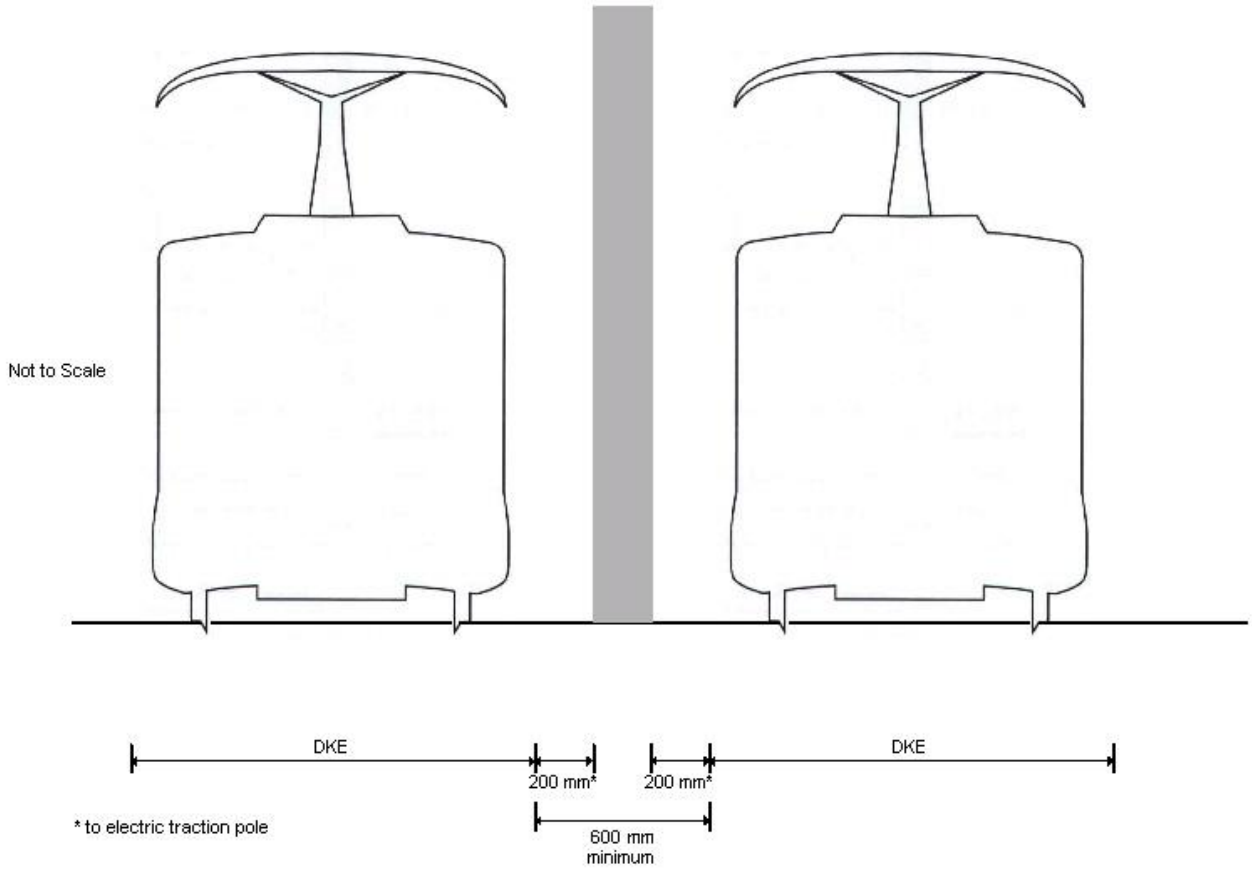

Figure 5: Minimum clearances between trams and electric traction pole

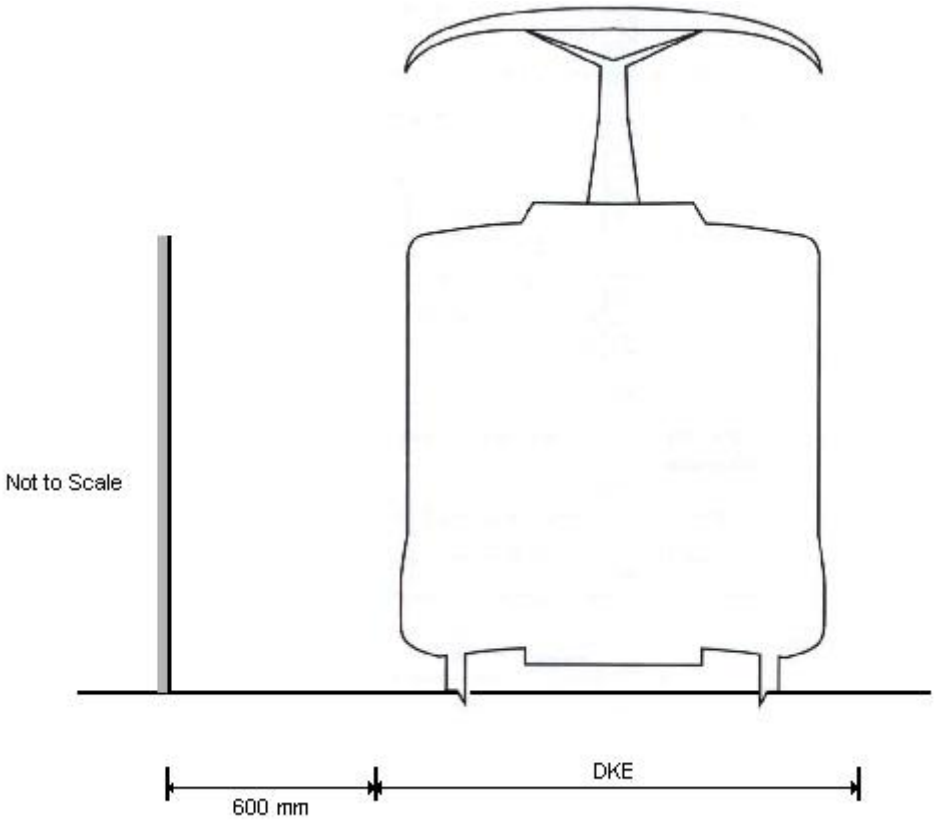

Figure 6: Minimum clearances between a tram and a side fence

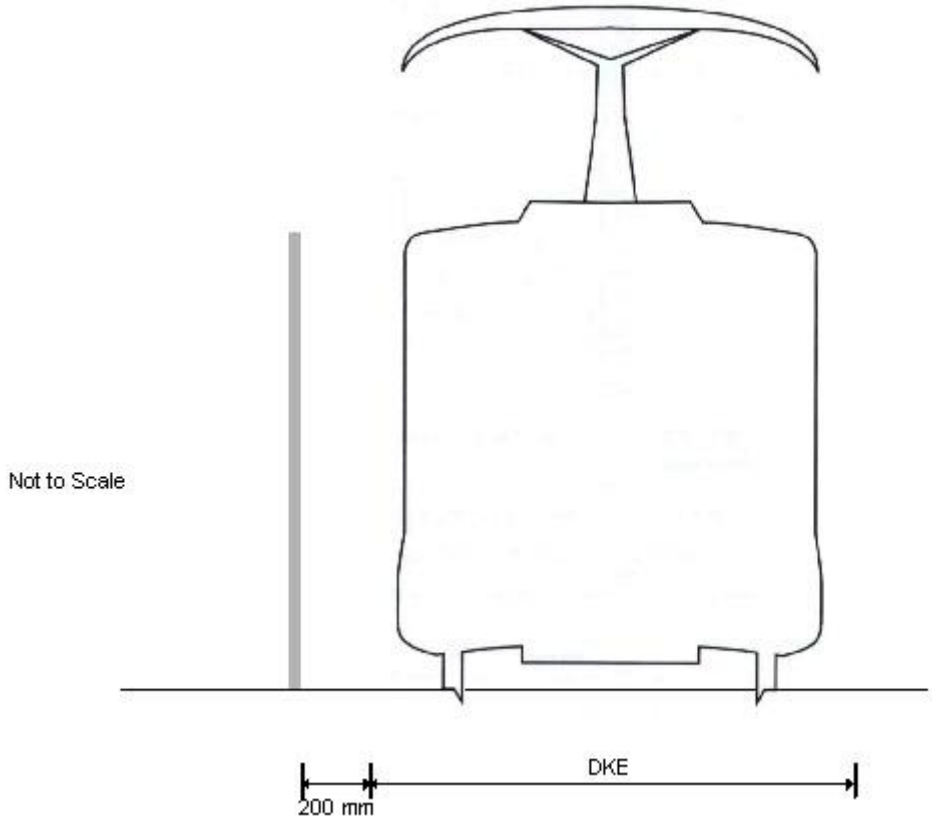

Figure 7: Minimum clearances between a tram and side electric traction pole

7.2.5. Clearances on roadways

7.2.5.1. Lanes used by both trams and laden goods vehicles (LGVs) or passenger-carrying vehicles (PCVs) should be at least 3530mm wide for a single-lane carriageway and preferably 3650mm but not less than 3300mm wide for a two-lane carriageway. Exceptionally a lane adjacent to that used by trams may be reduced in width to 3250mm. Lane widths which are shared between trams and other road vehicles will probably be dictated by the needs of the latter.

7.2.5.2. Proposals for lanes narrower than the above should be agreed with the Road Authority after discussion with the RSC, but it should be borne in mind that the loaded road vehicles up to 2900mm wide are permitted, and mirrors can extend beyond this.

7.2.5.3. The widths of the lanes used by trams are based on a tram having an overall static width of 2650mm. Where narrower trams are used, the recommended lane widths for sole use by trams may be reduced accordingly.

7.2.5.4. Where a tramway is physically separated from other road users, the separation between the tramway and road lanes should be the greater of the tramway and road clearance requirements.

7.2.5.5. Where the edge of a swept path is indicated by a raised kerb, street furniture (such as pedestrian guard rails, posts for road traffic signs or light signals, or traction power supply poles) should be at least 450mm back from the face of the kerb (see Figure 8). Where the footway is less than 2000mm wide and there is no traffic other than trams using the road the distance from the street furniture to the edge of the kerb may be reduced to 200mm.

7.2.5.6. Where a cycle track is to be incorporated into the carriageway alongside the tramway the guidance in section 7.1.10 should be taken into consideration.

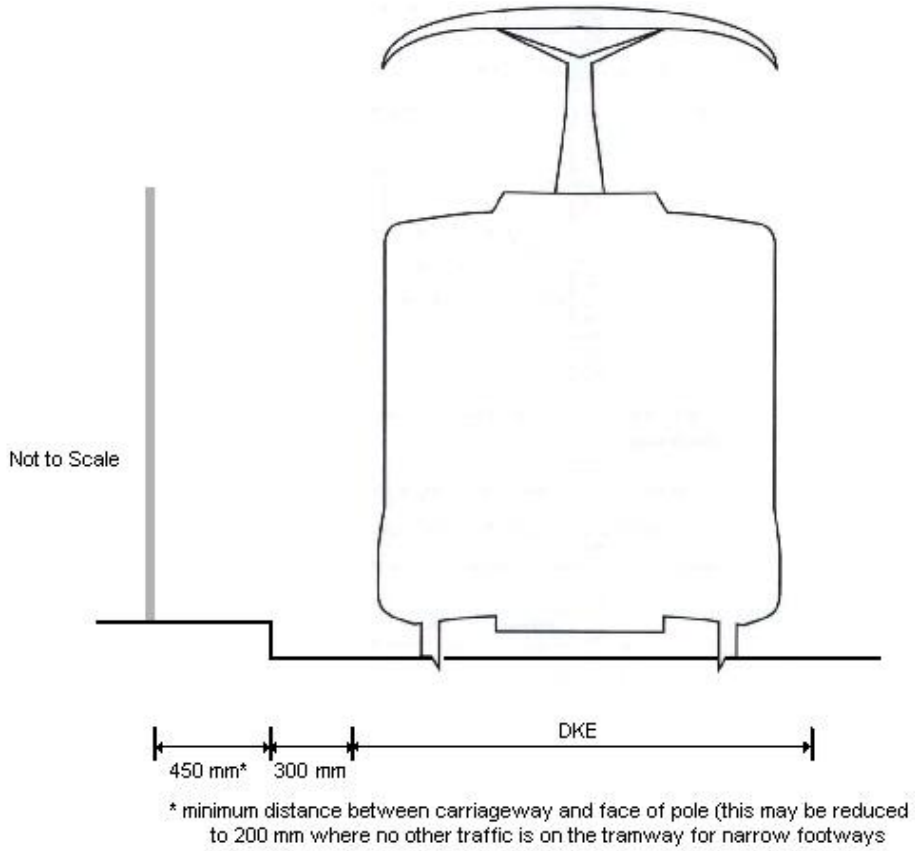

Figure 8: Minimum clearances between a tram and side electric traction pole on a footway

7.3. CIVIL ENGINEERING WORKS (TRACK, BRIDGES AND STRUCTURES, ACCESS CONTROL)

Principle 7.3 Civil engineering works (track, bridges and structures, access control)

Embedded on-street track should minimise risks to other road users. Structures may need special measures to prevent any new risks from tram operations. Careful design should facilitate authorised access to trams and across the tracks, whilst deterring risk-taking.

7.3.1. Running rails

7.3.1.1. The following guidance applies to all rail track laid in the carriageway or in pedestrian areas. For tram tracks which are ballasted, see the relevant guidance in section 1 Permanent way, earthworks and structures. Due to the different wheel profile used for trams the guidance relating to check rails in section 1 may not be appropriate.

7.3.1.2. Steel running rails should conform to the appropriate European Standard or an equivalent standard acceptable to the RSC. The rail profile should be carefully selected in relation to the tyre profile of the trams. Particular attention should be paid to this aspect where both plain and grooved rail sections are used on the same tramway and/or interrunning with heavy rail vehicles is intended.

7.3.1.3. 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 in particular cyclists, motorcyclists, wheelchair users and pedestrians pushing prams. Where such rails are laid 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. It will be particularly important to minimize level differences across the joints. When first laid, the head of the rail should not be higher than the adjacent road surface.

7.3.1.4. Grooved rails should have suitable drainage slots provided at appropriate intervals and connected, when laid in the street, to surface water drainage systems. Temporary earthing clamps may need to be fitted to grooved rails and provision for this may be necessary.

7.3.1.5. Where rails are laid in a carriageway that is used by rubber-tyred vehicles travelling in a direction along or parallel to 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. Consideration should also be given to aligning the track within the carriageway width so that it does not coincide with the path normally taken by the wheels of rubber-tyred vehicles. Flexible filling may also have significantly less skid resistance than the adjacent road surface and may require particular surface treatment to enhance its natural properties. Additional warnings of the risk of skidding may need to be given to motorists. Rubber tyred vehicles may skid when accelerating as well as braking or cornering.

7.3.1.6. The tramway track should be engineered to present a uniform road surface which:

a) can support the normal loads of vehicles using the road;

b) has differences in level that are kept within road construction tolerances for overbanding of surfaces; and

c) has a seal between the rail and adjacent road surface to minimise the ingress of water where this could cause damage to the road surface.

7.3.1.7. The design of the base and the sub-base should be able to accommodate the protection system for guarding against the leakage of return currents to earth. One form of protection is a half Faraday-cage bonded to an additional return conductor. Ducts for the bonds and for the conductor may be required and both may need to be accessible for inspection.

7.3.2. Track geometry

7.3.2.1. The minimum radius of curvature and the maximum gradient of a tramway 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.

7.3.2.2. Where other circumstances permit, the cross-section of the road should accommodate any

superelevation on curved tram track.

7.3.2.3. Other matters should be considered, such as whether drainage of surface water can be directed away from the grooves in the rails by providing a cross-fall, or whether the surface between the rails (the four-foot) has to be cambered.

7.3.2.4. Provision should be made for drainage of any surface water and for the clearance of any detritus which may collect in the grooves.

7.3.3. Tram track points in the roadway

7.3.3.1. Points should not be located where the movement of the blades would cause a hazard to other road users. 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 formally identified crossings;

b) where there would be a particular danger to wheelchair users or pedestrians with prams;

c) where there would be a particular danger to cyclists or motor-cyclists; or

d) in busy traffic or where traffic lanes carrying laden goods vehicles or passenger-carrying vehicles cross or merge with a tram lane, in particular where this is also aggravated by a turning movement. The reason for this restriction is primarily to reduce delays to other road traffic caused by damage to the point mechanisms from turning rubber tyred vehicles. Pre-sorting or other techniques may be used where practicable to achieve these objectives.

7.3.3.2. Where the locating of points at the places in section 7.3.3.1 is unavoidable, special precautions may be necessary to minimise the risk (see section 7.6).

7.3.3.3. The switch blades, or their equivalent, of any points used in the facing direction should be positively locked in position during the passage of a tram. Mechanisms which 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.

7.3.3.4. Where spring force or hydraulic pressure is used, 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 locked in position.

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

7.3.3.6. Where the points are some distance beyond a signalled road junction, the arrangements should be such that if the incorrect route is set, or the point blades are misaligned, a tram standing at them should not obstruct the junction. These arrangements are shown in section 7.6.19.4.

7.3.4. Bridges

7.3.4.1. The safety principles and guidance given in section 1 Permanent way, earthworks and structures should be applied so far as they are appropriate to the design and construction of all bridges and structures carrying a tramway.

7.3.5. Bridges carrying the tramway

7.3.5.1. Adequate derailment containment should be provided on all bridges and structures and elsewhere where the consequences of derailment would result in a significant hazard.

7.3.5.2. As an alternative to the derailment containment measures given in section 1 Permanent Way, Earthworks and Structures, 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.

7.3.5.3. It is recognised that existing bridges over roadways may not meet the requirements for new bridges. As long as the aspects specifically mentioned in the above section are satisfactorily addressed, other modifications to bring the bridge into full conformity with the provisions of section 1 might not be essential.

7.3.6. Bridges over the tramway

7.3.6.1. Bridge parapets should deny access to the live overhead electrical traction power system in accordance with the guidance provided in section 1

7.3.6.2. Bridges and supporting structures within 5220mm of the centre-line of a tram track should be designed to withstand the nominal impact forces. Existing structures which do not meet this requirement should be modified or should be protected by cutwaters or other deflecting barriers.

7.3.7. Nominal Impact forces

7.3.7.1. In assessing the protection required, the nominal impact forces used should be based on the weight and structural strength of the tram. For example, for a tram with a tare weight of 35 tonnes and a coupler rated at 300 kiloNewtons (kN), the following impact forces would be appropriate:

a) A nominal force of 500 kN acting horizontally at a level of up to 1000mm above the adjacent ground level in any direction, unless it can be demonstrated that the structure concerned is vulnerable only from certain directions.

b) In addition a nominal force of 100 kN acting horizontally and coincidentally with the force at a) above at a level anywhere between 1000mm and 3500mm above the adjacent ground level in any direction.

7.3.8. Tunnels

7.3.8.1. The safety principles and guidance on tunnels should follow, as far as is appropriate, that given in section 1 Permanent way, earthworks and structures

7.3.8.2. Double-track tunnels may be acceptable. New tunnels should be designed so that walkways outside the swept path are available. If the walkway forms part of the road as a normal footway it should meet current roadway design standards.

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

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

a) the trams have doors on both sides;

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.

e) there is reasonable stepping distance from the tram to the track

7.3.9. Access control

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

7.3.9.2. 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 section 7.5).

7.3.9.3. 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 road users, and make appropriate provisions for their safety.

7.3.9.4. While the tramway is normally unfenced, some fencing may be necessary to segregate or direct pedestrians away from it at particular locations such as where there are large flows of children or emergency evacuation points from buildings close to the tramway .

7.3.9.5. At some locations it may be necessary to provide pedestrian deterrent measures such as signing and paving treatment to ensure people do not walk in certain areas for reasons such as inadequate clearance to the swept path for envisaged pedestrian flows.

7.3.9.6. Special consideration should be given to the needs of mobility impaired people whether on foot

or in wheelchairs or with pushchairs.

7.3.9.7. Deterrents should be provided to discourage trespass by both pedestrians and road vehicles where an on-street tramway changes to off-street track. See section 7.1.13.

7.3.10. Identification of the infrastructure

7.3.10.1. A means of establishing one's location along the tramway should be provided, for example, by numbering the structures supporting the overhead electric power supply. All bridges and other fixed structures, as appropriate, should be uniquely and conspicuously identified.

7.4. TRAMSTOPS

Principle 7.4 TRAMSTOPS

Tramstops should be designed for safety of access and safe waiting, boarding and alighting conditions for all passengers, including those of impaired mobility.

7.4.1. General guidance

7.4.1.1. The term ‘tramstop’ includes stops with a raised platform above pavement level and those with platforms at pavement level. Tramstops are different to bus stops.

7.4.1.2. Where trams operate underground or are contained within a larger building such as a railway station or shopping complex the guidance in section 2 Stations should be referred to for aspects of the design affecting those features which are not addressed in this section such as evacuation, fire safety and management of large pedestrian flows.

7.4.2. Tramstop location

7.4.2.1. 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; and

c) lighting.

7.4.3. Tramstops should be sited so that:

a) people that 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 on or approaching the tramstop; and

d) other road users have adequate visibility of the tramstops and pedestrians at or approaching a tramstop.

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

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

7.4.3.3. Locations at which the tram may ‘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%). A gradient steeper than 1:500 falling towards the end of the track may be acceptable in conjunction with a secondary means of preventing a tram runaway subject to the approval of the RSC. Where single-ended trams are used and turning loops are provided at terminals, the terminal tramstops will be considered as through running.

7.4.3.4. Other tramstops may be built at the gradient of the line. However, when tramstops are located on gradients, consideration should be given to the difficulties which might be created for those who are mobility impaired when alighting onto a sloping surface.

7.4.4. Tramstop platforms

7.4.4.1. Platforms may form part of the surrounding pavements which are part of the roadway or other public areas accessible to pedestrians.

7.4.4.2. Platforms should be provided with a tactile surface to indicate the approach of the edge to visually impaired people. Platforms should have an anti-slip surface and be either level or sloped away from the track edge. Platform edges should be clearly defined with a strip of lighter colour. The design of the tactile surfaces should be subject to RSC approval.

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

7.4.5. Platform height

7.4.5.1. The height of the platform should be determined by the height of the tram floor or passenger door threshold. A platform which has a level of more than 400mm above the uppermost rail level of the tram track (even though the step-height above the surrounding road or pavement may be less than 200mm) is deemed to be a high platform.

7.4.5.2. Where high platforms are provided and the height difference between the footway and the platform is more than 400mm, 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.

7.4.5.3. There should be level access for mobility impaired people, from the platform to the floor of the tram. Where this is not practicable through all doors, adequate signing should be provided to indicate the door or doors to be used which provide level access. In this context, 'level' means 'not impeding the access of a wheelchair'. Any difference in level should not exceed 35mm either above or below the platform edge level.

7.4.5.4. It should also be recognised that 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 and the signing of 'level access' doorways should take this into account.

7.4.6. Platform width

7.4.6.1. The width of the platform 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.

7.4.6.2. 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 1500mm.

7.4.6.3. An island platform should normally be at least 3000mm wide, but may be narrower for low platforms. Where an island platform has a structure on it, section 7.4.6.2 should be applied and the platform width increased. An island platform is one which lies directly between two tram tracks. A platform between a tram track and another carriageway lane not used by trams is a side platform. Similarly a platform between two tram tacks where only one face is used for boarding and the other is fenced is a side platform.

7.4.7. Clearances between platforms and trams

7.4.7.1. For newly constructed platforms the horizontal clearance to the passenger door thresholds of the static tram should not exceed 75mm on straight or curved, level track. On straight track this should be reduced where practicable. The amounts by which the static vehicle profile (see Section 7.2) has to be increased to form the kinematic envelope or the developed kinematic envelope are speed dependent, therefore the gap is also dependent on the speed of any tram arriving, departing or passing through it. Constraining this increase by the platform edge may require the imposition of a speed limit through the tramstop.

7.4.7.2. Where former or existing railway platforms are incorporated into a tram system, the horizontal clearance to be achieved should be discussed with the RSC.

7.4.7.3. A recess below a platform coping is not required for tram platforms.

7.4.7.4. Where a side platform has road traffic adjacent to the non-tramway side, the non tramway side should be fenced other than at access/egress locations and clearances should be provided in accordance with the appropriate advice of the DoT.

7.4.8. Overhead clearances at platforms

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

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

7.4.9. Lighting at tramstops

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

7.4.10. Access to tramstops

7.4.10.1. A safe and convenient access to tramstops should be provided for all, including mobility impaired people. Where possible, access which avoids having to cross the tram tracks to reach platforms is preferred.

7.4.10.2. 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. Ramps at the ends of all high platforms are required, irrespective of whether they are used for access or not.

7.4.10.3. Where access to a tramstop is by ramp from an adjacent roadway bridge, the length of the ramp will, if the slope is 1 in 20 (5%) be in the order of 100 m where the roadway 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.

7.5. ELECTRIC TRACTION SYSTEM (ETS)

Principle 7.5 Electric traction system

Any overhead traction current system should be installed and managed to minimise the risks it presents to people in the public environment, and environmental risks from stray currents. A central control facility should monitor the electric traction system and safely manage any variations from normal operation.

7.5.1.1. This section provides guidance on the overhead electric traction system for tramways.

7.5.1.2. Trams should be supplied with electric traction power from overhead line systems at a voltage not exceeding 750 V dc nominal for on-street sections. This voltage may be increased to any normal railway voltage (subject to the normal safety requirements) for off-street sections.

Note 1: The future application of conductor rail systems was considered but is not suitable for on-street sections and is not preferred for off-street sections.

Note 2: On on-street systems, ac power supply systems should not be used without prior consultation with the RSC. On off-street systems, ac power supply systems may be used as long as the guidance given in section 3 Electric traction systems is observed.

7.5.1.3. The design of overhead electric traction power supply systems should, in so far as is appropriate, follow the guidance for main-line railways (see section 3 Electric traction systems). However, on-street or up to 750 V sections may use trolley wire or catenary systems.

7.5.2. Overhead line equipment (OHLE) on the street

7.5.2.1. Structures supporting an overhead electric traction power supply system on on-street sections should be positioned so that they neither significantly obstruct the street, road or footway nor are unduly exposed to damage from an errant road vehicle. Appropriate warning signs as prescribed in the relevant regulations should be erected.

7.5.2.2. Electric traction supply (ETS) 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 construction and material of poles for overhead ETS should be approved by the RSC.

Note 2: The general requirements for clearances to electric traction supply poles are given in section 7.2.

Note 3: Where footways are a minimum width (normally 1800mm) the Road Authority may require the poles to be located beyond the back of the footway.

7.5.2.3. All poles in public places are required to be resistant to climbing.

7.5.2.4. Structures supporting the overhead line equipment should be double-insulated as a minimum and any poles earthed rather than connected to the electric traction return.

Note: The use of multiple insulators or lengths of continuous insulation in the support system of the overhead live equipment may reduce the risk of insulation degradation causing hazardous touch potentials in structures to an acceptable minimum. The recommendations of section 3, Electric traction systems to bond structures to the return conductor of the electric traction supply may then be unnecessary. This technique will help to reduce conductivity between the electric traction return system and the earth and so reduce stray currents.

7.5.3. Security of conductor wire in the event of collapse or loss of one support

7.5.3.1. The design of the overhead line supports should aim to minimise the vulnerability of each support to damage. The loss of a single support (e.g. a fire loosening a building fixing or a pole 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 5200mm above the road.

Note: Connections between the pole and the conductor wire should be less strong than the conductor wire system itself to ensure that if a pole is damaged, the support will fracture before the live equipment is dragged down.

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

7.5.4.1. 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.

Note: Where street lighting or other electrical equipment is proposed to be fitted to existing electric traction power supply poles, prior agreement from the RSC should normally be obtained. Precautions may include double insulation in respect of the different electrical systems and specially designed earthing systems.

7.5.5. Management and safe operation of power supply

7.5.5.1. The design of the overhead electric supply system should ensure that dangerous touch potentials are avoided under normal and fault conditions.

Note: The spacing of electrical sub-stations may be significant.

7.5.5.2. Tripping devices should be provided so that the electric traction power supply can be discharged in an emergency.

Note: Automatic or manually operated tripping devices may be used. The design of manual tripping devices should allow a person authorised by the tramway operator to operate the device.

7.5.5.3. 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 must be protected from casual interference by unauthorised people and located so as not to cause a hazard.

7.5.5.4. Designated earthing points are required so that, either in emergency or as part of a planned isolation, the normally live equipment can be earthed. The earthing points may either be contained in draw pits which give access to a return conductor or, preferably, mounted on designated poles which should be identified.

7.5.5.5. Arrangements for the maintenance of the street lighting should be designed so that, as far as practicable, such maintenance can be done without affecting the tram system.

7.5.6. Sectioning

7.5.6.1. 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.

Note: Further factors to consider about sectioning can be found in section 3, Electric traction systems.

7.5.7. Central control facilities

7.5.7.1. Provision should be made at the tramway operational control centre for the safe and efficient management of the electric traction power supply system.

Note: Where the traffic control is located separately from the electric traction power supply control then communication facilities are required between the two control facilities (see section 7.6).

7.5.7.2. There should be a monitoring system which shows clearly the position or status of all switches, isolators, circuit-breakers or other devices controlling the power supply.

7.5.7.3. The arrangements for the control of the traction supply should be such that under all normal or failure conditions of the control system a demand for the emergency discharge of that supply at a particular location can be met within the response time required by the emergency services.

7.5.7.4. 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 overhead 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.

7.5.8. Avoidance of dangerous touch potentials to adjacent structures

7.5.8.1. 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: It should be understood that the 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 will be at a different potential particularly at sites remote from feeder stations and under fault current conditions.

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

7.5.9. Minimisation of leakage of stray current to earth

7.5.9.1. The design of the electric traction supply system should ensure that the leakage of stray current is normally minimised, particularly where:

a) the risk of galvanic corrosion to structures or apparatus belonging to gas, water supplies and others needs to be kept as low as reasonably practicable; and

b) dc currents in the earth might lead to danger by corrosion or malfunction in other structures or equipment (e.g. railway track circuits).

7.5.10. Traction Current Return System

7.5.10.1. To achieve the forgoing requirements of clauses 7.5.8 and 7.5.9 consideration should be given to the optimum traction power system design and arrangement of traction return currents. Where running rails our used as traction return conductors a potential difference will exist with respect to earth, this can give rise to hazardous touch potentials and cause leakage currents to earth. These effects can be minimised if the longitudinal resistance of the return path and the distance between supply connection points is minimised. Earth leakage current can be further reduced by have the maximum resistance between the running rails and earth; and allowing the traction power supply to "float" with respect to earth. In the case of an earth fault the system design must ensure that hazardous potentials cannot arise. Further guidance may be found in EN 50121 Part 1 & 2.

7.5.10.2. In depots the overriding requirement to prevent hazardous touch potentials may necessitate special arrangements including solidly cross bonding all steel structures thereby preventing isolation of the running rails from earth. In this case it may be necessary to completely segregate the depot power supply and traction return current system from the reminder of the light rail system. Further guidance may be found in EN 50121 Part 1 & 2.

7.5.10.3. The Traction power system design should describe and justify the measures taken to ensure that hazardous touch potentials doe not arise during normal, abnormal or fault conditions. The means to reduce the effect of stray traction return current and the steps necessary for ongoing surveillance should also be described.

Note 1 EN 50122-1:1997 Railway Applications Fixed Installations Part 1. Protective provisions relating to electrical safety and earthing.

Note 2 EN 50122-2:1999 Railway Applications Fixed Installations Part 2. Protective provisions against the effects of stray currents caused by d.c. traction systems

7.5.11. Clearances

7.5.11.1. 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.

7.5.11.2. It takes into account dynamic effects including the uplift from a pantograph.

7.5.11.3. The appropriate clearances for tram systems are:

	Up to and including 750 Vdc (nominal)	Up to and including 1500 Vdc (nominal)	
	Normal minimum	Normal minimum	Special reduced
Static Clearance	75 mm	150 mm	100 mm
Passing Clearance	25 mm	100 mm	80 mm

Table 1: Static and passing clearances

Note 1: Special reduced clearances should be discussed with the RSC at the design stage in each case.

Note 2: For voltages up to 750 V dc nominal, the minimum clearances result more from physical constraints than from electrical considerations so that smaller clearances are generally impractical. For higher voltages, clearances equal to or above the normal minimum should be provided unless the RSC has advised that a lower figure, but one which is normally equal to or greater than the special reduced figure, is suitable in the particular circumstances.

Note 3: For voltages up to 750 V dc nominal, the static clearance may be reduced with prior agreement from the RSC as long as sufficient insulation is provided.

7.5.11.4. The vertical clearance between the underside of new structures or ones which are being significantly modified and the developed kinematic envelope should not be less than 400mm to accommodate the necessary electrical clearances over the tramway.

7.5.12. Height

7.5.12.1. The height of the contact wire or any other live part of the overhead electric traction supply system should not be less then 5800mm above the surface of any carriageway except where a lower headroom is necessary beneath existing bridges over the tramway.

7.5.12.2. At other places accessible to the public, the height of the contact wire or any other uninsulated live part should be not less than 5200mm above the ground, or above a place where a person might reasonably stand (e.g. a platform or adjacent raised surface).

Note: EN 50121-1:1997 specifies a minimum vertical clearance of 4700mm which allows the required clearance of 300mm for vehicles up to 4200mm for voltages up to 1.5 kV dc 1 kV ac. Heights of vehicle likely to be encountered are 4200mm high (i.e. A standard container on a suitable flatbed vehicle). The EU Directive 96/53/EC specifies a maximum permissible height for commercial vehicles of 4000mm. This applies equally to domestic and cross-border traffic within the European Union. However, a number of member states including the UK and Republic of Ireland, take advantage of the opportunity to permit exemptions from the directive in their own countries. Above 1.5kV dc/1kV ac EN 50121-1 requires a minimum of 5500mm.

7.5.12.3. Where the headroom below the contact wire of the OHLE is reduced, the ‘safe height’ should be indicated on road traffic signs. Both advance warning signs to Traffic Signs Manual Figures

6.36 and 6.37 should be provided.

Note: The indicated safe height for voltages up to 750 V dc should be at least 460mm less than the actual headroom unless height gauges are installed, in which case the indicated safe height should be at least 380mm less than the actual headroom.

7.6. SIGNALLING

Principle 7.6 Signalling

Any off-street running may be signalled as a normal railway, but on-street tram signals should be provided only to allow safe movement in relation to other road users. The system should be supported by a central control and a radio communications network.

7.6.1. General guidance

7.6.1.1. The objectives of a signalling system on a tramway are to control the movement of trams, prevent collisions and prevent possible derailment on points and crossings.

7.6.1.2. Where a tramway operates on a segregated right-of-way, any signalling may be similar to that used on a main-line railway (see section 4 Signalling). Otherwise, tramways predominantly operate on the basis of line-of-sight. When operating in this mode, tramway signals have a similar meaning to road traffic signals, i.e. it is the tram's turn to proceed but only if it is safe to do so.

7.6.2. Types of signalling systems

7.6.2.1. Line-of-sight driving is required to be used on all on-street tramways.

7.6.2.2. Conflicting road and tram movements at roadway intersections and places where a tramway crosses a carriageway should, where necessary, be controlled by road signalling.

7.6.2.3. 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 indicates the route is clear may be used in association with clearly identified signals to allow trams through the area at a higher line speed.

Note 1: This option is only available in tunnels or other places where other traffic and pedestrians can be excluded.

Note 2: The prescribed tram signal head may be used with a supplementary plate to indicate its status as a route clear signal.

Note 3: On tramways which have a mixture of on and off-street sections a tram signal may be used on the off-street section.

7.6.2.4. Part-time traffic signals may be employed to allow the use of emergency crossovers and other infrequently required tramway routes on the roadway. The appropriate signing for part-time traffic signals on the road as given in the relevant regulations should be provided. This may need to be supplemented to give more information to other road use (e.g. 'tram reversing').

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

7.6.3. Track sharing

7.6.3.1. 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 characteristics.

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

7.6.4. Location of tram signals

7.6.4.1. On the roadway, the layout and positioning of signals for trams and the associated staging and phasing at intersections should follow current roadway traffic engineering principles.

7.6.4.2. Where tram signals on the roadway 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 Road Authority.

7.6.4.3. Where the tramway track layout allows for the reversal of trams in a way which 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.

7.6.5. Tram detection

7.6.5.1. Systems of detection should be configured so that the failure of an individual detector does not compromise the safe operation of the road junction or pedestrian crossing. The form of detection for trams may be different from those used for other vehicles on the roadway.

7.6.5.2. If each end of a tram is separately identified for route-calling and route-releasing then suitable arrangements should be provided for inhibiting one end if required. Similarly, if two or more trams are coupled together, suitable arrangements should be provided for inhibiting selected ends.

7.6.6. Route setting

7.6.6.1. The setting of points should be entirely within the tramway system control and may be pre-selected.

7.6.6.2. The throw of the points (unless they lie in a fully segregated place) should only occur 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.

7.6.6.3. An indication of the lie of facing or non-trailable power-operated trailing points should normally be given to the tram driver by a visual signal, positioned close to the points. Where necessary to avoid clutter, the indicator may be co-located with the tram signal at the road junction.

7.6.6.4. Points located within depot areas not used for passenger movements do not normally require detection and indication. Emergency trailing crossovers on the running lines which are only used in exceptional circumstances may not require detection and indication subject to approval by the RSC.

7.6.6.5. If the points are incorrectly set, or misaligned, the place where the tram would stop should be where it does not cause an obstruction to other road users and should be clearly marked.

7.6.7. Reversal and 'wrong direction' running

7.6.7.1. Fixed tram signals to enable running in the 'wrong' direction in an emergency are not required. Such movements on on-street tramways should only be made under the direction of a person holding an authority granted by the Gardai.

7.6.8. Design and construction of tram signals

7.6.8.1. A tram signal should be provided at all road traffic signalled installations.

7.6.8.2. Traffic signals applicable to tramways should follow relevant regulations as approved by the DoT.

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

7.6.8.4. The tram signal may be a single lamp design showing a bar or dot symbol, or a multi-lamp design showing an array of five white lights.

a) 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.

b) 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.

7.6.8.5. The tram signal design should make provision against showing an indecipherable aspect, for example, by being able to detect a defined minimum number of lamps to be shown for each aspect and alerting the control centre 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.

7.6.8.6. Duplicate or additional primary tram signals may be provided if necessary.

7.6.8.7. Tram signals should be located on the left-hand side of the track. On on-street tramways, these

may be located on the right-hand side, i.e. between pairs of tracks, subject to the clearance requirements being met.

7.6.9. Tramway and road traffic signs

7.6.9.1. Signs for other road users consequent upon the introduction of a tramway are to be either contained in the relevant regulations or authorised by the Minister for the Environment and Local Government.

7.6.9.2. A proliferation of signs should be avoided.

7.6.9.3. Signs applicable to tram drivers only should be mounted so as to be conspicuous to drivers of trams but presenting as little distraction to other road users as possible, e.g. on electric traction supply poles. These signs will be prescribed in regulations made by the Minister for the Environment and Local Government or authorised by the Minister and included in the Traffic Signs Manual or other such guidance document.

7.6.10. Speed limits

7.6.10.1. Approved lineside signs indicating the maximum permitted speed should be shown throughout a tramway. All signs should be similarly mounted. These signs should be located wherever:

a) the tramway system changes from off-street to on-street;

b) the maximum permitted speed on a section of tramway changes;

c) the maximum permitted speed of a tramway located in the carriageway differs from the limit for other road vehicles.

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

7.6.10.3. 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 Gardai and the Road Authority and prescribed in the speed limit regulations made by the Minister foe Public Enterprise under the Transport (Railway Infrastructure) Act 2001.

7.6.11. Control of tram signals

7.6.11.1. 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.

7.6.11.2. Signalling equipment and software to be used on the roadway must comply with European standards and the requirements of the Road Authority.

7.6.11.3. 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.

7.6.11.4. 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.

7.6.11.5. 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.

7.6.11.6. 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.

7.6.11.7. 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 relevant Road Authority, as described in section 7.6.

Note 1: In fixed time systems, the tram phases should run irrespective of the presence of a tram.

Note 2: For demand dependent systems, tram signal phases should run in conjunction with parallel and complementary phases for other roadway users.

7.6.11.8. Where tram movements conflict with other road traffic flows, separate stages or phases should be provided solely for tram movement. The phases used for trams are required to finish (i.e. return to 'Stop') simultaneously with, or earlier than, the parallel phases for other road vehicles.

Note 1: An allowance should be made for a longer stopping period to give the tram earlier warning of the impending 'Stop', and thus reduce the risk of the tram overrunning the stop land a longer all-red period (i.e. the inter-green period) may be required following the termination of the tram phase.

Note 2: 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.

7.6.11.9. The design of a pedestrian crossing should ensure that, subject to a time-out 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.

7.6.12. Control centre

7.6.12.1. The tramway traffic control room should be provided with a line diagram showing, at least, the track layout and positions of tramstops.

7.6.12.2. Unless the tramway traffic control room is combined with the electrical control room, the former should also have a line diagram of the electrical supply system showing the locations of feeding points, 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 displayed unambiguously. A fixed line diagram should also be provided if display screen equipment is used for the main displays. It is preferred that the tramway traffic control room should be combined with that for the control of the electric traction power supply system.

7.6.12.3. A direct telephone link, which is not routed through an internal exchange, should be provided between the two control rooms if they are not combined and between the tramway traffic control room and the local emergency services control. A link should be provided to the controlling signal-boxes of any railway system which shares an alignment with the tram system.

7.6.12.4. Whenever control-room staff form part of the safety-critical signalling system, all messages between them and out-stations 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.

7.6.13. Radio communications systems

7.6.13.1. An adequate system of radio communication between the tramway operational control centre and trams should be provided. A discrete system between the tram driver and the controller should be provided if instructions which are critical to safe operation are to be passed over a voice channel.

a) if safety-critical messages are to be transmitted by voice by radio, control-to-tram driver voice radio communications should be designed so that, except for an 'all-stations' call, transmitted as an emergency call by control, only the intended tram receives the call;

b) safety signalling messages may be sent over an open-channel radio system by data-stream providing a unique, fail-safe address system is used;

c) except as provided for in d), 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;

d) on tramways where the trams are crewed by one person and which have significant parts of their route in tunnels or on viaducts, the operation of the driver's safety device (DSD) should open a direct means of communication between passengers and the system controller.

7.6.14. Road and tram traffic signalling integration

7.6.14.1. The following sections provide 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. Figure 9 and Figure 10 illustrate ways in which detectors may be positioned.

7.6.15. Controlled intersections

7.6.15.1. Detectors for trams should be provided where road traffic light control systems employ some degree of demand dependency. The detectors' 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.

7.6.15.2. 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.

7.6.15.3. The minimum provision is a 'stop line detector' and a 'cancel detector'.

7.6.15.4. 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. 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.

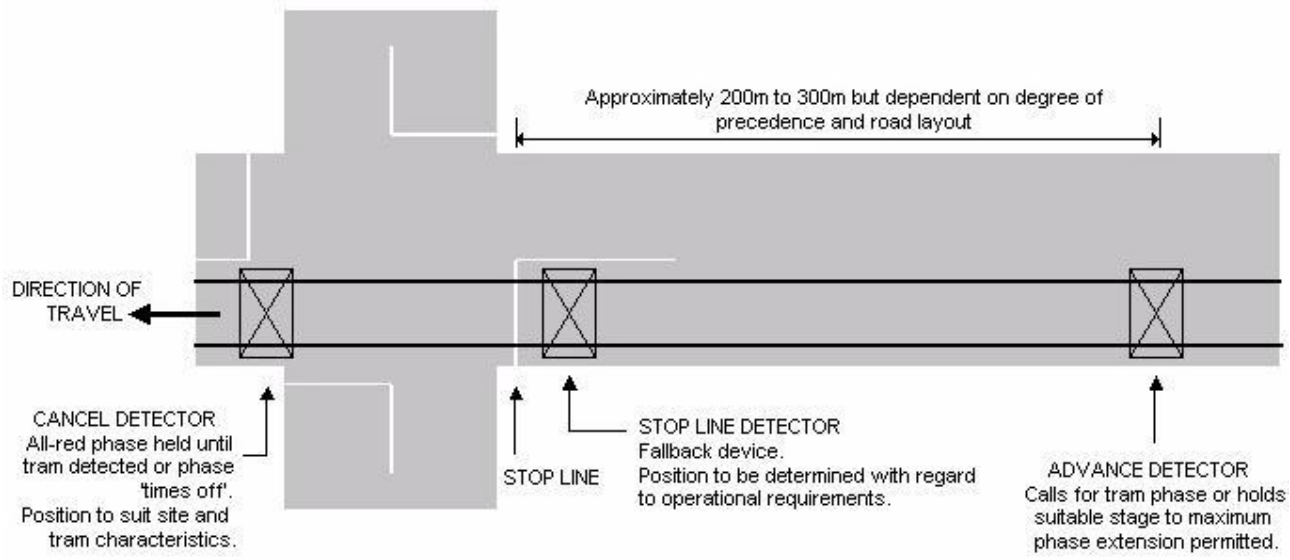

Figure 9: Tram detector positions

7.6.15.5. Further advanced detectors may be necessary to allow the tram the maximum precedence and permit it to run unimpeded through the intersection. See Figure 9.

7.6.15.6. 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 go to the appropriate phase, the objective being for the Proceed aspect to be shown before or just as the tram reaches an overall service braking distance (includes reaction time) from the stop line.

7.6.15.7. A stopping amber equivalent aspect should be displayed for a period commensurate with the service braking performance and approach speed of trams. The nominal time for this aspect to be displayed will be 5 seconds, but may be varied between systems according to local geographic, climatic and traffic conditions, which may affect the braking performance of the trams. However, the time specified should be consistently applied throughout each individual system.

7.6.16. Priorities at controlled intersections

7.6.16.1. 'Hurry call' signals for emergency service vehicles should override all other demands.

7.6.16.2. Where a tramstop is located between where the advanced detector would be positioned and an intersection, a 'vehicle ready to start' transponder (VRS) should be provided so that the tram driver can initiate the tram phase when the tram is ready to depart from the tramstop. See Figure 10.

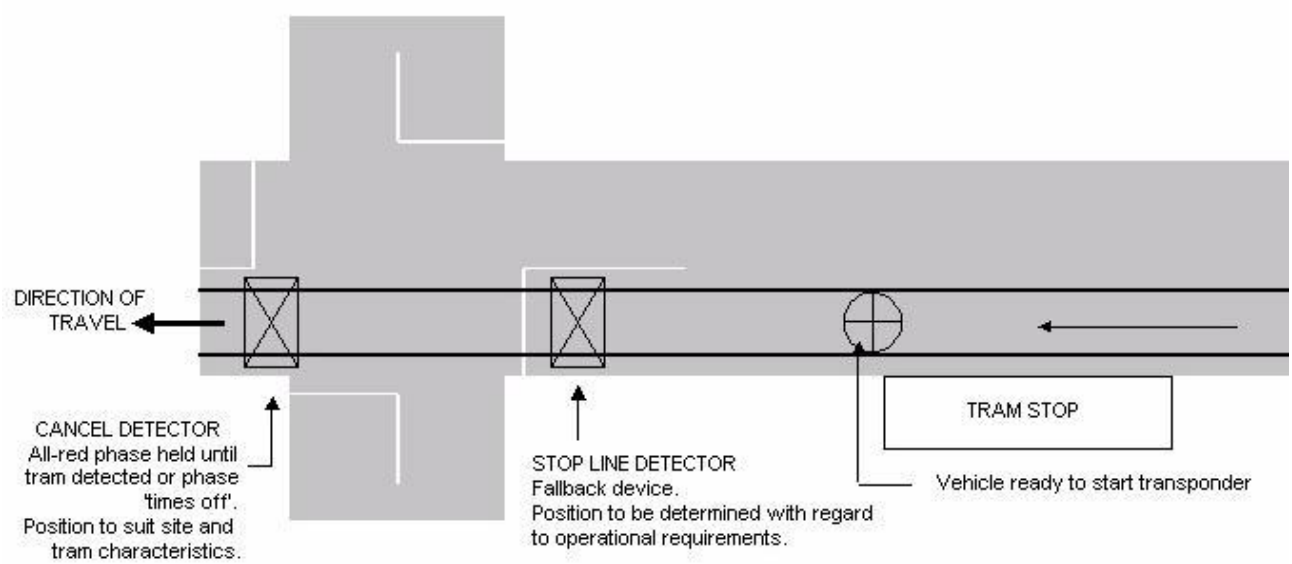

Figure 10: Tramstop and VRS positions at an intersection

7.6.16.3. Where a tramstop is so close to the intersection that the vehicle ready to start transponder would be located with or very close to the stop detector, then the vehicle ready to start transponder should replace and also assume the role of the stop detector.

7.6.17. Pedestrian crossings

7.6.17.1. Pedestrian crossings which are at a signalled road intersection should be controlled by the road traffic light controller.

7.6.17.2. Where pedestrian crossings traverse 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.

7.6.18. Pelican (stand alone) pedestrian crossings

7.6.18.1. 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 will be subject to a time-out when the tram is unduly delayed).

7.6.19. Road traffic light controllers

7.6.19.1. Tram signals should be of a unique appearance and operation. They lend themselves to a phase-based operation.

7.6.19.2. A road traffic light controller modified to control tram signals is required at all signalled intersections. Road traffic light controllers will need to comply with relevant European standards and the requirements of the Road Authority.

7.6.19.3. Communication is required between the road traffic signal controller and any tram detectors and transponders. 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 transponders or from a tramway traffic control facility. The tram detection equipment will normally be provided by the tram operator. It may also be necessary to provide an interface unit between the road traffic light controller and the tram detection equipment.

7.6.19.4. 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. See Figure 11.

7.6.19.5. 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.

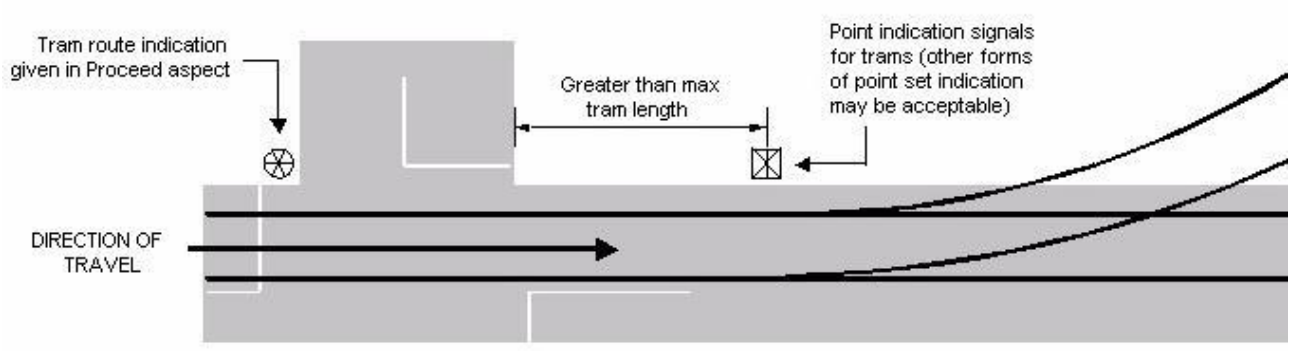

Figure 11: Tram junctions with points after road intersection

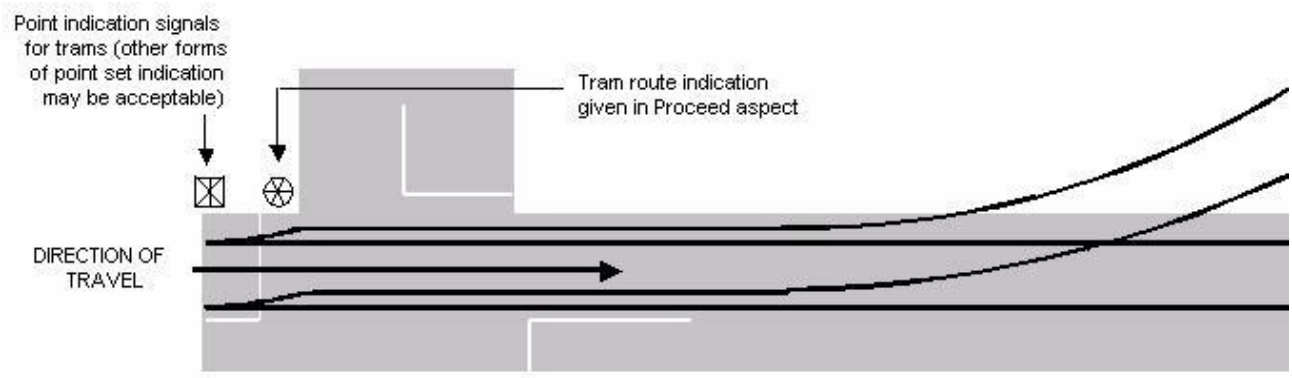

Figure 12: Tram junctions with points before road intersection

7.6.19.6. Local point indicators should be provided adjacent to the point ends (see Figure 12); only these indicators and not the tram signal can show the lie of the points.

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

7.6.20. Urban traffic control systems

7.6.20.1. 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.

7.6.21. Equipment monitoring

7.6.21.1. The road traffic light controller is required to monitor the failure of lamps in the tram signal.

7.6.21.2. 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.

7.6.21.3. Where tramway systems operate within a UTC area, the road traffic light signals will be monitored regularly, but, in addition, monitoring of the tram signal lamps is also required. To prevent a misleading tram signal aspect being shown in a combined, single-unit array, having individual lamps or clusters of 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 which case the control centre should be alerted.

7.6.21.4. Where tram systems operate outside UTC areas, or in towns and cities without UTC, a dial-up monitoring system which complies with the requirements of the Road Authority should be provided.

7.6.21.5. A change of design of some existing road traffic light controllers is required to comply with this guidance.

7.6.21.6. 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).

7.6.21.7. An alternative means of registering a tram demand is required in the event of failure of a detector, such as vehicle ready to start transponder which doubles as a stop line detector. Alternatives may be:

a) the creation of a plausible demand. (If any detector fails where other detectors are available for inputting plausible demands they may be used to call up a tram phase).;

b) recognition of a stop line detector registering a permanent demand (Where a road traffic light controller can recognise that a stop line detector is registering a permanent demand, e.g. 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;);

c) a key-operated override switch located at the local traffic controller (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); or

d) remote input from the urban traffic control system (Consideration should be given to providing a facility to enable UTC to activate a tram phase from the UTC centre to assist with trams, or tram maintenance vehicles, that for various reasons may be unable to call up their phase at road traffic light signals e.g. because of a faulty transponder).

7.6.22. Detectors and transponders

7.6.22.1. Tram selective detectors may employ any approved technique but they are required to respond to trams only. Selective detectors may also pass information for tramway operational purposes.

7.6.23. Approval

7.6.23.1. All equipment: used to control road traffic on the road, connected to a road traffic light controller or housed with the road traffic light controller is required to be approved by the relevant Road Authority before being put into service.

7.7. TRAMS

Principle 7.7 Trams

Trams should be designed to be safe for the conveyance of passengers and staff and to minimise the risks they may present to other road users, both vehicles and pedestrians.

7.7.1. General Notes of Tram Design and Construction

7.7.1.1. Section 6 Trains gives much general guidance which is also appropriate to light rail and trams. This section gives guidance on those aspects which are specific to trams, it is not intended that any guidance also applicable to trains be repeated in this section.

7.7.1.2. This section has been formatted into similar sections to section 6 (trains) to make referencing easier.

7.7.1.3. A dual-purpose passenger-carrying vehicle, adapted for use on both road and rail, should be regarded as a tram when using rail guidance.

7.7.1.4. For guidance on the design and construction of non-passenger-carrying trams, see section 7.9-Non-Passenger-Carrying Trams.

7.7.2. General guidance

7.7.2.1. 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 roadway.

7.7.2.2. In general a tram which operates on-street should conform to the current requirements for the construction and use of road vehicles, in so far as appropriate.

7.7.2.3. Although not subject to the mandatory requirements for road vehicles, trams should nevertheless include features in their construction and performance which make them safe for use on the roadway and in other places where they share the route with other users.

7.7.2.4. The tram design should ensure that it is conspicuous at all times.

7.7.3. Running gear

7.7.3.1. Running Gear should be designed to guide the train safely along the track.

7.7.3.2. Running gear should take the following into account:

a) the need to reduce noise in sensitive residential areas;

b) the use of grooved rail, and in some areas the use of flange running at points and crossings, means that a wheel profile should be purpose-designed to interface with all forms of track construction proposed for the tramway;

c) effective obstacle deflection equipment should be provided to reduce the risk of derailment on the roadway. This equipment may be attached to the running gear or to the tram underframe;

d) effective obstacle deflection should be provided to mitigate against the risk of injury to pedestrians knocked under a tram.

7.7.4. Structural integrity

7.7.4.1. The structural integrity of trams should be maintained in normal operations and afford protection to people in the event of an accident.

7.7.4.2. 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;

c) have adequate jacking points with their positions clearly identified on the outside of the tram and accessible for use by the emergency services.

Note: The end loading standard should be compatible for all trams on a system. Maintenance vehicles used only during non-traffic hours or during absolute possession of the line may be to a different standard. The

impact speed of collision may be taken to be 25 km/h.

7.7.4.3. Collision protection should be provided against vehicles and large obstacles as follows:

a) trams on on-street tramways should be provided with underrun protection at the ends and sides, similar to that required for other passenger-carrying vehicles and large goods vehicles;

b) trams used exclusively on off-street tramways should be fitted with an appropriate obstacle deflector.

Note: In all cases, where the underframe does not provide sufficient protection, additional measures may be required.

7.7.4.4. 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 any person or livestock which may come into contact with the tram and stop them from passing under the vehicle;

b) where the skirting at the end of a tram does not provide adequate protection, there should be a fixed guard immediately in front of the leading wheels designed to deflect objects out of their path;

c) where the design of the tram requires, because of a large distance between the leading wheels and the front of the vehicle, a 'survival space' should be provided between the front of the vehicle and the wheel guard to protect against a person being crushed.

Note: The fixed guard should be positioned as close to the roadway 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 roadway. The bottom edge of the guard should not be less than 50mm or more than 100mm from the level of the top of the rail.

7.7.4.5. 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 roadway.

7.7.4.6. It should not be possible or necessary for people to lean out of windows or other apertures or throw large objects through them.

7.7.4.7. 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.

7.7.4.8. Couplers should be designed to withstand the loads for which they are intended.

a) If the coupler is designed for regular service use, it should, as a minimum, accept the load imposed when hauling or propelling a 'dead' tram at 10% overload of its maximum laden weight, anywhere on the system.

b) Couplers for emergency use only should be able to haul or propel a 'dead' tram at 10% overload of its maximum unladen weight.

7.7.5. Speed Regulation

7.7.5.1. The speed regulation of the tram should meet the operational requirements of system on which it is being used without causing any danger.

7.7.5.2. Trams should be fitted with:

a) a continuous system for the control of the service brake, operable from the cab in service, on one or more trams coupled in service conditions;

b) a parking brake which is automatically applied when the tram is 'shut down';

c) where the braking force applied through the wheels is insufficient to meet the required braking

performance criteria, a brake or brakes acting directly on the track are required to be fitted;

d) a reliable and accurate speed indication system.

7.7.5.3. 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;

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.

7.7.5.4. An irrevocable emergency brake application should result from:

a) a lack of correspondence between vital control systems;

b) the loss of control air pressure;

c) the loss of brake activating pressure;

d) the accidental parting of vehicles;

e) the opening of doors or the unintended deployment of steps.

7.7.5.5. Trams running on the roadway should have brakes which provide deceleration rates similar to other public service vehicles and road vehicles, particularly in an emergency stop.

7.7.5.6. The application of the brake should produce a retardation of about 1.3 m/s^2 for service braking and 3 m/s^2 for emergency braking. The latter may include use of the track brake.

7.7.5.7. The change in the rate of deceleration (jerk rate) should not exceed 0.8 m/s^3 and definitely should not exceed 1 m/s^3, however, the performance of brakes in an emergency should not be compromised.

Note 1: An emergency brake application may exceed these jerk rates, but should be jerk limited so far as is reasonably practicable so as not to endanger standing passengers.

7.7.5.8. On systems which are exclusively off-street, the service braking rate and the signalling system are required to be compatible.

7.7.5.9. The parking brake should be able to hold a fully laden tram on the steepest gradient or to hold itself and another, unladen, tram with failed or isolated brakes on the steepest gradient on the system.

7.7.5.10. The use of other means to ensure that the speed is regulated should be considered, such as:

a) sanding equipment to increase wheel/rail adhesion;

b) protection against wheel spin when accelerating;

c) protection against wheel slide when braking.

7.7.6. Powered systems

7.7.6.1. The electrical and other powered systems and equipment on-board trains should not endanger other systems or people in either normal operational, maintenance or failure modes.

7.7.6.2. 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.

7.7.6.3. Preventative measures should be provided to guard against fire or the overloading of a system under fault conditions and to enable a tram either or both of the following:

a) to be operated safely under emergency conditions in the event of failure;

b) to be recovered or otherwise removed from causing an obstruction on the roadway.

7.7.6.4. 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).

7.7.6.5. The power supply system on-board the tram should provide an adequate, protected path for the

return current and must be protected against the effects of accidents and unauthorised access to the live parts.

7.7.6.6. The power systems must be appropriately guarded against unauthorised access.

7.7.6.7. The following should be considered when designing electric traction and current collection equipment:

a) the 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;

b) 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 must be roof-mounted for overhead electric traction systems;

c) overhead systems should be fitted with roof-mounted lightning surge arrestors.

d) sufficient and effective bonded paths to the wheel-rims from the superstructure must be provided on any tram used on an electrified tramway system or on an alignment shared with an electrified railway. The return path, if this is through the rails, must be designed to ensure that conductivity remains sufficient through the wheelsets at all times.

7.7.6.8. 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 main power supply between the current collector(s) and any 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 source should be fitted so that it is accessible from ground level outside the tram; its position should be clearly marked.

7.7.6.9. 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.

7.7.6.10. Electric traction power cables must be routed so that they are protected from mechanical damage which may occur as the result of a traffic accident. In addition, the following precautions are required to be taken:

a) where the cable route passes through a fire barrier, adequate fire stopping should be provided;

b) if the cable route passes through the passenger compartment, this should be by the shortest practicable route.

7.7.6.11. Electrical equipment working above 50 V should not normally be in areas accessible to passengers.

7.7.6.12. 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 posted.

7.7.6.13. Cubicles containing power control equipment which could emit toxic fumes if set on fire should not be ventilated into the passenger compartment.

7.7.7. Access and egress

7.7.7.1. Doors and associated areas should be designed to be safe so as to minimise the danger of trapping injury, e.g. they should be padded or have sensitive soft-edges. Power-operated doors should not operate with excessive force. It should be possible to release limbs or other objects trapped by the doors without difficulty.

7.7.7.2. Facilities should be provided for mobility impaired passengers in accordance with current legislation.

7.7.7.3. Level access should be provided from the platform through at least one door of the tram. This access should be adjacent to the space allocated for wheel-chairs.

7.7.7.4. Folding steps or sliding plates should be provided where the maximum permitted stepping distances from platform to tram floor, as defined in Section 7.4.4, would otherwise be exceeded. They should be interlocked with the electric traction power controller and brakes to prevent movement of the tram when they are deployed.

7.7.7.5. 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. Consideration should be given to simultaneous operation of the brake.

7.7.7.6. Passenger door controls and the method of operation should be clearly and unambiguously signed.

7.7.7.7. All passenger doors should be provided with a means to allow passengers to release the door in the event of an emergency.

7.7.7.8. 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 at, or nearly at, a stand. Door emergency releases should be operable to open the external and internal doors even if there is a failure of any tram equipment, power supply etc.

7.7.7.9. If passenger-operated door control buttons are provided, they should be:

a) as conspicuous as possible;

b) positioned between 700mm and 1200mm above the platform level for external buttons and the same distance above the tram floor for internal buttons;

c) made operational by the driver when the tram is correctly located at a tramstop and/or it is safe to disembark.

7.7.7.10. 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 apply the brake. It should not be possible to open the doors until the tram is at, or nearly at, a stand.

7.7.7.11. There should be a means of releasing designated external doors from the outside in an emergency. The design and labelling of the release mechanism should deter non-emergency use.

7.7.7.12. The tram driver should be able to identify easily 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.

Note: If the external emergency release device is intended to be also used as a means of opening tram crew-access doors, it should be possible to reset it from both inside and outside the tram.

7.7.8. Interiors

7.7.8.1. The interior layout and fittings of passenger trams should be designed to minimise injuries to passengers and tram crew.

7.7.8.2. Doorway hand rails should not be accessible from the exterior when the doors are closed.

7.7.8.3. 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/m^2 of available standing space.

7.7.8.4. Gross laden weight calculations and floor strength requirements should be based on a standing passenger density of 8 passengers/m^2 of available standing space.

7.7.8.5. Internal steps and stairways should meet the current Regulations for passenger-carrying road vehicles. Any proposals for steps or stairways which will not comply should be discussed with the RSC.

7.7.8.6. Interior lighting in trams should meet the luminance levels provided in other passenger-carrying vehicles. In common with these vehicles, additional lighting in doorways, steps and internal stairways may be required.

7.7.8.7. Lower lighting levels are acceptable in the event of electric traction power being lost. The level of lighting should be sufficient to enable the vehicle to be evacuated.

7.7.8.8. 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 with limited movement which should be secure under load, an suitable alternative may be used;

c) interior glass which conforms to current passenger-carrying vehicle standards and has protected exposed edges;

d) passenger-operated buttons (door opening, alarm, stopping request).

7.7.8.9. Facilities should be provided for mobility impaired passengers in accordance with current legislation. They should include:

a) wheel-chair accommodation (a tramcar with accommodation for 100 or more persons shall contain not less than 2 wheelchair spaces), adjacent to a specially designated access;

b) at least one stopping request and emergency communication apparatus in a convenient position for wheel-chair users.

7.7.8.10. Equipment for emergency use should be carried on each tram. The equipment to be carried should depend on the type of the tramway but include for example:

a) a fire extinguisher;

b) other emergency gear, including if necessary track-circuit operating clips;

c) a bracket to hold the tram driver's hand lamp which should be sited so that, in emergency, the lamp can be used as a temporary tail light;

d) a first-aid kit.

7.7.9. Communications

7.7.9.1. 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.

7.7.9.2. 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.

7.7.9.3. A radio communication system should be installed to all trams, this should be compatible with the infrastructure and allow communication between the tramway operational control centre and trams. Further details of the requirements are provided in section 7.6.

a) except as provided for in b), 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;

b) on tramways where the trams are crewed by one person and which have significant parts of their route in tunnels or on viaducts, the operation of the driver's safety device (DSD) should open a direct means of communication between passengers and the system controller.

7.7.10. Tram compatibility

7.7.10.1. A tram to be used on the roadway should be equipped with a system of communication to permit it to be detected by roadway 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.

7.7.10.2. The external lighting of trams which run on-street should conform as nearly as possible with the lighting requirements for road vehicles, 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;

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.

7.7.10.3. 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 (Bi-directional trams – Two amber)	Two red (Bi-directional trams – Two amber)	-
SIDE MARKER LIGHTS	-	-	At least three for a 30m 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 30m long tram, 1m above road level – amber
BRAKE LIGHTS	-	Two or clusters – red	-
FOG LIGHTS	-	Two high intensity – red	-

Table 2: Arrangements for lamps and reflectors

7.7.10.4. Lamps should be positioned as closely as possible in accordance with the relevant road traffic regulations. 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:

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 400mm;

b) front and rear position lamps and direction indicators should be approximately 1500mm from the ground and the end outline marker lamps not below the top of the windscreen at either end;

c) the main pair of headlamps should be placed between 500mm and 1200mm from ground level and the central headlamp, if above the other two, as high as possible.

7.7.10.5. While running on-street:

a) all the headlamps, the position and the end outline lamps and 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 side direction indicators should flash in time with the front and rear indicators. If a combined filament lamp is used to provide both side marker and side direction indicator lamps, the higher wattage filament is required to flash on at the same time as the direction indicator;

d) the normal road vehicle configuration for hazard warning lights should apply.

7.7.10.6. On systems which are exclusively line-of-sight off-street tramways, the following lamps should be provided:

a) a single long-range headlamp (capable of being dipped), front position lights and rear position lights;

b) brake lights;

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.

7.7.10.7. 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.

7.7.10.8. The light output of the various lamps and size of reflectors should conform as nearly as practicable to those specified for use on road vehicles. The following points should be noted:

a) care should be taken not to oversize the side marker lamps;

b) the light output of the central headlamp should be such that it does not dazzle other roadway users but does give the distinctive tram pattern. A focused beam is not required unless it is to be used as the long range beam required for an off-street tramway;

c) 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;

d) showing a red light to the front of a bi-directional tram (i.e. a tram with cab at each end), must be avoided.

7.7.10.9. 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.

7.7.10.10. 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;

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.

7.7.10.11. 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;

b) for emergency use only in all other cases.

7.7.10.12. Any couplers required for regular service use on trams on on-street tramways should be designed to fold away or otherwise be retracted when not in use.

Note: The extended position of a coupler should be included within the kinematic envelope.

7.7.11. Driver Interface

7.7.11.1. The driving cab should be designed on ergonomic principles. All the controls needed while driving should be readily to hand.

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

7.7.11.3. 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.

7.7.11.4. The design of the tram driver's cab should offer optimum internal and external visibility for the driver.

7.7.11.5. Tram signals and signs should be clearly visible from the cab on approach under all reasonably foreseeable operating conditions.

7.7.11.6. 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 should be included within the kinematic envelope.

7.7.11.7. Where mirrors are provided, they should 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.

7.7.11.8. 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.

7.7.11.9. The following driving controls should be provided:

a) a traction and brake controller, which incorporates an emergency 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;

e) an event recorder;

f) an emergency 'pantograph down' button;

g) switches to operate the main tram traction power supply circuit-breakers;

h) means to disable the appropriate controls at the non-driving end so as to prevent interference with them, this should not prevent the cab being fit for use when changing driving cabs.

Note: The button controls for c) and f) are required to be easily identifiable from other button controls and should be easily accessible from the driving position.

7.7.11.10. Controls may also be provided to:

a) limit the speed generally or when operating in a particular mode, e.g. on-street;

b) protect against wheel spin 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.

7.7.11.11. 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.

7.7.11.12. Whatever traction control system is used, security to fail-safe standards should guard against:

a) the taking of power or release of the brakes, when any external doors are detected as not closed, or 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 emergency brake, from more than one cab at a time; and

d) the movement of the tram in a direction opposite to that selected by the tram driver;

Note 1: Where a single microprocessor is used in the tram control system, it should be designed to appropriate safety-critical standards.

Note 2: A combined traction and brake controller is preferred.

7.8. TRAMWAY SIGNS TO TRAM DRIVERS

Principle 7.8 Tram signs to tram drivers

Signs imparting information to tram drivers only should minimise the risk of confusion with other road signs.

7.8.1. Draft Regulations

7.8.1.1. Regulations to provide for the traffic and signage regulatory aspects arising from the on-street running of light rail vehicles are currently in draft format and it is hoped that these will be finalised in September 2002. Information on signage can be obtained from the following sources.

7.8.1.2. Road Traffic (Traffic and Parking) (Amendment) Regulations.

7.8.1.3. Road Traffic (Signs) (Amendment) Regulations.

7.8.2. Draft Guidance

7.8.2.1. Guidance notes on traffic regulations and signage for the on street running of light rail vehicles.

7.9. NON-PASSENGER-CARRYING TRAMS

7.9.1.1. Non-passenger-carrying trams should follow the design principles for passenger-carrying ones where practicable or appropriate. However, where such trams are infrequently used or unpowered or are self-propelled works vehicles, some features may be difficult to achieve or considered unnecessary. The RSC should be consulted if some relaxation is proposed.

7.9.1.2. Trams used for the maintenance of the tramway 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 trams are used, in or out of service hours;

c) whether the trams are self-propelled or not.

7.9.1.3. Works trams should follow, unless specifically excluded below, the guidance for:

a) underframe and body;

b) driver's cab;

c) mirrors;

d) external lights and horn;

e) electric traction power controllers;

f) brakes.

7.9.1.4. Works trams are not required to follow the guidance for couplers, which may be non-folding and are not fendered.

7.9.1.5. Unpowered works trams are not required to follow the guidance for:

a) underrun protection;

b) skirts;

c) lighting and horns, but must carry side marker lights.

7.9.1.6. Unpowered works trams used at the extreme leading end of a works train should carry the appropriate forward lighting and be equipped with a shunter's position from which a member of the staff can 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 tram body is more than 2500mm above rail level.

7.9.1.7. Non-passenger-carrying trams, which operate on lines that are exclusively off-street, should meet the guidance for underframe and body.

7.9.1.8. The following lighting guidance for powered non-passenger-carrying trams replaces those given for off-street trams in section 7.7.

a) Facing forwards:

(i) at least one main, long-range, headlight (white);
(ii) two front position lights (white).

b) Facing rearwards:

(i) two rear position lights (red);
(ii) if the tramway is operated on line-of-sight driving principles, two brake lights (red).

7.9.1.9. Unpowered trams are only required to be equipped to display the appropriate lamps when the tram is either the leading or the trailing tram in a train.